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Institute of
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INTERNAL DOCUMENT No. 337

The SWINDEX Experiment: mooring design and implementation
SWINDEX Technical Report 1991-1993

I Waddington, K Goy, M Hartman, D White
& R Bonner

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Natural Environment Research Council

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DOCUMENT DATA SHEET

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TITLE The SWINDEX Experiment: mooring design and implementation. SWINDEX Technical Report 1991-1993.	
REFERENCE Institute of Oceanographic Sciences Deacon Laboratory, Internal Document, No. 337, unpaginated. (Unpublished manuscript)	

ABSTRACT

The design and implementation of SWINDEX moorings: full depth moorings deployed in the southwest Indian Ocean as a contribution to the WOCE programme.

The detail design and supply of components and assemblies for the moorings with methodology of deployment.

The calibration and setting up of Aanderaa current meters and temperature profile loggers with methods and examples.

The document is prepared as an historical record and as a guide to techniques employed in the preparation and operation of full ocean depth moorings at IOSDL.

KEYWORDS

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Introduction

An array of moorings was requested for the SWINDEX experiment by Dr R T Pollard , James Rennell Centre for Ocean Circulation , .from the Mooring team .at IOSDL . These moorings were to be deployed in early 1993 and to be recovered two years later .
The array was costed and the budget and equipment available then fitted to provide the optimum number of moorings and current meters for the budget available .

The array thus became eight moorings all of full depth with current meters of the Aanderaa type fitted with sensors to optimise measurements for scientific requirements .

IOSDL had previously deployed moorings of this type for 12 month periods and deep ocean mid water moorings for 20 months . These mooring experiences were used to develop the two year duration moorings required for SWINDEX and designs evolved based on past IOSDL experience .

This document sets out the proceedures evolved and techniques and materials used to deploy the array .

SWINDEX TECHNICAL FILE

INDEX

SWINDEX Technical File

1.Mooring Design and Layouts

I Waddington

Index

1.1

Mooring Design Process

To illustrate the work patterns involved in producing the SWINDEX array a flow chart is shown,from start up of the design to field installation.In all a period of 22 months . The deployment was to take place on Discovery Cruise 201 . Sailing from Capetown to Capetown in the spring of 1993 .

Cruise 200 ADOX is shown on the flow chart as dotted lines.IOSDL contributed mooring design,hardware and instrumentation for the cruise,prepared at IOSDL with the SWINDEX equipment.Deck equipment was then continued onto Cruise 201 .

The tasks allocated shown in the flow chart can be summed up as :

1.Mooring design and procurement . I Waddington.
A set of topographical charts were prepared from the DBD85 data set by S G Alderson which were used to more accurately determine water depth and identify any difficult topography at or near the mooring sites.

2.Allocation of instruments,calibrationsand refurbishment . K Goy.
Current meter sensor range data was provided by Pollard,Read and Alderson.

3.Acoustics systems and procurement . G Phillips
Note that acoustics systems operations at sea were undertaken by D.White

4.Production of mooring hardware . I Waddington.

5.Mooring Machinery . R Bonner.

6.Freight . R Bonner,I Waddington.

7.Mooring deployment methods and hardware trials Darwin Cruise 66 . I Waddington.

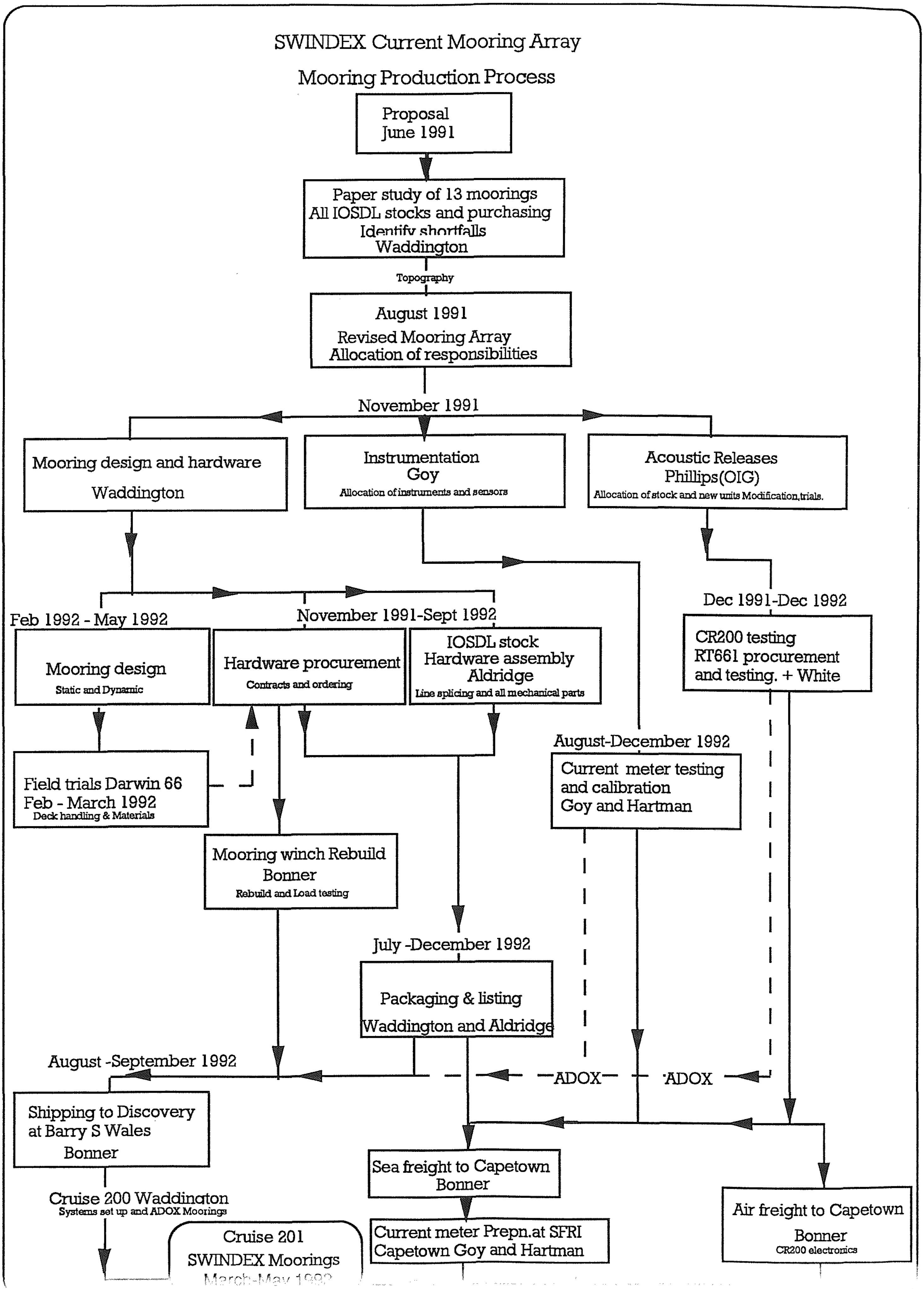
8.Mooring Recovery from S Iceland . K Goy,G Phillips.
The recovery of mooring instruments from a mooring array south of Iceland for allocation to SWINDEX.

The mooring array as finalised for design was ;

SWINDEX Mooring Array
Mooring positions(as proposed 06-ii-1992)

Mooring	Latitude	Longitude	Depth (m)	Current Meter Depths Shallow	AAIW		Mid	NADW Deep
A	45S	48E	3000	300	600	1300	2100	2900
B	45S	45E	1500	300	600	1300	2100	2900
C	44.5S	41E	2200	300	600	1400		
D	43.8S	39E	2700	300	600	1300	2300	2600
E	43.1S	36.5E	3500	300	600	1300	2500	3400
F	42.4S	34E	5000	300	600	1300	2500	4900
G	41.7S	31.5E	5000	300	600	1300	2500	4900
H	41S	29E	5000	300	600	1300	2500	4900

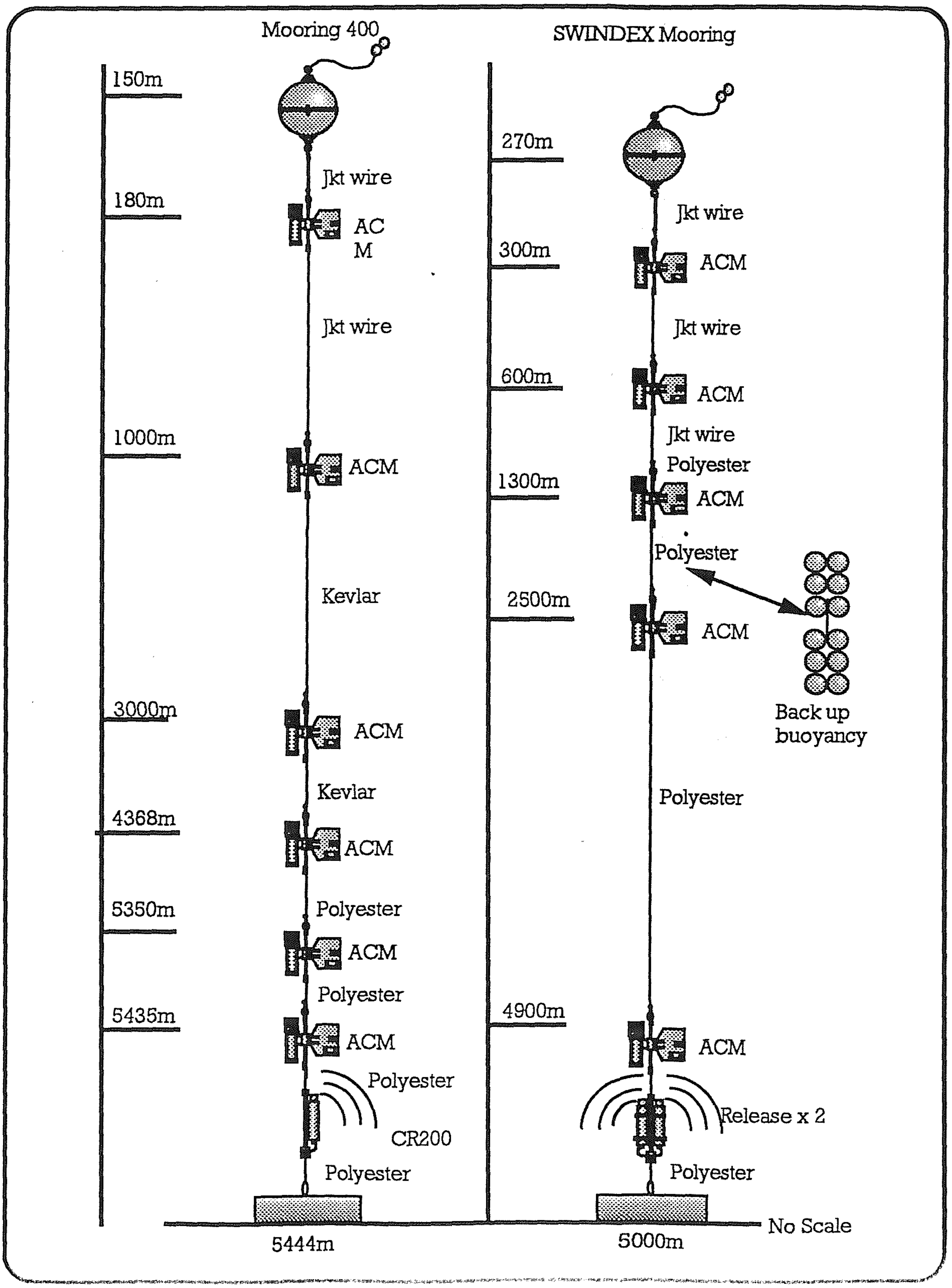
Pressure sensors were to be fitted to all current meters at 300m as a measure of instrument and mooring depth . Conductivity sensors on all current meters at 600m as an added parameter for water mass identification . All temperature ranges were to be low range with other reduced range temperatures as recording channels available .
Temperature profilers were to be added on moorings A and D spanning the depths 300 to 400m.


SWINDEX Current Mooring Array
Mooring Production Process
Proposal
June 1991
Paper study of 13 moorings
All IOSDL stocks and purchasing
Identify shortfalls
Waddington
Topography
August 1991
Revised Mooring Array
Allocation of responsibilities
November 1991
Mooring design and hardware
Waddington
Instrumentation
Goy
Allocation of instruments and sensors
Acoustic Releases
Phillips(OIG)
Allocation of stock and new units Modification,trials.
Feb 1992 - May 1992
November 1991-Sept 1992
Dec 1991-Dec 1992
Mooring design
Static and Dynamic
Hardware procurement
Contracts and ordering
IOSDL stock
Hardware assembly
Aldridge
Line splicing and all mechanical parts
CR200 testing
RT661 procurement
and testing. + White
Field trials Darwin 66
Feb - March 1992
Deck handling & Materials
August-December 1992
Current meter testing
and calibration
Goy and Hartman
Mooring winch Rebuild
Bonner
Rebuild and Load testing
July -December 1992
Packaging & listing
Waddington and Aldridge
August -September 1992
ADOX
ADOX
Shipping to Discovery
at Barry S Wales
Bonner
Sea freight to Capetown
Bonner
Air freight to Capetown
Bonner
CR200 electronics
Cruise 200 Waddington
Systems set up and ADOX Moorings
Current meter Prepn.at SFRI
Capetown Goy and Hartman
Cruise 201
SWINDEX Moorings

1.2 Historical comparison to previous IOSDL moorings.

As a starting point for designing the mooring a search was made of designs and installations made by IOSDL.
The mooring layout compares to IOSDL Mooring 400, a full depth mooring in 5444m water Designed and deployed by Waddington et al.

fig 2 Mooring 400 and representative SWINDEX mooring .



The mooring was deployed for a one year duration at Great Meteor East ,31 29N 24 44W Sept 1985 to September 1986.Mooring Log 351-400,Discovery Cruise reports 180 and 241.

Mooring 400 was subjected to currents of 50 cm/sec and apparent knock down of the subsurface sphere was in the region of 2m to 8m,Unpublished report Packwood April 1987
It was apparent that as marine growth became established on the jacket wire and upper fibre lines the mooring performance was improved ie knockdown of the subsurface float decreased.This could be attributed to the hairy fairing effect of the growth,reducing strumming of the system,thus reducing drag.

The SWINDEX moorings are different to Mooring 400 in that the main subsurface spheres are at greater depth and back up buoyancy is included.
The back up buoyancy will act to stiffen the lower 1000m of the mooring in the lower current region.Thus the glass spheres will create greater tension in the deeper line than seen in Mooring 400.Thus overall the SWINDEX moorings will be stiffer than Mooring 400 which should yield a marginal gain in reducing sphere knock down.

Mooring 400 was recovered after the one year period and all items examined for fouling,corrosion and abrasion of the mooring and current meter components.

Marine Fouling

Marine fouling was observed to extend throughout the length of the polypropylene coated mooring wire.The fouling was of the simple strand like growth,similar to Hydroids,varying in length from 5mm to 30mm from bottom to top.No evidence of any damage to the coating or the internal wire was observed.
The steel sphere was coated on one upper side with a similar fouling growth to the wire section.This appears to indicate that the sphere stabilised in the flow with the growth occuring more on the downstream side.The underside of the buoy had comparatively little growth.
The current meters in the upper 1500m of the water column had fouling around the rotor arches and some small fouling on the vane surfaces.The SWINDEX units will therefore have additional anti fouling on the rotor arch shortly before deployment.This should inhibit growth substantially.

Corrosion

There was insignificant corrosion on the steel sphere and mooring wire connections,some corrosion was apparent at the lower end of the steel sphere chain.This could be attributed to the stainless mooring swivel having some electrolytic effect in close proximity to this chain end.The SWINDEX chain has been increased in diameter from the 13mm of Mooring 400 to 5/8" to provide an increase in material, the chain will preferentially corrode when in close contact with the mooring swivel.
The current meters and acoustic releases had no corrosion.Preparation of these items was carefully carried out prior to deployment with Greases and sealants liberally applied.

Abrasion

No evidence of abrasion was seen throughout the length of the mooring.

1.3 Designing the mooring

Mooring 400 was used as the basis for the mooring design.Certain features were not required and others had to be included.Consideration was first given to materials referenced to the static and dynamic performance of the mooring designs.

1.3.1.Synthetic Mooring Lines.

i.Kevlar mooring line.The kevlar line used in mooring 400 was considered for the SWINDEX designs but on assessing the mooring requirement the low stretch high load capability of this line was not required.The kevlar line used in mooring 400 was necessary to position the subsurface buoyancy at 100m water depth or less,ie very close to the sea surface in 5444m depth with minimal long term extension.The kevlar was all pre stretched and measured under load overside to achieve this.

ii.Substitution of Polyester for Kevlar.As the sphere depth was to be at 270m for the SWINDEX array it was felt that the line could be Polyester.Careful in house measuring and splicing combined with on ship loaded line measurement would achieve accurate deployed lengths.
As the design line tensions were determined it was found that the 8mm Polyester used in mooring 400 was not within the IOSDL Safety Factors and consequently the line diameter was increased to 10mm to obtain adequate strength.
Throughout the 1980s IOSDL has built up a catalogue of successful moorings using polyesters in the SWINDEX type configuration.Detailed specifications are shown in Section 2 .1.

1.3.2Steel wire rope.

Steel wire rope is used in the top 1000m of all long term moorings as a fish bite resistant material,Evidence of bite has been seen on 2 year moorings in the Agulhas Current region down to 1000m.Discovery cruise 165A,WHOI.Waddington personal observation.

The steel wire rope used in mooring 400 performed well throughout the 1 year period,subsequent reuse of this wire achieved a deployment duration of 3 years.Lengths being reused in the Faeroes Channel and PML Bay of Biscay applications.

The material availability within the UK has improved since the purchases made in 1984 and other manufacturers were approached to supply to the IOSDL specification.A suitable material was obtained and tested in the laboratory and in field conditions.Detailed specifications and test data is shown in Section 2.1 and in field testing in Annex 3.

Design tensions are higher than mooring 400 but are within the IOSDL safety factors.

1.3.3Mooring Fittings.(Shackles,links,swivels)

The fittings used in the design are as used in mooring 400 and the 20 month duration Southern Iceland moorings,deployed July 1990 recovered March 1992.No significant changes were made to the fittings,details of which are given in Section 2.3.

1.3.4.Buoyancy.

The steel buoyancy was of the type used in mooring 400 with the glass buoyancy as in the Southern Iceland moorings.The steel buoyancy provides the major stiffness of the mooring,this buoyancy was produced by IOSDL with significant cost savings compared to commercially available products. The glass buoyancy providing further stiffness and acting as back up buoyancy,should the steel sphere be lost.Technical specifications and assembly details are given in Section 2.4.

1.3.5.Anchoring.

The anchoring of the system is by a deadweight anchor system comprising steel anchor chain clumps connected with galvanised steel chain.This system has been succesfully used in deep ocean high moorings in the North Atlantic maintaining 1500m moorings on position for 12 month periods.See Section 2.2.

Acoustic Releases

The acoustic releases were to be a blend of IOSDL CR200 and modified MORS RT661 units.These assemblies are discussed in detail in SWINDEX TECHNICAL FILE 4.

Current Meters

The current meters are a mix of Aanderaa types allocated within the array to give the most favourable sensor configurations.High quality calibrations and performance testing was carried out on all the sensors and electonic units.See Section 4 Technical specifications,Annex 1.Preparation and calibration methods.Goy and Hartman
The current meter hardware is modified for 2 year operation.See Section 2.5.

Current meter Sensors in the array

Optimum depths and sensors.

Depth	Temperature	Pressure	Conductivity	Direction & Speed
300m (All)	Low Range & +2 +12 C	Yes	No	Yes
600m (All)	Low Range & +2 +10 C	No	Yes	Yes
1300m (1400m B)	Low Range & +1 +7 C	No	No	Yes
2500m (2100m C) (2300m D) (2600m D)	Low Range & 0 +6 C	No	No	Yes
4900m (2900m A) (3400m E)	Low Range & -0.5 + 2.5 C	No	No	Yes

Temperature Profilers

Two temperature profilers were specified for inclusion in moorings A and D these were to be Aanderaa units logging on tape with 100m thermistor chains.The in line mountings were of IOSDL design proven on one year deployments.

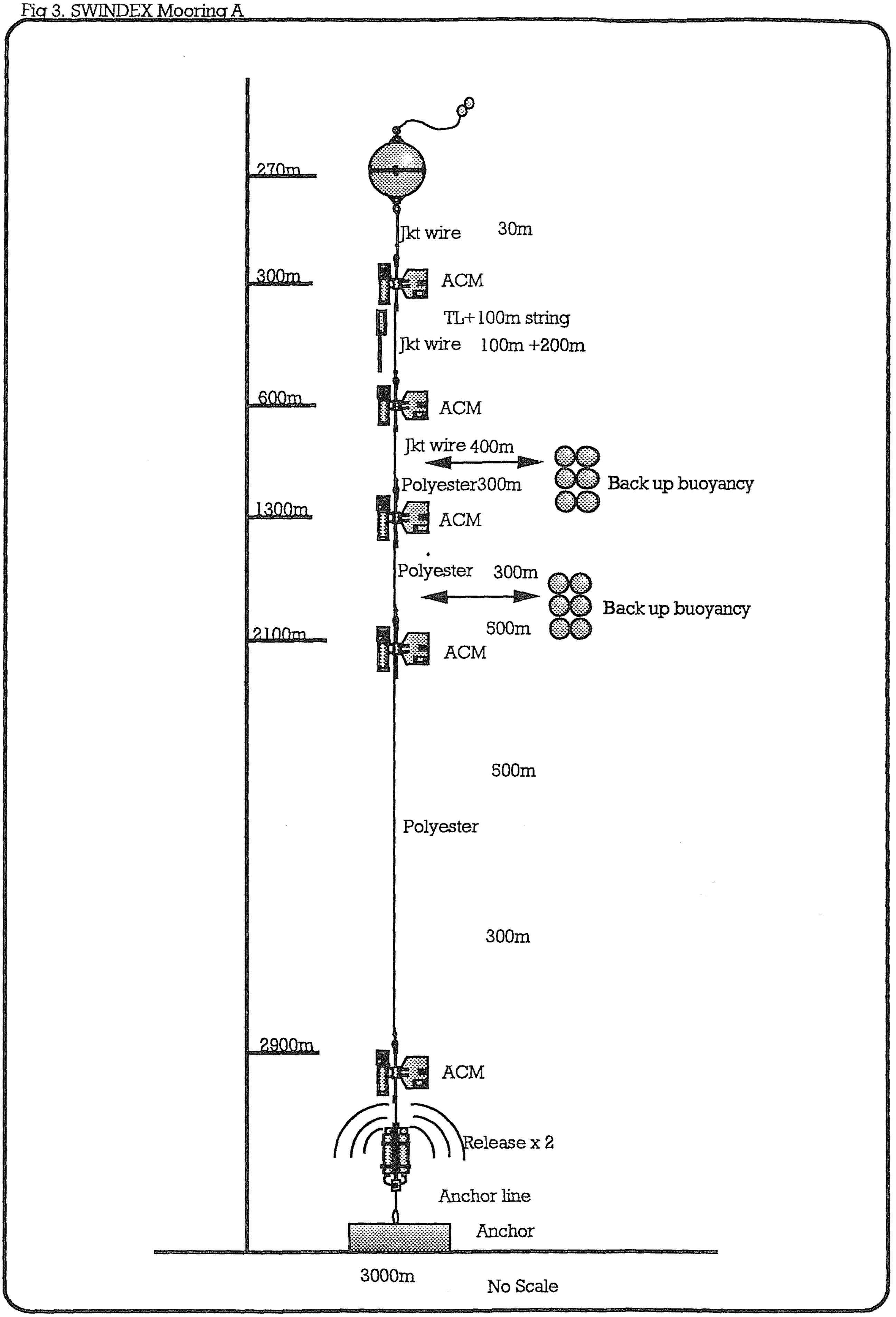
Mooring Static and Dynamic design

Having established materials type and instruments , a design layout was produced for each mooring and buoyancy and anchoring established with respect to safe working loads and mooring performance.The design is a series of trade offs to optimise performance with respect to stock held and funding available. The layout is then run through the Static Design Spreadsheet and Moor Design program to establish tension and motion charecteristics of the system.

Methods

Consideration is given to deployment method,collapse of mooring and recovery for the designs.Machinery available and techniques of operation are also of importance to establish any add on costs in preparation and freighting.

Fig 3. SWINDEX Mooring A



1.4 Mooring A

Static Loading.

Overall Mooring

Main Buoyancy 651	kg	Total buoyancy in system	1099	kg	
Anchor air weight	1581	kg	Mooring hold up	481	kg
Anchor hold down	300	kg	Back up recovery buoyancy	100	kg
Total 17" spheres		18			

Upper Mooring Section

Buoyancy	651	kg	Instrument load	167	kg
OA buoyancy	484	kg			
GS of wire	2250	kg	GS of polyester 3190	kg	
SF under steel sphere in position		4.6			

Mid mooring section

Buoyancy glass 228	kg	Instrument load	39	kg	
OA buoyancy	484	kg			
Tension in polyester	Glass + OA Buoyancy -Instrument load			673	kg
SF under glass spheres in position		4.7			

Lower mooring section

Buoyancy glass 228	kg	Instrument load	90	kg	
OA buoyancy	673	kg			
Tension in polyester	Glass + OA Buoyancy IOSDL-Instrument load			811	kg
SF under glass spheres in position		3.93			

Dynamic Response of Mooring.

Static depth of subsurface buoy	270m	Dynamic depth	337m	Current	47cm/sec
Tension at subsurface	627kg	Horizontal excursion	580m		
Dynamic depth of ACM2	670m	Horizontal excursion	552m	Tilt 5.4 deg	40cm/sec
Dynamic depth of glass sphere1	1065m	Horizontal excursion	481m	Tilt 10 deg	39cm/sec
Dynamic depth of glass sphere 2	1659m	Horizontal excursion	342m	Tilt 14.4deg	24cm/sec
Anchor vertical load	645kg	Horizontal load	191kg		
WHOI safe dry anchor weight	1660kg				

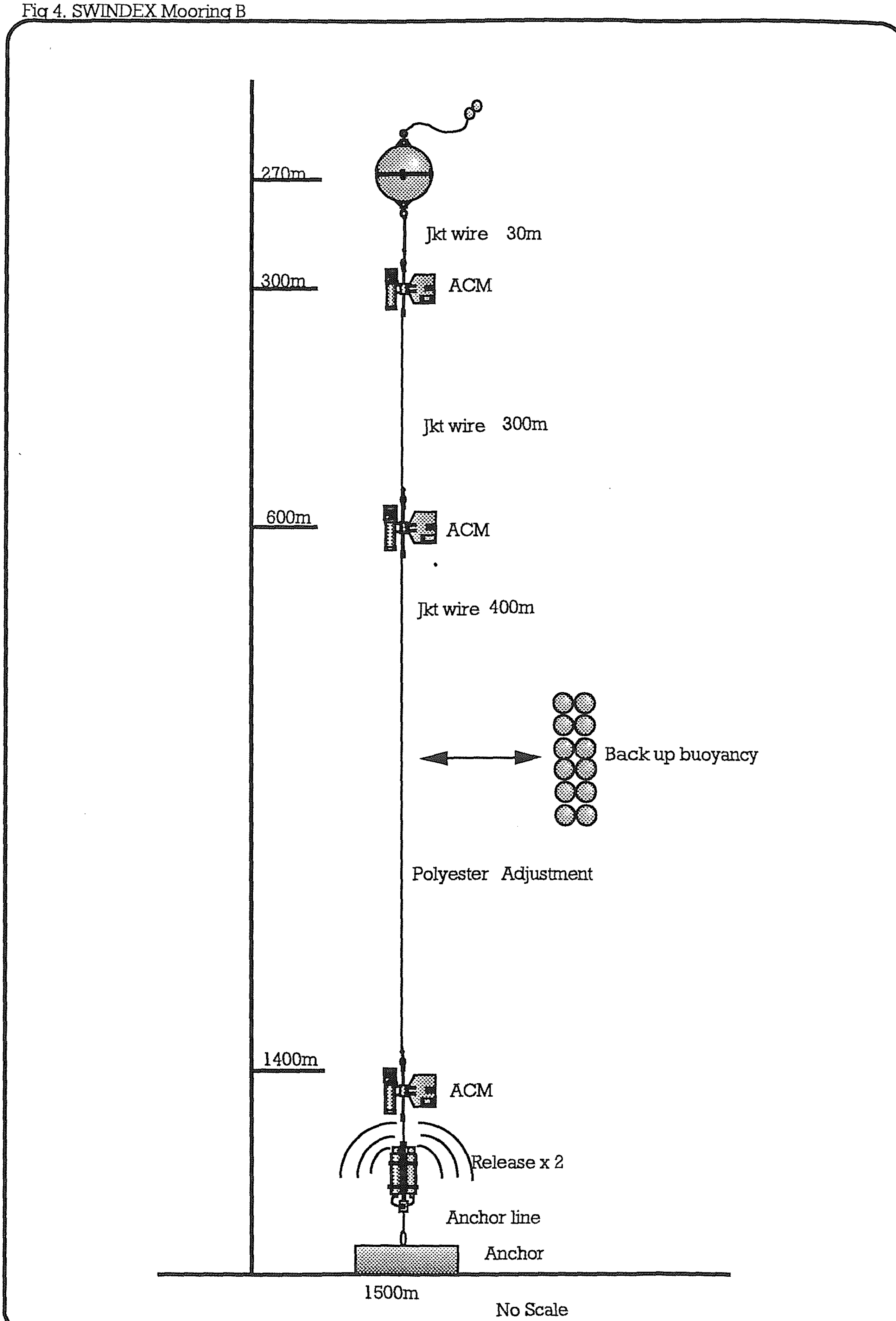
Mooring A.

Design for a water depth of 3000m.The mooring component load at the subsurface with no back up buoyancy is 337 kg.To recover this load two packages of glass buoyancy are include at approximately1000 metres and 1600m,equivalent to the component load plus an excess of approximately 100 kilos.The upper package is placed below the swivel to permit rotation in the wire section which is also decoupled by swivel from the main sub surface unit.

Should the steel sphere become detached from the mooring the steel mooring wire will fall to the upper glass package.The load of this section is 159 kilos,the load beneath the package is 32 kilos.The total load on the upper package is 191kilos.With a buoyancy of 225 kilos the upper package will thus support the collapsed mooring although the current meter at 1300m will be fouled by the collapsed line.
The current meters at 2100m and 2900m will be supported by the lower package with a buoyancy of 100 kg which will maintain the current meters in a functioning configuration and will not permit the collapsed line to foul the acoustic release units.

On recovery this mooring will probably tangle due to the back up buoyancy rising through the surfaced mooring line above it.This is an inevitable consequence of the inclusion of buoyancy of this type and configuration.

Fig 4. SWINDEX Mooring B



1.5 Mooring B

Static Loading.

Overall Mooring

Main Buoyancy	651	kg	Total buoyancy in system	993	kg	
Anchor air weight	1461	kg	Mooring hold up	468	kg	
Anchor hold down	300	kg	Back up recovery buoyancy	100	kg	
Total 17" spheres	14					

Upper Mooring Section

Buoyancy	651	kg	Instrument load	142	kg	
OA buoyancy	509	kg				
GS of wire	2250	kg	GS of polyester	3190	kg	
SF under steel sphere in position			4.42			

Mid mooring section

Buoyancy glass	335	kg	Instrument load	142	kg
OA buoyancy	509	kg			
Tension in polyester	Glass + OA Buoyancy -Instrument load			844	kg
SF under glass spheres in position			3.8		

Dynamic Response of Mooring.

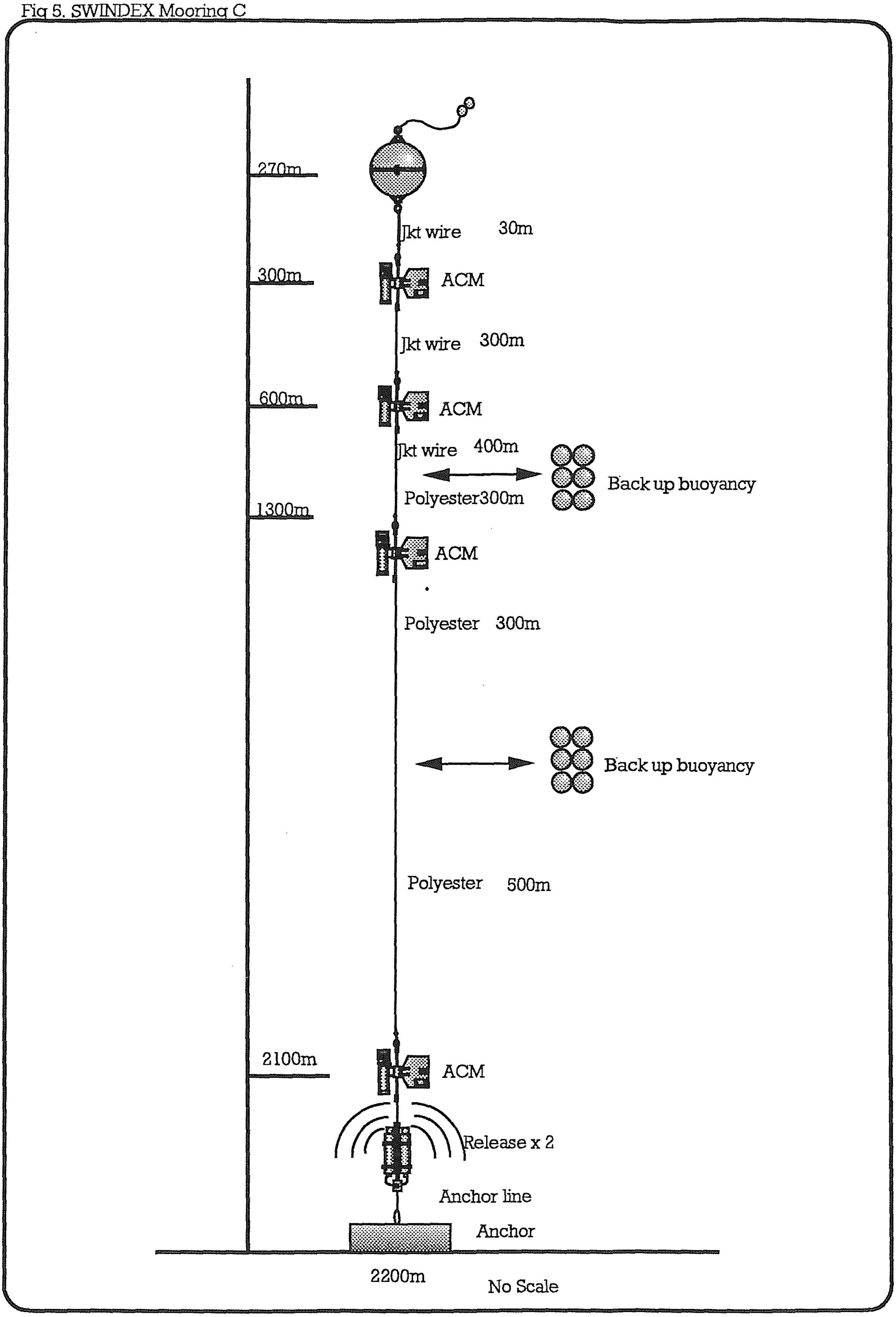
Static depth of subsurface buoy	270m	Dynamic depth	285m	Current	49cm/sec
Tension at subsurface	627kg	Horizontal excursion	183m		
Dynamic depth of ACM2	616m	Horizontal excursion	154m	Tilt 5.7 deg	40cm/sec
Dynamic depth of glass sphere1	1010m	Horizontal excursion	481m	Tilt 10 deg	29cm/sec
Anchor vertical load	701kg	Horizontal load	129kg		
WHOI safe dry anchor weight	1578kg				

Mooring B

Designed for a water depth of 1500m.IOSDL has not previously considered the use of full back up buoyancy for a mooring at this depth.Back up buoyancy is included as an option below the lower swivel to enhance recovery prospects should the subsurface buoy fail as in mooring A.The collapsed line can however foul the acoustic release and anchor assembly which may cause the mooring not to be recoverable.
The glass sphere buoyancy will give 100 kilos of buoyancy with a failed subsurface.

Inclusion of this buoyancy will be dependent on buoyancy availability and dynamic response.

Fig 5. SWINDEX Mooring C



1.6 Mooring C

Overall Mooring

Main Buoyancy 651	kg	Total buoyancy in system		1021	kg	
Anchor air weight	1537	kg	Mooring hold up		471	kg
Anchor hold down	300	kg	Back up recovery buoyancy		100	kg
Total 17" spheres	15					
Upper Mooring Section						
Buoyancy	651	kg	Instrument load		135	kg
OA buoyancy	516	kg				
GS of wire	2250	kg	GS of polyester	3190	kg	
SF under steel sphere in position			4.4			
Mid mooring section						
Buoyancy glass 203	kg	Instrument load		39	kg	
OA buoyancy	516	kg				
Tension in polyester	Glass + OA Buoyancy -Instrument load				680	kg
SF under glass spheres in position			4.7			
Lower mooring section						
Buoyancy glass 203	kg	Instrument load		39	kg	
OA buoyancy	680	kg				
Tension in polyester	Glass + OA Buoyancy IOSDL-Instrument load				844	kg
SF under glass spheres in position			3.8			

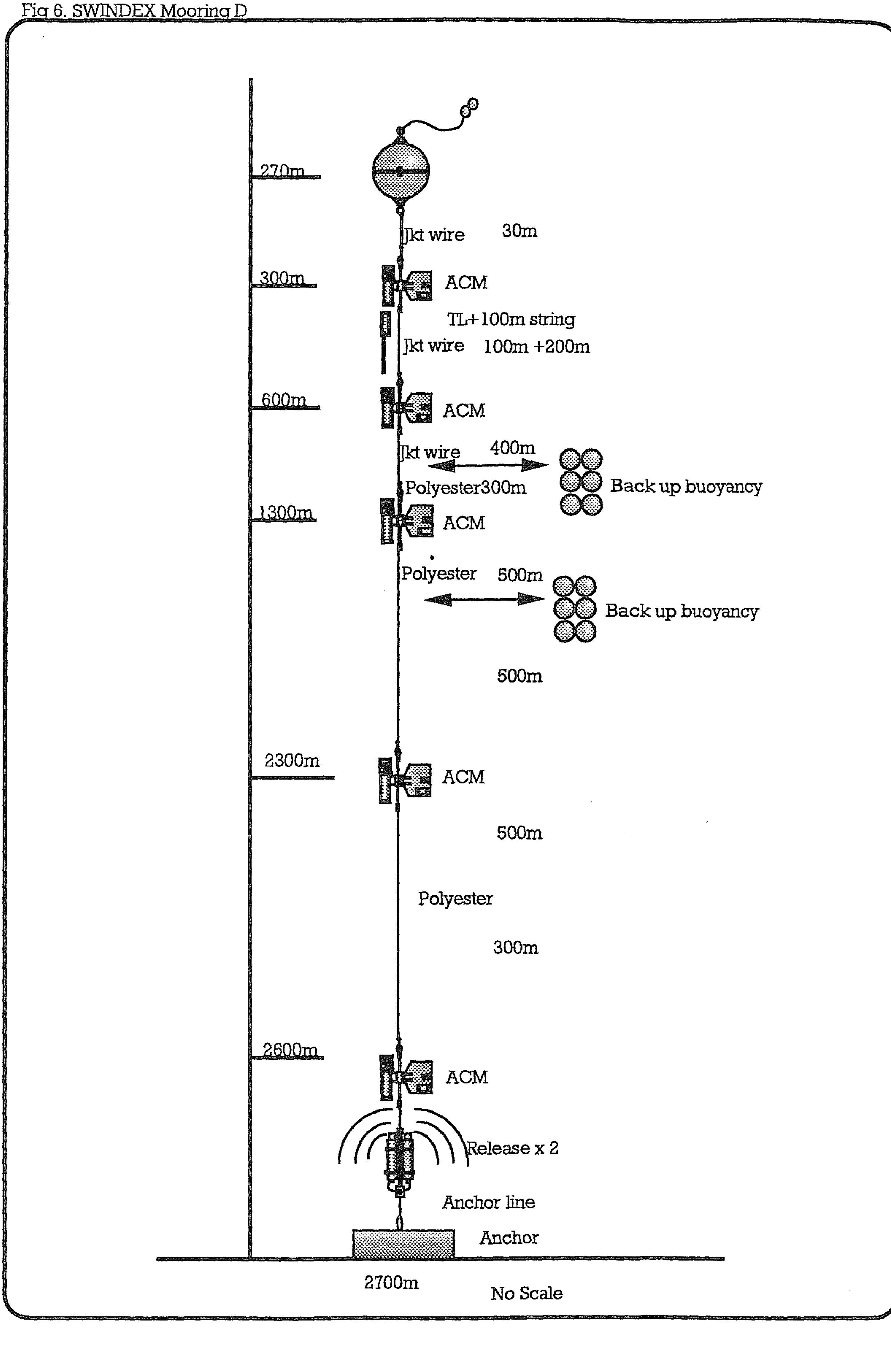
Dynamic Response of Mooring.

Static depth of subsurface buoy	270m	Dynamic depth	300m	Current	49cm/sec
Tension at subsurface	627kg	Horizontal excursion	326m		
Dynamic depth of ACM2	631m	Horizontal excursion	298m	Tilt 5.6 deg	40cm/sec
Dynamic depth of glass sphere1	1026m	Horizontal excursion	227m	Tilt 10 deg	39cm/sec
Dynamic depth of glass sphere 2	1623m	Horizontal excursion	112m	Tilt 11.5deg	18cm/sec
Anchor vertical load	671kg	Horizontal load	144kg		
WHOI safe dry anchor weight	1570kg				

Mooring C

Design depth 2200m.
As with mooring A the mooring will be fully supported with the back up buoyancy.Should the subsurface fail the upper package will see a load of 142 kg from the collapsed components and line beneath.Thus the buoyancy at the upper package will remain at 58 kg.The current meter at 1300m will be fouled by the collapsed line with the current meter at 2100m fully functioning.

Fig 6. SWINDEX Mooring D



1.7 Mooring D

Overall Mooring

Main Buoyancy 651	kg	Total buoyancy in system		1078	kg	
Anchor air weight	1557	kg	Mooring hold up		479	kg
Anchor hold down	300	kg	Back up recovery buoyancy		100	kg
Total 17" spheres	17					

Upper Mooring Section

Buoyancy	651	kg	Instrument load		167	kg
OA buoyancy	484	kg				
GS of wire	2250	kg	GS of polyester	3190	kg	
SF under steel sphere in position		4.6				

Mid mooring section

Buoyancy glass 228	kg	Instrument load		39	kg	
OA buoyancy	484	kg				
Tension in polyester	Glass + OA Buoyancy -Instrument load				673	kg
SF under glass spheres in position		4.7				

Lower mooring section

Buoyancy glass 203	kg		Instrument load	80	kg	
OA buoyancy	673	kg				
Tension in polyester	Glass + OA Buoyancy IOSDL-Instrument load				796	kg
SF under glass spheres in position		4				

Dynamic Response

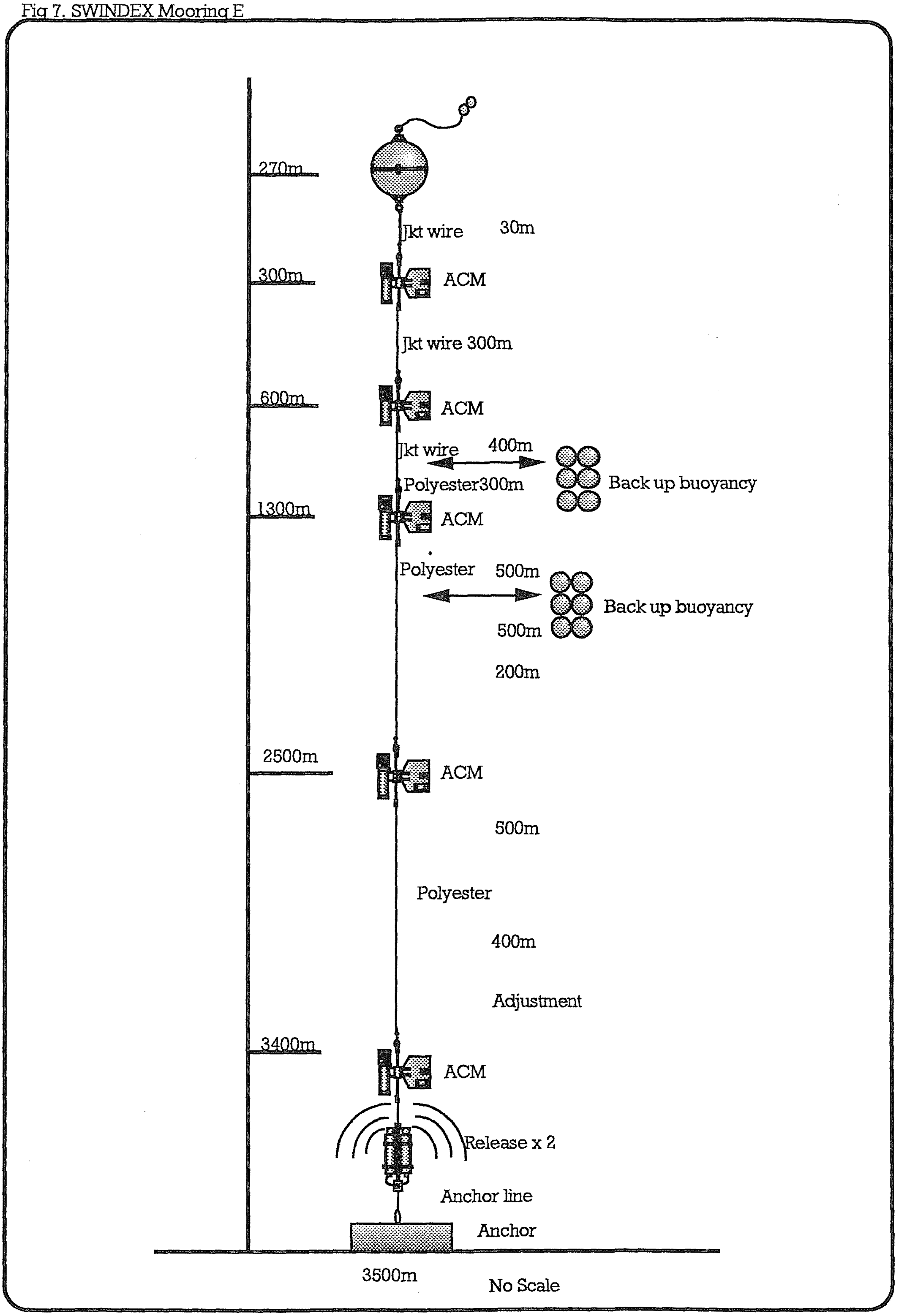
See Mooring A.

Mooring D

Design depth 2700m.

This mooring will perform as mooring A,being almost a duplicate.Back up buoyancy is slightly increased due to the line length reduction.

Fig 7. SWINDEX Mooring E



1.8. Mooring E

Overall Mooring

Main Buoyancy 651	kg	Total buoyancy in system	1073	kg	
Anchor air weight	1551	kg	Mooring hold up	478	kg
Anchor hold down	300	kg	Back up recovery buoyancy	100	kg
Total 17" spheres	17				

Upper Mooring Section

Buoyancy	651	kg	Instrument load	135	kg
OA buoyancy	516	kg			
GS of wire	2250	kg	GS of polyester	3190	kg
SF under steel sphere in position			4.4		

Mid mooring section

Buoyancy glass 228	kg	Instrument load	41	kg	
OA buoyancy	516	kg			
Tension in polyester	Glass + OA Buoyancy -Instrument load			703	kg
SF under glass spheres in position			4.5		

Lower mooring section

Buoyancy glass 203	kg		Instrument load	108	kg
OA buoyancy	703	kg			
Tension in polyester	Glass + OA Buoyancy IOSDL+Instrument load			998	kg
SF under glass spheres in position			3.2		

Dynamic Response of Mooring.

As an exercise in mooring response to differing current profiles the mooring configuration was run with two sets of profiles.

1.Low current profile.

Static depth of subsurface buoy	270m	Dynamic depth	286m	Current	39cm/sec
Tension at subsurface	627kg	Horizontal excursion	322m		
Dynamic depth of ACM2	619m	Horizontal excursion	304m	Tilt 3.6 deg	28cm/sec
Dynamic depth of glass sphere1	1018m	Horizontal excursion	263m	Tilt 5.7 deg	19cm/sec
Dynamic depth of glass sphere 2	1823m	Horizontal excursion	179m	Tilt 6deg	10cm/sec
Anchor vertical load	657kg	Horizontal load	87kg		
WHOI safe dry anchor weight	1382kg				

2.High current profile.

Static depth of subsurface buoy	270m	Dynamic depth	362m	Current	46cm/sec
Tension at subsurface	627kg	Horizontal excursion	737m		
Dynamic depth of ACM2	694m	Horizontal excursion	712m	Tilt 4.9 deg	40cm/sec
Dynamic depth of glass sphere1	1090m	Horizontal excursion	646m	Tilt 9.3 deg	38cm/sec
Dynamic depth of glass sphere 2	1877m	Horizontal excursion	456m	Tilt 14.9deg	22cm/sec
Anchor vertical load	627kg	Horizontal load	213kg		
WHOI safe dry anchor weight	1692kg				

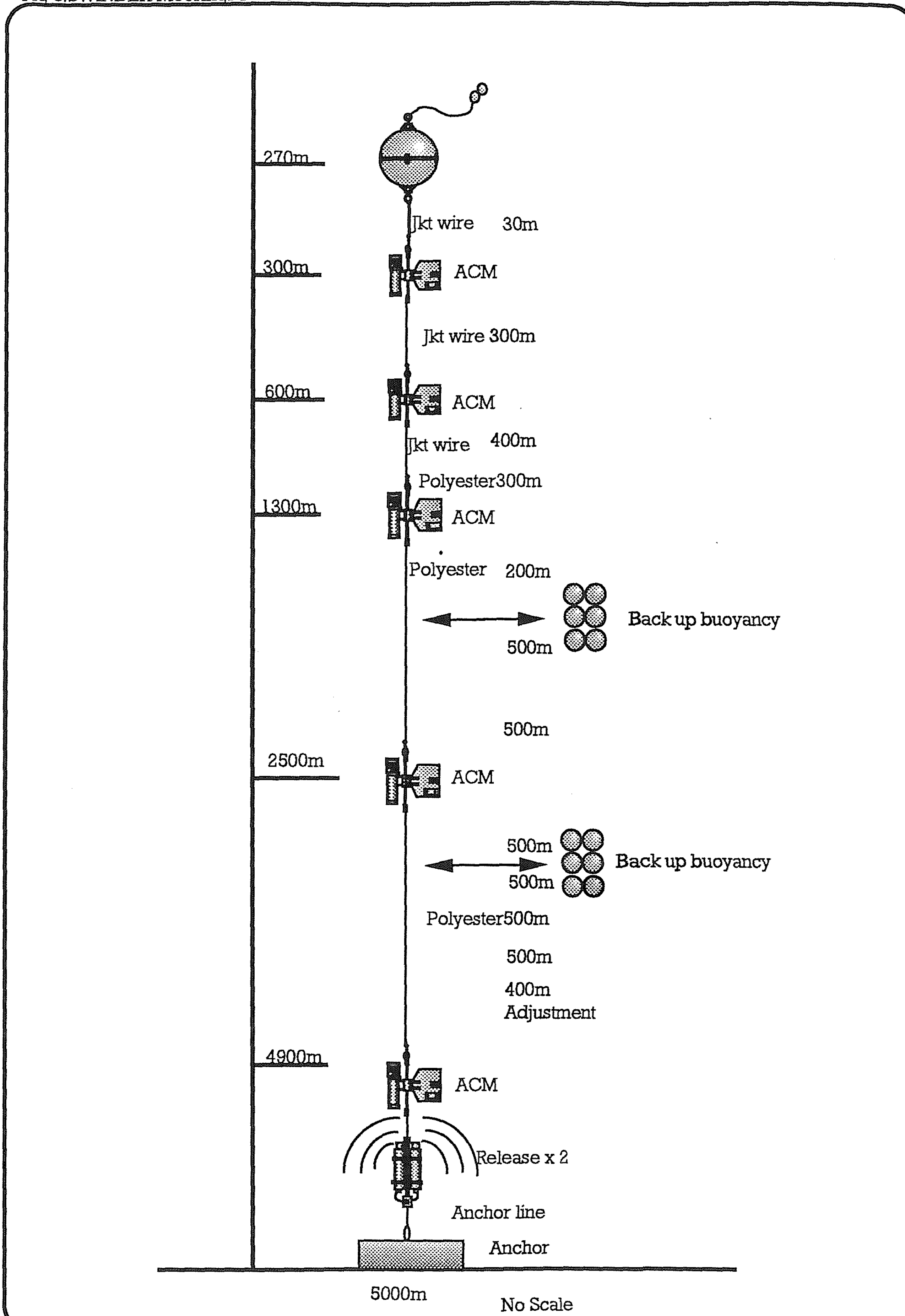
Mooring E

Design depth 3500m

As with above moorings the back up buoyancy will maintain the recovery capability.With a failed subsurface the current meter at 1300m will be fouled by the collapsed line.Current meters at 2500m and 3400m will be fully functioning.

The collapsed line in this instance will not foul the lower package thus increasing the prospects of survival,as no damage will occur about this secondary package.

Fig 8.SWINDEX Moorings F-G-H



1.9 Moorings F,G,H

Overall Mooring

Main Buoyancy 651	kg	Total buoyancy in system	1106	kg		
Anchor air weight	1589	kg	Mooring hold up		483	kg
Anchor hold down	300	kg	Back up recovery buoyancy		100	kg
Total 17" spheres	18					

Upper Mooring Section

Buoyancy	651	kg	Instrument load		178	kg
OA buoyancy	473	kg				
GS of wire	2250	kg	GS of polyester	3190	kg	
SF under steel sphere in position			4.75			

Mid mooring section

Buoyancy glass 228	kg	Instrument load		56	kg	
OA buoyancy	473	kg				
Tension in polyester	Glass + OA Buoyancy -Instrument load				645	kg
SF under glass spheres in position			5			

Lower mooring section

Buoyancy glass 228	kg		Instrument load	104	kg	
OA buoyancy	645	kg				
Tension in polyester	Glass + OA Buoyancy IOSDL-Instrument load				769	kg
SF under glass spheres in position			4			

Dynamic Response of Mooring.

Static depth of subsurface buoy	270m	Dynamic depth	308m	Current	39cm/sec
Tension at subsurface	640kg	Horizontal excursion	585m		
Dynamic depth of ACM2	640m	Horizontal excursion	567m	Tilt 3.4 deg	27cm/sec
Dynamic depth of glass sphere1	1537m	Horizontal excursion	475m	Tilt 7.2 deg	14cm/sec
Dynamic depth of glass sphere 2	3035m	Horizontal excursion	279m	Tilt 7.8deg	10cm/sec
Anchor vertical load	656kg	Horizontal load	104kg		
WHOI safe dry anchor weight	1429kg				

Moorings F,G,H

Design depth 5000m.

These moorings are similar to many full depth abysall plain moorings deployed by IOSDL.The buoyancy configuration is similar to moorings A to E.The upper package is deeper on the moorings due to line loadings.As of this time the design is not fixed and I shall be looking into repositioning the packages using adjusting lengths to move the upper buoyancy above the current meter at 1300m.This move will improve the collapsed line position such that the current meter at 2500m will not be fouled.

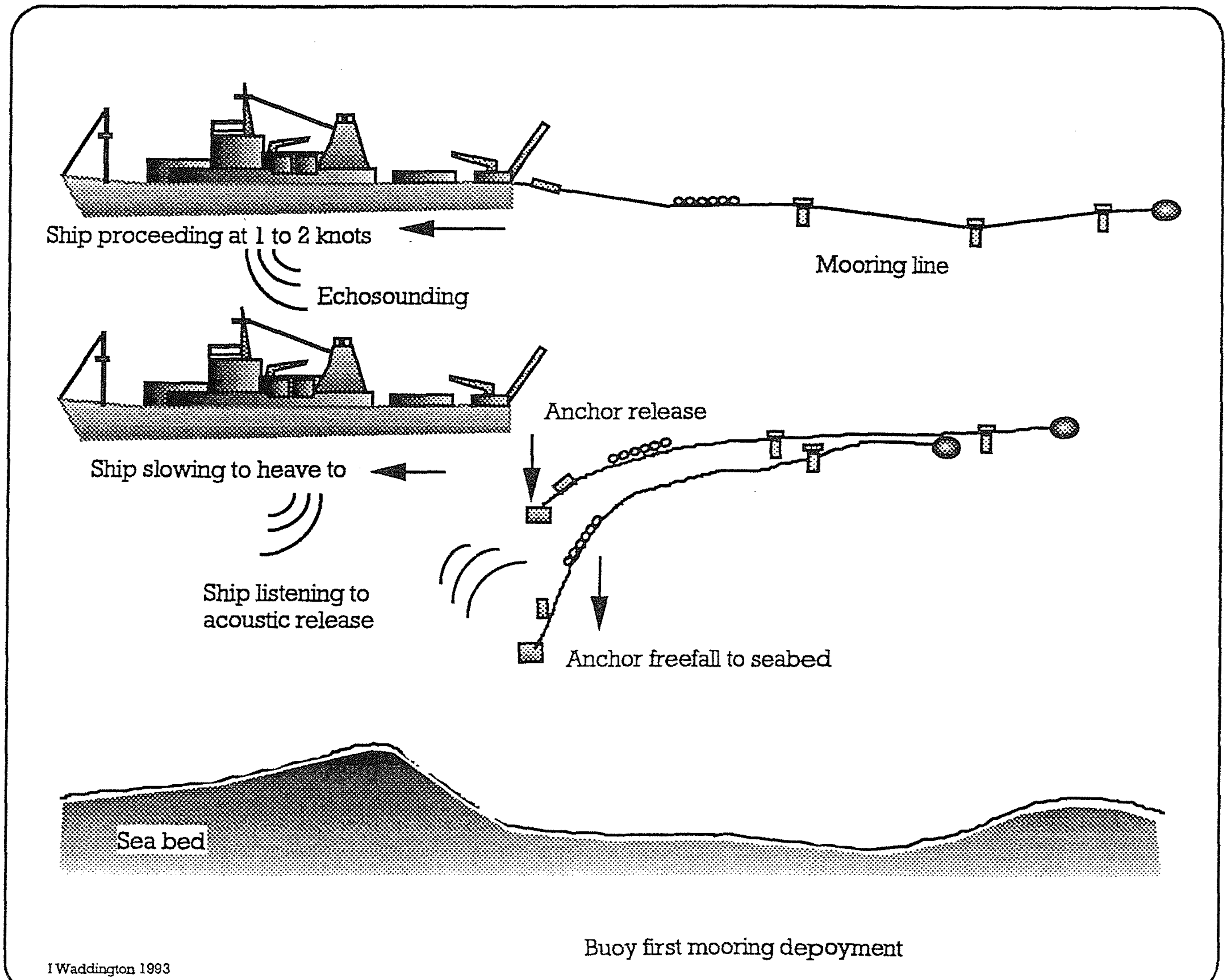
1.10. Deployment

As the design evolved it became apparent that these mooring designs with high buoyancy and anchor loading were not suitable for anchor first deployment.The mooring lines would see excessive loading in the static mode and dynamic loadings in excess of twice the static load could be induced due to ship pitch. Thus the mooring deployment had to be buoy first,with the anchor free fall last.

A scheme was evolved to deploy the moorings using the machinery available both on the Charles Darwin and the recently refitted Discovery.This was successfully tested on the Darwin Cruise 66 with further refinements made on Discovery 200,ADOX. Positioning of the anchors on the Discovery cruise 201were more critical due to topography and determination of anchor set down position was to be investigated on the first moorings deployed on flat topography to best position the moorings on the more complex topography.Section 11.

Consideration was given as to the machinery required . What would be available as fitted to the vessel and as portable machinery.It could be seen that Discovery had all the capabilities for lifting over the stern but with no suitable mooring winch.No winch was available for the period required within NERC and no suitable winch could be hired,the Mooring Team thus proceeded to refurbish the IOSDL Double Barrel Capstan Mooring Winch.

A comprehensive document was produced for ships use detailing the deployment proceedures.



Buoy first mooring depoyment

SWINDEX Technical File

2.Mooring Hardware

I.Waddington

Index

Mooring Lines

2.1 Jacket 6mm wire

Jacket steel wire is to be used in the top 1000m of the water column as a precaution against fish bite.The wire is coated with polypropylene to prevent corrosion.This wire has survived for one year deployments in the Faeroe and Great Meteor regions and has been recycled to 3 years exposure.

The wire is a 6mm diameter 7x19 galvanised construction,produced as a special item with no internal grease.The wire is then coated,by extrusion,with polypropylene to a thickness of 1mm,thus increasing the overall diameter to 8mm.
The coating is smooth and as such can assist in reducing drag of the mooring wire.

IOSDL has previously obtained supplies from British Wire Ropes,later Bristol Wire Ropes.Estimates for production were obtained from several manufacturers to the IOSDL specification.
Midland Wire Cordage,MWC offered a favourable price on the specification and provided a sample to IOSDL for testing.The sample was pressure tested with the ends sealed to 3000 psi for 5 days with no ingress of water.
Bending and load tests were carried out indicating the material to be up to specification.

The heat shrink shroud material was obtained from Ampliversal and was tested for sealing,adhesion and durability in the laboratory.
A termination suitable for IOSDL and RVS was manufactured by MWRC to IOSDL specifications and fitted to a test length for load testing.

RVS were to deploy one year moorings for PML,Dr R D Pingree,which IOSDL was to design and specify. The opportunity to field trial the wire using these deployments was taken and all the wires were manufactured by MWRC for this.
Trials were carried out on the wire onboard RRS Charles Darwin Cruise 66,Mar-April 1992 proving the wire suitable.Plymouth Marine Laboratory Cruise Report RRS Charles Darwin 66/92.Details of these moorings and trials are given in Annex 3

Supplier.Midland Wire Cordage Ltd. Orchard Works,Arthur St,Redditch,Worcestershire,B98 8LJ

Type. Steel wire rope 6mm dia,7x10 Galvanised,preformed,tensile 1770 N/mm to BS 302/1987.
Manufactured with no grease.Impregnated with blue polypropylene to 8mm o.d. B.L.2350 kg.
To be supplied on drums for cutting and measuring at IOSDL.
Termination.MW 12-12-91 special product.
Shroud.AMH 1-727120-2.AM-Black Medium Wall Tubing with sealant.Cut to length at IOSDL.
Supplier.Ampliversal UK

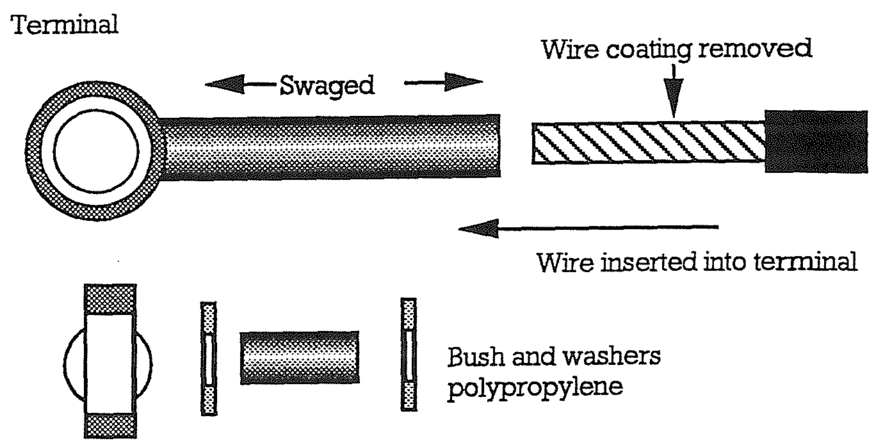
This wire is not suitable for in field terminating and as such adequate spares and adjustment lengths must be carried.
The lengths required for SWINDEX were determined and the wire ordered in bulk to be measured and cut at IOSDL.After cutting from the stock drums the lengths were returned to MWRC for swaging and end terminations.Each end of the wires was made accessible and fitted with a heat shrink shroud loosely slipped onto the wire prior to swaging of the termination.On return to IOSDL each termination was inspected before fitting of the shroud.All terminations were to a good standard and subsequent wires are to be cut and terminated at MWRC with inspection only at IOSDL.

Mooring Wire Preparation

On return from swaging at MWRC the terminations were inspected and found satisfatory.

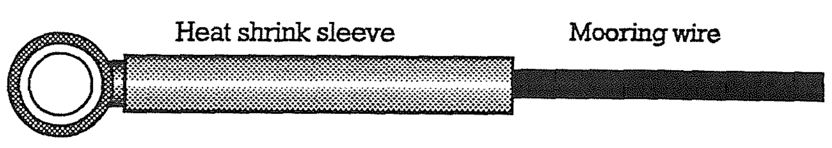
1.Heat shrink shrouds.The wire and terminal was thoroughly degreased for 250mm from the terminal.The shroud was then slid along the wire and over the swage terminal.Using a hot air gun fitted with a deflector the shroud was heated from the terminal end progressing slowly and evenly to the wire end to shrink the terminal evenly onto the wire.Sealant could be seen to extrude from the shroud completing the shrinking process.

fig 9.Mooring wire termination components



2.Polypropylene Bushes.Bushes are fitted within the swage terminal eye to reduce abrasion and corrosion.The terminal eye is liberally coated with TECTYL 506 both externally and internally within the eye.With the coating still wet the bushes are inserted and the outer washers fitted.The coating provides a watertight barrier within the bush and acts a location to hold the bush and washers in place.

fig 10. Mooring wire termination assembled.



Shipping

The wires need to be treated carefully when shipping to prevent damage to the polypropylene coating.The 30metre wires are secured in coils and shipped in cardboard boxes.The 300m wires are wound onto smooth finished wooden drums,wrapped with sturdy polythene.The drums and boxes used are low cost disposable items which can be disposed of on completion of the mooring,thus saving return freight.

2.2 Synthetic Lines

Fibre lines are used below 1000m water depth where fish bite is minimal.The line chosen for the IOSDL section is polyester,which is also to be used in the SWINDEX array.This gives a reasonable cost return per metre and has been used at IOSDL for several years.IOSDL has acquired historical data through usage of polyester lines which can be used to better estimate stretch over the long term deployments for a given mooring loading and/or configuration.

Most major European manufacturers produce lines suitable for this application and were approached for quotations and specifications.Marlow Ropes Ltd.offered favourable prices and delivery for the specification required.

Supplier.Marlow Ropes Ltd. South Rd,Hailsham,East Sussex.BN27 3JS
Type. Marlowbraid polyester,10mm dia,white,GS 3760 kg.

Stretch Allowance.

The calculated maximum in position tension in the Polyester line is 800 kg,the stretch expected is 5% plus 3% to 8% for initial settling in of the line.An accurate line length must be detremined by actual stretching of the lines under load at sea.

Stretch Measuring.

All the lines were reeled and measured at IOSDL.At sea a representative quantity of lines will be stretched overside using a suitable weight and measured with the metre wheel of the Double Barrel Capstan mooring winch.

Splicing

All the splices were produced at IOSDL by Sterling Aldridge.
A splice was produced by Sterling using the Marlow reccomended proceedure This splice was tested at RVS to ensure its integrity and to observe the splice performance at the thimble when under load.Splicing can be achieved at sea using the approved tools and a suitable large bench vice.

Mooring Line Testing

The mooring lines were taken to RVS Barry and load tested with the RVS test bed.Tests were carried out by K M Goy and S Aldridge,25-vi-1992.

Line type	Splices	Test Load	Comments
1.Marlow 10mm SPB Two samples tested.	Spliced each end Aanderaa One end coated on each.	1.5 tonne (0.5 GS)	No movement in splices Thimbles secure under load.
2.Liros 12mm Br/Br Two samples tested.	As above	2 tonne	As above
3.Marlow KT3 8mm One sample tested.	IOSDL splice/factory splice	2 tonne	No movement in the IOSDL splice Some movement at factory splice

The splice load tests indicated the IOSDL splice adequate to be adequate for the expected tensions.The thimbles retained their position and on relaxation of the tension the thimbles remained tight within the spliced eyes.Problems were later encountered in onboard stretching with the thimbles"popping out"as they went over the sheave under load.Section 8.

Splice Coating

Superthane Abrasion Resistant Coating is a liquid,water thinnable,plastic type coating.Its primary use is in coating tow lines to reduce external abrasion to the fibres.
IOSDL has been experimenting with the material as a protective coating for umbilical cables,MAST 1,and as a splice lock and coating,PML drifting buoys and short term moorings,1992-1993.
The end terminations of mooring lines can experience significant abrasion on deployment and with subsequent shackle corrosion can become contaminated with rust products.
The material adheres well to Polyester braids and when thinned with water penetrates to the core of the lines bonding the fibres together and sealing the line from the ingress of abrasive contaminants.
The end terminations of all the fibre lines are dipped in a thinned solution of Superthane for 15 minutes and then removed to drain vertically with the thimble at the lower position.The termination is allowed to dry for 12 hours at which time the Superthane has set sufficiently to allow the splice to be handled.
The finished protection extends from the thimble 300mm along the line,completely covering the splice.

Test coatings were load tested,page iv,to ensure the Superthane did not adversly effect the splice strength.

Nylon Thimbles

The Polyester 10mm mooring line is terminated around a solid nylon thimble manufactured by Aanderaa Instruments.This thimble has been load tested to 2 tonnes with minimal distortion with the rope dry and when loaded to 2.9 tonnes some distortion observed due to rope heating,H&T Marlow Report for IOSDL 03-iii-1989,The thimbles were used successfully on the 20 month mooring deployment S.E Iceland array ,1991-1992,with no significant signs of wear.
The thimble accepts a 1/2" Dee shackle pin which is used as standard for these mooring types.

Supplier. W.S.Ocean Systems,Unit 4,Omni Business Centre,Alton,Hants.GU34 2QD.
Type. Thimble for spindle end piece,Part no.935021.

Nylon Anchor Line

A compliant 20 metre section,Part no AD004, is inserted below the Acoustic Release assembly to act as a tow line when positioning the mooring and also as a shock absorber to prevent the release over running the line as the anchor reaches the sea floor.
The line is measured,spliced and coated with Superthane at IOSDL.
The thimble used is a BS 16mm Heart type,hot dip galvanised,suitable for steel wire.
A test sample spliced each end with thimbles was produced for testing to 2 tonne at RVS,C Washington.

Supplier. English Braids Ltd,Spring Lane,Malvern,Worcestershire.WR14 1AL.
Type. Anchorline 16mm diameter,nylon,8 plait,GS 5300 kg(dry)

Polyester Anchor line

A negatively buoyant 25 metre section of heavy duty polyester braid is inserted beneath the Nylon Anchor line and above the anchor riser chain.This acts as a rugged connector between the Anchor Line and the chain.The line acts a buffer between the abrasive chain and the relatively soft fibre of the Nylon.
The line is connected to the chain with a single shackle thus reducing the chance of overshoot tangling.
The thimble used is a BS 14mm Heart type,hot dip galvanised,suitable for steel wire.

Supplier. English Braids Ltd,Spring Lane,Malvern,Worcestershire.WR14 1AL.
Type. Braid on Braid 14mm diameter,GS 4000 kg.

Recovery/Handling Line

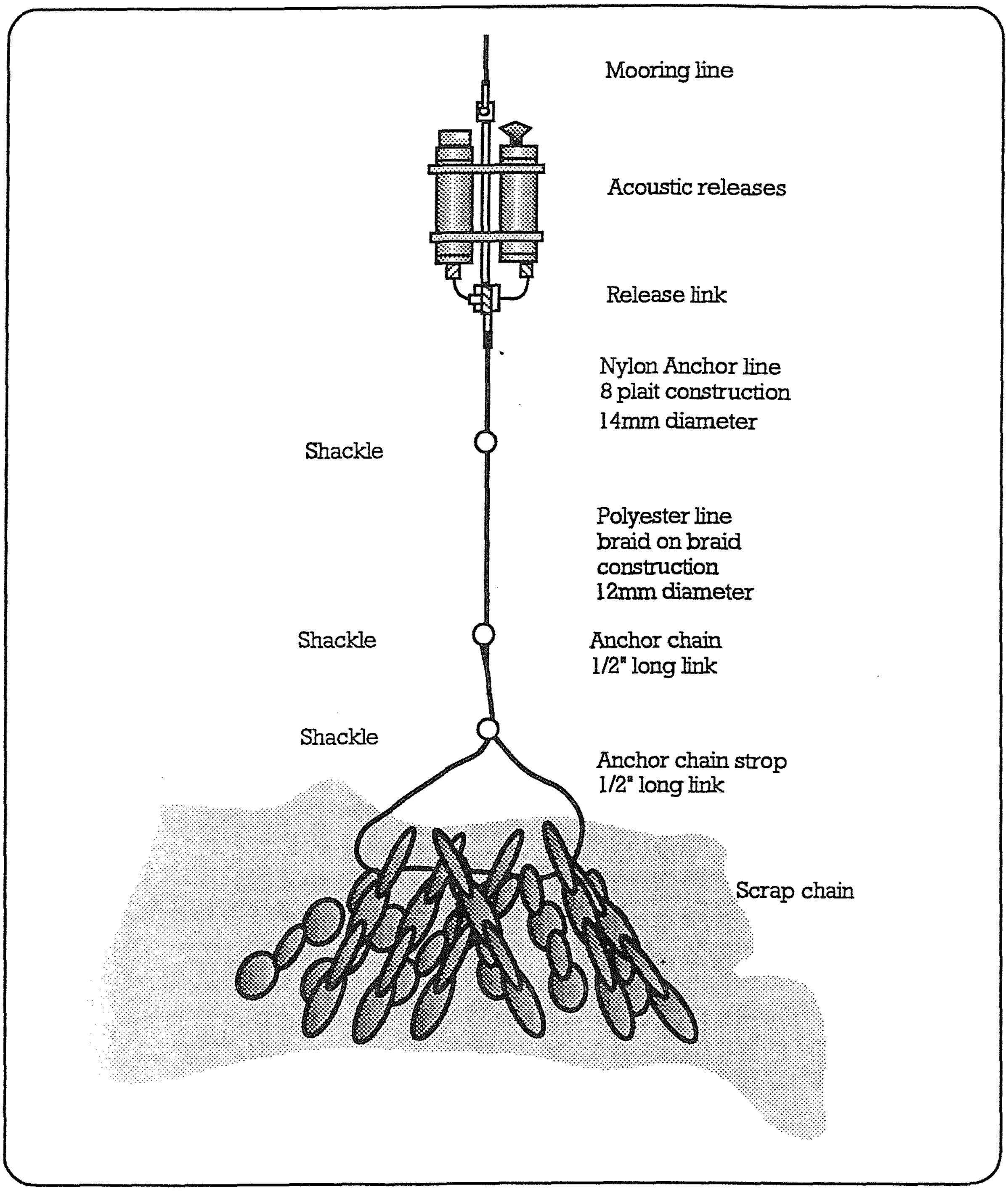
IOSDL has for many years used one product for recovery and handling lines,STURDEE split film polypropylene.The line is competitively priced,robust and reliable.
The line is purchased in bulk and cut and spliced at IOSDL.Each end is spliced with a large soft eye.

Supplier. Marlow Ropes Ltd. South Rd,Hailsham,East Sussex.BN27 3JS
Type. Sturdee,20mm diameter,3 strand,GS 6210 kg.

Mooring line Shipping.Lines in excess of 100m are to be shipped on disposable lightweight wooden drums,all shorter lines are to be shipped in disposable cardboard cartons.

fig 11. Anchor line and anchoring.

Fig 11 . Anchor line and anchoring



2.3 Chains,Shackles,Swivels

Mooring Chains

There are two sizes of chain used in the moorings,13mm long link and 5/8" long link.Thes chain sizes are chosen for the load application and the corrosion expected.

13mm/1/2" Chain. The chain is used for glass sphere attachment,anchor riser chain and as the drag anchor chain.The chain is purchased in bulk and cut to suit the application at IOSDL and onboard ship.The chain is easily cut using wire rod cutters which are carried as standard mooring tools.
Supplier. JW Chains Quarry rd,Dudley Wood,Dudley,West Midlands.DY2 0ED
Type. 1/2 x 6 MS Long link,Galvanised

5/8" Chain. The chain is used as a thresher chain beneath the subsurface buoy .Previous deployments have used 13mm chain.However it has been noted that there appeared to be increased corrosion at the stainless swivel end of the chain,possibly by electrolytic action.This corrosion is acceptable for a one year deployment but the rate of corrosion could not be forecast for a two year deployment.It was therefore decided to increase the chain size for safety.

The chain is purchased in bulk and cut to length at IOSDL.Cutting the chain can be done by oxy-acetylene torch or by a cutting wheel.Cutting by hack saw is time consuming but can be done onboard ship.
Supplier. JW Chains Quarry rd,Dudley Wood,Dudley,West Midlands.DY2 0ED
Type. 5/8 x 6 MS Long link,Galvanised
Shipping. Chains are shipped in steel barrels.

Shackles and Links

All the shackles and links in the moorings are proven components for one year deployments.

1/2" BS Dee Shackles.The shackles are 1/2" body with 1/2" screw pin.Hot dip galvanised.SWL 800 kg.These shackles are used to join all mooring lines in the upper section.

5/8" Green Pin Alloy Bow.5/8" screw pin size,galvanised.SWL 2 tonne.These shackles are used in the buoy chain assembly and anchor riser assembly.

1/2" BS Reevable Links.1/2" body,pear shaped,hot dip galvanised.SWL 1 tonne.Used throughout the mooring line for stopping off.

5/8" Weldless Sling links.5/8"body,pear shaped,hot dip galvanised.SWL 4.2 tonne.Used in the buoy chain assembly for stopping off.

1/2"Commercial Dee Shackles.1/2" body,1/2" screw pin.These are used as glass sphere mounting shackles.

Cable ties.Nylon cable ties are used to secure the shackle pins in the mooring.The ties must be all nylon,care must be taken not to use the types with stainless steel locking fasteners as these can corrode thus releasing the tie.

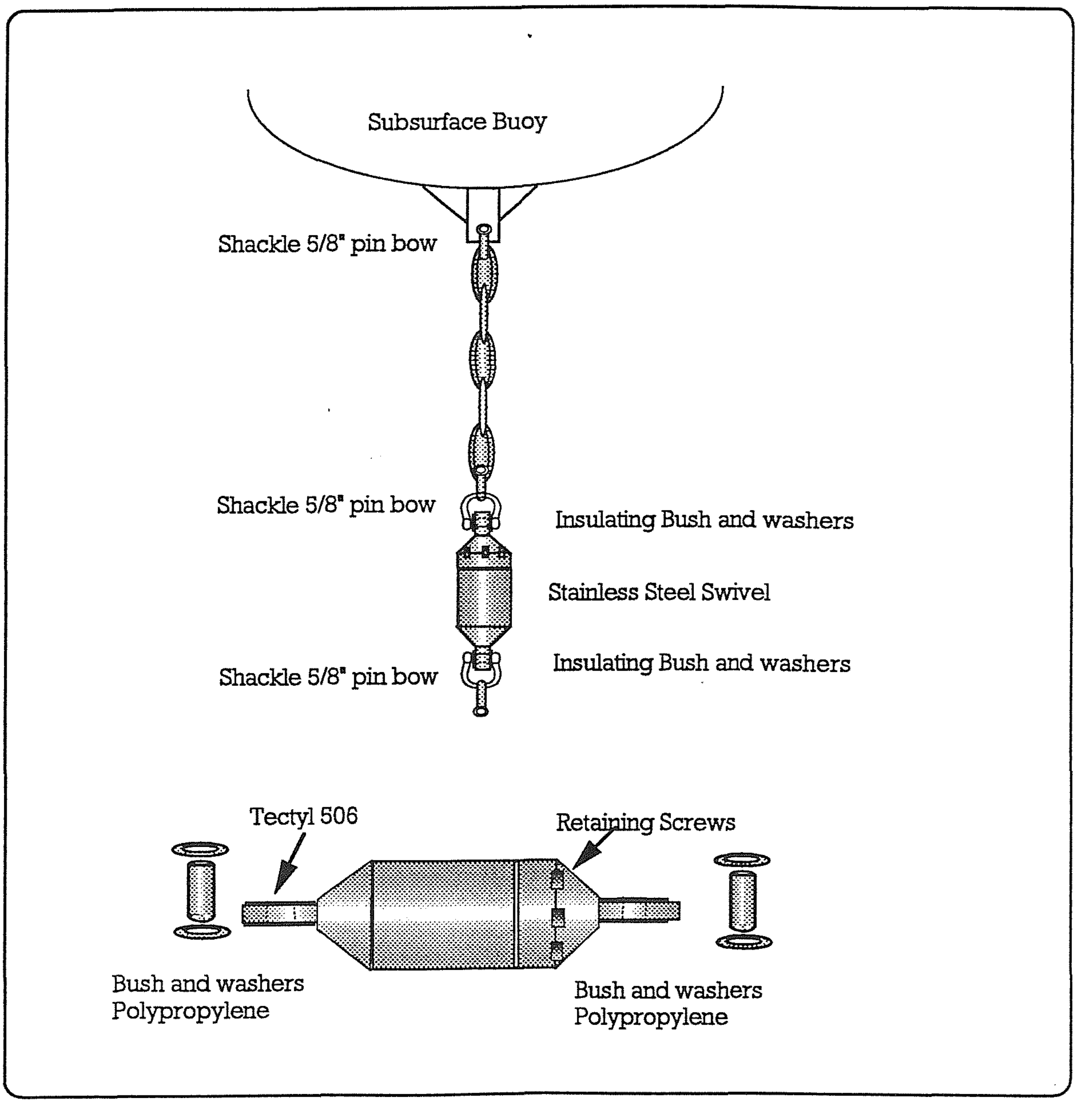
Stainless Steel Swivels

The units used for two year moorings are Stainless Steel-Pressure balanced units manufactured for IOSDL. The swivels are stainless steel 316 bodies with roller and ball race turning components sealed in oil.The oil is pressure balanced using a pressure transmitting membrane and is operable to 6000 metres.
The turning force under load is small,1 ft/lb at 1500 kg,allowing free movement of the wires and lines.

The swivels for these moorings are all new units coated with TECTYL 506.This coating is applied within all threads and enclosed surfaces to prevent crevice corrosion.

Bushes and Washers are fitted to the shackle end holes to isolate the stainless and galvanised steel components from each other.The bushes,washers and all the swivel surfaces are coated with TECTYL 506 before assembly.The swivel assemblies are overcoated with Weather-X for shipping and storage.

fig 12.Buoy chain and swivel assembly.



2.4 Buoyancy

Steel Subsurface Buoy.

The main buoyancy of the moorings is a 1.3m steel sphere manufactured by IOSDL.

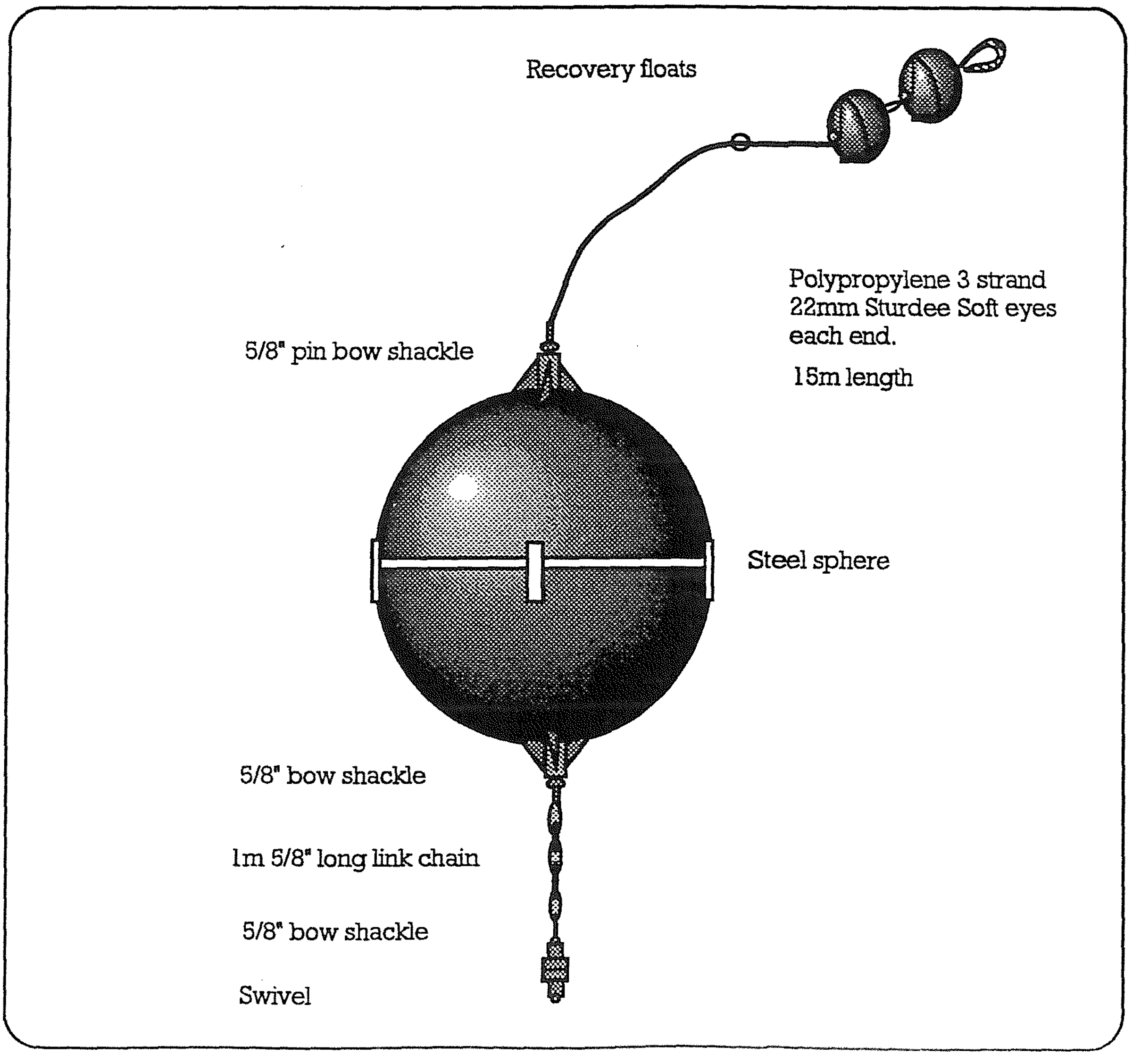
Type.IOSDL 1.3m diameter,buoyancy 637 kg,air weight 318 kg,O/A diameter 1219mm.
Each sphere labelled with ID number , IOSDL address , telephone , fax and telex numbers .
Shipping.The spheres are transported on IOSDL steel buoy stands,suitable for craneage and fork lifting.

Pick up Buoys

Pick up buoys are used on the mooring recovery line to buoy up the recovery line when the mooring is released.The buoys then keep the recovery line clear of the subsurface as it rises and buoy the line at the surface.
IOSDL has used commercial fishing floats for this purpose.However catastrophic flooding has occured with a recent batch from one manufacturer,experienced by IOSDL and PML.
The purchase of these floats was conducted on the most historically reliable units available,not on cost.

Supplier. Bridport Gundry Marine
Type. Pantherplast float,11" diameter,8.5kg buoyancy,working depth 500m,Centre hole.

fig 13.Steel Subsurface buoy with pick up line and floats.



Glass Spheres

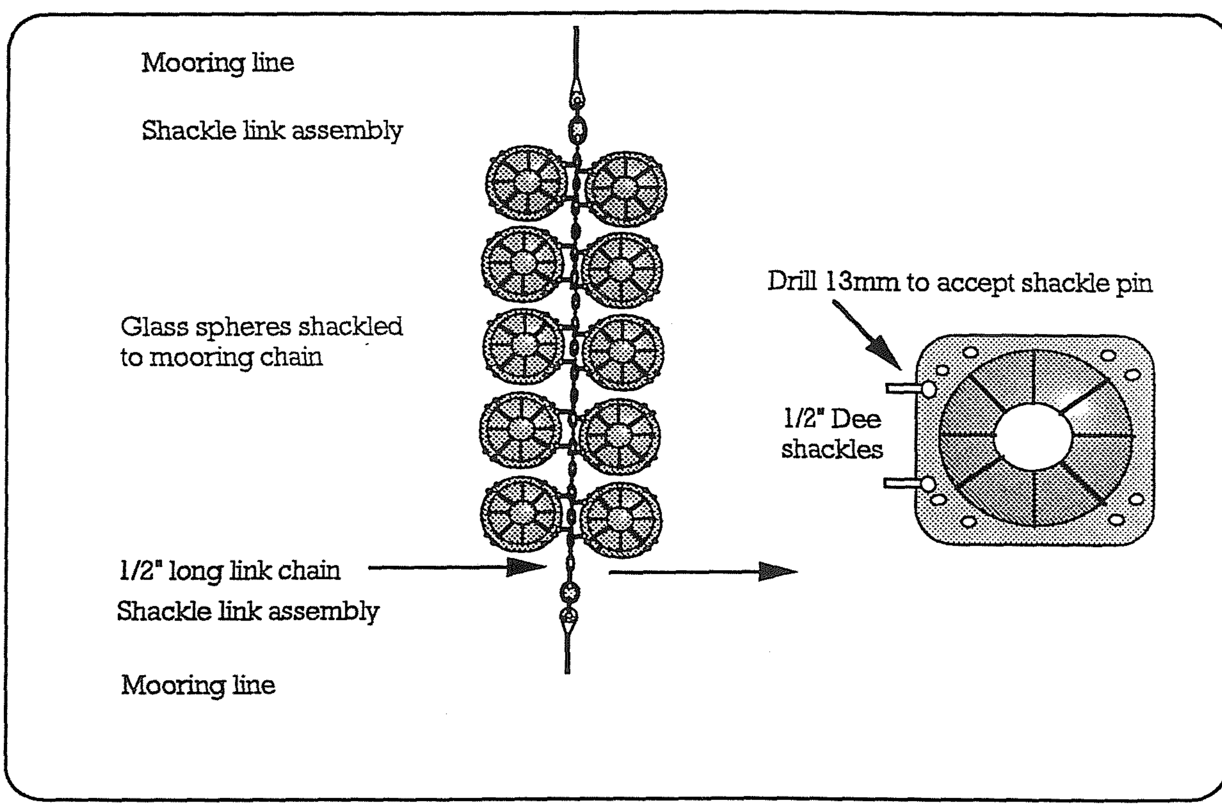
Glass buoyancy spheres of various manufacture are used by IOSDL for deep water applications.Each sphere was inspected at IOSDL with any chipped or flaked glass units being rejected.
New units were purchased on competetive tender from Benthos USA to complete the mooring specificied quantities.
The spheres are all fitted into plastic type hard hats of various designs,each hat being drilled to accept two commercial 1/2" shackle pins for attachment to the in line buoyancy chain.

Spheres used.

Manufacturer	Type	No.off.	
Benthos USA.	17" dia in various hard hats.	105	
Oceano France	17" and 16" in standard hats.	20	
Corning USA	16"in standard hats	13	These are no longer in production.

Shipping.The spheres were transported in steel wire mesh pallet cages,each holding 10 spheres,or in cargo nets which could be lifted into open top containers on top of another load,such as winches and mooring line drums.

fig 14. Glass sphere assembly



2.5 Aanderaa Current Meter Vanes

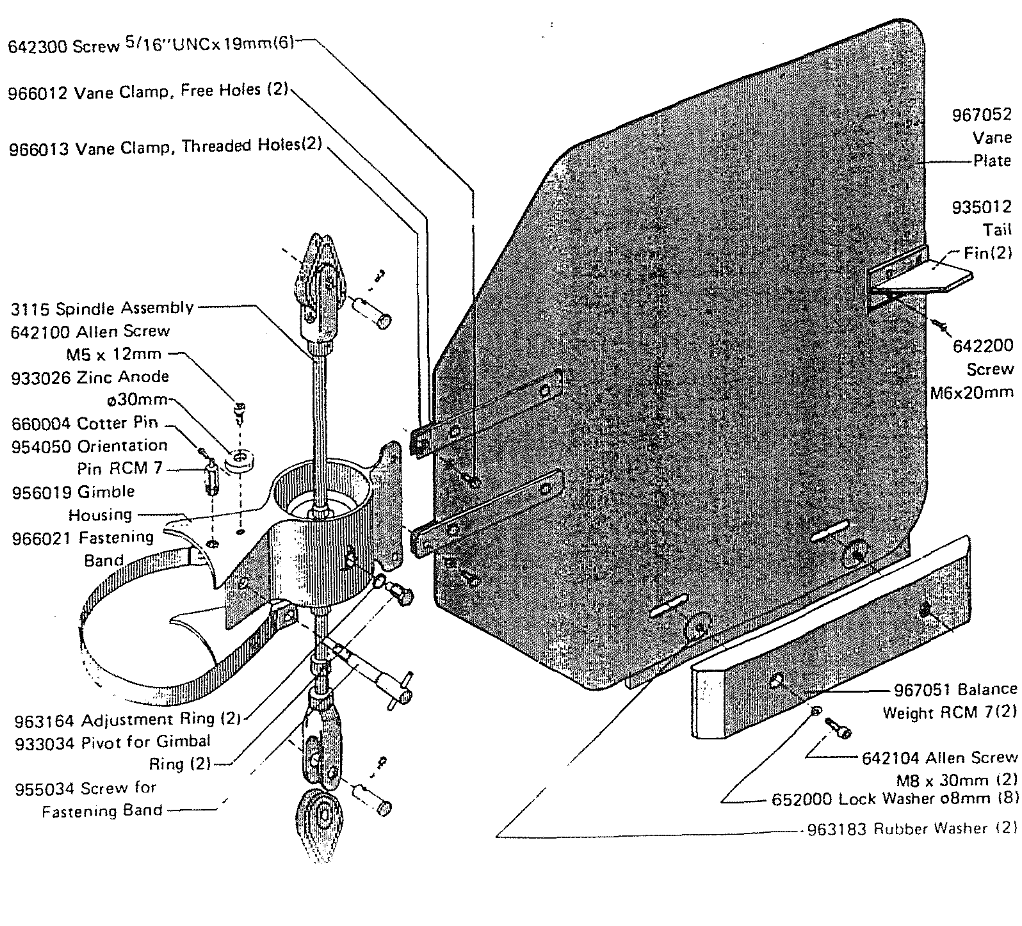
The current meters are all of Aanderaa manufacture and of various types.RCM 7 and 8 units were supplied to IOSDL without Spindles,part no.3115,as IOSDL does not use this reduced length pattern.This is due to magnetic interference from mooring components on the adjacent compass.

Titanium spindles of IOSDL manufacture and stainless steel spindles,part no 971207 are of increased length and have been used for 20 months and 12 months respectively by IOSDL in deep ocean moorings.It should be noted that the majority of spindles used were titanium with stainless steel being used only after close inspection of all parts.
The titanium spindles were a blend of new and recycled units,all inspected and assembled to new or overhauled yoke assemblies.
The stainless steel spindles were dismantled to their component parts and inspected for wear and corrosion.All suspect parts being rejected.
The Aanderaa paint was removed from all components to facilitate inspection of the materials beneath,crevice corrosion has been seen to occur beneath the paint on some units where the coating has been penetrated by sea water.Two coats of Hypalon,a proprietary flexible rubber type coating,was applied to each part before reassembly.This being overcoated with Tectyl 506,a waxy coating.

The older yoke units were shotblasted to remove all coatings and recoated with two coats of Hypalon.This method of preparation had been successfully tested on the FI Array 1991-1992 for 20 months.
The RCM7 and 8 units,part no.956019,were new as received from the manufacturer.Corrosion can occur in the screw threads of this assembly and so all components were dismantled and threads and surfaces coated with Tectyl 506.

The spindle assembly and yokes were then assembled with the pivots overcoated with Tectyl.The pivots were locked in place with PVC coated wire,rather than the manufacturers stainless steel as this has been seen to corrode.

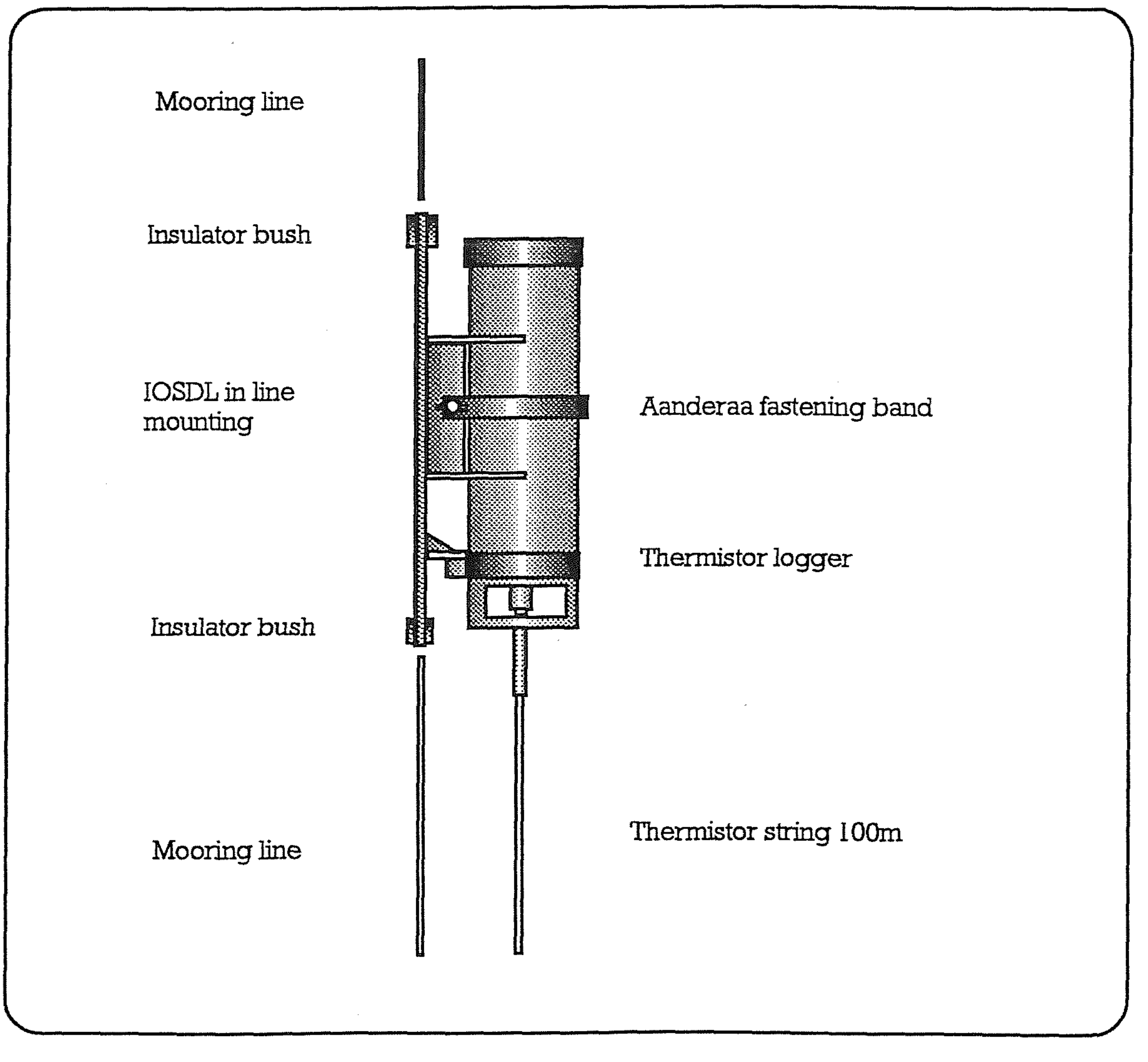
The older RCM4 and 5 vanes were inspected and bent or brittle units replaced with IOSDL manufactured components.These IOSDL vanes were developed using compatible material machined to standard dimensions at a considerably reduced cost.A trial fin had been tested on Darwin Cr 66.



2.6 Temperature Profiler

The temperature profile loggers were mounted on IOSDL designed in line mountings.These mountings were manufactured in mild steel and shotblasted.Applications of four coats of Hypalon were applied to all surfaces with paricular attention being paid to welds.The in line shackles are attached through standard IOSDL polypropylene insulating bushes to reduce abrasion.
The thermistor strings are multicore electrical cables with thermistor beads potted into the lines at predetermined intervals.Thes wires cannot withstand the through load of the mooring and are thus attached in parallel with a strain cable.In this case a mooring wire cut to length to suit the string length.The string is attached with a low temperature adhesive tape on deployment at approximately 1 metre intervals.

fig 16 Temperature Profiler-Logger mounting



SWINDEX Technical File

3.Aanderaa Current Meters

K.M Goy

Index

3.1. Instrument preparation and overhaul

The current meter allocation of thirty eight current meters and two thermistor chains for the Swindex array necessitated the use of almost the total stock of units held by the Marine Physics departments of IOSDL and JRC

Twenty RCM7/8 units purchased since 1989 were all in as new condition,however the balance of the instruments comprising RCM 4/5 units had either recently been recovered from a 20 month long deployment or had been deployed for short term testing following extensive rework of the electronics units.Some of these latter units had histories of unreliable performance.

All units were surveyed in the laboratory and a schedule prepared to include the rectification work and the spares required to produce instruments of high quality with a good predicted reliability over a 24 month deployment .

RCM 7 & 8

These instruments required minimal mechanical rectification.To minimise crevice corrosion, rotor shields were removed and all mating surfaces and screw threads were liberally coated with Tectyl 506 prior to reassembly Units supplied during 1992 (ser nos 10852 onwards) were found to have a defective rotor which in extreme circumstances could cause creep of the magnet ring on the shaft. The manufacturers were notified and as a precaution, all rotor magnets were attached to the shaft with cyanoacrylate adhesive (Locktite 480). The stainless steel locking wire securing the upper rotor bearing was removed and replaced with plastic coated equipment wire which is known to survive well for long deployments. A liberal coating of Tectyl 506 was applied to all edges of the rubber base to eliminate corrosion.

RCM4/5

All of the older type instruments, with the exception of ACM 7401, were housed in the IOSDL deep pressure cases. Many of these units had recently been recovered following a 20 month deployment and the exterior surfaces had suffered heavily biological fouling with poor paint finish and some corrosion. Instruments were removed from their cases and the cases and rotor arches stripped for aluminium oxide shotblasting. All components of the top and bottom end caps were removed and inspected for damage and corrosion, where necessary components were replaced prior to reassembly.

Following shotblasting, the cases were visually examined for deep pitting corrosion and then cleaned thoroughly with solvent to remove surface contamination. Each case and rotor arch was finished with two coats of liquid marine hypalon paint which has proved to provide a hard wearing resilient finish even in deep water at low temperature.

All rotor components including bearings were replaced with new items. Upper rotor bearings were secured with plastic coated equipment wire.and to prevent degradation of the araldite by the antifreeze solution, the lower bearings were not secured until after the units had been calibrated in the temperature bath.

The hole orientation on the IOSDL top cap is non standard and a trial fitting of the new type 3239 pressure sensor obscured the adjacent locating hole for the electrical terminal. This required a modification to the end cap assembly, fig 3, on ACMS 8010, 7517, 5204, 5205, 6225, and 2108 to allow correct fitting of the updated pressure sensor. Pressure integrity tests, post modification, were carried out on ACM 6225 in the IOSDL facility. No leaks were apparent after 1 hour at 7400 psi.

In an attempt to reduce corrosion around the shaft of the pressure sensor, the top caps of these instruments were drilled and tapped to allow the fitting of a zinc anode.

All mating surfaces were coated with Tectyl 506 on reassembly

Thermistor loggers

The thermistor loggers required minimal mechanical overhaul.All external surfaces were examined for integrity of finish and mating surfaces and securing screws coated with tectyl 506.

Electronic overhaul:

RCM 7/8:

The solid state circuitry of these instruments requires little or no maintenance except for the checking of connections for security
ACMS pre ser no 10852, fitted with DSU 2990 ser no 2700 and above (EEPROMs) were returned to Aanderaa for gratuitous replacement to allow full battery life (7 years) at the beginning of the experiment.Units pre ser no 2700 with CMOS RAMS were fitted with new lithium cells in the laboratory.

All RCM7/8 instruments post ser no 10273 are equipped with the facility to reduce current consumption on sampling rates of 20 minutes and above. This reduces the sampling rate of current speed and direction by 50% and is effected by linking pins 21 and 22 on the electronics board. All deployed units Ser no 10273 and above were modified, reducing the sampling rate from 100 to 50 times each recording interval.

RCM 4/5 and Thermistor loggers

Careful examination of the recent performance histories of these instruments enabled a comprehensive overhaul schedule to be drawn up. All tape transport mechanisms ie. drive wires and pinch rollers were replaced as a matter of course and particular attention was paid to the encoder and rotary switch mechanisms which are known to cause problems particularly on long deployments.Three of the instruments, ACMs 2406 , 6372 and 8011 had been previously assessed as unserviceable subject to further investigation and required major component replacement and ACM 2109 which had flooded required a total rebuild from spare components.

Details of rework is contained in Annex 1

2. Current Meter Allocation

Ranges for fine temperature and conductivity were allocated IAW memo from S Alderson dated 28th April 1992.

Current meters were allocated to mooring positions within the constraints of the depth ratings of the instruments i.e RCM4/7 2000M RCM 7/8 6000M. The requirement for pressure and both standard and fine temperature on the instruments at the 300m depth dictated the use of RCM 4/5 instruments at these positions.

All the sensors used are standard Aanderaa sensors modified for "Special"ranges at IOSDL.

Details of current meter sensor allocations are shown in Appendix 2

2.i Special Range Temperatures.

IOSDL Marine Physics Group has fitted the special range temperature to Channel 4 which enhances the resolution and accuracy of the current meters for a given reduced range.

This is achieved by connecting terminals 4 and 14 on the electronic board and fitting selected high grade resistors between terminals 34 and 14b,34 and 15b.A Basic program has been written,S Watts RVS,1990 which is used to accurately determine the resistor values required for a specified range.Determination carried out by K M Goy 29-iv-1992.

Range deg.C	R 14b Ohms	R 15b Ohms	Fenwal Thermistor resistive range Ohms
+2 to +12	785	708	5240-3360
+2 to +10	633	546	5240-3660
+1 to +7	500	395	5480-4150
0 to +6	514	387	5740-4340
-0.5 to 2.5	266	184	5860-5070

Thermistors were fitted with +2 to +12 ranges to all channels.

The resistors used are Precision Metal Film with a resistance tolerance of +/- 15 ppm/degree C , ambient temperature range -55 to +155C ,power rating 0.125W. Careful selection of resistor values is carried out to obtain the best match to the theoretical values above.

The resistors are carefully soldered to the tags on the board and the range checked by substituting an accurate Vishay resistance box for the thermistor.The box resistance is varied to known thermistor resistances,corresponding to the desired range,establishing correct range selection and performance.

2.ii Conductivity Ranges

A salinity range of 34.1 to 34.5 , corresponding to a conductivity range of 30 to 40 mmhos cm -1 (P. Saunders) was suggested,S G Alderson internal memo 28-iv-1992,for the current meters at 600m depth position on each mooring.

The range and lower point are determined using the Aanderaa factory formulae ; i.e

Total conductivity range required 10 mmhos/cm

$$\text{Range mmhos/cm} = \frac{1000}{WR5 + 1000} \times 90.5$$

Where WR5 is a resistor between terminals 18 and 17 on the current meter electronic board,value in ohms.

Lower range point required 30 mmhos/cm

$$\text{Lower range point} = \frac{1000}{WR6} \times 90.5$$

Where WR6 is a resistor between terminals 14 and 17 on the current meter electronic board,value in ohms.

The resistors used are Precision Metal Film with a resistance tolerance of +/- 15 ppm/degree C ,ambient temperature range -55 to +155C ,power rating 0.125W.Careful selection of resistor values is carried out to obtain the best match to the theoretical values above.

The resistors are carefully soldered to the tags on the board and the range checked by placing a wire loop connected to an accurate Vishay resistance box through the conductivity cell.The box resistance is varied to simulate conductivity values,corresponding to the desired range,establishing correct range selection and performance.

The most suitable resistor values are WR5 = 8450 ohms WR6 = 3160 ohms

These give a Lower point = 29.93 ohms and a range of 10.01 ohms.

3. Current Meter Calibrations

All the sensors are calibrated at IOSDL by Marine Physics staff using established techniques and standards. A spreadsheet was developed to enhance presentation,archiving and data processing for 1992 and calibration sheets in this document are in this format.

3.1. Temperature Calibrations

IOSDL calibrates temperature sensors by immersing the current meter completely in a controlled,well stirred temperature bath and varying this bath through the expected temperature range.With the bath at a stable temperature the temperature is measured using an ASL Ac F25 precision digital thermometer.The current meter is externally triggered from a Printer 2860 and the current meter values noted.This technique simulates the instrument in the ocean and thus all components which may have an effect on calibration are subjected to temperature change.

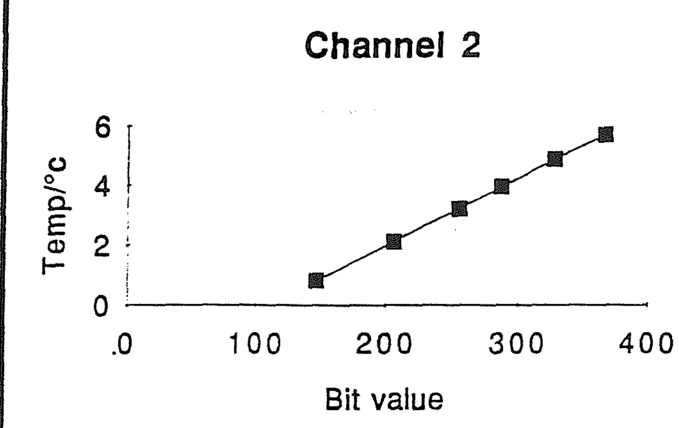
The calibration is controlled manually and progress is monitored as the temperature is changed,this has been found to be most effective in identifying defective units before an invalid calibration is produced. An example of a calibration is given below and a detailed calibration procedure and equipment set up is given in Annex 2 .

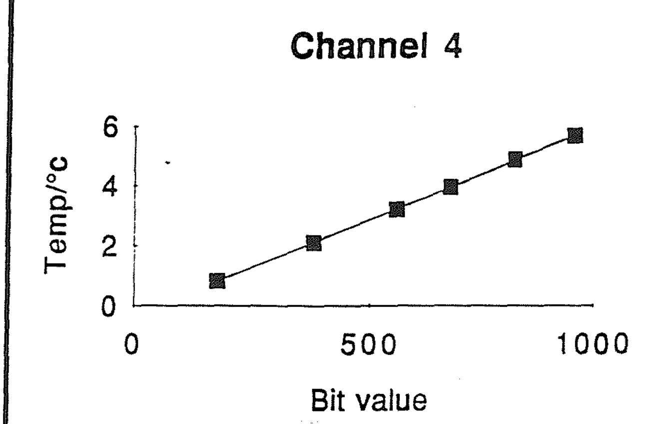
Date	Site	Range	Operator	Standard
Oct-92	IOSDL	0 to 6°c	GOY	F25

T/°c	T(cal)/°c	Channel 2	Channel 4	Calc. Ch.2	Ch.2 Error	Calc. Ch.4	Ch.4 Error
0.808	0.8068105	148	167	0.809	-0.002	0.809	-0.002
2.112	2.1097428	206	377	2.111	-0.001	2.106	0.004
3.210	3.2068678	255	556	3.211	-0.004	3.210	-0.004
3.946	3.9422935	287	674	3.930	0.013	3.939	0.004
4.856	4.8515971	328	822	4.850	0.001	4.852	-0.001
5.702	5.6969632	366	959	5.704	-0.007	5.698	-0.001

	Slope	Intercept
CHANNEL 2	2.245E-2	-2.51470
CHANNEL 4	6.173E-3	-0.22158

F25 Calibration Coefficients		
C	B	A
9.1E-06	9.99E-1	-5.12E-4



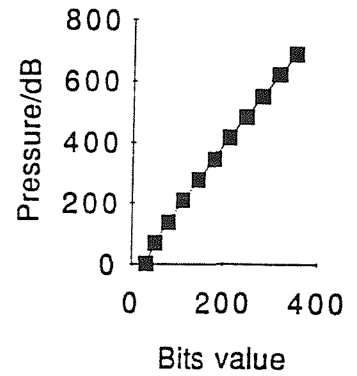


3.2 Pressure Calibrations

Pressure sensors are calibrated at IOSDL by Marine Physics Staff using a Budenberg 10543/280L Deadweight Tester.The tester is connected to the pressure transducer stem using an adaptor developed by IOSDL OIG workshops,R Peters 1992.Pressure is varied on the sensor from 0 psi,ambient air,through the expected pressure range with current meter output values monitored on a Printer 2860.Values are noted at stable pressure values both on increasing and decreasing pressure to establish the calibration and also to monitor any hysterisis of the sensor.

An example of a calibration is given below and a detailed calibration procedure and equipment set up is given in Annex 2 .

Date	Pressure		Reading	Calculated	Error
Oct-92	PSI	dBars	Bits	Pressure dB	dB
Site	0	0	31	27.179296	-27.1793
IOSDL	100	68.9708	51	68.953614	0.017186
Range/PSI	200	137.9416	79	127.43766	10.50394
0 to 3000	300	206.9124	111	194.27657	12.63583
Operator	400	275.8832	146	267.38163	8.501573
GOY	500	344.854	181	340.48668	4.367315
Standard	600	413.8248	214	409.41431	4.410489
BUD	700	482.7956	249	482.51937	0.276232
Sensor No	800	551.7664	283	553.53571	-1.76931
502	900	620.7372	318	626.64077	-5.90357
	1000	689.708	351	695.56839	-5.86039



Slope	Intercept
2.08872	-37.5709

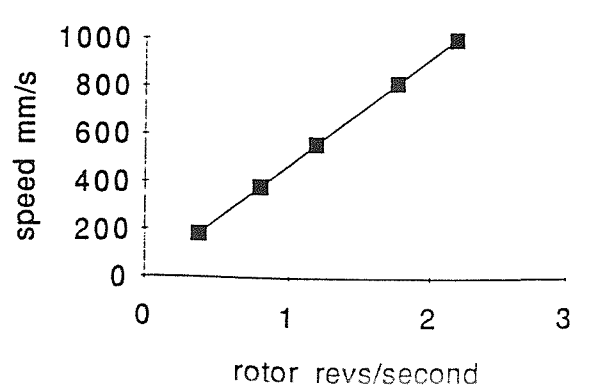
3.iii Rotor Calibration

Rotor calibrations are carried out in the IOSDL tow tank with the instruments being towed in water at at controlled speeds.The tow speed is accurately monitored and rotor response is determined at steady state tow speeds.Rotor revolutions are counted using a Hall effect diode mounted on the top cap of the current meters.Rotor threshold,the lowest tow speed at which the rotor responds,is determined.

Tow speeds for ADOX are from threshold,typically 12 to 20 mm/sec, up to 1000 mm/sec.

An example of a calibration is given below and a detailed calibration proceedure method is given in Annex

RCM 10854 Calibration Spreadsheet		
RCM No.	Mean rotor	Carriage
10854	revs/sec	speed mm/s
Date	0.3913	183.5
Oct-92	0.801289	378.7
Operator	1.184782	557.6
MOSS,GOY	1.7613	813.1
Threshold	2.182402	997.1
13.0	Slope	Intercept
mm/s	453.466	12.721

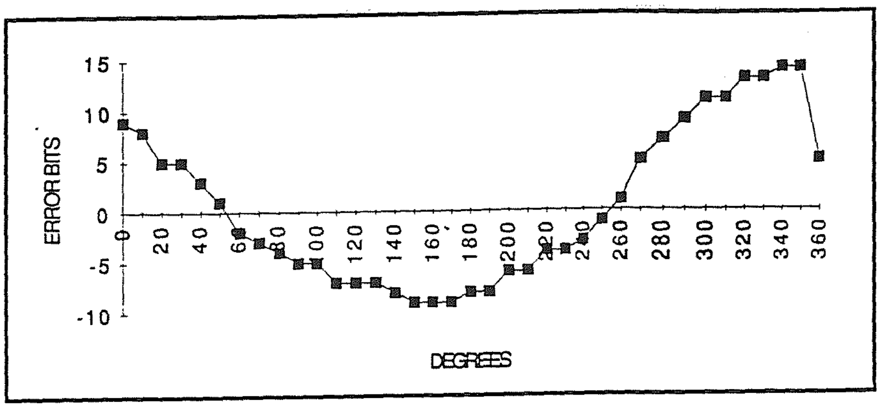


3.4. Compass Calibration

The RCM 7 and 8 current meters use fixed coefficients in the internal calibration formulas.At IOSDL the compasses are checked for errors from the theoretical values.Error offset is equalised about each side of the theoretical values by adjusting the compass position on the mounting plate.
The later series of current meters are fitted with a Rotor counter switch type 3240 which detects the rotor revolutions using a Hall effect sensor.This arrangement causes the compass to be offset dependent on the rotor position.

Calibration is carried out to minimise this effect

An example of a calibration is given below and a detailed calibration procedure is given in Annex 2

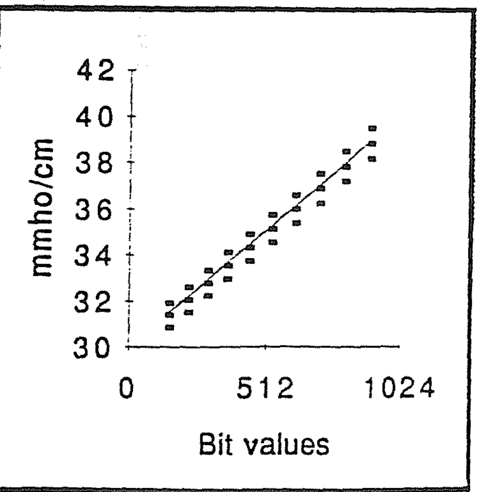


3.5. Conductivity calibration

IIt was considered that Conductivity calibrations to the accuracy required for this experiment could be satisfied using a Vishay resistor box with a single loop of wire through the conductivity cell to provide a resistive input.

An example of a calibration is given below and a detailed calibration procedure is given in Annex

Date	R / Ohms	bits	mmho	mmho/cm
Oct-92	74	1003	13.513514	39.86486
Site	76	895	13.157895	38.81579
IOSDL	78	795	12.820513	37.82051
Range	80	699	12.5	36.875
30 to 40	82	607	12.195122	35.97561
Operator	84	519	11.904762	35.11905
GOY	86	435	11.627907	34.30233
Standard	88	356	11.363636	33.52273
Vishay	90	283	11.111111	32.77778
Sensor No	92	211	10.869565	32.06522
4081	94	139	10.638298	31.38298
Slope	9.832E-3	30.0092	Intercept	



Cell factor = 2.95 ± 0.05 cm-1

4. Current Meter Testing and Preparation

The testing and preparation was carried out in three phases.

4.1.	Performance, timing and data quality tests	IOSDL
4.2.	Post shipping and battery tests	SFRI Capetown
4.3.	Pre deployment preparations	RRS Discovery

4.1. Performance, timing and data quality checks

The performance of the current meters was monitored throughout the calibration procedures.

The current meter's sampling interval is controlled by a Quartz crystal clock unit with a quoted accuracy of +-2 seconds a day over a temperature range of 0 to 20 C. Additionally the DSU fitted to the RCM7/8 contains a real time clock which time stamps the data with the time of switch on and subsequently every 24 hours at the first measurement after midnight.

The current meters, fitted with the deployment battery pack, are set up in the laboratory to sample at the deployment interval. The DSUs (RCM 7/8) and the magnetic tapes are erased and the DSU clock reset.and RAM banks checked . The current meters are then started at an accurately known time and left to run for several days on the bench with rotors turning.

On completion of the test the end time and last data cycle time are recorded as the current meters are switched off.

The DSUs and magnetic tapes are then removed and downloaded to a PC using the Aanderaa program,P3059.The data is then analysed for timing accuracy, correct current meter operation and data quality.

On completion of the tests the DSUs and magnetic tapes are erased of all test data and the main battery disconnected.

All pressure cases were purged with zero grade nitrogen prior to shipping.

All instruments were shipped in Aanderaa transit cases.

4.2. Post shipping and battery tests

All instruments were checked for damage following shipment. This included the check tightening of all terminal screws and examination of encoder mechanisms, rotary switches,rotor bearings and follower magnets.ACM 5205 was found to have an open circuit thermistor which was replaced and subsequently recalibrated on board RRS Discovery using ACM 6225 as a calibration standard.

Battery voltages and quiescent and max voltages were measured and confirmed to be.

lithium cells RCM7/8 > 8.9v	quiescent - <7 mA	max	<80mA
leclanche RCM 4/5 > 9.8v	quiscent <80uA	max	<80mA

4.3. Predeployment preparation

The requirement for two year deployment necessitated that all instruments be set to a sampling interval of at least 120 mins in order that the data capacity is not exceeded (10000 records RCM 4/5 and T.L - 10900 records RCM7/8) and the batteries not prematurely exhausted.

RCM 7/8s were set to 120 mins giving a max deployment time of 832 days

RCM 4/5 were set to 180 mins giving a max deployment time of 1250 days

Thermistor loggers were set to 180 mins giving a max deployment time of 775 days (The Thermistor logger records 12 channels of data each recording interval, using data capacity at twice the rate of the current meters which only record 6.Extended recording tapes giving approx 25% more data capacity were fitted to the thermistor loggers to achieve the deployment duration.)

The selected recording interval and rotor revolutions per count determine the max current velocity which can be measured with the RCM 4/5 and is determined by the formula

1023 x 42 x revs/count / sampling interval (secs) = max speed (cm/s)

The rotor revolution per count was selected to 32 giving a max speed of 127 cm/s

Rotor counters were spun 33 revolutions and instruments checked for correct bit output on channel 6.

The RCM 7/8 samples rotor revolutions and compass direction 50 times during the 120 min sample interval.The data is combined to represent a current vector,the magnitude derived from rotor revolutions and direction from the compass reading.The current vector is resolved into East-West and North-South Components which are successively added and stored.At the end of the sample period the resulting average vector and its angle are calculated internally and stored to the DSU.

DSU clocks were reset to Discovery GMT

All instruments were rechecked for data recording and quality and all magnetic tapes and DSUs erased.and refitted.

The watertight receptacles were removed and replaced by sealing plugs on completion of all tests.

The RCM 7/8 records the first data cycle on switch on, the RCM4/5 and thermistor loggers, however , record their first data cycle 1 sampling period after switch on. Instruments were switched on and 1st data times noted.Because of the different sampling intervals and 1st data regimes of the RCM4/5 and RCM7/8 the switch on times were staggered to achieve the max no of simultaneous records for the two types of instrument.

Instruments were monitored over a period of 24 hrs ensuring that the DSUs incremented correctly and tapes wound on at the correct timing intervals.

All the O ring seals and faces were checked and greased using clean Vaseline and the pressure cases purged with zero grade nitrogen before the instruments were cased up.

SWINDEX Technical File

4.Acoustic Releases

D.White,I.Waddington

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4.1 Acoustic Release Mooring specifications.

The moorings being drawn as sketch outlines with in line tensions being ascertained,the acoustic release specifications could be drawn up and existing equipment best fitted to the application.
Acoutic Release overall requirement.
Eight moorings depths from 1500m to 5500m.
Load in position,400kg to 750kg through assembly.
Dual release operation.
Secure acoustic coding.
Duration 2 years.
Temperature -1C to 20C(in position and in laboratory)

Acoustic release units required.

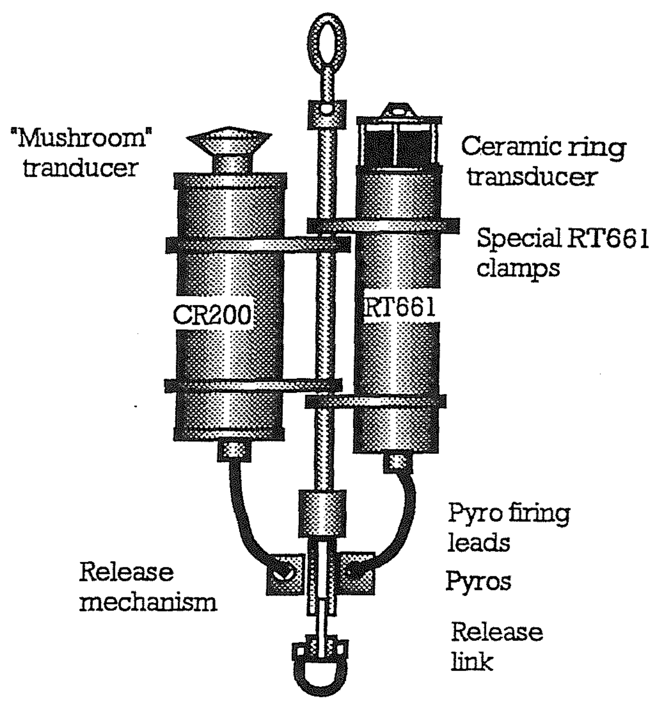
The CR200s fulfilled the above requirements,however stocks held at IOSDL could not meet the quantity required.
With the CR200 range approaching obsolescence commercial alternatives were considered.A comparative exercise was carried out on all known reliable manufacturers products with the accent on long term deep ocean expertise and compatability with existing UK users.This exercise was carried out by OIG and MP staff.
MORS RT661s did meet the above specification but required specific functions to be built in to meet the IOSDL/NERC compatability requirement and modification to fire a pyro when paired with an IOSDL CR200 unit.
These units were a new design both mechanically and electronically. In order to enhance recovery the units were to be paired with IOSDL CR200 units.
Brackets to adapt the MORS units to clamp onto the CR200 load bar were designed at IOSDL.

Mechanical Configuration.
Each acoustic release unit was made up of a CR200 and an RT661.
The RT661 was clamped to the titanium CR200 load bar, and configured to fire a single pyro on the release command; the CR200 firing another pyro.
The RT661 units were assembled as several variants.Three in the MORS ferallium cases,and six in IOSDL hard anodised aluminium pressure cases.

Transducer Configuration.
The MORS cased units used the manufacturers supplied Ceramic rings.One unit had the lifting lug removed above the transducer to investigate any possible acoustic interference.The six units in the IOSDL cases using Marine Acoustics ceramic ring transducers.

RT661 battery packs.
The units were all powered by six packs of three cells of Lithium Thionyl chloride D cells,with an IOSDL 15V Lithium Manganese dioxide pinger battery configured as a pyro release firing pack.

Fig 4.1 Mechanical arrangement of dual acoustic release.



Deployment and Ranging
Subsequent to each deployment a number of ranging and equipment trials were carried out to determine the depths and slant ranges at which the RT661 units could be commanded and at what range the pinger could be heard.This is discussed in detail in IOSDL Internal Report No. 325 .Acostic trials of the MORS RT661 and TT301 . D White 1993 .

All the acoustics units deployed could operate in the pinger mode,IOSDL units at various determined precision repetition rates and RT661 units at 2 second precision rates.
Thus all the units could be observed on a suitable system and displayed on a facsimile or IOSDL waterfall display.

SWINDEX Technical File

5.Equipment Freight

R.N.Bonner

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5.1 . U.K.Loading

Equipment was shipped to Discovery primarily in 20 foot I.S.O. containers with the opportunity taken to load some items to RRS Discovery before its departure from the UK in August 1992 . The reasons for this were to save on freighting costs and avoid the complications of shipping dangerous goods , gases etc , commercially . In all 11 tonnes of equipment were loaded to the Discovery , thus saving shipping costs of two containers later in the programme .

The dangerous goods , nitrogen gas and lithium batteries , were loaded to the Discovery as IMO regulations make it illegal to freight different classes of goods in the same container , and this would have meant seperate shipments for each class .

5.2 . ADOX

The ADOX experiment was to utilise common equipment with SWINDEX and in December 1992 the first of the container shipments to Cape Town was loaded at IOSDL into an open top ISO unit .This unit carried 7.5 tonnes of winches and deck equipment plus the IOSDL mooring hardware for ADOX . Fragile items for the cruise were shipped to MAFF Lowestoft for loading into a dry freight container . Both containers were shipped by the Medite Shipping Company , operating a twice weekly service from Felixtowe to South Africa , arriving in Cape Town on the 18th of January .

Discovery docked in Capetown on the 1st of February and mobilisation for ADOX commenced the following day on delivery of the containers by road .

SWINDEX

The shipment comprised one dry freight container and two open top units loaded at IOSDL during the first week of February 1993 . The open top units containing mooring hardware and 12 tonnes of anchor chain .The dry freight unit containing current meters , acoustic releases and electronics .

There was concern about heat and vibration affecting the current meters during the transit to Cape Town and thus the shipment was made two weeks earlier than planned , in order that pre-cruise checks could be carried out before Discovery sailed . The current meters were transferred from the freight container such that checks could be carried out at the Sea Fisheries Research Institute of Cape Town by K Goy and M Hartman .

Prior arrangements had been made through the ships agent for customs clearance of the current meters but a delay of four days was incurred through the customs bureaucracy .

Discovery docked one day early from ADOX and equipment to be returned was unloaded the same day into a container , giving an extra day for the SWINDEX loading .

The two open top containers were delivered alongside Discovery and unloading by shoreside crane to the ship was completed by 1400h . One dry freight container being loaded to the upper slot of the ship .
However , the dry freight unit could not be located by the agent having been mistakenly returned to the container terminal after unloading the current meters . Once traced the container was delivered late in the afternoon and unloading was completed that day .

5.3 . Return Shipment

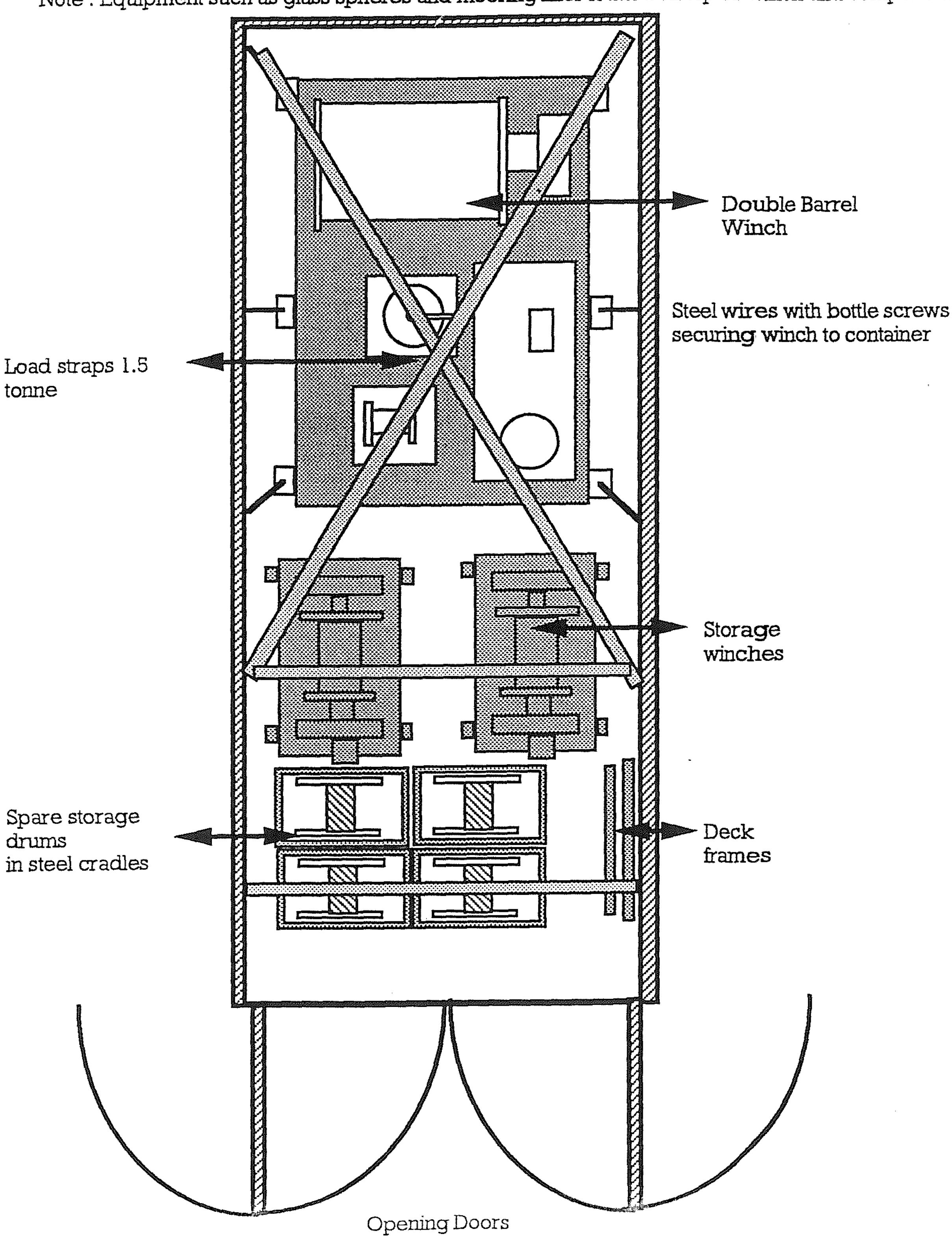
SWINDEX was the last of three consecutive WOCE cruises and ended in Cape Town on the 3rd of May 1993 . The dry freight container was lifted to the after deck by ships crane and loaded .Overnight the ship moved berth and with two open top containers on trailers on the quay the mooring deck equipment and remaining hardware was loaded by shore crane to the containers . Mooring team members supervising stevedores in loading .

5.4 . Weights and loading

August 1992	Discovery loaded at RVS Barry	11 tonnes
December 1993	Containers loaded at IOSDL and MAFF	8.5 tonnes
February 1993	Containers loaded at IOSDL	22.5 tonnes
May 1993	Return freight from Cape Town	22.5 tonnes

Fig 5.1 Mooring winch located in 20 foot ISO container . Plan view .

Note : Equipment such as glass spheres and mooring lines loaded on top of winch and components



SWINDEX Technical File

6.Operational details for Ships officers

I.Waddington

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6.1 Operational details.

A document was produced to present the operational details relevant to ships officers outlining the proceedures and overall mooring arrays for both the ADOX and SWINDEX cruises,Discovery 200-ADOX,Discovery 201-SWINDEX.
This document was prepared to provide a "picture"of the moorings and to outline the requirements for ships personnel and vessel manouvering during the operations.

ADOX/SWINDEX Deployment Methods

Mooring Arrays.
There are to be three arrays of moorings deployed;
1.Crozet-Kerguelen Array.Discovery cruise 200.MAFF.ADOX.
2.Princess Elisabeth Trough.Discovery cruise 200.MAFF.ADOX.
3.SWINDEX Array Discovery cruise 201.JRC.

Mooring Types.
The moorings are of two types;
1.Full depth moorings extending to near surface.All eight SWINDEX with two ADOX moorings of this type.
2.Deepwater moorings rising to midwater depths.All but two ADOX moorings.Crozet-Kerguelen Array-8 off.Princess Elisabeth Trough-6 off.
fig 1.SWINDEX Array.
fig 2.ADOX Kerguelen-Crozet Array.
fig 3.Princess Elisabeth Trough Array.
fig 4.Typical Full depth Mooring.
fig 5.Typical MAFF mooring.
All the moorings are to be deployed Buoy first-Anchor last.This is a requirement for the Full depth Moorings as the anchors exceed safe working conditions on the mooring lines for deployment anchor first.
Line measuring of the synthetic fibre will be required prior to deployment of the Full depth Moorings.
Line measuring.
The fibre lines for the full depth moorings will need to be stretched under load to establish the correct lengths for the moorings in position.The subsurface buoy is designed to be between 300 and 200m from the sea surface which is approximately 6% of the water depth.We should expect stretch of the lines in the region of 8% on initial loading.It is therefore essential that we simulate the line loadings overside and accurately measure the mooring lines under load.

The Deepwater moorings will not require measuring as positioning is not so critical and line loadings are much reduced giving less stretch.

For the ADOX Full Depth moorings I would propose to stretch all the synthetic fibre mooring lines under load and measure the line lengths on deployment and on recovery.This will establish the line length under deployed conditions and test the lines/splices.The steel wire does not require measuring as this has been accurately established at IOSDL.

For the SWINDEX Full depth moorings I would propose to stretch a representative quantity of lines to establish the stretch compared to the accurately measured unstretched lengths prepared at IOSDL.An allowance has already been made,when prepared at IOSDL,to permit 8% stretch of the lines to the correct length required.
Line measuring technique.
The line should be deployed overside with a weight suitable to simulate the line loading. This operation can take place in any suitable water depth with the vessel hove to.The line will be deployed over the stern using a suitable wide throat block suspended to clear the stern of the vessel.
For this we will use the IOSDL Double Barrel Capstan,DBC,to pay out and recover the lines.The lines should be deployed through the barrels connected as required for the mooring deployment ie.Buoy first lines to go overside first.The line to be measured using the DBC measuring sheave,accuracy 0.5%,on deployment and on recovery.The line when recovered should then be flaked into a steel cage ready for deployment and any adjustment for line stretch/topography can then be made during deployment.

Fig 1.SWINDEX Array

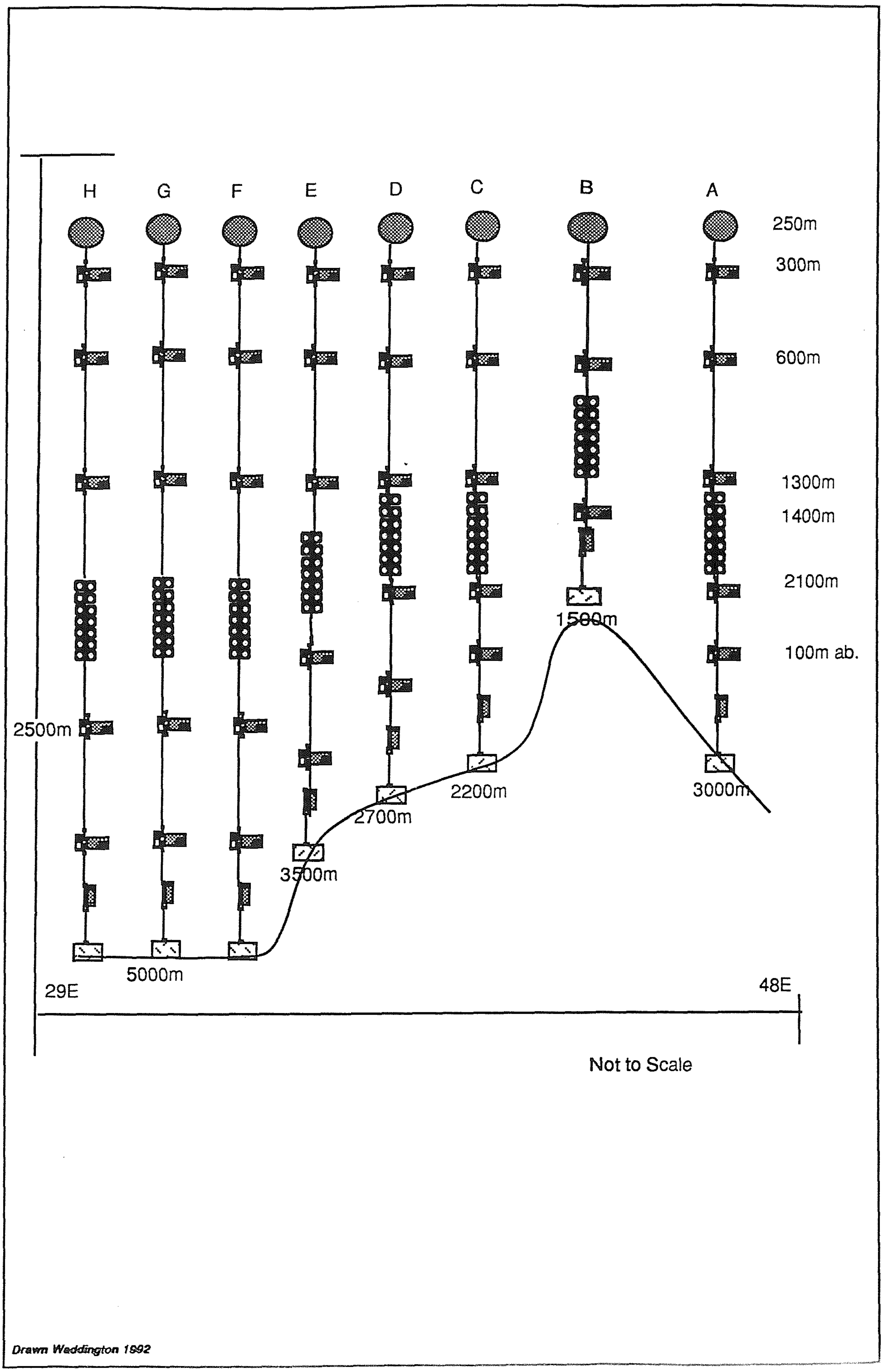


Fig 2.Kerguelen-Crozet Array.

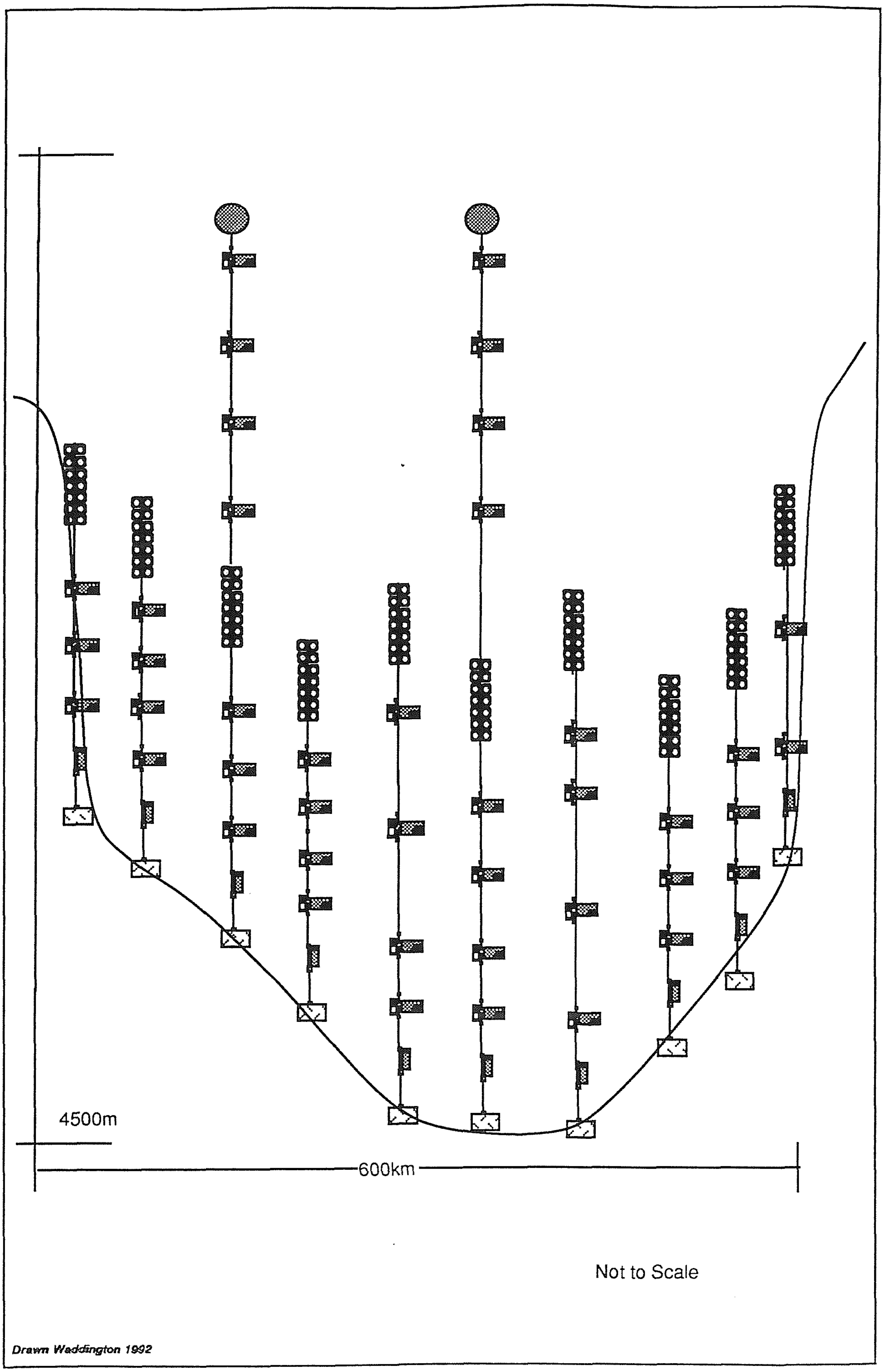


Fig 3.Princess Elisabeth Trough Array

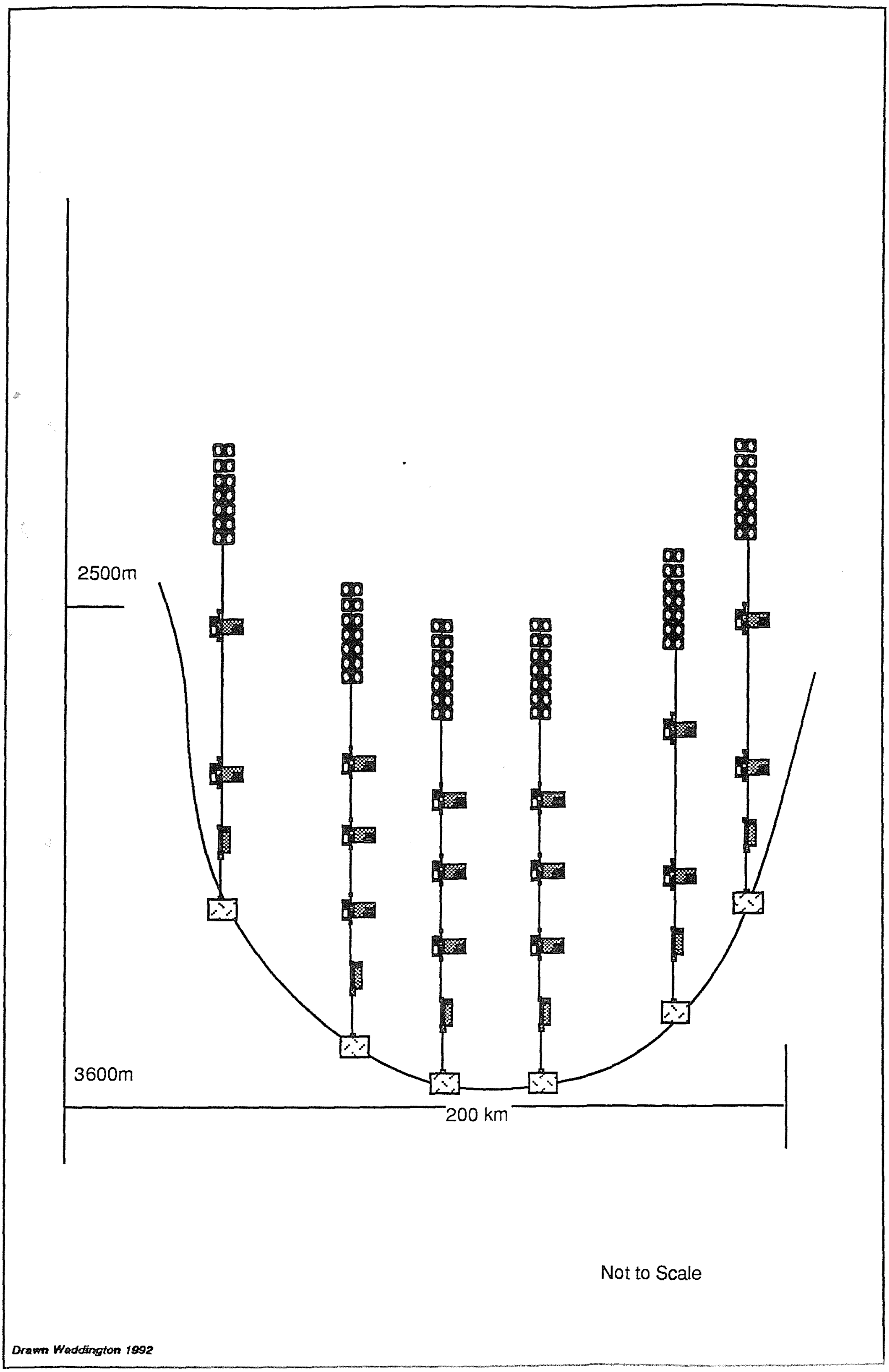


Fig 4.Typical Full Depth Mooring

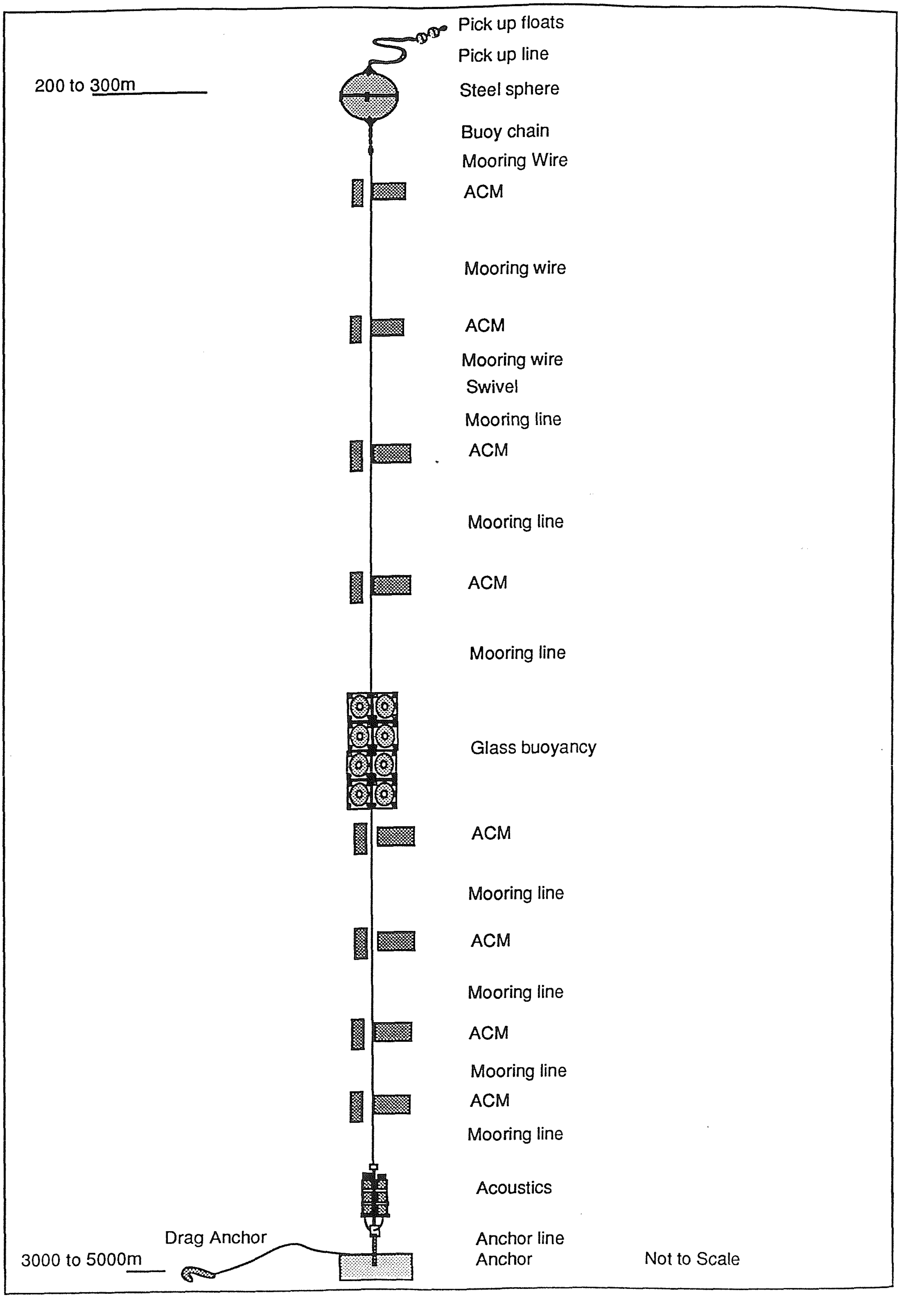
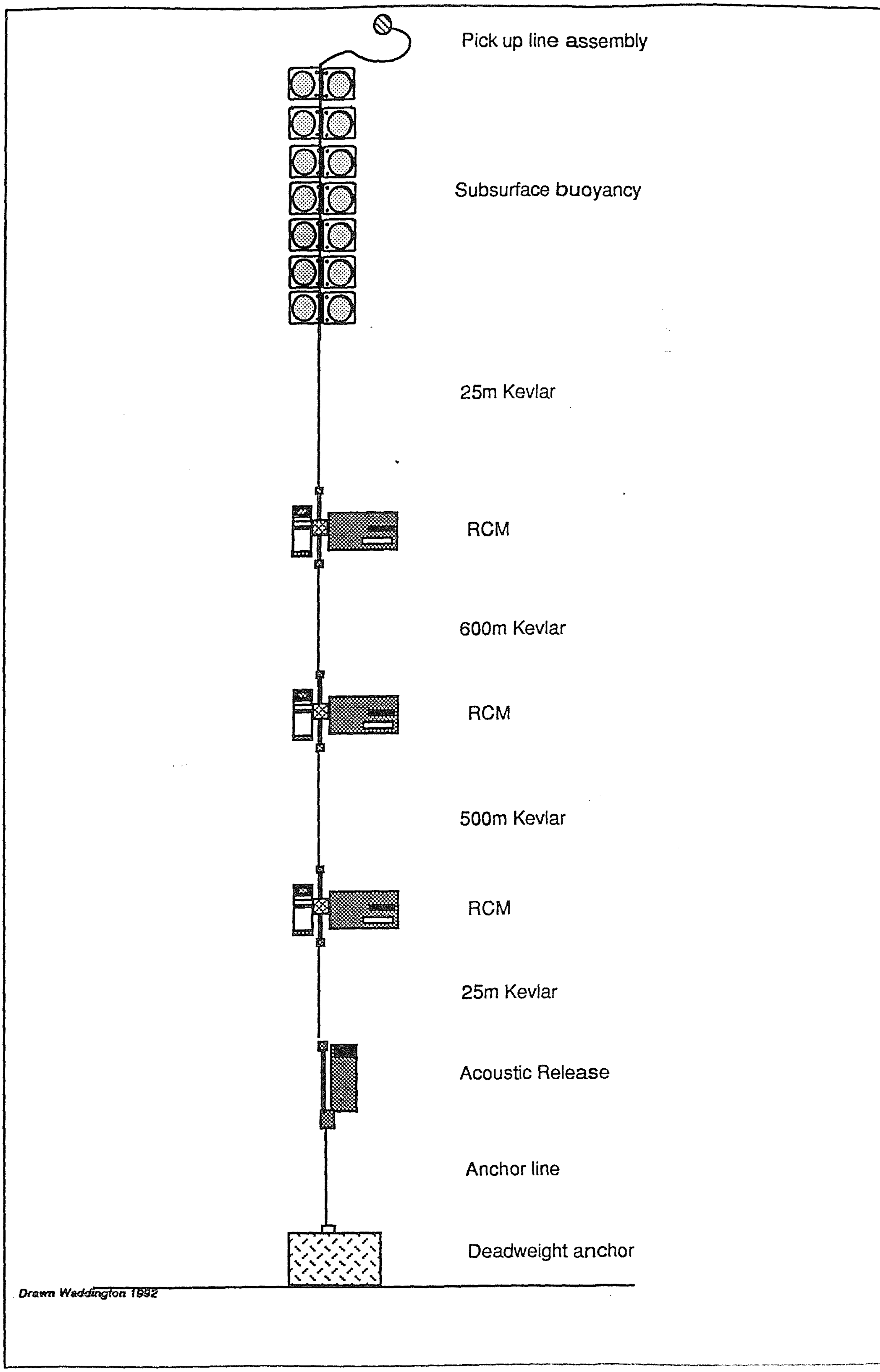


Fig 5.Typical MAFF Mooring



6.2 Mooring Pre deployment Preparation.

I will assume that surveying in the site is now a routine part of all mooring operations and will take place along recognised lines,depth sounding and plotting contours to define the topography and geographical location.This operation is normally coordinated between scientific and ships personnel.

1.Synthetic Lines.

The mooring synthetic line having been stretched,measured and stored for deployment should then be ready to deploy subject to adjustment for topography.Line lengths should have been brought to the deck to accomodate line adjustment at short notice during the deployment.These should be stowed securely adjacent to the working area.

2.Steel wire Lines.

The steel wire lines have to be wound onto the DBC storage drums preconnected with all fittings in the correct order and position.The wires are wound on from wooden drums through the DBC which acts to tension the wires onto the storage drum.It is essential that the wires are tensioned on evenly and that all joints are protected by parcelling with strurdy canvass.This prevents damage to the polypropylene jacket of the wire when paying out the line.

3.Shackles and links.

IOSDL normally greases the shackle pins prior to use,this makes the pins easier to unscrew during deployment and acts to protect the threads when deployed.
Shackles which are not required to be unscrewed during the mooring operation are tightened and seized.
Adequate supplies of greased shackles and links are prepared in a deck box for use during the mooring.This box is secured close to the working area and usually also contains hand tools.

4.Steel Buoy assemblies.

The steel buoys are prepared with recovery lines and floats attached.A loop is tied in the line such that with the buoy in the water the deployment hook can be reached and released by hand.
The swivel and chain assembly is attached and all shackles seized.
The buoy in its stand is placed near the stern just prior to deployment.

5.Glass sphere assemblies.

The glass spheres are assembled as required to form modules of buoyancy for the mooring.These are prepared with all shackles and links attached ready for deployment.The sphere assemblies if used as primary buoyancy are secured near to the stern , or if as secondary , back up , buoyancy then adjacent to the working area.Cargo nets can be used to hold the buoyancy assemblies securely on deck .

6.Anchor.

The anchors consist of clumps of scrap anchor chain bound together with chains or wires.All shackles are seized on deck prior to deployment.Immediately before deployment commences the anchor is secured over one quarter with a strong cut off line,normally 22mm Polypropylene,the anchor riser chain is then led back onboard to the main working area and secured clear of deployment operations.

7.Instruments.

Dependent on weather conditions the instruments are either prepared in the lab area and strored ready for bringing out when required or brought out ready prepared and secured on deck.Extreme cold can affect instruments and it may be wise to bring the instruments out when the operation requires them to be attached,thus minimising chilling.Similarily in bad weather instruments can be damaged by waves on deck.
Acoustic releases using pyro devices are best brought onto the working deck as required.Arming of these devices is at the discretion of the expert in charge of them.In good weather this is done outside on the working deck,if the weather is bad a suitable safe area must be defined.
All instruments should be handled carefully with respect to personnel lifting.Acoustics units are particularily heavy.

8.Wire testing Acoustics.

All the acoustic units will be required to be wire tested to near the deployment depth prior to deployment.This will be defined by the acoustics expert in charge.Wire tests can be conducted on the CTD frame during dips.There will be a requirement to hold the CTD at depth for these tests.

9.Personnel.

Adequate personnel should be allocated to the operation to cover all the functions required.Provision should be made to provide relief personnel if the operation is to require persons on deck for long periods.

All personnel should be familiar with the overall operation and must be aware of potential hazards.

Experienced personnel should be the only persons operating machinery and close to overside operations.

Training will be given as required.

Signals controlling cranes and winches will be to standard or previously agreed clear types.

Persons signalling will have been previously nominated and made known to the machinery operators.

Persons not involved with the operation will not be on the working deck.Photography and video will be previously agreed.

Personnel required for a full depth mooring.

On working deck.

Ships side.

Officer overseeing and bridge communication.

Bosun or experienced crewman.Overside operations.

Crewman operating storage winch and controlling pay out of mooring line.

Crewman operating crane.

Scientific side.

Overside control.	1 Scientist in charge of signals and monitorring lengths and instruments.
Instrument attachment.	1 Scientist in charge of attaching instruments,signals.
Instrument movement	1or 2 persons to move instruments from lab spaces to working deck.
IOSDL DBC.	1 person with standby man to control winch.

6.3 Deployment.

With the site having been surveyed in.The vessel will proceed to a position down wind of the proposed site a distance in excess of the mooring length and with respect to the vessels deployment speed.Steerage needing to be maintained to control the line deployment.
The vessel would then heave to whilst final preparations are made;
1.Positioning anchor chain.
2.Positioning buoyancy.
3.Connecting all relevant mooring lines through machinery.
4.Connect top instrument into lines.

With the vessel starting to make way the main buoyancy is deployed overside with a release hook or similar attached to the recovery line.
The buoyancy is then disconnected and floats clear of the stern.The upper instrument is preconnected in the mooring line and positioned to be deployed overside as the buoyancy moves astern.
The Full depth moorings use a steel wire between the buoyancy and the top instrument which must be held along the deck in a loop.Such that as the buoy goes astern this loop is walked over the deck to prevent the wire forming kinks and becoming damaged.

As the tension comes on the mooring line the instrument is lowered clear overside and the mooring line veered from the winch.

The crane is positioned to best suit deployment of the wire through the sheave and over the stern.
As the next instrument joint is coming off the storage drum the crane is adjusted to position the joint for stopping off on the deck chain.

The joint is connected to the deck chain as it passes and the tension of the towing mooring is transferred from the winch to the deck chain.

The joint can then be disconnected for instrument insertion.

The crane is adjusted as mooring line is paid out such that with the instrument connected,the winch hauls on the mooring and takes the tension.
The deck chain is then released and the instrument lifted by winch and crane such that it can be safely deployed over the stern.

This proceedure is repeated for all subsequent instruments and buoyancy packages.

With the mooring deployed to the acoustic release the anchor must be attached into the line.
For the comparatively light loads of the ADOX Deep water moorings this can readily be achieved by slowing the ship and as the tension comes off,the anchor tail can be transferred to the release by hand.The release is then deployed outboard as the ship increases speed to tow the line out.

For the deep moorings the release is some way above the anchor and can be fully deployed with the mooring anchor line secured to the deck chain by a cut off line.
The anchor riser chain is then connected to the mooring anchor line and as anchor release is approached the cut off is freed on the deck chain,permitting all line tension to be transferred to the anchor cut off line.

When on mooring position the anchor cut off line is cut and the anchor falls clear of the ship.
For moorings with drag anchors,the drag anchor must be deployed overside just before anchor release.The ships way then streams the anchor clear of the falling clump.

As the anchor is released the ship heaves to.It may be possible to visually observe buoyancy approaching the ship and submerging.

The acoustic release is then monitorred as the mooring descends.If possible time on bottom is determined and height of release off bottom.The acoustics are then reset for the deployment period.

Fig 8. Double barrel Mooring Capstan

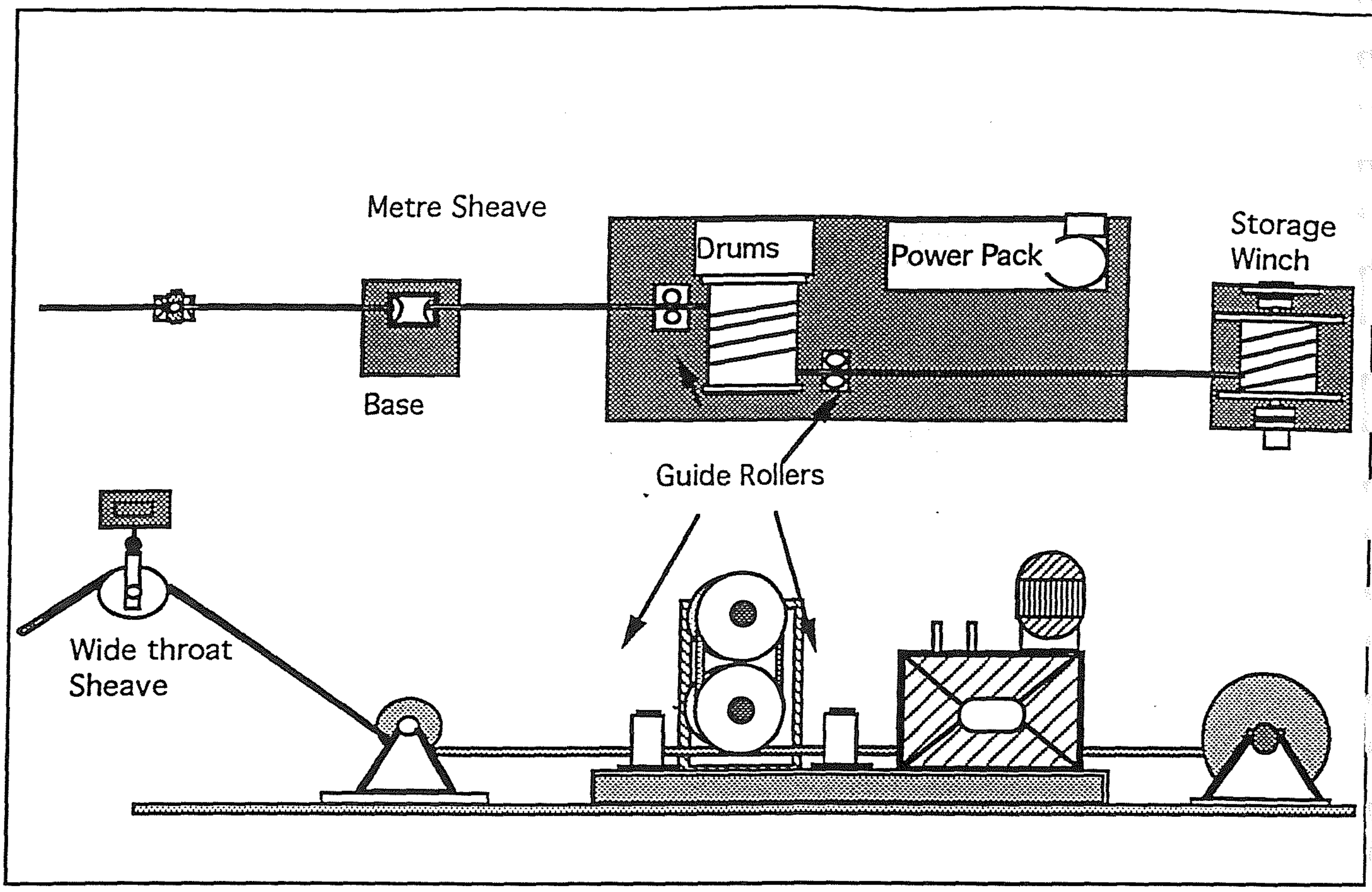
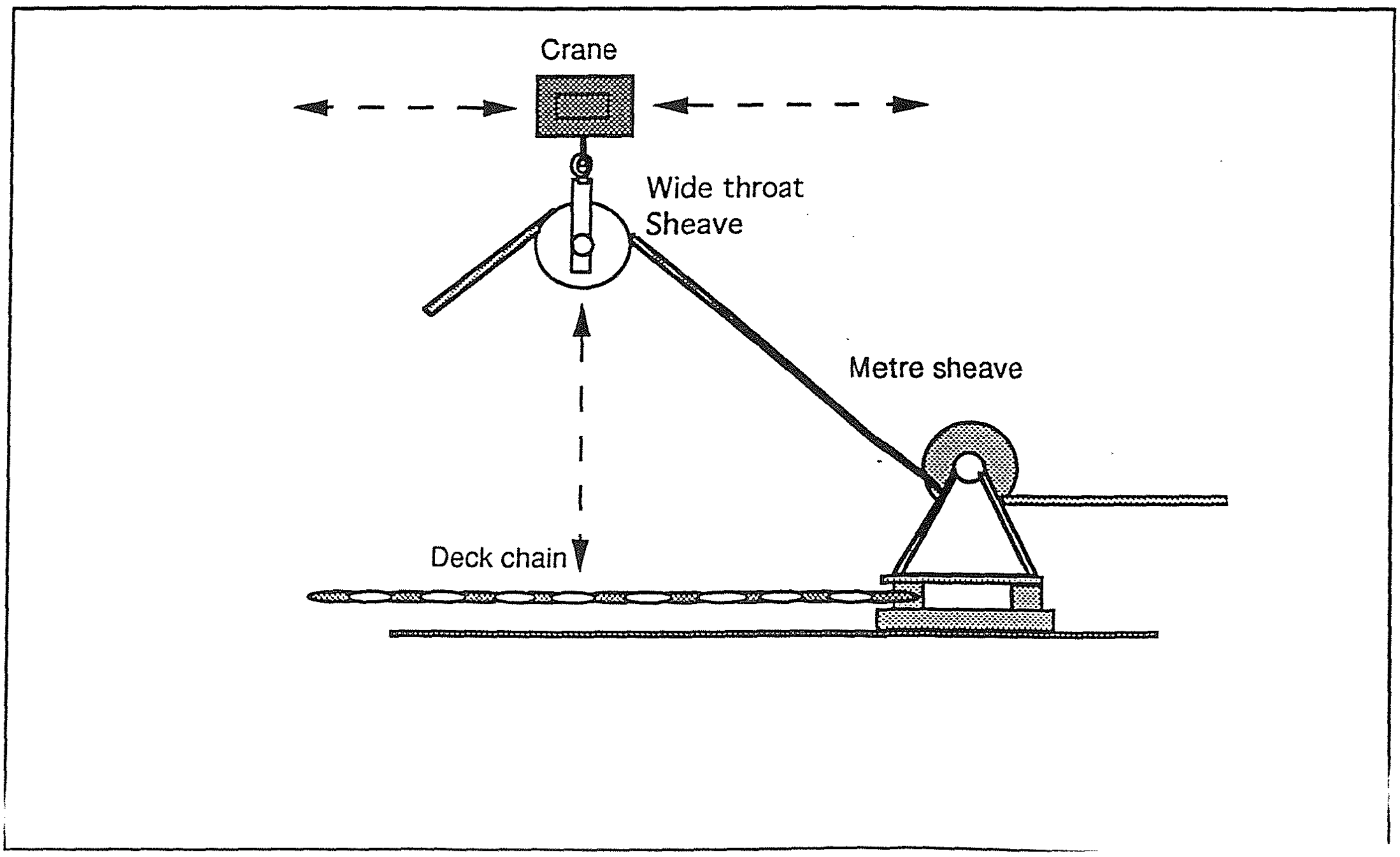


Fig 9 Deck chain and Crane



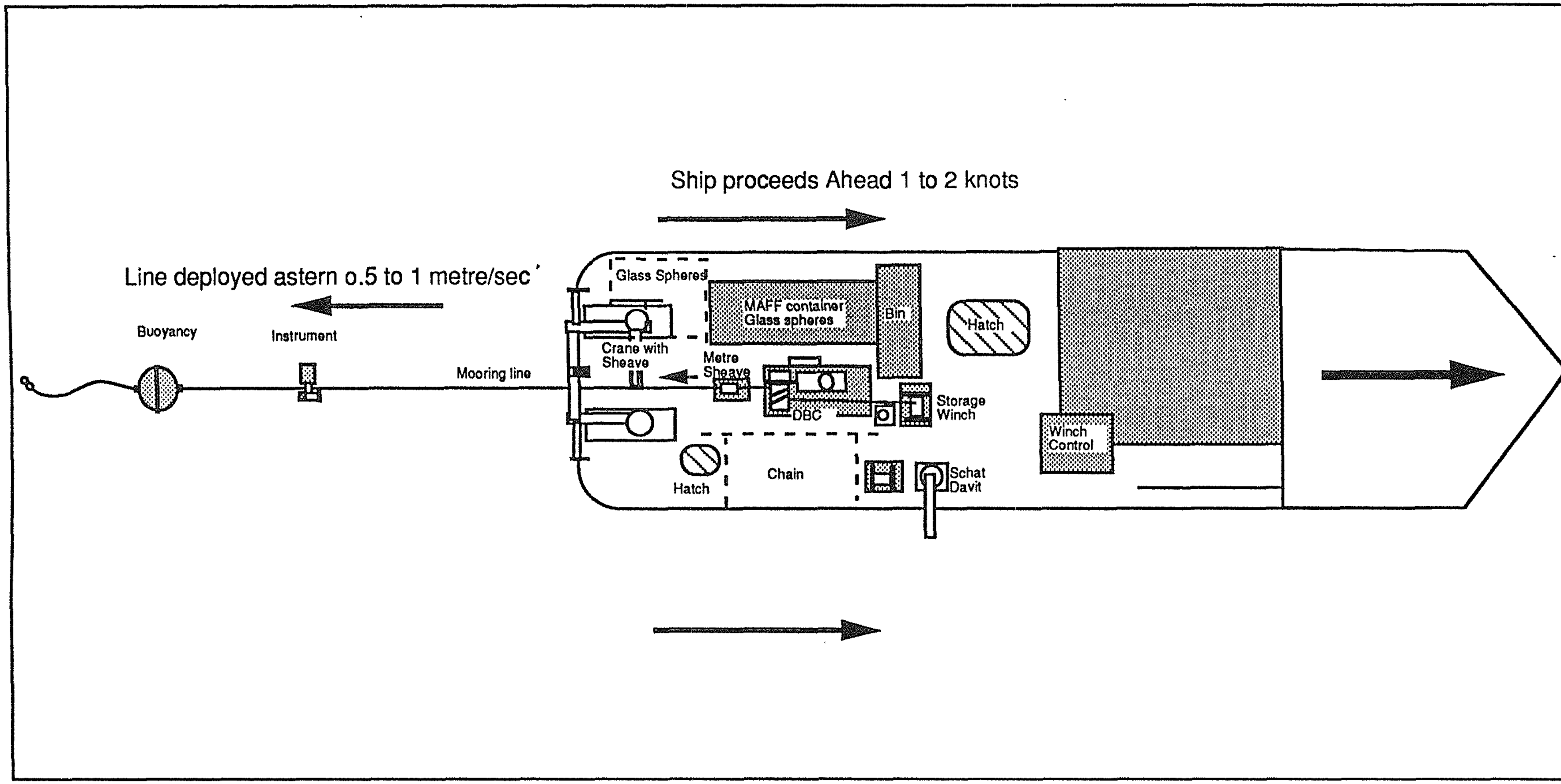


Fig 10. Buoy First Deployment

SWINDEX Technical file

7.Onboard Operations.

M.Hartman,I.Waddington,D.White

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7.1 Overside Operations as carried out.

Rope stretching.

As opportunitities were presented in the programme,rope stretching was carried out.Lines were selected for stretching with reference to the mooring next to be deployed.A surplus of lines stretched was built up throughout the programme such that stretched lines were usually prepared well before they were required.

Lines were wound onto the DBC storage drums with a maximum capacity of 2000 metres per drum.Where the opportunity presented itself two drums could be preloaded and stretched in sequence using the two storage winches.

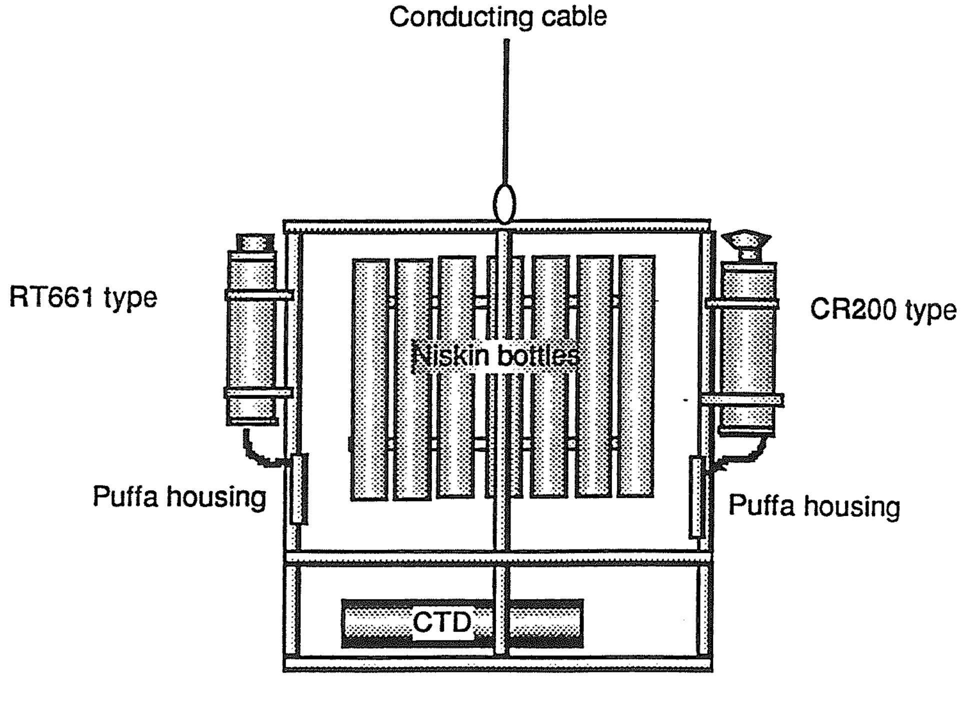
Some problems were encountered with the plastic thimbles being damaged when passing over the mooring sheave.This was minimised by carefully guiding on the fittings and positioning the sheave to reduce the wrap around required as the line was deployed.Damaged thimbles were replaced with heavy duty galvanised steel thimbles carried as spares to cover this eventuality.

Stretch was determined at 13% and was consistent throughout the 10mm Polyester lines.The line lengths prepared at IOSDL were consistent throughout.It could have been possible to stretch a sample quantity of lengths and apply a stretch figure for all the lines.But as the opportunity to stretch all the lines was available it was felt that for accuracy in positioning stretching every line was preferable.

Acoustic Release Testing

All the acoustic releases were tested in the water to operating depth to determine correct operation.The units were tested in conjunction with CTD dips with the units clamped to the CTD/Rosette framework with IOSDL designed clamps.

fig. Acoustic Release units mounted on Rosette frame.



7.2 Mooring Design Refinement.

Mooring Redesign.

During the cruise mooring geograpical positions were adjusted. Depths changed and necessitated redesign of some moorings.The revised mooring layouts were run on the Moor Design Program to check dynamic performance and optimum positioning of the buoyancy in the mooring.This was done as the mooring site survey was concluded,if a significant change to the original design was to be implemented.With small changes the design was rerun at the earliest opportunity to clarify the design.

Mooring Line adjustment.

With determination of stretched lengths,the true lengths of the mooring lines could be inserted into the designs.Some lines when stretched were overlength and adjustments to correct were made by substituting several shorter adjusting lengths to best position the instrumentation. Fine adjustments could be made at the lower end of the mooring as the mooring was being deployed , by using a selection of adjusting lengths.

Additional Instrumentation.

Limited additional instrumentation was available onboard.For mooring A the one spare current meter was inserted into the design to improve the sensor spread across a particular depth range.This was achieved by utilising spare wires,carried in the event of damage on deployment,and adjusting the buoyancy to compensate for the additional instrument. The revised design was rerun on the Moor Design Program before deployment.

7.3 Mooring Design Practical Deployment

The deployment procedure was as outlined in Section 6.The major change was that on testing the port side crane in Cape Town the main telescopic jib failed rendering the crane inoperable throughout the cruise.The starboard crane was thus the only unit available and had to be tested with full working loads simulated.Using this crane necessitated a much longer jib length than proposed,as the crane had to reach across the deck from starboard to port.This proved suitable in practise and in fact required less operator manipulations of the controls.Care had to be taken to minimise side loading on the slew mechanism.

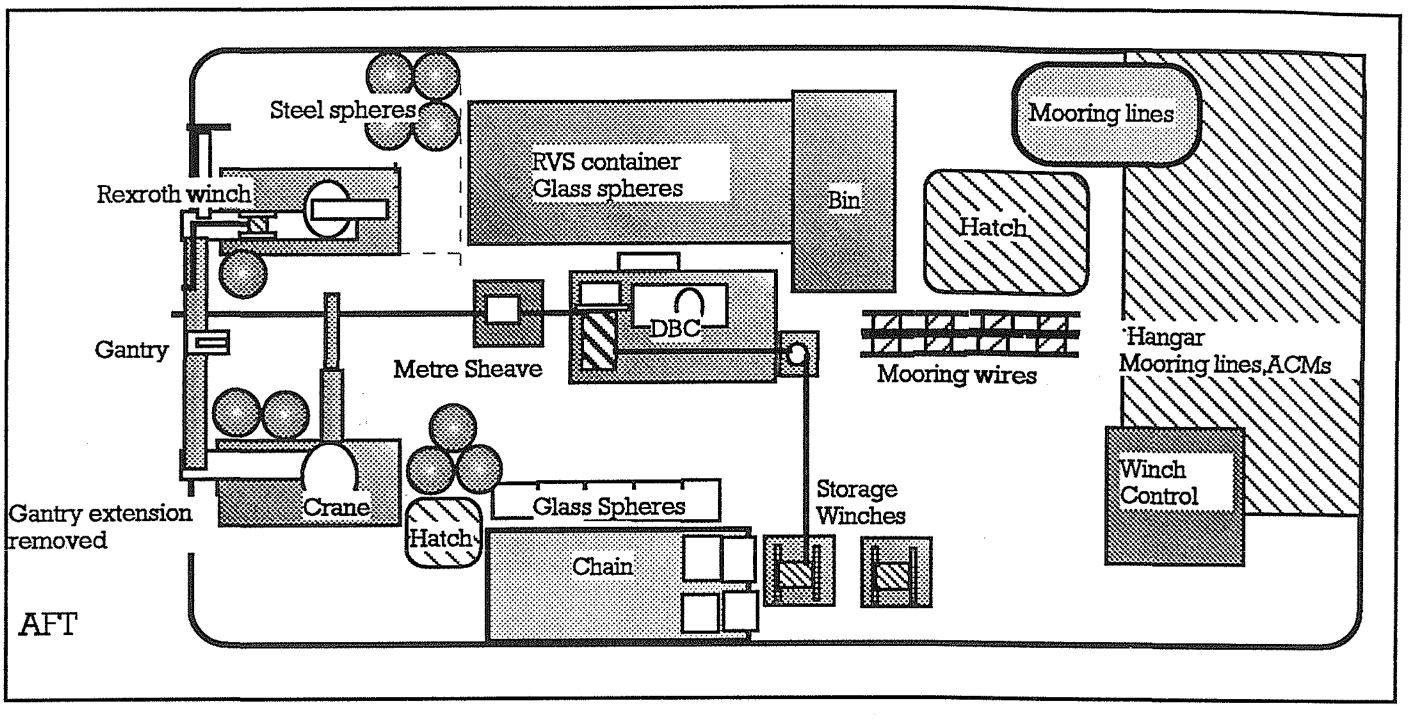
The ships officer of the watch on the bridge was provided with mooring diagrams of each mooring before operations commenced and was briefed as to position of mooring anchor drop.A deck officer was present on the working deck throughout the mooring operations to lliase with the bridge regarding ships speed,heading,and progress.

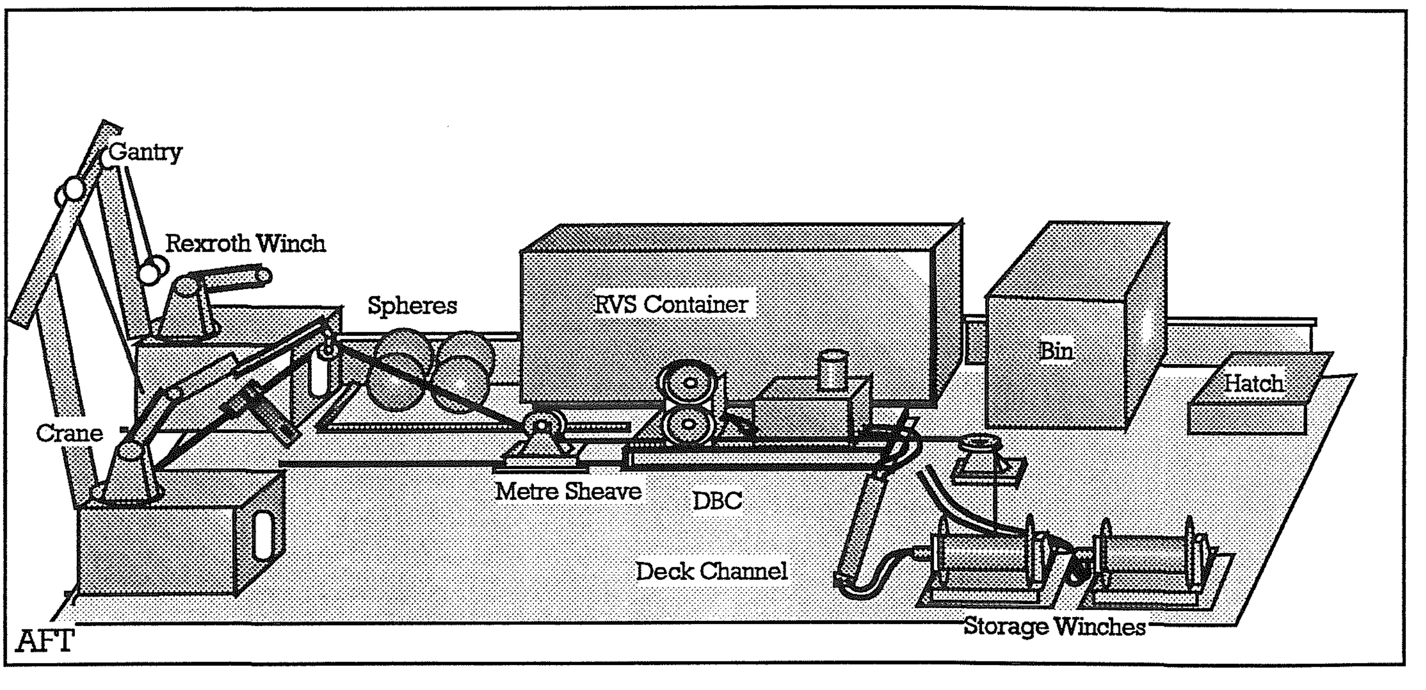
The ship run in to deployment of the anchor was determined from positional determinations made on moorings F,G,H and the bridge officers observed positions.Towing into position was thus minimised.

All operations were timed on deck and timings logged onto a rough sheet.Bridge officers also noted timings and positional information for significant events.Thus positional information could be obtained from the Bridge Scientific Rough Log and from the onboard logged Best Nav.

The mooring deployments were operated in conditions from force 2 to force 7 with no problems.Personnel operating near the open stern were obliged to wear safety harnesses attached to deck mounted running wires.Lifejackets were worn by other personnel within an agreed zone.

Revised Deck Layout Cruise 201





7.4 Moorings Deployed.

The moorings were deployed in the order H to A and details of position,timing and depths are shown on the following pages.All details are taken from;

1.Mooring Rough Log Sheets.
2.Ships Scientific Rough Log.
3.Acoustic release navigation.
4.Scientific echo sounder.
5.Logged Best Nav.

Topographic Surveys

The moorings were deployed in the order "H" to "A".Each site was surveyed using the shipboard Simrad echosounder,noting steepness of topography,depth and from this determining a best position to locate the moorings.
Wind direction and sea state were noted to determine the approach course whilst deploying the moorings.The reciprocal course was steamed and observations of bottom topography made as the ship was positioned for the commencement of deployment.
Echosounder corrections were made using Carters Tables and applying a correction for echosounder fish depth,typically +17m hove-to,+10m at 10 to 12 knots.During deployment at 1 to 2 knots the fish correction was taken as +17m.

Summary

Moorings H,G,F and E were deployed in steep sided valleys orientated approximately North to South.
Mooring G was in deeper water than originally proposed and the deepest IOSDL moorings have been deployed in.
Mooring D was at the head of a valley,with the most irregular topography encountered of all the sites.
Moorings C and B were on gently sloping topography.
Mooring A was on a flat shelf on the western side of a large channel.

Topographic Charts

The topographic charts were created by an interpolation program.This program can produce contours outside of the ships track,such areas should be treated with caution as they may not represent the true bathymetry of the region.
Areas of the plots with more track crossings will provide a more realistic representation of the bathymetry.
All the data used was Carter corrected with a running mean applied and was then despiked.A linear interpolation routine was then used to produce the contouring for the plots.

Mooring H

Dynamic Performance.

Water depth	4430m
Static depth of subsurface	366m

Actual current profile from Shipborne ADCP

Depth in metres	200	300	400	450
Velocity metres/sec	26	11	10	10

Input current profile

Depth in metres	300	500	1000	2000	3000	4000
Velocity metres/sec	40	40	30	20	20	10

Knock down of subsurface	107m
Tilt at ACM 1259	1.1 deg
Tilt at ACM 9590	5.3 deg
Tilt at ACM 6372	13 deg
Tilt at ACM 3726	7.1 deg

Anchor Forces

Vertical	621 kg
Horizontal	205 kg

Topographic Survey

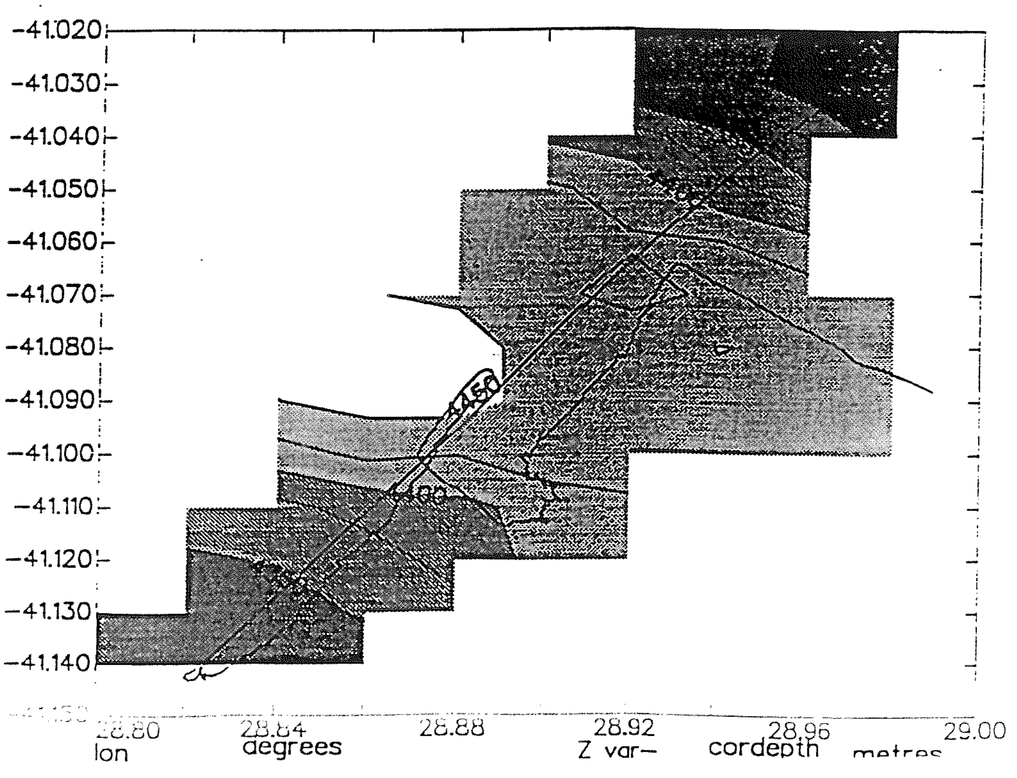
This mooring was deployed in a valley running approximately north-east to south-west. The ship steamed in on a bearing of 133 degrees. The PES correction was +32m at 12kts and +25m when hove-to.

A gentle slope dropped from 3860m to 4070 over 11 miles, before becoming a lot more irregular as it dropped to 4350m over the next 10 miles. There was a steep ridge, rising to 4010m over 1 mile before dropping to the valley floor at 4450 over a further mile. This was the proposed site, fairly even but with a side-echo from the ridge.

The ship steamed 2 miles up-wind on 43 degrees; the floor stayed fairly steady at 4440m. Steaming downwind on 224 degrees there was a 200m hill 1 mile on with a flatter area beyond it. The side-echo from the ridge was not visible.

The deployment was started from 5 miles downwind and the mooring was eventually deployed in 4395m (4420m corrected).

fig 7.3 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring H.

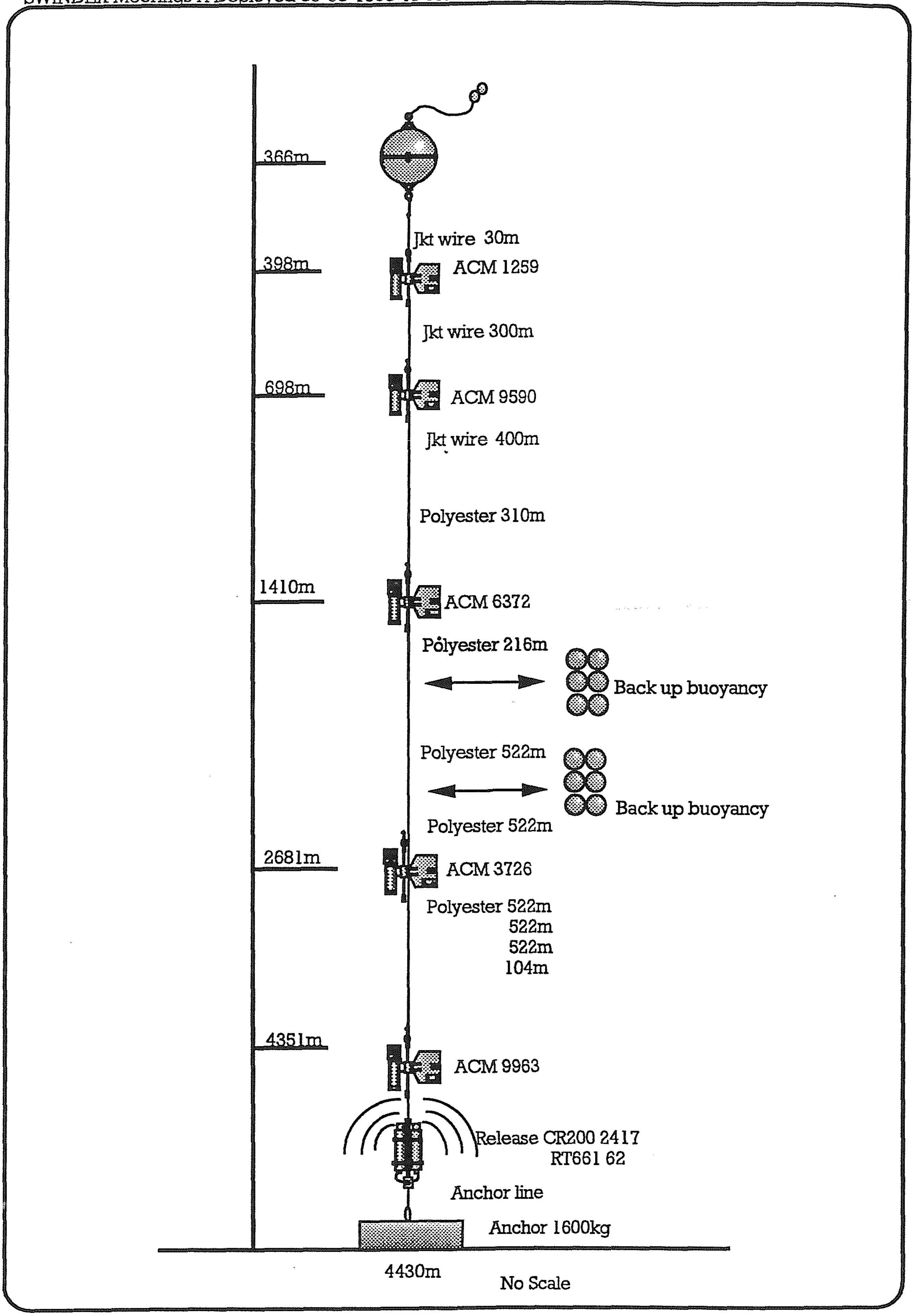
Deployed. Day 089 30-iii-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0621	41 08.5S 28 49.6E	351
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL			366
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	1259 IOSDL	0622		398
Mooring wire	Jkt 6mm 300m			
ACM	9590 RCM7	0634		698
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Line	Poly 10mm 310m			
ACM	6372 IOSDL	0702	41 08.0S 28 50.5E	1410
Line	Poly 10mm 216m			
Glass spheres	10x 17"			
Line	Poly 10mm 522m			
Glass spheres	8x17"			
Line	Poly 10mm 522m			
ACM	3726 RCM8	0744	41 07.2S 28 51.3E	2680
Line	Poly 10mm 522m			
Line	Poly 10mm 522m			
Line	Poly 10mm 522m			
Line	Poly 10mm 104m			
ACM	9963 RCM8	0828	41 06.3S 28 52.2E	4351
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2417			
	RT661 62			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			
Freefall		0833+41	41 06.23S 28 52.36E	4430
On bottom		0901		

Acoustic Release Details.

CR200 2417			•
RT661 62			

SWINDEX Moorings H Deployed 30-03-1993 41 06.231S 28 52.361E



Mooring G

Dynamic Performance.

Water depth		5900m					
Static depth of subsurface		366m					
Current profile	Depth in metres	367	500	750	1000	3000	4000
	Velocity metres/sec	40	40	30	20	10	5

Knock down of subsurface 40 m
Tilt at ACM 8010 1.0 deg
Tilt at ACM 9588 3.9 deg
Tilt at ACM 1260 7.6 deg
Tilt at ACM 10278 5.6 deg
Tilt at ACM 3726 7.1 deg

Anchor Forces
Vertical 632 kg
Horizontal 85 kg

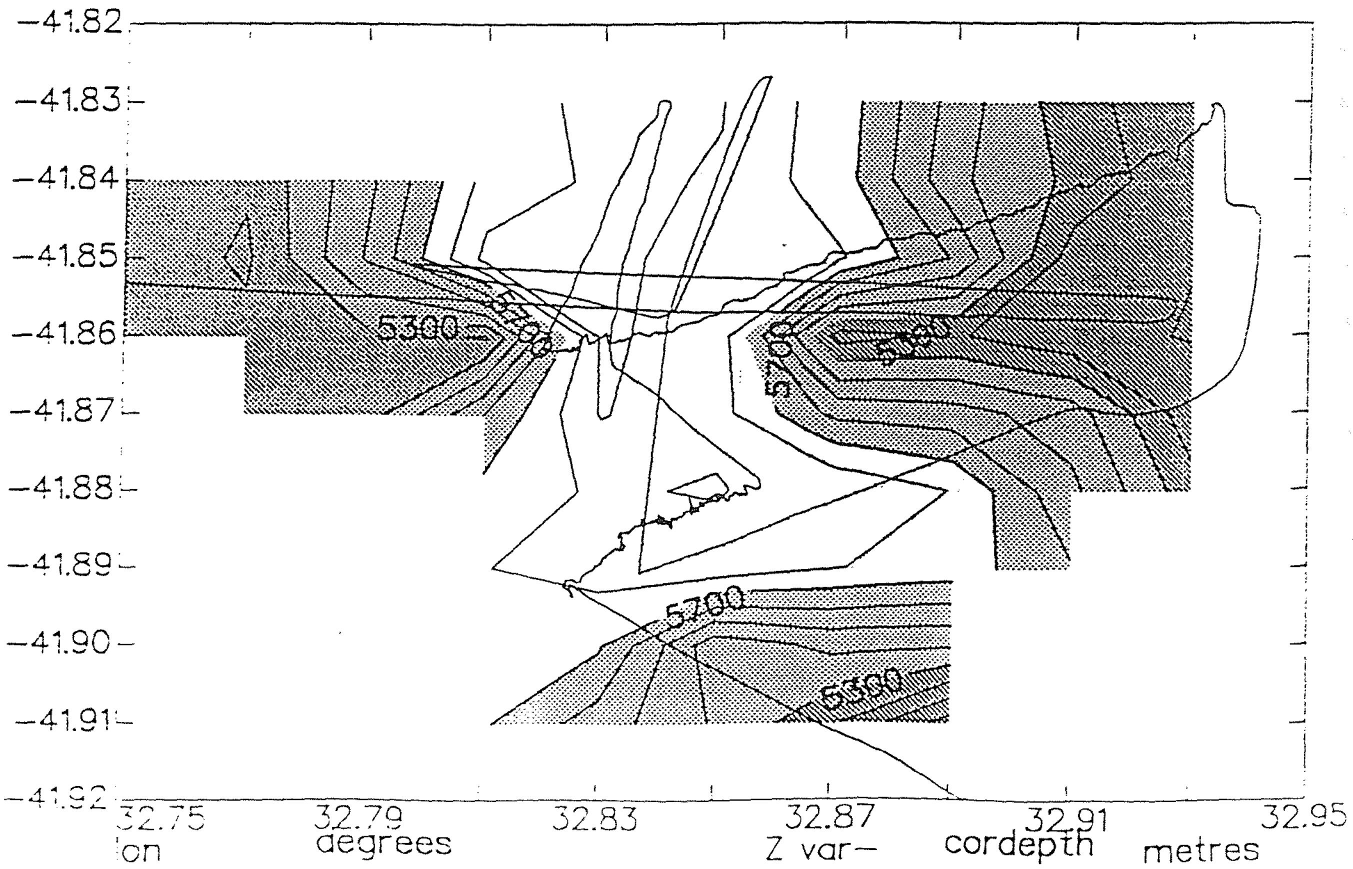
Topographic Survey

This mooring was deployed in a steep-sided valley running approximately north-east to south-west. The PES correction was +30m hove-to and +23m under way at 12kts.

The ship steamed in on a heading of 45 degrees, very nearly down-wind. An uneven slope from 4800m to 5100m over 10 miles terminated in a steep drop to 5870m over less than 2 miles. A flat valley floor about 4 miles across was bounded by an 800m cliff, rising to 5070m.

From the mooring point in the centre of the valley floor, the ship steamed 2 miles into the wind on 280 degrees, then two miles either side, on 25 and 202 degrees. The valley floor got slightly deeper to 5900m to the west, shallowed slightly to 5850m to the north and 5860m to the south. The deployment was started 3 miles downwind and the mooring eventually deployed in 5870m (5900m corrected).

fig 7.4 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring G.

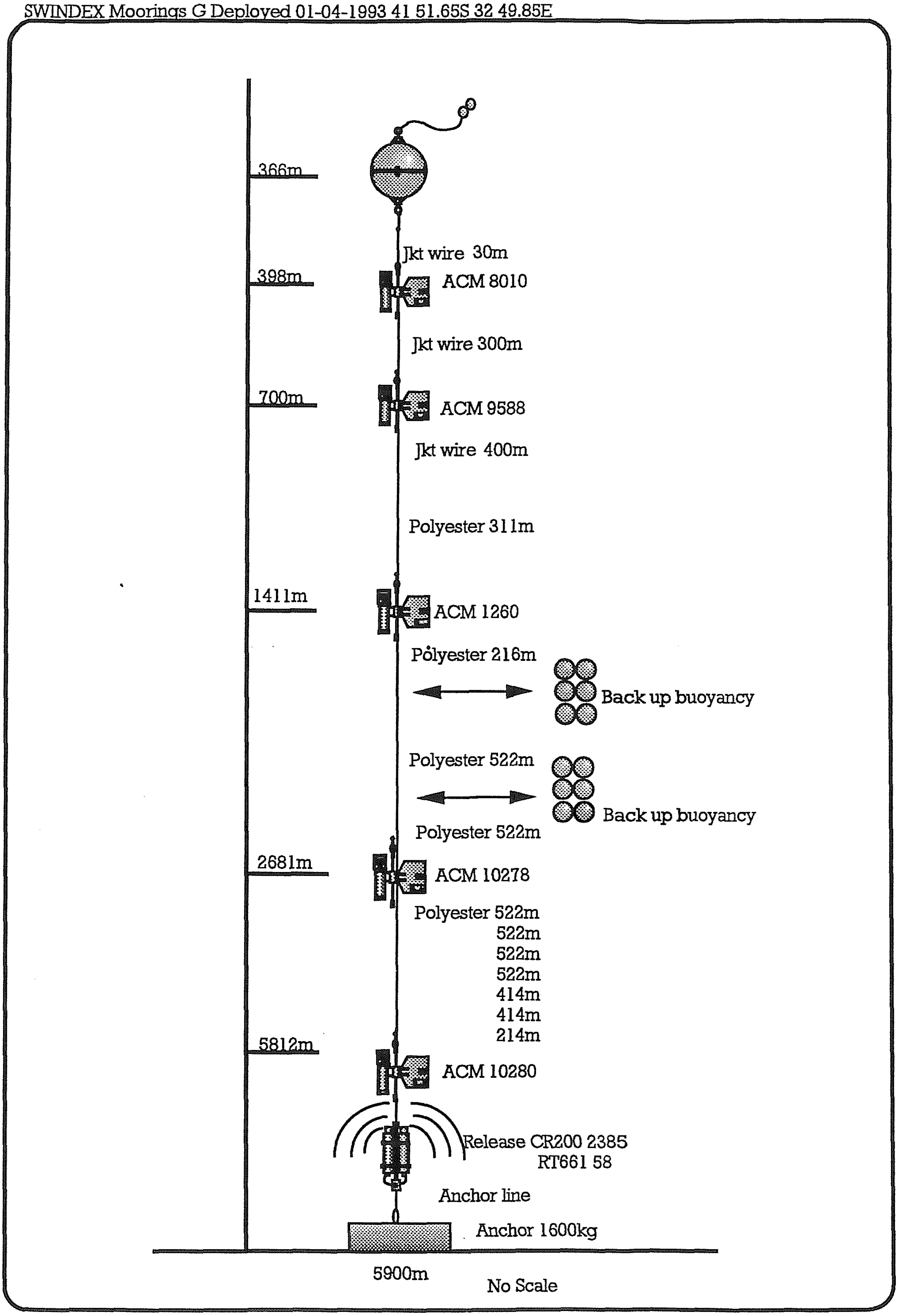
Deployed. Day 091 01-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0600	41 50.0S 32 55.9E	351
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0600		366
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	8010 IOSDL	0601		398
Mooring wire	Jkt 6mm 300m			
ACM	9588 RCM7	0617		700
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Line	Poly 10mm 311m			
ACM	1260 IOSDL	0646		1411
Line	Poly 10mm 216m			
Glass spheres	11x 17"			
Line	Poly 10mm 522m			
Glass spheres	9x17"			
Line	Poly 10mm 522m			
ACM	10278 RCM8	0725		2681
Line	Poly 10mm 522m			
Line	Poly 10mm 522m			
Line	Poly 10mm 522m			
Line	Poly 10mm 522m			
Line	Poly 10mm 414m			
Line	Poly 10mm 414m			
Line	Poly 10mm 214m		Towing	
ACM	10280 RCM8	0902	41 51.6S 32 50.0E	5812
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2385			
	RT661 58			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			
Freefall		0908	41 51.65S 32 49.85E	5900
On bottom	O/A descent 2.7m/sec	0944		

Acoustic Release Details.

CR200 2385			
RT661 58			

SWINDEX Moorings G Deployed 01-04-1993 41 51.65S 32 49.85E



Mooring F

Dynamic Performance.

Water depth	4262m
Static depth of subsurface	350m

Current profile							
	Depth in metres	350	500	750	1000	2000	3000
	Velocity metres/sec	50	40	40	30	25	10

Knock down of subsurface	80m
Tilt at ACM 7517	1.2 deg
Tilt at ACM 9587	4.5 deg
Tilt at ACM 7943	12 deg
Tilt at ACM 10275	12 deg

Anchor Forces

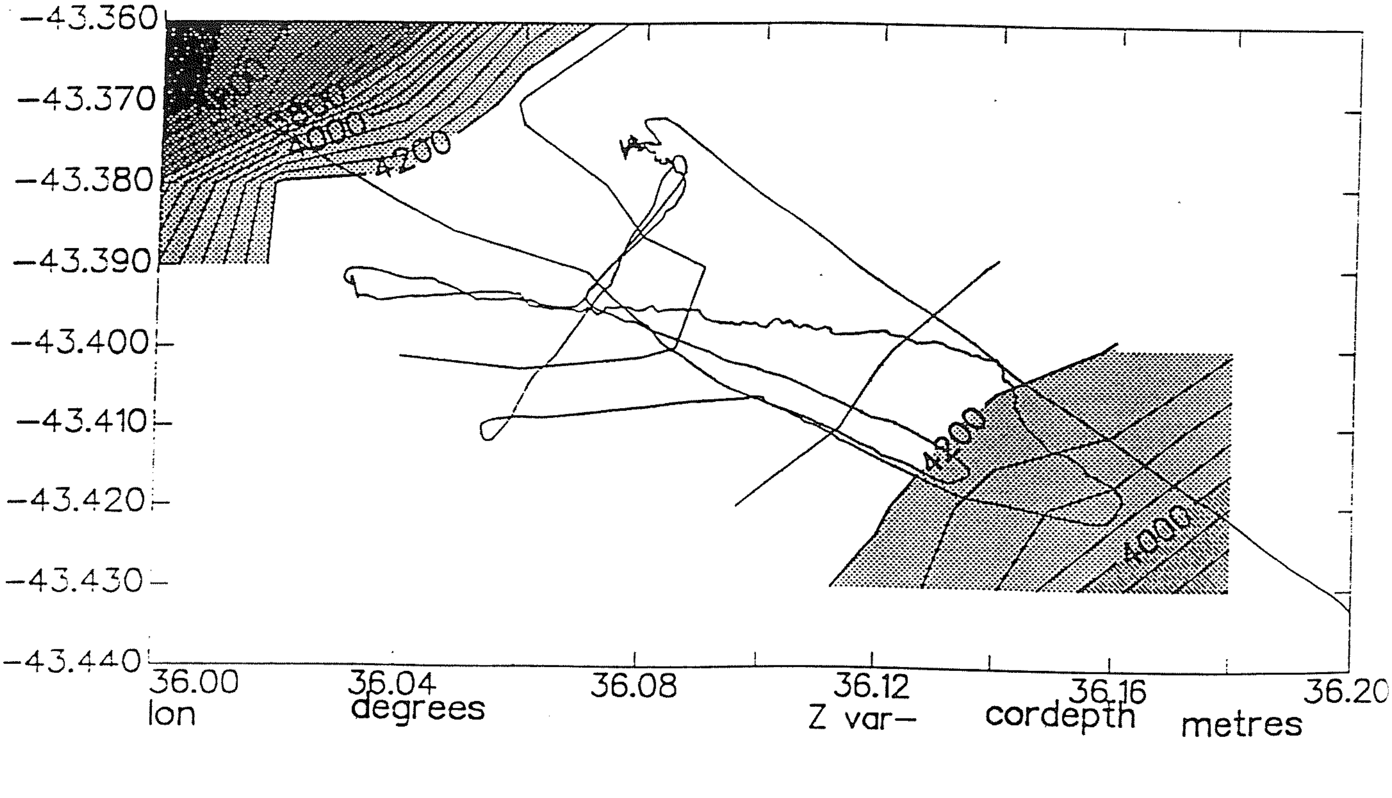
Vertical	651 kg
Horizontal	181 kg

Topographic Survey

This mooring was deployed in a valley running approximately north-east to south-west. The PES correction was +14m hove-to and +7m underway at 11kts.

The ship steamed in on a heading of 125 degrees. At 10 miles out the sea-bed dropped from 2800m to 3480m, ran fairly flat for 2 miles, then rose to a ridge of 3250m over 2 miles before dropping away rapidly to 4240m over 1.5 miles. The valley floor was fairly flat for 2.5 miles, with some irregularities of the order of 10-20m, before rising more steeply on the other side. Steaming from the centre of the valley floor on a heading of 35 degrees revealed that the valley floor sloped down gently by 35m to 4275m. Steaming a mile to the other side on a heading of 220 degrees, the floor sloped down gently to 4296m.
The deployment was started 3 miles downwind on a bearing of 96 degrees, and the mooring was eventually deployed in 4248m of water (4262m corrected).

fig 7.5 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring F.

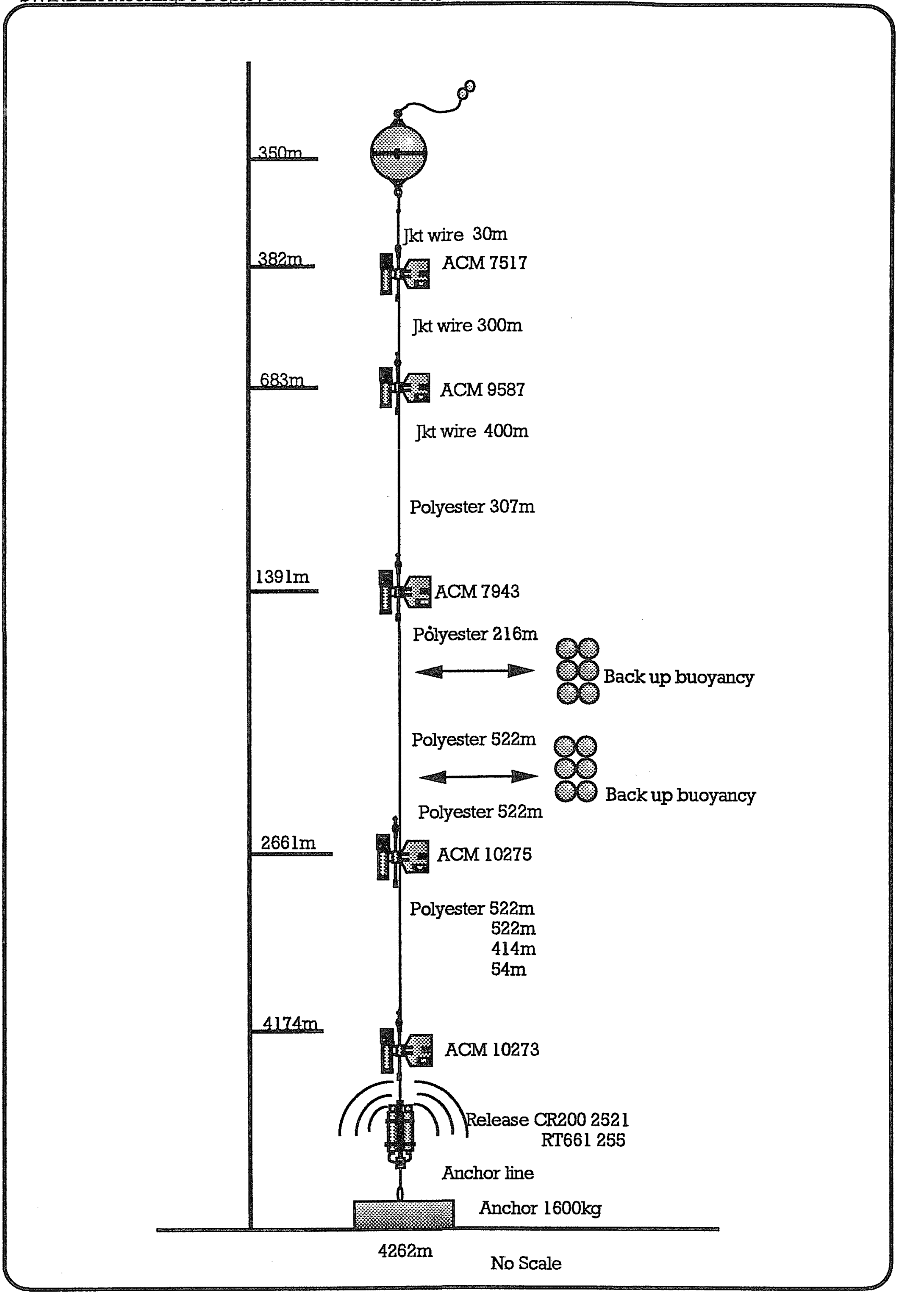
Deployed. Day 093 03-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0441	43 24.25S 36 08.9E	335
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0441		350
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	7517 IOSDL	0443		382
Mooring wire	Jkt 6mm 300m			
ACM	9587 RCM7	0456	43 24.0S 36 08.2E	683
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Line	Poly 10mm 307m			
ACM	7943 IOSDL	0523	43 23.9S 36 07.4E	1391
Line	Poly 10mm 216m			
Glass spheres	10 x 17"			
Line	Poly 10mm 522m			
Glass spheres	8x17"			
Line	Poly 10mm 522m			
ACM	10275 RCM8	0603		2661
Line	Poly 10mm 522m			
Line	Poly 10mm 522m			
Line	Poly 10mm 414m			
Line	Poly 10mm 54m			
ACM	10273 RCM8	0708		4174
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2521			
	RT661 255			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			
Freefall		0714	43 23.7S 36 03.92E	4262
On bottom				

Acoustic Release Details.

CR200 2521			•
RT661 255			

SWINDEX Moorings F Deployed 03-04-1993 43 23.7S 36 03.92E



Mooring E

Dynamic Performance.

Water depth	3403m
Static depth of subsurface	332m

Current profile							
	Depth in metres	327	500	750	1000	2000	3000
	Velocity metres/sec	50	40	40	30	25	10

Knock down of subsurface	55m
Tilt at ACM 7401	1.3 deg
Tilt at ACM 9589	5.0 deg
Tilt at ACM 6867	9.2 deg
Tilt at ACM 9648	13 deg
Tilt at ACM 9965	13 deg
Anchor Forces	
Vertical	662 kg
Horizontal	181 kg

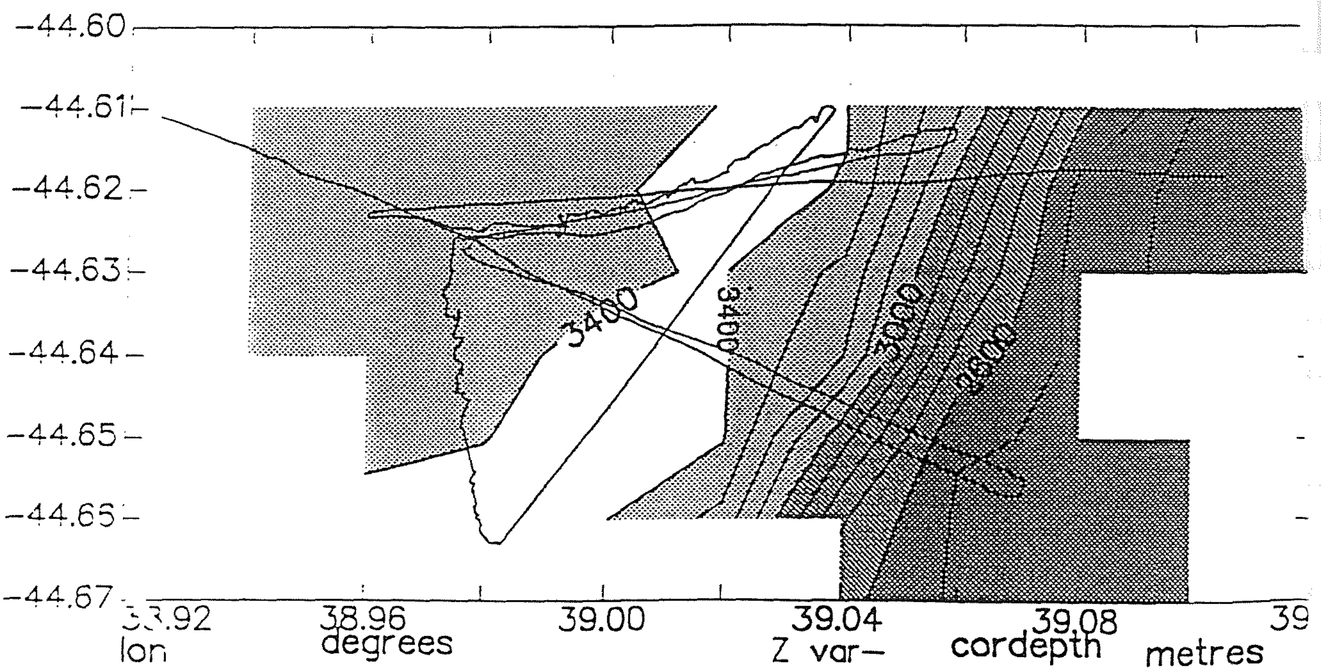
Topographic Survey

This mooring was deployed in an asymmetrical valley running approximately north to south. The PES correction was -24m at 11 kts and -17m hove-to.

The ship steamed in on a heading of 112 degrees. There was a long, irregular slope from 2700m to 3326m over 6 miles, then a gentle slope over 4 miles down to 3416m. This was the valley floor which sloped gently down to 3432m over 3 miles, before rising by 900m in a single cliff to 2518m. The mooring position was chosen as half-way between the cliff base and the start of the valley floor.

The deployment was started at a point 2.5 miles downwind on a heading of 80 degrees and the mooring was eventually deployed in 3417m of water (3403m corrected).

fig 7.6 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring E.

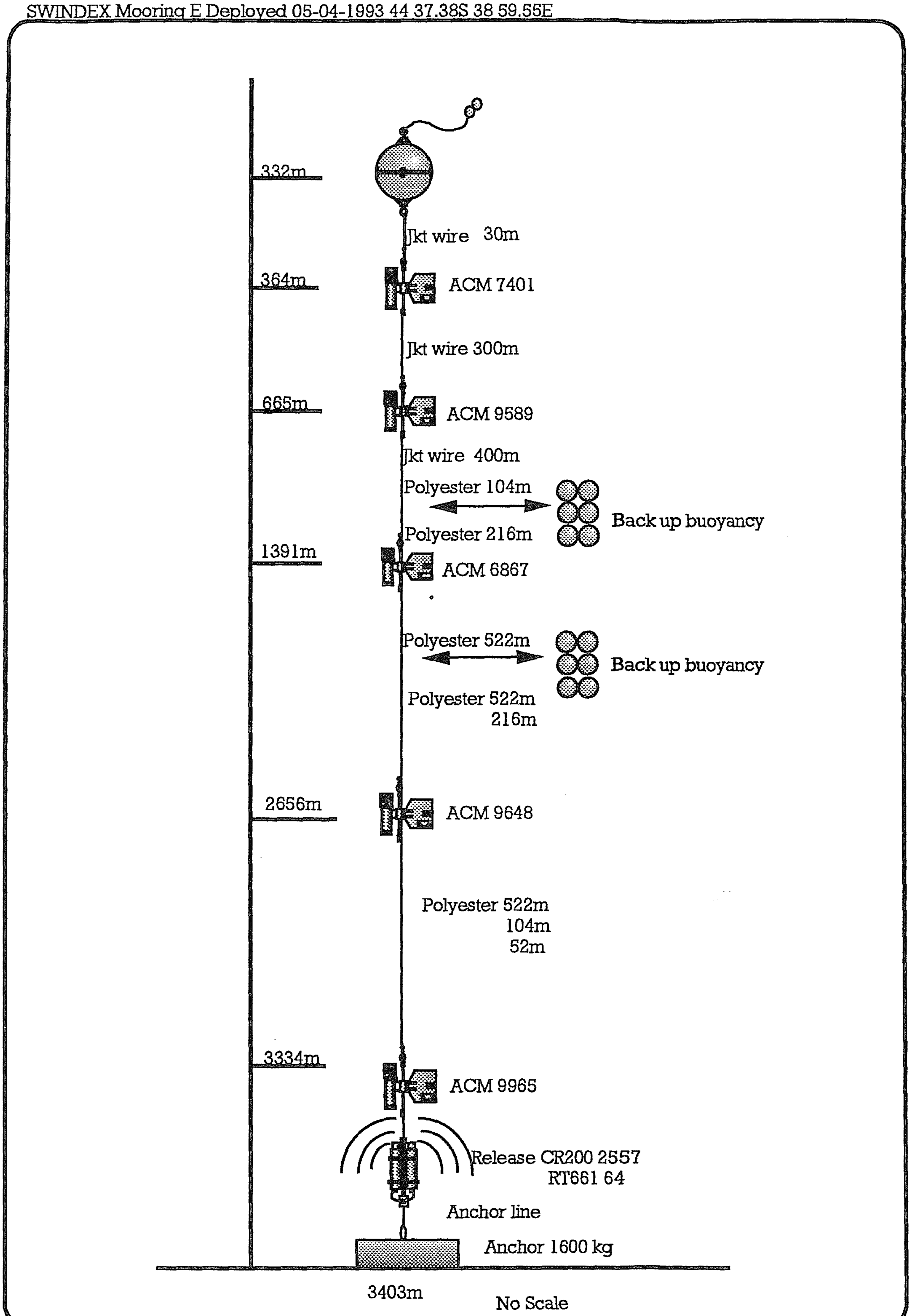
Deployed. Day 095 05-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0410	44 36.5S 39 02.7E	317m
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0410		332
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	7401 IOSDL	0413	44 36.5S 39 02.6E	364
Mooring wire	Jkt 6mm 300m			
ACM	9589 RCM7	0426	44 36.6S 39 02.2E	665
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Line	Poly 10mm 104m			
Glass spheres	9 x 17"			
Line	Poly 10mm 216m			
ACM	6867 IOSDL	0456	44 37.0S 39 01.3E	1914
Line	Poly 10mm 522m			
Glass spheres	8x17"			
Line	Poly 10mm 522m			
Line	Poly 10mm 216m			
ACM	9648 RCM8	0542	44 37.3S 39 00.2E	2656
Line	Poly 10mm 522m			
Line	Poly 10mm 104m			
Line	Poly 10mm 52m			
ACM	9965 RCM8	0607	44 37.3S 38 59.8E	3334
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2557			
	RT661 64			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			
Freefall		0612	44 37.38S 38 59.55E	3403
On bottom		0631		

Acoustic Release Details.

CR200 2557			•
RT661 64			

SWINDEX Mooring E Deployed 05-04-1993 44 37.38S 38 59.55E



Mooring D

Dynamic Performance.

Water depth	2710m
Static depth of subsurface	303m

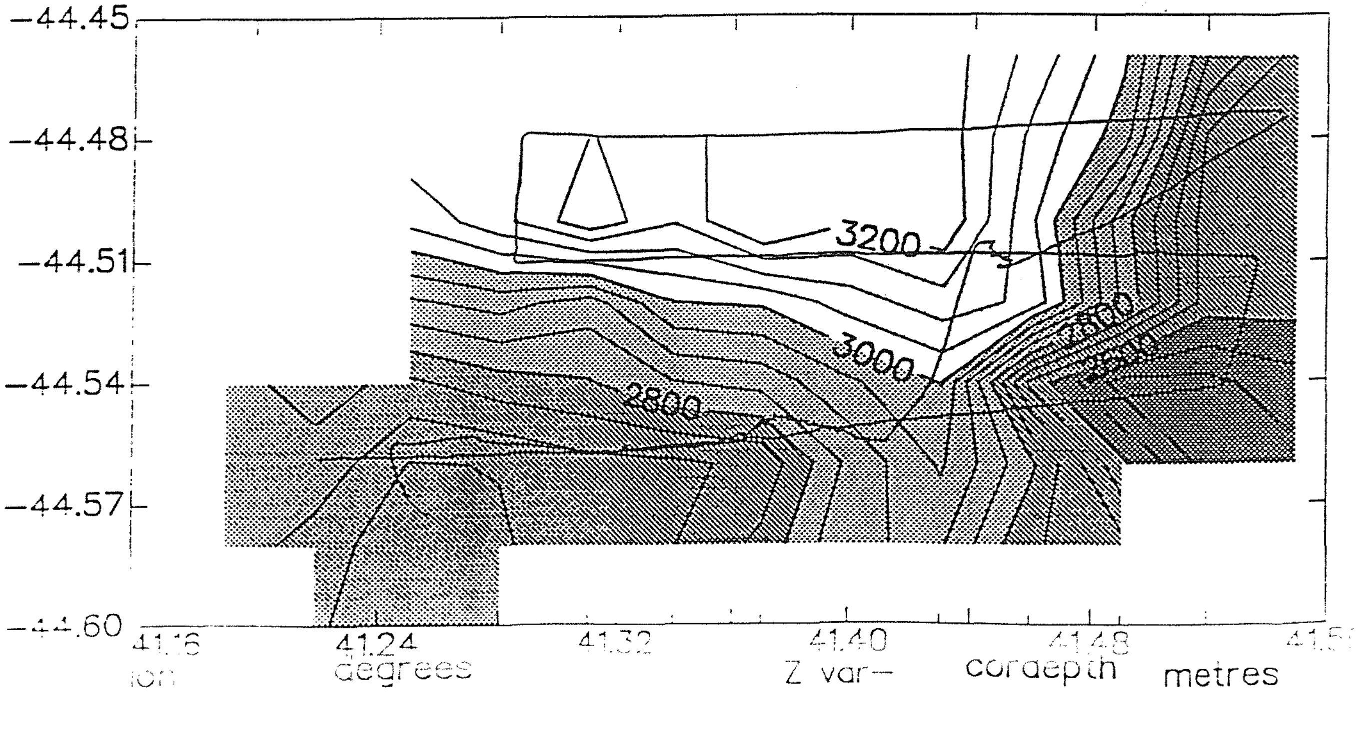
Current profile							
	Depth in metres	303	500	750	1000	2000	2500
	Velocity metres/sec	50	40	40	30	25	10

Knock down of subsurface	43m
Tilt at ACM 5204	1.4 deg
Tilt at ACM 10857	5.3 deg
Tilt at ACM 3727	9.5 deg
Tilt at ACM 10276	13 deg
Tilt at ACM 10281	13 deg
Anchor Forces	
Vertical	694 kg
Horizontal	183 kg

Topographic Survey

This mooring was deployed at the southern end of a broad, irregular valley on a flat area above and to the west of the main channel. The PES correction was -12m at 11kts and -5m hove-to.
The ship steamed in on a heading of 90 degrees. A long, irregular slope ran down from 2700m to 2870m over about 5 miles. This dropped gently by 100m over 2 miles to 2972m, then dropped to the floor of the main channel at 2992m. This was irregular and barely a mile across, and rose irregularly to 2415m over 2 miles on the other side.
Two more east-west lines were run across the valley, one 2 miles north and one 4 miles north. They revealed an irregular valley with a channel running down the eastern side. This channel was a mile across, irregular and only 100m or so deeper than the general valley floor.
There appeared to be a longitudinal ridge running down the middle of the valley, about 100m higher than the general valley floor in the north, less in the south. The ground to the west of the ridge was very irregular. The neck of the valley was chosen because the ridge here was insignificant (10-20m high) and the main channel was less than 50m deeper than the chosen target area. The target area was also the only relatively flat piece of sea-bed greater than 1 mile across that we encountered in four hours of survey.
The deployment was started 3 miles downwind, due east,and the mooring was eventually deployed in 2715m of water (2710m corrected).

fig 7.7 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring D.

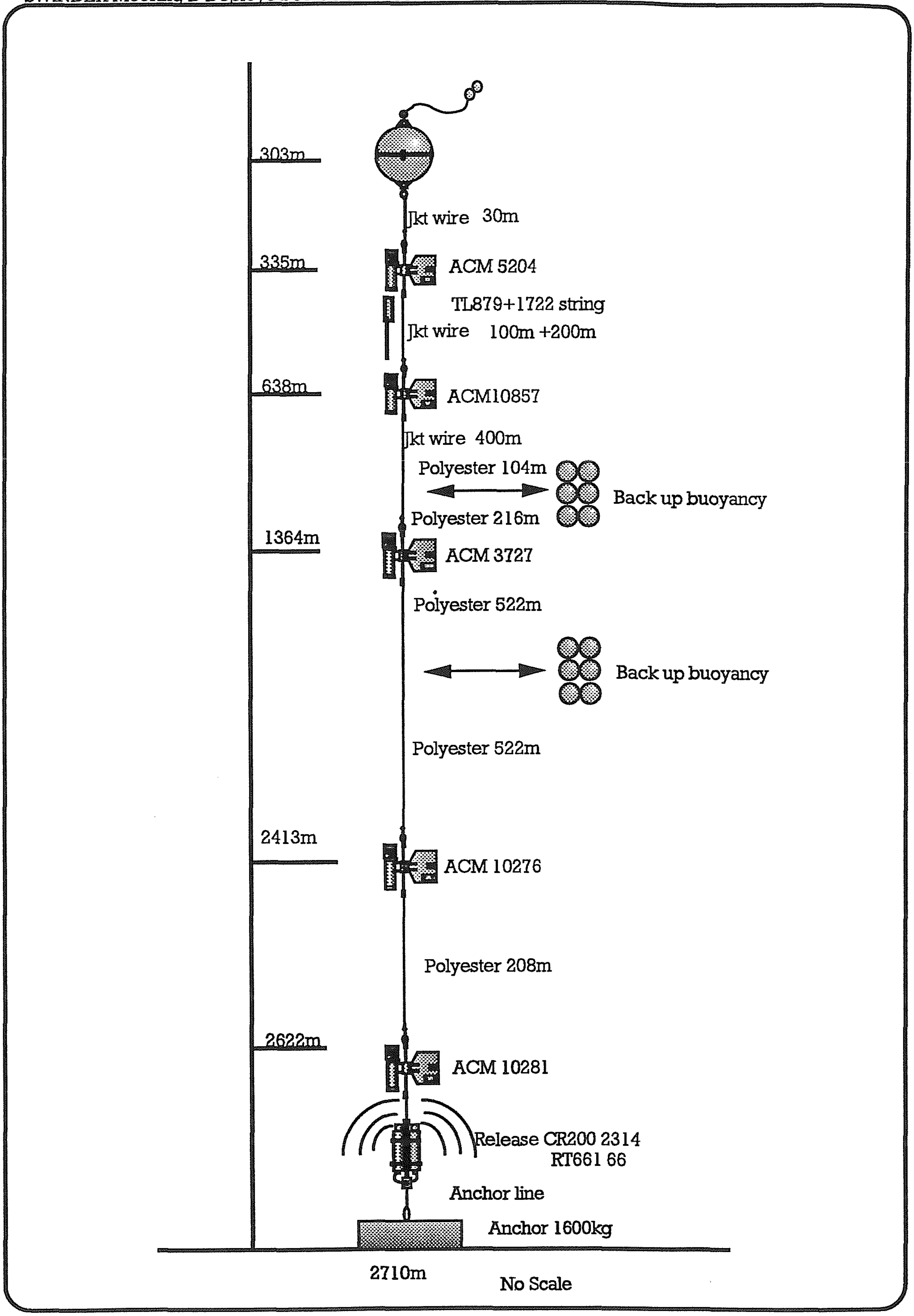
Deployed. Day 096 06-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0838	44 33.1S 41 23.7E	288
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0838		
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	5204 IOSDL	0841		335
TL	879			
T.String	1722 100m	0912		
Mooring wire 100m	In parallel with above			
Mooring wire 200m				
ACM	10857 RCM7	0922	44 32.9S 41 22.4E	638
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 400m			
Line	Poly 10mm 104m			
Glass spheres	9 x 17"	0941	44 33.1S 41 22.0E	
Line	Poly 10mm 216m			
ACM	3727 IOSDL	0953		1364
Line	Poly 10mm 522m			
Glass spheres	8x17"			
Line	Poly 10mm 522m			
ACM	10276 RCM8	1026	44 33.3S 41 20.3E	2413
Line	Poly 10mm 208m			
ACM	10281 RCM8	1037	44 33.4S 41 19.6E	2622
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2314			
	RT661 66			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			
Freefall		1043	44 33.40S 41 19.33E	2710
On bottom		1059		
Buoy observed to	submerge	1057		

Acoustic Release Details.

CR200 2314			
RT661 66			

SWINDEX Mooring D Deployed 06-04-1993 44 33.40S 41 19.33E



Mooring C

Dynamic Performance.

Water depth	2379m
Static depth of subsurface	270m

Current profile							
	Depth in metres	270	500	750	1000	1750	2000
	Velocity metres/sec	50	40	40	30	25	15

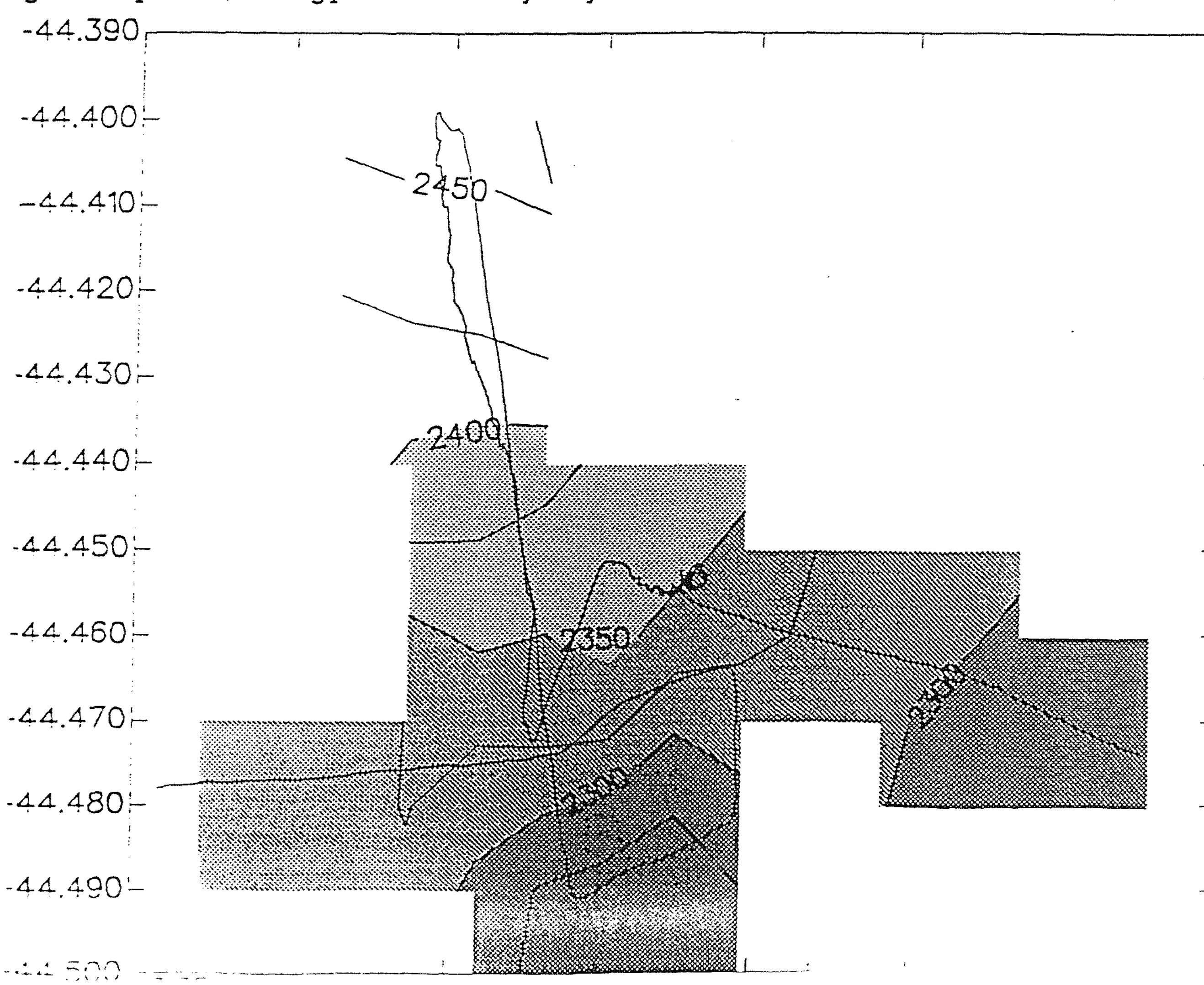
Knock down of subsurface	30m
Tilt at ACM 5205	1.4 deg
Tilt at ACM 10863	5.5 deg
Tilt at ACM 3624	10 deg
Tilt at ACM 10274	11.6deg
Anchor Forces	
Vertical	706 kg
Horizontal	157 kg

Topographic Survey.

This mooring was deployed on a gentle north-south slope. The PES correction was -22m at 11kts and -15m hove-to.
The ship steamed in on a heading of 83 degrees. The sea-bed sloped gently down by 55m to 2371m over 7.5 miles. The ship ran past the proposed drop site by 1 mile, then 1 mile on a heading of 173 degrees, 2 miles on 275 degrees and then north for 1 mile. This revealed a 40m ridge running diagonally across the slope, immediately adjacent to the proposed site.

The deployment was started 2 miles downwind, on a bearing of 335 degrees, and the mooring was eventually deployed in 2394m of water (2379m corrected).

fig 7.8 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring C.

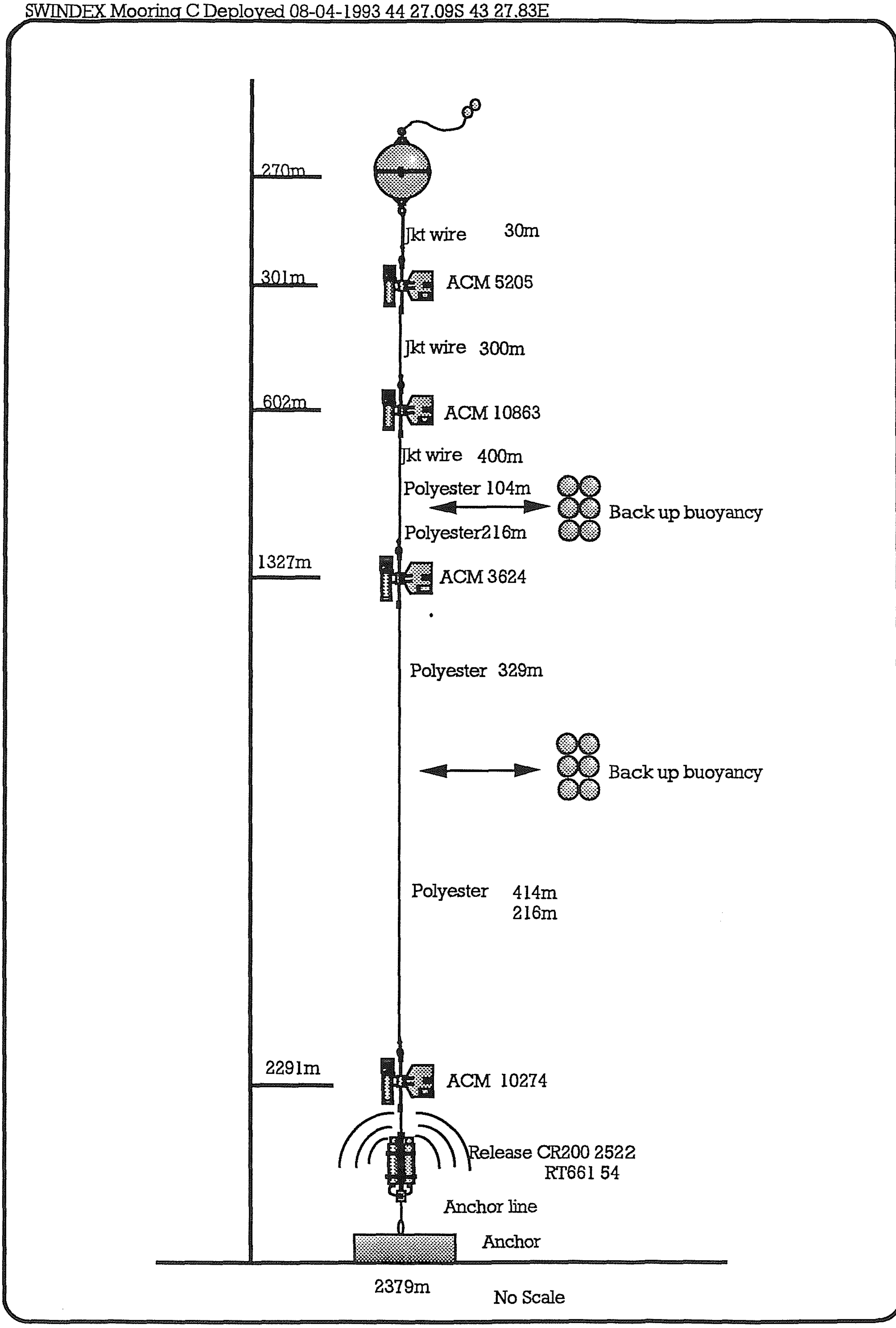
Deployed. Day 098 08-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0542	44 24.6S 43 26.3E	255
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0542		270
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	5205 IOSDL	0545		301
Mooring wire	Jkt 6mm 300m			
ACM	10863 RCM7	0601	44 24.9S 43 26.4E	602
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Line	Poly 10mm 104m			
Glass spheres	8 x 17"			
Line	Poly 10mm 216m			
ACM	3624 IOSDL	0636	44 25.9S 43 27.1E	1327
Line	Poly 10mm 329m			
Glass spheres	8x17"			
Line	Poly 10mm 414m			
Line	Poly 10mm 216m			
ACM	10274 RCM8	0706	44 26.9S 43 27.8E	2291
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2522	0706		
	RT661 54			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			2379
Freefall		0714	44 27.09S 43 27.087E	
On bottom		0728		

Acoustic Release Details.

CR200 2522			
RT661 54			

SWINDEX Mooring C Deployed 08-04-1993 44 27.09S 43 27.83E



Mooring B

Dynamic Performance.

Water depth	1614m
Static depth of subsurface	279m

Current profile							
	Depth in metres	279	500	750	1000	1250	1500
	Velocity metres/sec	50	40	40	30	25	15

Knock down of subsurface	20m
Tilt at ACM 6225	1.4 deg
Tilt at ACM 10864	5.6 deg
Tilt at ACM 7948	13 deg

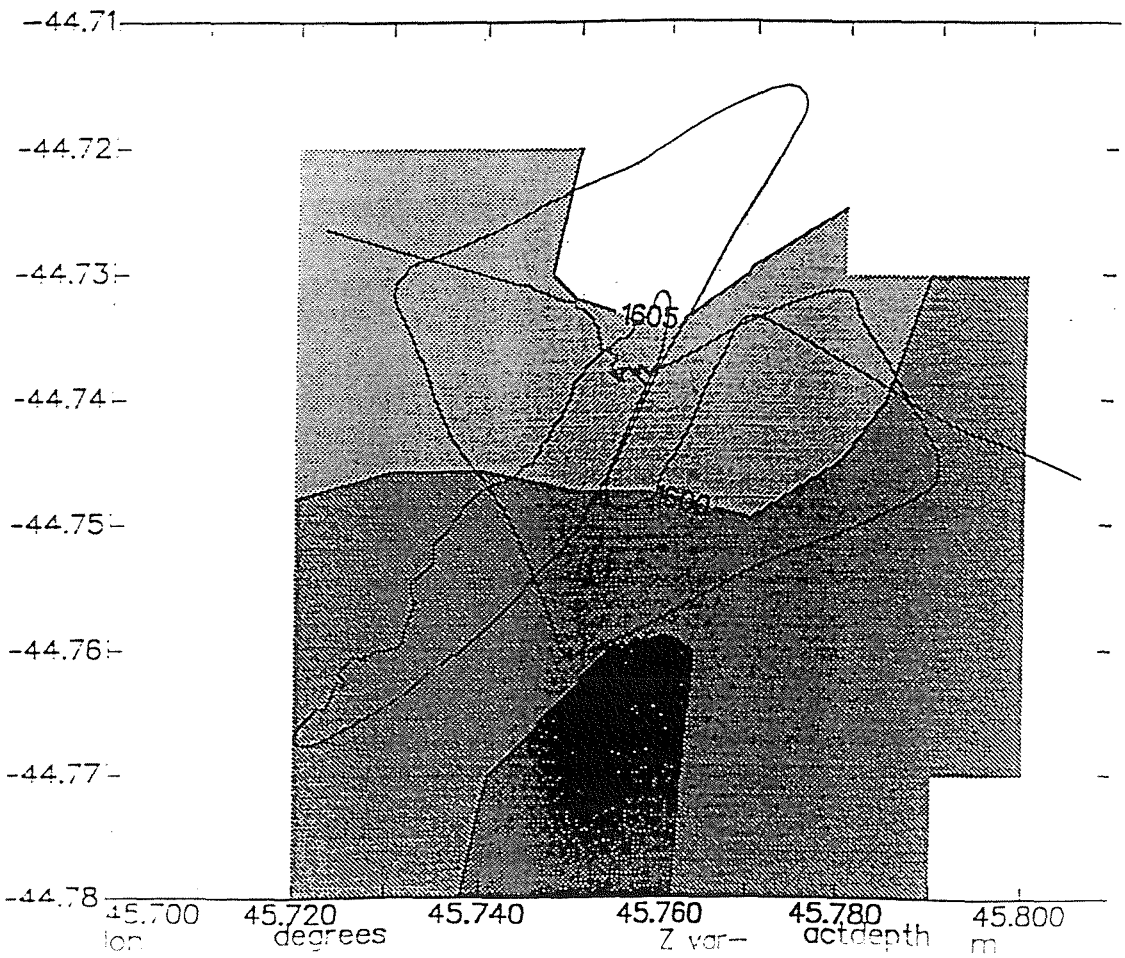
Anchor Forces

Vertical	370 kg
Horizontal	106 kg

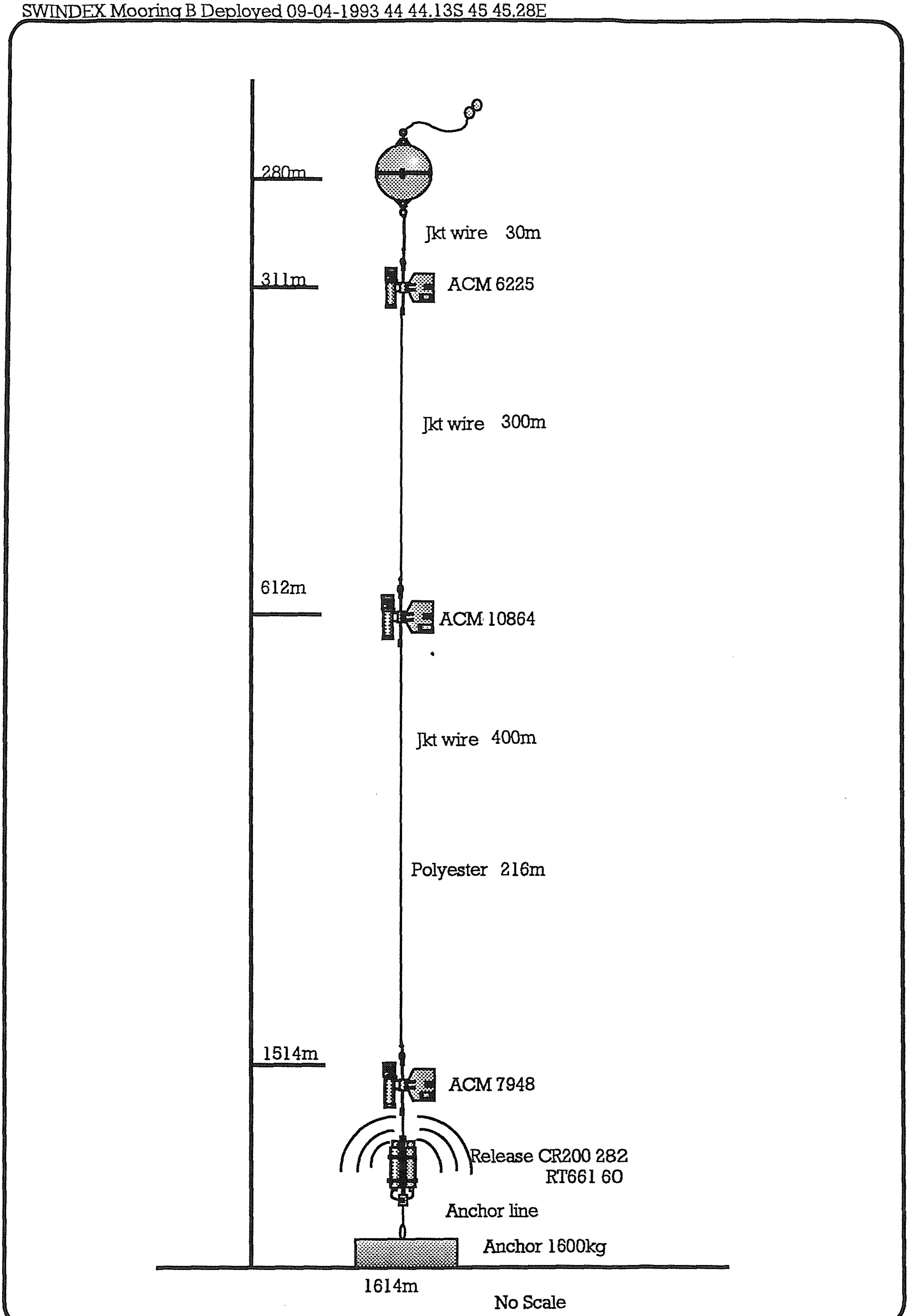
Topographic Survey.

This mooring was deployed on a smooth, flat plain. The PES correction was -8m hove-to and -15m at 11kts.
The ship started off at the proposed mooring site (at the end of a CTD) and steamed on a heading of 65 degrees for 1 mile, then on 157 degrees for one mile, 247 degrees for 2 miles and so on, to describe a square two miles on each side around the site. The depth when hove-to at the centre was 1621m. The depth at the south-west corner was 1609m and at the north-east corner 1622 with a regular slope in between.
The deployment was started 1.75 miles downwind on a bearing of 247 degrees and eventually deployed in 1622m of water (1614m corrected).

fig 7.9 Ships track,mooring position and bathymetry.



SWINDEX Mooring B Deployed 09-04-1993 44 44.13S 45 45.28E



Mooring Log Sheet

Mooring B.

Deployed. Day 099 09-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0710	44 45.5S 45 43.9E	265
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0710		280
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	6225 IOSDL	0714		311
Mooring wire	Jkt 6mm 300m			
ACM	10864 RCM7	0726	44 45.1S 45 44.1E	612
Swivel	S/S IOSDL			
Line	Poly 10mm 216m			
ACM	7948 IOSDL	0802	44 44.4S 45 45.0E	1529
Chain	1/2" long link 1m			
Acoustic Releases	CR200 282 RT661 60			
Anchor line	Nylon 12mm 25m Poly 12mm 50m Chain 1/2" 10m			
Towing				
Anchor	Chain 1600kg			1614
Freefall		0810	44 44.13S 45 45.28E	
On bottom		0816		
Buoy observed to submerge				

Acoustic Release Details.

CR200 282			
RT661 60			

Mooring A

Dynamic Performance.

Water depth	2906m
Static depth of subsurface	299m

Current profile							
	Depth in metres	299	500	1000	1500	1750	2000
	Velocity metres/sec	50	40	40	30	20	10

Knock down of subsurface	35m
Tilt at ACM 2108	1.4 deg
Tilt at ACM 4738	3.9 deg
Tilt at ACM 10852	5.2 deg
Tilt at ACM 7945	8.5 deg
Tilt at ACM 10279	10.7deg
Tilt at ACM 10277	11.5deg
Anchor Forces	
Vertical	693 kg
Horizontal	154 kg

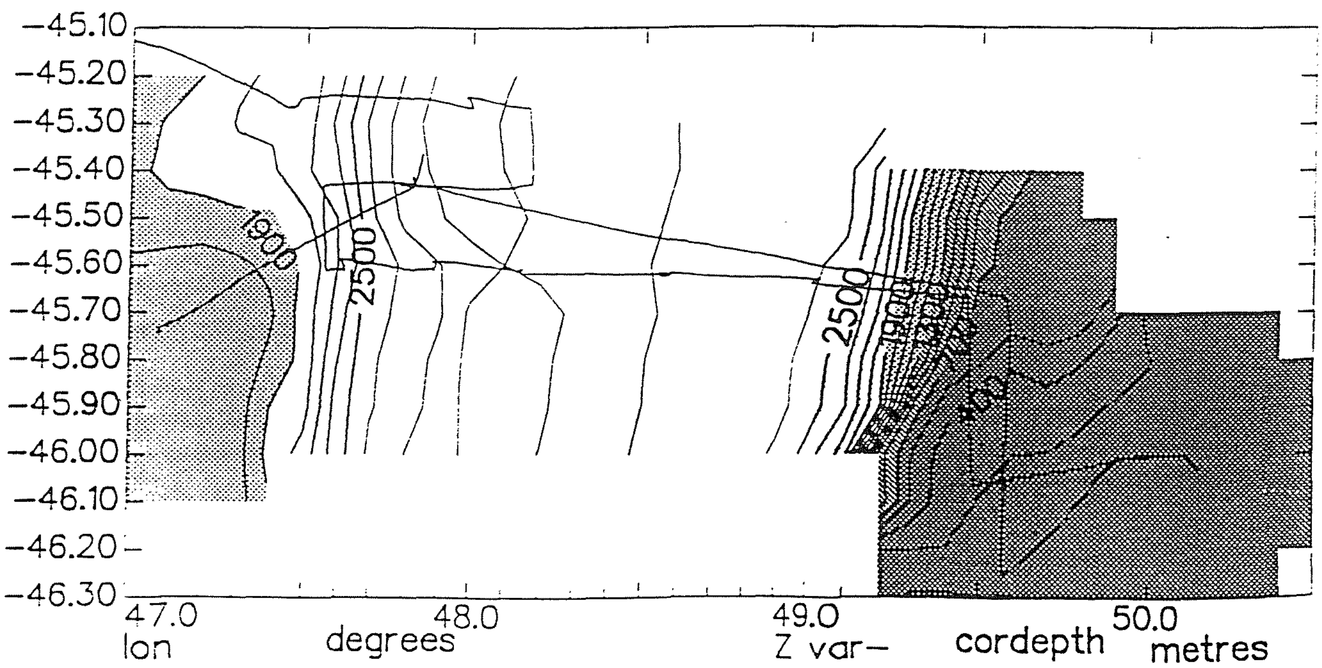
Topographic Survey.

This mooring was deployed on the western edge of a wide, deep channel. The site was determined following a CTD and ADCP survey, during which a fairly gentle section of slope was identified. The PES correction was +4m at 11kts, +11m hove-to.

The ship steamed in on a heading of 275 degrees. The valley side rose from 2955m to 2909m over 3.5 miles. There was then a flatter section which rose gently to 2896m over about 3 miles, before rising to 2831m and becoming more irregular.

The deployment was started at a point 2.5 miles downwind, on a bearing of 20 degrees, and the mooring was eventually deployed in 2900m (2911m corrected).

fig 7.10 Ships track,mooring position and bathymetry.



Mooring Log Sheet

Mooring A.

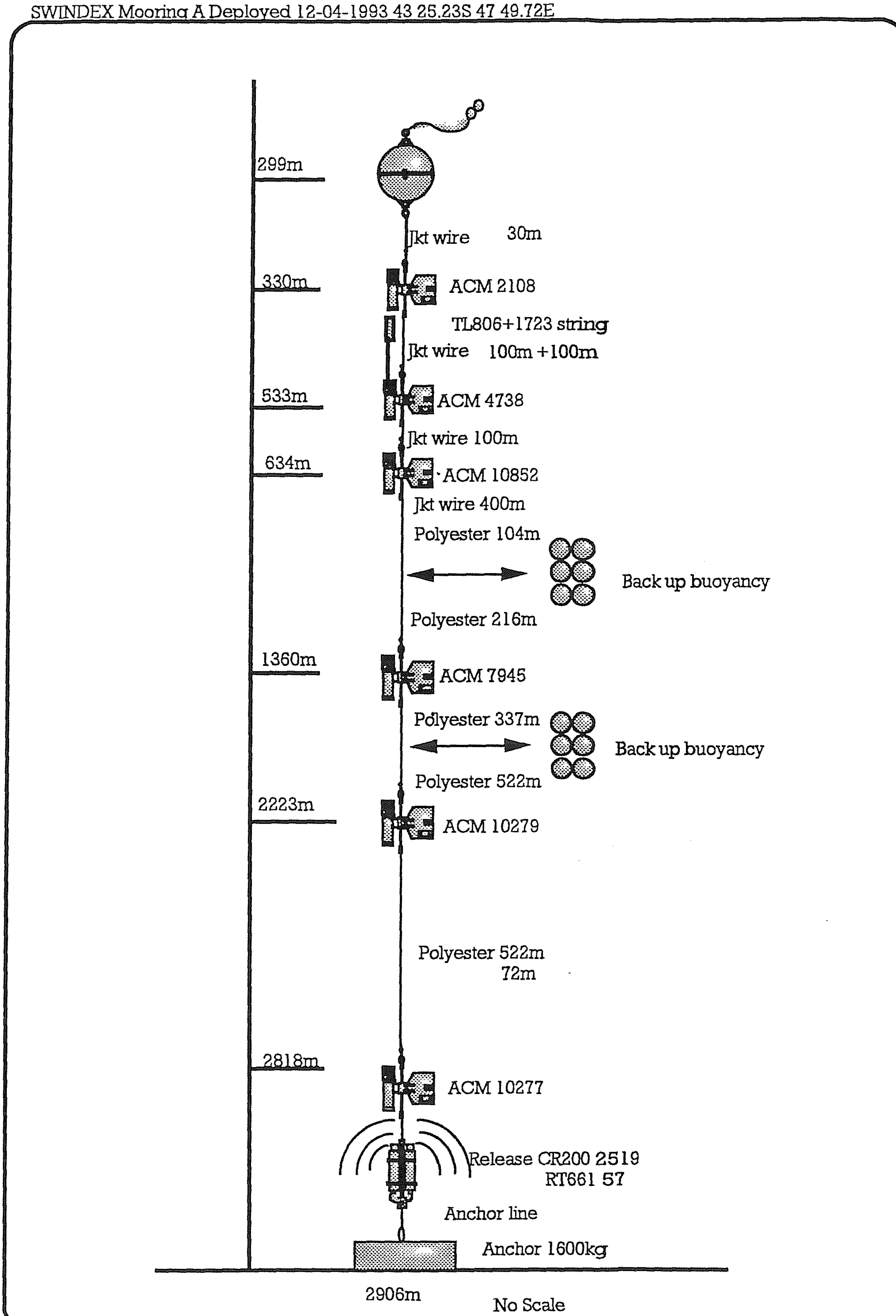
Deployed. Day 102 12-iv-1993 Ship Discovery Cruise 201

ITEM	Description	In Water	Position	Depth m.
Pick up floats	11"Nokalon x 2	0406	41 22.4S 47 50.3E	284
Pick up line	22mmPolyprop			
Subsurface Buoy	Steel 1.3m dia.IIOSDL	0406	45 22.4S 47 50.5E	299
Buoy chain	Steel long link5/8" 1m			
Swivel	S/S IOSDL			
Mooring wire	Jkt 6mm 30m			
ACM	2108 IOSDL	0409		330
TL	806			
T String	1723 100m	0431		
Mooring wire 100m	In parallel with above			
Mooring wire 100m				
ACM	4738 IOSDL	0439	45 22.9S 47 50.4E	533
Mooring wire	Jkt 6mm 100m			
ACM	10852 RCM7	0445	45 23.0S 47 50.4	634
Mooring wire	Jkt 6mm 400m			
Swivel	S/S IOSDL			
Line	Poly 10mm 104m			
Glass spheres	10 x 17"	0507		
Line	Poly 10mm 216m			
ACM	7945 IOSDL	0516	45 23.5S 47 50.1E	1360
Line	Poly 10mm 337m			
Glass spheres	9x17"	0530		
Line	Poly 10mm 522m			
ACM	10279 IOSDL	0545	45 24.0S 47 50.1	2223
Line	Poly 10mm 522m			
Line	Poly 10mm 72m			
ACM	10277 RCM8	0603	45 24.4S 47 45.0E	2818
Chain	1/2" long link 1m			
Acoustic Releases	CR200 2519			
	RT661 57			
Anchor line	Nylon 12mm 25m			
	Poly 12mm 50m			
	Chain 1/2" 10m			
Towing		0611		
Anchor	Chain 1600kg			
Freefall		0641	45 25.23S 47 49.72E	2906m
On bottom				

Acoustic Release Details.

CR200 2519			•
RT661 57			

SWINDEX Mooring A Deployed 12-04-1993 43 25.23S 47 49.72E



SWINDEX Technical File

ANNEX 1 Aanderaa Check list and Overhauls

K.M Goy

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RCM Checklist

SWINDEX Aanderaa RCM Calibrations						
Serial No.	Rotor	Fine Temp.	Temperature	Conductivity	Pressure	Compass
1259	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	1792
8010	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	12912
7517	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	12063
7401	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	3774
5204	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	7969
5205	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	7885
6225	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	9792
2108	0-100cm/s	2 - 12°c	"-2 - 22°c		0-1000psi	2909
9590	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		15792
9588	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		15821
9587	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		15820
9589	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		16462
10852	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		18667
10864	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		18678
10863	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		18677
10857	0-100cm/s	2 - 10°c	"-2 - 22°c	30-40mmho		18674
6372	0-100cm/s	1 - 7°c	"-2 - 22°c			10006
1260	0-100cm/s	1 - 7°c	"-2 - 22°c			9659
7943	0-100cm/s	1 - 7°c	"-2 - 22°c			12821
6867	0-100cm/s	1 - 7°c	"-2 - 22°c			10898
3727	0-100cm/s	1 - 7°c	"-2 - 22°c			5058
3624	0-100cm/s	1 - 7°c	"-2 - 22°c			15726
7948	0-100cm/s	1 - 7°c	"-2 - 22°c			12818
7945	0-100cm/s	1 - 7°c	"-2 - 22°c			15825
3726	0-100cm/s	0 - 6°c	"-2 - 22°c			10663
10278	0-100cm/s	0 - 6°c	"-2 - 22°c			17415
10275	0-100cm/s	0 - 6°c	"-2 - 22°c			17424
9648	0-100cm/s	0 - 6°c	"-2 - 22°c			15829
10276	0-100cm/s	0 - 6°c	"-2 - 22°c			17412
10274	0-100cm/s	0 - 6°c	"-2 - 22°c			18288
10279	0-100cm/s	0 - 6°c	"-2 - 22°c			17407
10281	0-100cm/s	0 - 6°c	"-2 - 22°c			17413
9963	0-100cm/s	"-.5 - 2.5°c"	"-2 - 22°c			16676
10280	0-100cm/s	"-.5 - 2.5°c"	"-2 - 22°c			17414
10273	0-100cm/s	"-.5 - 2.5°c"	"-2 - 22°c			17411
9965	0-100cm/s	"-.5 - 2.5°c"	"-2 - 22°c			16670
10277	0-100cm/s	"-.5 - 2.5°c"	"-2 - 22°c			17423

RCM Checklist

Spares	Rotor	Fine Temp.	Temperature	Conductivity	Pressure	Compass
2107	0-100cm/s	2 to 12°c	"-2 - 22°c			
4738	0-100cm/s		"-2 - 22°c			
2406	0-100cm/s		"-2 - 22°c			
8011	0-100cm/s		"-2 - 22°c			
2109	0-100cm/s		"-2 - 22°c			

ANNEX 1: ACM overhauls

ACM 3726:

All nuts check tightened
Encoder adjusted and cleaned
Rotary switch adjusted and cleaned
New drive wire and pinch roller fitted

ACM 7517:

All nuts check tightened
Encoder adjusted and cleaned
Rotary switch adjusted and cleaned
New drive wire and pinch roller fitted

ACM 2108:

All nuts check tightened
Encoder replaced with 11376
Rotary switch adjusted and cleaned
New recording head fitted
New drive wire,pinch roller and upper spool replaced
Wiring tidied

ACM 8010:

All nuts check tightened
Encoder adjusted and cleaned
Rotary switch adjusted and cleaned
New motor fitted
New drive wire and pinch roller fitted

ACM 5204:

All nuts check tightened
Encoder cleaned and adjusted
New encoder cap fitted
New rotary switch fitted and adjusted
New drive wire and pinch roller fitted
New pressure case

ACM 7945:

All nuts check tightened
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch roller fitted

ACM 1259:

All nuts check tightened
New encoder fitted
Rotary switch cleaned and adjusted
New recording head
New drive wire,pinch roller and upper spool fitted
New Fenwal thermistor
New 3825 ohm resistor fitted WR4
New pressure case

Note The calibrations for dirn,pressure and temperature were all noisy and as a result it was necessary to replace a significant number of items on this instrument.

ACM 6225:

All nuts check tightened
Encoder replaced by serviceable spare (ex RVS)
New encoder cap fitted
Rotary switch cleaned and adjusted
New recording head fitted
New drive wire and pinch wheel fitted

ACM 5205:

All nuts check tightened
Motor replaced by serviceable spare (ex RVS)
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch roller fitted

ACM 7401:

All nuts check tightened
New encoder cap fitted
Encoder cleaned and adjusted
New rotary switch fitted and adjusted
New drive wire,pinch wheel and upper spool fitted.

ACM 6867:

All nuts check tightened
Encoder replaced by serviceable spare (ex RVS)
New encoder cap fitted
Rotary switch cleaned and adjusted
New drive wire and pinch roller fitted

ACM 7948

All nuts check tightened
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch roller fitted
New rotor arch fitted

ACM 1260:

All nuts check tightened
Motor replaced by serviceable spare (ex RVS)
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New upper and lower spool holders fitted
New drive wire and pinch wheel fitted

ACM 7943:

All nuts check tightened
Encoder cap replaced.Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch wheel fitted
New case

ACM 3727:

All nuts check tightened
Encoder cap replaced.Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch wheel fitted
New rotor arch and guard

ACM 3624:

All nuts check tightened
Encoder cleaned and adjusted
New ratchet wheel fitted
Rotary switch cleaned and adjusted.

ACM 6372:

All nuts check tightened
Encoder replaced by serviceable spare(EX RVS)
Rotary switch cleaned and adjusted

New drive wire and pinch wheel fitted
New thermistor fitted (incorrect range during tcal)

ACM 8011:

All nuts check tightened
New electronics board fitted (erratic values ch 1&2)
New encoder fitted
Rotary switch cleaned and adjusted
New drive wire and pinch wheel fitted.

ACM 4738:

All nuts check tightened
Encoder brush and cap replaced.Encoder adjusted
Rotary switch cleaned and adjusted
New pinch wheel and drive wire fitted

ACM 2107:

All nuts check tightened
Motor replaced
Encoder cap repleced encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New recording head fitted
New lower spool holder fitted
New rotor arch fitted
Drive wire and pinch wheel fitted

ACM 2406:

All nuts check tightened
Electronics board replaced with serviceable spare
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch wheel fitted

ACM 2109:

Rebuilt totally from spares following flooding

T.L 806

All nuts check tightened
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch wheel fitted

T.L 879

All nuts check tightened
Encoder cleaned and adjusted
Rotary switch cleaned and adjusted
New drive wire and pinch wheel fitted

SWINDEX Technical File

ANNEX 2 Aanderaa Calibration Methods

K.M Goy

Index

2.1 Temperature Calibration Methods Facilities

Temperature calibration facilities for recording current meters at IOSDL are housed in a refrigerated cold room,the temperature, of which, can be controlled within the range -30°c to +15°c.

The room contains a water bath with thermo-static adjustment by a mercury and glass thermometer switch controlling heating and cooling sources. The cooling source is an air cooled condensation unit with an 18 inch evaporator coil cooling a small water/antifreeze bath. The contents of this bath are pumped on demand through cooling coils located around the inside of the main bath. The heat source is a Bunting Electric 3 kw immersion heater. Both heating and cooling controls have fine and course settings the latter primarily to adjust the temperature rapidly between calibration points.

To provide greater temperature stability, a smaller bath is located within the large bath to house the instruments during calibration, water within both the inner and outer bath is continuously circulated using Charles Austin centrifugal liquid pumps. The small inner bath is modified to house either ACMs or thermistor pods of the thermistor chains. The temperature of this bath is measured using a calibrated resistance thermometer inputted to an ASL F25 bridge.

ACM output bit values are monitored by one of twelve electrical connectors connected to the printer 2860 via a 12 position rotary selector switch.

Preparation

ACMS:

ACMS are normally calibrated three at a time when fine temperature calibrations are required. Instruments are fitted with serviceable batteries, set to manual start for the RCM7/8 or 180 mins for the RCM 4/5 and switched on

The instruments are totally immersed in the inner calibration bath so that thermistors are in close proximity to each other and the platinum resistance probe of the F25

Calibrations are made on the cooling cycle. Six readings are taken within the temperature range of channel 4, with the upper and lower points within 0.5 °c of the range minimum and maximum.The following method was used for each datum point.

The tank thermometer was set to the required tank temperature and the coarse setting on the temperature control panel used to lower the temperature to this value. The room temperature thermostat was also set to this temperature.

Once the required temperature had been achieved the tank cooling control was switched to the fine setting, the inner bath pump was switched on and the tank was left to equilibriate for not less than one hour.

When the F25 temperature remained stable within 1 milli degree the bit values for channels 2 and 4 for each instrument were noted and also the F25 temperature.
All channels were observed for correct operation.
The procedure was repeated for each of the six temperature points.

Thermistor Loggers.and chains.

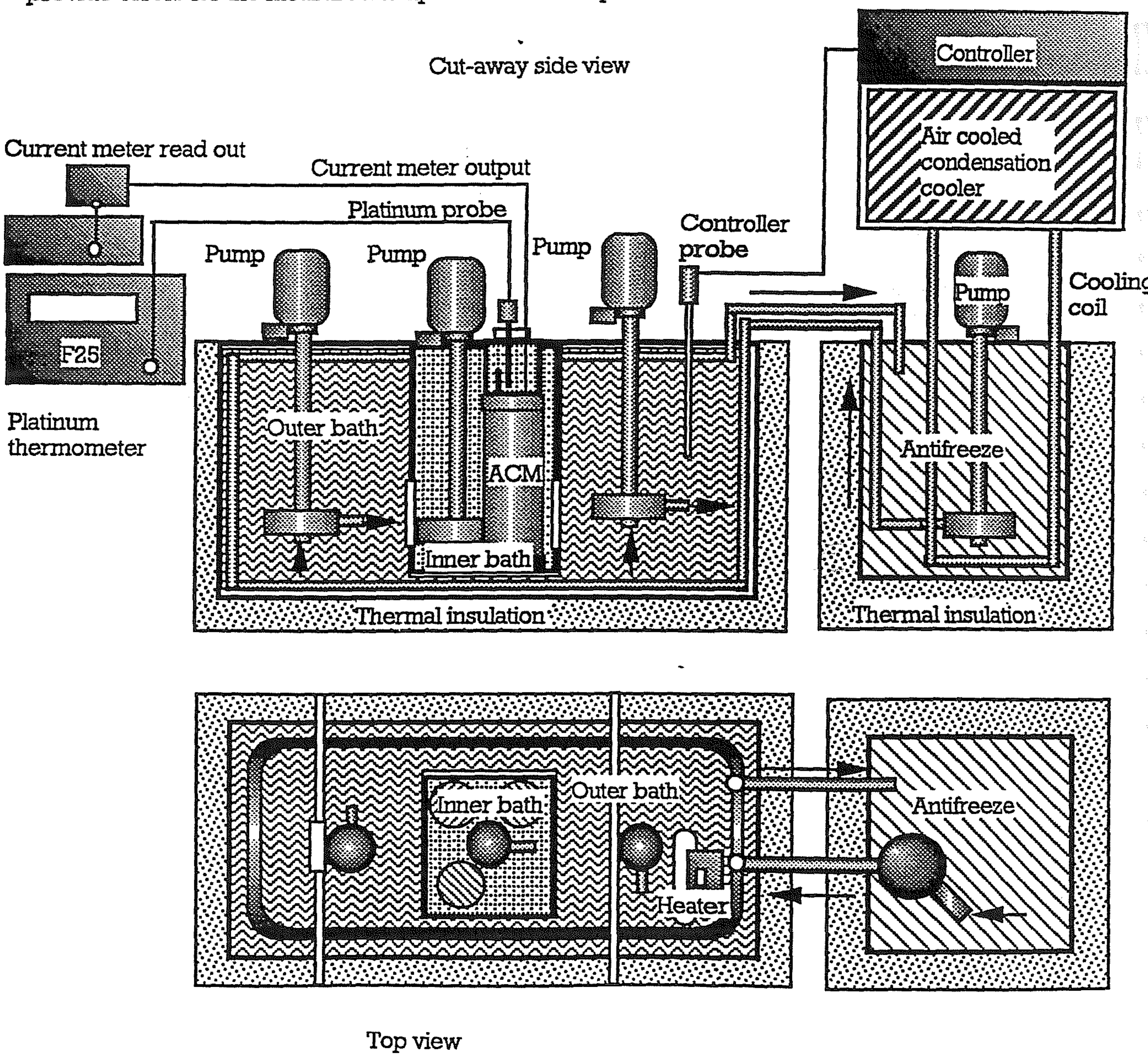
Because of the large volume, thermistor chains are calibrated with the chain and logger totally immersed in the outer bath. The thermistor pods are housed in the inner bath with each individual pod positioned horizontally within the bath and the whole stacked vertically to allow free water flow between them.

The calibration procedure is identical to that of the current meters except that space permits the calibration of only one set at the time..

The bit value of channels 2 to 12 were noted at each temperature point also the F25 temp

Results

Results are displayed in tabular and graphical form for temperature and bit value. A linear regression is carried out to determine the line slope and intercept and this is applied to provide errors for the measured temperature at each point .



Temperature Calibration system

2.2 Compass Calibration Method

Facilities

Compass calibrations at IOSDL are performed in a wooden hut, sited well away from any extraneous magnetic influences. The hut houses a compass table, the lower section of which is graduated in degrees. The upper part, which can be rotated, has an adaptor which enables the current meter to be located centrally on the table.

Preparation

Prior to the calibration, the compass table reference is aligned with geomagnetic North by attaching a North seeking sighting compass onto its lower section and rotating the table on its mounting until the compass indicates North.

RCM 7/8 Current meters fitted lithium cells were calibrated with a dedicated cell.

RCM7/8 current meters with a vector averaging facility had this facility disabled by connecting pins 20 and 22 together

Method

With the compass table at 0 degrees, the current meter is aligned so that the orientation block points north.

The current meter is rotated through 360 degrees with readings taken every 60 degrees.The offset of the mean errors from 0 are determined and, if necessary, the current meter compass realigned to correct this.

The RCM is then calibrated by rotating the table clockwise in 10° steps from 0° through 360° taking the compass bit values at each step. Compass bit values about the position of the dead band, the region where the compass values change from 1023 to 0.were also taken. Check values at the four cardinal points were obtained rotating the table anti-clockwise.

Aanderaa RCM's post serial no. 10168 have a modified rotor counter rotor type 3240 incorporating a magnetically operated switch triggered directly by the rotor magnet. This reduces the magnetic friction resulting in a lower rotor threshold. It was found during calibrations that the rotor magnet's field had an influence on the compass readings at low current speeds. This effect was negated by using a weight and pulley system to turn the rotor at an equivalent current speed of 1 ms^{-1} whilst the readings were being taken.

Results

The results of the calibration are displayed in tabular form showing the magnetic bearing, the bit reading at that bearing, the bit value expected from a 'perfect' compass for that bearing and the difference between the reading and the perfect value. The information is also presented graphically as the difference versus the bearing, the difference is given in 'error bits'.

Lithium Batteries: Magnetic effects on RCM7/8 compass calibrations.

Information from John Read (MAFF) suggested that the Lithium batteries supplied by AIM marketing were causing large errors in the compass calibrations on Aanderaa RCM7/8 instuments.

A compass calibration on ACM 9587 was carried out , using a Leclanche cell and the calibration compared with a comparitive calibration carried out with ACM 9587 fitted with a Lithium cell picked at random from the 35 delivered. The results showed large errors predominantly in the North / South axis.

Further calibrations on ACM 9587 , at the four cardinal points , were carried out using five Lithium batterie packs picked at random and a Leclanche cell as a control.

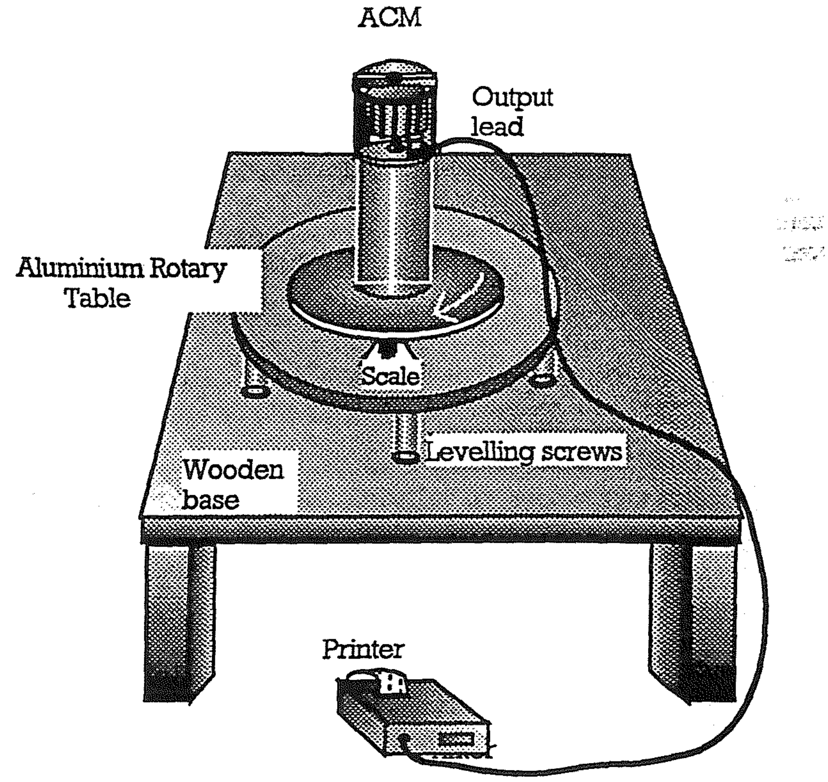
The results indicated large errors with the Lithium cells and variation in errors between individual cells.

It was found that by raising the height of the cell by approx 1 inch most of the errors could be eliminated.

All cells were returned to AIM marketing for modification to increase the cell height by 1 inch.

Recalibration was carried out on four of the modified cells (lithium 2 was missing),the results show a considerable improvement to the errors obtained and the variation in errors between cells.

As a precaution,the conductivity calibration was rechecked with the lithium cell and no significant change was found .



Compass Calibration table

2.3 Rotor calibration method

Facilities

RCM rotor calibrations at IOSDL are performed in a 40 meter wave tank fitted with an hydraulically driven, rail mounted carriage.The carriage moves along the rails at a measured speed, with the RCM suspended below at a depth of 1 m below the water surface.The carriage speed and rotor revolutions are inputted into a Mowlem Micro system autonomous data acquisition unit and processed to provide mean and RMS values of carriage speed and rotor revolutions.s^{-1}.

Preparation

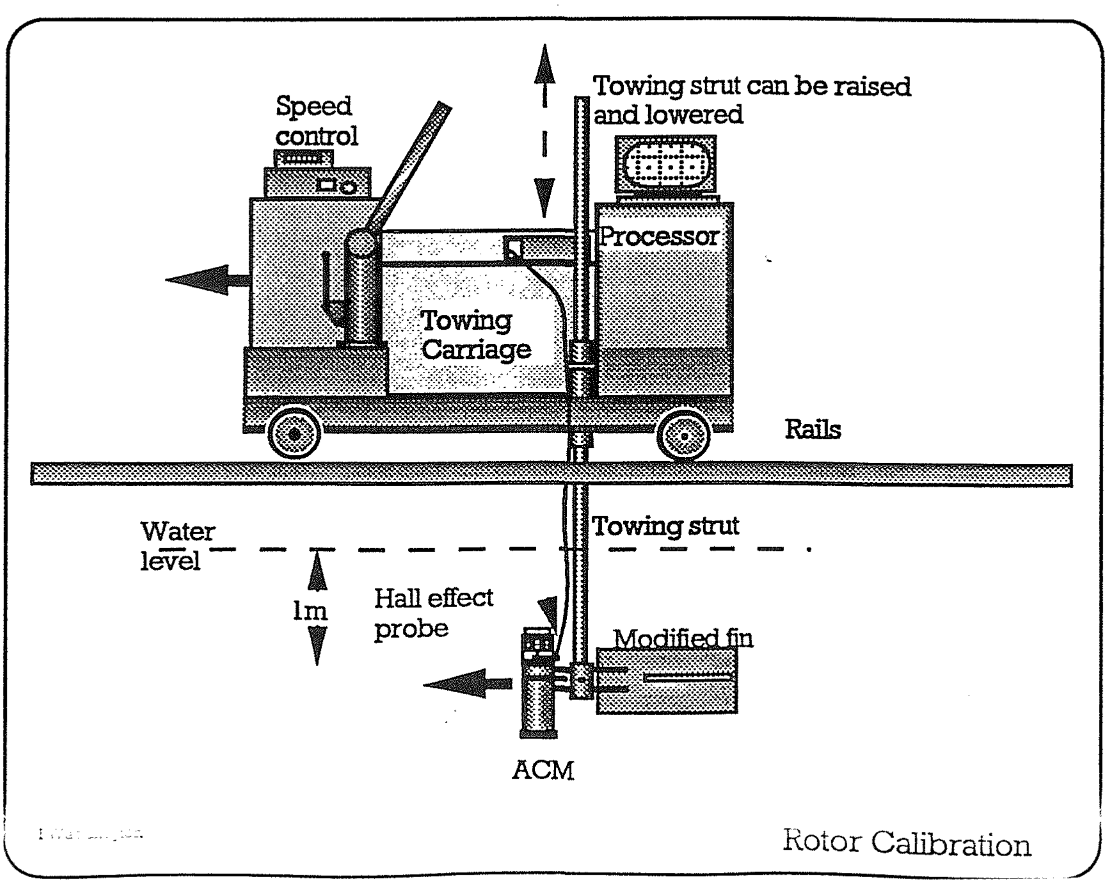
A Hall effect probe is attached to the RCM top cap to sense the revolutions of the rotor magnet. The RCM is attached to the carriage by a 4m long pole modified to accommodate a standard Aanderaa spindle housing and fin assembly. The pole is lowered to a preset stop and the current meter aligned in the direction of the initial carriage direction.

Method

Runs are made at carriage speeds of approximately 200, 400, 600, 800 and 1000 mm/sec. At the extremities of the tank, when the carriage direction is reversed time is allowed for motion generated currents within the tank to disperse before the calibration continues..Each run is timed over eleven rotor counts, on completion of which the ADU calculates and records the mean and RMS values of carriage speed and rotor revolutions/sec. On completion of the runs the threshold of the rotor is determined by increasing the carriage speed from standstill until the rotor just begins to rotate.

Results

Results of mean carriage speed and rotor revs/sec are transferred to a Mackintosh based Cricket Graph package and displayed graphically.



2.4 Conductivity 'Calibration' Method:

It was decided that, because of the accuracy of the conductivity measurements required for the experiment, calibration of the conductivity sensors could be adequately achieved using a Vishay resistance box.

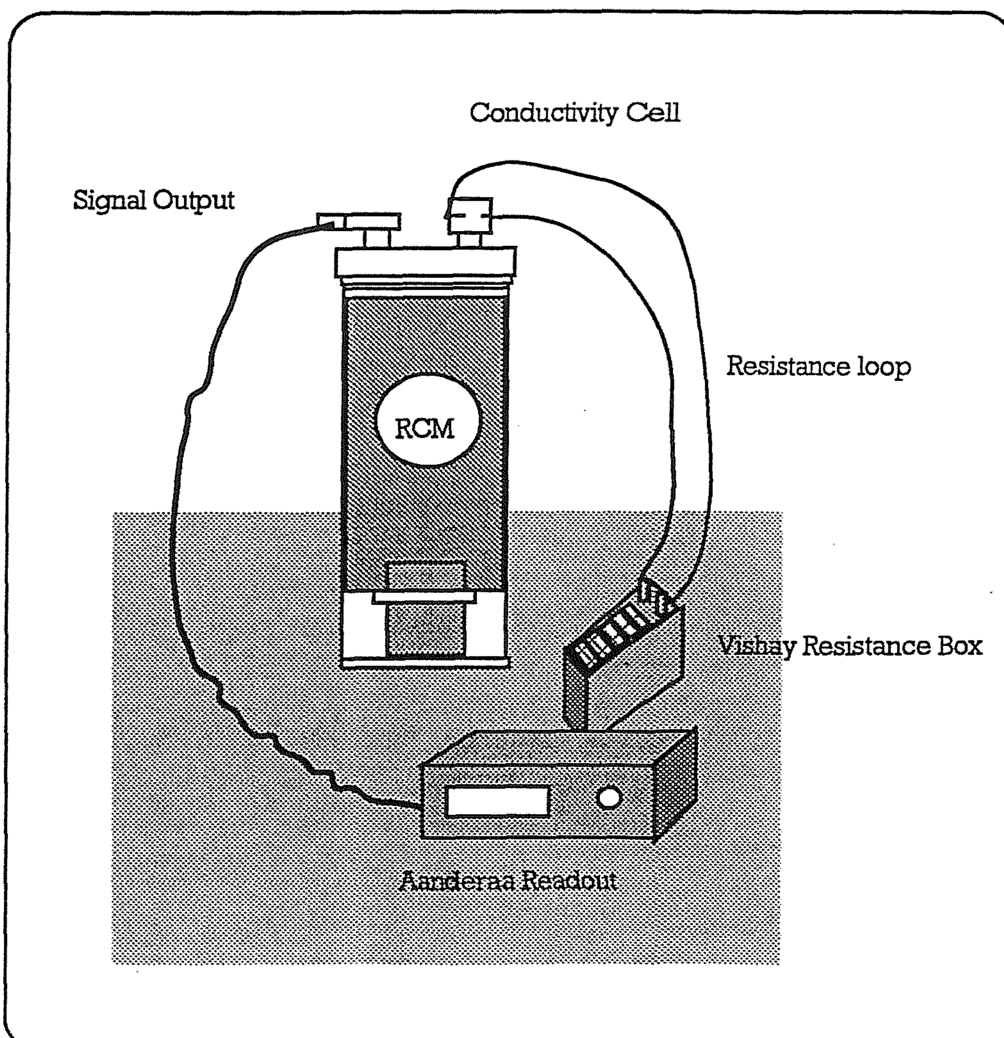
Method

The vishay resistance box is connected as a resistive input via a single loop of wire passing through the centre of the conductivity sensor.It was previously determined that a resistance range of 74 - 94 ohms gavè a conductivity range of 39.86486 - 31.38298 mmhos/cm-1 at a cell factor of 2.95 +/- 0.5 cm-1. The resistive input is adjusted in 2 ohm steps and the bit value of the conductivity channel noted at each step

Results

Results are displayed in both tabular and graphical form showing conductivity value and corresponding bit value. A linear regression is carried out to provide a slope and intercept for the graph. Error bars are plotted to reflect the uncertainty in the form factor of the conductivity cell.

Conductivity Calibration



2.5 Pressure calibration Method

Facilities

The pressure calibration facility is located in the main laboratory and comprises a Budenberg 10543/280L Deadweight tester

Preparation

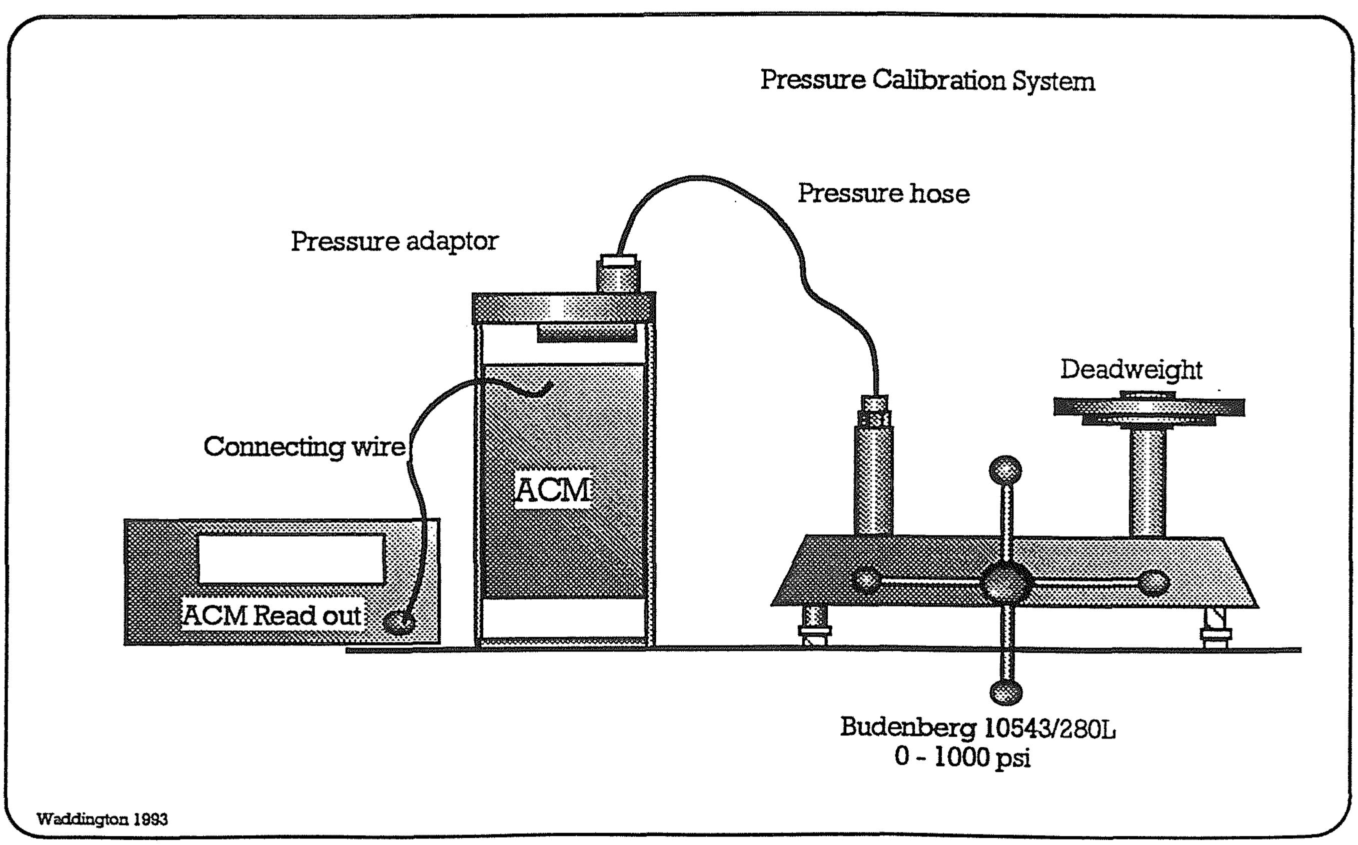
The current meter is switched on, and the pressure hose output from the Budenberg is connected to pressure sensor via an adaptor developed at IOSDL.

The pressure is increased from 0 psi, ambient air, through the pressure sensor range in steps sufficient to give 10 approximately evenly spaced spot values.At each point the reading is taken with the piston of the dead weight tester rotating slowly in order to eliminate stiction. The ACM bit value of the pressure channel is recorded on the printer 2860 over four cycles to ensure the system has stabilised.

Readings are taken at the points on both increasing and decreasing pressure calibration cycles to ensure there are no significant hysteresis effects.

Results

Results are displayed in tabular and graphical form for pressure and bit value. A linear regression is carried out to determine the line slope and interface and these are applied to provide errors for the measured pressure at each point



SWINDEX Technical File

ANNEX 3 Report onTesting and Methods for SWINDEX - ADOX Operations

I Waddington

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Report on testing and methods for SWINDEX/ADOX Mooring Operations.

I Waddington IOSDL 8th April 1992.

Charles Darwin Cr 66

The Moorings specified by IOSDL for PML and provided by RVS are to a very similar specification to the SWINDEX ,ADOX moorings for 1993.The opportunity was taken to test revised methods and materials on the cruise for use onboard RRS Discovery CR 200 and 201.

Equipment and Methods Testing

Longterm jacket wire for SWINDEX 1993.

The wire specified for SWINDEX was also to be used on the long term moorings for PML .RVS procured all the wire for PML to IOSDL specifications from Midland Wire Cordage Ltd.This gave IOSDL an opportunity to test and observe the material and handling of in field conditions.

Specification.

6mm dia 7x19 Galvanised Steel Wire Rope,Preformed,Tensile 1770N/M2 to BS 302/1987 impregnated with Blue Polypropylene to 8mm OD.

Terminations to IOSDL specification type MW 12-12-91.

The heat shrink boots specified AMH 1-727120-2 were not fitted due to long lead time on order,a substitute material RS 399-748 was used.

Handling.

The wire was reeled from suppliers drums onto the DBC storage winch under hand tension through the double barrels prior to deployment.Each connection was protected by parcelling with cloth along the whole length of the boots and shackles.The cloth used was ships rags as no canvass was available,this was adequate but the wire did become snagged on shackle pins on two occasions due to the cloth not adequately smoothing over these pins.Damage was caused on the first occasion to the jacket exposing the wire.This was repaired ,whilst under tension,by degreasing the area of damage and coating with Dow Corning Silastoseal overlaid with two layers of Telcohesive Self vulcanising tape and two layers of 3M 88 black insulating tape.

Short wire lengths handled on deck whilst deploying the subsurface sphere proved quite awkward due to their tendency to reform coils.These lengths were 20m and by stretching the line up the deck in a long loop controlled by two people the line could be kept relatively straight.

Substantial canvas protection is essential at mooring line joints when wound onto the winch.

Load testing.
The moorings were all deployed under low load buoy first methods.However moorings were towed onto position and the wire proved adequate in sea states up to Force 8.As this configuration was similar to the proposed SWINDEX applications no further load trials were made.

Abrasion Resistance.
During towing the wire was subjected to abrasion on the ships deck where the deck is rounded over to the stern.No damage was noted during a 20 minute period.However it is reccomended that the wire is either protected by canvas or held off the deck during towing.

Terminations.
The terminations and heat shrink boots gave no cause for concern.The terminals freely rotated around the winch barrels with no damage to the boots.

Line lengths.
Due to design requirement for on site mooring adjustment there were more terminations on the storage winch than was desirable.This caused slack turns when deploying and on the two occasions outlined above was partly responsible for wire damage.
The IOSDL modifed "large" drum type was used on the RVS storage winch giving a capacity of 2500m of wire with up to 12 mooring terminations.

Reevable in line links.
The type used by RVS were the CROSBY 1/2" Galvanised type.These are considerably larger than the IOSDL specified type and were used to improve "stopping off".However due to this increased size,capacity of winch was decreased and when stopping off the lower shackle was always used,yielding no significant advantage from the increased fitting size.

Shackles.
The shackles were supplied to RVS from IOSDL stores and were of the William Hankey 1/2" BS Dee type specified.On previous occasions problems have been encountered on thread and pin tightness causing the shackle to be difficult to unscrew.This had been pointed out to the manufacturer and the majority of the shackles from this batch were easy to unscrew.All the shackle pins were greased with BP High pressure grease before use.

Deployment Methods.

As a trial for SWINDEX the EFFER cranes fitted onto the Darwin aft were used to support the mooring deployment sheaves.
Previous deployments have all used the main A frame,with a sheave supported at mid height from a chain,guyed off to each side with lines or wires.This method although adequate has always caused problems when deploying buoy first due to the A frame being incapable of moving the sheave far enough inboard for instrument insertion and the necessity in this case to support the sheave 4m above deck height.

The EFFER cranes rated at 2 tonnes+ provide adequate strength to support a buoy first deployment and have the advantage that they can be adjusted to suit most instrument configurations.Succesfull deployments were made with instrument/buoyancy configurations up to 4m in length with no instrument being damaged on the stern.

Video log.

A video was taken of operations as a visual reference to illustrate all parts of the operation.This will be copiled and editted into more useful format.

Deployment of buoyancy.

The operations required several types of buoyancy to be deployed,steel spheres and glass sphere clusters on chains.
Steel spheres were deployed using the A frame and Rexroth winch.
Glass spheres using the DBC and EFFER crane.
Both methods proved suitable for our operations on ADOX and SWINDEX.

Stopping off.

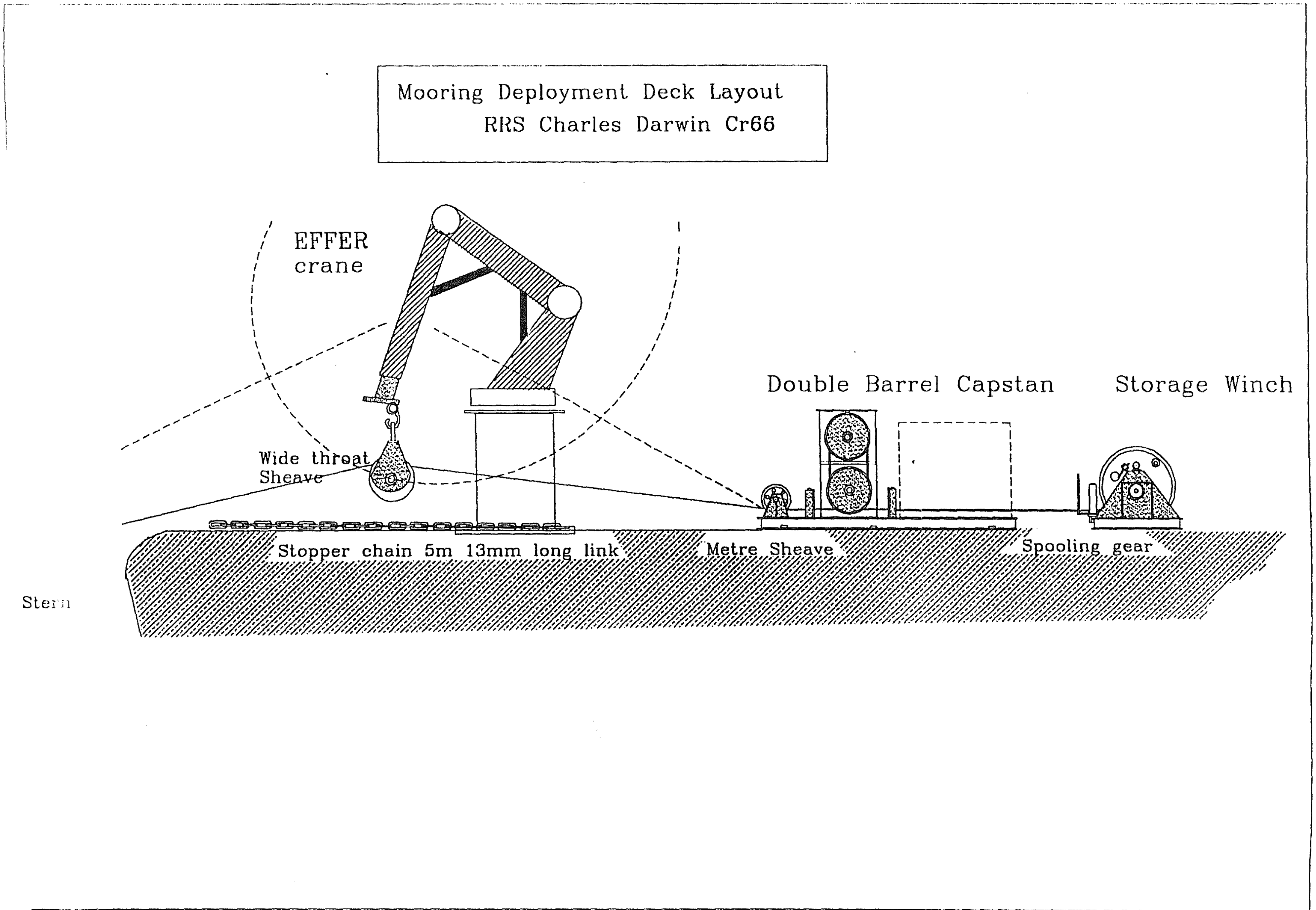
Stopping off is achieved by using a 5m length of chain attached along the deck from the deck matrix to the stern.The sheave can be brought inboard by the EFFER and lowered near to the deck for chain insertion by BOSS S6 hook.The load then being transferred to the chain by winch payout.
To increase the flexibility of stopping off the BOSS hook was shackled to another BOSS such that the hook could be easily moved along the chain for various instrument configurations.

Towing/Anchor transfer.

The anchor was always hung over the quarter from a cut off line at commencement of operations.A riser chain 10m in length could then be lead onto the working deck around the quarter and secured ready for attachment.

When transferring from the mooring line to the anchor chain the mooring line was secured to the stopper by a strong polypropylene strop 20mmx0.5m.This permits the anchor chain to be inserted whilst the mooring is secure at deck level.
Should towing be required a chain security is added between the stopper chain and the mooring wire,this is placed such that should the cut off line fail the mooring is retained by the chain.
To transfer to the anchor the chain security is removed and the polypropylene strop cut through.Thus the load transfers to the anchor cut off line ready for anchor free fall.

When towing,the stopper chain can be lifted off the deck by EFFER crane to allow the mooring line to be clear of the deck.Care must be taken at this point that the crane is not overloaded, the extension should be minimised.


Mooring Deployment Deck Layout
RRS Charles Darwin Cr66
EFFER
crane
Double Barrel Capstan
Storage Winch
Wide throat
Sheave
Stopper chain 5m 13mm long link
Metre Sheave
Spooling gear
Stern

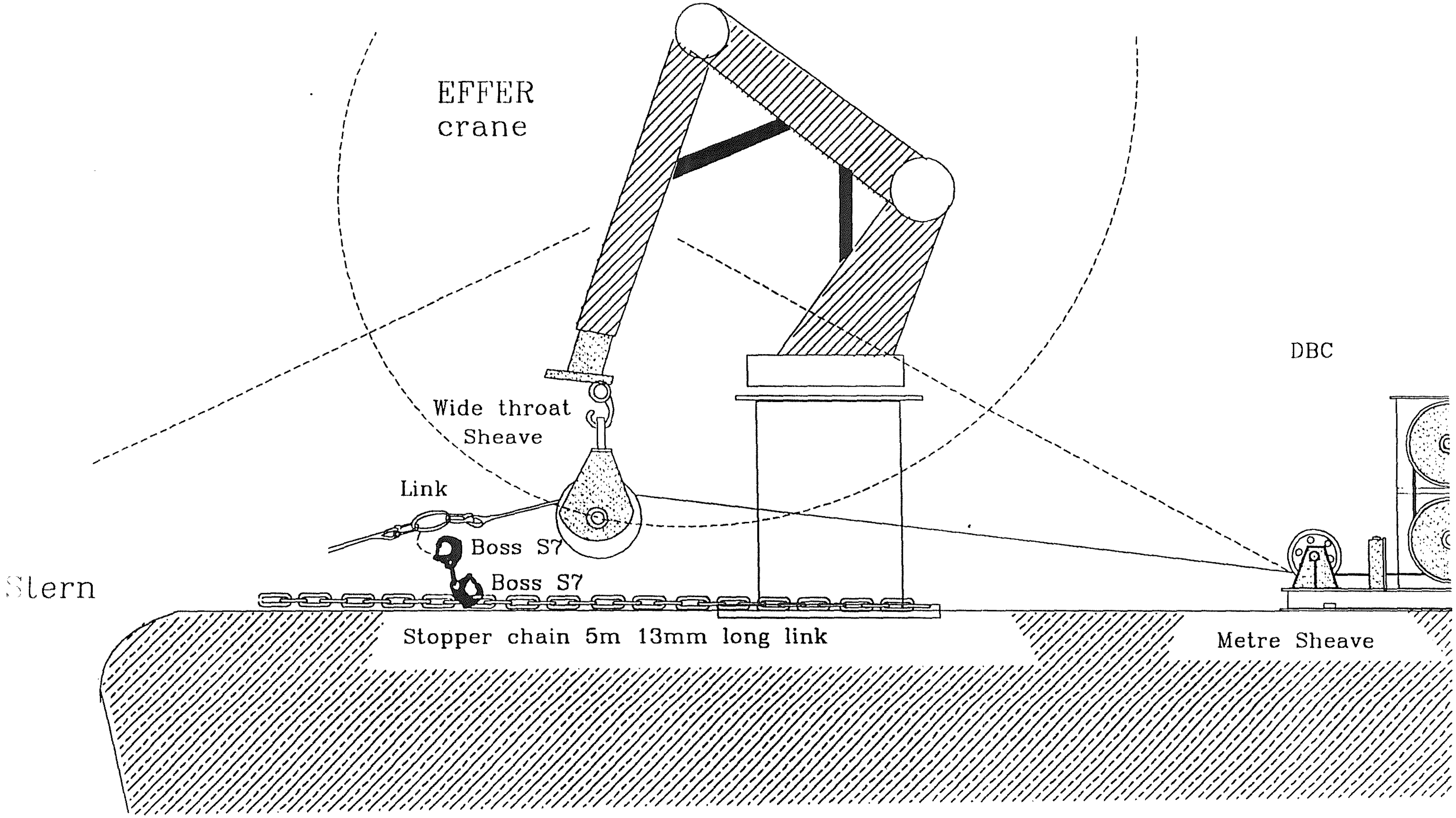
Bad weather Deployments.

We were fortunate that we had bad weather on the very edge of workable conditions(F8) with which to test all the above methods.No modifications are necessary to the methods in so far as all personnel are experienced in the type of operation.
For Southern Ocean deployments it is reccomended that adequate strong life line wires are attached fore and aft along the working deck at 1m height for personnel to clip on safety harnesses and also a chain along the deck secured to the matrix to allow personnel to clip to when stopping off for instruments.We did use eye bolts but these proved awkward when moving about on the deck as there is a possibility of tripping over and of fouling equipment.
The crane driver is very exposed on the Darwin and if the situation is similar on Discovery then he should be adequately protected or be brought down onto deck between operations.

Communications.
All communication was by VHF hand held transceiver working Channel 17.This was adequate and was controlled by a deck officer to the bridge.I suggest that the Scientific officer responsible for logging all activities should likewise be in contact with the laboratory and bridge for depth and position recording.It is not always possible to get the information on depth as required.
We operated 5 sets onboard which were adequate for all operations.However the scientific personnel did leave the units on when not in use and communications failures could occur.
In cold weather remote microphones may be beneficial.

Winching.
The RVS DBC was used throughout and was ideally suited to the operation being perfectly controlled and relative quiet in operation,allowing good communication between winch driver and deck controller.I would suggest that this type is the most suited for the Southern Ocean on two points.
1.Communication.IOSDL has a DBC which is diesel driven and consequently noisy,instructions must be by hand signal and from previous experience with this winch over a 3 to 4 hour period the noise can cause loss of concentration.VHF communication is poor due to the background noise level.
IOSDL has the old Discovery system which if it can be modified to run off the ships hydraulics will give quiet operation.
2.Diesel fuel freezing and hydraulic oil low temperature operation.We would have to carry sufficient low temperature diesel fuel in drums which would have to be pumped into the winch fuel tank and drums securely stowed.This is no problem with the RVS system and should be no problem with a modified old Discovery system.

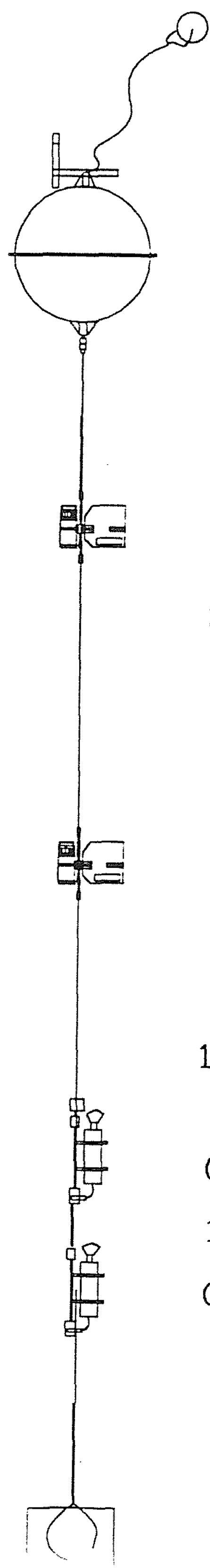
A single RVS storage winch was used which could have been improved with the addition of a second system.This can be available for Southern Ocean operations.This will give the benefit of prewound moorings being easily interchanged or of using two drums to reduce the quantity of wire on each drum.



Mooring Deployment Deck Layout
RRS Charles Darwin Cr66

Mooring 140 Morrocan Slope

34 07.33N 08 07.29W 1100m depth Day 82 1992



SWINDEX Technical File

ANNEX 4 Double Barrel Capstan Winch

R.N.Bonner

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4.1 . History and Rationale

RRS Discovery was withdrawn from service in late 1990 at which time IOSDL operated two Double Barrel Capstan winches (DBC)for mooring operations . One of which was permanently fitted to the fore deck of Discovery , the other being a portable unit maintained at IOSDL . RVS also had a portable DBC maintained at RVS .

The portable IOSDL DBC was manufactured by Vickers in 1975 .and was diesel - hydraulically powered . The ship fitted unit manufactured by LEBUS in 1978 was powered by a ship fitted electro - hydraulic power pack .

In Spring 1992 an assessment of the winching situation was undertaken for the SWINDEX experiment . This assessment reveled that the IOSDL portable although in working order used many parts for which essential sea going spares were now unavailable and to meet current lifting requirements the unit required fitting of mechanical brakes .
The formerly ship mounted unit was at RVS requiring considerable refurbishment and had no power pack , as this was ship fitted .
The RVS DBC was committed to several cruises throughout the ADOX and SWINDEX operational phases .

Thus for mooring operations throughout the NERC community only one winch could be considered a working unit .

It was therefore decided to utilise the parts of the two IOSDL systems to construct one portable unit .

This could be achieved by :-

1. Overhauling the DBC from Discovery . This unit was fitted with brakes to the lifting requirements but required major refurbishment .

2. Retaining the base unit from the IOSDL portable winch , as compatible with the deck matrices of Discovery and Charles Darwin . This to have 1 above mouted onto it .

3. Purchasing a new electo - hydraulic power pack compatible with ships supplies or poratble generators and fitting this to 2 above .

4.2 Replacement and overhaul of DBC

The LEBUS unit was brought back from RVS to IOSDL and completely stripped down with all parts inspected , refurbished or replaced . Units being replaced were drive shaft seals , and some brake actuator parts which had been damaged by sea water ingress . In the light of this sea water damage inspection panels were remanufactured with improved seals .

The Vickers unit was removed from the base unit and scrapped . the base unit being drilled to accept the LEBUS unit and the base then being paint stripped , rust treated and painted .

The rebuilt Lebus unit was fitted to the refurbished base and sent to LEBUS for fitting of an electro - hydraulic power pack and control system of their design .

4.3 Power Pack

The power pack is constructed with an electric motor mounted on top of the oil reservoir with drive coupled pumps underneath within the reservoir immersed in the oil . The main pump is a swash plate type driving the capstan drums with a smaller vane pump powering the reeler winches . The pumps immersed in the reservoir are thus protected from the marine environment with minimal external piping .

Winch controls and oil filters are mounted on top of the reservoir at a convenient position for the winch operator .

4.4 Acceptance tests

Acceptance tests were carried out at LEBUS and were witnessed by IOSDL and RVS staff .

1.Lifting lugs load test .

Due to the change from diesel to electrical drives and configuration changes relating to this , the lifting lugs had to be repositioned by LEBUS and the former four positon lifting was modified to three position . The operating weight of the winch is 3.6 tonnes and by placing weights on the the base the lugs were tested to just over 50% overload at 5.6 tonnes total weight . This trial was completed and IOSDL undertook to manufacture tested steel wire slings for operational use .

2.Relief valve settings .

The relief valves in the capstan and reeler hydraulic circuits control the maximum amount of pressure , hence torque , available to each unit .

For the test the drums of each unit were locked by the brakes , then the control valves opened to make the pumps work against the closed circuit . The pressure gauges were then checked and the relief valve noted to open at 225 bar and 69 bar respectively .

3.Speed control

For mooring operations an important safety factor is fine and precise control of winch speed .

The winch was tested to simulate mooring operations with the system hauled and veered at various speeds to ensure correct control .

4. Proof line pull

The winch is rated at 1.5 tonnes safe working load . Regulations state that testing should be carried out to 25% overload .The winch was test loaded to 2 tonnes ,in excess of the 25% by connecting the winch wire to a fixed point with an in line dynamometer . The load was then inched to 2 tonnes on two pulls .

5. Static brake

The lifting plant regulations specify that brakes should be capable of holding the proof load weight used when establishing the SWL , .in this case 2 tonnes .
The winch capstan drum brakes are spring loaded and stay on until the winch is hauled or veered , thus providing automatic braking when the winch is stopped .

This test was carried out at IOSDL using 2 tonnes of chain which was hauled by winch vertically to a sheave suspended on a crane . The load was raised and lowered whilst the brakes were adjusted to give the correct braking effect . With the brakes correctly adjusted the load was raised and held on load for five minutes with no detectable 'creep ' on the drums .

4.5 Operation at sea

The winch was shipped to Cape Town and fitted to the Discovery by IOSDL and RVS staff for the ADOX and SWINDEX experiments . Throughout these cruises the winch operated very well with only the cold temperature near the ice edge cooling the hydraulic oil between operations such that starting the electric power pack was difficult . This was due to the oil viscousity increasing and causing the motor to demand more current than the electric breaker was set up to provide . This was overcome by running the power pack on a regular basis to keep the oil warmed through .

4.6 Post cruise modifications

A n electrical tank heater was fitted to maintain the oil temperature at 20 C and lagging installed around the oil reservoir to reduce heat loss . Minor repositioning of sheaves and winches to new base plates were made to improve the positioning of wire lead and winch positioning options .

SPECIFICATIONS

HYDRAULIC POWER UNIT

Hydraulic Oils	Shell Tellus 37 or ISO32 equivalent mineral oil.
Electric Motor	ABB 415v 3 phase 22 kw to IP65 specification with star delta starter.
DBC Hydraulic Pump	Hagglund Denison PV29-1R1B-TO2 Axial piston pump.
Maximum system pressure	225 bar / 3300 psi.
Reeling winch pump	Hagglund Denison TC6R-003-1R00-C42-A1 Vane pump coupled to main pump.
Maximum system pressure	75 bar / 1100 psi.

DOUBLE BARREL CAPSTAN

SWL	1500 kg
Proof Load	2000 kg

Maximum load on winch with locking levers engaged. 4000 kg.
Weight of DBC and Power unit assembly on base. 3600 kg.
Hydraulic Motors. Staff D060.
Maximum motor working pressure. 289 bar/4250 psi.
Maximum torque at 225 bar. 3391 Nm/2500 ft/lbs.
Maximum haul rate at 1000 kg load. 1.3 m/sec.
Brake unit. Staffa F100 with S11 actuators.

REELING WINCH

Maximum load on winch with brakes applied. 1000 kg.
Weight of winch with drum fitted. 550 kg.
Hydraulic Motor as fitted. TRW MAB710-0190-320
Hydraulic Motor new spare units. TRW MB730-0190-320
Maximum working pressure. 140 bar/2000 psi.

HYDRAULIC CIRCUIT DESCRIPTION

DBC circuit

Oil is drawn from the tank through the suction filter 3 by the axial piston pump 8, passes through the pressure filter 20 and arrives at the directional control valve 19. When this valve is in the neutral position, the oil flows from this point back to the tank via the oil cooler 21 and return line filter 22. In this position the pressure and return lines to the motor are both connected to the tank.

The directional control valve 19 is a proportional valve, providing more flow the further it is opened. Also built into this valve is a check valve and the main pressure relief valve set at 225 bar. This relief valve is situated alongside the operating lever and can be easily adjusted or removed as a cartridge for inspection.

When the directional control valve is opened, oil from the pump passes through a check valve on the input side of the counterbalance valve 18 to the motor, and simultaneously via a two way check valve within it, provides oil to release the brakes. As soon as the pressure ratio between the input and return side of the winch motor is correct, the return side of the counterbalance valve will open allowing the motors to turn.

The axial piston pump 8 is fitted with a Power Limiter to prevent overloading the electrical supply available, and is set at a maximum of 22 Kw. As the load increases and the winch reaches this power limitation, the Power Limiter continues to increase the pressure required to control the load up to the relief valve setting, and proportionally reduces the flow available to stay within the power limit.

Reeling Winch circuit

Oil is drawn from the tank through the suction filter 4 by the vane pump 7. It then passes through the pressure filter 12 and arrives at the two-position detent directional control valve 13. When this valve is in the neutral position, oil from the pump passes through it and back to the tank via the oil cooler 21 and return filter 22. In this position the pressure and return sides of the motor 16 are also connected to tank, allowing the drum to be rotated by hand when the brake is released. Also built into this valve is a check valve and relief valve set at 75 bar/1100 psi. This relief valve is alongside the operating lever and can be easily adjusted or removed as a cartridge for inspection.

When the directional control valve is set to tension, oil pressurises one side of the motor. This pressure is controlled by the operator and is set by turning the handwheel controlling relief valve 15. Pressure to the motor can be varied from 0-1100 psi, the maximum setting governed by the other relief valve built into the directional control valve. When working, the minimal pressure for adequately tensioning the winch will be around 800 psi, and as the storage drum fills up, pressure will need to increase towards the maximum.

When hauling, oil will flow from the pressure line in the directional control valve, through the motor and back via the DCV cooler and return filter to tank. In the veer mode, wire being pulled off the drum drives the motor in the opposite direction, causing it to act as a pump. Oil from the vane pump cannot pass through the motor, but is relieved across relief valve 15 and provides make-up flow to prevent cavitation on the other side of the motor.

OPERATING INSTRUCTIONS

Before operating check

Motor is wired up for correct rotation.
Hydraulic oil level.
Oil cooler connected if required.
Hydraulic hoses connected to Reeling winch.
Directional valve for Reeling winch is in neutral.
Reeling winch pressure control wheel is set to zero (wound anticlockwise).
Reeling winch motor coupling is engaged.
Reeling winch brake coupling is engaged and brake applied.
Wire from Reeling winch is in guide rollers and not slack.
There is tension outboard of the DBC.
DBC drum locking levers are not engaged.

Wire run

The wire should lead from the underside of the Reeling winch drum, through its guide rollers to the bottom drum of the DBC. Four wire turns around the DBC are normally adequate, but five may be necessary if a low friction wire is in use. Provided the cant angle between the DBC drums is at its optimum setting, no adjustment of it should be necessary regardless of wire or rope sizes. Like all traction winches, tension is always necessary both inboard and outboard of the DBC to obtain drive.

To operate winch

1. Press start button on hydraulic unit and allow contactors time to engage.

2. Set Reeling winch direction control valve to tension.

3. Release band brake on Reeling Winch.

4. Slowly increase Reeling winch motor pressure to between 800 and 1000 psi, depending on amount of wire on Reeling winch drum.

5. Gently move DBC control valve lever to Haul or Veer. Speed is proportional to lever movement and load on DBC.

Changing Storage Drum whilst laying a Mooring

1. Stop off mooring overside and unshackle winch tailwire.

2. Attach separate tail rope approximately 50 metres long to tailwire under A frame and wind back through DBC until end of tail wire is at Reeling winch.

3. Reduce reeling winch pressure to zero and set Reeling winch DCV to neutral position.

4. Disconnect tailrope from tailwire and remove storage drum, leaving tailrope in place on DBC.

5. Fit new storage drum to Reeling winch and reconnect tailrope to Mooring wire.

6. Select tension on Reeling winch DCV and increase pressure to provide back tension.

7. Get overside operator to pull on tailrope under A frame as new wire is slowly fed through DBC to A frame.

8. Before continuing with mooring, ensure back tension is at adequate pressure.

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