BCLME Project EV/Angola/03/03

Assessment of the Present State of Oceanographic Environmental Monitoring in the Angolan Sector of the Benguela Current Large Marine Ecosystem

A project contracted to:
The Instituto de Investigação Marinha (IIM), Angola

By:
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On behalf of:
The Benguela Current Large Marine Ecosystem Programme (BCLME)

Final Report

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Submitted by Principal Investigator:

Quilanda Fidel

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BCLME Project EV/ANGOLA/03/03

Project Title:

Assessment of the Present State of Oceanographic Environmental Monitoring in the Angolan Sector of the Benguela Current Large Marine Ecosystem

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Executive Summary:

An early warning system for monitoring major (natural) environmental events within the BCLME has been identified as a high priority in the SAP. The main objective of this Project was to assess the state of oceanographic environmental monitoring in Angola's EEZ conducted by, or on behalf of, various sectors of government and industry. Organizations/individuals in the public and private sectors which are at present engaged in (or have during the past year been involved in) making routine oceanographic environmental measurements in Angola's EEZ have been identified.

Commercial enterprises in the petroleum industry are known to undertake routine oceanographic monitoring from oil platforms, but obstacles were encountered in meeting oil company representatives so that no information was obtained from them.

Amongst the organizations/individuals visited some of them are making routine oceanographic measurements of the following data:

- CTD profiles; ADCP ocean current measurements
- Sea water temperature; Salinity; Dissolved oxygen; pH; Transparency
- Chlorophyll-a; Fluorescence; micro-mezo plankton; phyto and zooplankton
- Air temperature and pressure; cloud; evaporation; precipitation; wind speed and direction; humidity and meteorological observations made by ships.

For the time being it can be noted that meteorological stations at the airports and IIM labs (in Lobito and Namibe) attempt to undertake observations but difficulties arise due to limited human and material resources.

Most of the equipment belonging to organizations/individuals visited is obsolete or out of order due to lack of a maintenance budget and limited trained human resources.

General Remarks:

- Oceanographic measurements can be done at daily or weekly intervals depending on human and instrumental resources. Motorized (small) boats are needed for undertaking monitoring at coastal fixed stations.
- No ports in Angola have tide gauges operating nor do they undertake basic meteorological measurements. Meteorological instruments need to be supplied or replaced in all coastal airport meteorological stations
- Most of the salt companies have not collected meteorological data and tidal observations for a long time. These measurements would assist salt production.
- Fishing harbours lack tide gauges & meteorological instruments.

This study has summarized the current situation with regard to monitoring activities undertaken in Angola's EEZ. Information obtained from individuals / organizations has revealed that the current situation of depleted monitoring is critical and it is urgent that a decision be made to take the initiative to improve the state of environmental monitoring in Angola's EEZ as soon as possible.

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List of Acronyms

ADCP	Acoustic Doppler Current Profiler
BCLME	Benguela Current Large Marine Ecosystem
CTD	Conductivity Temperature Depth probe
EEZ	Exclusive Economic Zone
HAB	Harmful Algal Bloom
IIM	Institute of Marine Research
SADCO	Southern African Data Centre for Oceanography
SAP	Strategic Action Plan
TS	Temperature / Salinity

List of Symbols

pH = negative log of hydrogen ion concentration = acidity/alkalinity of sea water

1. Introduction

The development of a needs-driven, cost effective early warning system for monitoring major (natural) environmental events within the BCLME has been identified as a priority in the SAP. As a pre-cursor for this it is necessary to have full particulars about existing environmental monitoring activities in the region. Such information is already available for Namibia and South Africa. In the case of Angola, however, it needs to be collated and formally documented.

The final date for delivery of this project did not coincide with the due date due to several obstacles. Despite this the project EV/ANGOLA/03/03 has been completed.

The project required that project team members visit and interview key persons at several organizations/institutions. Almost 30 organizations or individuals (see Table 1) in the public and private sectors have been visited. Project team members had lengthy meetings with both representatives of these organizations and individuals. The focus points of each meeting held were the following:

- Explanation on the project's background, objectives and the expected results and above all the benefit to the country if the projects were implemented successfully
- Whether these individuals or organizations are at present or were in the past engaged in making routine oceanographic environmental measurements in Angola's EEZ (Scope of Project EV/ANGOLA/03/03) and the nature, availability, quality, accessibility and format of the data.

More or less the same organizations/individuals consulted in this report were also consulted for the project EV/ANGOLA/03/01 because of their common involvement in marine-related issues. Access to those organizations/institutions was not always easy. However, the project's objectives (Phase 1-Assessment) have been completed at all organizations/individual visited.

2. A comprehensive annotated inventory of what oceanographic environmental measurements are being routinely made in Angola's EEZ, by whom, where, and how often

Implementation of this project provided an opportunity to interact with many people and to discuss critical concerns and the opportunity of continuing to make routine oceanographic environmental measurements. The benefit of such measurements to the country in general and the respective organizations or individuals in particular was also raised. Issues were focused primarily on assessment of the present state of Oceanographic Environmental Monitoring and its benefit to the country. Most discussions with organizations/individuals visited provided useful information.

At the moment, the only Angolan institution that is routinely making oceanographic measurements is IIM. Most organizations/individuals in the public and private sectors which have been involved in making routine oceanographic environmental measurements in Angola's EEZ do not make these measurements anymore. Meteorological observations are taken at coastal airports routinely but with some limitations.

Amongst organizations/individuals visited some are making routine oceanographic / meteorological measurements (Tables 2, 2.1 & 2.2) covering the following parameters:

- CTD profiles; ADCP current meter measurements
- Sea water temperature; Salinity; Dissolved oxygen; pH; Transparency
- Chlorophyll-a; Fluorescence; micro-mezo plankton; phyto and zooplankton
- Air temperature and pressure; cloud; evaporation; precipitation; wind; humidity and meteorological observations taken by ships at sea.

3. A brief assessment of the (inferred) quality of the data being generated through the present monitoring activities

To avoid loss of data and information about the data collected by organizations or individuals, appropriate data sheets were created (Figures 1 and 2). Information received was filled in and recorded electronically in *Excel* spreadsheets. This will make it easier to know the existing information held by organizations/individuals visited for the next step of the project (*i.e.* phase 2).

Oceanographic studies, depending on the objective, mainly require high quality data in order to describe the temporal and spatial variability of physical, chemical and biological parameters in the oceans.

A shortcoming in the data collection method is that the data quality score was determined by the project team in consultation with the data 'owners'. The scoring system is therefore largely subjective and the results cannot easily be compared between organizations. In order to mitigate this, the quality assessment was based on criteria published in the December 2003 SADCO Newsletter Vol. 14 No 4: Table 3 "Parameter limits", Table 4 "Acceptable values for various temperature parameters" and Tables 5.1, 5.2 and 5.3 (Boyer and Levitus, 1994).

4. Comments on problems presently being encountered in oceanographic environmental monitoring off Angola and on the prospect of the present monitoring activities continuing

It is known that petroleum industry companies have made routine oceanographic measurements both offshore and inshore from oil platforms, but obstacles have been encountered in attempting to meet with oil company representatives. Also, one cannot ignore that the war conditions that Angola endured in the recent past still negatively affects our ability to routinely conduct oceanographic monitoring in Angolan's EEZ.

Much of the equipment of the organizations / individuals visited is obsolete or out of order due to lack of a budget for maintenance and human resources. These problems impact not only on the measurements of data but also on the maintenance of a database and calibration of instruments and their maintenance. Nowadays oceanographic monitoring requires “state of the art” technology and requires constant updating.

For the time being it can be noted that meteorological stations at the coastal airports and IIM labs (in Lobito and Namibe) attempt to make routine measurements but again difficulties arise due to limited human and material resources. Meteorological observations at the Namibe laboratory have improved recently due to the installation of new sensors (air temperature and wind speed) and provision of spare sensors (wind direction and humidity) through the BENEFIT Inshore Monitoring programme (Geoff Bailey, *pers. comm.*).

5. Recommendations/suggestions/comments in respect of sustainable and cost-effective and affordable future monitoring

Interested individuals / organizations need to resume making routine oceanographic / meteorological measurements (Table 6) and should submit a project proposal with phases specifying the instruments that they need. It will be best to begin with simpler projects (with basic measurements) and later on, according to progress, other more sophisticated instruments could be acquired.

Provision of adequate human resources through capacity building is a crucial factor to maintain continuous measurements. Further it is recommended that a team of national and/or foreign experts or consultants should assist individuals/organizations to identify activities needing to be done by them. In order to implement these activities, funding should be allocated and immediately afterwards, development of a needs-driven, cost effective early warning system for monitoring major natural marine and coastal environmental events should be set up in Angola and incorporated within the BCLME.

General Remarks:

- Ocean measurements can be done at daily or weekly intervals (depending on both human and instrumental resources). Motorized inflatable boats are needed for work at coastal fixed stations.
- No ports in Angola have tide gauges operating and they also need to take basic meteorological measurements. Instruments for undertaking observations are needed at all coastal airports.
- Most of the salt companies have not collected meteorological and tidal measurements for a long time; these measurements would improve their production
- All (small) fishing harbours lack tide gauges and meteorological measurements.

6. Summary and conclusions

A devastating war that ruined Angola had a negative impact on all sectors to the extent that it has handicapped oceanographic monitoring activities in Angola's EEZ. Just a few organizations are presently conducting monitoring because of a lack of funds and capable human resources.

This study summarized the current situation regarding monitoring activities undertaken in Angola's EEZ. Individuals/organizations have indicated that the current situation is critical and it is urgent that a decision be made to take the initiative to improve the state of oceanographic environmental monitoring. With Angola at peace, many individuals and organizations want to restore their monitoring activities therefore an assessment of the needs of individuals/organizations should be done to identify further activities to be implemented in phases in order to achieve good results. It is important to point out that the lack of regular and permanent communication affected a lot of our work during this project. Due to serious communication problems mainly in Namibe province (and the Namibe lab in particular) and sometimes in the Benguela lab, the project's members encountered many obstacles to maintain contact outside and even within Angola

7. Recommendations

As suggested for EV/ANGOLA/03/01, it is strongly recommended that the quality control of oceanographic and meteorological data has a dedicated phase one (*i.e*. a sub-project) because of the complexity and the exhaustive work involved.

Quality control procedures involve a variety of problems (Boyer and Levitus, 1994) and have been improved with time (Levitus and Boyer 1994a,b, c; Levitus *et al.*, 1994). The only way that project team members can at present communicate with one another most times is through use of personal cell phones. This is at the expense of the individuals themselves and they are naturally reluctant to use this means of communication for anything other than short messages.

In order to work within the established deadlines of the next phases of the project, project members must have access to a communication system which is fully functional with permanent access to the Internet and consequently, email. Without that vital means of communication, difficulties will continue to arise, resulting in deadlines being missed. This reflects badly on efficient execution of the established goals of the project.

8. Capacity Building

Senior project members trained colleagues in some useful data handling techniques during completion of this work. Data handling techniques included:

8.1 Training in the use of some *Excel* and *Word* tools:

Handling tools from the main toolbar such as “File”; “Edit”; “View”; “Insert”; “Format”; “Tools”; “Table” that helped to prepare data in a table form in *Excel* and *Word*

8.2 Converting files of the different formats into ".xls" format in *Excel:*

".txt" and ."cnv" format files were converted into ".xls" *Excel* files to facilitate the task.

Steps:

- Go to *Excel* and activate the file (use the item "all files" instead of "files in Microsoft E*xcel*")
- For the ".cnv" file format: "Delimited" (next); "Space" (next); "Finish" (next). It is necessary to verify the number of each column belonging to the respective parameters. If necessary, eliminate all unnecessary information then save the new file in the *excel* format ".xls"
- For the ".txt" file format: "Delimited (next); "Finish". It is necessary to verify the parameter of each column. If necessary, eliminate all unnecessary information then save the new file in the *Excel* format as an ".xls" file.

8.3 Preparing files with data in *excel* and *word*

After data has been converted or transformed into ".xls" format, the data are standardized in table form both in *Word* and *Excel*

8.4 Training to perform TS diagrams in *excel*

TS diagrams were used to plot temperature and salinity data for water samples, and hence to identify water masses (Brown *et al*, 1992) within Angola's EEZ.

9. Acknowledgements

The project members would like to express our sincere appreciation to all interviewees from the organizations or individuals who were willing and gracious to share their time with us. It is pleasing we could enjoy opportunities to learn the required information and to be able to interact with different people. During the meetings we met with many individuals within the time period available to us. Special thanks to all project team members, Nkosi Luyeye, Lesley Staegemann, Maria de Lourdes Sardinha, Francisca Delgado, Victoria de Barros and other individuals who made the current project possible. Geoff Bailey assisted with the editing and formatting of the final document.

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SADCO NEWSLETTER, Vol. 14 No 4 - December 2003.

Sheet N°_____/_____; / Date:_____/_____/_____; Person in charge (name and signature):_____ /_____

Project EV/ANGOLA/03/01: Compilation of Inventory and Acquisition of Oceanographic Environmental Data in the Angola Sector of the Benguela Current Large Marine Ecosystem: Phase 1 (Inventory)

Inventory of all (available) historic oceanographic environmental data collected in Angola's EEZ (prior to 2003)

Organization / Individual's name:_____

Parameters: Temperature; Salinity; Dissolved oxygen; Nutrients (silicate; phosphate; nitrate; nitrite, ammonium;…); Tides; Sea level; Chlorophyll; Phytoplankton; . Primary production; HAB; Zooplankton; Temperature via satellite; Waves; Optical measurements; Altimetry via satellite; Other data...;

BACKGROUND:

CURRENT SITUATION:

EXISTING DATA:

DIFFICULTIES:

PROPOSALS:

PERSPECTIVES:

Figure 1: EV/ANGOLA/03/01 project data sheet form 1

Sheet N°_____/_____; / Data:_____/_____/_____; Person in charge (name and signature):_____ /_____

Project EV/ANGOLA/03/01: Compilation of Inventory and Acquisition of Oceanographic Environmental Data in the Angola Sector of the Benguela Current Large Marine Ecosystem: Phase 1 (Inventory)

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Parameters: Temperature; Salinity; Dissolved oxygen; Nutrients (silicate; phosphate; nitrate; nitrite, ammonium); Tides; Sea level; Chlorophyll; Phytoplankton; . Primary production; HAB; Zooplankton; Temperature via satellite; Waves; Optical measurements; Altimetry via satellite; Other data...;

Parameter: _____	Area / Coordinates	Period/measurement frequency/ Depth (m)	Quality (very good:1; good:2; normal:3; bad:4)	Remarks/Comments
Parameter: _____				
Parameter: _____				

Figure 2: EV/ANGOLA/03/01 project data sheet form 2

Table 1: List of organizations/individuals visited

ORGANIZATIONS	INDIVIDUALS
Airport of Benguela	Employees in the technical area
Airport of Lobito	Employees in the technical area
Airport of Namibe "Yuri Gagarine"	Mr.Terça Jesus F. Adriano, Director of the meteorological services of Namibe
Angolan national library	Employee linked to the services of the library
Baia-Farta local fishery board	Employee linked to the services of the fishery section
Benguela municipality administration	Employees
Benguela provincial environmental board	Mr. J dos Santos, Head of provincial department
Benguela provincial fishery board	Eng. J Silva, Head of production department
Port Captain of Lobito	Mr. Henriques Pedro, Captain of the Lobito port
Port Captain of Namibe	Mr. Germano, Captain of the Namibe port
CRIM Lobito (Benguela lab, IIM)	Mr. Enoque Cangajo, Responsible of the oceanography sector
CRIM Namibe (Namibe lab, IIM)	Mr. Q Fidel, Director of lab; P Tchipalanga, Head of the technical sector
Fishery factory Praia Amelia	Mr. Manuel Francisco, Head of production
IIM-Luanda	Mr. F de Almeida, Oceanographer; Mr. D Azevedo, database manager
INAMET Benguela (Weather Bureau)	Employee linked to the services of the weather bureau
INAMET Luanda (Weather Bureau)	Eng. Manga Waku
Institut of agronomy research of Angola	Eng. C Nequetela, Head of technical area
Laboratory of technology and fish processing, Benguela	Head of the lab
Laboratory of technology and fish processing, Tombwa, IIM	Ms. E Mangueira, Head of lab; Mr. F Junior, Head of inspection sector
Lobito municipality administration	Employees
Luanda international airport "4 de Fevereiro"	Eng. Osvaldo, Chief of the meteo division of the airport
Luanda provincial fishery board	Employee of the fishery section
Namibe library	Employees
Namibe provincial fishery board	Employee of the fishery section
Port of Luanda	Mr. Mariano Neto / Area of safety and environment of the port
Port of Namibe	Employee linked to the services of the port
Salt company "sal do sol"	Mr. Chitomba, Head of production
Salt company of Cacuaco	Dombaxi Tana, Director
Tombwa shipyard of naval repairing	Employees in the technical area

Table 2: Organizations/individuals that have been routinely making oceanographic measurements (since 1995)
Organization: Ministry of Fisheries
Observations from research and fishing vessels

Nomination	**Parameters**	**Remarks/ Comments**
1- Lobito Fixed Station		
Location: 12°18'36'' S;13°34'38 E Depth (m): 0 - 35 Period: 1995 - 2000 Quality: 1 Sampling: Daily (except w/ends/holidays) Holding: CRIM - Lobito Contact: K. Kilongo/E.Canganjo	Sea water temperature Salinity Oxygen pH Cloud Transparency	Data with some gaps
Period: 2001 - until now (2004) Quality: 2. For pH "4" Sampling: Daily (exc. weekends/holidays) Holding: CRIM - Lobito Contact: K. Kilongo/E.Canganjo	Sea water temperature Transparency Cloud pH	Continuation of determination of pH but because of the lack of spare electrodes, results are doubtful; continued use of old Nansen bottles, thermometers and other old instruments Data with some gaps

2- Namibe Monitoring Line (transect)		**Time**	**Vessel**	
Location: 15° S 12° 08.598'- 11°17.360' E Stations: 7 (depending on vessel size) Distance: 1, 2, 5, 10, 20, 30, 50 nmiles Depth (m): to a maximum of 2000m offshore Period: 1999 - 2004 Quality: 1 Sampling: Bi-monthly (ideally) Holding: CRIM - Namibe / IIM - Luanda Contact: Q. Fidel/P. Tchipalanga	Sea Temperature Salinity Oxygen nutrients ADCP currents distrbtn., abundance species composition phyto, micro-mezo & ichthyoplankton, fluorescence and chlorophyll-a	26/7/1999	*Welwitchia*	CTD data (T,S,O)
		12/4/2000	*Tico - Tico*	Winch problem - slow
		26/8 & 16/9/2000	*Meteor*	T,S,0 nuts,chl,ADCP
		24/1/2001	*Tico - Tico*	Winch problem - slow
		21/3/2001	*Welwitchia*	CTD data (T,S,O)
		31/5/2001	*Calafate*	Namibian STD u/s
		2001/07/08	*Welwitchia*	CTD data (T,S,O)
		2001/07/11	*Calafate*	3 stations (1,2,3)
		03-04/3/2002	*Africana*	T,S,0 nuts,chl,ADCP
		21/1/2003	*Paulo Sergio*	T,S,0,chl,plankton
		13/2/2004	*Humboldt*	CTD data + chl-a
		05/05/2004	*Humboldt*	CTD data

3 - Regular Survey off Angola by Norwegian *RV Fridjtof Nansen*			**Date**
Location: ~05°30' S - 17°00 S Stations: Selected (regular) transects Depth (m): 0 - 1600 m Altit. (m): 10 m (meteorological measurements) Period: 1995 - 2004 Quality: 1 Sampling: 2x / year (summer and winter) Holding: IIM - Luanda Contact: D. Azevedo/ A. Filomena	CTD (T, S, O) ADCP currents Ship's met data	1995	Feb-Apr; July - Sept
		1996	Feb-Mar; Aug-Sept
		1997	Feb-Mar; May-Jun; Aug-Sept
		1998	Mar; May; Jul-Aug
		1999	March; Aug
		2000	March-Apr; July-Aug
		2001	Mar; Jul-Aug
		2002	Feb-Mar; Aug-Sept
		2003	Jul-Aug
		2004	Mar-Apr; Aug

Table 2.1: Organizations/individuals that have been routinely making meteorological measurements (since 1995).
Organization: Ministry of Transport and Communication
Meteorological observations at coastal airports

Nomination		Parameters	Remarks/ Comments
1- Luanda airport "4 de Fevereiro"			
Location:	08°51' S;13°14' E	Wind	
Altitude (m):	74 m	Air Temperature	
Period:	1995 - 2004	Precipitation	
Data Quality	1	Cloud	Altitude of cloud base (m): Above sea level
Sample Period:	Daily average	Humidity	
Holding:	INAMET - Luanda	Pressure	
Contact:	Eng Manga Waku	Evaporation	
2 - Benguela airport			
Location:	12°35' S;13°25' E	Wind	
Altitude (m):	5 m	Air Temperature	
Period:	1995 - 2004	Precipitation	
Data Quality	1	Cloud	Altitude of cloud base (m): Above sea level
Sample Period:	Daily average	Humidity	
Holding:	INAMET - Benguela	Pressure	
Contact:	Enoque Cangajo	Evaporation	
3 - Lobito airport			
Location:	12°22' S;13°32' E	Wind	
Altitude (m):	10 m	Air Temperature	
Period:	1995 - 2004	Precipitation	
Data Quality	1	Cloud	Altitude of cloud base (m): Above sea level
Sample Period:	Daily (Dt = 06 h)	Humidity	
Holding:	INAMET - Lobito	Pressure	
Contact:	Enoque Cangajo	Evaporation	
4- Namibe airport			
Location:	15°12' S;12°09' E	Wind	
Altitude (m):	44 m	Air Temperature	
Period:	1995 - 2004	Precipitation	
Data Quality	1	Cloud	Altitude of cloud base (m): Above sea level
Sample Period:	Daily average	Humidity	
Holding:	INAMET - Namibe	Pressure	
Contact:	Tercas de Jesus (head office)	Evaporation	

Table 2.2: Routine oceanographic data inventory (since 1995 in Angola's EEZ)

Variable	Organization	Geographical location	Sampling interval	Remarks/ Comments
sea water temperature salinity oxygen pH cloud transparency	Lobito fixed station CRIM-Benguela, Lobito (IIM)	12° 18' 36'' S; 13° 34' 38'' E	&t=24h	Conventional bottle data station Data with some gaps 1995-2000 Depth: 0 - 35m Observations are made during working days only (except weekends and holidays);
sea water temperature transparency cloud pH	Lobito fixed station CRIM-Benguela, Lobito (IIM)	12° 18' 36'' S; 13° 34' 38'' E	&t=24h	Conventional bottle data station Data with some gaps 2001-until now (2004) Depth: 0 - 35m Continuation of determination of pH but results are in doubt because Of a lack of spare electrodes;
CTD nutrients ADCP currents distribution, abundance and species composition of phyto, micro-mezo and ichthyoplankton fluorescence and chlorophyll-a	Namibe monitoring line CRIM-Namibe, Namibe (IIM)	The line of sampling extends from the bay at Namibe directly offshore, at 15°S, with stations at 1, 2, 5, 10, 20 ,30 & 50 miles offshore	monthly and or bi-monthly	CTD data station 2000-until now (2004) NML transects performed: 26 Aug-16 Sep 2000 04 December 2000 24 January 2001 21 March 2001 31 May 2001 07 August 2001 07 November 2001 03-04 March 2002 21 January 2003 13 February 2004 17 May 2004
CTD ADCP currents ship's meteo data	Institute of Marine Research, (IIM), Luanda	Off Angola (entire Angolan coast) ~05° 30S; ~17° 00S	periodically (seasonally)	IIM's headquarters are in Luanda, data are collected from the RV Fridjtof Nansen pelagic and demersal surveys

Table 3: Parameter limits

(source: SADCO Newsletter Vol 14 No 4-December 2003)

Parameter	**WMO limits**	**SADCO**
SST	(-) 2 to 37 deg C	See Table 4
Drybulb	(-) 25 to 40 deg C	See Table 4
Wetbulb	(-) 25 to 40 deg C. < Drybulb	See Table 4
Dewpoint	(-) 25 to 40 deg C. < Wetbulb	See Table 4
Atmospheric pressure	930 to 1050 kPa	Same as WMO
Wind speed	0 to 40 m/s	Same as WMO
Wave height	0 to 17.5m	Same as WMO
Wave period	0 to 20s	Same as WMO
Swell height	0 to 17.5m	Same as WMO
Swell period	0 to 25s	Same as WMO

Table 4: Acceptable values for various temperature parameters
(source: SADCO Newsletter Vol 14 No 4-December 2003)

Latitude	Sea Surface Tempera		Drybulb (C)		Wetbulb (C)		Dewpoint (C)	
	west	east	west	east	west	east	west	east
10 - 05 N	18 to 37	15 to 37	19 to 38	17 to 37	16 to 38	17 to 37	16 to 38	16 to 37
05 - 00 N	19 to 37	18 to 36	19 to 37	19 to 35	16 to 37	17 to 37	14 to 37	16 to 35
00 - 05 S	16 to 37	20 to 36	16 to 38	19 to 35	15 to 38	17 to 37	12 to 38	14 to 35
05 - 10 S	**12 to 37**	**19 to 37**	**12 to 40**	**19 to 37**	**12 to 40**	**17 to 37**	**10 to 40**	**14 to 37**
10 - 15 S	**8 to 33**	**20 to 37**	**7 to 33**	**19 to 37**	**8 to 33**	**16 to 37**	**7 to 33**	**11 to 37**
15 - 20 S	**7 to 33**	**21 to 37**	**7 to 33**	**14 to 36**	**4 to 33**	**13 to 36**	**3 to 33**	**9 to 36**
20 - 25 S	7 to 33	15 to 36	7 to 33	13 to 37	4 to 33	7 to 37	0 to 33	3 to 37
25 - 30 S	7 to 33	13 to 35	7 to 33	9 to 35	3 to 33	6 to 35	0 to 33	2 to 35
30 - 35 S	6 to 33	6 to 34	2 to 30	5 to 33	2 to 30	2 to 33	-13 to 30	-2 to 33
35 - 40 S	5 to 33	7 to 30	0 to 28	2 to 30	-1 to 30	0 to 34	-7 to 28	-5 to 30
40 - 45 S	-2 to 28	-2 to 28	-10 to 27	-10 to 27	-10 to 27	-10 to 27	-10 to 27	-10 to 27
45 - 50 S	-2 to 20	-2 to 20	-15 to 25	-15 to 25	-15 to 25	-15 to 25	-15 to 25	-15 to 25
50 - 55 S	-2 to 18	-2 to 18	-15 to 17	-15 to 17	-15 to 19	-15 to 19	-15 to 19	-15 to 19
55- 60 S	-2 to 16	-2 to 16	-19 to 17	-19 to 17	-19 to 17	-19 to 17	-19 to 17	-19 to 17
60 - 65 S	-2 to 14	-2 to 14	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15
65 - 70 S	-2 to 8	-2 to 8	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15
70 - 75 S	-2 to 8	-2 to 8	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15
75 - 80 S	-2 to 8	-2 to 8	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15	-25 to 15

Table 5.1: Temperature ranges for the Atlantic Ocean as a function of depth
(source: Boyer, T., and S. Levitus, 1994); units=° C

Depth	North Atlantic		Eq. Atlantic		South Atlantic	
	Low	High	Low	High	Low	High
0	-3	35	5	35	0	32
10	-3	35	5	35	0	32
20	-3	35	5	35	0	32
30	-3	32	5	35	0	32
50	-3	32	5	35	0	32
75	-2	32	5	35	0	32
100	-2	30	5	30	-1.5	32
125	-2	28	5	30	-1.5	30
150	-2	28	5	30	-1.5	30
200	-2	28	5	30	-1.5	30
250	-1.7	28	3	28	-1.5	28
300	-1.7	28	3	28	-1.5	28
400	-1.5	20	3	28	-1.5	28
500	-1.5	20	3	28	-1.5	28
600	-1.5	20	3	20	-1.5	20
700	-1.5	20	3	20	-1.5	20
800	-1.5	20	-0.5	20	-1.5	20
900	-1.5	20	-0.5	20	-1.5	20
1000	-1.5	18	-0.5	18	-1.5	18
1100	-1.5	18	-0.5	18	-1.5	18
1200	-1.5	18	-0.5	18	-1.5	18
1300	-1.5	18	-0.5	18	-1.5	18
1400	-1.5	18	-0.5	18	-1.5	18
1500	-1.5	18	-0.5	18	-1.5	18
1750	-1.5	13	-0.5	13	-1.5	13
2000	-1.5	13	-0.5	13	-1.5	13
2500	-1.5	13	-0.5	13	-1.5	13
3000	-1.5	7	-0.5	7	-1.5	7
3500	-1.5	7	-0.5	7	-1.5	7
4000	-1.5	7	-0.5	7	-1.5	7
4500	-1.5	7	-0.5	7	-1.5	7
5000	-1.5	7	-0.5	7	-1.5	7
5500	-1.5	5	-0.5	3	-1.5	3

Table 5.2: Salinity ranges for the Atlantic Ocean as a function of depth
(source: Boyer, T., and S. Levitus, 1994); units=psu

Depth	North Atlantic		Eq. Atlantic		South Atlantic	
	Low	High	Low	High	Low	High
0	0	40	0	40	0	40
10	27	38.2	20	37.6	28	38.5
20	28.3	38.2	28	37.4	28	38
30	28.5	38.2	31	37.4	30.6	38
50	28.9	38	31.4	37.4	31	38
75	28.9	38	31.8	37.4	31.2	38
100	29.4	38	31.8	37.4	31.4	38
125	29.4	38	31.8	37.4	31.4	37.8
150	29.6	37.2	31.8	37.2	31.4	37.4
200	29.9	37.4	31.8	37	31.4	36.6
250	30.3	37.1	32	37	31.4	36.2
300	30.8	36.8	32.2	36.8	31.6	36
400	30.8	36.6	32.4	36.6	32	35.8
500	31.2	36.6	33.7	36.5	34	35.5
600	32.2	36.6	33.7	36	34.1	35.1
700	33	36.6	33.6	35.8	34.1	35.1
800	33	36.6	33.6	35.6	34.1	35
900	33	36.6	33.6	35.6	34.1	34.9
1000	33	36.6	33.6	35.4	34.2	34.9
1100	33	36.6	33.6	35.4	34.2	34.9
1200	33	36.6	33.6	33.6	34.2	34.9
1300	33	36.6	33.6	33.6	34.3	34.9
1400	33	36.6	33.6	33.6	34.3	35
1500	33	36.6	33.6	33.8	34.4	35
1750	33	36.6	34.6	34.6	34.5	35
2000	33	36	34.7	34.7	34.6	35
2500	34.7	35.5	34.8	34.8	34.6	35
3000	34.8	36.6	34.8	34.8	34.66	35
3500	34.8	35.4	34.7	34.7	34.64	35
4000	34.8	35.4	34.5	34.5	34.62	35
4500	34.8	35.4	34.5	34.5	34.62	35
5000	34.8	35.4	34.5	34.5	34.62	35
5500	34.8	35.4	34.5	34.5	34.62	35

Table 5.3: Oxygen ranges for the Atlantic Ocean as a function of depth
(source: Boyer, T. and S. Levitus, 1994); units=ml/l

Depth	North Atlantic		Eq. Atlantic		South Atlantic	
	Low	High	Low	High	Low	High
0	0.01	12	0.01	12	0.01	12
10	0.01	12	0.01	12	0.01	12
20	0.01	12	0.01	12	0.01	12
30	0.01	12	0.01	12	0.01	12
50	0.01	12	0.01	12	0.01	12
75	0.01	95	0.01	9.5	0.01	9.5
100	0.01	95	0.01	9.5	0.01	9.5
125	0.01	95	0.01	9.5	0.01	9.5
150	0.01	95	0.01	9.5	0.01	9.5
200	0.01	90	0.01	9	0.01	9
250	0.01	90	0.01	9	0.01	9
300	0.01	8.5	0.01	8	0.01	8
400	0.01	8.5	0.01	8	0.01	8
500	0.01	8.5	0.01	8	0.01	8
600	0.01	8.5	0.01	7.1	0.01	7.1
700	0.01	8.5	0.01	7.1	0.01	7.1
800	0.01	8.5	0.01	7.1	0.01	7.1
900	0.01	8.5	0.01	7.1	0.01	7.1
1000	0.01	8.5	0.01	7.1	0.01	7.1
1100	0.01	8.5	0.01	7.1	0.01	7.1
1200	0.01	8.5	0.01	7.1	0.01	7.1
1300	0.01	8.5	0.01	7.1	0.01	7.1
1400	0.01	7.1	0.01	7.1	0.01	7.1
1500	0.01	7.1	0.01	7.1	0.01	7.1
1750	0.01	7.1	0.01	7.1	0.01	7.1
2000	0.01	7.1	0.01	7.1	0.01	7.1
2500	0.01	7.1	0.01	7.1	0.01	7.1
3000	0.01	7.1	0.01	7.1	0.01	7.1
3500	0.01	7.1	0.01	7.1	0.01	7.1
4000	0.01	7.1	0.01	7.1	0.01	7.1
4500	0.01	6.9	0.01	6	0.01	6
5000	0.01	6.9	0.01	6	0.01	6
5500	0.01	6.9	0.01	6	0.01	6

Table 6: Organizations / public sectors in Angola wanting to restore oceanographic monitoring.

Organizations & Public sectors	**Type of needed/restored measurements**	**Remarks/ Comments**
IIM-Luanda CRIM-Namibe, IIM (Namibe lab) CRIM-Benguela, IIM (Benguela lab)	coastal / nearshore daily hydrographic measurements coastal / nearshore daily hydrographic measurements coastal / nearshore daily hydrographic measurements	> Measurements can be done at daily or weekly intervals time (depending on both human and instrumental resources) > a powerful motorized (small) boat is needed for coastal fixed stations' works
Port of Luanda Port of Lobito Port of Namibe Port of Cabinda	tide gauges (sea level, tides, waves) meteorological measurements	> Angolan ports & jetties do not have tide gauges operating nor do they have any of the basic meteorological measurements
Airport of Namibe "Yuri Gagarine"	electronic barometer, electronic weather vane, electronic anemometer, hygrometer, hydrograph, thermograph, Picher's vapor meter, depth thermometer of 0 and 10 cm, electronic weather station	> These instruments or upgrades are needed at all coastal airport meteorological stations
Salt company of Cacuaco Salt company "sal do sol"	meteorological measurements, tides	> Most salt companies have not collected meteorological or tidal measurements for a long time. They need these measurements to aid production
Tombwa naval shipyard	tide gauges (sea level, tides, waves) meteorological measurements	> Almost all small ports lack these instruments