

# SEYCHELLES NATIONAL REPORT ON SEA LEVEL DATA

BY SEYCHELLES METEOROLOGICAL SERVICES

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# **SEYCHELLES NATIONAL REPORT ON SEA LEVEL DATA**

## **1. INTRODUCTION**

### **1.1 General**

Located just south of the Equator, the Seychelles archipelago is made up of 115 islands scattered over an exclusive economic zone covering an area of 1,374,000 square kilometers, situated to the west of the Indian Ocean between 4 and 9 degrees south of the equator. The total land area is 455 square kilometers (45,250 hectares). Forty-one of the islands are granitic and are all found within a radius of 50 kilometers from the main granitic island. With a land area of 148 square kilometers, Mahe, the main island and seat of the government, constitutes about one-third of the total land area. The remaining 74 islands are coralline, Aldabra being the furthest located 1150 kilometers to the south-west (Figure 3).

The country has a unique and protected environment hardly seen anywhere else in the world. The economy is heavily based on the tourism industry which provides approximately 60% of foreign currencies required to sustain the population and which employ almost 40% of the labour force. The environment, therefore, is of prime importance in sustaining tourism and socio-economic development of Seychelles.

### **1.2 Climate of Seychelles**

The climate of the Seychelles is tropical and the ocean exerts a strong influence. Temperature and humidity remain generally high throughout the year with a mean maximum temperature of 29.9C with a mean minimum of 24.5C. April and May are the warmest months, but maximum temperatures rarely exceed 34C.

The main climate influences are the monsoons and in general there are two distinct climatic seasons. The north-west monsoon typically affects the region from November to March (Southern Hemisphere summer), and the south-east monsoon typically from May to September (Southern Hemisphere winter). The north-west monsoon brings high rainfall, with very humid and warm conditions. The south-east monsoon tends to bring drier air-mass over the island group, with reduced rainfall and a slight drop in humidity.

The climate is controlled by seasonal northward and southward movement of the Inter-Tropical Convergence Zone (ITCZ) and is

more active over the Seychelles between October and May, which is also the season of cyclonic activity in the Southwest Indian Ocean. On average there are eight to twelve tropical cyclones which formed and affect the Southwest Indian Ocean region. The feeder bands of the cyclone, on the one hand, has always been a common feature over all these islands creating maximum convection and causing weather events like thunderstorm, flash floods, and strong winds. On the other hand, with a Tropical Cyclone located between 15 and 20 degrees south of the granitic islands of Seychelles, Mahe and inner islands may experience a dry spell.

### **1.2.1 Climate Variability and Change**

Studies have shown that there has been substantial climate variability over the past hundred years in the Seychelles. Figure 1 below shows marked rainfall and temperatures anomalies for the period 1972 to 1997.

*Figure1: Rainfall and Temperature anomalies for Mahe (1972-1997)*

### **1.2.2 Rainfall patterns**

Rainfall in the Seychelles exhibits one peak in the year, from December to January (Figure2).

The topography of the granitic islands strongly influences rainfall patterns. The highest mean annual rainfall totals for Mahe are more than 2700mm at the highest peak, situated north of the island. The mean annual rainfall decreases towards the south. The extreme south of the island and the coastal areas experiences a mean annual rainfall of around 1700mm, whereas most of the hilly interior receives in excess of 2700 mm of rain. Rainfall also tends to be higher on the north facing slopes and ridges of the islands, since most rainfall occurs during the Northwest monsoon. Rainfall decreases further south, especially on the outer islands, which often face severe water shortages. As can be inferred from these figures the variability of rainfall is quite high.

*Figure2: Mean monthly rainfall for Mahe ( 1972 –1997)*

### **1.2.3 Seasonal Rainfall Patterns**

The length of the dry season also varies immensely throughout the Seychelles Island chain. Dry months, meaning those experiencing less than 100 mm of rainfall, increases southwestwards from Denis to Aldabra.

Mean annual rainfall on the coral islands are considerably less that those on the granitic but they exhibit trends influenced by

physical location. In the north-eastern atolls of Bird Island and Denis Island, the mean annual rainfall is twice as high (1973 mm and 1730 mm respectively) as in the Southwest atolls of Aldabra and Assumption (984.5 mm and 867 mm respectively). Consequently, the annual rainfall on Amirantes at D' Arros and Alphonse (1497 mm and 1350 mm respectively), which are located in between both groups of islands, is intermediate. Extreme rainfall occasionally occurs in the southwestern atolls, influenced by tropical cyclones.

### **1.3 Tide Gauge Installation History**

The earliest available records of sea-level measurements in Seychelles backdates to 1962 for Port Victoria at Ile Hodoul. The float stilling-well was maintained by the Port Authority of the colonial government. However, it appears there has not been any continuity between 1964 and 1975.

In 1970 the Royal Society undertook a survey to establish benchmarks around Aldabra for use as reference base from which such factors as the relative dept of the water table or the tidal anomalies in the lagoon may be studied. The results were published in March 1972 in the *Geographic Journal*, Vol 138. (Dale 1972) That same year, the Royal Society approached the Bidston laboratory of the Institute Oceanic Sciences (IOS) for advice on the installation of a gauge to record ocean levels at the research station on Aldabra atoll. These measurements were required for comparison with lagoon tides, for studies of regional tides, and primarily to establish a mean sea level value for the atoll (Pugh 1978).

Measurements of mean sea level changes at oceanic islands, undistorted by the shallow water effects of a continental shelf or coastal region are also valuable for global eustatic changes in sea level. Any long-term changes in the value might be related to eperigenic movements of the Earth's crust. A pneumatic bubble type was installed by IOS in May 1975.

It was decided by IOS that the scope of the investigation should be extended to obtain simultaneous sea level measurements from permanent tide gauges at Kilindi harbor in Mombasa, Kenya, and at Port Victoria, on Mahe, the principal island of the Seychelles (Figure3). Simultaneous meteorological data were available at all three sites, at Aldabra, from the research station, and from the local authorities at Mombasa and Mahe airport (Pugh 1978).

Analysis of the results considered the relationship between sea level and tidal forcing, atmospheric pressure and

winds. After giving details of mean sea level at all three sites the gravitational and radiational tides are considered in terms of harmonic analysis and special functions (Pugh 1978).

Fig.3: Seychelles Exclusive Economic Zone

On 08 May 1986, the "Brigade Hydrographique et Topographique de Seychelles (BHTS) installed a new tide-gauge in Victoria at the new port. It was a QR 16, mechanical autographic type. A year later on 12 August 1987, it was moved to the present site within the headquarters of the Seychelles Coastguards. Since then the gauge has been properly maintained by the navy personnel and there is a continuous record of the measurements now available at various data centers for an in-depth analysis of significant anomalies.

During 1991, several ad-hoc measurements were made by BHTS at different locations within the Seychelles archipelago (Table 1). This was part of a survey being carried out to map out Seychelles Exclusive economic Zone (EEZ).

<b>Name</b>	<b>Location</b>	<b>Period</b>
Boudeuse Cay	06 05 31S 052 49 59E	17-18 Feb. 1991
Cosmololedo	09 44 12 S 047 38 39 E	20-22 Feb. 1991
Ile-aux-Vaches	03 43 03S 055 12 05 E	02-04 April 1991
Denis	03 48 05S 055 39 07E	16-18 April 1991
Remire	05 06 07S 053 18 02E	09-10 Oct. 1991
Coetivy	07 08 06S 056 16 02 E	05-13 Nov.1991
Fregate	04 34 09S 055 56 08 E	11-14 May 1994

(Sources BHTS) Table 1: Ad-hoc tide measurements made by BHTS in 1991

That same year the University of Hawaii Sea level Center (UHSLC) which was carrying forward the objectives of the Tropical Oceans Global Atmosphere (TOGA) Sea Level Center, decided to install an automatic tide-gauge on Mahe. During TOGA, emphasis of the collection was in the tropics. As such Mahe was located in an ideal location. The objective was to prepare a scientifically valid, well -documented

archive of hourly, daily, and monthly sea level values in standardized formats that are readily available to the public and scientific communities. The data sets are submitted annually to the World Data Center-A for Oceanography and the monthly values are provided to the Permanent Service for Mean Sea Level (PMSL). The archive of daily and monthly data is also maintained on line with access through the World Wide Web and FTP. The International TOGA program was expected to end in December 1994. (Caldwell et al, UHSLC 1997). The tide gauge was installed at the International airport close to the Rawinsonde Station at Pointe La Rue and is being maintained by the personnel of the Meteorological Services within the Directorate of Civil Aviation. It has been in continuous operations since January 1993 and provides real-time reliable sea-level measurements directly to UHSLC via satellites. The data are immediately disseminated worldwide on the World Meteorological Organization (WMO) Global Telecommunication for Meteorological Data Distribution (MDD).

## **2. STATUS OF SEA LEVEL NETWORK**

### **2.1 Installed and operational stations**

The Port Victoria tide gauge was situated at latitude 04.40 S and Longitude 55.28E. It has the Gloss number 273, TOGA number 1053 JASL Number 111A and NODC Number 30054501. The instrument was contributed by the Institute of Oceanographic services. It was a MUNROE. Number 1861/593/280 float /stilling well.

Data are available in computer compatible form for the periods 1962-1964, 1975-1976 and 1978-1979.

Data were sent regularly to the Permanent Service For Mean Sea Level (PSMSL) which holds data from 1986-1991. Other data bank in which relevant information files are kept is Tropical Ocean Global Atmosphere Sea Level Center Hawaii (1977-1982, 1986-1991 and 1993 to date), WOCE Sea and Natural Oceanic Data Center, Level Dac, Bidston (Jan 1977-1982, May 1986-1991). The responsible organization was the then Ministry of National Development and now it is the Meteorological Services and BHTS who are responsible for managing the data and also for the maintenance of the gauges.

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### **Port Victoria (Mahe)**

Mahe is the main island with approximately 89% of the Seychelles population (78,846 as mid-1998). It has an area of 151 square kilometers stretching from 27 Km North to South and 5 to 8 Km East to West, with a central axis rising to over 900 meters. For most part of this 'central highlands' it is inaccessible for any development project, including human settlement (Figure 4).

Thus, there is only one way for further expansion and urbanization, and that is reclamation from the sea using dredging materials.

The operational tide gauge in Port Victoria- B was installed on 8<sup>th</sup> May 1986 by the Brigade Hydrographique et Topographique de Seychelles. It is a QR 16, mechanical autographic and has replaced the old one mentioned above at Ile Hodoul.

The project is dedicated to the TOGA Sea Level Center in Hawaii, WOCE Sea and Gloss. PSMSL also holds the Seychelles data from 1986 to date. Table 2 and figures 5, 6, 7a, 7b, 8, 9, 10 and 11 show the tidal benchmarks levelling records and some photos of these benchmarks and the location of the tide gauge.

**Table 2. Tidal Benchmarks Levelling Record at Port Victoria- B, Mahe**

<b>Tide gauge Station</b>	<b>Reference Point</b>	<b>Year of installation</b>	<b>Responsible</b>	<b>height (m)</b>	<b>Description</b>
Port VictoriaB	Old Custom House	?	BHTS	2.710	A whitish mark located on the right side of the stoney building 50cm below the window at the entrance.
	N86-1	1986	BHTS	2.909	An iron ring located at the

					southern entrance of the Port Victoria.
	N86-2	1986	BHTS	3.130	A bronze plate on the right side of the pavement located at the entrance of the Port Victoria
	Navy 1	1986	BHTS	2.945	An iron bolt at the navy base.
	White iron Bolt on the quay	1986	BHTS	3.064	A fixed iron white bolt mounted on a mooring iron block.

### 1.3 Tide Gauge Installation History

Fig 11: Tide Gauge of Port Victoria-

#### **Aldabra**

Aldabra with less than 10 people on it, is one of the world's largest atolls and also a World's Heritage administered by the Seychelles Island Foundation. It is unique because of its large collection of endemic species of plants and animals. During the colonial days (pre-1976) the island was administered by the British Royal Society and they had a tide gauge in operation.

It was located at longitude 9.30S and 46.20E. Nobody knows what happened after 1977 when the Royal Society moved out. The instrument was a pneumatic bubble type installed in May 1975 by the Institute Oceanic Science. As the local datum are less clearly defined it was necessary to establish a special tide gauge bench mark. A substantial concrete pillar was erected on bedrock 6 meter east of the tide gauge building (Fig3.) with a brass bolt into the top of the pillar with an aluminum plate with the name IOS Bidston Merseyside U.K. May 1975 engraved on it. Three secondary marks were also established. The gauge zero was leveled to this tide gauge bench mark in May 1975 and in March 1976, during which period the datum level was constant to within + 0.01m. The data were for 1975-1977 and at that time we were participating in the Toga program.

#### **Pointe La Rue**

The Pointe La Rue tide gauge was installed on 11<sup>th</sup> January 1993 and located at 04° 40.3S and 055° 31.7E. GLOSS No. 273, Toga I053, NODC II 30054502 and in fact it has replaced Port Victoria as the GLOSS station (Fig. 12, 13, 14 & 15 ).

Instrument type: float/well, Handar 436-A, Encoder 436-B. The gauge was a contribution of the University of Hawaii Sea Level Center in Honolulu, and was installed by personnel from the University of Hawaii. It is now under the responsibility of the Meteorological Office of the Directorate of Civil Aviation. The



Survey Division of the Ministry of Land Use and Habitat in 1992 established the benchmark for that particular station. The University of Hawaii technicians were using the following benchmarks as the references (Table 2) for installation.

Fig12: Pointe La Rue Tide Gauge(Left View)      Fig13: Pointe La Rue Tide Gauge(Right View)

Fig.14 Pointe La Rue Tide Gauge (Top View)

Fig.15 Bench Mark BMUH3

Table 2: Tidal Benchmarks Levelling Record at Pointe La Rue, Mahe

Tide gauge Station	Reference Point	Year of installation	Responsible	height (m)	Description
Pointe La Rue	BMTOS	1993	UHSL and SMS	2.002 above the zero of the staff	Top of a 2-meter fibreglass staff mounted on the west tide well.
	BMSWW	1993		1.053	A stainless hex head bolt on top of the black/grey end cap mounted on the west tide well.
	BMSWE	1993		1.061	A stainless hex head bolt on top of the black/grey end cap mounted on the east tide well.
	BMUH1	1993		3.064	A stainless one-inch plate mounted in white epoxy in between the two tide wells on top of the concrete deck.
	BMUH2	1993		2.979	A stainless one-inch plate mounted in white epoxy at the Southwest corner of the T.G. concrete slab and about 15 feet South of BMUH1.
	BMUH3	1993		2.269	A stainless one inch plate mounted in white epoxy in the South corner of the top step of the boat launch access steps (20ft west of gauge)
	BMGS			2.370	A stainless BM indented with a 1/4" hole and painted yellow, located at the Rawindsonde Station on the path to the instrument area used by German Researchers.
	BM37			1.959	This is a standard Survey Division BM which is a pin on the main road at Glacis, Pt. La Rue.
	TP1	1993		2.731	A section of 1/2" stainless rod mounted in white epoxy on the North breakwater wall at the start of the jetty access road.
	TP2	1993			A section of 1/2" stainless rod mounted in white epoxy on the North breakwater wall and 50ft East of the start of the jetty access road.
	TP3	1993			A section of 1/2" stainless rod mounted in white epoxy on the North breakwater wall and about 120 ft East of the start of the jetty access road on the curved lookout.
	TP4	1993			A section of 1/2" stainless rod mounted in white epoxy on the North breakwater wall and about 40 ft before the start of the jetty. A section of 1/2" stainless rod mounted in white epoxy on the North breakwater wall and about 40 ft before the start of the jetty.
	TP5	1993			A section of 1/2" stainless rod mounted in white epoxy on the South breakwater wall of the jetty access road at the outcrop, which is mid-way to the jetty.

## **Praslin**

The next biggest islands within the granitic group with a total area of 59 sq. kms and a population of just over 6,000. The main economic activities are tourism, fisheries and agriculture. Like Mahe human settlement is more concentrated in coastal areas. Visual observations reveal marked structural damage due to wind/tidal waves and erosion. There are indeed signs of encroachment by the sea. A possible rise in sea-level of 1 metre over the next century due to global warming, compounded with coastal erosion will surely shrink this islands and smaller ones adjacent to it and most small farms on Praslin will be completely inundated when there is a storm surge or a tsunami.

In 1986 a tide-gauge was installed on Praslin to monitor sea-level as part of the TOGA program but it was washed away by storm.

The Praslin tide gauge was located at latitude 04.20.6S and longitude 055.46.0E with JASL NUMBER 106a and NODC number 300545023 and was contributed by the University of Hawaii. The instrument was a Leupold and Stevens analogue gauge except from 01/02/1989 to 27/06/89; it was a Fischer and Porter analog to digital recorder. The data are in analog and digital format and they exist from 1986 - 1989 after which the gauge was knocked into the sea by a storm whilst the jetty on Praslin was being renovated. Data are held at the University of Hawaii and Bidston University.

### **Tide prediction**

Tide predictions are performed by the University of Hawaii .The predicted tides are obtained with the use of a harmonic analysis program, which is executed on a year of apparently good data for a given station.

Using the Port Victoria data collected in the early sixties and astronomical parameters, the tidal prediction is computed annually by the British Institute of Oceanic Sciences.

Data from the Pointe La Rue tide gauge are sent automatically by satellite to the University of Hawaii and the tide staff readings and floppy disk are sent through the post. Data obtainable are hourly, daily & monthly. The datasets can also be remotely access using the Internet. This allows datasets to be available on-line and does away with inconvenience and delay in writing letters and in sending tapes and floppy disks by airmail.

The main Meteorological Station is located about 2000 meters to the North-west of the Pointe La Rue tide gauge station so it is very easy for our technical staff to attend to the gauge.

The following meteorological parameters are recorded and available since 1972 (Table3) when the main meteorological station was established at the Seychelles International Airport. They are rainfall, winds, temperatures, humidity, radiation, sunshine duration and evaporation, unfortunately we do not

have a meteorological sensor to measure sea surface temperature. It should be noted that there is no river run off near any of the above-mentioned tide gauges.

**Table3: 27-Year Averages Of Meteorological Parameters Over Mahe (1972 - 1998)**

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Rainfall (mm)	389.9	274.3	183.8	196.5	149.3	96	78.4	125.7	146.6	201.7	208.4	281.9
TEMP(C)	26.8	27.4	27.8	28	27.8	26.7	25.9	25.9	26.5	26.8	26.8	26.8
Max. Temp.(C)	29.9	30.5	31	31.4	30.6	29.2	28.4	28.5	29.1	29.8	30.1	30.1
Min. Temp.(C)	24.2	24.8	24.9	25.1	25.4	24.7	24	24	24.3	24.4	24.1	24.1
Sunshine (hrs)	5.1	6.1	6.9	7.7	8	7.6	7.5	7.4	7.4	7.2	6.8	5.6
Rel. Humidity	82	80	79	80	79	79	80	80	79	79	80	82
Wind Speed (kts)	6.5	5.3	4.5	4.2	4.6	5.4	5.6	5.7	5.1	4.7	4.5	5
MSL Press(hPa)	1011.4	1011.1	1010.8	1010.4	1011	1011.9	10126	10129	10127	10123	1011.8	1011.6
Evaporation(mm)	4.5	5.1	5.4	5.2	5.4	5.3	5.4	6	6.3	5.7	4.8	4.3

### **2.2 Installed station but not operational**

Most of the tide gauges installed since 1962 have all been operational even if it was for a short period and most are located on atoll or on Mahe. But the main reasons for non-operation are due to:

- a. Lack of qualified personnel to maintain the gauges
- b. Lack of financial backing for continue operation
- c. Lack of proper maintenance of the equipment
- d. No reliable inter- islands transport particularly between the Mahe - Aldabra route.

### **2.3 Planned station**

Seychelles has 115 islands and the EEZ covers an area of 1.3 million square kilometers. The two gauges on Mahe, at Port Victoria and at Pointe Larue Airport are contiguous to each other. In the past there has been some good sets of data from Aldabra. There is also the infrastructure for a tide-gauge over there. It is therefore recommended to have another permanent station over Aldabra. Seychelles Island Foundation (SIF) has

qualified personnel to retrieve the data to be dispatched to Mahe whenever there is an opportunity.

Farquhar is the southernmost island and directly in the cyclone track. Such cyclones can cause devastating surges. Again the Coast Guards will be best in a post to maintain a tide-gauge on Farquhar and other islands namely; Ile-aux-Vaches, Coetivy and Amirantes. (Table 4).

<b>Name</b>	<b>Location</b>
Aldabra	09 30 00S 46 20 00E
Bird Island	03 43 03S 055 12 05E
Amirantes	07 05 00S 52 50 00E
Coetivy	06 50 00S 055 52 00E

Table 4. Planned Tide Gauge Stations

### **3. AVAILABILITY OF DATA FROM STATIONS**

#### **3.1 Form of data**

Data are in the form of analogue charts for the Hodoul and Port Victoria-A tide gauge whereas Port Victoria-B are both analogue and digital and are kept by the Brigade Hydrographique et Topographique des Seychelles Coast Guard.

The Praslin data are in digital format and are kept by the UHSCL and is non-operational since 1989. Real time data can be obtained from Hawaii as they are sent there via satellite.

<b>Station Name</b>	<b>Location</b>	<b>Operational Date</b>
Aldabra	09° 30.0S 046° 46.20E	1975 - 1977
Hodoul	04° 40.0S 055° 28.0E	1962 - 1964 1975 - 1976 1978 - 1979
Port Victoria-A Port Victoria-B	04 37.0S 055 28.0E 04 37.0S 055 28.0E	1977 - 1982 1986 - 1992
Praslin	04 20.6S 055 46.0E	1987 - 1989
Pointe La Rue	04 40.3S 055 31.7E	11 January 1993 to date

Table 5: Stations with available PSMSL data

Figure 16 below depicts variation in sea level anomalies over Mahe, for the year 1993 to 1998. The data was obtained from the University of Hawaii via FTP. Again the information is such that only comments on the trend can be made. The sea level seems to be rising and is quite alarming for small island state like ours. Measures to contain this problem should continue both regionally and globally.

### **3.2 Sensitivities to Sea Level Rise**

Seychelles is particularly vulnerable to sea level in that it would affect almost all of the economic sectors on which the country depends on, tourism and fisheries. This sensitivity is further enhanced by the fact that the main granitic islands, which rise up to more than a thousand feet, have steep hill slopes prone to landslides, and a very narrow strip of coastal plain. Both the Port and Airport of the country were built upon reclaimed land and will be severely impacted by a rise in sea level. On the other hand most of the coral islands will eventually disappear from the surface of the earth. A rise in sea level in the Seychelles will most probably affect Seychelles in the following manner:

1. Destruction to property and infrastructure located on the coastal plains and reclaimed land;
2. Inundate potential agricultural areas and displace wetlands and the coastal plains;
3. Cause several low-lying islands, especially the sand cays to disappear;
4. Erode the shorelines and tourist beaches;
5. Enhance coastal flooding especially during severe rainstorms and high tides;

6. Increase salinity of mangrove swamps and raise groundwater level affecting plant growth;
7. Threaten potability of groundwater aquifers and coral island lens;
8. Alter tidal ranges in the rivers and bays;
9. Alter sediment deposition patterns;
10. Reduce light penetration required by coral reefs to survive.

## **4. CAPACITY AVAILABLE**

### **4.1 Installation and Maintenance of gauges**

We do not have expertise personnel to carry out installation. However, when University of Hawaii installed the tide gauge at the Pointe La Rue, our local technicians were at hand to assist. Our technical staff maintains the gauges and if replacement is required this is done in conjunction with Hawaii.

Tide staff reading data are entered on a monthly sheet and sent to the University of Hawaii. But the gauge automatically sends 2 minutes interval data to Hawaii once every hour.

Mr. Mark Denousse who holds a degree in Meteorological Engineering from the University of Liverpool maintains the gauge. He works for the Seychelles Meteorological Service, which is within the Directorate of Civil Aviation on P.O. Box 181.

Brigade Hydrographique et Topographique maintains the one in Port Victoria under the command of Major Michael Rosette.

Mr. Wills Agricole who graduated with a Masters Degree in Toulouse, France in December 1997 is presently working with the Meteorological Services as a Principal Scientific Officer and has started to analyse the data available, particularly calculations on sea level anomalies and plots of the long-term changes in sea level at the Ponte La Rue tide gauge station.

There were two meteorological personnel who had followed IOC courses in UK, Bidston in 1983 and 1985, unfortunately they both left the meteorological service for greener pastures in 1986 and 1988 respectively.

### **4.2 Training requirement**

Presently, physical oceanography is practically an unknown field in the Seychelles. Resources must be made available to provide necessary training to Seychellois, so that as

far as possible there will be a local expert to carry out quality control and analysis of all available data. Hence there will be a continuous monitoring of sea level and sea level anomalies for future projections that could occur due to global warming, climate change and other forces. As such, training is required in the field of oceanography at Masters level for analysis, interpretation of data and to carry out research on sea level anomalies and prediction.

### **4.3 Analysis and interpretation of data**

At present we do not have qualified personnel specifically trained in the analysis and interpretation of sea level data. Very little analysis has been done by one of our senior meteorologists who graduated last year in Toulouse, France with a Masters Degree in Tropical Meteorology. Analysis was mainly on sea level anomalies over the Seychelles using the Pointe La Rue tide data from 1993 to 1998. The trend shows an increase of sea level of around 25 cm.

Training is thus required in that area.

## **5.0 SEA LEVEL PRODUCTS**

Presently we do not have any products produced locally apart from the tide data from the Pointe La Rue Station which has been in continuous operations since January 1993 and provides real-time reliable sea-level measurements directly to UHSCL where processing takes place. The data are immediately disseminated worldwide on the World Meteorological Organization (WMO) Global Telecommunication for Meteorological Data Distribution (MDD).

Again lack of the necessary capacity has greatly handicapped us of undergoing such work. However, this year with the help of a returning Masters graduate in Tropical Meteorology from France we have started to make very few product available to the government agencies interested in Sea level anomalies. But most of the products available locally are from overseas, namely tide predictions from the University of Hawaii and Institute of Oceanographic Science, Bidston Observatory, Birkenhead, Merseyside, U.K.

## **6. BILIOGRAPHY OF SEA LEVEL LITERATURE**

David Pugh, 1979. Sea levels at Aldabra Atoll, Mombasa and Mahe, western equatorial Indian Ocean, related to tides, meteorology and ocean circulation. Journal of Deep-Sea Research, Vol. 26A. pp. 237 to258.



Patrick Caldwell and Mark Merrifield August 1997. Research Quality Data Holdings of the University of Hawaii Sea Level Center

P.F. Dale March 1972. Leveling Operations on Aldabra Island. Geographical Journal Vol. 138, Part I. pp. 53 to 58.

## **7. RECOMMENDATIONS**

### **7.1 Institutional Strengthening.**

Even though in Seychelles, much has been done in coastal zone management, sea level monitoring is yet to be integrated in that respect. The measurements currently being carried out by the Seychelles Coast Guards and the Meteorological Service have been a significant contribution to oceanographic centers worldwide, especially for the TOGA Program. From past experiences it appears that the Coast Guards are in a better position to carry out the installation and maintenance of the equipment, particularly mechanical and electro-mechanical ones, whereas the meteorological personnel can be held responsible for data management, including dissemination. It is envisaged that within phase II of the Global Environmental Facility (GEF) Climate Change Enabling Activities project, there could be funding for a Climate Change Information Center. Such institution will be best in a position to coordinate activities related to sea level monitoring.

### **7.2 Capacity-Building**

It is recommended that fellowships be made available for university training of Seychellois graduates in physical oceanography and data processing. There is also a need to train personnel in the operation and maintenance of tide gauges if we are to set up a network of tide gauges within the Seychelles archipelago.

### **7.3 Improvements on tide-gauge network**

The two gauges on Mahe, at Port Victoria and at Pointe Larue Airport are contiguous to each other. In the past there has been some good sets of data from Aldabra. There is also the infrastructure for a tide-gauge over there. It is therefore recommended to have another permanent station over Aldabra. Seychelles Island Foundation (SIF) has qualified personnel to

retrieve the data to be dispatched to Mahe whenever there is an opportunity.

Farquhar is the southernmost island and directly in the cyclone track. Such cyclones can cause devastating surges. Again the Coast Guards will be best in a post to maintain a tide-gauge on Farquhar and other islands namely; Ile-aux-Vaches, Coetivy and Amirantes. (Table 4).

**Table 4: Proposed Tide Gauge Network For The Seychelles**

Name	Location	Agency
Port Victoria(on-going)	04 37 30S 055 27 50E	BHTS
Pte. La Rue (on-going)		Meteorological
Aldabra	09 30 00S 46 20 00E	
Bird Islands	03 43 03S 055 12 05E	
Amirantes	07 05 00S 52 50 00E	
Coetivy	06 50 00S 055 52 00E	

#### **7.4 Mapping of sensitive areas**

Requesting that IOC takes on the additional duties of helping small islands States vulnerable to sea level rise in mapping sensitive areas and to carry out case studies of selected sites e.g. Bird Island and North East Point on Mahe.