I.O.S.

RRS DISCOVERY
CRUISE 119

7th APRIL – 5 MAY 1981

PHYSICAL OCEANOGRAPHY OF A FRONTAL REGION SW OF THE AZORES

CRUISE REPORT NO 130
1982

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Physical Oceanography of a frontal region SW of the Azores

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The cooperation of the Master and officers of RRS Discovery in carrying out the work outlined in this report is gratefully acknowledged.

CONTENTS

Cruise objectives

(1) To carry out a survey of the temperature and salinity structure of the upper ocean northward from 37° N 14° W to 43° 30'N and thence towards the Azores.

(2) To make a survey of the thermal and salinity structure of an oceanic frontal region SW of the Azores (near 33° N 33° W).

(3) To make trials of and deploy the Bencat (Benthic current and temperature) instrument.

(4) To launch satellite tracked buoys in the Azores frontal region.

(5) To attempt to locate and recover for inspection two Canadian satellite buoys which had been launched on the Flemish cap and which were known to lie near the ship's track.

Narrative

Discovery sailed from Gibraltar at 1500A/7th April and course was set for 37° 30'N 14° 00'W, the start of a northward SEASOAR* leg. The PES fish was deployed at 1000A/8th and routine watches were started at 1200. A short stop was made during the evening of the 8th to make a test of the performance of the midships hydraulic winch to 3500 m. This was successfully completed ca. 2000A. When passage had been resumed the SEASOAR cable was streamed in order that the fairing could be inspected. The cable was recovered by 2215A. Clocks were retarded to GMT at

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*SEASOAR. An IOS modified version of the Hermes Batfish towed undulating CTD profiler.

On the morning of April 9th a shallow calibration station (300 m) for the SEASOAR CTD and fluorometer was worked and SEASOAR deployed at 1400z. Due to initial problems with the cable connectors the northward run was not commenced until 2200 and course was set towards 38° 00'N 13° 50'W and thence northwards at a speed of 8 kts. The SEASOAR profile continued throughout the 10th and 11th with the only incident being the fouling of the PES faired cable by a piece of mooring rope. Late on the 11th the SEASOAR performance became erratic and at 0200/12th the vehicle was recovered. It was found that one the wings on the vehicle had split and that the asymmetrical drag had caused the towed body to spin. This appeared to have unlayed the towing cable to some extent. When SEASOAR had been recovered an XBT drop was made and course set towards the west. A CTD station to 2500 m was worked at ca. 0900/2 and the PES fish recovered and inspected for damage. At the end of this station course was set for position 35° N 26° W at full speed with CTD stations to 2500 m every 30 miles. Between stations the SEASOAR cable was streamed to try to correct the unlaying caused by the asymmetry of the damaged fish.

SEASOAR was relaunched ca 2300/12 and towed until 1100/13 when it was recovered to investigate problems with the fish controller. A CTD station was occupied and SEASOAR relaunched at 1430. By 1800 the performance had again deteriorated and on recovery the cause was found to be a leak in the plug on the cable storage drum combined with further problems with the outboard connector to the towed vehicle. The vehicle was redeployed at 2300/13 but again showed cable problems and was retrieved. Passage continued throughout the 14th with a CTD station and XBT drop. A further CTD station was worked early on 15th and then passage resumed towards an interception position for two Canadian Argos buoys.

During the daylight hours of 16th April a radio and visual search for the two buoys was undertaken but although strong radio signals were heard from both buoys they were not seen. (See notes on buoy operations). The search was abandoned ca. 2030 and course set towards 34° 12'N 27° 55'W for a trial of the Bencat spar and sphere. The spar and E-M heads were lowered to 3900 m on the midships hydraulic winch and the sphere lowered to the same depth on the trawl warp. A successful test was made of the acoustic release and transponder operation during the lowering of the sphere. The tests were completed at 1514/17 and course set towards 34° N 27° 55'W for the start of an XBT survey of the frontal area. XBT drops on the odd hour were commenced at 1700/17th. The XBT survey was continued throughout the 18th and 19th. During the morning of the 19th an Argos buoy with the Bencat OAR radio attached and tethered to a dhan buoy was launched and the OAR and satellite buoy direction finding procedures evaluated. The buoys were recovered at 1200/20 and the XBT survey resumed. This continued through 20th, 21st and until the afternoon of the 22nd with only brief interruptions for the interrogation of moorings 294 and 295, (set on Cruise 114), both of which were in position. During the afternoon of the 22nd a PES survey of a site for Bencat deployment was made and deployment attempted at 1600. During preparations for deployment one of the E-M heads was broken and the launch was postponed. The survey of the frontal area was continued using SEASOAR starting at 1900/22nd continuing until 1100/25th. It had been planned to launch Bencat on the 24th but winds of 20-30 knots made this unwise.

Bencat was deployed 1345/25th and was seen to reach the bottom and the sphere to have detached from

the spar at 1817. Course was then set towards 31°N 31°W for the start of two CTD sections. This work continued throughout the 26th, 27th and 28th. Two satellite tracked buoys were launched in the front at 24° 03.5'N 33° 51.9'W in the late afternoon of the 28th. These had drogues at 20 m and 200 m. The CTD section was completed early on the 29th and course set for the Bencat position with XBT drops every odd hour. The Bencat position was reached at 0400/30th and the transponder turned on. Attempts to release the instrument from the sea bed were unsuccessful (see Bencat report) and the recovery was abandoned 1100/30th. Course was set towards 32° 10'N 31° 30'W, the start position for a final undulator survey of the front. En route for this position a calibration station for the SEASOAR CTD and fluorometer was worked and prior to the start of the SEASOAR survey two more satellite buoys (again drogued at 200 and 20 m) were deployed.

The SEASOAR survey continued from 1930/30th until 1200/3rd when course was set for Ponta Delgada, Azores. The PES was recovered at the end of the SEASOAR survey but XBT drops continued until 1900/3rd.

Discovery arrived at Ponta Delgada at 0730/5th.

I.O.S. Undulator (SEASOAR) (Lawford)

Prior to this cruise a new capstan had been fitted to ship to handle the faired cable. Throughout the cruise it performed well and gave no trouble whatsoever. The vehicle was fitted with a new design of towing bridle for this cruise as a trial. This consisted of a small drum around which the towing cable was wrapped three times before being simply stopped off. This arrangement supercedes the original Batfish tapered cone fitting. Throughout

the cruise the new towing arrangement gave no trouble, the cable around the drum showing no signs of strain or wear.

During the cruise the vehicle was launched seven times. Twice it had to be recovered after less than four hours towing due to faults in the cable termination in the vehicle. One run had to be terminated after 14 hours towing due to a fault in the controller. This unit is an original Hermes controller and is badly in need of replacement.* One run of over 50 hours duration had to be ended when the trailing edge of one wing split. This caused the vehicle to rotate and 'birdcaged' the cable considerably. Luckily no permanent damage was caused to the cable as it is the only one onboard. One short run had to be stopped due to a fault in a cable plug on deck. The remaining two runs, both of over 60 hours duration, ran to the end of their surveys. In all SEASOAR was towed for 201 hours, data being obtained for over 195 hours.

Throughout the cruise the vehicle was towed at between 8 and 9 kn, yo-yoing from close to the surface to a depth of 300 m at a rate of 8 or 9 cycles per hour.

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*During this run the vehicle was flown by hand control for some hours and it was noticeable that a similar yo-yo could be maintained but with very much lower maximum cable tensions than when the deck controller was in use.

XBT data (Gould)

XBT probes (Model T-7 max depth >750 m) were used for mapping the Azores front and at times on the northward SEASOAR survey. The performance of the XBT equipment was in general good with a high percentage of satisfactory data. A hand held launcher was used and some mechanical repairs to this were needed as a result of its inadequate stowage on board during previous cruises. A list of XBT positions and maximum depths is given in table 2. The positions of these profiles is given in fig.2.

Satellite tracked buoys (Hunter)

Four drifting buoys similar to those deployed in the FGGE Experiment in the South Atlantic during cruise 100, were deployed in two pairs in regions of high current shear south west of the Azores. Each buoy was fitted with a transmitter giving access to the Argos System permitting position location on a day to day basis. Drogues were attached to each buoy in order to lock the buoy to a particular water mass and minimise the effect of windage.

Radio Trials

In addition to these buoys, there were two buoys originating from the Canadian Flemish Cap Experiment, which were in the area; and it had been hoped to recover these for examination and possible redeployment. Lacking proper direction-finding equipment an attempt was made to use the TIROS test set as a receiver and a directional antenna steered by a rotator, was mounted on the after mast. The 5MHz IF output of the test set was brought out to an

Eddystone communications receiver thus providing audible signal and meter indication of relative signal strength.

The latest position obtained by TELEX via IOS was used to commence the search, and signals were obtained easily, it being possible to get an approximate bearing on the buoys. However as the range reduced, so the bearings tended to become increasingly indistinct until apparently good bearings were obtained in all directions. The lack of dynamic range in the receiving syustem made it difficult to judge the proximity but very strong signals were obtained which later experience showed were indicative of ranges less than mile; and yet no visual sightings were obtained, so the search was abandoned.

Later in the cruise an experiment was carried out to evaluate the effectiveness of this method of location. A Dhan buoy was prepared and fitted with a radar reflector. This was tied on a short tether to one of the satellite drifters (together with the BENCAT transmitter relocation beacon made by OAR operating on 156 MHz). The whole assembly was set adrift and tracked by radar to give range and bearing information for comparison with radio bearings taken. This method showed up the difficulty with short range bearings, and suggested that the best method of location was to obtain cross bearings at ranges of about 2-3 miles while the ship was stopped rather than attempting running fixes. Following these trials the radio receiver portion was replaced as an indicator, by a fast frequency response chart recorder driven by the rectified and filtered IF output from the standard TIROS test set. This arrangement gave greatly improved amplitude

information with good dynamic range and the ability to compare signals during the course of tracking.

Deployment of Drogued Buoys

The basic design of the buoy and drogue system was an attempt to improve the duration of the components of the drogue and buoy by decoupling the wave-induced motions of the buoy from the drogue with a compliant section. In the case of the two buoys drogued at 20 m, this is achieved with a 10 m length of rubber 'BUNGEE' cord above the drogue, whilst in the case of the two drogued at 200 metres, the size of the rope used was so adjusted as to give the same compliance as the 10 m rubber bungee.

Owing to difficulties of supply, the two buoys set at 200 m were not fitted with extra flotation collars and as a consequence it was necessary to reduce the net payload. This was achieved by reducing the amounts of chain ballast on the buoy and drogue, and supporting that on the drogue with an equivalent amount of buoyancy from deep trawl floats attached to the top bar; thus giving the effect of virtual mass on the drogue while retaining the same tension in the drogue side wires. With the possibility of recovery (on cruise 122) in wind a line was added to the drogue, attached to the bottom bar and rove through a link on the top bar and again at the triangular plate at the top of the bridles. A monkey's fist on the line prevents it running out and a large soft-eye was spliced at the end. When recovering the system the idea was to pull up this line on the capstan so lifting the bottom bar and reefing the drogue at least partially.

The deployments were accomplished in pairs, one shallow drogue and one deep drogue at each location. The buoy was lifted into the starboard gallows and its drogue line led around the outside of the rail, and back inboard. The drogue itself was lifted up just outside the stern rail using the crane. A short strop was attached to the crane hook together with a toggle operated release mechanism, the strop was wound around the drogue, which was folded up concertina fashion, one and a half full turns taken, and the other end taken to the release.

The buoy was lifted on a loop of rope taken back to the capstan, swung over board from the gallows and lowered to the surface. The rope was released and pulled back, and buoy allowed to drift away from the ship, which was making a small amount of way forward. When all the drogue line was out the drogue was lowered to the surface and the release operated. The drogue was seen to unfold in an orderly manner and sink.

Forward hydraulic ring main and midships winch.
(Clayson)

The winch was tested following servicing work, including an increase in ring main flow rate capability, carried out in Gibraltar. Apart from occasional cut out of the ring main motor-pump unit, thought to be due to transients when the A-frame rams were operated, the system worked well. The A-frame ram operation is still rather abrupt, although a slight reduction of speed by means of the throttle valves made an improvement. A proportional, rather than on/off, control valve is really needed here.

Winch performance figures were checked during a trial cast. Due to failure of the wire tension strain gauge these were unfortunately incomplete. Hauling rates were greatly improved by the recent modifications although pump pressure drop and hunting limited the practical haul rate to 1.3 m/s with 4000 m of wire out, rising to over 2 m/s with less than 500 m out. These figures were obtained in low sea state conditions.

The winch was used for routine casts of CTD with multisampler and pinger for a total of about 45 hours. The platform entrance was found to be marginally wide enough for this instrument package and it was also felt that the platform level should be lowered to deck level, for convenience. The seals on the deck console display panel were found to leak in heavy rain and a temporary perspex cover was installed to combat this.

Towards the end of the cruise, trouble was experienced with the cooling water pump cutting out. The pump room temperatures are, however, now satisfactorily low. Routine checks on some hydraulic components revealed the continued presence of swarf in the system. The ring main supply pressure was reduced from 3000 psi to 2500 psi to reduce noise and general wear whilst retaining full winch performance capability.

BENCAT (Thorpe)

'BENCAT' (BENthic Currents And Temperatures) is an instrument designed to measure turbulent currents and temperatures within the lower 2m of the water column using open-coil e.m. heads and thermistors. The purpose of the instrument is to assess the stress on the sea bed and the

heat flux, both quantities vital to the understanding of diffusion in the benthic boundary layer.

The objectives for BENCAT of the cruise were

(i) to test the integrity of the external wiring harness which is ducted through oil-filled pressure balanced hose

(ii) to test the acoustic releases by lowering the sphere containing the electronics to about 4000m and firing 'puffers'.

(iii) to determine the range of the radio beacon and the angular uncertainty in estimating its direction

(iv) to deploy BENCAT in about 4000m for 5-6 days.

The following tests were completed:

7th April. A simulated deployment was made in Gibraltar harbour.

17th April. The full harness (see i) and e.m. heads and thermistors, mounted on the spar were lowered to 3900 m on the CTD winch. The time-release was attached to the spar and fired satisfactorily. The harness survived the test but some drops of sea water were subsequently found to have entered the oil-filled hose. This was replaced by a more pliable hose and connections modified. One e.m. head subsequently went open circuit and was replaced.

The sphere (see ii) was lowered to 3900 m on the trawl warp and the release fired satisfactorily.

20th April. The radio beacon (see iii) was mounted on a FGGE buoy and deployed with a dhan buoy as a radar marker. The signal was detectable to a range of 5 n.mi. with an angular uncertainty of $\pm 20^{\circ}$.

An attempt was made to launch BENCAT on 22nd April but was aborted when one of the e.m. heads was accidentally broken.

BENCAT was deployed on 25th April (St. 10343) in a water depth of 4354 m (uncorrected). Deck handling and launch were completed with no difficulty and the descent, at about 0.9 ms^{-1}, and sphere deployment on the sea bed were normal. Recovery was begun by switching the transponder on at 0405 30th April. Transmission to release the instrument from its base was begun at 0525. The first stage release was completed at 0542. The final release sequence appeared to have been completed at 0552, but there was no indication of the instrument's leaving the sea bed. Contact was lost at 0606 and subsequent attempts to switch on transponder or release were unsuccessful. Close radio and visual watches were kept until the ship left the area at 1120. Further attempts to recover the instrument will be made during cruise 122.

TABLE 1

CTD Station List

	Day	Time z	Lat.	Long.	Comments
10336	9-IV	0856-1045	37° 24'.0N	12° 20'.0W	Shallow CTD unit Fluorometer calibration
10337	12-IV	0512-0905	44° 21'.7N	14° 19'.5W	Deep CTD
10338	12-IV	1228-1526	44° 00'.4N	14° 49'.2W	Deep CTD
10339	12-IV	1927-2110	44° 39'.4N	15° 16'.5W	Deep CTD
10340	13-IV	1221-1355	42° 33'.0N	16° 42'.6W	Deep CTD
10341	14-IV	1036-1222	40° 48'.5N	19° 15'.7W	Deep CTD
10342	15-IV	0118-0300	39° 11'.0N	21° 11'.4W	Deep CTD
10343	25-IV	1339-1350	31° 27'.9N	30° 57'.8W	Bencat deployment
10344	25-26-IV	2215-0112	30° 59'.8N	30° 59'.0W	Deep CTD
10345	26-IV	0510-0815	31° 29'.5N	31° 15'.5W	Deep CTD
10346	26-IV	1106-1406	31° 50'.0N	31° 30'.7W	Deep CTD
10347	26-IV	1743-2124	32° 19'.7N	31° 47'.3W	Deep CTD
10348	27-IV	0108-0400	32° 49'.4N	32° 04'.5W	Deep CTD
10349	27-IV	0812-1235	33° 21'.7N	32° 25'.3W	Deep CTD
10350	27-IV	1635-1902	33° 55'.8N	32° 43'.1W	Deep CTD
10351	27-28-IV	2348-0226	34° 39'.9N	32° 24'.4W	Deep CTD
10352	28-IV	0603-0838	34° 24'.7N	32° 59'.2W	Deep CTD
10353	28-IV	1248-1504	34° 10'.2N	33° 39'.6W	Deep CTD
10354	28-IV	2039-2322	33° 50'.3N	34° 18'.8W	Deep CTD
10355	29-IV	0242-0409	33° 35'.0N	34° 49'.8W	Deep CTD
10356	30-IV	1514-1618	31° 56'.5N	31° 26'.4W	Shallow CTD Fluorometer calibration

TABLE 2

XBT Data

Seq. No.	Date	Time z	Lat. N	Long. W	Max. depth (m)	Comments
1	9-IV	1630	37° 09.4	13° 20.9	907	
2	12-IV	0314	44° 21.5	13° 54.2	910	
3	14-IV	1835	40° 02.9	20° 10.9	832	
4	17-IV	1700	34° 03.7	27° 55.3	807	Start of front Survey
5	17-IV	1900	34° 00.6	28° 13.8	813	
6	17-IV	2058	34° 00.7	28° 38.7	803	
7	17-IV	2258	34° 00.0	29° 02.2	787	
8	18-IV	0058	33° 59.9	29° 26.1	770	
9	18-IV	0300	-	-		Failed
10	18-IV	0430	34° 00.0	30° 05.4	776	
11	18-IV	0700	34° 00.3	30° 33.1	845	
12	18-IV	0900	34° 00.7	30° 55.0	848	
13	18-IV	1100	34° 00.3	31° 17;9	798	
14	18-IV	1258	34° 00.9	31° 40.1	773	
15	18-IV	1459	34° 01.1	32° 02.5	772	
16	18-IV	1702	33° 58.8	32° 23.8	748	
17	18-IV	1900	33° 57.1	32° 44.0	472	
18	18-IV	1903	33° 57.1	32° 44.5	736	
19	18-IV	2101	33° 57.0	33° 01.5	760	
20	18-IV	2300	33° 57.5	33° 17.4	832	
21	19-IV	0100	33° 58.9	33° 29.2	804	
22	19-IV	0300	34° 00.2	33° 40.8	143	
23	19-IV	0600	33° 59.6	33° 59.7	887	
24	19-IV	0900	34° 00.0	34° 19.1	779	
25	19-IV	1100	34° 00.2	34° 33.7	482	
26	19-IV	1258	34° 00.7	34° 48.7	765	
27	18-UV	1423	34° 01.1	34.59.5	796	End of E.W. leg

Table 2. (XBT data cont.)

Seq. No.	Date	Time z	Lat. N	Long. W	Max. Depth (m)	Comments
28	19-IV	1700	33° 42.0	34° 41.1	835	
29	19-IV	1900	33° 27.1	34° 26.0	867	
30	19-IV	2103	33° 12.6	34° 11.2	817	
31	19-IV	2300	32° 58.0	33° 57.2	823	
32	20-IV	0100	32° 42.5	33° 42.9	883	
33	20-IV	0300	32° 28.1	33° 27.3	793	
34	20-IV	0545	32° 13.2	33° 11.0	893	
35	20-IV	0720	32° 00.6	33° 00.4	856	End of leg
36	20-IV	0900	32° 12.1	32° 47.2	847	
37	20-IV	1258	32° 22.1	32° 35.2	834	
38	20-IV	1458	32° 35.8	32° 17.9	843	
39	20-IV	1659	32° 50.0	32° 00.7	770	
40	20-IV	1914	33° 03.4	31° 45.9	803	
41	20-IV	2100	33° 19.2	31° 33.6	787	
42	20-IV	2302	33° 36.4	31° 19.5	798	
43	21-IV	0032	33° 48.5	31° 09.2	828	
44	21-IV	0145	33° 59.0	31° 00.1	825	End of leg
45	21-IV	6301	33° 51.7	30° 51.7	810	
46	21-IV	0500	33° 37.3	30° 36.0	810	
47	21-IV	0658	33° 22.3	30° 21.0	800	
48	21-IV	0859	33° 06.9	30° 05.7	879	
49	21-IV	1100	32° 52.7	29° 51.9	811	
50	21-IV	1258	32° 37.5	29° 37.1	831	
51	21-IV	1458	32° 22.3	29° 22.1	798	
52	21-IV	1702	32° 06.9	29° 07.5	833	
53	21-IV	1755	32° 00.1	29° 00.7	793	End of leg
54	21-IV	1900	31° 59.5	29° 11.5	808	
55	21-IV	2100	32° 00.2	29° 35.6	867	
56	21-IV	2300	32° 00.6	29° 59.2	783	

Table 2. (XBT data cont.)

Seq. No.	Date	Time z	Lat. N	Long. W	Max. depth (m)	Comments
57	23-IV	0058	32° 00.9	30° 23.0	790	
58	22-IV	0258	32° 00.9	30° 46.8	754	
59	22-IV	0500	31° 59.8	31° 10.1	752	
60	22-IV	0713	32° 00.7	31° 32.8	774	
61	22-IV	0900	31° 59.7	31° 52.9	778	
62	22-IV	1104	31° 59.4	32° 16.1	807	
63	22-IV	1257	32° 00.5	32° 37.1	810	
64	22-IV	1458	32° 00.6	32° 58.9	807	End of Survey
65	22-IV	1837	32° 18.7	33° 00.5	828	
66	28-IV	0943	34° 21.0	33° 08.6	704	Search for front
67	28-IV	1045	34° 17.0	33° 20.0	710	" "
68	28-IV	1144	34° 13.5	33° 29.5	710	" "
69	28-IV	1240	34° 10.3	33° 40.0	753	" "
70	28-IV	1610	34° 06.0	33° 48.2	710	
71	29-IV	0500	33° 31.1	34° 43.6	710	
72	29-IV	0700	33° 21.3	34° 24.5	Poor data	
73	29-IV	0900	33° 11.6	34° 05.8	Poor data	Repeat at 0915
74	29-IV	1100	33° 10.4	34° 03.4	Poor data	
75	29-IV	1300	32° 49.6	33° 29.0	750	
76	29-IV	1458	32° 39.2	33° 10.0	768	
77	29-IV	1800	32° 24.4	32° 40.2	750	
78	29-IV	1900	32° 19.1	32° 30.0	730	
79	29-IV	2100	32° 07.8	32° 09.6	Bad data	
80	29-IV	2300	31° 55.8	32° 50.5	Bad data	
81	30-IV	0105	31° 44.3	31° 29.3	760	
82	30-IV	0257	31° 34.0	31° 10.3	738	
83	30-IV	1300	31° 42.3	31° 10.8	760	
84	3 - V	1301	35° 01.4	32° 55.6	760	
85	3 - V	1501	35° 09.5	32° 34.2	760	
86	3 - V	1703	35° 18.1	32° 12.2	Poor data	

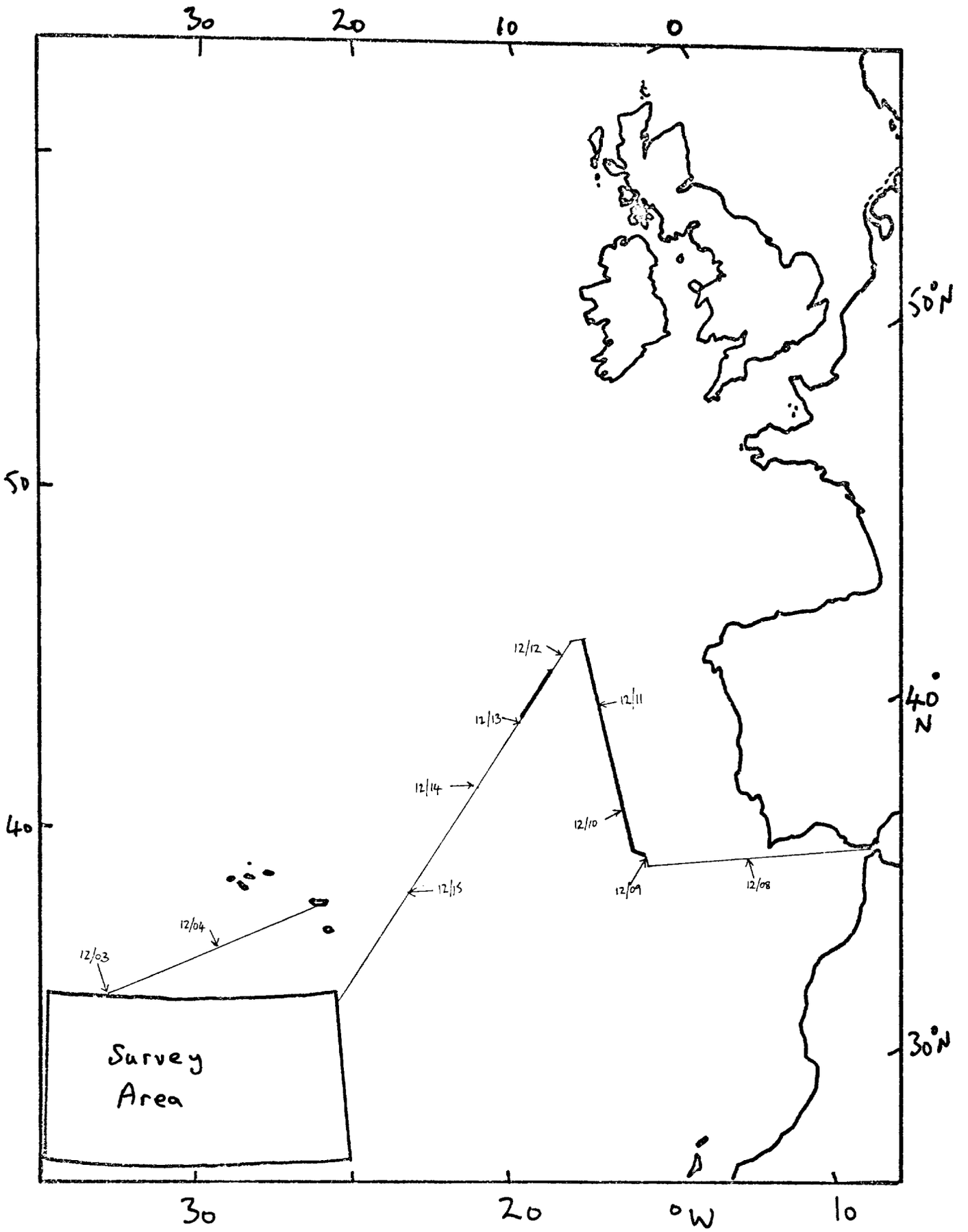
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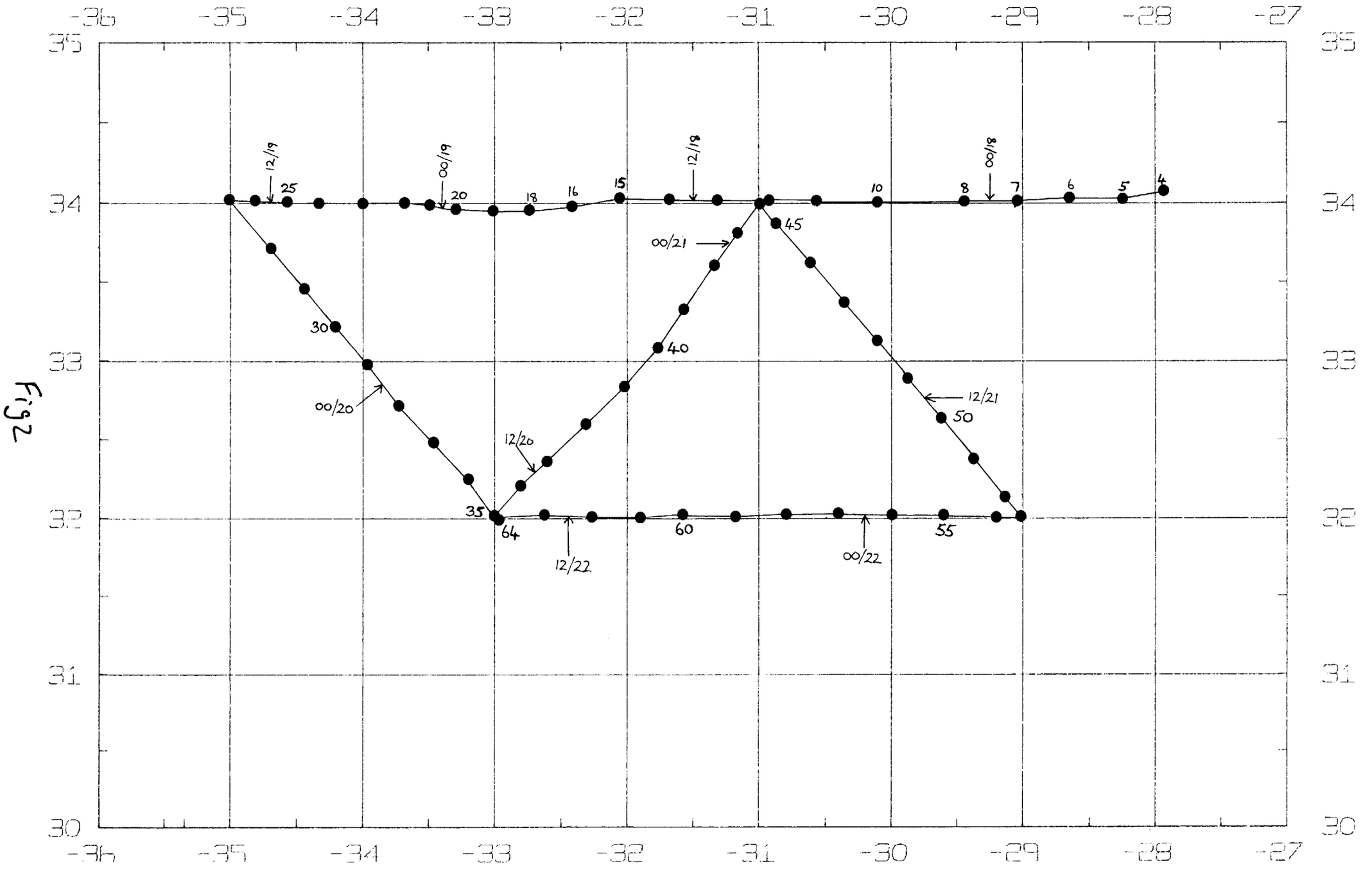
Fig 1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64
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55
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Fig 2

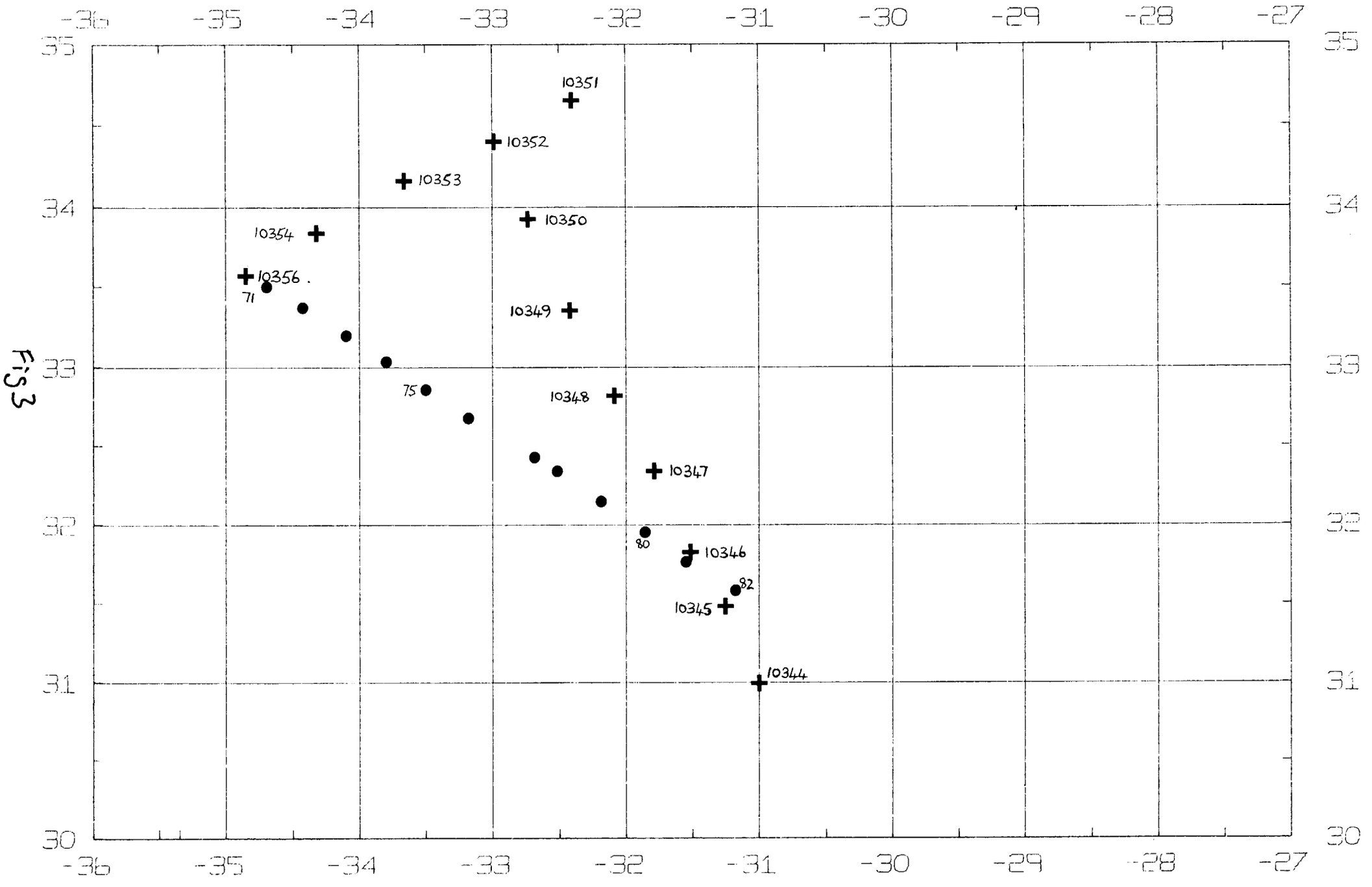
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Fig 3

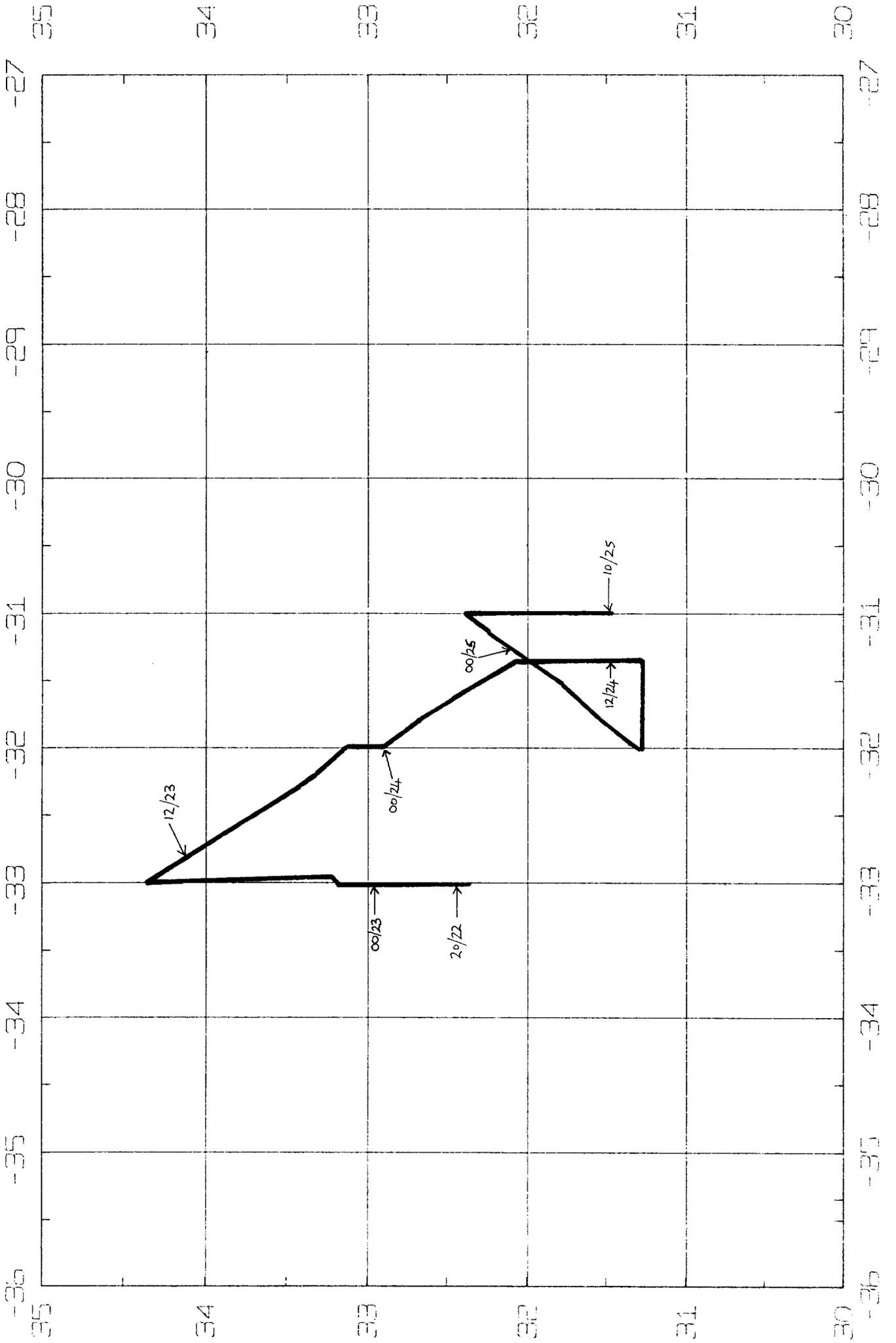
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Fig 4

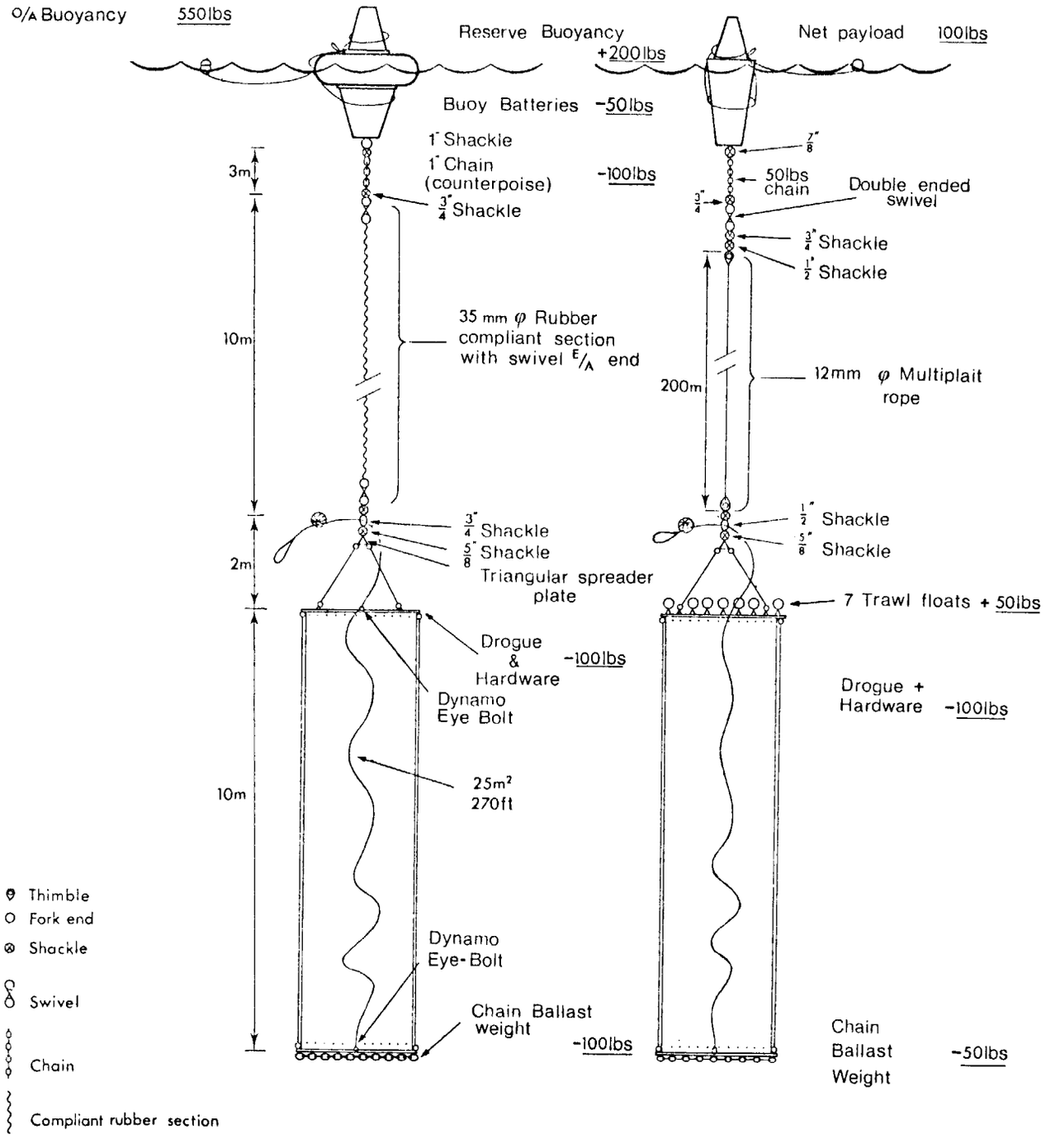
O/A Buoyancy 550lbs
Reserve Buoyancy +200lbs
Net payload 100lbs
Buoy Batteries -50lbs
1" Shackle
1" Chain (counterpoise) -100lbs
3m
3/4" Shackle
10m
35 mm φ Rubber compliant section with swivel E/A end
3/4" Shackle
5/8" Shackle
Triangular spreader plate
2m
Drogue & Hardware -100lbs
Dynamo Eye Bolt
10m
25m²
270ft
Dynamo Eye-Bolt
Chain Ballast weight -100lbs
7/8"
50lbs chain
3/4"
Double ended swivel
3/4" Shackle
1/2" Shackle
200m
12mm φ Multiplait rope
1/2" Shackle
5/8" Shackle
7 Trawl floats + 50lbs
Drogue + Hardware -100lbs
Chain Ballast Weight -50lbs
Thimble
Fork end
Shackle
Swivel
Chain
Compliant rubber section

Fig 5