INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

WORLD METEOROLOGICAL ORGANIZATION

DATA BUOY CO-OPERATION PANEL

DEVELOPMENTS IN BUOY TECHNOLOGY AND ENABLING METHODS

TECHNICAL PRESENTATIONS MADE AT THE ELEVENTH SESSION OF THE DBCP

DBCP Technical Document No. 7

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(Pretoria, October 1995)

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1996

NOTES

Editorial note: This publication is for the greater part an offset reproduction of typescripts submitted by the authors and has been produced without additional revision by the Secretariats.

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FOREWORD

At its tenth session, the panel supported several proposals for closer co-operation with the Surface Velocity Programme (SVP). In particular, the panel agreed that in future sessions of the DBCP, at least half-a-day should be spent on scientific/technical presentations which would appear as a separate agenda item. These presentations would enhance dialogue between the scientific and operational agencies concerned with ocean data buoys, and would also help to expand and give direction to the work of the panel.

Several agencies made presentations at the eleventh session of the DBCP on the developments in buoy technology and enabling methods, and the text of these presentation can be found in this DBCP technical document. The text of some presentaations were not however received in time for publication and in these cases an abstract of the presentation, when available, has been included instead.

AGENDA

(Pretoria, Wednesday 18 October 1995)

- Pierre Blouch, Centre de Météorologie Marine of Météo France, France
- OPERATING MARISONDE-GT BUOYS IN THE LAST TWO YEARS

- Andrew Sybrandy, Scripps Institution of Oceanography, USA
- SVP BAROMETER DRIFTER AND SVP METEOROLOGICAL DRIFTER

- Sergey Motyzhev, Marine Hydrophysical Institute, Ukraine
- MARINE, AIR, AND GROUND AUTOMATIC OBSERVING STATIONS DEVELOPED AT THE MARINE HYDROPHYSICAL INSTITUTE

- Derek Painting, Meteorological Office, United Kingdom
- IMPROVED AIR TEMPERATURE MEASUREMENTS FROM DRIFTING BUOYS
-
- Julie Fletcher, John Burman, Meteorological Service of New Zealand, Ltd., New Zealand
- DRIFTING BUOY CALIBRATION AND TESTING AT METSERVICE NEW ZEALAND
-
- Richard W. Reynolds, William J. Emery, NOAA National Meteorological Center, USA
- IN SITU AND SATELLITE SST COMPARISONS
-
- Alex Papij, Turo Technology Pty Ltd, Australia
- T-700 BAROMETER DRIFTERS, MULTIPLE PARAMETERS AND SOFTWARE MANAGEMENT

- Eric A. Meindl, National Data Buoy Center (NOAA/NWS), USA
- ENVIRONMENTAL BUOY DATA: THE HISTORICAL RECORD AND FUTURE POSSIBILITIES

- David Meldrum, Dunstaffnage Marine Laboratory, United Kingdom
- INTEGRATION OF GPS AND DRIFTING BUOYS

- Merritt Stevenson, Instituto Nacional de Pesquisas Espaciais, Brazil
- DEVELOPMENT OF A THERMISTOR CHAIN FOR USE WITH SEA ICE AND ANCHORED BUOYS

- Eugene Burger, South African Weather Bureau, South Africa
- USE OF THE SVP-B DRIFTER- THE SAWB EXPERIENCE
-
- William Woodward, NOAA National Ocean Service, USA
- THE TAO ARRAY

PRESENTATIONS

1) OPERATING MARISONDE-GT BUOYS IN THE LAST TWO YEARS

By: Pierre Blouch
Centre de Météorologie Marine of Météo France
Brest, France

Abstract

The Marisonde GT buoy is the most complete kind of drifting buoy used routinely in France by the Meteo-Oceanographic community. Developed and operated by the Centre de Météorologie Marine of Météo-France, it measures sea temperature at various depths down to 150 meters (10 levels), wind velocity and wind direction. About thirty of these buoys were deployed in October 1993 in the south of Azores for the SEMAPHORE experiment. Later, five others were deployed in the Brazil-Malvinas currents confluence (June 1995).

The paper recalls the characteristics of the buoy, presents some results obtained during the past 2 years and tries to look at its future.

2) MARINE, AIR, AND GROUND AUTOMATIC OBSERVING STATIONS DEVELOPED AT THE MARINE HYDROPHYSICAL INSTITUTE

By: Sergey Motyzhov
Marine Hydrophysical Institute, Ukrainian Academy of Sciences
Sebastopol, Ukrain

Abstract

The MHI accumulated large experience in development, creation and use of marine, air, and ground automatic observing stations. The presentation includes:

1. History of the space communication system (BUKAZ, CONDOR, SSPI-INTERCOSMOS, COSPAS, PLANETA).

2. Creation of the mathematical model of the swimming buoy for the radio-communication reliability and fixing accuracy increase.

3. Using the mathematical model when marine and air EPIRBs COSPAS/SARSAT were developed. Creation of the ground EPIRB.

4. Creation and utilization of the drifters:

   - use the surface floats LOBAN with COSPAS/SARSAT PTT in Atlantic ocean and Black Sea;
   - study the surface and subsurface slip currents using single drifter with "window shade" drogue;
   - creation the drifter for the deepwater currents;
   - creation the SVP WOCE / TOGA drifter;

5. Underwater buoys (diving and drifters).

6. Space markers for the balloons (atmosphere and stratosphere).

7. Creation ARGOS PTT (Transmitter, Data acquisition and processing unit, check apparatus).

Thus, to the end 1995 development of family marine, air and ground platforms, adapted under system of communication ARGOS will be completed.

MARINE, AERIAL AND GROUND-BASED AUTOMATIC OBSERVING STATION DEVELOPED AT THE MARINE HYDROPHYSICAL INSTITUTE

S.V. MOTYZHEV

1. THE MAIN DIRECTIONS IN THE PTT DESIGNING, MANUFACTURE AND UTILIZATION

This report focuses on the research carried out since 1978 up to date. Here, I would like to draw your attention to the data obtained in the domains:

The satellite communication systems, which we used.

Manufacture of the mooring buoys.

Peculiarities of drifter behaviour on the sea surface. The influence of sea waves on reliability space communication and buoy location.

Development of a mathematical model for buoy behaviour on the sea.

Model utilization in manufacturing the marine EPIRB COSPAS/SARSAT.

Development of the aircraft-mounted and ground-based EPIRBS.

Manufacture and use of drifters.

The construction of underwater and diving drifters.

The experience of development and use of balloon markers.

Development of the ARGOS technology in producing a new generation of platforms.

2. SPACE COMMUNICATION SYSTEMS FOR PTT

The first systems of space communication failed to define the platform's coordinates. The figure shows the mooring buoy OCEAN equipped with the system BUKAZ.

The figure shows the buoy SHELF, equipped with the system SSPI-IC.

The picture also shows the mooring buoy MHI-9301, together with the equipment CONDOR. This system permitted to establish the buoy's location, using the Doppler method; however, the accuracy was in sufficient. Therefor, it was impossible to use this system for the work with drifters.

3. THE INFLUENCE OF SEA WAVES ON THE RELIABILITY OF RADIOCOMMUNICATION AND ACCURACY OF THE BUOY'S LOCATION

There are three reasons affecting the quality of communication and location accuracy for Doppler systems. The first reason consists in that, as the buoy is rocking on a wave, the signal's amplitude changes when it is being received by a satellite. This leads to the satellite's failure to receive about 50% of the messages.

The second reason is closely connected with the first one. It consists in that, the smaller the number of messages received by a satellite, then lesser the accuracy of the buoy's location using the Doppler technique.

The third reason is that the larger the linear velocity of the antenna's radiating point the lesser the accuracy.

4. MATHEMATICAL MODEL FOR A FLOUTING BUOY ON ROUND SEA SURFACE

The model was generated on the basis of theory for ships rocking on the sea waves. It permits to design a buoy and concurrently to determine such principal characteristics as the period and the amplitude of natural oscillation. Using the model, one can design a buoy's case, to place various units and blocks inside it, to align the buoy and to find an optimal behaviour of its static and dynamic characteristics on the sea surface.

5. DEVELOPMENT OF THE MARINE EPIRB "MUSSON-501

Using the mathematical model, a new configuration of the EPIRB was developed. The figure shows the buoy model together with the stock-produced EPIRBs. It also shows the buoys, floating on the sea surface. With the designers work completed an external appearance of the EPIRB "MUSSON-501" is also shown on the figure.

6. DEVELOPMENT OF THE MARINE EPIRB "MUSSON-501

The utilization of model has allowed us to produce an EPIRB, which does not do any angular oscillations while floating on the sea surface. The tests have shown the number of messages, received by the satellite to be almost equally to the theoretical one. The error of establishing the buoy's location did not exceed 1 km. A series of messages was made, involving the establishing of the buoy's position when the satellite was behind the horizon. In 1992 the COSPAS / SARSAT Conference (London) recognised the EPIRB "MUSSON-501" to be one of the best.

7. AN AERIAL EPIRB FOR THE RESCUE SCREEN AIRCRAFT

It is necessary to equip the rescue screen EPIRB cartridge to indicate the site of accident. We have studied 3 methods of dropping the buoy onto the sea surface:

directly;

using a shock-absorber;

using a special droque.

The computation have shown variants 1 and 2 to be not suitable, as the buoy can experience an acceleration up to 50 g. As a result, for the rescue screen aircraft we chose the method of dropping the buoy by means of the droque.

8. GROUND-BASED EPIRB FOR HUNTERS, FOREST RANGERS, GEOLOGISTS

Frequently it is necessary not just to transmit a distress signal and to establish the position. Moreover, it may be vital for one to know specifically, what happened and what kind of assistance is required. With this borne in mind, we developed an EPIRB capable of coding of a signal; and then conducted an experiment in Siberia. Twenty EPIRBS were manufactured and distributed between various users. Two persons were rescued in taiga. The experiment has demonstrated the efficiency of such EPIRBS.

9. DRIFTING BUOYS

As regards the development of drifters, three major categories of drifters may be identified:

"LOBAN" surface float;

drifter with the window shade droque;

SVP drifter.

10. THE METHOD OF DRIFTER TRAJECTORY RESTORATION

The method of drifter trajectory restoration was developed on the basis of the least squares technique. It permits to take into account the scatter in establishing the buoy's position, to calculate the speed and the direction of drifting, as well as to restore the drifter's trajectory.

11. LOBAN DRIFTERS

LOBAN drifters have been used since 1985 to 1995 to study the heat transfer by surface currents. They were equipped with the sensors of the sea water temperature. The figure shows the results of one of the experiments conducted in 1985. Concurrently, remote sensing from a NOAA satellite was carried out. The remotely-sensed data were presented as the fields of radiation temperature. The data on sea water temperature compiled by drifters, jointly with the NOAA data permitted to construct sea surface temperature contours of the Black sea.

12. LOBAN DRIFTERS

As in all 24 LOBAN drifters have been used on the Black Sea and 10 drifters in the Atlantic Ocean. The results of the experiments are submitted on the figures. It is necessary to note that we failed to ensure the buoys lifetime in the Black Sea equal to 120 days. The maximal duration of operation amounted to 99 days. In the other cases, the buoys or were cast up ashore, or picked up by ships.

13. INVESTIGATION OF THE SHEAR CURRENTS IN THE ACTIVE LAYER

The method of measurement of subsurface and surface currents by the single buoy with the window shade droque was developed. It is known that the droque is not capable of moving with the subsurface current speed because of the resistance of the surface float. The essence of the method boils down to the measurement of the velocity at which the droque is slipping in a flow.

The pressure of the overflow leads to the deviation of the carrier cable from the vertical. The pressure gauge indicates the drogue's height and the compass attached to it shows the current's direction.

With the overflow vector and that of the drift velocity being known, one can determine more accurately the subsurface current velocity.

It may be supposed, that the current forces, applied to the droque and the float are equal. Then the known vectors of the slipping velocity and the buoy's drift velocity permit the surface current velocity vector to be defined.

14. INVESTIGATION OF THE SHEAR CURRENTS IN THE ACTIVE LAYER

The picture shows the results of calculations of subsurface and surface currents velocity vectors using the graphic and the analytical methods.

15. INVESTIGATION OF THE SHEAR CURRENTS IN THE ACTIVE LAYER

The figure demonstrates the formulas permitting the errors of the method to be calculated. To perform calculation, we use the errors made by the pressure sensor, the compass, and the result of establishing the buoy's position. The results are listed in the table.

16. EXPERIMENTAL DETERMINATION OF THE ERROR OF DROQUE ORIENTATION IN THE SUBSURFACE OVERFLOWING CURRENT

The study of the method's inaccuracy under the real conditions was conducted in the Atlantic Ocean. For the droque orientation in the overflowing current to be determined, two current meters were used. One was rigidly attached to the droque and indicated the droque's orientation in the flow. The second meter had a free suspension and indicated the direction of the overflowing current.

The results of the experiment are shown on the figure. The calculations point out that the difference is about 5°, which is the error in the determination of the overflowing current orientation.

17. EXPERIMENTAL DETERMINATION OF THE METHOD'S INACCURACY, USING A DRIFTER AND A MOORING BUOY

To test the method, a match-up experiment was conducted, using the drifter and the mooring buoy. Despite the fact that the mooring buoy and the drifter are designed to measure different currents, with steady flow being involved, such a comparison may be regarded as correct. The mooring buoy featured a current meter at a depth of the droque. The drifter was deployed 3 miles away from the mooring buoy. The obtained data are listed in the table.

If the buoy drift is assumed to be equal to the subsurface current, the difference between the mooring buoy - derived data and drifter - derived data amounts, in terms of speed and direction, to 115 and 13%, respectively. After processing the drifter data, with the overflowing current being taken into account, the respective differences are 15 and 6% . These results imply that the method is very efficient.

18. DRIFTER WITH THE DROQUE SUSPENDED TO THE BOTTOM ONE

The method suggested takes into account the fact that a drifter with the droque can not move with the speed of the subsurface current. At the same time a question arises: Is it possible to trace underwater currents using a drifter with the underwater droque? It is clear that the float's and tether line's resistances prevent to do this. It can be easily shown that floats with Í <D have a smaller resistance than floats with H> D. However, such floats strongly affect the droque. As a result of this the droque quickly gets out of order.

In the SVP drifter the float dives into the water, thus decreasing the load on the droque. It is possible to apply another method when the droque has the bottom suspension. In this case, the pressure on the droque is brought down by virtue of the distributed ballast. The buoy model has been tested in an air flow and has displayed its efficiency.

19. DEVELOPMENT OF THE SVP DRIFTER

Our first attempt to produce a SVP drifter was a failure. Then we received Green Book from Peter Niiler and developed a new buoy. The design of the SVP drifter completely corresponds to that of the "Green Book". In 1994 the buoy was tested at the Institute's sea test area. The tests lasted for 3 months. When the intense currents occurred, the load on the buoy was many larger compared with the typical conditions. Results of the tests allow us to deduce that the buoy can operate for at least one year.

20. DEVELOPMENT OF THE SVP DRIFTER

All the technological equipment was designed and manufactured, which is necessary for manufacturing buoys. We are ready to further cooperate with the interested parties with the purpose of joint utilization of SVP drifters.

21. CREATION THE DIVING BUOYS AND SUBMERGED DRIFTERS

We have carried out a large amount of work aimed at the development of diving buoys and submerged drifters. Diving drifters are designed to flout on the sea surface to dive and surface following the program prescribed. The submerged drifter has an alternative buoyancy and can move in the water according to the command given. A diving buoy is shown on the figure. It was produced in 1983 and is capable of making 30 divings down to a depth of 50 m.

22. SCHEMATIC PRESENTATION OF THE DIVING BUOY, WITH THE BUOYANCY BEING CONTROLLED BY MEANS OF METAL HYDRIDES

Much work has been done to study the new methods of buoyancy control. The figure shows schematically the diving buoy's buoyancy control system, using metal hydrides.

23. LABORATORY UNIT FOR THE METAL HYDRIDE TEST

Using the buoyancy control with involvement of metal hydrides we conceived to develop a diving buoy capable of making 200 divings to a depth of 200 ì . A special test unit was designed for conducting various tests. The tests have shown that the available metal hydrides have a large temperature hysteresis of hydrogen sorption and desorption. These metal hydrides can be used as a fuel for cars but can not be used for diving buoys.

24. SCHEMATIC PRESENTATION OF THE DIVING BUOY WITH THE BUOYANCY CONTROLLED BY MEANS OF METAL HYDRIDES AND DIFFERENCE OF TEMPERATURES BETWEEN THE SURFACE AND SUBSURFACE WATERS

Another pattern was developed in order to control buoyancy using metal hydrides. Energy consumption was reduced owing to the use of temperature differences between surface waters and deep waters.

25. SUBMERGED DRIFTER CONTROLLING BUOYANCY THROUGH THE USE OF THE DIFFERENCE IN THE DENSITIES SURFACE AND SUBSURFACE WATERS

The picture shows an underwater drifter which uses the density difference between surface and subsurface waters to control buoyancy.

26. UNDERWATER BUOY USING THE DIFFERENCE BETWEEN SURFACE CURRENTS AND THE SUBSURFACE ONES TO CONTROL BUOYANCY

This underwater buoy uses for shear currents to control its acting as an underwater drifter. This buoy can be used as underwater drifter and as mooring buoy.

27. MOORING BUOY DESIGNED TO STUDY INTERNAL WAVES

This buoys can be employed to feature temperature sensors facilitating the study of internal waves.

28. DIVING BUOY CAPABLE OF LATERAL SHIFTING IN THE DIRECTION GIVEN DURING LOWERING

This diving buoy can be used to study vertical features and jet currents.

29. DIVING BUOY CAPABLE OF LATERAL SHIFTING IN THE DIRECTION GIVEN DURING LOWERING

With the help a diving buoy which have possibility of the lateral moving in a given direction during immersing it is possible to study the underwater cyclones and jet currents.

30. UNDERWATER DRIFTER USING POTENTIAL ENERGY OF THE EARTH GRAVITY FIELD TO CONTROL THE BUOYANCY

This buoy uses the Earth's gravity energy to obtain an alternative buoyancy.

31. BUOY HAVING NEUTRAL BUOYANCY, DESIGNED TO DRIFT ALONG THE SAME ISOTHERM, WITH SALINITY BEING VARIABLE

This buoy having neutral buoyancy is capable of drifting along the path displaying the same temperature, with salinity being variable.

32. DIVING DRIFTER DESIGNED TO STUDY THE ACTIVE LAYER

Obviously, the buoys shown schematically here need a great amount of scientific and engineering work to be performed before they will have become a realty. This figure demonstrates the external appearance of a new diving drifter, which conforms with cur concept of buoy development. This buoy can dive 15 times to a depth of 150 m. To program the buoy's performance a computer is used along with RS232. The computer controls the sensors' operation, the data acquisition unit the transmitter, etc.

Supposedly the buoy will be used to study the hydrogen sulphide zone in the Black Sea.

I think, that this buoy may be effectively used to evaluate the stock of protein in the Southern Ocean.

33. STUDY OF THE OCEANIC TYPHOONS AND CYCLONES IN THE INDIAN OCEAN USING VENUS-HALLEY BALLOONS

The work on balloons began in 1990 when the "Venus-Halley" balloon was employed to study oceanic typhoons and cyclones. We produced a marker, which permitted to monitor the balloon's flight over the Indian Ocean via the COSPAS/SARSAT system. For the balloon's self-distraction we used a duplicated system, including an explosive charge and a chemical releaser. In all we launched 4 balloons in the Indian Ocean.

34. THE FIRST MARKER FOR STRATOSPHERIC BALLOONS

The work on stratospheric balloons began in 1991. For this purpose, we developed a marker with a heat-shielding housing. The marker incorporated a height indicator. The marker was used to perform a flight from Peking to Tashkent. We manufactured 8 markers, which are still being used.

35. SPECIAL BALLOON MARKER DESIGNED TO SPOT A BASKET ON THE SEA SURFACE

An interesting marker was constructed to provide for flights between Kamchatka and the Volga river. In the case of an unsuccessful launching, balloon basket may fall on to the sea surface. For finding the basket we developed a special marker, which is capable of separating from the sinking basket and surfacing . Having come to the surface, it transmitted a signal to a satellite. The marker was featured two temperature sensors: outside and inside of the hermetically closed housing. The data provided by the sensors allowed us to assess the efficiency of the heat-shielding. It is seen from the figure that over the 7 days-long flight, the temperature inside was not drop below - 22°C. At that time the outside temperature reached minus 60°C.

Heat defence provided near 40°C.

36. A MARKER FOR MARS BALLOON TESTS

A marker intended for testing MARS balloons is the our last development. It measures the height from 0 up to 50 km performs temperature correction of the height sensors and controls the balloon's equipment. The data from the marker can be transmitted to a satellite, as well as to a ground-based receiving station.

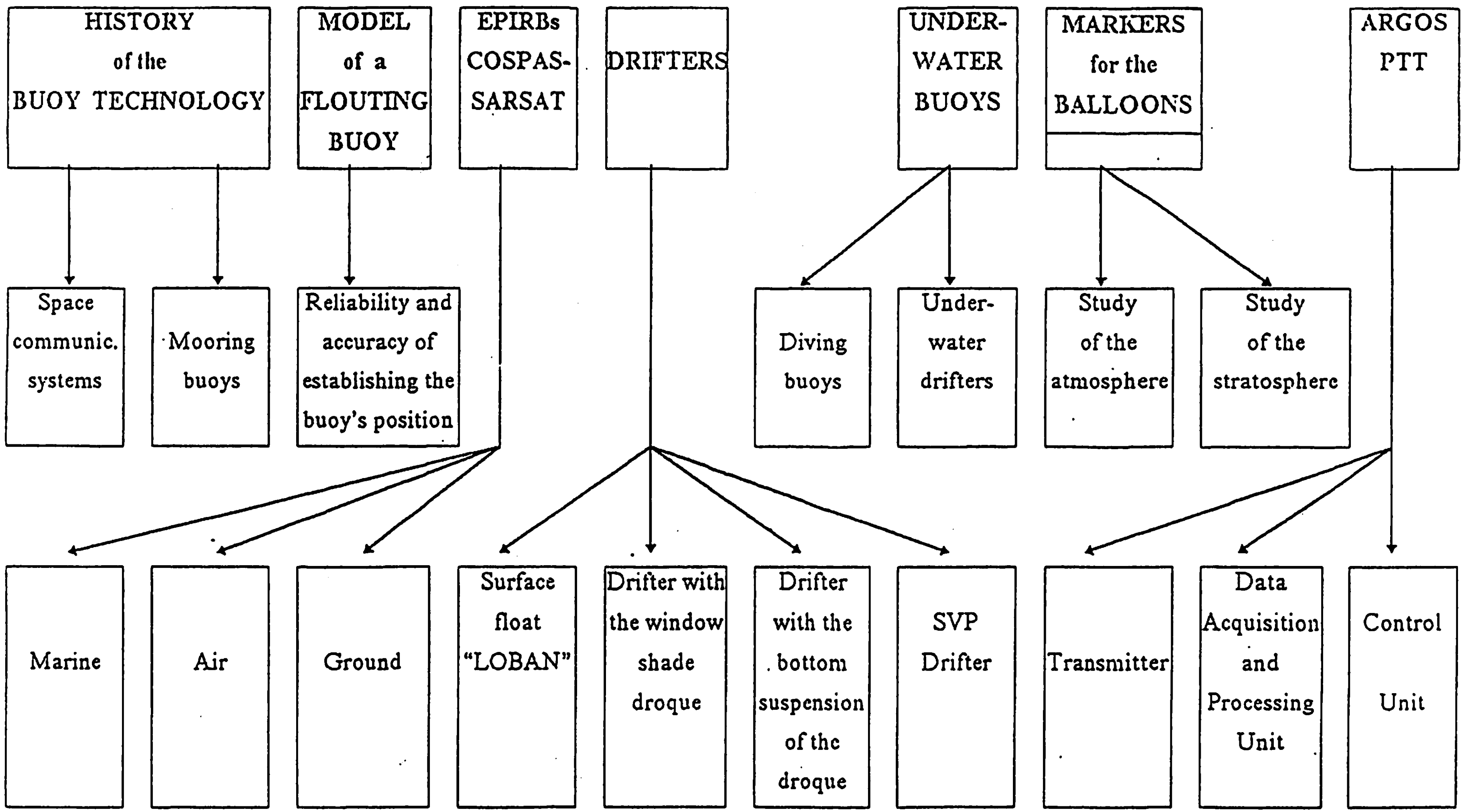
37. UNIFIED INSTRUMENTATION FOR MARINE, AERIAL, AND GROUND-BASED PLATFORMS

During this year, our objective was to develop unified instrumentation for collecting, processing, and transmission of data to be mounted on various types of platforms (marine, aerial, and ground-based). The platforms' equipment includes a basic set and a changeable set. The basic set includes a reprogrammable data processing unit and a unified transmitter. The unified transmitter can use one of the frequencies, namely, that of COSPAS/SARSAT, of ARGOS, or of CURSE. Any message is formed as a result of reprogramming the data collecting-and-processing unit. If necessary the satellite-mounted transmitter can be supplemented by a 121.5 MHz homing transmitter . The structure of the changeable set depends on the set of the sensors being used together with the transducers.

38. CHECKING INSTRUMENTATION FOR THE COMPLEX TESTING OF PLATFORMS

The portable checking instrumentation is intended for the complex testing of platforms. The checking includes the sensors testing and metrology, the testing of the data processing unit and transmitter. If necessary the checking instrumentation can be supplemented by a highly-sensate receiver, functioning on the space communication frequency. In this case, the data may be received from the platforms located at long ranges, for instance, when a MARS balloon is being tested.

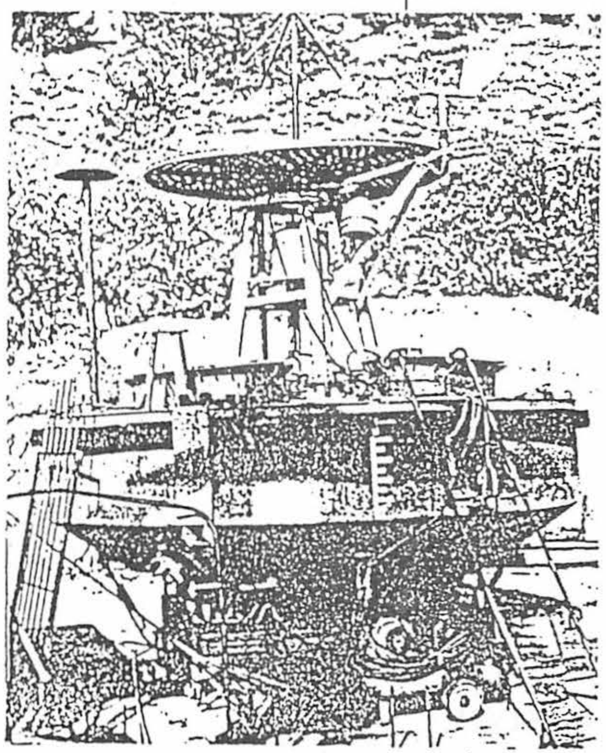
THE MAIN DIRECTIONS IN THE PTT DESIGNING, MANUFACTURE AND UTILIZATION



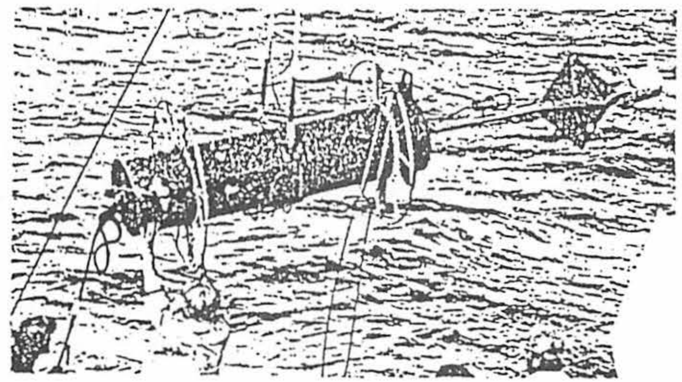
SPACE COMMUNICATION SYSTEM FOR PTT

Main characteristics

Name	Kind of Satellite Orbit	Call	Data Volume (bit)	Number of the PTT	Fixing mistake	Satellite Type
BUKAZ	Polar	Adress	24000	4	-	Ocean-E
SSPI-IK	-"-	-"-	10000	16	-	IC-20, 21
CONDOR-A	-"-	Withoutadress	200	10-12	±50 км	Ocean-O
CONDOR-M	-"-	-"-	2000	-"-	-"-	-"-
KENTAVR	-"-	Retransmit	16000	4-10	-	Mir
COSPAS	-"-	Without call	40	50-60	±2..3 км	Cikada
PLANETA-C	Geostat	Retransmit	5000	100-150	-	Elektra
COURSE	Polar	Withoutcall	32	70-90	±2..3 км	Cikada
ARGOS	-"-	-"-	32-256	-"-	-"-	NOAA



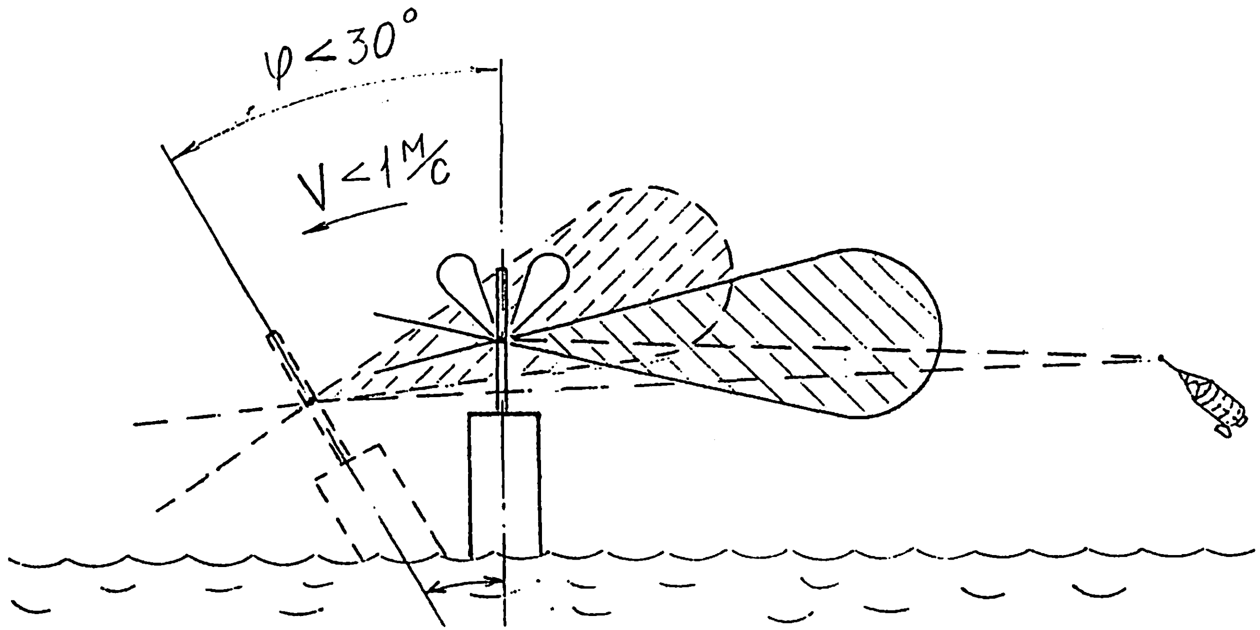
Mooring buoy
Ocean
with the
BUKAZ
space
communication
system
1978 -1979



Mooring buoy
MHI-9301
with the CONDOR
space
communication
system
1981 - 1983

Mooring buoy
Shelf
with the SSPI
space
communication
system
1979 - 1980

THE INFLUENCE OF SEA WAVES ON THE RELIABILITY OF RADIOCOMMUNICATION AND ACCURACY OF ESTABLISHING THE BUOY'S POSITION

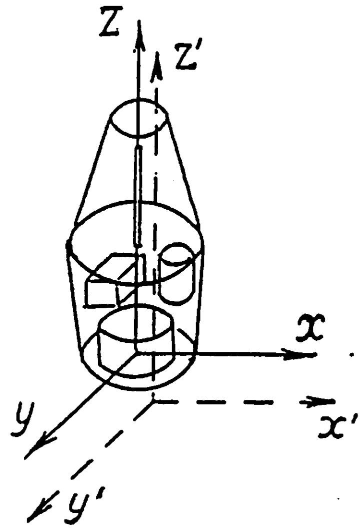


1. The loss of message at the satellite

2. The drop of accuracy of establishing the buoy's position, due to the loss of messages

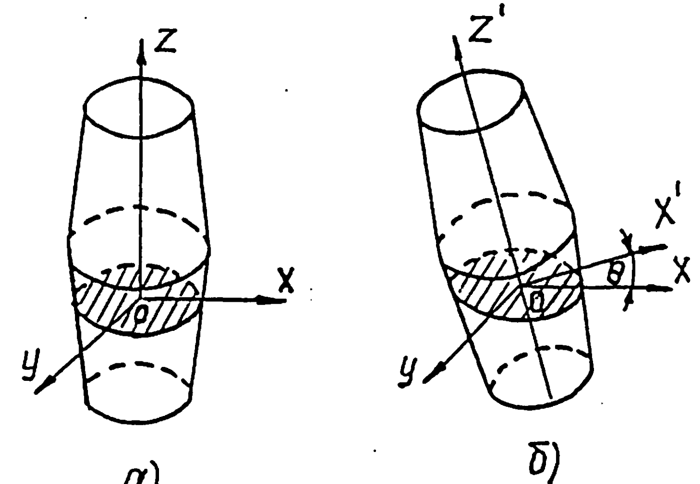
3. The drop of accuracy of establishing the buoy's position, due to the antenna's rocking

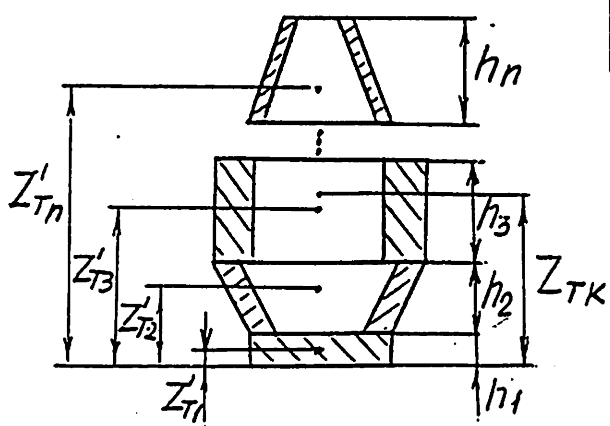
MATHEMATICAL MODEL FOR A FLOATING BUOY ON ROUGH SEA SURFACE

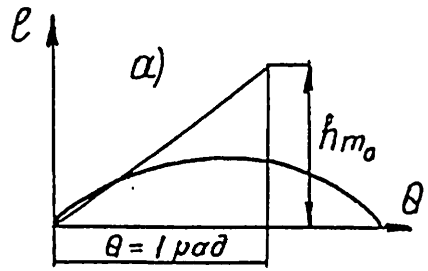


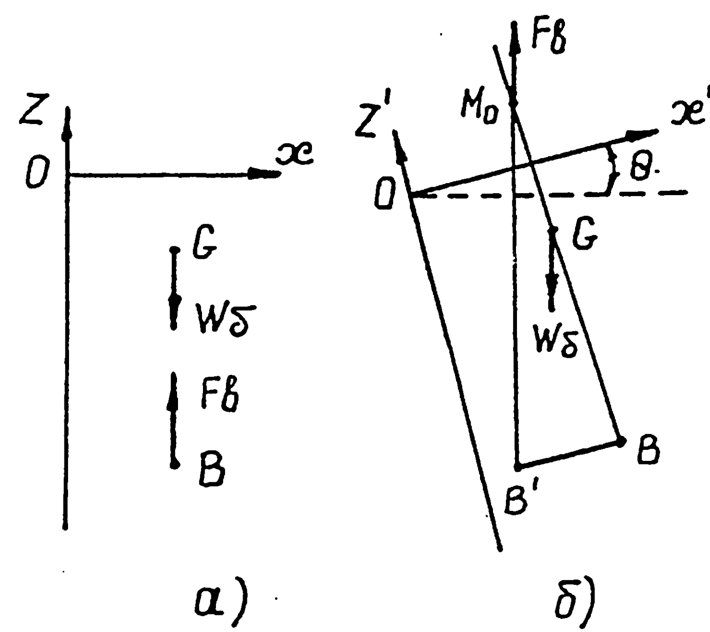
ENTER
h_i - height
d_i - external diameter
d_j - internal diameter
a_i - thickness
z_{gi} - centre of gravity
p_i - density

EXIT
T_a - period of angular fluctuation
φ_a - angle of fluctuation
T_v - period of vertical fluctuation
Z_b - buoy's centre of gravity

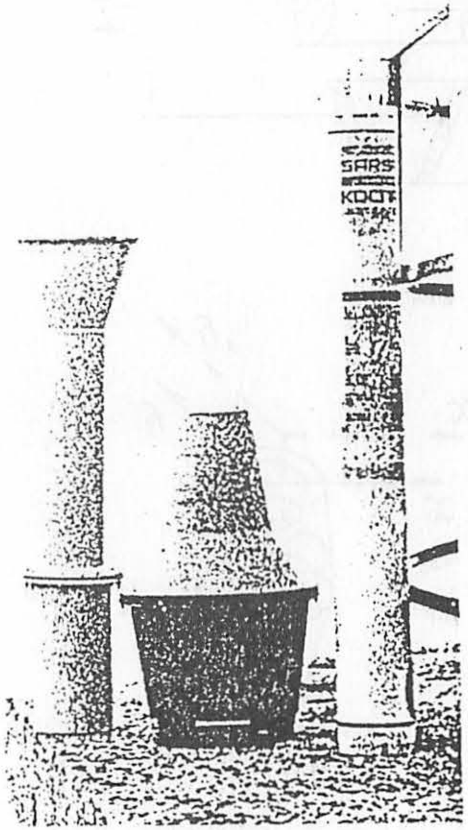


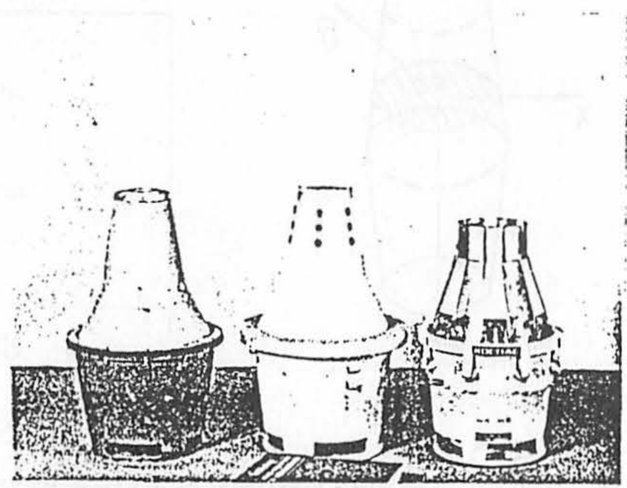




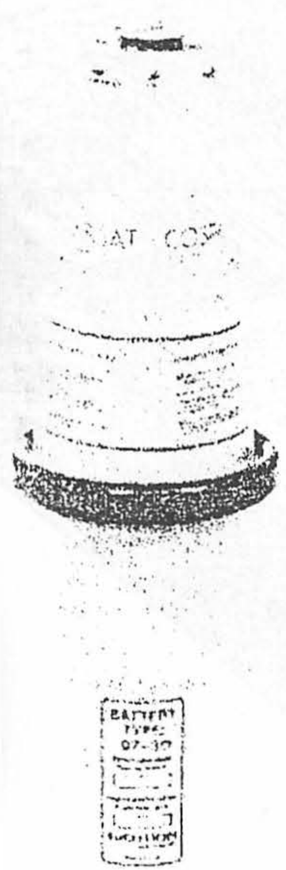


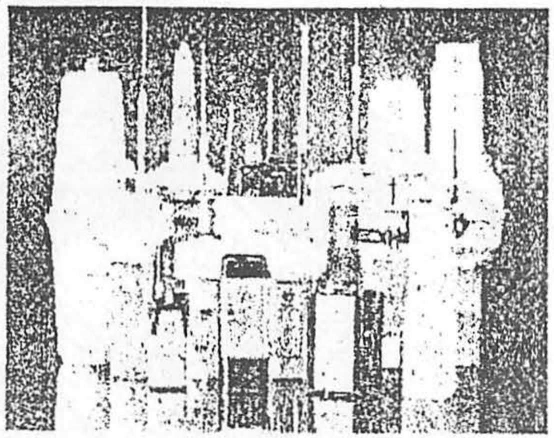
DEVELOPMENT OF THE MARINE EPIRB "MUSSON-501"

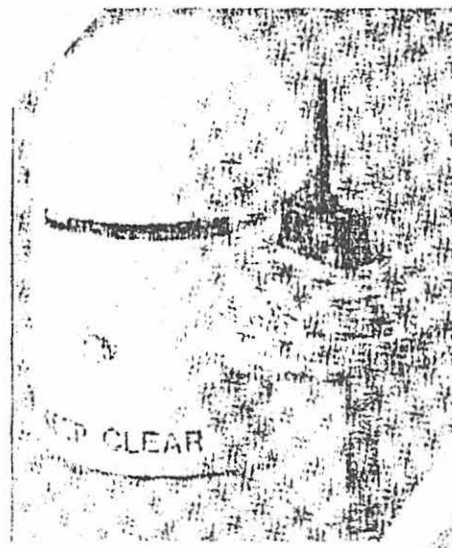




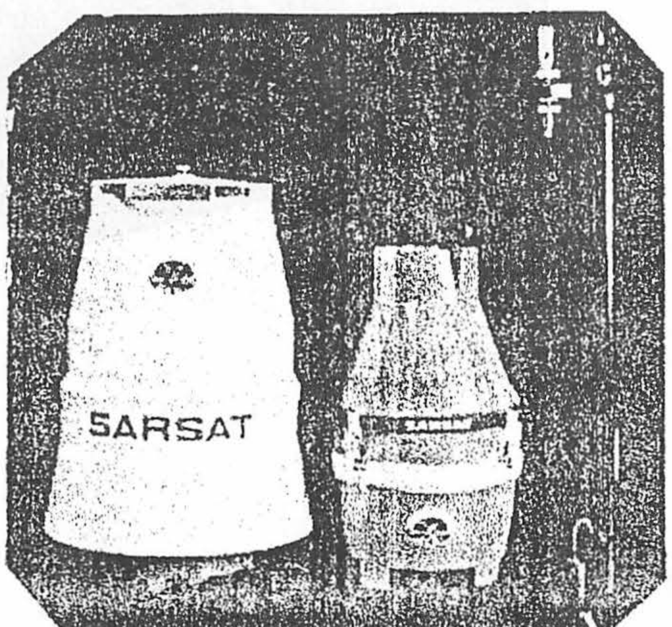
DEVELOPMENT OF THE MARINE EPIRB "MUSSON-501"



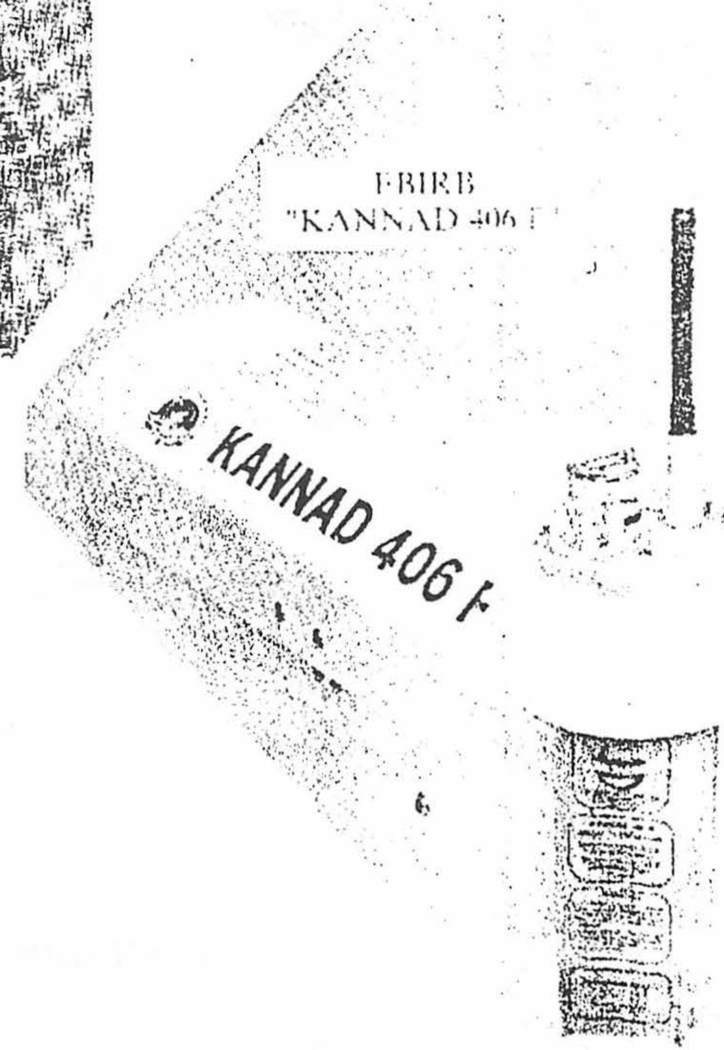




"LOKATA"
406H EPIRB

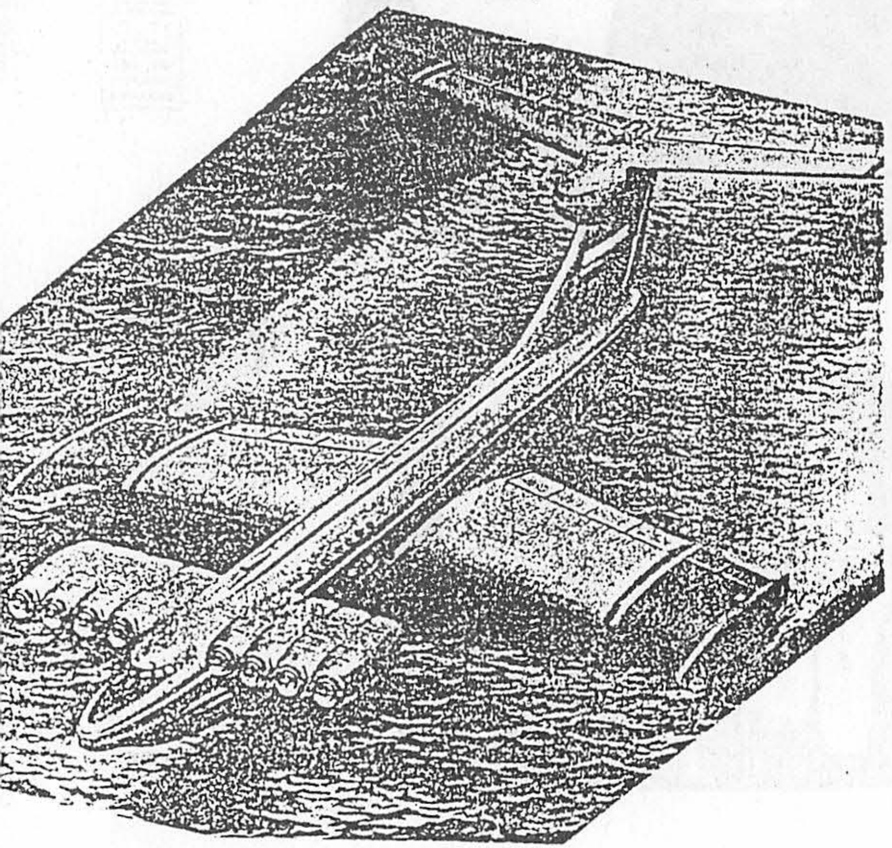


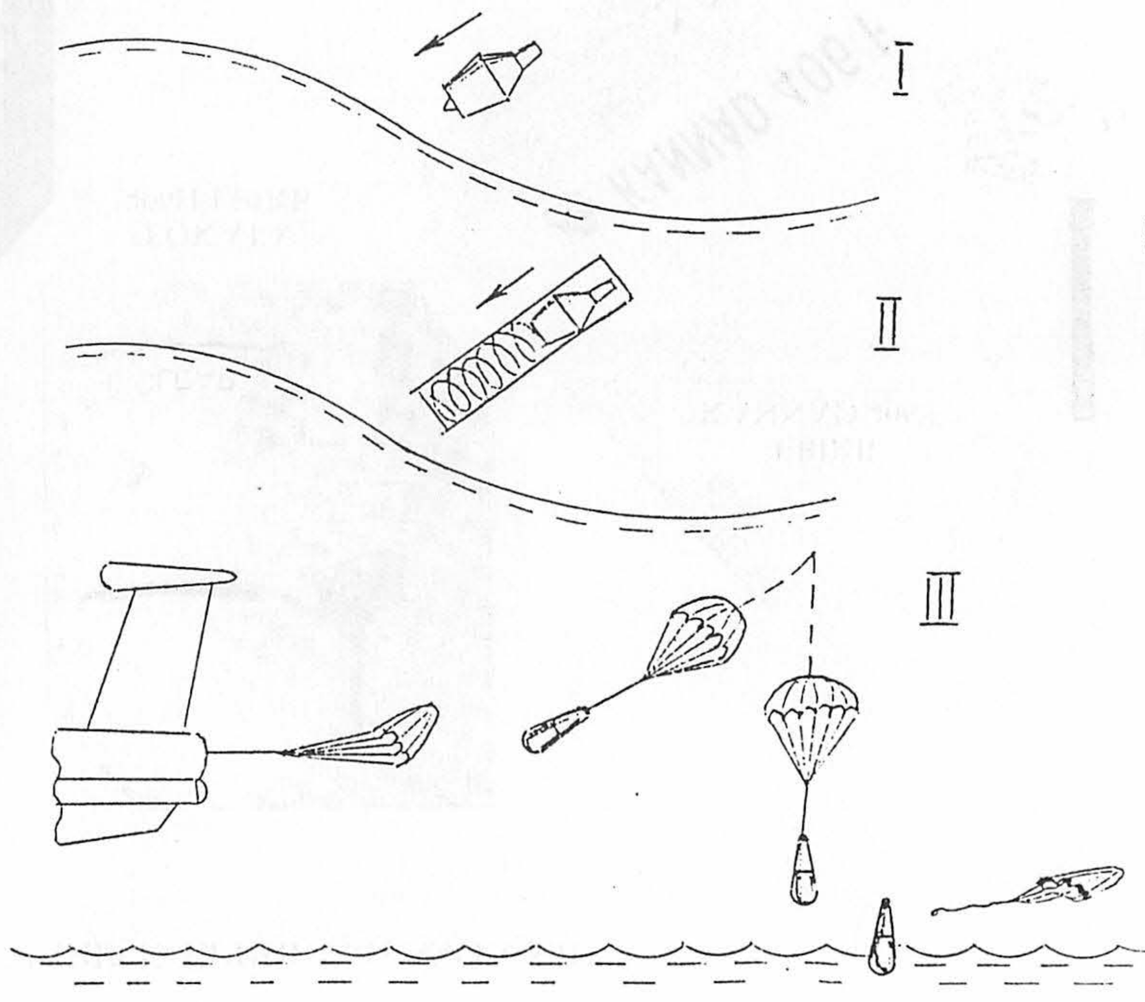
EPIRB
"MUSSON-501"



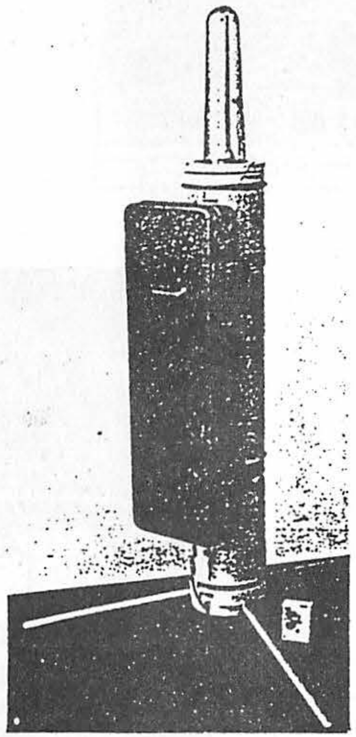
EPIRB
"KANNAD 406 F

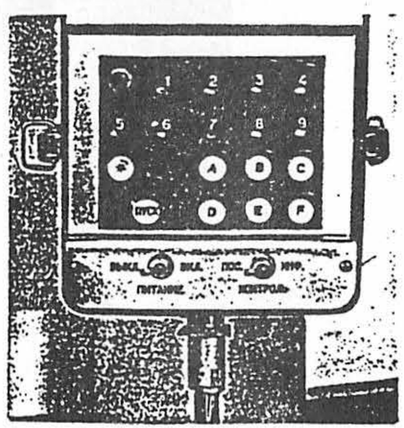
AN AERIAL EPIRB FOR THE RESCUE SCREEN AIRCRAFT





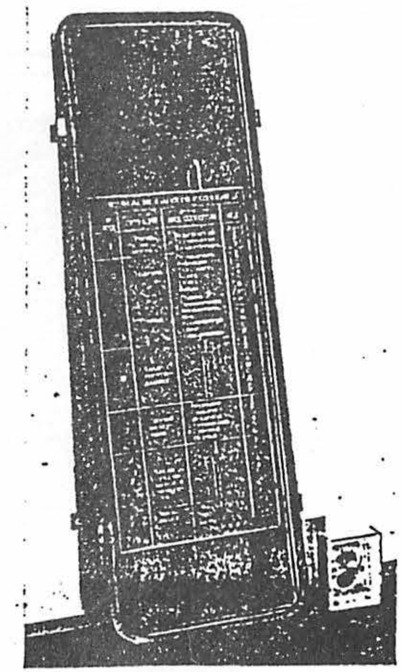
GROUND BASED EPIRB FOR HUNTERS, FOREST RANGERS AND GEOLOGISTS



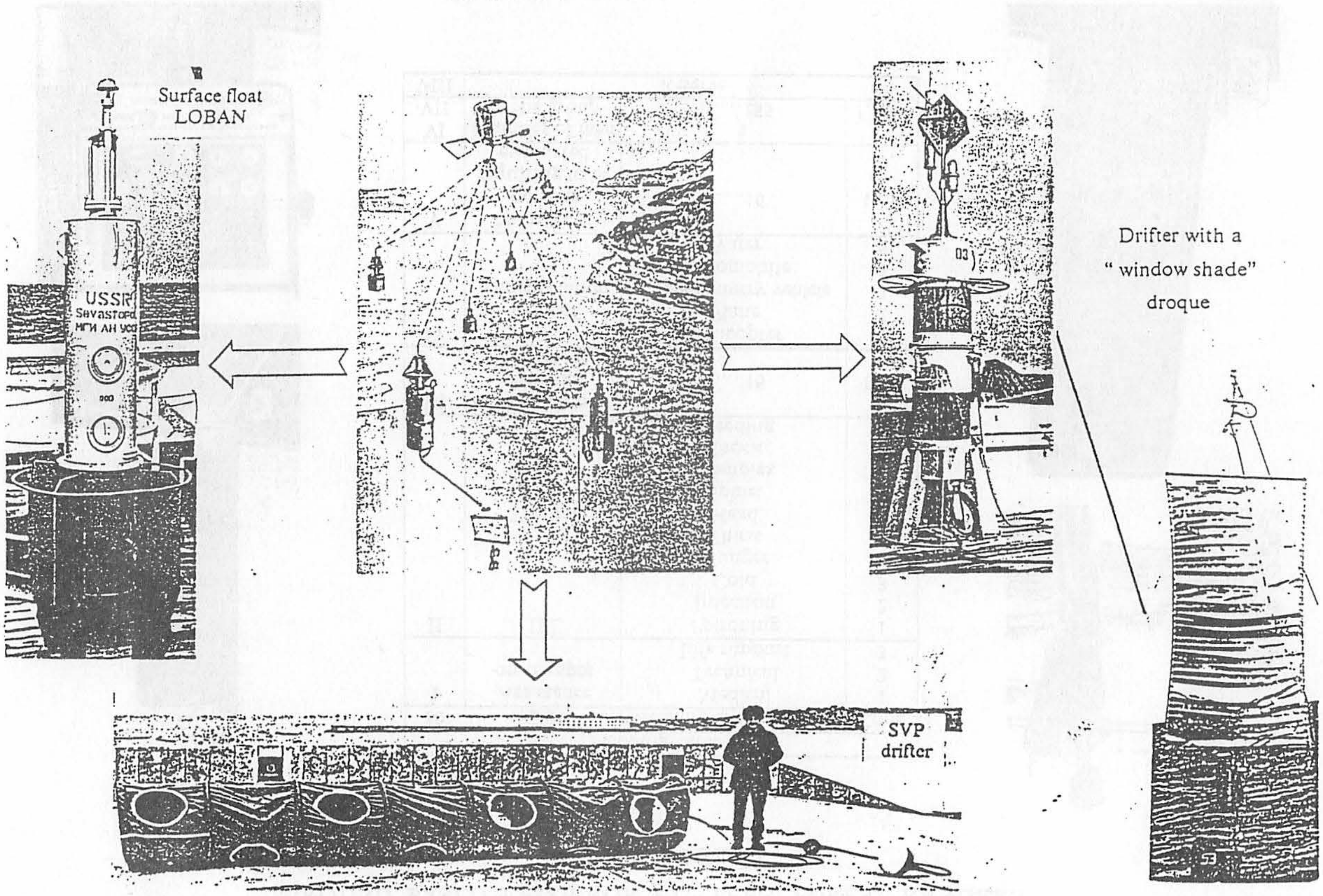


Coding table

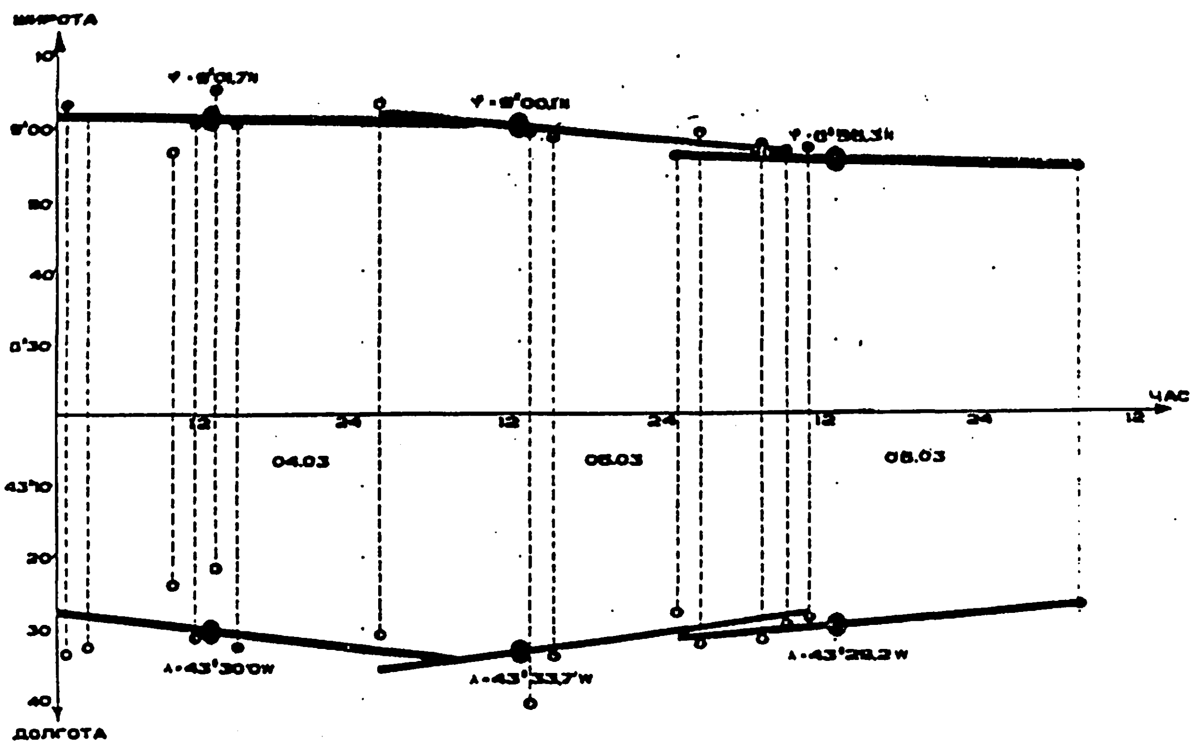
№	Case	Meaning of the message	Code
I	Assistance on the spot	Medical	1
		Technical	2
		Life support	3
II	ILL	Poisoning	1
		Infection	2
		Cold	3
		Hunger	4
		Thirst	5
	Trauma	Head	6
		Spinel	7
		Complex	8
		Shock	9
		Bleeding	10
III	Number of persons affected	1.....16	1...F
IV	Way of transportation	Helicopter	1
		Plane	2
		Cross-country vehicle	3
		Automobile	4
		Water	5
V	Number of persons requiring to be evacuated	1.....16	1...F
VI VII	Number of men in the group	1......255	1...FF
VIII	Reserve		



DRIFTING BUOYS



THE METHOD OF DRIFTER TRAJECTORY RESTORATION

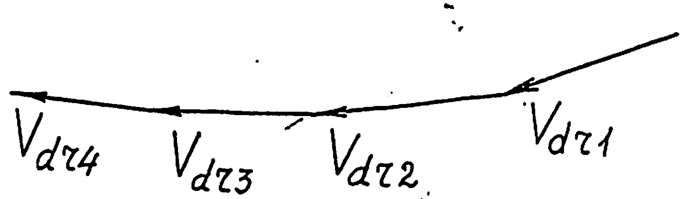


$$\varphi_t = a + bt_{обс}$$

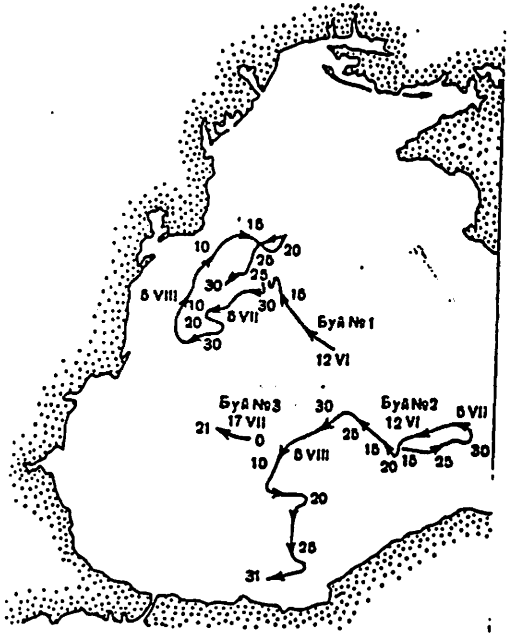
$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}\left[\varphi_{ti} - (a + bt_{обс.})\right]^2$$

$$b = \frac{\sum \varphi_t t - \frac{1}{n}\sum \varphi_t \sum t}{\sum t^2 - b\sum t}$$

$$a = \frac{1}{n}\left(\sum \varphi_t - b\sum t\right)$$

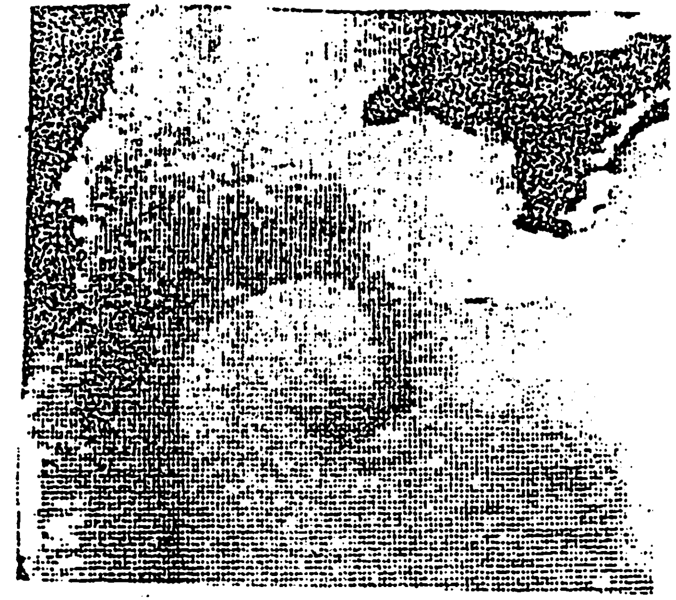


LOBAN DRIFTERS
1985 -1995



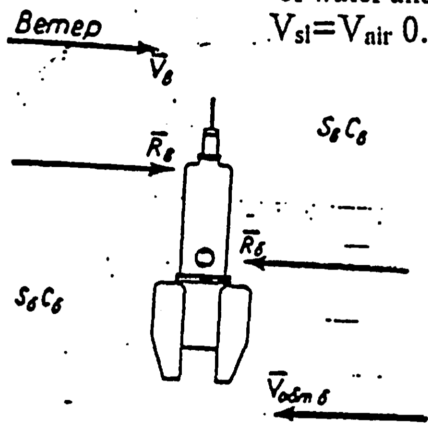
Drifter deployment in the Black Sea June-July 1987

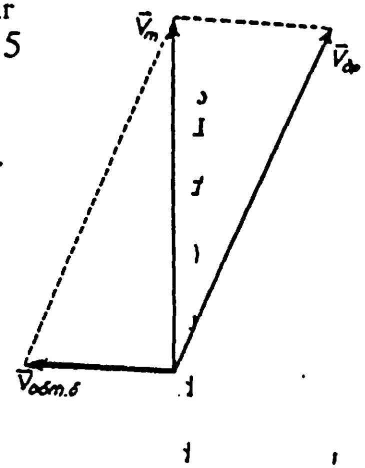
Observation from NOAA satellites

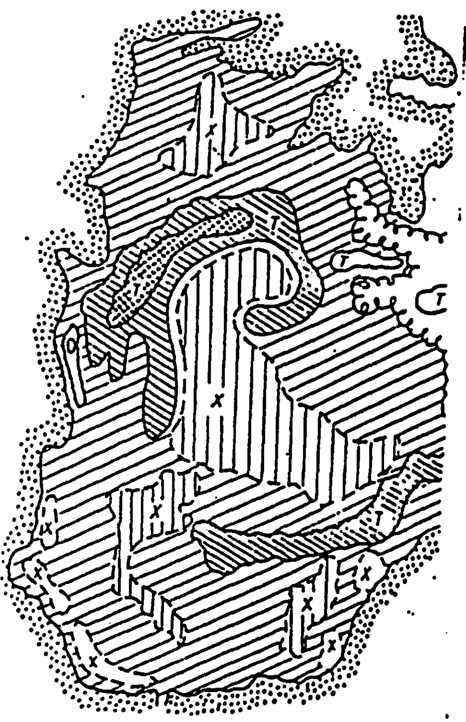


Drag Area Ratio with the calculation of the density of water and air

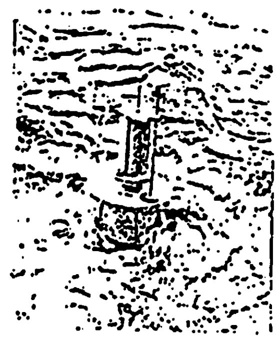
$V_{sl}=V_{air}$ 0.015





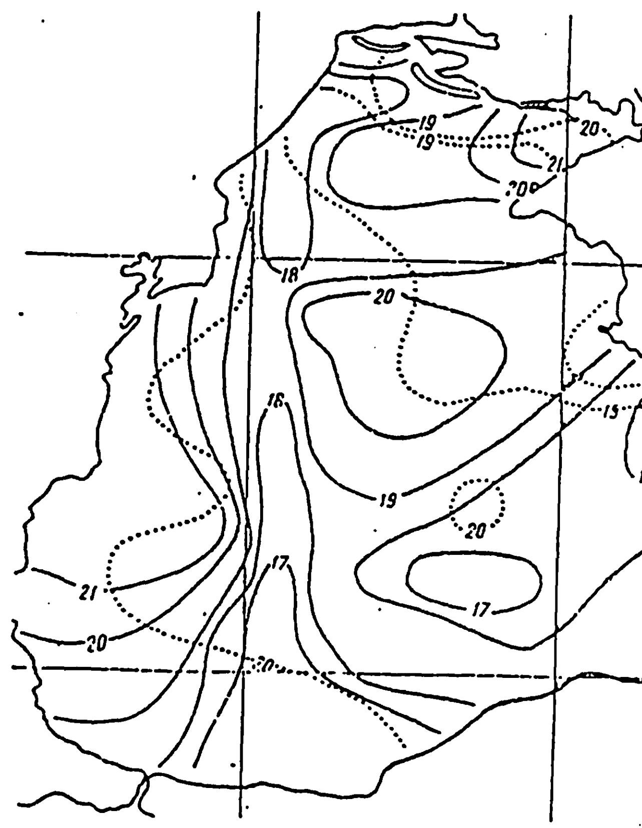


Radiation temperature fields



"LOBAN" drifter in the water

Sea surface temperature



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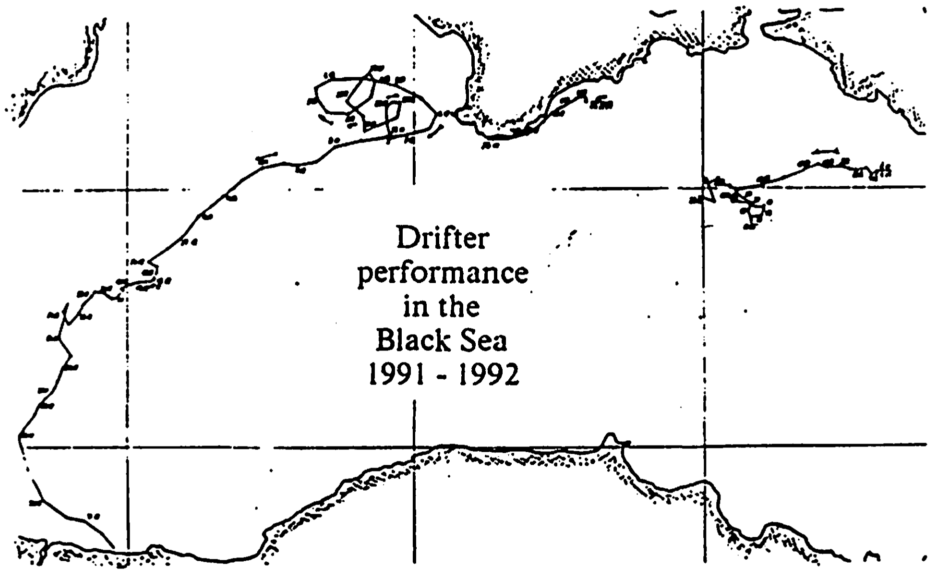
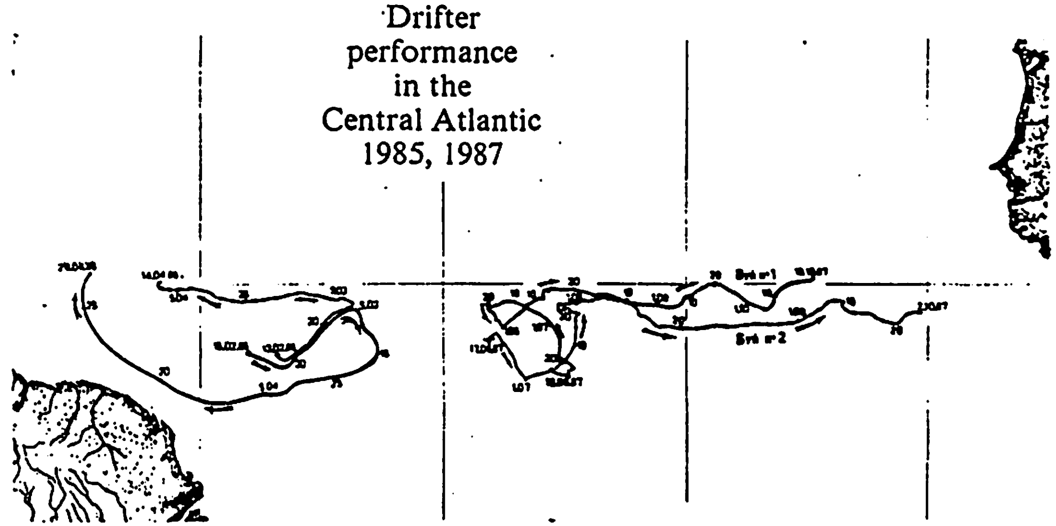
LOBAN DRIFTERS

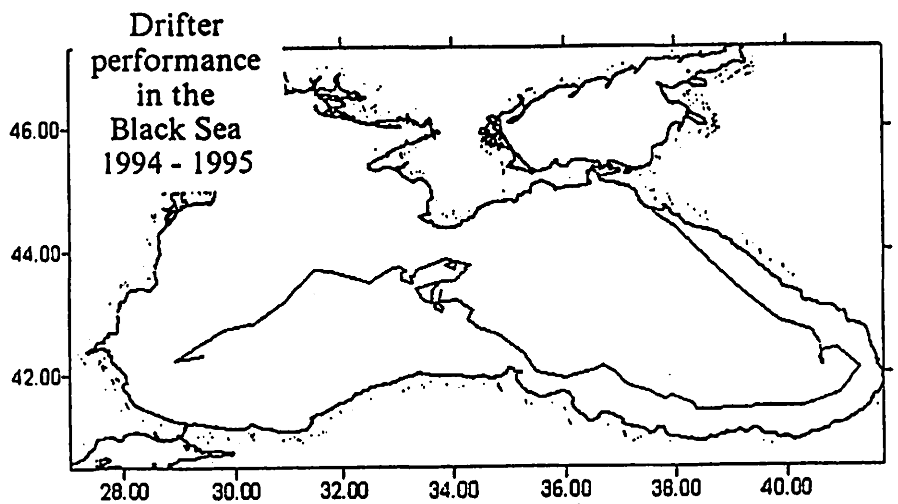
1985 -1995

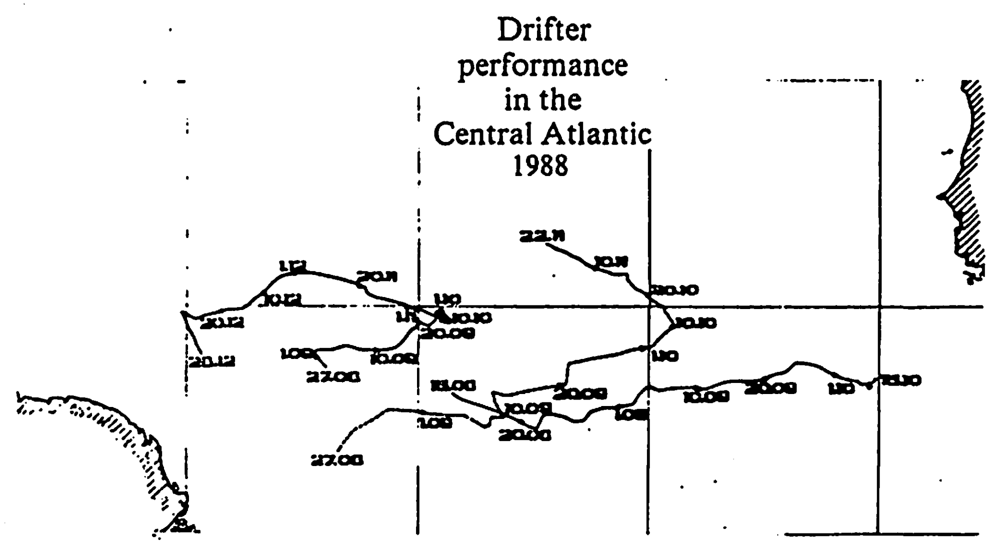
Atlantic Ocean - 10 buoys

Black Sea - 24 buoys

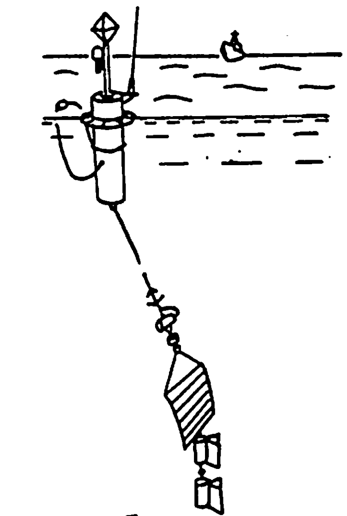




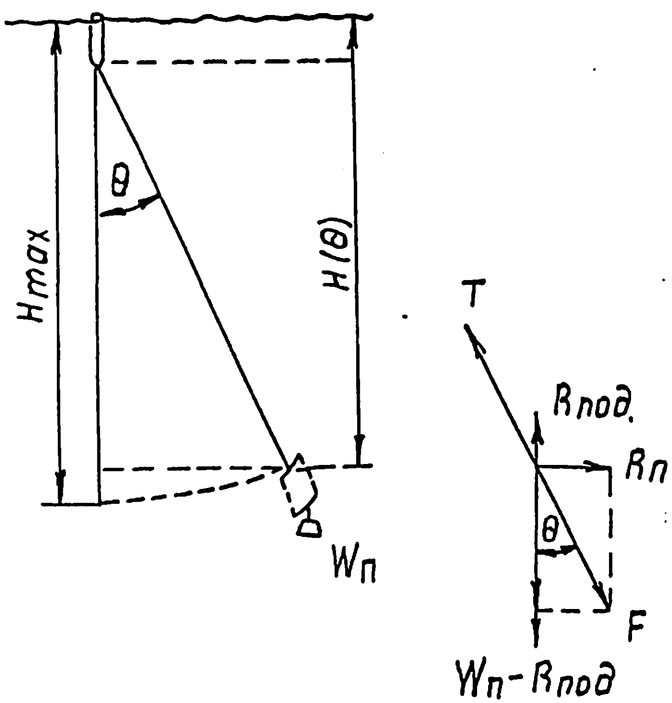




INVESTIGATIONS OF SHEAR CURRENTS IN THE ACTIVE LAYER



б

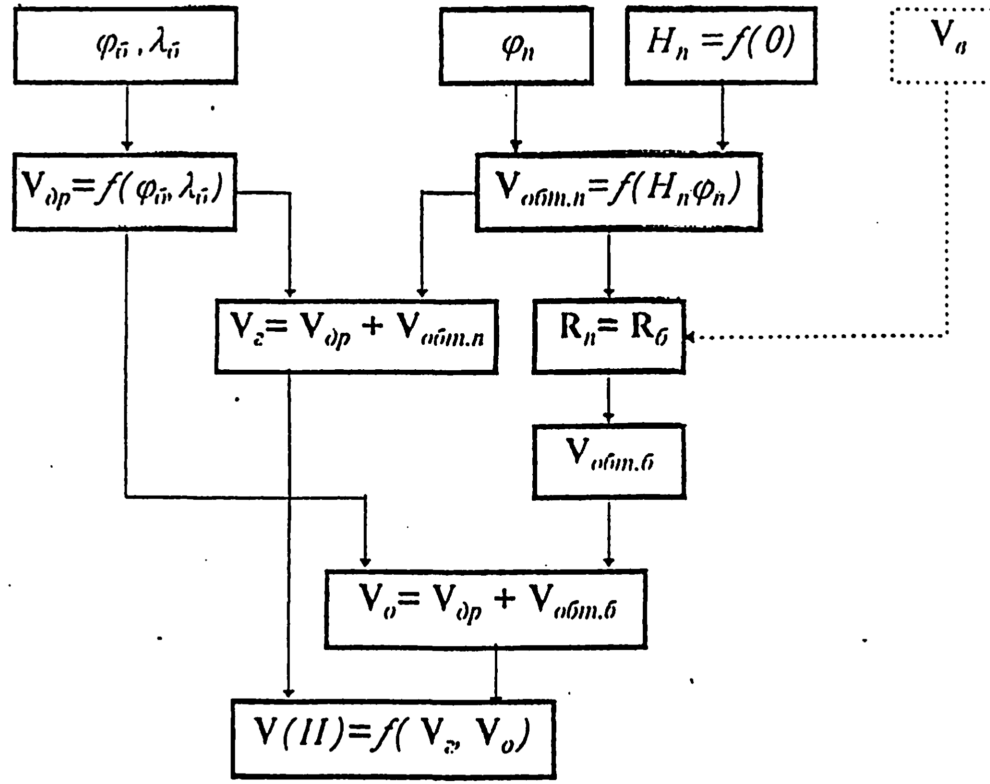


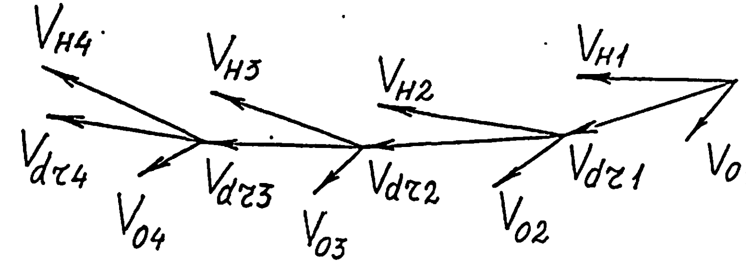
φb - is the latitude

λb - is the longitude

φn - is the droque's in the overflowing current

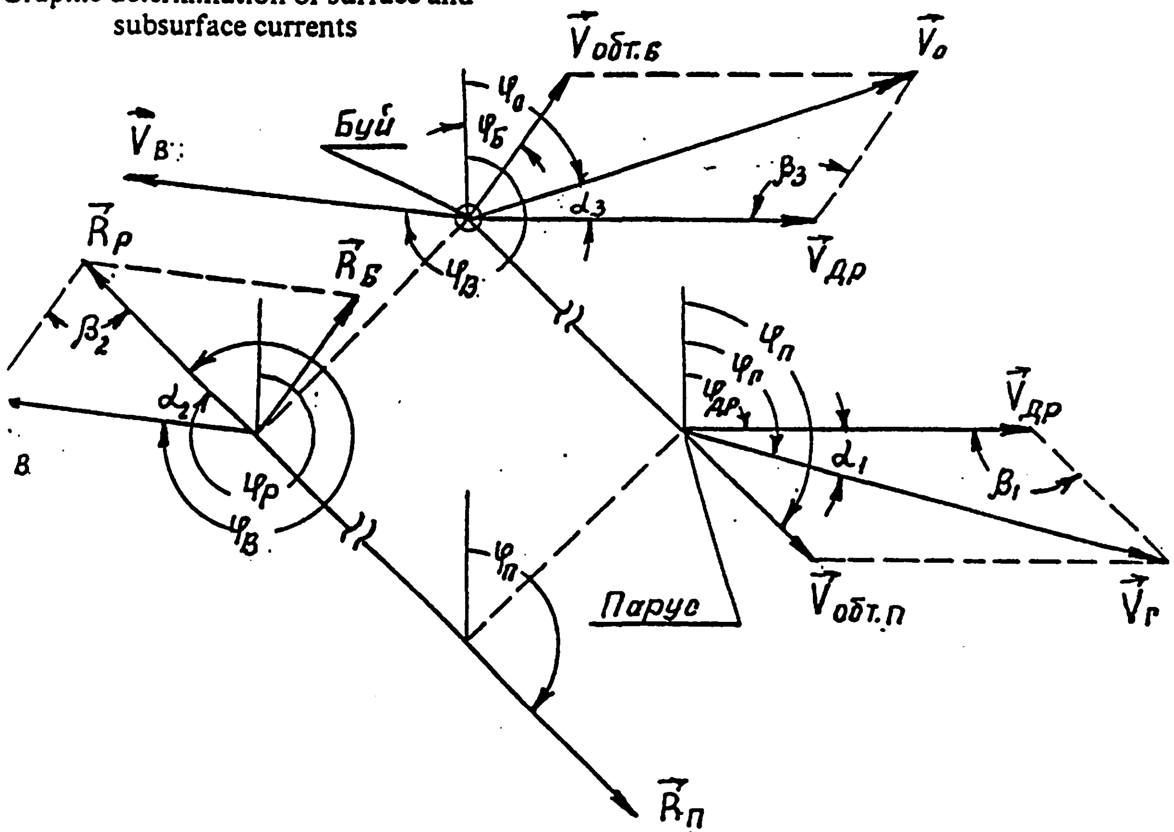
Hn - is the depth of drogue





INVESTIGATIONS OF SHEAR CURRENTS IN THE ACTIVE LAYER

Graphic determination of surface and subsurface currents



Mathematical determination of surface and subsurface currents

$$V_{обт.п} = 2.4\sqrt{\frac{W_п}{\rho_в C_п S_п}} \times \sqrt[4]{\frac{P_{max}[P_{max} - P(\theta)]}{[P_{max} + P(\theta)]^2}}.$$

$$V_г = \sqrt{V_{др}^2 + V_{обт.п}^2 + 2V_{др}V_{обт.п}\cos(\varphi_п - \varphi_{др})};$$

$$\varphi_г = \varphi_{др} + arc\,sin[\frac{V_{обт.п}}{V_г}\sin(\varphi_п - \varphi_{др})];$$

Velocity and direction of the subsurface current

$$V_о = \sqrt{V_{др}^2 + V_{обт.б}^2 + 2V_{др}V_{обт.б}\cos(\varphi_{др} - \varphi_б)};$$

$$\varphi_о = \varphi_{др} - arc\,sin[\frac{V_{обт.б}}{V_о}\sin(\varphi_{др} - \varphi_б)];$$

Velocity and direction of the surface current

$$\Delta V_z = \frac{[V_{\partial p} + V_{o6\,mn}\cos(\varphi_n - \varphi_{\partial p})]\Delta V_{\partial p}}{\sqrt{V_{\partial p}^2 + V_{o6\,mn}^2 + 2V_{\partial p}V_{o6\,mn}\cos(\varphi_n - \varphi_{\partial p})}} +$$

$$+ \frac{[V_{o6\,mn} + V_{\partial p}\cos(\varphi_n - \varphi_{\partial p})]\Delta V_{o6\,mn}}{\sqrt{V_{\partial p}^2 + V_{o6\,mn}^2 + 2V_{\partial p}V_{o6\,mn}\cos(\varphi_n - \varphi_{\partial p})}} +$$

$$+ \frac{V_{\partial p}V_{o6\,mn}\sin(\varphi_n - \varphi_{\partial p})]\Delta(\varphi_n + \varphi_{\partial p})}{\sqrt{V_{\partial p}^2 + V_{o6\,mn}^2 + 2V_{\partial p}V_{o6\,mn}\cos(\varphi_n - \varphi_{\partial p})}}.$$

The error in the determination of the subsurface current velocity

$$\Delta V_o = \frac{1}{\sqrt{V_{\partial p}^2 + V_{o6\,m6}^2 + 2V_{\partial p}V_{o6\,m6}\cos(\varphi_{\partial p} - \varphi_6)}} \times$$

$$\times\{[V_{\partial p} + V_{o6\,m6}\cos(\varphi_{\partial p} - \varphi_6)]\Delta V_{\partial p} +$$

$$+[V_{o6\,m6} + V_{\partial p}\cos(\varphi_{\partial p} - \varphi_6)]\Delta V_{o6\,m6} +$$

$$+V_{\partial p}V_{o6\,m6}\sin(\varphi_{\partial p} - \varphi_6)(\Delta\varphi_{\partial p} + \Delta\varphi_6)\}$$

The error in the determination of the surface current velocity

$$\Delta\varphi_n = \Delta\varphi_{\partial p} + \frac{1}{V_z\sqrt{1 - [\frac{V_{o6\,mn}}{V_z}\sin(\varphi_n - \varphi_{\partial p})]^2}} \times$$

$$\times[\sin(\varphi_n - \varphi_{\partial p})\Delta V_{o6\,mn} + \frac{V_{o6\,mn}}{V_z}\sin(\varphi_n - \varphi_{\partial p})\Delta V_z +$$

$$+V_{o6\,mn}\cos(\varphi_n - \varphi_{\partial p})(\Delta\varphi_n + \Delta\varphi_{\partial p})].$$

The error in the determination of the subsurface current's direction

$$\Delta\varphi_o = \Delta\varphi_{\partial p} + \frac{1}{V_o\sqrt{1 - [\frac{V_{o6\,m6}}{V_o}\sin(\varphi_{\partial p} - \varphi_6)]^2}} \times$$

$$\times[\sin(\varphi_{\partial p} - \varphi_6)\Delta V_{o6\,m6} + \frac{V_{o6\,m6}}{V_o}\sin(\varphi_{\partial p} - \varphi_6)\Delta V_o +$$

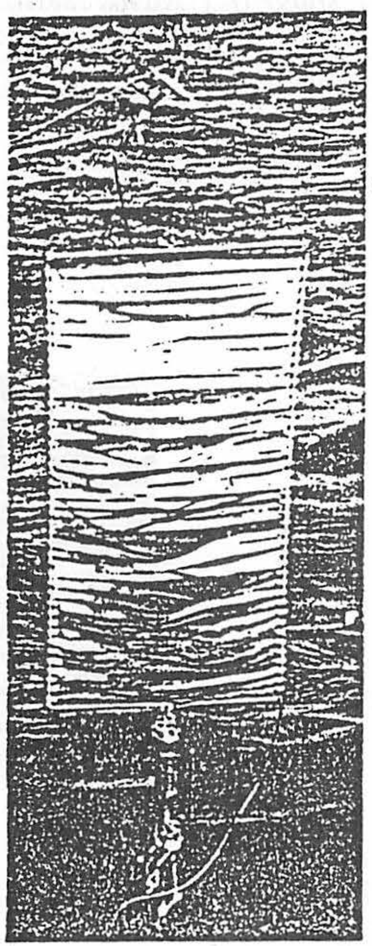
$$+V_{o6\,m6}\cos(\varphi_{\partial p} - \varphi_6)(\Delta\varphi_{\partial p} + \Delta\varphi_6)].$$

The error in the determination of the surface current's direction

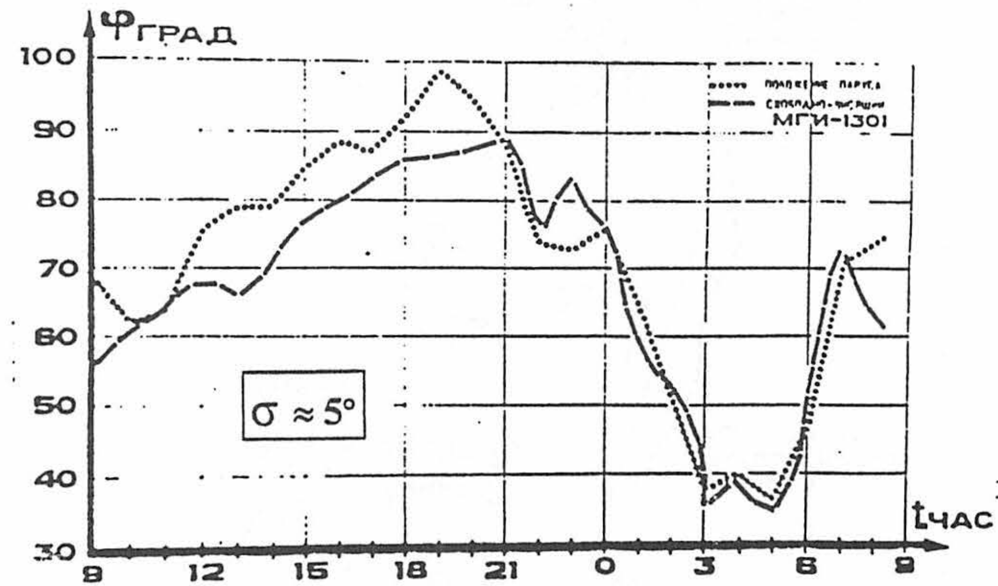
	Velocity	Direction
Error of the subsurface current vector	±0.02m/s	±10°
Error of the surface current vector	±0.07m/s	±16°

INVESTIGATIONS OF SHEAR CURRENTS IN THE ACTIVE LAYER

Experimental determination of the error of droque orientation in a slip subsurface current



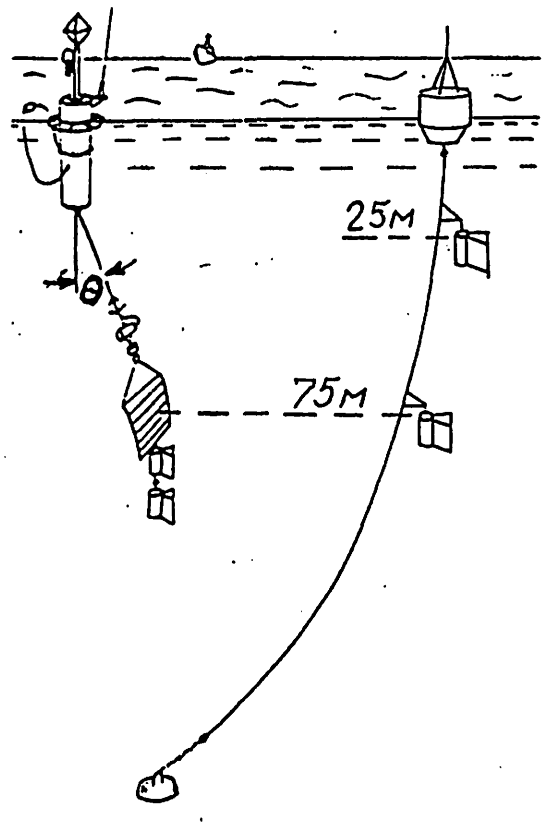
"Window shade" droque with two current's vector measuring devices

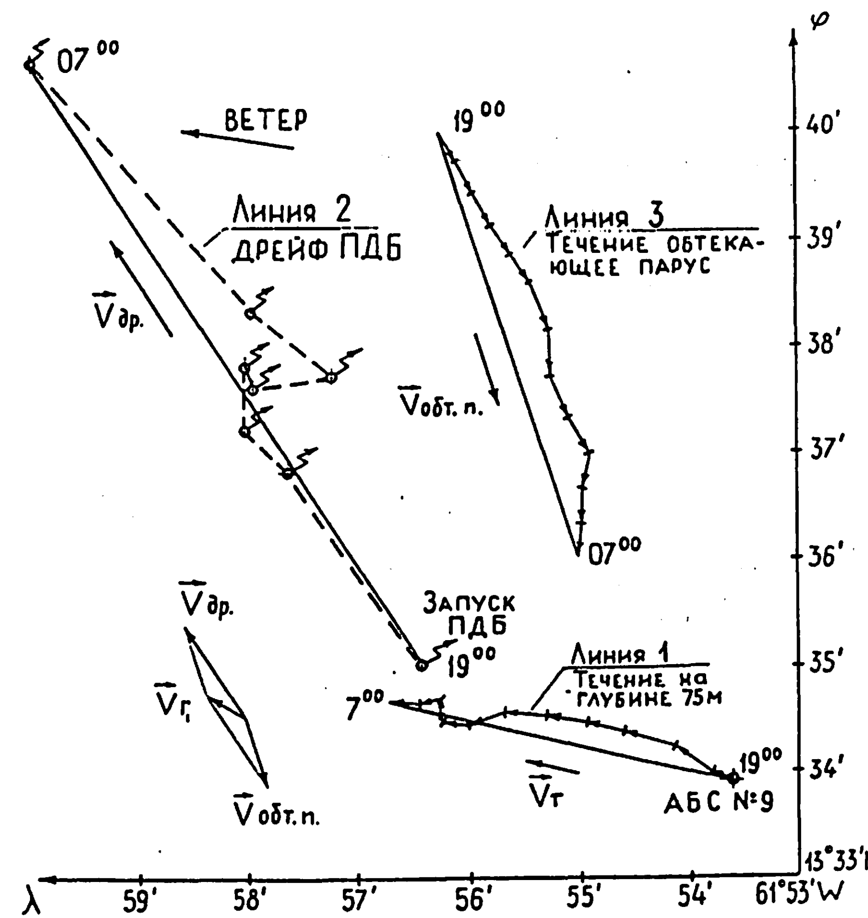


.... orientation of the droque

------- orientation of the slip subsurface current

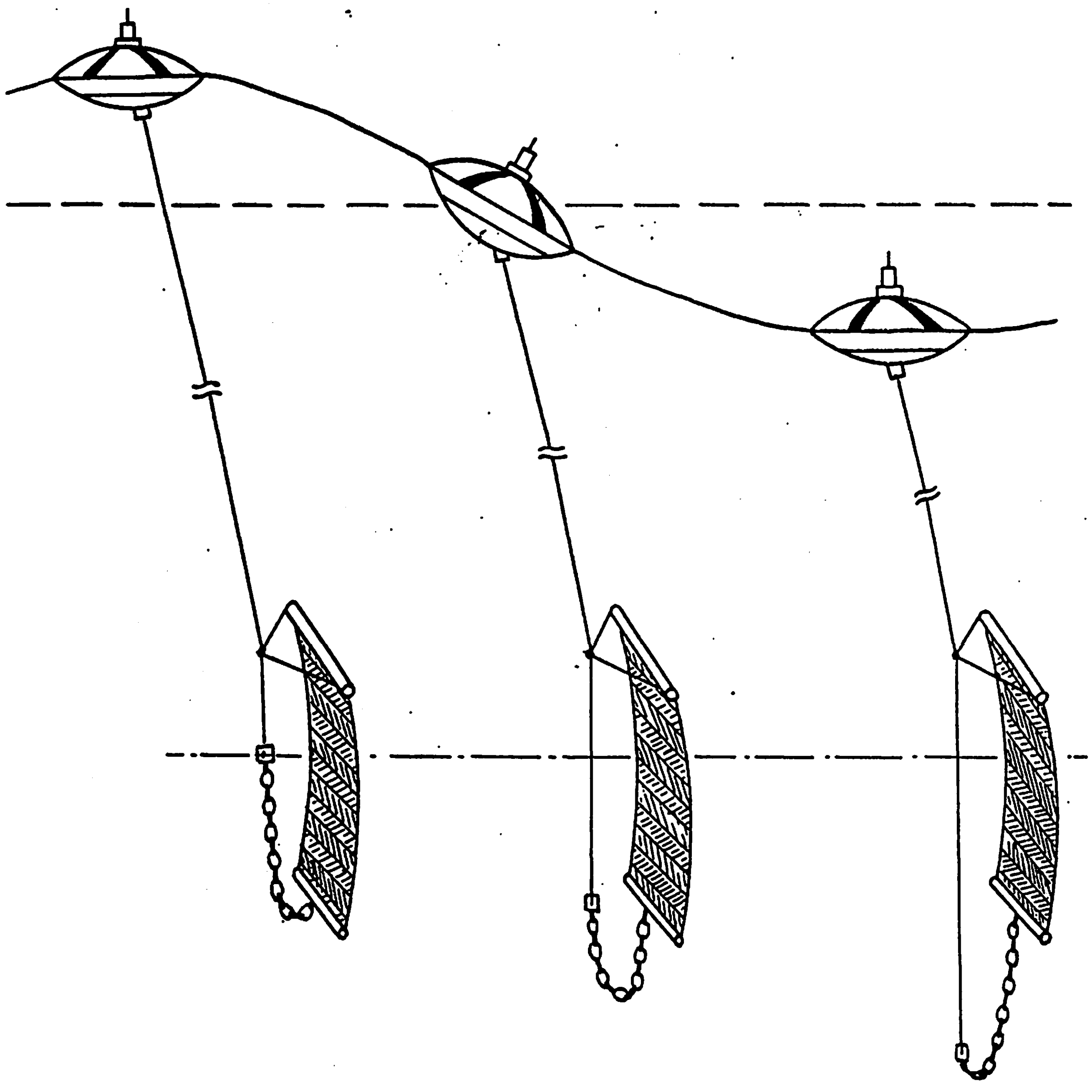
EXPERIMENTAL DETERMINATION OF THE METHOD ERROR USING THE DRIFTER AND MOORING BUOY

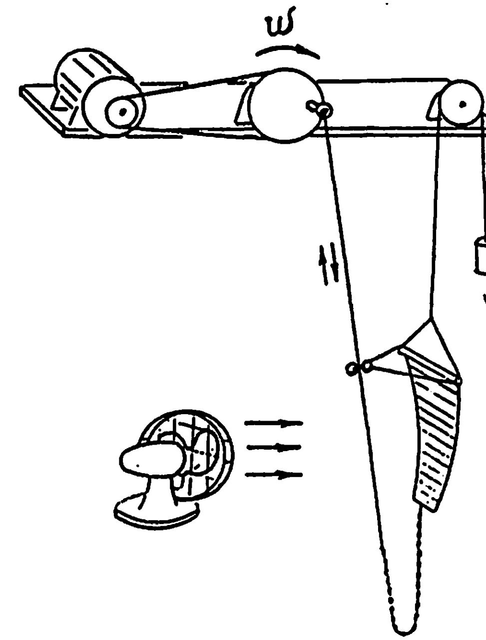




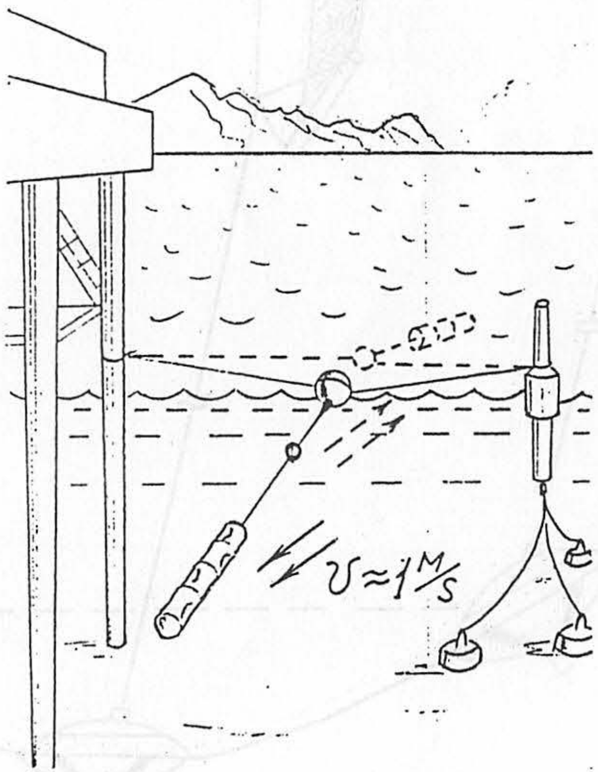
	Velocity	Direction	Velocity	Direction
Drift vector as a subsurface current vector	0.28m/s	328°	115%	13%
Mooring buoy	0.13m/s	283°		
Subsurface current vector by the new method	0.11m/s	305°	15%	6%

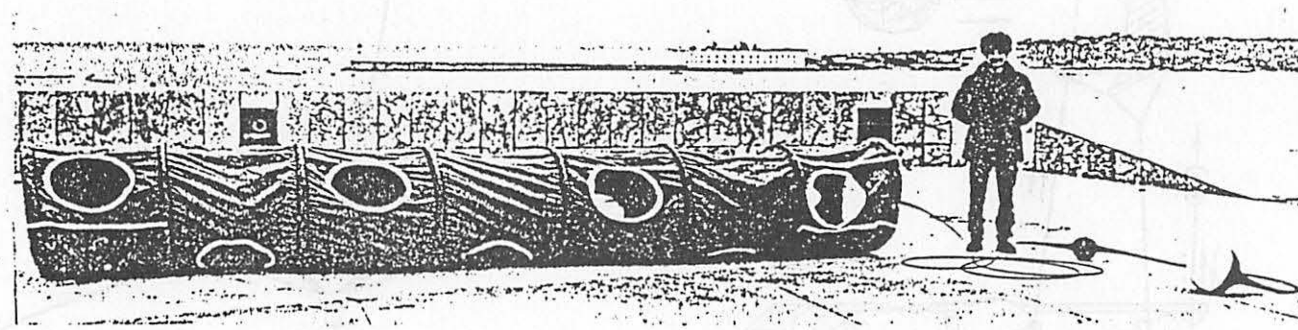
DRIFTER WITH THE DROQUE SUSPEND
SUSPENDED TO THE BOTTOM

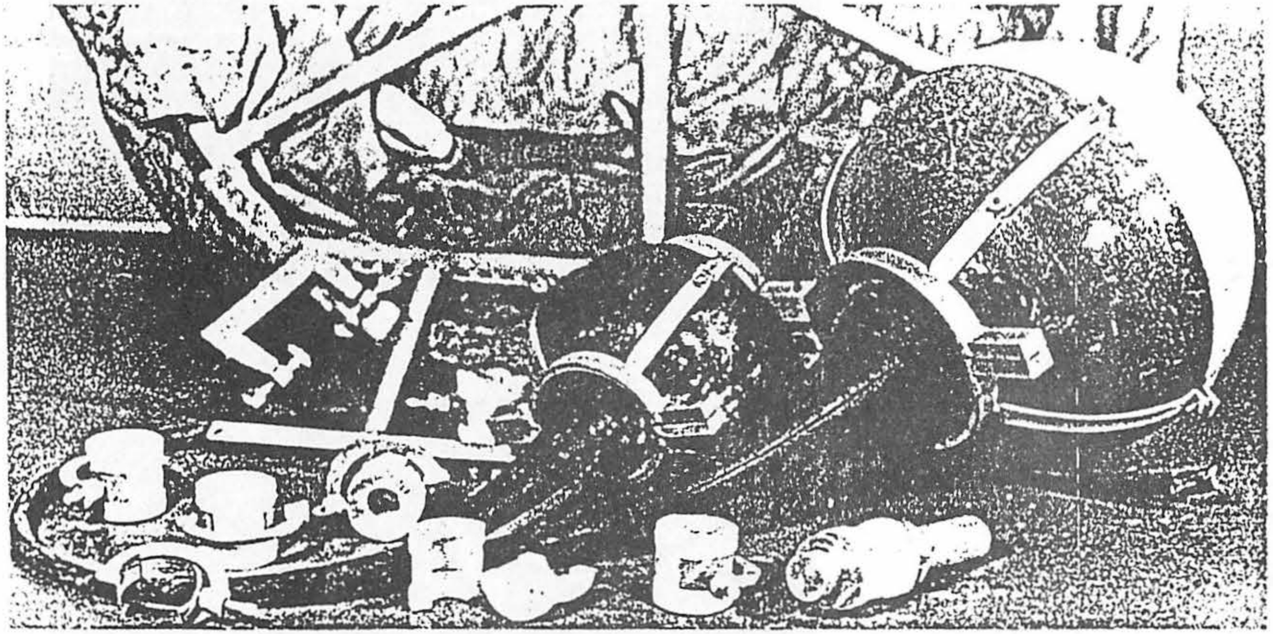


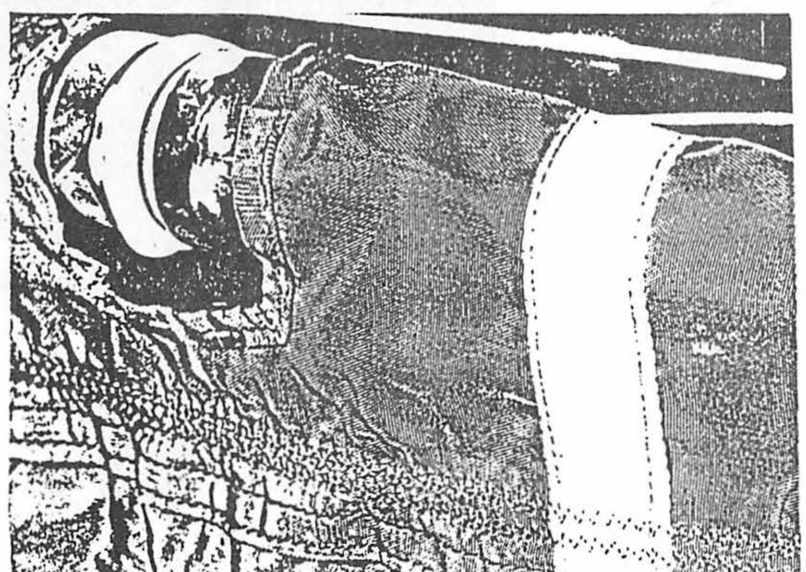


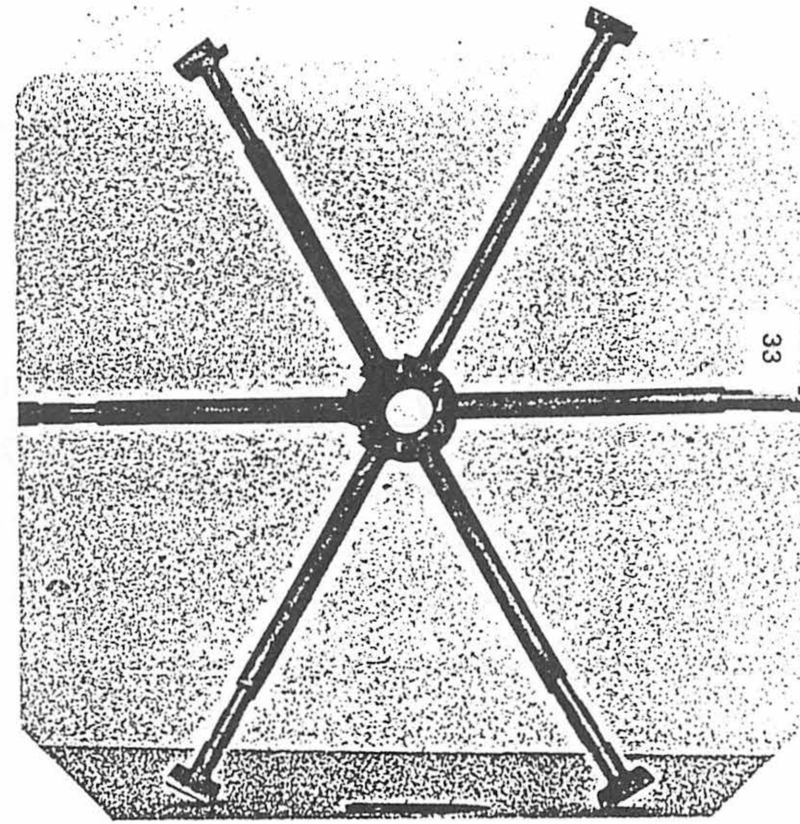
DEVELOPMENT OF THE SVP DRIFTER

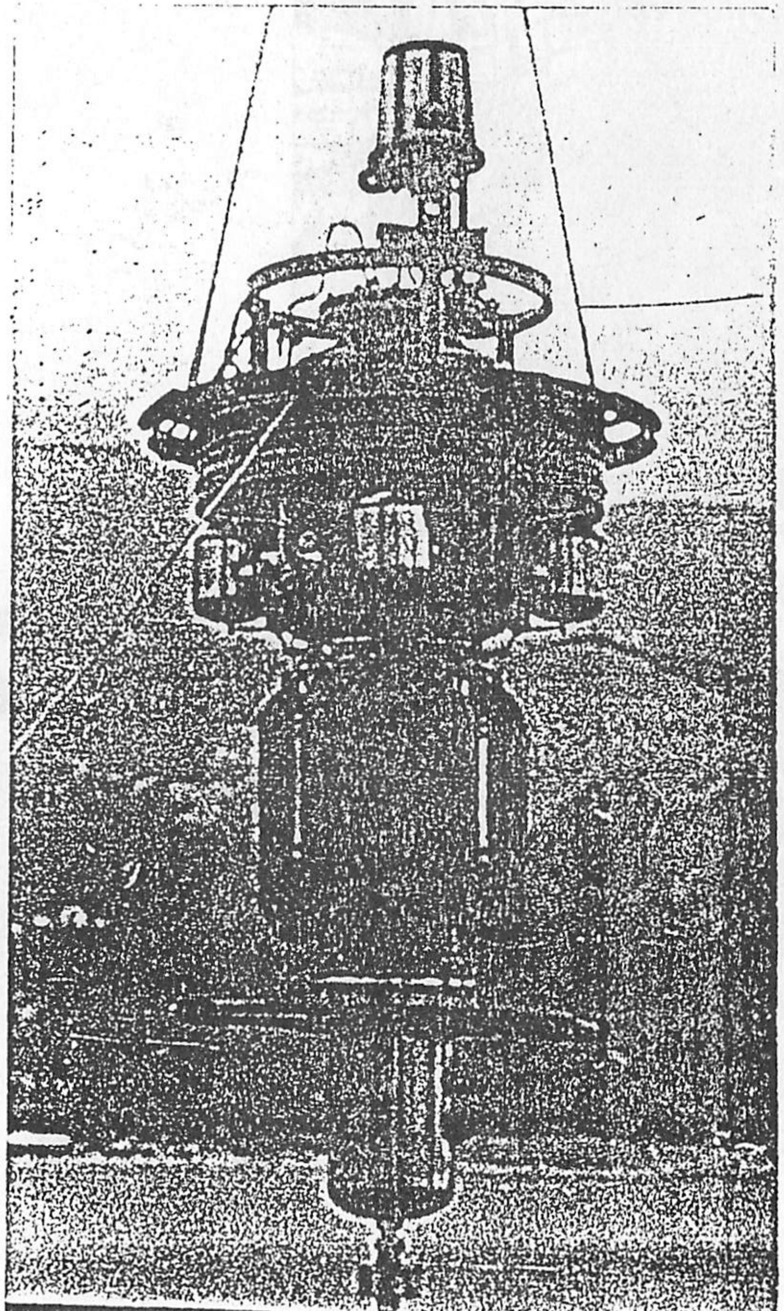




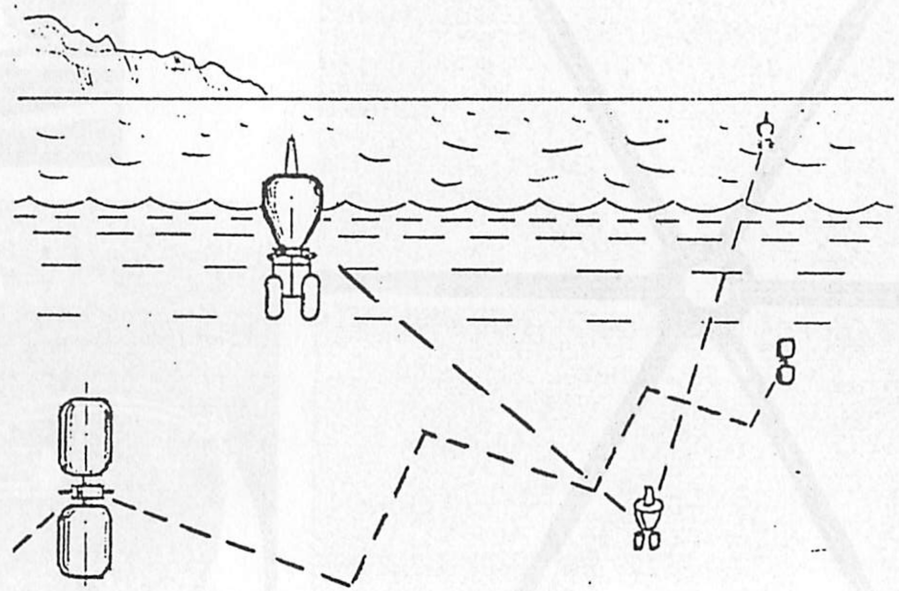


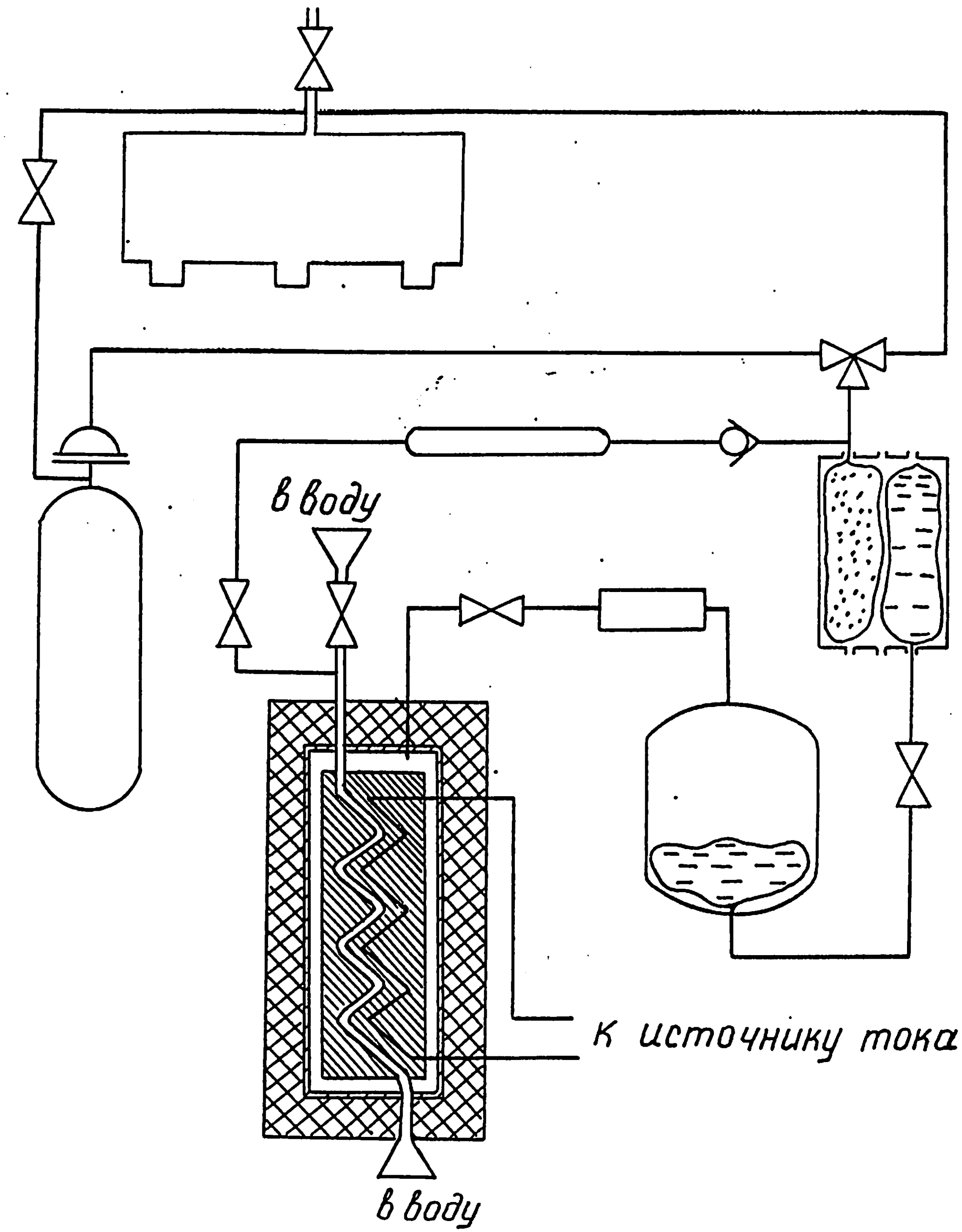




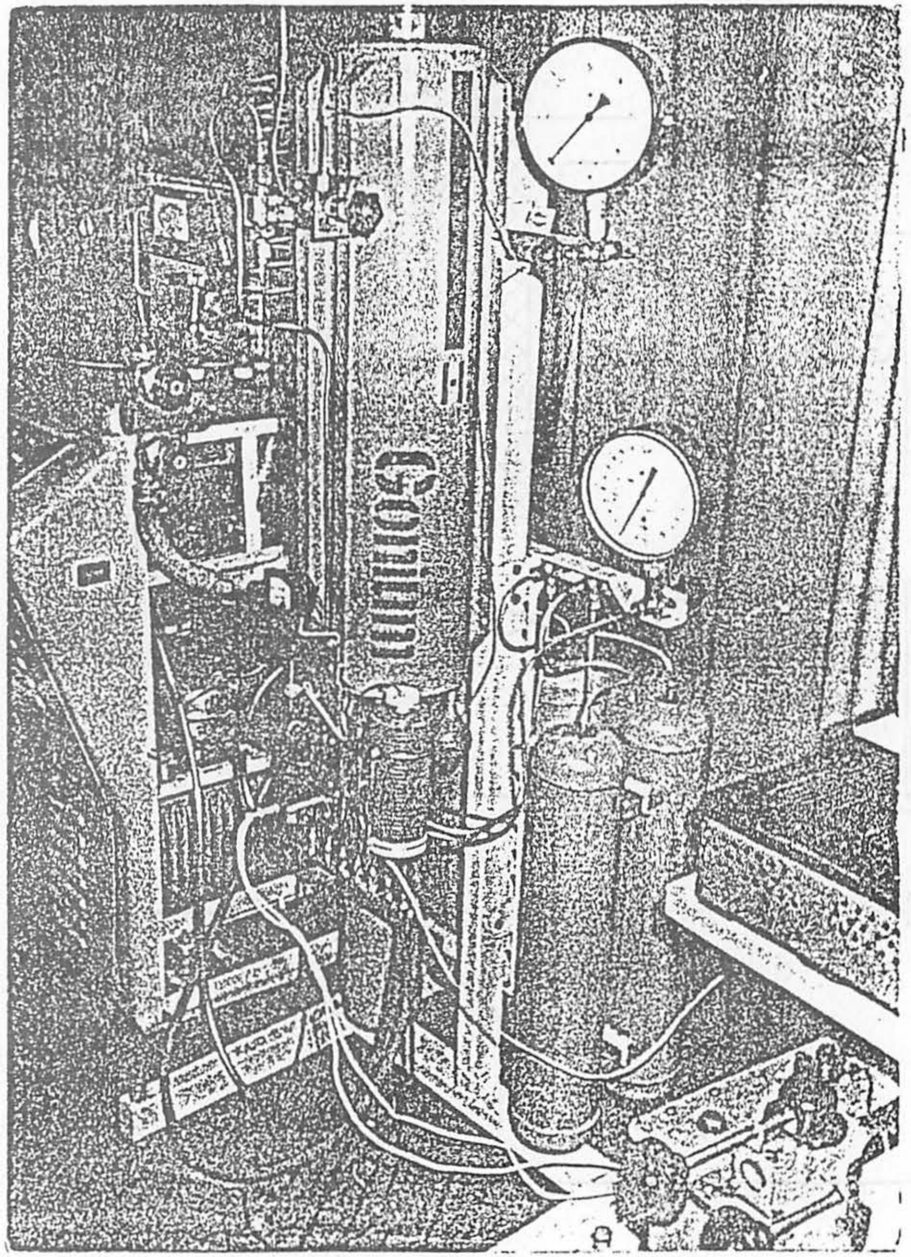


DIVING BUOYS AND SUBMERGED DRIFTERS

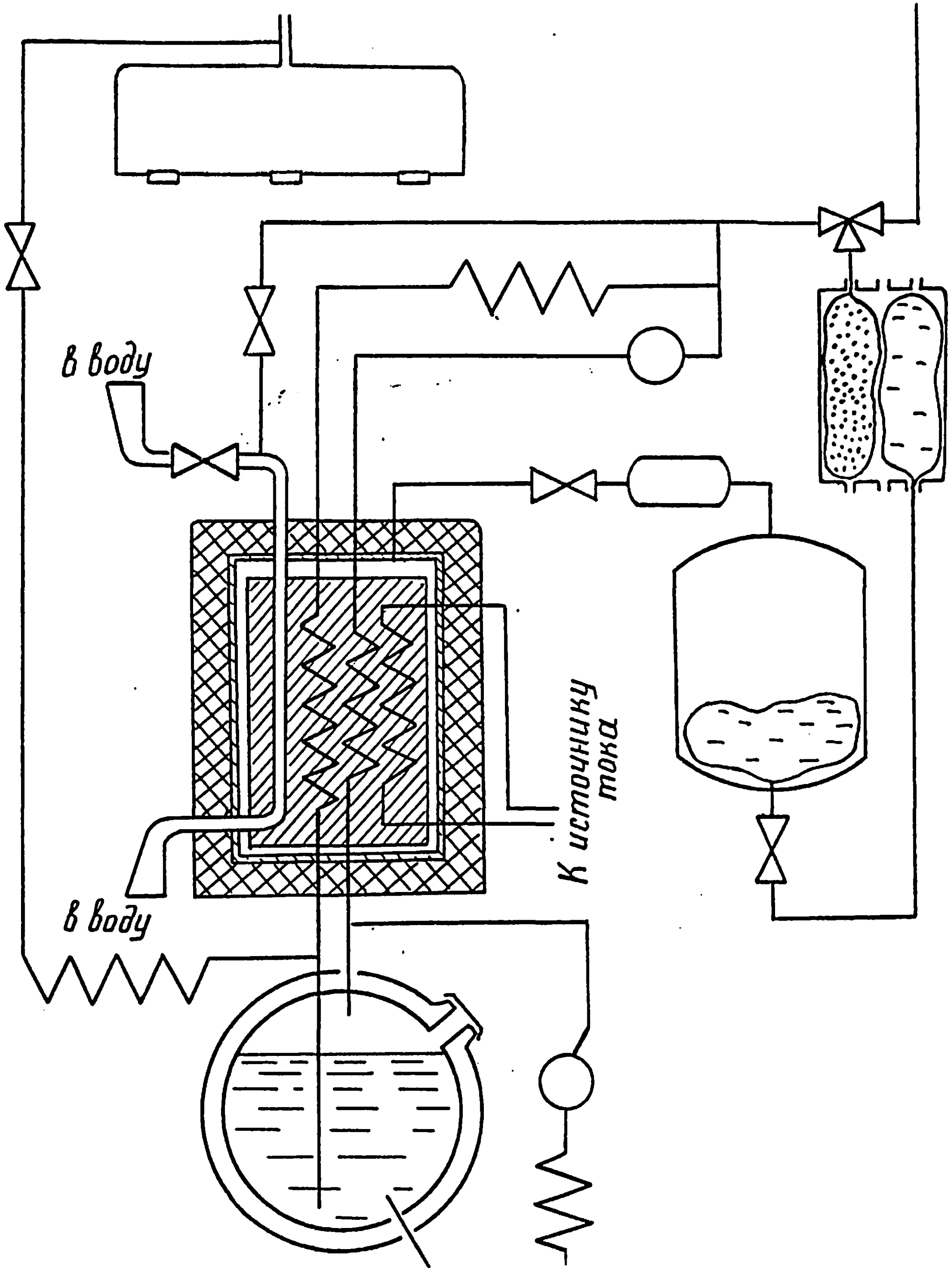




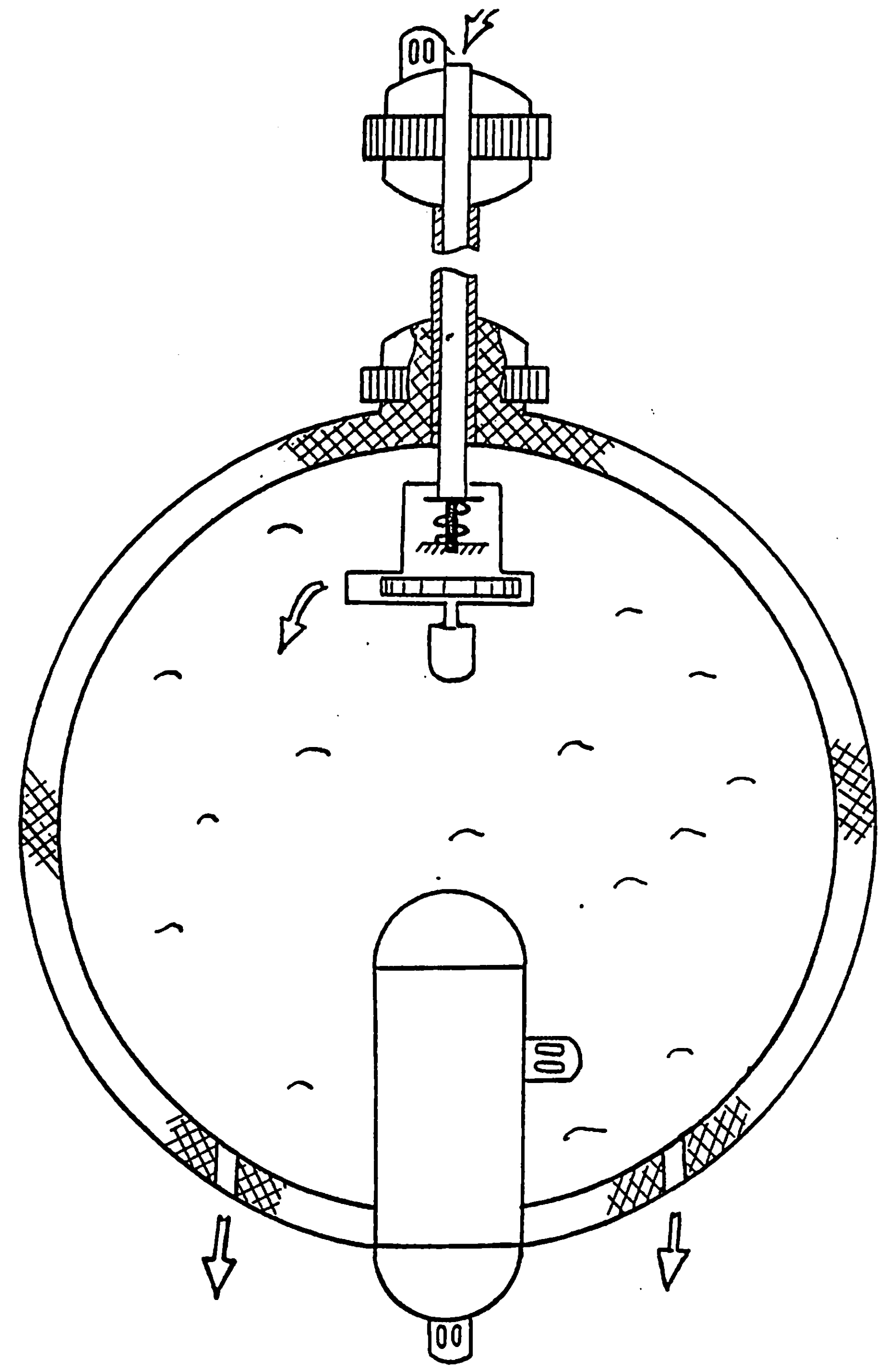
SCHEMATIC PRESENTATION OF THE DIVING BUOY WITH THE BUOYANCY CONTROLLED BY MEANS OF THE METAL HYDRIDE USE



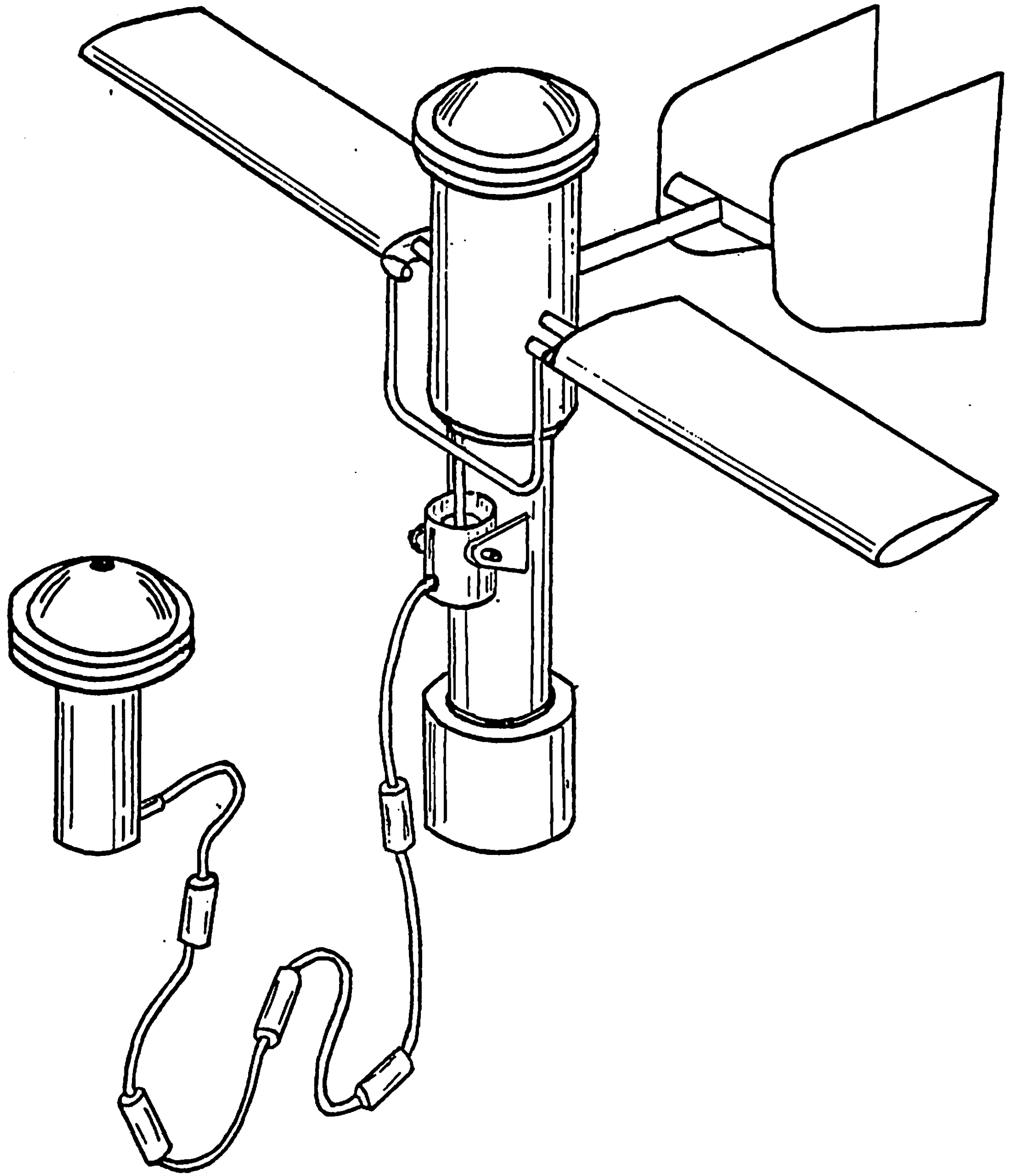
LABORATORY UNIT FOR
THE METAL HYDRIDE TEST



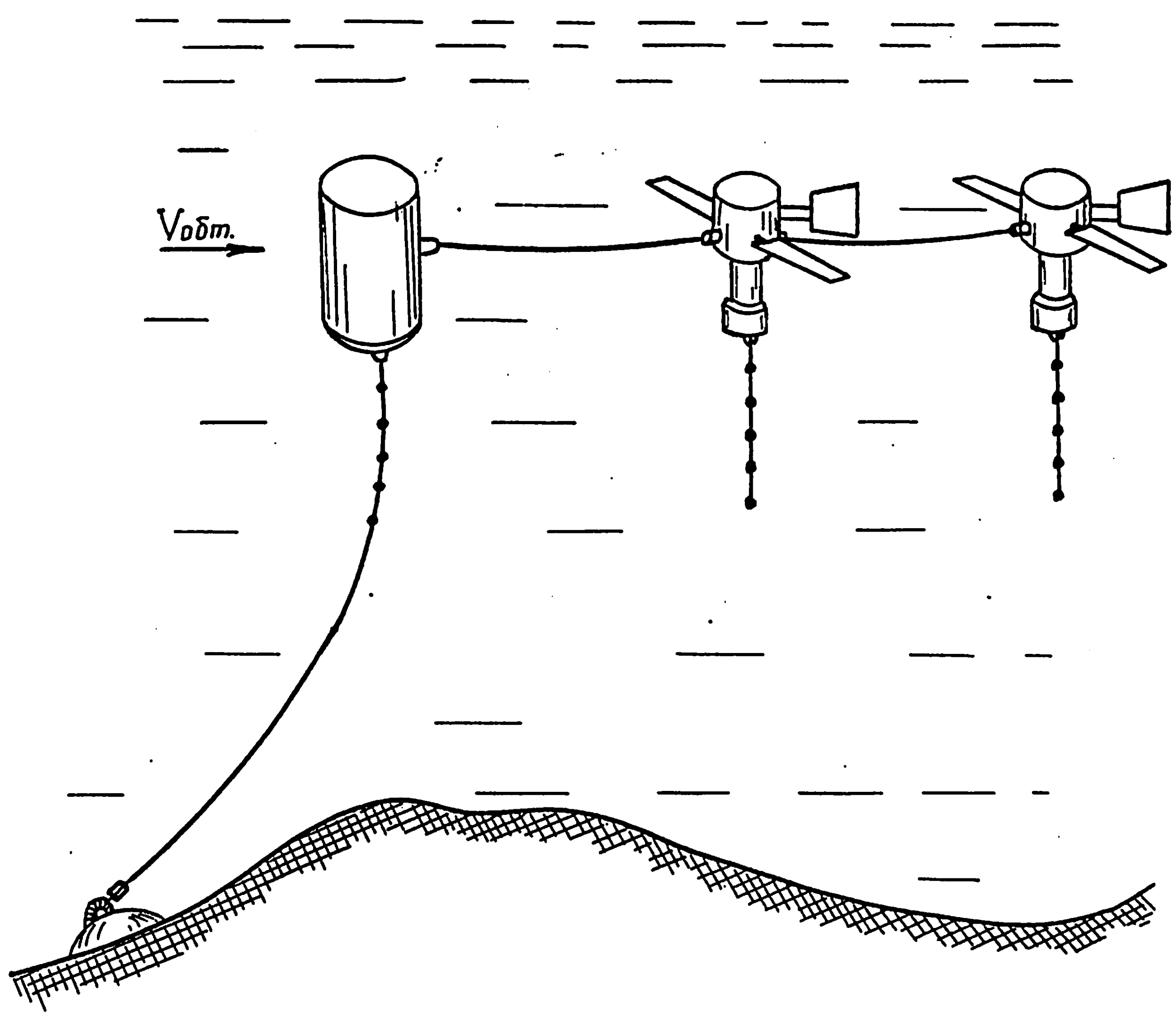
SCHEMATIC PRESENTATION OF THE DIVING BUOY WITH THE BUOYANCY CONTROLLED BY MEANS OF THE METAL HYDRIDE AND TEMPERATURE DIFFERENCE BETWEEN SURFACE AND SUBSURFACE WATERS USE



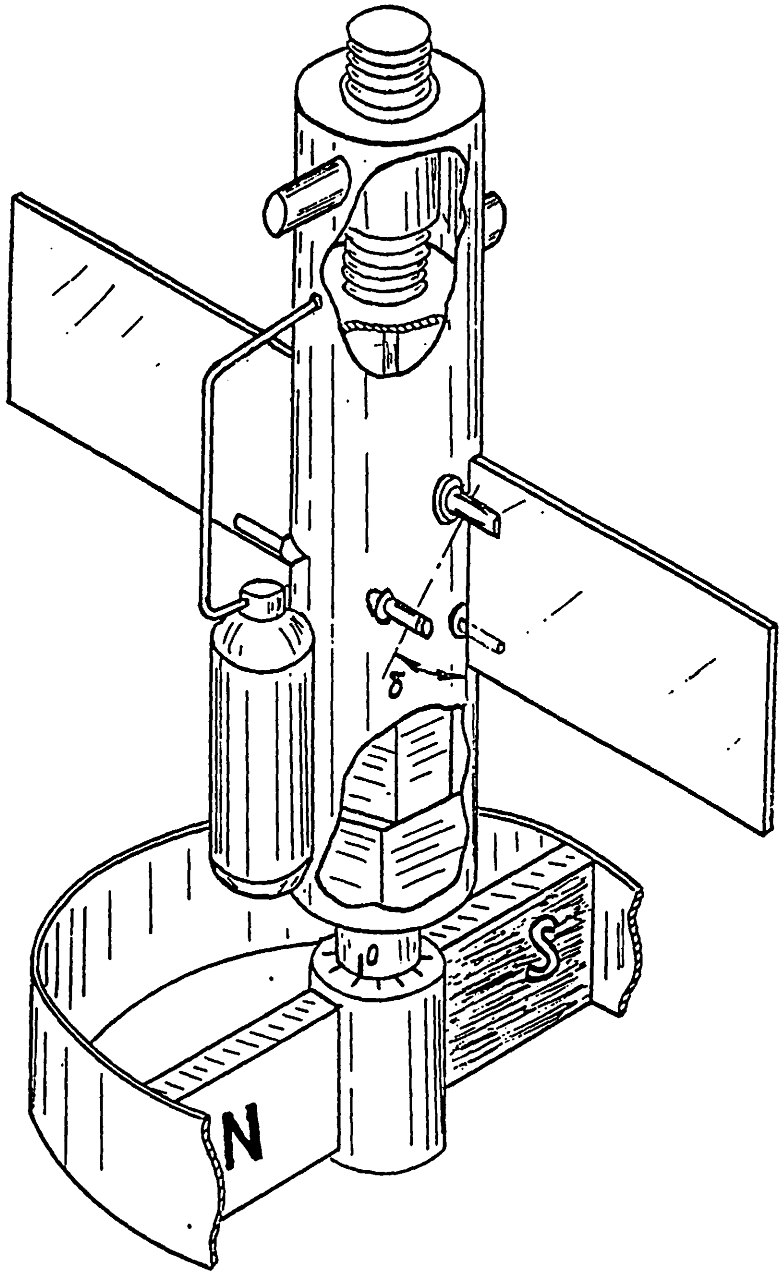
SUBMERGED DRIFTER USING
THE DIFFERENCE IN THE DENSITIES
OF SURFACE AND SUBSURFACE
WATERS FOR CONTROLLING
BUOYANCY



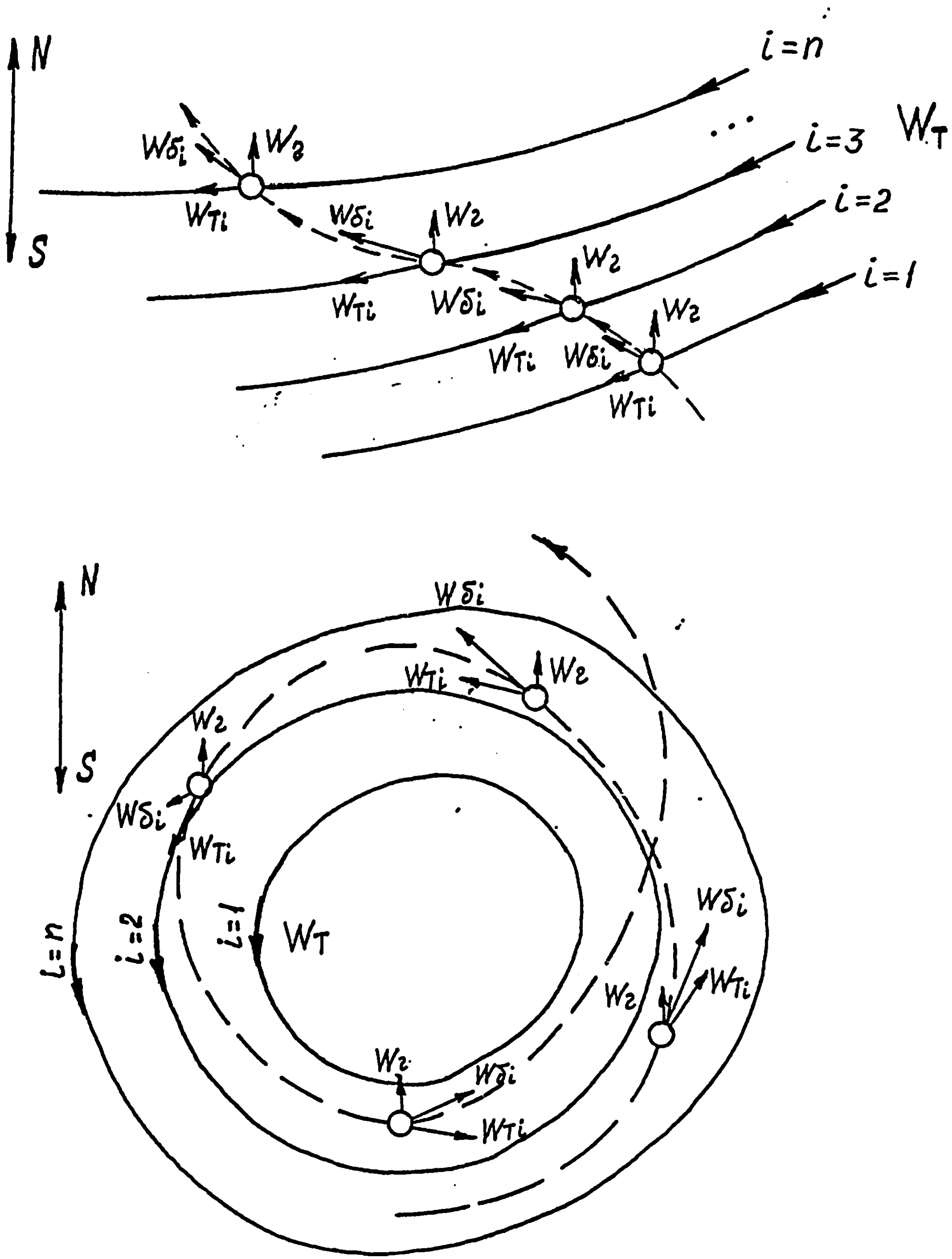
SUBMERGED BUOY
USING THE DIFFERENCE
IN THE SURFACE AND
SUBSURFACE CURRENT
VELOCITIES TO CONTROL
THE BUOYANCY



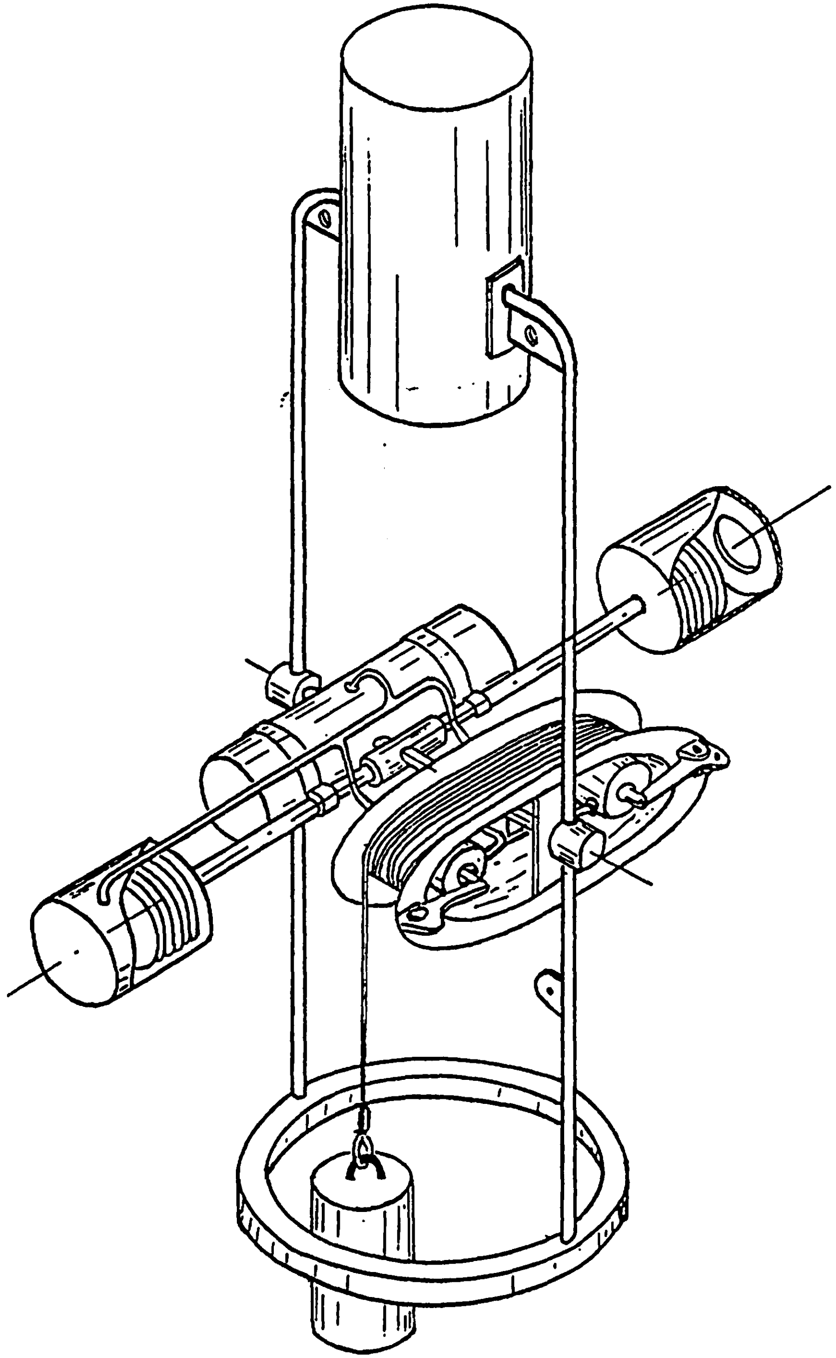
MOORING BUOY FOR
THE STUDY
OF INTERNAL WAVES



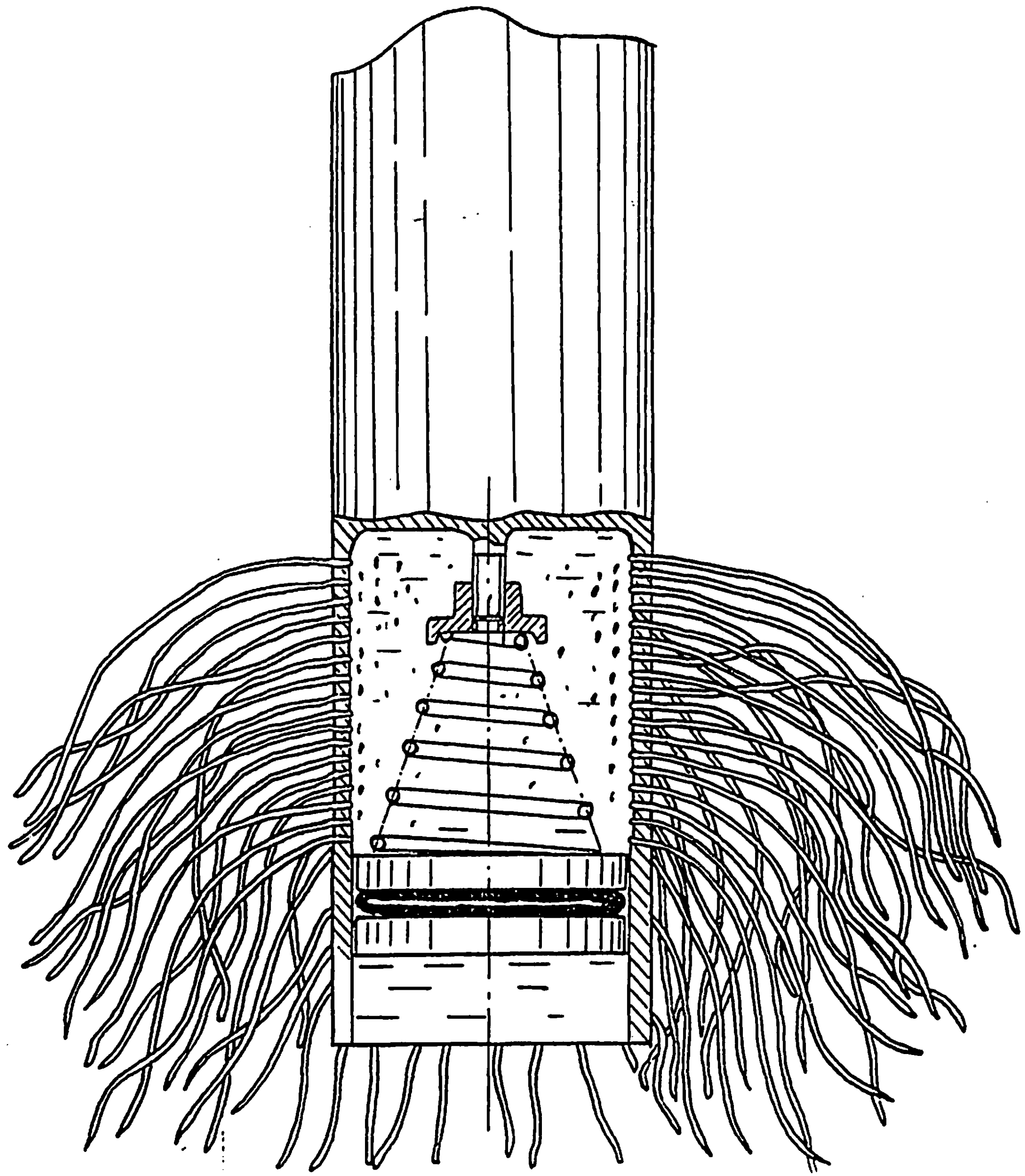
DIVING BUOY CAPABLE OF LATERAL SHIFTING IN THE PRESCRIBED DIRECTION DURING LOWERING



DIVING BUOY CAPABLE OF LATERAL SHIFTING IN THE PRESCRIBED DIRECTION DURING LOWERING

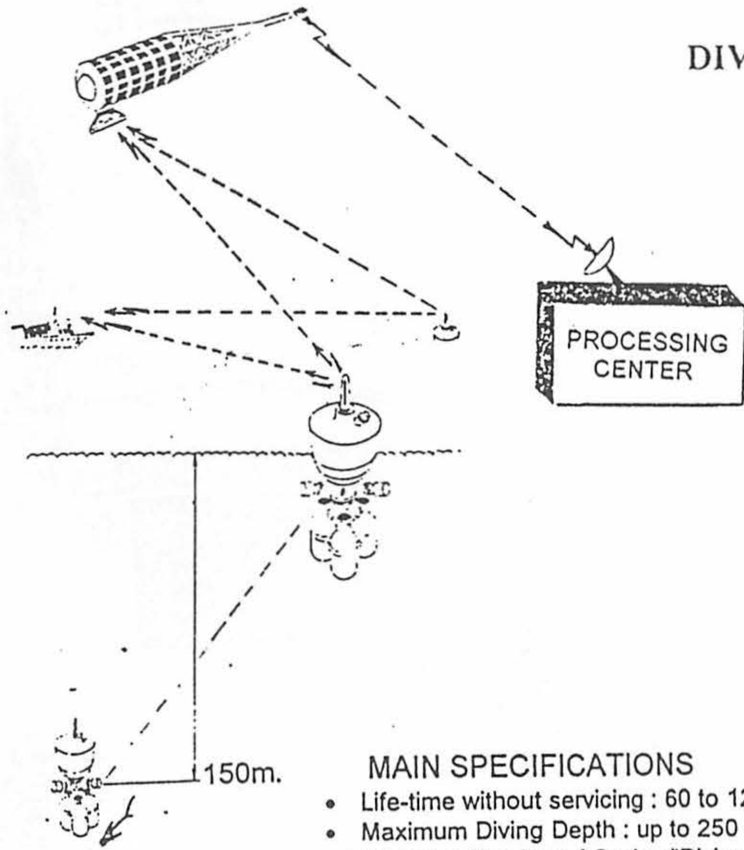


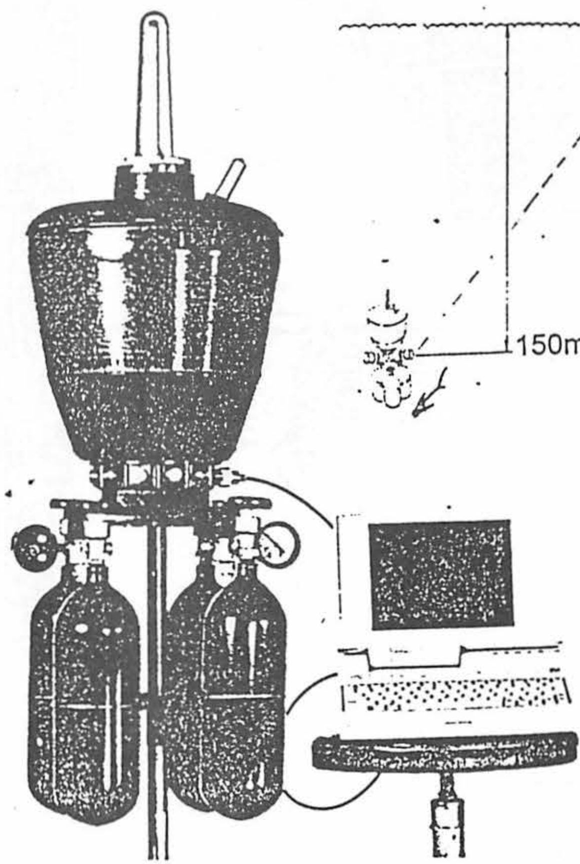
SUBMERGED DRIFTER
USING THE POTENTIAL
ENERGY OF THE EARTH
GRAVITATIONAL FORCE
FORCE FOR CONTROLLING
BUOYANCY



BUOY WITH NEUTRAL BUOYANCY CAPABLE OF DRIFTING ALONG THE SAME ISOTHERM WITH SALINITY BEING VARIABLE

DIVING DRIFTER DESIGNED TO STUDY THE ACTIVE LAYER STUDY



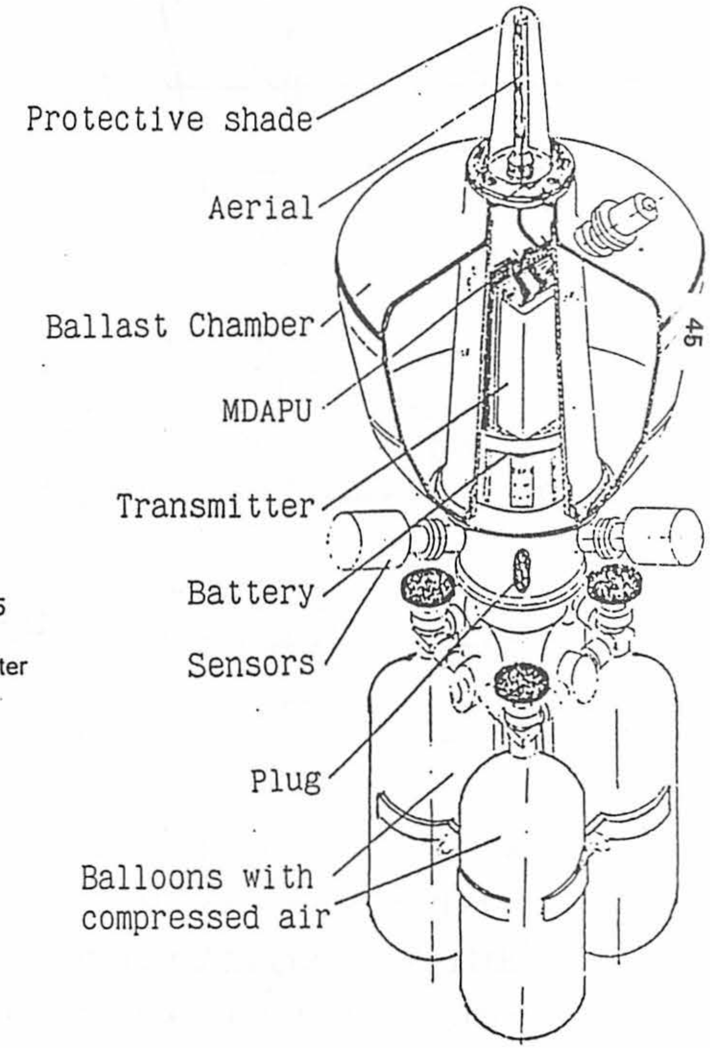


MAIN SPECIFICATIONS

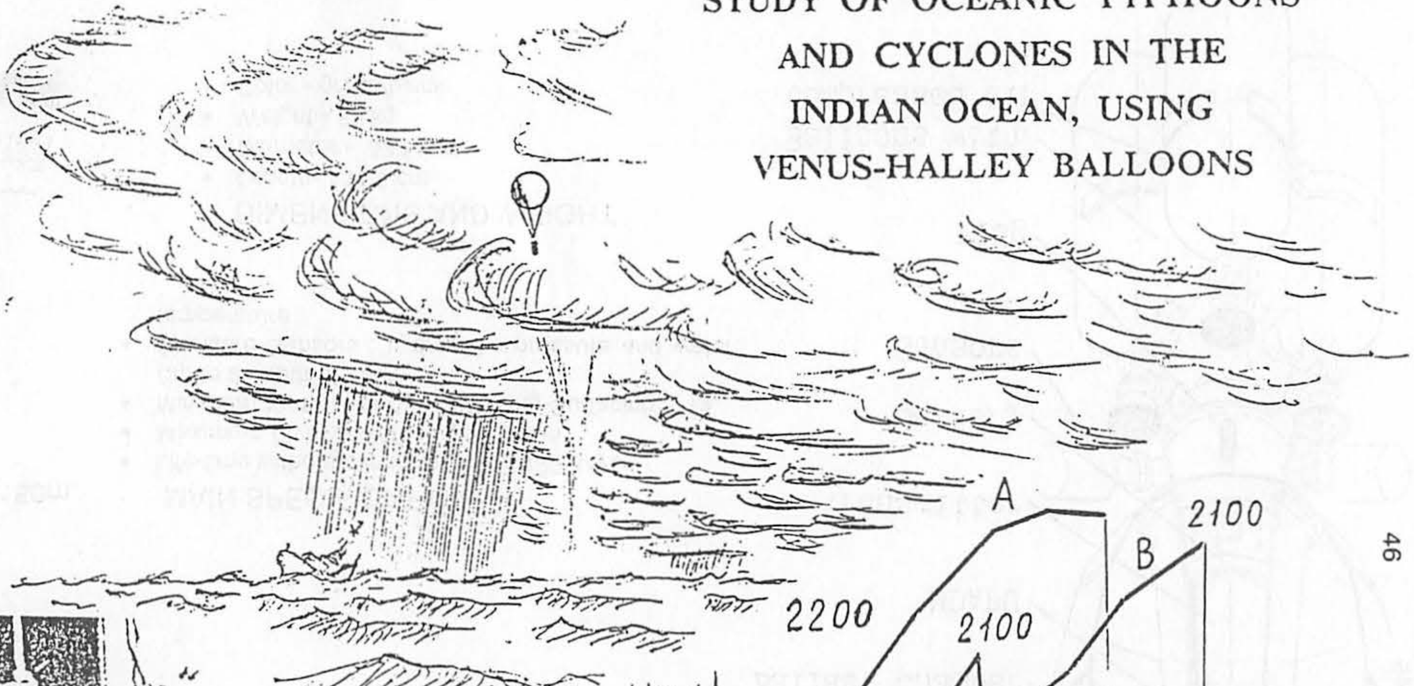
- Life-time without servicing : 60 to 120 days
- Maximum Diving Depth : up to 250 m
- Minimum Number of Cycles "Diving-Surfacing" : 15 (up to a depth of 150m)
- Standard Sensors : hydrostatic pressure and water temperature

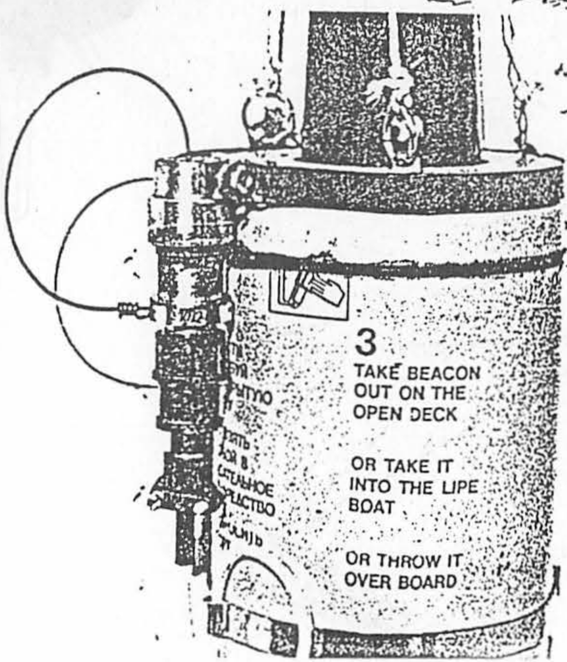
DIMENSIONS AND WEIGHT

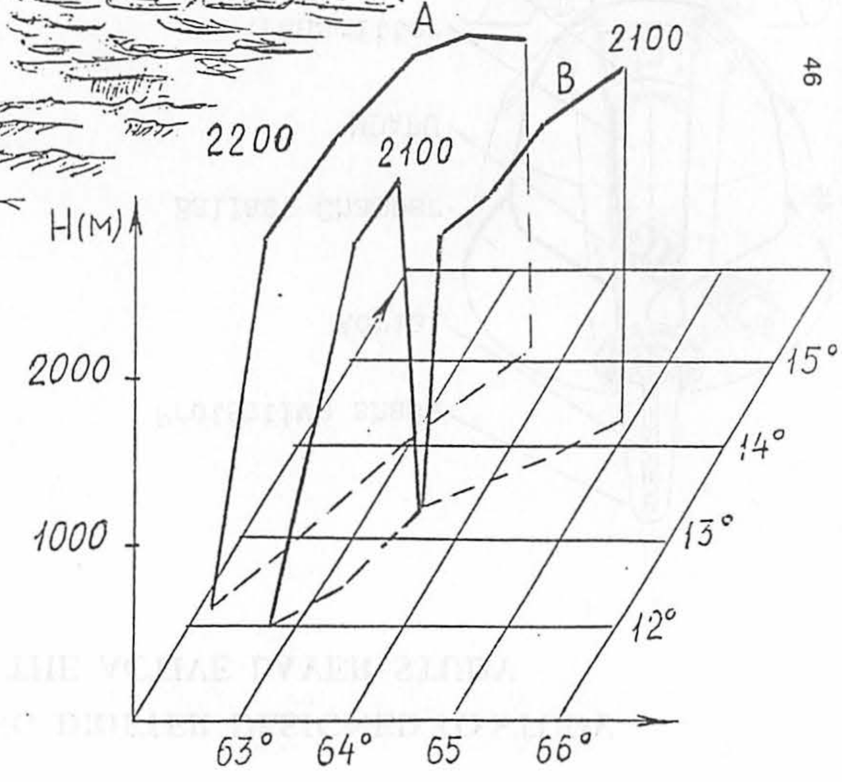
- Length- 117.5 cm
- Diameter - 32.5 cm
- Weight - 25 kg
- Color - green/black



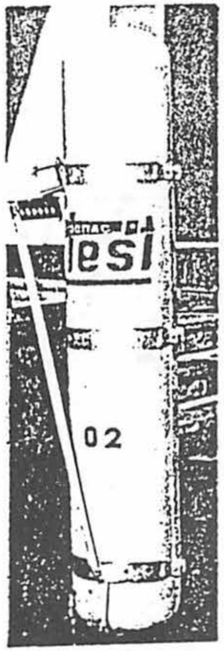
STUDY OF OCEANIC TYPHOONS AND CYCLONES IN THE INDIAN OCEAN, USING VENUS-HALLEY BALLOONS

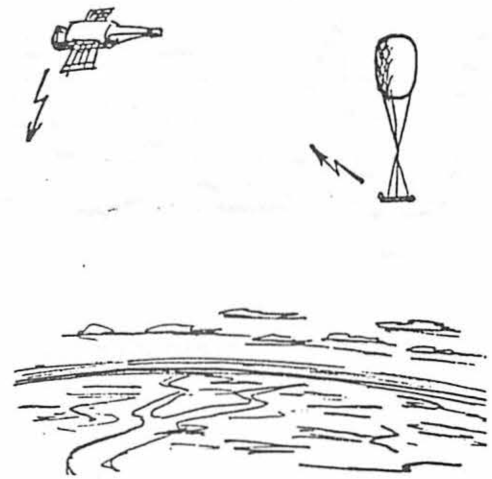


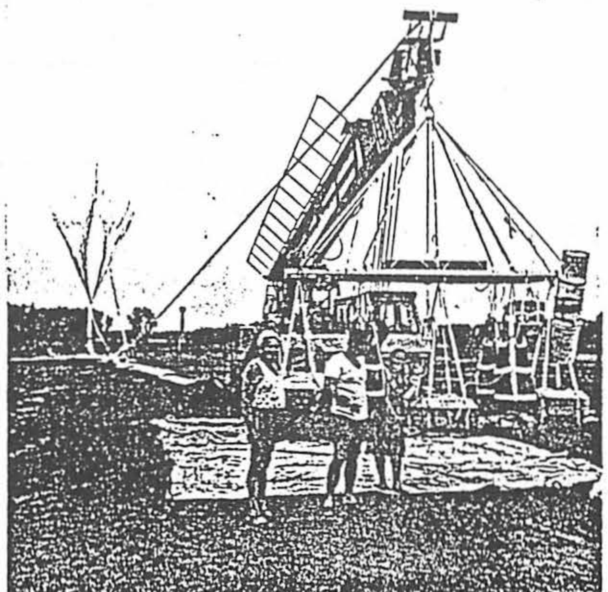


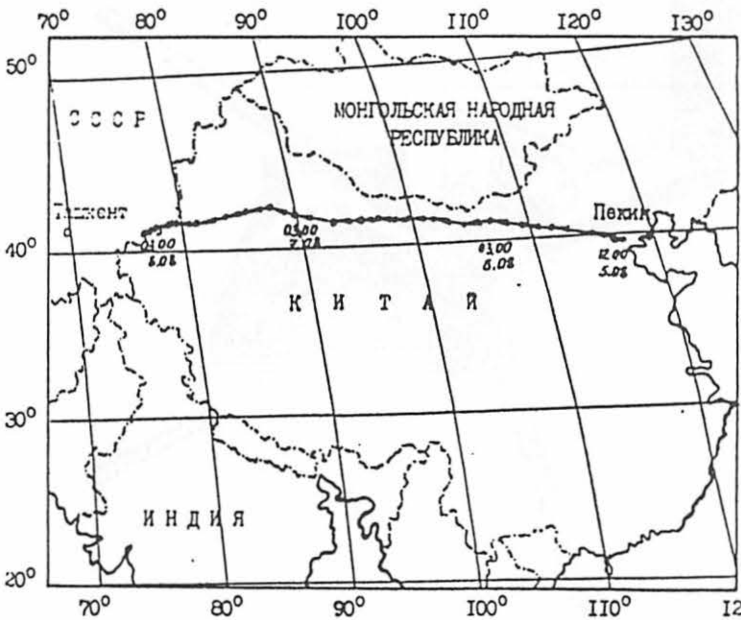


THE FIRST MARKER FOR STRATOSPHERIC BALLOONS

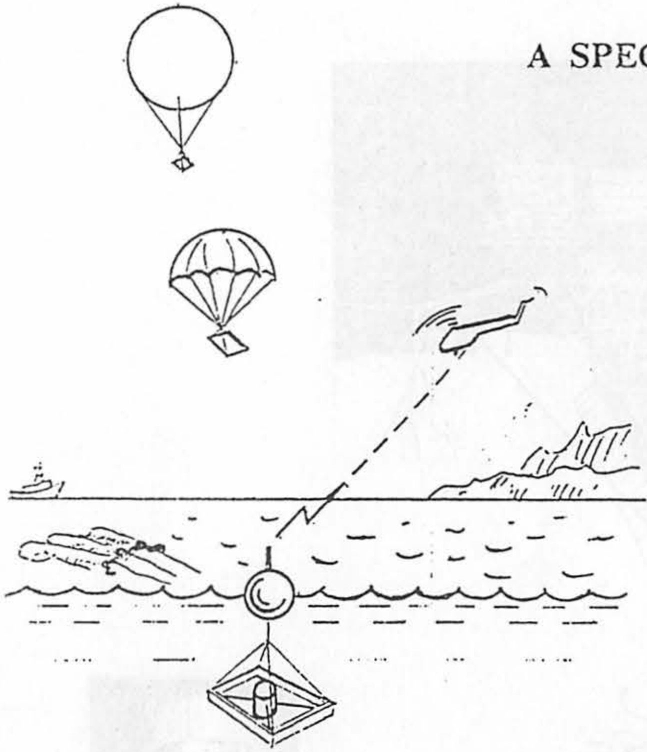


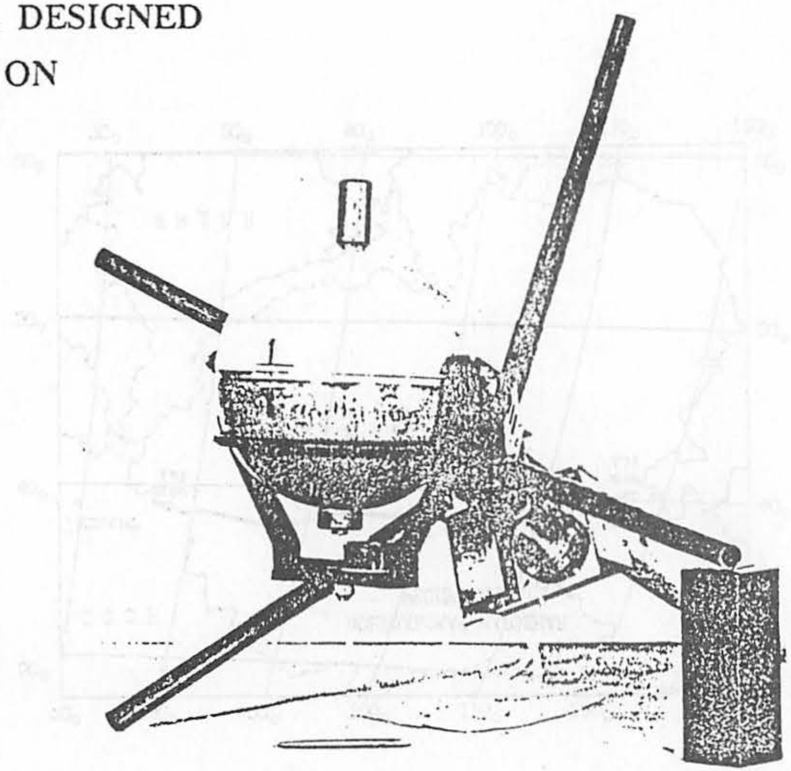


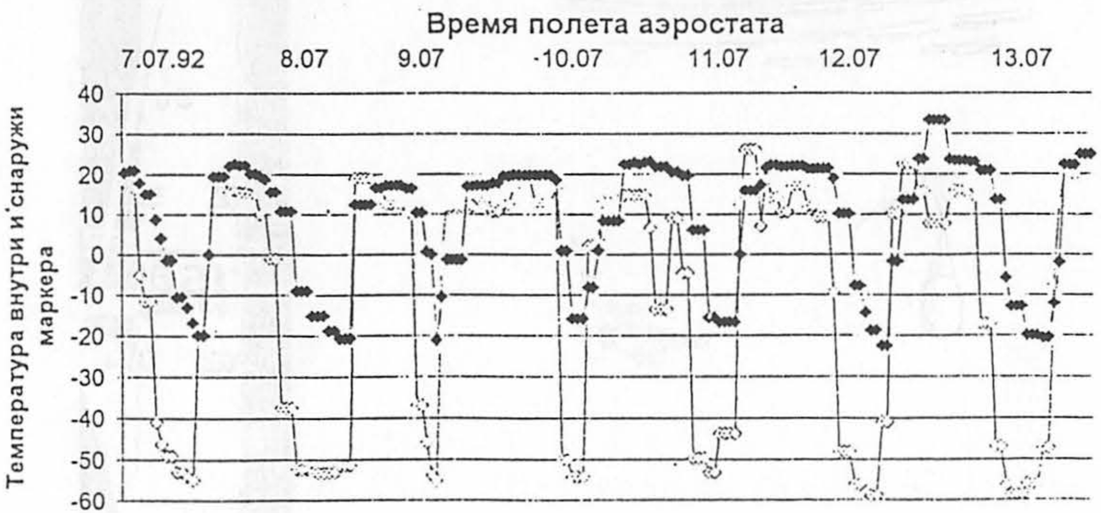


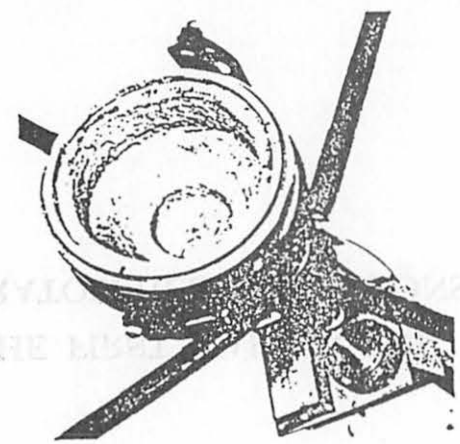


A SPECIAL BALLOON MARKER, DESIGNED TO SPOT THE BASKET ON THE SEA SURFACE

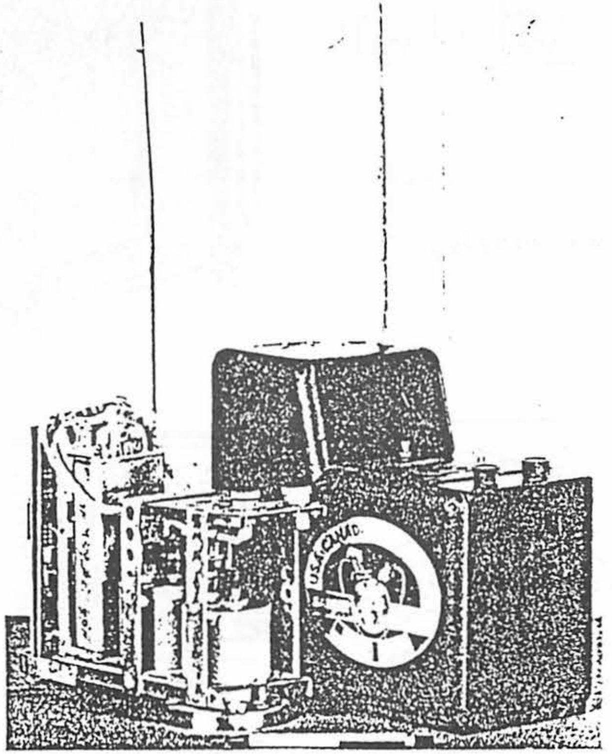


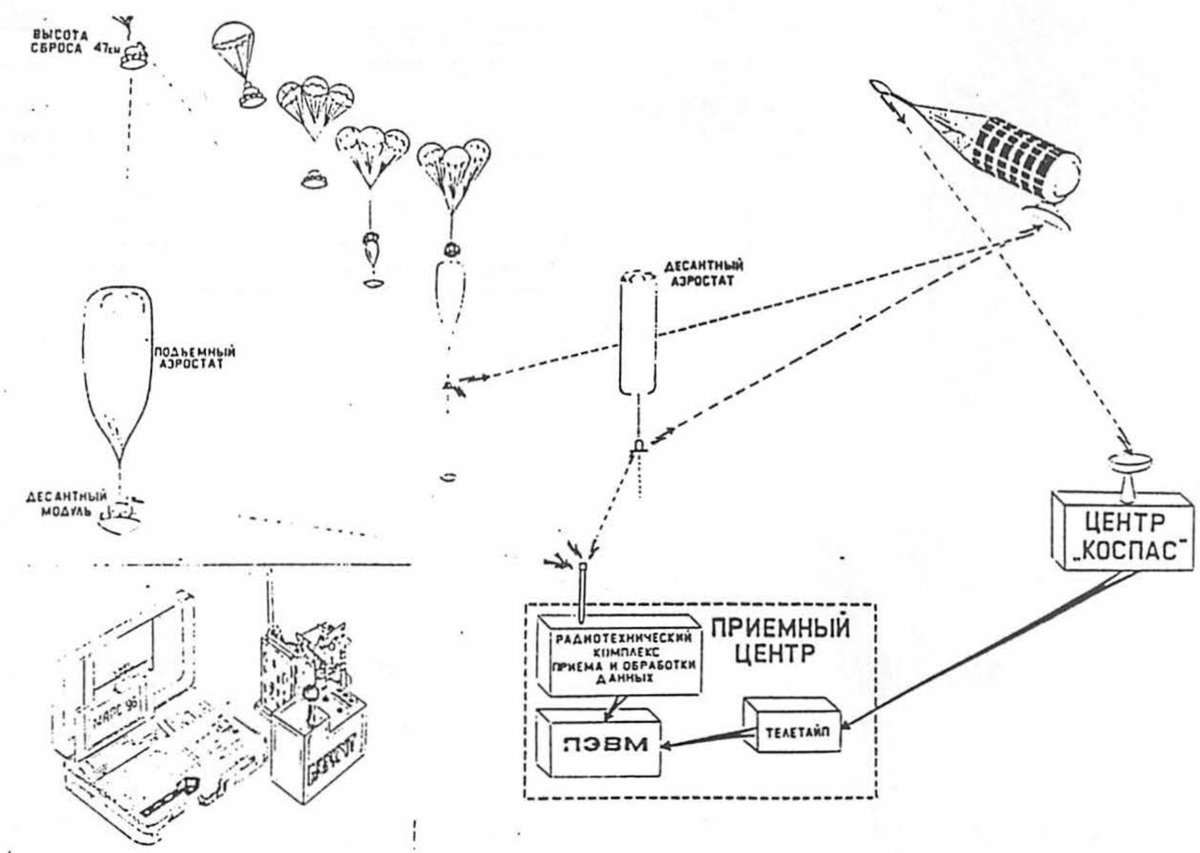




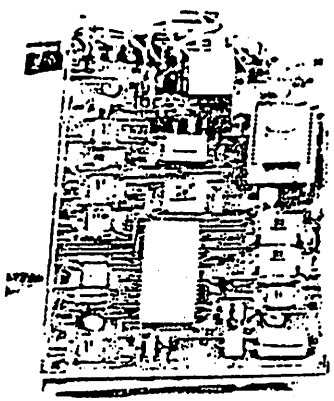


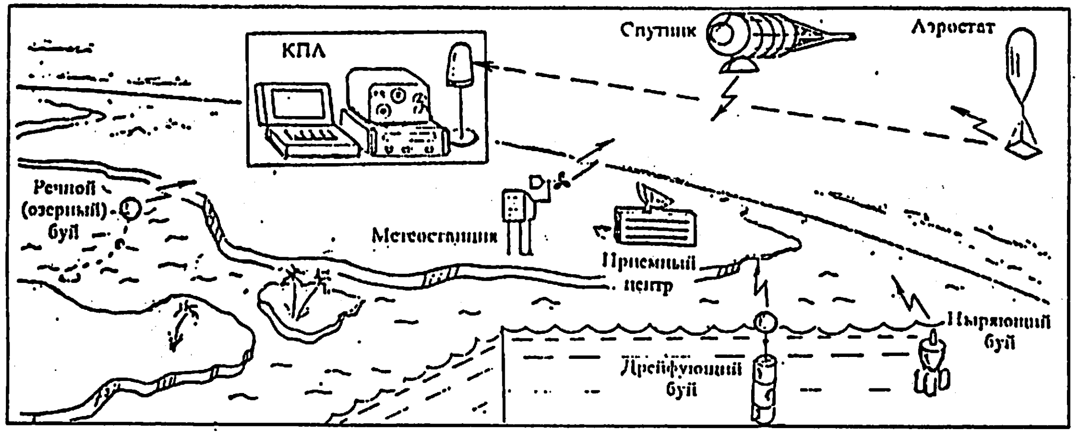
THE MARKER FOR TESTING THE MARS BALLOONS

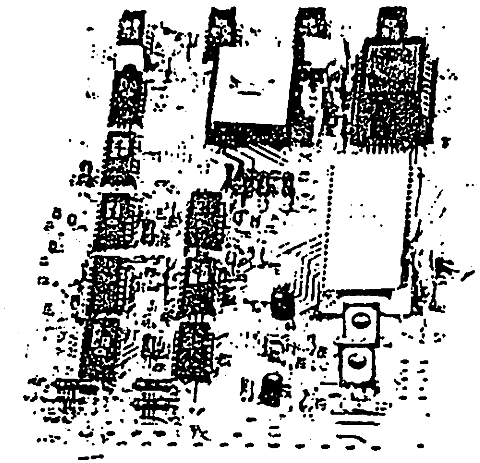


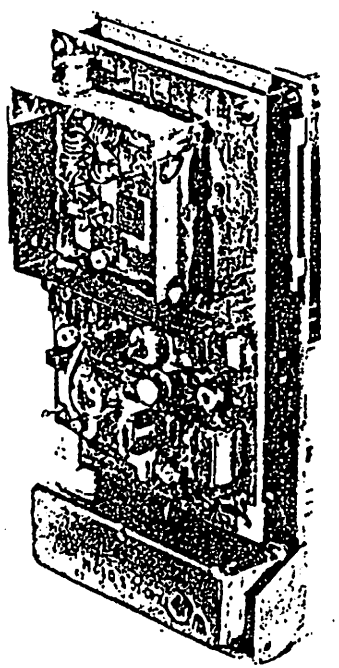


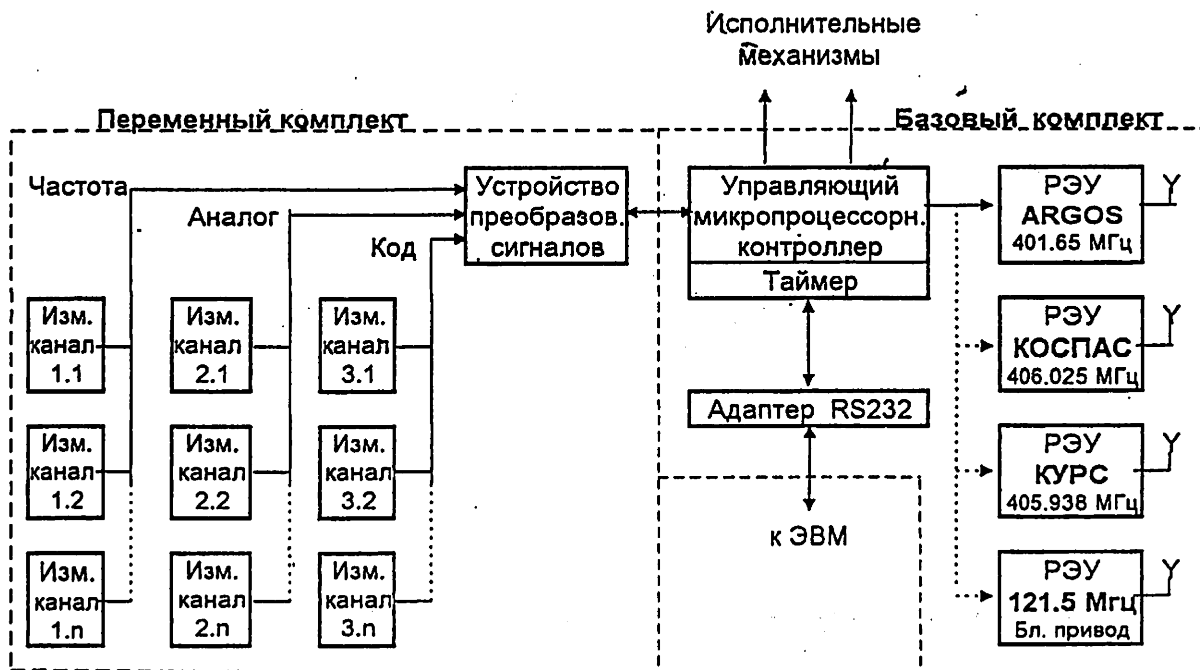
UNIFIED INSTRUMENTS FOR MARINE, AERIAL AND GROUND-BASED PLATFORMS

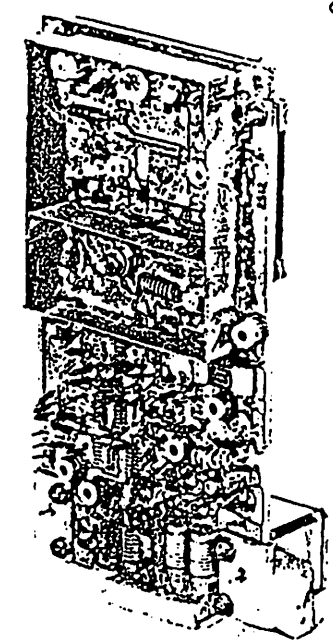




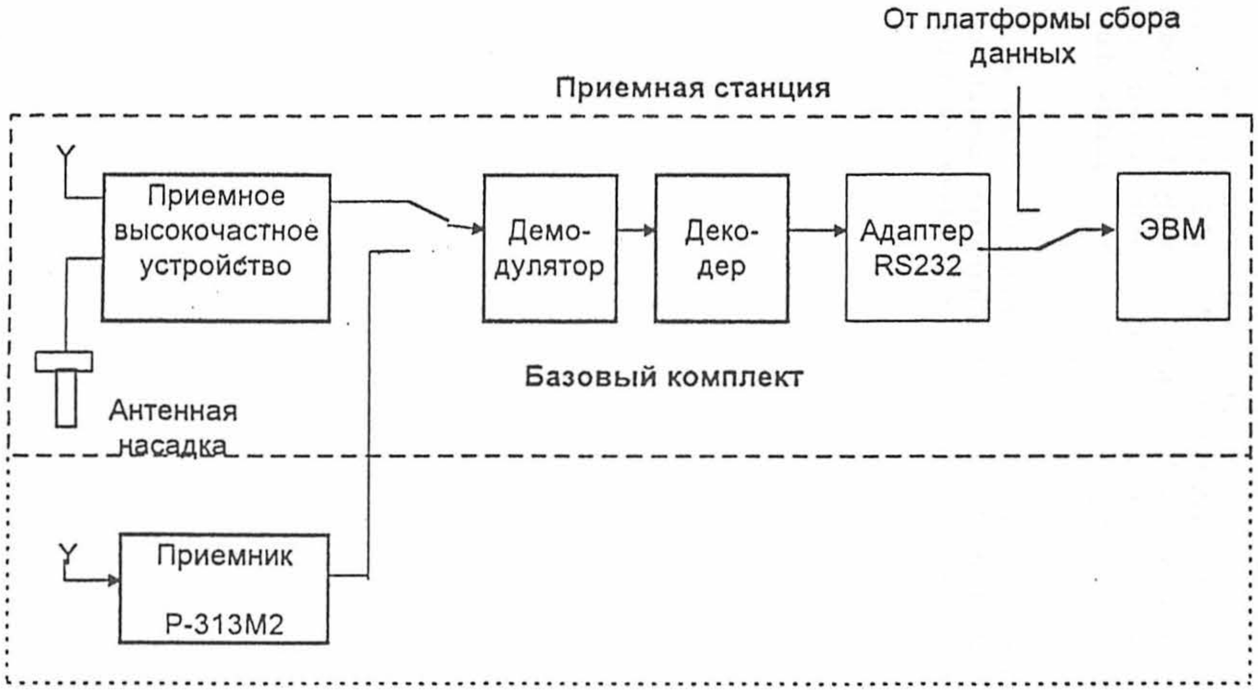


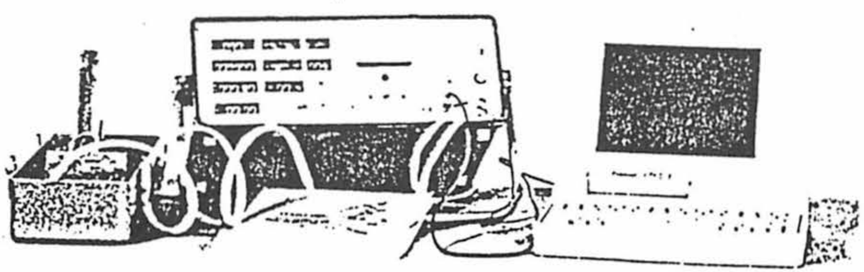


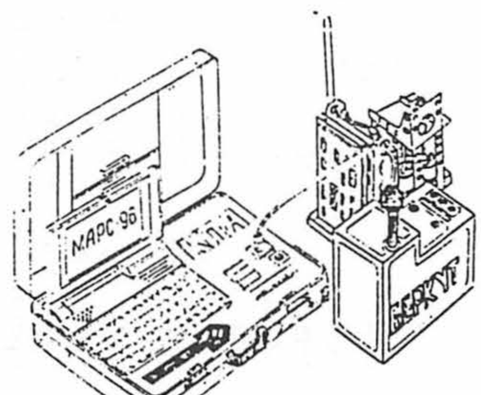




CHECKING INSTRUMENTATION FOR COMPLEX TESTING OF THE PLATFORM







3) IMPROVED AIR TEMPERATURE MEASUREMENTS FROM DRIFTING BUOYS

By: D. W. Jones and J.S. Irvine
Presented by Derek Painting
Meteorological Office
Wokingham, United Kingdom

Abstract

Drifting buoys are now indisputably an invaluable source of high quality data from the oceans. This is particularly true for barometric pressure and sea surface temperature, but many of these buoys also make measurements of air temperature; these data are all widely distributed on the GTS. Air temperature records have, however, tended to show much greater variability than would be expected for the oceanic atmosphere. Consequently, the major analysis centres and other data users have issued many reports of bad or poor quality data via the DBCP bulletin board, with requests for their suppression.

This paper will describe studies undertaken to determine the scale of these errors and their cause. It will also describe an alternative design of air temperature sensor housing and present results from both laboratory tests and operational deployments.

4) DRIFTING BUOY CALIBRATION AND TESTING AT METSERVICE NEW ZEALAND

By : Julie Fletcher Marine Meteorological Officer and
John Burman Calibration Engineer

Date: 1 October 1995

Abstract:
The high quality GTS data obtained from MetService New Zealand Drifting Buoys is directly attributable to the extensive in-house pre-deployment testing programme. This paper will describe how MetService performs all stages of buoy testing from factory inspection, to in-house calibration to pre-deployment testing.
The high recovery rate of buoys (80%) in New Zealand has given the opportunity to examine post operative performance. Modifications to buoy design have been implemented in areas where weaknesses were detected and these will be detailed.

The basic philosophy behind MetService's approach is check, check and check again.

History

Prior to 1988 pre-deployment testing of buoys at MetService New Zealand (MSNZ) was limited to following the manufacturer's assembly and deployment instructions and once assembled, transmission was confirmed using the basic audible beeper check. At that time the Drifting Buoy Programme was conducted by non-technical staff.

The deployment of 4 WSD buoys in the Tasman Sea in 1987 was a complete failure producing no valid data. Following this experience the Calibration Engineer became involved in the Buoy programme.

The next procurement (1988) of 5WSD buoys from a different manufacturer were the first to be fully checked out in the calibration laboratory. Although all 5 buoys were transmitting, all were found to have significant sensor faults e.g. problems with wrong Eeprom co-efficients, mis-matched sensors, all the anemometers were unsatisfactory with defective bearings.

After months of altercations with the manufacturer, replacement of defective components and extensive testing, the buoys were finally assembled and deployed with good results. (Average time to failure or recovery 17.2 months)

Buoys that were later recovered, were examined, and any design weaknesses found were addressed with the manufacturer ie. anemometer bearings, drogue attachments, reed switch and fuse holder failures.

It was decided for future procurements to include a factory inspection visit to ensure that Drifting Buoys purchased operated satisfactorily before leaving the factory. This policy paid off and a good relationship with the manufacturer has developed along with a much improved product and on-going support.

Current Procedures

The testing procedures now routinely performed on MSNZ buoys are documented below.

1. Factory Inspection of New Buoys

The Calibration Engineer visits the factory following notification that the 300 hour burn-in is complete. Physical inspection of the buoys is carried out to ensure compliance with MSNZ specification. Burn in and sensor calibration documentation is examined, and the following sensor checks are performed.

- Paroscientific barometers calibrated in 25 hPa steps over the pressure range
- 900 -1050 hPa
- Barometer port Gortex Membrane breathing rate timed
- Sea and air temperature sensors checked at ambient temperature
- Anemometers checked for start threshold and certificates of wind tunnel testing
- examined
- Heading sensors are calibrated in 30 ° steps clockwise and anti-clockwise

Final tests are carried out with the assembled buoys outside, to verify operational performance via transmission to the satellite.

2. MetService Calibration Laboratory Testing

After shipment to New Zealand all new buoys are taken to the laboratory for acceptance testing. A Telonics TSUR-B receiver is used during calibrations to collect the data.

Calibrations:

- Paroscientific barometer calibration over the pressure range 900.0 -1050.0 hPa in 10hPa steps against the Service's pressure standard
- Barometer port Gortex Membrane breathing rate timed
- Air temperature sensor tested at ambient with standard thermometer, also with a resistor network to simulate thermistor sensor (+25.0°C)
- Sea temperature sensor tested at ambient with standard thermometer
- Wind speed, frequency versus wind speed values from the wind tunnel test certificates are injected into the hull to verify output. After the hull checks the anemometer is connected and excited with a hairdryer to function test the system
- Wind direction, the heading sensor is calibrated in 30° steps clockwise and anticlockwise
- Transmissions are verified through Service ARGOS on-line consultation
- Battery voltage, all pucks individually measured with a 500ohm load applied

After satisfactory sensor calibrations, a laboratory burn-in of another 300 hours on laboratory DC power supply is carried out. Data output is monitored through Service ARGOS during this time. Any failures are resolved with the manufacturer.

3. Final Assembly Testing

When there is a requirement to deploy buoys, the laboratory acceptance tests are repeated on all sensors before final assembly (unless deployment is made immediately following the initial laboratory testing and burn-in).

The final assembly is performed outdoors, weather permitting. The battery assembly is mated with the electronics rack, the PTT co-axial cable is connected to the antenna and the buoy is powered up. There are no fuse holders, fuses, relays or reed switches in the power supply line. This means there is no protection for the electronics in the event of a malfunction. This course of action was adopted after two buoys fitted with fuses and reed switches failed after delivery to the ship, before final on board tests were conducted. One failure was traced to a defective reed switch and the other to a bad fuse holder.

The data output is checked using a Telonics TSUR-B receiver. Before sealing up the following checks are made :

- the anemometer is again tested with a hairdryer (before antenna assembly is sealed to the hull)
- the heading sensor orientation is checked to ensure alignment with the hull 'North' datum
- all ambient sensor output is checked
- the progressive 4 hour updating of data blocks is verified

A fresh 16 unit desiccant pack is fitted and the buoy is then sealed up, ensuring correct wind vane orientation. Once the buoy is connected to its own battery power it is not disconnected again, even if it is one or two weeks prior to loading on board ship for deployment. Throughout this time the buoy data is monitored through Service ARGOS. This continuous running time is very valuable, it allows the buoy to be monitored closely and gives time for any potential failures to show up before the deployment stage. The battery consumption during this time is inconsequential when compared with its expected lifetime.

4. Pre Deployment Testing

Once the designated ship arrives in port the buoy(s) are trucked 35miles (56km)to the wharf. The Marine Meteorological Officer and Calibration Engineer oversee the loading on ship and carry out final ambient and function checks using Telonics TSUR-B receivers. The data transmissions are monitored through Service ARGOS all the way to the deployment position. During this period if any problems show up the ship can be contacted at sea and requested not to deploy.

5. Post Deployment Data Monitoring

After receiving advice from the ship that the buoy has been deployed, the buoy data is checked to ensure all sensors are functioning and that the hourly data blocks are updating correctly . When these requirements have been satisfied, the buoy is declared 'operational' and the data is released for GTS distribution. Throughout the buoy's operational life its data is monitored to ensure continued data accuracy . Data monitoring involves feedback from local forecasters, monitoring the Buoy.QC bulletin board and studying the monthly model summaries. When an overseas agency 'flags ' a MSNZ buoy as having an unreliable sensor, the proposed change is put to MSNZ forecasters for comment and if they agree the sensor is recalibrated or deleted from GTS as soon as possible. Continuous monitoring and rapid response to any 'flagged' sensors ensures that only high quality data is disseminated on GTS. It is essential for the continued credibility of buoy data that any bad data is removed from GTS as quickly as possible.

Post deployment monitoring involves not only monitoring the accuracy of the sensor data, but monitoring the buoy positions as well. When operational buoys are seen to be nearing the coast, action is taken to attempt recovery (see Recoveries).

Recoveries/Refurbishments/Redeployments

All MetService Drifting Buoys are deployed in the Tasman Sea. The prevailing westerly and south-westerly currents carry the buoys from their deployment positions back towards New Zealand allowing approximately 80% of all buoys to be recovered. The positions of operational buoys are monitored and attempts are made to recover them when they are in close proximity to the coast. Buoys that are no longer active and whose positions are not known are sometimes recovered from beaches after reported sightings.

All buoys are marked "reward may be payable", and have a collect phone number to encourage buoy finders to call MetService to report beached buoys. This has worked well. Where practicable buoys are recovered and returned to the MetService laboratory for examination and assessment for refurbishment. Particular attention is paid to any sensors which were flagged as defective by the post deployment monitoring programme.

Buoys are refurbished and subjected to the same calibration procedures as new buoys in preparation for redeployment.

The recovery and refurbishment of buoys has been very successful. Using the same fifteen buoys since December 1988, MetService has made thirty deployments whilst maintaining sufficient operational buoys to maximise contracted PTT time, at an average of 6.3 PTT years per year 1989-1995. *See Figure 1*. Seven of the original fifteen buoys are still operational (as at 1/10/95) and two more recovered buoys are ready for redeployment. Of the operational buoys, three buoys are on their second deployment, three buoys are on their third deployment and one buoy is on its fourth deployment. The average buoy lifetime as calculated over the first twenty three deployments was 15.7 months per buoy, lifetime being counted until barometer failure, recovery or transmission failure. The high number of recoveries distorts the average lifetimes, and in MetService's case it is more representative to look at cumulative lifetimes achieved by buoys over several deployments. Of the buoys operational as at 1 October 1995, the cumulative lifetimes per buoy average 35.6 months. In the case of one buoy, now on its third deployment, its cumulative operational service is 61 months.

The Paroscientific Barometer (Models 215A, 216B) has proved to be very accurate and reliable as evidenced by only two barometer failures in 30 deployments to date since December 1988. *See figure 1*. (Buoy 6435 after 19 months flagged 2hPa low, when recovered at 52 months had degraded to 20hPa low. Buoy 6439, after 40 cumulative months, on its second deployment, was flagged as 2hPa low. This was confirmed in the laboratory after recovery at 42 months.) Over all the other recoveries the Paroscientific Barometer calibrations remained within specification. Sensor drift was generally less than 0.1 hPa.

The YSI 44020 temperature sensors are very good. The air temperature sensor is prone to damage/destruction on beaching.

List of Improvements

Recovered buoys present the opportunity to examine component and sensor performance. This has revealed various faults and weaknesses and has led to the following modifications being implemented.

1. Anemometer bearings.
An early buoy recovery revealed that anemometer bearing wear after seven months was excessive and reports would be unreliable in winds above about 8m/sec. The bearings (upper and lower) were doubled in length by the manufacturer to provide twice the bearing area to prolong life. Start threshold was not affected by this change. Recoveries since this modification showed the lower bearing life satisfactory (ie up to 24 months) with upper bearing wear likely to affect performance after about 12 months. Future buoys will be deployed with the upper bearing length increased yet again.

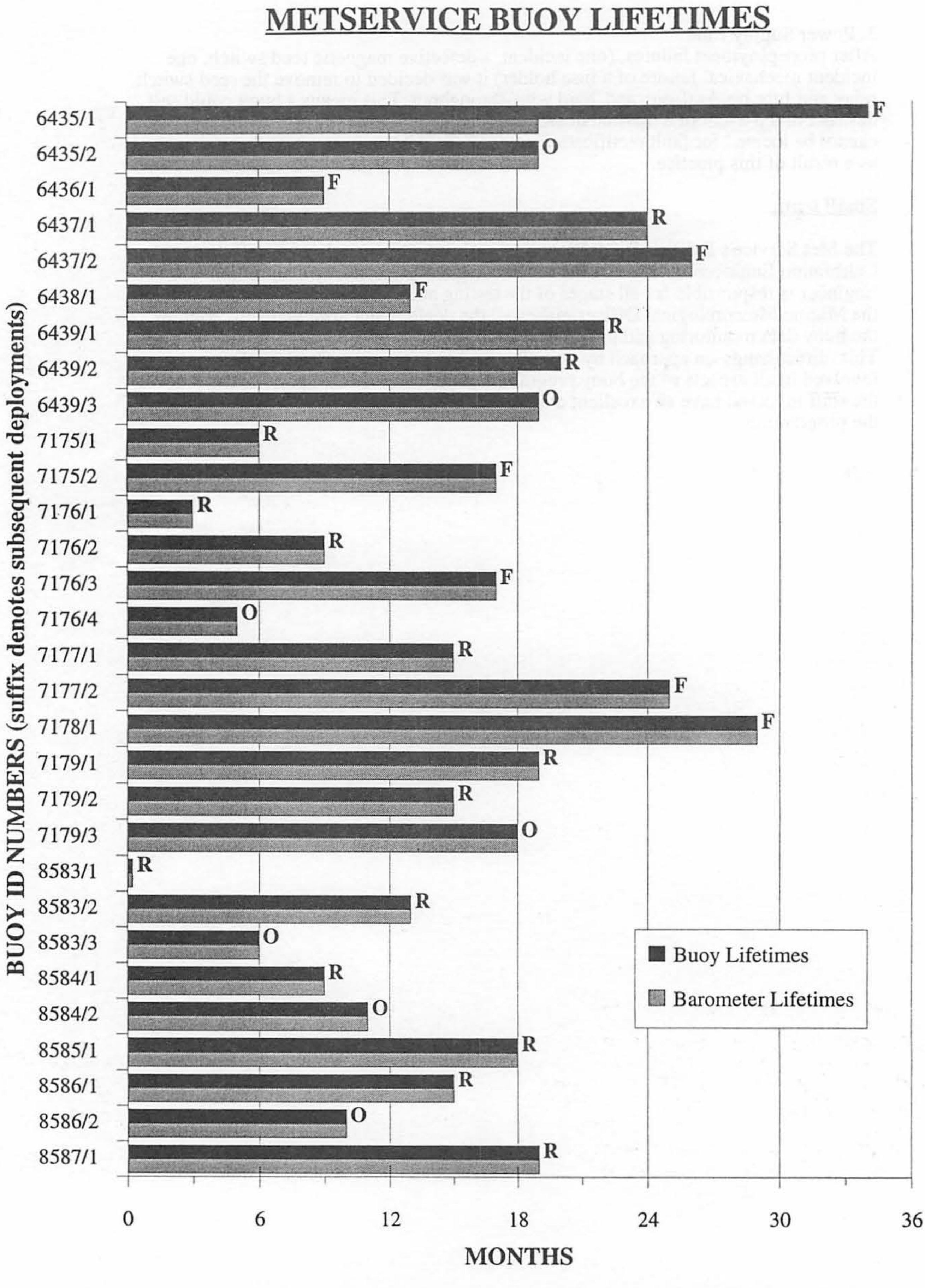
2. Drogue Attachment
Fatigue failures at the root of the threaded section of the attachment pin resulted in loss of the drogue eye and line. A swivel eyebolt design has replaced the original design and the drogue on/off switch has been deleted.

3. Power Supply Line
After predeployment failures, (one incident a defective magnetic reed switch, one incident mechanical failure of a fuse holder) it was decided to remove the reed switch, relay and fuse holder/fuse, and 'hard wire' throughout. This means a buoy could self destruct in the event of a malfunction/current overload. However a 'dead' buoy cannot be located for fault rectification anyway. To date no buoys have been damaged as a result of this practice.

Small team

The Met Service's Drifting Buoy Programme is managed by only two staff, the Calibration Engineer and the Marine Meteorological Officer. The Calibration Engineer is responsible for all stages of the testing and calibration programme, while the Marine Meteorological Officer makes all the deployment arrangements, handles the buoy data monitoring and undertakes all the JTA/Service ARGOS requirements. This direct hands-on approach by a small team has been very effective. Being directly involved in all aspects of the buoy programme, with control of all parts of the process, the staff involved have an excellent overview which must contribute to the success of the programme.

Figure 1



R = Recovered O = Operational (at 1/10/95) F = Final Transmission

5) IN SITU AND SATELLITE SST COMPARISONS

By: Richard W. Reynolds
William J. Emery
NOAA National Meteorological Center
Camp Spring, Maryland, USA

Abstract

Infrared satellite, ship, and buoy data are used to compute satellite and in situ match ups of sea surface temperatures (SSTs). The biases and standard deviations of the match ups are compared with each other for five individual months over a two-year period. August and February were chosen to represent two different seasons for the period between August 1990 and August 1992.

Results are presented to show that match ups using ship data were as useful as match ups using buoy data when extreme in situ SSTs were first eliminated. Thus, the relatively larger number of ship observations was able to compensate for the fact that the individual ship observations tend to have larger errors than individual buoy observations. Because satellite observations have far superior coverage compared to in situ data, the in situ data are only needed to verify and calibrate the satellite data. These results indicate that the deployment of buoys for SST observations can only be clearly justified in regions with sparse ship observations.

IMPORTANCE OF BUOY SST DATA

Richard W. Reynolds
National Centers for Environmental Prediction
NWS, NOAA
Camp Springs, MD, USA

The sea surface temperature (SST) analysis now implemented at the National Centers for Environmental Prediction (NCEP), formally the National Meteorological Center, uses both in situ (ship and buoy) and satellite SST data. The satellite data are used to improve the resolution while the in situ data are used to provide bias correction of the satellite data. The SST analysis is described in detail by Reynolds and Smith (1994).

In situ SST data are of critical importance in correcting the satellite data. Although the analysis is done weekly on a 1° grid, the corrections are done on a coarser 12° grid. The distribution of a recent week of real-time in situ data is shown in Figure 1. The upper panel shows the distribution of observations from ships. These observations depend on ship traffic and are most dense in the mid-latitude Northern Hemisphere. The lower panel shows the in situ observations from drifting and moored buoys. The deployment of the buoys has partially been designed to fill in some areas with little ship data. This process has been most successful in the tropical Pacific and Southern Hemisphere. However, it should be noted that there are areas, such as the tropical Atlantic, that have almost no buoy SST observations.

The critical importance of the in situ data for the SST analysis is clearly shown in Reynolds and Smith (1994). However, the cost of obtaining ship SST measurements is much lower than the cost of deploying buoys which can measure SST. The purpose of this note is to determine where buoy SST observations are needed to supplement the ship SST observations.

To do this, three versions of the SST analysis were used. The first analysis, henceforth called "Ships+Buoys", used ship and buoy data to correct the satellite data and produced an analysis using ships, buoys and corrected satellite data. The second analysis, henceforth called "Ships Only", was the same as the "Ships+Buoys" analysis except only ship data were used. The third analysis, henceforth called "Uncorrected", used all three types of data but did not correct the satellite data. For this study, drifting buoy data were compared to each of the three analyses in three regions: mid-latitude South Pacific, tropical Pacific, and mid-latitude North Atlantic. This was done for the period September 1991 to January 1993. This period was selected to include two periods of large negative satellite biases. The first occurred in the tropics due to aerosols from Mount Pinatubo (July-December 1991), and the second occurred in the Southern Hemisphere middle and high latitudes due to satellite algorithm errors (November 1991-February 1992). Reynolds (1993) discusses these biases in detail.

The biases of the analyses relative to the buoys are shown in Figure 2 for the mid-latitude South Pacific. The Uncorrected analysis shows a large negative bias during November 1991 through February 1992. This is expected due to the use of uncorrected satellite data. The Ships Only analysis shows only a slightly reduced bias. However, the Ships+Buoys analysis is able to remove the bias from the satellite data. In this region, see Figure 1, there is almost no ship data. Thus, buoy data is needed to correct the satellite data.

The analysis biases for the tropical Pacific are shown in Figure 3. The biases in the uncorrected analysis occur prior to December 1991 due to the satellite biases from the Mount Pinatubo aerosols. In this case, the biases in the Ships Only analysis are partially reduced by the ship data. In this region (20°S-20°N, 160°E-160°W) there are some ship data. However, east of roughly 140°W, the ship data are much sparser and buoy data would be more important. In the final region in the mid-latitude North Atlantic (not shown), the satellite biases can be completely corrected by the dense ship data alone.

These results show that buoy SSTs are not needed in the SST analysis in regions (e.g., northern mid-latitudes) with dense ship SST observations. However, the buoy information becomes more important in the tropical Pacific where ship data are sparser and becomes critical in southern mid-latitudes where ship data are very sparse. Thus, the deployment of buoys in southern mid-latitudes should be given the highest priority.

References

Reynolds, R.W., 1993: Impact of Mount Pinatubo Aerosols on Satellite-Derived Sea Surface Temperatures. J. of Climate, 6, 768-774.

Reynolds, R. W., and T. M. Smith, 1994: Improved global sea surface temperature analysis using optimum interpolation. J. Climate, 7, 929-948.

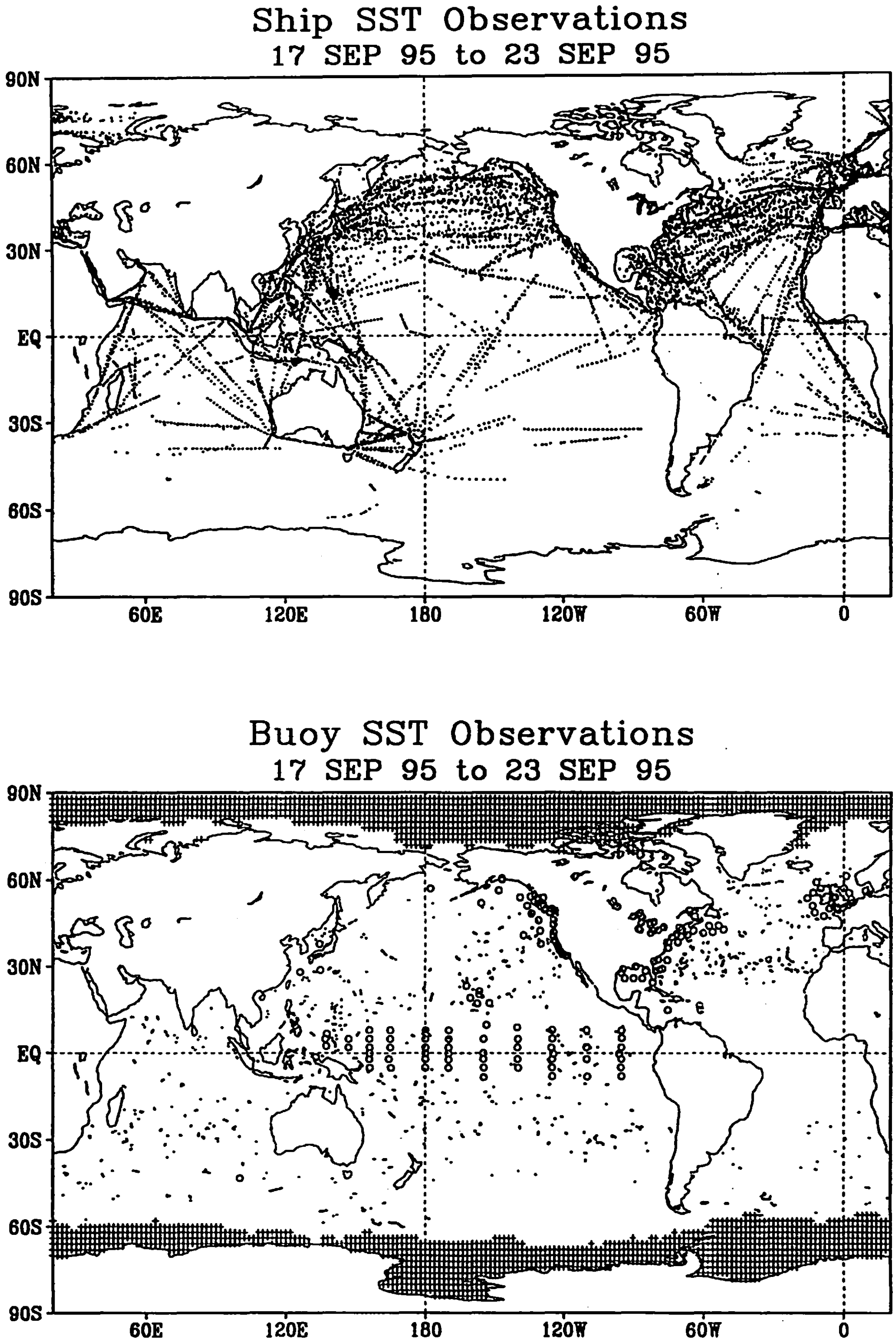


Figure 1. Distribution of ship (top panel) and buoy (bottom panel) SST observations received over the Global Telecommunication System during one week. In the lower panel moored buoys are identified by a circle and sea ice coverage is indicated by a plus.

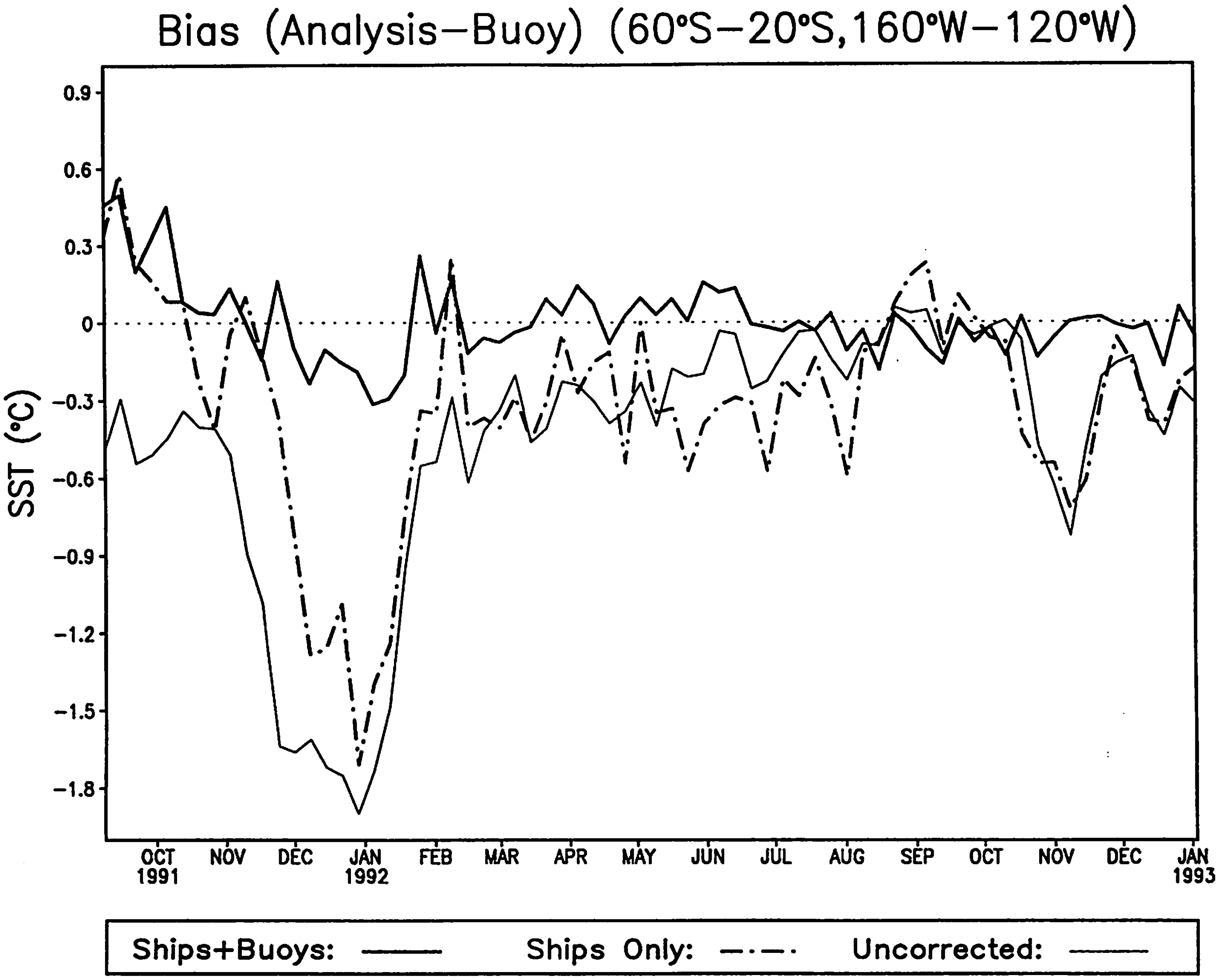


Figure 2. SST bias differences between drifting buoys and three different versions of the SST analysis for a 40° by 40° region in the tropical Pacific. The SST analyses are labeled "Ships+Buoys", "Ships Only" and "Uncorrected". The Ships+Buoys and Ships Only analyses use bias corrected satellite data; the Uncorrected analysis uses uncorrected satellite data.

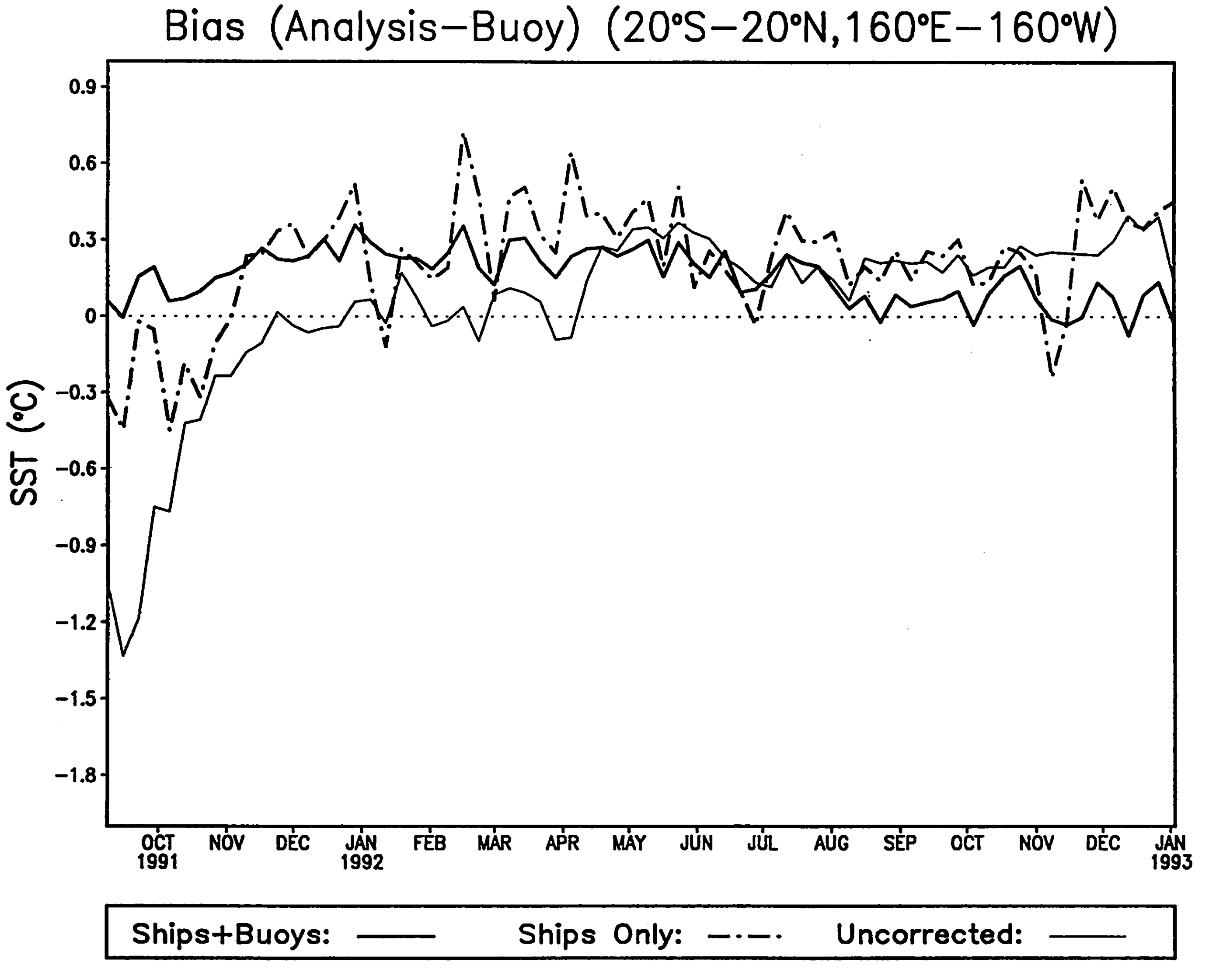


Figure 3. SST bias differences between drifting buoys and three different versions of the SST analysis for a 40° by 40° region in the mid-latitude South Pacific. The SST analyses are labeled "Ships+Buoys", "Ships Only" and "Uncorrected". The Ships+Buoys and Ships Only analyses use bias corrected satellite data; the Uncorrected analysis uses uncorrected satellite data.

6) T-700 BAROMETER DRIFTERS, MULTIPLE PARAMETERS AND SOFTWARE MANAGEMENT

By: Alex Papij
Turo Technology Pty Ltd,
Hobart, Australia

Abstract

The Turo T-700 barometer drifters are made from tough UV stabilized polyethylene and use standard sized holey sock drogues and standard pressure ports. When GPS and water quality sensors are combined with these T-700 drifters they have applications in accurate tracking and monitoring of ocean outfalls and river discharges in coastal waters. As more sensor and data options become available and customers request every permutation possible, managing the embedded software within the buoy electronics can become extremely complex. A simple Software Configuration System can handle a single version of software, very efficiently manage software upgrades and revisions and yet support many configurations - leading to greater reliability, better record keeping of delivered configurations, simpler engineering change orders and more options for the customer.

7) ENVIRONMENTAL BUOY DATA: THE HISTORICAL RECORD AND FUTURE POSSIBILITIES

By: Eric A. Meindl
National Data Buoy Center (NOAA/NWS)
John C. Stennis Space Center, Mississippi, USA

Abstract

High quality, in-situ observations from marine areas are critical to short-term (i.e., minutes to hours time frame) operational weather forecasting decisions, and may be used to anchor and verify atmospheric model output (hours to days). Such observations may also satisfy the need for long term study (months to decades) of atmospheric and oceanic variability.

The National Data Buoy Center (NDBC) of the US National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS), began deploying automated moored buoys in the early 1970s. While they have been particularly useful for operational purposes, an impressive record of hourly observations that covers more than a decade exists from many of these stations and may be used for longer term studies. Such data are supplemented by data from drifting buoys deployed in support of global research programs. This vast quantity of data is available from national and international archive centers, and on a newly-developed set of inexpensive CD-ROMs called SeaBreeze.

Finally, use of more sophisticated sensor types on buoy platforms (e.g., precipitation and relative humidity) will be discussed.

ENVIRONMENTAL BUOY DATA: HISTORICAL RECORD AND FUTURE POSSIBILITIES

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ELEVENTH SESSION
DATA BUOY COOPERATION PANEL
17 - 20 OCT 1995

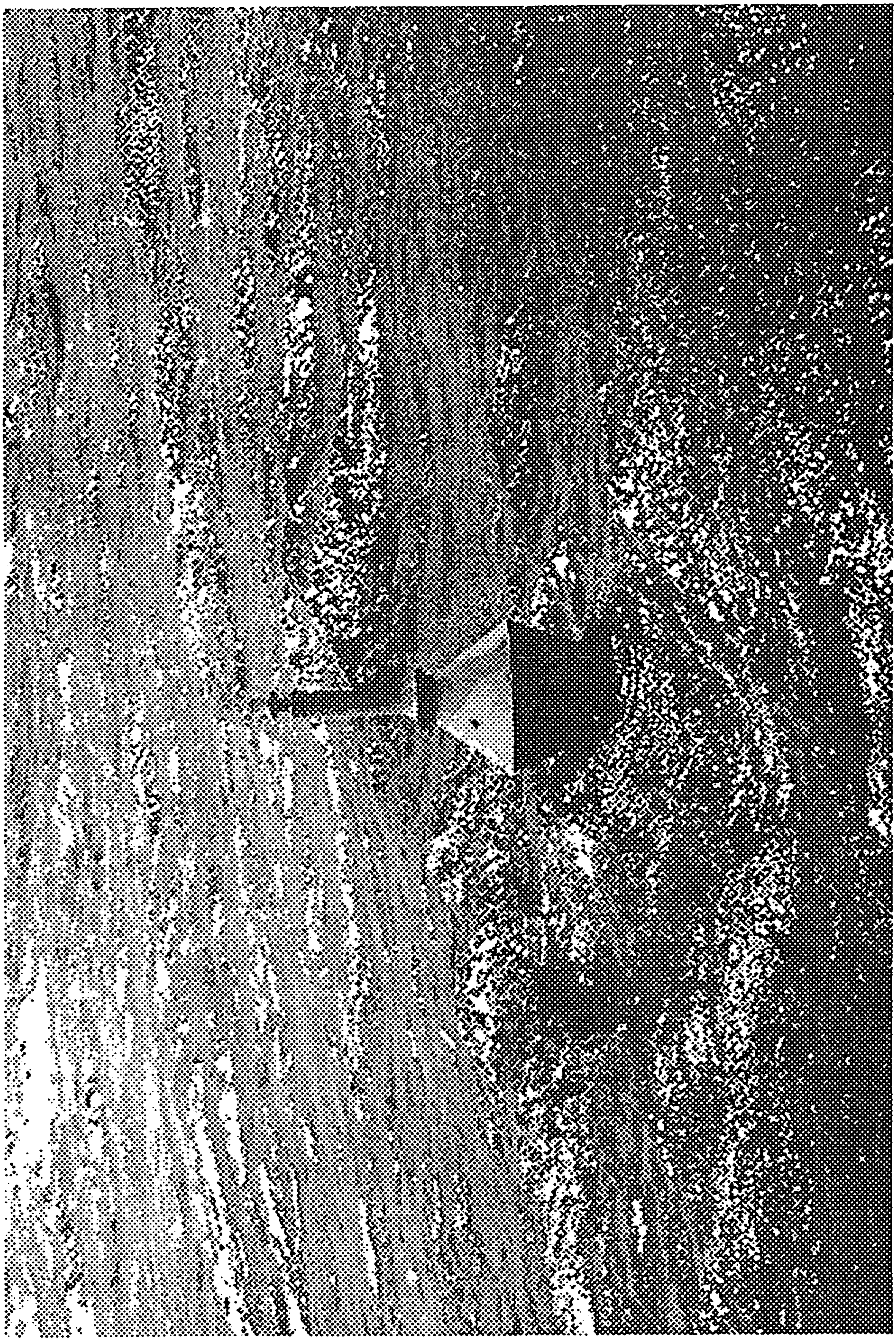

FIGURE 6. AN NDBC FGGE-TYPE DRIFTING BUOY.

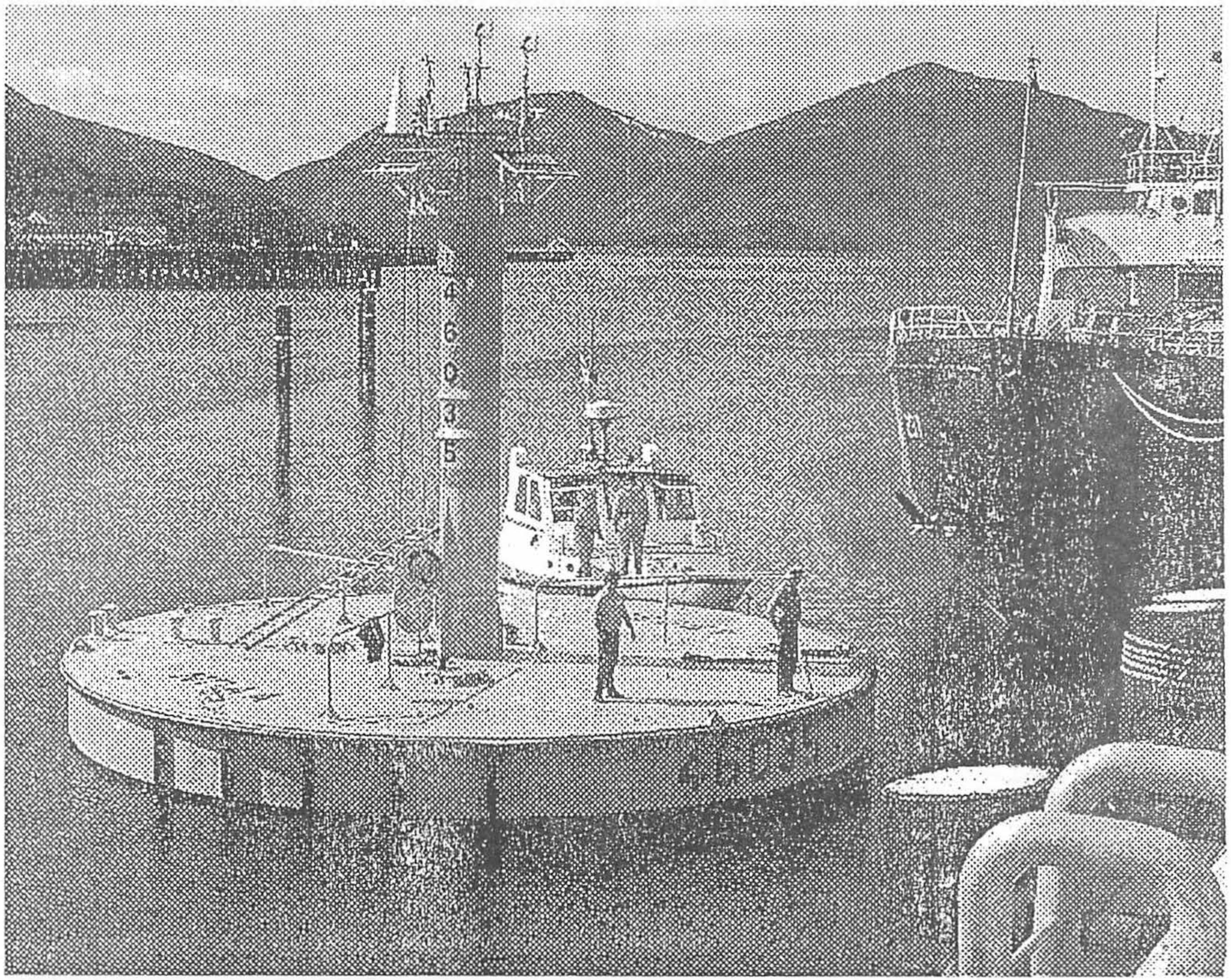

FIGURE 3. NDBC 12-M-DIAMETER DISCUS MOORED BUOY.

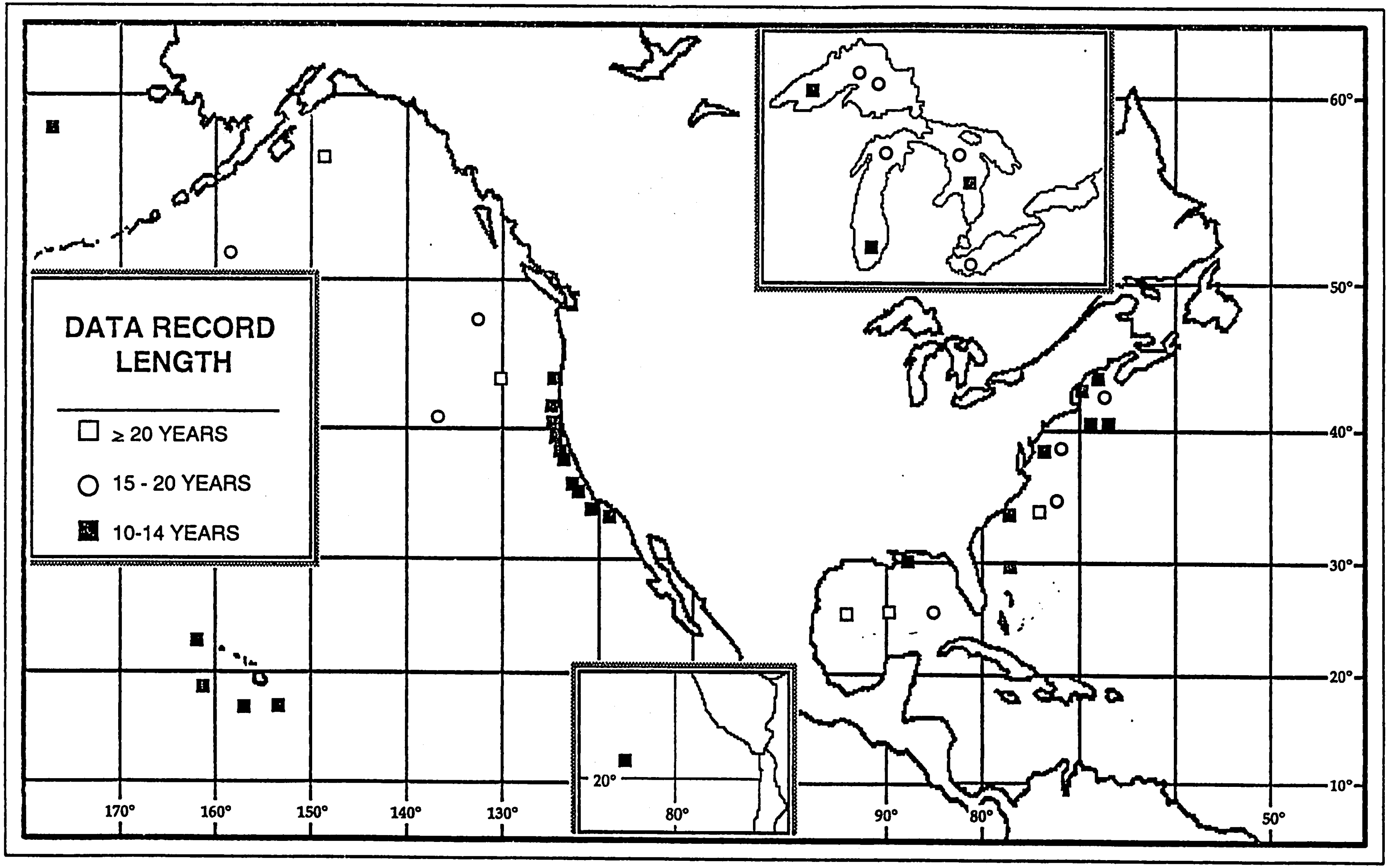

FIGURE 1. NDBC MOORED BUOY STATION LOCATIONS WITH DATA RECORDS MORE THAN 20 YEARS LONG (□), 15-20 YEARS LONG (○), AND 10-15 YEARS LONG (■).

8) INTEGRATING GPS AND ARGOS - A DRIFTING BUOY APPLICATION

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Introduction

An increasing number of experimenters and manufacturers, and even CLS Argos themselves, have considered ways of integrating positions derived using the satellites of the US Global Positioning System (GPS) into the Argos message structure. Advantages include the availability of locations at user-determined times, and a possible reduction in Argos charges by avoidance of the need for Argos-derived locations. Most systems proposed, however, use up a significant amount (32 or more bits) of the 256 bits available in the Argos message structure in order to transmit a single location with a resolution of the order of a few hundred metres. So far as is known, no system yet described makes use of the full accuracy (10 m or so) available to the civilian experimenter using differential (DGPS) techniques, nor fully exploits the potential of GPS to yield a sequence of locations at time intervals well below the repeat period of the Argos orbits.

This study was driven by an experimental requirement, within the UK Natural Environment Research Council's Land-Ocean Interaction Study (LOIS), to observe and model the fine structure of the circulation patterns close to the shelf edge west of Scotland using drifters. It was decided to use the WOCE Surface Velocity Programme drifter as the basic design element, modified to accommodate additional sensors and processing, and to carry a GPS antenna and receiver. The design goals to be addressed using GPS were:

- Fix accuracy of 50 m or better
- Fix interval of 20 minutes
- No gaps in the fix record, despite gaps in the satellite passes

This paper describes the thinking behind the design that evolved, and some details of its implementation.

Some relevant features of the Argos system

Gaps in coverage

It should not be forgotten that the Argos data collection system is carried as a passenger on board the NOAA weather-imaging satellites. The prime purpose of these satellites is to collect daytime imagery of the earth and its weather systems, and the orbits of the spacecraft are arranged to image a swath on either side of a given point on the earth's surface at roughly the same local solar times each day. One of the two operational satellites is assigned to the 'morning' orbit; the other to the 'afternoon' orbit. Fortunately, the Argos equipment is capable of receiving signals from virtually any transmitter in the field of view of the satellite (a circle roughly 5000 km in diameter), the result of this being that the Argos system collects data from additional orbits bordering on the 'imaging' orbits. Because of the convergence of the orbits towards the poles, the number of additional orbits available to Argos increases with distance away from the equator. Argos also collects data during the passage of the satellites over the dark side of the earth. The general picture can be seen in Figure 1, which shows every pass of the two operational NOAA satellites that would be seen by a drifter at 57° N during September 1995. A salient feature of the graph, and one of concern to many users of Argos, is the several hour gap in coverage around midnight local time, a direct consequence of the orbital configuration described above.

However, orbits do unintentionally drift over a period of time, which has the potential to make the midnight hole better - or worse. Up until August 1995, Argos was able to make available on request data from a 'spare' satellite, NOAA-9 (F), whose orbit had fortuitously drifted so as to partially fill the midnight hole. Unfortunately, equipment aboard this spacecraft eventually failed, and the third satellite now offered by Argos, NOAA-11 (H), has an orbit much like that of the operational NOAA-12 (D). This means that the three-satellite service currently available does little to decrease the midnight hole, although it does permit increased numbers of uplinks and locations at other times of the day (Figure 2).

An experiment that aims to recover an uninterrupted time series must ensure that a sufficiently large stack of historical data is transmitted to bridge the largest expected gap in the satellite coverage. In our case, at a latitude of approximately 57°N, gaps in coverage can exceed five hours (Figure 3), which implies a stack of at least that length. The situation will of course be worse for experiments lying closer to the equator.

A practical demonstration of the gap effect can be seen by looking at some simple statistics for our drifter (Argos ID 24283), whose track over a period of about 40 days is shown in Figure 4. There are very few fixes close to midnight (Figure 5), and the time intervals between fixes can be as high as 10 hours (Figure 6). Also of note, in the light of the design study which follows, is the distribution of distance covered between successive fixes (Figure 7), which can be as high as several km.

Fix accuracy

The current version of the Argos location algorithm claims to offer a number of enhancements over its predecessors, including a more reliable grading of locations in terms of their accuracies (Figure 8). It should be noted that the figures quoted are for one standard deviation (1-σ), rather than the 2-σ level commonly encountered elsewhere. Because of the data that we have accumulated over the last year from Argos transmitters (Seimac and Telonics) under test at our laboratory, an opportunity arose to perform an independent verification of Argos accuracy. Figure 9 shows the ensemble of 412 fixes of classes 1, 2 and 3 that were collected, whereas Figures 10, 11 and 12 divide the ensemble into its three Argos classes. The scatter is significantly worse than that claimed, particularly for the longitude axis. It should also be noted that the distribution of errors is non-Gaussian, and that outliers at several σ may be encountered more commonly than expected from Gaussian statistics (Figure 13).

Consequences for our experiment

These can be summarised as follows:

- Argos fixes are neither accurate nor regular enough for our requirements
- Gaps in the coverage will have to be bridged by transmitting a 5-hour stack of previous data, old data being deleted from the stack as new data are added
- Because of the Argos message-length limitation of 256 bits, messages will have to be interleaved to accommodate the entire stack.

The Global Positioning System

Basic characteristics

The system is implemented using a constellation of 24 or so satellites in high orbit, ensuring global operability round the clock. The GPS receiver is passive - it does not transmit - and estimates its range from each satellite in view by measuring the transit time of signals broadcast by the satellites (Figure 14). Ranges thus determined are called 'pseudo-ranges', as the receiver's clock is not initially synchronised to the satellites' clocks. The receiver computes the position of each satellite using a set of orbital parameters (the ephemeris) contained in the broadcast message, and thus is able to infer its own position. Table 1 summarises some technical features of the system, or at least that part of it (the L1 transmission) which is commonly used by civilian receivers. Errors in the pseudo-ranges arising from the unknown offset between the GPS clocks and the receiver clock are removed by using an additional satellite to solve for precise time. Thus a full three-dimensional solution (latitude, longitude, altitude and time) requires ranging to four satellites: for drifters, located more or less on the earth's geoidal surface, three satellites suffice to compute a two-dimensional solution (latitude, longitude and time).

The system is operated by the US Department of Defense, who currently exercise the right to degrade the accuracy available to civilian users by introducing errors into the satellite clocks, the broadcast ephemeris, or both. Full accuracy denial is termed Selective Availability (SA), and currently increases the 2-σ error in computed GPS locations from a few metres to about 100 m (Figures 15 and 16).

Table 1. Technical characteristics of GPS L1 signal.

Carrier frequency	1575.42 MHz
modulated by:	
Timing code (Pseudo Random Binary Sequence)	1.023 MHz
Navigation message (Orbital parameters and other data)	0.00005 MHz

SA causes errors in the pseudo-ranges measured by the GPS receiver. Because the satellites are in such high orbits (>20,000 km), the errors are sufficiently similar over a wide radius to permit pseudo-range errors determined by a base station at a known location to be subtracted from pseudo-ranges measured simultaneously by a remote receiver using the same set of satellites. This is known as Differential GPS (DGPS), and restores accuracies to the 10-metre level or better. A more unsophisticated technique simply subtracts measured errors in latitude and longitude from the remote's co-ordinates, once again computed at the same time and with the same set of satellites. This is variously known as Inverse DGPS or Pseudo-DGPS, and gives errors that are somewhat higher than with true DGPS. In both cases, the corrections can either be applied *post hoc*; or in real time, if a suitable communication channel exists between the base and the remote. Pseudo-DGPS is particularly attractive for drifter applications, as it is only necessary to transmit or store the computed fix, rather than the full set of measured pseudo-ranges, plus the IDs for the satellites used, and the fix time.

Pseudo-DGPS trials

As a first attempt, two conventional GPS receivers (Motorola OnCore) were established at two locations separated by about 30 km, and the fix data logged. Figure 17 shows the typical scatter resulting from SA as recorded at the 'remote' station. 2-σ values are several tens of metres, as expected.

The data from both receivers were then analysed to find simultaneous fixes where the same set of satellites had been used in both navigation solutions. Fix errors computed at the 'base' station were then subtracted from the simultaneous latitude and longitude reported by the 'remote'. As a result of this operation, the position error was reduced to about 10 m at the 2-σ level (Figure 18). Table 2 summarises the measured accuracies of the various systems described so far.

Table 2. Measured standard deviations of various systems.

	East (m)	North (m)	No of fixes
ARGOS			
Location quality 1	1440	790	130
Location quality 2	540	390	150
Location quality 3	310	390	132
GPS			
Base station	36	21	94
Remote station	36	22	94
Pseudo-DGPS			
Remote-Base	4	6	94

Note that the use of a conventional receiver at the 'base' imposes a major limitation on the usefulness of this particular variation of the Pseudo-GPS technique, as there is no way of guaranteeing that the same set of satellites will be chosen by both receivers, even if each sees the same constellation. Receivers are programmed to select satellites in terms of optimum geometry and signal quality, and to review this selection at regular intervals. The net effect of this often seems to be that quite different satellites are picked, even by receivers that are located relatively close to each other. In practice, this difficulty is overcome by using a base station that can output the pseudo-range data and current orbital parameters for all satellites in view. These data, and not the fixes, are stored and selectively processed into positions at a later date, when the precise times and satellite sets used by the remote are known.

Implementation of Pseudo-DGPS in a drifter

A first attempt at defining a message structure for the drifter might proceed as follows:

	No of bits
GPS latitude + longitude with resolution of a few metres	50
Time of fix with resolution of a few seconds	15
IDs of satellites used in 'remote' fix (4 x 5 bits)	20
	85

For our experiment, we need a new fix every 20 minutes, and we need to construct a data stack covering the maximum expected gap in Argos passes of about five hours. Thus the stack should contain 15 fix messages. The maximum Argos message length is about 256 bits, so it is clearly impossible to transmit the stack in a single message. However, by using multiple Argos IDs (which is expensive in terms of Argos costs), or by interleaving 256-bit messages by transmitting them in sequence, it is possible to achieve a practical message length of 4 or 5 times 256 bits.

Thus it would be technically feasible to transmit 15 fix messages of the above type (15 x 85 = 1275 bits) in a 5-fold interleaved Argos sequence (5 x 256 = 1280 bits). This would, however, leave only 5 bits (at a rate of 1 bit per hour!) for other sensor data and checksums, which is not very appealing.

The solution employed is to compress the GPS data by transmitting only the significant parts of it, namely the fine-scale resolution which is not achievable by Argos, and by using the Argos location to define the coarse position, or 'lane'. The width of the lane is set by the choice of the number of bits used to encode the GPS fine position, and by the bit step-size. For example, it is convenient with the Motorola OnCore GPS receiver, and consistent with the needs of the Pseudo-DGPS post-processing, to set the step size to 4 m; a 10-bit position thus has an approximate range of 0 - 4000 m. This means that the 10-bit GPS position has a lane size, or ambiguity, of 4 km, which must be resolved by other means, such as the Argos position. Recalling that the maximum observed drift between successive Argos fixes is likely to be of the order of a few km, it then seems that there may be grounds for hope that this technique might work. A further aid to ambiguity resolution results from the continuity of the drift tracks - even if a given Argos fix is unable to uniquely define the lane number, neighbouring fixes should allow unambiguous reconstruction of the track.

Prototype WOCE-SVP style drifters have therefore been built containing a GPS receiver and antenna mast, a sensor package, a microprocessor board (using the low-power PC-compatible 80C186EB processor), and an Argos transmitter. The message structure is as follows:

	No of bits
GPS fine latitude + longitude with resolution of 4 m, 4 km lane width	20
Time of fix with resolution of 1 s, 9-hour repeat cycle	15
IDs of satellites used in 'remote' fix (compressed)	18
Sensor data (2 thermistors + pressure transducer)	28
Checksum	4
	85

The base station consists of a Navstar XR5-M GPS receiver, continuously logging pseudo-range and orbital data to a PC in RINEX format. Post-processing of the RINEX data is carried out using software donated to us by Navstar.

It is hoped to report the results of test deployments, close to Dunstaffnage and on the shelf edge west of Scotland, at the next DBCP technical session, as well as some parallel work on the development of receiver firmware capable of reconstructing the GPS message from fragments.

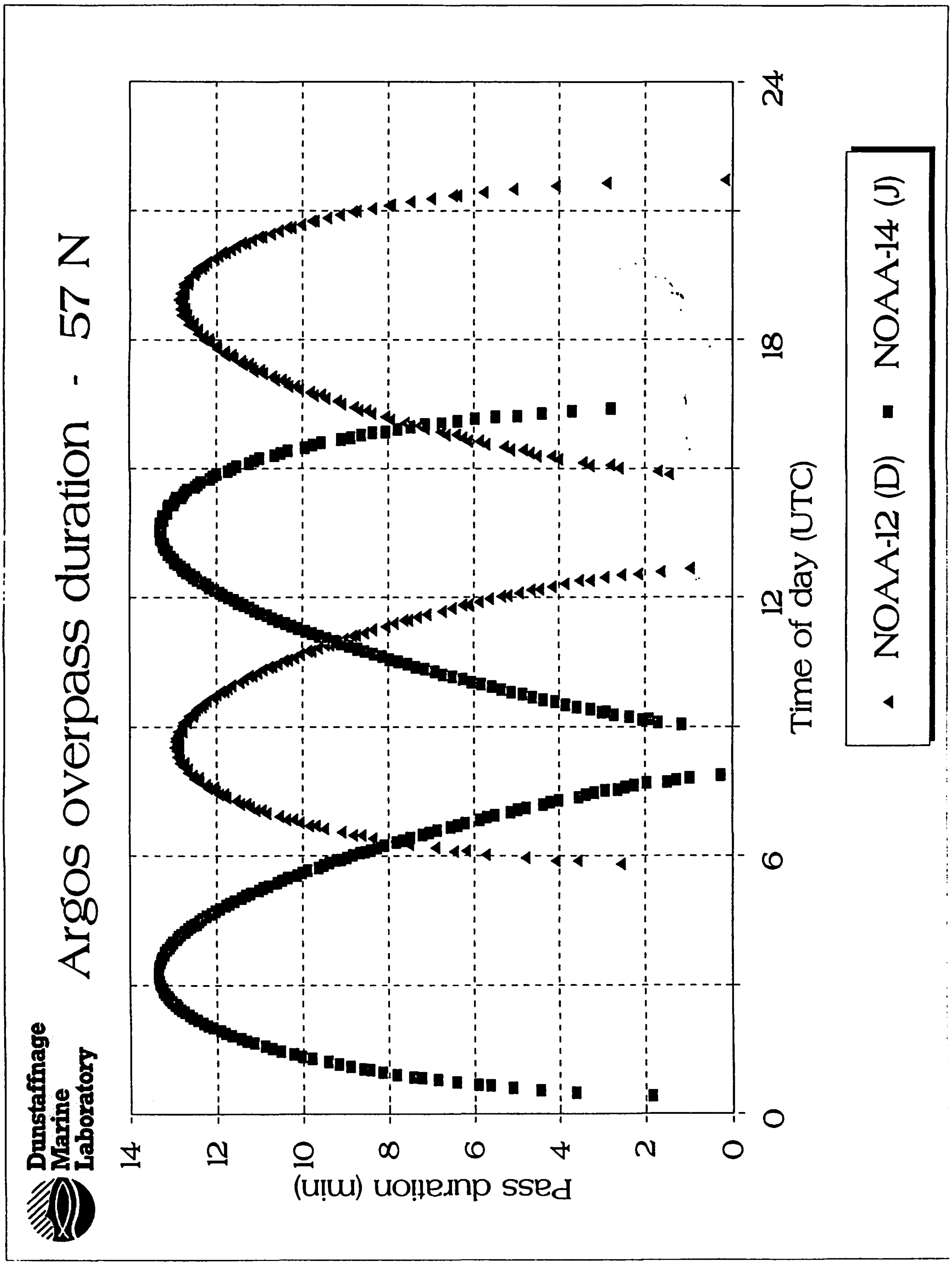
Summary of some possibilities of GPS for drifters

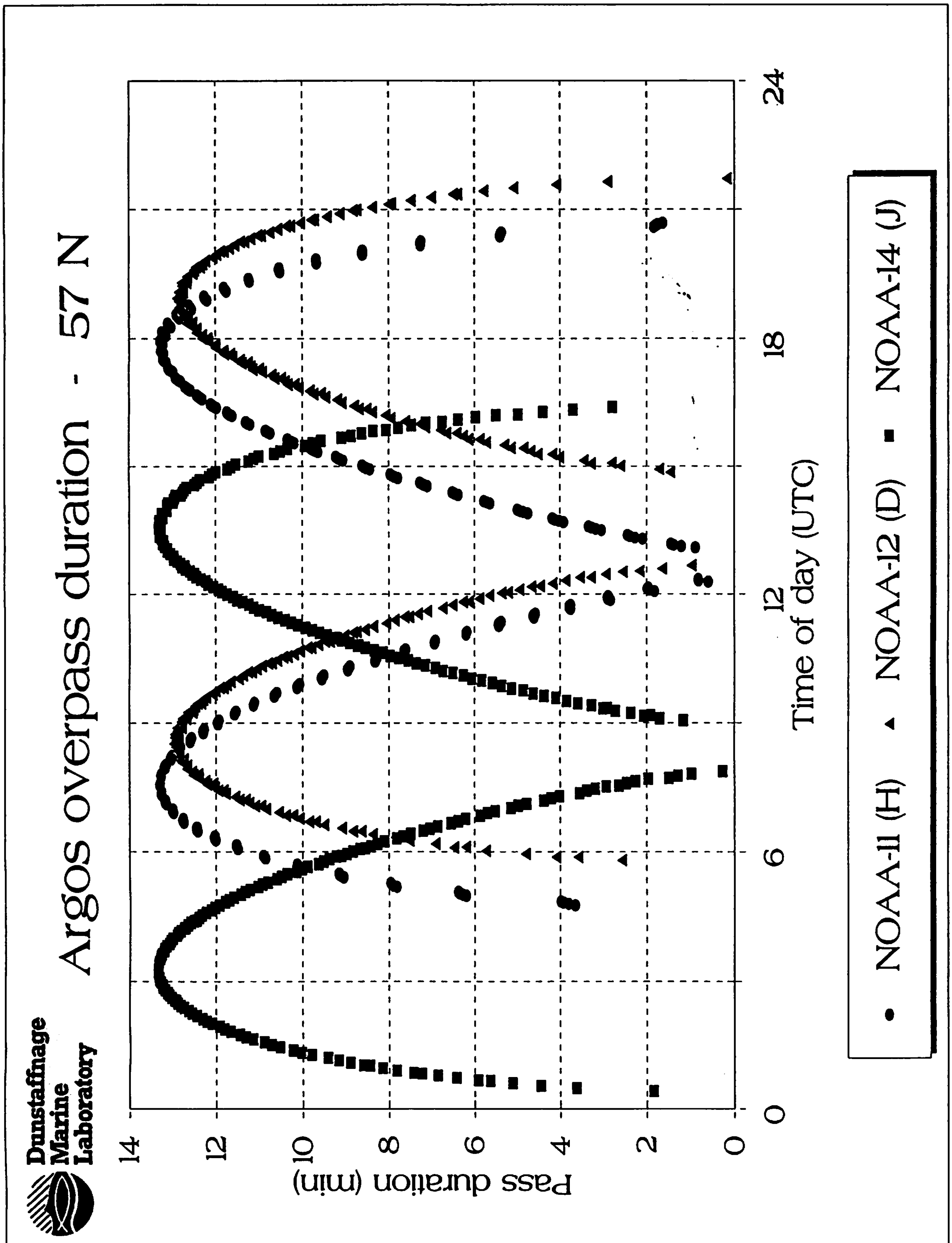
The fundamental point is that both **position** and **precise time** are known to a drifter carrying a GPS receiver. This opens up a whole host of possibilities for the drifter of the future, capable of adapting its behaviour in response to this knowledge. Some of these potential capabilities are listed below:

- Accurate Argos satellite pass prediction, permitting transmitter scheduling and dynamic data stack management
- Activity control according to position, permitting (for example) the drifter to shut down when leaving a pre-defined area of interest, and to re-start on re-entering it
- Activity control according to time (of day, of year)
- More accurate locations, at user-defined intervals
- Reduction in Argos costs (not yet used for this purpose by Dunstaffnage Marine Laboratory!)

Acknowledgements

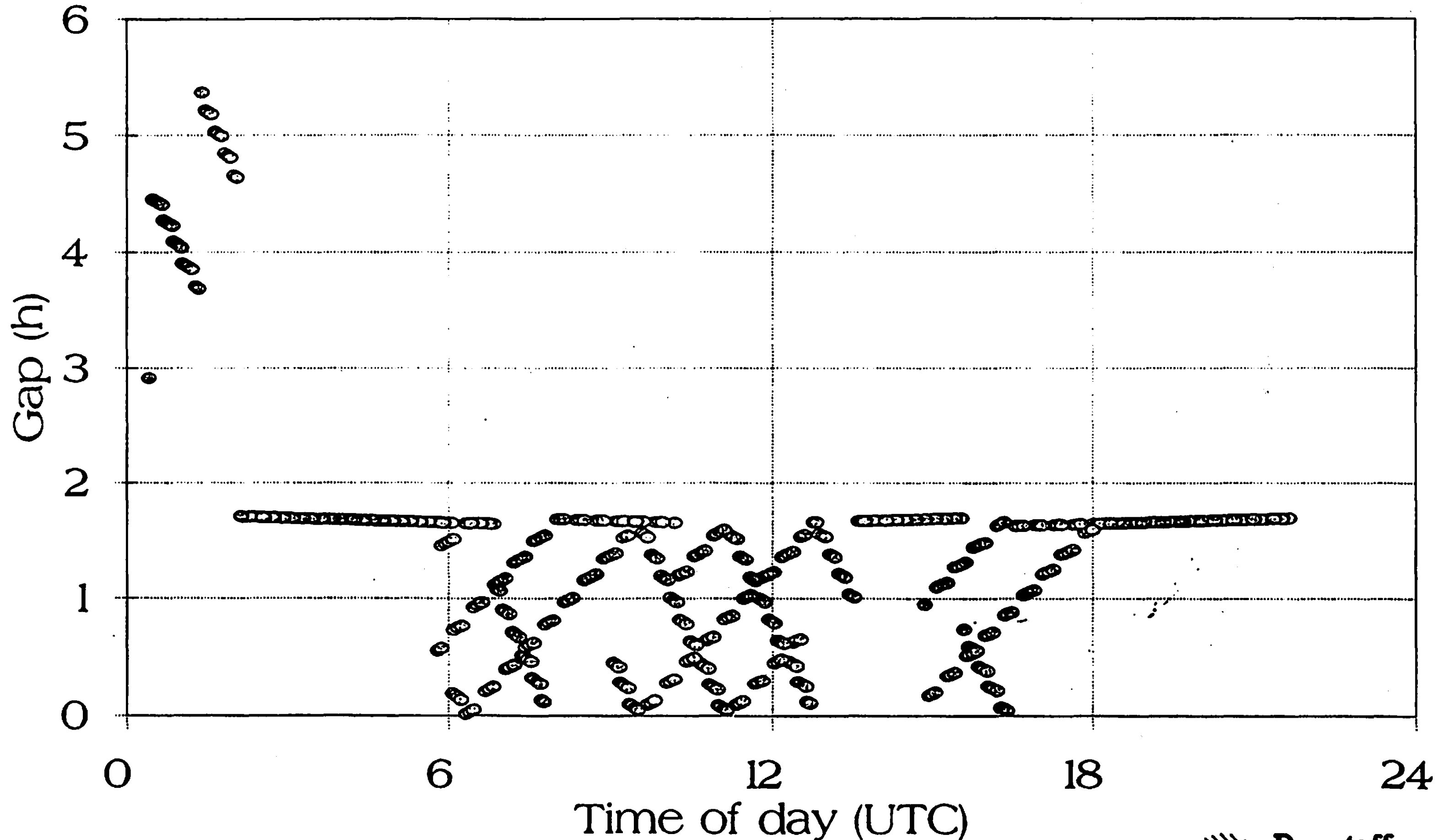
This work has drawn extensively on the experience and technology of Navstar Systems Ltd, whose generous assistance is gratefully acknowledged. Joe Graham at Dunstaffnage developed the microprocessor board which is at the heart of the data processing and message formatting; other members of the Marine Technology group (Jim Watson and Neil MacDougall) dealt with the mechanics of putting it all together in a working drifter. CLS Argos kindly relaxed the rules on transmitter repetition period to allow a greater chance of our messages being heard by the satellites. The study has been funded within the UK Natural Environment Research Council's LOIS and AUTOSUB community research programmes.


Dunstaffnage Marine Laboratory
Argos overpass duration - 57 N
Pass duration (min)
0
2
4
6
8
10
12
14
Time of day (UTC)
0
6
12
18
24
NOAA-12 (D)
NOAA-14 (J)

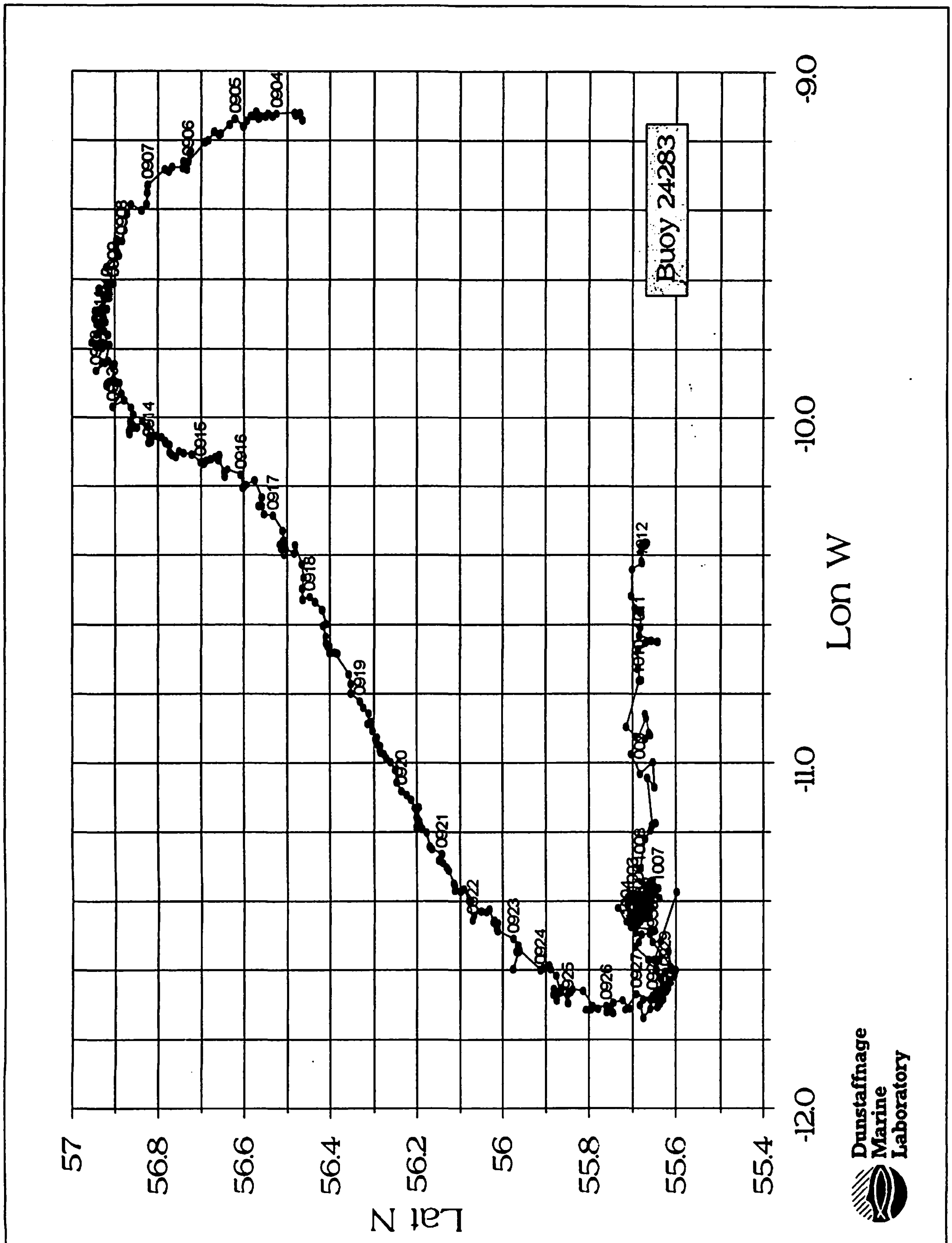

Dunstaffnage Marine Laboratory
Argos overpass duration - 57 N
Pass duration (min)
0
2
4
6
8
10
12
14
Time of day (UTC)
0
6
12
18
24
NOAA-11 (H)
NOAA-12 (D)
NOAA-14 (J)

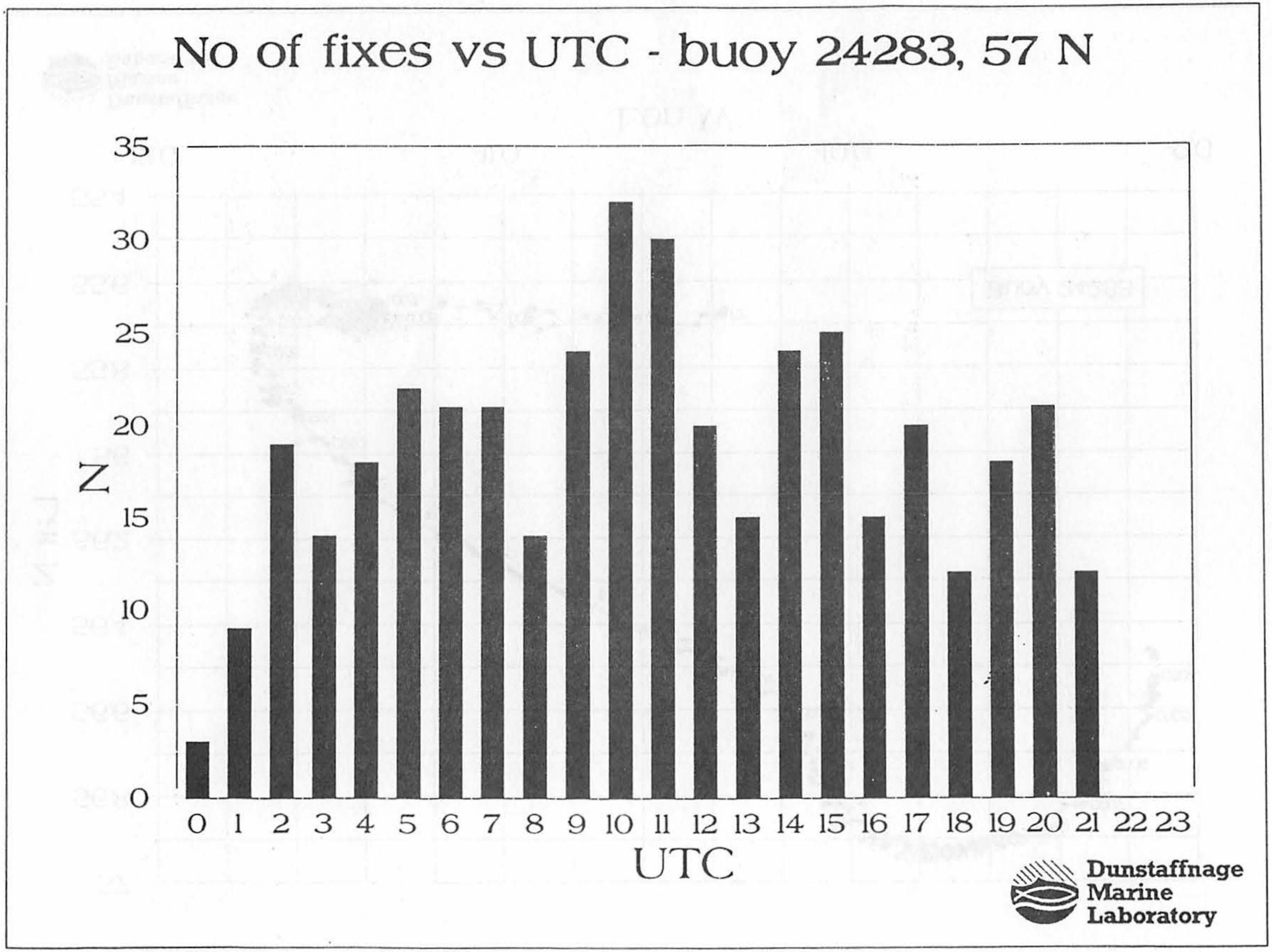
Gaps between Argos passes - 57 N

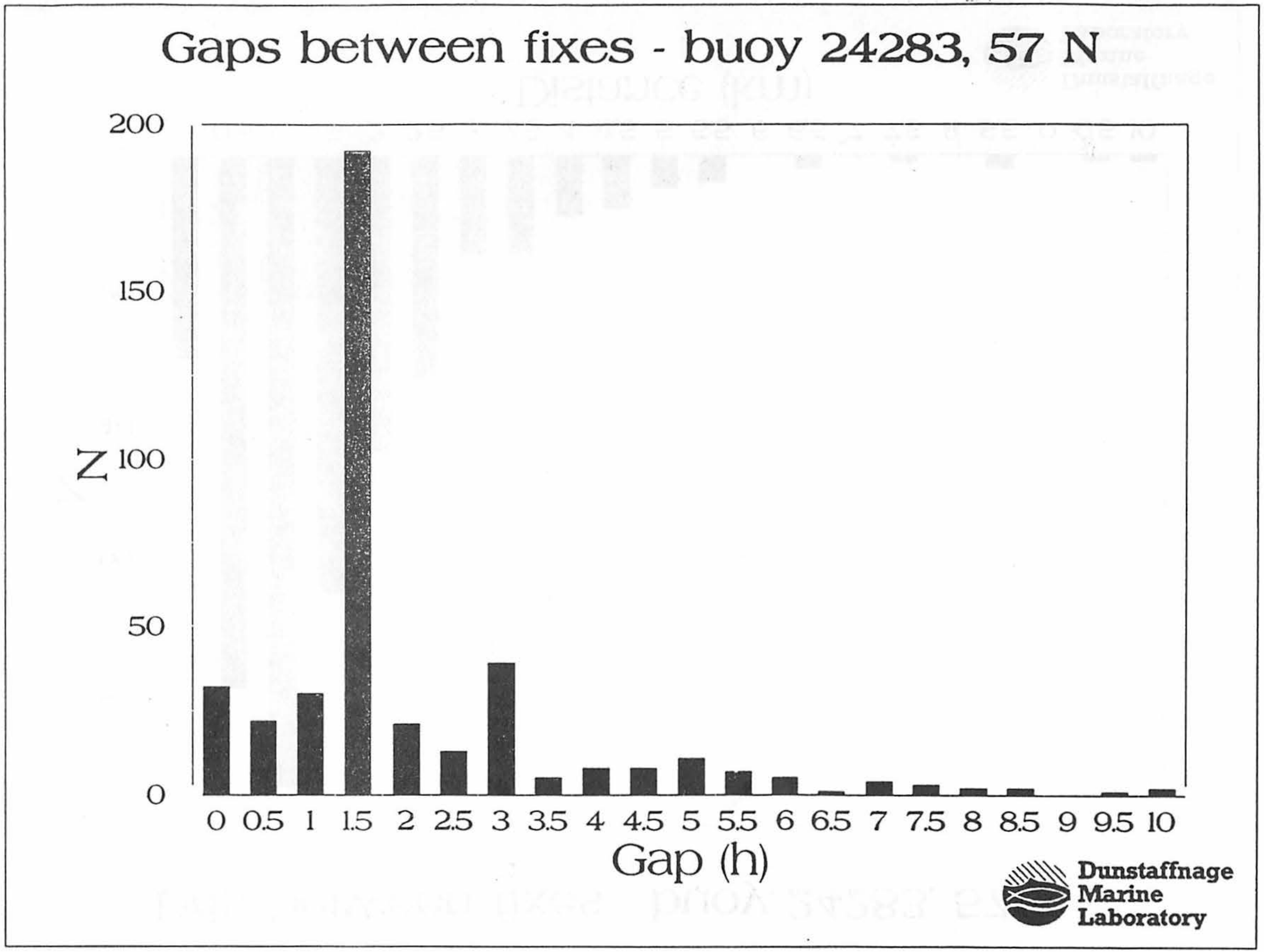
2 satellites: NOAA D, J 9/95

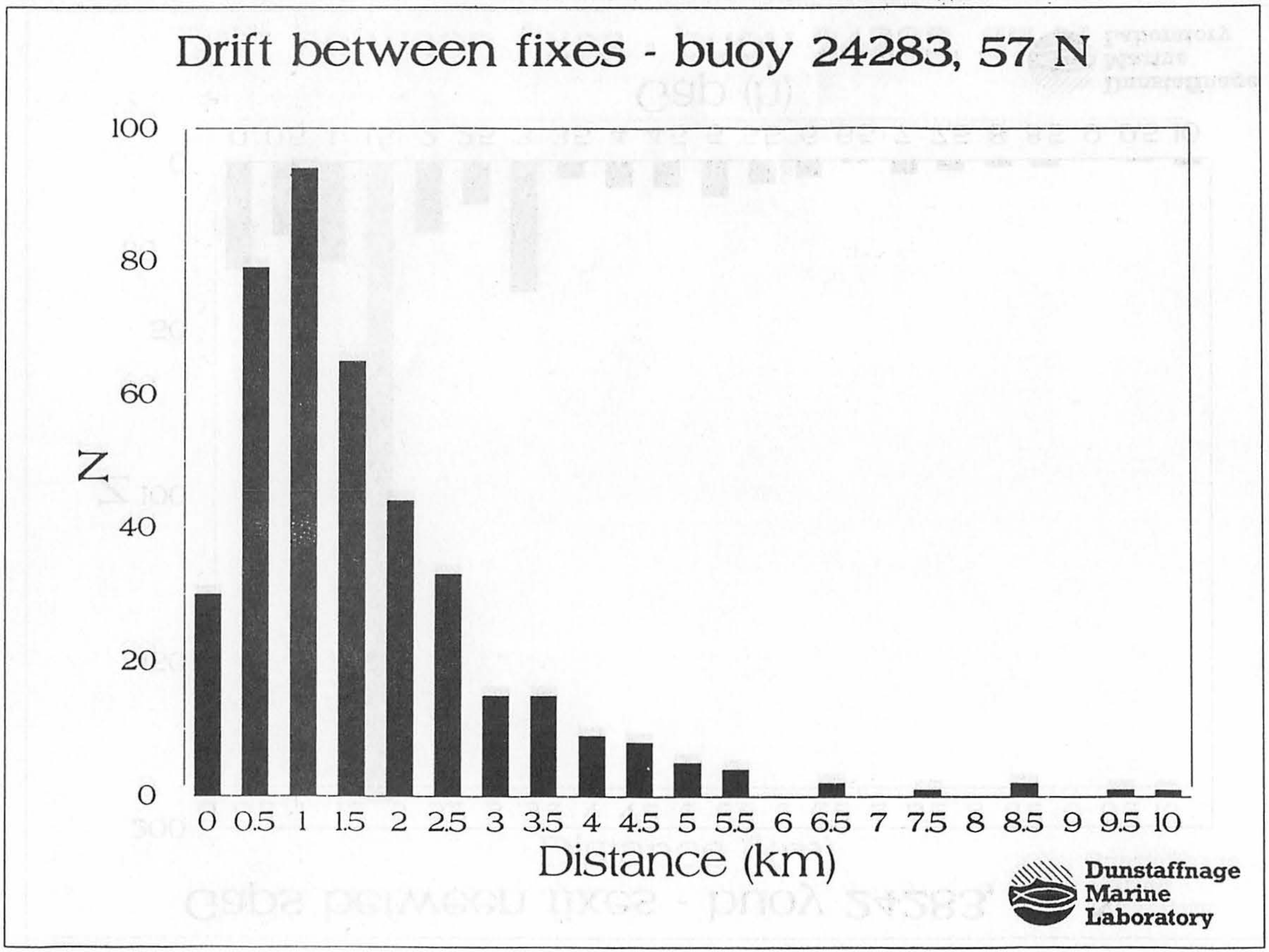


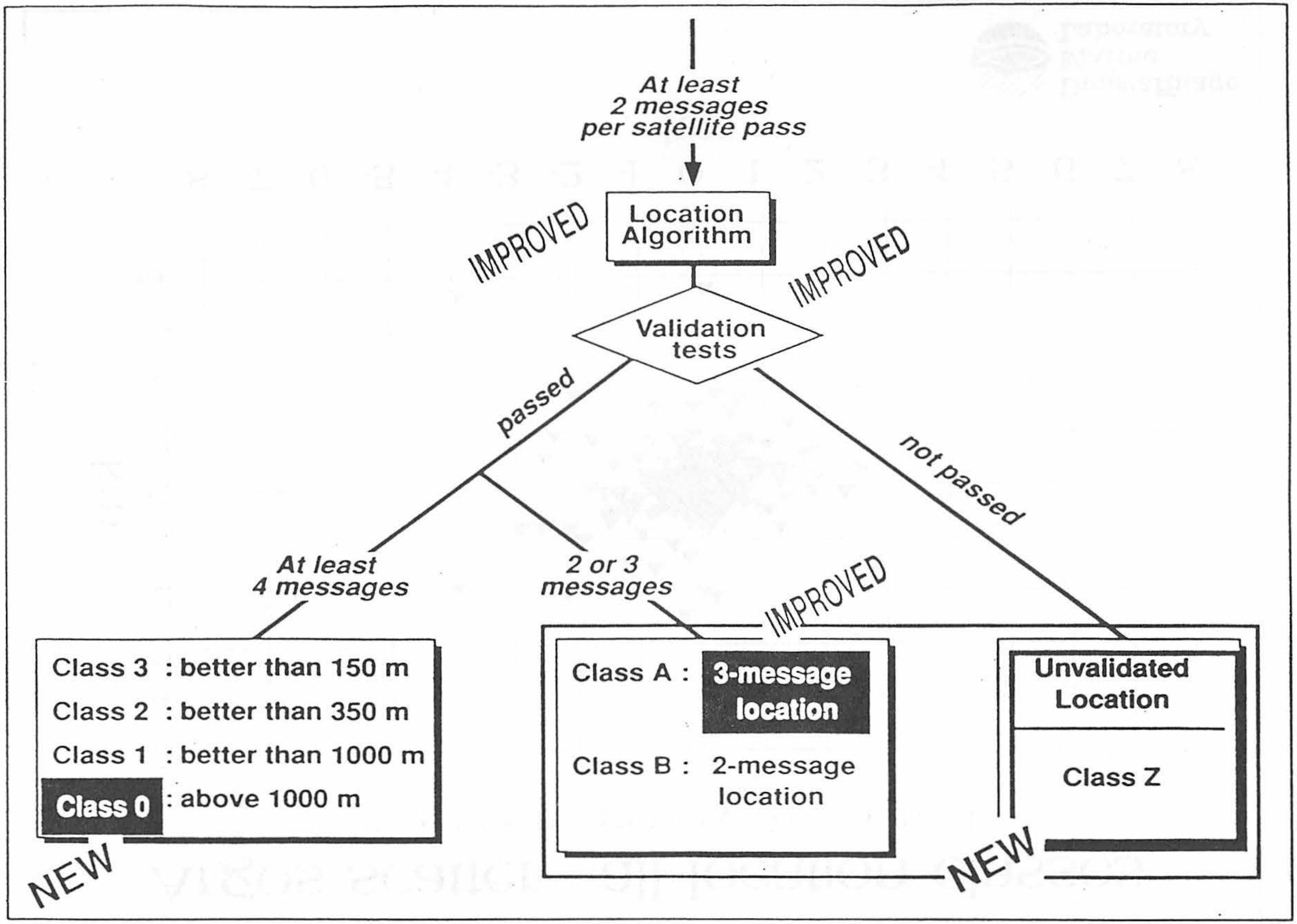
Dunstaffnage Marine Laboratory


Buoy 24283
Lat N
Lon W
57
56.8
56.6
56.4
56.2
56
55.8
55.6
55.4
-12.0
-11.0
-10.0
-9.0
0904
0905
0906
0907
0914
0915
0916
0917
0918
0919
0920
0921
0922
0923
0924
0926
0927
1007
1012
Dunstaffnage Marine Laboratory


No of fixes vs UTC - buoy 24283, 57 N
N
0
5
10
15
20
25
30
35
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
UTC
Dunstaffnage
Marine
Laboratory

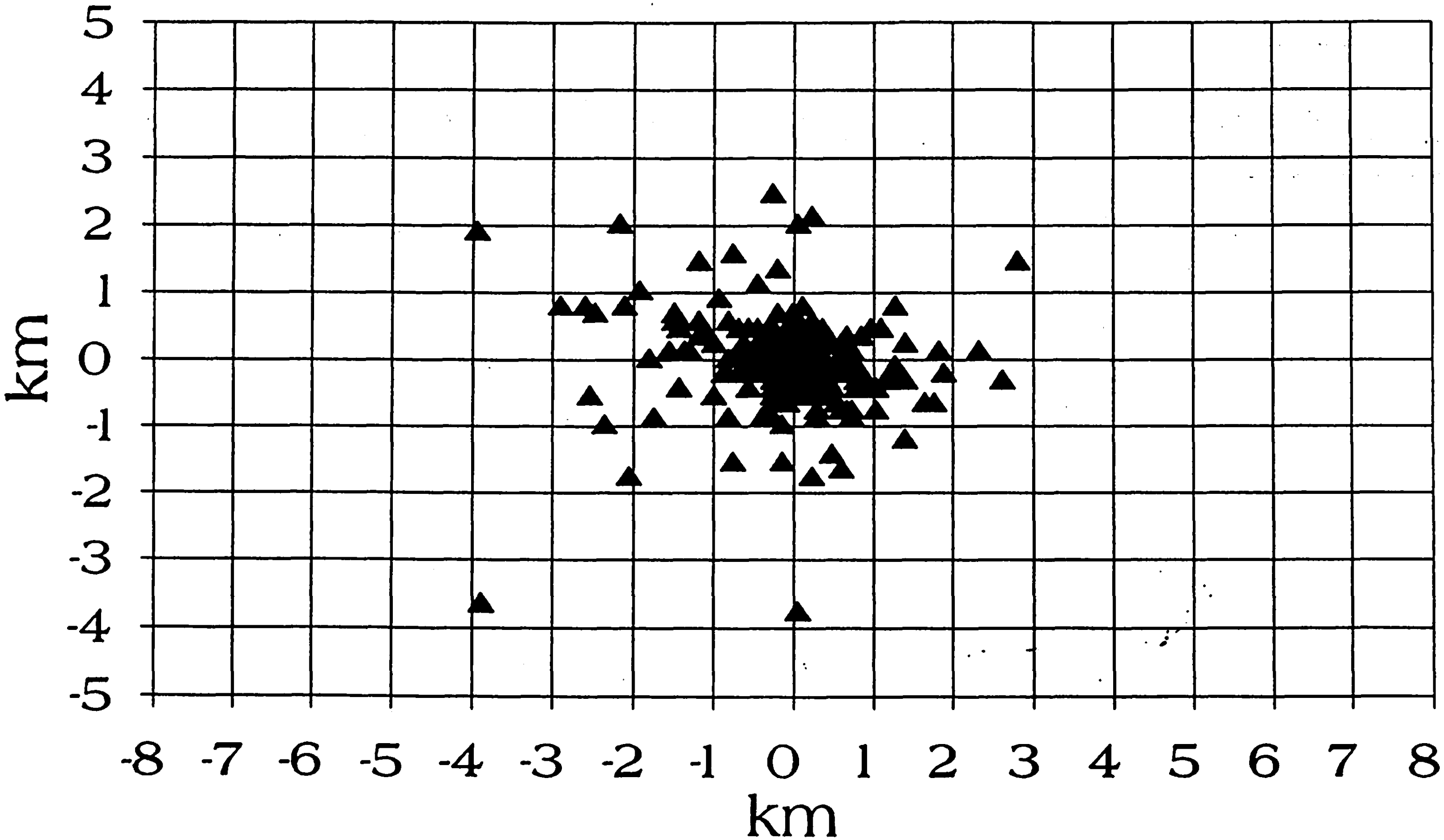

Gaps between fixes - buoy 24283, 57 N
200
150
N 100
50
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10
Gap (h)
Dunstaffnage Marine Laboratory


Drift between fixes - buoy 24283, 57 N
N
100
80
60
40
20
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8 8.5 9 9.5 10
Distance (km)
Dunstaffnage
Marine
Laboratory


At least
2 messages
per satellite pass
Location
Algorithm
IMPROVED
IMPROVED
Validation
tests
passed
not passed
At least
4 messages
2 or 3
messages
IMPROVED
Class 3 : better than 150 m
Class 2 : better than 350 m
Class 1 : better than 1000 m
Class 0 : above 1000 m
NEW
Class A : 3-message location
Class B : 2-message location
Unvalidated
Location
Class Z
NEW

Argos scatter - all location classes

sigma-x: 888 m   sigma-y: 545 m   n: 412



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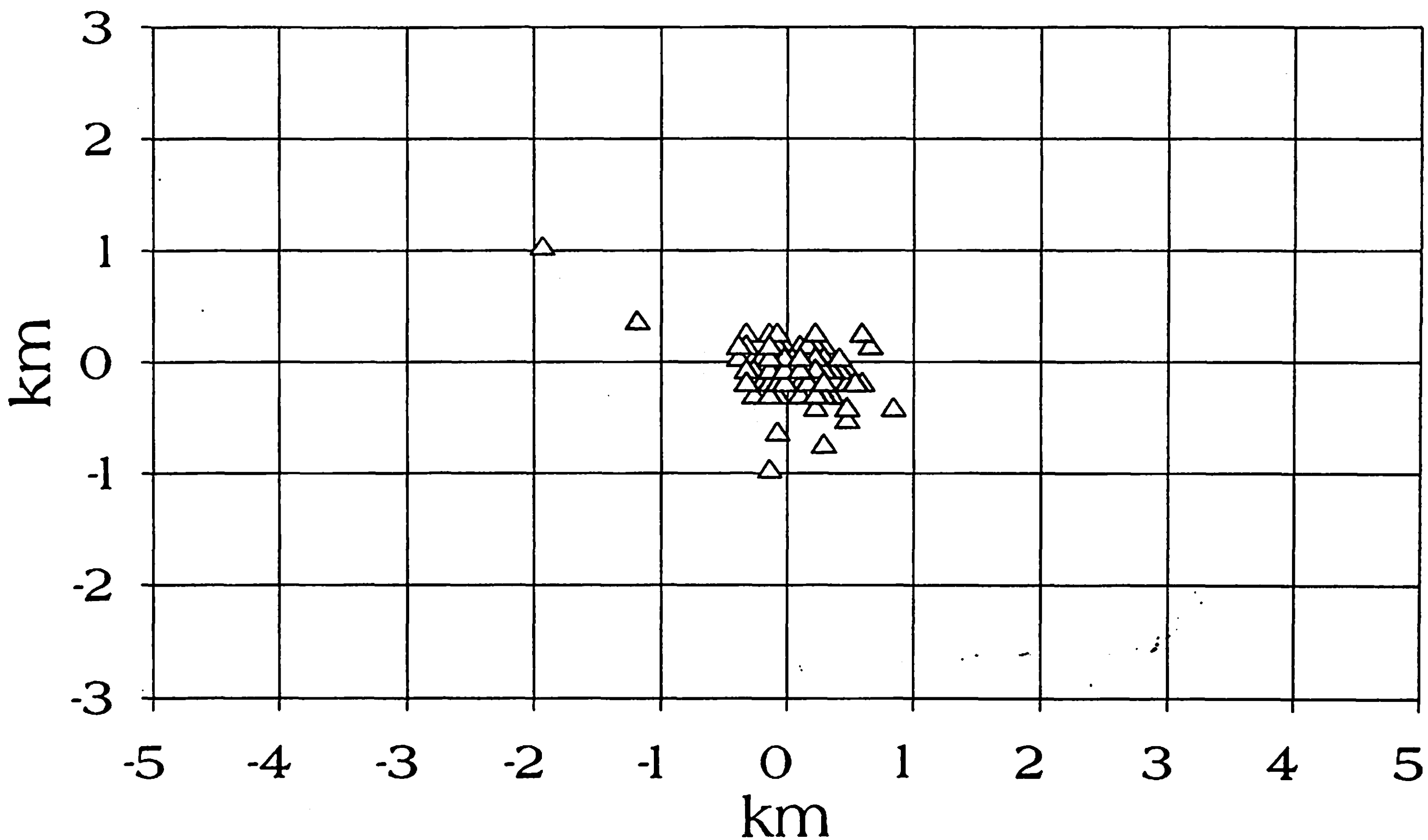
Argos scatter - location quality 3

sigma-x: 311 m sigma-y: 388 m n: 132



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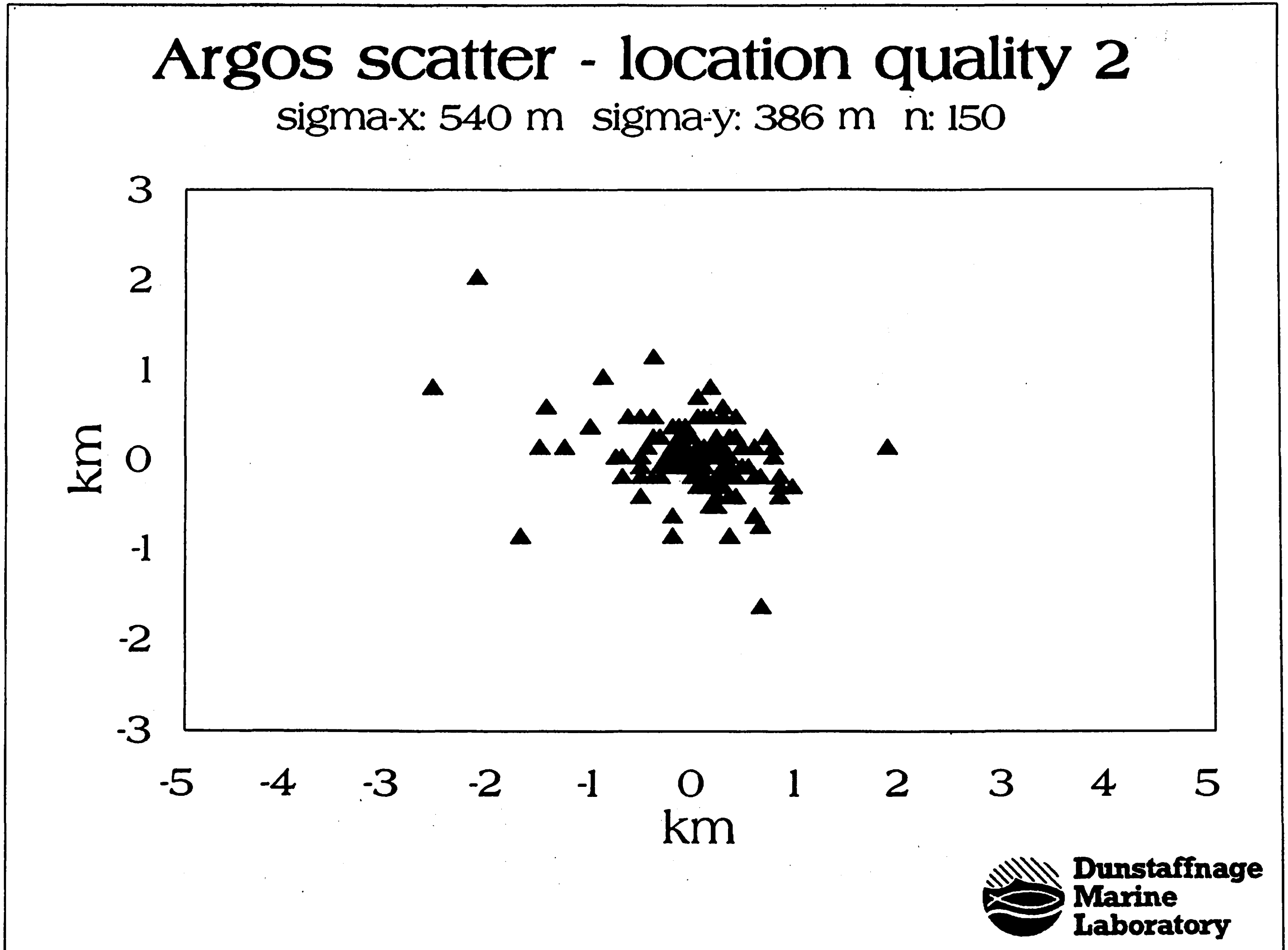
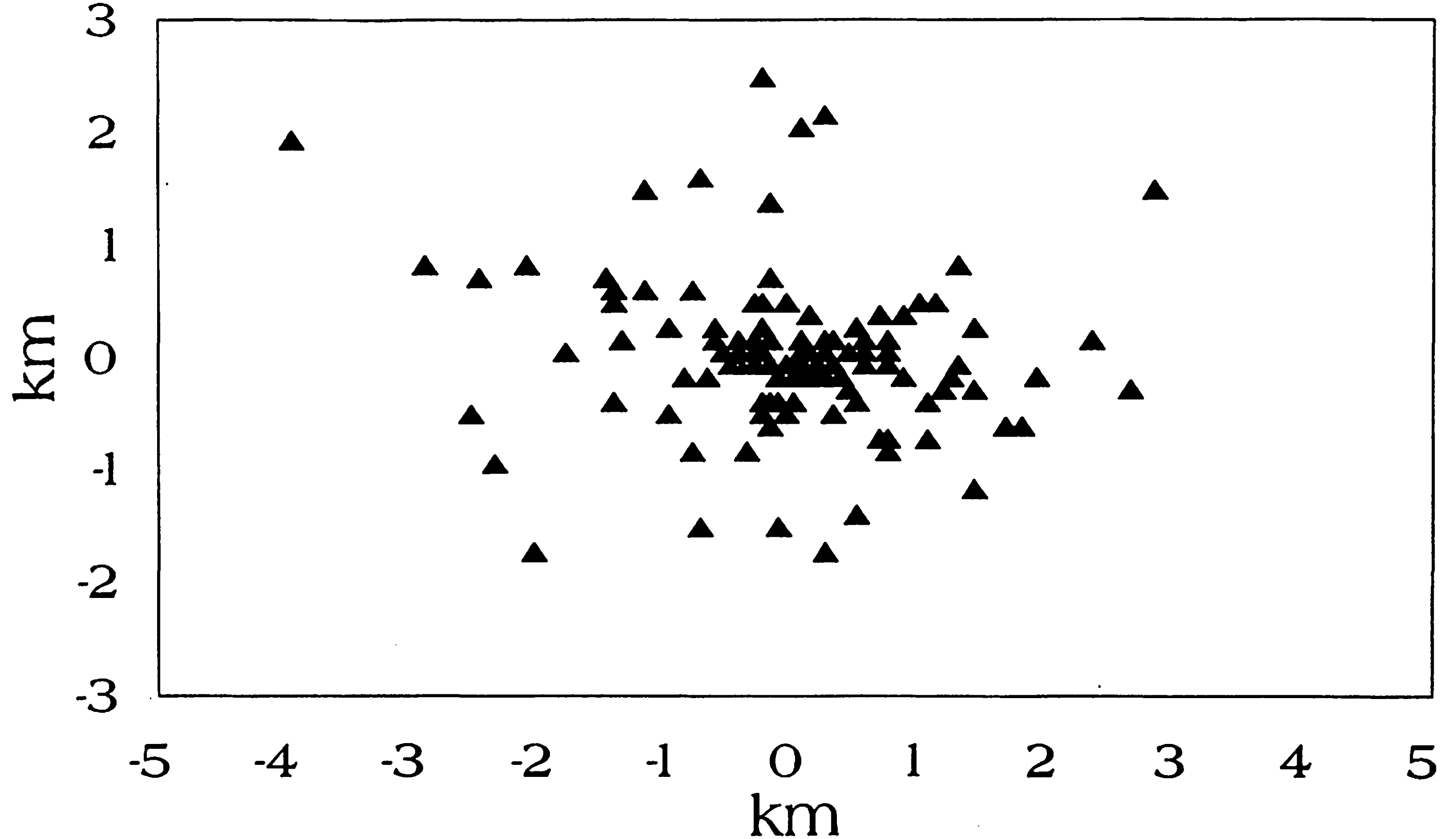
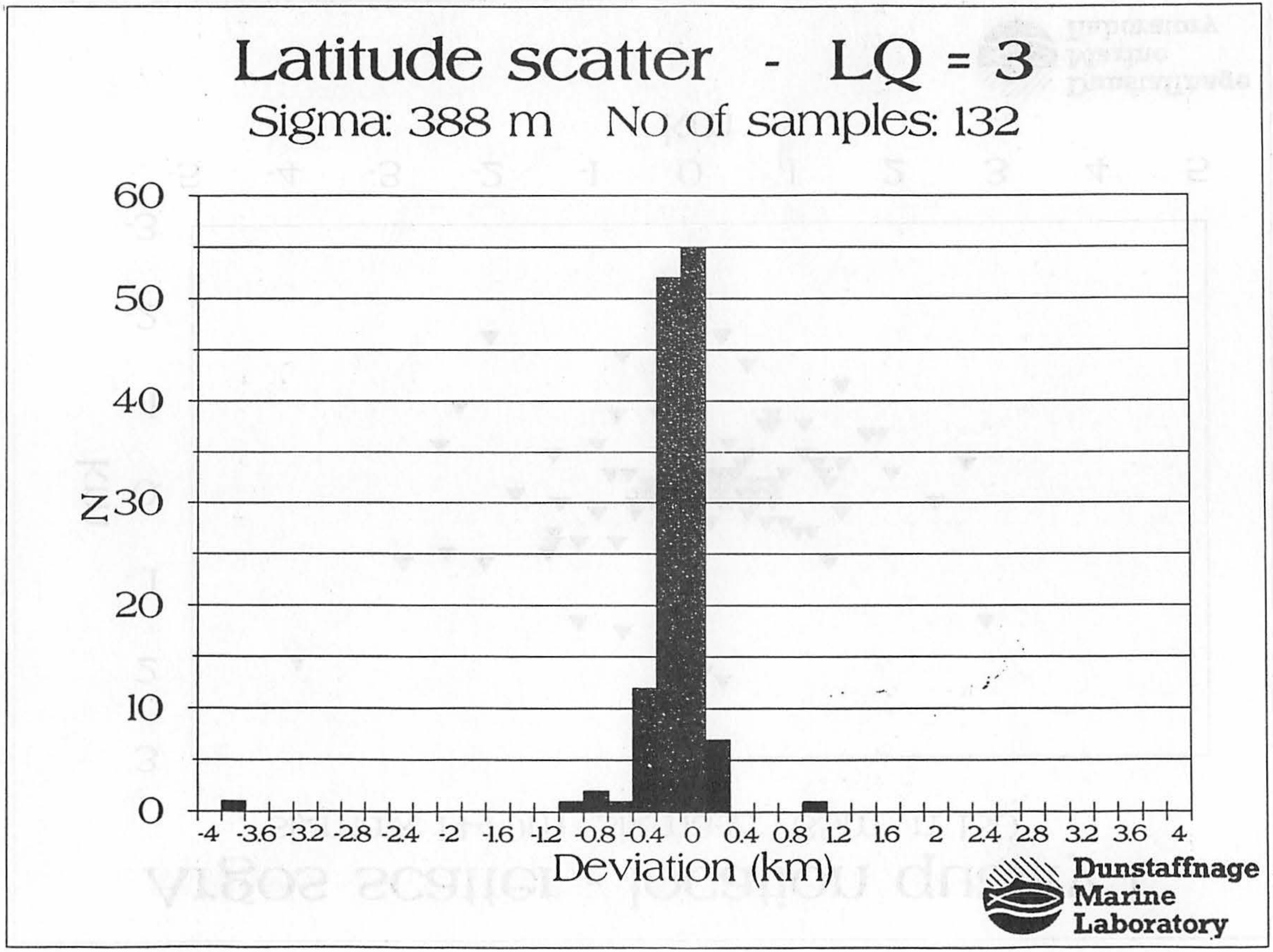

Argos scatter - location quality 2
sigma-x: 540 m sigma-y: 386 m n: 150
3
2
1
0
-1
-2
-3
km
-5
-4
-3
-2
-1
0
1
2
3
4
5
km
Dunstaffnage
Marine
Laboratory

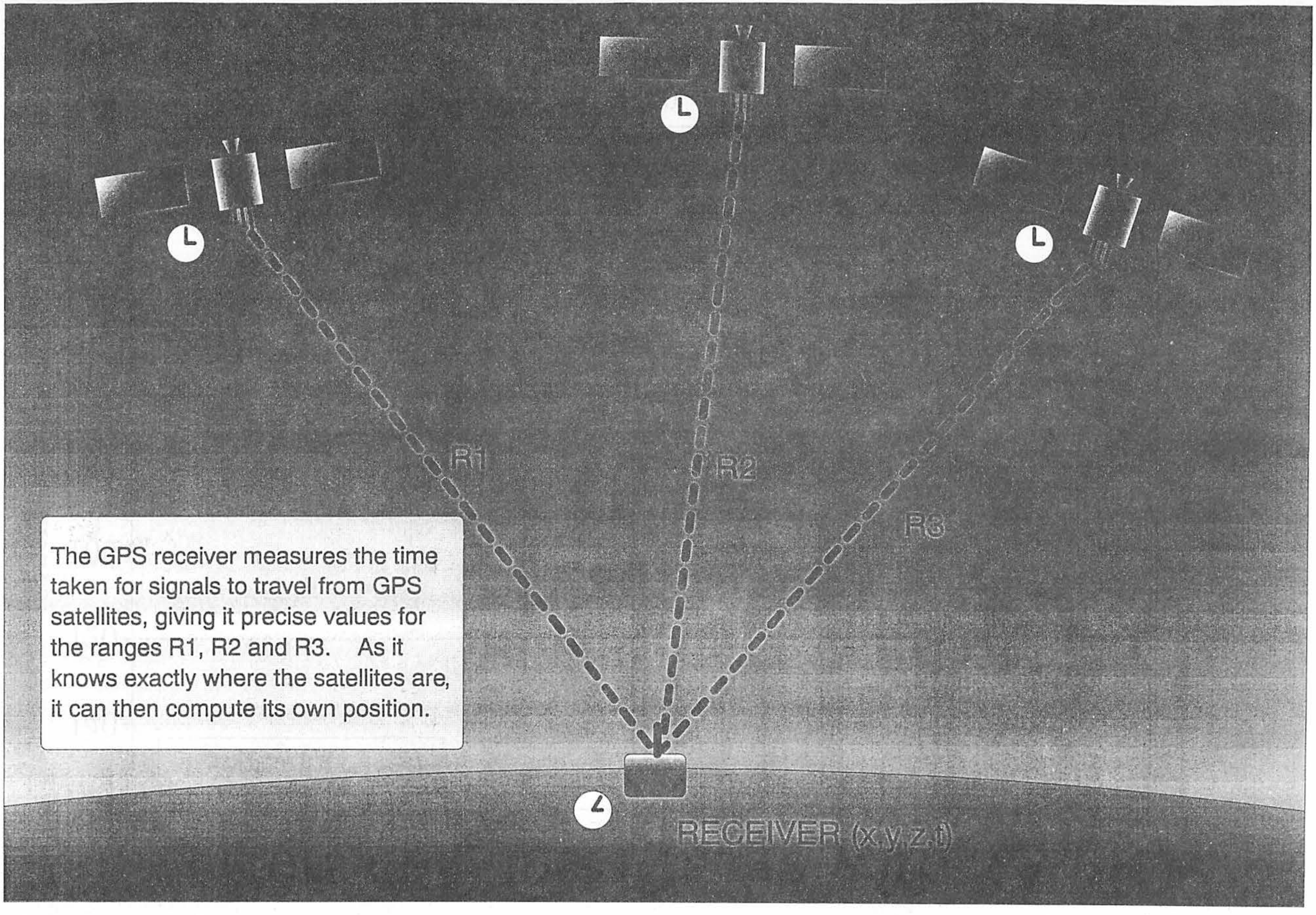
Argos scatter - location quality 1

sigma-x: 1440m sigma-y: 785m n: 130



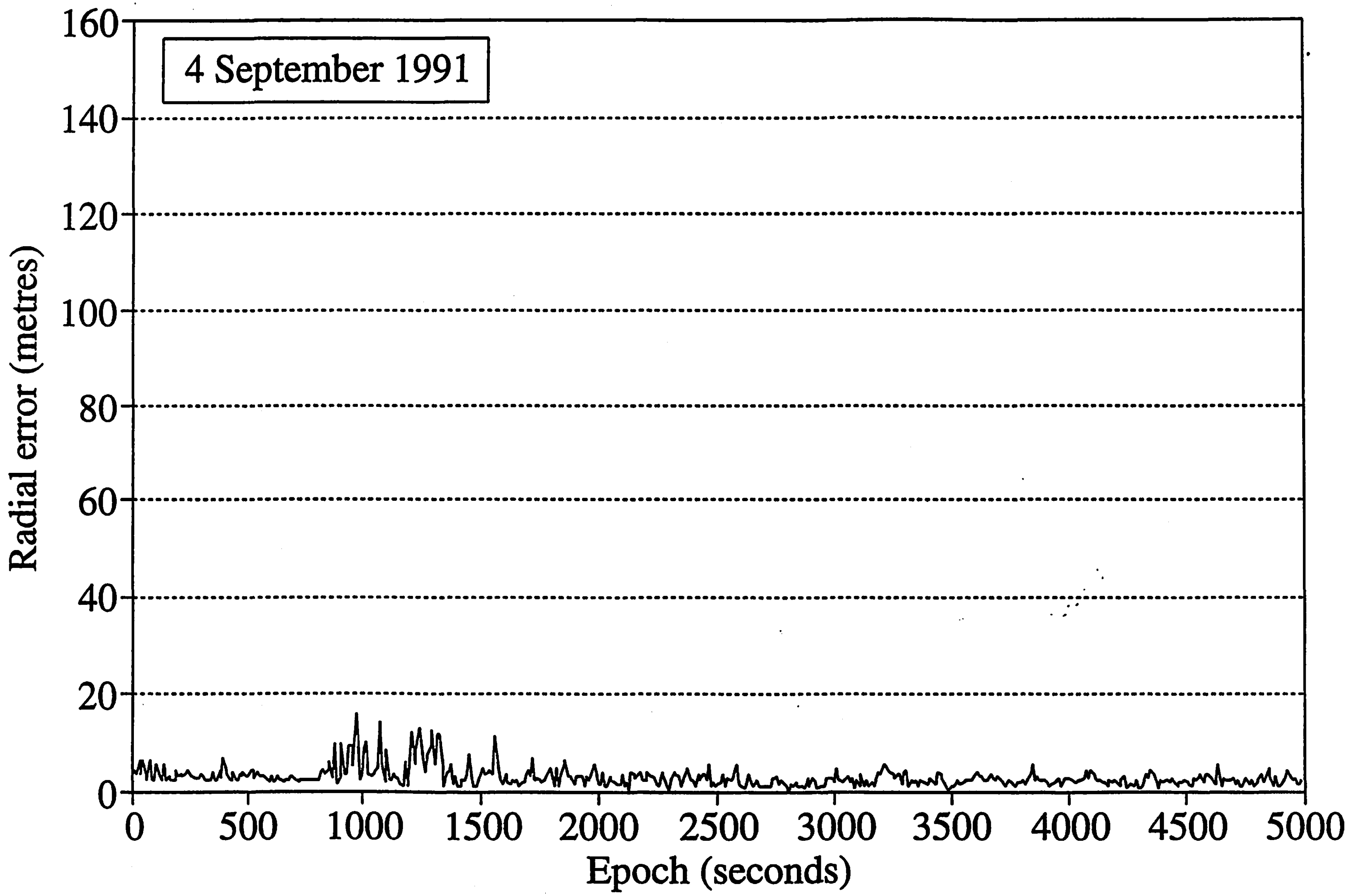
Dunstaffnage Marine Laboratory


Latitude scatter - LQ = 3
Sigma: 388 m No of samples: 132
60
50
40
N 30
20
10
0
-4 -3.6 -3.2 -2.8 -2.4 -2 -1.6 -1.2 -0.8 -0.4 0 0.4 0.8 1.2 1.6 2 2.4 2.8 3.2 3.6 4
Deviation (km)
Dunstaffnage Marine Laboratory

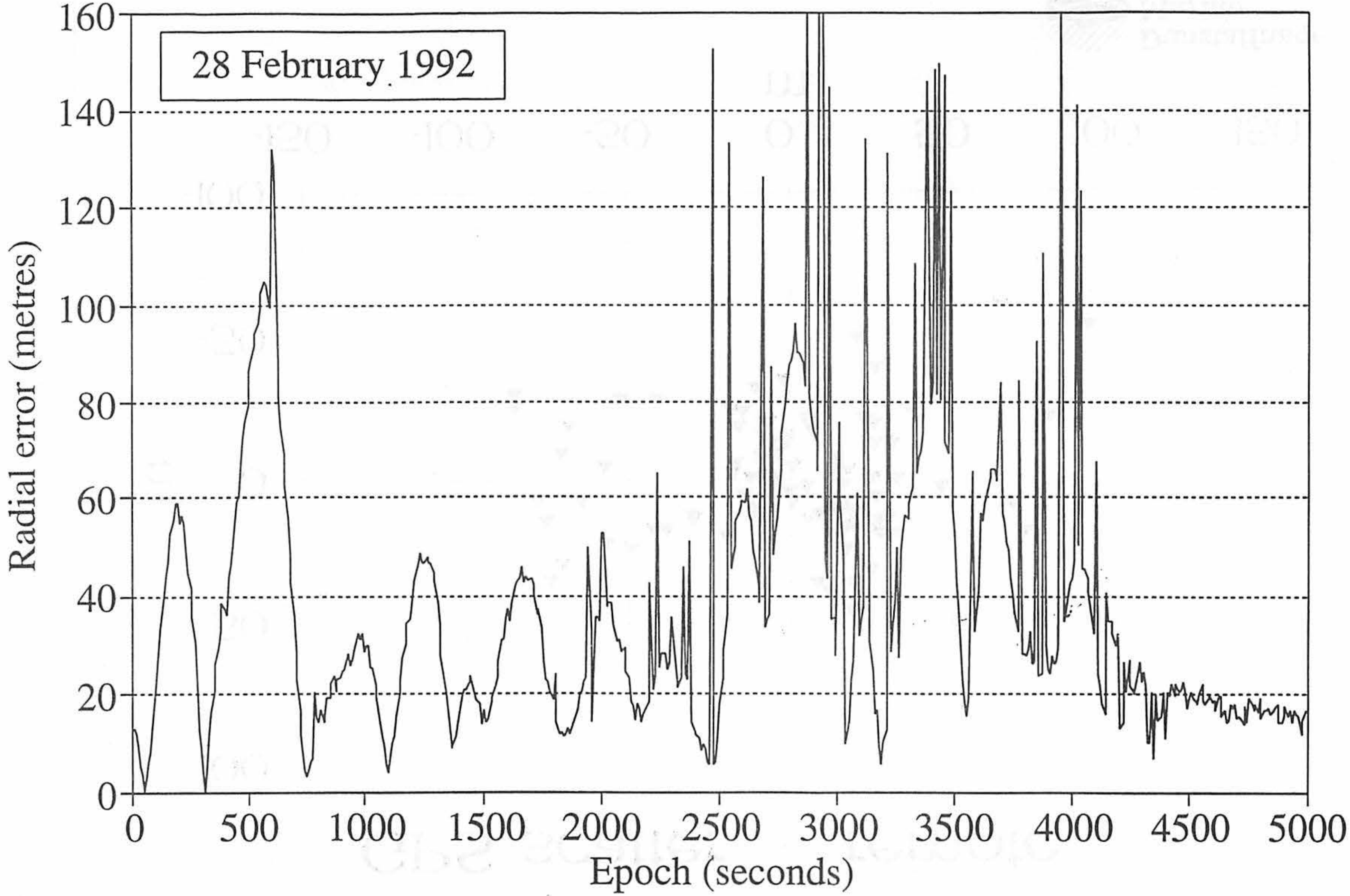


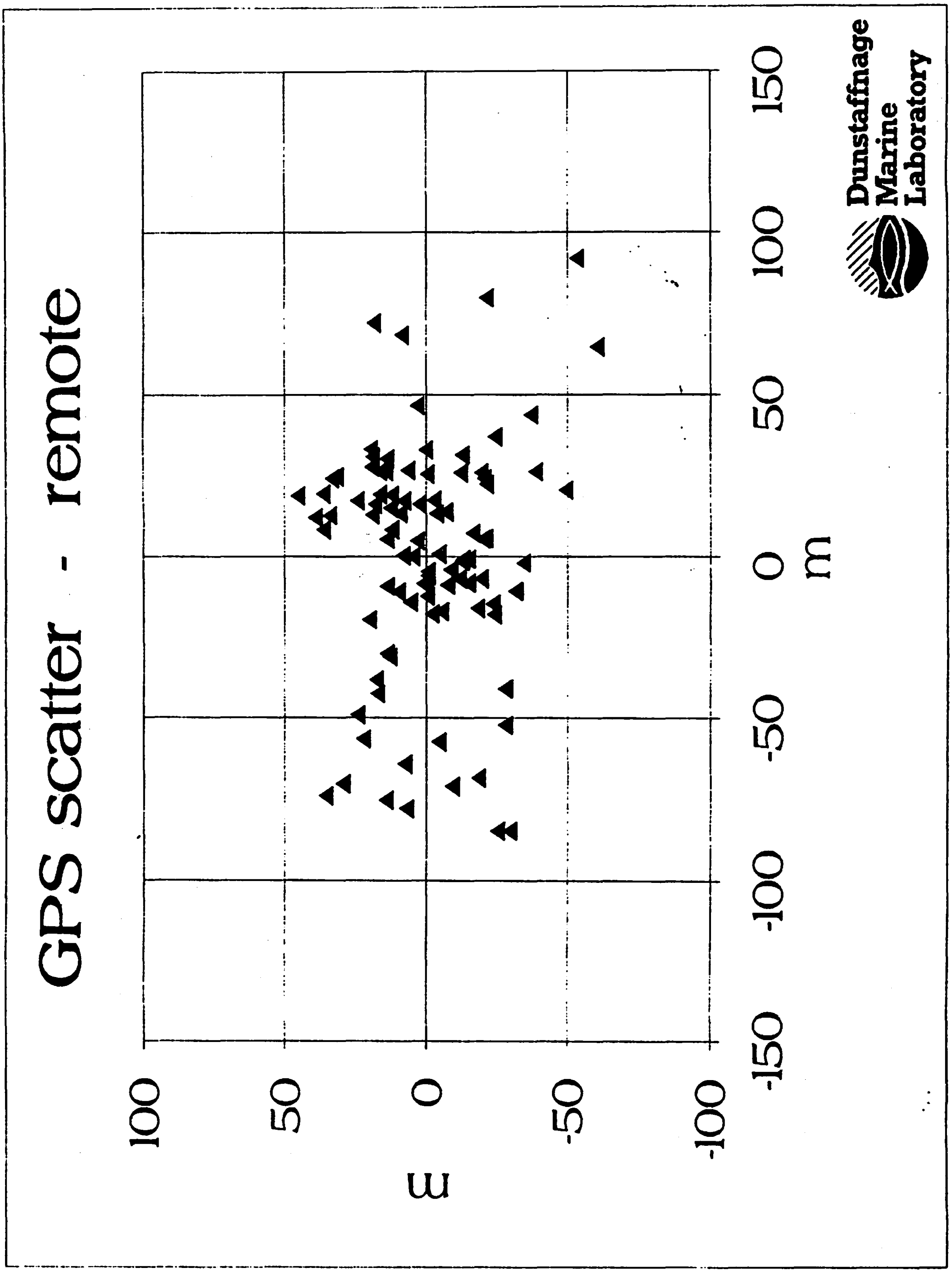
The GPS receiver measures the time taken for signals to travel from GPS satellites, giving it precise values for the ranges R1, R2 and R3. As it knows exactly where the satellites are, it can then compute its own position.

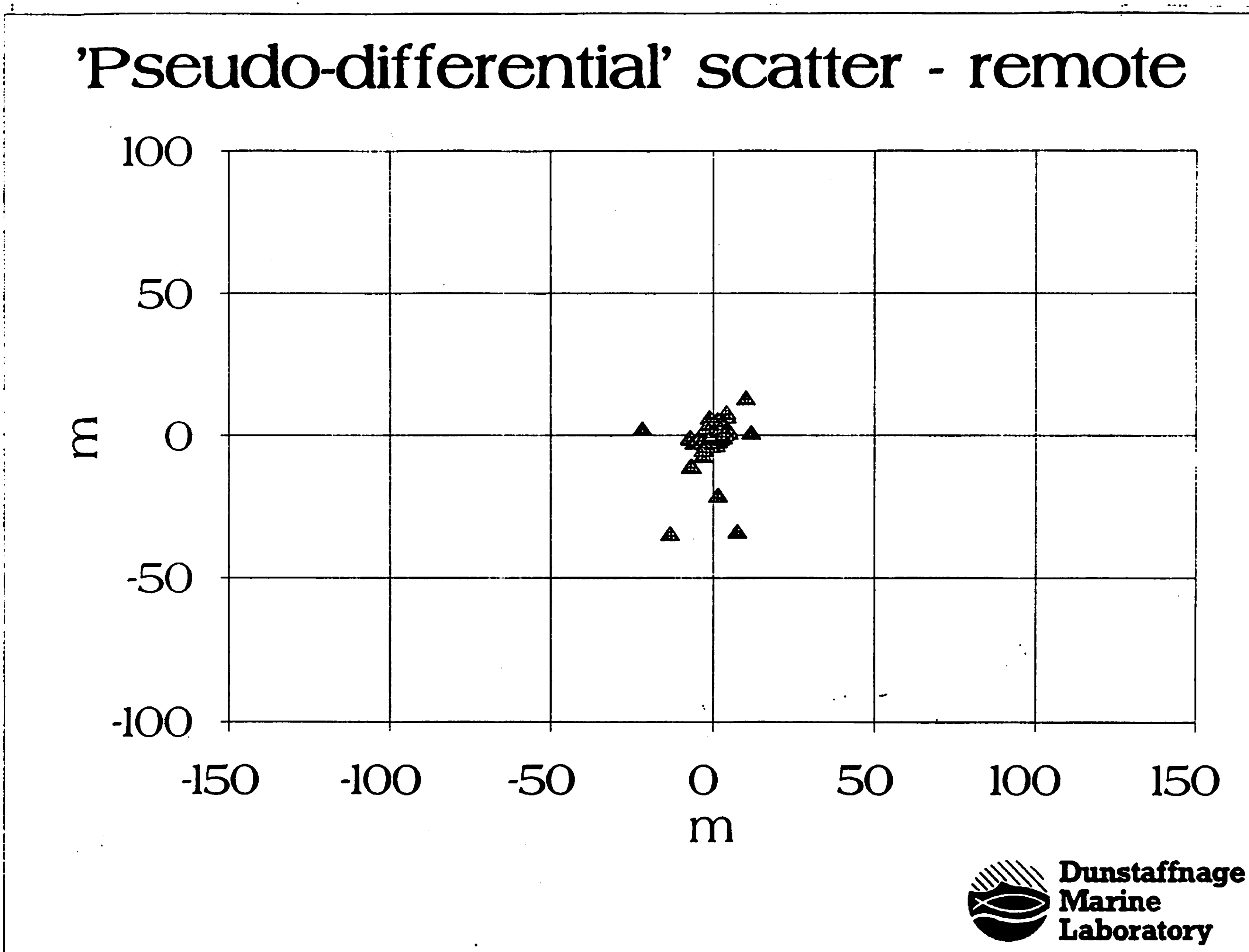
GPS errors at Dunstaffnage with SA off



GPS errors at Dunstaffnage with SA on




GPS scatter - remote
100
50
0
-50
-100
m
-150
-100
-50
0
50
100
150
m
Dunstaffnage
Marine
Laboratory


'Pseudo-differential' scatter - remote
100
50
0
-50
-100
m
-150
-100
-50
0
50
100
150
m
Dunstaffnage
Marine
Laboratory

Dunstaffnage Marine Laboratory

Measured standard deviations:

		x (m)	y(m)	n
Argos	LQ1	1450	800	130
	LQ2	550	400	150
	LQ3	300	400	132
GPS	Base	36	21	94
	Remote	36	22	94
Pseudo-DGPS		4	6	94

94

9) DEVELOPMENT OF A THERMISTOR CHAIN FOR USE WITH SEA ICE AND ANCHORED BUOYS

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Abstract

Sea ice buoys that are equipped with various environmental sensors and transmit their data via satellite telemetry are powerful tools for monitoring meteorological and oceanographic conditions in the polar seas. The Oceanographic Group at INPE has participated in Brazil's Antarctic research program (PROANTAR) through the design and use of a number of small (250kg) general purpose buoys. The buoy's hull has a biconic form and is fabricated in fiberglass. Data are transmitted at periodic intervals by an ARGOS compatible PTT and electronic interface boards located within the buoy. Batteries, placed in the lower part of the buoy to provide energy for the buoy, may or may not be recharged by solar panels. Meteorological sensors are affixed to the buoy by means of a compact tower, also made of fiberglass. Because of increasing international interest in making environmental observations in sea ice regions, the INPE instrumentation group decided to develop a thermistor chain for use with our biconic and larger anchored buoys. For reasons of economy and relative simplicity, it was decided to start with a thermistor chain 100m in length, that contained 8 thermistors and a hydrostatic pressure sensor. Large, stainless steel veterinary needles were found to be ideal for encapsulating the delicate thermistors. After their being encapsulated, the thermistors are embedded at predetermined positions along the length of the 20-lead cable. To provide further protection in the hostile sea ice environment, the thermistor needles are then encapsulated in synthetic rubber, using molds fabricated for this purpose. At the bottom end of the cable a hydrostatic pressure sensor is first electrically and then mechanically connected to the cable before being potted in the same synthetic rubber. Although the electrical cable is connected to its mating connecter at the base of the buoy, it was decided to mechanically reinforce this relatively sensitive location. A collar to physically surround the electrical connector was designed for this purpose and made of carbon fiber. With the intention of providing mechanical stress relief for the suspended electrical cable, a 6mm diameter flexible steel cable (101m in length) is attached to the base of the buoy by means of a rotating steel block. To provide the additional necessary ballast for buoy trim, a lead weight is attached to the bottom of the steel cable. The electrical cable is connected to the steel support cable using a number of molded rubber cylinders, placed on each side of a thermistor and at intervals along both cables. Ajustable steel hose clamps are then used to hold the corresponding rubber cylinders of each cable together. Other technical details about the thermistor chain are also described.

Introduction

Due to a recognized need for instrumented buoys and drifters for use in experiments of interest to Brazil, the oceanographic group at INPE, has, over the past 10 years, developed and deployed various types of buoys. The first type of buoy to be designed and constructed has a bi-conic shape, is fabricated in fiberglass and has an effective displacement of about 250 kg. This buoy can handle up to 16 data channels (8 channels per data transmission), can accomodate one of three types of sensor towers developed for the buoy and can be used in either the anchored (≤1000m depth) or drifting mode.

The second type of buoy is the TOGA/WOCE standard, low cost drifter (LCD). The Brazilian version of the LCD closely follows the SIO construction manual in design and materials (Sybrandy and Niiler, 1991). To date 17 of these LCDs have been built. As part of Project COROAS, the Brazilian contribution to SVP-WOCE, 15 LCDs were deployed off SE Brazil during 1993 and 1994. The 16th LCD was launched in the Polar Front of the Antarctic Circumpolar Current in November 1993, and is still transmitting to this date. Data about the longevity of our LCDs are based on the limited number of LCDs thus far launched, but suggest that life expectancy for Brazilian LCDs is about the same as for users of this type of drifter in other countries.

The third type of buoy was developed with the financial assistance of the University of Paraiba Valley (UniVap). The objective in developing this buoy is different from the other buoys. For Project SIMA (Integrated System for Environmental Monitoring), we use a system's approach. SIMA consists of: a) a data acquisition and transmission subsystem; b) a data reception subsystem; and c) a data processing and modelling subsystem.

The data acquisition and transmission subsystem consists of one or more toroidal buoys, each one being 2.3m in diameter and with a tubular aluminum tower to support sensors, solar panels and UHF antenna. The payload, consisting of an ARGOS compatible PCD connected to sensor interface boards and a CPU processor, memory and batteries is located in the toroid's well. In practice 20, 8-bit channels are available to transmit environmental data and times of data acquisition. Data acquisition is programmable, but presently set at one hour intervals. Data are stored in memory in hourly time bins before being transmitted at 95 second intervals. Combined buoy and tower mass is about 750kg; the buoy's physical displacement provides about one ton of positive buoyancy, in addition to compensating for the load produced by anchoring the buoy in several kms depth of water.

Data are received in real-time by the use of a compact VHF satellite receiver station, often referred to as a LUT (Local User Terminal). Data reception is facilitated with the use of software written for this purpose. Software presently available is limited to the reception of data transmitted by PCDs. Regional coverage for our LUT is about the same as for other LUTs, that is, data reception is limited to a radius of about 2,500 km from the receiver station.

The data processing and modelling subsystem consists of two types of specially written software: for the quality control of data (data voids and spurious values) and the determination of certain data statistics, and a barotropic circulation model (used where applicable) based on finite elements, that may be adapted to a particular field situation. Wind measurements from the buoy are used to force the circulation model. Data processing and interpretation are facilitated by the use of user friendly, pull-down window software developed for this purpose. The remainder of this report will discuss the modification of the previously developed bi-conic buoy for deployment in sea ice. Emphasis will be on the development of a thermistor chain which can be used with this buoy or the larger, anchored toroidal buoy.

Sea ice buoy

Anchored buoys that are equipped with various environmental sensors and transmit their data via satellite telemetry are powerful tools for monitoring meteorological and oceanographic conditions in the world's oceans. The large investment in funds and technological resources needed to develop and operate large programs such as the TOGA buoy array in the Pacific basin (Hayes *et al*, 1991) attests to the scientific importance of such field instrumentation. Robust buoys that provide reliable data for the polar regions are also needed in order to provide data for use in process and climate change studies. To date, however, most of the emphasis has been given to monitoring studies at the lower latitudes.

The Oceanographic Group at INPE has participated in Brazil's Antarctic research program (PROANTAR) through the design and use of a number of small (250kg) general purpose buoys (Figure 1). As previously noted, the buoy's hull has a biconic form and is fabricated in fiberglass. Data are transmitted at periodic intervals by an ARGOS compatible PTT and electronic interface boards located within the buoy. Batteries placed in the lower part of the buoy, which provide energy for the buoy, may or may not be recharged by solar panels. Meteorological sensors are affixed to the buoy by means of a compact tower, also made of fiberglass.

The use of thermistor chains, attached to drifting and anchored buoys, to obtain time series of vertical profiles of the thermal field in the upper several hundreds of meters of the ocean, has received relatively less emphasis due to the greater financial and technological investments necessary for their development. In their comprehensive review of air-sea interaction instrumentation, Dobson *et al* (1980) include almost no discussion of thermistor chains. It is because of this increasing international interest in making such environmental observations at sea including sea ice regions, that our instrumentation group decided to develop a thermistor chain for use with our biconic and larger anchored buoys.

Thermistor chain

The 500m long thermistor chain, developed and in operational use on the Atlas moorings in the TOGA-TAO array, has provided recent data of good quality and relatively high spatial resolution (Mangum *et al*, 1994; Freitag *et al*, 1994). Their Atlas buoy moorings equipped with these chains use thermistors whose variations in resistance are subsequently converted into a frequency range. Their method makes use of specially developed *in situ* electronics boards connected to the individual thermistors. Sensor calibration is included in the voltage/frequency conversion.

For reasons of economy and relative simplicity, the INPE group decided to start with a thermistor chain 100m in length, that contained 8 thermistors and a hydrostatic pressure sensor

(Figure 1). As can be noted in this figure, a flexible steel cable is mechanically connected to the thermistor chain (cable) to provide support for the electrical cable.

Because of the particularly hostile environment found in sea ice regions, it was necessary to physically protect the glass thermistors, while permitting the beads to be in contact with sea water. Large, stainless steel veterinary needles were found to be ideal for encapsulating the delicate thermistors (Figure 2). After their being encapsulated, the thermistors are embedded at predetermined positions along the length of the 20-lead cable. To provide further protection in the hostile sea ice environment, the thermistor needles are then encapsulated in synthetic rubber, using molds fabricated for this purpose (Figure 3). At the bottom end of the cable, a hydrostatic pressure sensor is first electrically and then mechanically connected to the cable before being potted in the same synthetic rubber mixture.

Temperature resolution of the thermistors is dependent on the desired thermal range and the digital conversion of the analogic signal. A thermal range of $-5C \leq T \leq 5C$ was considered adequate for the sea ice region. For the 8-bit A/D converters used in these buoys, the resulting digital resolution is about 0.04C.

The strain gauge hydrostratic pressure transducer used at the bottom of each cable was included so that depth corrections could be applied in case the cables deviated from the vertical position, due to current shear over the upper 100m of the water column. Using the 0-1 volt output signal over the 100m scale and the same 8-bitA/D converter used for the temperature data, the digital depth resolution is about 0.4m, adequate for the planned experiments. Because each data transmission is limited to 8 channels, data from 4 thermistors alternately spaced along the cable are first transmitted, followed 95 seconds later by the data from the remaining thermistors and pressure transducer.

Although the connector at the top of the electrical cable is connected to its mating connecter at the base of the buoy (Figure 4), it was decided to mechanically reinforce this relatively sensitive location. A collar that physically surrounds the electrical cable connector was designed and made of carbon fiber. The collar is fastened to the bottom of the buoy with steel bolts.

With the intention of providing mechanical stress relief for the suspended electrical cable, a 6mm diameter flexible steel cable (101m in length) is attached to the base of the buoy by means of a rotating steel block (Figure 4). The electrical cable is connected to the steel support cable using a number of molded rubber cylinders, located on each side of a thermistor and at intervals along both cables (Figure 5). Ajustable steel hose clamps are then used to hold the corresponding rubber cylinders of each cable together. To provide the additional necessary ballast for buoy trim, a lead weight is attached to the bottom of this steel cable. While the combined weight of the sensor and support cables in the air is more than 100kg, the mass of the prepared cables when placed in water is reduced to about 40kg.

Present plans call for three of these sea ice buoys to be used in a joint experiment in 1996, in either the southeastern part of the Weddell or Bellingshausen Seas. It is hoped that the buoys will provide useful environmental data for up to 12 months time.

Acknowledgments

Financial support for Project MEDICA has been kindly provided by PROANTAR (Antarctic Prog. Office) of the National Council for Scientific and Tecnological Research (CNPq) through contracts 480560-93.5 and 480740-94.0.

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Hayes, S.P., Mangum, L.J., Picaut, J., Sumi, A. and Takeuchi, K. 1991. TOGA-TAO: a moored array for real-time measurements in the tropical Pacific Ocean. **Bull. Am. Meteorol. Soc., vol.72:339-347.**

Mangum, L.J., Freitag, H.P. and McPhaden, M.J. 1994. TOGA-TAO Array sampling schemes and sensor evaluations. **Proc. of the Oceans '94 OSATES, Vol.2:402-406**, Brest, September 13-16, 1994.

Sybrandy, A.L. and Niiler, P.P. 1991. WOCE/TOGA Lagrangian Drifter Construction Manual. **SIO Ref. 91/6, WOCE Rep. No.63. 58 p.**

Figure captions

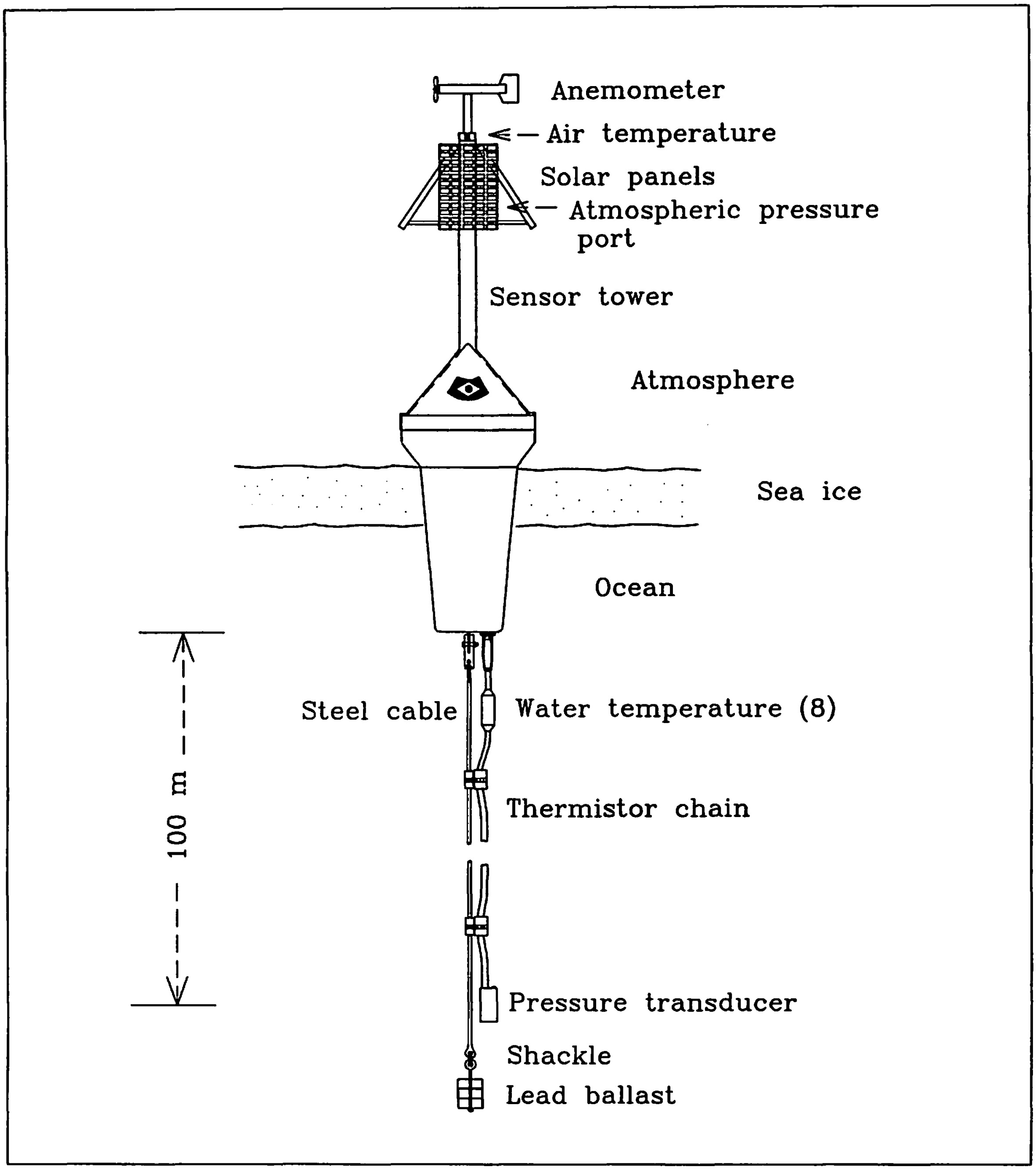
Figure 1. INPE's bi-conic buoy configured for sea ice experiment.

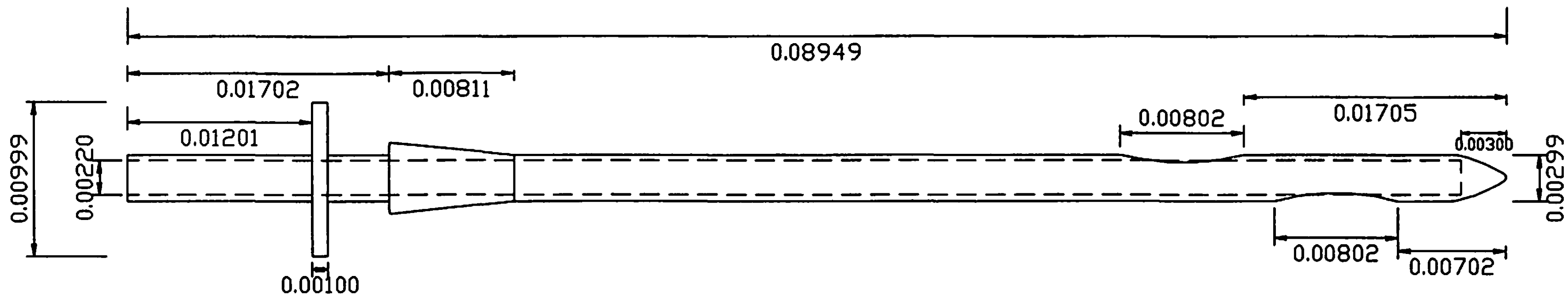
Figure 2. Large steel veterinary needle used to encapsulate individual thermistors. Thermistor is adjusted inside needle so that the bead is visible in outer opening of needle.

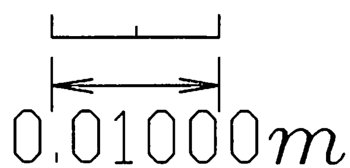
Figure 3. Encapsulation of thermister needle after electrical connections have been made within cable. Note that a small steel hose clamp is used on each side of the cuts in the jacket to assure proper closure and sealing of outer jacket on cable.

Figure 4. Electrical and mechanical connections are located at base of buoy hull. Alignment of steel attachment pad assures that rotating block cannot come closer to carbon casing that protects electrical cable connector.

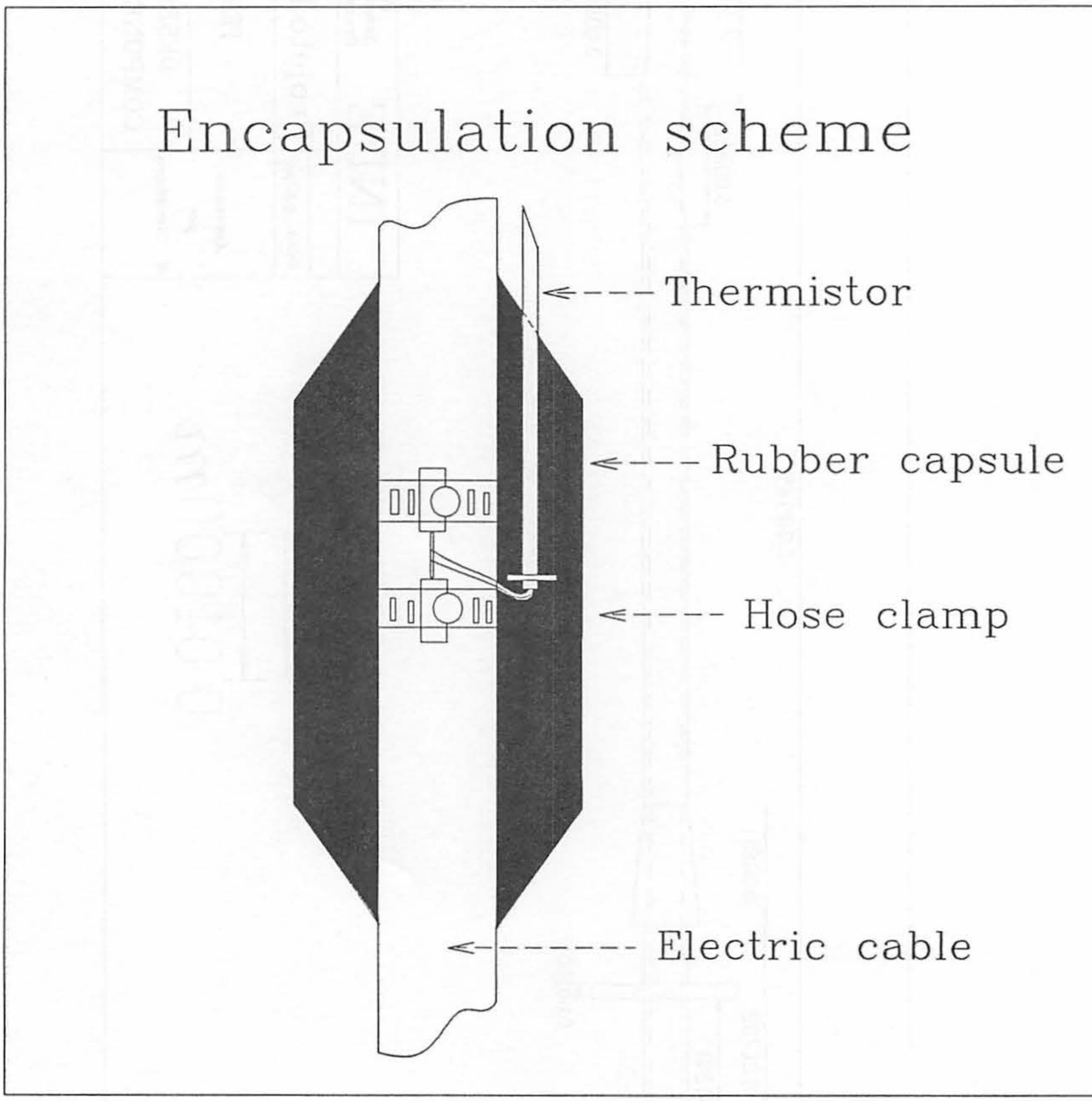
Figure 5. Rubber cylinders are molded on either side of thermistors and at predetermined positions along both cables. Small hose clamps and cable clamps are used to hold rubber cylinders in their respective positions.

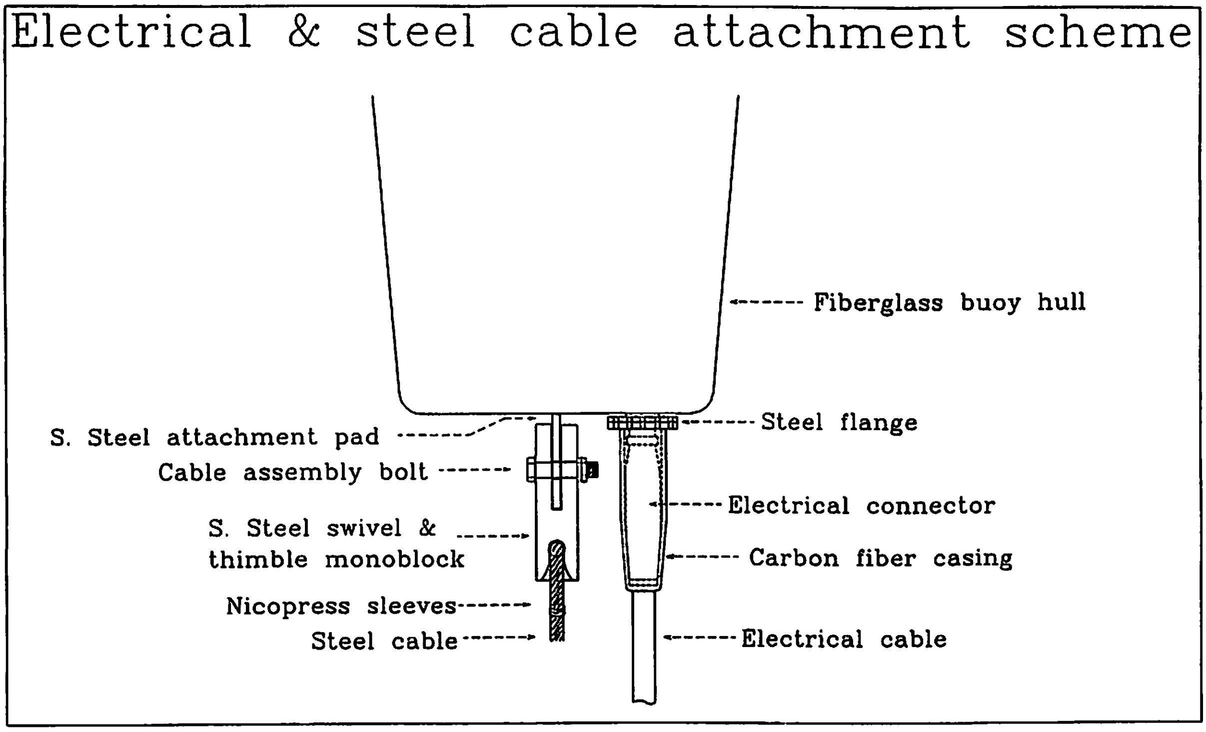

Anemometer
Air temperature
Solar panels
Atmospheric pressure port
Sensor tower
Atmosphere
Sea ice
Ocean
Steel cable
Water temperature (8)
100 m
Thermistor chain
Pressure transducer
Shackle
Lead ballast



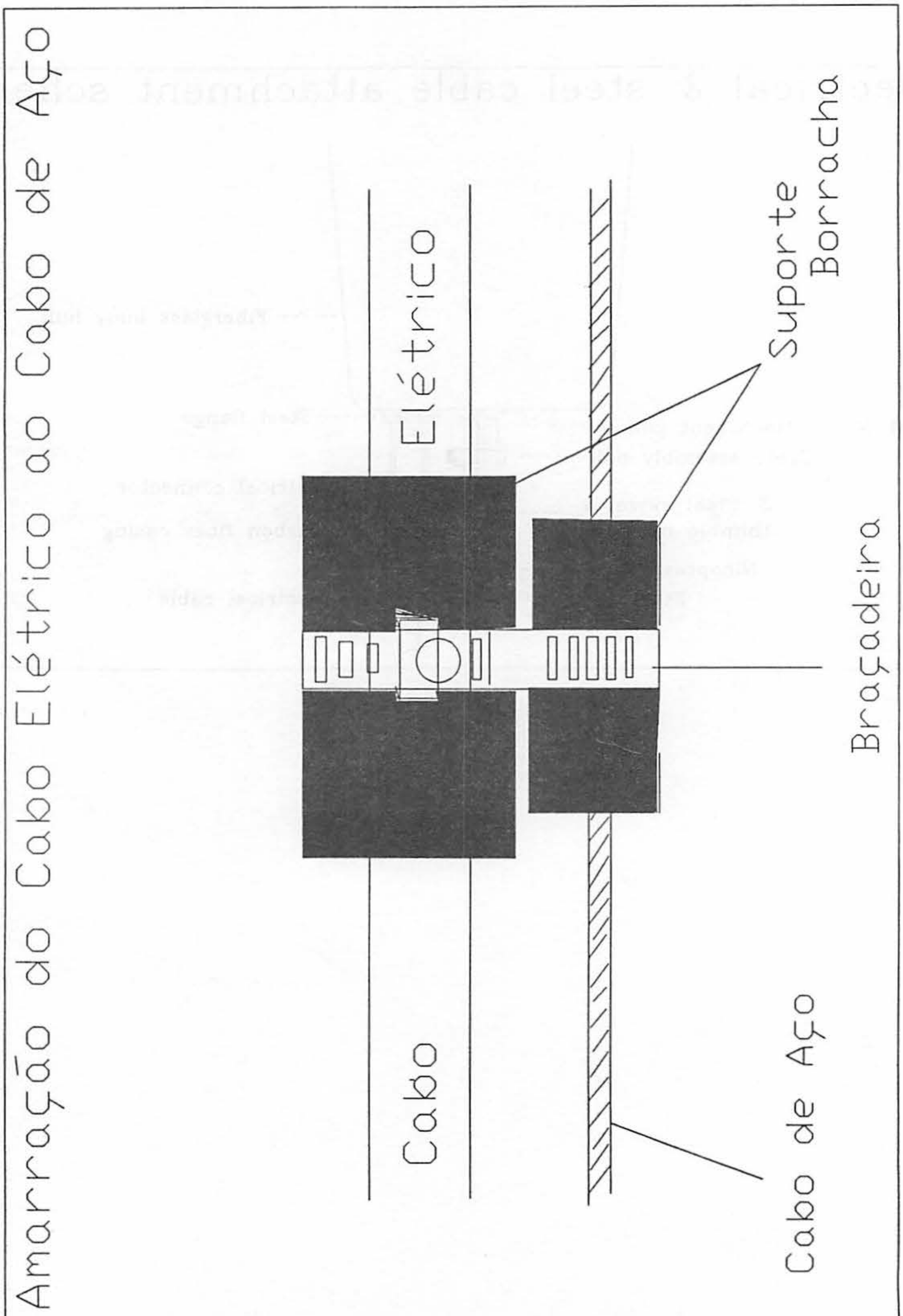


INPE	*Departamento de Sensoriamento Remoto e Oceanografia por Satélite*	
Data: 02/95	Projeto:MEDICA	*Desenhado por*
Aprovado por M. Stevenson	TERMISTOR	
	DESENHO: COMPONENTES-2	*Desenho # MED-105*


Encapsulation scheme
Thermistor
Rubber capsule
Hose clamp
Electric cable



Electrical & steel cable attachment scheme
Fiberglass buoy hull
S. Steel attachment pad
Steel flange
Cable assembly bolt
Electrical connector
S. Steel swivel &
thimble monoblock
Carbon fiber casing
Nicopress sleeves
Steel cable
Electrical cable


Amarração do Cabo Elétrico ao Cabo de Aço
Cabo Elétrico
Suporte Borracha
Braçadeira
Cabo de Aço

10) USE OF THE SVP-B DRIFTER - THE SAWB EXPERIENCE

By: Eugene Burger
South African Weather Bureau
Pretoria
South Africa

Background

Due to the wide expanse of ocean the South African Weather Bureau (SAWB) has to produce shipping forecasts for, the SAWB has been deploying drifters in the South Atlantic ocean for the past 10 to 15 years. It was decided to start deploying the new SVP-B drifter, and the SAWB placed its first order for these drifters with Metocean Data systems in March 1994.

Obviously the physical design of the drifter was as determined by the DBCP technical committee. There were however two changes that were made to the SAWB drifters:

1. Duty cycle
2. Data format

1. Duty cycle

The SAWB relies rather heavily on drifter data from the South Atlantic, probably more than other weather services. It is thus important to get as much "real-time" data as soon as possible from as many drifters possible after each satellite pass. For this reason it was decided to make use of an 100% on duty cycle, instead of the proposed 1/3 off, 2/3 on duty cycle. By comparing the occurrence of PRV data of a duty cycle and non-duty cycle drifter, I have found that there were about 60% more "hits" of non duty-cycle drifter.

As I understand it one of the main reasoning behind the duty cycle, was to conserve battery power. After more than 12 months in the water, the main area of failure of our drifters was sensor failure, and not loss of battery power. This then confirms that this was the correct choice for the SAWB needs.

2. Data format

SAWB Metocean SVP-B drifter data format

Variable	Bits
Barometric Pressure	10
Battery Volts	6
Sea Surface Temperature	8
Checksum	8
Barometric pressure 3 hours previous	10
Submersion count	6
Minimum barometric pressure	10
Blank	6
TOTAL	64

The data format used by the SAWB drifter was a very simplified version of the proposed DBCP format. As we have the 100% on duty cycle, it was not necessary to archive the large amount of data as is in the proposed data format. We have found this format also to be well suited to our requirement, which is data for mainly synoptic use.

Deployments

The first deployment the of these drifters was done by the SAWB was during September and October 1994, when twenty SAWB drifters and four NDBC SVP-B drifters were deployed in the South Atlantic from the SA Navy vessel, SAS Protea. This was the first major deployment of the International South Atlantic Buoy Programme (ISABP). Simultaneously 18 SVP-B drifters were being air deployed for the DBCP by the US Navy. (See diagram I showing total deployments).

Deployment procedure

SAWB (and for that matter all drifters deployed by the SAWB) are checked before, and immediately after deployment. Drifters are activated at least 24 hours before deployment. Transmissions are checked to ensure the data to be correct. After deployment we request the vessel (non VOS) to remain in the area of the drifter, and receive two or three transmissions, before steaming ahead. Should no transitions be received, this drifter will be recovered, and replaced with another.

The lifespan of the SAWB Metocean SVP-B drifter and sensor suite

After 11 months at sea, 65 of the drifters are still reporting reliable pressure data. Up to date none of the drifters have been lost, although 2 of the drifters are being processed under the Argos backup service. (see table 2)

Traverse speed of drifters.

Comparing the traverse speed of on SVP drifter to that of the FGGE drifter, we have found that the SVP drifter did move somewhat slower. The wind does still have a large affect on the drift speed of the drifter.

Recovery of drifters

During September it was attempted to recover one SAWB and one SIO drifter using DF equipment on loan from SIO. After searching for 6 hours, it was decided to abandon the search. During this time no signal was received on the DF equipment, or the buoy receiving equipment on board the vessel. The area that was searched was determined by the most up - to - date positions as they became available from Argos. Besides the adverse sea conditions, another contributing factor to the failure to locate these drifters, was the time lag between the location becoming available from Argos, and the Satellite pass time. This amounted to four hours. By the time the position reached the vessel, the buoy had drifted a considerable distance.

Future requirements

The addition of an anemometer to the drifter would be a useful for deployments in the tropical ocean areas. The development in this area by SIO will be closely followed by the SAWB.

In general

The SVP-B drifter has proved to be an reliable data platform, with a useful lifespan that is much improved on drifters previously deployed by the SAWB.

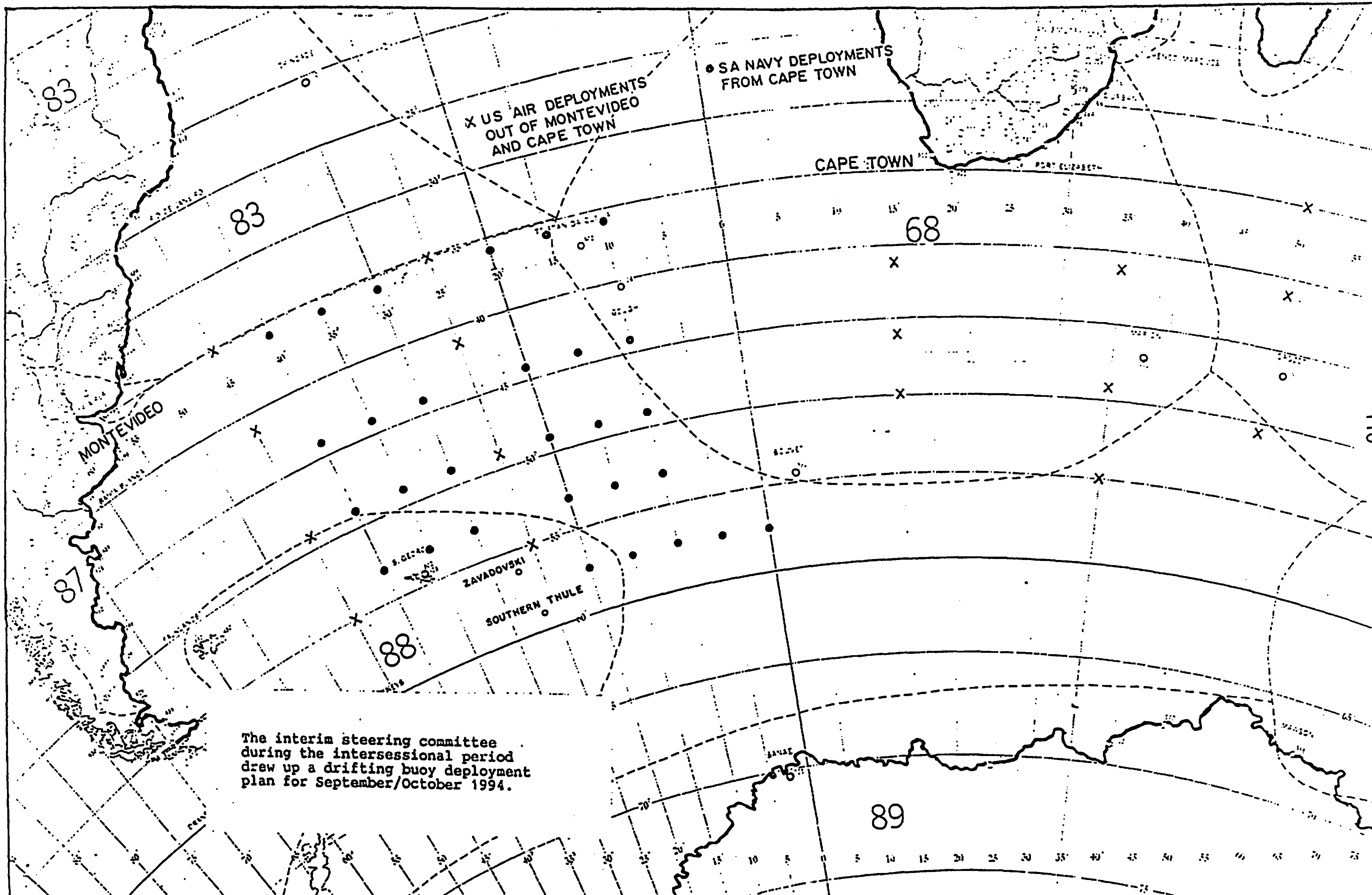
Eugene Burger

Status of SAWB Metocean SVP-B drifters

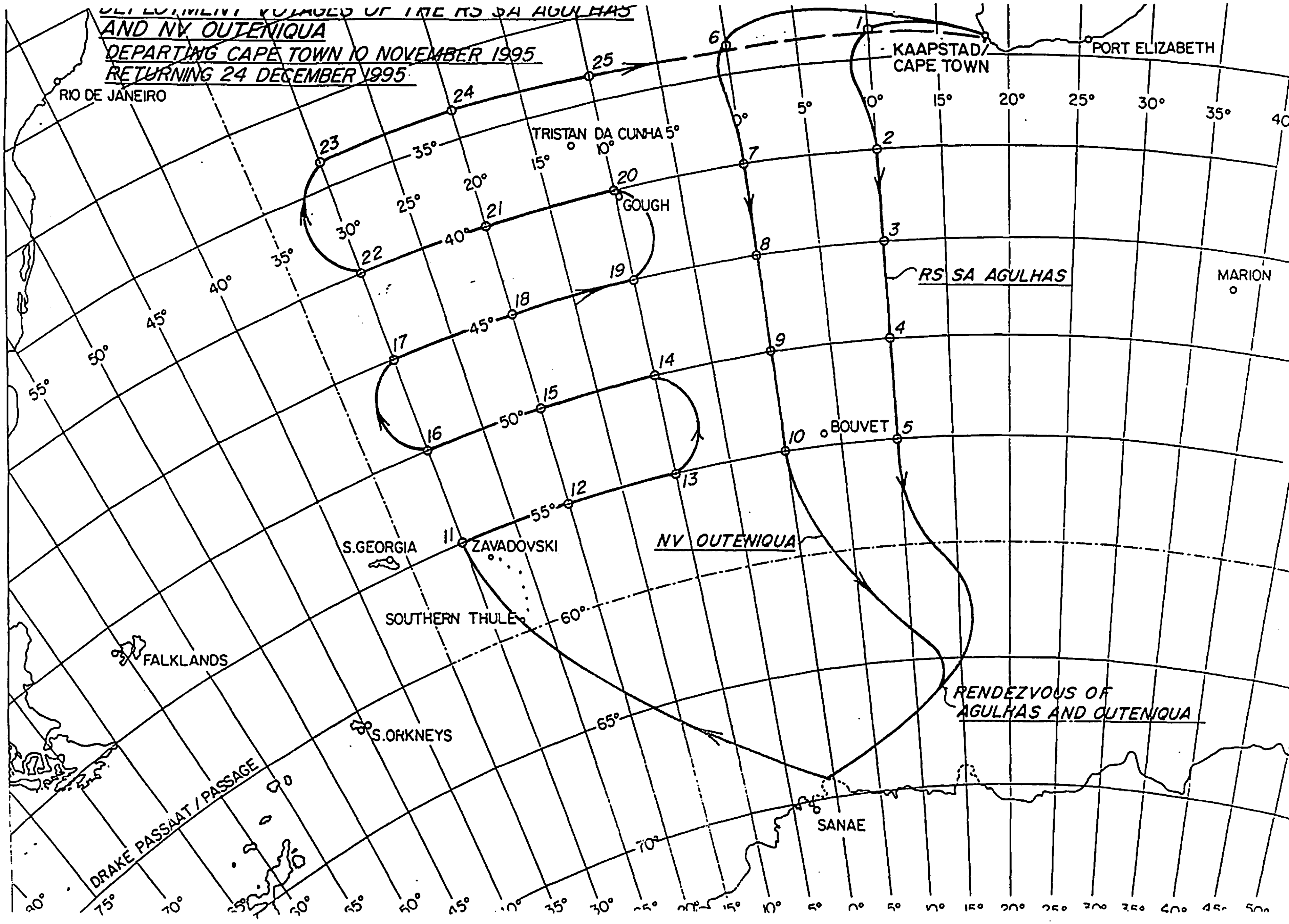
WMO #	Argos #	Deployment Date	Deployment Position	Position as on 06/10/1995	Sensor status as on 06/10/1995				Battery voltage. (originally 15,4V
					AP	Date of failure	SST	Date of failure	
22575	17606	29/09/1995	44S 20W	♠	+	05/12/94	+	05/12/94	
22576	17603	11/09/1994	17S 15W	29S 07E	*		*		11.2
22577	33537	23/09/1994	53S 35W	48S 24E	*		*		11.2
22578	33532	15/09/1994	37S 35W	35S 01W	+	04/06/95	*		10.6
22579	17612	17/01/1995	45S 10W	♠	+	18/07/95	+	18/07/95	
22580	33541	22/01/1995	60S 22W	54S 13W	*		*		12.8
22581	17613	27/01/1995	58S 02E	57S 38E	*		*		12.8
22582	17604	12/09/1994	37S 20W	31S 01E	+	18/08/95	*		11.0
22583	17608	02/10/1994	50S 20W	45S 13E	+	03/10/95	*		11.2
22584	33538	24/09/1994	53S 30W	52S 18E	*		*		11.2
22585	33540	28/09/1994	44S 30W	44.1S 09E	*		*		11.6
22586	33533	19/09/1994	37S 40W	39S 09E	*		*		12.0
22587	33539	26/09/1994	50S 35W	42S 26E	+	21/02/95	*		12.8
22588	33534	19/09/1994	44S 40W	39S 19W	*		*		11.6
22589	17607	01/10/1995	50S 15W	45S 36E	*		*		11.4
22590	17610	04/10/1994	53S 10W	50S 33E	+	13/03/95	*		12.4

22591	33536	21/09/1994	53S 40W	50S 52E	+	05/06/95	*		12.0
22592	33531	15/09/1995	37S 40W	33S 03W	*		*		11.4
22593	17609	03/10/1994	53S 20W	46S 36E	*		*		10.4
22594	33535	21/09/1994	49S 40W	41S 24E	*		*		12.0

* paremeter operational
\+ parameter failure
♠ Drifter processed under backup mode



The interim steering committee during the intersessional period drew up a drifting buoy deployment plan for September/October 1994.

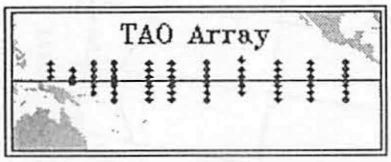

AND NV OUTENIQUA
DEPARTING CAPE TOWN 10 NOVEMBER 1995
RETURNING 24 DECEMBER 1995
RIO DE JANEIRO
TRISTAN DA CUNHA
GOUGH
KAAPSTAD/
CAPE TOWN
PORT ELIZABETH
RS SA AGULHAS
MARION
BOUVET
NV OUTENIQUA
S.GEORGIA
ZAVADOVSKI
SOUTHERN THULE
FALKLANDS
S.ORKNEYS
RENDEZVOUS OF
AGULHAS AND OUTENIQUA
SANAE
DRAKE PASSAAT / PASSAGE

11) THE TAO ARRAY

By: William Woodward
NOAA, National Ocean Service
Silver Spring, Maryland
USA

U.S.Dept of Commerce / NOAA / OAR / ERL / PMEL / TAO Project Office

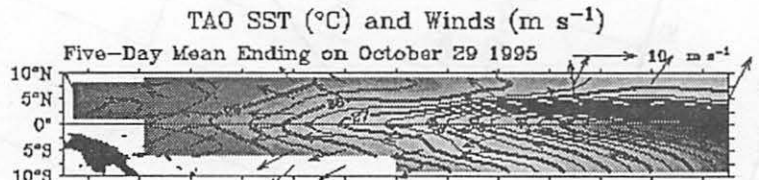
The TAO Array



The TAO array consists of approximately 70 ATLAS and current meter moorings in the Equatorial Pacific Ocean, telemetering atmospheric and upper ocean data in realtime via the Argos satellite. Supported by an international consortium, it is a major component of the global climate monitoring system, maintained in support of CLIVAR, GOOS and GCOS.

TAO Data Access

Realtime data always includes data received and processed during the previous night.



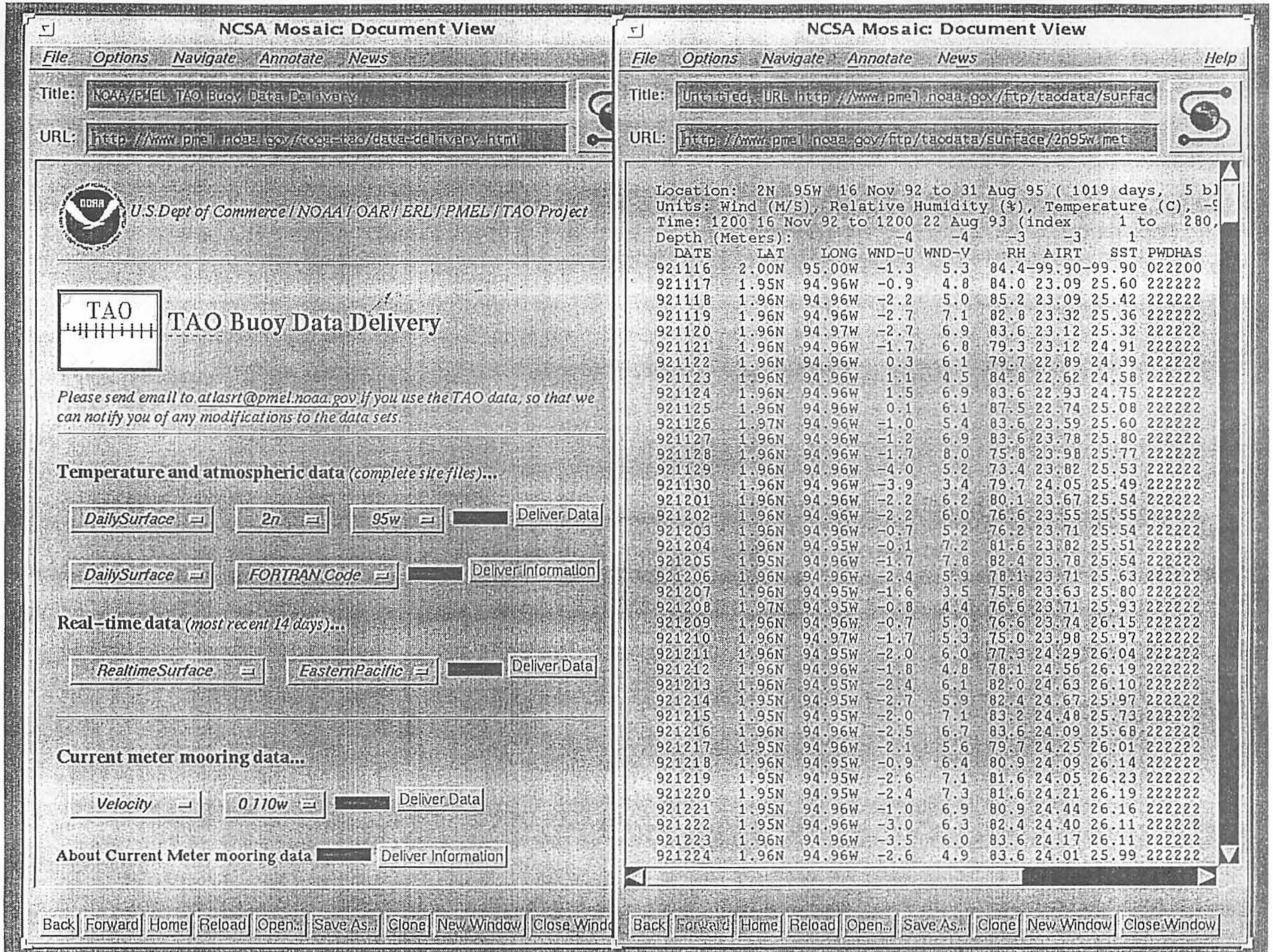
WWW and Mosaic Access to realtime TAO data

Realtime data and displays from the TAO buoys via Mosaic and the WWW. TAO data and related data sets, such as TOGA drifting buoy data, TOPEX/Poseidon data, and operational analyses model data from the National Meterological Center, are available as plots and animations. Data is available for download as well. See *http://www.pmel.noaa.gov/toga–tao/realtime.html* and *http://www.pmel.noaa.gov/toga–tao/data–delivery.html.*

Unix and X–windows Access to realtime TAO data

The TAO Display Software is an interactive system delivering realtime data and displays from the TAO buoys to remote users, in a Unix or x–window environment. Data includes realtime and historical currents, temperatures, computed quantities, with user control of axis limits, contour levels and vector scaling. The data subscription service provides automatic data file updates. It is available at *ftp.pmel.noaa.gov* in *anonymous/tao*, with no software purcahse necessary. See *http://www.pmel.noaa.gov/toga–tao/taows.html.*

Nancy Soreide, NOAA/PMEL, nns@pmel.noaa.gov, http://www.pmel.noaa.gov/toga–tao/home.html



NCSA Mosaic: Document View

File Options Navigate Annotate News

Title: NOAA/PMEL TAO Buoy Data Delivery

URL: http://www.pmel.noaa.gov/toga-tao/data-delivery.html

U.S.Dept of Commerce / NOAA / OAR / ERL / PMEL / TAO Project

TAO

TAO Buoy Data Delivery

Please send email to atlasrt@pmel.noaa.gov if you use the TAO data, so that we can notify you of any modifications to the data sets.

Temperature and atmospheric data *(complete site files)*...

DailySurface | 2n | 95w | Deliver Data

DailySurface | FORTRAN Code | Deliver Information

Real-time data *(most recent 14 days)*...

RealtimeSurface | EasternPacific | Deliver Data

Current meter mooring data...

Velocity | 0 110w | Deliver Data

About Current Meter mooring data Deliver Information

Back | Forward | Home | Reload | Open... | Save As... | Clone | New Window | Close Windo

NCSA Mosaic: Document View

File Options Navigate Annotate News Help

Title: Untitled, URL http://www.pmel.noaa.gov/ftp/taodata/surfac

URL: http://www.pmel.noaa.gov/ftp/taodata/surface/2n95w.met

```
Location:  2N  95W  16 Nov 92 to 31 Aug 95 ( 1019 days,   5 bl
Units: Wind (M/S), Relative Humidity (%), Temperature (C), -9
Time: 1200 16 Nov 92 to 1200 22 Aug 93 (index      1 to   280,
Depth (Meters):               -4     -4     -3     -3     1
  DATE       LAT     LONG WND-U WND-V    RH  AIRT    SST PWDHAS
921116    2.00N  95.00W  -1.3    5.3  84.4-99.90-99.90 022200
921117    1.95N  94.96W  -0.9    4.8  84.0 23.09 25.60 222222
921118    1.96N  94.96W  -2.2    5.0  85.2 23.09 25.42 222222
921119    1.96N  94.96W  -2.7    7.1  82.8 23.32 25.36 222222
921120    1.96N  94.97W  -2.7    6.9  83.6 23.12 25.32 222222
921121    1.96N  94.96W  -1.7    6.8  79.3 23.12 24.91 222222
921122    1.96N  94.96W   0.3    6.1  79.7 22.89 24.39 222222
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921126    1.97N  94.96W  -1.0    5.4  83.6 23.59 25.60 222222
921127    1.96N  94.96W  -1.2    6.9  83.6 23.78 25.80 222222
921128    1.96N  94.96W  -1.7    8.0  75.8 23.98 25.77 222222
921129    1.96N  94.96W  -4.0    5.2  73.4 23.82 25.53 222222
921130    1.96N  94.96W  -3.9    3.4  79.7 24.05 25.49 222222
921201    1.96N  94.96W  -2.2    6.2  80.1 23.67 25.54 222222
921202    1.96N  94.96W  -2.2    6.0  76.6 23.55 25.55 222222
921203    1.96N  94.96W  -0.7    5.2  76.2 23.71 25.54 222222
921204    1.96N  94.95W  -0.1    7.2  81.6 23.82 25.51 222222
921205    1.95N  94.96W  -1.7    7.8  82.4 23.78 25.54 222222
921206    1.96N  94.96W  -2.4    5.9  78.1 23.71 25.63 222222
921207    1.96N  94.95W  -1.6    3.5  75.8 23.63 25.80 222222
921208    1.97N  94.95W  -0.8    4.4  76.6 23.71 25.93 222222
921209    1.96N  94.96W  -0.7    5.0  76.6 23.74 26.15 222222
921210    1.96N  94.97W  -1.7    5.3  75.0 23.98 25.97 222222
921211    1.96N  94.95W  -2.0    6.0  77.3 24.29 26.04 222222
921212    1.96N  94.96W  -1.8    4.8  78.1 24.56 26.19 222222
921213    1.96N  94.95W  -2.4    6.1  82.0 24.63 26.10 222222
921214    1.95N  94.95W  -2.7    5.9  82.4 24.67 25.97 222222
921215    1.95N  94.95W  -2.0    7.1  83.2 24.48 25.73 222222
921216    1.96N  94.96W  -2.5    6.7  83.6 24.09 25.68 222222
921217    1.95N  94.96W  -2.1    5.6  79.7 24.25 26.01 222222
921218    1.96N  94.95W  -0.9    6.4  80.9 24.09 26.14 222222
921219    1.95N  94.95W  -2.6    7.1  81.6 24.05 26.23 222222
921220    1.95N  94.95W  -2.4    7.3  81.6 24.21 26.19 222222
921221    1.95N  94.96W  -1.0    6.9  80.9 24.44 26.16 222222
921222    1.95N  94.96W  -3.0    6.3  82.4 24.40 26.11 222222
921223    1.96N  94.96W  -3.5    6.0  83.6 24.17 26.11 222222
921224    1.96N  94.96W  -2.6    4.9  83.6 24.01 25.99 222222
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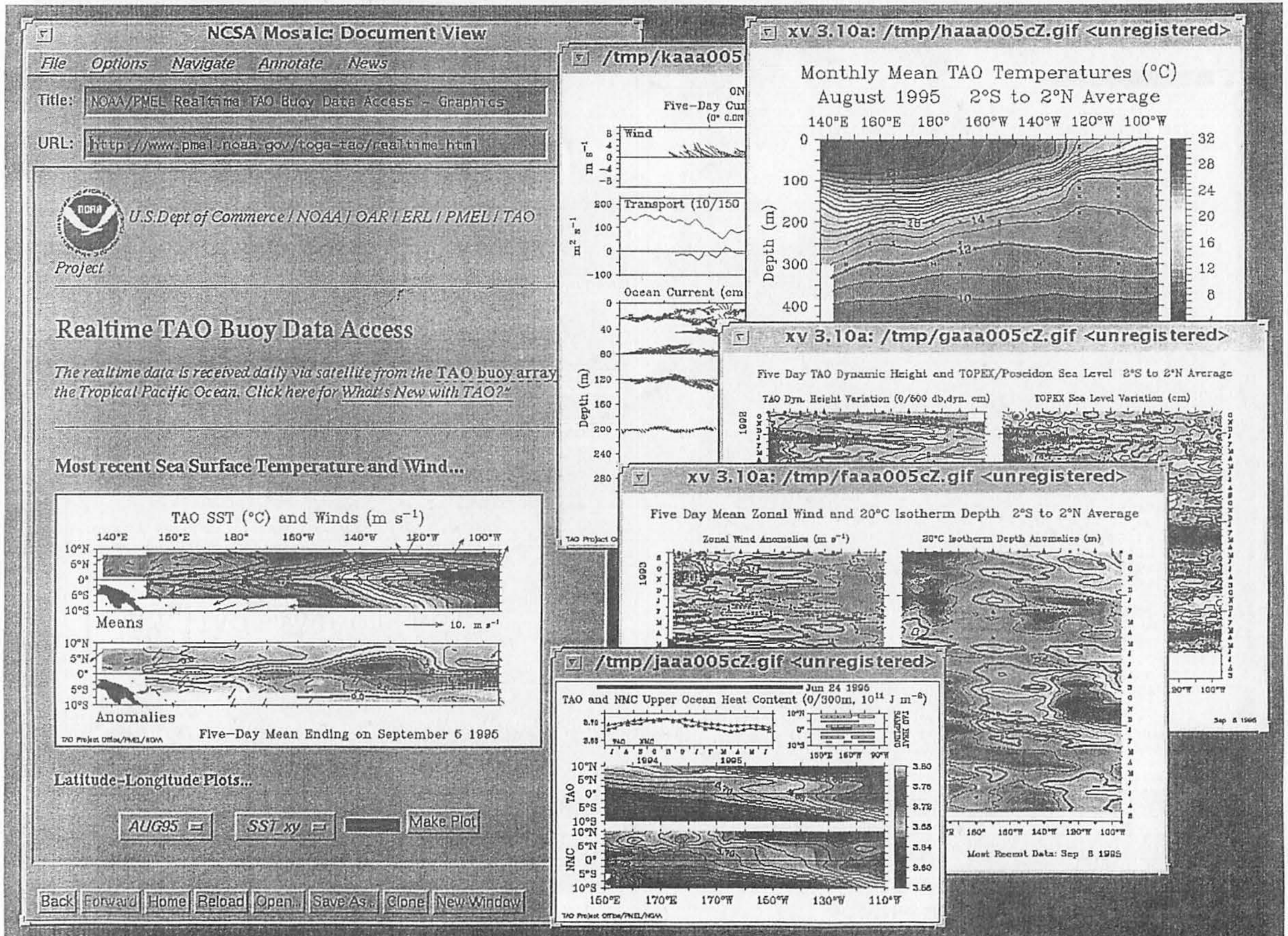
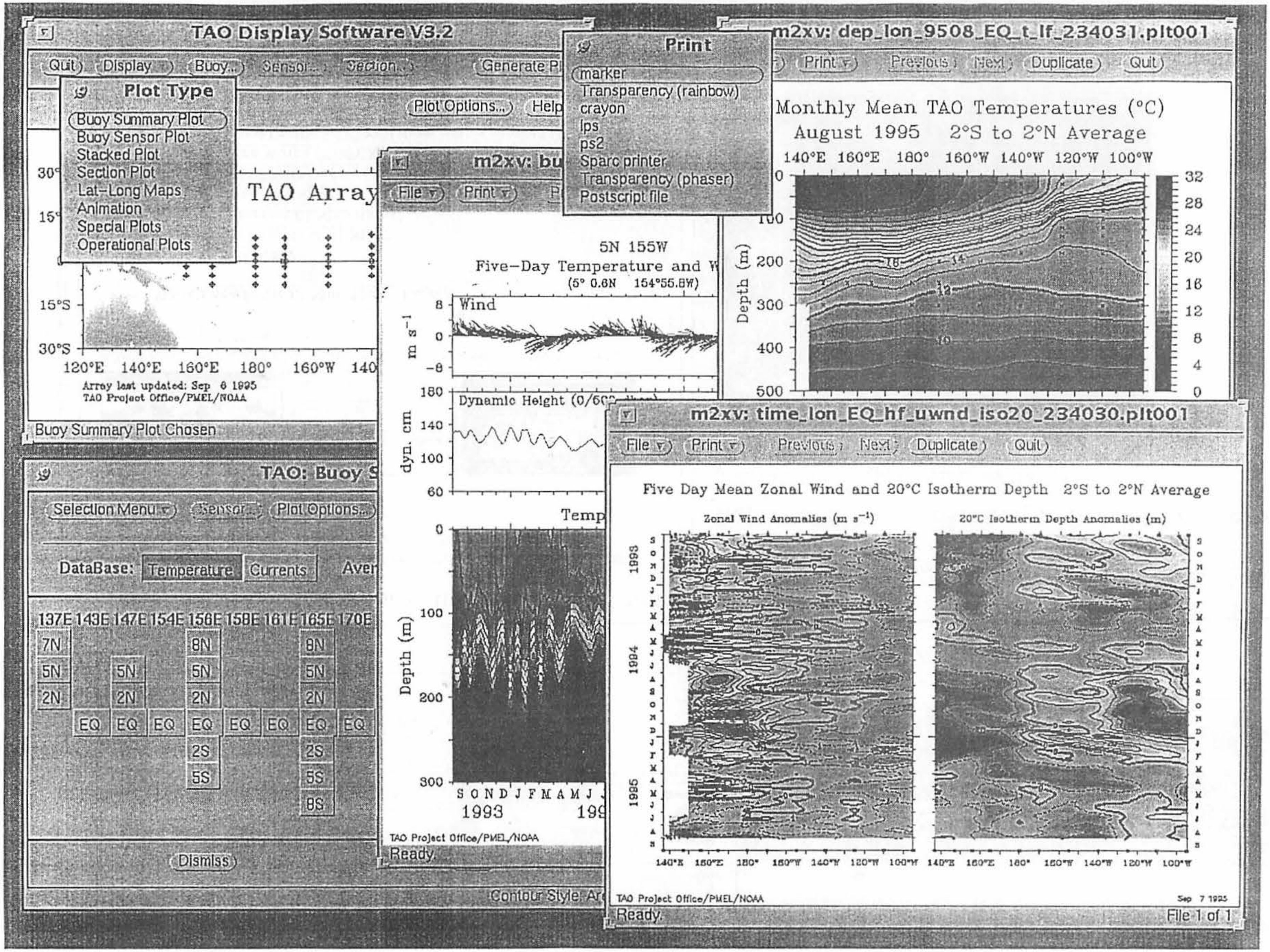
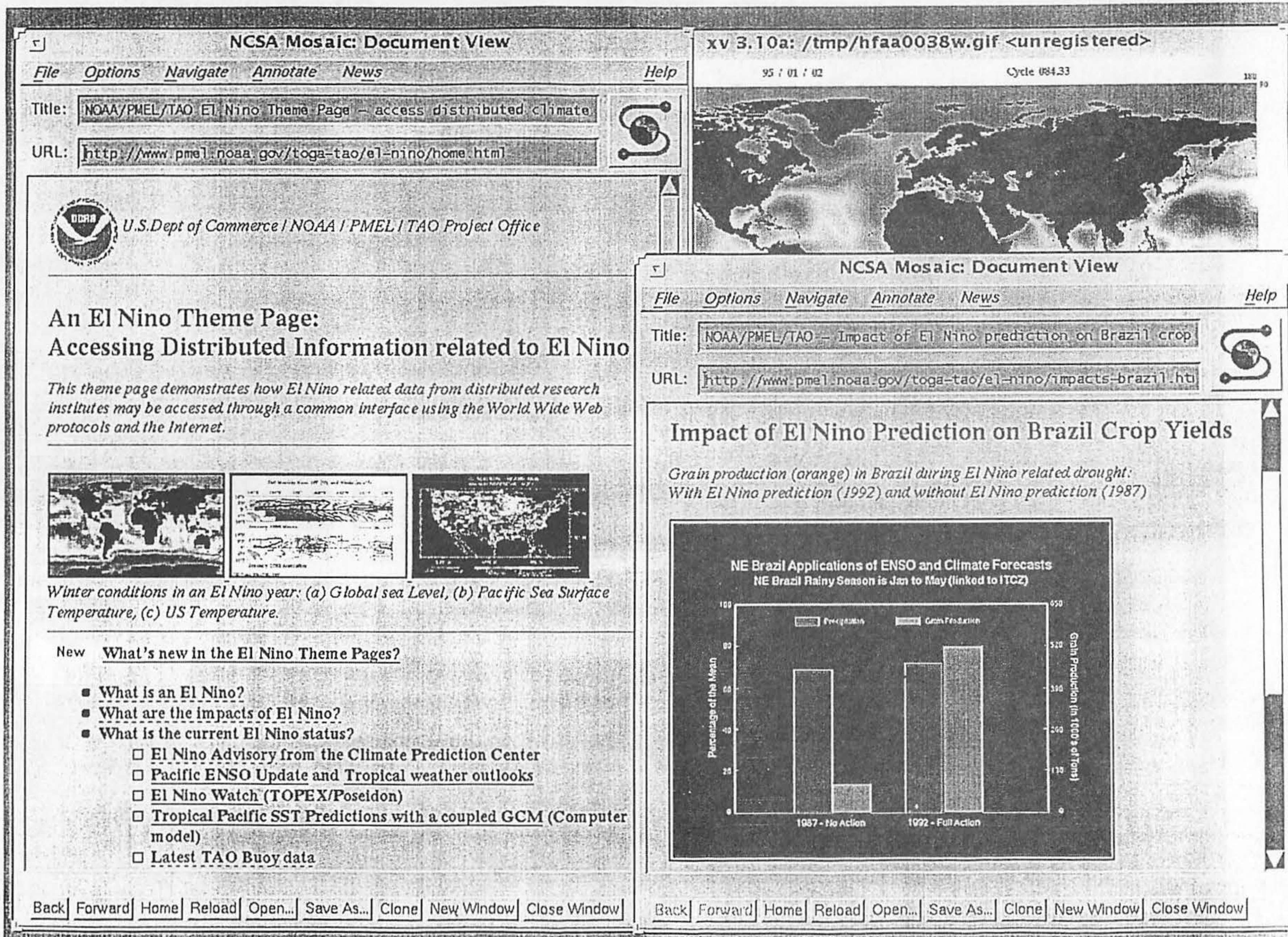


NCSA Mosaic: Document View
File Options Navigate Annotate News
Title: NOAA/PMEL Realtime TAO Buoy Data Access - Graphics
URL: http://www.pmel.noaa.gov/toga-tao/realtime.html
U.S.Dept of Commerce / NOAA / OAR / ERL / PMEL / TAO Project
Realtime TAO Buoy Data Access
The realtime data is received daily via satellite from the TAO buoy array the Tropical Pacific Ocean. Click here for What's New with TAO?
Most recent Sea Surface Temperature and Wind...
TAO SST (°C) and Winds (m s⁻¹)
Means
Anomalies
Five-Day Mean Ending on September 6 1995
Latitude-Longitude Plots...
AUG95
SST xy
Make Plot
Back Forward Home Reload Open... Save As... Clone New Window
xv 3.10a: /tmp/haaa005cZ.gif <unregistered>
Monthly Mean TAO Temperatures (°C)
August 1995 2°S to 2°N Average
Depth (m)
xv 3.10a: /tmp/gaaa005cZ.gif <unregistered>
Five Day TAO Dynamic Height and TOPEX/Poseidon Sea Level 2°S to 2°N Average
xv 3.10a: /tmp/faaa005cZ.gif <unregistered>
Five Day Mean Zonal Wind and 20°C Isotherm Depth 2°S to 2°N Average
Most Recent Data: Sep 8 1995
/tmp/jaaa005cZ.gif <unregistered>
TAO and NMC Upper Ocean Heat Content (0/300m, 10¹¹ J m⁻²)
/tmp/kaaa005
Wind
Transport
Ocean Current
Depth (m)


TAO Display Software V3.2
Quit
Display
Buoy
Sensor
Section
Generate Pl
Plot Type
Buoy Summary Plot
Buoy Sensor Plot
Stacked Plot
Section Plot
Lat-Long Maps
Animation
Special Plots
Operational Plots
Plot Options...
Help
TAO Array
Array last updated: Sep 6 1995
TAO Project Office/PMEL/NOAA
Buoy Summary Plot Chosen
Print
marker
Transparency (rainbow)
crayon
lps
ps2
Sparc printer
Transparency (phaser)
Postscript file
m2xv: dep_lon_9508_EQ_t_lf_234031.plt001
Previous
Next
Duplicate
Monthly Mean TAO Temperatures (°C)
August 1995 2°S to 2°N Average
Depth (m)
m2xv: bu
File
5N 155W
Five-Day Temperature and W
(5° 0.6N 154°55.8W)
Wind
Dynamic Height (0/5
dyn. cm
Depth (m)
TAO Project Office/PMEL/NOAA
Ready.
TAO: Buoy S
Selection Menu
Sensor
Plot Options...
DataBase:
Temperature
Currents
Aver
Dismiss
Contour Style: Ar
m2xv: time_lon_EQ_hf_uwnd_iso20_234030.plt001
Five Day Mean Zonal Wind and 20°C Isotherm Depth 2°S to 2°N Average
Zonal Wind Anomalies (m s⁻¹)
20°C Isotherm Depth Anomalies (m)
TAO Project Office/PMEL/NOAA
Sep 7 1995
Ready.
File 1 of 1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File Options Navigate Annotate News Help
Title: NOAA/PMEL/TAO El Nino Theme Page - access distributed climate
URL: http://www.pmel.noaa.gov/toga-tao/el-nino/home.html
U.S.Dept of Commerce / NOAA / PMEL / TAO Project Office
An El Nino Theme Page:
Accessing Distributed Information related to El Nino
This theme page demonstrates how El Nino related data from distributed research institutes may be accessed through a common interface using the World Wide Web protocols and the Internet.
Winter conditions in an El Nino year: (a) Global sea Level, (b) Pacific Sea Surface Temperature, (c) US Temperature.
New What's new in the El Nino Theme Pages?
What is an El Nino?
What are the impacts of El Nino?
What is the current El Nino status?
El Nino Advisory from the Climate Prediction Center
Pacific ENSO Update and Tropical weather outlooks
El Nino Watch (TOPEX/Poseidon)
Tropical Pacific SST Predictions with a coupled GCM (Computer model)
Latest TAO Buoy data
Back Forward Home Reload Open... Save As... Clone New Window Close Window
xv 3.10a: /tmp/hfaa0038w.gif <unregistered>
95 / 01 / 02
Cycle 084.33
NCSA Mosaic: Document View
File Options Navigate Annotate News Help
Title: NOAA/PMEL/TAO - Impact of El Nino prediction on Brazil crop
URL: http://www.pmel.noaa.gov/toga-tao/el-nino/impacts-brazil.ht
Impact of El Nino Prediction on Brazil Crop Yields
Grain production (orange) in Brazil during El Nino related drought:
With El Nino prediction (1992) and without El Nino prediction (1987)
NE Brazil Applications of ENSO and Climate Forecasts
NE Brazil Rainy Season is Jan to May (linked to ITCZ)
Percentage of the Mean
Grain Production (in 1000's of Tons)
1987 - No Action
1992 - Full Action
Back Forward Home Reload Open... Save As... Clone New Window Close Window

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NEXT GENERATION ATLAS SAMPLING SCHEME
September 1995

	"HIGH RESOLUTION" INTERNALLY RECORDED DATA	"REALTIME"* TRANSMITTED DATA
SURFACE PARAMETERS		
Air Rel Hum Winds	2 min average of data sampled at 2 hz centered on every 10 min (2359-0001, 0009-0010,0029-0031...)	Hourly average of 6 2-min averages of data sampled at 2 hz (2359-0001, 0009-0011..,0049-0051). Daily avg also available.
OCEAN PARAMETERS		
SST Subsurface T Subsurface P Subsurface C	Spot samples taken every 10 minutes (0000,0010...)	Daily average of data spot-sampled every 10 min (0010,0020...2400)

* Data in Realtime: Winds, AirT, RH, SST, 10 Subsurface temps, 4 subsurface conductivities, 2 subsurface pressures

ATLAS BUOY SAMPLING (Standard ATLAS)

Data Sampling Regime

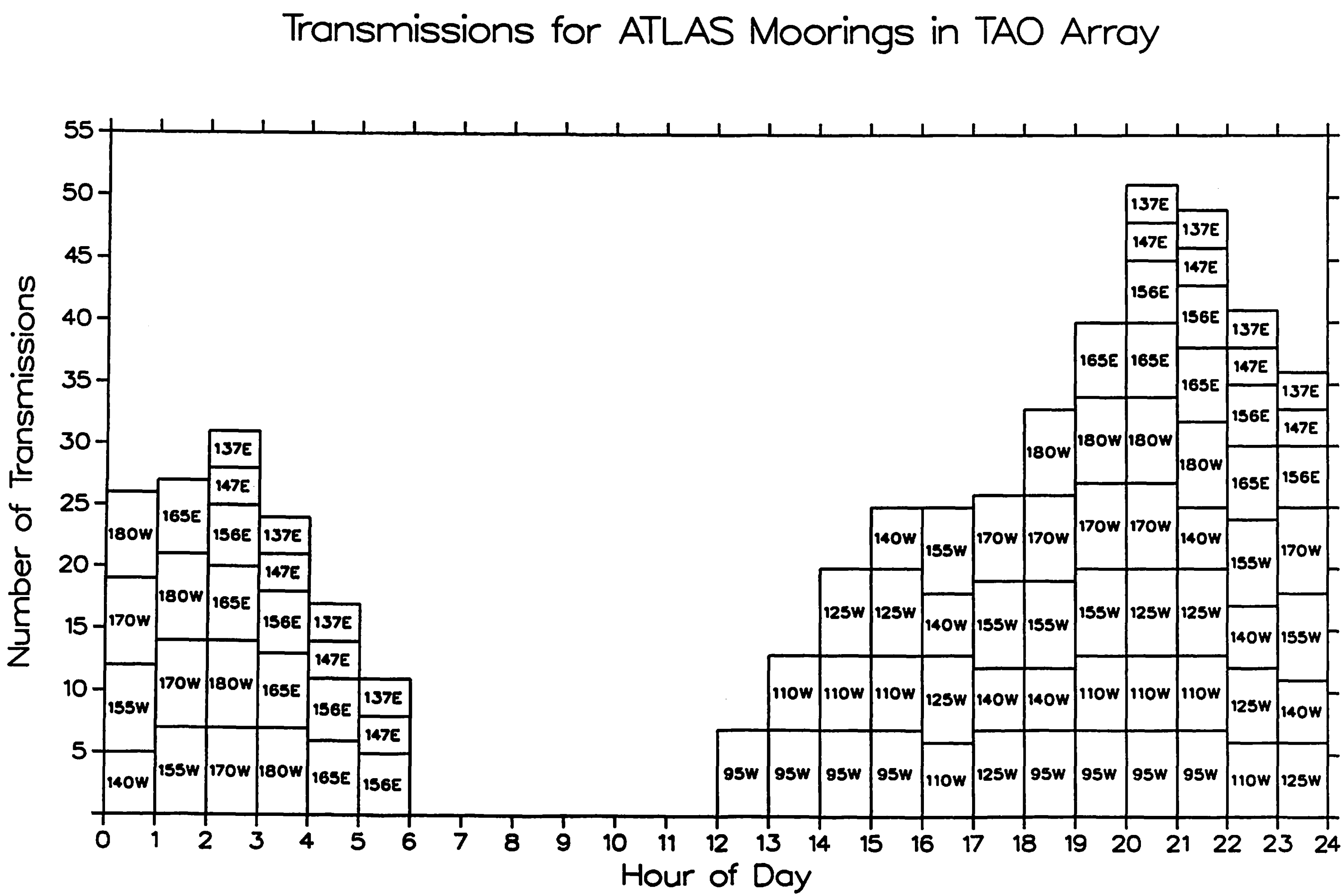
- **Winds**
  - High resolution
    Sampled at 2 Hz for 6 minutes every hour (centered on the hour)
  - Daily values
    Calculated from High Resolution values.
- Surface data (Air, SST, Relative Humidity)
  - High resolution
    Discrete sample taken every 10 minutes
    Averaged at the end of each hour
  - Daily values
    Averaged at the end of each day at buoy
- Sub–surface temperatures
  - Daily values
    Discrete sample taken every 10 minutes
    Averaged at the end of each day

Data Transmitted

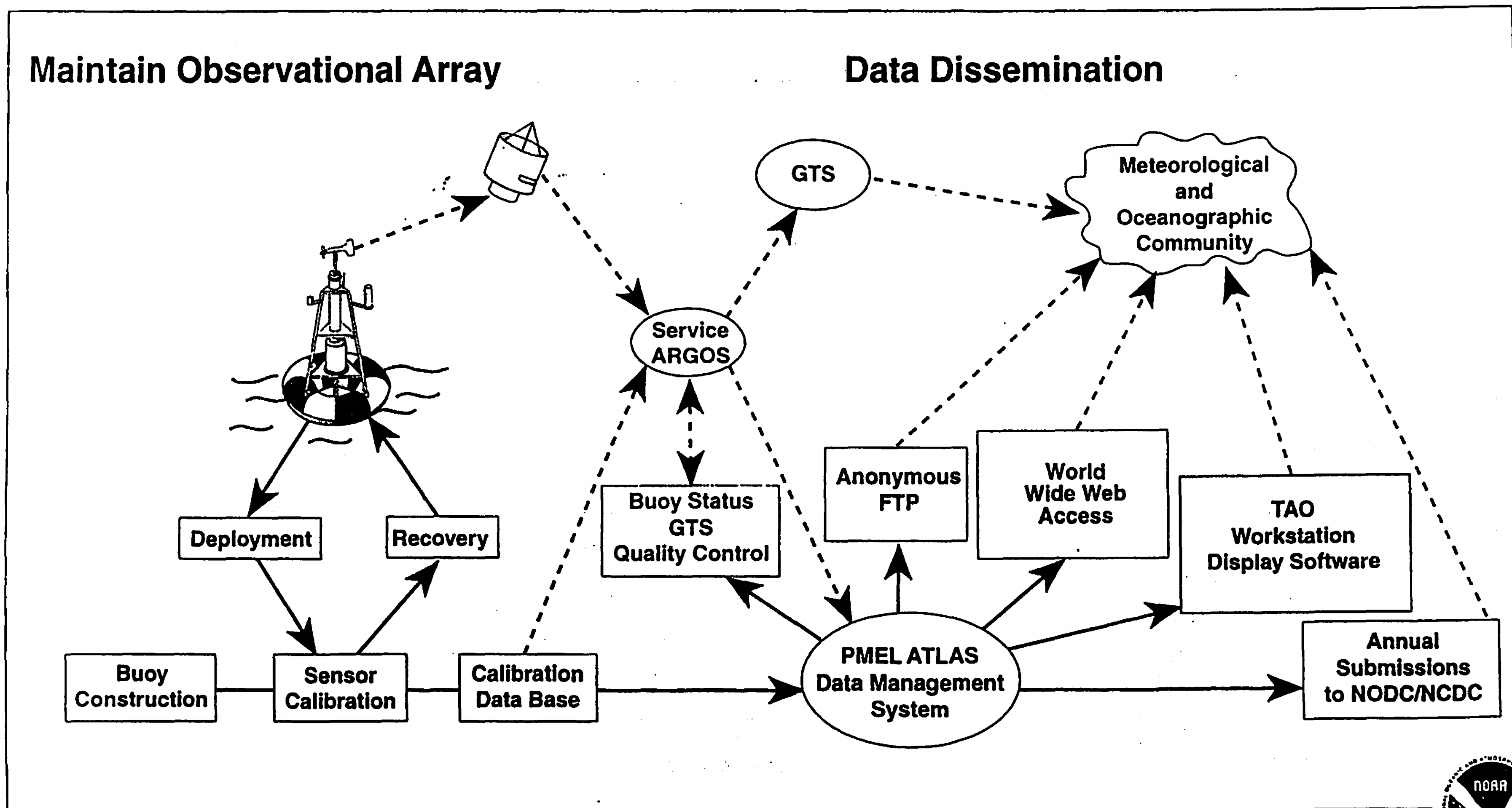
- Buoy transmission regime
  Transmits 6:00–10:00 am (buoy local time)
  Transmits 12:00–16:00 pm (buoy local time)
- **Winds**
  - High resolution
    3–4 spot–hourly values transmitted per day
  - Daily values always transmitted
- Surface data (Air, SST, Relative Humidity)
  - High resolution
    3–4 spot–hourly values transmitted per day
  - Daily values always transmitted
- Sub–surface temperatures
  - Daily values always transmitted

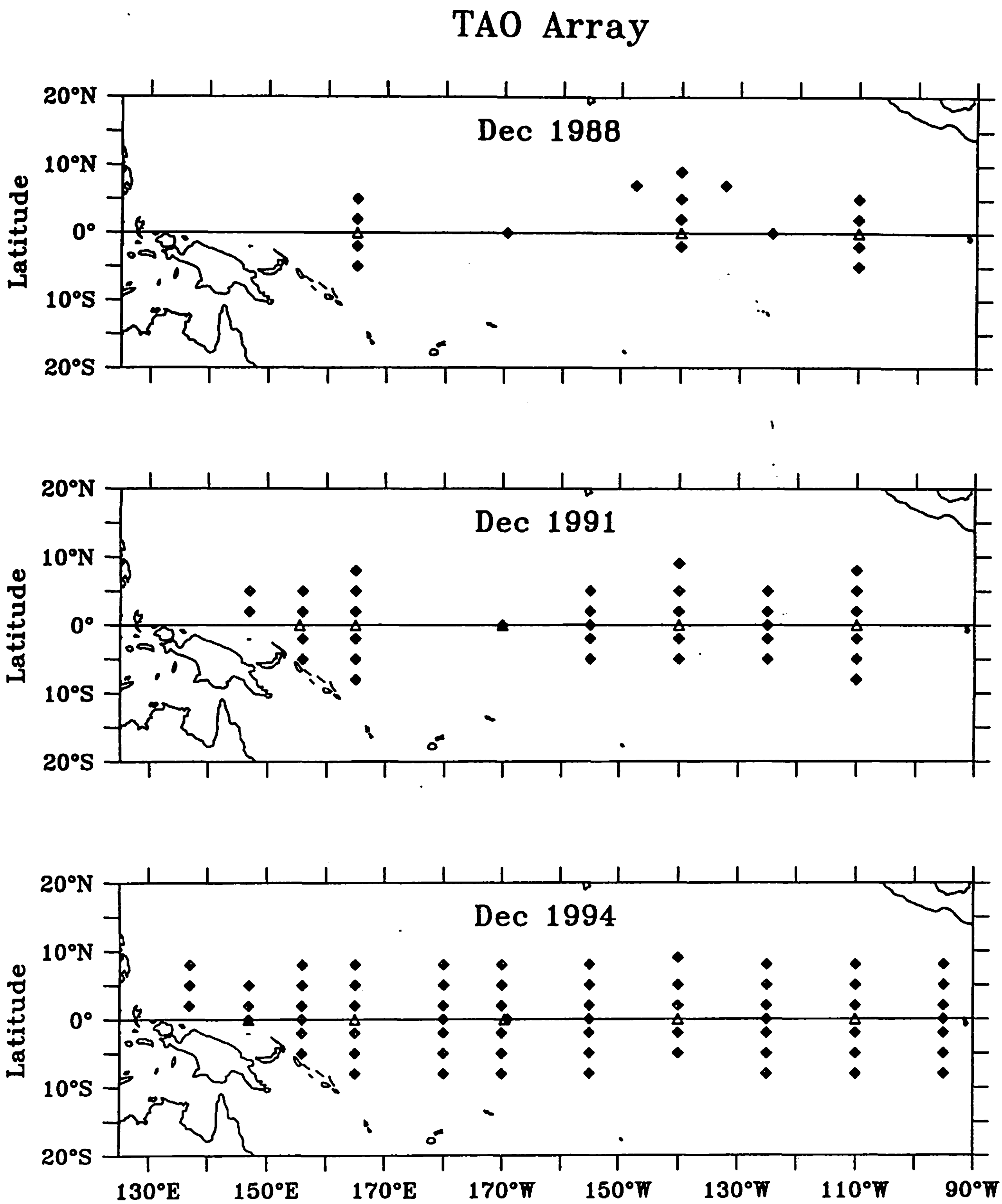
RAM Data (available after buoy recovery)

- Surface Wind, Air, SST, Relative Humidity
  - Complete hourly time series available


Transmissions for ATLAS Moorings in TAO Array
Number of Transmissions
Hour of Day
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
5
10
15
20
25
30
35
40
45
50
55
140W
155W
170W
180W
155W
170W
180W
165E
170W
180W
165E
156E
147E
137E
180W
165E
156E
147E
137E
165E
156E
147E
137E
156E
147E
137E
95W
110W
125W
140W
155W
170W
180W
165E
156E
147E
137E

TAO System Overview




TAO Array
Dec 1988
Dec 1991
Dec 1994
Latitude
20°N
10°N
0°
10°S
20°S
130°E
150°E
170°E
170°W
150°W
130°W
110°W
90°W

Annex: References of speakers

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TECHNICAL DOCUMENTS ISSUED WITHIN THE DATA BUOY CO-OPERATION PANEL SERIES

No.	Title	Year of issue
1	Annual report for 1994	1995
2	Reference Guide to the GTS Sub-system of the Argos Processing System	1995
3	Guide to Data Collection and Location Services using Service Argos	1995
4	WOCE Surface Velocity Programme Barometer Drifter Construction Manual	1995
5	Surface Velocity Programme (SVP) - DBCP/SIO Workshop on SVP barometer drifter evaluation	1996
6	Annual report of the DBCP for 1995	1996
7	Developments in buoy technology and enabling methods - Technical presentations made at the eleventh session of the DBCP	1996

These publications can be ordered from: Etienne Charpentier, Technical Co-ordinator of the DBCP, CLS/Service Argos, 18, Av. E. Belin, 31055 Toulouse Cédex, FRANCE - Email charpentier@atlas.cnrs.fr fax +33 61 751 014