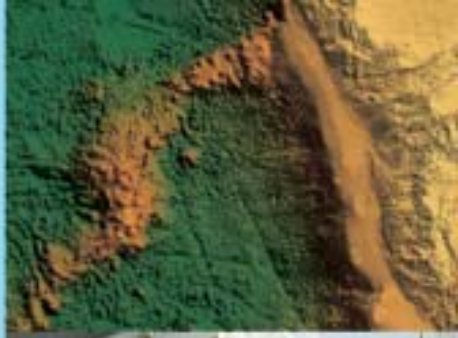
AFRICAN OCEANS AND COASTS



IODE International Oceanographic Data and Information Exchange

ODINAFRICA

Acknowledgments:
Appreciation is expressed to all those who assisted in the preparation of this book. It is the culmination of the hard work of the many people and institutes involved in ODINAFRICA III, with special thanks due to the invited authors for their contribution. The editors would like to thank Thorkild Aarup and Bernardo Aliaga for their review of Chapters 4 and 6. Rita Anyumba for the preparation of the first draft and Sam Ngete of KMFRI for producing all maps of Chapter 7. Special thanks are due to Brian Harding, Malika Bel Hassan-Abid and Peter Pissierssens for providing a final edit of the book.

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For bibliographic purposes this document should be sited as follows:
UNESCO-IOC. 2009. *African Oceans and Coasts*. Odido M. and Mazzilli S. (Eds).
IOC Information Document, 1255, UNESCO Regional Bureau for Science and Technology in Africa, Kenya.

IOC/INF-1255

ISBN 92-9158-017-1

Published by the United Nations Educational, Scientific and Cultural Organization
Regional Bureau for Science and Technology in Africa.
P.O. Box 30592, Nairobi, 00100 GPO,
Kenya

Layout, design and printing by Lino Typesetters (Kenya) Ltd.

Printed in Kenya on chlorine free paper produced from sugar cane pulp for sustainable afforestation.

Contents

Preface

Coastal and marine resources provide the basis for a substantial proportion of economic and social activities in Africa. These include fishing, tourism, offshore mining (including oil and gas), navigation and other industries. Africa, like the rest of the world is experiencing a steady migration of populations to the coastal areas, in search of improved livelihoods and economic opportunities. This has led to intense competition for the use of coastal areas and resources by different sectors of the society. Science-based approaches to sustainable management will ensure equitable solutions.

The stress on the coastal and marine resources originates in: industrial and municipal pollution, coastal change and modification, destructive fishing and over-fishing, invasive species, and global issues such as sea level rise and climate change. These human-driven factors exacerbate natural degradation of coastal resources due to storm surges, droughts, floods and threats to the availability and use of freshwater. Given that the lives and livelihoods of much of the coastal population are dependent on coastal and marine resources, conserving and sustainably managing these resources is essential for social and economic development and in efforts towards poverty alleviation in Africa.

The availability of reliable, up-to-date, accessible data and information is essential as a basis for integrated and sustainable management of coastal and marine environment and resources. Indeed, the shortage of such data and information has been and continues to be a major constraint to sustainable development in coastal and marine areas in Africa. The Johannesburg Plan of Implementation approved in 2002 as a major outcome of the World Summit on Sustainable Development (WSSD) places great emphasis on the need to obtain information about the environment as the basis for monitoring its behavior and forecasting the effects of environmental change, so as to provide decision makers with the tools they need to improve and sustain development and to mitigate or reverse undesirable trends or effects.

An increasing number of initiatives, supported by national governments and international partners, to address coastal and marine resource management in an integrated manner have been launched in Africa in recent years. However the data and information generated from these projects and programmes remain virtually inaccessible to marine scientists and resource managers though they are in the public-domain.

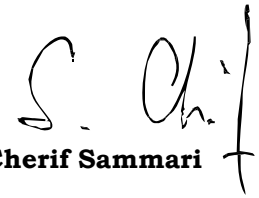
The Ocean Data and Information Network for Africa (ODINAFRICA) brings together more than 40 marine related institutions from twenty five countries in Africa (Algeria, Angola, Benin, Cameroon, Comoros, Congo, Cote d'Ivoire, Egypt, Gabon, Ghana, Guinea, Kenya, Madagascar, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Senegal, Seychelles, South Africa, United Republic of Tanzania, Togo, and Tunisia). With the support of the Intergovernmental Oceanographic Commission of UNESCO (United Nations Educational, Scientific and Cultural Organization) and the Government of Flanders (Kingdom of Belgium) the network has strived to address the challenges faced in ensuring that ocean and coastal data and information generated in national, regional and global programmes are readily available to a wide range of users in an easily understandable format.

Each of the participating institutions has developed a suite of data and information products including: directories of marine and freshwater professionals, catalogues of marine related data sets, marine species databases, library catalogues, and catalogue of marine related publications from or about Africa. ODINAFRICA made substantial contribution to the development of the African sea level network, which currently comprises more than 40 tide gauges installed and maintained by several organizations, including national agencies and international programmes. The African Marine Atlas (www.africanmarineatlas.net) developed in collaboration with the African Coelacanth Project (ACEP), and the United Nations Environment Programme (UNEP) provides access to maps, images, data and information to a wide range of users.

These are but a few of the products that have been developed by the Ocean Data and Information Network for Africa. The IOC through its continued efforts in capacity development during the last 25 years

has endeavored to put in place at the national level the scientific and technical capabilities necessary to use these resources in the formulation of national policies. New cohorts of young African scientists and technicians are rapidly populating the old science institutions left from the colonial times. New, more modern institutions are emerging and the old ones are being re-invented to serve new needs. Without an autonomous development of science in Africa, the continent will remain reliant on external help and guidance. There is still a long way to go, and significant resources will be needed to achieve a seamless end-to-end system, from scientific facts to policy and management decisions. This said, what has been achieved so far is both refreshing and encouraging.

The Intergovernmental Oceanographic Commission of UNESCO and the Government of Flanders are proud to have been partners in this worthwhile endeavor and look forward to continued collaboration with the Members States from Africa in further development and strengthening of the network so that it continues to provide the data, information and products required for management of the marine and coastal environment and resources for the benefit of the coastal populations of Africa.



Dr. Cherif Sammari

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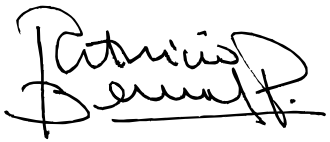

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Executive Secretary
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Assistant Director-General of UNESCO

1 Introduction

1 Introduction

The IODE capacity building activities in Africa were initiated in 1989 with the Regional Cooperation in Scientific Information Exchange in the Western Indian Ocean (RECOSCIX-WIO) project.

The Intergovernmental Oceanographic Commission (IOC) launched RECOSCIX-WIO after a fact-finding mission undertaken in 1987 (Onyango and Pissierssens, 1987), funded by UNESCO. The objective of this mission was to investigate the feasibility of establishing a regional network (with point-to-point electronic links using modems) for the exchange and sharing of scientific literature. The study concluded that such a network was indeed feasible and this led to the RECOSCIX-WIO project being founded in 1989. The programme evolved to incorporate data management, and extended to other regions in Africa as illustrated below:
Between 1989 and 1996 RECOSCIX-WIO created an effective network of marine libraries in Eastern Africa. The network not only established institutional linkages but also human networks. This led the region to request support from UNESCO/IOC to expand the scope of the network to include exchange of oceanographic data.

The start of the cooperation between the Government of Flanders and UNESCO/IOC in 1997 enabled UNESCO/IOC through IODE to respond to the request and this led to the establishment of the Ocean Data and Information Network for Eastern Africa (ODINEA).

ODINEA focused on providing basic infrastructure in 7 African countries (Kenya, Madagascar, Mauritius, Mozambique, Seychelles, South Africa and Tanzania). An important element in the project was support provided to institutes to access the Internet. This was crucial in exposing the participating institutions to the rapidly expanding Internet through which data could be obtained and through which fast communication with colleagues became possible. During the final ODINEA workshop the project participants stated:

> *"The capacity of the data centres to collect, process, analyze, store and interpret various categories of data sets was strengthened through the provision of up-to date computer equipment and peripherals, software as well as training for data centre personnel.*
>
> *The centres have used this capacity to develop national meta databases, thereby enabling users to know what data sets are available and how to access them. The development of national data archives has contributed to the preservation of data sets which were in danger of being lost. Through linkages established within the framework of the project, the centres have been able to access data sets from regional and international data centres."*

Figure 1. Development of IODE projects in Africa 1989-2008.

A pilot information exchange project for Western Africa – the Regional Cooperation in Scientific Information Exchange for the Central Eastern Atlantic (RECOSCIX-CEA) was implemented at the same time as ODINEA.

The achievements of ODINEA and RECOSCIX-CEA laid the foundations for establishment of a truly pan-African Ocean Data and Information Network (ODIN) for Africa. Thanks to funding from the Government of Flanders it was possible for IODE to implement the ODINAFRICA-II[1] project. Twenty Member States of IOC from Africa (Benin, Cameroon, Comoros, Cote d'Ivoire, Gabon, Ghana, Guinea, Kenya, Madagascar, Mauritania, Mauritius, Morocco, Mozambique, Nigeria, Senegal, Seychelles, South Africa, Tanzania, Togo and Tunisia) participated in this project.

The main objectives of ODINAFRICA-II were:

1. Providing assistance in the development and operation of National Oceanographic Data (and Information) centres and establishing their network in Africa;
2. Providing training opportunities in marine data and information management by applying standard formats and methodologies as defined by the IODE;
3. Assisting in the development and maintenance of national, regional and Pan-African marine metadata, information and data holding databases;
4. Assisting in the development and dissemination of marine and coastal data and information products by responding to the needs of a wide variety of user groups using national and regional networks.

Ten new National Oceanographic Data and Information Centres (NODCs) were established in Benin, Cameroon, Comoros, Gabon, Ghana, Mauritania, Morocco, Senegal, Togo, and Tunisia during ODINAFRICA-II.

Support from the project enabled the NODCs in the participating Member States to cater for a wide range of activities such as operational expenses

[1]Note: ODINEA and RECOSCIX-CEA were considered as ODINAFRICA-I

Figure 2. A librarian at one of the ODINAFRICA institutions assists a user access information.

(including internet connection), development of meta databases and data archives, and development of data and information products. The ODINAFRICA-II activities in each country were publicized through websites, brochures, information sheets, data summaries, calendars, meetings/seminars, lectures to educational institutions, and meetings with key government officials.

In order to improve networking between the ODINAFRICA institutions, databases developed at national level (such as directories of experts and institutions, meta databases, library catalogues etc.) were now collected, quality controlled and formatted for access via the Internet in order to encourage broader usage.

One of the conclusions of ODINAFRICA-II was that data management capacity had now been created in all participating countries but that more emphasis should be put on stimulating data collection through the establishment of observing systems.

Figure 3. Installation of equipment for VSAT internet access at IHSM, Tulear, Madagascar.

The third phase, ODINAFRICA-III started in 2004 as a large scale project funded under the UNESCO-Flanders Trust Fund for Science (FUST). An additional five Member States (Algeria, Angola, Congo, Egypt, and Namibia) joined the network, bringing the total to twenty-five.

ODINAFRICA-III aimed to construct a Pan-African coastal observing system including a core network of tide gauges, but also making other in situ measurements where appropriate. The core network was to capitalize on existing systems like the global network of tide gauges established by IOC's Global Sea Level Observing System (GLOSS) programme. The data stream from the observing network would be fed into the network of data centres established through the ODINAFRICA project, and would provide the basis for development of a wide variety of products and services, so as to ensure the widest possible use for the data centres created during the ODINAFRICA project. The observing network would make a fundamental contribution to in situ ocean observing system of Regional Ocean Observing and Forecasting System for Africa (ROOFS AFRICA) and to global networks of ocean-related data and information. ROOFS-AFRICA is part of the Global Ocean Observing System for Africa (GOOS AFRICA) and has been accepted as a key project of NEPAD.

One of the core methodologies of ODINAFRICA-III was the concept of national versus regional work plans. Although the project had a number of regional objectives and expected deliverables, each partner institution was expected (and provided with the support) to address specific national needs for data or information products. This approach resulted in a wide and rich variety of data and information products being generated.

The implementation progressed well, with the achievements including:

- Each of the participating institutions developed a suite of data and information products that have been quality controlled, merged and availed through the project website (www.odinafrica.org). These include: library catalogues, catalogues of national data sets and data sources (meta databases), directories of marine and freshwater professionals, directories of marine related institutions and their profiles, marine data archives and marine biodiversity databases. These are also available from NODC websites (www.nodc-countryname.org e.g. www.nodc-senegal.org). Training was provided on a wide range of topics such as data and information management, development of e-repositories, websites development, application of remote sensing and GIS to coastal management, marine biodiversity data management, modeling; end to end data management; and sea level data analysis and interpretation.

- New tide gauges were installed in Cameroon, Congo, Djibouti, Egypt, Ghana, and Mauritania. The installation of Global Navigations Satellite Systems – GNSS receivers at the sea level stations in Takoradi (Ghana), and Inhambane and Pemba (Mozambique) provides the connection between the horizontal and

the vertical datum at these locations. This brings the total number of tide gauges installed along the African coastline to more that 40. Information on the network is available on the African Sea Level Network website (www.iode.org/glossafrica), while the data from 22 of the stations can be accessed near-real time at www.sealevelstations.net.

- The African Marine Atlas developed in collaboration with the African Coelacanth Project (ACEP), and the United Nations Environment Programme (UNEP) provides access to maps, images, data and information to a wide range of users. The static website (http://omap.africanmarineatlas.net) contains over 800 downloadable data products derived from the fields of marine geo-sphere, hydrosphere, atmosphere, biosphere, geopolitics and human socio-economics.

- ODINAFRICA used several mechanisms to publicize its activities and products. These included: posters and brochures, newsletters (WINDOW and COSMARNews), and websites (http://www.odinafrica.org; African Ocean Portal: http://www.africanoceans.net; African repository of marine related publications - OceanDocs-Africa: http://iodeweb1.vliz.be/odin/handle/1834/1337; African marine atlas www.africanmarineatlas.net; the Sea level data facility www.sealevelstation.net; the sea level information site www.iode.org/glossafrica).

These and other products and activities are described in details in other chapters of this book.

The fourth phase of ODINAFRICA (2009 – 2012) will focus on application of data and information products to the sustainable management of marine and coastal resources, as well as reducing the risks of ocean related hazards. The following are the expected outcomes and deliverables of ODINAFRICA-IV:

(i). Strengthened and sustainable marine data and information management infrastructure in the ODINAFRICA countries

(ii). National multi-sectoral and multi-stakeholder data networks to maximize the use of available data and to make available IODE NODC's data management expertise to other stakeholders

Figure 4. Technicians practice levelling of tide gauge benchmarks at a training course in Ostende, Belgium.

(iii). Prioritize customized products such as forecasts, predictions, models, atlases, scenarios addressing the key issues which were identified such as shoreline change, marine related hazards and disaster management, management of key ecosystems and sustainable use of resources.

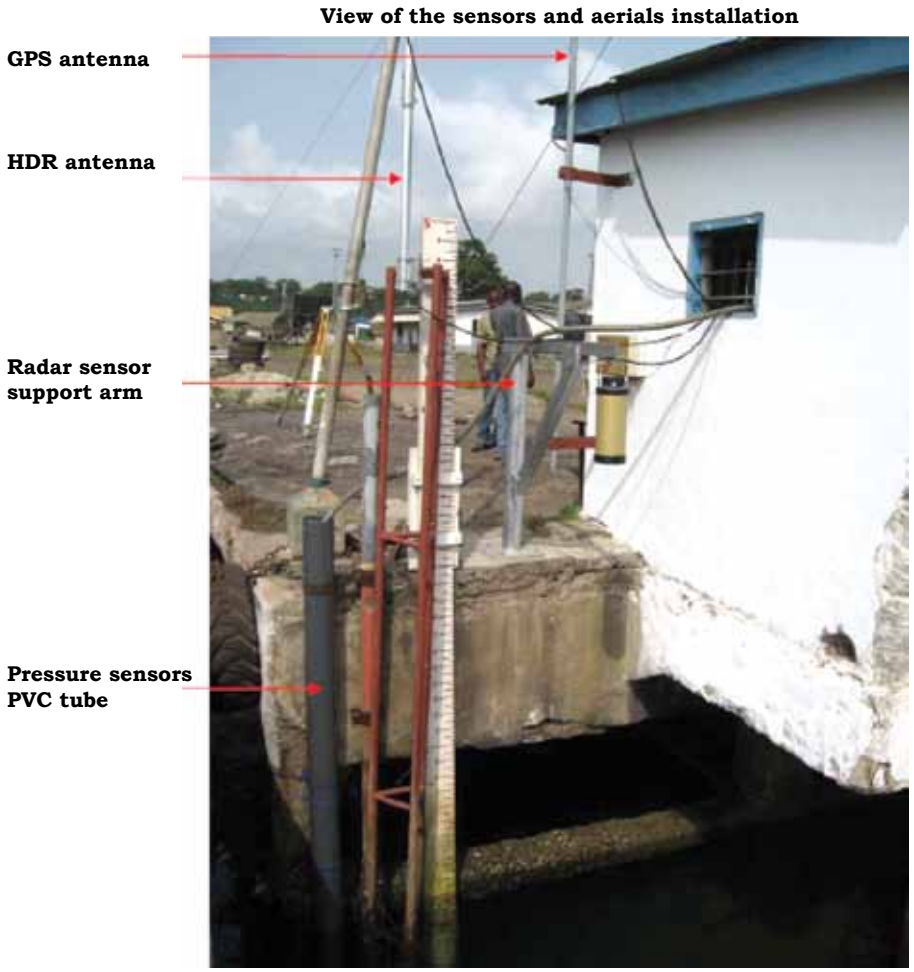

Figure 5. Tide gauge installed at Takoradi, Ghana.

(iv). Improved mechanisms for the dissemination and application of data, information and products through standards based catalogues of data and metadata and integrated web based portals and connection to the IODE Ocean Data Portal

More than the previous phases, ODINAFRICA-IV will be product and user driven. ODINAFRICA-IV will aim to assist decision makers by coordinating the data management and product development through a multi-sectoral approach.

Figure 6. Students on a pilot boat at the Port of Lomé, Togo during an awareness course organized by ODINAFRICA.

2 Where is the Data?

Development of National Oceanographic Data Centres in Africa

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The availability of reliable, up-to-date, accessible data and information is an essential basis for integrated coastal area management (ICAM), and sustainable management of coastal and marine resources. Large amounts of data are collected daily from diverse sources such as equipment installed on the shore, moored and drifting buoys, research ships and merchant ships, aircraft, and satellites. The users and uses of these data are also varied and include industries, fishermen, coastal communities, academics, researchers and resource managers. Though the primary user of the data may have no further need for the data after utilizing it for the purpose it was collected, they are often valuable to subsequent users. Data is always unique even if only in the timing of collection, and is therefore irreplaceable. Proper management and archiving of the data is essential to provide access to subsequent users. It enables new studies to compare data with baseline information of the past and integrate data sets from different sources. This facilitates multidisciplinary studies and better knowledge and understanding of the marine environment.

The Intergovernmental Oceanographic Commission of UNESCO established the International Oceanographic Data and Information Exchange (IODE) in 1961 to address the requirements for data and information, and in particular: to enhance marine research, exploitation and development. This would be achieved by facilitating the exchange of oceanographic data and information between participating Member States and by meeting the needs of users for data and information products. The IODE system consists of a network of Designated National Agencies (DNAs), and National Oceanographic Data and Information Centres (NODCs).

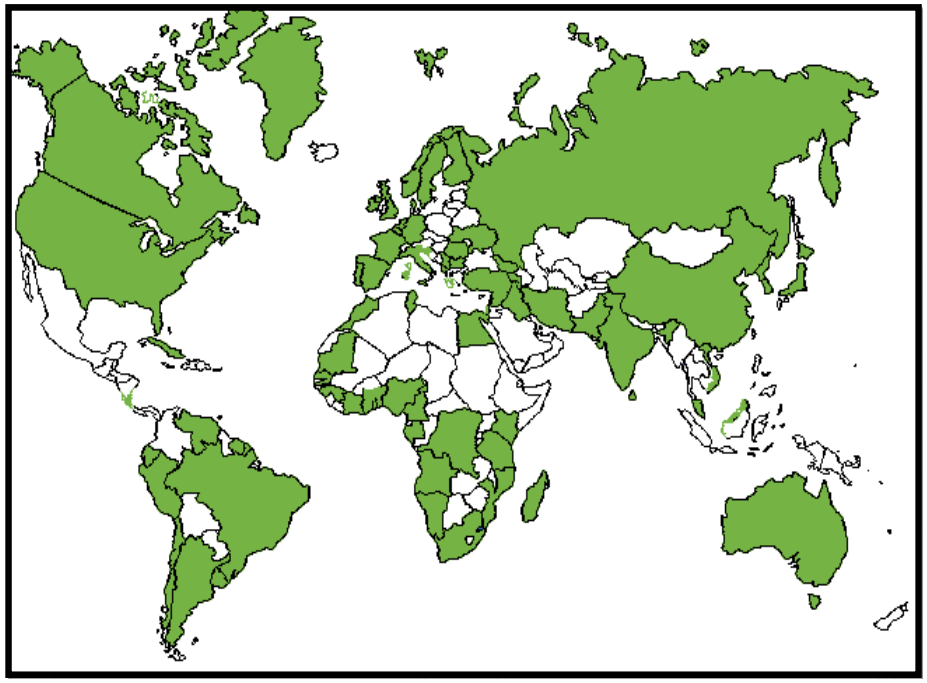

Figure 1. The IODE Network of National Oceanographic Data Centres.

IODE collaborates closely with the International Council for Science's system of World Data Centres that include the four dealing with marine data: Silver Spring, USA, Bremen, Germany, Obinsk, Russian Federation, and Tianjin, China.

The IODE committee structure comprises regional Ocean Data and Information Networks (for Africa, Caribbean and South America, Central Indian Ocean, Western Pacific, Black Sea, and European Countries in Economic Transition), and groups of experts dealing with specific topics such as Biological and Chemical data (GE-BICH), Marine Information Management, and Expert Team on Data Management Practices (ETDMP). IODE also implements special projects that are managed by Steering Groups. These include OceanTeacher, OceanDataPortal, MarineXML, and the Marine Environmental Data Information referral catalogue (MEDI).

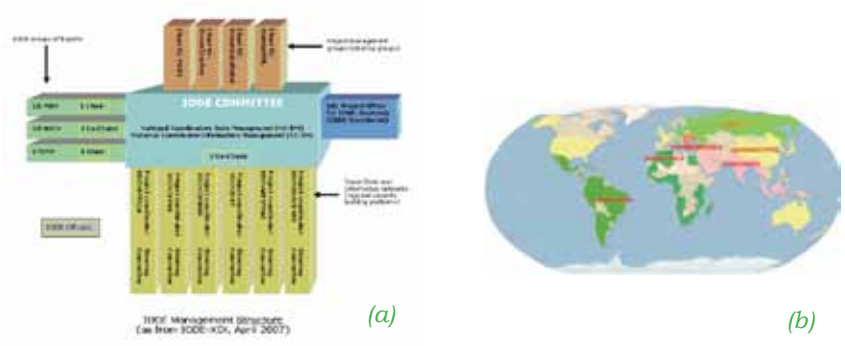

Figure 2. (a) IODE Management Structure (as from IODE-XIX, April 2007), and (b) IODE Regional Ocean Data and Information Networks.

Marine Data Sources for Africa

Most African countries gained independence between the late 1950s and mid 1960s. After independence the countries started building local capacities in all frontiers including coastal and marine sciences. However, it was in the mid 1980s when the results of these efforts with respect to coastal and marine sciences started to be of real benefit to the countries. Because of the existence of some local capacity there was a rapid increase of local marine and coastal research initiatives and projects. These generated large amounts of data and information. The coastal African states started to experience another burden of how to make efficient use of the data and information being generated by the ongoing as well as completed projects. It was realized that capacity available for ocean data and information management was insufficient in most of the African states and this needed to be addressed urgently. This includes the capacity for collection, analysis and distribution of data and information. African states through their various meetings of regional bodies, such as the Pan African Conference on Sustainable Coastal Management – PACSICOM (18 – 25 July 1998, Maputo, Mozambique), the IOC Regional Committees the Western Indian Ocean (IOCWIO), and the Central and Eastern Atlantic (IOCEA) requested assistance. In response the IOC of UNESCO, in collaboration with marine related institutions from African member states, developed a proposal for the Ocean Data and Information Network for Africa (ODINAFRICA).

Training of staff of NODCs

The initial focus of ODINAFRICA was on enabling member states from Africa to get access to data available in other data centres, develop skills for manipulation and processing of data, and develop infrastructure for archiving, analysis and dissemination of the data and products. Training was provided on data and information management. The aim was for the data centres to prepare databases, and data and information products for integrated management of the coastal environments and resources. These would enable the Member States to address the key issues such as: (i) coastal erosion, (ii) management of key ecosystems and habitats, (iii) pollution, (iv) sustainable use of living resources, and (v) tourism.

Figure 3. Experts from ODINAFRICA institutions at a data management training course at the IODE Project Office, Ostende, Belgium.

Ocean Data View (ODV) was one of the basic training tools for ODINAFRICA data managers and has been incorporated in Ocean Teacher (www.oceanteacher.org) which is the IODE training package. It is a software package for the interactive exploration, analysis and visualization of oceanographic and other geo-referenced profile or sequence data. ODV is supported by, and supports several oceanographic databases such as the World Ocean Database which are regularly updated. The software as well as the several databases are available freely for download from the home page of ODV at the URL: http://odv.awi.de. The databases comprise of a broad range of the basic oceanographic data such as salinity, oxygen, depth, and others. Additionally, the ODV software supports many useful functions such as plotting of oceanographic data. The ODINAFRICA Data Centres built their initial national archives starting with ODV data and have developed many products from these archives. Furthermore, many Data Centres import locally collected data into the ODV system for processing because the system is user friendly.

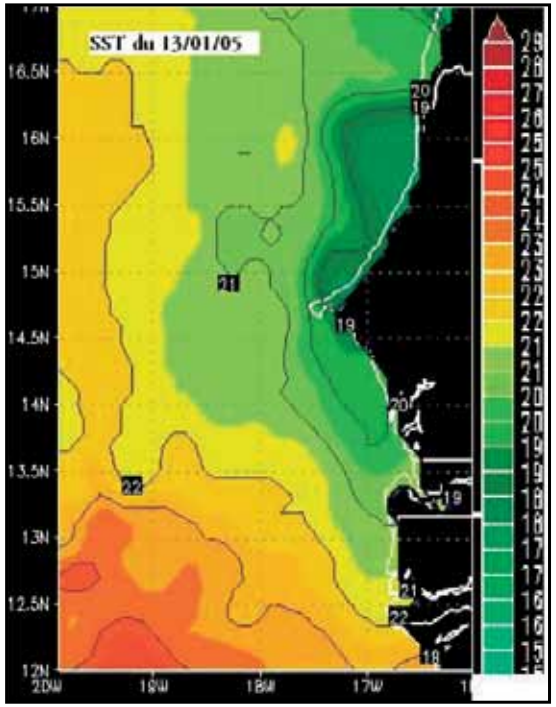

Figure 4. Sea surface temperature of Senegal on 13th January 2005 as plotted from the ODV system (NODC, Senegal).

Data from IODE network of data centres

The growing pool of local coastal and marine scientists needed more types of ocean data than they were able to collect nationally. This includes satellite data and data from global ocean programmes. These data sources were made available through other international centres and programmes.

Within the framework of ODINAFRICA all marine data sources for Africa were explored in order to ensure that African states have access to all useful and relevant available data, and that it is accessible to decision-makers.

ODINAFRICA enabled the newly established data centres in Africa to join the IODE network of data centres. These data centres archive marine data from all over the world. By joining the IODE system ODINAFRICA Data Centres gained access to virtually all available unrestricted data in the network. The IODE identified various data sets that were collected from African oceans and these were repatriated to the respective countries through the national ODINAFRICA Data Centres. These are available on CD/DVD ROMS, as well as in the form of digital atlases. They included geophysical, oceanographic, biological, chemical, as well as satellite and remotely sensed data. Data managers were acquainted with the skills to handle the various data types through the data management training organized by ODINAFRICA. Data repatriation exercise brought a lot of data into ODINAFRICA Data Centres.

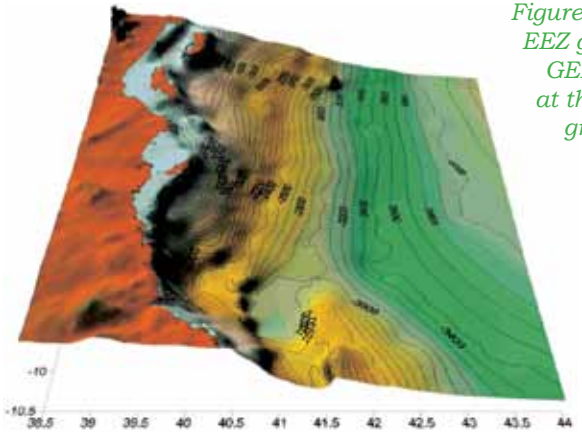

Figure 5. A 3D map of the Tanzania EEZ generated from the Centenary GEBCO Atlas datasets extracted at the Tanzania National Oceanographic Data Centre (TzNODC).

Local research project and programmes

Increased local research capacity brought about an increase in the coastal and marine research projects implemented in most coastal African states. These projects generate a substantial amount of data, which is critical for the development of the respective states. They range from small initiatives within creeks, lagoons and coastal waters, to work undertaken in deeper waters. Resulting data sets are critical because most projects address current issues or concerns. When the projects end, the data sets should be archived at the NODC. Locally collected data come from many different players including the faculty and students from teaching and research institutions, non-governmental organizations, and many others. It is important for the NODC to forge good partnerships and working relations with the local players and stakeholders to ensure that finally these data are archived at the NODC. Data managers were trained on how to positively engage local players on the importance of ocean data management.

Figure 6 (a).

Figure 6 (b).

Figure 6. Sampling for marine micro algae (photos by Ndirangu, Kenya Marine & Fisheries Research Institute).

Regional and International research projects and programmes

Global or regional issues such as climate change, coral reefs degradation and the need to conserve an ecosystem or species such as the fossil fish (Coelacanth) usually trigger International or regional research need to conserve an ecosystem or species such as the fossil fish. Several of these projects are implemented in the African oceans and coastal waters and include the Large Marine Ecosystem projects in the Agulhas, Somali, Benguela, Guinea and Canary current regions, as well as the World Ocean Circulation experiment. These projects generate substantial amounts of data, which should be accessible to local researchers.

Figure 7. Scientist from Madagascar prepares sampling bottles for launch from a research vessel.

It is critical for the Data Centre to be recognized locally to be able to engage international and regional projects on data management issues. Several ODINAFRICA Data Centres are actively involved in regional and international research projects in which they archive all data collected. An example is the Tanzania National Oceanographic Data Centre (TzNODC) which is involved in the efforts to conserve the coelacanth in Tanzania and in the region. The TzNODC is actively collaborating with the African Coelacanth Ecosystem Programme (ACEP) in the conservation efforts of the fossil fish in Tanzania. All data collected in Tanzanian waters and coastal environments have been archived at the TzNODC. Through this collaboration the TzNODC has received hundreds of gigabytes of data. Another example is the collaboration and participation of the NODCs in the Western Indian Ocean (WIO) region in the UNEP project on "Addressing Land Based Sources of Marine pollution (WIO Lab). All data collected within the framework of the WIO Lab project are archived at the NODC in the respective country.

On the other hand, some of ODINAFRICA Data Centres (e.g. those in Benin, Madagascar, Nigeria and Tanzania) in collaboration with respective local institutions and authorities are now accessing data collected in their respective ocean waters by Ships of Opportunity.

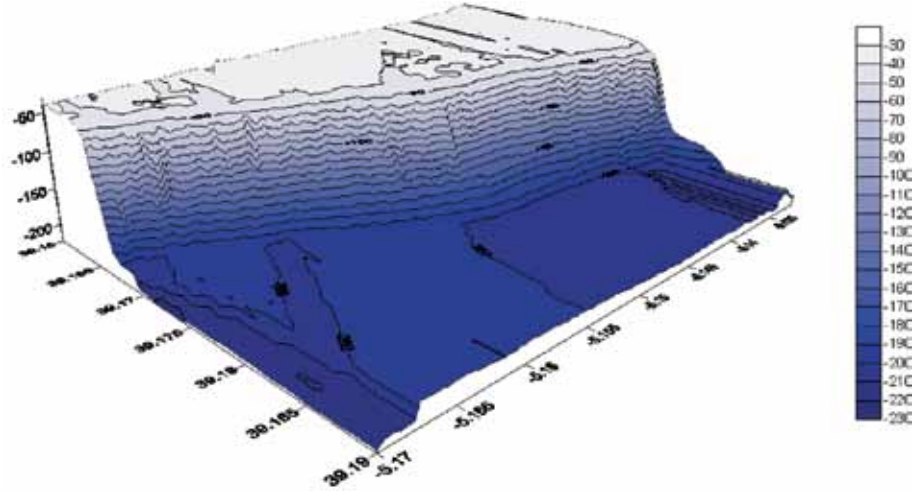

Figure 8. Three dimensional bathymetric map of Mwarongo, Tanga (Tanzania) as mapped by ACEP in collaboration with the TzNODC and other local institutions.

Accessing the data

The ODINAFRICA data centres have prepared catalogues of data sets in their collection, and others that are in possession of institutions in the respective countries. These catalogues have been incorporated in the Marine Environmental Data Inventory (MEDI), a global inventory of information about marine related datasets developed within the framework of the IOC's International Oceanographic Data and Information Exchange (IODE) system. The MEDI directory has been developed to provide a reference point for locating marine and coastal datasets and will be populated with metadata descriptions of marine datasets from IOC member states. The African component of MEDI comprises metadata descriptions of the data available in ODINAFRICA countries. MEDI Africa database is updated regularly and can be accessed at http://ioc.unesco.org/medi/.

Figure 9. The MEDI home page.

The data centres established within the framework of ODINAFRICA have developed websites through which they advertise their services and products. The information on available data sets and how to retrieve them can also be accessed through these websites. The URLs for the national websites are of the format www.nodc-countryname.org (e.g. www.nodc-kenya.org).

Figure 10. The homepage for the Kenya National Oceanographic Data and Information Centre – KeNODC (www.nodc-kenya.org).

The ODINAFRICA website (www.odinafrica.org) and the websites for key products also provide access to a wide range of data and information. These include:

- The African Marine Atlas (www.africanmarineatlas.net)
- The African Register of Marine Species
- The African Sea level Network (www.iode.org/glossafrica)

FUTURE FOCUS OF ODINAFRICA

Availability of coastal and ocean data and information has and continues to be a major constraint to sustainable development in coastal and marine areas in Africa. Although ODINAFRICA has significantly improved access to data and information, the data from many regional and global marine related projects and programmes that have been implemented in Africa over the years, remain virtually inaccessible to marine scientists and resource managers. This is due to the combined effect of several factors, including: complex data use agreements, reluctance to share data without financial compensation, scattered data repositories in various institutions, the fact that many datasets are not digitized, and the wide variety of data formats and metadata formats that are prevalent. In some cases, projects and programmes that generated valuable data sets did not have a good institutional home, leading to data being lost once programmes cease to be funded.

The next phase of ODINAFRICA will address this by collaborating with other projects to develop data products and to ensure that the data and products are widely accessible to users. In particular the focus will be on:

- Expanding and strengthening the network of marine scientists and institutions in the region to foster the sharing of data and information. Whereas previous phases mainly involved the institution hosting the National Oceanographic Data Centres and Marine Institution Libraries, the next phase will require a multi-sectoral approach that involves other stakeholders.
- Developing high quality products and tools to support decision making, management and conservation of the marine and coastal environment. This includes atlases, forecasts, predictions, models, and scenario development. The following priority areas will be addressed: shoreline changes, marine related hazards and disasters, management of key ecosystems, and sustainable use of resources. The African Marine Atlas will be further developed, and higher resolution national marine atlases created.
- Promoting the use of data, as well as products and services developed by the project, to all stakeholders. Improved mechanisms will be developed for the dissemination and application of data, information and products. This includes standards based catalogues of data and metadata, and integrated web based portals connected to the IODE Ocean Data Portal.

3 African Marine Atlas

3 African Marine Atlas

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The African Marine Atlas is a continental-scale online resource of public-domain geospatial data for the support of coastal and marine research and management in Africa. The project was designed to identify, collect and organise data sets into an atlas of environmental themes. A second aim was to provide training to increase the use of Geographic Information Systems (GIS) and spatial data products for the dissemination of appropriate, timely and relevant information. The structure of the atlas is also in accord with the end-to-end data management systems paradigm of earth observations systems. The Atlas provides maps, images, data and information to users who include scientists, students, coastal resource managers, planners, and decision-makers from administrative institutions and specialized agencies in Africa.

Figure 1. African Marine Atlas project participants.

The Atlas Project was designed and implemented by countries participating in ODINAFRICA III, in collaboration with the African Coelacanth Ecosystem Programme (ACEP) and the United Nations Environment Programme (UNEP). The Intergovernmental Oceanographic Commission's (IOC) International Oceanographic Data and Information Exchange (IODE) Programme coordinated the project and identified international ocean data specialists to provide training and key inputs in data analysis.
The Atlas will ultimately also be of use to naturalists, local administrators, park managers, fishing cooperatives, tourists, hotel keepers, teachers, NGOs, the general public, and any others interested in coastal and marine environments. At present, the resolution and coverage of most data in the atlas lend themselves towards regional scale applications. Future development of the atlas products will be geared towards adding higher resolution data at national or local scales, thereby providing useful data for local management applications and reaching a wider user group.

The inventory of data sets in the atlas is a useful indicator of gaps either in: the knowledge base; the available public domain data, or where efforts at repatriation or processing of new data sets should be directed.

A suite of data dissemination products is planned for the atlas, including web data services, web mapping, a static clearinghouse service and a hardcopy atlas publication.

The African Marine Atlas online

The initial list of over 200 data sets which were identified for the atlas were based on an extensive survey of coastal and marine data needs undertaken in early 2006 by all the countries participating in ODINAFRICA. A website was set up and hosted by the UNESCO/

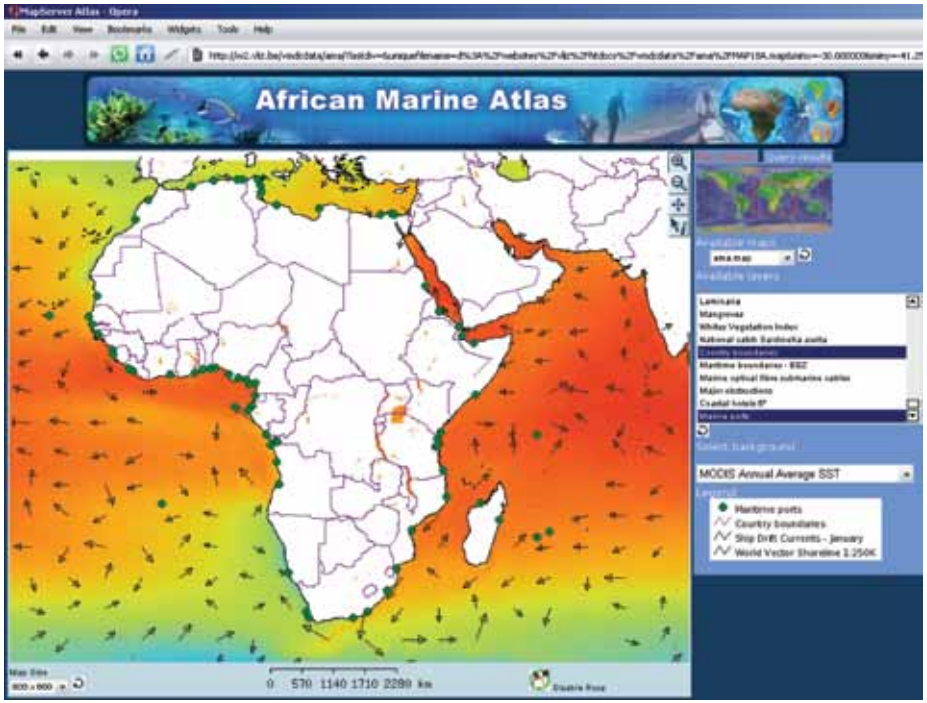


Figure 2. African Marine Atlas using Mapserver.

IOC Project Office for IODE, as a clearinghouse of data sets (http://omap.africanmarineatlas.net). This site currently serves over 800 downloadable spatial data products in the fields of marine geosphere (19 products), hydrosphere (445 products), atmosphere (96 products), biosphere (231 products), and human environment (27 products). In addition, 61 basemap data sets are provided to give spatial reference to the other data layers.

A Mapserver demonstration site (www.africanmarineatlas.net) was developed by the atlas team using a sub-set of data, as a joint training and data dissemination exercise. Through the IODE, the African Marine Atlas joined the International Coastal Atlas Network (ICAN), a growing body of organizations developing new approaches for interoperability of coastal web atlases.

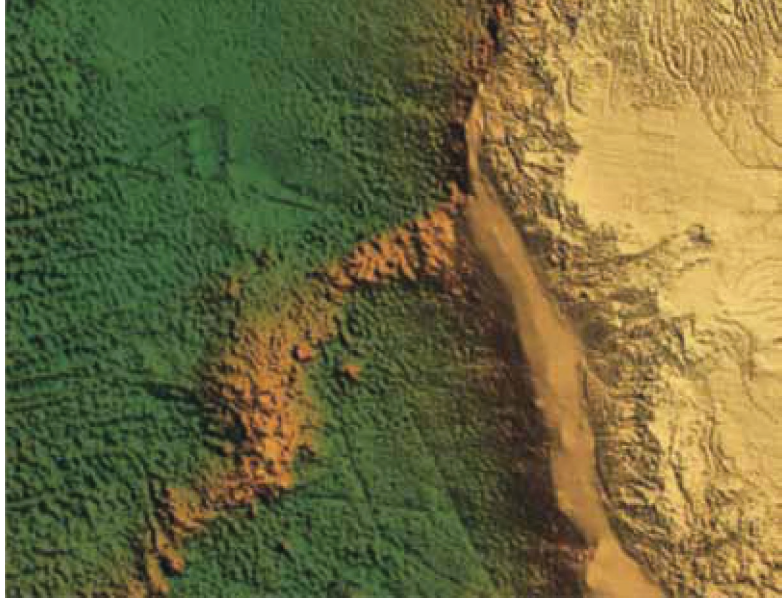
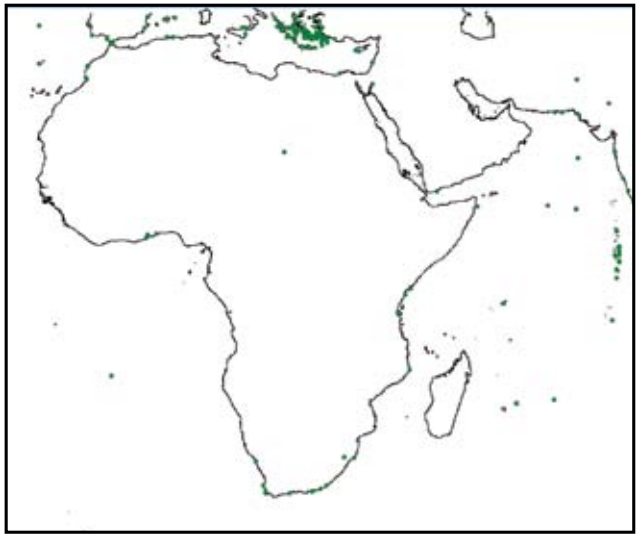


Figure 3. Bathymetry of the Namibian continental shelf.

BASE MAPS: The backbone of the Atlas is a set of fundamental maps and images onto which the thematic data layers can be overlaid. These include several coastlines of different resolution, the depth contour lines from the global GEBCO bathymetry data, the best available gridded bathymetry (at 1-minute resolution - as illustrated in the figure shown here with the Namibian coastline), a gazetteer of ocean place names, and masking files to use with satellite images where either water or land is not desired in the outputs.

GEOSPHERE: The solid earth and its mineral resources are represented in the Atlas by geohazard data (for example earthquakes, tsunamis, underlying fault structures), clas-sical geology data (minerals, core sample data, coastal soils), and physical parameters (for example sediment thickness - an important data set for implementation of the Law of the Sea). The sample figure presented shows historical tsunami runup sites.

Figure 4. Tsunami run-up sites around Africa.



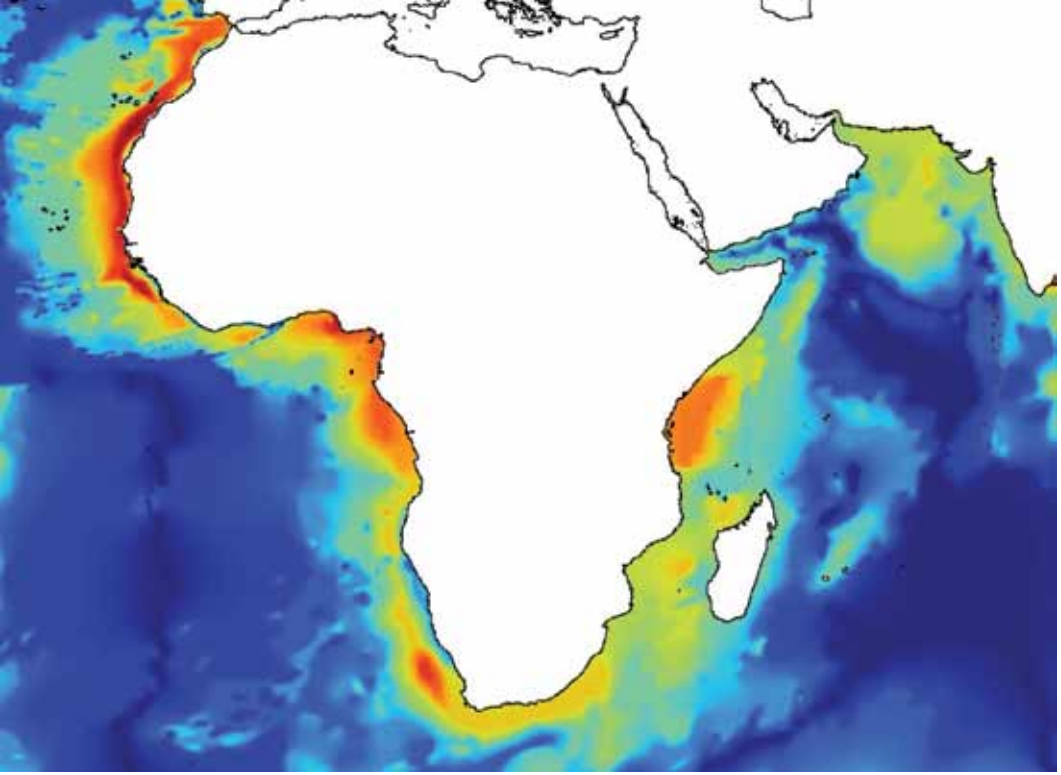


Figure 5. Marine sediment thickness.

As mentioned above, sediment thickness is very important for legal considerations and as an indicator of possible hydrocarbon deposits. This figure shows the variation in marine sediment thickness (deep deposits shown in brown), which interestingly mirror areas of high productivity.

HYDROSPHERE: The largest number of themes available in the Atlas covers marine and fresh waters, and includes:

- *Physical Oceanography* – data layers covering sea level, average currents, surface and at-depth temperatures and salinity
- *Chemical Oceanography* – oxygen, nitrate, nitrite, phosphate, silicate grids for selected depths
- *Optical Oceanography* – incoming light fields, and climatologies of light intensity in the water column, as related to photosynthesis
- *Limnology* – gridded runoff data

ATMOSPHERE: The Atlas includes both climate and weather themes. Seasonal climatologies of cloudiness, precipitation, humidity, pressure and temperature set the background for valuable collections of synoptic wind, storm track and storm zone patterns (currently in draft form).

BIOSPHERE: The most difficult task facing the Atlas team was the selection and compilation of biological themes from the thousands of possible options. Many of the most desired themes (for example the distribution patterns of principal fisheries species) are not well known or are not in the public domain. The team contacted a wide cross section of specialists in the following areas, obtaining a unique and valuable collection of data layers (some never before published in this way). These include:

- Phytoplankton distribution, biomass, and seasonal patterns
- Chlorophyll/pigments distribution and seasonality
- Zooplankton taxonomy and distribution
- Algae and kelp species distribution
- Mangroves occurrence and spatial extent
- Coastal vegetation type
- Fishing areas
- Fisheries catch statistics and aquaculture production
- Distribution of important fisheries resources
- Coral cover
- Fish species distribution
- Invertebrate species distribution
- Protected areas
- Exotic and invasive species distributions (selected species)
- Protected species distributions (selected species)

In addition, although downloadable files are not provided, links are provided to other data sites providing data on mammals, reptiles and birds.

HUMAN ENVIRONMENT: The selection and compilation of human social and economic themes directly relevant to coastal and marine resource management was one of the most complex challenges facing the atlas team. In this area, the African Marine Atlas was greatly assisted by the involvement of the United Nations Environment Program, in particular UNEP's national-level GIS projects along the African coast. With their help, the team was able to assemble data layers in the following useful areas:

- Country and international boundaries
- Exclusive Economic Zone (EEZ) boundaries
- Maritime features
- Population
- Industrial and commercial entities
- Transportation
- Energy transmission
- Hospitality and tourism

CONCLUSION

The African Marine Atlas Project has brought benefits to participating national institutions and marine practitioners; by increasing capacity for working with spatial data, as well as increasing access to useful information about the coasts and oceans.

The African Marine Atlas will be augmented with new datasets during the course of the ODINAFRICA IV project, as the project partners discover and convert them to standard GIS formats. A considerable undertaking in itself. The next phase will also focus on developing additional value-added products and content that can support interrogation and information services at national and local level, specific to coastal management issues of current concern.

Partnerships that have been formed through this project extend beyond Africa and the IOC of UNESCO, to other regional and global programmes and data vendors. The African Marine Atlas project has motivated and encouraged scientists to work together, learn new techniques, and build collaborative teams for the future.

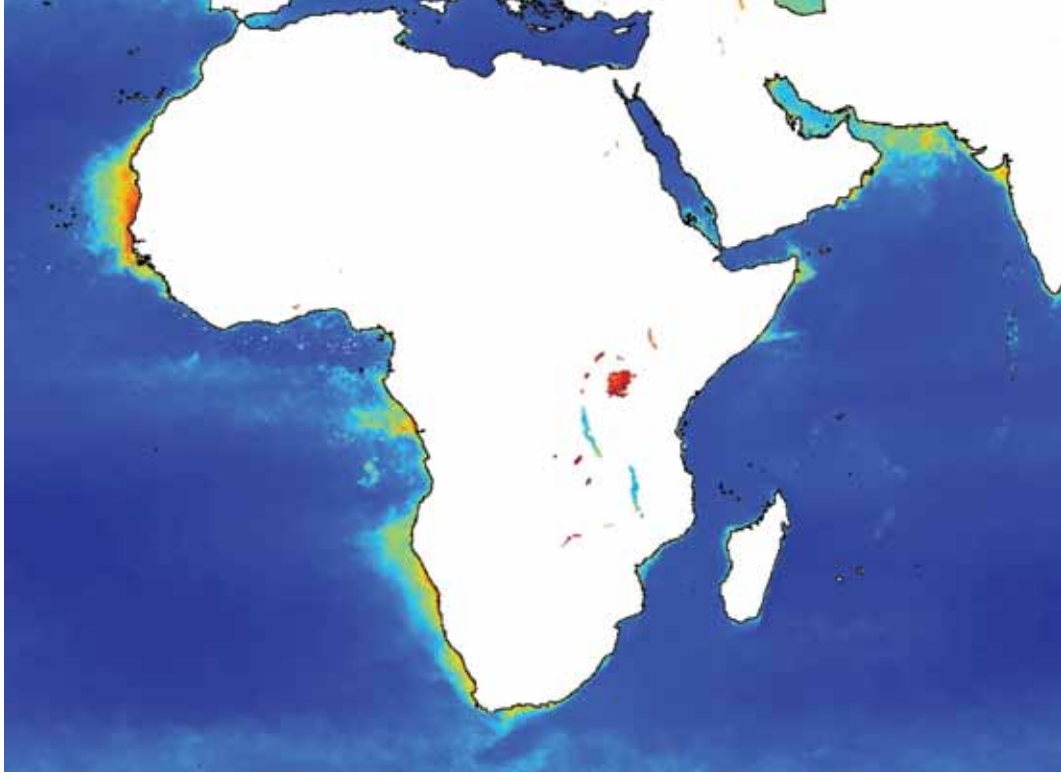


Figure 6. Chlorophyll concentration for African surface waters.

Figures and some of the text from this chapter were first published in Position IT and the UNESCO Nairobi Office Bulletin.

4 Is the sea level changing?

4 Is The Sea Level Changing?

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SEA LEVELS AND TIDES

The sea level is defined as the height difference between the level of the ocean's surface (most commonly the level halfway between mean high and low tide) and the level of a fixed point on the adjacent land. Sea levels are used as a standard in reckoning land elevation or sea depths. Sea levels are measured by tide gauges and determine the relative position of land and sea at the coastline.

The mean sea level is the average level of the sea calculated from long series of observations. It is a convenient datum from which all terrestrial elevations and submarine depths can be referred. Any instantaneous measurement of sea level in a series may be considered as the sum of three components parts:

Observed sea level = mean sea level + tides + meteorological residuals

Tides are the alternate rise and fall of the sea caused by periodic astronomic factors (relative motions of earth, moon, sun and other stellar bodies). These tide generating factors can be predicted with reasonable accuracy. The sea level data from tide gauge records also contain meteorological and oceanographic signals as well as vertical movements of the earth associated with glacial and other tectonic processes.

Some of the oceanographic signals that can be deduced from tide gauge data include:

- Static inverted barometer effects
- Geotrophic currents
- Coastal upwelling
- Coastal trapped waves
- Seasonal variability
- Low frequency atmospheric forcing
- El-Nino effects
- Secular variability

HISTORICAL EVOLUTION OF SEA LEVEL

The present climatic and continental positions were established in the Cenozoic era. About 35 000 years ago, the level of the sea surface was the same as it is now. This level then reduced, reaching a minimum of about 130m below the current levels about 15 000 years ago. From that point there was a relatively rapid rise in the sea level, gradually slowing down 8 000 years ago when the levels were about 15m below the present levels. The present levels were reached more gradually some 4 000 years ago. Since then the changes in the level of the sea surface have not been as dramatic.

In recent years there has been increasing concern about the projected rise in the level of the sea surface, due to global climate change. Industrialization has led to increased emission of green house gases (carbon dioxide, methane, etc) resulting in a rise in the global temperatures. Global sea level has risen by the order of 15cm over the past 100 years. Current models predict an increase in atmospheric temperatures of between 1.5 - 4.5°C in the next 50 years, accompanied by a consequent rise in the levels of the sea surface in the region of 35 - 60cm.

However many other factors also contribute to the relative sea level change (e.g. precipitation, evaporation, river run-off, changes in land elevation, deformation of ocean basins, changing wind systems,

changes of ocean circulation etc). In fact in some areas of the world the sea level is actually falling due to some of these factors.

The change in sea level due to crustal movements (land elevation) can be monitored by installing Global Navigation Satellite System (GNSS) receivers at tide gauge locations. The combination of both tide gauge and GNSS measurements allows one to discern whether the tide gauge is sinking into the harbour, or the sea is rising.

MEASUREMENT OF SEA LEVEL

Sea level and tides can be measured by several types of instruments that are available. The choice of equipment will depend on the requirements of the user and resources. The simplest method of measuring the level of the sea surface is using a graduated pole or string immersed in the water. The stilling well float gauge is the most common type of gauge used worldwide. This type of gauge consists of stilling well and a float counterbalanced by some weight. The well filters out high frequency variability. The sea level is determined from the length of the float wire relative to a level fixed to the benchmark. Other methods of measuring sea level include acoustic tide gauges which measure the travel time of acoustic pulses reflected vertically from the air-sea interface, and pressure sensors which measure the hydrostatic pressure of the water column at a fixed point and convert this to sea level. The sea level can also be determined using satellite altimetry.

PRACTICAL APPLICATIONS OF SEA LEVEL DATA

Sea level data and information have a wide range of scientific, research and practical applications that include coastal engineering (in which sea level data are needed as instantaneous levels), as well as statistics of extreme levels over long periods. Short-term measurements, often with real-time data transmission, are needed for ship movements in harbours and ports, for issuing storm surge, tropical cyclone and tsunami warnings, and for the operation of sluices and barrages.

Over a longer period, sea level data are needed for tidal analysis and prediction, for control of siltation and erosion, for the protection of coral reefs, for inputs to models to estimate the paths of pollutants, to forecast water quality, and for the design of reclamation schemes and the construction of disposal sites. In addition, they have application in studies of upwelling and fisheries throughout tropical areas.

Historically, many national datum levels for land surveys are based on measurements of mean sea level over some defined period. These levels are often used to define state and national boundaries, as specified in the United Nations Convention on the Law of the Sea. Low water levels are used as the datum for tidal predictions and for the datum level in hydrographic charts.

Scientific and practical applications interact in many ways. For example, knowledge of long term sea level rise will need to be input into the engineering design of coastal structures, many of which will have a lifetime of many decades or centuries. Insight into the rate of sea level rise may also help in the understanding of complex coastal processes, such as sedimentation and erosion, which may result in high costs. A second example concerns sea level data assimilation into numerical models (e.g. storm surge, water quality, etc).

Sea level data is also used for studies on ocean circulation, long-term sea level changes as well as calibration and validation of satellite altimeter data.

SEA LEVEL VARIATIONS IN AFRICA

There is increasing consensus in the earth science community on the rate of sea level change globally. The Intergovernmental Panel Climate Change (IPCC) reported an increasing overall global rate of change; from 1.7mm per year for the 20th Century to 1.8mm year for the period 1961-2003 (Bindoff et al., 2007). Analysis of sea level rise is based on tide gauge data taken since the 19th century, as well as historical land records, archaeological data, geological evidence from the Holocene period, and more recently, altimeter data. To estimate present and future global and regional rates of change using tide gauges, records must be long (more than 50 years), and be free of crustal movements due to plate tectonics. Continuous sea level records from Africa are very short (generally less than 20 years).

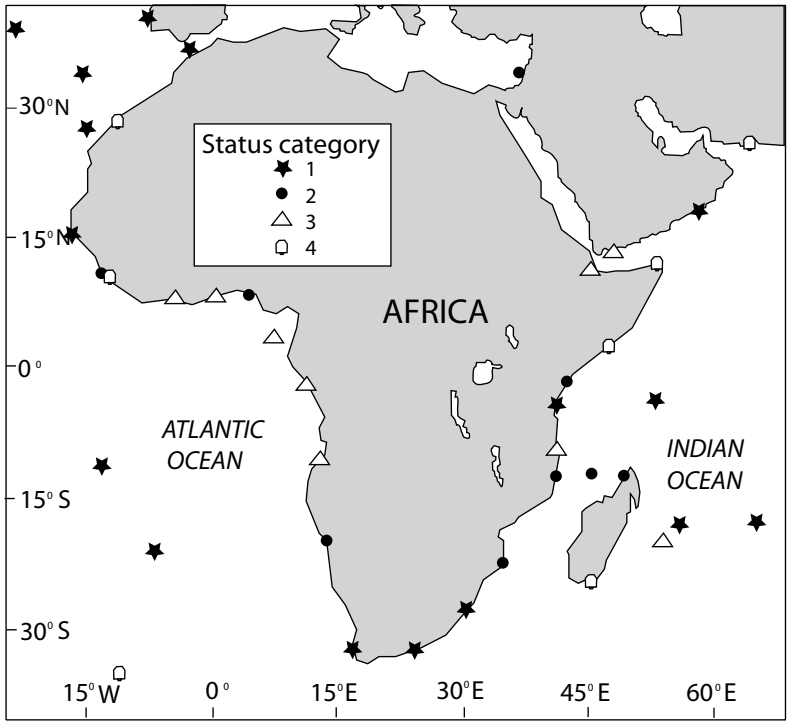

Figure 1. Map of GLOSS Core Network stations in Africa. Those marked by stars are category 1 (relatively recent data having been received by the PSMSL). Categories 2 and 3 indicate that historic but no recent data exist, whereas Category 4 stations have no historic or recent data at all. Categories are defined as of October 2006 (Woodworth et al. 2007).

Figure 1 shows the status of monthly and annual sea level data received by the Permanent Service for Mean Sea Level -PSMSL- (Woodworth and Player, 2003) from locations in the core network of the Global Sea Level Observing System (GLOSS). It can be seen that major sites identified by the GLOSS working groups, are spaced approximately 500km between them and with locations of oceanographic interest (e.g. Straits of Gibraltar) included. This set of stations is clearly not enough to satisfy the complete set of scientific and practical requirements. This figure shows that with the major exception of stations in South Africa and ocean islands, there are few relatively stations which provide recent data to PSMSL in Africa.

Figure 2 provides a histogram of the length of records, demonstrating that few are longer than 20 years (Woodworth et al., 2007).

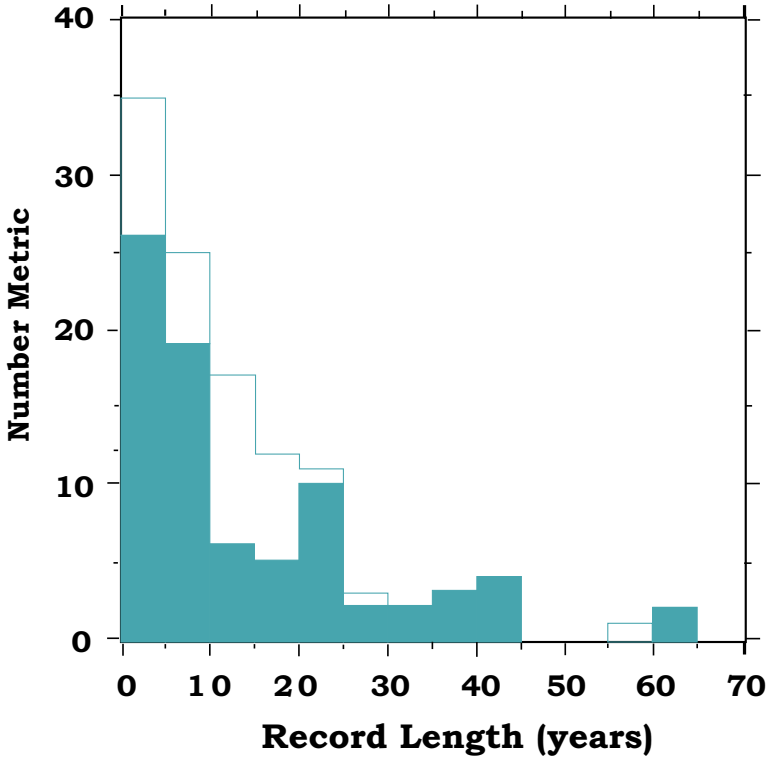

Figure 2. Histogram of the total number and record lengths of stations from continental Africa (Woodworth et al. 2007).

Even though the current sea level network in Africa is not as extensive as one would like, there is a considerable amount of existing information which can be used for research and education

RECENT TIDE GAUGES INSTALLATION

There is a great need to reinforce the ability of African states to acquire and use sea level measurements to support sustainable development and climate change studies. The urgency was demonstrated by the

occurrence of the Indian Ocean Tsunami in December 2004, when few countries had functional tide gauges to provide the necessary data. In 2003, the Government of Flanders (Belgium) and Intergovernmental Oceanographic Commission (IOC) through the programme Ocean Data and Information Network for Africa (ODINAFRICA) installed 10 new sea level stations.

Stations planned and installed by ODINAFRICA include:

(i) Nouakchott (Mauritania) - December 2006
(ii) Takoradi (Ghana) - December 2006
(iii) Djibouti (Djibouti) - February 2007
(iv) Pointe Noire (Congo) - April 2007
(v) Limbe (Cameroon) - June 2008
(vi) Alexandria (Egypt) - 2009
(vii) Casablanca (Morocco) - 2009

Stations installed/upgraded by partners include:

(i) Port Louis and Rodrigues in Mauritius by UHSLC/IOTWS (2005)
(ii) Mombasa and Lamu in Kenya by UHSLC/IOTWS (2006)
(iii) Pointe La Rue in Seychelles by UHSLC/IOTWS (2006)
(iv) Zanzibar in Tanzania by UHSLC/IOTWS (2006)
(v) Dakar in Senegal by UHSLC (2007)
(vi) Inhambane and Pemba in Mozambique by GLOSS (2006)
(vii) Lamu, Kilifi and Shimoni in Kenya by Kenya Meteorological Department (2007)
(viii) Lagos in Nigeria by Nigerian Institute of Oceanography and Marine Science
(ix) Walis Bay in Namibia by BCLME (2008)
(x) Agadir and Tan Tan in Morocco by Service Hydrographique and Océanographique (Ministère de l'Equipement et du Transport, Direction des Ports et du Domaine Public Maritime)
(xi) Durban, Simonstown, and Port Elizabeth by GLOSS

The equipment employed at most sites consists of a radar tide gauge, which measures sea level from the time-of-flight of the radar pulses reflected back from the sea surface. Figure 3 presents a view of the radar sensors and aerials installation at Nouakchott. Figure 4 shows the status of the African sea level network (August 2008).

Figure 3. View of the radar sensor and aerials installation at Nouakchott station (Simon F., 2006).

Figure 4. African tide gauge status (August 2008).

TIDAL VARIATIONS ALONG AFRICAN COASTLINE

Time series data are often used to compute significant time-table tidal parameters, which describe the tidal regime at the place of observation. These parameters are called tidal constituents on the assumption that the responses of the ocean and seas to tidal forces do not change with time.

Figures 5a and 5b show different types of tides along the west African coastline. Table 1 represents the main constituents, amplitude and phase at Takoradi.

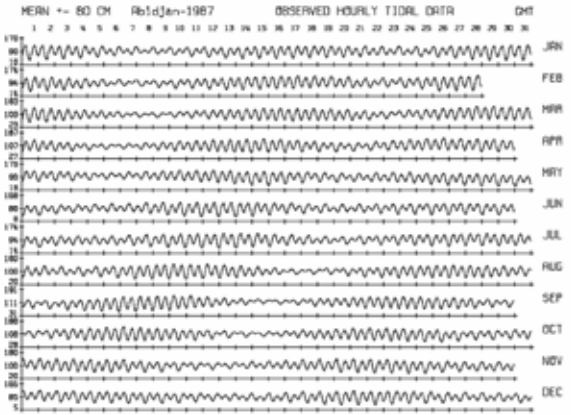

Figure 5a. Tides at Abidjan.

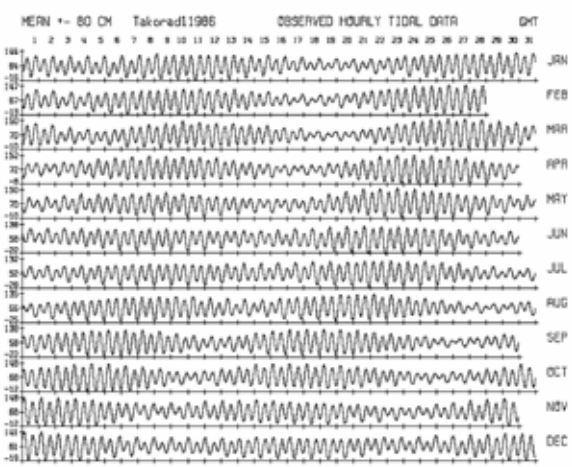

Figure 5b. Tides at Takoradi.

Table 1. Tide description for Takoradi based on TASK2000, T_TIDE and SLPR2 software.

	$F=\frac{K_1+O_1}{M_2+S_2}$	(M_2+S_2)	(M_2-S_2)	(M_2+S_2)
TASK -2000	0.2041	1.1842	0.2925	0.5921
T-TIDE	0.2253	1.2388	0.2964	0.6194
SLPR2	0.225	1.23882	0.296371	0.619441

AFRICAN SEA LEVEL VARIATIONS

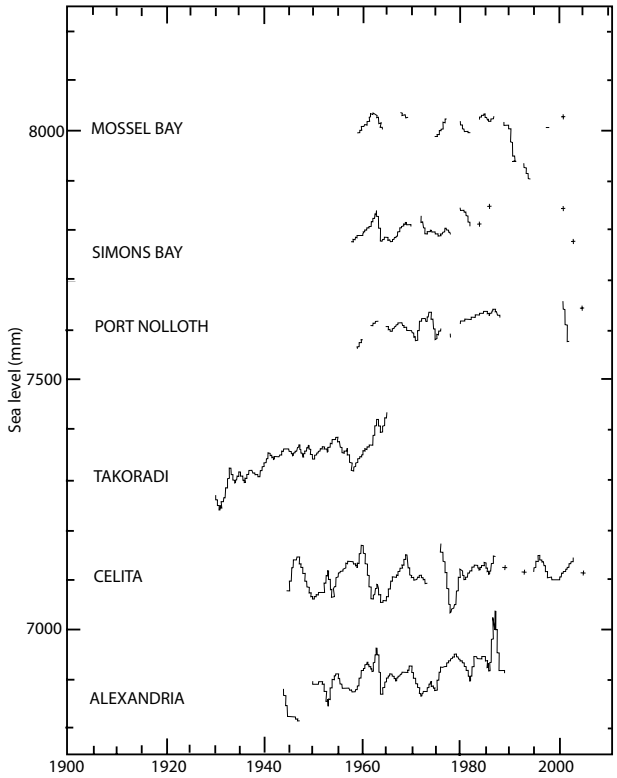

Figure 6. Annual Mean Sea Level for six stations in continental Africa with 40 or more years of data (Aarup et al., 2001).

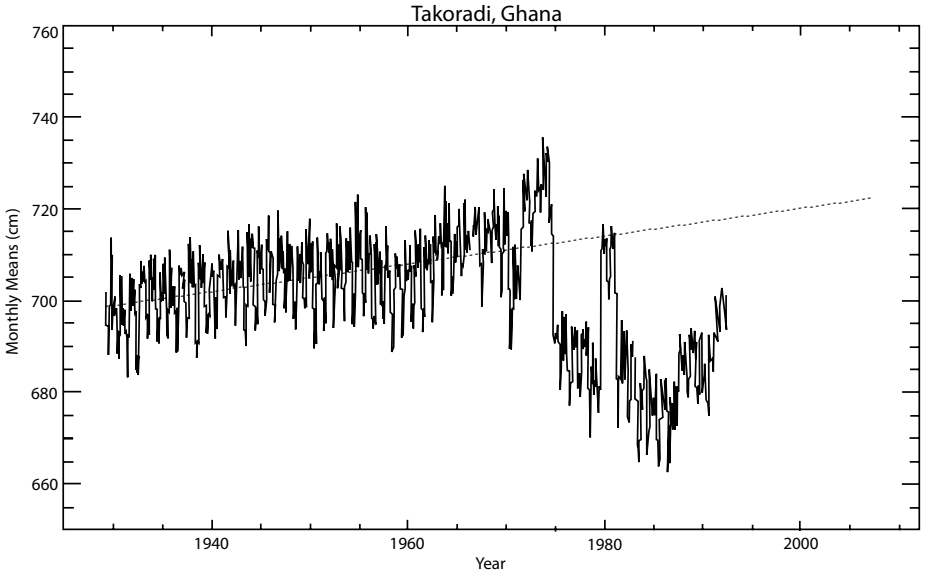

Figure 7. Monthly Mean Sea Levels reported from Takoradi. The dot represents Mean Sea Level for the first three months of 2007 from a newly installed ODINAFRICA tide gauge (Woodworth et al., 2007).

Figure 6 presents the annual mean sea level time-series for the six stations in continental Africa having record lengths over 40 years of data (Aarup et al., 2001). The secular trends for the six stations vary between -0.83 mm y-1 (for Mossel Bay) and 3.05 mm y-1 (for Takoradi). The many gaps observed in South Africa data reflected the problems with the acoustic gauges during the 1990s (Woodworth et al., 2007). The recent developments of African sea level network represent a good opportunity for studies of long term sea level change in recent years.

Figure 7 presents the historical monthly mean sea level values together with the first three months of 2007 from the newly installed ODINAFRICA tide gauge at Takoradi (Woodworth et al., 2007). This is a positive message for the future especially for ODINAFRICA. This finding is consistent with observations at other sites, which suggest little acceleration or deceleration in rate of sea level change during the past century (Woodworth et al., 2008). The linear trend of the extrapolation is 3.05mm per year. However, one should keep in mind that the recent data sets are short and the linear trend observed is the result of vertical land movements in addition to ocean changes.

In conclusion, the study of African sea level variations is not easy because the African sea level and the historical data sets are limited in size and quality. In Africa, sea level time series have only a short duration. Some times there is a gap of several years between data sets. In order to produce useful results for scientist and the broader community, it is important to maintain the new equipment at sites where historical data exist. As tide gauges can provide data to a large range of users in operational oceanography, African countries should develop a local skill-base to make maximum use of the data, and generate value added products.

TSUNAMI SEA LEVEL STATI/RING FACILITY

ODINAFRICA, in collaboration with the Global Sea Level Observing System, the Indian Ocean Tsunami Early Warning and Mitigation System, and the Flemish Marine Institute have developed the Tsunami Sea level Data Facility (www.sealevelstation.net) with the following functions: (i) data capture via the Global Telecommunication System - GTS and archive in relational database as an ODINAFRICA backup to national and GLOSS data centres, (ii) web-display (including plots and raw data provision) and provision of tide-gauge operator alerts in case of equipment malfunction, and (iii) semi-automatic data quality control. The facility receives real time sea level data directly via GTS. The GTS link was made possible through the kind cooperation of the World Meteorological Organization. The sea level station status map provides information on which stations are operational.

Real time data display: the real time data display section of the Tsunami Sea Level Monitoring Facility provides a graph of the sea level variation over a given interval. Figure 9 shows the station plot for Lamu. You can also get data report, and the station metadata. The red shading for the stations indicates that no data were received for this station during 2 transmission intervals. The light-blue shading indicates no data available for the respective stations.

Database services: Specific site data can be retrieved from Tsunami Sea Level Monitoring Facility and users can plot, generate a report table, or download the data. The system has stored data received since 7 June 2006.

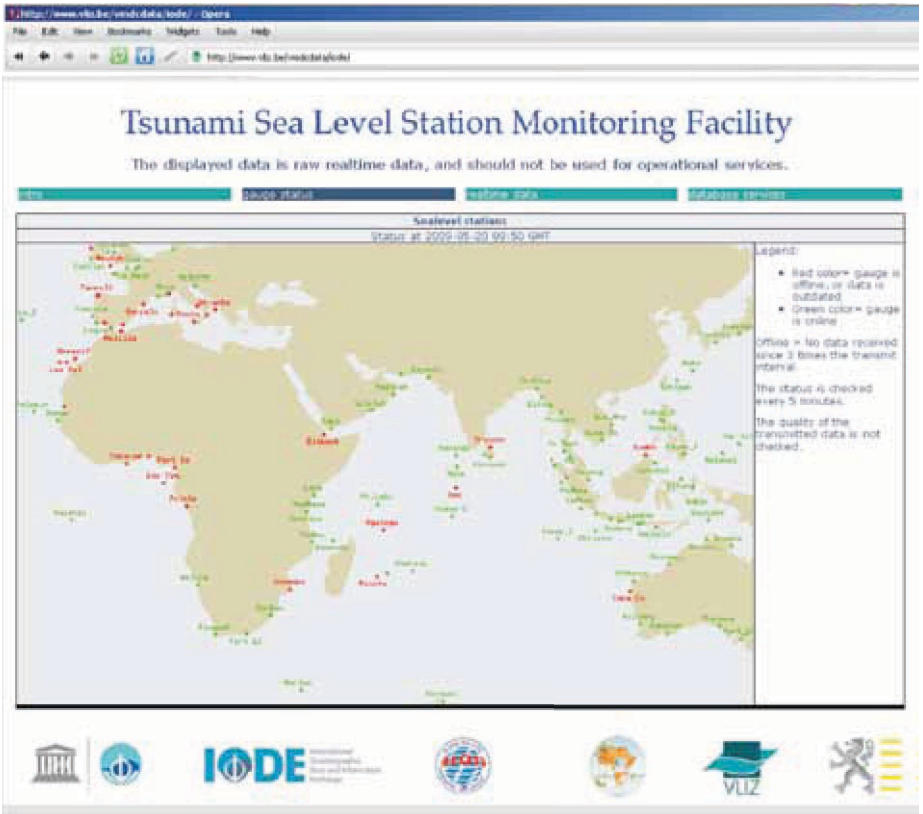

Figure 8. The sea level station status map provides information on which stations are operational.

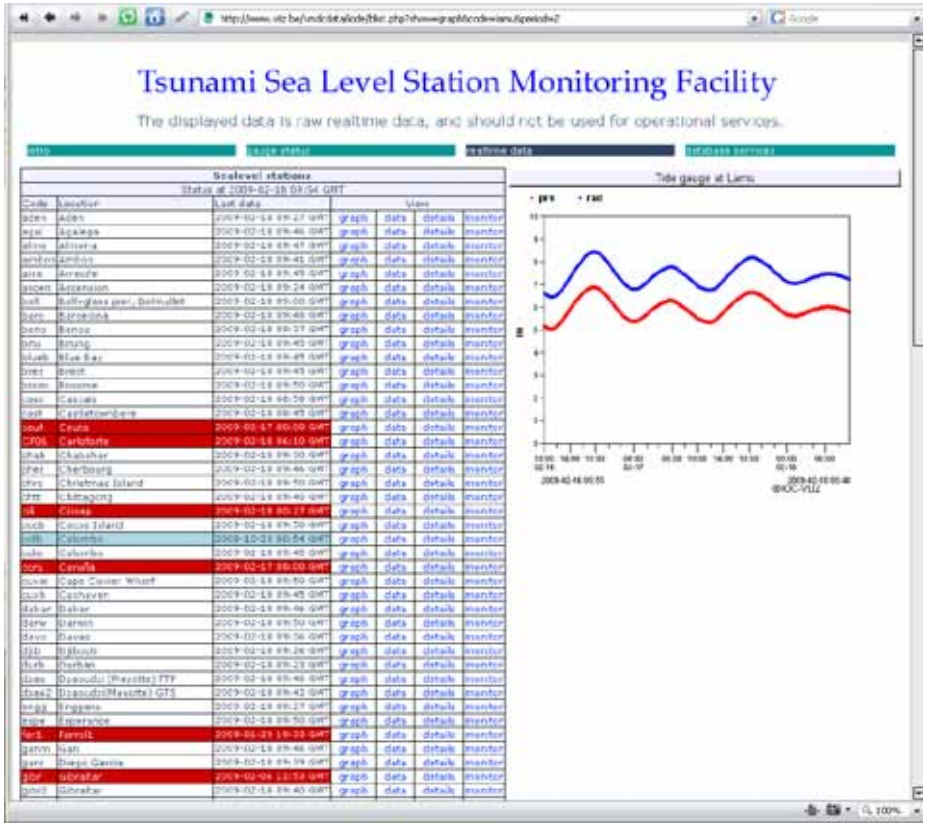

Figure 9. This screen capture shows the station plot for Lamu providing a real time graphic display of the sea level variation over a given interval.

Figure 10 shows a display of 30 days starting 7th June 2006 for the Zanzibar station. It is also possible to save the report for the same period, and spreadsheets generated, by using the "Download" function.

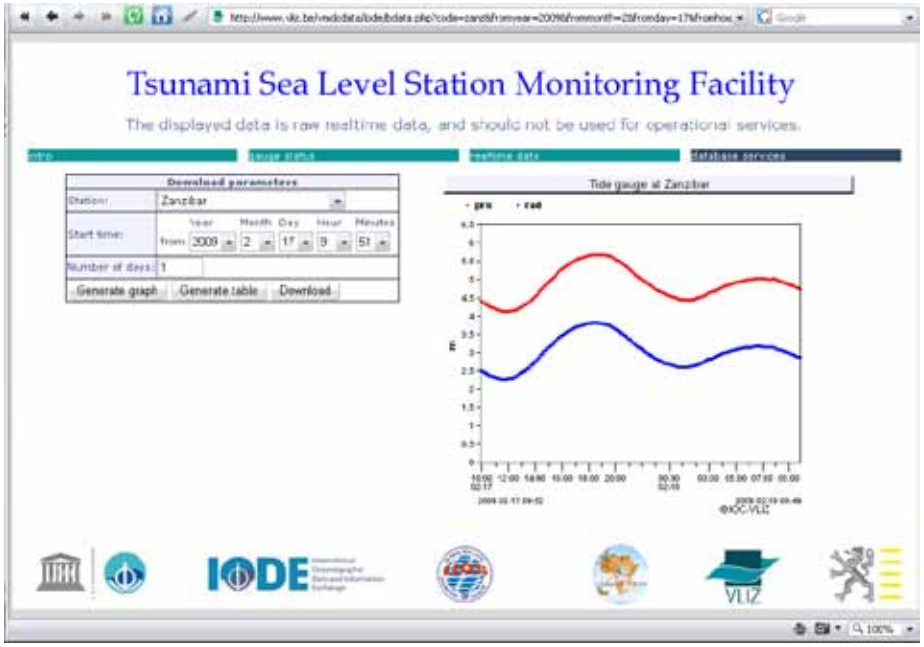

Figure 10. This screen capture shows 30 days of data plotted for the Zanzibar station.

ACKNOWLEDGMENT

We are grateful to Flanders Government, UNESCO/IOC and GLOSS for providing support for carrying out the ODINAFRICA project. Many thanks to M. Odido, J. Ahanhanzo, T. Aarup of IOC, P.Woodworth and P. Foden of POL.

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5 Sources of Marine Information for Research and Management

5 Sources of Marine Information for Research and Management

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Relevant information delivered in a timely manner is necessary for the successful implementation of research and management activities. The Ocean Data and Information Network for Africa ODINAFRICA has strived to facilitate better access to reliable information for management of coastal and marine resources and environment in Africa to a wide community of stakeholders. By developing and facilitating networking between 25 marine information centres in the African coastal states, ODINAFRICA have enabled them to produce products and services, and improve the understanding of ocean processes and conditions.

The marine information centres have improved access to data and publications accessible by developing online catalogues. These include specialised collections, regional repositories enabling preservation and access to research findings in full text publications, and digitised collections of difficult to find studies. Within this chapter we review the resources developed by African institutes in collaboration with ODINAFRICA, as well as other global resources of marine related information available through IODE partners.

Resources from ODINAFRICA

ODINAFRICA has developed several catalogues and databases to achieve it's objective. These include:

Union Catalogue of libraries of marine institutions in Africa (AFRILIB)
AFRILIB is the distributed library holding database of all marine partner libraries in Africa with about 14 000 bibliographic citations. One of the objectives of AFRILIB was to build a global access point to local resources from all marine information centres in Africa in order to facilitate information access to the wide community of users from Africa and out side.

AFRILIB, which is hosted at the UNESCO/IOC Project Office for IODE as a central database, has assisted the marine information centres in displaying their local resources to regional and international audience by responding to the information requests from a wide community of users. The user friendly web interface of AFRILIB has enabled information access and exchange and sharing of resources. The database contains resources such as articles, journals, books, multimedia, and maps.

Some of the national marine libraries also provide access to the national catalogues through their institutional or NODC websites.

For more information on AFRILIB visit
http://www.odinafrica.org

Electronic repository of marine related publications from or about Africa

The electronic repository of marine related publications - OceanDocs (www.oceandocs.net) is a web-based platform for storing, preserving and distributing digital documents. The ODINAFRICA librarians have developed the African component of Ocean Docs. They also maintain it and add documents regularly to ensure that it remains a useful source of literature on marine science and oceanography in Africa, especially those published by scientists affiliated to the ODINAFRICA institutions. OceanDocs provides the opportunity to African researchers to reduce publishing costs, allowing them to self-publish and giving higher visibility to their work.

Ocean-Doc-Africa contains preprints, published articles, technical reports, working papers, conference proceedings, theses and valuable grey literature on African marine and related issues. Each publication contains information including title, author, abstract, publication year etc, and full-text documents, which can be freely downloaded. Copyright issues and publishers policies also are addressed at the repository management level. The OceanDoc initiative is the basis for the Aquatic Commons project which aims to provide wider access to aquatic science publications.

For more information on Ocean-Docs visit:
http://www.oceandocs.net/

AFRICAN OCEAN PORTAL

The African Ocean Portal is one of the major information sources, which contributes to the understanding and management of the oceans, coastal environment and marine resources in Africa. The portal is designed as a high-level directory of ocean data and information related web sites.

The web interface enables easy information access for specialised users on the following topics:

- Capacity Building
- Coastal Ecosystems and Processes
- Endangered and Invasive Species
- Fisheries and Aquaculture
- Institutions and Organizations
- Large Marine Ecosystems
- Legislation and Conventions
- Management and Conservation Programmes
- Marine Pollution
- Marine Protected Areas
- Maritime Activities
- Non-Living Resources
- Tourism
- Access by Countries
- Newsletters

Figure 1. Ocean-Docs-Africa editorial team enter records in the repository.

Information on countries can be obtained through the "Access by Countries" link. These include maps, population, and natural resources.

The portal already had more that 5,000 knowledge objects in 290 topics at the end of 2008.

For more information on the African Ocean Portal visit:
www.africanoceans.net

The Directory of Marine and Freshwater Professionals - OceanExpert

OceanExpert is a global directory of marine and freshwater professionals developed in 1997 under the auspices of the IODE's Group of Experts on Marine Information Management. The information in the directory includes names, addresses, institutional affiliation, specialization and bibliographic information on publications of the experts. The librarians of the ODINAFRICA institutions maintain the African records in the

OceanExpert. It is a tool for scientists, policy makers and anyone who needs to contact a marine or freshwater professional in Africa.

For more information on OceanExpert visit:
http://www.oceanexpert.org

OTHERS SOURCES OF MARINE RELATED INFORMATION

Several initiatives have been launched by various organizations and programmes to assist researchers and resource managers get the information that they require for their work. Many of these can be accessed either free of charge or at reduced costs. Below we provide information on some of these initiatives.

Aquatic Sciences and Fisheries Abstracts (ASFA)

ASFA is a bibliographic database covering the world's literature on the science, technology, management, and conservation of marine, brackish water, and freshwater resources and environments, including their socio-economic and legal aspects.

Figure 2. Librarians participating in OceanDoc's training in December 2005.

Figure 3. AFRILIB demonstration at the ODINAFRICA Seminar in 2006.

ASFA contains more than a million references, with coverage since 1971. About 3,200 new bibliographic references are added each month to the database. Each record contains information on: title, author, abstract, publication type, publication name, year, etc. Links are provided to the full text article where it is available electronically.

Though ASFA is a commercial database, institutions from Low Income Food Deficient Countries (LIFDC) are eligible to benefit from free access to ASFA via the internet or on CD-ROM. This initiative, which was started in 1999, currently covers 38 institutions in Africa and 13 from other regions. You can get information on how to apply for free access from ftp://ftp.fao.org/fi/asfa/faq/faq9_e.pdf.

For further information on ASFA visit:
http://www.fao.org/fi/asfa/asfa.asp

Figure 4. Marine Information Management training, September 2005.

International Association of Marine Science Libraries and Information Centres (IAMSLIC)'s Z39.50 distributed libraries

IAMSLIC facilitates international resource sharing among aquatic and marine science libraries and information centres. IAMSLIC is a international organization dealing with recording, retrieval and dissemination of knowledge and information in all aspects of aquatic and marine sciences, and allied disciplines.

The website provides a full range of resources including the Z39.50 online catalogue and the union list of marine and aquatic serials. The IAMSLIC Z39.50 is a distributed library that enables users to identify publications from libraries in order to request them via interlibrary loan. Even information from libraries that do not have online catalogues can be searched via Z39.50.

The Union List contains information for more than 15 000 serial titles, largely from worldwide journals on aquatic and marine sciences.

Besides this, several regional list of serials are also available such the one of Africa Regional Group of the International Association of Aquatic and Marine Science Libraries and Information Centres (AFRIAMSLIC Union list): http://library.csumb.edu:80/iamslic/africa/unionlist/search.php.

This database provides information on journal holding from African institutions participating in IAMSLIC, and allows free access and provision of electronic journal articles to users among the regional and international network. ODINAFRICA has subscribed all participating institutions in Africa, enabling them to participate in the IAMSLIC initiative and utilise this global network of aquatic and marine information providers.

For more information on IAMSLIC visit:
http://www.iamslic.org

Figure 5. Ocean Docs training in February 2005.

Open Science Directory

The Open Science Directory is a federated search tool for open access and reduced cost directories and online journals. It is being developed through the joint effort of the Intergovernmental Oceanographic Commission of UNESCO, Hasselt University, and EBSCO Publishers.

After registration, African institutions can access many of the major journals on marine science and oceanography, and other related topics and issues.

Figure 6. Oceandoc Africa regional coordinators.

Table 1. Programmes and collections providing access to online journals through the Open Science Directory.

AGORA - Access to Global Online Research in Agriculture http://www.aginternetwork.org
This program provides free or low cost access to major scientific journals in agriculture and related biological, environmental and social sciences, to public institutions in developing countries. Led by the Food and Agriculture Organization (FAO) of the United Nations, the goal of AGORA is to improve the quality and effectiveness of agricultural research, education and training in low-income countries, and in turn, to improve food security. Through AGORA, researchers, policy-makers, educators, students, technical workers and extension specialists have access to high-quality, relevant and timely agricultural information via the Internet.
OARE - Online Access to Research in the Environment http://www.oaresciences.org
This is an international public-private partnership that provides developing nations access to one of the world's largest collections (1300 journal titles) of natural and environmental science research with the possibility to download complete articles from the publishers' websites.
DOAJ - Directory of Open Access Journals http://www.doaj.org/
Operated by Lund University Libraries, DOAJ provides access to more than 2000 scholarly and scientific open access journals, and aims to include all open access publications, that use peer review or editorial control standards. The objective is to improve the visibility and access to open access publications and to increase their use and impact in the research and education community.

PERI - Programme for the Enhancement of Research Information
http://www.inasp.info

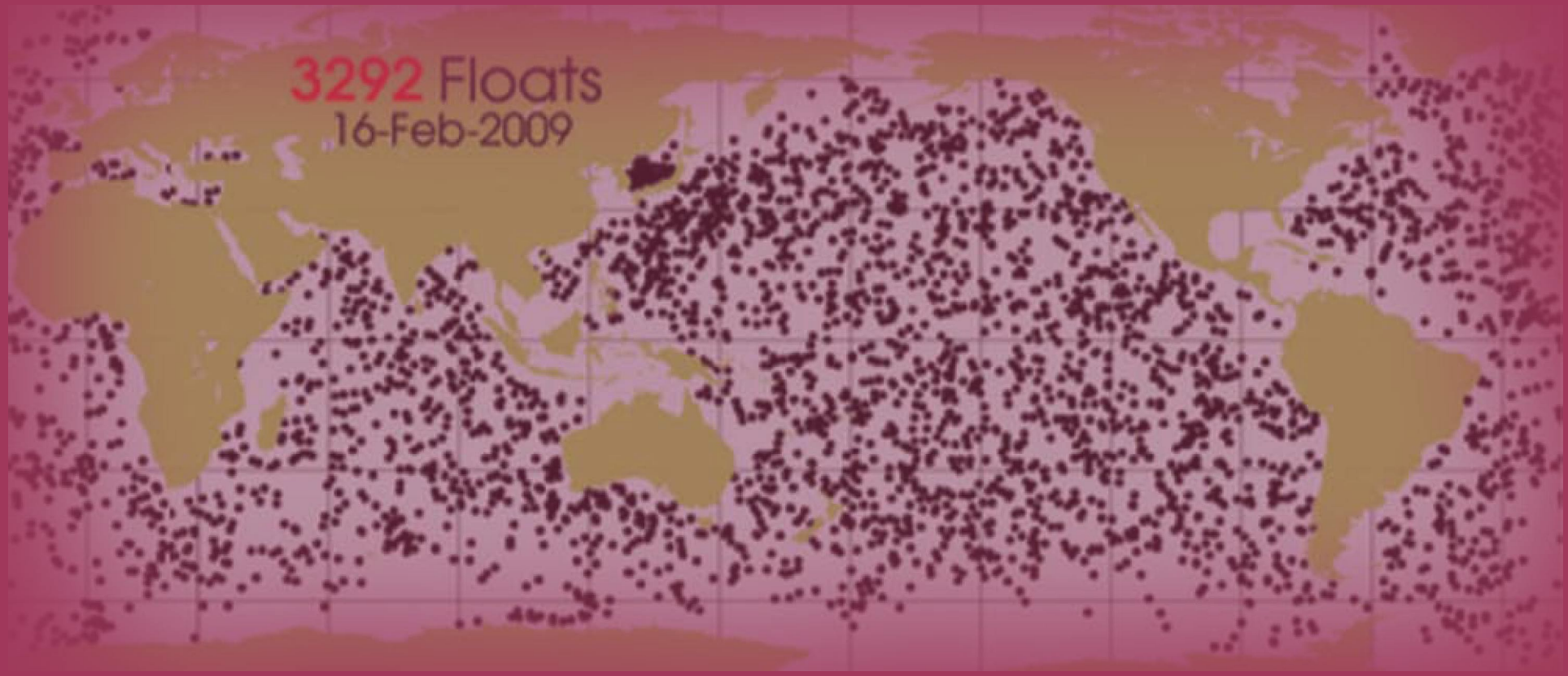
PERI is implemented by the International Network for the Availability for Scientific Publication (INASP). PERI offers free or affordable access to research literature, access to full-text online journals, document delivery from more than 20 000 journals, dissemination and promotion of local research, Information Communication Technology (ICT) training, publishing management and production training, and a publishing partnership programme. The aim is to further the acquisition of international knowledge and information, and the awareness and use of ICT's. Subscription costs are set according to the GDP and/or the HDI of the country.

AJOL - African Journals Online
http://www.ajol.info/

Offers free access to scientific journals published in Africa, and includes more than 175 English and French-language publications from 21 African countries. Emphasis is on agriculture, science and technology, health, and social science journals. The aim is to increase awareness and use of indigenous African research around the world, and support journal publishing in Africa. Registration is open to individuals and organizations worldwide.

For more information on the Open Science Directory visit:
http://www.opensciencedirectory.net

6 Ocean Data Applications: Examples from Africa



6 Ocean Data Applications: Examples from Africa

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A better understanding and management of the marine environment require improved access to data and information by government agencies. Such data and information helps nations in prudent and sustainable exploitation of marine resources, forecasting events, improving safety at sea, and mitigation of disasters such as tsunamis.

A survey by the Ocean Data and Information Network for Africa in 2006 revealed a wide range of data and information requirements. Covering physical, biological, meteorological, geological, and chemical aspects of coastal and marine science (Table 1). Though, it was evident all the countries surveyed regularly collect some amount of the various data types, none however has the capability to generate adequate data for optimal management of its coastal and marine environments. The need to share data across countries therefore is necessary to help mitigate the paucity of data and information. The problem also has an in-country dimension. In several of the countries surveyed, data collection is often duplicated and existing datasets not shared, or other relevant sectors and agencies may not be aware of their existence.

In this chapter, examples of the application of ocean data and information are presented to help increase awareness on the importance of such efforts.

Forecasting Events

Event forecasting depends on availability of quality data as well as the ability to model them. In certain instances, rapid dissemination of real time data is paramount, as is the case with tsunamis for example.

Figure 1. Data and information requirements for Integrated Coastal Area Management, identified during the ODINAFRICA survey in 2006. The listed data types and end users are not shown in any order of priority.

Typical end-user	Data /Information type
Fishing industry	Weather forecast, storm surge forecast, tides forecast, maps of fishing grounds, upwelling strength prediction, fish catch statistics, marine traffic guides, pollution indices
Governing authorities (regional, district and local authorities)	Effluent discharge rates/models, erosion/sediment budget models, fish catch statistics, land use/land suitability maps, population census data
Ports and harbours authorities	Tides forecast, storm surges forecast, sediment budget models, current maps, oceanographic charts (bathymetry and navigational hazards, etc), marine traffic guides
Tourism sector	Tides forecast, game fish atlas, thematic maps on lagoons, estuaries, beaches (i.e. location, water quality, permitted recreational use (i.e. bathing, fishing, etc), type of wildlife available, etc), environmental sensitivity maps, bio-geographical maps, species list for ecotourism and land use maps
Water sector	Coastal aquifer recharge/salt water intrusion information
Navy and maritime authority	Tides forecast, storm surges forecast, sediment budget models, current maps, sea density, oceanographic charts (bathymetry and navigational hazards, etc), marine traffic guides
Industry (offshore oil and gas)	Seismic survey data, weather forecast, current regimes, bathymetry, environmental sensitivity maps, physiographic/hazard maps, marine traffic routes
Researchers academics and non-governmental organizations	All of the above

Predicting changes over a longer period, such as potential sealevel rise and shoreline change, does not necessarily require realtime data. This said, it does need vast amounts of data from multiple sensors and studies, including tide data, for the time period addressed.

Tsunami

Long wavelength moving waves caused by quick displacement of ocean water are called tsunami, a Japanese word combining tsu (harbour) with nami (wave). When the waves reach shallower waters, wave height greatly increases and the water can surge ashore like a very fast high tide causing a potentially giant catastrophic wave. Earthquakes under the sea, landslides, and volcanic eruptions can all can create tsunamis.

Tsunami waves travel long distances. With modern sensors deployed around the globe, it is possible to alert coastal countries of an imminent tsunami threat and enable precautions to be taken to save life and property. Knowledge of local tidal information could make a significant difference to the potential impacts of a tsunami. If the estimated arrival time of a tsunami wave happens to coincide with the time of the local high tide, the predicted wave height will be of a higher magnitude, and impacts would be correspondingly more severe. Thus, not only information of the propagation of the wave is vital, but also the predicted local tidal data which helps in a determining the extent of the disaster.

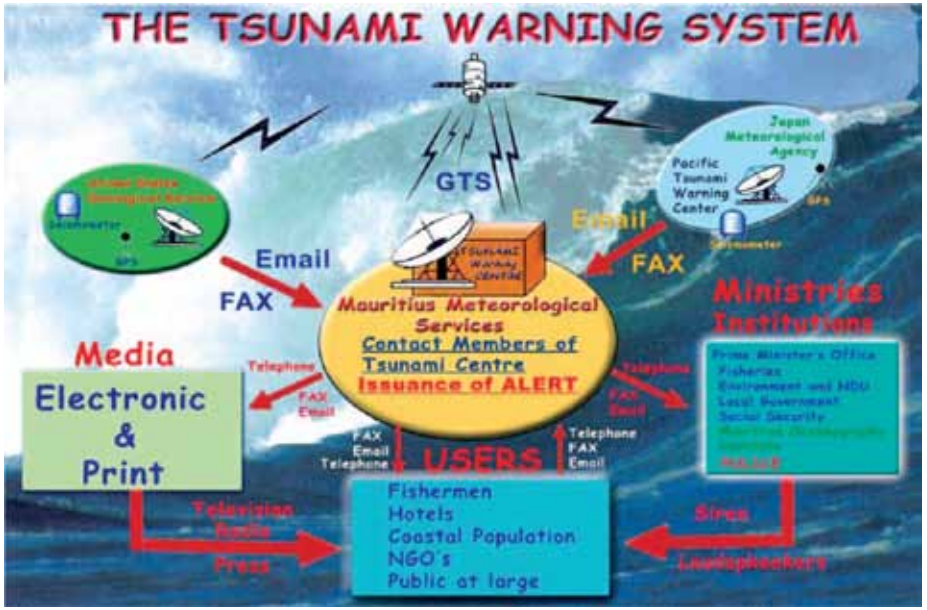

Figure 2. The Tsunami warning system of Mauritius.

Sea Level Rise and Shoreline Change

Tide data are important in many ways in both global and national contexts. Globally, they are particularly important in estimating how

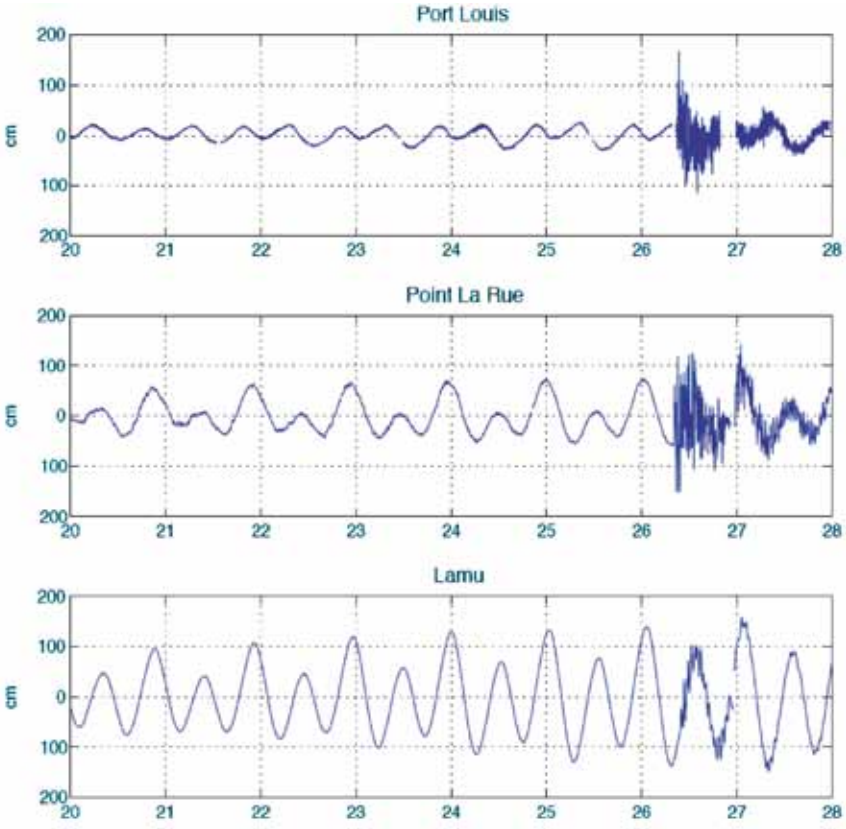

Figure 3. Tidal stations data during the Indian ocean tsunami of December 24, 2004 from Port Louis (Mauritius), Point La Rue (Seychelles), and Lamu (Kenya).

fast the sea level is potentially rising. At national, or even local scales, raised sea levels may exacerbate shoreline erosion and recession rates. Therefore, tide data must be included in such models, particularly in areas where sediments are unconsolidated. Coastal planners and developers may use such predictions for determining the best sites for planned developments, such as building of new cities and important infrastructure.

Ocean and sea surface temperature (SSTs) data

One of the most common parameters collected from the marine environment is temperature. Temperature data is obtained either directly with probes or remotely from satellites. Ordinary thermometers as well as more sophisticated tools like expendable bathythermographs (XBTs), and satellite – linked Argo floats and buoys are now deployed globally to provide sub-surface, sub-sea surface temperature data and other data.

Expendable Bathythermographs (XBTs)

XBTs are launched from the bridge of ships using a hand launcher to monitor the upper ocean thermal structure along several transects in all ocean basins (Figure 4). The data are logged to a computer, where it is processed and formatted for satellite transmission in real-time through the Global Telecommunications System (GTS). The data are then used by national and international organizations, universities and government laboratories for weather and climate forecasting, and for climate research.

ARGO Floats

Another temperature data recorder is the Argo float (Figure 5). Most ARGO floats drift at a depth of 2 000 m for about 10 days, and then make a profile of temperature and salinity from 2 000 m to the surface. The float then stays at the surface for about 5 hours sending the data to a satellite, descending afterwards to the resting depth of 2 000 m (Figure 5).

Figure 4. XBT (left) being shot into the sea off the Ghana coast (right).

Both XBTs and floats provide vital observations to estimate the heat contained in the upper ocean and the surface currents which drive the sea surface temperatures. These are critical ocean variables determining the locations of high and low atmospheric pressure systems. The understanding of the upper ocean temperatures provided by XBT observations is vital for better forecasts of marine weather. Several thousand ARGO floats have been deployed worldwide (Figure 6).

Coral bleaching

Corals are colonial animals and the individuals, called polyps, are very similar to tiny sea anemones. They grow in warm, clear, shallow waters with optimal temperatures of 23^0 to 25^0C. The polyps harbour in their tissues symbiotic masses of single-celled algae called zooxanthellae. The coral provides the algal cells with a protected environment and nutrients for growth as well as carbon dioxide. The algal cells photosynthesise returning oxygen and removing waste. Under certain

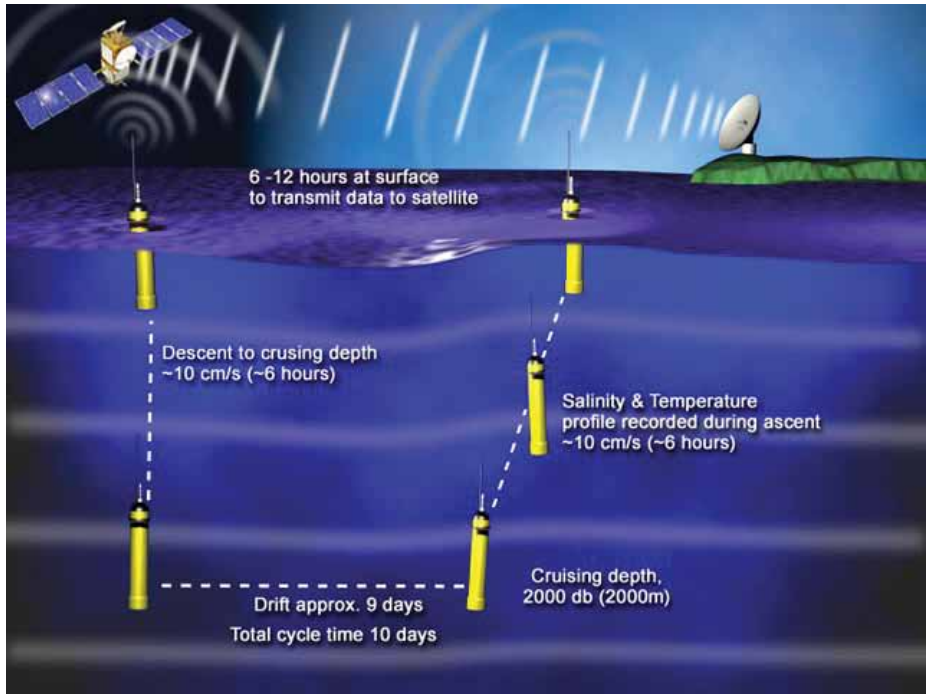

Figure 5. Diagrammatic representation of how an ARGO float works (available at UCSD: http://www.argo.ucsd.edu, accessed on the 8th May 2009).

unfavorable conditions, such as increased sea temperatures, the corals become stressed and expel the algal cells. They become quite pale, a condition described as coral bleaching.

Data on ocean temperature may help explain certain catastrophic ecological events. Elevated temperatures, for example, have been implied in instances of coral bleaching in Tanzania (Figure 7.) and continuous monitoring of sea temperature would serve as an early signal to onsets of coral bleaching and death.

Sea surface temperature (SST), upwelling strength and marine productivity in the Gulf of Guinea

Small pelagic fisheries constitute the main source of livelihood for several coastal communities of the Guinea Current area in West Africa.

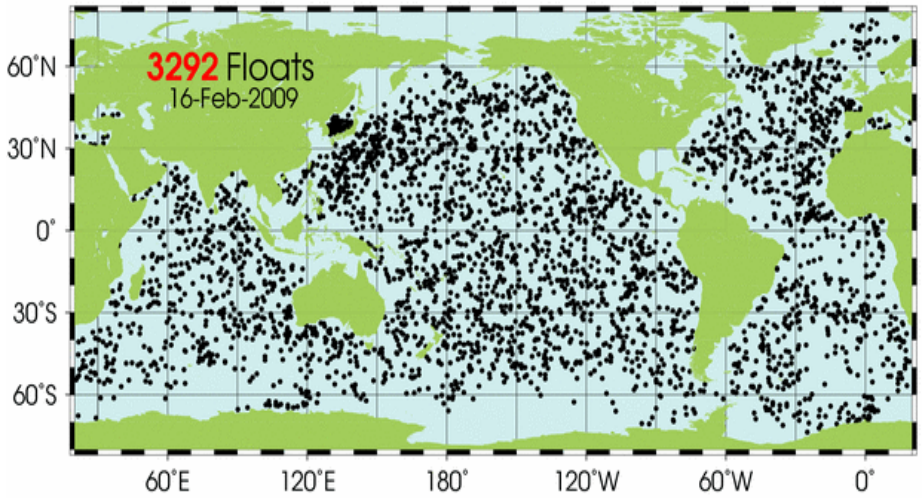

Figure 6. Global coverage of ARGO floats (available at UCSD: http://www.argo.ucsd.edu/FrAbout_Argo.html accessed on 16th February 2009).

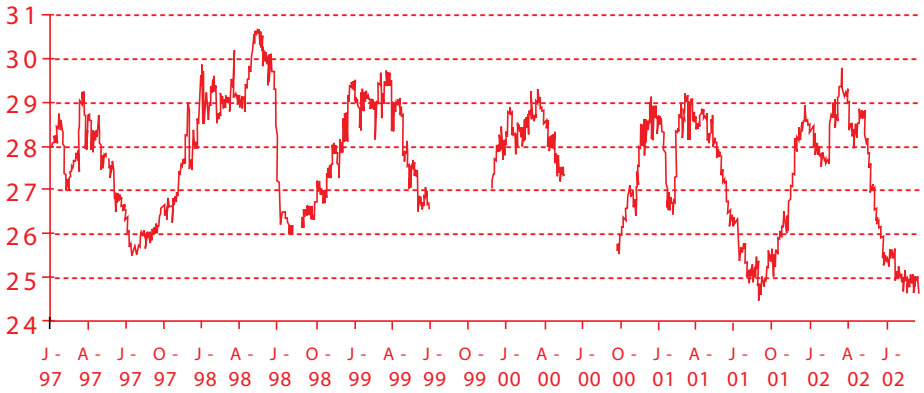

Figure 7. The daily mean seawater temperature records on coral reefs off Zanzibar town (1997 -2002). The higher temperatures in March – May 1998 coincided with coral bleaching in the study area. (Source: Muhando, 2002).

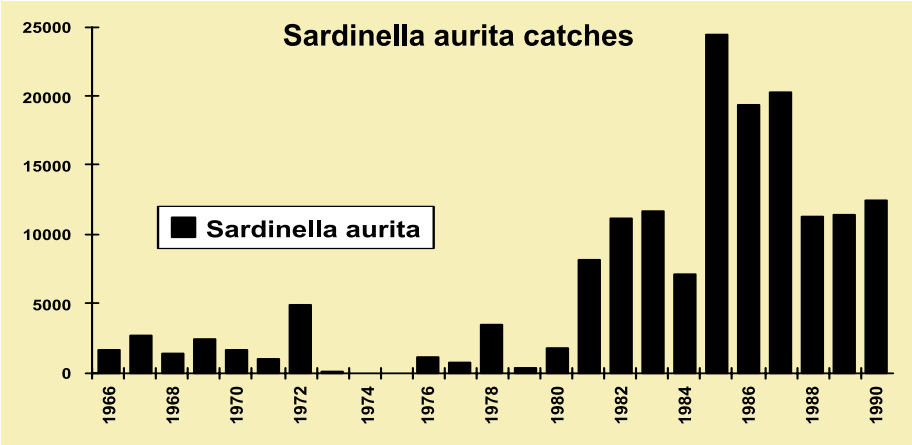

Figure 8. Sardinella aurita catches off Cote d'Ivoire from 1970 to 1990.

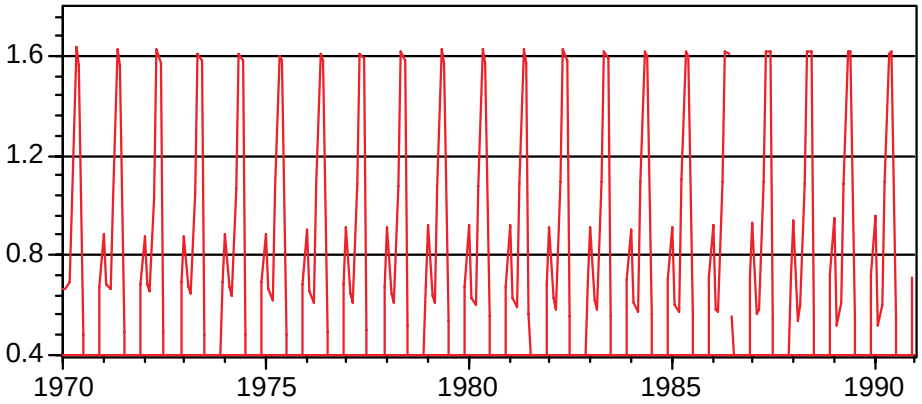

Figure 9. SST anomalies off Côte d'Ivoire from 1970 to 1990.

The success of the fishery depends on the strength of the upwelling. Because strong upwelling periods are associated with the duration and spatial extent of upwelled colder water, data on near shore temperatures may be useful indicators for forecasting the success of the fishery.

A good example is illustrated by the catch statistics from Cote d'Ivoire and SST anomalies measured from 1970 to 1990 (Figures 8 and 9). Increases in the strength of the upwelling, indicated by the amplitude

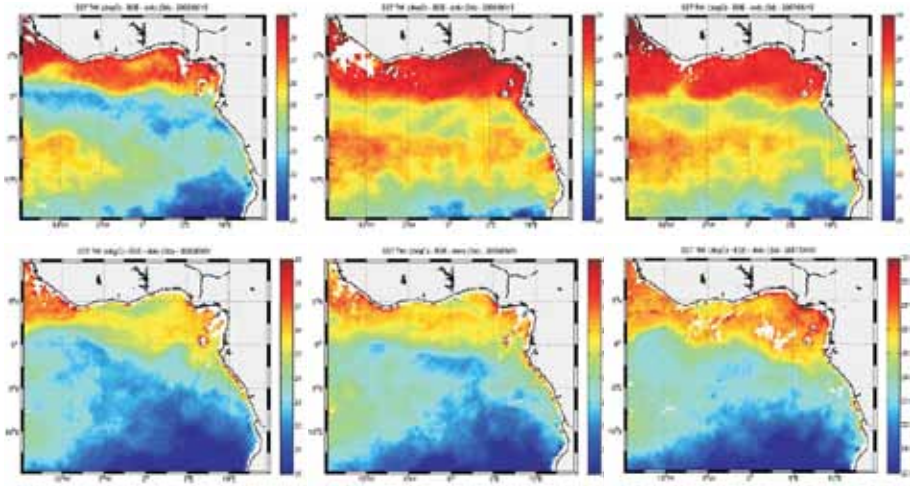

Figure 10. Upper panels: sea surface temperature on June 15th 2005 (left), 2006 (middle) and 2007 (right). Lower panels: same for September 1st 2005 (left), 2006 (middle) and 2007 (right) Courtesy Dominique Dagorne and B. Bourles; TMI/TRMM data) Aman et al. (2008).

of the SST anomalies, appear to correlate with the rise in catches of *Sardinella aurita*, the main species caught by the small pelagic fishery Figures 8 and 9).

SST and regional climate of West Africa

SSTs in the Gulf of Guinea vary at seasonal and inter-annual time scales (Figure 10), and may have a strong impact on regional climate (west Africa monsoon onset and intensity), precipitation i.e. water resources (Figure 11), and fisheries. In particular, the coastal upwelling may have a regional impact on air-sea exchanges and thus on precipitation during the West African monsoon period.

Knowledge and availability of near real-time data on SSTs in the Gulf of Guinea can be applied in forecasting rainy (wet) years or drought (dry) years in the west African hinterland influenced by the monsoon.

Regional scale SST data therefore can be useful in predicting to reasonable extents probable wet and dry years. This in turn could

assist in the formulation of critical management strategies for certain national sectors, such as power use from hydroelectric dams, as well as the security of rain-fed agriculture in west Africa.

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7 The Ocean Data and Information Network of Africa

The Ocean Data and Information Network for Africa

The Ocean Data and Information Network for Africa was launched to address the challenges identified in various fora for and by African coastal countries. These included the IOC Regional Committees for the Western Indian Ocean (IOCWIO), and the Central and Eastern Atlantic (IOCEA), the UNEP Regional Seas Programme (the 1985 Nairobi Convention for the Protection, Management and Development of Marine and Coastal Environment of the Eastern African Region; and the 1981 Abidjan Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African region), the Pan African Conference on Sustainable Coastal Management – PACSICOM (1998, Maputo, Mozambique), and the World Summit on Sustainable Development (2002, Johannesburg, South Africa).

The network, which started off with libraries in seven member states in Eastern Africa (Kenya, Madagascar, Mauritius, Mozambique, Seychelles and Tanzania), sharing resources to improve access to scientific literature by marine and freshwater professionals now encompasses more than forty institutions in twenty-five countries all over Africa. The scope has also grown to include data processing, archiving, analysis and interpretation as well as installation of tide gauges.

The librarians have worked together to develop institutional library catalogues that have been merged into a union catalogue. They have also developed directories of marine and freshwater professionals, and repository of marine related publications from Africa. They have formed an African chapter of the International Association of Marine Science Libraries and Information Centres. Nine of the institutions from Cote d'Ivoire, Egypt, Guinea, Kenya, Mauritania, Mozambique, Senegal, Tanzania and Tunisia have been accepted as input centres for the Aquatic Sciences and Fisheries – ASFA database.

The National Oceanographic Data Centres (NODC's) have on the other hand developed infrastructure for processing, analysis and interpretation of data. They have acquired data collected from their national waters available in other data centres in the region and internationally, and enriched these with information available in national institutions to create national ocean databases. Some of the specialized databases created cover datasets such as marine biodiversity databases, hydrographic data, and environmental data. They have joined forces to create the African Marine Atlas. Tide gauges were installed at selected locations along the African coastline.

The network has developed strong links with other organizations and programmes such as the Western Indian Ocean Marine Science Association, the secretariat for the Coastal and Marine sub-theme for the New Partnership for African Development (NEPAD/COSMAR), the African Coelacanth Project (ACEP), and the United Nations Environment Programmes Division of Early Warning (DEWA). These enabled the joint implementation of activities and sharing of resources.

In this chapter, the ODINAFRICA contacts in 19 countries have provided important national marine information, including key issues that need to be addressed, as well as information on the development of the NODCs and information centres. Each section starts with a map and table of demographic, socio-economic and environmental statistics. The information is derived from a set of international sources referenced at the end of the chapter, or is derived from the alternative data sources noted.

Figure 1. Map showing countries participating in ODINAFRICA.

7.1 Benin

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Capital city	Porto Novo (Administrative capital) Cotonou (Economic capital)
Population (2005 est.)	8,500,000 (2.9% growth)
GDP per capita (USD 2005 est.)	$1 141
Life expectancy at birth (2005 est.)	54.4 years (male - 54.1, female - 56.5)
Total Area	112,620 km^2 (land - 110,620, water - 2 000)
Length of coastline	121 km
Highest point of elevation	Mountainous region of Atacora which is greater than 800 m.
Coral reef area (2001 est.)	Coral covering approximately 50 km in length in the western area of continental shelf (Djiman, pers. comm.)
Mangrove area (2005 est.)	1 150 ha
Proposed marine protected areas (2007 est.)	Four sites have been proposed at the time of publication (Djiman, pers. comm.)
Capture fisheries prod. (2006 est.)	38,021 metric tones
Aquaculture fisheries prod. (2006 est.)	415 metric tones

Rivers on the Country's Coast: The principal rivers on the coast of Benin are the Ouémé river (510 km), Couffo river (125 km), and the Mono river (100 km). There are a number of lakes and lagoons which include; Lake Nokoué, Lake Ahémé, coastal lagoons and the Porto-Novo lagoon.

Coastal Climate: The sub-equatorial climate in the South comprises of the following seasons: a long rains season from April to July, a short dry season from July to September, a short rainy season from September to October, long dry season from November to March.

Coastal Geomorphology: The coastal area of Benin includes the southern part of the coastal sedimentary basin and the coastal plain. The zone is located between 6°10' and 6°40' North Latitude and 1°40' and 2°45' East Longitude.

Geomorphology of the coastal area of Benin consists of:

- Ranges separated by valleys of the rivers Mono and Couffo Ouémé
- A coastal plain with a number of different geomorphological features connected to the Ahémé and Nokoué lakes and the sea. In the lower valley (Ouémé), there are also adjoining delta areas
- A continental shelf of 22 kms at the western border and 33 kms at the eastern boarder. It has a gentle slope up to 35 metres deep, then breaking to deeper waters from 35 to 45 metres in depth.

Coastal Habitats: The habitats of the coastal zone include natural ecosystems and those affected by anthropogenic influences. There are several ecosystems including bush scrub and savanna grassland. Bush scrub characterizes the coastal zone and barrier beaches. Savanna grassland is dominant further inland. In the flood plains the dominant species are *Paspalum vaginatum, Cyrtosperma senegalensis* and *Cyperus articulatus, Typha australis* and *Cyperus striatus*. *Pterocarpus santalinoïdes Cola* and *Cordofolia* are located on the banks of rivers Mono, Ouémé, Couffo and their tributaries. Mangroves are specialised halophiles, and forests are found on the coasts and estuaries with muddy soils, both hydromorphic and asphyxia (Toffi, 1991). They are found on the banks of rivers Mono, the SAZU, the "lake" Ahémé of Aho.

Coastal Currents and tides: Currents of Benin can be described in the following groupings:

Surface currents: warm and to the west-east in direction, the surface currents move at the speed of 1 to 3 knots from the coast of Ghana towards Nigeria

Deep currents: there are three predominant deep currents: the first between 35 - 34m, the second approximately 55 m bearing on Sèmè, and the last circulates at 75 m to greater than 100 m of depth.

Reverse currents: there are two principal reverse currents: The first is periodic and circulates in the South-eastern/North-western direction (S-E/N-W) of Nigeria towards Togo. The other stronger one goes from the coast towards the open sea with a North-eastern South-western component (N-E/S-W).

Local currents: there are other local currents of less importance than the previously described currents. They are the wind driven "Atramessi", caused by river water under the pressure of the "Afoutou" and the "Gbeya" or "Kpodjohon" which results from the calm winds coming from the continent.

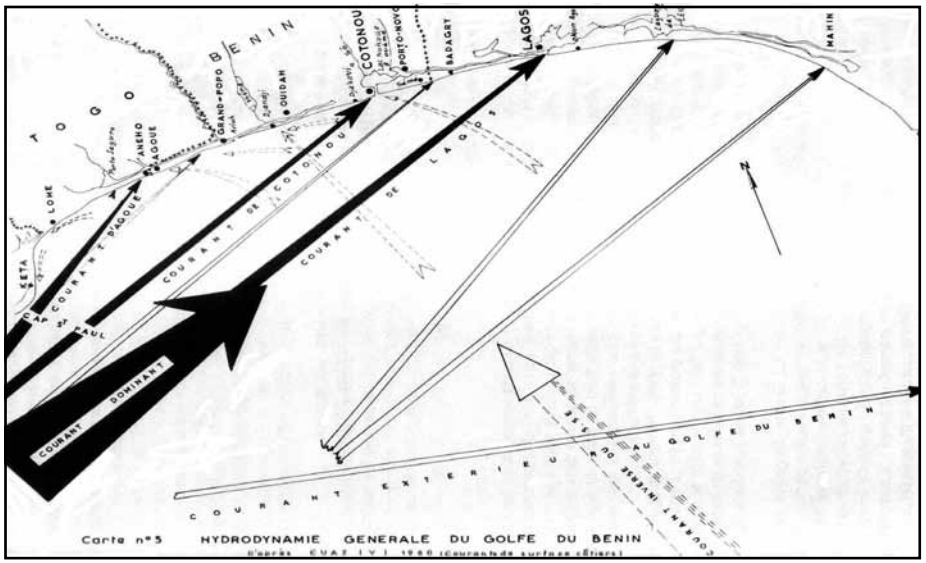

Figure 1. Horizontal circulation of beninese waters (reproduced from Cuaz, 1960).

The tide on Benin's coast is mixed with a semi-diurnal cycle, between 0.50 and 1.50 m. The extremes observed on the coast are +1.95 and 0.20 m (BCEOM, 1974). This is due to two types of swells:
1) long wave occurring far from the coast, with a 180 - 200 m length and an average amplitude of 1.2 m and,
2) localized short wave swell due to the influence of local winds and very variable length of approximately 50 m.

Coastal Observations: The coastal observations made by Centre de Researches Halieutiques et Océanologiques du Bénin (CRHOB) are:

- Regular monitoring of surface temperature through the deployment of thermometers since July 2005 to date.

- Weekly measurements of various physio-chemical parameters of sea water.

Ports and Harbours: The role of the port and the Cotonou Port Authority (CAP) in the current economic development of Benin is significant. The port of Cotonou supports not only Benin, but is an important gateway for the import-export traffic of some landlocked countries in West Africa (Mali, Burkina-Faso, and Niger).

Coastal Economy: The coastal zone is the economic engine of the country, due to its proximity to the main cities, its infrastructure (harbours and airports), and number of important national industries. Tourism, which is significant in the coast, is also very important. Through its beaches and tourist infrastructure, the coast offers close to fifty tourist resorts concentrated especially in the towns of Cotonou, Grand-Popo, Ouidah and Sèmè.

Other activities in the coastal area of Benin which are of considerable economic importance include:

- Exploitation of the sand pits for construction in the district of Ouidah, Grand-Popo, and Sèmè-Kpodji
- Salt production in Ouidah and Large-Popo district
- Installation of the acadjas system of trapping fish in certain lakes (Nokoué, and Ahémé districts)
- Exploitation of petroleum resources in coastal waters. These are transported by inland waterways which is the least expensive mode of transport.

Fisheries: Fishing is a traditional activity, with the species of fresh water (tilapia) and shellfish providing important sources of food for the population. Since the construction of the port of Cotonou in 1960, fishing was principally developed by Ghanaian immigrants who introduced motorized boats which has now industrialized the work. With a total production close to 40,000 tones per annum, industrial and artisanal maritime fishing provided 27% of total production against 73% by freshwater fishing. This production is carried out by an industrial fleet of 10 to 12 trawlers and shrimp harvesters, 850 artisanal open sea fishing boats and 35,000 small fishing boats (Direction des Pêches, 2001, and CRHOB, 2004).

Mineral Resources: Peat, natural gas, oil reservoirs, sand, gravel and clay are all valuable resources used in the coastal area of Benin, in addition to the extraction of water.

Agricultural products: Coconut plantations in coastal areas provide a substantial income to the owners who often undertake other livelihoods such as fishing. Next to the coastal lagoons, food crops (corn, manioc, niébé) are grown but only at small scales. Generally these crops are not very productive in the coastal area. Corn (the principal staple food), manioc, niébé, groundnut and vegetables such as tomatoes are also grown for local consumption.

Other marine resources: Marine cetaceans, sea-birds, mangroves, salt production, and sand are all additional marine resources of the Benin coast, of value for tourism or to the local economy.

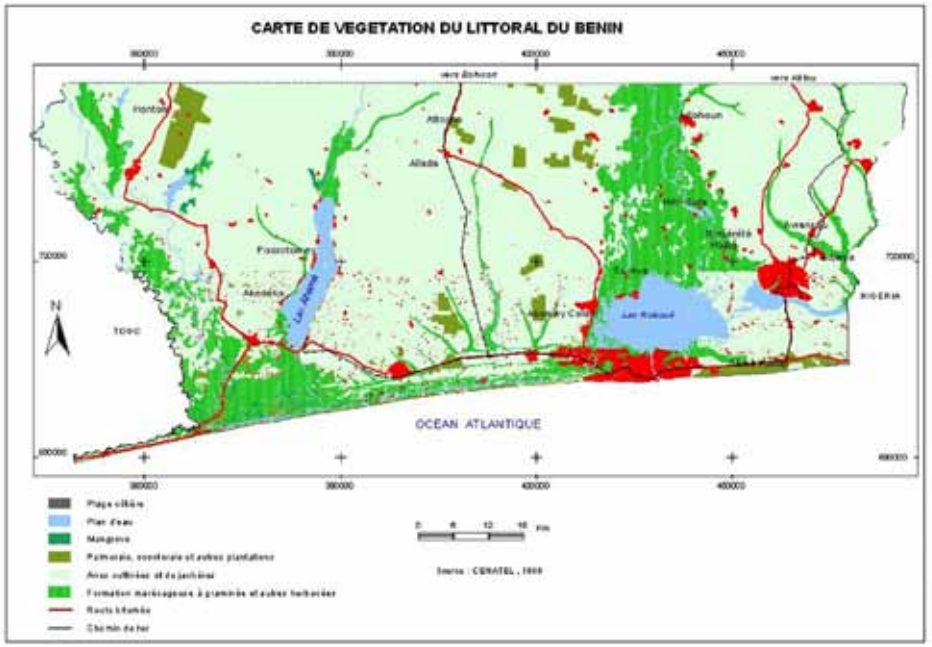

Figure 2. Map of Benin coastal area (LEFI/ CENATEL/ CRHOB 2003).

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

The densely populated coastal area of Benin has been exploited since the 17th century. Even though the historical records of occupation of the area are not conclusive, it is certain that this area has been occupied for nearly ten centuries by the socio cultural groups of Peda, Xwla, Gen and Fon (Pliya, 1980). Current estimates put the density of the rural population on the Benin coast at nearly 200 people per km^2. This area is one of the largest settlements in the country. (INSAE/ RGPH 2000)

Coastal urbanization is due primarily to the large industrial and tertiary sectors in Cotonou. The population of the main cities (Grand-Popo, Ouidah, Cotonou and Sèmè) is estimated at nearly 1,500,000 inhabitants. The urbanization of Cotonou is more alarming. The city, with approximately 750,000 inhabitants, is the only viable area for urbanization and has expanded rapidly, resulting in significant erosion.

Figure 3. Fishing boats anchored in an estuary in Beninn.

Figure 4. CRHOB researchers prepare oceanographic equipment for data collection.

More broadly, the main issues affecting coastal area of Benin are:

a. Coastal erosion and the impoverishment of the soil at Sèmè along the coast in East area of the Cotonou port and Grand Popo and Agoué towns in West
b. Industrial pollution of the sources of fresh and coastal water mainly around Cotonou and Porto-Novo towns
c. Impacts of increasingly high population density in the coastal zone.

Figure 5. Z. Sohou, Benin Data Manager chats with R. Chuchla of IRD on board RV Suroit during monsoon cruise.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The National Oceanographic Data and Information Centre (CNDO-Benin) is based at the Centre de Researches Halieutiques et Océanologiques du Bénin (CRHOB), which is the centre that oversees the national research of the coastal area. The centre is overseen by the Benin Centre for Technical and Scientific Research in the Ministry for Higher Education and Scientific Research.

A National Pilot Committee was put in place for the implementation of the NODC activities. The objectives of the CNDO-Benin include:

- To facilitate a network of exchange and filing of oceanographic data and information at the national level
- To promote and facilitate communication among scientists at the national and sub-regional level.
- To disseminate scientific information throughout the country.

Products and services include:

- Analysis, workplans and reports on the management of maritime fisheries, oceanographic and trawling campaigns, protected areas, and marine mammals
- Marine atlases on fish and other products, and coastal and marine mapping products
- National directory of researchers, institutions, and NGO's working in marine sciences and coastal areas
- Bibliographical information on marine and coastal science
- Provision of oceanographic and fishing data and information both in printed and electronic form, such as CD-ROMs, data bases, and through the centre's website
- Research and consultancy on management and protection of fisheries and development of aquaculture
- Document and inter-library loans
- Public information and sensitisation on fisheries and oceanography issues
- Training in data management and oceanographic information.

National Partners

- Direction des Pêches
- Port Autonome de Cotonou (PAC) – E-mail: pac@leland.bj
- Institut Géographique National (IGN)
- Centre National de Télédétection (CENATEL)
- Direction Générale de l'Environnement (DGE)
- L'Agence Béninoise pour l'Environnement (ABE) – E-mail: abepge@bow.intnet.bj
- Institut National de la Statistique et de l'Analyse Economique (INSAE)
- Direction de la Météorologie Nationale (DMN)
- Direction de la Marine Marchande (DMM)

- Direction Générale de l'Eau (DGE)
- Force Navale
- Université d'Abomey-Calavi (UAC)
- NGO's: Nature Tropicale, Littoral, Bénin 21 et Bénin Nature

Marine Related Programmes And Organizations

- Sub-regional and International Oceanographic and Data Centres (Togo, Nigeria, Côte d'Ivoire, Ghana)
- Guinea Current Large Marine Ecosystem (GCLME) project - http://www.gclme.org
- Multidisciplinary Analysis of African Monsoon (AMMA) project - http://www.amma-international.org/
- Centre des Pêches du Golfe de Moncton (NB-Canada) - http//www.dfo-mpo.gc.ca
- Programme Régional d'Océanographie Physique en Afrique de l'Ouest (PROPAO) bringing together Côte d'Ivoire, Ghana, Togo, Benin and Nigeria - http://www.nodc-benin.org

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7.2 Cameroon

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Institute of Agricultural Research for Development (IRAD)
Ministry of Scientific Research and Innovation (MINRESI)
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Capital city	Yaoundé
Population (2005 est.)	17,800,000 (1.9% growth)
GDP per capita (USD 2005 est.)	$2 299
Life expectancy at birth (2005 est.)	49.8 years (male - 49.4, female - 50.2)
Total Area	475,440 km^2 (land - 469 440, water - 600)
Length of coastline	402 km
Highest point of elevation	Mount Fako (Mount Cameroon) 4 095 m
Mangrove area (2005 est.)	250,000 ha
Marine protected areas (2007 est.)	7.31 km^2 (0.09% of total territorial waters)
Capture fisheries prod. (2006 est.)	137,232 metric tones
Aquaculture fisheries prod. (2006 est.)	340 metric tones

Geographic Location: Cameroon is located in West Africa, bordering the Bight of Biafra between Equatorial Guinea and Nigeria (6^{0}N, 12^{0}E). It is bounded on the north by Chad, on the east by Central African Republic, on the south by Congo, Gabon and Equatorial Guinea, on the west by Nigeria and on the Southwest by the Atlantic Ocean, with total land boundaries 4,591 km (Central African Republic 797 km, Chad 1,094 km, Congo 523 km, Equatorial Guinea 189 km, Gabon 298 km, Nigeria 1 690 km) and Economic Exclusive Zone (EEZ) about 15,000 km^2.

Rivers on the country's Coast: (Table 1 shows various Cameroonian rivers which flow to the Atlantic Ocean)

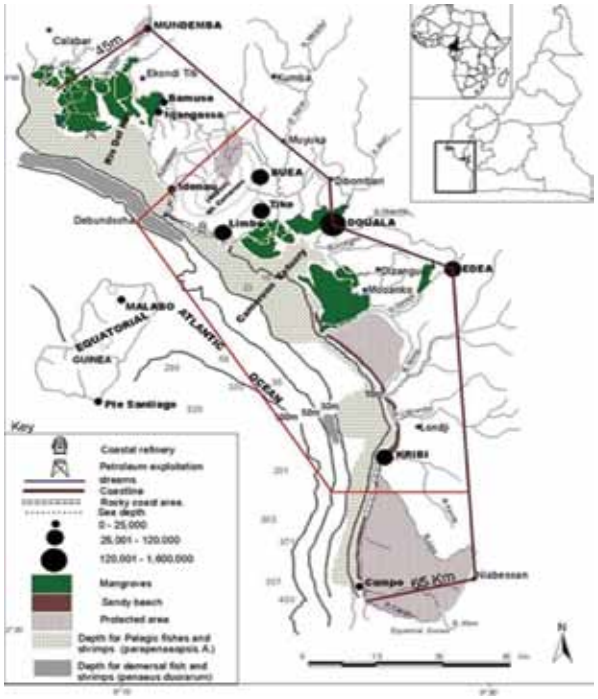

Figure 1. Characteristics of the coastal zone of Cameroon (Folack, 2003).

Table 1. Catchments area and estimated annual discharge (1974 - 1989) of the main coastal rivers in Cameroon (from IRGM, Yaoundé).

River	Catchment area (km^2)	Discharge (m^3 s-1)	
		Maximum	Minimum
Mungo	2 420	636	27.5
Wouri	3 250	1 425	49.0
Nyong	26 400	376	25.7
Sanaga	131 500	7 570	171.0
Ntem	26 350	764	50.0
Ndian		246	
Meme		300	

Coastal Climate: The climate of the coastal region is equatorial, with a regular alternation of dry (three months) and rainy seasons (nine months). This regime is marked by a permanent presence of the monsoon winds of the Guinean type, which account for very high humidity (often at saturation). Frequent and abundant rains, heavy haze and low evaporation rate characterise the coastal zone. The air temperature is high and steady. However, the configuration of background relief and orientation of the coast with regards to influx of the monsoon winds creates remarkable disparity in the quantity of rainfall, as well as other climatic parameters. The coast near Mount Cameroon experiences the most abundant rainfall: Debundscha, at the foot of Mount Cameroon, has an annual average rainfall of 11,000 mm. This is due to the orographic effect of the imposing volcano, as well as the orientation of the coast, which is perpendicular to the main oceanic influence. These rains reduce to the west and east, but remain quite high, measuring 4,000 to 6,000 mm in the Rio-del-Rey mangrove region and 4,000 to 5,000 mm in the Douala mangrove region.

Coastal Geomorphology: The coastal zone is characterized by three sedimentary basins: Campo Kribi, Douala and Rio-del Rey from the south to the north. These basins are rich in hydrocarbons and exploited by several petroleum companies.

Coastal Currents and Tides: Water circulation is slow, resulting in high rates of sedimentation. The tides are semi-diurnal and can reach amplitudes of 0.5 to 2.7 m, depending on the location. Their most spectacular effects are felt in the estuarine complexes of the mangroves where the waves penetrate deeply (Morin et al., 1989). Tidal influence can extend as far as 40 km in the Wouri, 20 km in the Mungo; riverine penetration is retarded by the narrowness of the creeks. The propagation of the waves and ebb tides are enormous, but poorly understood. The currents generally observed are those related to tides. At the level of Mabeta, Keita et al. (1991) measured current speeds varying between 0.5 and 1.4 m s^{-1} for the flux, and 0.5 to 3 m s^{-1} for the reflux. Observations of sea swells made by Chaubert and Garrand (1977) from November 1974 to November 1977 at Cape Limboh (Limbe) show that those from the south-south-west sector are of distant origin. They are generated by the “westerlies” of the South Atlantic (Guilcher 1954) and are little influenced by the dominant, but weak, south-westerly wind. The swells are diminished by the obstacle constituted by the Malabo South Island

and the expansion of the continental shelf in the south-west (up to 80 km wide). Consequently, the sea swells are generally weaker than on the rest of the west African coast which is more exposed. At Cape Limboh, the minimum amplitudes is 1.91 m and the maximum only 2.8 m. The strongest sea swell (226 m long) is generally experienced in the southern sector from June to September; the weakest swells occur from November to April.

Ports and Harbours: There are three main coastal ports in Cameroon: Douala, Limbe and Kribi. Kribi is a small port located at the mouth of the river Kienke mainly serving timber exportation. Douala is the bigger commercial port and is located on the river Wouri, 20 km from the sea. Limbe is the only sea port, which is focused on transport of passengers and goods to Malabo and Nigeria.

Figure 2. Coastal erosion impacts the Cameroon coastline (photo credit: Mr Jules Romain Ngueguim).

Figure 3. Cutting of the mangrove ecosystem for firewood to smoke fish (photo credit: Mr Jules Romain Ngueguim).

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The National Oceanographic Data Centre (NODC) Cameroon was created on 28th February, 2001 with the aim to:

- Improve on capacity building of oceanographic data and information management
- Facilitate access to data and exchange with other African states and national partner institutions
- Coordinate networks of national institutions involved in management of coastal and marine areas

The centre is hosted by the Specialized Research Centre for Marine Ecosystems (CERECOMA) based in Kribi. CERECOMA is an operational structure of the Institute of Agricultural Research for

Figure 4. Installation of Tide Gauge at Port SONARA (photo credit: Frédéric Simon, 22 June 2008).

Development (IRAD). IRAD is under the Ministry of Scientific Research and Innovation (MINRESI). A National Project Management Committee (NPMC) of 10 members was established in order to coordinate project activities in Cameroon. Beneficiaries of the products and services include: port services; coastal engineering; fisheries services; tourists; coastal management services; scientific research; university lecturers and students; NGO's, and civil society.

Figure 5.Tide gauge installed at Port SONARA (photo credit: Frédéric Simon, 22 June 2008).

The products and services include:

- Production of almanac and field guides e.g. guide to coastal and marine fishes in Cameroon
- Electronic and printed outreach materials e.g. posters, CD-ROMs such as the natural and anthropogenic characteristics of the coastal zone of Cameroon
- Maintenance of online databases, directories, bibliographies and catalogues e.g. directory of marine and freshwater professionals in Cameroon, catalogue of marine and coastal biodiversity in Cameroon
- Website development and maintenance
- Mapping products such as those required for the creation of a marine protected area

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The followings organizations are considered as secondary data sources for aquatic research and fisheries after the Specialized Research Centre for Marine Ecosystems (CERECOMA).

Institutions	Missions/Objectives	Types of data generated or to be generated
MINEPIA (Ministry of Livestock, Fisheries and Animal Husbandry)	Follow up law implementation Training and equipment for fishermen	Fishery statistics; typology of fishing gear and landing sites
Kudu Project on marine turtles conservation	Protection of marine turtles Improvement of livelihood of coastal population	Spawning area maps, migration information, statistics on marine turtles conservation and migration
INC (National Institute of Cartography)	GIS and elaboration of coastal maps	Coastal maps production, zonation maps, maps of risk areas and natural hazards, coastal towns master plans
MINDAF (Ministry of Domain and Land Affairs)	Land management	Record and database (statistics on land use) in coastal zone
MINEP (Ministry of Environment and Nature protection)	Follow up law implementation on environment issues	Data base on environmental impact assessment for all projects to be settled in the coastal area; delivering of authorisation to these projects
GCLME (Guinea Current Large Marine Ecosystem) Project	Restore the health of the GCLME	Country Coastal profile, pollution and hotspots maps, maps of nutrient load to coastal zone, water quality, fisheries and biodiversity, training
Douala Port Authority	Port management	Data on port traffic and goods
SONARA	Petroleum refinery	Sea level measurement, statistics on fuel production
SNH (National Hydrocarbon company)	Petroleum exploration and exploitation	Map of potential crude oil reserve zones, statistics on oil production and commercialisation
ENVI-REP Cameroon	Protection of natural resources and its environment	Environmental impact assessment, biodiversity, integrated coastal management, pollution monitory, resource management

Figure 6. Office equipped with tide gauge components including pressure and temperature sensors (photo credit: Frédéric Simon, 22 June 2008).

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Figure 7. Participants at the Kribi ICAM workshop (August, 2006).

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7.3 Congo

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Capital city	Brazzaville
Population (2005 est.)	58,700,000 (3.2% growth)
GDP per capita (USD 2005 est.)	$714
Life expectancy at birth (2005 est.)	45.8 years (male - 44.4, female - 47.1)
Land and water area	2,345,410 km^2 (land - 2 267 600, water - 77 810)
Length of coastline	37 km
Mangrove area (2005 est.)	8 000 ha
Marine protected areas (2007 est.)	None recorded
Capture fisheries prod. (2006 est.)	59,485 metric tones
Aquaculture fisheries prod. 2006 est.)	21 metric tones

Geographic Location: Congo is a coastal country located between 3°5N and 5° latitude. It bordered by the Congo river and its tributaries to the north of Bangui and is bordered to the north by Cameroon and Central Africa, to the west by Gabon and the Atlantic ocean and to the south by Angola.

Rivers on the Country's Coast: Mayombe, Loémé, Noumbi, Ngongo, and Kouilou.

Coastal Climate: The climate in the region is characterized by (Vennetier, 1968): a hot and dry season (May/June to September) and the rainy season (October to April/May). The average annual temperatures vary between 24 - 26°C (Heecketsweiler et Mokoko Ikonga, 1991 en citant Leroux, 1989)

Coastal Geomorphology: Largely situated between latitudes 4° and 5° south and longitudes 11° and 12°2' east, the coastal zone is found in Kouilou province located in south west Congo and is about 13,650 kilometres, about 4% of the national territory (Vennetier, 1968).

The coastal band has four sections i.e. Massabi (Cabinda) to Pointe Mvassa, Pointe Mvassa to Pointe-Noire; from Pointe-Noire to Pointe-

Indienne from Pointe-Indienne to Pointe-Kounda and is characterized by an altitude of about 5 to 30 metres except in the areas closest to the beach where it is 130 metres.

Coastal Currents and Tides: At Pointe-Noire, the current generally flows north-west to north-north-west. Being at the coast, due to the wind, the current is irregular and depending on the season, the speed of the surface currents is 26 cm/s. During the Great Dry Season (GSC), the speed increases (65% north-west and 35% south-east). During the Great Cold Season (GSF), the speed is much weaker.

Coastal Observations: The Centre d'Assistance Météorologique aux Activités Maritimes et Connexes (CAMAN) is the institution charged with maritime navigation, fishing, maritime and related activities as well as meteorological and oceanographic information and products. The installation of the new KAELESTO tide gauge under the IODE-ODINAFRICA programme at the Port of Pointe Noire was undertaken. It collects current and other real time oceanographic information.

Figure 1. Tide gauge installed by ODINAFRICA at Pointe Noire port.

Ports and Harbours: Located in the centre of the Gulf of Guinée, Pointe-Noire is in a strategic location and is an essential port for ships. Also known as "Porte océane de l'Afrique centrale", Pointe-Noire plays an important role in the economies of landlocked countries in the sub-region. In 2003, the general traffic experienced in Pointe-Noire was about 10,810,537 tones and the total commercial traffic was 1,890,366 tones. The second port, Djéno petroleum terminal, is the main terminal for transporting oil and is situated about 13 miles from the public port. In 2003, 8,920,170 tones were transferred at the petroleum terminal.

Coastal Economy: Fishing is a major activity as it serves as a food source for a large part of the population. Its development is a key part in the national plan. All the activities are centred on production, income generation, and employment. By extension this improves the lives of those dependant on the fishing economy. In the tourism sector, the activities are concentrated on developing ecotourism which is modelled on conservation, preservation and protection of nature in the Conkouati protected area, a national marine park. The objective of tourism in Kouilou is to preserve the coastal ecosystems and make them a tourist attraction. Kouilou has a number of attractive environmental tourist sites.

Table 1. Environmental tourism sites in Kouilou.

Area	Sites
Pointe Noire	Côte sauvage Plage mondaine Pointe indienne Plage de Loango
Zone côtière de Loango	Mission Catholique de Loango Stèle du Port d'embarquement des esclaves Route de caravane
Diosso and its environs	Musée Ma-Loango à Diosso Les Gorges de Diosso La baie de Tchissanga Bois de singes
Djéno coastal zones	Bas Kouilou avec le pont sur le fleuve kouilou Plage de Mvassa
Lake zones	Plage de djéno Site Nanga et son lac loufoualéba Lac Cayo sur la route du Cabinda
Natural Reserves	Le sanctuaire de Tchimpounga Parc national de Conkouati-Douli

Fisheries: Fishing is considered to be a major activity by the government as it is a source for food as well as a sector with great potential for investment. Annual capture is estimated at 70 - 80 000 tones for continental fishing and 20 - 30,000 tones for maritime fishing (current production being 20,000 and 32,000 tones respectively). Currently, there are about thirty ships divided into eleven fleets that are part of the total number of industrial ships in Congo. Industrial production stands at about 12,000 tones. Artisanal fishing contributes to about 40% of the national sea fish catch, practised by the Béninois and Congolese fishermen.

Mineral Resources: Congo has a number of minerals but the most important include: petroleum, potassium, bitumen, sand and gold.

Agricultural products: Agriculture in the costal area is traditional in nature and the crops grown include, manioc, bananas, beans, maize, yams and courgettes. In industrial plantations, the main crops grown are coffee and cocoa.

Other marine resources: Mangroves represent a significant portion of coastal ecosystems, dominated predominantly by Rhizophora. This mangrove develops mainly in the estuaries of Loémé, Kouilou and Noumbi on the one hand and in the lagoons of Malonda and Conkouati. These formations shelter various vertebrate and invertebrate fauna as well as flora. These include; gastropods, crustaceans, endemic fish and *periophthalmus papilio*. Currently, the mangroves are experiencing the effects of over exploitation such as wood cutting for domestic or industrial use. Additional marine resources are shells and other dead corals on the beaches.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Délégation générale de la recherche scientifique et technique (DGRST) Centre is a government body which works in partnership with the Institute for Research Development (IRD). It was hosted by IRD in Pointe-Noire but as of April 2008, the centre was redeployed to the government. The centre now has become Pointe-Noire DGRST Research Centre. The centre is being reconstructed and will be streamlined with the policies of the government department. The National Oceanographic Data and Information Centre (CNDIO) is a public scientific and technological centre. It is located at the Centre de Recherche DGRST de Pointe – Noire and is under the Ministry of Environment and Tourism.

The CNDIO has three fundamental objectives:

- Improving the system of collecting, controlling and storing oceanographic data and information
- To provide oceanographic data to users of this information
- Increasing access to data and information to users

The management of coastal areas of Congo remains a major concern both in the areas of policy and environmental monitoring. In line with the plan for integrated management and development of the coastal areas the CNDIO provides already processed products that are directly usable. The data is also available in archives and includes oceanographic, environmental, physical, biological, pedological, and geological data.

Products and services available at the NODC:

Products and services that have been developed include:

- Catalogue of institutions that are involved in the acquisition and management of marine related information and data
- National directory and catalogue of marine and fresh water related professionals and researchers
- Catalogue of marine and coastal areas professionals and researchers
- Catalogue of oceanographic and trawling campaigns carried out in the Congolese continental shelf since 1957
- Catalogue of oceanographic campaigns and environmental data
- Catalogue of databases available on marine science and coastal areas
- Associations and NGO's in the coastal area (Department of Kouilou)
- State of the Congo coastal and marine ecosystem
- Reports on the state of the coastal area in relation to the national plan, including profiles of the changes noted in the coastal features, cartography/evaluation of the hot spots, formulation of the hot and sensitive areas
- National Report e.g. climate change and biodiversity
- The National Plan of Action for the Environment (PNAE), and state of the environment.
- Information and library management, including document and inter-library loans.

Figure 2. Example of erosion on the Congolese coast.

At the moment, the Centre offers the following services:

- Regular interactive mailing list on data available in the Centre
- Production of information notes, leaflets, bulletins, and other online and printed outreach material to sensitize the public to on going activities and issues.

The centre has identified 15 oceanographic and related products users in the management of marine and coastal ecosystems, and it is expected that a policy for the collection of these products will be developed at the national level. Several common products have several users (Table 2).

Marine Related Programmes and Organizations

Eight organizations have been identified as having the capacity to produce oceanographic data. Table 3 describes dates these organizations and their role in the acquisition of oceanographic data.

Table 2. Products required by users.

Users	Products
Ministry of Tourism and Environment	Data on coastal erosion, tides, forecasts of sudden rise in water levels, maps of fishing grounds, availability of fish, pollution index.
Port autonome de Pointe-Noire	Tide prediction and models, forecasts of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks).
Institute de recherche pour le dévelopement	Tide prediction and models forecasts of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks, erosion maps, water quality, atlas on fishing areas, lagoon and estuary maps).
Direction Départementale des pêches	Tide prediction and models forecasts, of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks etc), erosion maps, water quality, atlas on fishing areas, lagoon and estuary maps, fisheries statistics, fishing models.
Service hydrographique du Port	Tide prediction and models, forecasts of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks, etc).
Communauté des pêcheurs	Tide prediction and models, forecasts of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks etc), erosion maps, water quality, atlas on fishing areas, lagoon and estuary maps, fisheries statistics, fishing models.
Industrie et AOPC (Association des Opérateurs Pétroliers Congolais)	Tide prediction and models, forecasts of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks etc), erosion maps, water quality, atlas on fishing areas, lagoon and estuary maps, fisheries statistics, fishing modelling, lagoon and estuary maps).
Chercheurs, Universitaires et étudiants	All available products.
Centre d'assistance météorologique aux activités maritimes et connexes (CAMAM)	Tide predictions and models, forecasts of sudden rise of sea levels, marine traffic guides, pollution index, sedimentary models, maps of the currents, oceanographic diagrams (bathymetry, SST, navigation risks etc).
Users	**Products**
Unité de recherche sur la production des plantations industrielles (UR2PI)	Ground maps, bio-geographic maps, maps on activities carried out on the ground.
Centre de Recherche Forestière du Littoral (CRFL)	Ground maps, bio-geographic maps, maps on activities carried out on the ground.
Cellule anti-pollution	Hydrocarbons.
Ministère de l'environnement	All available products.
O.N.G (Organisation non gouvernementale)	All available products.
PNCD (Parc National de Conkouati Douli)	All available products.

Table 3: Organizations and their roles.

Organization	Roles
1. Institut de Recherches pour le Développement	Oceanographic data, hydrological, pedologies and weather information, information circulars to users, researchers and students.
2. Direction départementale des pêches	Updating marine and fisheries information.
3. Centre d'assistance météorologique aux activités maritimes et connexes	Updating coastal meteorological information and assisting in marine related activities.
4. Direction départementale de l'environnement et tourisme	Monitoring and evaluation, repository of biological and physical information.
5. Agence pour la navigation aérienne (ANAC)	Updating coastal meteorological information.
6. Université Marien Ngouabi (faculté des sciences et de géographie, de géologie)	Collecting and disseminating information to users, repository of biological, chemical and geological data.
7. Service hydrographique du port	Essential information on sea navigation, the sea level, bathymetry, sedimentary models.
8. Marine marchande	Maintenance of law and order in the marine sectors, repository of essential information on navigation.
9. Cellule anti-pollution	Monitoring and evaluating pollution, repository of information on oil exploration.
10. Centre de Recherche Forestière du Littoral (CRFL)	Monitoring and evaluating pollution, repository of information on coastal ecosystems.
11. PNCD : Parc National de Conkouati Douli.	Monitoring and evaluation, repository of biological, physical and other information on protected areas.

Figure 3. Example of erosion on the Congolese coast.

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7.4 Cote d'Ivoire

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Capital city	Yamoussokro (political capital) Abidjan (economic capital)
Population (2005 est.)	18,600,000 (1.8% growth)
GDP per capita (USD 2005 est.)	$1 648
Life expectancy at birth (2005 est.)	47.4 years (male - 46.5, female - 48.3)
Land and water area	322,460 km^2 (land - 318,000, water - 4 460)
Length of coastline	515 km
Mangrove area (2005 est.)	9 900 ha
Marine protected areas (2007 est.)	1.32 km^2 (0.01% of total territorial waters)
Capture fisheries prod. (2006 est.)	32,644 metric tones
Aquaculture fisheries prod. (2006 est.)	817 metric tones

Rivers to the Country's Coast: The five principle rivers in Côte d'Ivoire are Cavally, Sassandra, Bandama, Comoé and Tanoé. These rivers flow into the coastal lagoons or ocean. River flow has very strong inter-annual variability which has been monitored over many years. For example, the average flow of the Comoé River was 331m^3/s during the 1960 - 1970 period, 161m^3/s during the 1970 - 1980 period, and finally 110m^3 during the 1980-1990 period.

Coastal Climate: The climate is tropical and characterized by four seasons: - two dry seasons from November to March and August to September; - two rainy seasons from April to July and from September to October. The coastal area has an average temperature that fluctuates between 25°C in August and 30°C in March. The minimum temperatures are between 12°C in December and 21°C in April. The maximum temperatures are between 28°C in August and 37°C in February. During the 3 or 4 months in summer, Côte d'Ivoire experiences the humid monsoon air. The monthly averages are rarely less than 80%.

Coastal Geomorphology: The coastal area is characterized by several geological formations: granites, granitoid and metamorphic rocks. The granites are most widespread and vary in composition: leucocratic granite with biotite, microcline with fine grain, sub-alkaline granite,

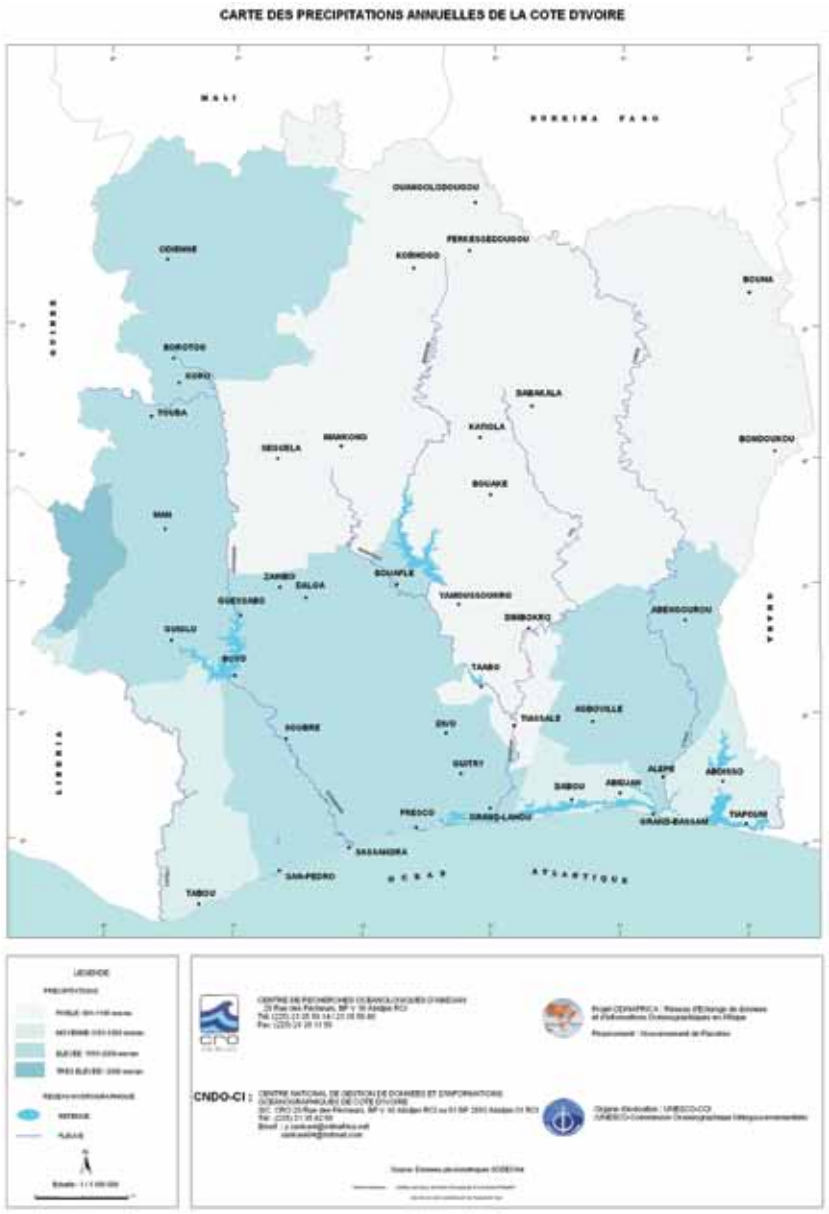

Figure 1. Map showing annual precipitation for Cote d'Ivoire.

Figure 2. ODINAFRICA National Coordinator for Cote d'Ivoire Dr Sankare with a representative of their embassy in Brussels during a ODINAFRICA seminar.

Figure 3. Map showing coastal drainage of Cote d'Ivoire.

and monzonic, or akeritic granite are present. Generally, the coastal sandy grounds dominate almost all the entire area, but a number of soil types are present, including: rough mineral, brunified, hydro-morphic and ferralitic soils.

Coastal Habitats: The coastal area is about 32,960 km^2 between latitudes 4° and 5°30' N and longitudes 2°25' and 7°30' W. Its coast extends from the Cap des Palmes (Liberia) to Cap des Trois Pointes (Ghana) (Abe, 2005). From west to east, the coastal area consists of low, often marshy, plains which narrow gradually. The lagoon system is parallel to the gulf of Guinea between western longitude 2°50' and 5°25'. It is nearly 300 km and covers a total surface area of about 1 200 km^2. It consists of three distinct lagoons: the Grand-Lahou, the Ebrié lagoon and the Aby lagoon, they are connected by the Azagny channel dug in 1955 and the Assinie channel, built between 1955 and 1957.

Ports and Harbours: The two main ports are the Port of Abidjan and the Port of San Pedro. There are many smaller docks on the coast and in the villages bordering the lagoons.

Coastal Economy: The principal activities in the coastal area include forestry, plantations, factories, tourism, fishing and various infrastructures (for instance roads, tourist resorts and hotels and houses). The service sector accounts for 50% of the GDP and employs a large portion of the population in industries such as telephone companies, security, general trade and restaurants. Current estimates indicate that there are approximately 6 to 8,000,000 people living in the coastal areas

The coastal area has grown into a tourist destination due to it's natural beauty and infrastructure developed. Attractions include:

- Assinie and Assoindé beaches
- Assinie (capacity 200 rooms) and Assoindé (capacity 314 rooms) hotel complexes
- Assinie and Assoindé Marinas

Fisheries: Fishing on the Ivorian coast is an important activity which is practised by national and foreign communities. It is the main activity and the principal source of income for the population living in the south of the country. Indeed, fisheries carried out along the coast in 2000 generated an income of 33 billion Communaute Financiere Africaine Francs. All the coastal cities that have marine frontage have fishing centres. There were 3 500 dugouts counted along the coast and in the lagoons in 1996. 14,774 fishermen working at sea and in the lagoons were counted in the year 2000 (DPH, 2000).

Table 1. Distribution of fishermen on the coast. Source: DPH, 2000.

Area	Number of fishermen				Total number of fishermen
	Ivorians	%	Non Ivorians	%	
Abidjan	25	94	4 783	39	4 808
Adiaké	1 736	66	1 524	13	3 260
Dabou	26	98	532	4	558
Grand-Bassam	82	3	549	5	631
Grand-Béréby	1	3	470	4	471
Grand-Lahou	745	28	692	6	1 437
Fresco	22	83	96	80	118
San-Pedro	4	15	1 459	12	1 463
Sassandra	0	0	1 145	9	1 145
Tabou	8	30	875	7	883
Total	**2 649**	**100**	**12 125**	**100**	**14 774**

Two types of fishing are carried out in the ocean,

Industrial fishing uses about 38 ships and takes place on the continental shelf not far from the ports of Abidjan and San Pédro. The catch includes tuna (between 58,000 and,62 000 tones), crustaceans (trawling about 6 000 tones), sardines (between 28,000 and 30,000 tones), and shrimp (515 tones in 1999 and 1314 tones in 2000).

Mineral Resources: There are a number of mineral resources exploited in the area, notably gold in the Aboisso region and extraction of various construction materials including stone, sand, gravel, ceramic, and clay. In the Afema mines of the Bassam area extraction produces 800 000 tones of ores containing 3 200 kg of gold (approximately 4g/ton).

Table 2. The economic fish operators in a few coastal towns. (Sources: Coordination inter-régionale halieutique du Bas-Sassandra, 2000, Rapports DPH, 1996, 1999).

Area / Operators	Abidjan	Adiaké	Grand Bassam	Dabou	Grand-Lahou	San Pedro	Sas-sandra	Grand-Béréby	Tabou	Fresco	Total
Pêscheurs	4 808	3 260	631	558	1 437	1 463	1 145	471	883	118	14 774
Mareyeurs						13		20		8	41
Revendeurs	3 592					473	438	112	334	3	1 535
Fumeuses						130	261	424	401	51	1 267
Pisciculteurs											445
Autres opérateurs						48	3	9			60
Total	**8 400**	**3 260**	**631**	**558**	**1 437**	**2 127**	**1 847**	**1 036**	**1 626**	**172**	**21 094**

Agricultural products: Primarily, there are two types of agriculture practised in Côte d'Ivoire: 1) semi-intensive with fields varying between 2 and 10 ha, and 2) modern agriculture with larger fields. The principal products grown for export are coffee (868,000 tones), cocoa (1,000,000 tones), soft bananas (200,000 tones), pineapple (195,000 tones), héveas (55,000 tones), palm tree oil, cotton, cajou, and cereals for local consumption (e.g. rice, fonio, millet, maize, yam, manioc etc).

Other marine resources: A number of marine resources can be found in Côte d'Ivoire notably petroleum and natural gas.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

The coast of Côte d'Ivoire has a number of impediments to its sustainable development. The uncontrolled urban development at the coast has outgrown the waste management systems that were implemented without consideration for the levels of growth that is now being witnessed on the coast. The poor management of solid waste and household refuse has put further pressure on coastal ecosystems and resulted in rapid degradation. The various forests and national parks are increasingly being occupied by farmers and some forests have been completely converted into villages. For example, the forest of Monogaga has about 28 villages and campsites.

Water ways, and in particular those in the Ebrie lagoon, have been affected by pollution. The water contains heavy metals such as zinc, lead, mercury, most of which comes from the tanneries and factories built on the edge of the lagoon. The lagoon and coastal areas have also been turned into dump sites and the resultant seepage of solid waste compromises the quality of water. Poor collection and treatment of water compromises the quality of the surface water, which is affected by industrial as well as domestic waste.

Another problem is the use of waste water for food crops which are invariably sold in the markets and subsequently pose a potential health risk. Air pollution is also rife in the coastal areas with smoke and dust, posing a serious health risks. Odors from the fish treatment plants located on the beaches are also an issue.

The average erosion rate of the beaches is from 1 to 3m per a year according to available statistics. This is partly due to lack of protection policies as well as to the natural sedimentation processes. However the continued sensitisation of the public by the authorities has led to short to medium term management of this coastal crisis. Indeed, the government has put in place a strategy for the management of erosion at the coast and has proposed to build gabions to reduce or control the rate at which the coastline is receding (PNAE 1996 - 2010).

Agriculture is the engine of the Cote d'Ivoire economy. In 1997, agriculture contributed 26.6% of the GDP (Côte d'Ivoire, éléphant d'Afrique, 1999) but the development of agriculture, particularly agriculture for export, was done in the forest zone which saw the forest's surface decreasing from 12 million hectares in 1960 to approximately 2 million hectares today. Agriculture does not constitute the only cause of forest clearing, but the haphazard clearing of the classified forests and national parks is a major issue in the coastal zone. Thus, the authorities are faced with the problem of protecting agricultural interests on one hand and on the other hand protecting ecological interests. This is exacerbated by the fact that a large proportion of agricultural production is for export. In the south for example, local food crops cover only 25% of the cultivated

area, the remainder being occupied by food grown for export. Arable land is becoming increasingly rare in the coastal zone and various workshops addressing this issue have identified the growing conflicts between the agro-industries and the local farmers in the area.

In the area of artisanal, lagoon and fishing in lakes and rivers, there are conflicts between artisanal and industrial fishermen Koffié-Bikpo (2001), states that the leading cause of conflict between, artisanal lagoon and continental fishing are differences on the appropriation and rights to fishing areas by those they consider aliens. The residents assert that the lagoon or coastal areas exploited by the settlers are their property, and that the exercise of fishing rights is subjected to their authorisation. The most serious conflicts were experienced in 1994 on the Aby lagoon in the south east, and in 1998 in Sassandra at the mouth of the river with the same name.

The absence of clear and coherent regulations has had an impact on the coastal area. The situation is exacerbated by ambiguous and often unclear laws and the fact that the laws that are in place are not applied. Lack of comprehensive policies and management tools affect the coast and, with exception to policies that are applied in the tourism sector, no specific measures have been taken to protect the coast. A general framework must therefore be put in place in order to address coastal issues in a comprehensive manner.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The National Oceanographic and Data Centre was first created on 8th August, 1958 and was under the control of the Ministry for Agriculture. It was managed until November 1991 by the French Institute of Scientific Research for Development and Co-operation (Ex - O.R.S.T.O.M), until 1991 when it was reorganized into a National Public Corporation, according to Decree n° 91-646 of 9th October, 1991. The NODC is presently under the supervision of the Ministry for Higher Education and Scientific Research.

The National Oceanographic Data and Information Management Centre (CNDO-CI) is a newly formed national data centre, which is part of the Oceanographic Research Centre (CRO) in the port area of Abidjan. It is charged with carrying out nationally, all research on safeguarding and protecting water environments, and implementing sound policies for the management of marine and coastal resources.

The CNDO-CI has the specific role:

- To provide users with oceanographic data and related information
- To encourage the use of national and regional documents available at the centre
- To promote and to facilitate networking between national and regional scientists
- To train and sensitize users and the broader population in its fields of competence
- To contribute to documents within its fields of competence

Activities at the CNDIO-CI include:

Education: Student activities are integrated within the framework of CNDO-IO implementation. Activities include various collections made with support from INSAAC and the University of Abidjan, Cocody.

Development of various databases and information tools: These include the production and dissemination in print form, CD-ROM, and the web of databases on biological diversity, catalogues and bibliographies on coastal environmental studies, contribution to the ASFA Database (Aquatic Sciences and Fisheries Abstracts), and more recently a photo-bank on fish and other marine species

Website: Through the web CNDO-CI presents users all the activities carried out and all the products available through the data centre.

The different users of the products and services available include

- University and college students
- Scientific researchers in universities and other research institutes
- Shipping and navigation
- Development agencies
- Diplomatic missions
- International organizations
- Non Government Organizations
- Professional organizations
- Tourists
- The private sector
- Defence and security forces
- Hotel complexes
- Environmental agencies
- Decision makers
- Local authorities
- The coastal population

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

Institutions	Information collected
Centre de Recherches Océanologiques	Physio-chemical, microbiological and biological – lagoons and ocean
Ports Autonomes (Abidjan et San-Pedro)	Physical-ocean
SODEXAM	Physical atmospheric-throughout the country
CIAPOL	Physio-chemical, microbiological, biological- lagoons- continental waters
Universités et Instituts de Recherche Curat (CRE)	Biotic and abiotic-ocean-continental waters
Laboratoire d'Hydrobiologie	-
Direction de la Faune et des Ressources Cynégétiques (Min des Eaux et Forets-DFRC)	Bio-ecological, ethological-lagoons-continental waters
BNETD	Physical atmospheric - throughout the country
Société de Développement de l'Eau de Côte d'Ivoire (SODECI)	Physio-chemical and microbiological-Continental and bordering waters
Direction de l'hydraulique Humaine (DHH)	Physio-chemical, information on water resources-Continental and bordering waters
Direction des Productions Halieutiques (DPH)	Production – Lagoons and the ocean
CNTIG	Socio-economic
INS	Population statistics
Marine nationale	Physio-chemical - the ocean
CONARAF (Ministère des eaux et forêt)	Information on humid areas- socio-economic-flora and fauna-physio-chemical atmospheric parameters in the lagoons- Continental waters
ANADER	Socio-economic-Physical atmosphere-Physio chemical- Continental waters
Direction des Politiques et Stratégie de l'environnement (Min. de l'Env. DPS)	Biodiversity and organic pollutants
LANEMA	Physio-chemical- microbiological-Industrial pollution- lagoons- Ocean

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7.5 Arab Republic of Egypt

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Capital city	Cairo
Population (2005 est.)	72,800,000 (1.7% growth)
GDP per capita (USD 2005 est.)	$4 337
Life expectancy at birth (2005 est.)	70.7 years (male - 68.5, female - 73.0)
Land and water area	1,001,450 km^2 (land - 995 450, water - 6 000)
Length of coastline	2 450 km
Highest and lowest point of elevation	Highest: Mount Catherine (2,629 m) Lowest: Qattara Depression (-133 m)
Coral reef area (2001 est.)	3 800 km^2
Mangrove area (2005 est.)	500 ha
Marine protected areas (2007 est.)	6 994.94 km^2 (9.91% of total territorial waters)
Capture fisheries prod. (2006 est.)	375,894 metric tones
Aquaculture fisheries prod. (2006 est.)	595,030 metric tones

Geographic Location: The Arab Republic of Egypt is located in the north-eastern corner of Africa and south-western Asia. It is bounded on the north by the Mediterranean Sea, on the east by Palestine and Israel, on the south by Sudan, and on the west by Libya, with total land boundaries 2 665 km (Gaza Strip 11 km, Israel 266 km, Libya 1 115 km, Sudan 1 273 km). The country is about 1 085 km from north to south and about 1 255 km from east to west. It has a total area of 1,001,450 km^2, with land area 995,450 km^2 and water area is 6 000 km^2. The coastline is about 2 450 km.

Rivers on the Country's Coast: The Nile River is the longest river in the world, stretching for 6 738 km. The Nile flows from south to north and is formed by three major tributaries: the White Nile, the Blue Nile and the Atbara. The Nile splits into two branches, the Rosetta Branch to the west and the Damietta to the east. Lake Nasser is a man-made lake created by the construction of the Aswan High Dam, which was opened in 1971 and built to regulate the flow of the Nile River, and thus benefit the region's inhabitants. However, technological interventions such as dams often affect and disrupt local ecosystems.

Figure 1. Cairo, the capital of Egypt, is situated on the Nile river delta (Photo credit Aloha Earth).

Coastal Climate: Except for the Mediterranean coast the country experiences a desert climate, which is hot and dry most of the year, especially in the summer months (June to August). Winter is from December to February with average temperatures of 20°C to 26°C (68°F to 79°F). The Egyptian summer is hot and dry in most of the country, and humid in the delta and along the Mediterranean coast. In the coastal region average annual temperatures range from a maximum of 37°C (99°F) to a minimum of 14°C (57°F). Wide variations of temperature occur in the deserts, ranging from a maximum of 46°C (114°F) during daylight hours, to a minimum of 6°C (42°F) after sunset. During the winter season desert temperatures often drop to 0°C (32°F). The Mediterranean coast and southern region are the most humid and have an average annual rainfall of about 200 mm.

Coastal Geomorphology and Habitat: The Mediterranean coast of Egypt extends to 900 km and can be divided into three sections: 1) a western section - the Mareoties coast, between Sallum and Abu Qir (550 km); 2) a middle section - a delta coast between Abu Qir and Port Said (180 km), and 3) the eastern section - the Sinai coast, between Port Said and Rafah (240 km). The geomorphology of the Mediterranean coastal area along the Nile delta extends from Abu - Qir head land in the west to Port Said at the east, and lies between longitudes 30^0 - $32^020'$ and latitudes $31^010'$ - $31^038'$ north. The main geomorphological features of the Nile Delta coastal area can be divided into the following units: beach, sand dunes, lagoons, salt marshes and sabkhas salt flats.

Coastal Currents and Tides: The currents along the Mediterranean coast are mainly thermohaline and wind driven, namely the North Atlantic Current directed eastward which varies in velocity between 1.5 and 2.5 knots. Along the Egyptian Red Sea coast the current is mainly driven by tides and vary semi diurnally between north and south. It varies in speed between 1.2 and 4 knots. Tides along the Mediterranean coast are limited, with a maximum tidal range of about 0.55 m and are mainly semi diurnal. Along the Red Sea coast the tides are semi diurnal and varies in range between 0.0 m at the nodal points near Ras-Gharb and Mersa-Alm and up to 2.5 m in between.

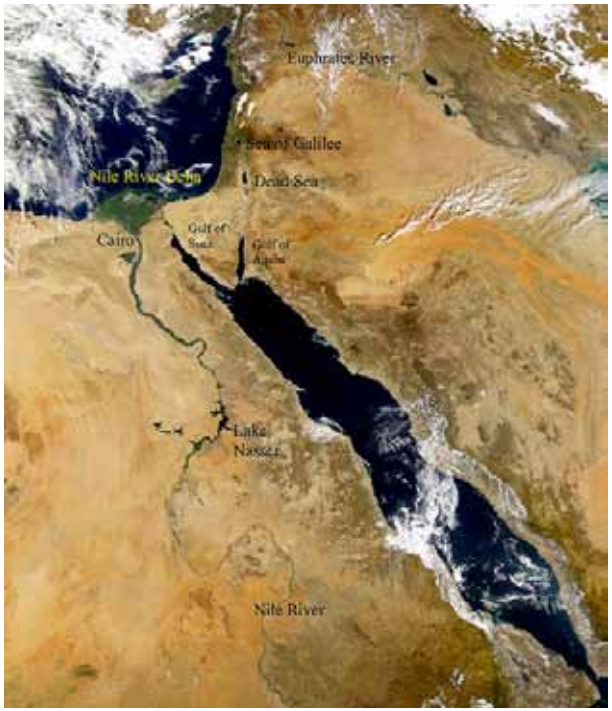

Figure 2. The Nile River, the longest river in the world (image credit NASA - http://disc.gsfc.nasa.gov/).

Figure 3. Old tide gauge at Alexandria Port.

Coastal Observations: At Alexandria Port there is a tide gauge that has been working for 70 years, as well as a new meteorological station.

Ports and Harbours: Egypt's geographic location adds an important aspect to the maritime transport sector. There are 41 ports in Egypt that service commercial, fishing, mining, and petroleum industries, as well as tourism. Among the most important ports are: 1) Alexandria which is the biggest port in Egypt; 2) Dekheila which is a natural extend to Alexandria port; 3) Damietta which has the largest container terminal and most sophisticated equipment in the Middle East, 4) Said, and 5) Suez port located at both ends of the Suez Canal.

Coastal Economy: Coastal tourism accounts for 50% of the national tourism industry. There are many marine national coral reefs along the Egyptian Red Sea. In addition there are several national parks and reserves along the Mediterranean and Red Sea coast (Ras Mohamed, Elba, Nabq, Red Sea Islands, Abu Gallum, Lake Brullus, Ashtum El-Gamil, El-Omayed, Zaranik, Lake Qarun, and Nile Islands).

Fisheries: The fisheries resources along the Egyptian Mediterranean coast are commercial fisheries, while the fisheries resources along the Egyptian Red Sea are artisanal and commercial fisheries (benthic, pelagic fish, shrimp and bivalves). The artisan fishery is concentrated between the coral reef and the shore, while the commercial fishery is composed of demersal fish, shrimp and bivalves.

Marine fisheries are an important source of protein for the coastal population. The production of marine fishes, lake fishes, and Nile river

Figure 4. One of the NIOF Research Vessels.

fish were 130,748; 144,033 and 97,710 tones respectively in 2007. Accordingly, the production of aquaculture is 635,517 tones for 2007, representing 63% of the total production of fisheries in Egypt (GAFRD, 2007).

Other Marine Resources: Touristic and other marine resources include coral reef and mangrove areas, sea cucumber in the Red Sea, as well as sponge in Mediterranean.

Mineral Resources: Egypt is famous for its numerous mineral resources in its mountains and deserts. The principal minerals are iron ore, phosphates, salt, manganese, limestone, gypsum, and gold.

Agricultural products: Cotton, rice, wheat, corn, sugarcane, sugar beets, onions, and beans are the principal crops. Increasingly, a few modern operations are producing fruits, vegetables and flowers, in addition to cotton, for export. Approximately one-third of Egyptian labour is engaged directly in farming, and many others work in the processing or trading of agricultural products. Nearly all of Egypt's agricultural production takes place in some 2.5 million hectares (6

million acres) of fertile soil in the Nile Valley and Delta. Some desert lands are being developed for agriculture, including the ambitious Toshka project in Upper Egypt, but some other fertile lands in the Nile Valley and Delta are being lost to urbanization and erosion. Warm weather and plentiful water permit several crops a year. Land is worked intensively and yields are high (Travel Docs, 2008).

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

The Egyptian Mediterranean and Red Sea coast receives large amounts of industrial, agricultural, sewage waste water without treatment, and coastal waters suffer from pollutants in some areas including: Eastern Harbour, Abu-Qir Bay, El-Mex Bay, and Western Harbour. The Red Sea coast is subjected to oil pollution which has potential affects on coral reefs communities, and may affect the tourism industry in future.

Alexandria is the second largest city in Egypt containing more than one third of the national industries and is considered to be the principal seaside summer resort on the Mediterranean. The coastal zone is presently experiencing two main problems resulting from natural and human activities: beach erosion and pollution. Most of the Alexandria coast is rocky and has very little or no beach. Significant erosion occurs along most of Alexandria beaches as a result of the combined effects of sediment starvation, coastal processes and potential sea level rise.

One of the most serious threats to the coastal zone comes from inland pollution sources including lakes and sewage pipelines. As a result of increasing population and industrial development, poorly untreated industrial waste, domestic sewage, shipping industry waste, and agricultural runoff are being released to the coast. With continued rapid expansion of industry and population, changes in water quality would have potential consequences for the large growing population of the Alexandria region. Recommendations for environmental recovery and restoration are proposed for the preservation of Alexandria resort beaches and harbours, and in order to facilitate the development of environmental and tourist activities in the future (Frihy et al., 1996).

The Red Sea coast of Egypt has seen major resort facilities created over the last 20 years. Improper design and non-environmentally friendly sea shore recreation facilities have been constructed by some developers. These include hard structures; earth embankment jetties; digging of lagoons and landfill of coastal areas. All of these improper coastal development activities create harmful impacts on the ecosystem, including: 1) changing the depositional-hydrodynamic regime through the blocking of littoral currents by protruding structures; 2) creating down-drift erosion to the neighboring beaches, 3) deteriorating water quality and 4) degrading the marine biota and habitat. Moreover, these actions usually put additional costs on developers either through direct restoration costs, or through fines received for improper construction (Frihy et al., 2006).

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

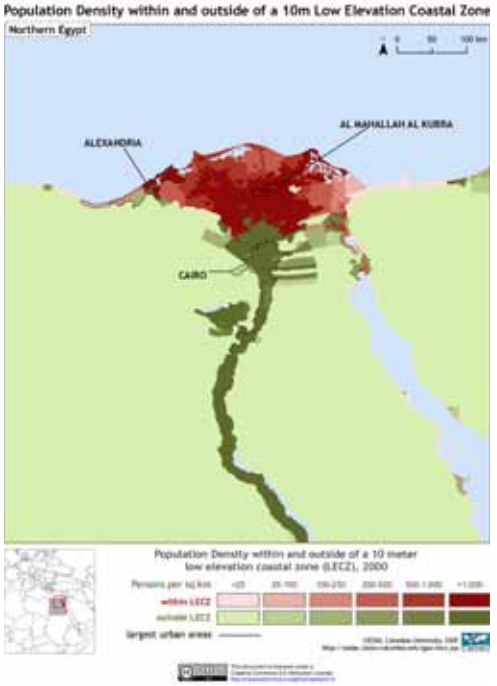

Figure 5. Population density in and around the Nile River and delta (figure credit CIESIN - http://sedac.ciesin.columbia.edu).

Egyptian National Oceanographic Data and Information Centre (ENODC) was established at the National Institute of Oceanographic and Fisheries (NIOF), Alexandria, Egypt, in 1977 in accordance with the resolution adopted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO 1961 as well as the reports of the Ministry of Scientific Research, National Institute of Oceanography, Egypt. The ENODC became part of the ODINAFRICA-III project at the end of 2004. ENODC receives data observed by NIOF and branches. These cover most of the coastal area of Egypt, Meteorological Agency, Fisheries Agency, universities and other organizations in Egypt addressing Oceanographic data and information collection.

Figure 6. NIOF Alexandria branch.

Figure 7. NIOF Central Laboratory.

Through data exchange ENODC also acquires foreign data through the International Oceanographic Data and information Exchange system (IODE).

ENODC receives worldwide physical-chemical oceanographic data from government agencies, academic institutes, and other organizations and projects in Egypt and internationally. Data is processed, archived, and made available to the public. ENODC's data holdings provide global coverage of basic oceanophysical and hydrophysical properties such as temperature, salinity, ocean current, tides, currents, geomagnetism, gravity and bathymetry.

ENODC's master data files hold numerous individual data submissions that undergo ENODC quality control procedures and are stored in standard World Ocean Database format. Data in these files are available as copies of specified date subsets on magnetic tapes, floppy disks, CD-ROMS or printed form.

The main objectives of the Centre include:

- Prepare and maintain a metadata data base of all national data holdings
- Coordinate the collection and archival of ocean data in Egypt
- Receive, manage and diffuse oceanographic data and products
- Publicize data and products available in Egypt
- Develop and maintain a home page on ocean data and products
- Promote the exchange of ocean data and products at all levels
- Establish a network of all stakeholders to facilitate exchange of data and products
- Provide appropriate training in marine data and information management
- Organise training workshops seminars for the benefit of the marine community
- Coordinate local participation in overseas training activities
- Participate in the activities of the IODE programme of the IOC of UNESCO

Products and services available at the NODC include:

- Predicted tide data for locations in Egypt, e.g. Alexandria, for the period 1993 - 2000, and the Mediterranean
- Production of national taxonomic inventories and checklists, e.g. Egyptian Mediterranean Fishes, Mediterranean Polychaetes, Red Sea Fishes, and Copepoda in the Gulf of Aqaba
- Hydrographic studies of lagoons and near shore waters e.g. lagoons near Hurgada
- Circulation, current and tide studies of ocean and near shore waters, e.g. physical oceanography data for Red Sea (1990 - 2000) and circulation study of the Levantine Basin
- Survey studies e.g. exploratory drilling site Hurgada
- Topography and physio-chemical studies, e.g. characteristics of the Egyptian Mediterranean shelf waters off Sinai
- Dissemination of various reports, bibliographies and studies, e.g. bibliography
- of the physical oceanography of the Mediterranean sea,
- environmental pollution and chemical parameter, biodiversity,
- fisheries and microbiology

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following organizations are collaborating with the NODC, or can provide directly data sources for aquatic researches and fisheries.

- Egyptian Environmental Affaires Agency (EEAA)
- Alexandria University
- Institute for Graduate Studies and Research (IGSR)
- College of Maritime Transport and Technology (AASTMT)
- Arab Academy of Science and Technology and Maritime Transport (AAST)
- Cairo University
- Ain Shams University
- Egyptian Universities network
- Tanta University
- Mansoura University
- Helwan University
- Minia University
- Menofia University
- South Valley University
- Al-Azhar Al-Sharif University
- International Academy for Media Science
- 6 October University
- German University in Cairo
- Higher Institutes of King Mariout
- Alsun Academy
- MSA University
- Central Metallurgical Research and Development Institute (CMRDI)
- Egyptian Petroleum Research Institute (EPRI)
- Electronics Research Institute (ERI)
- National Authority of Remote Sensing and Space Sciences
- National Research Centre

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7.6 Gabon

Dr François Edgard Faure, Carine Moussounda (Msc)*

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(CENAREST)
National Center for Data and Information Oceanographic
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Capital city	Libreville
Population (2005 est.)	1,300,000 (1.5% growth)
GDP per capita (USD 2005 est.)	$6 954
Life expectancy at birth (2005 est.)	56.2 years (male - 55.6, female - 56.9)
Land and water area	267,667 km^2 (Land - 257 667, water - 10 000)
Length of coastline	885 km
Highest point of Elevation	Mount Birougou 1 190 m (Mombo, 2004)
Mangrove area (2005 est.)	150,000 ha
Marine protected areas (2007 est.)	1 054.93 km^2 (4.86% of total territorial waters)
Capture fisheries prod. (2006 est.)	41,521 metric tones
Aquaculture fisheries prod. (2006 est.)	126 metric tones

Rivers to the Country's Coast: The dominant river is the Ogooué, which flows for 1 200 km forming a delta at the Atlantic Ocean. 1 000 km of this is within Gabon. It drains a basin of 215,000 km^2, approximately 4/5 of the country. In addition to the Ogooué, there are other smaller coastal rivers. From north to south, they are: the Noya, the Mbeya, the Ntsini and the Komo (which flows into the estuary of the same name as the city), and the Nyanga.

Coastal Climate: The coastal environment is located in two distinct climatic areas: the equatorial climate of transition in the central area and the equatorial climate of transition in the south-west and central Atlantic coast.

The equatorial climate of transition in the central area has the estuarine climate, situated in the coastal area north-west of the country including the Coco beach and Libreville. This sub climate is characterized by high precipitation, varying between 2 000 and 3 800 mm per year.

The equatorial climate transition in the south-west and central Atlantic coast has the sub climate as found in the area south of Port-Gentil to the border with Congo. The area of influence extends far beyond this region of lagoons– including much of the delta of the Ogooué. The proximity to the sea means it is very rainy, with annual precipitation between 1 700 and 3 500 mm.

There are two main climatic seasons: the dry season and rainy season, with periods of both wet and dry throughout. For example, we present the temperatures and precipitation recorded for Libreville and Port-Gentil (Tables 1 - 3).

Table 1. Libreville average annual temperatures (1991-2000).

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Max	27,6	27,2	27,6	27,3	27,8	27,5	27,5	28,2	27,5	27,6
Min	24,9	24,7	24,9	24,8	25,2	24,8	24,6	24,8	24,6	25,1
Range	2,7	2,5	2,7	2,5	2,6	2,7	2,9	3,4	2,9	2,5

(Source: Direction of the French Central Meteorological Office)

Table 2. Annual total precipitation and days of rainfall in Libreville (1991-2000).

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total volume of precipitation (ml)	2167.8	2663.3 3	2423.2 2	2330.7 7	2392.3 3	3337.1 1	2747.1 1	2669.6	2595.9 9	3345.5 5
No of days of rainfall	198	196	186	157	172	189	207	217	203	193

(Source: Direction of the French Central Meteorological Office)

Table 3. Averaged temperatures in Port-Gentil (1992-2001).

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Average	**26**	**26.3**	**26.2**	**26.5**	**26.2**	**26.2**	**27.4**	**26.7**	**26.5**	**26.3**

(Source: Direction of the French Central Meteorological Office)

Coastal Geomorphology: The coast of Gabon is characterized by a diversity of coastline, including: low rocky areas, sand and mud flats, cliffs, beaches, estuaries, lagoons and delta areas. The coast of Gabon has three main morphological units spread from north to south.

The first unit is a large estuarine area in the north-west, between 1°09' north on the border with the Republic of Equatorial Guinea, and the position of the geographic equator, near the village Nyon. This area comprises three main estuaries: Mouni estuary, Mondah estuary and

Figure 1. Erosion of a beach in Port-Gentil.

Komo estuary. This stretch of coastline is distinguished from the rest of the Gabonese coasts by its rocky low-lying areas dominated by sandy deposits, and mud flats covered by the mangroves.

The second unit is a complex delta in the centre of the country, formed by the mouth of the Ogooué. It lies between 0°30' and 1°30' latitude south, between the southern region of Wonga-Wongué and the mouth of the lagoon to Olende Fernan Vaz. The system is complex. The part of the delta oriented to the north is asymmetrical and large, whereas to the south the delta is smaller.

The third morphological unit runs in roughly a straight line from the north-west to south-east. It is characterized by barrier beaches delineating the vast lagoons from the coast. The coast is linked to a series of lagoon systems, stretching from the lagoon Fernan Vaz, in Gabon and beyond the border with Congo. The lagoons within the system vary in size. Among the most important there are the lagoons of Fernan Vaz Nkomi, Ngove, Ndogo and Banio.

The continental shelf width varies between 15 and 40 km in the north of Cape Lopez, and rarely beyond 80 km wide south of this point. Usually at the shelf limits there is a strong drop in depth corresponding to isobaths of 120/130 metres. This was the extent of the former shoreline of the coastal environment during the Palaeolithic era.

Coastal Habitats: The land area of Gabon is 267,667 km^2 of which 2/3 are covered with forests. Many rivers flow to the coastline with an area of 10,000 km^2 that flow into estuaries (north), the delta (centre) and lagoons (south) of Gabon. Several ecosystems are found along the coast of Gabon. The dominant systems are mangrove, coastal savannah, and coastal forests. These ecosystems are diverse in terms of flora. The fauna of the mangrove forests of Gabon are also quite diverse, though little is documented. Gabon has nearly 395,000 ha of mangrove (Rabenkogo, 1995), divided among the following: the estuary of the Muni, the Bay of Mondah, the Komo estuary, the delta of the Ogooué and the southern coastal lagoons. Mangrove forests provide coastal communities of Gabon with needed resources, including firewood and wood for construction.

Coastal Observations: A tide gauge has been installed and operational at the port of Owendo since August 2008. A tide gauge is proposed to be installed in Port-Gentil. In addition, the Gabonese Government has been discussing the possibility with the Intergovernmental Oceanographic Commission (IOC) to deploy three buoy profilers that will contribute towards the ARGO programme. The development of this programme in Gabon will strengthen its system of coastal observation. Weather stations exist in Libreville and Port-Gentil, and one rain gauge exists at Gambia.

Ports and Harbours: After petroleum, the second greatest economic resource of the coast of Gabon is trade through the ports Owendo-Libreville and Port Gentil. Indeed, maritime transport is of particular importance to Gabon. Approximately 90% of the country's foreign trade is carried by sea. Imports include food and manufactured goods. Exports are based primarily on timber, manganese and oil. In terms of traffic, results of operations of the port of Libreville-Owendo during the years 2004 and 2005 have been rising sharply. Thus, the total volume of goods handled at Owendo rose from 4,548,722 tones in 2004 to 5,720,252 tones in 2005, an increase of 25.8%. Conversely, activity in Port-Gentil has deteriorated, partly because of lower volumes of oil and forest products exported. Its traffic is therefore decreased from 14,222,204 tones in 2004, to 14,034,058 tones in 2005, a decrease of 1.3% (EPA, 2007).

Coastal Economy: The largest coastal economic activities are offshore petroleum extraction activities, port activities, fishing, forestry, mining and tourism. Tourism and fisheries are described in the following sections.

Coastal Tourism: Coastal tourism contributes more than 80% to the national tourism industry, and the coastline offers great opportunity for tourism. This includes bathing, sight seeing and sports, particularly sport fishing. Tourists, residents and foreign visitors, tend to benefit from the quality of beaches with gentle slopes and relatively moderate swell. The most famous are in the provinces are 1) Estuaire (la Sablière, Cap- Estérias, la pointe- Dénis, Pongara, Ekwata, Nyonié), 2) Ogooué-Maritime (Cap Lopez, Ozouri, Olendé, Iguéla, Sétté-Cama), and the 3) Nyanga (Mougagara, Panga, Mayumba).

Tourism sight seeing is predominantly based on the observation of marine animals such as turtles, dolphins, whales and orcas that frequent Gabonese waters.

On 30 August 2002, Gabon created 13 national parks, 4 of which are located along the coast of Gabon: Akanda, Pongara, Loango and Mayumba. The network of thirteen national parks covering a total of 2,837,000 hectares, more than 10.6% of the total land area (Vande Weghe, 2007).

In addition, there is also the presidential reserve of Wonga-Wongué bordering the Ogooué northern delta.

Fisheries: In Gabon, the biodiversity of the marine environment is considerable. Covering an area of nearly 265,000 km^2, Gabonese waters contain a wide variety of fish and crustaceans, and support larger organisms such as whales. Port-Gentil was in fact a whaling port until the late 1940s.

The demersal species fisheries are estimated at a potential 312,480 tones per year. Small pelagic fisheries (such as sardines and mackerel), are estimated at 153,000 tones per year. The estimated potential of large pelagic fisheries is around 250,000 tones per year for the entire region of the Gulf of Guinea (EPA, 2007). Large pelagic (tuna and other species) as well as the deep shrimp and cephalopods are operated on a seasonal basis within the framework of fisheries agreements with the European Union, Japan and China.

A decree of 1994, regulating fishing in Gabon, divides the waters under national jurisdiction in fisheries as follows:

- *Zone 1:* including inland waters (rivers, lakes, lagoons) and extends to the mouth, and is strictly reserved for the fishing activities of nationals
- *Zone 2:* extends from the mouth to 3 nautical miles, and is reserved for artisanal fisheries
- *Zone 3:* which cover 3 to 6 nautical miles, are reserved for activities of the local fishing industry
- *Zone 4:* which runs from 6 to 12 miles, is only authorized to non-national vessels.

The division of the Gabonese coast Effectives Fishing Areas (PTA) has five main sections. The fishing sector employs about 21,000 people. It generates an annual turnover of 41.5 billion CFA francs, and contributes to gross domestic product (GDP) up 1.5%. The industrial fishing fleet in 2003 was 87 vessels. Shrimp is the dominant and lucrative catch, with 9 500 tones taken in 2005. Artisanal fisheries (marine and continental) include a wide variety of fish species, with a production of 32,240 tones in 2005 (EPA, 2007).

Mineral Resources: Oil is the principal mineral resource on the Gabonese coast, with exploitation beginning in the mid 1950's. Since the late 1980's, oil production seems to have slowed. Indeed, between 2003 and 2005, production has stabilized at around 13 million tones. The extraction of sand for industrial purposes, particularly in the area of Libreville and Port-Gentil, is one of the major mineral resources of the coast. Limestone quarries are also located in the province of Estuaire (Ministère de l'Environnement et de la Protection de la Nature et de la Ville, in Gabon: Profil Environnemental de la Zone Côtière, 2007).

Agricultural Products: Agricultural production in coastal areas is very low and soils are of low agricultural potential. The main food crops include plantain, cassava, taro yam, sweet potato, maize, and groundnuts. Urban and peri-urban agriculture takes place especially in the coastal zone. Produce includes tomatoes, amaranth, eggplant, okra, peppers, onions, and coconuts.

Other Marine Resources: Gabon is rich in marine and coastal biological resources, particularly mangroves, and fisheries which are exploited by the Gabonese population. From the perspective of the biological potential, marine primary productivity of Gabonese marine waters is high- around 1704 mg C m^{-2} day^{-1} (Ministère de l'Environnement et de la Protection de la Nature et de la Ville, in Gabon: Profil Environnemental de la Zone Côtière, 2007). This productivity is higher in the south and around Cape Lopez (Port-Gentil). This environment is the limit of cold water and rich marine life from the Benguela Current, including an abundance of small pelagic species. The Guinea Current, with warmer waters, produces large pelagic fish such as tuna. The point of contact with these bodies of water in Gabon provides diverse and abundant living marine resources.

Figure 2. Mangroves in the bay of Mondah.

Marine animals are also present and appreciated by many tourists every year. The leatherback turtle *(Dermochelys coriacea)*, and three other species of marine turtles visit Gabonese beaches. There are Green turtle *Chelonia mydas* and the Hawksbill turtle *Eretmochelys imbricate* abundant in the Bay of Mondah. The Olive Ridley *Lepidochelys olivacea* is the only turtle seen fairly regularly south of Port-Gentil and is more common.

ADDRESSING COASTAL KEY ISSUES AND HOT SPOTS

Gabon has a large maritime area estimated at about 265,000 km^2, which includes a territorial sea of 12 nautical miles (expandable to 24 miles) of exclusive economic zone Better Term Needed. The large coast and marine waters are rich in mineral and biological resources. Navigation, port activities, exploitation of marine resources, tourism, and coastal development all play important roles in the development of the country. Paradoxically, the country lacks data for managing these resources and activities, particularly in the area of oceanography.

The coast of Gabon is characterized by diverse ecosystems and coastline. These are threatened by rising sea levels, coastal erosion, pollution, and over exploitation. In fact, in certain coastal areas there have been 100 to 250 metre advancements of the shoreline inland since 1950, for example Cape-Lopez to the north of Port-Gentil (Rabenkogo, 2007).

In the south of Libreville, in the Owendo area, a rate of 3 metres per annum advancement of the shoreline has been recorded since 1980 (NTOLE,. 2008).

At Nkomi the lagoon mouth has undergone considerable modification since the 1980's. Compared to the situation of 1957, the sand bank of the Ozouri mouth had moved back 2.5 km by 2000, and the mouth of Olendé (Bar of Arabic) has moved back 4 km (Rabenkogo, 2007).

Mangrove systems have disappeared at a rate of 50 hectares per year between 1960 and 1990 (Rabenkogo, 1998). Oil pollution and industrial and household waste are also present. The urbanization and development of Libreville and Port Gentil (which accounts for nearly 60% of the population) without prior impact assessment has significantly deteriorated these important coastal areas. In the Bay of Mondah, for example, ecosystems are threatened by the uncontrolled use the mangroves as firewood by growing population of the city of Libreville and surrounding populations.

Gabon also contains many rare marine creatures, and associated habitats, that face management challenges. Beaches National Park and the Pongara Mayumba are two nesting sites for leatherback turtles *(Dermochelys coriacea)*. At sea, the leatherback turtles are often victims of trawlers, and some die asphyxiated by plastic bags that they mistake for jellyfish.

The problems faced in Gabon are compounded by the absence of policy and adequate conservation of coastal ecosystems, as well as unplanned development. The legislative and regulatory institutional frameworks are inadequate, and often the public is not informed of the ecological, social and economic values of the coastal areas at stake.

DEVELOPMENT AND ACHIEVEMENTS OF CNDIO

The National Ocean Data Center of Gabon (CNDIO) was created with the support of the Intergovernmental Oceanographic Commission of UNESCO and ODINAFRICA on the 16th June 2003.

The General Directorate of the Law of the Sea (DGDM) of the Ministry of Foreign Affairs, coordinates the centre, housed and administered by the Research Institute in Social Sciences (IRSH) of National Center of Scientific and Technological Research (CENAREST). In addition, the Department of Marine Sciences of CENAREST was established in December 2005 to develop research in the fields of oceanography and geography of the seas

The main objectives of the CNDIO are:

- Disseminate information on research in marine science to scientists of the country
- To use scientific information for oceanography and coastal management

- To promote exchanges and communication between various actors involved in the ocean
- To promote institutional and human capacity building in the field of oceanography, through promoting inter-state and inter-agency research
- Sensitize stakeholders, the public, and government to issues of conservation and development in the marine and coastal environment

In addition, the CNDIO has reached an agreement with the Ministry of Fishing for the compilation of statistics (already completed 60%) and the management of national marine fisheries. CNDIO is preparing to develop a partnership agreement with the Port Authority (Office of Transportation and Roads, Gabon) and the manager of the commercial ports (Gabon Port Management) to manage tide gauge data collected at Owendo/Libreville port.

Products and services include:

- Creation of atlases, such as a fisheries atlas
- Provision of marine weather observations
- Provision of data and products on oceanography and fisheries
- The recipients of these products and services include some of the organizations and programmes listed in the following section.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following are organizations that work in collaboration with the Gabon NODC:

- Institut de Recherche en Sciences Humaines (CENAREST), Libreville
- Institut de Recherche en Ecologie Tropicale (CENAREST), Libreville
- Institut de Recherche Agricole et Forestière (CENAREST), Libreville
- Institut National de Recherche sur l'Océan et le Climat (en création), Lebreville
- Archives Nationales du Gabon (ANG), Libreville
- Union des Pétroliers du Gabon (UPEGA), Libreville (E-mail: upega@inet.ga)
- Direction Générale des Pêches et de l'Aquaculture
- Comité des Pêches pour l'Atlantique Centre Est (COPACE).
- Commission Intérimaire du Courant de Guinée (CICG)
- Commission du Courant de Benguela
- Comité Régional des Pêches du Golfe de Guinée (COREP)
- Direction de la Météorologie Nationale
- Gabon Sea Turtle Conservation Partnership
- Direction Générale du Droit de la Mer, Libreville (E-mail: dgdm@internetgabon.com)
- Direction Générale de l'Environnement, Libreville
- Ministère des Mines et des Hydrocarbures, Libreville
- Ministère de la Marine Marchande et des Equipements Portuaires, Libreville; (website: http://marine-marchande-gabon.net).
- Université Omar Bongo de Libreville, Libreville
- Université des Sciences Techniques de Masuku, Franceville
- Gabon Ports Authority
- Gabon Ports Management

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7.7 Ghana

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Capital city	Accra
Population (2005 est.)	22,500,000 (1.9% growth)
GDP per capita (USD 2005 est.)	$2 480
Life expectancy at birth (2005 est.)	59.1 years (Males - 58.7, Females - 59.5)
Land and water area	239,460 km^2 (land – 230, water – 8 520)
Length of coastline	539 km
Highest point of elevation	Mount Afadjato 885 m
Mangrove area (2005 est.)	12,400 ha
Marine protected areas (2007 est.)	None recorded
Capture fisheries prod. (2006 est.)	366,919 metric tones
Aquaculture fisheries prod. (2006 est.)	1 150 metric tones

Rivers to the Country's Coast: The Volta River basin dominates the country's river system, including the 8 480 km^2 Lake Volta. This artificial lake is the largest in the world, formed behind the Akosombo hydroelectric dam, it enters the sea at the Volta estuary in the Volta region. The Pra which enters the Gulf of Guinea east of Takoradi rises south of the Kwahu Plateau and flows southward. In the early part of the twentieth century, the Pra was used extensively to float timber to the coast for export. The Ankobra, which flows to the west of the Pra, has a relatively small drainage basin. It rises in the hilly region of Bibiani and flows in a southerly direction to enter the gulf just west of Axim. At one time, the Ankobra helped transport machinery to the gold-mining areas in the vicinity of Tarkwa. Rivers Amisa, Nakwa and Ayesu flows into the sea through lagoons. The Tano enters the sea through a lagoon at the Ghana / Cote d'Ivoire border. The rest are the Butre, Kakum and Densu.

Coastal Climate: The climate is tropical, the eastern coastal belt is warm and comparatively dry and the southwest corner is hot and humid. It becomes progressively drier from south-west to the north-east of Accra. Two-thirds of the coastal area falls within the dry coastal savannah strip where rainfall ranges from 625 mm to 1 000 mm averaging 900 mm per annum. The south western coast falls within

the tropical rain forest with annual rainfall value of over 2 000 mm per annum. There are two rainy seasons, from March to June and from September to October. They are separated by a short cool dry season in July/ August and a relatively long dry season from December to February. The major rainy season is in May/June and the minor one in September/October. June experiences the peak rainfall and January the lowest. Average temperatures are 23 - 24°C in August on the west coast, to 28 - 30°C in December/January towards the central and eastern coast.

The relatively dry coastal climate of the south-east is believed to be caused by the prevailing wind (south-south-westerly in direction) blowing almost parallel to the coast and to a cool current of water immediately offshore as a result of the local annual up welling.

Winds blowing over the coast are the south-westerly monsoon (relatively weak reaching a maximum speed of 5m/s during boreal summer) and the Harmattan (northeast trade winds).

Coastal Geomorphology and Habitats: The coastal area is a low lying plain rising from the Atlantic coast and the altitude is generally low not more than 200 m above sea level except in the east. It has a narrow continental shelf extending outward to between 20 and 35 km, except off Takoradi where it reaches between 80 and 90 km. The Economic Exclusion Zone of 200 nautical miles has a surface area of nearly 200,000 km^2.

The coast consists of low lying plains and sandy shores which is interspersed with rocky shores, numerous lagoons (92 in total), and estuaries. The area is also intersected by several rivers and streams, most of which are navigable only by canoe. Two large capes (Cape Three Points on the west and Cape St. Paul on the east) are important landmarks along the coast. Each of the four coastal regions has different vegetation cover, western-tropical rain forest, Central and Greater-Accra-coastal savannah, and Volta-guinea savannah.

Coastal Currents and Tides: The warm Guinea current flows along the coast of Ghana at the surface in an eastward direction. It is about 370 km wide and takes its source from the North Equatorial Counter current (NECC) and the Canary Current with an estimated velocity close to 100cm/s. The Guinea current is weakest in winter (December - February) and strongest in summer (July - September). At its southern edge it encounters the westward flowing South Equatorial current. A small westward flowing counter current also lies beneath the Guinea current and is believed to be a branch of the cold Benguela current which separates and dominate the Guinea current. The strength of the Guinea current is positively related to up welling seasons in Ghana. The coast experiences diurnal tides with annual average high tide of 1.70 m and low tide of 0.17 m. The lowest tides are experienced during the major up welling (late June to early September).

Figure 1. MFRD researcher downloads data from a tide gauge.

Coastal Observations: Two tide gauges have been installed at Takoradi to measure daily sea level and tides. They are operational and performing well. At the time of publication the tide gauge at Tema is not operational. The tide house was demolished a few years prior and is yet to be reconstructed before a tide gauge can be installed. Sea levels and tides are monitored by the Survey Department. The Marine Fisheries Research Division of the Ministry of Fisheries has eight coastal observing stations at Keta, Tema, Winneba, Elmina, Takoradi,

Cape Three Points, Axim and Half Assini. Coastal climate and weather data are managed by the Ghana Meteorological Agency based in Accra.

Ports and Harbours: Tema harbour (in greater Accra) is the bigger of the two harbours in Ghana. The other is the Takoradi harbour. Both import and export, however the Tema port is utilized more for importation, while the Takoradi port more for exportation. Another port construction has begun at Elmina in the Central region.

Coastal Tourism: It has emerged in recent times as an important foreign exchange earner for Ghana as the coastal area offers rich and varied opportunities for tourism. There are five main types of tourism in Ghana - cultural and heritage, eco-tourism, beach, conference and business, and urban. Tourist resources include beautiful beaches and cliffs, coastal lagoons and estuaries, monuments (forts, castles, lighthouses etc.) and cultural activities. The major coastal attraction sites are Keta, Ada, Ningo, Prampram, Tema, Labadi, Accra, Winneba, Kromantse, Cape Coast, Elmina, Breni-Akyini, Komenda, Sekondi,-Takoradi, Axim and Busua.

Coastal Economy: The economy of Ghana traditionally depends on primary production and exports of cocoa and minerals. Agriculture remains the dominant sector of the economy. About 60% of the labour force is employed in agriculture. The service sector is the second largest employer consisting largely of trade and public sector services. The industrial/manufacturing sector is next in importance. Economic activities in the coastal area include: manufacturing industries, mining, fishing, agricultural activities, tourism and historical monuments. The main historical monuments are the numerous forts and castles along the coast and their significance for tourism lies in their rich and diverse history. The two most prominent are located at Elmina and Cape Coast which have been designated World Heritage sites by the World Heritage Organization. A further 20 of the castles and forts have been designated as World Heritage monuments by UNESCO. However some of them are under threat of being washed away by coastal erosion, especially those at Keta and Prampram.

Coastal Industries: Industries are concentrated in Accra, Tema, Cape Coast and Takoradi and among them are those that: process food, metal products, textiles, chemicals, as well as cement factories and an oil refinery. There is also a thermal plant at Aboaze near Takoradi.

Fisheries: Fish is the country's most important non-traditional export commodity and the fisheries sub-sector accounts for about five percent of the agricultural GDP. In 2002, export earnings from fish and fishery products amounted to nearly 96 million US Dollars. Fishing activities in the marine sector range from artisanal, to semi-industrial, to industrial operations, exploiting both pelagic and demersal fish resources. The artisanal sector alone contributes 75% of fish landings and the rest is contributed by the inshore and industrial sector. Lagoon and estuary fishing are mostly subsistence.

Mineral Resources: In the coastal area the major resources mined include sand, gravel, and quarrying of stone, which continue to be an important economic venture as far as construction and development are concerned. It has been a major cause for coastal erosion. Only few mineral resources such as columbium, tantaliun, kaolin, silica, cassiterite, feldspar and limestone are being explored by some companies along the coast. There are three oil and gas exploration

Figure 2. Fishermen showing effects of algal bloom on fishing nets.

fields along the coast – the salt pond oil and gas fields, the North and South Tano oil and gas fields and the recently discovered oil and gas field at Cape Three Points. Explorations are on going in all fields by international oil companies which have signed agreements with the Ghana government and the Ghana National Petroleum Corporation. Salt production is done manly along the eastern dry savannah belt of the coastline. Extensive production occurs at the Songaw and Sakumo wetlands. Others include at Keta, Gyankai, Laloi, Nyanya, Apabaka, Eture and Ahwin lagoon.

Agricultural Products: The Agriculture sector contributes 45 - 50% of the GDP and about 75% of export earnings of Ghana. It provides a livelihood for about 70% of the population and raw materials for agro-industries. Agricultural products important in the coastal area include livestock and crops such as roots, grains, coconuts, and vegetables such as shallots. Semi-nomadic rearing of cattle is an important livestock activity in the coastal savannah. Livestock include pigs, sheep goats and poultry.

Other Marine Resources: Wetlands and mangrove serve as spawning and breeding grounds for several commercial marine fish species and shrimps. Mangroves provide the local communities with fuel wood, house construction materials, fences and furniture and fish attracting devices. However these resources have been degraded over the years along the coast. Mangrove forests have been cleared to make way for agriculture, fish ponds, salt pans, residential houses, industries and waste disposal.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

Though problems facing the coastal area are numerous and multi-faceted, six key issues seem critical. They are: erosion, pollution, impacts of crop production, impact of fisheries, biodiversity loss and habitat loss.

Erosion has mainly been due to the destruction of coconuts trees that fringe the coastline and serve as wind breakers to Cape St Paul. Sand and pebble extraction, wave action and construction of dams have also contributed to coastal erosion. Twenty-five key areas for erosion

Figure 3. Researcher from MFRD deploys a plankton net during a research cruise.

have been identified and the government has been trying to construct various defence structures, and prosecuting offenders for sand and pebble extractions when caught.

Some of the pollutants affecting the coast include municipal and industrial waste, chemical runoff from agriculture activities, and oil spillage. There have also been a few cases where DDT and mercury had been found in cockles *(Anadara senilis)* in Benya lagoon. The possibilities of oil spillage which can have major repercussions on marine life and coastal tourism has led to the production of a sensitivity map by the Environmental Protection Agency for quick response if an oil spillage was to occur.

Sinking of wells for irrigation in crop production (such as shallots and other vegetables) along the coast is depleting freshwater aquifers, resulting in significant salt water intrusion into these aquifers.

Figure 4. Members of the Ghanian ODINAFRICA project team.

Marine fisheries resources, especially small pelagic fisheries have, suffered serious decline due to over fishing, and violation of fisheries' laws and regulations. However, the fisheries department has established management units to enforce laws and regulations. It is promoting aquaculture and encouraging alternative livelihood to help manage the resources and step up production. Lagoon and estuary fisheries have also suffered depletion.

Biodiversity has suffered great loss as a result of anthropogenic impacts through over-exploitation, habitat damage and pollution. Within the coastal area, biodiversity issues are related to fin and shell fishes, birds, benthic macro fauna, sea turtles, and aquatic plants like sea weeds and seagrass. Coastal mangroves and wetlands have been destroyed to make way for development and settlement expansion.

Finally coastal research has not received the support required to carry out all the necessary research for coastal area management. There are no research vessels, nor basic research facilities and equipment to enable quality coastal research for sustainable management.

DEVELOPMENT AND ACHIEVEMENTS OF THE GNODC

The Ghana National Oceanography Data Centre (NODC) was established in 2002 under the ODINAFRICA-II Project. It was a timely intervention as Ghana was faced with the problems of integrating its ocean data and information management into sustainable coastal area management activities. The Marine Fisheries Research Division (MFRD) established in 1962 as part of FAO technical assistance to Ghana is the host institution. MFRD is mandated to conduct marine environmental and fisheries research and monitoring as part of fisheries resource management in Ghana by giving technical advice to the government concerning rational exploitation of the resources. MFRD has three scientific sections: 1) Environment, Biology; 2) Fish Stocks and Statistics, and 3) Gear Techniques and Improvement.

The principal function of the NODC is to collect, process, stock, archive, and manage oceanographic data and information in the country.

Products and services provided by the GNODC include:

- Data manipulation including raw data entry, spreadsheets and relational database manipulations and data downloading and collection,
- Grid and contour methods
- Image analysis and multi-parameter synthesis in GIS
- Data analysis, provision, and products and services development,
- Updating of meta data and directories, cataloguing and books classifications,
- Electronic transmission of documents and interlibrary loan facilitation,
- Updating and modification of Website
- Consultancy for data acquisition and analysis and systematic identification of plankton
- Collection of ocean and coastal data and information
- Provision of ocean and coastal data and information, such as tide predictions

The NODC supports Integrated Coastal Area Management (ICAM) in Ghana through holistic approaches, including:

- Development and provision of products and services to coastal zone managers and decision makers,
- Ecosystem approaches
- Education and public awareness
- Modelling of coastal processes
- Fore-casting and now-casting
- Community involvement.

The NODC has worked hard to maintain the following databases: sea level and tides data from Takoradi station, medi metadata, collection of ocean data and information sets on CD-ROMS, directory of freshwater and marine professionals and institutions in Ghana, Electronic catalogue holdings and species database (biogeography).

The users of GNODC Products and Services are: policy makers, resource managers, researchers, Non Governmental Organizations, educational institutions, and private companies.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following organizations collaborate with the NODC internationally: GLOSS; GOOS; GCLME; Nansen's Survey; AOML Global Drifter, IOC; WMO, and DBPC

Nationally the following organizations work with the GNODC:

- Environmental Protection Agency (EPA)
- Survey department
- Geological survey department
- Hydrology division–in works and housing
- Meteorological services department
- Ghana National Petroleum Corporation
- Regional Maritime University
- Department of Ocean and Fisheries - University of Ghana
- Ghana Ports and Harbours Authority
- Water Research Institute - CSIR

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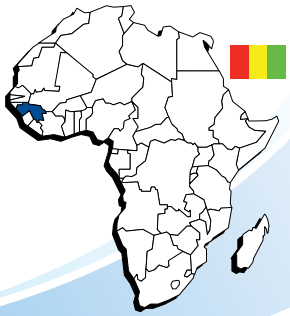

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Capital city	Conakry
Population (2005 est.)	9,000,000 (2.4% growth)
GDP per capita (USD 2005 est.)	$2 316
Life expectancy at birth (2005 est.)	54.8 years (male - 53.2, female - 56.4)
Land and water area	245,857 km^2
Length of coastline	320 km
Highest point of elevation	Mount Nimba 1 752 m
Mangrove area (2005 est.)	276,000 ha
Marine protected areas (2007 est.)	None recorded
Capture fisheries prod. (2006 est.)	94,000 metric tones
Aquaculture fisheries prod. (2006 est.)	None recorded

Coastal Climate: Guinea enjoys a humid tropical climate characterized by two seasons: the dry season (November-April), whose trade winds blow from the north-east (harmattan) and the rainy season (May-October) whose trade winds blow from the south-west (monsoon). In all of Guinea, the annual average rainfall is 1 835 mm. The rainy season lasts for about six to seven months and the annual rainfall rates vary between 2 000 to 4 000 mm. The climate is hot and humid.

Coastal Geomorphology: The total land area is estimated to be 245,857 km^2 with a coastline of about 300 km. Lower Guinea covers about 18% of the land and supports 32% of the population. It is a coastal region that is characterized by coastal plains, plains and mountains rising steadily towards the heights of Fouta Djallon. Guinea's maritime area covers an area of about 43,730 km^2 and forms about 300 km of the coast. A broad coastal strip of about 100 - 150 km can be found west of Fouta Djalon on the ocean's coast. Guinea's marine system is unique in the diversity of its landscape. The coastal formations characterized by two rock projections (the Verga course and the Kaloum peninsula) formed by volcanic activity and now are primarily marshes.

Coastal Habitats: The coastal vegetation has unique characteristics. In spite of its poor composition, it is dense and contains very unique flora

and fauna (mangroves). From an ecological point of view, the coastal zone it is located in the 'rivers of the south'- a natural area that extends from Gambia to Sierra Leone. Crossed by many rivers, most of which descend from Fouta Djalon, the marshes cover a surface of 360,000 ha of which about 260,000 ha consists of mangrove – comprising one of the most important of these areas in west Africa. These mangroves are characterized by a halophilous vegetation made up of trees which grow in the upper inter tidal part of the land and herbaceous plants, which are a very rich medium, very dynamic and are quite significant. The mangrove has for a long time been exploited by the local population (Oliver Rue, 1994).

Coastal Currents and tides: The major currents of Guinea are the Canary current, the Alizé current, and the Gulf of Guinea current. The gulf of Guinea current is the counter current to Alizé.

Coastal Observations: The coastal observation programmes in Guinea are directed towards monitoring: 1) climate, 2) the continental shelf, and 3) mangroves. The programmes of observation undertake:

- Evaluation of annual and total solar radiation averages, clouds, atmospheric pollution or changes in the country
- Monitor the annual the radioactive processes
- Monitor annual migrations and inter-tropical convergence - this has made it possible to undertake rainfall forecasting
- Monthly, seasonal, synoptic and inter-annual hydro-physical and hydro-chemical variability
- Monitoring of the major currents of Guinea, and upwelling events
- Taxonomic composition of plankton and the development of its space-time distribution and seasonal dynamics according to the structure and movement of the water masses
- Concentration and spatial distribution of chlorophyll and primary production

Ports and Harbours: The principal port of Guinea is Conakry, with secondary ports of Benty and Kamsar. In addition, there are 65 fishing ports along the coast.

Figure 1. Guinean fishermen deploying their fishing nets.

Coastal Economy: The coastal economy is based on agricultural and industrial products, fish, as well as mineral resources. The rural economy is an integral element in the economic and social dynamics of Guinea's maritime economy

The coastal administrative region is approximately 150 km wide boarded by the Fouta-Djalon plateau to the east. Due to the presence of the capital city, Conakry, about 36%, almost 2.5 million inhabitants (or 1.4 million inhabitants and 20% of the total population reside in the coastal zone, a considerable portion of the economic activity of the country takes place there.

Fisheries: In Guinea, three types of fishing are practiced; artisanal fishing, industrial fishing and semi-industrial fishing. Data and information on fisheries in Guinea is summarized in the Guinea atlas of fisheries in the form of maps and figures by the departments of fishing and the other technical institutions collaborating with the Department

of Fishing. This includes information on: the Exclusive Economic Zone (EEZ), sediments, salinity, temperature, and demersal artisanal and industrial fisheries.

Mineral Resources: The mineral resources are varied (bauxite, gold, diamond, iron etc). The mining sector contributes about 20% to the GDP and represents by itself about 80% of products for export and 29% of products for domestic use. The extraction of materials for construction is also an important mining activity. Guinea is a country with great mineral wealth. There is a need for greater economic and technological investment in order to get more value from its mineral resources.

Agricultural Products: The agricultural products in the lower part of Guinea are of two types: agro-industrial and local scale farming. The agro-industrial products include: bananas, palm tree oil, mangoes, pineapples, and coconuts. The local scale farming for local consumption include: rice, maize, potatoes, manioc, the arachidela mango, vegetables and oranges. Crisis has occurred when the local scale farming does not satisfy family needs. This insecurity leads to chief breadwinners of the family undertaking activities in other sectors to meet the families' financial obligations. In such cases, it is possible to maintain an agricultural culture within the family unit, financed by the extra monetary activities.

Other Marine Resources: The other marine resources in the marine and coastal environment include mining and energy resources that have not yet been utilized. Mangrove resources contribute, to a large extent, to the economy of the coastal area and the country in general.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

The natural resources of Guinea show signs of over exploitation and degradation for several reasons. Because of their economic and social importance, their management for access and exploitation, and protection has become priority. Accordingly, there has been the creation of reserves, natural parks and artificial reefs in order to safeguard their sustainability.

Mangroves habitats along the coast are a particular example of the difficulties faced in managing natural resources in Guinea. The mangrove forests are used in the construction industry and in the manufacture of the small fishing boats. They are also used for construction and as coal in households. The increasing demand for wood-energy and arable land has arisen as a result of an increase in human pressure. The result is the deforestation of this natural environment and degradation of the ecosystem. These competing needs make the management of the mangroves, and the coastal area more broadly, difficult. This problem can be resolved by involving all the principal actors involved in maintaining the ecosystem of the area, including the local population that live there.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Centre de Recherche Scientifique de Conakry Rogbanè (CERESCOR) is the focal point for the NODC in Guinea: the Centre National des Données Océanographiques (CNDO). CERESCOR is a public scientific and technical institution that is under the supervision of the Ministry of Scientific and Technical Research.

Figure 2. The CERESCOR research centre.

Within the scope of its activities with ODINAFRICA, CNDO Guinea develops products and services that benefit the general public, national and international institutions, and Non Government Organizations.

The products and services available are:

- Development of national databases on oceanographic and coastal zone observations and studies. This includes a database of salinity, phosphates, silicates, nitrates, and plankton samples compiled for about 1 743 expeditions at 101,804 locations, obtaining 4,270,555 samples for the period 1906 to 2005
- Development of metadata and bibliographical databases on oceanographic, fishing, and related activities
- Website design and management including the CNDO website
- Maintenance of a national directory of institutions and researchers in marine and coastal science
- Physical and conceptual models
- Different products and services used by scientists and members of the public
- Geographic Information Systems data manipulation and map production, including thematic maps on the resources available in the country's coastal zone

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

International cooperation constitutes an important component of CNDO-Guinea's role in the conservation and monitoring of environmental resources that each one of us must preserve and for the future (CNDO-GN, 2007)

Nationally, partners of the Centre National des Données Océanographiques (CNDO) in Guinea are:

- Centre de Recherche Scientifique de Conakry Rogbanè (CERESCOR) siège du (CNDO) BP: 1615 Conakry Guinée.
- Division Promotion et Statistique (DPS) de la Direction Nationale de la Pêche Maritime (DNPM)
- Chaire UNESCO/Université de Conakry
- Institut Géographique National (IGN), Conakry
- Service National de Gestion des Catastrophes et Urgences Environnementales Ministère de
- l'Environnement (SNGCUE), Conakry
- Direction de la Météorologie Nationale (DMN), Conakry
- Direction de la Protection et de la Surveillance des pêches (DPSP/Ministère de la pêche), Conakry
- Direction du MAB l'Homme et la Biosphère Direction Nationale de la Recherche Scientifique et technique, Conakry
- Fonds Mondial pour la Nature (WWF), Conakry
- Institut de Recherche pour le Développement (IRD), Conakry
- Observatoire de la Guinée Maritime (OGM)
- Département de Géographie (DG)/ Université de Sonfonia Conakry (USC)
- Port Autonome de Conakry (PAC), Conakry
- Direction Nationale de la Géologie (DNG), Conakry
- Centre d'Etude et de Recherche en Environnement (CERE)/ Université de Conakry (UC)
- Direction Nationale de l'Hydraulique (DNH)
- Univers Sel (US), Dubréka

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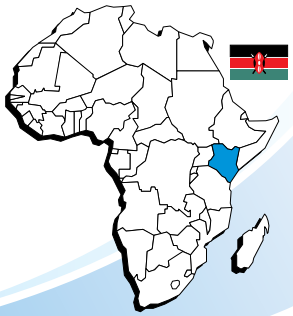

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Capital city	Nairobi
Population (2005 est.)	35,600,000 (2.6% growth)
GDP per capita (USD 2005 est.)	$1 240
Life expectancy at birth (2005 est.)	52.1 years (male - 51.1, female - 53.1)
Land and water area	582,650 km^2 (land - 569 250, water - 13 400)
Length of coastline	536 km^2
Highest point of Elevation	Mount Kenya, 5 199 m
Coral reef area (2001 est.)	630 km^2
Mangrove area (2005 est.)	50,000 ha
Marine protected areas (2007 est.)	783.24 km^2 (5.76 % of total territorial waters)
Capture fisheries prod. (2006 est.)	158,684 metric tones
Aquaculture fisheries prod. (2006 est.)	1 012 metric tones

Geographic Location: Kenya is located on the Eastern African coast between latitudes 5^{0}40' north and 4^{0}4' south and between longitudes 33^{0}50' and 41^{0}45' east. The country is bordered by Tanzania to the south, Uganda to the west, Sudan and Ethiopia to the north, and Somalia and the Indian Ocean to the east.

Rivers to the Country's Coast: River Tana, the longest in Kenya drains the Mt Kenya and Aberdares Range, and enters the ocean at Ngomeni. River Sabaki (also called the Athi and Galana in the upper reaches) is the second largest river along the coast and enters the ocean at Malindi.

Coastal Climate: January – March is generally dry, and the main rains comes between end of March and June, with the maximum rains in May. Temperatures range from 22 - 34^0 during the North East monsoon season (December – March), reducing to about 19 – 29^0 in June – August.

Figure 1. A GIS assistant seen assisting with map processing at the KeNODC office.

Coastal Geomorphology: The coastal belt of Kenya may be divided into four physiographical units which are almost parallel to one another. These are from the coast to inland: the coastal plain, the foot plateau, the coastal range, and the Nyika. The width of the coastal plain varies between 4 km in the south to 40 km in the north and is generally under 50 metres altitude. Kenya has a narrow continental shelf with depths dropping below 200 metres within less than 4 km in most places. However, the shelf widens significantly at the mouths of rivers Tana and Sabaki, exceeding 15 km off the northern end of Ungwana Bay. The shoreline is protected by fringing reefs running along the coast with gaps at the areas adjacent to the mouths of the main rivers.

Coastal Habitats: The main coastal habitat types found in Kenya are: coral reefs, estuaries, mangroves and sea grass meadows.

Coastal Currents and Tides: During the South West monsoon season (March-August) the swift northerly "East African Coastal Current" flows along the entire Kenyan coast. The current is enhanced by the momentum from local winds and reaches velocities of up to 4 knots. However, during the north eastern monsoon season (November - February) the flow is southward along the coast to about 2^0 South, just south of Lamu, where the Somali current meets the East African Coastal Current. The velocity of the current is reduced to about 2 knots during the season. The Kenyan coast experiences semidiurnal tides with the spring range of up to 4 metres and neap range of about 1.8 metres.

Coastal Observations: Tide gauges are installed and operational at Lamu, Malindi, Mombasa and Shimoni. Meteorological stations exist at Mombasa, Lamu, Malindi.

Ports and Harbours: The second major economic resource in the Kenyan coast after tourism is the Kilindini harbour in Mombasa. It derives its viability from its strategic position as a natural harbour serving Kenya as well as Rwanda, Uganda, Burundi, and parts of Tanzania, DR Congo, and Sudan. Other ports and harbours are located in Lamu, Malindi and Shimoni.

Figure 2. Sea Observations – A GLOSS tide gauge station at Lamu.

Coastal Tourism: Coastal tourism accounts for 60 - 70% of the national tourism industry. There are six marine national parks/reserves along the Kenyan coast located at: Kiunga, Malindi, Watamu, Mombasa, Kisite and Mpunguti. In addition there are several terrestrial parks and reserves along the coast. Other attractions include the museums at Fort Jesus in Mombasa and Lamu Fort in Lamu and several ruins and old settlements dating back to the seventh century scattered along the coastline.

Coastal Industries: The location of the port has attracted many industries of Mombasa. The main industries include cement manufacture, petroleum refinery and motor vehicle assembly.

Fisheries: Marine fisheries are an important source of protein for the coastal populations. The main fishery along the Kenyan coast is artisanal. Most of the fishing is done in the creeks, on the reefs and in shallow inshore waters. While there has been a big increase in the quantity and value of freshwater fish landed in Kenya (more

than 200,000 tones/year), the marine fisheries sector has continued to perform poorly, with less than 20,000 tones/year landed, due to some extent to the inability to fully exploit this resource.

Mineral Resources: There are several minerals being extracted along the Kenyan coast. These include: salt, gypsum, iron ore, lead, barite, lime, stone, coral stone for building, clay and apatile. A major discovery of titanium deposits, described as one of the largest and highest grade undeveloped resources of rutile and zircon in the world, is yet to be extracted.

Agricultural products: Most of the land in the coastal areas is of low agricultural potential. The following agricultural products are important in the coastal region: horticultural products, especially vegetables and tropical fruits, sisal, cotton, coconuts, cashew nuts and bixa.

Other marine resources: The mangrove forests along the coast provide local communities with fuel wood, timber for house construction, fences and furniture. In recent years the mangrove forests have been cleared to make way for agriculture, fish ponds, prawn farms, salt pans, residential houses, industries and dumpsites.

Figure 3. KMFRI mariculture activities – seaweed experimental farm at Shimoni.

ADDRESSING KEY COASTAL ISSUES

Experts taking part in a national assessment of environmental and social issues and impacts identified a number of hot spots (currently suffering measurable degradation), sensitive areas (likely to be subjected to some degradation in the future, and major issues of concern. These are reproduced in Table 1 (ACOPS 2002a).

Table 1. Results of the Integrated Problem Analysis undertaken for Kenya (ACOPS 2002a).

Major issue of concern overall for the country
Over-exploitation of fisheries and other living resources.
Modification of ecosystems or ecotones, including community structure and/or species composition.
Destructive fishing practices.
Hot spots
Mombasa Inshore Water Areas: Issues included microbiological pollution, chemical pollution, eutrophication, suspended solids, solid wastes, spills, over-exploitation of fisheries and mangrove resources and destructive fishing practices.
Lamu Inshore Water Areas: Issues include microbiological pollution, suspended solids, solid wastes and modification of ecosystems or ecotones.
Ungwana Bay: Issues include destructive fishing practices, excessive by-catch and discards from trawling activities (98% of which is for foreign export), suspended solids and modification of ecosystems, and threats to endangered species such as the Green Turtle.
Malindi Bay: Threats include suspended solids (especially silt deposition from River Sabaki), over-exploitation of fisheries resources (trawling and artisanal fishing), modification of ecosystems and threats to endangered species.
Diani Reefs: Threats include destructive fishing practices, over-exploitation of fisheries resources and modification of ecosystems and accelerate coastal erosion.

Sensitive areas
Vanga Creek: threats include destructive fishing practices, over-exploitation of fisheries resources, microbiological pollution, and modification of ecosystems.
Wasini Channel: threats include destructive fishing (especially by foreign fishermen using dynamite and beach seines), over-exploitation of fisheries resources, and loss and modification of ecosystems.
Gazi Bay: threats include over-exploitation of fisheries resources, destructive fishing (both local and foreign), and modification of ecosystems including over-harvesting of mangroves and coastal erosion.
Ngomeni Mangrove Swamps: threats includes: modification of ecosystems including complete clearing of mangroves for the salt works.
Malindi/Watamu Marine National Park and Reserves: threats include suspended solids impacting coral gardens, modification of ecosystems from over-harvesting of mangroves and trampling on corals, and microbiological pollution from domestic sewage.

A high load of suspended solids discharged through the river Sabaki has made this estuary devoid of mangrove vegetation unlike other estuaries. The sediments have similarly impacted the coral system, including those extending into the Malindi Marine Park and Reserve. Sea-grass communities have suffered a loss of biodiversity. Beach accretion has led to loss of frontage for some beach hotels impacting on their aesthetic value and becoming less attractive for the development of tourism in the Malindi Bay. Variations of freshwater discharges are thought to have impact on fish biodiversity in the estuaries, though indicator information is lacking.

The fisheries resources along the Kenyan coast are of two types, artisanal or subsistence fisheries and commercial fisheries. The artisanal fishery is concentrated between the coral reef and the shore, while the commercial fishery is composed of demersal fish, shrimp and lobster in the Bays of Malindi and Ungwana. The artisanal fishery is considered fully exploited with over-fishing now taking place in the reefs with ensuing changes in community structures.

The Kenyan coast is part of the main marine highway used by oil tankers, offloading at the port of Mombasa and destined for the Kenyan mainland and the landlocked countries of Uganda, Rwanda and Burundi. There are therefore the possibility of oil spills that can have major repercussions on the marine life and the thriving coastal tourism industry.

Pollution from industrial and domestic sources are limited to the coastal cities of Mombasa, Malindi and Lamu. These are likely to increase with the growing coastal populations.

Figure 4. Litter collection – World Environment Day.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Kenya National Oceanographic Data and Information Centre (KeNODC) is hosted at KMFRI with the support of UNESCO/IOC through the Ocean Data and Information Network for Africa (ODINAFRICA) and has been in existence for 10 years.

The main objectives of the Centre are to:

- Provide marine scientists in the region with the necessary scientific information
- Enhance the use of indigenous scientific information in the region
- Promote and facilitate communication between the scientists, both intra - and inter - regionally
- Disseminate information on marine scientific research activities in the country

The centre has provided training in data and information management to staff from collaborating institutions in the country. KMFRI is an input centre for the Aquatic Sciences and Fisheries Abstracts (ASFA) database and has been designated to provide training in ASFA methodologies to other input centres in Africa.

KeNODC has accumulated a wealth of data and information, the majority held in CDs which are utilized to develop a wide range of products and services in support of various communities involved in coastal management. KeNODC collection covers oceanographic, freshwater, and related terrestrial data. In the case of oceanographic data, an area of interest, bounded by the following latitudes and longitudes has been defined: 0.5°S, 6°S and 39°E, 50°E from the World Ocean Database 2005 produced by the US-NODC. Quality controlled ocean profile data for this area has been extracted from the World Ocean Database 2005 produced by the US-NODC. These depth profile data span several years and include measurements of temperature, salinity, oxygen, phosphate, nitrate, silicate, chlorophyll, alkalinity and pH.

The centre has actively sought to present various sets of data in GIS, providing an opportunity to visualize the Indian Ocean basin in progressive colors that may show variations in chlorophyll, sea surface temperatures, etc. The centre is set to avail more information on coastal terrestrial environment following the implementation of the Nairobi Convention Clearinghouse and Information Exchange System. This will be implemented through national institutional networks with each institution acting as a node for particular categories of data.

KeNODC has contributed to the development of the African Marine Atlas (www.africanmarineatlas.net) and the electronic repository of marine related publications (www.oceandocs.net).

The following are some of the products and services available at KeNODC:

- Catalogue of marine related datasets, which provides information on types, quantity, geographic coverage, sensors used, institutions/individuals holding the data, and conditions for access
- Library catalogue (the SAMAKI database has more than 7 000 records)
- Directory of marine and freshwater scientists within the country
- Computer software tools for quality control, analysis and sub setting of data
- Provision of datasets and meta data from ocean observing programmes, including sea level data
- Tide predictions for Mombasa and Lamu (high and low waters, as well as hourly heights)
- Development of products such as maps, graphs and statistical analysis
- GIS services for scientists and coastal management practitioners
- Provision of bibliographic search and delivery services to the scientific community in the institute

These products and services are available through the KeNODC website (www.nodc-kenya.org). The beneficiaries include coastal communities, resource managers, students, researchers and policy makers.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following are organizations that work in collaboration with the KeNODC:

- Kenya Marine and Fisheries Research Institute (http://www.kmfri.co.ke)
- National Museum of Kenya (http://www.museums.or.ke)
- Oil Spill Mutual Aid Group
- Forest Department
- Kenya Association of Hotelkeepers & Caterers (http://www.kahc.co.ke)
- Fisheries Department Coast Region
- Kenya Meteorological Department
- Kenya News Agency
- Department of Resource Surveys and Remote Sensing (http://www.drsrs.go.ke)
- Kenya Sea Turtle Conservation Committee
- Kenya National Chamber of Commerce and Industry (http://www.kenyachambers.com)
- Coast Development Authority (http://www.cdakenya.org)
- Kenya Association of Tour Operators
- National Environment Management Authority (http://www.nema.go.ke)
- Kenya Petroleum Refineries Ltd
- Jomo Kenyatta University of Agriculture & Technology (http://www.jkuat.ac.ke)
- Kenya Ports Authority (http://www.kpa.co.ke)

Figure 5. The Executive Secretary of IOC Dr Bernal plants a tree to commemorate his visit to KMFRI.

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7.10 Madagascar

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Capital city	Antananarivo
Population (2005 est.)	18,600,000 (2.6% growth)
GDP per capita (USD 2005 est.)	$923
Life expectancy at birth (2005 est.)	58 4 years (male - 56.7, female - 60.1)
Land and water area	587,040 km^2 (land - 581 540, water - 5 500)
Length of coastline	4 828 km
Highest point of elevation	Maromokotro, 2 876 m
Coral reef area (2001 est.)	2 230 km^2
Mangrove area (2005 est.)	303,814 ha
Marine protected areas (2007 est.)	121.84 km^2 (0.10% of total territorial waters)
Capture fisheries prod. (2006 est.)	134,417 metric tones
Aquaculture fisheries prod. (2006 est.)	11,213 metric tones

Geographic Location: Located in the southern hemisphere between latitudes 10°S and 30°S, and longitudes 40°E and 50°E, the Tropic of Capricorn crosses the southern part of the "Great Island" Madagascar. Madagascar is separated from Africa by the Mozambique Channel and bounded by the Indian Ocean to the south, north and east.

Rivers to the Country's Coast: The Mananara and Mangoro rivers flow from the central highlands to the east coast, as does the Maningory, which flows from Lake Alaotra. Other rivers flowing east into the Indian Ocean include the Bemarivo, the Ivondro, and the Mananjary. These rivers tend to be short because the watershed is located close to the east coast. Owing to the steep elevations, they flow rapidly, often over spectacular waterfalls. The rivers flowing to the west coast and emptying into the Mozambique Channel tend to be longer and slower, because of the more gradual slope of the land. The major rivers on the west coast are the Sambirano, the Mahajamba, the Betsiboka (the port of Mahajanga is located at the mouth), the Mania, the North and South Mahavavy, the Mangoky, and the Onilahy. The Ikopa, which flows past Antananarivo, is a tributary of the Betsiboka. The Mangoky River has a basin area of some 50,000 km^2, the Ikopa River and the Betsiboka River have basin areas of 18,550 and 11,800 km^2 respectively. The principal

river in the south, the Mandrare, has a basin area of some 12,435 km^2, but it runs dry during certain months in this desert region.

Coastal Climate: The climate is generally tropical along the coast, temperate inland and arid in the south. There are two seasons in Madagascar – hot and rainy from November to April and cooler and dry from May to October. The island occasionally experiences cyclones.

Coastal Geomorphology: The coastal zone is mainly made up of sedimentary rock. The west coast has a wide continental shelf with maximum width around 90 km. It is characterized by the presence of estuaries and fringing coral reef attenuating wave energy. About 300,000 ha are occupied by mangroves and the total length of coral reef is around 1 000 km, whereas the east coast is very straight and has a narrow continental shelf with few estuaries. Coral reef is absent and waves break directly on the coastline.

Coastal Currents and Tides: Data from tide gauges show a semi-diurnal tide for west and east coast. The average tide range for the west coast is around 3.2 m while for the east coast is about 0.30 m. Only a few investigations are done concerning the coastal currents. However, the results of current measurements carried out on the north west coast show the influences of the tide and the wind on coastal current pattern.

Coastal Observations: During French domination up to 1960, some sea level measurements were made for some harbours: Nosy-Be, Antsiranana in the North and Toamasina in the East of Madagascar. The mean sea level was defined for each harbour as well as the major component of the tide. Therefore, a tide table is produced every year by the Service Hydrographique et Océanographique de la Marine (SHOM) in Brest for Nosy-Be, Antsiranana, Toamasina and some other harbours.

Operational and recorded data:

Nosy-Be Tide gauge: Observed and predicted data are available from the Centre National de Recherches Océanographiques. Analog data from charts are available from 1987 up to now. However, there are some gaps due to some technical problems. Raw hourly observed data is available in TOGA Sea Level Centre (TSLC) format from 1992 to 1996. Quality controlled data are available from 1992 to 1994 in TSLC format. Hourly predicted data are available from 1996 to 2000 in TSLC format. Predicted high and low tide are also available from 1996 to 2000.

Taolagnaro Tide gauge: Only raw analog data on charts are available at the Centre National de Recherches Océanographiques up to 1989 with many gaps which are due to some technical problems.

Toliara Tide gauge: Raw analog data on charts are available at the Foibe Taosarintanin'i Madagasikara from 1991 to 1993. Digitized data are available at MD NODC for the years 1963 and 1964.

Coastal Economy: The coastal economy is mainly based on fishery activities, mineral and offshore oil resources exploitation. Recently, seafood processing industries are developing and since 2004 tourism (including eco-tourism) has become progressively more important. Malagasy Government encourages development of shrimp aquaculture and suitable habitats are increasingly used by the private business sector. Because of relatively low population densities and availability

Figure 1. Mangroves swamp of the Bombetoka bay in the northwest coast. Approximately 3 200 tones of lime are produced per year by 27 family of Belobaka village (image source: CIREEF Mahajanga).

of wood from other sources, direct harvesting of the mangrove trees has been relatively low with the exception of some areas, particularly Mahajanga and Toliara (Rasolofo 1993). However, demographic trends suggest this situation could change in the future (Spalding et al. 1997).

Fisheries: Despite the island's long coastline, fishing is a relatively under-developed industry in Madagascar. On the east coast, stormy seas and a lack of harbours mean that fishing is restricted mainly to coastal lagoons. There are approximately 52,000 artisanal fishers in Madagascar. The total catch in 2000 was estimated at 132,093 tones, of which 30,000 tones were caught in inland waters. Vessels from the European Union are licensed to catch up to 11,000 tones of tuna and prawns in Madagascan waters each year.

Mineral Resources: Madagascar has a number of natural resources, including graphite, chromite, coal, bauxite, salt, quartz, tar sands, semi-precious stones and mica. There are also fishing areas offshore, and potential for hydropower. In 2001, it was estimated that 5.07% of the land area was used for arable land, 1.03% had permanent crops.

Figure 2. Satellite dish for VSAT link installed at IHSM with ODINAFRICA support.

Due to slash and burn agriculture, only 26% of the land remains forested.

Agricultural Products: Agriculture, including forestry, accounts for more than one quarter of GDP and employs 80% of the population. Some of Madagascar's main agricultural products are coffee, vanilla, sugarcane, cloves, cocoa and rice. However, deforestation and erosion are serious concerns for farmers. Key industries are meat processing, seafood, soap, breweries, tanneries, sugar, textiles, glassware, cement, automobile assembly, paper, petroleum and tourism.

Other Marine Resources: Madagascar's long coastline, east and west facing coasts, large latitudinal range and 'upstream' location in relation to eastern and southern Africa provide suitable environments for most of the marine species and habitat-types of the region. The coastal waters host an impressive array of marine life, supporting populations of humpback whales, dolphins, marine turtles and over 56 species of sharks. However, many of Madagascar's endemic sea creatures are seriously endangered as a result of deforestation, habitat loss, overfishing and the introduction of exotic predators.

Addressing Key Coastal Issues: The principal marine and coastal environments of south-western Madagascar are mangroves, estuarine mud flats, beaches, coral reefs and seagrasses. Of the 3 540 km of reef systems surrounding the island of Madagascar, the majority are found on the west coast which has 90% of the island's coral reefs and 98% of its mangroves. In contrast, the east coast is dominated by steeply shelving beaches and rocky shores. The reef structures present in south-west Madagascar are emergent fringing reefs, true barrier reefs, patch reefs and submerged coral banks and shoals comprising 113 km of fringing reef, 557 km of reefs around islands and inlets, and patch reefs, 52 km of true barrier reefs (all in the Toliara region), and 1 711 km of submerged coral banks and shoals.

On Madagascar, mangroves are found primarily along the western coast. They occur in a wide range of environmental and climatic conditions, fostered by a low coastal platform, high tidal range, and a constant freshwater supply from numerous rivers that also bring a high silt load which is deposited along the coast (CEC 1992, Rasolofo 1993). The largest mangrove stands are found at Mahajamba Bay,

Bombetoka, south Mahavavy and Salala, and Maintirano (Spalding et al. 1997). Mangroves occupy a stretch of coastline of approximately 1 000 km in length where they are often associated with coral reefs, which protect the mangroves from ocean swells. The southern part of Madagascar has fewer mangroves because, in addition to having a longer dry season and lower rainfall, it is subject to intensive ocean swells and lacks the necessary alluvial sediments deposited by major river systems. This latter point is especially true of the eastern side of the island.

Mangroves are threatened by development of urban areas, over-fishing, and erosion caused by tree-cutting in the highlands. Some mangrove areas have been converted to rice farming and salt production.

Coastal erosion, which is amplified along the west, north-west and east of Madagascar (region of Mahajanga, Maintirano, Morondava and Manakara) takes place following the coastal hydrodynamic modifications. The best known for this phenomenon is located in the northwest coast of Madagascar. The Betsiboka Estuary on the northwest coast of Madagascar is the mouth of Madagascar's largest river and one of the world's fast-changing coastlines. Nearly a century of extensive logging of Madagascar's rainforests and coastal mangroves has resulted in nearly complete clearing of the land and exceptionally high rates of erosion. After every heavy rain, the bright red soils are washed from the hillsides into the streams and rivers to the coast. Astronauts describe their view of Madagascar as "bleeding into the ocean." One impact of the extensive 20th century erosion is the filling and clogging of coastal waterways with sediment - a process that is well illustrated in the Betsiboka estuary. In fact, ocean-going ships were once able to travel up the Betsiboka estuary, but must now berth at the coast.

A bad situation is made worse when tropical storms bring severe rainfall, greatly accelerating the rates of erosion. As an illustration, observations made from the International Space Station documented widespread flooding and a massive red sediment plume flowing into the Betsiboka estuary and the ocean in the wake of Tropical Cyclone Gafilo, which hit northern Madagascar on March 7th and 8th, 2004.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC:

The Madagascar National Oceanographic Data and Information Centre (MD NODC) is hosted by IHSM (Institue Halieutique et des Sciences Marines) and under supervision of the High National Ministry of Education. The centre is supported by UNESCO/IOC through the Ocean Data and Information Network for Africa (ODINAFRICA) since 1998.

The main objectives of the Centre are to:

- Provide marine scientists, students and operators in the country and the region the necessary scientific information related to the marine and coastal environment
- Promote the use of marine data and information both in the country and regionally
- Promote and facilitate communication between the scientists, both intra - and inter - regionally
- Disseminate information on marine scientific research activities in the country

Figure 3. Betsiboka river runs out to the sea - Brick-red lateritic soils, the result of tropical weathering, are responsible for the strong color of the sediments. The sediment lost is an irreplaceable natural asset (Image source: NASA, Image reference ISSOO8-19233, taken on March 25, 2004).

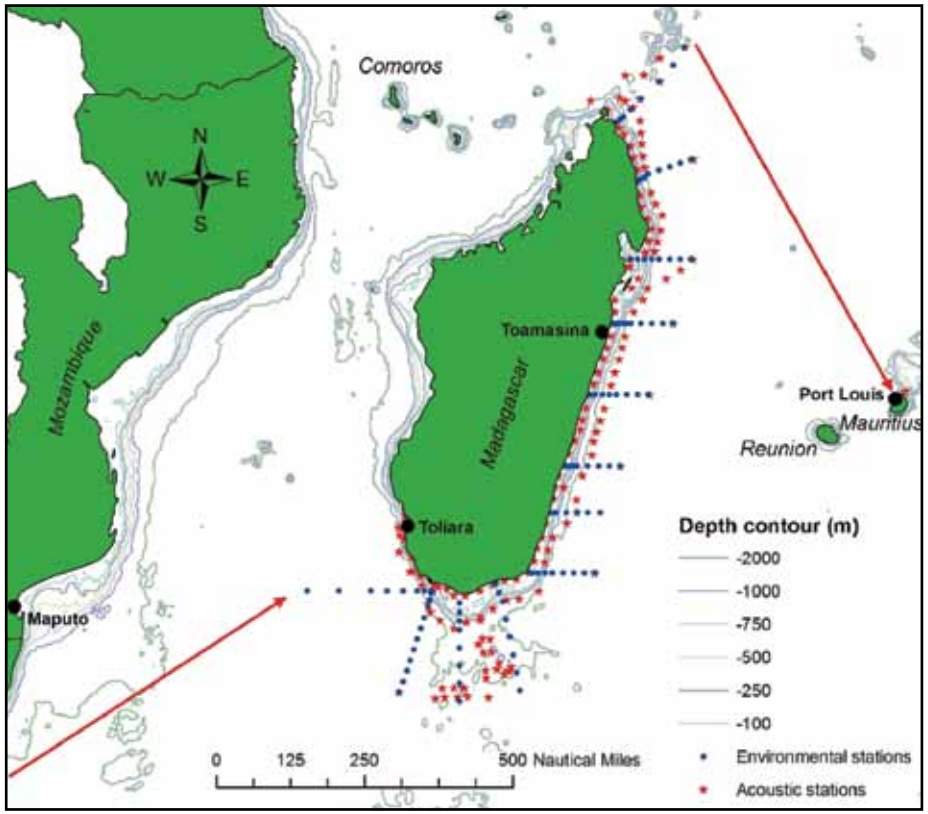

Figure 4. Results of a Madagascar ecosystem assessment survey of the shelf and deep water regions carried out in 2008. Acoustic assessment of the pelagic fish assemblages are shown in red and environmental sampling including nutrient analyses, and to collect data on zoo- and phytoplankton are shown in blue (image source: ASCLME. 2008. - to be made available at: www.asclme.org).

The centre receives students from various sectors for training in marine data and information management regularly. MD NODC also provides lectures on marine data and information management and Operational Oceanography to local graduate students.

National marine data and information collection has been done, and is available at the centre to be used by those working in marine and coastal management. The collection covers meteorological, oceanographic, freshwater, and related terrestrial environmental data. Oceanographic data collection combines data both from national and international databases delimited by an area of interest from: latitude: 10°S, 37°S and longitude 37°E, 57°E. International data is mainly from the World Ocean Database 2005 produced by the US-NODC, IFREMER/SISMER-France and SHOM (Service Hydrographique et Oceanographique de la Marine). SHOM deals with sea level data management. Data are flagged and quality controlled by using Ocean Data View (mp) software for data from the World Ocean Database 2005. Parameters include measurements of temperature, salinity, oxygen, phosphate, nitrate, silicate, chlorophyll, alkalinity and pH.

Complete Marine Ecosystem Survey in the south and east coast of Madagascar was carried out in the last semester of 2008 by R/V Dr Fridtjof Nansen. The main objective is to establish a baseline for the ecosystem off southern and eastern Madagascar. MD NODC has actively participated in this campaign and data from the survey is available at the centre.

Products and services available at the NODC include:

- Metadata of marine related datasets, which provides information on types, quantity, geographic coverage, sensors used, institutions/individuals holding the data, and conditions for access
- Library catalogue recorded with the INMAGIC software
- Directory of marine and freshwater scientists within the country
- Provision of datasets and meta data from ocean observing programs such as ARGO floats (provided by SISMER-France) and sea level data (SHOM)
- Provision of bibliographic search and delivery services to the scientific community in the institute

The beneficiaries of these products and services are mainly:

- Students
- Marine scientists and researchers
- Development bodies
- Professional bodies
- Maritime administration
- Maritime operators

Marine Related Programmes And Organizations

The following are organizations that work in collaboration with the MD NODC:

- The Institut Halieutique et des Sciences Marines (IH.SM) (www.nodc-madagascar.org/ihsm)
- The Ministry of High Education and Scientific Research
- The Ministry of Environment
- The Fishery Department
- The National Centre for Oceanographic Research (CNRO)
- The National Service of Meteorology
- The national committee of Tsunami Warning System

Figure 5. Students using the Madagascar Oceanographic Data Centre facilities.

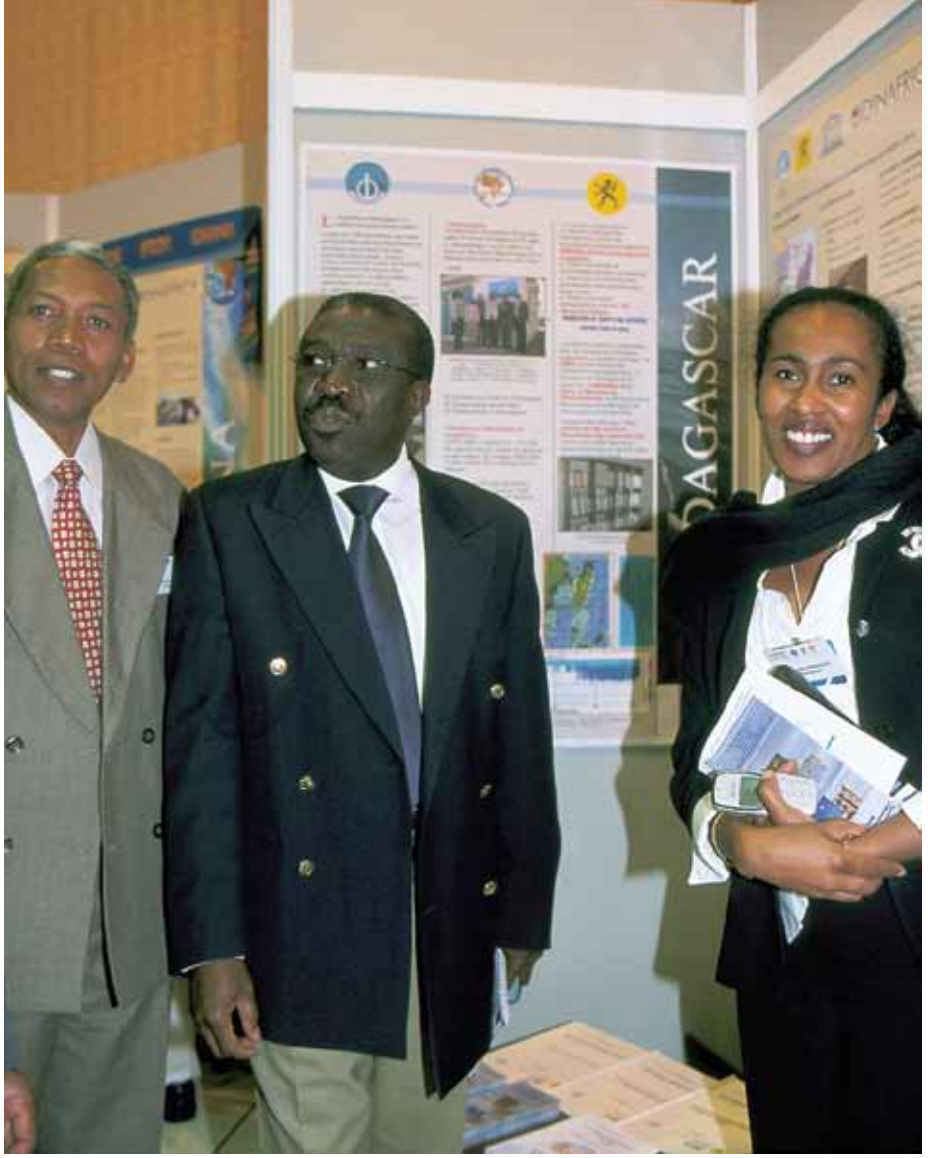

Figure 6. Dr Mara, ODINAFRICA Coordinator Madagscar with representatives of the Angola and Madagscar embasssies in Brussels during a seminar in 2003.

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7.11 Mauritania

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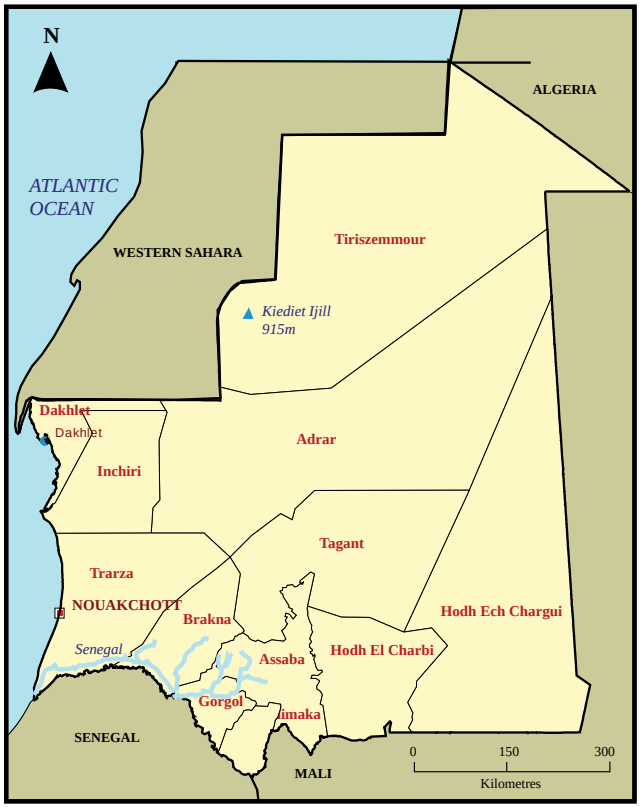

Capital city	Nouakchott
Population (2005 est.)	3,000,000 (2.4% growth)
GDP per capita (USD 2005 est.)	$2 234
Life expectancy at birth (2005 est.)	63.2 years (male - 61.5, female - 65.0)
Land and water area	1,030,700 km^2 (land - 1 030 400, water - 300)
Length of coastline	754 km
Highest point of elevation	Kiedier Ljill 915 m
Mangrove area (2005 est.)	100 ha
Marine protected areas (2007 est.)	6 311.68 km^2 (31.33% of total territorial waters)
Capture fisheries prod. (2006 est.)	193,230 metric tones
Aquaculture fisheries prod. (2006 est.)	0 metric tones recorded

Coastal Climate: The climate is characterized by extremes in temperature and by meagre and irregular rainfall. Annual temperature variations are small, although diurnal variations can be extreme. The harmattan, a hot, dry, and often dust-laden wind, blows from the Sahara throughout the long dry season and is the prevailing wind, except along the narrow coastal strip, which is influenced by oceanic trade winds. Most rain falls during the short rainy season (Hivernage), from July to September. The average annual precipitation varies from 500 to 600ml in the far south, to less than 100ml in the northern two-thirds of the country. Prevailing oceanic trade winds from the Canary Islands modify the Harmattan, producing a humid but temperate climate. Rainfall in Nouadhibou is minimal, averaging less than three centimeters annually and occurring between July and September. Temperatures are moderate, varying from mean maximum of 28°C and 32°C to mean minimum of 16°C and 19°C for Nouadhibou and Nouakchott respectively.

Coastal Geomorphology: Mauritania is generally flat, it is 1,030,700 km^2 forming vast, arid plains broken by occasional ridges and cliff like outcroppings. A series of scarps face southwest, longitudinally bisecting these plains in the centre of the country. The scarps also separate a series of sandstone plateaus, the highest of which is the Adrar Plateau, reaching an elevation of 500 m (1 640 ft). Spring-fed

oases lie at the foot of some of the scarps. Isolated peaks, often rich in minerals, rise above the plateaus; the smaller peaks are called guelbs and the larger ones kaédi. The concentric Guelb er Richat (also known as the Richat Structure) is a prominent feature of the north-central region. Tiris Zemmour, has an elevation of 1 000 m (3 280 ft) and is the highest peak. Approximately three quarters of Mauritania is desert or semi desert. As a result of extended, severe drought, the desert has been expanding since the mid-1960's. To the west, between the ocean and the plateaus, are alternating areas of clay plains (regs) and sand dunes (ergs), some of which shift from place to place, gradually moved by high winds. The dunes generally increase in size and mobility toward the north. The country is mostly desert, with the exception of the fertile Senegal River valley in the south and grazing land in the north.

The Coastal Zone, or Sub-Canarian Zone, extends the length of the approximately 754 km along the Atlantic coast. Battering surf and shifting sand banks characterise the entire length of the shoreline. The Ras Nouadhibou (formerly Cap Blanc) peninsula, which forms Dakhlet Nouadhibou (formerly Lévrier Bay) to the east, is fifty kilometres long and up to thirteen kilometres wide.

Coastal Currents and Tides: Current meter measurements obtained during the coastal up welling experiment JOINT-I (Feb. to April 1974) are used to describe some aspects of the semi-diurnal tidal currents on the shelf and across the continental slope off Mauritania. On the shelf the semi-diurnal tides represent the dominant short-period fluctuations. Semi-diurnal current speeds range between 1 and 10 cm s^{-1}. The mean speeds of about 5 cm s^{-1} are 15% to 25% of the residual current speeds. The main contribution to the semi-diurnal currents comes from the M2 tide. The mean amplitude of the currents at the period of the S2 tide is about half as large as the amplitude due to the M2. The signal of tidal currents at the period of 12.00 hours (S2) is probably biased by the influence of weak semi-diurnal wind variations. At the diurnal frequency band the daily wind fluctuations of the land-sea-breeze interferes with the tidal currents. When averaged over time, the semi-diurnal tides inshore appear barotropic. Over the continental slope baroclinic tides contribute significantly to the tidal currents and enhance the tidal energy there. The interactions of barotropic and baroclinic tides also contribute to the observed marked phase differences of the semi-diurnal currents across the continental slope. Whereas the semi-diurnal currents rotate counter-clockwise on the shelf they rotate clockwise 50 km offshore the shelf break.

Ports and Harbours: Nouakchott, is the capital city of Mauritania and one of the newest capitals in the world. It is located near the West African Atlantic coast and was developed as the capital of Mauritania after it gained independence in 1960. In the past Mauritania lay on one of the most lucrative trade routes in West Africa. Mauritania had always had to rely on neighboring ports, for it only had the fishing harbour of Nouadhibou, located in the extreme north-west, without any useful links to the southern, central and eastern parts of the country. Several projects to build a port were consequently contemplated but due to the peculiar configuration of the coast line which includes a sandy coast, lack of natural safe havens and moving sand banks it did not justify building a traditional harbour with quays. Plans were consequently drawn up at the beginning of 1963 to build a port called Port Wharf, including the construction of industrial and trade buildings. This became operational in 1966. This wharf, located 350 km south of Nouadhibou

Figure 1. Tide gauge installation at Nouakchott port.

Figure 2. The IMROP Research Vessel.

and 450 km north of Dakar was designed to accommodate traffic of up to 50,000 tones. The ports capacity was successfully increased in stages to 200,000 tones by improving available equipment and organic growth. This was mainly due to cope with the traffic of copper ore from Akjoujt (120 miles (195 km) northeast). In 1977 the Wharf was lengthened to provide 3 extra berths for ships of average tonnage raising its capacity to 320,000 tones. However, the rapid growth of traffic, coupled with projects developing new industries and the increase in inland trade to land locked countries led the Mauritanian government to negotiate with the Peoples Republic of China in order to build a deep sea harbour at Nouakchott. These negotiations led to the signature in October 1974 of an economic co-operation agreement in order to build such a port. Preliminary work commenced in 1978 with the foundation stone being laid on 10th April 1979. The inauguration of the Nouakchott deep-sea harbour, christened the 'Port of Friendship' took place on 17th September 1986. The Autonomous Port of Nouakchott, called PANPA for short, took over the management of the port and as such the port became operational in 1987 attracting trade between the two Capes (White and Green). Stevedoring activities were privatized in 1990 offering competitive storage facilities and warehousing tariffs. While there has been a steady increase in the port's activity, the level of traffic remains below that of the more northern port of Nouadhibou. PANPA's capacity is now estimated to be 1.5 million tones per annum and processes more than 90% of Mauritania's imports. Nouakchott port is an import port representing approximately 96.4% of all annual traffic. Imported goods include wheat, cement, clinker, flour, sugar, semolina, milk and general equipment. Exports include plaster from Samia (Mauritania's main producer), animal skins and fish.

Coastal Economy: The Majority of the population still depends on agriculture and livestock as a source of livelihood even though most of the nomads and many subsistence farmers were forced into the cities by recurrent droughts in the 1970's and 1980's. Mauritania has extensive deposits of iron ore which account for almost 50% of the total exports. The nation's coastal waters are among the richest fishing areas in the world, but over exploitation, predominantly by foreign fishermen, threatens this key source of revenue. Offshore oil deposits began to develop in 2004.

Fisheries: The main impact of oil activities in the coasts of Mauritania will be undoubtedly over fishing activities, both artisanal and industrial, because the country has one of the most productive marine eco-regions in Western Africa. In Mauritania, close to 50% of the commercial trade comes from fisheries, which is 43% of their total exports, 25% of their national budget, and more than 14% of the GDP. 40,000 of the country's jobs depend on fisheries. For many centuries the economy of Mauritania was based on bartering. Later a large portion of their income came from the mining of iron ore in the north western part of the country. There are three types of fisheries in Mauritania. Industrial fisheries are carried out in deep waters and the Government of Mauritania has to grant the permits. European countries are the main beneficiaries of these permits. Then we have artisanal fisheries that are carried out mainly in shallow coastal waters; the fleet is made up of out-board motorboats (pirogue-type) that come to the coasts to deliver their cargoes, or that approach the big industrial ships offshore; their fishermen are mainly from Senegal or Guinea Bissau and Moorish Mauritanian businessmen are in charge. The third type of fisheries is artisanal on foot or the traditional Imraguen lanches style (previously

Figure 3. Artisinal fishermen at the Banc d'Arguin.

described). Although there is greater control over the industrial and artisanal and traditional fisheries, the pressure on coastal resources is still too great, and the current fishing levels should be lowered. Today, fishing in Mauritania exceeds 600,000 tones per year, of which 80% is industrial fishing and the rest artisanal. The most valued species are certain types of sharks, rays, croakers and grey mullets. The latter are especially valued for their eggs (caviar), particularly in Spain, France and Italy. In Mauritania's maritime exclusive economic zone, we can detect close to 13,000 ship movements every year, having caused already adverse impacts on biodiversity. In fact, of all the oil waste dumped from every ship that goes through the waters of Mauritania, it is estimated that more than 7% will come from the Chinguetti oil field.

Mineral Resources: The exploitation of iron which is currently ensured by the industrial National Company and mine (SNIM) which replaced Miferma, started with time of French colonization in the area of Zouérate. The ore is extracted from open mines and brought to the harbour terminal of Cansado in Nouadhibou by rail. This is a distance of 650 km following the border of the Western Sahara. The train ore tanker is one of the largest in the world with three motorized carriages drawing 200 coaches weighing 24,000 tones. The total exploited iron corresponds to 10.4 million tones per annum. The total of the iron exported to Europe corresponds to 10.2% of its needs. It acts as the most important source of revenue for Mauritania (94.9%). Currently, Mauritania is the 13th highest iron producer in the world.

Agricultural products: Agriculture is especially practised in oases and the area bordering Senegal. It is principally practiced in the major river beds after the withdrawal of flooding, and farmlands are generally irrigated with pumping of water from the river. Rain fed cropping is practised in the back-country, but is seriously compromised in periods of dryness.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

The coastal area constitutes a vital element of the marine ecosystem due to its biological and ecological functioning, including zones important for reproduction and productivity. These zones are exposed to human activities which can present potential threats to their ecological functioning. Their sustainable management requires thorough knowledge of these systems.

The peninsula of the Cape Blanc shelters more than 100 individuals of the seal monk of the Mediterranean (Monachus) which constitutes the greatest global concentration. Other marine mammals are also protected by law, taking into account the role that they play in the ecosystem.

Research and management activities are being undertaken with the following objectives:

- To study the eco-biology of the marine mammals, in particular that of the seals
- To ensure the follow-up of the standings of marine mammals
- To guarantee survival and the reintroduction in their natural environment of the sick, wounded or orphan seals
- To sensitize the public with the protection of the seal monk and its habitat

Figure 4. Islands and channels in the shallow part of Banc d'Arguin.

The results and activities thus far include:

- IMROP is one of the rare African institutes to have an operational centre of rehabilitation for the seals. The wounded baby seals or orphans are cared for and observed, before being returned to sea as soon as their conditions allow it
- Development of a national expertise in the field of the rehabilitation of the seals
- Vaccination of several small seals against the Herpes virus
- Regular monitoring of the population of the seals and their habitat
- Sensitizing of the population and local fishermen
- Development of a national action plan to safeguard the seal monk and determination of the causes of mortality of these marine mammals

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The NODC of Mauritania was founded in 2001 and placed under the responsibility of the Oceanographic and Fisheries Mauritanian Research Institute (IMROP). Two structures of the IMROP ensure the essence of work of the NODC: 1) the Laboratory Environment and Medium (LEM), and 2) the Service of Information and Communication (SIC). The activities of ODINAFRICA are an important part of the action plans of these structures.

The Objectives of the centre include:

- To describe the coastal mediums and their dynamics in both physical and biological terms
- To include/understand the functions of these mediums and the interactions with the marine ecosystem

Figure 5. Analysis of physical parameters of water on board RV Amrigue.

- To evaluate the current and potential impacts of the human activity on the coastal mediums
- To study the biodiversity of the aquatic environments and to thus contribute to a better conservation of the species

Products and services of the NODC include:

- Oceanographic database management
- Study of coastal water hydrodynamics, including the influence up-welling
- Studies of coastal water quality
- Description of the habitats and the littoral ichthyologic settlements
- Studies of human activity in the coastal zone
- Publication of atlases on various topics including hydrology
- Training and outreach with local experts, including data base management
- Management of library collection and bibliographies, including the computerised management of the library catalogues using INMAGIC software, ODINAFRICA (Afrilib), and the African numerical deposit (Ocean docs)
- Provision of access to the bibliographical databases and catalogues of libraries of international associations (ASFA, AGORA, AFRILIB, IAMSLIC IT, Z39)
- Edition and publication of coastal and marine research, including publication through “e-repository” online

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Figure 6. Students using the IMROP library facilities.

Figure 7. Release of young Seal into the ocean after rehabilitation at IMROP.

7.12 Mozambique

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Capital city	Maputo
Population (2007 est.)	20,530,714 (INE, 2009)
GDP per capita (USD 2005 est.)	$1 242
Life expectancy at birth (2007 est.)	42.8 years (male - 45.2, female - 49) (INE, 2009)
Total Area	801,590 km^2 (land - 784,090, water - 17,500)
Length of coastline	2 306 km (Africa Pilot, 2006)
Highest point of elevation	Mt Binga, 2 436m
Coral reef area (2001 est.)	1 860 km^2
Mangrove area (2005 est.)	390,200 ha
Marine protected areas (2007 est.)	2 802.97 km^2 (4.01% of total territorial waters)
Capture fisheries prod. (2006 est.)	42,536 metric tones
Aquaculture fisheries prod. (2006 est.)	1 174 metric tones

Rivers to the Country's Coast: Mozambique has 25 rivers, of which the most famous and largest are the Zambezi (18°50'S 36°15'E) and the Limpopo (25°10'S 33°30'E). Other major rivers include the Rovuma, which forms part of the Tanzania border, and the Save. The country's rivers flow from the highlands of the west to the Mozambique Channel in the East. The largest body of inland water in the country is Lake Niassa, the Mozambique section of Lake Malawi. Lake Niassa forms part of the Malawi border and drains south through the Shire River into the Zambezi River (Africa Pilot, 2006).

Coastal Climate: Mozambique has a tropical climate, hot and wet from October to March, while it is cooler and dry from May to August. The coastal areas are much hotter than the highlands.

Coastal Geomorphology: Highlands dominate the west, especially at the borders with Zimbabwe and Malawi, but most of Mozambique is a low plateau, descending to the Indian Ocean, where the coast has many shallow lagoons.

The coastal lowland is narrow in the north, but much wider in the south, making Mozambique two-fifths coastal lowlands. Nearly half the country is less than 1 000 m (3 280 ft). Inland the altitude rises westward in a series of low hills and plateaus that reach high points of 2 436 m (7 992 ft) on Mount Bingo near the western border and 2 419 m (7 936 ft) in the Namuli Highlands of the north. To the northwest is the Angonia Plateau which forms the western rim of Africa's Great Rift Valley. Soils are generally poor, except along river valleys and in parts of the Angonia Plateau (Africa Pilot, 2006).

Coastal Habitats: The coastal ecosystems of Mozambique include mangrove, corals, and seagrass beds, all with significant ecological and socio-economic value. Local communities depend on these coastal habitats and they contribute significantly to the national fisheries. Mangroves contribute at least 250,000 tones of fish to annual production per year, at a rate of 0.5 tones of fish per hectare of mangroves. Corals

Figure 1. The GPS antenna installed in Inhambane Tide Gauge station.

Figure 2. Tide gauge at Kalesto, Pemba Quay, 2006.

are the source of production of an estimated 38,700 tones of fish annually, based on a figure of 25 - 30 tones of fish per km^2 for the 1 290 km^2 of the area of coral (Rodrigues and Motta, in press). About 75,000 artisanal fishermen and mussels' collectors, together with their families, depend at greater extent from the fisheries resources (MICOA, 1998).

Coastal Currents and Tides: The circulation patterns of ocean waters along the Mozambique coast are characterized by anti-cyclonic cells and by small vortices between these cells (Saetre and Silva 1982). There is a coastal current for the north caused by these vortices and winds. The patterns of tidal currents are barely known, studies carried out in some areas of Maputo Bay, have revealed that in some areas currents reaches values of 1.5 m/s (Moura,1973).

Coastal Observations: There are 4 operational tide gauges in Mozambique, as shown in Table 1.

Table 1. Tide gauges in Mozambique.

Station Name	Location (latitude; longitude)	Tide gauge type and model	Year of Installation	Responsibility
Maputo	25°58.5' South 32°34.2' East	Radar Gauge	1994/2007	INAHINA
Nacala	14°27.8' South 40°40.8' East	OTT R20 - 20102	1995	INAHINA
Pemba	12°58.0' South 40°29.3' East	OTTR20-20102/ astRadar gauge	1992/2005	INAHINA
Inhambane	25°87 South 35°38 East	Radar Gauge	2005	

Figure 3. Installation of the various types of tide stations in Mozambique. Red indicates the locations where the OTT R20 tide type were installed; yellow is the locations where the radar tide gauges were installed (GLOSS stations), and blue is the stations where INAHINA installed the radar tide gauges.

Figure 4. Mangroves destroyed for use as firewood.

Coastal Economy: Mozambique has a long coast which is one of its greatest economic assets. Tourism and fisheries are the principle economic activities, with tourism being one of the fastest emerging sectors, driven largely from South African tourists. The major centres on the coast are: Ponta de Ouro, Inhaca, Tofo, Pomene, Bazaruto and Quirimbas. The coast of Mozambique is one of its main assets. The fishing industry plays an important role in the country's economy.

Fisheries: Capture fisheries in Mozambique are an important sector and contribute significantly to the diet of the population. Approximately 75,000 artisanal fishermen and mussels collectors and families depend directly on fisheries resources (MICOA, 1998). Artisanal production in 2003 was estimated by the Ministry of Fisheries of Mozambique to be about 67,074 tones. In 2003 registered total catches (from industrial and semi-industrial fishing boats) were reported to be 22,037 tones and accounted for 10% of the country's total exports. In 2003 the annual value of exported fish products was US$ 79.7 million (DNEP, 2005).

Figure 5. Ms. Ana Maria Alfredo is demonstrating to the students the usage of marine databases at INAHINA.

Agricultural Products: Mozambique's major agricultural products include cotton, cashew nuts, sugarcane, tea, cassava, corn, rice, tropical fruits, beef and poultry.

Mineral Resources: Mozambique is rich in mineral resources including gold, marble, heavy minerals from coastal sands, pegmatite, iron ores, diatomite, bentonite, tantalite, graphite, precious and semi-precious stones, bauxite, granite, phosphates, clays, asbestos, beryllium and mica.

ADDRESSING KEY COASTAL ISSUES

Experts taking part in a national assessment of environmental and social issues and impacts identified a number of hot spots (currently suffering measurable degradation), sensitive areas (likely to be subjected

Figure 6. INAHINA Library and information centre.

Figure 7. The RV Bazaruto INAHINA's hydrographic survey vessel.

to some degradation in the future); and major issues of concern. These are reproduced in Table 2 (ACOPS 2002b).

Table 2. Results of the Integrated Problem Analysis undertaken for Mozamabique (ACOPS 2002b). All are number in order of precedence where prioritised.

Major issue of concern overall for the country
1. Modification of stream flow (abnormal river runoff, foods, draughts) 2. Loss and modification of ecosystems and ecotones (erosion, depletion of mangroves, destruction of corals and sea grass beds) 3. Over-exploitation of fisheries resources (shrimp resources, demersal fisheries) 4. Destructive fishing practices (use of mosquito nets, dynamites, fish poisoning)
Hot spots
Maputo Bay: threats include pollution of existing supplies, over-exploitation of fisheries resources, and solid waste *Sofala Bank:* threats include over-exploitation of fisheries resources, destructive fishing practices, and excessive by-catch and discards *Nacala and Mozambique Islands:* threats include degradation of infra-structure (cultural heritage), loss of ecosystem or ecotones, erosion, and solid waste
Sensitive areas
Bazaruto Archipelago: threats include modification of ecosystems, over-exploitation, destructive fishing practices *Quirimbas Archipelago:* threats include over-exploitation, destructive fishing practices, and modification of ecosystems *Inhaca and Matutuine Area:* threats include modification of ecosystems. impact on biological and genetic diversity *Marromeu and Zambezi Delta:* threats include reduction in stream flow, modification of ecosystems, and over-exploitation

DEVELOPMENT OF THE NODC

The Centro Nacional de Dados Oceanográficos (CENADO) is the Mozambique National Oceanographic Data Centre, hosted by the National Institute of Hydrograph and Navigation (INAHINA). The centre has two permanent staff who, in collaboration with staff from INAHINA and other Institutions, have collaborated on collecting data and information and developing products on the state of the coast and ocean of Mozambique. The centre assists scientists from the partner institutions, university students and interested members of the public by acquiring and providing relevant and necessary scientific marine data and information for management, research and study purposes.

The center has developed the following products and services:

- Data sets of the dilution coefficient in Espirito Santo Estuary
- Information on the water masses in Maputo Bay
- Information on the fisheries associated with Bazaruto
- Library catalogue that contain approximately 500 records
- Directory of marine scientists within the country
- Various public information materials such as brochures, newsletters, and a website

Figure 8. Participants at an "Advanced Leadership Workshop for heads of Marine institutions" hosted by INAHINA and INAM in Maputo, 2008.

Data collected under the National Institutions' mandate includes: sea level data, water transparency, sediments, and Conductive Temperature Depth (CTD) data. Meta-databases include information on: institutions, scientists, coastal districts level information, GIS layers, documents, programmes and projects.

Upgrades were done in 2007 to various sea level stations providing information to CENADO and the global community. The equipment installed enables accurate recording of observed data and near real-time transmission through the MeteoSat satellites system to the Tsunami centres, and GLOSS Fast Center at the University of Hawaii. This data, available at CENADO, is also accessible through the ODINAFRICA website.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

National institutions and programmes that work in collaboration with CENADO include:

- Fisheries Institute (IIP) - http:// moziip.gov.mz
- Meteorology Institute (INAM) - http://www.inam.gov.mz/
- Department of Physics and Biology of Eduardo Mondlane University
- School of Marine and Coastal Science - http://www.marine.uem.mz/

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7.13 Namibia

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Capital city	Windhoek
Population (2005 est.)	2,000,000 (1.2% growth)
GDP per capita (USD 2007 est.)	$5 200 (CIA, 2008)
Life expectancy at birth (2005 est.)	51.6 years (male - 50.9, female - 52.2)
Total Area	825,418 km^2
Length of coastline	1 572 km
Highest point of elevation	Königstein 2,606 m
Coral reef area (2001 est.)	None
Mangrove area (2005 est.)	None
Marine protected areas (2007 est.)	51.07 km^2 (0.15% of total territorial waters)
Capture fisheries prod. (2006 est.)	509,395 metric tones
Aquaculture fisheries prod. (2006 est.)	50 metric tones

Coastal Climate: Namibia has an arid climate with rain fall of 15 - 20 mm per year and temperature between 10 - 40˚C.

Coastal Geomorphology: The littorial and sublittorial substrata on the Namibian coast are predominantly sandy with the only continuous rocky coast occurring between Lüderitz and Bogenfels (80 km south of Lüderitz). South of this the coast is sandy with a few rocky outcrops. The occurrence of rocky outcrops becomes less frequent in a northerly direction (Molloy, 2003). The continental shelf is widest at the Orange River, then off central Namibia (Walvis Bay area), and narrow at Lüderitz and at the Kunene River mouth at the northern border.

Coastal Currents and Tides: The dominant surface current is the cold north-north-west highly productive Benguela current. During late summer the warm nutrient poor Angola current intrudes into Namibian waters. The Angola current feeds into the northern Namibia system as a poleward undercurrent with a strong seasonal signal (strongest in summer/autumn). Namibia has semidiurnal tides with a tidal amplitude of about 1.8 m.

Coastal Observations: Namibia has four coastal weather stations (Cape Frio, Möwe Bay, Swakopmund and Lüderitz). A tide gauge is installed and operational at the Walvis Bay harbour. Regular in situ sampling off the jetty in Swakopmund is done for Sea Surface Temperature, oxygen, H_2S, Chlorophyll-a and phytoplankton.

Coastal Economy: There are four major towns on the coast, which support the majority of the coastal economic activities including fisheries, tourism and the import and export of goods. Major fisheries include: pilchard, horse mackerel, hake, monk, rock lobster, red crab, line fish, seals, kingklip, west coast sole, orange roughy, and tuna.

Mineral and Agricultural Resources: Mineral resources are an important part of the national economy including: uranium, gold, tin, copper, diamonds, semi precious stones, zinc, and lead. Agricultural products include: cattle, sheep, maize, and game.

Other marine resources: Other resources include diamonds, guano, mariculture (oysters, abalone), and salt.

ADDRESSING KEY COASTAL ISSUES

Ninety percent of the coastline is conservation area with controlled access including almost the entire coast of the Namib desert. Namibia is one of the first countries to include environment protection within its constitution (CIA, 2008). Three RAMSAR sites exist at: the Orange River mouth, Walvis Bay lagoon and Kunene River mouth. Sandwich Harbour is another important coastal area and under special protection. This said, Namibia faces challenges in coastal and marine management. These include the management of small recreational areas around towns, urban development, and tourism and recreational use of the coast such as quad-biking. Diamond mining in closed areas in southern Namibia is also an issue of potential environmental degradation of resources, as well as industrial fishing

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

Namibia does not have online access to the NODC. However, there is

Figure 1. Jetty in Swakopmund where measuring equipment are attached for daily water samples for temperature, oxygen and phytoplankton (photo taken by Deon Louw).

an in-house data base at the Ministry of Fisheries & Marine Resources where oceanographic data is archived and available on written request. In addition, Conductivity, Temperature and Depth (CTD) data is also provided and archived at the Southern African Data Centre for Oceanography (SADCO).

The main objectives of the NODC are to support national:

1) monitoring of the coastal and ocean environment; and
2) fisheries management using the Total Allowable Catch approach.

Figure 2. CTD which is used on the "R.V Welwitchia" for oceanographic measurements (photo taken by Deon Louw).

The beneficiaries of the products and services include national and international scientists, managers and members of the public.

Products and services available at the NODC are based on the following sources:

- *Biological parameters* – Chlorophyll-a, phytoplankton species, zooplankton species and biomass
- *Physical parameters* - temperature, salinity, wind speed & direction, tide, air pressure, dissolved oxygen
- *Chemical and nutrient parameters* - phosphate, nitrate, nitrite, silicate, ammonium, hydrogen sulphide
- *Satellite derived data:* Sea Surface Temperature and Chlorophyll-a

Figure 3. During winter months Namibia has berg winds (warm desert winds) and sand particles can be blown more than 150 km into the sea (satellite image by Oceans-pace on 24 June 2003).

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following are organizations that work in collaboration with the NODC:

- Benguela Current Commission
- Namibia Coast Conservation and Management Project (www.nacoma.org)
- South East Atlantic Fisheries Organization (www.seafo.org)
- Commission for the Conservation of Antarctic Marine living Resources (www.ccamlr.org)
- Southern African Data Centre for Oceanography (www.sadco.csir.co.za)
- International Commission for the Conservation of Atlantic Tunas (www.iccat.es)

Figure 4. African penguins on Mercury islands off southern Namibia (photo taken by Deon Louw).

Figure 5. NatMIRC (National Marine Information and Research Centre) offices in Swakopmund. The National Aquarium as well as the following research section are situated here: Environment, Demersal, Pelagic and Aquaculture (Mariculture) (photo taken by Deon Louw).

Figure 6. Research vessel "R.V. Welwitchia", named after the famous desert plant the Welwitschia mirabilis (photo taken by Deon Louw).

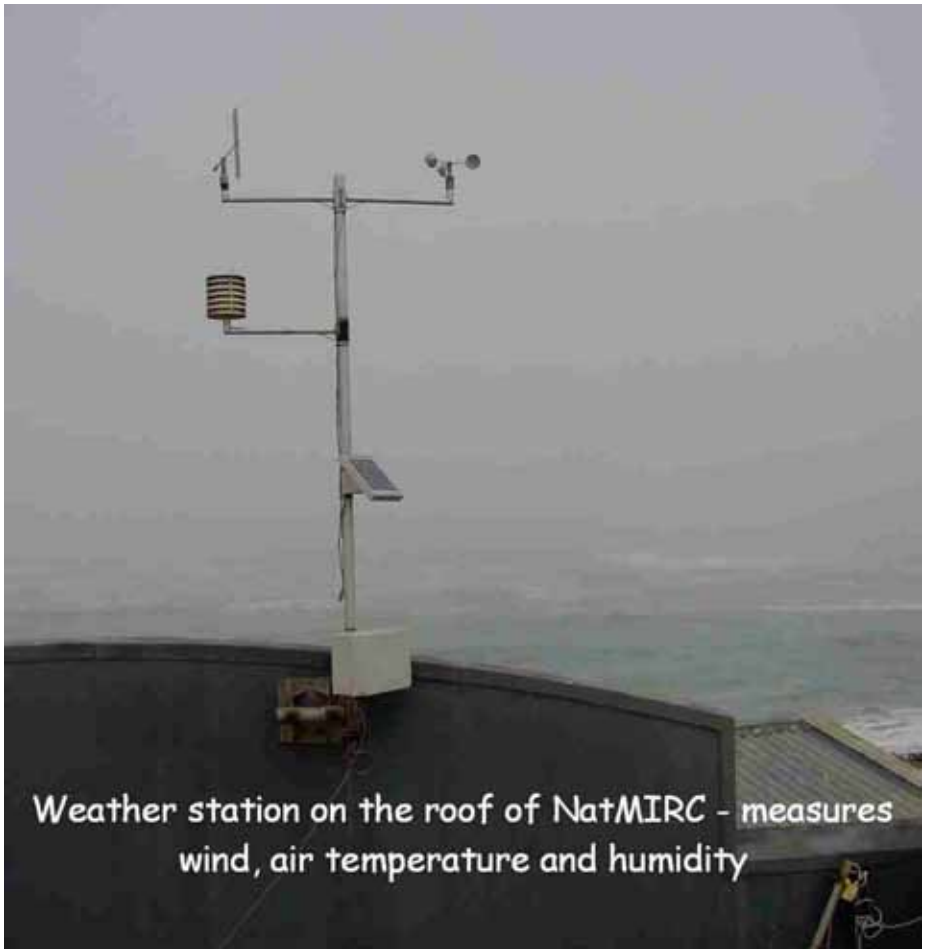

Figure 7. The weather station on the roof of NatMIRC in Swakopmund (photo taken by Deon Louw).

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7.14 Nigeria

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Capital city	Abuja
Population (2005 est.)	141,400,000 (2.2% growth)
GDP per capita (USD 2005 est.)	$1 128
Life expectancy at birth (2005 est.)	46.5 years (male - 46.0, female - 47.1)
Land and water area	923,768 km² (land - 910 768, water - 13 000)
Length of coastline	853 km
Highest point of elevation	Mount Chappei Waddi 2 419 m
Coral reef area (2001 est.)	0 km
Mangrove area (2005 est.)	997,000 ha
Marine protected areas (2007 est.)	0 km² (0% of total territorial waters)
Capture fisheries prod. (2006 est.)	552,323 metric tones
Aquaculture fisheries prod. (2006 est.)	84,578 metric tones

Rivers to the Country's Coast: The river catchment basins in the coastal zone consist of the western Nigeria catchment basin, the Niger Benue catchment basin, and the south-eastern catchment basin.
The major rivers in the western Nigerian catchment basin consist of Ogun, Owena, Osun and Shasha which are sourced from the Yoruba highlands and drain the landmass in the south western part of Nigeria. These rivers empty into the Lagos lagoon.

The Niger Benue catchment basin is dominated by the Niger and Benue rivers. The Niger River flowing over coarse, crystalline, Cretaceous and Cenozoic base complex enter the country in the west, and has a total length of 4 123 km - making it the eleventh longest river in the world. At Lokoja, the Niger River is joined by the River Benue before continuing its course due south into the Gulf of Guinea. Other important tributaries of the Niger include Rivers Sokoto, Zanfara and Kaduna. Some 233 km below the Lokoja at Aboh, the Niger River starts to break up into tributaries to form a delta. The Niger River drains a total area of 621,351 km². NEDECO, (1961) estimated the annual discharge of freshwater to the delta to be 200 x 109 cubic metres, while

total annual discharge has also been estimated to be about 300 x 109 cubic metres.

The south eastern river catchment basin is drained by Imo River, Calabar and several other smaller rivers which take their sources from the eastern highland south of the Benue River. These rivers empty into the ocean through estuaries.

Coastal Climate: The Nigerian coastal zone experiences a tropical climate consisting of a rainy season (April to October) and dry season (November to March). Temperatures are high reaching an annual mean of 28°C. Relative humidity is high throughout the year and rarely goes below 60%. The month of June receives the highest rainfall.

Total annual rainfall of between 1 500 mm and 3 000 mm is also experienced with a short dry break in August. The dry season, which lasts from November to March, is characterized by the northeast trade winds with speeds of up to 0 - 2 m per second. During this period, low visibility and relatively cold conditions are experienced at sea. Minimum wind gusts of 2.5 to 4.7 m per second are usually recorded during the months of November to February when mean wind direction ranges from 161 to about 190 degrees in direction.

Coastal Geomorphology and Habitat: The Nigerian coastal and marine area consists of a narrow coastal strip of land bordered by the Gulf of Guinea of the Central Eastern Atlantic. The coastal areas stretch inland for a distance of about 15 km in Lagos to about 150 km in the Niger Delta and about 25 km east of the Niger Delta. The Nigerian coastal area is divided into four main geomorphic zones (figure 1) namely:

- Barrier Lagoon Coast
- Mahin Mud Coast
- Niger Delta
- Strand Coastline

Each of these are described in the following section, as well as the continental shelf of Nigeria.

The *Barrier lagoon Coastal Complex* (Figure 1.) stretches from Badagry

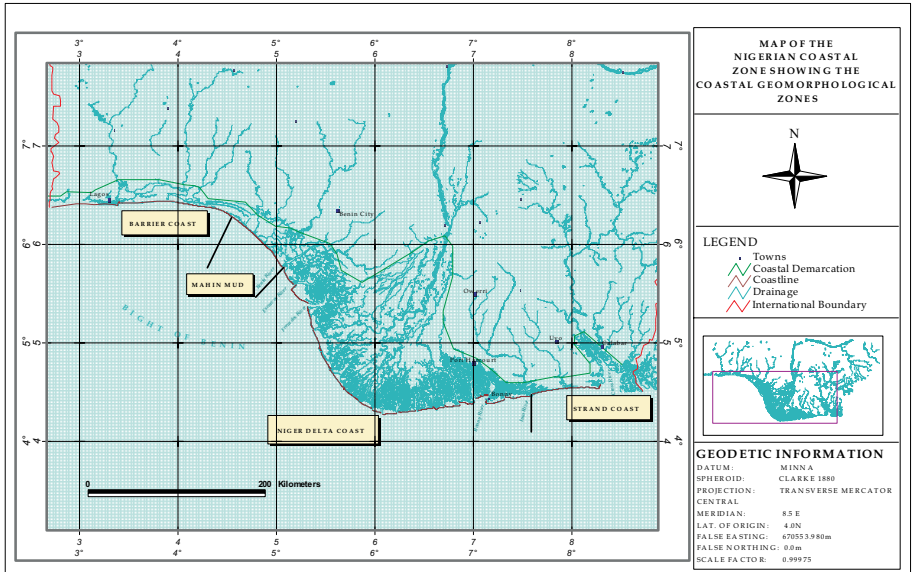

Figure 1. Map showing the Nigerian geomorphologic zones (Awosika et. al. 2000).

in the east to around Agerige village where the coastline starts a southward inflection. The barrier bar consists of beach ridges fronted by a very narrow beach with a foreshore gradient of about 1:50. Beach crest elevation is between 3 - 4 m above mean low water. The foreshore is backed by narrow and sandy beach ridges, which are aligned parallel with the modern coast. The beaches are subjected to high-energy waves, resulting in the formation of characteristically steep beach profiles. This coastal complex is very fragile as it is composed of narrow low lying sandy barrier bars backed by the Lagos, Lekki, and Yelwa lagoons, and linked together by many tortuous creeks. The coastal vegetation in the barrier lagoon complex is dominated by coconut trees, palms and other plants including sedges *Cyperus spp.;* herbs such as *Euphorbia hypossopifolia* and *Diuodia vaginalis* as well as climbers including species of *Ipomea*, *Vigna* and *Amaranthus*.

The *Mahin Mud Coast* is a muddy coastal complex which lies east of the barrier lagoon coast and stretches to the Benin River in the north-western flank of the Niger Delta. The Mahin mud coastline runs from the north-west to south-east between latitudes 5°52'00"N and 6°25'00"N. The coastline is so named because of the absence of sand

Figure 2. Deploying ADCP in the Lagos lagoon.

along the beach and the predominance of silt and clay size sediments. The coastal plain embodying this area stretches about 20 km inland. Relief ranges from sea level along the coast backed by a wide expanse of tidal flat, wide expanse of coastal plain with relief rising gently from 2 m to about 50 m above mean sea level. The coastal vegetation along the transgressive mud beach is dominated by mangrove, especially the red mangrove *Rhizophora racemosa* and the white mangrove *Avicennia spp.* Also present are the hardy grass *Paspalum vaginatum*, the *fern Acrositichum anreum*, the palm *Phoenix reclinata* and various climbers and shrubs.

The *Niger Delta* extends over an area of about 75,000 km^2 and accounts for 7.5% of Nigeria's land mass covering a coastline of 560 km, about two-thirds of the entire coast line of Nigeria. The Niger delta is rimmed by a chain of sandy barrier islands approximately twenty in number (Allen 1965). The Niger delta spreads over a number of ecological zones; sandy coastal ridge barriers, brackish or saline mangroves, freshwater permanent and seasonal swamp and lowland forests. The mangroves and wetlands along the major estuaries between Benin river in the west and Cross River in the east have a total brackish area of 2 520.79 km^2 (Ndaguba, 1983). Most of the nation's fragile mangrove ecosystems are to be found in the Niger Delta area especially between the Benin and Cross-River. The mangrove vegetation in this zone occupies an area of about 7 500 km^2 in 30 - 40 km wide belt. The red mangroves -*Rhizophora racemosa* make up about 90% of the vegetation of the mangrove ecosystem. Other species are *R. harrisonii, R. mangle* and the white mangrove *Avicennia nitidae.*

The *Strand Coast* stretches from Imo River eastwards to the Cross River estuary along the Nigerian Cameroon boundary. The vegetation of the 85 km long strand coast comprises mangrove swamps with species composition similar to those of the Niger Delta zone. Some parts of the estuaries in this zone are populated by the palm: *Nypa fructicans* which is particularly dominant in the Kwa Iboe River area. The mangrove species *Rhizophora racemosa* are found along the Cross river estuary and in isolated pockets along the coast.

Nigeria has a narrow continental shelf, ranging from 15 km offshore off Lagos to about 75 km in front of the Niger delta, and about 85 km off Calabar, along the Strand coast. The shelf starts to break at an average depth of 90 m. The Nigerian continental shelf has three major canyons, namely: 1) Avon canyon just east of Lagos; 2) Mahin canyon off the Mahin mud coast, and 3) Calabar canyon off Calabar. There are other smaller gullies especially off the Niger delta while the outer shelf with depths between 80 - 90 m are characterized by dead Holocene coral banks. Some of the coral banks stick out from the bottom of the ocean and reach heights of 7 m above the sea bed (Awosika, 1990). The near shore area of the Nigerian shelf is composed of coarse to fine sand except off the Mahin mud coast, which is void of sand. Further out to sea, sediment grades vary from fine sand to silt, to mud at the outer shelf.

Coastal Currents and Tides: The Nigerian coast and marine areas are influenced by **tides, waves, long shore currents,** and **ocean currents**. They are described in the following sections:

Tides along the entire Nigerian coast are semi diurnal with two inequalities. The tides arrive in a south westerly direction. Tidal range varies from 1m at Lagos and increases progressively eastwards to about 3 m at Calabar. Intense tidal activities are more destructive along the Mahin coast during spring tides, during which tidal range reaches 1.5 m. Though the tidal range is relatively small, the effects of tides on the general morphology of the coastline are very significant.

Most of the areas along the Nigerian coastline experience moderate to high wave dynamics. The waves have a south westerly component driven by the south westerly winds. Waves are predominantly of the plunging and spilling types averaging about 1 to 2 m high along the Bar beach in Lagos. However, during the rainy months of June to September when storms are more frequent, waves of well over 3 to 4 m are common along most areas. While plunging breakers are more dominant along the Barrier-lagoon and the Niger delta coastline (Forcados), the Mahin coastline is normally subjected to spilling breakers with less intense wave action.

The currents affecting the Nigerian coastline consist predominantly of **long shore currents** generated by south-westerly breaking waves. The transport or drift, of beach sediments along a coastline, caused primarily by the action of waves and tidal currents, is a major factor in the long-term development of beaches. Long shore currents along the barrier lagoon coast in the west, have a west to east directional component. The Mahin mud coast has little or no long shore currents due to the fact that the south westerly waves arrive parallel to the coast. Long shore current along the north western Niger Delta is north westerly. The eastern Niger delta from Akassa Point to the Calabar estuary is characterized by a west to east flowing long shore current direction.

The West-East Guinea current is the dominant **ocean current** affecting the Nigerian continental margin. The Guinea current, which is an extension of the north Equatorial Counter current, attains speed of 0.3m per second with some reversals. The Guinea current runs above an undercurrent. This is thought to be a westward flowing extension of the northern branch of the Equatorial undercurrent, which splits into two branches after reaching upon the African continent at Sao Tome Island. Due to the fact that the Equatorial undercurrent carries cool,

Figure 3. Lagos tide gauge house.

highly saline water, the thermo cline beneath the Guinea current is particularly intense. The other important surface current in the Gulf of Guinea is the South Equatorial current (SEC).

Coastal Observations: Tide gauges are installed and operational at Lagos at the Nigerian Institute for Oceanography and Marine Research (NIOMR) Jetty Lagos. Meteorological stations exist at Eket, Brass and Forcados and Escravos. Salinity and water temperature measurements are also taken at the NIOMR jetty.

Ports and Harbours: Nigeria's major ports include Apapa and Tin Can in Lagos, Port Harcourt, Warri, Calabar and Koko ports.

Coastal Economy: Nigeria's petroleum industry is considered the back bone of the Nigerian economy. Nigeria is the largest oil producer in Africa, the eleventh largest producer of crude oil in the world, and a member of the Organization of Petroleum Exporting Countries (OPEC). Oil and gas operations concentrate traditionally on land, swamp, and shallows offshore in the Niger Delta area. Oil and gas provides 20% of

GDP, 95% of foreign exchange earnings, and about 65% of budgetary revenues. From the mid-nineties, major exploration activity in the deepwater offshore (500 - 1500 m) has expanded production. In 1997, Nigerian oil production reached a historic record of 2.3 million barrels per day, while in 2006 oil and gas production reached over 2.5 million barrels per day. In 2006, total Nigerian oil production, including lease condensates, natural gas liquids and refinery gain, averaged 2.45 million barrels per day (of which 2.28 million barrels per day was crude oil).

Fisheries: The inshore fish resources of the Nigerian waters (0-50 m) includes demersal, pelagic and shellfish resources. The potential yield from inshore waters is estimated at 201,000 metric tones per annum. Small-scale fisheries contribute between 50 - 70% of total domestic production. Tobor, (1965 and 1968 recorded about 157 species of fish belonging to 71 families in the Nigerian inshore waters. Demersal species are grouped according to their area of occurrence either above or below the thermocline at 30 - 40 m depth.

The pelagic fish resources are mainly the Clupeid family and the most exploited are; *Ethmalosa fimbriata, Sardinella maderensis, Sardinella aurita* and *Illisha africana*. Others such as anchovy and the scombrids are not the major targets of the small-scale fishery. Shellfish harvested by the artisanals include white shrimps *(Nematoplaemon hastatus, Palaemon hastatus)*, brackish prawn *(Macrobrachium macrobrachion),* river prawn *(Macrobrachium vollenhovenii),* and juvenile pink shrimp *Penaeus notialis* and *Penaeus duorarum*. The industrial shellfish fisheries targets the adult pink shrimp *Penaeus notialis* and *Penaeus duroarum* taking considerable quantities of the guinea shrimp *Parapenaeopsis atlantica* in the process (Adetayo and Ajayi. 1982). Shrimp resources are abundant around river mouths and lagoon entrances. Important species occurring in Nigerian waters are the pink shrimp *Penaeus notialis*, dominant in 10 to 50 metres of water, the tiger shrimp *Penaeus kerathurus*, and the near shore shallow coastal shrimp *Parapenaeopsis atlanticat.*

Mineral Resources: Apart from petroleum, sand is one of the most important resources in the Nigerian coastal zone. Sand is mined along major estuaries, lagoons, near shore and along the beach. Much of the sand mined from lagoons, near shore areas are used for nourishment of eroding beaches like the Bar beach in Lagos, sand filling swamps for development like in the Lekki area of Lagos, and construction of buildings and roads. Over 13.22 m^2 of sand was dredged from the Lagos lagoon between 1984 and 1989 to sand fill 552 hectares of the Lekki phase 1 residential area (Awosika et al., 1994). Local people usually mine beach sand for construction. Such activities are very prevalent among the rural dwellers in the Niger delta. Other non-renewable resources include heavy minerals, salt, gravel, and clay.

Agricultural Products: Subsistence agriculture is widely practised in the coastal areas. Food crops include maize, vegetable, yam, and cassava. Development of agriculture within the mangroves and swamps however is handicapped by poor drainage and high salinity of the soils, which are both difficult and expensive to control. Furthermore, draining the wetlands tends to increase soil acidity with adverse effects on plant growth (NEST, 1991). This is because the mangrove soils, usually characterized by large quantities of iron sulphides, are stable for as long as they remain submerged. Acidity increases progressively with oxidation of sulphides promoting the release of aluminium salts and other chemicals which are toxic to plant and animals.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

The Nigerian coastal environment, which is richly blessed with a variety of both living and non-living resources, is responsible for almost 90% of its economic earnings. However, the coastal environment is presently subject to various issues, largely deriving from rapid expansion, particularly in industrial and agricultural areas. This is to meet the food, energy, goods and other needs of the large and growing population.

The Nigerian national report for the GEF MSP Project for Sub Sahara integrated problem analysis (Awosika et al., 2001) identified the hot spots and the following common problems at the national level:

- Modification of ecosystems from coastal erosion, flooding, deforestation
- Pollution from oil spills, solid wastes, sewage and industrial effluents
- Global climate change and sea level rise

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Nigeria National Data Center (NODC) is presently located at the Institute for Oceanography and Marine Research (NIOMR) headquarters, in Victoria Island, Lagos.

The NODC provides products and services to the management, research, and academic community. This includes products for issues such as Integrated Coastal Area Management (ICAM), as well the archiving and dissemination of research and scientific documents and data in electronic format.

Several types of data are available at the NODC. These include:

- Coastal erosion data (beach profiles, littoral observation data)
- Bathymetric, Physio-chemical parameters of coastal waters
- Fisheries, Salinity, CTD, MBT, XBT

Two sets of water temperature data have been compiled for Lagos. The first set of data using the bucket system span from 1978 to 1999. The frequency of data gathering is weekly, with occasional data gaps of less than 10 days. The second set of data is compiled from the Next Generation tide gauge. This data set is based on 6-seconds intervals from 1992 to 1996.

ICAM products can be developed by the centre. Previous data that were compiled as part of the development of ICAM products include:

(i) Sediment grain size: Sediment grain size has been analyzed from 1986 to 1987 along the Nigerian coastal area, especially in Badagry, Brass, Ibeno Eket and along the estuaries of Bonny and Forcados. Each station has between 12 and 48 sub-sampling stations.

(ii) Sediment organic content: Sediment organic content has been analyzed for Bonny, Escravos and Nana Creek estuaries in the Niger delta. Data on the sediment organic content is available for Nana Creek and Escravos, while for Bonny data is available for only 1986.

(iii) Collection and processing of historic data: A significant percentage of historical data on hydrodynamics, biological and socio-economics of fisheries data are available at the NODC.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following organizations and contact work in collaboration with the NODC:

- Federal Department of Fisheries - 1 Wilmot Point Road, Victoria Island, Lagos
- University of Lagos -Marine Science Department, Akoka-Yaba
- University of Obafemi Awolowo - Department of Geology/ Geophysics, Ile Ife
- Lagos State University- Department of Fisheries, Ojo, Lagos
- University of Calabar- Department of Oceanography and Fisheries, Calabar
- Ministry of Environment - Integrated Coastal Zone Management, Abuja

Contacts:
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7.15 Senegal

M. Anis Diallo[1], Arame Ndiaye Keita[2]*

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Capital city	Dakar
Population (2005 est.)	11,800,000 (2.3% growth)
GDP per capita (USD 2005 est.)	$1 792
Life expectancy at birth (2005 est.)	62.3 years (male - 60.4, female - 64.4)
Land and water area	196,190 km^2 (land - 192,000, water - 4 190)
Length of coastline	531 km
Highest point of elevation	Diakha 581 m
Coral reef area (2001 est.)	0ha recorded
Mangrove area (2005 est.)	115,000 ha
Marine protected areas (2007 est.)	1 455.42 km^2 (12.95% of total territorial waters)
Capture fisheries prod. (2006 est.)	377,685 metric tones
Aquaculture fisheries prod. (2006 est.)	200 metric tones

Coastal Climate: Most of Senegal has a typically tropical climate, but the northern regions lie in the sub-tropical semi-arid belt called the Sahel. November to May is generally dry, the rainy season starts in June and the maximum rain occurs in August. Temperature ranges from 16 - 25^0 C along the coast during the cold season and 20 - 32° C in the country side. During the rainy season (June-October) temperature ranges from 25 - 40° C.

Coastal Geomorphology: The coastal belt of Senegal is composed of a number of physiographical units from north to south: 1) mud, 2) sandy, 3) very fine sand, 4) medium to large grain sand, 5) rocks, 6) discontinued rocky and marshy zone. The continental shelf goes, to a depth of up to 200 m and is larger in the south than in the north. The Kayar Pit is a large depression in the north, dropping from a depth of 10 m. The rockiest zone is around Dakar and along the north coast until Mboro.

Coastal Currents and Tides: Senegal has a cold and hot season with two very different current characteristics. The hot season is from July to October. Following, the cold season is from December to May with two transitional periods separating them (June and November). During

the cold season the trade winds (wind from north-west to the north-east) are established and generate a cold deep-water up welling towards the surface at the coast which supports trophic enrichment. These two seasons are also marked by two large different marine currents: the current of the Canaries and Equatorial current.

In addition there are three large swells present:

- The swell of north-north-west which takes place all the year
- The swell of south-south-west appearing during the winter period
- The swell of west occurs around November

Senegal has semidiurnal tides, the highs range from 0.2 to 2.0 m.

Coastal Observations: There are two tide gauge stations on the Senegalese coast, located at Saint Louis and Dakar. During phase III of the ODINAFRICA project, a new tide gauge was installed in Dakar and has been operational since November 2007. There are seven coastal oceanographic stations: St Louis, Kayar, Yoff, Goree, Thiaroye, Mbour and Cap Skiring. In addition, there are also three meteorological stations.

Ports and Harbours: Dakar Port Authority manages the country's main port located in the capital. It is located at the western most sea front side of the African Continent and is the first port of call by northbound vessels, and the last deep sea port for southbound vessels. In addition, this port has a strategic point in the region as a gateway for some landlocked neighboring countries. There are also ports in Kaoloack, Saint Louis and Ziguinchor.

Coastal Economy: Coastal tourism is a major source of income and Saint Louis, Dakar, Gorée, Mbour, Saloum and Cap Skiring are the main tourist zones. In the Dakar region, there is a pink lake which is a tourist area, with salt extraction activities as an additional source of income for the local population.

Fisheries: Fish are the major source of protein for the local population in Senegal. The fish resources along the Senegalese coast are of two types, artisanal and industrial fisheries. The artisanal fishery is concentrated between the beach and the shore, while the industrial fishery is composed of demersal fish and shrimp. Marine fisheries are a major source of income contributing approximately $US 350 million per year. Annual landing is around 300,000 tones/year, with 600,000 direct and indirect jobs. Total inland landing is less than 10,000 tones/year. Major stocks are fully or overexploited and landing had decreased since 1995.

Figure 1. NODC team visiting the new gauge in Dakar (PAD, Phares & Balises) - Photographer Anis Diallo, January 2008 -www.nodc-senegal.org/actualanis.htm.

Mineral Resources: The main mineral resources available are phosphate, ore, iron and marble. Offshore petroleum is available on the border with Guinea Bissau.

Agricultural Products: Most of the land in the coastal area is of low agricultural potential. The north border from Dakar to St Louis (Niayes) supports the growing of vegetables and some fruits.

Other Marine Resources: The mangrove forest is a source of domestic fuel wood and timber for roofing houses. Its roots are also collected and used in building structures for smoking oysters. Its degradation in the last two decades has now led to new regulations requiring replanting projects for its restoration.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS

Experts taking part in a national assessment of environmental and social issues and impacts identified a number of hot spots (currently suffering measurable degradation), sensitive areas (likely to be subjected to some degradation in the future); and major issues of concern. These are reproduced in Table 1 (ACOPS, 2002c).

Figure 2. The Senegalese research vessel RV Itaf Deme.

Table 1. Results of the Integrated Problem Analysis undertaken for Senegal (ACOPS, 2002c).

Major issue of concern overall for the country
• Modification of stream flows – Changes in the hydrodynamic regimes has resulted in observed "inverse" estuaries like those of Saloum and Casamance. • Modification / destruction of ecosystems • Chemical pollution
Hot spots
• The Djoudj bird national park which is located in the north-western part of the Senegal delta • Hann Bay located south-east of the capital Dakar • Djiffere located on the Sangomar spit that limits the Saloum river
Sensitive areas
• The Sénégal delta – located in the north on the border with Mauritania • The Saloum estuary – located centrally • The Casamance estuary – located in the south

Two decades of drought in the 1980's caused the increase of salinity in Saloum and Casamance estuaries (up to 160 parts per tonne) during the dry season. This is exacerbated by the changes in hydrodynamics of the system with reduced flows being a major issue of concern (Table 1). Furthermore, this has had additional effects, causing a loss of biodiversity, affecting the growth of fish, and the degradation of mangrove forests. Due to the construction of dams (Diama in Senegal and Manatali in Mali - for agricultural and electricity purposes), the Senegal River has lost biodiversity, with a resultant decrease in fish landing.

The Senegal coast is off the main marine highway used by oil tankers, which also offload oil at the port of Dakar for Senegal and the land locked country of Mali. This presents a potential threat to the environment.

Figure 3. Fishing along the beach at Thiaroye near Dakar (photo credit: Anis Diallo, 2004).

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Senegalese National Oceanographic Data and Information Centre (NODC) was established on 13th October, 2001 during the second phase of the ODINAFRICA project. The data centre is hosted by the Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT) and the information centre by the Direction des Pêches Maritimes (DPM).

The information centre is leading marine information activities for Senegal at the national and international level. It also is acting as national partner for many resources sharing programmes including ASFA of FAO, OCEANDOCS, and IAMSLIC.

Products and services available are as follows:

- Develop information tools and services for research and decision making including mapping products such as the marine atlas
- Analyse, edit, and distribute data on CD-ROMs and the internet
- Provide data and information products such as statistics, atlas of ocean variables
- Assist in global and regional data and information management
- Create and maintain inventory and meta data bases including a directory of national ocean experts
- Develop standards on documentation and data processing
- Participate in the development of data and information management plans for sustainable fishing, oceanographic and coastal and marine ecosystems
- Promote the development of data and information exchange at national, regional and international level through the IODE/IOC/UNESCO system.

Figure 4. Direction des Pêches Maritimes.

The beneficiaries of these products and services are: scientists, students, NGO's, government, private sector. Further information can be found on the website:

Centre - www.nodc-senegal.org/cndoanis.htm
Products - www.nodc-senegal.org/produitanis.htm
Services - www.nodc-senegal.org/servicanis.htm

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following are organizations that work in collaboration with the Senegalese NODC (www.nodc-sengal.org/reseauanis.htm):

- Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT), Parc de Recherches ISRA/HANN, BP. 2241 Dakar
- Centre de Suivi Ecologique (CSE): rue Léon G. Damas. BP. 15532, Dakar, Fann
- Délégation aux Affaires Scientifiques et Techniques (DAST): Bulding Administratif, 5ème étage, pièce 525
- Département de Géographie (Chaire Unesco/UCAD): BP. 5005, Dakar-Fann
- Département des Sciences/UCAD: Campus Universitaire, UCAD, Dakar
- Direction de l'Environnement et des Etablissements Classés (DEEC/Ministère de l'Environnement et de la Protection de la Nature): 106, rue Carnot, Dakar
- Direction de la Météorologie Nationale (DMN): BP. 8257, Dakar-Yoff
- Direction de la Pêche Continentale et de l'Aquaculture (DPCA/ Ministère de la Pêche): Route du Front de Terre, Dakar. BP. 11979 Dakar
- Direction de la Protection et de la Surveillance des Pêches (DPSP/Ministère de la Pêche): Fenêtre Mermoz, Dakar
- Direction des Parcs Nationaux (DPN): Zone Parc Zoologique de Hann
- Direction des Pêches Maritimes (DPM): 1, rue Joris BP. 289 Dakar
- Fonds Mondial pour la Nature (WWF): Sacré Cœur III, villa 9446, Dakar
- Institut de Recherche pour le Développement (IRD): Hann, BP. 1386, Dakar
- Institut Fondamental d'Afrique Noire (IFAN/UCAD): BP. 206, Dakar
- Laboratoire d'Etude et de Recherches en Géomatique (LERG): Campus Universitaire de l'ESP. BP. 25275, Dakar-Fann
- Laboratoire de Physique Atmosphérique (LPASF): Campus Universitaire de l'ESP
- OCEANIUM: Route de la Corniche EST, BP. 2224, Dakar
- Parc National des Iles de la Madeleine (PNIM/ Direction des Parcs Nationaux): Corniche Ouest, Dakar
- Port Autonome de Dakar (PAD), Phares & Balises
- Société Nationale d'Aménagement et d'Exploitation des Terres du Delta du Fleuve Sénégal et des vallées du Fleuve Sénégal et de la

Falémé (SAED/Ministère de l'Agriculture): Route de Khor, BP. 74 St Louis

- SOS-Environnement: BP. 1008, Dakar. (ONG)
- Sous Commission Région des Pêches (CSRP): km 10 5 Bd du Centenaire de la Commune de Dakar
- Union Mondiale pour la Nature (UICN): Avenue Bourguiba, Dakar
- Université Cheikh Anta DIOP (UCAD): Avenue Cheikh Anta Diop, Dakar
- West African Association for Marine Environment (WAAME): 21, cité Belvédéré, Dalifort. BP. 26352, Dakar. (ONG)
- Organisation pour la Mise en Valeur du Fleuve Sénégal (OMVS), 3 Place de l'Indépendance, 3ème Etage. BP. 3132 Dakar
- Haute Autorité chargée de la coordination de la Sécurité Maritime, de la Sûreté Maritime et de la Protection de l'Environnement Marin (HASSMAR)

Figure 5. A laboratory at CRODT, Dakar, Senegal.

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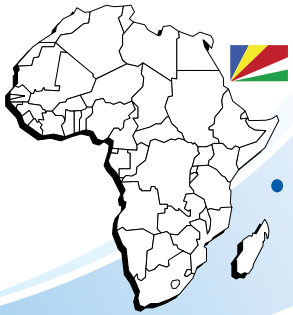
7.16 Seychelles



Mr. Calvin Gerry

Seychelles Fishing Authority
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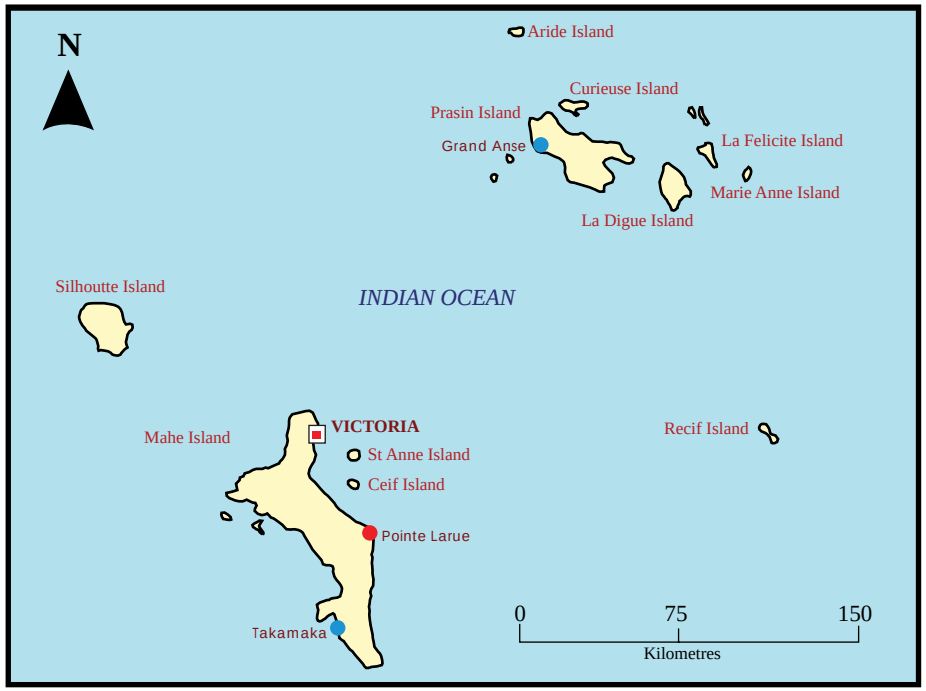
Fishing Port, Victoria, Mahe Seychelles
E-mail: cgerry@sfa.sc

Capital city	Victoria
Population (2005 est.)	86,956 (2.2% growth) with approximately 90% on the main island of Mahe (NSB, 2008).
GDP per capita (USD 2005 est.)	$16 106
Life expectancy at birth (2005 est.)	72.7 years
Land and water area	455 km^2
Length of coastline	491 km
Coral reef area (2001 est.)	1 690 km^2
Mangrove area (2005 est.)	2 500 ha
Marine protected areas (2007 est.)	194.56 km^2 (0.40% of total territorial waters)
Capture fisheries prod. (2006 est.)	92,623 metric tones
Aquaculture fisheries prod. (2006 est.)	704 metric tones



Geographic Location: Seychelles is located in the Western Indian Ocean between 4^0 South and 11^0 South and between 45^0 East and 56^0 East. Seychelles is an archipelago of more than 115 islands with two distinct collections of islands, some comprised of granite and others of coral. The main islands are Mahe, Praslin and La Digue, with a total area of 455 km^2 and coastline of approximately 746 km.

Rivers to the country's Coast: Mahe has approximately twenty five major rivers, Praslin has eight major rivers and La Digue has only one major river. The rivers' main sources are from the mountains and discharge into the sea.

Coastal Climate: The climate in Seychelles can be divided into two main seasons, the Northwest Monsoon (December - March) and the Southeast Monsoon (May - October), separated by two relatively short inter monsoon periods in November and April respectively.

The following are the average annual meteorological features characterizing the Seychelles climate:

- Rainfall: 2 942 mm
- Sunshine: 6.9hrs per day
- Mean max temp: 30.1^{0}C
- Mean min temp: 25.0^{0}C
- Humidity: 78%

Coastal Geomorphology: The natural coastline of Seychelles can be classified as either steep granitic shoreline or the flatter coastal plains. The steep granitic shoreline is highly resilient to waves and comprised of large boulders, thus waves break directly onto granitic rocks. The flatter coastal plains are fronted by fringing reefs and comprise of sandy shores and they are most vulnerable to wind and wave action.

Coastal Currents and Tides: The tides of the Seychelles can be characterized by the following (De Comarmond, 2008):

- Astronomical tide: 2.10 m
- Mean high water spring: 1.63 m
- Mean high water: 1.45 m
- Mean high water neap: 1.27 m
- Mean Level: 1.10 m
- Mean level water neap: 0.81 m
- Mean level water: 0.63 m
- Mean level water spring 0.45 m
- Lowest astronomical tide: 0.20 m

Coastal Observations: A tide gauge is operational at Pointe de Larue.

Coastal Economy: The main economic activities along the coast are related to tourism and fisheries. This also includes related goods and services such as tourism infrastructure support (hotels, restaurants), marine parks, and fishing activities.

Fisheries: Fishing is one of our main industries, and it is practiced all over the main islands. Seychelles' fisheries industry is divided into three groups:

- Artisanal fisheries which is done by the local fishermen and most of their catch is for the local market
- Semi industrial fisheries which comprises both local and foreign owned vessels and the catch are distributed among the local and international markets
- Industrial fisheries comprising of mostly foreign owned purse seiners who mostly target tuna, to be processed by the tuna canning factory located at the port and the majority of the products are for the international market

Mineral Resources: No significant quantities of minerals are being extracted in the Seychelles.

Agricultural products: Agriculture is scattered all over the main islands and is done on a small scale to support local demand.

Addressing Key Coastal Issues: Most of the coastal issues fall under the responsibility of the Ministry of Environment. It is important to note that there are other local authorities working in close collaboration with the Ministry of Environment on issues relating to coastal and marine resources. These include: Seychelles Centre for Marine Research and Technology, Marine Parks Authority, Seychelles Fishing Authority, Port Authority and numerous Environmental Non-Governmental Organization (ENGO's).

Experts taking part in a national assessment of environmental and social issues and impacts identified a number of hot spots (currently suffering measurable degradation), sensitive areas (likely to be subjected to some degradation in the future); and major issues of concern. These are reproduced in Table 1 (ACOPS, 2002d).

Table 1. Results of the Integrated Problem Analysis undertaken for the Seychelles (ACOPS 2002d). All are number in order of precedence where prioritized.

Major issue of concern overall for the country
1. Pollution (eutrophication) 2. Habitat and Community Modification (modification of ecosystems and ecotones) 3. Global Change (sea level rise)
Hot spots:
La Digue – West Coast Plateau: impacts include removal of forest cover, loss and modification of remaining wetlands, changes in hydrology (flooding, shortage of groundwater, etc.), increased pollution, and coral bleaching *East Coast Mahe (from North Point to Anse Forban):* impacts include silt from reclamation, and those caused by increased tourists to the park Anse Volbert, Praslin: issues include coastal erosion, discharge of wastewater and coral bleaching from elevated sea surface temperature events
Sensitive areas
1. ***Port Launay and Baie Ternay Marine Parks/Port Glaud Mangroves and islands of Conception and Thérèse:*** threats include changes in water flow; pollution (microbiological, eutrophication, chemical, solid wastes); modification of eco-systems (mangroves, coral reefs, seagrass beds); over-exploitation of coral reef resources and coral bleaching
2. ***Cosmoledo Atoll:*** threats include illegal fishing, poaching, invasive species, diseases and coral bleaching
3. ***Mahe Wetlands:*** threats include modification, agricultural septic tanks and other runoff, excess siltation from clearing of uplands, extraction, and potential salination of freshwater marshes from sea level rise

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The National Oceanographic Data Centre is a joint implementation of the Seychelles Fishing Authority and the Intergovernmental Oceanographic Commission of UNESCO under the ODINAFRICA Project. The NODC was established in 1997 and is a member of the International Oceanographic Data Exchange (IODE) Programme.

Objectives:

- To archive and make available to users data or data products (biological, chemical, physical and hydrological)

Figure 1: Map of Mahe the main island of Seychelles.

- To maintain databases/meta-databases
- To maintain contact and exchange data with National Oceanographic Data Centres around the world
- To assist users in ocean data access, management, quality control, and data visualization and interpretation

Products and services available are as follows:

- Metadata base consists of: physical and chemical oceanographic variables; atmospheric variables, and marine species.
- Databases include information on: fisheries, fishermen, marine species; marine organizations and experts; oceanographic and atmospheric variables, and INMAGIC bibliography services.
- Products: atlases, charts, maps, and publications.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

Programmes and projects

- A national Ocean Temperature Network and database whose main aim is to strengthen knowledge of climate variability and climate change dynamics in marine ecosystems. The output will facilitate the development of adaptation and coping mechanisms for use by marine resource managers. We intend to launch a website to provide information and metadata for the project
- The objective of the African Monitoring of the Environment for Sustainable Development (AMESD) programme is to help African countries to improve the management of their natural resources by providing them with suitable information on their environment, using state-of-the art technology. Member countries of the Indian Ocean Commission work and collaborate on a project and thematic area: 'Management of Marine and Coastal Zone'. This project will provide low resolution Sea Surface Temperature, Ocean Color and Altimetry data for the management of marine resources
- The regional Tuna Tagging Program in the Indian Ocean has been completed but they are still in the process of recovering tags. The data from the tags recovered until now provides promising information for management. No definite conclusion can be deduced until the majority of the tags have been recovered. For more information visit the website: http://www.rttp-io.org.

Marine Related Organizations:

- Seychelles Fishing Authority, P.O. Box 449 Victoria, Mahe, Seychelles, http://www.sfa.sc
- Seychelles Centre for Marine Research and Technology- Marine Park Authority, P.O. Box 1240 Victoria, Mahe, Seychelles, http://www.scmrt-mpa.sc
- Ministry of Environment, P.O. Box 166 Victoria, Mahe Seychelles, http://www.env.gov.sc
- Island Conservation Seychelles, P.O. Box 775 Victoria, Mahe Seychelles, http://www.islandconservationsociety.com
- Seychelles Meteorological Service, P.O. Box 1145, Victoria, Mahe, Seychelles, http://www.pps.gov.sc/meteo
- Seychelles Island Foundation, P.O. Box 853, Victoria, Mahe, Seychelles, http://www.sif.sc
- Seychelles Coast Guard, P.O. Box 257, Victoria, Mahe, Seychelles
- Nature Seychelles, P.O. Box 1310, Victoria, Mahe, Seychelles, http://www.natureseychelles.org
- Marine Conservation Society Seychelles, http://www.mcss.sc

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7.17 Tanzania

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Capital city	Dodoma
Population (2005 est.)	38,500,000 (2.4% growth)
GDP per capita (USD 2005 est.)	$744
Life expectancy at birth (2005 est.)	51.0 years (Male - 50.0, Female - 52.0)
Land and water area	945,087 km² (land - 886 037, water - 59 050)
Length of coastline	1 424 km
Highest point of elevation	Mt Kilimanjaro, 5 896 m
Coral reef area (2001 est.)	3 580 km²
Mangrove area (2005 est.)	125,000 ha
Marine protected areas (2007 est.)	1514 km² (39% of total territorial waters) (Nyika E. Pers Com.)
Capture fisheries prod. (2006 est.)	110,000 metric tones (Division of Fisheries, 2007)
Aquaculture fisheries prod. (2006 est.)	13 metric tones (Division of Fisheries, 2007)

Geographic Location: The United Republic of Tanzania is located in eastern Africa between longitude 29° and 41° East, Latitude 1° and 12° South. The country is bordered by Kenya to the north east, Uganda to the north west, Rwanda, Burundi and Democratic Republic of Congo to the west, Zambia south west, Malawi south and Mozambique to the south east, and the Indian Ocean to the east. The Island of Zanzibar is 2 000 km².

Rivers to the Country's Coast: The coast is strongly influenced by rivers that bring to it water, sediments, nutrients and pollutants. The Pangani, Wami, Ruvu, Rufiji, Matandu, Mbemkuru, Lukuledi and Ruvuma, flow to the Indian Ocean. These rivers influence the coastal environment through creation of productive brackish water environments in estuaries, maintenance of deltas, tidal flats and shorelines, as well as nourishment of mangroves and seagrass beds.

Coastal Climate: The climate of Tanzania can be broadly classified into four types: the hot, humid coastal plains; the hot, arid zone of the central plateau; the high, moist lake regions; and the temperate highland area. The climate is controlled by two major factors:

- Its geographical location within 1°S - 12°S latitude, which creates a truly equatorial setting, with high temperatures, high humidity (60 to 80%), low wind speeds and absence of cold season
- Its position on the eastern edge of Africa exposes Tanzania to large seasonal changes brought about by the general circulation of air over the Indian Ocean

The monsoons are the dominant influence on climate, particularly, wind direction and strength, temperature and rainfall. There are two monsoon seasons, namely the northeast monsoon (Kaskazi) which prevails from November to February and is characterized by higher air temperatures (30°C) and weaker winds, and the southeast monsoon (Kusi) which lasts from April to September and is marked by lower air temperature (approximately 23°C) as well as stronger winds. Occasionally, the southeast monsoons are associated with storms and cyclones. The months of March/April and October/November are the inter-monsoon periods and usually are the calmest. June and July are the windiest months while March, April and November experience the lowest and most variable wind speeds. January to February is generally dry, from March to May the coastal area experiences long rains, and short rains between November and December. The long rains are heavier than the short rains, while the heaviest rains are received in either April or May.

Coastal Geomorphology: Most of the country lies on the Great African Plateau with an altitude ranging between 1 000 and 2 000 m above sea level, the exception being the narrow coast belt. The coastal plains are composed of both marine and terrestrial sediments. Much of the coast is of Pleistocene and recent coral limestone. A belt inland from the coast, an area of continental and coastal deposition of cretaceous and tertiary period, includes limestone, sands and gravel. The marine rocks consist chiefly of marls, limestone and shells. The rocks of Zanzibar, Pemba and Mafia are composed of calcareous sediments with some marine clays, sandstone and coralline limestone. They range in age from the Miocene to more recent formation. The continental shelf is narrow, with 200 m depth contour approximately 4 km offshore, except at the Mafia and Zanzibar Channels where the shelf width extends to 60 km. The 200 m depth is about 2 km from the coast at the narrowest point (latitude 9°30'S) and 80 km at the widest point (latitude 6°25'S). The continental shelf is widest in the Zanzibar and Mafia Channels and off the Rufiji Delta.

Coastal Habitats: The coastline of Tanzania is characterized by a mixture of beautiful sandy beaches, rocky outcrops, extensive coral reefs, and dense mangrove stands, especially around river deltas. The intertidal zone is mainly of sandy-muddy flats or rocky reef platforms, while the sublittoral zone consists of extensive seagrass beds and reefs. Among the more famous of these natural resources are the beaches of Bagamoyo, the Jozani forest reserve, the coral reefs of Mafia, Unguja and Pemba, and the Amboni caves. These coastal ecosystems support a wide variety of marine life.

Coastal Currents and tides: The dominant major currents prevailing in the coastal waters of Tanzania are the south equatorial current, which flows westwards permanently at around 12°S and the northward-flowing East African Coastal current (EACC). The EACC is strongest in the southern monsoon (April-October) with an average speed of about 2 m/s and occasionally reaching 3.5 m/s and weaker during the northern monsoon (November-March), with an average speed of less than 0.5

Figure 1. Drs. Narriman Jiddawi and Aviti Mmochi with a group of pearl farmers at Bweleo, Zanzibar (photo credit: Dr. Flower Msuya, 2007).

Figure 2. Seaweed ready for harvest at a seaweed farm in Mukuchuni, Tanga (photo credit: Dr. A.J. Mmochi, 2007).

m/s. The tides along the Tanzanian coast are of semi-diurnal type, characterized by two occurrences of both high and low waters within a day. These are the mean spring tide of about 3.5 m and mean neap tide of about 2.5 m. The age of the tide (time lag between the new or full moon and the peak of spring tide) in most of the areas ranges from one to two days.

Coastal Observations: Tide gauges are installed and operational at Zanzibar and Dar es Salaam and another one will be installed at Mtwara.

Coastal Economy: The Tanzanian economy is heavily dependent on agriculture (primarily coffee, cotton, tea, cashew nuts, sisal and tobacco) which accounts for 50% of the gross domestic product (GDP). Tourism is one of Tanzania's dynamic sectors and has shown significant growth in recent years. The five coastal regions which comprise 15% of land area of Tanzania, contributes about one third of the national GDP, with Dar es Salaam leading overall with 20% of the national GDP. Economic activities in the coastal areas include subsistence farming, fishing, trade and tourism. In addition, the coastal area's historical attractions, including old buildings, ruins, and the monuments, particularly those in Zanzibar, Kilwa and Bagamoyo, are among the finest in the region.

Ports and Harbours: The major ports on the Tanzanian coast are Dar es Salaam, Zanzibar, Tanga and Mtwara. There are also small ports on the coast, namely Pemba, Lindi, Kilwa and Mafia. With the exception of Zanzibar port which handles only Tanzania cargo, the other major ports handle Tanzanian goods as well as transit goods for neighboring landlocked countries.

Fisheries: Marine fisheries are an important source of protein for the coastal populations. The main fishery along the Tanzanian coast is artisanal. Most of the fishing is done in the creeks, on the reefs and in the shallow inshore waters. The present annual fish catch is about 350,000 metric tones. The number of fishermen who are permanently employed is about 80,000.

Mineral Resources: There are several minerals being extracted along the Tanzanian coast. These include: salt, gypsum, iron ore, lead, barite, limestone, coral stone for building, clay and apatile. The discovery of petroleum and gas deposits in Mtwara, Pemba and Songosongo will boost the coastal economy.

Agricultural Products: Most of the land in the coastal areas is of low agricultural potential. The following agricultural products are important in the coastal region: horticultural products include vegetables and tropical fruits, sisal, coconuts, cashew nuts and bixa.

Other Marine Resources: The mangrove forests along the coast provide local communities with fuel wood, timber for house construction, fences and furniture. In recent years the mangrove forests have been cleared to make way for agriculture, fish ponds, prawn farms, salt pans, residential houses, industries and dumpsites.

ADDRESSING KEY COASTAL ISSUES

In Dar es Salaam, Tanga and Zanzibar town, and to a lesser extent, Bagamoyo, Lindi and Mtwara, there are many types of pollution, i.e., industrial, institutional, and domestic discharge; agro-chemical pollutants; and sedimentation brought about by deforestation, poor agricultural practices, and construction activities. These types of pollution affect nearby reefs. So far, there is no evidence that pollution of various types has caused loss of coral reef ecosystems in Tanzania. However, it appears that some modification of coral reefs that are near sources of pollution has occurred (Muhando 2001). Another type of pollution in Tanzania is microbial pollution. Sewage accumulation in settlements poses a serious health risk to the population leading to the spread of diseases, mortality, morbidity, increased public and private medical costs and loss of labour force productivity (Francis, 2001). The degradation of river water quality often degrades valuable water resources of downstream communities. Communities draw their water for domestic and agricultural use and the degradation undermines income opportunities and food supply. The extent and costs of the impacts is often under-estimated or has not been determined.

Natural impacts that have led to ecosystem modification or loss in Tanzania include storms and coral bleaching. Damage due to strong wave action is common on exposed fringing reefs and on the seaward side of patch reefs and islands all along the coast of Tanzania, though there is no evidence that the extent of storm impact has been any different recently than it was many decades ago. The coral bleaching event (March to May 1998) coincided with higher than normal seawater temperatures and increased rainfall (lower salinity) (Muhando, 1999). Coral bleaching was reported on all parts of the Tanzanian coast with variable severity. Bleaching was worse in shallow waters (reef flats) than in deeper waters. In Zanzibar, overall more than 60% of the scleractinian corals showed signs of bleaching, with Acropora being most affected; while a few corals such as Diploastrea and Pachyseris were seemingly unaffected (Muhando, 1999). Some species of Porites were affected, while others were not (Wilkinson, 1998). After the bleaching event, the dead corals were colonised by filamentous algae. By November 1998, these were replaced by macroalgae and coralline algae. By January 1999, some areas showed the recruitment of small corals, while others were colonised by corallimorpharians and soft corals. On the economic

Figure 3. Ms. Kulekana (TAFIRI) and fish farmers inspecting fish ponds under construction at Mkuranga (photo credit: Dr. Mmochi, 2008).

side, some dive operators reported a decline in tourist potential due to the bleaching event (Muhando, 1999).

Coastal communities in Tanzania have traditionally exploited rich products of the mangrove ecosystems as well as various parts of the mangrove trees themselves. In recent years, the rate and variety of human influences on the mangroves have increased to the extent that they are threatened with destruction in some areas (Semesi, 1997). One of the most pressing issues in the mangroves forests is the loss of areas due to conversion for commercial purposes (Semesi, 1997). It may be concluded that although there is no quantification of losses arising from mangrove habitat loss or modification, there is clear evidence that coastal communities are losing in terms of income and wood for other household purposes (Muhanda, Mgaya, Daffa 2001).

Experts taking part in a national assessment of environmental and social issues and impacts identified a number of hot spots (currently

Figure 4. Fish farms at Mkuranga – These are some of the many fish ponds developed through the SUCCESS project between IMS, CRC and WIOMSA, and funded by USAID (photo credit: Dr. A.M. Mmochi, 2008).

suffering measurable degradation), sensitive areas (likely to be subjected to some degradation in the future); and major issues of concern. These are reproduced in Table 1 (ACOPS, 2002e). Pollution was identified as the major threat to hotspots, while the sensitive areas are threatened by over-exploitation; destructive fishing practices, and modification/ loss of ecosystems (Table 1).

Table 1. Results of the Integrated Problem Analysis undertaken for Tanzania (ACOPS, 2003e).

Major issue of concern overall for the country
Modification/ loss of ecosystems. Current status: increased awareness to coastal communities, government enforcement concerning misuse of coastal ecosystems; participatory projects between the government and coastal communities on coastal ecosystem management
Destructive fishing practices. Current status: eliminated due to regular enforcement patrols and effective prosecution of offenders increased awareness to fishermen.
Over-exploitation. Current status: increased awareness and enforcement to coastal communities
Microbiological pollution. Current status national strategies management of, sold waste, ground water and sewerage outlets
Hot spots
Dar es Salaam city Zanzibar municipality Tanga municipality
Sensitive areas
Rufiji-Mafia-Kilwa complex Tanga coastal area Bagamoyo

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Tanzania National Oceanographic Data and Information Center (TzNODC) is hosted at Institute of Marine Science of the University of Dar es Salaam (IMS), with the support of UNESCO/IOC through the Ocean Data and Information Network for Africa (ODINAFRICA). TzNODC has been in existence for 10 years.

The main objectives of the Centre are to:

- Provide marine scientists in the region with the necessary scientific information
- Enhance the use of indigenous scientific information in the region
- Promote and facilitate communication between the scientists, both intra - and inter - regionally
- Disseminate information on marine scientific research activities in the country.

The centre has provided training in data and information management to staff from collaborating institutions in the country. IMS is an input centre for the Aquatic Sciences and Fisheries Abstracts (ASFA) database.

TzNODC has accumulated a wealth of data and information, the majority of which is held in CD-ROMs which are utilized to develop a wide range of products and services in support of various communities involved in coastal management. TzNODC's collection covers oceanographic, and related terrestrial data. In the case of oceanographic data, an area of interest, bounded by the following latitudes and longitudes has been defined: 0.5°S, 6°S and 39°E, 50°E from the World Ocean Database 2005 produced by the US-NODC. Quality controlled ocean profile data for this area has been extracted from the World Ocean Database 2005 produced by the US-NODC. These depth profile data span several years and include measurements of temperature, salinity, oxygen, phosphate, nitrate, silicate, chlorophyll, alkalinity and Ph.

The centre has actively sought to present various sets of data in GIS, visualizing information on the Indian Ocean basin such as variations in chlorophyll and sea surface temperatures. The centre is set to avail more information on coastal terrestrial environment following the implementation of the Nairobi Convention Clearinghouse and Information Exchange System. This is implemented through national institutional networks with each institution acting as a node for particular categories of data.

The following are some of the products and services available at TzNODC:

- Catalogues of marine related datasets, which provide information on types, quantity, geographic coverage, sensors used, institutions/individuals holding the data and conditions for access
- Library catalogue
- Union library catalogue (holdings) of all institutions dealing with marine and aquatic sciences in Tanzania
- Directory of marine and freshwater scientists within the country
- Computer software tools available for quality control, analysis and sub-setting of data
- Provision of datasets resulting from ocean observing programmes and respective meta data
- Tide predictions from tide gauges in Zanzibar and Dar es Salaam
- Delivery of data and information in the form of maps and graphs and other services for scientists and coastal management practitioners
- Provision of bibliographic search and delivery services to the scientific community
- Provision of various information products to the local community

Figure 5. IMS Librarian introduces users to databases developed with support from ODINAFRICA.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The following are organizations that work in collaboration with the TzNODC:

- Institute of Marine Sciences (http://www.ims.udsm.ac.tz)
- National Museum of Tanzania (http://www.museums.or.tz)
- The Tanzanian Navy
- Tanzania Fisheries Research Institute (http://www.tafiri.org)
- Division of Fisheries
- Western Indian Ocean Marine Science Association (WIOMSA) (http://www.wiomsa.org)
- National Environment Management council (http://www.nemc.gov.tz)
- Sokoine University (http://www.sua.ac.tz)
- University of Dar es Salaam (http://www.udsm.ac.tz)
- Tanzania Ports Authority (http://www.tpa.co.tz)
- Tanzania Meteorological Agency (http://www.tma.org.tz)
- Marine Parks and Reserves
- Mbegani Fisheries Development Center
- Zanzibar Department of Fisheries and Coastal Products
- Department of Fisheries and Coastal Resources Zanzibar
- Zanzibar Port Authority
- The Commission for Lands and Environment - Zanzibar
- Commission for Science and Technology (COSTECH - http://www.costech.org)
- Ministry of Livestock and Fisheries
- Ministry of Natural resources and Tourism
- Prime Ministers Office
- The Vice Presidents Office

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Figure 6. Participants at a Leadership workshop for Head's of marine institutions in Eastern Africa hosted by IMS in Zanzibar 2006.

7.18 Togo

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Capital city	Lomé
Population (2005 est.)	6,200,000 (2.5% growth)
GDP per capita (USD 2005 est.)	$1 506
Life expectancy at birth (2005 est.)	57.8 years (male - 56.0, female - 59.6)
Land and water area	72,700 km² (land 56,600, water 16,100)
Length of coastline	50 km (Blivi, pers. comm. 2008)
Highest point of elevation	Pic d'Agou, 986 m
Coral reef area (2001 est.)	None
Mangrove area (2005 est.)	1 000 ha (Blivi, pers. comm. 2008)
Marine protected areas (2007 est.)	4.50 km² (0.18% of total territorial waters)
Capture fisheries prod. (2006 est.)	15,000 – 20,000 tones (Blivi, pers. comm. 2008)
Aquaculture fisheries prod. (2006 est.)	Less than 50 tones (Blivi, pers. comm. 2008)

Rivers to the Country's Coast: The Mono River (560 km) flows from the Tchaoudjo, through a system of lagoons to the ocean at Grand Popo in Benin. The Zio (about 176 km long) and the Haho flow into the coastal lagoons, which in turn flow into the ocean between d'Apounoukpa and Aneho.

Coastal Climate: The coastal region of Togo has a tropical climate with two rainy seasons, the first between April and June, and the second between September and October. The average annual rainfall is 850 mm per year, and temperatures vary from a minimum of about 25°C in July – August, to a maximum of 30°C and occur in the dry season of February – March. Harmattan, a warm and dry wind blows from the northeast in December and January, while the monsoon is warm and humid and blows from the southwest bringing rains.

Coastal Geomorphology: Togo's coastal plain is comprised of an internal and external beach ridge, both of an average altitude of 5 m, a lagoon system and an area of clay substrate. The clay area has an average altitude of 20 m and includes the north-eastern part by the Lama Depression. It consists of a series of clay-sandy deposits with

limestone and phosphate resources. To address shoreline change occurring on the coast between Kpémé and Aného, a number of groynes and breakwaters were constructed in 1988. Togo has a relatively narrow continental shelf of approximately 23 km.

Coastal Habitats: Togo is located in the Gulf of Benin, within the larger Gulf of Guinea in the Atlantic coast of West Africa. Its marine and coastal systems are part of the geosystem between the deltas of the Volta and Niger rivers, which is mainly composed of sandy strips and lagoons. Mangroves are found at the estuaries of the Gbaga and Mono river, covering about 1000 ha. The sea-bed is relatively flat, and marked by linear valleys formed through lagoons erosion. In addition to coarse sands, there are areas of mud, gravel, and corals. These habitats are broken by a series of beach-rock on the foreshore.

Coastal Currents and Tides: The Togolese coastal waters experience semi-diurnal tides. The Guinea current flows along the coast from west to east with an average velocity of 1m/s. The derived littoral drift transports an average of 1.2 million m^3/year of water. There are regular swells spurred by the winds from the south Atlantic, with average heights of 1.0 - 1.5 m in July, August, and September. The maximum heights vary from 2 - 3 m, with periods of between 10 - 15 seconds. The angle of incidence is about 6° and 7° from a south-south-west direction. The period of strong swell is from August to September, with low swells ranging from 0.4 - 0.5 m height during the periods October to November, and May to June. Coastal waves cause sediment movements along the beach with moderate to high energy. The average height reaches 1.25 m, with average periods of 4 - 6 seconds. Overall, the hydrodynamics of the Togo coast are fairly homogenous and marked by coastal drift (ONUDI/MEPF, 1999).

Coastal Observations: There is an oceanographic station at Kpeme. The data collected includes air and sea surface temperatures, wind and rain. The meteorological station in Lome town facilitates the monitoring of rainfall and atmospheric conditions. The Togoville College station Ventage Pro is located on an area of clay substrate and collects 21 different observation parameters.

Ports and Harbours: The Port Autonome de Lome, is a free port constructed in 1968. It receives large vessels due to the depths of its berths (up to 14 metres deep). It has a pier for normal cargo, and another specializing in containers and mineral ores. The harbour at Kpeme is for loading minerals and phosphates.

Coastal Economy: The coastal economy is based on agriculture, livestock farming, fisheries and industry. In the coastal zone, agriculture accounts for 18% of the work force, most of them on small scale farms. The contribution of coastal agriculture to the national GDP is 5%. Though the area under cultivation increased slightly between 1982 and 1996, the production did not follow the same trends due to the very basic means of production used. Farming is practised on the ridges and constitutes an out of season activity in the floodplains. The number of local farmers increased by 297% between 1982 and 1996. The coastal region is home to more than 76% of the national farming community (ONUDI/MEPF 1999; CNDO-TOGO, 2003.)

Traditional small scale livestock farming is based on small ruminants and poultry. Sheep are rare in the coastal area. Artisanal and industrial fishing are practised at the coast, with some lagoon fishing as well.

There are two seasons for artisanal fisheries: a high season from July to October, and a low season from November to June. Marine fish accounts for 4% of the GDP of primary sectors. The artisanal fishery represents more than 70% of the annual national fish production. Industries begun in the 1960's, and has been strengthened with the establishment of free zones in 1989. Until 1997 there were 106 industrial and mining enterprises in Togo, 95% located in Lome. The mining, manufacturing and food production sectors are the most important (ONUDI/MEPF, 1999).

Fisheries: There are some twenty fishing camps or sites along the coast. The average production in 2001 was between 15,000 – 20,000 tones. In 2002 the total amount of fish landed at the Lome fishing port was 13,840 tones, representing 87% of the volume of artisanal fish catches at sea. The main species caught were grey whales, sardines, mackerel, and herring (ONUDI/MEPF, 1999).

Mineral Resources: The principal minerals are phosphates, gravel and sand. The phosphates are mined in the quarries of Hahotoe and Kpogame, about 35 km from Lome, and then ferried to Kpeme where

they are processed. The production has been declining for several years. The annual production in the period 2003 to 2005 was 1.3 million tones per year. The extraction of sand and gravel of marine origin is allowed in Lome and Aneho. Small scale extraction of gravel is done by the rural populations along the beach.

Agriculture Products: The main agricultural products in the coastal zone are maize, cassava, sweet potatoes, beans and groundnuts. The farming is practised on sandy soils. Livestock is essentially the traditional type practised extensively in the context of mixed farming-main animals kept are cattle, sheep, goats, and pigs.

Other Marine Resources: The fauna includes terrestrial and aquatic mammals, birds, reptiles, molluscs, bivalves, gastropods, crustaceans and marine turtles. The degradation of the natural habitats is endangering these resources.

ADDRESSING KEY COASTAL ISSUES

Togo faces a number of coastal issues including: shoreline change, flooding, pollution, and the potential effects of sea level rise. The beach is eroding at an average rate of about 7 m/year (Blivi, 1993). The coast is protected by breakwaters and groynes for 12 km between Kpeme-Gumukope and Aneho.

Figure 1. Phosphate mining at Hahotoé-Kpogamé in the north of Lake Togo (photo credit: Johnson C. K., 1987).

The construction of a dam at Nangbéto in 1987 led to dramatic changes in the flow of the Mono river. The mouth of the river which was previously a source of freshwater for the local populations has between affected by saltwater intrusion. The management of water on the coastal plains is also a major issue, demonstrated by the recurrent floods.

The exploitation of phosphates takes place in the open areas of Hahotoé and Kpogamé. The mineral ore is processed at a plant in Kpémé, situated on the coast. This results in the need for treatment of two types of mineral wastes which comprise 40% of the ore: solid waste composed of coarse particles, and liquid slurries rich in fine particles. These total more than 2.5 million tones per year. Phosphates liquid waste is discharged into the coastal waters without any treatment.

Figure 2. Coastal erosion at a beach on the coast of Togo (photographer Prof. A. Blivi, 2005).

Figure 3. Coastal protection at Aného (photographer: Prof. G. Rossi, 1988).

Figure 4. Flooding of the coastal plains consisting of ridges and lagoons (photographer: Prof. A. Blivi, October, 2007).

Figure 5. Aerial photograph of sediment drift along the coast from Togo to Benin and Nigeria (photo credit: Institut Géographique National, France, 1985, TOG BEN 20-100-166).

Figure 6. Discharges into the sea from the jetty loading phosphate (photographer: Prof. A. Blivi, August, 2006).

The Centre de Gestion Intégrée du Littoral et de l'Environnement de l'Université de Lomé is studying the rising sea levels, which is one of the consequences of increases in mean global temperatures and climate change. Fifty five years of data (1933 - 1988) from the Takoradi sea station in Ghana allow the statistical analysis that shows an upward trend in sea level at this location. The expected impacts are exacerbated by the rapid erosion of beaches, and salt water intrusion in groundwater, lagoons and alluvial plains.

DEVELOPMENTS AND ACHIEVEMENTS OF THE NODC:

The objectives of the National Oceanographic Data and Information Centre are:

- respond to the needs of users by developing and making available data and information products
- archiving scientific information

Figure 7. The National Oceanographic Data and Information Centre in Lome, Togo.

The NODC is open to all people working on similar topics and sharing the same objectives. The principal users are:

- Staff of Centre de Gestion Intégrée du Littoral et de l'Environnement (CGILE) de l'Université de Lomé
- Research institutions and laboratories
- Students and researchers
- Departments or ministries and other public institutions addressing the marine and coastal environment
- Non Governmental Organizations

The NODC collaborates with the Centre for Integrated Coastal and Environment Management at the University of Lome. The products and services available are:

- Training workshops and internships
- Implementation of public awareness activities and associated media, such as the "Small Window on Ocean" programme which was an awareness exercise focused on students
- Development of brochures, posters and other novel printed and electronic materials such as compilations of photographs from coastal areas and costal issues such as the "Coastal zone photos collection"
- Raising awareness on the need for collection and management of oceanographic data
- Data collection at Kpeme oceanographic station and surveys of the coastline
- Repositories of publications on the marine and coastal environment, including publications and meeting proceedings available in eight collections covering: morphology, oceanography and climate, socio-economics, fauna and flora, administrative structures and urbanization, history and culture
- Directory of experts and institutes, including details of 42 researchers from different coastal management themes in Togo

MARINE RELATED PROGRAMMES AND ORGANIZATION

- Direction Régionale du Plan et du développement
- Service de l'Hydrologie,
- Direction de l'Économie,
- Direction Générale de la Statistique et de la Comptabilité Nationale,
- Ministère de l'Agriculture, de l'Élevage et des Pêches,
- Ministère du Tourisme, de l'Artisanat et des Loisirs,
- Direction des Affaires Maritimes,
- Ministère de l'Équipement, des Mines, de l'Énergie, des Postes et Télécommunications,
- Direction de la Météorologie Nationale,
- Mairie Centrale de la Ville de Lomé,
- Ministère de l'Industrie, du Commerce et du Développement de la Zone Franche,
- Direction des Pêches,
- Direction de l'Environnement,
- Universités, Centres et Laboratoires de recherche.
- Société Nationale des Phosphates du Togo.
- Port Autonome de Lomé (PAL).
- Non Governmental Organization: AGBOZEGUE–LOME-TOGO.
- Non Governmental Organization: GEPIB - ANEHO–TOGO.
- Non Governmental Organization: AVOTODE - ANEHO-TOGO.
- Chercheurs de l'université (CGILE), auditeurs libres et particuliers, et étudiants.

Figure 8. Students on a pilot boat at the Lome port during a public awareness course sponsored by ODINAFRICA.

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7.19 Tunisia

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Capital city	Tunis
Population (2005 est.)	10,100,000 (1.0% growth)
GDP per capita (USD 2005 est.)	$8 371
Life expectancy at birth (2005 est.)	73.5 years (male - 71.5, female - 75.6)
Land and water area	163,610 km^2 (land - 155 360, water - 8 250)
Length of coastline	1 148 km
Highest point of elevation	Mt. Chambi 1 544 m
Mangrove area (2005 est.)	None recorded in study
Marine protected areas (2007 est.)	55.80 km^2 (0.15% of total territorial waters)
Capture fisheries prod. (2006 est.)	111,288 metric tones
Aquaculture fisheries prod. (2006 est.)	2 775 metric tones

Coastal Climate: Tunisia's climate is temperate in north with mild, rainy winters and hot, dry summers; desert in the south.

Mineral Resources: Phosphate and iron ore.

Agricultural Products: Olives, olive oil, grain, tomatoes, citrus fruit, sugar beets, dates, almonds; beef and dairy products.

ADDRESSING KEY COASTAL ISSUES AND HOT SPOTS:

Tunisia faces major challenges in connection with the management of its natural resources. Its main problems are water quality, waste management, marine and coastal pollution and nature conservation. The development of industry and tourism and the growth in road traffic, which are concentrated along the coast, coupled with a rapid increase in the urban population, have put water resources under considerable pressure and are increasing pollution in coastal areas and waste generation. Notwithstanding the significant work carried out by Tunisia on environmental protection, the negative ecological effects caused by the intensified use of coastal natural resources associated

with economic development remain the country's most serious environmental problem.

DEVELOPMENT AND ACHIEVEMENTS OF THE NODC

The Oceanographic Data and Information Centre is hosted by Institut National des Sciences et Technologies de la Mer (INSTM). The data centre is a research structure in charge of identifying, collecting and disseminating data on the marine environment. The data are fundamental to understanding the process control of our natural environment. They can provide answers to local questions, for example the risk of coastal pollution, or the global issues, such as predicting the impact of global warming. The better we can understand these events, the better we can protect ourselves in the future.

The Data centre deals with physical, chemical and biological data. The data are originating mainly from national research and monitoring programs. Many of the data centre staff have direct experience of marine data collection and analysis. Through collaborations with specialists in information technology data are well documented and stored for current and future uses. Users of the data centre include: scientists, students, government (administration), and the private sector. The main objectives of the Data Centre are:

- Store, quality control, and archive data, ensuring they are not affected by changes in technology and will be available in the future
- Maintain and develop national oceanographic databases
- Work with scientists during marine research projects and provide data management services during the life of the project
- Distribute data for scientific, educational and development purposes. An effort is made to improve access online data through the web site
- Develop marine data products and digital atlas

Products and services available are as follows.

Further information can be found on the website (http://www.instm.rnrt.tn/fr/observatoire/observatoire.html):

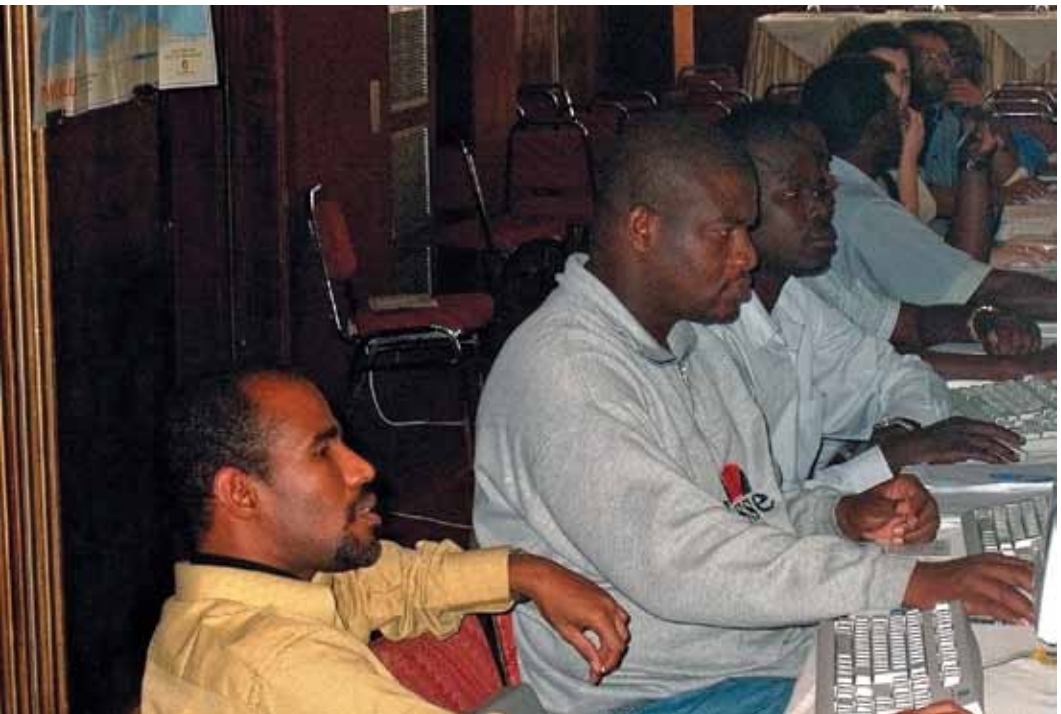
- Catalogue Of Library Holdings contains over 7, 600 records. This catalogue will be a part of a national libraries catalogue.
- Cruise Summary Report Database: the cruise inventory is a catalogue of Tunisian research vessel activities dating from 1995 to the present day. It is a valuable resource for scientists, programme managers and data managers providing information on who has collected what, where and when, in addition to details of measurements taken and samples collected.
- Hydrobase: is a user oriented discovery tool for viewing and downloading services of physical and bio-chemical data. It includes conductive Temperature Depth (CTD) and water bottles data collected in the framework of national research cruises in Tunisia. Currently, HydroBase contains over 1,000 CTD profiles, CTD time series over 5 years measurements and 7,000 measurements concerning 11 bio-chemical parameters. The data cover the geographical area between 6°E and 13°E longitude and between 30°N and 39°N latitude.
- Phytoplankton Database: this database contains data collected in the framework of the national phytoplankton monitoring program established since 1995 in more than 15 sampling sites along the Tunisian coast. Among the main activities of this network is the detection of toxic phytoplankton species that may affect the Tunisian coast. This program operates with a weekly sampling and the database contains nearly 6,000 observations.
- National Oceanographic Atlas is a collection of oceanographic data published in specialized databases throughout the word. The Atlas provides substantial maps, images, data and information to marine resource managers, planners and decision-makers from various administrative institutions and specialized agencies in Tunisia.

MARINE RELATED PROGRAMMES AND ORGANIZATIONS

The data centre cooperates with several partners nationally:

- Official Authorities of the Ministry for the execution of the research projects and the studies which are entrusted to it by the Government.
- The institutions and public companies which have a close links with the sea as well as with the field of protecting the environment (the Ministry of Agriculture, Environment and Hydraulic Resources represented by the Directorate-General of Fisheries and Aquaculture, the Inter-professional Grouping of Fisheries Products, the National Agency for the Protection of the Environment, the Agency for the Protection and development of the Littoral and the National Company for the Diffusion and Exploitation of Water), with whom it cooperates to conduct specific studies.
- Professionals (in fisheries, aquaculture and valorisation of sea products).

Figure 1. Participants at a data management training course hosted by INSTM in 2002.



- Higher Education and scientific research Institutions to carry out research programs.
- Conscious of the importance and the need to work in a regional framework, the data centre is involved in several regional data management projects:
- MAMA Project -Mediterranean network to Access and upgrade the monitoring and forecasting Activity in the area.
- SeaDataNet Pan European Project- aims to develop an efficient data management system for the present and future ocean observing and forecasting programmes, able to handle the diversity and large volume of data collected
- via the Pan-European oceanographic fleet and the new observation systems
- CIRCE project: aims at developing for the first time an assessment of the climate change impacts in the Mediterranean area. It attempts to predict and to quantify physical impacts of climate change in the Mediterranean area, to evaluate the consequences of climate change for the society and the economy of the populations located in the Mediterranean area and to develop an integrated approach to understand combined effects of climate change.
- SEASAME project: aims to assess and predict changes in the Southern European Seas (Mediterranean and Black Sea) ecosystems and in their ability to provide key goods and services with high societal importance, such as tourism, fisheries, ecosystem biodiversity and mitigation of climate change through carbon sequestration in water and sediments.

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Figure 2. Participants at the ODINAFRICA meeting, Mombasa, Kenya in July, 2008.

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All maps were produced by Kenya Marine and Fisheries Research Institute.
Capital cities are marked with a red square, highest elevation point by a blue triangle, ports with blue circles and the location if tide gauges with a red circle.

Unless otherwise stated, the following sources were used for the statistics table located at the beginning of each country section:

- Capital city – provided by author or editors
- Population (2005 est.)[1, 2]
- GDP per capita (USD 2005 est.) [1, 2]
- Life expectancy at birth (2005 est.) [1, 2]
- Land and water area[3]
- Length of coastline[3]
- Highest point of elevation – provided by author or editors
- Coral reef area (2001 est.)[4, 5]
- Mangrove area (2005 est.)[6]
- Marine protected areas (2007 est.)[7]
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   Note that: "Total area is the sum of all land and water areas delimited by international boundaries and/or coastlines. Land area is the aggregate of all surfaces delimited by international boundaries and/or coastlines, excluding inland water bodies (lakes, reservoirs, rivers). Water area is the sum of the surfaces of all inland water bodies, such as lakes, reservoirs, or rivers, as delimited by international boundaries and/or coastlines"- World Fact Book (CIA, 2008).

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