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INTERNAL DOCUMENT No. 336

The SWALES Experiment: mooring design and implementation Technical Report 1993

I Waddington & K Goy

1994

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
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DOCUMENT DATA SHEET

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TITLE The SWALES Experiment: mooring design and implementation. Technical Report 1993.	
REFERENCE Institute of Oceanographic Sciences Deacon Laboratory, Internal Document, No. 336, unpaginated. (Unpublished manuscript)	

ABSTRACT

The design and implementation of SWALES inshore moorings: shallow water moorings deployed in Camarthen Bay to support the BD10 contract.

The design of assemblies with methodology of deployment. Contruction of a Mean Meteorology buoy.

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

KEYWORDS

ISSUING ORGANISATION

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SWALES Technical File

IOSDL Mooring design and implementation

I Waddington & K M Goy

1993

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SWALES Moorings.

Design Study.

The Mooring / Survey team was approached to provide moorings , buoys and sensors to support the SWALES experiment . The specifications were defined as to scientific criteria and sensors required .A preliminary design study was undertaken within the group . This study was to provide outline designs , costings and operational proceedures .

Site.	Camarthen Bay.	51 29.5N	04 45W.
Water depth.	50m HW 40m LAT		
Deployment.	Week of 18th October 1993.		
Recovery.	Mid December 1993		
Duration.	8 weeks		

Moorings Required.

Two sets of moorings were to be prepared . A primary set to be deployed by the RMAS Warden or other vessel and a Standby set to be stored at Pembroke should a mooring be lost during the operation . The Standby moorings were to be prepared to deployment condition requiring minor attention before deployment .

1. **Primary set.**

1. SONIC buoy Mooring.	1 off
1.2. VAESAT buoy.1m sensor with ADCP.	1 off
1.3. Directional Waverider.	1 off
1.4. Current Profile Mooring.	1 off

Items 1 to 4 are regarded as IOSDL predesigns , ie moorings of similar type deployed previously North Sea and Western Approaches.

1.1. SONIC Buoy Mooring.

The mooring was as the Trial Mooring assembled and deployed in early 1993 .

1.2. VAESAT Mooring.

This mooring design was derived from the deployments in the Southern North Sea 1991-93 .

1.3. Directional Waverider Mooring.

The mooring design is derived from the Datawell mooring specifications.

1.4. Current Profile Mooring.
Measurement of current speed , direction and temperature to be made using a subsurface mooring carrying Aanderaa RCM meters . These will be positioned to overlap with the buoy mounted ADCP measuring bins . The mooring will be subsurface in type but fitted with a surface mark for navigational purposes .

2. Back up Moorings.

2.1. Met.Buoy Mooring .	1 off
2.2. VAESAT buoy.2m sensor .	1 off.
2.3. Directional Waverider from IH .	1 off

2.1 and 2.2 Met buoy and VAESAT moorings.

These moorings are similar and will require the same anchoring . The buoys and mooring materials will require dry storage at Pembroke throughout the duration of the experiment . Access to 240v mains supply will be required to power up the buoys prior to deployment.

2.3. Directional Waverider.
This buoy is on hire from IH and should come complete with mooring.The anchor may be required and is subject to confirmation.

3. Mooring Operations Planning.

Following a visit to the RMAS Warden , 20 September 1993 , the vessel was deemed suitable to deploy all the moorings . IOSDL have deployed the VAESAT and Current buoys from similar vessels.Some technique variations can be accomodated and the Survey team will be providing engineering support for all the mooring components and Survey Team scientific instruments , both in preparation , deployment and recovery phases.

3.1Deployments.

3.1.1. SONIC buoy.and Standby Met Buoy.
The SONIC buoy has been deployed from the WARDEN on trials and the technique of streaming the buoy astern is preferred . Survey Team will provide a manually operated release hook to deploy the buoy. The anchor is to be freefall to the sea floor .

3.1.2. VAESAT buoy.and Standby VAESAT.
This buoy is considerably smaller than the SONIC but incorporates an S4 current meter in line beneath the buoy . This sensor is delicate and requires careful handling . Deployment techniques can be formalised onboard WARDEN .

3.1.3. Waverider buoy and Standby Waverider.
This simple mooring requires the buoy to be streamed astern and the anchor to be freefall on position . The buoy is sensitive to spinning and this must be avoided during deployment .

3.1.4. Current mooring.
The mooring arrangement is shown on the diagram . The mooring should be simply deployed by streaming astern with the instruments carefully handled over the stern . Deployment techniques can be formalised onboard WARDEN .

3.2. Recovery Operations.

Recoveries can be formalised nearer to recovery time.If however a premature recovery is required we should discuss this onboard the WARDEN at the deployment phase and provide a suitable set of recovery ropes at the deployment phase .

4. Items for supply by Pembroke.
Subsequent to discussion at Pembroke the supply of the heavy mooring anchors can be arranged on site.

Anchors.

4.1. SONIC buoy.	1.5 tonne Ships type anchor	1 off
4.2. VAESAT buoy.	750kg to 1 tonne Sinker type	1 off
4.3. Waverider buoy.	200kg Plough anchor	1 off

Standby.

4.4. VAESAT and Met buoys.	750kg to 1 tonne Sinker type	2 off
4.5. SONIC buoy .	1.5 tonne ships anchor	1 off
4.6. Waverider mooring .	Supplied with standby buoy .	1 off

5. IOSDL supplied items.

5.1. All mooring lines shackles etc.

5.2. Lifting strops for all buoys.

5.3. Anchors as indicated on diagrams.

6. Other IOSDL mooring requirements.

6.1. During the deployment and recovery of the Current mooring it will be necessary to deploy a light weight dunking transducer over the side to communicate with the Acoustic Releases.This is normally managed by hand with the lowering wire(5m) overside amidships.However if we have communication problems with the sea unit or have to search for the mooring,we will need to tow a 25 kg fish from amidships.This could be achieved from the Effer crane if permissible.

6.2. Handling of the acoustic release units.Thes units are acoustically triggered and when activated a burn device releases the anchor to allow the mooring to rise to the surface.This device will need to be handled with care and IOSDL will supply an expert to handle this device on deck.

7. Mooring Designs .

The designs were worked through and final designs and parts lists compiled .

7.1. SONIC Buoy Mooring Finalised Design .

The design of the mooring is by ORCINA Ltd Consulting Engineers and was commisioned by the Ocean Instrumentation Group .

The mooring will be as the Trial Mooring assembled and deployed in early 1993 . The mooring components from the Trial Mooring were thoroughly inspected on recovery and all items were in good condition . All ropes will be replaced with new items to be assembled at IOSDL . The anchor should be provided by Pembroke as per the diagram . Fig.1 SONIC Buoy Mooring.

The anchor shown is as deployed on the Trial Mooring and is a ships type of 1.5 tonne air weight . All hardware will be inspected and other than the fibre lines will be reused . The fibre lines are to be purchased and assembled at IOSDL with end fittings and special coatings applied .

SWALES SONIC Buoy Mooring.

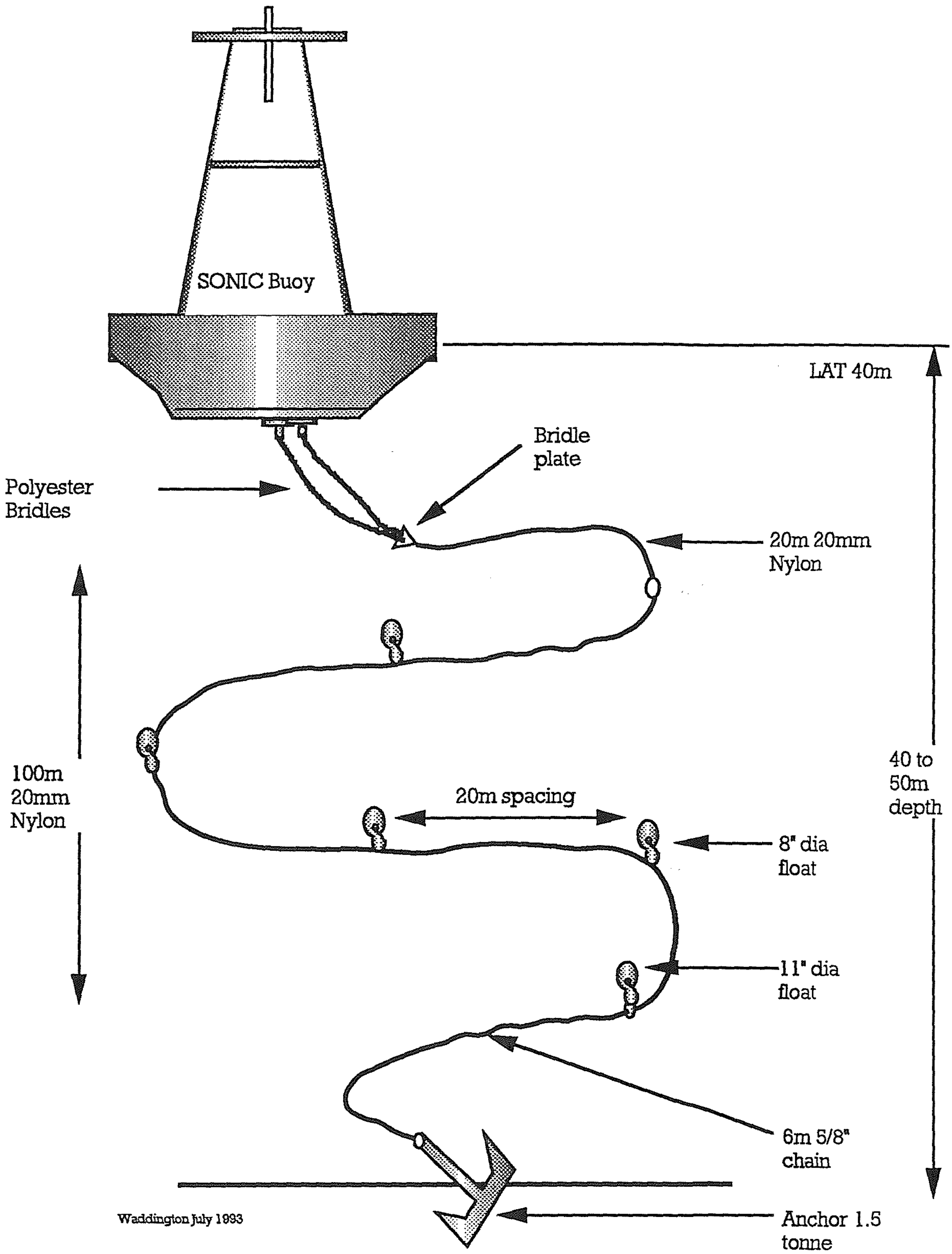


Fig 1.

7.2. VAESAT Mooring.

The mooring design is derived from the deployments in the Southern North Sea 1991-93 MAST . 0033 . C (JR) . The design is also a derivative of previous North Sea and South Western Approaches deployments and incorporates the materials and techniques developed from these deployments . All the mooring materials are to be assembled at IOSDL . The anchor can be either a ships type or clump chain anchor . Subsequent to the design outline an S4 current meter was obtained from RVS Barry replacing the EG & G 610C . This improved mooring drag and in line tensions .

The buoy is semi wave following and has a ballast chain suspended on a polyester line to provide stability . The mooring lines in this configuration have been found not to interfere with the ADCP signals .
The riser line from anchor to ballast is twice the overall water depth for storm conditions and is constructed of 8 strand polypropylene , resistant to unlaying and buoyant. It is important that the line is buoyant to prevent chafing on the sea floor . This allows the buoy to ride out severe storms without inducing violent shock loads through the line to the anchor.
The anchor is a circular 1000 kg steel sinker ,1.25 metres diameter , adequate to hold the buoy on position in very severe conditions . Attaching the anchor to the mooring line is a chain which acts as a chafer on the sea bed and to prevent the mooring line entangling the anchor.This is supported by a float to hold up the mooring line connection . All shackles joining are 'seized' with galvanised steel wire to prevent unscrewing .

Fig 2 VAESAT Buoy Mooring .

SWALES VAESAT+ADCP Buoy Mooring

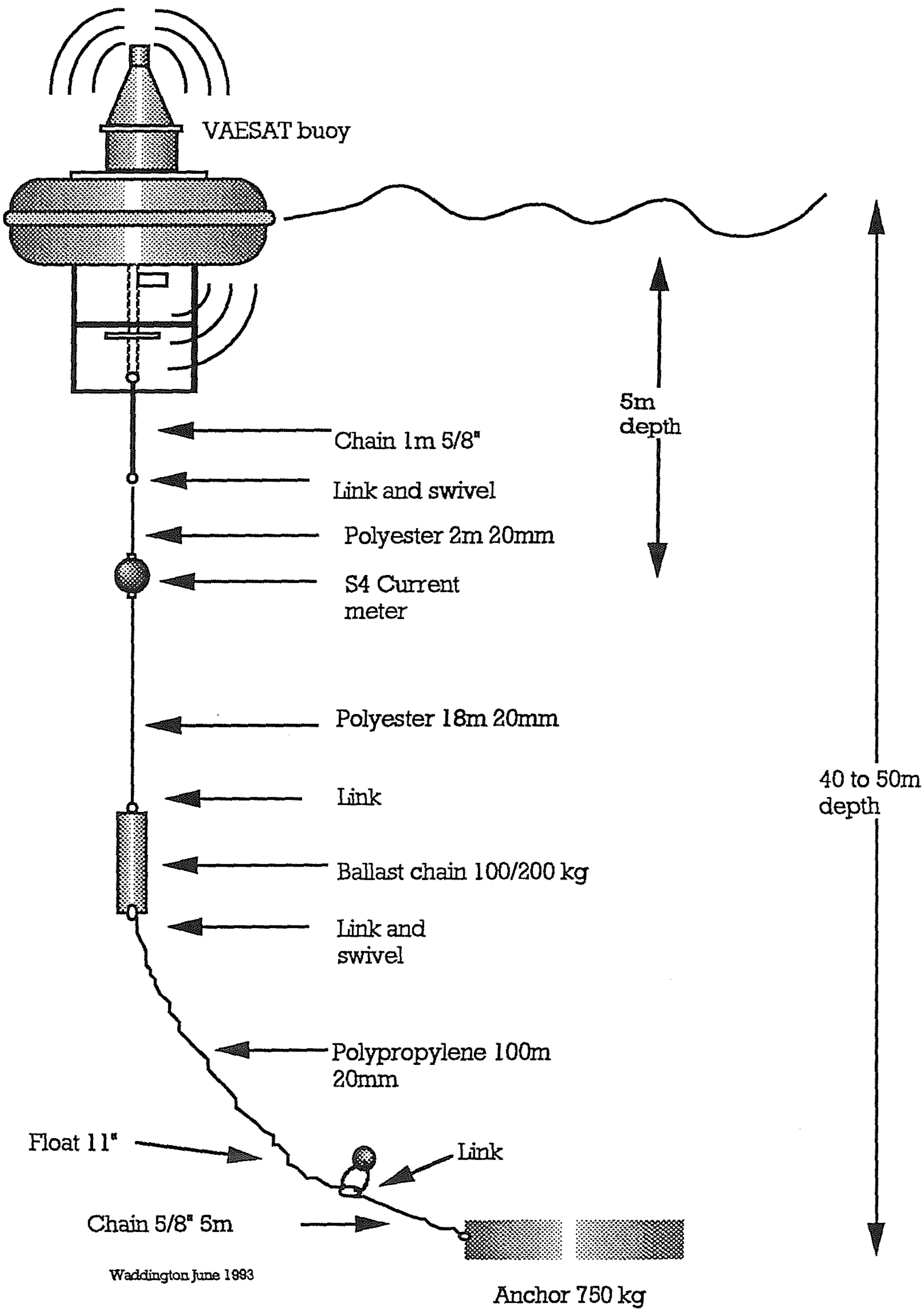


Fig 2.

7.3. Directional Waverider Mooring.

The mooring design is derived from the Datawell mooring specifications.The anchor is shown as a chain clump. Using a plough anchor and chain will give good holding power in the current conditions expected for a comparatively light weight and should be relatively easy to break out on recovery with a vertical lift to the recovery vessel. Fig 3 Waverider Mooring .

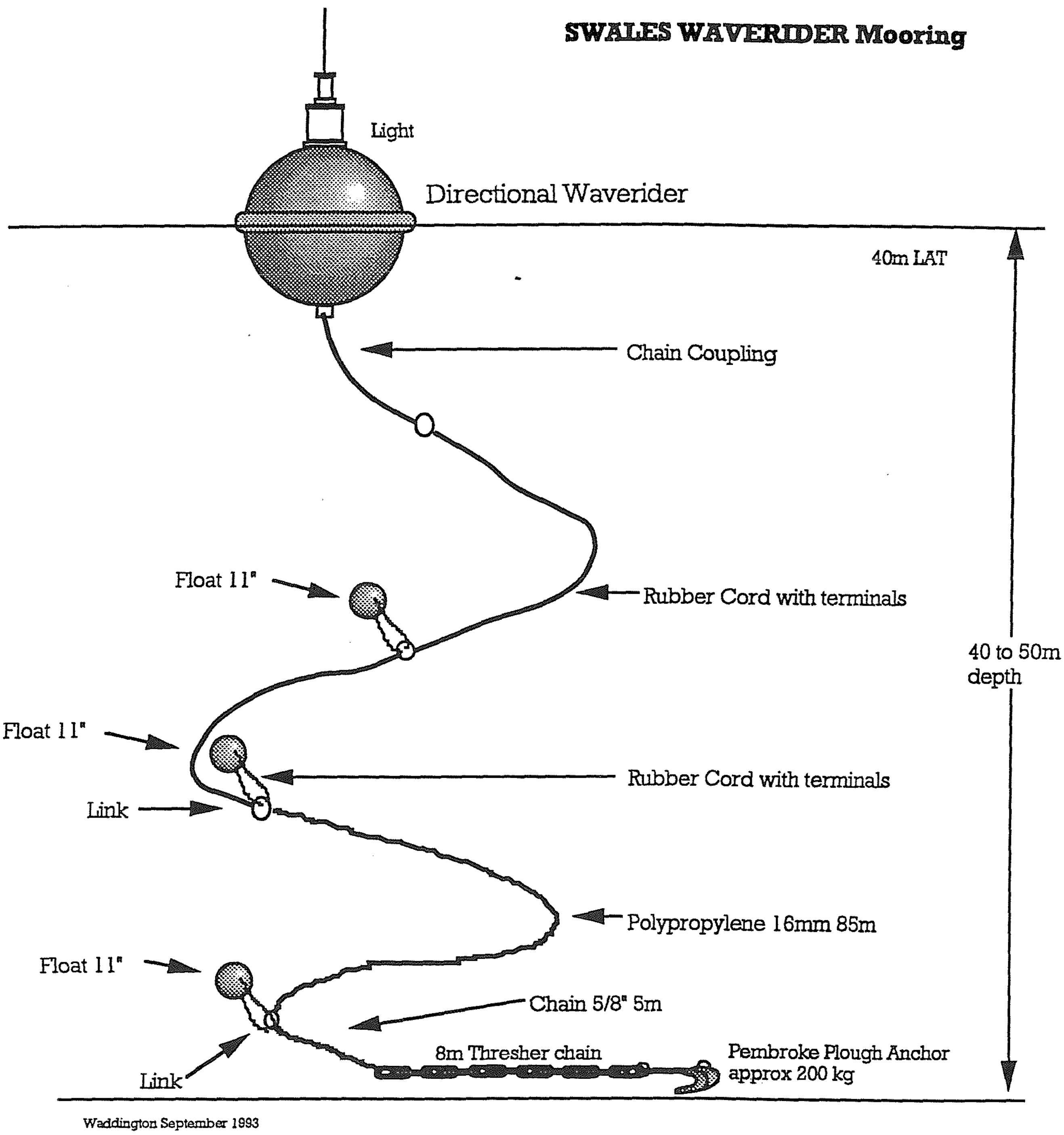


Fig 3.

SWALES Current Mooring

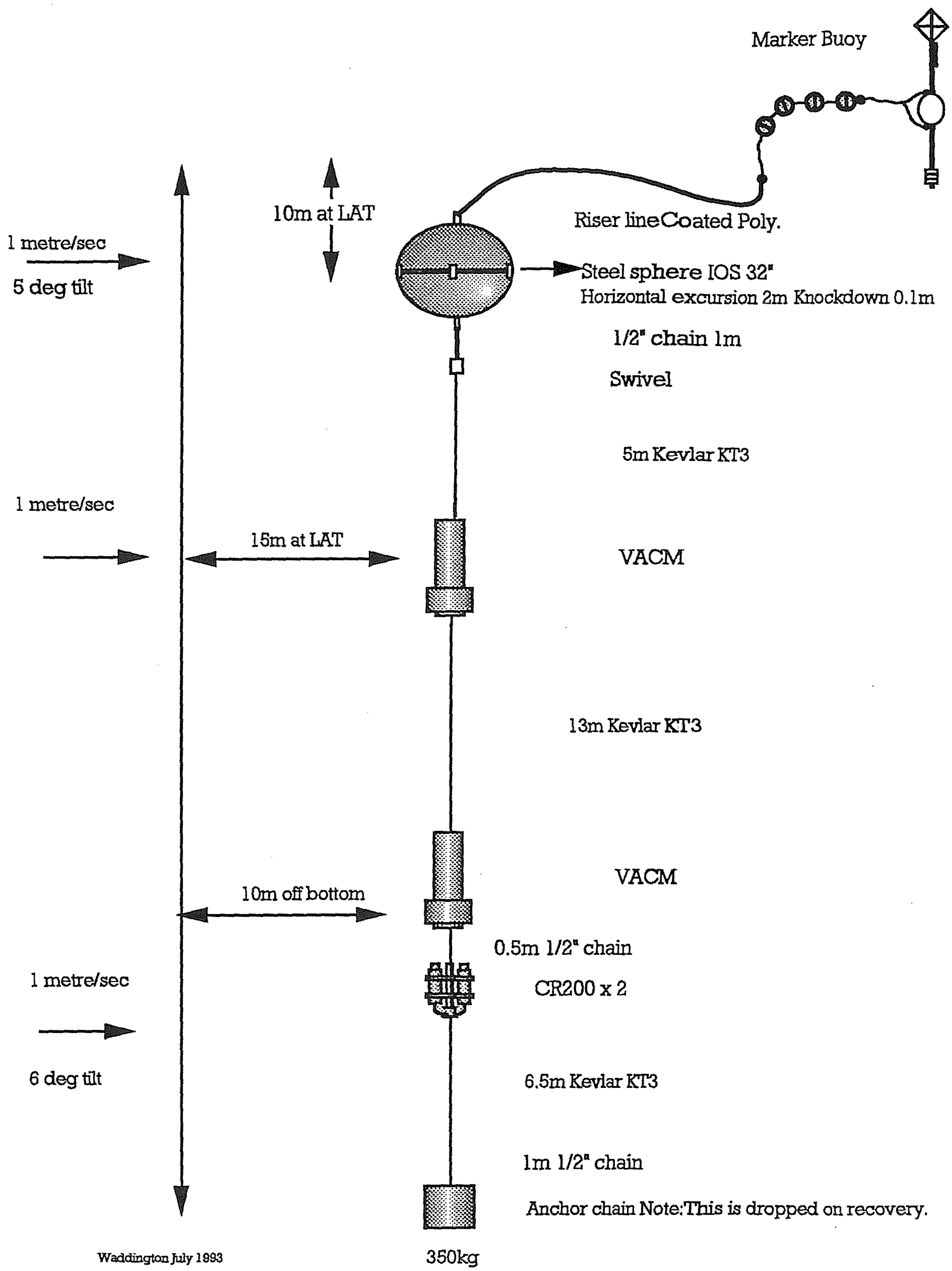


Fig 4.

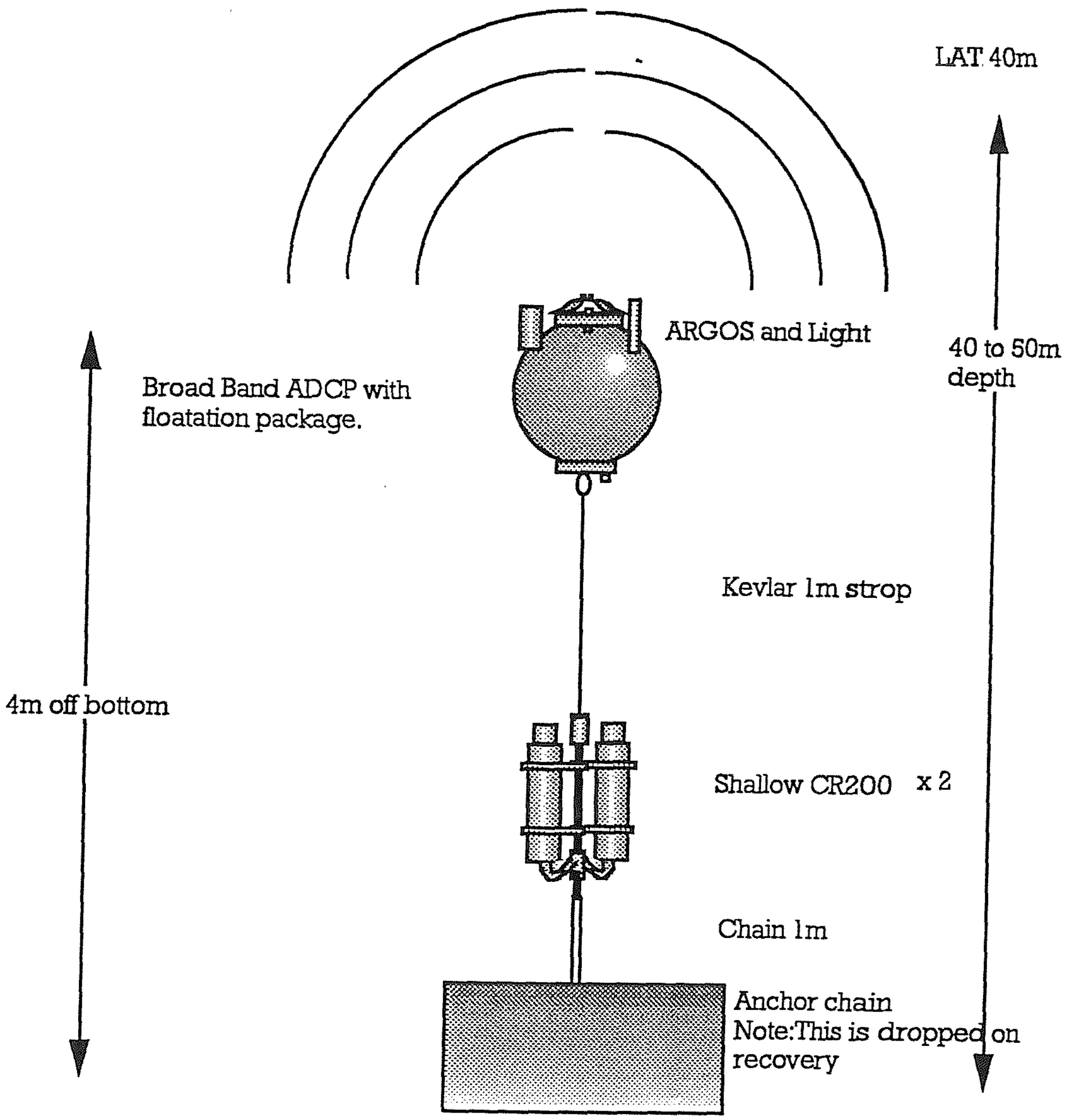
7.4. Current Profile Mooring.

Measurement of current speed direction and temperature was to be made using a subsurface mooring carrying Vector Averaging Current meters , type EG&G 610C . Positioned to overlap with the buoy mounted ADCP measuring bins to give comparative measurements for calibration validation .
The design outline was subsequently modified as Aanderaa current meters were available to the project , improving drag characteristics and reducing static mooring loadings .
The mooring is subsurface with a surface marker buoy to provide a navigational warning . The mooring is recovered from the surface marker or by releasing the anchor by acoustic release as a back up should the marker be lost . The riser line from the subsurface buoy to the surface marker is a relatively new material , plastic coated to reduce drag and limit marine organism growth .
fig 4.Current Profile Mooring.

7.5. Upward Looking ADCP.

As an addition to the experiment it is proposed that an RDI Broadband ADCP is added to the mooring array for intercomparison purposes .
As of the time of outline design the ADCP units are on order and we are awaiting delivery early July.The units require a buoyancy collar which we will be acquiring for a trial with Ellet,Challenger NW Scotland . This should have been thoroughly tested and equipped with navigation aids,ARGOS and lights .
A preliminary look at the near bottom package is as below . The mooring can be either as a subsurface stand alone or as a U mooring with surface marker . This will be looked at in terms of handling and security as we proceed with the ADCP assembly .

Fig 5.Near Bottom ADCP.



7.6. Back up Moorings.

7.6.1. Mean Meteorology Buoy .

The costs of refurbishing the Toroid buoy and tower have been compared to converting the spare VAESAT hull into a Met buoy for this experiment . It is preferred to use the modified VAESAT as there is a need to move on from the bulky 8 feet diameter toroids to a smaller buoy with enhanced capabilities .
The VAESAT buoy and mooring has a proven performance in severe conditions and has an adequate watertight compartment to carry all batteries and electronics .
The tower can be fabricated in a different format to our existing toroid tower in that we could consider a lighter weight structure with similar sensor protection to that of the toroid .

An outline buoy design was prepared by the Survey team and construction of a new buoy based on the VAESAT hull was undertaken in IOSDL OIG workshops . A mooring design has been produced to support the proposed buoy design based on the VAESAT design .Internal buoy ballasting and mooring ballasting will need to be investigated as the buoy is completed this is expected to be 100 kg in buoy and 100 to 150 kg in the mooring .

Fig 6.Met Buoy mooring.

SWALES Met. Buoy Mooring

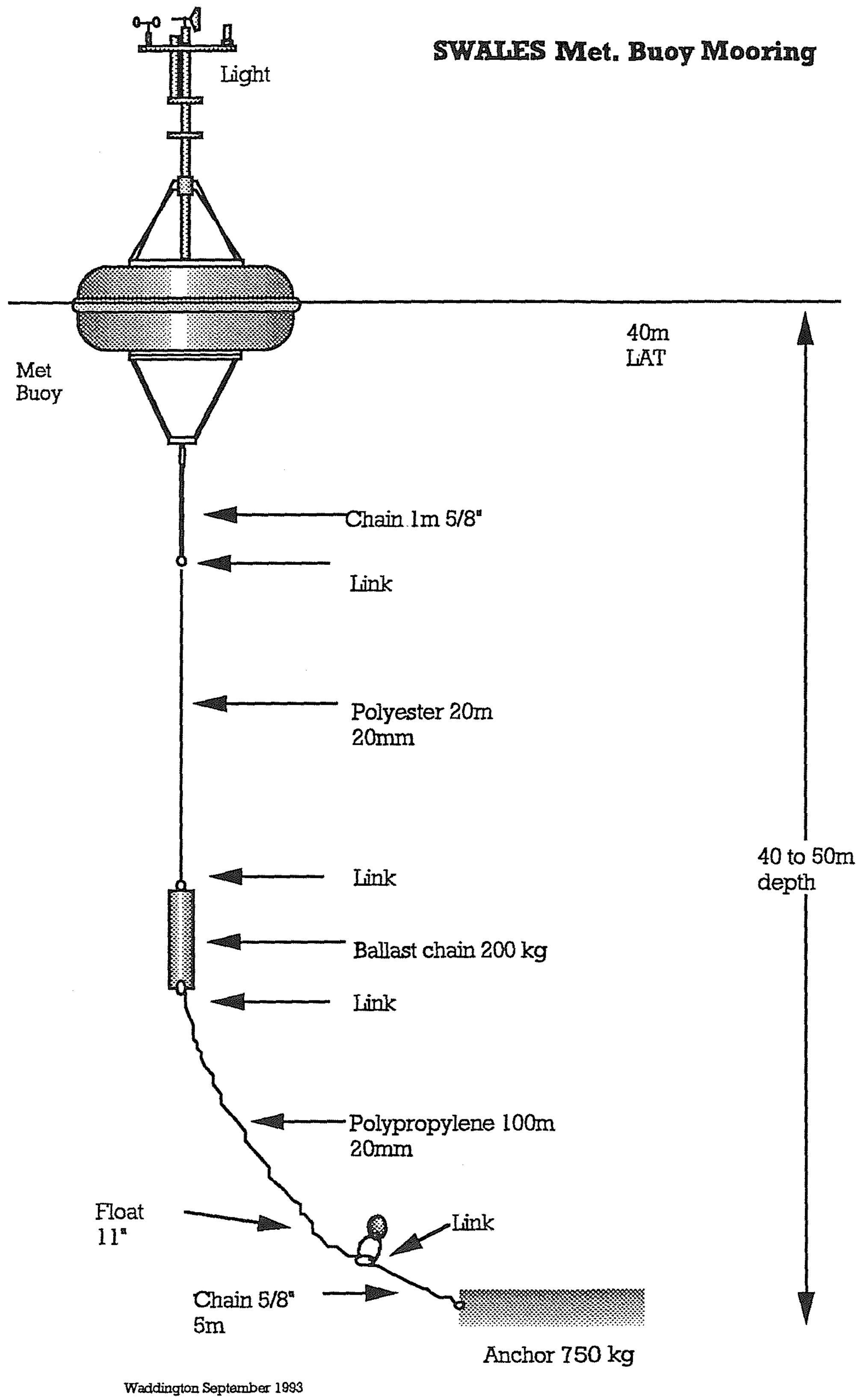


Fig 6.

7.6.2. VAESAT buoy . 2m sensor.

The VAESAT 2m buoy has a similar mooring to the VAESAT with Doppler.This mooring should be provided as a kit of labelled parts for shoreside storage.

7.6.3. Directional Waverider

Dependent on the option chosen the Survey team could provide the mooring from stock in so far as "standard"mooring components.Bungees would be required .

8. Predeployment Phase .

With the mooring designs finalised , complete parts lists were prepared and procurement and assembly progressed . Buoy electronics and sensors were tested and calibrated as appropriate .

8.1. SONIC Buoy mooring.

The mooring was prepared at IOSDL to the ORCINA design . Terminations and assemblies were to IOSDL specification and incorporated improved end terminations for the fibre lines . A second standby mooring was prepared using the recycled lines from the Trial mooring with new mooring fittings .
All components were test assembled and packed for freighting to Pembroke as a complete set of equipment .

8.2. VAESAT Mooring .

The buoy comprises a Vector Averaging Electromagnetic Current meter (VAECM) at 1 metre depth and a 1 MHz Acoustic Doppler Current Profiler (ADCP) consisting of 16 cells , each 1.3 metres in depth . The ADCP profiles current from 2.9 metres to 24.2 metres .

The VAECM and ADCP electronics were set up in the laboratory and tested . Battery packs were purchased and when all testing completed the electronic and battery packs were assembled within the buoy and further in situ tests made .
The buoy was shipped to Pembroke sealed but powered down . On arrival at Pembroke the buoy was uncased and tests conducted on the electronics to ensure correct operation . The electronics were powered up and set to record , testing being carried out during recording , subsequently the buoy was sealed and prepared for deployment .

The S4 was fitted with Lithium batteries at RVS Barry and operational and set up instructions demonstrated to IOSDL staff . The S4 was then taken to IOSDL for testing and shipped to Pembroke with the VAESAT buoy . The S4 was set up at Pembroke and tested and set for recording .

The mooring components were prepared at IOSDL and test assembled before shipment to Pembroke . As an anchor was to be provided from Pembroke the mooring was prepared to accomodate several types of anchor fitting . This was then tested at Pembroke to ensure a reliable termination to the anchor .

8.3. Directional Waverider Mooring.

The IOSDL Waverider mooring components were test assembled prior to shipment . with the Standby Mooring supplied by IH also being checked and prepared for shipment .

8.4. Current Profile Mooring.

The Current meters for the mooring were of the Aanderaa RCM type and were calibrated and tested at IOSDL .

The acoustic release sea and deck units were prepared by the OIG group and were provided as working systems requiring only sea tests before deployment .

The mooring was to be used as a test for an improved surface tether material which was assembled and tested at IOSDL .
The mooring components were all prepared at IOSDL and assemblies tested before freighting .

8.5. Upward Looking ADCP.

This mooring was aborted due to the loss of the unit on trial , Barra Fan . No equipment was prepared .

8.6. Back up Moorings.

8.6.1. Mean Meteorology Buoy .

The buoy design was outlined to OIG workshops , who working with the Survey team evolved a complete buoy assembly incorporating a mast and all sensor fittings . Electronics and sensors were prepared by the Survey team and a new logger mechanical assembly and interconnecting leads assembled and tested .

The ARGOS beacon HERMES type ....was assembled at IOSDL and lab tested on a dummy load .
The navigation light assembly was prepared from a commercial unit ,RYOKUSEI Sea Light , adapted by OIG workshops to suit the requirement .
The buoy was assembled and ballasted in the IOSDL acoustics tank internal ballasting being added in the form of lead sheet . Final ballasting and testing to be done at Pembroke .
The buoy was shipped with the internal electronics installed and powered off with the buoy hull sealed for deployment. The sensors and other mast mounted equipment shipped seperately boxed .

At Pembroke the buoy systems were tested and assembled to the mast , the internal systems were powered up externally and logging monitorred as correct by a through hull connector . With the logger working and monitorring the sensors , the buoy was placed in a salt water lagoon with a 100 kg external ballast weight beneath to check stability .
The buoy stability and ballasting was not adequate and with the addition of a further 100 kg external ballast the correct waterline was achieved . The buoy was then left in the lagoon for " soak tests " to determine water tight integrity and with the logger running to test the electronics . When required for deployment the buoy was to be lifted out and delivered to the ship in a running condition . Requiring switch on of the navigation light and addition of the ARGOS beacon .

8.6.2. VAESAT buoy . 2m sensor.

The buoy is configured similarily to the VAESAT 1m buoy but with no ADCP fitted or S4 current meter in the mooring line. The systems were checked and the mooring assembled as for the 1m buoy and the completed assemblies shipped to Pembroke powered off and with mooring components boxed .

8.6.3. Freighting .

The VAESAT and Met buoys are shipped on fork liftable wooden pallets which can be transported by road . These pallets are used onboard the deployment vessel for secure stowage prior .

The mooring hardware was prepared as sets and transported in steel collapsible cages . These are taken onboard as deck stowage .

9. Operational Details .

The buoys and systems are detailed seperately and operations and comment are chronological .

9.1. SONIC Buoy.

9.1.1. Initial Deployment.

The buoy was deployed 20th October 1993 by RMAS Warden . The deployment was buoy first with the vessel making headway at 1 to 2 knots .The buoy was lifted into the stern well by gantry using an RFD no load hook . With the hook released the buoy streamed astern and the mooring line hand deployed to the anchor . The vessel then positioned on slow speed to the intended deployment positon , where the anchor was released using a wire toggle . The buoy was observed to move towards the anchor drop position and with the anchor on the sea floor was observed to steady up into the wind . Visual and ARGOS observations were made on the buoy to ensure sensors and mooring were performing correctly . fig 7 .

9.1.2. Positional Check.

A visual check was conducted on the buoy , 30th October 1993 , during an inspection of the Waverider buoy . Radar ranging was checked from RMAS Scarab with the buoy being clearly identified at 3.5 miles range . The buoy appeared to be aligned correctly to the wind and was riding a short confused sea .

9.1.3. Recovery operation , Buoy Capsized .

The buoy was determined as capsized by the OIG/JRC team and a salvage attempt was mounted using the RMAS Halifax , a fast patrol boat , on the 11th of November . Survey and OIG staff embarked on the Halifax from Tenby and proceeded to the SONIC buoy position . On arrival at the site the buoy was seen to be capsized and streaming with the current exposing the mooring line at the surface .
The Halifax was manouvered alongside and with some difficulty a line was passed through the bridle assembly , securing the buoy to the boats forward capstan .
These boats have poor low speed control and after several attempts at manouvering on the buoy mooring to get adequate slack the decision was made to cut away the mooring and tow the buoy capsized in an attempt to right it.
The mooring line was very taut in the tidal stream and was cut using a knife on a boat hook .
The buoy was then hand hauled astern where a further line was attached at the mooring bridle plate . By manouvering slowly ahead and adjusting the position of tow in the bridles the buoy was righted and towed to Tenby for recovery ashore . On inspection of the bridles and severed mooring line all the recovered components were in good condition .

9.1.4. Redesign of mooring and buoy ballasting .

As a consequence of the capsize , OIG consulted ORCINA with the actual capsize conditions which when run by ORCINA on computer simulation , revealed a capsize scenario in the conditions prevailing at the time . Reference was made to other designs of mooring for commercial and scientific applications and a redesign was proposed .
The mooring was to be surface attached to the SONIC buoy with the SONIC having a ballast put beneath attached from three mountings by chains . This was again referred to ORCINA who suggested a further improvement by increasing the surface line buoyancy to restrict the forward capsize of the buoy.

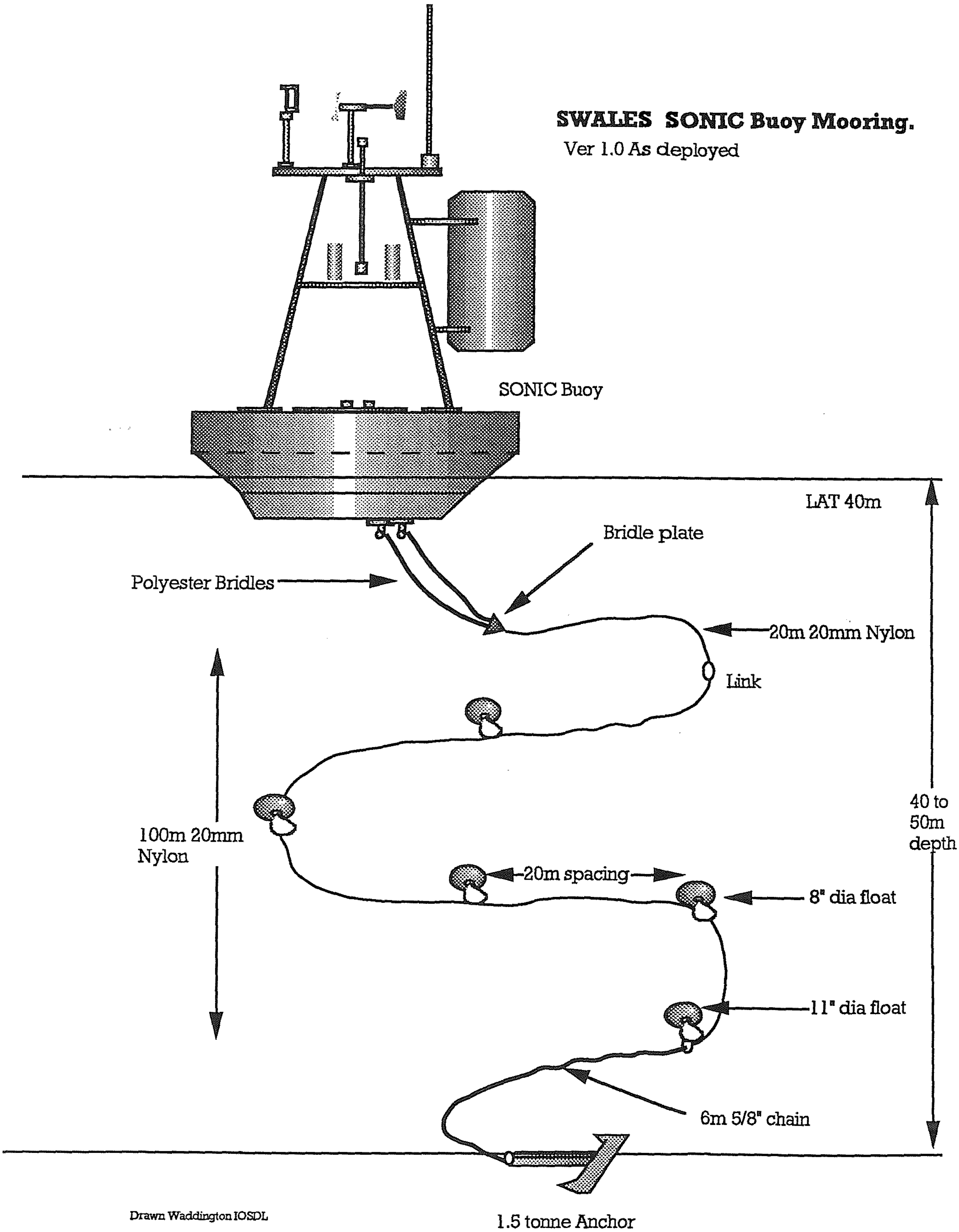

SWALES SONIC Buoy Mooring.
Ver 1.0 As deployed
SONIC Buoy
LAT 40m
Bridle plate
Polyester Bridles
20m 20mm Nylon
Link
100m 20mm
Nylon
40 to
50m
depth
20m spacing
8" dia float
11" dia float
6m 5/8" chain
Drawn Waddington IOSDL
1.5 tonne Anchor

Fig 7.

The redesign was translated into materials and fittings available 'off shelf ' from the Survey stocks at IOSDL and on standby at Pembroke . Subsequently a mooring was constructed in 1 day and shipped to Pembroke .

9.1.5.Deployment of redesigned SONIC mooring .
The rebuilt SONIC buoy was deployed on the 22nd November 1993 using the RMAS Warden . Deployment was as 9.1.1. and the buoy was observed moored on site with the navigation light and ARGOS being monitorred onboard . The mooring was observed streamed out on the surface with the two surface floats well out of the water . fig 8.

9.1.5. Buoy washed ashore .
The buoy was washed ashore at and recovered .The mooring had become detached at the outboard end of the surface 5m harness but no sign of either the thimbles or shackles was evident, suggesting some kind of interference may have taken place.or alternatively they had become detached during the buoys movement over the rocks.

9.1.6. Recovery of the SONIC mooring .
A 12 hour weather window , for recovery , occurred on the 17th January 1994 . RMAS Warden sailed from Pembroke at 0935 GMT arriving at the mooring site at 1215 During recovery of the Vaesat at slack water, a trawl float from the remains of the Sonic mooring 9.1.5. was observed floating on the surface . This was secured and the mooring successfully recovered onboard.
All ropes were found to be in good condition but some shackles showed evidence of wear as a result of the severe mooring motions encountered during the gales of the previous month . The complete absence of the two surface buoyancy floats on the surface line suggest that the mooring had probably been tampered with prior to the buoy breaking adrift . Shackle pins on the upper mooring components were considerably worn by mooring motion . The nylon mooring line showed signs of abrasion when inspected at IOSDL . Reduction in line strength was minimal and the abrasion was prbably caused on recovery .

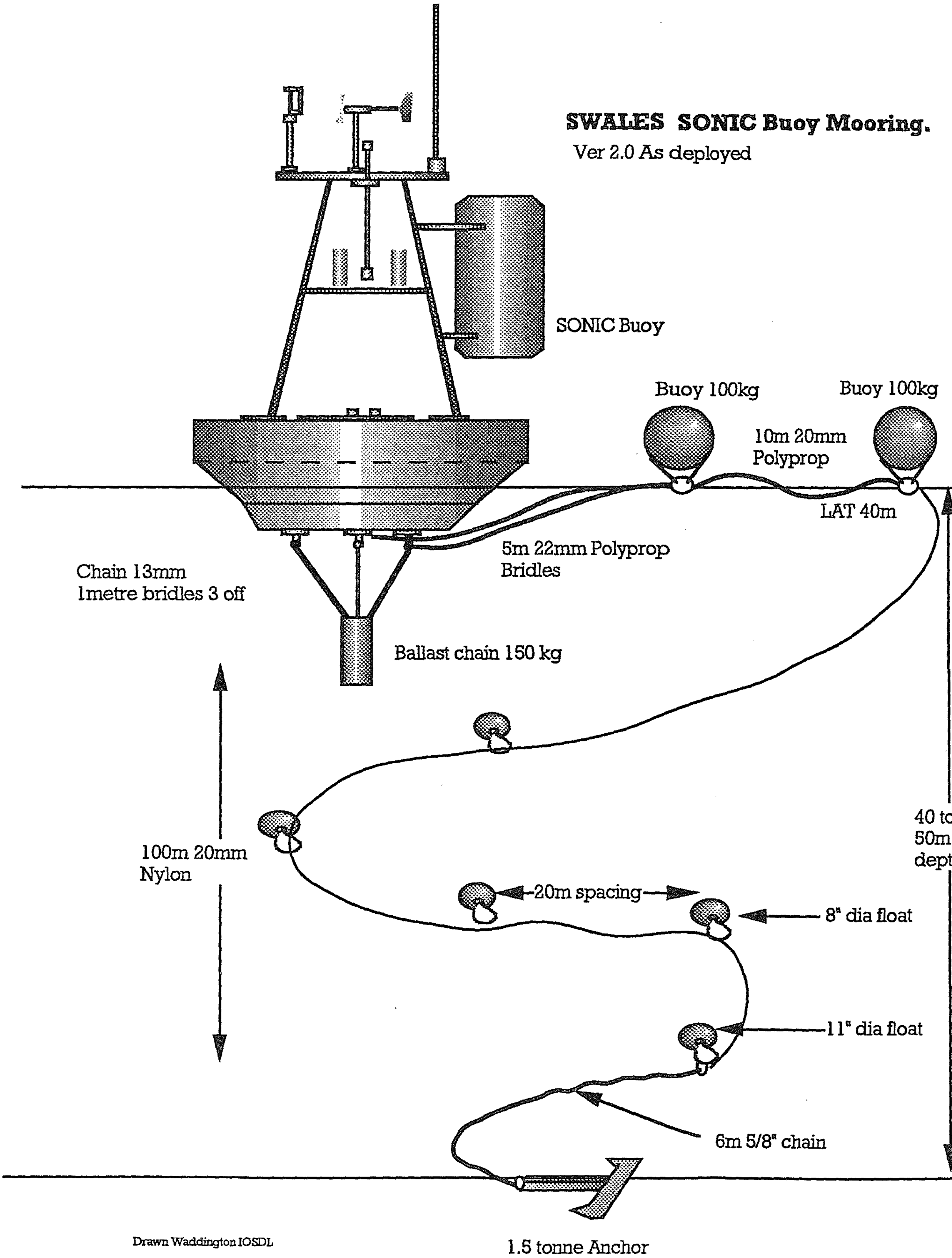

SWALES SONIC Buoy Mooring.
Ver 2.0 As deployed
SONIC Buoy
Buoy 100kg
Buoy 100kg
10m 20mm
Polyprop
LAT 40m
5m 22mm Polyprop
Bridles
Chain 13mm
1metre bridles 3 off
Ballast chain 150 kg
100m 20mm
Nylon
20m spacing
8" dia float
11" dia float
40 to
50m
depth
6m 5/8" chain
Drawn Waddington IOSDL
1.5 tonne Anchor

Fig 8.

9.2. VAESAT buoy .

9.2.1. Deployment.

The buoy was deployed 20th October 1993 by RMAS Warden . The deployment was buoy first with the vessel making headway at 1 to 2 knots .The buoy was lifted into the stern well by gantry using an RFD no load hook .

With the buoy in the stern well and hanging on the gantry , the S4 was lowered by hand such that it hung clear in the water beneath the buoy . The hook was then released and the buoy streamed astern with the mooring line hand deployed to the buoy ballast. The ballast was slipped down the stern ramp and the polypropylene mooring line allowed to free run until the buoy ballast chain bottomed out .the remaining line was then hand deployed to the anchor . The vessel then positioned on slow speed to the intended deployment positon , where the anchor was released using a wire toggle . The buoy was observed to move towards the anchor drop position and then steady up with the anchor on the sea floor . Visual and ARGOS observations were made on the buoy to ensure sensors and mooring were performing correctly . fig 9.

9.2.2 Positional Check .

A visual check was conducted on the buoy , 30th October 1993 , during an inspection of the Waverider buoy . The buoy was riding a short confused sea with the deck awash at times .

9.2.4. Positional Check .

Observed 6th November from RMAS Warden during Waverider recovery and relay .

9.2.5. Positional Check .

A visual check was also made on the 6th of January 1994 during recovery of the Waverider buoy . The navigation light was observed and the buoy observed by searchlight from RMAS Grasmere .

9.2.3. Recovery operation .

The buoy and mooring were recovered on the 17th of January 1994 from RMAS Warden . The Gemini was launched and a floating recovery line secured to the Vaesat buoy. The buoy was lifted onboard and the gantry manoevred to allow the S4 current meter to be lead safely over the stern. The mooring was all recovered safely by 1515GMT.

An examination of the mooring showed no damage or wear to the components.

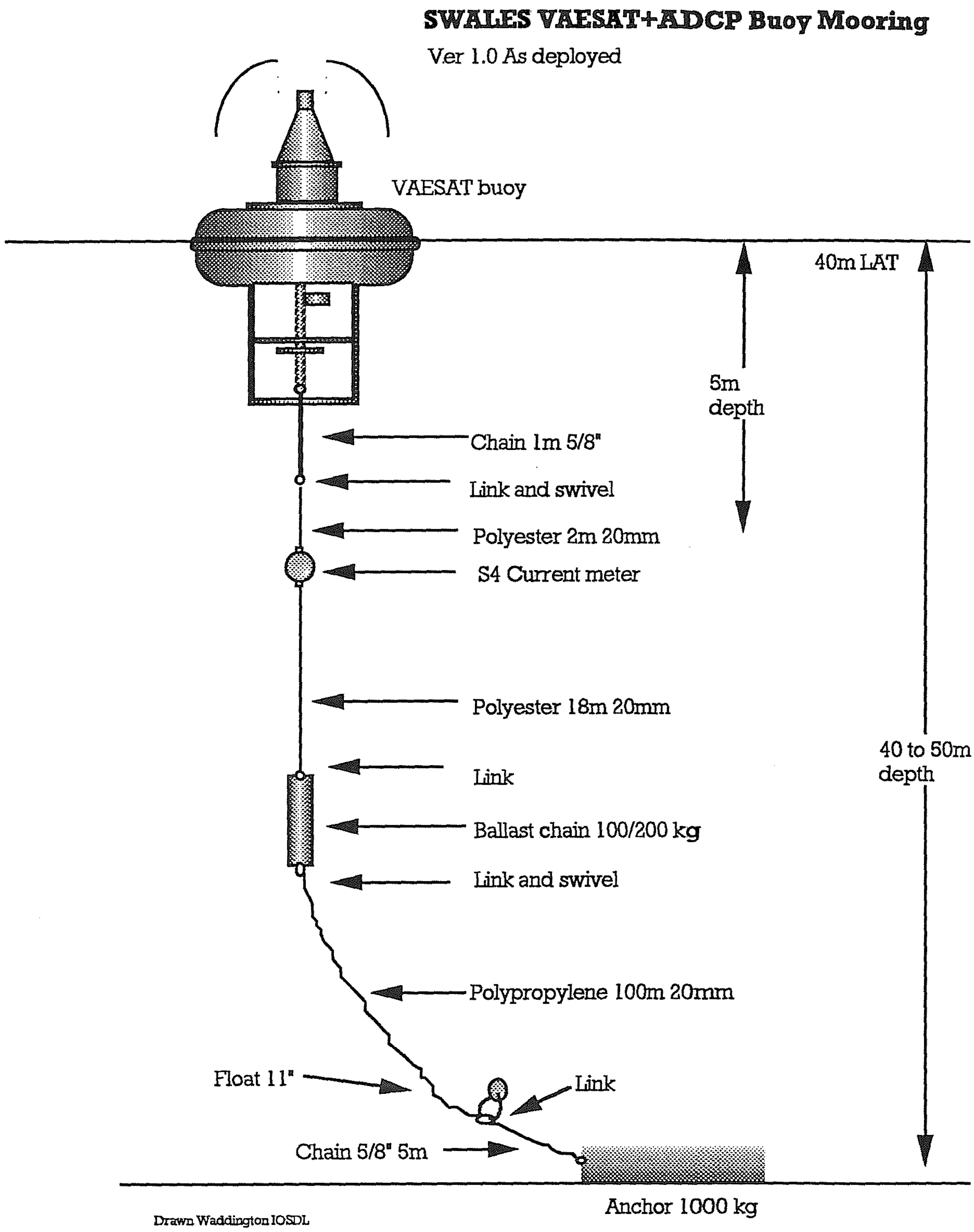

SWALES VAESAT+ADCP Buoy Mooring
Ver 1.0 As deployed
VAESAT buoy
40m LAT
5m
depth
Chain 1m 5/8"
Link and swivel
Polyester 2m 20mm
S4 Current meter
Polyester 18m 20mm
Link
Ballast chain 100/200 kg
Link and swivel
Polypropylene 100m 20mm
40 to 50m
depth
Float 11"
Link
Chain 5/8" 5m
Anchor 1000 kg
Drawn Waddington IOSDL

Fig 9

9.3. Directional Waverider mooring.

9.3.1.Deployment .

The mooring was deployed from RMAS Warden on the 20th of October 1993 . Deployment was buoy first with the buoy being lowered into the water on the after gantry using the RFD No load hook to release . The buoy had a steady line attached to prevent rotation , which can damage the internal sensors .
With the buoy in the water the vessel proceeded at slow speed to deploy the mooring to the anchor . The buoy was then towed onto position and the anchor released . fig 10.

9.3.2. Possible fishing interference and inspection .

A trawler reported fouling a buoy to Milford Haven coastguard on the 27th of October and by description this was the Waverider .The trawler then abandonned his trawl and warps on site as he was unable to recover them .
An inspection and possible rescue attempt was prepared from IOSDL and RMAS Scarab proceeded to sea on the 30th of October with a Survey team member and the standby mooring components .
The weather conditions prevailing on site did not permit recovery of the buoy and as the buoy was floating apparently normally no recovery attempt was made . The abandonned fishing gear was identified buoyed off some 200 metres from the buoy .

9.3.3. Recovery and redeployment of the Waverider .

The Waverider mooring fouled by the trawl was to be inspected and a possible recovery of the trawl made from RMAS Warden on the 6th of November . The standby mooring was taken onboard for possible renewal of the mooring .
On arrival on site the Waverider buoy was seen to floating almost awash with the ARGOS antenna occasionally submerging .
An unsuccessful attempt was made to recover the abandonned trawl and it was decided to recover the Waverider .
The work boat was launched but it was found impossible to grapnel the mooring as the load on the mooring was pulling the bungee almost vertically down . A floating line was passed from the Warden and attached to the buoy . The Warden then steamed slowly away in the hope of lifting the buoy . The buoy towed underwater and as the ship eased speed was seen to pop up and ride high in the water . The mooring had broken enabling the buoy to be towed to the ship by workboat for craning onboard.
The standby mooring was assembled and after checking the buoy redeployment off to .... was commenced , as 9.3.1 , the mooring slipped easily away and the buoy was observed securely moored and floating correctly . fig 11.

9.3.4. Recovery of Waverider .

Whilst the recovery operation of the SONIC buoy was taking place onboard RMAS Halifax , 22 nd November 1993 , details of the Waverider being adrift were received by OIG and Survey team staff onboard . No action could be taken that day and Survey team staff requested the Survey GONIO ARGOS RDF be sent from IOSDL the following day to assist in relocation . Further ARGOS position fixes were relayed from JRC by Cell phone .
The survey team staff transferred to RMAS Falconet by 1200h on the 23 rd and set up the GONIO RDF on the flying bridge . To calibrate the system the Falconet made for the mooring site , on passage the Waverider signal was detected but no direction could be obtained as the GONIO RDF had not been zeroed . Falconet positioned one cable away from the VAESAT mooring with the ships head pointing at the buoy . This enabled the RDF to be zeroed to the ARGOS signal from the buoy .

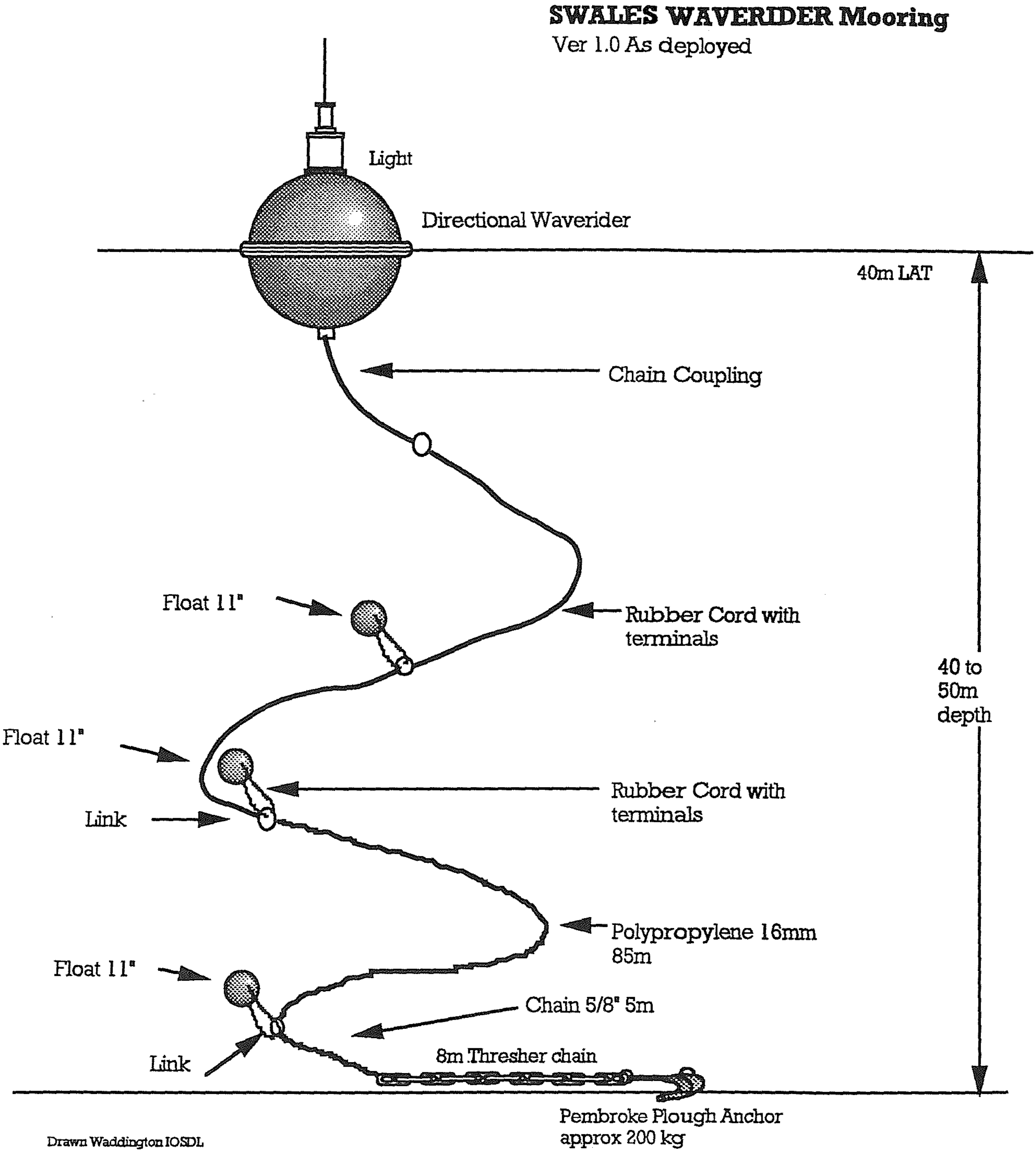

SWALES WAVERIDER Mooring
Ver 1.0 As deployed
Light
Directional Waverider
40m LAT
Chain Coupling
Float 11"
Rubber Cord with terminals
40 to 50m depth
Float 11"
Rubber Cord with terminals
Link
Polypropylene 16mm 85m
Float 11"
Chain 5/8" 5m
8m Thresher chain
Link
Pembroke Plough Anchor approx 200 kg
Drawn Waddington IOSDL

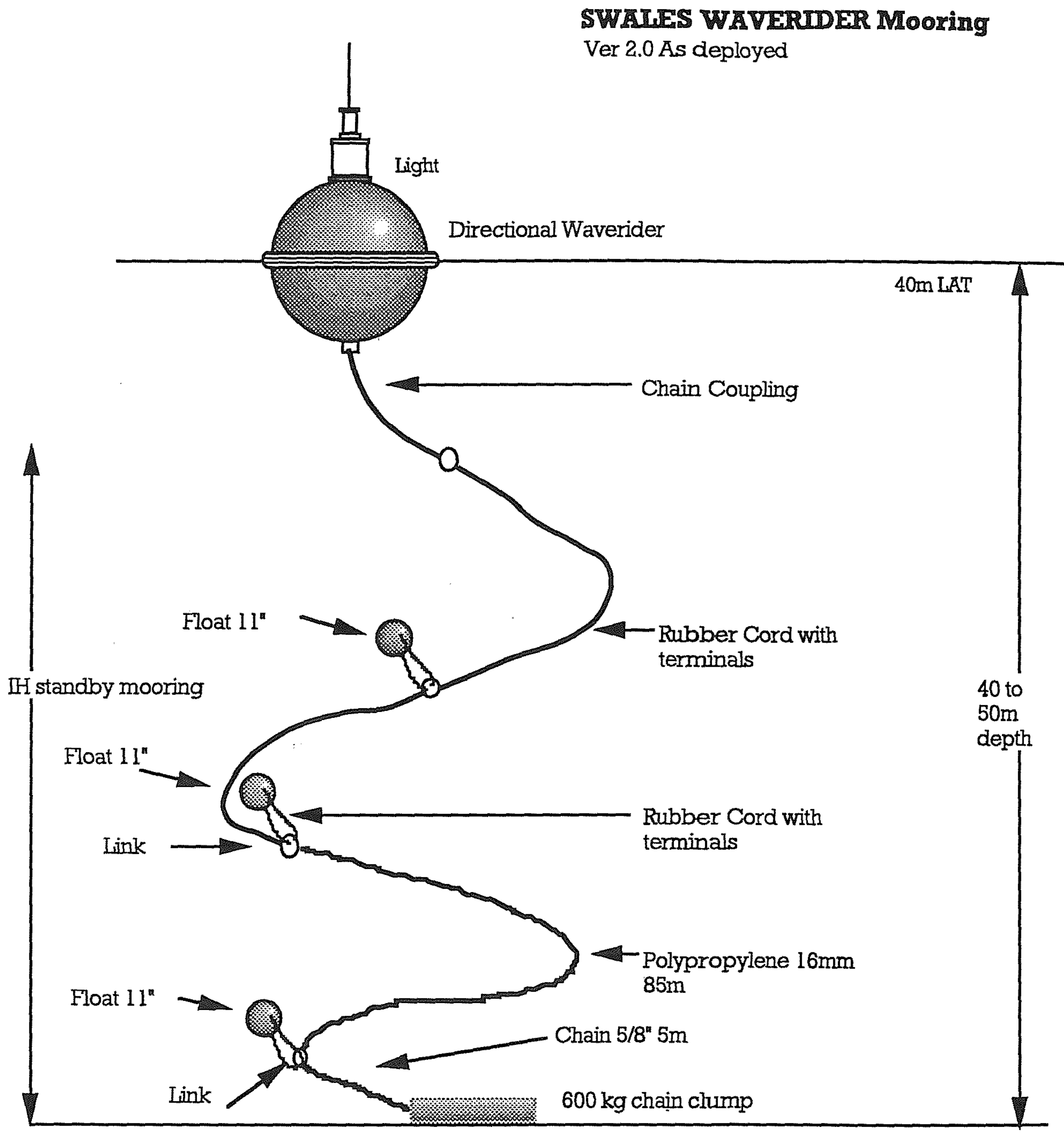
Fig 10.

By manoeuvring towards the latest positions relayed from JRC by Cell phone the Waverider signal was relocated and using the indicated RDF direction the Waverider was visually relocated .
The buoy was man handled to the boats side , with difficulty due to poor slow speed control , and lifted aboard using the workboat crane . The lower rubber bungee was seen to have been severed 2/3 along its length and on close examination severe abrasion was seen , along with flakes of blue paint embedded in the rubber . This was probably caused by the mooring being caught up on a trawl wire and then bumped along the vessels side in an effort to free the mooring . The cut end appeared severed by a sharp edge , possibly a knife .

The buoy was taken to Pembroke on the Falconet and unloaded to the pontoon for transfer to under cover storage for examination .

9.3.4. Redeployment .
The buoy was redeployed using spares from IOSDL on the 22nd of November 1993 , as 9.3.1. fig 12.

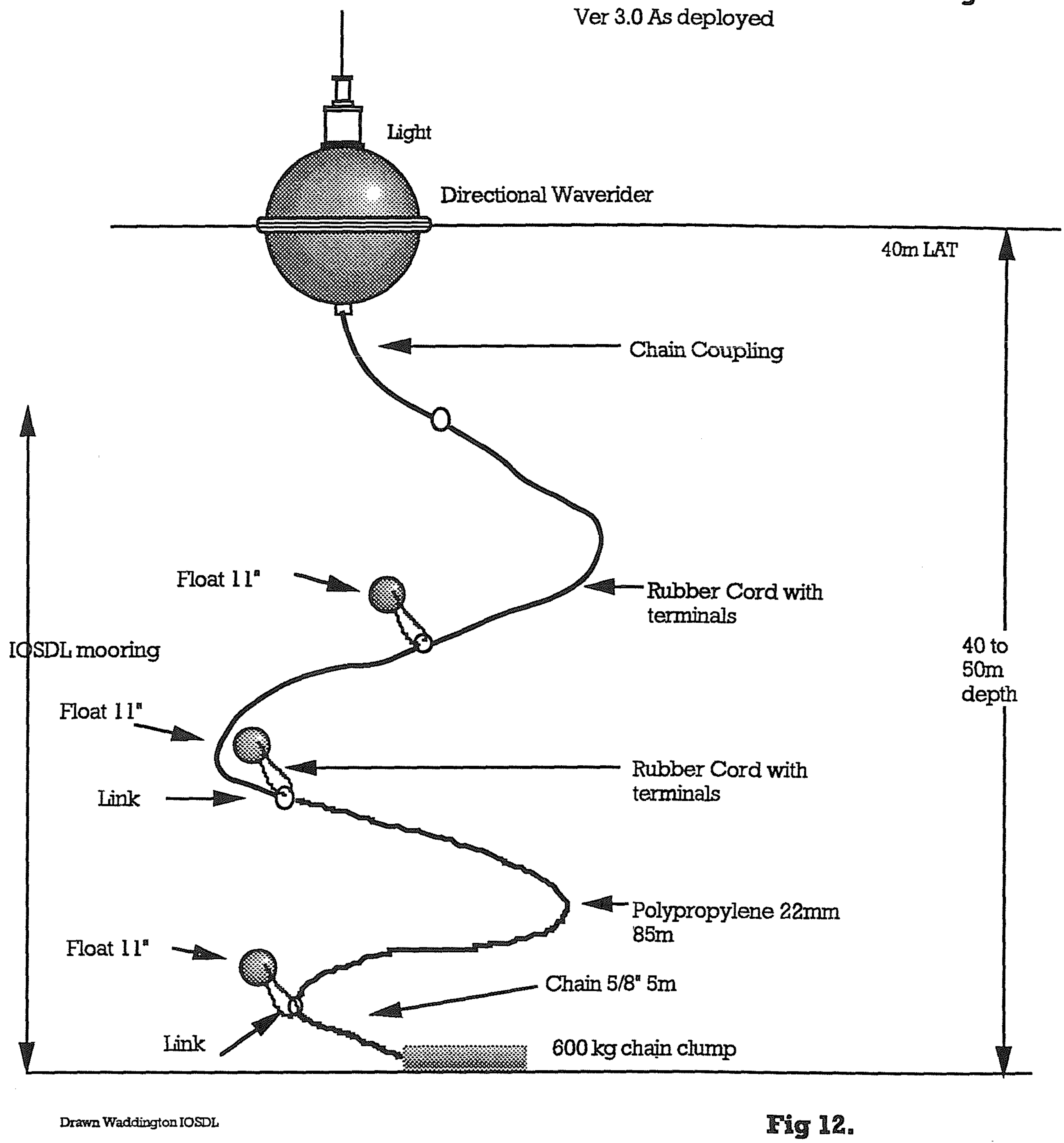
9.3.5. Recovery .
Bad weather prevented recovery until 6th January 1994 .
RMAS Grasmere stood off Tenby and took onboard Survey team member K Goy by small boat and wading . The vessel arrived on site at 1950 h , low water slack , and located the Waverider . The buoy was seen to be floating with two support floats on the surface.
During recovery the lower bungee pulled out of its bottom fitting and and the lower mooring was lost . The mooring components recovered were in good condition .
The lower section was subsequently recovered on the 17th Jan when it was confirmed that the mooring had failed at the joint of the lower bungee.



Drawn Waddington IOSDL

Fig 11.

SWALES WAVERIDER Mooring
Ver 3.0 As deployed



Drawn Waddington IOSDL

Fig 12.

9.4. Current Profile Mooring.

The current profile mooring was prepared at sea onboard RMAS Warden 20th October 1994 . The Aanderaa RCMs were fully set up and recording correctly. A rig was set up to test the acoustic releases in the water and they were deployed to 20metres depth . The units would not function correctly in the water and were recovered . On deck tests were made using a clip on transducer and neither unit functioned correctly . It was therefore decided to abandon the deployment .

9.5. Current Profile and Met buoy mooring .

With the failure of the acoustic releases the units had to be returned to IOSDL for rectification by OIG staff . During this time the SONIC buoy batteries appeared to be failing and it was necessary to deploy the standby Mean Met Buoy .
A mooring design was proposed by the Survey team which incorporated the Met buoy and the current profile mooring as one unit . This mooring required production of new wires and increasing the subsurface buoyancy to cope with the increased surface buoy drag . A design was produced and the mooring assembled in one day from Survey Team stocks .fig 13.

9.5.1.Deployment .

The revised mooring assembly was assembled at Pembroke on the 6th of November and was deployed that day from RMAS Warden .
The buoy was deployed using the after gantry and a short rope strop which could be unhooked when the buoy was afloat in the stern well . This went very smoothly but for damage to one anemometer cup by an untended gantry hook line .
The buoy was streamed clear astern and the subsurface slipped down the ramp followed by the mooring wire and current meters . A short tow was required to position and stream out the assembly to prevent tangling . The anchor was then released and the subsurface buoy observed to submerge and the Met buoy to settle on position .
The ARGOS beacon signal was observed as correct when deployed but very shortly thereafter became noisy and spurious values were obtained on the GONIO . As no spare was available the buoy was left on position . Overnight the buoy was monitorred and no improvement was seen in the ARGOS quality . The navigation light was observed to 2400h and buoy position checked .

9.5.2. Recovery .

Recovery was delayed to the poor weather conditions until 17th of January 1994 when the Warden was on site again . The Gemini was launched and a floating line attached to the Met buoy. The initial attempt to recover the mooring was abandoned when the Warden failed to maintain station in the strong tidal flow, resulting in the buoy being dragged under. A second attempt was tried with the Warden anchored uptide of the mooring but this was again abandoned. A third attempt proved successful and the buoy was recovered onboard at 1420 GMT 17th. During recovery, the subsurface sphere appeared on the surface indicating the mooring had failed. Examination showed that the lower current meter spindle had failed at the upper eye end and as a result the current meter and and components below it were lost.
The upper current meter RCM 7643 had only approx 20cms of the fin remaining and this is can, from the data, be shown to have occurred on the 18th December. Damage to the upper ring of the Met mast may have been sustained at the same time.All other components were in good condition.

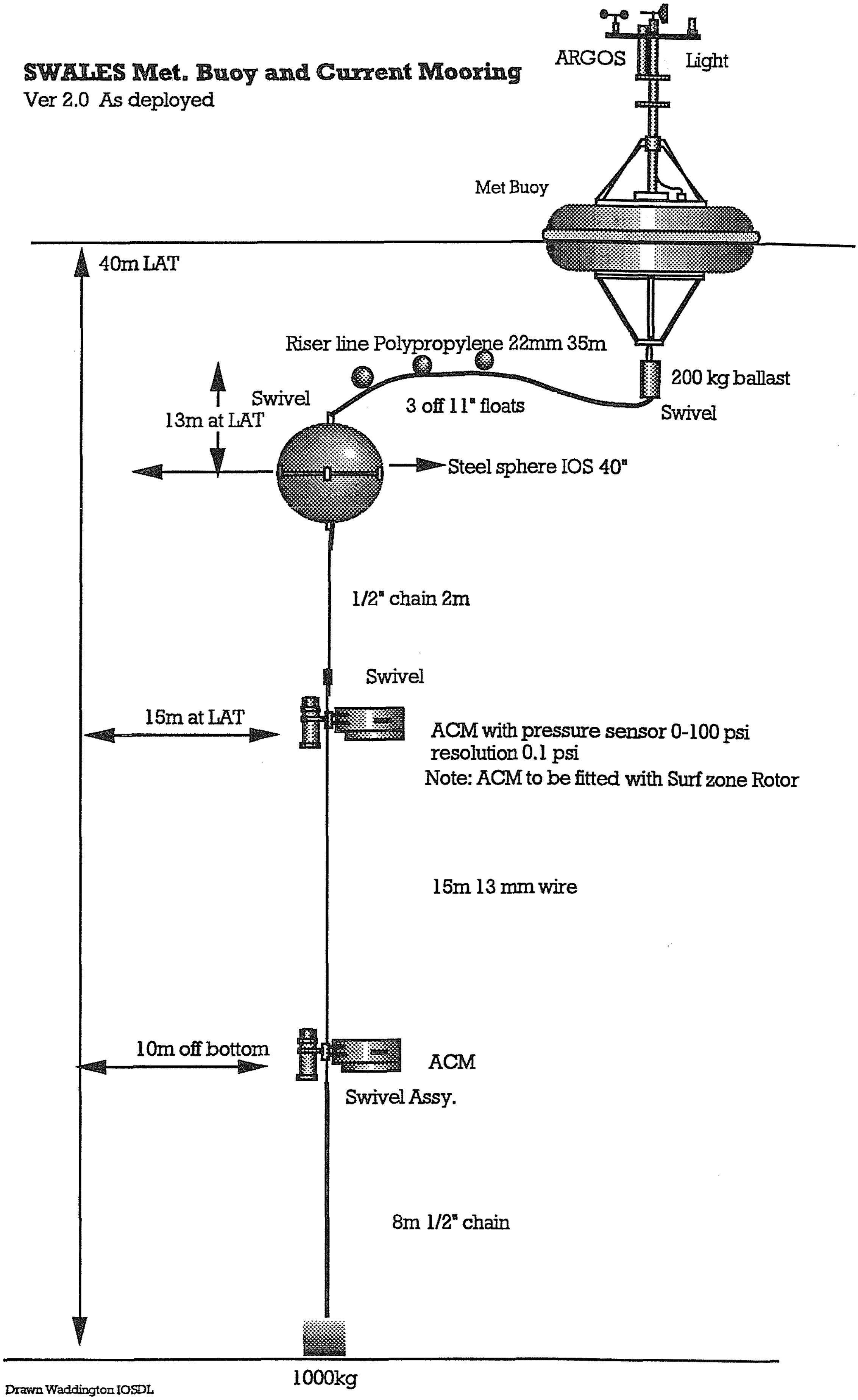
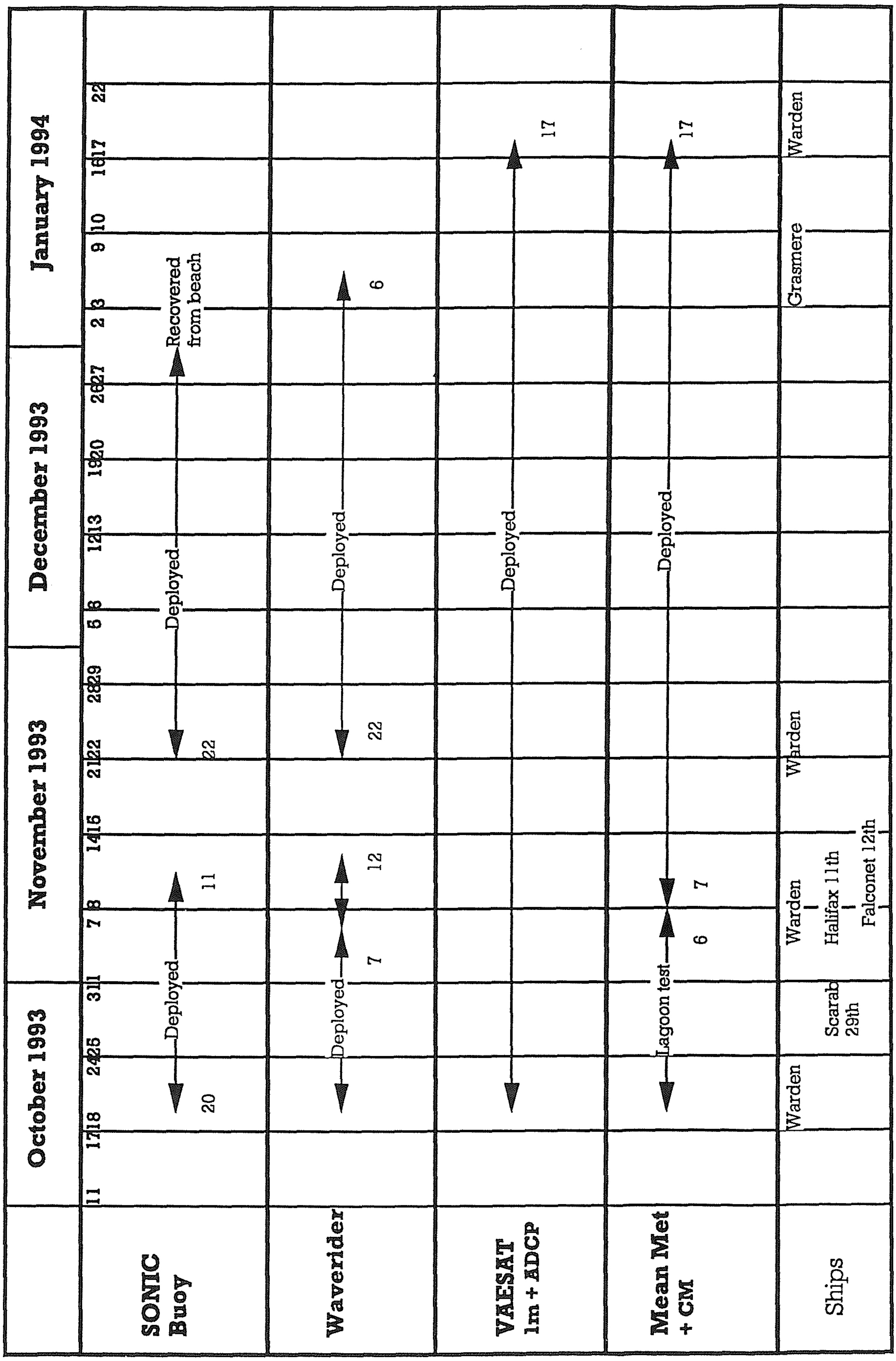

SWALES Met. Buoy and Current Mooring
Ver 2.0 As deployed
ARGOS
Light
Met Buoy
40m LAT
Riser line Polypropylene 22mm 35m
200 kg ballast
Swivel
3 off 11" floats
13m at LAT
Swivel
Steel sphere IOS 40"
1/2" chain 2m
Swivel
15m at LAT
ACM with pressure sensor 0-100 psi
resolution 0.1 psi
Note: ACM to be fitted with Surf zone Rotor
15m 13 mm wire
10m off bottom
ACM
Swivel Assy.
8m 1/2" chain
1000kg
Drawn Waddington IOSDL

Fig 13.

10. Mooring Summary

The table below illustrates the mooring operations required and the survival time of the moorings .



Mean Meteorology Buoy

The Mean Meteorology Buoy (Met buoy) was developed for this project as a progression from the Toroidal buoy (Toroid)previously employed for deep sea applications . The Toroid is a doughnut 8 feet in diameter with a 2.5 metre tower onto which the met sensors , logger and battery housings are mounted . The Met buoy based on the VAESAT buoy hull was proposed as a lighter,smaller and more manageable package with all batteries and logger within one water tight housing . Thus reducing mast loading and the requirement for several watertight packages . fig 1.

1.Mechanical Construction .

The VAESAT hull , special keel and deck plates were fabricated by external suppliers to IOSDL design .
The mast and all brackets and deck plate fittings were manufactured inhouse by OIG workshops , much of the design and fabrication being undertaken by the workshop staff as the buoy was constructed .

1.1. Hull and canister assembly.

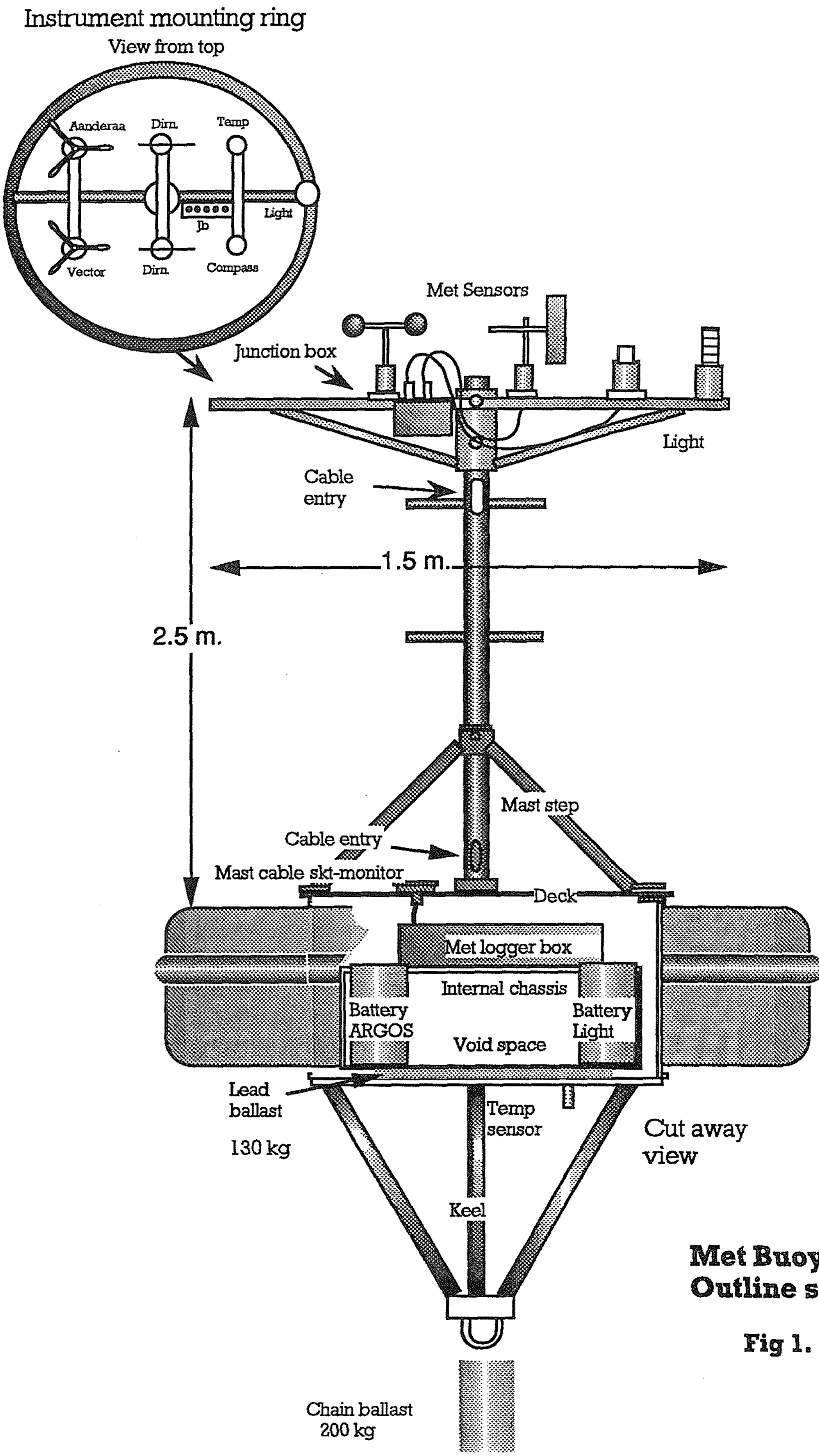
The VAESAT buoy hull is a semi discus hull with central watertight canister held within the buoys 'bobbin' structure , closed by detachable aluminium bulkheads as deck and hull plates . This canister is detachable from the main buoy aluminium 'bobbin' structure .
The Met buoy central hull assembly uses the aluminium 'bobbin' as the watertight canister with deck and hull plates attached by bolts directly to it . This simplifies construction and reduces maintenance .
The hull is consructed around this aluminium and is fabricated from closed cell polyurethane foam overlaid with fibreglass bonded to the central bobbin . This gives the external hull its rigidity . The hull has also been fitted with a rubber rubbing strake around its diameter to limit damage on deployment and recovery should the buoy impact with the ships side .

1.2. Tower assembly .

The tower is constructed to carry meteorological instruments and navigation aids . The instruments are at 2.5 metres above sea level .

IOSDL has traditionally employed a multi-legged tower design for this structure giving rigidity and strength to carry loggers and battery packs . With the revised concept of carrying these items within the hull , a lighter structure was possible .
The tower takes the form of an aluminium mast stepped into a deck support with a subassembly of four supports to position and strengthen the lower mast . This mast therefore needs no standing rigging to support it , giving a reduced windage .

The upper mast has an aluminium instrument mounting ring located on a central boss slid onto the mast and secured with stainless steel bolts . This ring is supported by four aluminium struts from the boss and has a central horizontal mounting bar onto which instruments and connectors are bolted .



Met Buoy Outline sketch

Fig 1.

Brackets are welded onto the ring to support the navigation light and instrument connector box .
The mast has a cutaway near the base to carry cables up to the mounting ring .

1.3. Deck plate .
The deck plate is an aluminium plate shaped to the diameter of the bobbin flange drilled to accept the bobbin bolts .

The deck is cutaway to carry an attachment plate which provides the mounting for the through deck connectors and allows removal of the internal connector cable and multiway plug .
The deck also carries the aluminium mast step welded centrally .

1.4. Hull plate .
This plate is the closure of the hull underwater and is prepared as the deck plate .

The plate carries the sea surface temperature probe which is in the form of a boss welded through the hull . This boss is drilled and threaded to accept the temperature sensor .

1.5. Surface finishes.
The mast assembly and deck plate are coated with an etching primer and then overcoated with Hammerite flat yellow paint .
The hull plate is coated with etching primer only .
The steel keel assembly was shotblasted and coated with read oxide primer overcoated with Hammerite flat yellow paint .

1.6. Internal chassis assembly .
The chassis assembly carries the battery packs , logger assmbly and internal ballast . As this assembly is very much a prototype fabrication was in wood with simple location brackets fabricated from aluminium and steels . This construction was by Survey Team staff .

The chassis is square in plan view and to locate it securely within the circular hull simple clamping brackets were devised to locate the chassis by pressure and friction to the aluminium bobbin .
All wiring is secured to the chassis using self adhesive cable clamps .

1.7. Meteorological mountings .
A design has been evolved to mount instruments to the toroid tower and this was continued for the new mast . The brackets clamp to the horizontal mounting bar on the top ring and enable two instruments to be fitted at ech end of a horizontal mounting plate . The instruments are Aanderaa and Vector Instruments types and the brackets can accept both types of anemometer .

The brackets are positioned to provide the optimum exposure for the instrument types within the protective ring .

1.8. ARGOS beacon mounting .
The ARGOS beacon is fitted within a diecast aluminium box which is clamped to a diagonal ring support . This was acceptable but added considerable weight to the mast assembly . Future ARGOS beacons should be fitted within the hull with the antenna only on the mast .

2.Meteorological Sensors and Logger .
The system is based on an Aanderaa package used on the Met Toriod buoy . This assembly was rebuilt to be fitted within the buoy hull and also to provide a met system which could be used as a land based system for other deployments .

2.1. Logging and interfacing .
A Sensor Scanning Unit 3010 is used to interconnect and to provide switching and formatting of the sensors .
This unit has a selectable 12 channel configuration with only 9 channels utilised in the present configuration . Wiring is incorporated to access further channels and is provided to the mast top junction box .

Channel	Sensor	Type
1	Reference value	Fixed value
2	Wind direction	Aanderaa 2750
3	Wind speed average	Aanderaa 2740
4	Wind speed Gust	Aanderaa 2740
5	Buoy Orientation	Aanderaa
6	Air Temperature	Aanderaa 3145A
7	Wind speed	Vector 2536
8	Wind direction	Aanderaa 2057
9	Sea temperature	Aanderaa

The Vector wind sensor is a cup anemometer with a switched Reed sensor . This is interfaced to the Scanning unit using an Aanderaa pulse counter type 2891 and a simple circuit to divide the counts to numbers acceptable with reference to the sampling period of the scanning unit .

The sensors can be connected independently to sockets for each channel or through the mast cable plug and sockets . This is done as applicable to the sensor location and type .
Power is provided to the Scanning unit by two 9v Leclanche cells paralleled with Schottky diodes giving an operating period in excess of 80 days at 20 minute sampling . The power supply is switched at the mast junction box by a connecting plug . Thus the buoy can be powered up/down without opening the hull .
Alternatively a land based power input is provided to run the unit on 240 volts ac. although this is not brought outside the buoy hull and is for test or land use only .
The Scanning unit can be monitorred at the deck plate using a through plate mounting socket which gives access to the PDC 4 output to the DSU .Thus the buoy does not need to be opened to check operation .

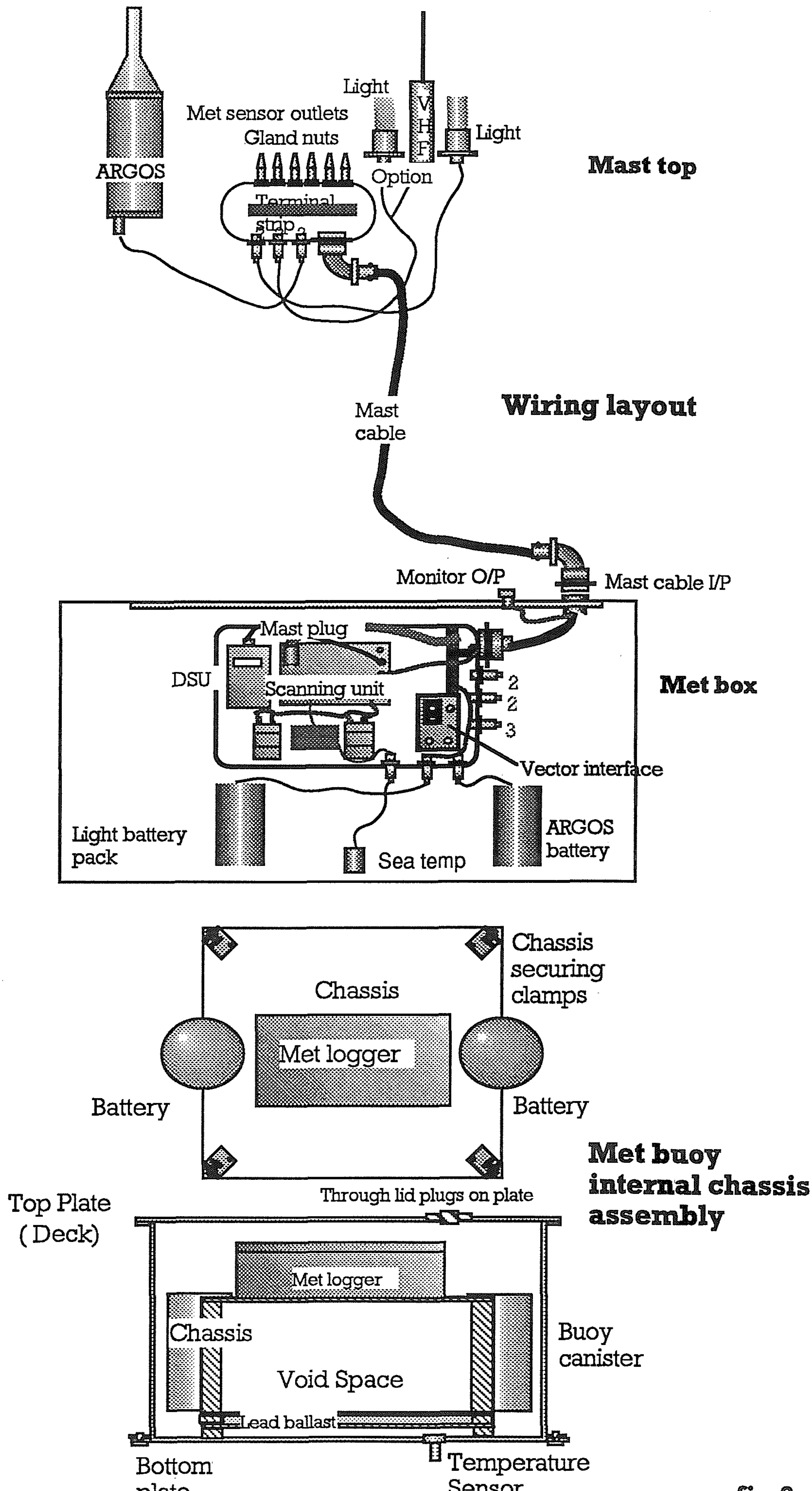

Mast top
Light
Met sensor outlets
Gland nuts
Light
VHF
ARGOS
Terminal strip
Option
Wiring layout
Mast cable
Monitor O/P
Mast cable I/P
Mast plug
DSU
Scanning unit
2
2
3
Met box
Vector interface
Light battery pack
Sea temp
ARGOS battery
Chassis
Chassis securing clamps
Met logger
Battery
Battery
Met buoy internal chassis assembly
Top Plate (Deck)
Through lid plugs on plate
Met logger
Chassis
Void Space
Buoy canister
Lead ballast
Bottom plate
Temperature Sensor

fig 2.

The data is logged at selectable intervals to an Aanderaa Data Storage Unit (DSU) type 2990E through 6 core cable from the Scanning unit .The DSU has its own internal settable clock to monitor time of scans at 24 hour periods and on/off times . The unit is powered by an internal Lithium cell with a seven year operating lifetime .2.2. Mechanical assembly .

The Scanning unit , DSU , batteries and wiring are located within a splash proof casing fitted with external bayonet type connectors for sensors and other power connections . This casing acts as a junction box for other power supplies such as ARGOS and navigation light and is provided with spare sockets for future applications .

Fig 2 . Internal chassis and logger assembly.

3. Navigation aids .

Navigation aids are provided to locate the buoy and warn off other vessels . Using ARGOS a daily monitorring can be made of the buoys position . VHF beacons were used on previous buoys as aids to relocation . However with the GONIO ARGOS radio direction finder now available these are considered unnecessary .

3.1. ARGOS .
The buoy is fitted with an ARGOS PTT transmitter to provide monitorring of the buoys position . The prototype used a mast mounted beacon whcih should be superceeded by an in hull transmitter with the antenna only on the mast .
The PTT is provided with 15V dc power from a standard VAESAT buoy alkaline battery pack , this was for convenience on the prototype and could be by any suitable cells giving adequate battery capacity .

3.2. Light .
The navigation light is a RYOKUSEI Sea Light modified to fit within a housing for external battery supply .The light is Xenon and flashes once per two seconds . For future deployments this should be replaced with a navigation approved light .

4. Operational Experience .

The buoy was test assembled at IOSDL and all functions checked . The hull was then sealed for deployment with the tower and all sensors removed .

4.1. Working on the mast .

At Pembroke it proved beneficial to have a ladder to reach the top ring for sensor fitting .

At sea with the buoy secured to its pallet it was possible to climb the mast to check sensors and brackets .

4.2. Deployment . fig 3.

The buoy assembled in this format had not been deployed or recovered and a suitable simple scheme was evolved to lift the unit overboard on RMAS Warden . Lifting strops were provided from the buoy deck which positioned a soft strop up to the lifting hook of the gantry . When the buoy lifted it was off vertical with the mast away from the soft strop .

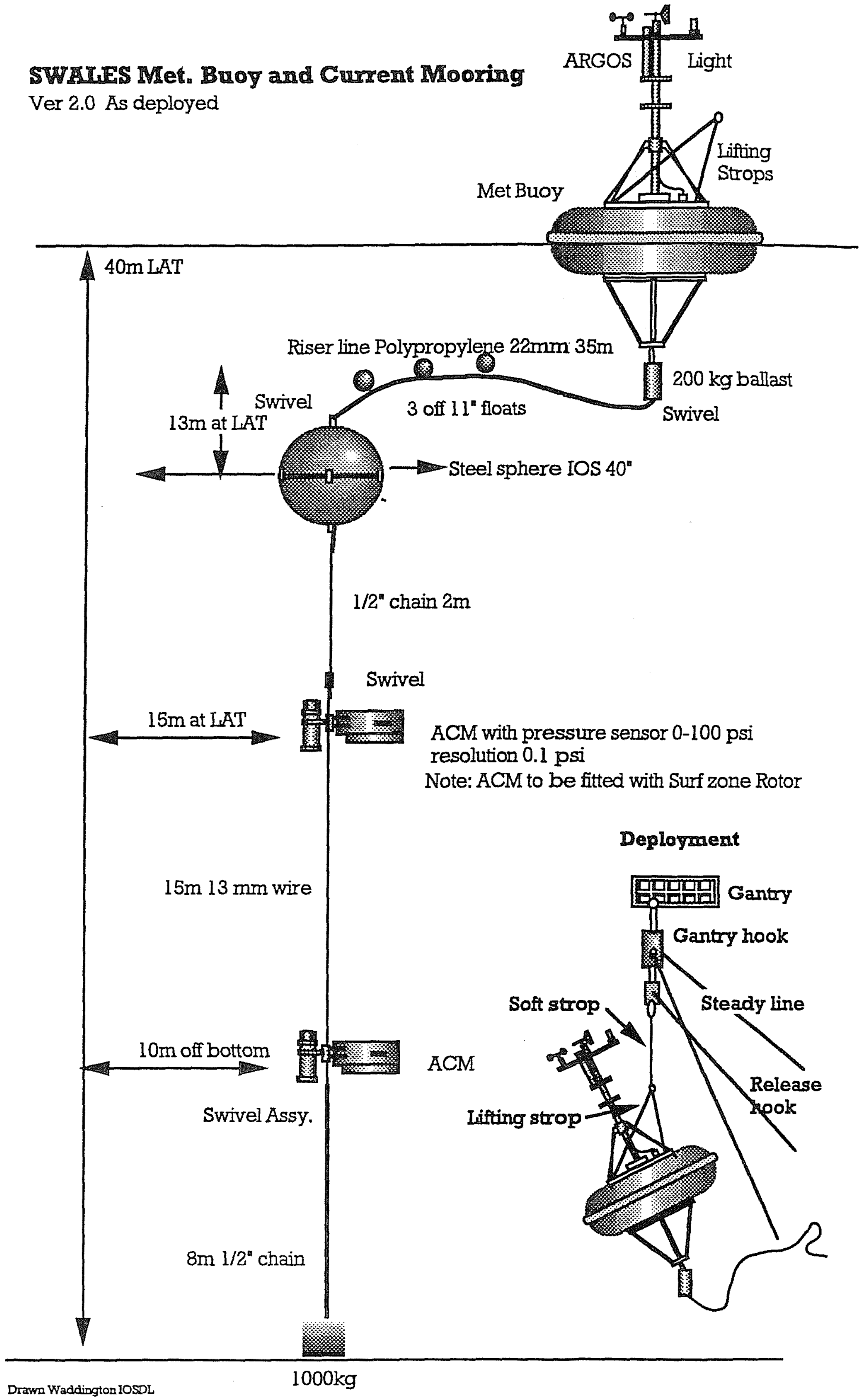
As the buoy entered the water the mast came vertical and the lifting hook released and pulled clear of the instruments . It was at this point that an untended gantry line fouled one cup of the Aanderaa anemometer and broke it off .

There needs to be further thought put into launching the buoy and to sensor protection .

4.3. Recovery .

The mooring was deployed as a combination current and met. mooring and this induced greater drag and lifting loads than originally conceived . However the buoy was recovered with no sensor damage using a recovery line to the lifting strops and hauling aboard .

Further attention is required to strengthen the lifting lugs at the deck bolts .


SWALES Met. Buoy and Current Mooring
Ver 2.0 As deployed
ARGOS
Light
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Riser line Polypropylene 22mm 35m
200 kg ballast
Swivel
3 off 11" floats
Swivel
13m at LAT
Steel sphere IOS 40"
1/2" chain 2m
Swivel
15m at LAT
ACM with pressure sensor 0-100 psi
resolution 0.1 psi
Note: ACM to be fitted with Surf zone Rotor
Deployment
Gantry
Gantry hook
Soft strop
Steady line
15m 13 mm wire
10m off bottom
ACM
Release hook
Lifting strop
Swivel Assy.
8m 1/2" chain
1000kg
Drawn Waddington IOSDL

Fig 3.

5. Post deployment inspection .

The buoy was returned to IOSDL with mast and sensors removed . The hull seal was unbroken .

5.1. Unsealing .

The deck seal was difficult to break as the sealants had bonded very effectively.The sealant was cut away from the joint and a large bar inserted between the deck and hull to open up the seal . With the joint opened slightly the deck seal was cut through progressively with a sharp thin bladed knife until the deck could be lifted off . It was noticed that there was a significant vacuum within the hull preventing the seal breaking .

5.2. Logger and chassis assembly .

The logger and chassis were as originally fitted with no signs of leakage or movement . This was encouraging as the buoy had been subject to severe weather conditions and a significant road journey .

5.3. Battery packs , electronics and sensors .

The navigation battery packs were at acceptable working voltages . However the Scanning unit batteries were below operating voltage .
The navigation light was working correctly.
The ARGOS beacon appears to have failed electronically .

The Scanning unit had stopped working prematurely and on testing all parts it was found that the Aanderaa wind sensor had failed and was taking significant continuous current . This had caused the battery failure . The DSU was found to be working correctly and stored data extracted for analysis .The DSU clock was checked to determine time of failure and as a measure of clock drift with reference to events measured .
This failure was disappointing as data was not acquired throughout the deployment period . This fault has not been observed at IOSDL before and the sensor is to be sent to Aanderaa for assessment .

All other sensors were tested and found to be functioning correctly . The Vector wind sensor bearings were quite noisy and stiction was significantly high .

5.4. Mast assembly .

The top ring was damaged and welds broken through . There appears to have been an impact on the ring from beneath . This would indicate that the buoy has been interfered with , perhaps a passing vessel .
The mast otherwise was in good condition .

5.5. Deck and Hull

There was no damage to either deck or hull and minimal corrosion on the deck . However the hull plate under the buoy had started to corrode and significant corrosion was apparent on the temperature sensor . This plate and assembly had not received the full protective coatings on assembly due to time constraints . The assembly can be recoated and reused .

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