Tanzania

Coastal

Management

Partnership

ANNOTATED BIBLIOGRAPHY BASED ON MARINE SCIENCE LITERATURE IN TANZANIA.

Edited by:

A.S. Ngusaru and S. Mahongo
Tanzania Coastal Management Partnership and the
Science and Technical Working Group
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PREFACE

The Tanzania Coastal Management Partnership (TCMP) established Science and Technical Working Group (STWG) in July 1999. TCMP is a joint initiative between the Government of Tanzania, the National Environmental Management Council, the United States Agency for International Development (USAID) and the Coastal Resources Center (CRC) of the University of Rhode Island (URI). The main goal of TCMP is to establish the foundation for effective coastal management in Tanzania. TCMP is committed to working with the existing network of Integrated Coastal Management (ICM) programme and practitioners to facilitate a participatory transparent process to unite the Government and the community, science and management, sectoral and public interests with a primary goal of conservation and development of coastal ecosystems and resource. STWG is intended to provide the primary bridge between coastal managers and the science community studying coastal marine issues at the local and national level. More specifically, STWG provides a clearinghouse mechanism for the integration of science and better coastal management. The Institute of Marine Sciences (IMS) of the University of Dar es Salaam provides the Secretariat to the STWG and the IMS Director is the Chairperson of the Group.

This document contains the selected annotated bibliographies based on the available marine science literature in six thematic areas: shoreline erosion, water quality and pollution, marine fisheries, coral reefs, mangroves and other marine living resources. These were selected as natural science topics with relevance for coastal management in Tanzania. The annotations were prepared after careful reviewing of a comprehensive list of literature with the goal of establishing the state of existing scientific knowledge in these themes. Therefore the bibliography exhausted most of the existing literature (publications, reports, grey literature, proceedings, etc.) that were readily available in major libraries and marine research and teaching institutions in Tanzania.

The information presented is the summary of the considered papers the bibliography and followed the same format for all the papers. The title of the papers and their corresponding authors are given first, followed by the aim of the study and major equipment and methodologies applied. Summary of the main results of the study and major conclusions and recommendations are given last. The level of detail in this document is therefore somewhat more than what is normally published in the books of abstract. The literature reviews work started in 1999 and involved the formation of a team of six "Theme Expert Leaders" (TELs), all members were from the University of Dar es Salaam under the coordination of the Science and Technical Working Group. The TELs worked together with their graduate students in expanding the list of scientific references and writing of the annotated bibliographies. The theme expert leaders and their respective themes were, Narriman Jiddawi (marine fisheries), Dr. Salim M. Mohammed (water quality and pollution), Dr. Yunus D. Mgaya (other marine living resources), Dr. Jude P. Shunula (mangroves), Dr. Alfonce M. Dubi (shoreline erosion), and Dr. Greg Wagner (coral reefs). The bibliographies from all themes were later compiled and edited by Dr. A.S Ngusaru of TCMP/University of Dar es Salaam. Dr. Jim Tobey of the Coastal Resources Center, University of Rhose Island provided the scientific advisory during the period of preparation of this document.

The annotated bibliography is a valuable reference to marine scientists conducting research in Tanzania, graduate students and resource managers. As a complement to this document, the full list of references is given in the Reference Location Guide available at TCMP.

Science and Technical Working Group

Chairperson

Julius Francis	Institute of Marine Sciences University of Dar es Salaam

Members

Narriman Jiddawi	Institute of Marine Sciences University of Dar es Salaam
Salim Mohammed	Institute of Marine Sciences University of Dar es Salaam
Jude Shunula	Institute of Marine Sciences University of Dar es Salaam
Yunus Mgaya	Zoology and Marine Biology University of Dar es Salaam
Greig Wagner	Zoology and Marine Biology University of Dar es Salaam
Alfonce Dubi	Institute of Marine Sciences University of Dar es Salaam

Secretariat/Editor

Amani Ngusaru	Institute of Marine Sciences University of Dar es Salaam

Technical Advisor

Jim Tobey	Coastal Resources Center (University of Rhode Island)

TABLE OF CONTENTS

SHORELINE EROSION

Alfonce Dubi
University of Dar es Salaam, Institute of Marine Sciences, P.O.Box 668, Zanzibar.

Alexander, C.S., 1969: Beach ridges in north-eastern Tanzania. ***The Geographical Review,*** **59:105-122.**

Aim of study: This study investigated the origin and manner of preservation of beach ridges of the Mtoni terrace by examining the environment in which the ridges occurred.

Study area: The study included the area between Tanga and Msasani Bay (North of Dar es Salaam).

Method: Field observations and measurements

Results: ***Sediment transport*****:** Field observations suggested that the Ruvu and the Wami transport large loads of sediment to the coast, but that the Pangani carries little material. Of the three intermittent streams, the Msangasi, the Mligaji and Mpiji carry considerable sediment, whereas the Sigi, flowing mainly through a limestone hinterland, transports relatively little.

The Beach-Ridge system: In the field, the ridges could be grouped into three general systems: younger, intermediate, and older, each differing from the other in the thickness of the weathered layer and if the individual ridges can be defined. The largest number of ridges was found north of the mouths of the Ruvu and Wami Rivers and north of the intermittent Msangasi and Mligaji Rivers. The ridges in the youthful system numbered from 2 to 8 and were clear and well defined. They were typically symmetrical in cross-section, with rounded crests and troughs. The height from trough to crest was from 0.9m to about 2.5m, and the wavelength from crest to crest was 33m to about 110m. The intermediate systems ranged in depth from 20cm to 40cm. The older system consisted, everywhere, of no more than two ridges, 110m to 164 in maximum width and 0.9m to 1.85m in height.

Description of the ridges: The ridge zone between Tanga and Msasani bay could be divided into several sections: between Tanga and the Pangani River; from the Pangani River to the Msangasi River; between the Msangasi and Sadani; from Sadani to Bagamoyo, and from Bagamoyo to Msasani bay. Each section had some distinctive feature that reflected the influence of the factors important to the origin and preservation of its beach ridges.

In the Tanga to Pangani River section, the ridges were not being subjected to marine erosion, although they seemingly lied in a precarious position on the narrow terrace platform. In the Pangani River to the Msangasi River section, the terrace platform and the beach ridge zone are narrow in the north but widen considerably in the vicinity of Ushongo Mabaoni (Fig. 2). That there were few ridges (one to three) in the younger systems may be a reflection of the fact that beach erosion was active south of Ushongo Mabaoni, except for a small section of the shore east of Kipumbwi, where a deposit of fresh sand formed a low ridge. In the Msangasi River to Sadani section, the beach zone was narrow except at Mkwaja and Mbuyuni. Erosion was active here and there along this entire section, and had removed one or more of the youthful ridges. The frequent occurrence of undercut and uprooted coconut trees and large outcrops of beach rock on the shore south of Mbuyuni indicated a recent onset of marine erosion. This accounted for the absence of

the younger system here; it had been removed through wave erosion. In the Sadani to Bagamoyo section, the separation and preservation of the ridges on the Wami delta were probably due to the rapid deposition of ridges because of abundant sediment. Nevertheless, though ridges were still being deposited, their immediate predecessors had undergone some erosion. In the Bagamoyo to Msasani Bay section, only the younger and intermediate systems were present, represented by two or three regular, evenly spaced ridges. By and large, these systems paralleled the trend of the shore. Everywhere along this section the beach was currently undergoing severe erosion, and it was probable that some of the youthful beach ridges had been removed by this recent onset of erosion.

Origin of the Tanzanian beach ridges: In Tanzania, there is an exceptional development of beach ridges immediately north of river mouths. This confirms field observation of a prevailing northward alongshore drift. This means that sand brought to the coast by rivers is drifted generally northward. Observation indicates that the berm's are not a result of storm surf. Wave action is usually slight because the shore is nearly everywhere protected by coral barrier islands, some 5 to 15 miles offshore. Wave action is strongest during those rare times when especially high tides coincide with local storms accompanied by strong onshore winds. Two such combinations were observed in 1961, and the resulting vigorous wave action produced severe beach erosion rather than deposition. The berms are probably built by long wave swell during periods of calm weather and spring high tides. The distinct differences in soil profile between the system of ridges indicate that each major phase of ridge formation was separated by a period of time probably dominated by beach erosion. The current shore erosion is thought to have begun at least 25 years ago.

Conclusion: From the evidence of undercut and uprooted trees and of the increased exposure of beach rock it was clear from this study that shore-zone erosion between Tanga and Dar es Salaam increased in intensity from north to south. It was also clear that this part of the shore had, in the recent past, changed from a condition of deposition to one of erosion. Although it could not be demonstrated, the individual ridges in each system might have been deposited during the rises of Recent oscillations in sea level, or during small periodic but non-cyclic changes in climate that might have produced periodic change from wave deposition to wave erosion.

Cilek, V., 1976: The Development of Beach Mineral Deposits with Reference to Tanzanian Beaches. Tanzanian Beach Sand Deposits. Rozpravy Ceskoslovenske Akademie Ved, Rada Matematickych A Prirodnich Ved, Rocnik 86 – Sesit 7. Praha.

Aims of study: To study Tanzanian beach sand deposits. To look into beach sand deposits with content of heavy minerals so that they can be economically exploited.

Study area: The area studied is part of a wide sedimentary basin along the coast of East Africa, including the Mozambique Channel and the continental shelf along the coast of Tanzania, Kenya and Somalia. In Tanzania black sand deposits found on beaches in the beaches in the vicinity of Dar es Salaam have been investigated and proved reserves have been indicated during 1970. New deposits were discovered between Dar es Salaam and Bagamoyo, around Sadani River mouth, south of Dar es Salaam. During this study (1971), the investigation for HM deposits on the remaining Tanzania beaches has been undertaken.

Method: The whole seashore was surveyed from the air except Pemba and the Zanzibar islands and a small part of the seashore between Mtwara and Mozambique. Owing to the poor condition of the banka drill this method of sampling had to be abandoned in favour of shallow pits and surface sampling on the beaches. The depth of the pits in most cases was less than two metres

because of the danger of collapse of unconsolidated sand and a shallow water level. During the period of investigation several thousands pits were dug. Four boreholes were drilled at Changwahela and many surface samples were collected. In the laboratories at Dodoma, recovery tests were carried out using generally the same methods as are used in the industry. The separation of light minerals from valuable heavy minerals has been easy performed by heavy media application. The minerals of heavy fraction can be divided into five groups depending upon their electrical and magnetic properties using high tension and magnetic separation. The separation of zircon from other minerals was done by gravity separation.

Results: Beaches are affected by permanent changes in close relationship with hydrodynamic factors, which are waves, tides, currents and eolian transport. These factors in combination with wind, changes in barometric pressure, effects of gravitational field, differences in specific gravity of sea water, climatic factors, alter the movement of sediments and its sorting. Only some areas of beach sand deposits in Tanzania are of economic importance. Table 6 gives a review of the areas. According to the content and especially the volume of beach sand together with HM reserves the most important deposit is Mtwara – Msimbazi, second Kiswere and some sections of beaches of Kisiju area around the north of Luhule River. Other promising deposits were discovered in the vicinity of Sadani and within the area of Pangani North. The present mineralogical assemblage is result of multi-cycle sedimentation developments of sand fraction both on mainland and seashore. The replenishment of sands on the present beaches still continues and the equilibrium stage is not reached for long stretches of seashore.

Conclusion: The beach sand deposits can be divided into two big groups according to the development of the seashore: deposits on seashore where accumulation is prevalent (accretion seashore) and deposits on erosional seashore. In both cases the concentration can be due to tides, storms the change in submarine morphology, disturbances in longshore transport due to natural or man-made obstacles, etc. The beach deposits change their configuration in connection with cycle of sedimentation during different times of periods as for example fortnight cycle or one year cycle, etc. During the wintertime or during the time of monsoon blowing, erosion processes taking place thus result in best concentrations of HM. In Tanzania, black sand deposits were discovered on the beaches. According to the development of these deposits they can be divided in five groups: Deposits within the area of Mtoni terrace in the younger complex. Deposits of beach sands on the foot of cliffs. Deposits on the coral platform. Older deposits of sand with HM of Late Pleistocene. Older cemented black sand deposits. During the exploratory work, which touched only surface layer on beaches, several black sand deposits of economical importance were discovered on the Tanzanian seashore. Some of these deposits are undergoing a detailed exploration to be prepared for mining.

Cooke, H.J. 1974: The Coastal Geomorphology of Tanga, Tanzania. Geographical Review. The American Geographical Society of New York, October 1974, pp. 517 – 535.

Aim of study: To establish a sounder basis for detailed and specific interpretation on different parts of the north-eastern coast of Tanzania.

Study area: The area stretches northward from Kilalle Creek, 20 kilometres south of Tanga, to Tanga Bay and its environs and eastward from the Usagaran – Jurassic contact near Mlingano, 25 kilometres to the west of Tanga, to the fringing reefs and islands.

Method: Field work (including boreholes) and analysis of Admiralty Charts

Results: ***Geomorphology of the area:*** The western boundary of the study area has been taken as the slope that lies between about 130 and 200 metres, which marks the Usagaran-Jurassic contact. To the east, the plateau undulates but the general ridge and hilltop level shows a gentle and distinctly uniform slope. The gently sloping surface terminates at about 60 metres. There is a decline to about 24 metres and thereafter a gentler slope to the sea or to a final cliff of about 8 metres, that overlooks a coastal beach strip. The break of slope between 24 and 60 metres is a significant feature and can be clearly traced from the Kenya border to point south of the mouth of Pangani River. Between 60 metres and sea level, a number of distinct surfaces can be seen. They are arranged in a series of steps and slope gently seaward between steeper and shorter slopes.

The two main rivers in the study area are the Sigi and the Mkulumuzi, both of which are allogenic streams that arise in the high-rain fall zone of the Usambara Mountains to the west. They flow in incised courses across the plateau and their long profiles show a number of distinct breaks of slopes. The incision becomes more pronounced to the east and in the lower courses, where the rivers and their tributaries flow in deep gorges. Along the flanks of the lower valleys are valley side benches; the rivers themselves are cut into alluvial, not bedrock, and are flanked by alluvial terraces.

Emerged surfaces of the coastal zone: The seaward part of the coastal zone consists of coral islands, shoals, and partly sand-covered reefs, up to a distance of about 10 kilometres from the mainland. In the immediate vicinity of Tanga the main islands are Kwale, Ulenge, Yambe, and Kerenge. The latter is little more than a mangrove-colonised bank, but the other three are bush-covered islands formed of emerged reefal limestones that rise to about 8 metres. They are edged by low cliffs, deeply undercut at their base by wave and solution attack. The two reefs, Niule and Fungu Nyama are planed-off coral platforms, just awash at neap tides, on which sand is slowly banking up. Between the island and the mainland is a zone of tidal estuaries, fluviatile tidal creeks with much alluvial, area of tidal mud flats, and extensive mangrove swamps. Low, gently rising sandy slopes and steep shirt cliffs of emerged reefal limestones, as at Ras Kazone, mark the shoreline. Along the coast and a short way inland are the remnants of a number of terraces and benches or platforms.

Conclusion: The gently inclined surface sloping eastward from about 130 metres, which begins to break away at about 60 metres shows a marked consistency of slope and height. It is suggested that the sea cut into this gentle slope during a prolonged still-stand at the 41 – metre level. Given the evidence that at certain time sea level was lower than it is at present, it becomes possible to put forward a scheme of alternating phases of high and low sea levels. The position and character of the raised fringing reefs support such a hypothesis. Details of the configuration of the coastline would heave varied during this sequence, as the fragmented and discontinuous beach and terrace remnants indicate. Lagoons and inlets must have existed between the reefs and the mainland, and it is likely that at the same time at or before the 24- to 27- metre still-stand these hollows would have been filled. Sedimentary material being derived from the calcareous reefs to the east and from the sands and clays of the mainland to the west would have produced the inter-fingered deposits revealed in the boreholes. This paper has attempted to describe certain important geomorphic features of a section of the East African coast and to show that these are largely the result of sequence of higher and lower sea levels. It is suggested that these fluctuations have probably been eustatic, in that land movement since the end of the Pliocene does not seem to have been appreciable. It must be emphasised, however, that these findings are tentative and correlation of the various levels along the East African coast is difficult. It will be solved only after much more detailed field work at other sites, with careful instrumental levelling from an agreed standard datum and with intensive studies of the post-Miocene reefal material and other deposits as key elucidatory techniques.

Dubi, A.M., 1998: Evaluation of extreme wind speeds in relation to the design of coastal structures in Tanzania. (In press), Uhandisi Journal, Faculty of Engineering, University of Dar es Salaam.

Aim of study: To evaluate extreme wind speeds, which are normally used in the determination of the design wave climate, currents and water level and sediment transport.

Study area: Coastal locations of Tanzania, particularly Tanga, Zanzibar, Dar es Salaam and Mtwara.

Method: Wind data records for Tanga, Dares Salaam, Mtwara and Zanzibar for the period between 1972 and 1996 were obtained. These are 3-hourly records of wind speeds and direction at airport stations recorded by a rotating cup anemometer mounted at the top of a 10-meter high tower. A series of the annual maximum values was constructed by drawing the maximum value in every year from the full data record. No data of some years with low wind activity were omitted. Five candidate distribution functions, viz. Fisher-Tippet Type I and Weibull with the exponent *k* ranging from 0.75 to 2.0 were fitted to the input array of wind speeds following the approach developed by Goda (1988). The input data was then arranged in descending order of magnitude of wind speeds and a probability or plotting position assigned to each wind speed using Gringorten formula (1963) for FT-I and the modified formula (by Goda, 1988) of Petruaskas and Aagaard (1970)

Results: For Tanga, Dar Es Salaam and Mtwara winds the Weibull distribution with k = 1.0, 2.0 and 2.0 respectively are found to have the highest correlation coefficient and the smallest sum of the squares of residuals. For Zanzibar winds, the FT-I distribution has the highest correlation while the Weibull distribution with k = 2.0 has the least sum of residuals. The corresponding 100-year extreme wind speeds for these distributions are 30.07 knots for Tanga, 27.76 knots for Dar Es Salaam, 31.09 knots for Zanzibar (taking the value for the highest correlation) and 37.24 knots for Mtwara.

Discussion and Conclusion: The results presented in Tables 3 through 6 show that the 50- year and 100-year extreme wind speeds for the Weibull distribution function with k = 2.0 and the FT-I have the highest correlation coefficient and the least sum of the squares of residuals. When the five distribution functions are fitted to the extreme wind data, the Weibull distribution with k = 0.75 predicts the largest return speeds and the Weibull distribution function with k =2.0 the smallest. The FT-I distribution function predicts values between those of the Weibull with k =1.0 and 1.4. Although the extreme wind speed analysis can predict the return extreme wind speeds, the true return wind speeds are unknown because the winds and significant wave heights are random variables. It is, therefore, up to the design engineer to make a decision to select a certain value within the predicted confidence interval. The selection of a certain value will depend mainly on the safety margin of the structure and the extent of the damages that would be incurred by a possible failure of the structure under design.

Dubi, A.M. and Nyandwi, N. 1999. Preliminary studies for the mitigation and control of coastal erosion at Kunduchi beach, Dar es Salaam. Institute of Marine Sciences Report No. IMS/1999/01.

Aim of study: To augment the existing scientific information on the area and provide a design option for the mitigation and control of erosion at Kunduchi, which could be applied elsewhere

along the coastline, where conditions are similar. The study will benefit the tourist industry and contribute to the advancement of coastal research in Tanzania.

Study Area: Kunduchi Beach, Dar es Salaam.

Method: ***Currents, waves and wind:*** A self-recording current meter (RCM9) was deployed in April for one month and again in August for another month in 1998. It measured the horizontal current speed and direction, temperature, conductivity and turbidity as well as pressure. Wind data were measured using a 'wind messe' instrument. However, at a later stage it was found more useful to collect long-term data from the Meteorological Department for statistical analysis.

Profiles and Bathymetry: Prior to profiling, a temporary benchmark (TBM) was selected as the primary reference point. This was given an arbitrary elevation of 100 dm. A surveyor's level was used (Zeiss NA 828) to take profile measurements. Profiling was done once during neap and spring tides for one month in each of the seasons. Detailed bathymetry off Kunduchi Beach was measured using an echosounder.

Results: ***Bathymetric features off Kunduchi Beach****:* Kunduchi lies in an area where the continental shelf width increases rapidly seawards to include the Islands of Unguja and Mafia. At Ras Ndege, approximately 20 kilometres south of Dar es Salaam, the 200 metre contour, which indicates the approximate edge of the continental shelf, lies only 3 kilometres offshore, while at Kunduchi the 200 metre contour lies 16 kilometres away and therefore the intermediate area consists of relatively shallow water. The Zanzibar Channel, which separates Zanzibar from the Mainland, has depths hardly exceeding 60 metres at the northern and southern entrances, while the mean depth of the Channel is 20 metres. In the vicinity of Kunduchi, there are some small rock outcrops, such as those found at Bahari Beach and extensive rocky shores at Ras Kankadya. Off kunduchi Beach, there are three reef islands, Mbudya, Pangavini and Bongoyo with a core of raised coral reef. Temple (1970) found that the raised reef rock and the surrounding inter-tidal reef appear to have an interesting relationship in terms of location relative to each other. The raised reef is located on the north-western sector of the inter-tidal flat. The asymmetrical disposition can be related to some physical control, which is probably the dominant south-east trade winds and the waves generated by them (Temple, 1970). Shelf features, particularly submarine depressions, banks and reefs are important features that influence coastal processes. As there is no detailed information for the accurate description of the form of the inshore submarine along the coastline of Tanzania, from the Admiralty Charts we can get a general outlook of the continental shelf. From the Admiralty Chart of 1954 (Approaches to Dar es Salaam), we see submarine trenches in the inner shelf. There are two most important submerged channels off the coast of Dar es Salaam. The main shipping approach to Dar es Salaam is zigzag channel with depths of almost 40 metres. Beginning south of Bongoyo, another channel can be identified. It is a 15-metres deep channel that passes west of Bongoyo running almost parallel to the coastline and passing between Pangavini and Mbudya islands. A shallower channel with a depth of 10 metres branches off the main channel to pass between the coastline and Pangavini. Both channels have steep banks on their western sides. A detailed bathymetric survey was conducted off Kunduchi Beach in August 1998.

Winds*:* Analysed wind data (Dubi, 1998) for the period 1972-1996 for Tanga, Dar es Salaam, Zanzibar and Mtwara shows that the 50-year return wind speeds are 13 m/s for Tanga, 13.5 m/s for Dar es salaam, 14.5 m/s for Zanzibar and 18 m/s for Mtwara. The maximum wind speeds recorded for each month for the 25-year period of 1972-1996 are given in that paper. It was established that generally the coast of Tanzania experienced the peak speeds during the July and August except Zanzibar, which experienced the peak speeds during the Northeast monsoons in

January. Dar es Salaam had peaks in February, April and July. In short, Tanga and Zanzibar experience peak speeds during the Northeast monsoons, while Mtwara experience peak speeds during the Southeast monsoons. Dar es Salaam experiences peak speeds during both seasons.

Tides, currents and waves: The coast of Tanzania experiences a semi-diurnal tide with two almost equal maxima and minima during a lunar day (24.8 solar hours). There is a considerable rise and fall of water against the coast of Tanzania, which has important geomorphologic and hydrodynamic repercussions when combined with the inter-tidal profile and the prevailing winds. While the ebb and flood tidal movements tend to be self-balancing on the open coast, individual features will influence the extent of fluctuations. Tidal currents in estuaries and areas with islands and sand spits such as at Kunduchi are localised and important in their effect on coastal and offshore shelf topography.

Tidal information for the coast of Tanzania can be obtained from three sources: Admiralty Charts, predicted tidal heights, which are published by the Tanzania Harbours Authority and from tide gauges. Dar es Salaam has the lowest water level after Lindi, while Bagamoyo has the highest water levels. From measured tides it was evident that the highest water levels are observed just before the winds change direction, i.e. in March/April and October/November. The maximum tidal range was over 4 metres (e.g. 4.25 metres in 1989)

At Kunduchi Beach, during flood tide the current direction is southerly (an average of 210 degrees) and at high tide the average direction is 150 degrees. The direction of the ebb tidal current is northerly (an average of 360 degrees). This result is in agreement with the composite current direction found by Lwiza (1987), but is opposite to what he found for only flood and ebb tide directions. On the average, the current speed was 0.1 m/s. Significant waves heights increased with increasing water level, from 0.1 metres in water depth of 0.5 metres to about 0.4 metres when the water depth reached 2.4 metres. The wave period did not show significant variation with increasing water depth. The average wave period was 8 seconds.

Profiles and grain size distribution: In the periods of April/May and September/August, we notice general depositional features on the tidal flat and erosion features on the dune and the beach face. In the beginning on 27th April 1998, the dune was at elevation 102.48 (dm) and a week later on 4th May 1998 the dune elevation had risen to 107 (dm). The accumulation of sand on the dune occurred during the El-Nino rains that fell after the first profiling. A week later, on 12th May 1998, the dune's elevation had dropped to almost it original level of 102.85. This elevation was kept almost the same until the end of the month. The beach face experienced net deposition on its lower part and erosion on the uppermost part while the tidal flat experienced deposition of more than 50 cm. During August/September, the general trend from the first to the last profile is continued deposition on the flats and erosion of the lower and upper parts beach slope.

In summary, the upper part of the beach eroded during both periods, whereas lowermost part of the beach showed deposition during April-May, whereas there was accretion on the tidal flat. Erosion of the dune and deposition on the tidal flat indicate a cross-shore sediment transport as a result of steep waves probably in combination with long-shore currents. During the Southeast monsoon, a waveform was observed on the upper part of Kunduchi. Beach face beginning from the rubble mound revetment of the Kunduchi Beach Hotel in front of the Kunduchi Fisheries Training Institute northwards. The waveform had crests and troughs oblique to the shoreline and an approximate wavelength of 22 metres and wave height of about 50 centimetres.

In the beginning of May, when the northerly monsoon winds have reached their peak speeds and are in transition, the median size (d_{50}) is about 1 phi (=0.5 mm), which can be classified as medium size. In August and September, during the southerly monsoon winds the median size is about 0.9 phi (=0.54 mm) at the berm and about 0.5 phi (=0.7 mm) on the beach face (10 m from the berm). The fact that there was coarser sand during the Southeast winds than during the Northeast winds, shows that there was more wave and current activity during the southerly monsoons. On 19 May the median size was about 1.5 phi (0.35) mm and about two weeks later on 28 May, there were coarser grains with a median size of 0.9 phi (=0.54 mm). This change of grain size is associated with a change in a hydrodynamic regime; something like a storm must have happened. Between 25 august and 11 September there appears to no big change in the median grain size.

Recommendations: **Recommendation 1:** Since this report has produced detailed bathymetry off Kunduchi Beach, and in the absence of long-term wave and current data, wave hindcasting, refraction and diffraction analysis and mathematical and/or physical modelling can now be done to simulate time-dependent erosion scenarios. From the results, a detailed engineering design should be done.

Recommendation 2: The design process should include the following necessary stages after knowing the wave condition during the highest possible tide. One must base the design on the worst wave situation with a reasonable safety margin obtainable from past experiences.

• *conceptual design*: this is the first stage of design in which all alternatives, deemed to meet the functional requirements, are generated. At this stage, designs are general and only main dimensions are given. The relative importance and consequence of each alternative are evaluated and rough figures are obtained.

• *preliminary design*: at this stage a limited number of alternatives are selected after a screening procedure. Structural dimensions are quantified in some detail and a check is made on the economic feasibility.

• *detailed engineering design*: detailed structural design and engineering drawings are made. Along with this, possibilities for financing are explored and environmental and socio-economic aspects are considered. When designing, operation and maintenance should be considered carefully. If possibilities for maintenance are poor or too costly, the initial design should be such that the structure can operate with minimal or without regular maintenance. If local labour cost is cheap and capital investment is difficult, a cheap structure may be appropriated and regular maintenance should be guaranteed.

Recommendation 3: Although choosing a protective measure is difficult, experience has shown that groynes have not solved the problem at Kunduchi and adjacent areas. Kunduchi Beach experienced the first (two) groynes built to protect Kunduchi Beach Hotel in late 1977 (Lwiza, 1987). As of today, the groynes are not there as they probably failed.

The functional performance of a protective measure should also be considered when choosing type of protection. From table we recommend that serious consideration be given an offshore breakwater, beach drain and the removal of the sand spit off the Kunduchi-Manyema creek.

Dubi, A.M., 1998: Ocean Wave Measurement and Analysis Systems for Climate Evaluation. A Review and Critical Assessment of Derived Parameters and their Use in Coastal Engineering. In: Proceedings of Exposition workshop on mathematical/computational models for studying beach erosion. 9 - 14 November 1998, Bagamoyo, Tanzania.

Aim of study: To review ocean-wave measurement systems and analysis and assess critically the derived parameters from the instruments. To underscore the need to assess our own capacity, equipment needs and methods because data gathering is a complex operation.

Study area: Review paper.

Method: Mainly review of existing ocean wave measurement and analysis systems. Assess critically the derived parameters and their use in coastal engineering.

Results: ***Specific requirements for sensors:*** The instrument we want should be durable; i.e. it should survive mechanical loads, corrosion, fouling and other processes of the harsh marine environment. It should be insensitive to other aspects of the environment and its response characteristics should be permanent and accurate during the measurement period, despite large changes in the environment. Calibration should be simple and checking, servicing and replacement be easy and inexpensive. Its electrical power consumption should be little.

Wave measurement systems: The different types of wave measurement systems can be grouped into three main categories. According to the manner of data collection, we distinguish those instruments that collect data while fixed at a given location (in-situ data collection) and those which are not fixed (satellite data collection). In relation to the water surface, we have surface-piercing, surface-following and subsurface instruments. The third category includes those instruments, which measure directional parameters and those that do not.

Surface-piercing instruments are generally known as wave staffs. They are used when a structure is available to mount them. Their output is time series recorded on site, telemetered or sent along a cable. One of the biggest constraints is that they should be placed well away (about 10 diameters of the largest member of the structure) from a sizeable structure. The disadvantages of such instruments are the weathering and formation of insulating films due to marine growth and refuse material.

Sub-surface instruments are mounted near or on the seabed. They include pressure sensors, inverted echo-sounders, current meters, *PUVs* (These are a combination of the pressure (*P*) sensor and two particle velocities, *U* and *V*, in the *x*- and *y*- axes respectively). Each of the instruments has advantages and disadvantages. *Ship-borne systems*: These consist of two pressure sensors boxes mounted symmetrically on each side of the ship. The pressure is given by $P = exp(-kd)$, where d is replaced by $2.5D$ and D is depth below mean water level (Tucker, 1956)

Surface-following wave measurement systems are generally known as buoys. This type of instruments is used mainly for offshore measurements. They usually measure acceleration, which is then integrated twice to give vertical displacement. The various types that are found in the market are for example small accelerometer buoys and spar buoys. The collected data can be sent through the satellite or telemetered within a radio range of 10-20 km.

Directional measurement can be accomplished by measuring a number of variables at a point: pitch, roll, heave or pressure together with two particle velocities. A spatial array of sensors each measuring surface elevation can be used for directional measurement. The prime output of these instruments is time histories and accelerations.

Short-term statistics: Probability distributions are particularly important for short-term probabilities of the random wave parameters. We distinguish between Gaussian (**or normal) and Rayleigh distributions. One of the first steps in the analysis of a wave record at a single**

point is the examination of an instantaneous surface elevation sampled at a certain time interval. Basing on many instrumental observations of ocean and coastal waves, many investigators have concluded that the distribution of the surface elevation of waves is closely Gaussian, provided that non-linear interactions are small enough to assume that component waves are statistically independent.

Wave climate evaluation and extreme wave statistics: The wave climate of a certain location can be described both directly and indirectly. The direct way of describing a wave climate of a location is through data presentation. The following are typical presentations of data (Goda, 1990). Annual, seasonal, and/or monthly averages of significant wave heights and periods, with or without their standard deviations and the maximum values in the corresponding time span. Joint frequency tables of significant wave heights and periods with or without classification in the wave direction.

Distribution functions: The evaluation of wave climate requires that wave data cover a sufficiently long period of time, the minimum being one year. The wave climate of a given location can be evaluated from data sources such as visually observed data, instrument-measured data, wave-forecast data and wave hindcast data. From the full data set, we then construct an annual (or monthly) maximum series by drawing the maximum value of significant wave height in every year (or month). So far, there no leading theories for the wave climate statistics and consequently most of the investigations are based on field data. Wave climate evaluation deals mostly with significant wave heights, significant wave periods and wave directions. In dealing with the wave climate parameters, it is usual to work with cumulative probabilities such as t*he Weibull distribution* and *The Fisher-Tippet type I (FT-I).*

Choice of a favourable fit*: There are two ways to check the goodness-of-fit of a fitted distribution function. The experienced eye will visually inspect the fits and make a judgement (This method is referred to as 'qualitative test'). However, when large quantities of fits are involved, one should apply quantitative tests to choose between various distributions, e.g.:* Kolmorov-Smirnov (KS), Anderson-Darling (AD). Chi-Square (χ^2), Correlation coefficient (r), Residue of correlation coefficient (REC), Minimum ratio of residual correlation (MIR). In practice, the correlation coefficient (r) is used to judge the quality of the fit; the higher the correlation, the better the fit. For a better judgement, Goda and Kobune (1990) propose the REC and MIR criteria to be used to qualify the fit. Extreme wave heights for different return periods: *After fitting the peak value series to a distribution, return values corresponding to return periods are then calculated.*

Conclusion: As can be seen from data analysis, wave parameters derived directly from a wave record and those derived through statistical analysis will be different. The significant wave height H_s obtained by averaging the highest one-third will have a different value from through the use of spectral moments.

Statistical analysis is an important tool in the determination of the wave parameters for sediment transport studies and the design of coastal and offshore structures. At present no preferred distribution function for extreme wave statistics and no consensus that has yet been established on the best method for data fitting. Consequently, the extreme wave analysis can only predict values, but it cannot tell the 'true' return wave height. All these values are subject to sampling errors in the same way as the parameters of the chosen distribution function. Following these uncertainties, the design engineer must define confidence intervals within which design parameters will be selected. The question whether to select values in the upper or lower limit of the confidence

interval will depend on the reliability of the wave data, the safety margin of the structure and the extend of damages incurred by a possible failure and some other relevant factors.

There are several sources from which errors are accumulated. These sources include accuracy of the sampling instrument. If at any time during the sampling interval, the instrument malfunctions, this will lead to a data bank containing 'outliers'. There will be errors associated with the prediction method; that is, distribution functions and data fitting. The prediction of sea-state parameters will contain errors due to calculating *H* from the measured record. One should assess the goodness-of-fit by available methods.

Edet, E.O. 1991: Coastal processes and beach erosion north of Dar es Salaam (MSc Thesis, Dept. of Civil Engineering, University of Dar es Salaam)

Aims of study: To establish the specific processes and the extent to which they contribute to the coastal erosion along the beach. Compare the findings with previous results obtained in order to determine optimal design parameters. Evaluate the performance of the groynes and advance reasons for their poor performance. Make appropriate recommendations aimed at curbing or ameliorating the erosion problem.

Study area: Sandy beaches north of Dar es Salaam extending from Msasani Bay to Mbweni except for a short rocky stretch of shore north of Kunduchi, and from north of Mbweni to Bagamoyo.

Method: Introduction of an experimental groyne system using standard principles of design of groynes. Protect the beaches using rock and concrete riprap.

Results: Dominant wind direction was from the sea to land during the day with a maximum speed of 20 m/s were observed in February. At night, the breeze blew seaward. Waves at breaking point were observed at Kunduchi Beach with a height of about 1 metre and period of 8 seconds. The currents in the surf zone and offshore had values not exceeding 0.5 m/s. Sediment transport by longshore currents were estimated to be about 228 m^3/year. This excludes sediment input from seasonal streams during rainy seasons. Sediment accretion occurs during rainy seasons, while erosion commences as soon as the rains cease. Reconstruction of groynes according to recommend transition, size of blocks, length and spacing between compartments will obviate the ineffectiveness associated with the present groynes. Riprap blocks will protect the berm slopes from erosion

Conclusion: The study of the shore processes in nature which result in erosion is complicated by the presence of a large number of mutually dependent variables, none of which is susceptible to control in the field. The peak wind velocity at Kunduchi Beach was 20 m/s and occurred in February during the Northeast monsoon. Higher wind velocities are attained during the Southeast winds. The present groynes should be reconstructed according to specifications. The size of the coral limestone is 550 mm for Kunduchi and 450 mm for Silver sands and Bahari beaches. The sloping face of the berm at each beach should be protected with coral limestone riprap along the

Fay, M.B., 1992: Maziwi Island off Pangani (Tanzania): History of its destruction and possible causes. *UNEP Regional Seas Reports and Studies No. 139*.

Aim of this study: To carry out preliminary investigations on the disappearance of Maziwi Island off the Tanzanian coast. This consultancy work was geared towards complimenting the activities that were being undertaken by the East African Task Team on "Global Climate Change" established by the UNEP's Oceans and Coastal Areas Programme Activity Centre (OCA/PAC). The study was undertaken in October, 1989.

Study area: Maziwi Island.

Methods: Methods applied in the investigation included air photographs and maps; review of literature, site investi4gations, and; interviews with Pangani fishermen. The Island was visited on five days during low tide. The size of its remaining terrestrial part during low and high tides, inclination angles of beach slopes, ripple patterns and other sedimentary structures, the boundary to the surrounding coral platform and the distribution of remnants of the former vegetation were studied. The submarine part down to a depth of 35m was investigated by SCUBA diving. The water depths on the northern and western side of the Island were determined by echo sounding. Samples from laboratory studies were taken from the supratidal, intertidal, and subtidal parts of the island. Short visits were paid to the mainland beaches around Pangani town. Interviews were carried out with fishermen from Pangani town, who used to fish in the waters around Maziwi Island since 1924, 1926, 1948 and 1955.

Results: At the time of this investigation, the largest part of Maziwi Island was a shallow coral reef flat reaching the sea level only during low tides. On the western margin of the reef platform was a sand spit composed of carbonate particles. From the air, this sand spit looked tongue- to hook-shaped, its convex side pointing north and westward. The length of the sand spit exposed to air during low-tide (E-W) was about 320m, its width (N-S) was 130m. The vertical distance between low tide level and the top of the sand spit was 3.5m. The size of its uppermost part, which was usually still positioned above high tide level, was about 70m (E-W) by 40m (N-S). Occasionally during extreme spring tides, this part of the sand spit seemed to be submerged, too.

Originally, the shape of the island was roughly circular with a diameter of 500-600m. The island was elevated about 2m above maximum high tide level, its base was the reef flat surface, about 4m below maximum high tide level. Based on these figures, the total volume of calcareous sand that was accumulated on the reef platform amounted to 1.2-1.7 million cubic meters. This corresponded well with the estimated volume of the sand fan of 1.5 million cubic meters that was present at the time of this investigation. Maziwi Island was vegetated up to 25m high casuarina trees and shrubs. The trees were probably planted during the German colonial period. The last casuarina tree fell most likely in 1977, and the last (small) vegetation disappeared most likely in 1980. A chance of natural rebuilding of a large terrestrial sand island on the Maziwi coral platform in the near future did not exist.

Conclusion: Possible causes for the disappearance of Maziwi Island was discussed. They included: Rapid tectonic subsidence; erosion due to ex(ta)raordinary heavy storm events; wave erosion due to higher sea level or due to significantly changed long-term wave climate, and; to a combination of the above events. Seismic data that were available for this section of the East African coast excluded the possibility of rapid subsidence caused by an earthquake. Although precise data on wind, current or wave regimes around Pangani were not available, there was no reason to assume that any significant changes had occurred since the 1920s. The rise of sea level could therefore be the only reason for the disappearance of the Island within less than two

decades. It was also assumed in this study that the situation was similar for most parts of the Tanzanian coast.

Recommendations: In order to exclude the possibility that the disappearance of Maziwi Island was a unique event due to local factors, the author suggests case studies (similar to the present one) to be done on a small number of these islands in the region. The following islands between Pangani and Tanga are regarded to be suitable: Fungu Tongone, Karambe and Yambe Islands, Fungu Kizimkazi (Latham Island). Tanzania urgently needs the establishment of a coastal inventory and a littoral data base for her entire shoreline, comparable to the one existing for the West and Central African region. Tanzania should contribute to the global monitoring of short and long-term sea level fluctuations, self recording tidal gauge stations are required to be installed in the major harbours of Tanzania (Tanga, Dar es Salaam, Kilwa, Lindi, Zanzibar), and staff for operating the stations must be trained.

Francis, J., Nyandwi, N. and F.E. Msuya 1997: Interdisciplinary survey on the status and socio-economic impacts of coastal erosion along the Tanzanian coastline and islands. Institute of Marine sciences, Zanzibar. Report Commissioned by UNESCO, Nairobi.

Aim of study: This study was intended to carry out a survey on the socio-economic impacts of coastal erosion on the various communities along the Tanzanian coastline and islands.

Study area: The study was conducted along the coastal areas of Mainland and the Islands in Tanzania during December 1996 to March 1997.

Method: The methodology involved a random questionnaire survey, which was targeted to fishermen, local communities, decision-makers and hotel owners. Questions asked included, knowledge on coastal changes; types of environmental physical changes; information and concerns about erosion; severity and causes of erosion, and; government and community-based efforts/strategies to mitigate erosion. A total of 85 people were interviewed, including 34 local community members, 10 decision-makers, 34 fishermen and 7 hotel owners.

Results: The study reported several places along the coast where the extent of erosion was estimated. At Mikindani township in Mtwara, more than 5 m of beach had been eroded over the previous years. In the Rufiji delta, aerial photography had indicated that up to one kilometre wide of mangrove vegetation had been lost since the 1966 aerial survey at Simbaulanga Island. The report quoted a study by Hemed (1987) who found that beaches like the one in front of Silver sands Hotel at Kunduchi (Dar es Salaam) experienced bouts of erosion and accretion in successive periods of 33 to 35 days. But over the previous 12 years or so there had been a net erosion of up to 5m/year. However, this study reported that some beaches like those at Africana Hotel (Kunduchi) had been accreting for the previous two years.

Other reported estimation on the extent of erosion included those of Kunduchi Beach Hotel (Kunduchi). At the time this hotel was built in the 1970's, the sea was over 100m away but due to erosion, it was 1m away from the hotel buildings by the time of writing of this report. At Pangani delta in Tanga, erosion was reported to take place along the banks of the estuary at about 5m/year, eroding mangroves at places. An erosion rate of 2.5m/year was estimated at Unguja Ukuu beach (Unguja Island). At Nungwi beach (Unguja Island), a study by Nyandwi and Muzuka (1991) was referred to which reported that 1.2 km of land had been lost in 30 years (1947 to 1997). The erosion rate had also changed from 3m/year in the mid 1970's to 4.5m/year in the late 1980's (IOC, 1994).

Factors that were considered to be responsible for coastal erosion were identified as natural and anthropogenic causes, which are sand extraction along stream beds and beaches, destructive fishing methods, engineering structures at the shoreline, mangrove cutting, salt pans, lime making, rope making, seaweed farming and coastal construction.

Conclusions and recommendations: The survey has shown that coastal erosion in Tanzania is a serious problem affecting all types of shorelines. The majority of the interviewed people are aware of the problem and its current effects and impacts. Most of the people mentioned breakage of corals, indiscriminate cutting of mangroves and destructive fishing methods as causes of erosion in addition to the natural causes. Stakeholders strongly propose that the government play a more active role in addressing the problem, particularly by developing acceptable strategies for community participation. It is recommended that the construction of anything, whether it is industries or other, should consider the very dynamic geomorphic features of beaches. There is a need to increase the current setback line of 60m (as per Government Notice of 1992) from the highest watermark. Mangroves should be replanted in areas where they thrive well. There is a need to explore alternative and equally cheap building material to limestone. For example, Darwall et al. (1995) proposed the use of sun-dried and pressed mud bricks as an alternative building material on Mafia Island instead of live corals. There is need to intensify campaigns to raise public awareness on the anthropogenic causes of coastal erosion. It is also recommended that detailed studies and monitoring the causes and mitigation options and their effects be undertaken.

Glasgow University Tanzania Expedition 1991 (G. Buchanan, S. Carlisle, M. Cumming, C. Gerard, A. Martin, J. I. B. McChesney, A. McMillan and C. White, eds.), 1991: A geographical investigation into the causes and effects of beach erosion north of Dar es Salaam. Royal Geographic Society, London/Department of Geography, University of Dar es Salaam, 64p.

Aim of study: This investigation aimed at conducting an analysis of a stretch of coast to the north of Dar es Salaam, including in its remit the causes of any erosion and the resulting physical and socio-economic consequences. Study area: The study area extends northwards of Dar es Salaam from Msasani Bay for a distance of 17 km to Ras Kiromoni (Map 1 &2). The geological map was also presented (Map 3).

Method: The methods employed in this study included: Mapping the location and specifications of coastal defences and eroded areas; taking beach profiles along the study area and collecting data from other sources, and; investigation of the hypothesis of erosion due to sand extraction on the seasonal feeder stream beds. Clinometers were used to record each of the profiles and during profile recording, a sample of beach material was collected from the high tide and low tide marks of each for grain analysis. Sediment samples were also taken from the feeding rivers.

Results: The profile locations were shown in a map and man made coastal defences between Msasani Bay and Ras Kiromoni weremapped. Sediment distribution of each of the 10 profiles were obtained. A diagram from Schiller and Bryceson (1978) was redrawn, showing the current location of a sea wall in 1991.

Conclusion: It was concluded in this report that sediment extraction from seasonal streams was not the sole cause of erosion, which continued despite sand extraction transferral to more southerly rivers, and it was undoubtful whether it was even the main cause. It was found in this study that sand extraction was not taking place from the rivers that fed the study area, but rather from rivers south of Dar es Salaam that emptied into the city harbour. If sediment extraction was

a cause of coastal erosion it would be to the detriment of Msimbazi Bay and Oyster Bay that run from the harbour northwards to Ras Kankadya peninsula, and not the stretch of coast, including the study area, further north. Dynamite fishing was referred to as a "nonsense" theory since its inception because at spring high tides and storm surges (when most erosion occurred) the coral islands were submerged and could not therefore expect to interfere with the fetch and consequently the force of incoming waves. The cause(s) of erosion in the area was therefore "left open for debate".

Griffiths, C.J., 1987: The Impact of Sand Extraction from Seasonal Streams on Erosion of Kunduchi. In Beach Erosion along Kunduchi, North of Dar es Salaam. Report for National Environment Management Council by Beach Erosion Monitoring Committee, pp. 36-47.

Aim of study: The aim of the study was to investigate the scale of sand extraction (for use as building materials) from the seasonal streams and its impact on the beach erosion processes.

Study area: The study area is situated north of Dar es Salaam and extends northwards from Msasani Bay for a distance of 17 km to Ras Kiromoni, including the seasonal streams which empty onto this stretch of beach and supply the sand.

Method: Fieldwork involved the researcher and assistants walking along the stream beds for much of the lower stretches and estimating the length, width and depth of extraction. Localities within military areas along the Mlalakuwa stream could not be visited and the upper reaches of the Tegeta and Mbezi were not walked beyond where the digging and adjacent settlement stopped. Interviews were conducted with sand diggers at all the major localities of extraction. Measurements were carried out during the months of March and April, 1987. Due to the lateness of the heavy rain season, the extent of sand digging was measured directly in the field at the end of the dry season when the maximum amount of digging was to be seen. Fieldwork involved walking along streambeds for much of their lower stretches and estimating the length, width and depth of extraction. Interviews were also conducted with the sand diggers at all the major localities of extraction. Rivers surveyed included Tegeta, Mbezi, Mlalakuwa, Kijitonyama, Nyakasangwe-Kalekwa, Mpiji and the Tabata and Mbagala areas (Fig. 1.1,6.3 and 6.4).

Results: The Tegeta River, with a catchment area of 62.5 km^2, was the most heavily exploited. It was estimated that the annual total rate of extraction for Tegeta River was 65,000m^3. The Mbezi River (catchment area: 56km^2) was also heavily exploited, but it differed from Tegeta in that it was flanked by extensive terraces which had also been heavily exploited. Approximately 37,500 m^3 of sand had been extracted. The upper and lower reaches of the Mlalakuwa River (catchment 19km^2) flow through military areas and therefore were inaccessible. An average estimate of 3,000m^2 per year was being extracted from the upper reaches of the Mlalakuwa. This estimate was done through the 1982 aerial photographs. The Kijitonyama River (Catchment: 8km^2),a very small stream, had a total sand extraction of about 70,965 - 106,447m^2 from the streambed. At the Nyakasangwe-Kalekwa River (catchment; 120 km^2), almost no sand extraction was observed on the riverbed, although very good sand for building was available. Sand from Mpiji River was considered to be the best river sand for building purposes in Dar es Salaam. It was estimated in this study that a minimum of 100,000^3 of sand was extracted annually from the four disturbed streams that drain the hinterland of Kunduchi Beach (Tegeta, Mbezi, Mlalakuwa and Kijitonyama). However, this figure was considered to be an underestimate, especially for the Mlalakuwa because there were no figures for the widest and longest section of the stream that runs through the military area.

Conclusion: An estimation was made that, if the sand extracted from rivers equalled the deficit reaching the beaches, about 100,000 m^3/year would be equivalent to a retreat of 10m to a depth of 1m along a length of 10 km of coastline. This was approximately the same distance that was suffering severe erosion between Mbezi Beach and Ras Kiromoni. Alternatively, it was equivalent to a retreat of 5m to 2m depth for a horizontal distance of 10 km. However, it was acknowledged that realistic comparisons could not be made until mapping of rates of beach retreat was complete.

Griffiths, C.J. 1985. The Geological Evolution of Tanzania. Journal of the Geographical Association of Tanzania. No. 24, pp. 1-33.

Aim of study: The purpose of the paper is to present an up-to-date summary of the geology of Tanzania. It attempts to explain the evolution of the country's rocks in a form understandable to students and non-specialists.

Study area: The whole of Tanzania.

Method: The data are entirely secondary and drawn from a variety of sources, particularly from quarter degree geological map sheets published by the Geological Survey Division, Dodoma, from Tanzania in Maps (1971) and from the Geochronology of Africa (Cahen et al., 1984)

Results: Emphasis is placed on *Coastal Sediments of the Mesozoic, Tertiary, Quaternary and Recent Eras.* The sediments of coastal Tanzania form a continuous belt varying in width between 17 km at Sadani and 150 km at Kimbiji, just south of Dar es Salaam. They range in age from Jurassic to Cretaceous, Palaeocene (Lower Tertiary) and Quaternary and they are comprised of both marine and non-marine detritus. In Tanzania, the breaking up of Gondwana land began with the rifting of in the Mozambique belt. A major fault line separates the Precambrian basement to the west from the thick sedimentary sequence, which borders the present day coastline to the east. In places, such as Pangani District in Tanga Region, there is marked break between the two groups of rock whereas else where, subsequent erosion processes have obscured this important geological boundary.

Inception of marine conditions in the Jurassic coincided with major faulting with a down throw between 3000 - 6000m which defined the inland edge of the sedimentary basin which lies along the coast of East Africa from the Horn of Africa to Mozambique. Along this stretch, the continental shelf is insignificant except off Tanzania where it extends to include the three large offshore islands of Pemba, Zanzibar and Mafia. These are of comparable sizes being 67.97 and 48 km long respectively which is the characteristic size for African fault blocks. Pemba is separated from the mainland by a 700-m deep channel, which is probably a graben whereas the Zanzibar and Mafia channels are shallow. All three islands are composed of Miocene to Recent calcareous sediments with some marine clays and sandstones. Zanzibar is largely composed of reefal limestone and all three islands have living coral communities forming fringing reefs.

Despite the absence of continental shelf, great thickness of detrital sediments typical of shelf sedimentation is found at least as far as 150 km east of Zanzibar beneath 1000 m deep. These sediments which are upwards of 5000 m thick represent a sequence dating back to the Lower Cretaceous/Upper Jurassic. It is not known what underlies these layers but an oceanic crust has not been found.

Conclusion: It is clear from the foregoing that the geological history of Tanzania is a long and interesting one. For the past 3,000 Ma, the continental crust of Tanzania and the rest of Africa has been growing and consolidating. Geological processes have remained the same through time although the environment has changed a great deal and mechanisms have varied. During the Archaen the crust was thinner and perhaps the geothermal gradient steeper so that plutonic conditions were reached at shallower depths. Various interpretations have been put on the origin of granite-greenstone terrain. Whether vertical or horizontal movements predominated in their evolution is not clear.

The Proterozoic orogenies in Tanzania and Africa were generally characterized of sediments and volcanics accumulated in troughs on a granitoid basement. In-situ upwelling of hot material from the mantle combined with a thickening, subsiding pile of sediments and volcanics led to the high grade of intensely deformed mobile belts such as the Ubendian and Usagaran. This mechanism contrasts with the large scale horizontal movements involving the closing of an ocean that occurs in the plate tectonics which operated in the Mesozoic – Tertiary orogenies to create the modern day fold mountains elsewhere in the world.

Palaeomagnetic evidence from different African craton indicates that the bulk of Africa has behaved as an integral unit during the period 2300-400 Ma. During the Mesozoic era Gondwanaland fragmented creating marine conditions along the present day coastline while during the Upper Tertiary the East African Rift Valley developed in another attempt for continental break up. The widespread vertical movements and associated volcanism have given rise to the spectacular landscape of present day Tanzania.

Harvey, J. 1977. Some aspects of the hydrography of the water off the coast of Tanzania: A contribution to CINCWIO. University Science Journal (Dar. Univ.), 3, (1&2), pp. 53-92

Aim of study: To investigate the temperature and hydrographic structure of the Tanzanian offshore waters. To study currents in the Zanzibar Channel. To measure water currents and other hydrographic conditions off Kunduchi.

Study Area: Tanzanian offshore waters including the Zanzibar Channel.

Method: The first two investigations have been studied utilising data from the Oceanographic Data Centre, Hydrographic Department of U.K. The data have been analysed from 78 stations off the coast of Tanzania. The data have been acquired during the years 1954 – 1974 inclusive, mostly by U.K. ships using bathy-thermographs. At three of the stations occupied by French and USSR vessels, water samples were obtained, and salinity and σ_t data are also available for these. The stations were divided into four groups, A, B, C, and D essentially according to latitude. Current measurements in the Zanzibar Channel were made at six locations between 1951 and 1954 from H.M.S. Dalrymple. At each position observation of speed and direction were made at half – hourly or hourly intervals for a period of about 25 hours using a 30 foot (or, at a shallow station off Zanzibar, a 15 foot) pole. At each station the wind force and direction were noted.

In the third investigation, the author carried out the work using the University of Dar es Salaam's 10 m research boat, POMBOO. Between March and June 1977 a programme of drogue tracking and hydrographic observations was carried out from the research boat POMBOO in the waters immediately off Kunduchi, about 10 nautical miles north of Dar es Salaam. Each drogue comprised a wooden cross of overall dimensions 0.8x0.8x0.8 m and was suspended between 1 and 2 m below a surface float. Their positions were fixed at intervals of 45 min. by bringing POMBOO alongside and taking fixes on coastal features with a hand-bearing compass. The

hydrographic observations were made at intervals of about 2 hrs whilst tracking the drogues. The observations included (a) water temperature measurements, made with a reversing thermometer in a frame, (b) secchi disc observation of penetration of visible light, using a 30 cm white secchi disc, and (c) surface samples taken with a bucket, which were subsequently analysed for salinity using a T-S bridge. Observations of wind strength and direction were also made, using a cup-anemometer when available but on other occasions by estimation Beaufort strength.

Observations were carried out on seven different occasions. On some occasions more than one drogue was tracked and these are then indicated by the addition of lower case letters e.g. 2a, 2b. The observations were confined to day light hours, and various other constrains further reduced the period of observations on most occasions, so that on only three occasions did the observations continue for a period greater than eleven hours.

Results: *Temperature – Salinity Relationships and* σ_t*:* In each case temperature decreases rapidly with depth between about 100 and 250 m, and then more slowly to the maximum depth of observation. Salinity reaches a maximum between 100 and 250 m, there being double maximal at two of the stations, and then decreases to a minimum at about 500-m depth. σ_t is largely controlled by temperature, but where salinity decreases with increasing depth the rate of increase of σ_t is reduced

Seasonal variations of thermal characteristics: For all 78 stations the mean temperature of the layer between the surface and 10 m, the temperature at 125 m (where observations extended to this depth), and the depth of the base of the upper mixed layer were listed. The base of the mixed layer was taken rather arbitrarily as the depth at which the temperature was 1^o C below that at the surface. But where there was a shallow thermocline less than 10 m depth the drop in temperature across this thermocline was ignored in determining the depth of the mixed layer. The temperature of the 0 – 10 m layer was maximum in early March, whereas the time of the minimum temperatures, which was less clearly defined by the data occurred in August or September. The annual range was greatest in areas furthest from the equator (4.6^o C for Group C and 4.5^o C for Group D), and least for Group B (3.3^o C). The depth of the mixed layer generally shows two maxima and two minima during the year. The main maximum of about 80 m occurs during July and August when the surface temperatures are low and the southerly monsoons are strongest. A secondary maximum occurs between December and February when the northerly monsoon is blowing. The mixed layer generally has a minimum depth of about 30 m in March when the winds are weak and the surface temperatures are highest, and a secondary minimum between October and December when the winds are again weak. The temperatures at 125 m depth failed to show any discernible seasonal variation. The mean values for the Groups of stations ranges from 19.2^o C for Group A to 20.3^o C for Group D, indicating that there is no general tendency for temperatures to decrease southwards off the coast of Tanzania.

Hydrography of the Zanzibar Channel: The Zanzibar Channel separates the island of Zanzibar and Tanzania Mainland. The depth along the axis of the Channel decreases from over 500 at the southern entrance to about 30 m in latitude 6^o 15´ S and then increases again northwards to more than 300 m at the northern entrance. Along both sides of the Channel, particularly the eastern side, and in the shallow section in the centre, are numerous coral reefs and islands. Flood streams enter the Zanzibar Channel from both the north and south whilst ebb streams flow out of both ends of the Channel. The maximum speeds were observed where the streams flow past the north–east corner of Zanzibar at between 2 and 4 hours before and 2 and 4 hours after H.W. at Zanzibar (Table 1). Where the streams meet – between latitudes 6^o 10´ and 6^o 15´ S – the tidal currents are very weak throughout the tidal cycle.

Currents and hydrographic conditions in the waters off Kunduchi:
The tracks followed by all of the drogues have been plotted on Fig.2. The predominant directions are parallel to the coastline but there is also tendency for displacement offshore which, if it is real, must indicate either on-shore transport in deeper layers or convergence in the flow in this region.

Between 1 hr. and 3 hr. after H.W. when the tide is ebbing the flow is southerly and south-easterly for all drogues except 6 and mean hourly speeds reach 0.9 knots for the second hour for drogues 1 and 3a. Between 3 hr. and 5 hr. after H.W. the flow begins to turn more easterly and speeds generally decrease, though drogues 2b and 6 have mean hourly speed of 0.6 knots; drogue 4 turns west and then north-north- west. Between 5 hr. after H.W. and 5 hr. before the next H.W. (i.e. over low water) the flow generally turns from eastwards to northwards; mean hourly speeds are generally low reaching a maximum of 0.5 knots for drogue 4. From 2 to 3 hr. before H.W. the flow is generally between north and north-west, parallel to the direction of the coastline and, whilst mean speeds do not generally exceed 0.5 knots, that for drogue 7a in the second hour is 0.9 knots. The flow continues in the same general direction between 3 hr. and 1 hr. before H.W. T o the north-west of Mbudya the drogues reach 0.5-0.6 knots in the first hour and drogue 7a has a mean speed of 0.8 knots in the first hour. Over high water, from 1 hr. before to 1 hr. after, the speeds decrease further; the flow for the drogues to the west and south-west of Mbudya reverses, but the drogues further to the north being tracked on later occasions showed no indication of southward flow during this period.

The water temperature measurements showed some evidence of diurnal warming at the surface on every occasion. This varied in magnitude, however, from less that 0.1^{o} C on occasion 5. Temperatures of more than $29.^{0}$ C were experienced in March and the temperatures decreased thereafter, having fallen to 25.3^{o} C when an additional observation was taken towards the end of July. The individual surface salinity values on each occasion all lay within ± 0.06% of the mean value for that occasion.

Hemed, I., 1987: Seasonal Variations in the Beach Configuration. In: Beach Erosion along Kunduchi Beach, North of Dar es Salaam. Report for National Environment Management Council by Beach Erosion Monitoring Committee, pp. 26-31.

Aim of study: This study aimed at finding seasonal variations of the configuration of the beach and the nearshore area.

Study area: The study area is situated north of Dar es Salaam and extends northwards from Msasani Bay for a distance of 17 km to Ras Kiromoni. In the study area the profiles were located on specific areas of interest to observe various changes due to the erosion and effectiveness of the measures taken to minimize it. The profiles (seven) were located at the American Club (Bahari Beach), Bahari Beach Hotel, between Rungwe Oceanic and Silversands Hotels, Boat house of Kunduchi Fisheries Institute, Kunduchi Beach Hotel, Africana Hotel and Msasani Beach.

Method: *Field measurements:* The method involved repeated observations of spot levels along fixed beach profiles. Observations were made during low tide and all the seven profiles were observed in the same period. The observed profiles consisted of a starting point permanently marked and situated close to the shoreline and a back orienting mark. Upon reaching the site a ranging pole was placed on the starting point and this together with the back orienting mark, established a line extending seaward. More ranging poles were placed on-line to establish it, and a tape with a zero on the starting point was extended along it. Chaining arrows and wooden pegs were then placed every 2m for the first 20m from the starting point and every 5m for the remaining 80m of the profile. Levelling then commenced from a nearby temporary benchmark

and spot heights of all marks placed including the starting point were measured using a level instrument and a levelling staff. Office work included reducing the observations to the benchmark and to obtain the spot levels. The spot levels of each mark from the shoreline were then plotted against time (months) so that the variations could be extracted. The time interval between observations was usually a fortnight.

Visual observations: As the results obtained from profiles were considered not representative of the whole area, visual observations were made by walking along the beach.

Results: From the observations, it was noted that the groins that were built along Bahari Beach, Rungwe Oceanic, Silver sands and Kunduchi Beach Hotels had been totally ineffective in stopping erosion. In contrast, it was perhaps enhancing the effect. It was also noted that in most places, the crest had by then moved far beyond the top end of the groynes, leaving them underwater during high tides so that they served no useful purpose and spoilt the beauty of the beach. However, the type of groynes that were built at Africana Beach Hotel and their way of alignment seemed to be effective. The results showed a net increase in the levels implying that accretion of sand along the beach was taking place. The erosion that was taking place along Msasani Beach was not as severe as that observed in other beach hotels. The factors that caused erosion at this site were considered to probably differ from those that were acting along the beach hotels.

Conclusion: From the field observations and analysis of data the following conclusions can be drawn: The groynes built along Bahari Beach, Rungwe Oceanic, Silver sands and Kunduchi Beach, have been totally ineffective in stopping the erosion and in fact might be enhancing the effect. Since in most places the crest has by now moved far beyond the top end of the groynes, leaving them under water during high tides, they serve no useful purpose and spoil the beauty of the beach. They should either be removed or rebuilt following proper specifications. The erosion taking place along Msasani beach is not as severe as that taking place along the beach hotels. It could be that the factors causing this erosion are different to those acting along the beach hotels. It is recommended that observations should be stopped for the present study and the profile and the profile be moved to a new location. Large variations on the spot levels are observed only on the first 40m or so from the crest on most of the profiles with points farther down showing little or no variation at all. It is recommended that the profile should be shortened to about 50m and the interval reduced to 2m throughout the profile to make them more sensitive. The profiling should continue for at least another five years in order to reduce the inter-annual variability.

Kaaya, C.Z. and Boenigk, W. 1986: Sedimentological and geomorphological studies on the Pleistocene Tanga terrace north of Dar es Salaam. Zeitschrift fur Geomorphologie, N.F. 30 (3): 303 – 316.

Aim of study: Analysing the sediments and morphology of the Tanga terrace with the aim establishing the mode of sedimentation in relation to terrace formation for a 15 km long strip north of Dar es Salaam.

Study area: The area of investigation is situated between the rivers Mbezi (to the south) and Nyakasangwe (to the north).

Method: Geomorphic analysis was pursued by studying stereoscopically aerial photographs with a scale of 1:12.500. Altitudes were obtained from topographic maps, scale 1:50.000**.** The limits of the Tanga terrace are defined to the west by a steep 50 m high backslope, probably faulted in the

nothern part with a less steep backslope to the south. The eastern limit is defined by the discontinuous backslope of the lower Mtoni terrace. Where this backslope is missing, the terrace limit is defined by a change of lithology to beach ridge sands and salt marshes belonging to the Mtoni terrace. Grain size analysis was done using the methods after Müller et al. (1967), Folk (1974) and Carver (1971). Of the 42 samples analysed, the clay-free loose sands were dry sieved and clayey sands were wet sieved using a whole phi interval from –2 phi to 4 phi. Cumulative weight percentages were calculated for each grain size fraction and represented graphically. Furthermore, statistical graphic parameters were calculated (Folk and Ward, 1957) and plotted on bivariate diagrams in order to determine the environment of deposition. Heavy minerals were separated from light minerals using bromoform following the method of Carver (1971) and Boenigk (1983). Clay fractions from 15 samples were analysed for clay minerals using a Phillips-Müller Micro III X-ray diffractometer. Th/U – datings were carried out by R. Hausmann (Cologne) on samples of reef limestones from Bahari Beach Hotel (0 – 8 m above sea level), the Kunduchi quarries (35m – 40m above sea level) and Wazo Hill (90m above sea level).

Results: *Geomorphology:* The width of the terrace varies from 375 m to 3.5 km. It lies between 8 m and 40 m above sea level and displays a fairly uniform relief and an easterly slope of less than 3%. Parallel to the coast, morphological steps occur on the terrace. These steps were interpreted as either tiny faulty steps or coast-parallel stream valleys with an asymmetrical cross section (Alexander, 1968). However, the latter is in contrast to the easterly flow of the streams in this area.

Geology of the area: The terrace consists of loose sands to clayey sands with a thickness of 6 m to slightly more than 15 m. Underlying these sediments are the relatively more consolidated clay-bound sands also form the higher Inland Plateau to the west. Reef limestone underlie the loose sediments in some places and an outcrop occurs north of Bahari Beach Hotel. Surface sediments display a W – E variation.

Sediment distribution: The shape of the cumulative frequency curves approximate closely to fluviate curves of Visher (1969). The cumulative frequency curves show a well developed saltation population representing 40% - 96% of the whole population. The coarse truncation points are normally between 3 phi and 4 phi. The traction population represents 10% - 40% of the whole distribution in most of the samples. Suspension population represents 0.5% - 30% of the whole population except for the clayey upper parts of the cyclothems. Mean grain sizes in the six cyclothems range from 0.1 phi to 5.35 phi, i.e. from grain sand to medium grained silt. The variation with a cyclothem reflects the fining up pattern which corresponds to deposition under high to low energy regimes. Standard deviation values in most of the samples range from 1.09 to 3.59, i.e. from poorly sorted to moderately sorted. Most of the values fall within a sorting range of river sediments, i.e. from 0.40 to 2.5 (Folk, 1974). The few samples with a better degree of sorting were from unconformities where reworking has probably taken place. Inclusive graphic skewness values for 84% of the samples are between 0.05 and 1.81 i.e. nearly symmetrically skewed to strongly positively skewed. 26% of the samples have values between 0.05 and 0.96, i.e. nearly symmetrically skewed to strongly negatively skewed. The skewness indicate a general dominance of the fine grained material. Transformed graphic curtosis KG´ given by KG´ = KG/(1+KG) for the samples analysed, ranges from 0.367 to 0.603 which means the distribution is from very platykurtic to leptokurtic.

Heavy minerals: the compositonal spectrum of the heavy minerals in all samples is invariably uniform. It comprises opaque minerals, epidote, kyanite, garnet, zircon, rutile, hornblende, pyroxenes, sillimanite, tourmaline, andalusite and staurolite. The total weight percentage of the

heavy minerals in the sediments varies between 0.2% to 4% except for some local enrichment on the riverbeds.

Clay minerals: In all samples, montmorillonite and illite are the dominant minerals. Kaolinite occurs with a very small 001 peak. The abundance of montmorillonite in the sediments suggests magnesium and calcium rich igneous or metamorphic source rocks (Folk, 1974), which in this case points to Usagaran metamorphic rocks. It also indicates a generation under alkaline conditions with poor drainage. These conditions inhibit the formation of Kaolinite. Illite seems to have been derived from the older shales and mudstones.

Th/U – datings: The results obtained show that the data of all investigated reef limestone are beyond 300,000 years. This means that the carbonates due to their age aren't suitable for this dating method. Concerning their age it can only be said that they are probably Lower Pleistocene. Investigations carried out on carbonates occurring at the same elevation as the Tanga and Mtoni terrace have shown that the carbonates are much older and do not belong to this terrace formation.

Morphogenesis of the area: The oldest sediments in the area are the clay-bound sands which underlie the Coastal Plain and form the Inland Plateau to the west. They are fluviatile deposits formed in a fan-out delta in Upper Miocene to Pliocene time (Moore, 1963). After a long period of erosion and peneplanation the sea transgressed over the area depositing reef limestones believed to be of Lower Pleistocene for the data obtained by Th/U – dating indicated an age beyond 300,000 years.

Uplift and/or sea regression led to the emergence of the limestones and the area was subjected to intensive weathering and erosion which removed all marine clastic sediments. Coastal uplift was followed by faulting and warping along the eastern edge of the Inland Plateau. Subsequently the area was under fluvial sedimentation. The cyclic sedimentation sequence characterised by fining-up pattern, indicate point bar deposits in an intermittently subsiding area relative to the provenance, i.e. (Inland Plateau), coupled with relatively rising sea level. Continued relative sea level rise resulted into incursion of the sea over the area. The absence of marine clastics and the presence of miniature morphological steps suggest that the net effect of the incursion was erosion. Each morphological step is corresponding to a stand –still in which regression commenced before an equilibrium between erosion and deposition was established. Marine molluscs on the surface of the terrace document the incursion of the sea.

Conclusion: It is suggested that the Tanga terrace immediately north of Dar es Salaam was shaped by down-warping and down-faulting along a line just behind the ancient shoreline. Intermittent subsidence of the area relative to the Inland Plateau, coupled with abundant sediments from the latter and probably a relative sea level rise resulted into fluviatile cyclic sedimentation pattern in the area. Other areas within the terrace in the northeast coast of Tanzania consist of different types of deposit, which reflects varied conditions associated with terrace history. Appreciation of the history for the whole terrace will require in addition to systematic geomorphologic and sedimentological research work and reliable radiometric dates.

Kaaya, C., 1996: Coastal Erosion Problem in Tanzania. Session 1.06, *Zanzibar Environmental Study Series No. 20*. Commission for Lands and Environment, Zanzibar.

Aim of study: This paper discussed on erosion of the Tanzanian Mainland coastline, causes of beach erosion and protection measures, with concentration being made on areas that were most affected.

Study area: The entire coastline of Tanzania Mainland and Zanzibar.

Results: Shorelines that were considered to suffer most from erosion were those with loose sediments (Holocene beach terrace, sand spit, sandbank, and mangrove shorelines). On the Tanzania Mainland coastline, the most affected areas were Mtwara (Mikindani area), Lindi, Kilwa (Kilwa Kivinje and Kilwa Kisiwani), several areas along the Dar es Salaam-Bagamoyo coastline and several localities in Tanga. In Zanzibar, several localities in the eastern and western coasts of Pemba and Unguja Islands were reported to experience erosion. With the exception of Mkoani (Pemba) and Maruhubi (Unguja), the erosion in Zanzibar was attributed to natural processes. Causes of beach erosion due to natural processes were mentioned as sea level rise, tectonics and increase of stormy events. However, none of these factors had been proved "beyond reasonable doubts". Anthropogenic causes were due to extraction of sand along streambeds, dynamite fishing and construction of civil structures in the coastal zone.

Conclusion: Various measures were taken to curb erosion problems. They included construction of groynes and of sea walls. In Dar es Salaam, groynes were constructed perpendicular to the shoreline in front of three large hotels in Kunduchi area. The groynes were effective in trapping sand for only a short while, but they were later found to be ineffective. They were either both laterally and vertically too short or that they were not optimally spaced. A rock-cement wall was constructed along Ocean Road between the State House and Aga-Khan hospital in Dar es Salaam. This wall was held for a number of years but there was an undercutting at some places.

Linden, O and Lundin, C.G., (eds.) , 1996: Proceedings of the National Workshop on Integrated Coastal Zone Management in Tanzania.

Aim of the Workshop: To increase awareness of the need for coastal management at political and executive level in the countries of the region through seminars and workshops, where policy-makers, heads of governmental agencies and others can meet and discuss the issues at stake.

Study area: The whole coastal zone of Tanzania.

Method: Environmental issues related to the coastal zone in Tanzania are presented in three broad areas: resource degradation, pollution and fisheries depletion. The issues, causes and possible actions to address these problems re included in the sections with recommendations for action.

Results: *Coastal and Marine Resource Degradation:* Coastal and marine resources degradation is a result of many human activities such as agriculture, forestry, urbanisation, fishing and tourism. The activities result in coastal erosion, physical destruction of mangroves, beaches, sea-grass beds and reefs, biodiversity loss, land degradation and depletion of fish stocks. Agricultural run-off and fishing appears to be particularly important contributors to coastal degradation in Tanzania. Rural poverty is increasingly pushing people toward unsustainable farming on fragile land. In the Rufiji delta and to a lesser extent in Pangani, Bagamoyo, Kisarawe, Kilwa and Lindi, clearing of mangroves for rice cultivation is often done on a seven-year cycle, from clearing to time of abandoning. Fishermen often use destructive techniques such as explosives and small mesh nets, which destroy sensitive habitats and catch juvenile fish. In Tanga, up to 95% of all coral reefs have been destroyed by destructive fishing practices. Tourism development without

proper planning destroys habitats during construction, and unmanaged tourism damages reefs and has a negative impact on local people. The institutional capacity and legal framework for integrated coastal zone management is clearly inadequate in Tanzania. Sectoral policies fail to take into account inter-relationships among resources. For example, siltation of rivers like the Rufiji and Pangani are caused by agriculture and energy policies, but affect mangroves and coral reefs further offshore. People cut mangroves for fuel-wood, boiling brine for salt production and agriculture, particularly in Tanga, Bagamoyo and Rufiji. The loss in mangroves leads to disturbances in the ecosystem, degradation of fisheries, increased sedimentation on reefs and damage caused by flooding.

Marine Pollution: Marine pollution in Tanzania is currently a localised problem primarily affecting the coastal cities, urban settlers and the international shipping lane. Land-sources of agricultural pollution, sewage and industrial contaminants contribute to degradation of the water quality in the coastal zone. Sewage is the most widespread and serious source of pollution. Only 15% of Dar es Salaam residents are connected to the sewage system and most of the collected sewage is discharged untreated in the harbour. Industrial discharges are primarily located in the four regional towns of Dar es Salaam, Tanga, Lindi and Mtwara. Sources of pollution range from food processing (releasing waste with high BOD), fertiliser industry (gypsum and phosphates), textile (dyes and strong alkalis), power generation (oil and sulphur), metal industries (heavy metals) and petroleum industries (discharge oils and tars) to soap and cleaning manufacturers (detergents). This pollution is the result of inappropriate and inefficient technology and policy failures, in the form of weak enforcement of existing regulations and standards. Marine based sources pollution include tanker discharges and non-tanker bilge discharges that eventually end up in Tanzanian coastal waters and on beaches. The capacity to deal with oil spills in the country is very limited and insufficient, and the existing contingency planning is therefore theoretical only.

Coastal Fisheries Depletion: Over-fishing is taking place in the near coastal zone along most of Tanzania, particularly in the regions of Zanzibar, Tanga, and Dar es Salaam. Most of the degradation of the coastal environment is caused by destructive fishing methods.

Recommendations: *Agriculture and Forestry:* The intensification of agriculture that has taken place in the northern part of Tanzania coast and on the islands is now spreading to the southern part of the coast. In order to develop sustainable production systems in coastal agriculture, the following measures should be taken: Promotion of soil conservation through the adoption of better farming methods. This includes avoiding intensive agriculture in sensitive areas such as hill slopes and on riverbanks. The use of tree crops and crops that require less fertiliser and pesticide, discourage shift cultivation, reduce subsidies that promote excessive and inefficient use of fertilisers and pesticides and avoid irrigation that withdraws ground- water to the extent that the water table decreases. Introduce mangrove property rights or tenure systems for coastal people.

Beach Erosion: Promote education and scientific evaluation of the impact of erosion on beaches and coastal developments should be promoted. Erosion and flooding should be prevented by applying low cost and low technology measures. Re-establish the 200-metre buffer zone from the high water mark and where possible a phased disengagement within the 200-m buffer zone should be considered. Discourage current practices of permitting exceptions to existing rules. This practice leads to undermining coastal policies as well as government credibility.

Biodiversity Conservation: Studies of different species and ecosystems are needed to increase the knowledge of their occurrence, distribution, usage and management needs before more of them are lost.

Local communities should be involved in biodiversity conservation projects Biodiversity conservation projects should include habitat restoration, species rehabilitation and establishment of marine protected areas, particularly the less accessible areas like Mafia Island, Latham and some parts of Zanzibar. Multiple use should be developed, with core areas with a strict conservation and buffer zones where limited fishing and other traditional activities are allowed.

Pollution Control: Develop oil spill contingency plans based on oil spill trajectory predictions and sensitivity mapping of vulnerable areas for the entire coast of Tanzania. Create and train response network for clean up operations. Tanzania should ratify existing conventions like MAR-POL and others providing protection and assistance when marine pollution occurs. To control the sewage pollution, investment in low cost sewage collection and treatment facilities for local communities should be made. Pit latrines and septic tanks should not be used in coastal areas with a high water table. Standards and regulations for effluents and receiving bodies should be imposed and enforced. Incentives for modernising plants and adopting less polluting particles, including equipment for pollution control should be given. When privatised the new owner should be required to ensure improvements in pollution control.

Fisheries: Influx of new people in the sector must be controlled by introducing tradable and non-tradable permits. Promote alternative activities such as mariculture, salt production, mangrove silviculture or even game-fishing. A fisheries management plan should be developed in co-ordination with ICZM. Regulations on fishing activities among fishermen such as those regarding mesh size, total catch, minimum length, closed seasons as well as the banning of destructive methods such as dynamite fishing must be strictly enforced. Systematic research on the ecology of the commercially important stocks available should be carried out.

Tourism: Low volume/high value tourism and eco-tourism should be promoted to give a better long-term economic return to the country. A national policy clearly spelling the limits for tourism development should be developed. Regulations of tourism development in terms of wastewater treatment and setbacks from the beach should be enforced.

Mahongo, S.B., 1999: The Tanzanian sea level network: Report submitted to IOC's Regional Committee for Co-operative Investigations in the North and Central Western Indian Ocean (IOCINCWIO), Nairobi, 16p + Appendices.

Aim of study: This report was prepared for the Western Indian Ocean Project within the framework of IOC-Sida-Flinders Marine Science Programme, and in response to recommendations that were put forward by IOCINCWIO-IV.

Study area: The report thus described the status of sea level observations and related activities in Tanzania. A compilation of some relevant oceanographic and meteorological data was also made in the study.

Method: Information was gathered from various sources, including electronic internet surfing in the websites of international data centres such as GLOSS (Global Sea Level Observing System), WOCE (World Ocean Circulation Experiment), UHSLC (University of Hawaii Sea Level Centre) and PSMSL (Permanent Service for Mean Sea Level). Visits were also made at the sea level recording stations in Dar es Salaam and Zanzibar while data on rainfall, humidity, cloud cover and wind speed near the tide gauge stations were collected from the Department of Meteorology in Dar es salaam.

Results: It was reported in this study that the Tanzanian sea level network consisted of two operational stations of Zanzibar and Dar es Salaam. Zanzibar had a satellite transmitting station linked to UHSLC while Dar es Salaam had a float gauge station utilizing analogue charts. There were also three non-operational stations in Tanga, Mtwara and Mkoani (Pemba). A table showing the availability of data from these stations was presented in a table. The report indicated also that local experts had rarely analysed data collected from the Tanzanian sea level stations. Most oceanographic works had been site-specific, utilising mainly pressure gauge data collected in the field. It was stated that, it would be of immense benefit if all the past data were analysed and interpretations made on the trend of sea level, and identification of any anomalies. A linkage of sea level rise to aspects such as coastal erosion was stated to be potentially one of the most useful applications of sea level data in Tanzania.

Conclusion: Finally, it was proposed that the three non-operational stations of Tanga, Mtwara and Mkoani be rehabilitated, and additional stations be considered for establishment at Chole Bay (Mafia Island), Lindi and Kilwa Masoko in future. It was also proposed that a single agency be commissioned to co-ordinate the activities of sea level stations in Tanzania which were being operated by different institutions.

Mushala, H. M., 1978: Coastal processes along Kunduchi Beach. *Journal of the Geographical Association of Tanzania,* 17: 41-73.

Aim of study: This study explored the factors that influenced coastal erosion, sediment transportation and deposition along Kunduchi beach. These factors were winds, wave action, tides, currents and the geology of the area. The study area had several tourist hotels, a fishing village and some national institutions. During the period of this study, parts of the beach were experiencing a severe retreat, which posed an immediate threat to the inhabitants of the area.

Study area: The study area is Kunduchi Beach.

Method: Examination of aerial photographs and casual observations and compilation of information from earlier studies. Investigations were carried out at six stations: Silver sands Hotel; off the Besaminco plant; Tegeta River mouth; Shipbuilding yard; Marine Biology Station, and; at Kunduchi Beach Hotel. Measurement of beach profiles was done using a method similar to that employed by Duyverman (1977), which involved measuring beach gradients using a clinometer attached to a Brunton compass.

Results: Results showed that erosion, sediment transportation and accretion were taking place simultaneously at varying rates with time and location along Kunduchi beach. The maximum rates of erosion recorded showed a loss between two consecutive profiles of 4m thickness over one month and the minimum was a vertical variation of about 0.2m over one month. Maximum accretion was indicated by a 2.2m gain between two consecutive profiles in a month's period, while the minimum sediment gain was about 1.0m within a similar period. During the months of July and August 1977, observations at Kunduchi revealed a dramatic disappearance of beach huts at Silversands Hotel, uprooting of some trees and exposure of root systems of others, together with an encroachment of the sea on the hotel premises. The rates at which the beach processes occurred had a direct linear relationship with changes in the monsoon winds. Severe erosion was observed during the Southeast monsoons in April while accretion normally took place at times of transition of wind direction of the monsoons (October/ November and February/March). Noted also was a net loss of sediment along the beach. This was revealed by the comparison of the figures on the seasonal changes along the measured profiles.

Conclusion: Several conservation measures were discussed in relation to the sea encroachment at Kunduchi. They were construction of groynes; a sea wall or breakwaters; injection of sand from other localities or the planting of deep-rooted vegetation. The ineffective use of sticks and inappropriately constructed groynes in front of Kunduchi Beach Hotel were also discussed. It was pointed out that, over a 20-year period, there had been a recession of more than 50m for both the Silversands Hotel and Kunduchi Beach Hotel sites. A further research of say 2-5 year duration or more was recommended in order to be able to note long-term and short-term seasonal variations over time.

Mushala, HM, 1983: Beach Processes and Coastal Landform Evolution around Dar es Salaam. In (JR Maine, P.O.J. Bwathondi and H.B. Pratap, eds.) *Proceedings of the Workshop on the Current State and Development of Marine Sciences in Tanzania*. Zanzibar, 2-8 April, 1982. pp. 55-65.

Aim of study: This paper attempted to relate the occurrence of various landforms with beach processes along the Kunduchi Beach stretch.

Study area: The study area comprised a coastal stretch in north of Dar es Salaam City from Mudumbwe River to Bahari Beach Hotel in Kunduchi. This is a sandy beach area bounded to the north and south by cliffs of raised Pleistocene coral platform.

Method: The study reviewed literature on the beach processes around Dar es Salaam, land use practices and described the coastal landform evolution along Kunduchi using topographic map sheets, aerial photos of the area, physical surveys on points where specific features had developed and through an examination of existing literature.

Results: It was reported that processes of erosion, sediment transport and accretion were common along the Kunduchi beach and its environs. The process had thus threatened a lot of public and private property along the shore.

Measures devised to combat the situation had unfortunately been directed only towards particular sites. As such, they had not arrested the problem. Over the previous few years, the intensity of beach erosion had shifted from Kunduchi Beach Hotel surroundings to the Africana Hotel, the Rungwe Oceanic Hotel and far south to the Kawe Club. Since longshore drift is not confined to small localities but to the entire expanse of the beach, erosion in one place therefore supports sedimentation in another and vice-versa. One of the measures taken to combat beach erosion in some of these sites, the report says, was the erection of groynes along the beach. At Kunduchi some groynes were constructed opposite the Kunduchi Beach Hotel, Africana and Silver sands Hotel, respectively. These groynes however, did not completely check beach erosion since they were confined to particular sites.

Conclusion: It was advised that conservation measures need concerted effort while integrated scientific studies would lead towards co-ordinated efforts in coastal development.

Mwaipopo, O.U., 1984: Dynamic response of the Tanzania coastal waters to the onset of the south-east monsoon.

Aim of study: To study the monsoonal response of a section of oceanic water in the northern part of the Indian Ocean. The prevailing winds in the area are S to SE monsoon (April – October), NE monsoon (November – March) and the East African Coastal Current with a speed up to 4 knots.

Study area: The oceanic water on the continental shelf bounded by the coastline of Tanzania and extending 10^o S to 5^o S. Islands of Zanzibar, Pemba, Mafia and numerous small islands and coral reefs are inclusive. The estimated continental shelf was narrow about 60-km. wide, depths range from a few metres near the coast to about 600 m at the shelf break. The shelf break was at 10 km. from the east of Zanzibar Island.

Method: This is a mathematical model. The study neglected the effect of the islands and coral reefs to the flow and assumed homogenous oceanic water with uniform depth. Linear theory was applied by neglecting the non-linear inertia terms appearing in the equations of motion. Theories of Johnson (1976), Manja (1978) and Johnson and Manja (1980) of shelf currents were applied. Secondary upwelling theories by Hill and Johnson (1974), Johnson and Killworth (1975), Johnson and Manja (1979) were applied. The ocean model consists of flat shelves with meridional boundaries at $x = 0$ and $x = 1$,, and shelf breaks at $x = a$ and $x = b$.

Results: The surface Ekman layer can be obtained by using equation W_o (x,y,0) = k.(curl (Y/f) where k = (0,0,1) is the vertical unit vector. This gives the value of the interior vertical velocity just below the Ekman layer and is called the Ekman suction condition or Ekman pumping. It is also a condition by which the shelf layer is matched with surface Ekaman layer. Interior flow is a flow in the oceanic region lying between two shelf breaks, at x = a and x = b. At shelf break the interior velocities have the following magnitudes $U = O(E^{1/3})$, $V= O(E^{1/6})$, $W = O(E^{1/3})$. Meridonal boundary layer is affected by frictional influence of the coastal boundary. It plays an important role in geophysical fluid dynamical flows.
Shelf solution as boundary layer region was selected. The width of a shelf is $O(E^{1/3})$ and the depth is $O(E^{1/6})$. The time scale has been chosen to be one week. A number different numerical solutions as been computed by applying two types of wind stresses for a monsoonal response of 16 weeks. The general picture of the wind data used shows very small variations in the wind speed along the study area and that after the onset of the southeast monsoon the winds reach maximum speed after one month. The wind stresses proposed therefore agree with these observations. The wind stress of due to southerly wind is represented by $\tau^y = (\xi\text{-}0.02)T^4\exp\{-(T\text{-}1.8\xi)\}$. It switches on at T = 0, increases gradually to a maximum value at T = 4 and there after decays to zero at $T \to \infty$. At the coast, at $\xi = 0$ the wind stress is approximately –0.1 dyne/cm^2 and the induced northward velocity is zero. At $\xi = -0.5$ (30 km from the coast) both the wind stress and the velocity have minimum values and for $\xi < -0.5$ they decay to zero as $\xi \to -\infty$. The wind stress changing from southerly to northerly winds is represented by $\tau^y = \{(24\xi - 0.3)/(1 - 2\xi)^2\}\exp\{-\pi T/8\}\sin(\pi T/8)$. It switches on at T = 0, grows to maximum value at T = 2 and thereafter oscillates slowly with time and vanishes as $T \to \infty$. The time lag is one week and the residual velocity is small. The direction of the induced northward velocity is the same as that of the applied wind stress. It changes from the northerly to southerly as the wind. The time lag for the velocity is about 3 weeks and residual velocity is large. The velocity does not always follow the direction of the wind, the velocity is always northerly.

Conclusion: The induced northward velocity decays to zero faster in shallow shelf than in a deep shelf after the applied wind stress has decayed to zero. The numerical results show that for a given wind stress the magnitudes of the induced northward velocity are greater in shallow shelf than in a deep shelf. The profiles of the wind stress and the induced northward velocity show that the induced longshore currents follow the direction of the winds in a shallow shelf. If wind reverses direction, the current may still be flowing in the same direction. The phenomenon can be compared with observation on East African coasts where the East African Coastal Current flowing northward throughout the year for both the SE and NE monsoon periods.

Mwaiseje, B. 1973. Some aspects of the ecology of sandy/muddy inter-tidal zone in the Dar es Salaam area

Aim of study: To give a general account of ecological factors, both physico-chemical and biological of the inter-tidal sandy/muddy habitat on the coast of Tanzania. Make a step towards understanding the ecology of tropical Indian Ocean shores. To make, in future, a basis of comparison in the event of pollution of the Tanzanian shores as was unpolluted at that time.

Study Area: The study area stretches 75 kilometres north of Dar es Salaam and 8 kilometres south. Detailed study and analysis was concentrated to a few selected sites within the stretch, which are Kunduchi Beach, Mbegani Beach, Ocean Road Beach and Mjimwema/Kendwa Beach. Mbegani is backed by a mangrove forest and a coral patch in front. Behind the mangrove forest the beach is narrow, sloping and predominantly muddy with shell components.

Kunduchi is more exposed than that of Mbegani though is protected by from strong open sea waves by the offshore islands of Bongoyo, Pangavini and Mbudya. It was the most used beach of all sites selected. There was a concentration of different institutions with interest in the sea (hotels, local fishing port for villagers, Kunduchi Fisheries Training Institute and the Kunduchi Marine Biological Station).

The transect was at Ocean Road beach were selected at the south of the sewage pipeline in front of the eastern gate of the State House. The beach during low water springs is very wide with a short steep upper sandy slope. From the harbour mouth, the beach extends northwards to the Msimbazi creek mouth, where the substrate is predominantly muddy with mangrove vegetation in the creek itself. At certain points, rocky cliffs back the beach. The beach is protected from the open sea by the Kigamboni headland, which has a mangrove forest on the shore facing ocean road beach. Human activities are confined to the sothern end of the beach near the ferry at the Banda Beach Swimming Club.

Mjimwema-Kendwa beach has very short sandy slopes with a very wide inter-tidal zone. The site was part of the long soft substrate beach that extends all the way from the mangrove forest of Kigamboni headland to south of Mboamaji village. The beach is sheltered by a line of discontinuous islands: Inner and Outer Sinda, Kendwa, Inner and Outer Makatumbe. Offshore, there is a coral reef.

Method: At each beach, a transect was chosen and the beach profile and tidal levels measured. An automatic level and a graduated pole were used for measuring beach profiles. To determine tidal levels: At Kunduchi: a graduated pole was placed at the extreme low water springs and the level of water recorded as well as time of reading. Tidal levels at all other beaches were determined from beach profiles during surveying. Tide tables for Dar es Salaam were also used. For substrate analysis, at every 10 metres interval samples of substratum were taken for texture and sand particles analysis and shape characterisation in the laboratory. Temperature variations of water were noted farther off from the shore. The beaches with hydrogen sulphide were easily identified by smell and colour. Every month 4– 6 samples of water in pools of poorly drained areas were taken for salinity determination and after every three months, interstitial water was taken from the low end of the steep slopes. Dissolved oxygen concentration in inter-tidal pools on both sandy and muddy areas was determined using an improvised syringe. All specimen or samples collected at specific tidal levels were taken alive to the laboratory for sorting and classification and then killed for tests. Other specimen were collected from the surface along the beaches and tested at the laboratory.

Results: Low tides below datum occurring during day-time was between 0900 hours and 1400 hours in February, March, August, September and October. Examination of beach profiles at Kunduchi and Ocean Road showed differences in slopes during spring and neap tides throughout the year. Physico –Chemical factors of sandy/muddy inter-tidal shores appeared to vary with the amount of exposure of the beach, location and time of the year. Sheltered shores appeared to have finer substrate particle size than exposed areas, steep sandy slopes had coarser particle size than flat muddy shores. Sheltered shores were richer in burrowing forms than exposed beaches; flat sandy/muddy zones contained the largest number of species and animal species changed with seasons. Flora and fauna distribution is influenced by three main factors: substrate particle size, underground water table and water level in inter-tidal pools and infra-littoral fringe. The epifauna were predominantly of gastropods and crabs, while infauna was mostly of polychaetes and bivalves. Pattern distribution of animals and plants in Dar es Salaam beaches was similar to other beaches that have been studied in tropical shores. The study serves as a baseline for any future work on the effects of pollution and /or natural environmental changes. An investigation of population density in facilitating comparisons with other beaches, as well as determining if and to what extent the ecology of the Dar es Salaam beaches is changing with time. An investigation of the relationship between the shores and the open sea would be worth pursuing.

Mwandosya, M., Nyenzi, B.S. and M. L. Luhanga, 1998: *The Assessment of Vulnerability and Adaptation to Climate Change Impacts in Tanzania.* The Centre for Energy, Environment, Science and Technology, Dar es Salaam, 235p.

Aim of Study: This book presents findings on vulnerability and adaptation to climate change impacts in Tanzania. The aim was to identify areas of potential vulnerability to climate change with implications on natural resources and ecosystems. Assessment of the impact of climate change in economic sectors of national development. Evaluation of policy options to reduce vulnerability to impacts of climate change. Analysis of the feasibility, viability and costs of the alternative options. Creation of awareness to the public on the impacts of climate change.

Study area: The entire coastline of Tanzania.

Method: In order to facilitate the study, the Tanzanian coastline was divided into three main sub-areas namely: Northern Coast, which included Tanga Region; Dar es Salaam and Coast regions, and; Southern Coast, which included Mtwara and Lindi regions.

Topographic maps of 2 m and 20 m contour intervals were used to estimate the loss of coastal area and infrastructure. This was done by considering first order approximations where the land was assumed to rise linearly from the sea level to the 2m and 20m contours and approximation of the 1m, and 0.5m contours and their respective area coverage, was made. The areas had an error of 5%. Another methodology was the engagement in fieldwork and estimation of losses. After videotaping, ground trips were made to representative coastal types. Land loss by erosion caused by a rise in sea level was estimated using the Bruun Rule (Bruun, 1962) as given by Hands (1983). Tide gauge records were not used as it was claimed that they only covered a short period, and with some data missing. Also, the trend that was indicated by these data was statistically insignificant. Consequently, the global sea level scenarios that had widely been used (IPCC, 1990) were adopted in this study. These scenarios of eustatic sea level rise were 0.5m and 1.0 and by the year per Century.

Results: The analytical approach (topographic maps) showed that in Tanga region, Moa was the most vulnerable coastal unit area while Kigombe was the least vulnerable. In Lindi and Mtwara, Nangurukuru was most vulnerable followed by Mnazi Bay while Lindi was the least vulnerable.

In Dar es Salaam and coast regions, Salale was the most vulnerable followed by Mbwera while Kawe was the least vulnerable. On the whole of the Tanzanian coastline, mangroves were the most vulnerable coastal resources and Dar es Salaam/coast area was the most vulnerable while Tanga was the least vulnerable.

Results of land loss estimates due to erosion in response to a 0.5m and 1.0m sea level rise scenarios showed that 247km^2 and 494 km^2 would be lost, respectively. The area that would be inundated for the Tanzanian coastline by a sea level rise of 1.0 was estimated to be 470 km^2. Tables showing the amounts of inundation for the various coastal ecosystems were given (Tables 3-7).

Nieuwolt, S. 1973. Breezes along the Tanzanian East Coast: Arch. Met. Geoph. Biokl., Ser. B, 21, 189 – 206 (1973)

Aim of study: To study The general circulation of the land and sea breezes along the Tanzanian East Coast. The effects of these winds, especially the sea breeze, on the physiological temperature conditions near the coast.

Study Area: Dar es Salaam in the main study area because of its central location along the Tanzanian coast. Wind records are also available for Tanga, Lindi and Mtwara. However, these records are limited to the period from 0600 to 1800 hrs local time.

Method: Analysis of a series of wind observations, taken at three-hourly intervals during 4 years.

Results: *Dar es Salaam*: Data for January indicate that the conditions during the period from about December to February. During this time the winds at the 850 mb level, which is around 1500 m above sea level, and therefore largely free from surface influences, are generally between north and north-east. This is the northeast monsoon, locally known as “kasikazi”. As the coastline near Dar es Salaam runs approximately in a direction from northwest to southeast, these winds provide a landward trend to winds near the surface. During the day this trend is reinforced by the sea breeze effect, which reaches its maximum during the late afternoon. During the night the same winds are from the same direction as the general circulation, though the land breeze effects weaken them, as indicated by the large number of calms. A real land breeze hardly develops this season. From March to May the general circulation is weak and winds are often of variable direction. During April weak southerly winds prevail at the 850 mb level. These conditions appear quite favourable for the development of both land and sea breezes, as the general wind direction is almost parallel to the coastline near Dar es Salaam. During the night a land breeze appears, reaching a maximum around 0900 hrs. But during the days no sea breeze develops, southerly land winds continue to prevail and actually increase speed and frequency during the afternoon. Presumably the sea breeze develops during sunny days, and these are relatively rare in April, the main rainy month at Dar es Salaam. July conditions illustrate the period from June to September, when the general circulation is manly from the south, locally known as “kuzi”. A sea breeze does not develop during this period and the daily maximum temperatures are around 29^o C, which is apparently not enough to produce a clear sea breeze effect against the general southerly winds. As in April the southerly winds increase in strength during the afternoon. From the end of September to November, the general circulation is again rather weak. The winds at 1500 m are mainly from the south-east during October. During this season a clear sea breeze develops regularly and its direction is mainly from east and north-east. But during the nights calms prevail, with as much as 94% of all observations at 0600 hrs showing wind speeds below 1 knot. No land breeze occurs during these two months.

Wind at Other Coastal Stations (Tanga, Lindi and Mtwara): The relative frequencies from directions within 45 degrees of perpendicularity to the coastline at these stations show many similarities with conditions at Dar es Salaam. The differences can largely be attributed to different exposures of the coast in relation to the prevalent winds of the general circulation and to distances from the coast. There seems to be a general tendency for the period with prevailing sea breezes to decrease in length from north to south along the coast, and for the land breezes to increase in the same direction. However, the relatively strong contrasts between Lindi and Mtwara, which are only 64 km apart, indicate that local factors possibly are decisive and that a comparison between coastal station does not produce reliable conclusions.

Conclusion: At the Tanzanian east coast the prevailing winds of the general circulation exhibit seasonal changes in direction in a kind of monsoon system. The sea and land breezes, which are limited here to diurnal modifications of the general winds, therefore also vary with seasons. During the northeast monsoon season the main trend prevails most of the time, while in the southeast monsoon season the main trend is from the land. Only during the intermediate periods between the the monsoons a diurnal reversal of the sea and land breezes develops regularly. The effects of these winds, especially the sea breeze, on physiological temperature conditions near the coast are of considerable importance. A decrease of the physiological temperature is produced by the advection of cool air, and a further reduction of thermal stress is provided by the improved air ventilation related to the higher wind velocities of the breezes.

Nyandwi, N., 1996: Individual problem areas related to man's influence. *Zanzibar Environmental Study Series No. 20,* Session 2.04. Commission for Lands and Environment, Zanzibar.

Aim of study: To investigate human activities including removal of beach material, removal of protection against wave breaking, and obstruction of sediment supply, that contributed to beach erosion problems on Zanzibar.

Study area: Zanzibar (Unguja and Pemba) beaches.

Method: The study presented information from observations made during a fieldwork by a coastal erosion study team and those made and compiled by the Zanzibar Department of Environment in 1996. The paper was presented at the National Workshop on Coastal Erosion that was held in Zanzibar, 11-12 April 1996.

Results: Beach structures that were considered to contribute to erosion in Zanzibar were the Mkoani jetty, Mtoni jetty, Jambiani seawall and Maruhubi seawall. At Mkoani, the erection of the jetty had led to concentration of wave energy leading to accelerated erosion. The jetty-like structure at Mtoni impeded longshore sand supply leading to intensive erosion at Maruhubi. Although the Jambiani seawall had been effective in protecting a section of a beach from erosion, the effect had shifted to the northern end of the wall where loss of land amounted to about 10m in width in 19 years since 1977. At Maruhubi, erosion at the ends of the seawall was reported to continue unabated. The effect of sand mining was also mentioned. At Unguja Ukuu, a 5m wide coastal strip had been lost due to this activity in the previous two years. Trees were also being uprooted in the process. A similar process was expected at Chuini where sand extraction was also taking place. The cutting of mangroves and its effect on erosion was also discussed. At Mbweni beach, the area was experiencing serious erosion. Mangroves usually acted as buffer against wave battering and their removal aggravated the problem. Lastly, erosion was also linked to poor planning. There was a trend of erecting beach hotels and residential houses directly on or

very close to the beaches. The hotels at Uroa, Chwaka and the bungalows at Uroa were cited as examples.

Conclusion: Sand extraction from the beach should be stopped and alternative sources from offshore or on land should be explored. Mangrove cutting for any purpose should be discouraged and controlled more effectively. Construction of structures on beaches must be discouraged and if deemed necessary should be done professionally based on both stability criteria and effects on the environment. Construction of expensive properties on or too close to the beaches should be discouraged. Most of the complaints and awareness of the problem is because property is threatened and not because one sympathises with the land being eaten up by the sea.

Nzali, L.M., Johnstone, R.W. and Mgaya, Y.D. 1998: Factors affecting Scleractinian Coral Recruitment on a Nearshore Reef in Tanzania. Ambio Vol. 27, No. 8, Dec. 1998

Aim of study: To examine recruitment patterns for hard corals on a reef that has areas subjected to different levels of dynamite fishing and sedimentation. To assess factors such as dynamite fishing, sedimentation rate, temperature, competition for space with other organisms, rainfall and water transparency how they might affect coral recruitment to the reef at Taa, northern Tanzania.

Study area: The study was carried out at Taa Reef along the coast of Tanga Region.

Method: *Charcterisation of the coral community at each site:* Coral cover and community composition were determined using the line intercept transect method as described by English and Wilkinson (1994). The community was characterised by using growth-form categories, which provided morphological description of the reef community. These categories were recorded for each of ten transects of 20 m length carried out at each site. All transect locations were chosen randomly. The data obtained from transects was summarised and used to calculate the percentage cover and frequency of occurrence of each growth-form.

Recruitment rates: Recruitment rates were determined using terracota tiles. The tiles were used because of the large number of replicates required within the study, and because of local concerns about the destruction of corals. The clay tiles had a size of 13cm x13 cm and were approximately 8mm to 10 mm thick. The tiles were attached to racks made of reinforced steel raised approximately 20 cm above the seabed. Tiles were fixed onto the racks in pairs, separated by a length of approximately one centimetre and placed with an angle of 45^{o} to the horizontal. Three racks were established at each site, and each rack contained 18 tiles; giving a total of 54 tiles per site 108 tiles for the entire study. Racks were distributed randomly over the reef at each site with a high depth of about 5 m. After two months 14 tiles were retrieved from each site and these were replaced by the same number of new tile in each rack. After retrieval, all tiles were washed and rinsed with fresh water, and then dried in the sun. They were then wrapped with soft paper and stored for later examination in the laboratory. Coral recruits were identified and counted using a dissecting microscope and identification key constructed by English and Wilkinson (1994). The number of recruits was standardised per unit area and tabulated together with genus, distribution and abundance of each type of coral recruit.

Seawater temperature and water transparency: Temperature readings were taken in surface waters at a depth of 30 cm, and in bottom water at approximately 20 cm from the benthos. These measurements were taken at least four times a month (once per week), between 11.30 hrs and 12.00 hrs on each occasion. Measurement of water transparency was done by using a secchi disc attached to weighted rope that was marked at 10cm intervals. All measurements were conducted on the same day and at the same time as temperature measurements.

Sedimentation rates determination: Sedimentation rates were determined using the method describe by English and Wilkinson (1994). The sediment traps used were straight-sided plastic jars approximately 19 cm high and 6 cm diameter. The open jar was secured to a metal post at 20 cm above the substrate and 3 traps were paled randomly at each site. After 4 to 5 days, jars were kept under water and brought to the laboratory for analysis. In the laboratory, the contents of each trap were filter through a pre- weighed Whatman filter paper and each sample was rinsed several times by gently running approximately 200 ml of distilled water through the filter to remove the salt from the sediment. The same procedure was used on duplicate bank filters to control for any contamination form the filter. Both the filtered sediment and blank filters were dried in an oven at 60^{o} C to constant weight. Sedimentation rates were calculated as mg of sediment per square centimetre per day.

Results: *Levels of recruitment:* A significant difference was observed in mean recruitment densities between site so f 12 months sampling period ($0.005 < p < 0.01$) and both sites showed maximum recruitment during April. The mean number of recruits at each site was 374 and 190 per square metre for sites 1 and 2 respectively. The highest recruitment was observed at site 1, which also had the highest percentage cover of living corals. It was also observed that there was no strong or statistically significant correlation between recruitment and temperature, rainfall, water transparency or sedimentation when considered over the entire 12 months investigation. Notably, however, the period of maximum recruitment in April coincided with the highest yearly temperatures (March to April)as well as the period of lowest sedimentation rates, and of highest rainfall.

Distribution of recruitment: No statistically significant difference was observed in the mean density of recruits within sites when comparing the distribution of recruits between racks and tiles. However, there was a significant difference in the mean density of coral recruits between sites with site 1 having the highest level of recruitment. I addition to site differences, there was also a significant difference between the level of recruitment observed on the upper and lower surfaces of the tiles at both sites. The data collected from both sites showed a higher number of recruits on the under surface of the tiles compared to the upper surface.

Sedimentation rates: Between sites high sedimentation occurred in periods of low water transparency. There was no significant difference in mean sedimentation rates over the 12-month study with mean rates of 77.1 ± 205 mg cm^{-2} d^{-1} at site 1, and 18.9 ± 25.7 mg cm^{-2} d^{-1} at site 2. The large standard deviation at site 1 is due to the very high peak in January. Without this peak, the mean was 20.4 ± 17.1 mg cm^{-2} d^{-1} at this site.

Conclusion: Results from the study show no significant correlation between recruitment and temperature or rainfall, over the 12-month study period. However, the highest recruitment occurred during the period of highest temperature and rainfall. It is difficult to ascertain which factor dominates. The current lack of more definitive experiment work in this field hinders firm conclusions. One of the aspects of distribution of coral recruits observed in this study was the preference of recruits for the underside of the settling plates. This phenomenon has been recorded elsewhere and is likely to be due to the combination of light intensity, sedimentation and competition for space that the new recruits have to cope with on the respective upper and lower surfaces. Coral recruitment may also be affected by a number of other factors such as availability of seed population that supply recruiting planula, the stability of the substratum available for settling, the degree of sedimentation occurring in the area. A favourable level of colonisation by other organisms, which does not hinder settlement and metamorphosis by the recruiting planula may affect the process. The role of seed populations in coral recruitment is seen at Taa Reef. The

two study sites differed significantly in the percentage cover of living coral. Site 2, which had been subject to extensive dynamite fishing, had large areas of coral rubble, which were nearly devoid of living corals. Coral recruitment was lower at site 2 throughout the year. In the light of the above discussion, it may appear that the major impact of dynamite fishing has had on coral recruitment at Taa Reef is via the removal of viable seed populations. Taa Reef may represent a good location for the application of remedial measures such as coral transplantation. However, in the light of the rapidly expanding anthropogenic influences from nearby Tanga town (approx. 10 km away) there is a strong potential for the reef to develop into a different type of ecosystem.

Pattantyus, E., 1988: Beach erosion in the northern Dar es Salaam area: A review. Institute of Resource Assessment *Research Report No. 75 (New Series), University of Dar es Salaam.*

Aim of Study: The aim of the paper is to give a review on the beach erosion problem in the particular area, on how it came about and on how to overcome it. It is intended to contribute to solution of the problem by means of a pragmatic method that can provide us with a starting point to measures to be taken in order to improve the situation.

Study area: The built up area threatened by erosion situated 18 km north of the City having a coastal length of 5 km.

Method: It is mainly a review of information on the recent situation, geographical setting (e.g. Temple (1970) and Alexander (1966, 1968, 1969)), coastal exposure (e.g. Mushala (1978), Bertlin and Partners (1977)), shore dynamics (e.g. Schiller and Bryceson (1978), previous studies and measures taken to control erosion.

Results and Conclusion: Protective measures taken so far have not fulfilled expectations, the erosion has not been arrested, it is still going on. The proposal to modify the construction, notably to remove every second groyne and to use the boulders to strengthen the remaining ones both upwards and downwards, have not been carried out so far. Large-scale excavation of sand and gravel is being carried out in the catchment area of the respective coastal sector. The excavation has extensively damaged the banks of the Mbezi river and destroyed large portions of farmland depended on by about 300 families. At the same time erosion is threatening buildings, and the bridge connecting the beach hotels with the city centre along Bagamoyo road can collapse upon the recurrence of heavy downpour. Stopping sand excavation in the respective area appears to be a promising idea, a powerful contribution to arresting the beach erosion.

Pethick, J. and T. Spencer, 1990: Mangrove response to sea level rise: The Rufiji delta, Tanzania. Frontier – Tanzania Interim Report, Society for Environmental Exploration/University of Dar es salaam, 7p.

Aim of study: This research project attempted to see whether a number of conclusions drawn on temperate salt marsh systems suffering from accelerated sea level rise due to tectonic changes could also apply to the tropical mangrove system. The intention was to ascertain whether the mangrove system works in the same way as the temperate salt mash and then to produce a detailed management plan for such areas that would allow the mangrove to maintain itself despite increased sea levels. The study area was shown in a map.

The research project commenced in 1989 with a series of baseline surveys. Island margins were mapped using compass/pace and levelling methods, with particular regard to evidence for former mangrove colonisation to establish the change in elevation between former mangrove surfaces and present inter-tidal mudflats. Standard UNESCO point-centred quadrat methods were used to

determine mangrove composition and structure at selected sample sites and along transects within the swamps. Measurement of tree diameter, height and spacing were made to determine relative density, dominance and frequency of mangrove tree species. Some sediment sampling was also undertaken beneath representative forest types. Several surveys were initiated with the intention of repetitive measurements at yearly intervals over the next three years. These were mapping of the horizontal extent of the mangrove and its associated mudflat complex using theodolite and air photographs, and; measuring of surface elevation using standard levelling techniques. A number of measurement systems were also set up in 1989 to provide further data over the next three years. These were accretion/erosion measurements; tidal measurements; ecosystem function, and; wave energy measurements.

Preliminary observations indicated that erosion was extremely rapid along the sea coastline of the delta and a strip up to 1 km wide of mangrove vegetation appeared to have been lost since the official survey in 1966. If this was a true reflection of the erosion rate along the Rufiji delta front then there was cause for serious concern. An erosion rate of 40m/year was extremely rapid on a world scale. However, it was stressed that further results were necessary before any such conclusions could be firmly stated.

The preliminary results of accretion plate measurements supported a hypothesis that vertical accretion was taking place within the mangrove area at the same time that horizontal erosion was removing the outer seaward margin. Accretion rates of 2 cm per year were extrapolated from these results, but again caution was given in interpreting such short-term measurements.

On the deltaic peninsulas of Simba Uranga and Kiomboni, the mangrove erosion had been concentrated in the Northwest, while the south-eastern extremity on Simba Uranga was accumulating sandy beach deposits, and on Kiomboni had new mangrove colonisation. Each of these peninsulas had a coastline which was oriented Northwest to Southeast. It was suggested from this distribution that the coastline of these two peninsulas so far studied were becoming reoriented. They were tending towards a more west-east orientation rather than their present Northwest to Southeast orientation. Reasons for this reorientation were difficult to define.

Conclusion: Preliminary conclusions drawn were thus the long term development of the profile translation both upward and landward and the effect of the reorientation of the shoreline must depend on the rates of global warming and its associated sea level rise. A sensible management plan proposed to ensure the continued survival of the mangrove environment was to allow natural processes of coastline adjustment to changing sea level to continue without human interference.

Quennel, A.M., McKinlay, A.C.M. and W.G. Aitken. 1956 & 1960: Summary of the Geology of Tanganyika.

Aim of study: To outline the geology of Tanganyika in a more detailed manner. This was initiated by the necessity to prepare entries for the new edition of Laxique Stratigraphique International. The previous account has had to be drastically revised and enlarged. To revise the concept of basement, and to give consideration to the position of the Nyanzian and Kavirondian systems in the standard column. Another objective was to re-examine the uncorrelated Ancient Rocks of Teale (1936).

Study Area: The study area is the whole territory of Tanganyika, which is situated between the great lakes of Central Africa and the Indian Ocean and lying just south of the Equator. Tanganyika has a coastline extending for a distance of approximately 500 miles from Umba river

in the north to the Ruvuma river in the south. The total area is 362,688 square miles, which include about 20,000 square miles of inland water. It is a land of plains and plateaux.

Results: Tanganyika has three climatic zones: The warm and humid coast region with the immediately adjoining hinterland. Here conditions are tropical with yearly average temperature of 76^{o} F and average rainfall of about 40 inches. The hot and dry zone of central plateau with altitude varying between 2000 and 4000 ft. The climate shows considerable variations but prevailing characteristics are low humidity and small rainfall of 20 – 40 inches annually. The semi-temperate regions with high altitudes over 5000 ft. Here frosts occur and the nights are cold. Low level closed forest occurring at low altitudes in high rainfall areas and as a fringe to the rivers is found most extensively on the lower slopes of the main mountain masses and in parts of Lake Victoria basin. It contains a great variety of hardwood species. The Miombo woodlands, found chiefly in drier inland areas at altitude between 1000 and 4000 ft is the most extensive vegetation type in the territory. It covers approximately 1/3 of the total area of the territory, about 119,000 square miles. So far very few of its timber are in general use, except for mninga of which annually are cut in greater volume. Coastal bush land includes a variety of vegetation types. Important timbers are mvule, mkora and mpingo (African black wood). The mangrove swamps found in the waters along the coast have been a source of building poles and firewood. Mangrove bark for tanning is an important minor forest product. The country has a greater measure than other countries in the central belt of Africa, having a large number of wild mammals. Birds comprising 1000 species ranging in size from Ostrich downwards, are numerous and beneficial to the country in the control of locusts and other injurious insects, except for the grain-eating species Quelea are a serious problem. Reptiles are well represented, crocodiles are well reduced in fresh water since the war because of exploitation of their hides. Over 100 species of snakes about 25 are poisonous, but fatalities are comparatively rare. Fish are abundant and their economic importance has been latterly enhanced by the stocking of dams and ponds. Insect life abounds and the problem created by injurious species and disease vectors play a major part in the economy of the territory.

Estimated population at the end of June 1995 was 8,205,000 Africans, 25,000 Europeans and 94,400 other non-Africans, mainly Asians. The outline of the geology of Tanganyika consists of the oldest rocks and the youngest rocks classified as the Dodoman, Nyanzian, Usagaran, Karagwe-Ankolean and Bukoban systems. Marine rocks make up a disconformable sequence occupying a belt of limited width adjacent to the present coastline. There are no marine rocks of this age west of this belt. Contemporaneous with the deposition of marine sedimentation in the east, there was accumulation inland of terrestrial deposits of various kinds. Commencing probably in the late cretaceous times, there was volcanic activity associated with rift faulting movements which produced the tertiary – recent volcanics. In the south-west, the activity was centred at Rungwe Mountain in the Rukwa-Nyasa rift valley. In the north it extended from Hanang Mountain to the Kilimanjaro massifs and extensive flows of basic intermediate and alkaline lavas and pyroclastics accumulated. Volcanic activity continues on a small scale at the present day. Geology are of economic importance due to its deposits: Metalliferous deposits. These are precious metals such as gold, silver, copper, iron etc. which are generally found together in varying proportions and occur epigenically in a number of fields Non-metalliferous deposits. Of these the most important are diamonds, both gemstones and industrials. Material for cement making are known to occur near Dar es Salaam, Tanga and elsewhere. Salt is manufactured from brine from springs as at Uvinza and from sea water. Other deposits are of mica, gypsum, kaolin, etc. Fuel-coal of fair quality is found principally in the Ruhuhu coal fields in the southwest. Petroleum may be found in the marine sediments in the coastal area. Uranium occurs either in pegmatites as uranite, pyrochlore; the ore mineral of niobium thorium is found in orthite in pegmatites or as monazite in beach and river sands.

Schiller, E. J. and I. Bryceson, 1978: Beach erosion in the Dar es Salaam area. *Tanzania Journal of Science,* 4:101-119.

Aim of study: This study presented a summary of the available data and interpretations of the phenomenon of beach erosion in the Dar es Salaam area.

Study area: The study area is the same as that defined by the Beach Erosion Committee of the University of Dar es Salaam, which was formed to co-ordinate investigations on the problem. The committee defined the boundaries of as extending from Msasani peninsular in the south to the Mpiji River beyond Ras Kiromoni in the North. The observations were made especially in relation to the problems at the beach hotels, which were threatened by erosion.

Method: Review of available data and make interpretations.

Results: It was noted in this study that, at the time of the northern monsoon (November-March), the wind has a clear path between Fungu Yasin and Mbudya Island. This wind alley lead directly to the coast in the vicinity of the Kunduchi Beach Hotel. Larger waves were therefore expected to strike this area during this period. Analogously, a similar effect is expected during the Southern monsoon in the area of the Silversands Hotel as the winds find a clear pass between Mbudya and Bongoyo Island.

A cross sectional survey at Kunduchi Beach Hotel indicated that at the highest tide, water levels reached within 0.8m of the hotel excluding the effects of wave action. At Silversands Hotel, the corresponding height was 1.2m. The high level berm in front of the Kunduchi Beach Hotel offered some protection but this was also being eroded away by the wind. At silversands Beach Hotel, the surging effect of high waves could lift the water over the protective berm. Another problem at Silversands Beach Hotel was that the largest waves could be expected during the time of the Southeast monsoons when the northward littoral current would also be flowing strongly. Observation by Duyverman (1978) also indicated that erosion was greatest during the time of the southern monsoons.

Five main methods that might be used to counteract erosion at the coastal shores, namely breakwater, groins, vegetation and sand injection, were compared. The construction of groins perpendicular to shore was viewed to be widely practised technique for arresting beach erosion. The construction of groins of limited size was proposed and implemented for the Kunduchi Beach Hotel area. The vegetation method was also supported, and it was referred to be supplementary to the construction of groins. It has the advantage of increasing the beauty of the beaches.

Conclusion and recommendations: In conclusion, it was suggested that careful study and consideration of the situation was desirable before making any alterations or construction of solid structures. Also, sand movements should be monitored over a long period of time wherever possible. Regular monitoring should be continued long after alterations were made.

Semesi, A.K., Mgaya, Y.D., Muruke, M.H.S., Francis, J., Mtolera, M. and Msumi, G., 1998: Coastal Resources Utilization and Conservation Issues in Bagamoyo, Tanzania. Ambio Vol. 27 No. 8 Dec. 1998

Aim of study: To provide information about the importance of the management of coastal resources in Bagamoyo. To create awareness among the resource users on the linkages between

various coastal ecosystems. This article presents the crustacean resources, fish, sea cucumbers, mangrove products, coral reefs, tourism and salt production works.

Study area: The study was carried out along the Bagamoyo coast. The marine water is part of the Zanzibar Channel where the shelf reaches a width of about 60 km.

Method: Fisheries officers of Bagamoyo assisted in collecting data. Because of the lack of data in the District records for some resources, the trends were obtained from log books of various dealers and most of the information is thus qualitative based on people's perceptions.

Results: *Mangrove resources:* Eight species of mangrove trees are found in Bagamoyo, the most abundant being " Mkoko" (*Rhizophora mucronata)* and "Mchu (*Avicennia marina*). Together they cover 70% of the area. Village communities often look for a few direct output from mangroves, mainly: fire wood for home consumption or for small scale marketing, wood for charcoal making and poles for housing. Fishing within the mangroves is a minor activity but most people fish in coastal waters adjacent to the mangroves. Several species of fish are found, some of the most common being marine catfish (*Arius sp.*) and milk fish *(Chanos chanos).* The potential for crab fishery is said to be good, but these are hardly exploited because the market within the country is very small and the catch is not even recorded in the fishery statistics.

Salt production: Salt is produced by using either solar evaporation (Table 1) or by boiling method. Boiling is mainly done by women on a very small scale. Large-scale conversion of mangroves to salt production is done by entrepreneurs from outside the District. Twenty-seven sites varying in size from 18.5 ha to 102 ha have been allocated for salt production but only 19 ha are operating. Production of the average saltworks is 2000 tonnes a year, however, the District does not keep proper records of the salt produced. The season for salt production is from September to March, the second half of which coincides with a need for high labour input in agriculture. Fishing is the main activity in the salt ponds during the rainy season, when conditions are unfavourable for salt production. Several species of fishes and prawns were identified in the lagoon from which water is drawn for the ponds.

Coral reef resources: It is unfortunate that the reefs of Bagamoyo have not bee studied and it was not possible to obtain written document describing the reefs of the area. However, from discussions with fishermen, it was learned that the coral reefs are the main fishing grounds. The largest one is Mwamba Kuni followed by Mshingwi. Many species of fish, sea cucumber, octopus, etc. are caught here Up to 30 local boats visit Mwamba Kuni daily. Other sand-bars fringed by coral reefs are Manyema, Chumbe, Mwambaboya, Vijamba Saba and Kitame. While looking for shells and sea cucumbers, people trample on coral reefs and corals are smashed to scare fish. Areas affected by dynamite fishing are Changwahela, Kondo, Mlingotini, Mwambakuni, Mbegani and Kitame. Areas of highest concentration of coral reefs have more records of dynamite fishing than areas of lower concentration of coral reefs.

Finfish resources: Fish is the main source of protein in Bagamoyo, but fishermen seldom get enough returns for their labour and are quite poor. More than 96% of the fish catches take place on the continental shelf and come from artisan fishery, which deploys some simple fishing gear

identified filamentous alga known as "Mwani wa Tasi" are harvested as drift during the months of October and November. This sun dried stored and later used as bait for rabbit fish (*Siganus* spp.). It is highly sought after fishermen from Dar es Salaam and Zanzibar. This is the only type of fish bait that is known in Tanzania that is traded. However, factors that trigger its productivity is not known or what is its nutritional value. It appears that the production of this alga is mainly localised to the Bagamoyo area. Orange and green sponges (locally known as "Zimba") growing on mangrove roots of *S. alba* are used in basket traps of bait for rock cod and emperors. *Prawns:* Five species dominate the catches of industrial trawlers in Tanzania: *P. indicus* (74.8%). *Metapenaeus monoceros (*17.2%), *P. monodon (3.8%), P.semisulcatus (3.8%)* and *M. stebbingi (0.4%)*. In Bagamoyo *P. monodon* and *P. indicus* are the main species caught by artisanal fishermen there Table 6). Industrial trawling (Table 7) is mainly carriedout by foreign vessels and is done from March to November, with very little enforcement. *Lobsters:* The painted lobster (*Panulirus versicolor)* and the ornate lobster (*Panulirus ornatus*) were the common species seen on landing stations. There were no records of lobster fishery from the District. Information was gathered from dealers.

Sea cucumber fishery: In Bagamoyo 20 different types of sea cucumbers (beche-de-mer) are harvested (Table 9), graded into three categories A, B and C for export. This study shows that there are many more species harvested in Tanzania than previously reported. *Mollusk resources:* In Bagamoyo, in addition to their value as food, mollusks are also of economic importance because of their shells, which are valued as souvenirs. Most of the women were collecting shellfish for food mainly on the mud/sand flats of Mbegani and Kaole.

Tourism: Bagamoyo town attracts about 0.8% of the total tourist volume in Tanzania due to its old history of association with slave trade. At the moment, the beach are has been divided into approximately 29 plots for constructing beach hotels. Five beach hotels have already been constructed. So far there is no gainful employment and income to the District. Conflicts between hotel developers and artisan fishermen have already arisen. This is because fishermen are denied access to the beaches fronting the hotels. Mangroves are being cleared for a better view from hotels and this is causing beach erosion. Some hotels are assisting the District by financing boat patrols to combat dynamite fishing and also by providing good market for lobsters and fish.

Conclusions: The main problem facing Bagamoyo is the limited capacity to enforce regulations. Lack of detailed information about the resources in Bagamoyo is identified as a major bottleneck in resource management. The District fisheries statistics are unreliable and are not geared for understanding the character and processes controlling productivity. The resource abundance, distribution, trends of exploitation, biodiversity, and the biology of most species, and information about users are, thus, unknown. Large areas of Bagamoyo mangroves have been allocated for shrimp Aquaculture and salt production, but not all have been developed. The main fishing areas are close to or on coral reefs, which are being destroyed by destructive fishing methods. All users in Bagamoyo acknowledge a decline in catch of prawns, fish, sea cucumbers, and most resources. In order to improve our understanding of the coastal resources in Bagamoyo, there is an urgent need to improve government fisheries data collection and to strengthen research and monitoring. Interdisciplinary research that involves government officials and local communities should be practised. Fisheries officers should accompany fishermen to their fishing grounds to obtain more accurate data sets, and information collected by research institutions must be transmitted to managers. Creation of awareness at all levels on ecosystem functioning, threats, values and policy changes are necessary. The government should develop a formal strategy to address issues related to zonation of areas suitable for various activities. Since government decision have been dominated by those of technical "experts" who have often ignored local knowledge, norms and

community institutions, the government is urged to improve the consultation process with local people and to consider the needs and opinions of women and youth groups.

Shaghude, Y. W., Mutakyahwa, M. K. D. and S. K. Mohammed, 1994: National report on the status of coastal erosion, sea level changes and their impacts: Tanzanian case. IOC Workshop Report No. 96 – Supplement 1. ***IOC-UNEP-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and Their Impacts.*** **Zanzibar, 17-21 January, 1994: pp. 85-106.**

Aim of study: This was done for the purpose of assessing the extent of erosion at the affected sites on the Mainland as well as Zanzibar.

Study area: Fieldwork was conducted from the southern to the northern part of the territory, which included Mtwara, Lindi, Kilwa, Dar es Salaam, Tanga and Zanzibar regions. This report discussed on the status of coastline changes in Tanzania.

Method: Visual observations.

Results: It was generally noted that there had been excessive erosion accentuated by sea level changes. These processes were supported by the disappearance of ancient towns, modern buildings and infrastructures. The report thus made an account of previous studies such as those by Alexander (1966; 1969), who studied on coastline changes in Tanzania and the work of Fay (1992), who discussed on the fate of Maziwi Island near Tanga which had disappeared. According to Fay (1992), the possible cause of the disappearance of the island was due to sea level rise. Factors such as human interference on the island's ecosystem, crustal movements due to subsidence and erosion were ruled out. The report also reviewed earlier literature on the coastline changes along Kunduchi beach, north of Dar es Salaam. The review involved the works of Griffiths (1987), Schiller *et al*. (1977), Schiller and Bryceson (1978), Bryceson and Stoemer (1980), Mushala (1978), Norman (1985), Fay (1987) and NEMC (1985). The coastal erosion in Zanzibar was also studied. Activities that were believed to create negative impacts on the coastal environment included fishing, beach sand mining, quarrying along coral rag areas and mangrove cutting, which were discussed. Two localities in Zanzibar, Nungwi and Maruhubi were believed to be among the worst affected areas on the island. The extent of erosion in these areas was elaborated.

Conclusion: In conclusion, nine factors were listed as causes of coastal erosion in Tanzania. They were dynamite fishing; quarrying of beach rocks and coral limestone; sand mining on river beds and heavy mineral mining from beaches; coastal construction; geological influence; sea level rise; blasting of hard rocks; and parking of cars along beaches. Finally, the report reviewed the national legislation on coastal erosion by referring to the Mining Act of 1979 and the subsidiary legislation on Mining regulations of 1980. Also reviewed were laws on fisheries and on mangroves.

Shayo, L.K. 1979: A mathematical model for the Rufiji River open channel flow

Aim of this study: To study environmental and socio-economic effects of the proposed Stiegler's Gorge Dam on the Rufiji River plains as regards maximising hydropower production and at the same time minimising the risk of flood disaster. The problem is to determine the best time-discharge relationship of the dam in connection with flood control, agricultural and hydropower production.

Study area: Rufiji river downstream of the proposed Stiegler's Gorge Dam to the Indian Ocean. This is the section from the dam to a distance 5 kilometres downstream and that from Mloka to Mibuyusaba.

Method: This is a theoretical study in which a mathematical model is formulated to determine the best time-discharge relationship at the dam. Shayo´s model is presented as an improvement of Schweigman's mathematical model, which described the interrelationship of the various factors characterising the flow into and out of the Stiegler's Gorge reservoir, the Rufiji River and the flood plains. Whereas Schweigman presented a mathematical model for each of the three areas (dam, river and floodplains) consisting of constant cross-section, Shayo allows the cross-section of the channel to vary continuously with downstream distance from the dam.

The model takes the form of an open channel of known geometry and topography and through which water flows from the reservoir at upstream end (the Steigler's Gorge dam) to another reservoir at the downstream end (the Indian Ocean). Rectangular Cartesian co-ordinates (x,y,z) are employed with x along the channel, y vertical and z across the channel. The origin is taken at the dam and on the intersection of the horizontal plane along the channel and bisecting the channel.

In general the channel bed and sides boundaries are quadric surfaces and the angles are functions of distances. Since the geometry of the channel is assumed known, the angle for any cross-section is expressed in terms of the upstream cross-section parameters. If the discharge at the dam is kept constant over a sufficiently long time, the flow along the channel will become steady . This will be the case when the discharge needed for irrigation is required to be constant for several days. Flow variables are assumed independent of time. Unsteady rainfall in any one year will cause unsteady flow in any natural river. It is therefore more informative to study the unsteady problem in greater detail.

Results: It is seen that the stage is decreasing with distance downstream, as expected, while the discharge varies slowly. It should be noted that it is the stage rather than the discharge, which determine when the flooding should occur. However, when flooding occurs, it is the discharge that determines the severity of the flooding. The variation of the discharge, Q(x,t) does not follow a simple formula, but as can be seen in table 5.2.2 there is a correlation between the upstream and down stream values. For example, Q(0,1) = 1210 while Q(2049,1) = 1243 is a manifestation of the memory of the flow. The water reaching x = 2049 at t = 1 must have left the dam at a time t = t1 < 1.

Conclusions: The analysis demonstrated that the knowledge of flow in the Rufiji river at any point of the channel together with the cross-section at some suitably selected points and the Manning's number downstream is sufficient for determination of the flow at every point downstream, using a very simple computer program. The comparison made with results from direct measurements has demonstrated the high accuracy of the analysis. Although comparison was made only for the stage, the accuracy of the results for other flow variables, including the discharge and the flow velocity may be expected to be of the same order of magnitude. This follows from the fact that the flow variables are strongly coupled through the non-linear partial differential equations of St. Venant, and any significant errors in one may be expected to affect the others.

The report is incomplete because of lack of the necessary field data for comparison. Three things are to be done in order to improve the report. A more comprehensive set of measurements is necessary to complement that of the varying cross-section. This may then be used to give more

confidence on the reliability of the mathematical model, which may in consequence be improved as appropriate. Assuming that enough data is available for comparison, the open channel flow problem with flooding may be considered. The aim here is to analytically determine beneficial flooding for the Rufiji flood plains, while maximising hydropower production. This will necessitate a modification to the present model to incorporate these factors in the form of constraints. Mathematical approach has obvious advantages. For example, the input data can be changed arbitrarily to answer questions, which could not be answered otherwise. On this merit more work in this line should be encouraged in the future.

Temple, P.H and Sundborg, Å. 1972: The Rufiji River, Tanzania. Hydrology and Sediment Transport. Geografiska Annaler – 54 A (1972), pp. 345 – 368.

Aim of study: The main purpose of the Rufiji investigations is to study the water and sediment discharge characteristics of the river and their influence on the morphology and soils of the lower flood plain and delta. This paper presents a short analysis of the available data on hydrology and sediment load.

Study area: Rufiji Basin and its principal components. The river is known as Rufiji only in its downstream section below the confluence of the rivers Kilombero and Luwegu at Shuguri Falls. The Rufiji collects water from three principal sub-catchments: (a) the Kilombero river system; (b) the Great Ruaha river system and (c) the Luwegu – Luhombero rivers. These components show considerable variation in run-off characteristics. Table 1 presents data on the area – altitude relationships within the Rufiji basin and its principal components. The most important hydrological stations for the discussion in that paper are those at Stiegler's gorge and at Pangani rapids (Station 1 K3A). The Stiegler's gorge station was established in October 1954 and used mainly for gauging, while the Pangani rapids Station was established in December 1959 and used mainly for recording water levels.

Method: It is mainly reprocessing and re-evaluation of previously existing data, such as the 'new' topographic maps, excellent semi-controlled mosaics at a scale 1:50,000 and air-photos at a scale of 1:40,000 together with less complete data on water discharge, suspended sediment concentration and geology. Data on suspended sediment load spans the period 1955/56 to 1961/62, while discharge data covers the period 1954/55 through to 1969/70

Results: *Hydrology of the Rufiji River:* Average daily discharge is highest in April and lowest in November. On average, the April discharge accounts for nearly 25% of the annual total compared to 2% in November. The maximum for mean monthly discharge was recorded in January 1961 (5173 m^3/s) and the minimum in November 1959 (76 m^3/s). The dispersion graphs indicate that over the recorded period, the month of January was subject to by far the greatest fluctuations of mean discharge and the month of October to the least. The graphs also indicate that, on the average, the months June through November are not subject to floods. The period December through May has experienced high average discharges, in excess of the highest floods of some dry years of the record. Figue 9 shows examples of the annual hydrographs 1959/63 of the Rufiji river at Stiegler's gorge.

Flow duration and flood frequencies: On the basis of the 24 – hour mean discharge values from these gauging stations, flow duration curves have been constructed for each of the 16 hydrological years. Typical data from the 16 individual duration curves are given in a Table. The table shows the discharge values for each water year with duration of certain percentages.

Sediment transport in the Rufiji River: Suspended sediment load data indicates a maximum daily transport of approximately 1,000,000 tons during the investigated period. Sediment – rating – curve and duration – curve analyses indicate that some 250 – 300 million tons of suspended sediment have passed through Stiegler's gorge in the 16 years covered by discharge records. To this figure should be added the bed load transport and probably also a certain increase due to inaccuracy in the sampling and analysis procedures. Heaviest loads of sediment are related sudden flash floods in the rising limb of the annual hydrography. The suspended sediment peaks are out of phase with the flood peaks, indicating an early annual flushing of the sediment from the system with the onset of the flood season. The sources of this sediment and the characteristics of the tributary basins are dependent on relief, geology and seasonal rainfall regimes.

Conclusion: *Effects of dam construction: Reduction of planned reservoir storage*: It has been shown above that the Rufiji river currently transports large quantities of sediment into its flood plain. The mean annual suspended sediment transport is estimated to be 15 – 20 million tons with recorded sediment yields in one day of well over 1 million tons associated with high floods. It has been suggested that only a rather small proportion of this sediment originate from the Great Ruaha system. With the completion of Kidatu dam, all Ruaha sediment will be trapped at Kidatu. This will nonetheless have impact on Stiegler's gorge due to the rather small amounts involved and may not be important even at Kidatu, a supposition, which calls for further investigation. The initial storage capacity will be reduced at a rate approximating 10 – 15 mill. m^3. This progressive storage reduction will shorten the life of the reservoir. The riverbed upstream will be raised as a consequence: flooding may result and water levels will be higher.

Reduction of sediment transport in the flood plain after reservoir construction. As a consequence of very pronounced reduction in sediment load transported into the flood plain, there will be: erosion downstream of the reservoir when the river, deprived of its supply of coarse- and medium-grained sediment, entrenches its channel towards a reduced gradient of water depth. Loss of water by irrigation and from the proposed reservoir surface by evaporation will reduce water flow in the lower river In seasons of low water discharge, tidal incursions of sea water may be permitted into the lower flood plain with consequent deterioration of water and soil. The loss of sediment by reservoir detention and control of floods by reservoir operations will terminate the natural cycle by which the soils of the flood plain and delta are renewed and kept fertile, viz. by deposition of silt and water. Artificial fertilisers will be needed for the flood plain soils and new methods, presumably irrigation schemes may have to be introduced.

Recommendations: This paper has demonstrated that sediment transport through Stigeler's gorge is by no means insignificant. It is recommended that sediment transport needs very full consideration in any feasibility study concerned with water development on the river. The study indicates a severe lack of information vital to the proper development of the Rufiji flood plain, particularly of information on discharge characteristics and sediment transportation in the Luwegu and Luhombero rivers. It is urged to establish gauging stations to monitor accurately the regime of these rivers. It is recommended to re-establish water quality and sediment sampling programme for the Rufiji, initiated by FAO, but with more limited operational schedule concentrating on Stigler's gorge, the Luwegu river and the Luhombero river. It is laso recommended as full an analysis as possible of the probable sedimentation in the propose

Stiegler's gorge reservoir using the data on sediment transport provided in this report. Threlfall, H.R., 1950: Some physical features of the Dar es Salaam District. Tanganyika Notes and Records, 29: 68 - 72.

Aim of study: To suggest the origins of the creeks and the steps related to each other, and that both were formed by the action of water. To seek circumstances which are favourable for the erosion of steep-sided, flat-bottomed valleys by flowing water.

Study area: The Dar es Salaam District.

Method: Study of the 1/ 25,000 map and 1/500 contoured map sheets of the Dar es Salaam District Nos. 3, 7, 11, 15 and 19.

Results: Both profile and cross-section suggest that aggradation (i.e. deposition of sediment) has occurred in the lower reaches of the floor of the creek. This effect is often associated with rise in sea level. As the sea rises and floods the lower part of the valley, the stream entering the still water of this arm of the sea deposits there the load of sediment it has been carrying. If the sea level ceases to rise, this deposit of sediment will be built up to approximately that sea level, but if the sea continues to rise, the level of sedimentary deposit will rise with it. When the rise in sea level does eventually cease to rise, the lower part of the valley will be filled with alluvium whose surface slopes gently seawards. This appears to have happened in the creeks. The main factors that have influenced the local physio-graphical history are earth movements, glacial eustacy and rainfall. During one or more of these fluctuations of sea level, the steps and risers of the Dar es Salaam District were cut, and the most probable period for this was during the final withdrawal of the sea from the Pleistocene high level. A falling sea is favoured because a rising sea tends to destroy its own work, and the nature of the material in which the features are found precludes their having been formed in any other than a very recent geological period.

Conclusion: It appears from available evidence that the low lying steps of the Dar es Salaam District owe their origin to pauses in the retreat of the sea level during one of the late phases of the Pleistocene glaciation. When this retreating sea was much lower than at present, the creeks were formed as deep channelson the seaward slope of the land, and their erosion was probably accentuated by a contemporaneous pluvial epoch. The advancing sea caused the aggradation of the creek channels resulting in their present flat-bottomed form.

WATER QUALITY AND POLLUTION

Salim M. Mohammed
University of Dar es Salaam, Institute of Marine Sciences, P.O.Box 668, Zanzibar

Walvoord, M.A., 1993: Environmental impact study of sewage pollution along the west coast of Zanzibar Town. SIT Marine Ecology, Tanzania. 38p.

Aim of study: This study assessed the impact of sewage pollution on marine and terrestrial ecosystems along the West Coast of Zanzibar. The main objectives of the study were to determine whether the dumping of raw sewage in this area was ecologically sustainable and if not to provide suggestions for alternative sewage disposal methods.

Area of study: The study was conducted along the East Coast of Unguja (Zanzibar).

Methods: Water samples from 14 sites located along the shore fronting the Stone Town were taken 20 m from shore and were analysed for dissolved inorganic nutrients (ammonia, soluble reactive phosphorus, and nitrate plus nitrite) according to standard methods. Other parameters measured were dissolved oxygen, biochemical oxygen demand (DOD_5) and salinity. Data for faecal and total coliforms were referred from another study.

Results: High levels of dissolved nutrients were possibly introduced into the area through sewage input. There was a significantly high correlation between DOD_5 and faecal coliform concentrations implying that the source of pollution in the area was organic i.e. from sewage (See Appendix 1). Results suggest that the extent of pollution from sewage is greatest and puts the most stress on the marine ecosystem in areas where water circulation is restricted such as the harbour area and Bwawani. The nature of currents along the Zanzibar coast act to redeposit waste in areas where currents are not as active.

The report contends that at present Zanzibar does not have standards for bathing or swimming waters. This situation places serious health risk on the public. In addition, the water quality in swimming areas is not monitored at all and the public is not informed of what is known of the water quality. The report cautioned that serious pollution is also threatening the rich coral communities in the area. In order to alleviate the problem, the report recommends that the leaks in the sewage disposal system must be repaired immediately to prevent further contamination. Also the faecal concentrations in the coastal waters must be reduced below health concern standards or must be publicly reported so that people are aware of the risks of swimming in these waters. Faecal coliform concentrations can be reduced by ceasing all sewage discharge into the sea or by treating it chemically before discharging it.

Anderson, B., 1994: An environmental monitoring approach to sewage pollution issues along the west coast of Zanzibar. SIT Marine Ecology Tanzania. 31p.

Aim of study: The aim of this study was to monitor seawater quality in the waters off Zanzibar Town.

Area of study: In this regard, a monitoring site for water quality was set up at the entrance of the Zanzibar Harbour to generate data that would help to assess trends in the water quality over time.

Methods: The monitoring exercise entailed a two-week measurement of pH, dissolved nutrients (soluble reactive phosphorus, nitrate), temperature, salinity, turbidity, and dissolved oxygen. Dissolved nutrients were measured by standard methods. Salinity was measured by a hand held refractometer, while an oxygen meter measured dissolved oxygen. Data on turbidity was obtained with the help of a secchi disc. All measurements were made during both low and high tides. The study also analysed current patterns in the vicinity of the study area (data from other sources) and their influence on the dispersal of pollutants.

Results: Concentrations of dissolved nutrients were higher than normal (up to 7.76 µ-at N/l and 4.01 µ-at P/l for nitrate and phosphate respectively) for tropical waters, indicating that the water around this area is polluted (Appendix 2). This pollution is threatening the exotic marine life in the area and hence negatively affects the tourism industry in Zanzibar upon which the country heavily depends. The study recommends a continuous monitoring of the seawater of the Zanzibar harbour and in the path of the eddy system. Monitoring should also involve the activities of a representative species to assess its metabolic adaptation to water quality variations. Furthermore, there should be a periodic look at the population composition. The study also recommends that rehabilitation of the sewerage system should be effected to reduce further pollution of the area.

Kastner, T., 1996: Measurements of nitrification rates in three coastal ecosystems in Zanzibar. SIT Marine Ecology, Tanzania. 27p.

Aim of study: This study compares nitrification rates in mangrove swamps and in polluted and unpolluted sandy soils in Unguja Island, Zanzibar. The main objectives of the study were to assess human influence on soil quality and overall functioning of the three different ecotypes on the island.

Area of study: The study was carried out in an unpolluted mangrove forest in Chwaka Bay area, east of Unguja. The other sites were at a polluted beach in front of the Stone Town and at Fuji Beach a relatively an unpolluted sandy beach situated approximately 10 km north of the Stone Town. Nitrification in the sediment was estimated by the ATU inhibition technique in sediment cores incubated over a period of six hours.

Results: Generally, results were inconclusive. However, there were indications that all three sites have very low nitrification rates. The low nitrification rates in all the areas were attributed partly to low levels of nitrate both in the water column and in the sediment and increased competition for ammonia, an essential ingredient in the nitrification process. The report speculated that over-exploitation of mangroves was thought to contribute to low levels of organic matter in sediment and hence to low ammonia levels due to reduced mineralisation.

Gillian, A., 1998: Waste management: An assessment of waste disposal practices of hotels on Unguja. SIT Coastal Ecology, Tanzania. 42p.

Aim of study: This study set out to assess waste disposal practices in hotels and guesthouses located in four tourist zones on Unguja Island, Zanzibar.

Area of study: Pwani Mchangani/Kiwengwa area, Bwejuu, Nungwi and in Zanzibar Town. Pwani Mchangani is located on the East Coast, Bwejuu in the southeast corridor, while Nugwi is located on the extreme north of the Unguja Island. Zanzibar Town, which hosts a number of hotels and guesthouses, is the capital.

Methods: The methodology employed in this study was by interviews of hotel personnel including local managers, receptionists, housekeepers, maintenance persons and owner/managers. Interviews were also conducted with government personnel which included the Director of Environment; the Director of Planning and Development, Commission for Tourism; Head of Pollution Control, Department of Environment and the Director of Investment, Zanzibar Investment Promotion Agency.

Results: With the exception of the Zanzibar Town, where hotels use the municipality services for waste disposal, there is neither land designated for waste dumping nor waste collection system in tourism zones. Waste disposal practices include burning, burying and in very few cases composting. In all cases there is no garbage separation with the exception of separating glass bottles from the rest of the garbage. Sewage is disposed of via septic tanks. The Commission for Lands and Environment has set up waste disposal regulations and guidelines, however it appears that hoteliers are not aware of these. In general there is a serious lack of concern about disposal practices and hygiene in many of the hotels studied.

Lugenda, C., 1998:The effect of pollution on the phytoplankton biomass and composition. A Third Year Project Report. Department of Zoology and Marine Biology, University of Dar es Salaam.

Aim of study: This report gives the results of an investigation in which the impact of pollution on phytoplankton biomass and composition at Kunduchi and the harbour area in Dar es Salaam was studied.

Methods: The parameters studied were chlorophyll *a* concentration, phytoplankton cell numbers and community composition. These parameters were studied in relation to some environmental water quality parameters, viz turbidity, pH, temperature and dissolved phosphate.

Results: The result showed that concentration of Chlorophyll *a* in Kunduchi waters ranged between 0.069 mgm^{-3} and 0.111 mg m^{-3} while that at the harbour area concentration ranged between 0.417 and 0.702 mg m^{-3}.

Mlay, E.H., 1997: Abundance of phytoplankton in relation to certain environmental factors in the sewage ponds at the University of Dar es Salaam. A Third Year Project Report. Department of Zoology and Marine Biology, University of Dar es Salaam.

Aim of study: The aim of this investigation was to assess the interrelationship between environmental conditions and algal abundance and chlorophyll *a* concentration in the University of Dar es Salaam wastewater sedimentation ponds.

Methods: The environmental parameters measured include temperature, pH, oxygen, and dissolved nitrate plus nitrite.

Results: Variations in algal abundance depended on a complex interrelationship between several factors in the algae-bacteria systems in the ponds. The pond into which raw sewage effluent flowed had the lowest abundance of phytoplankton. This was attributed to result from high organic loads and the existence of anaerobic conditions in this pond. By contrast, the facultative pond, which was characterised by high oxygen levels and high temperatures, exhibited the highest algal abundance. Only two genera of algae were found in the ponds of which *Microcystis* was more abundant and occurred in all ponds. The other species was *Spirulina*. This alga was less prevalent and was not common to all the ponds.

Lyantagaye, S.L., 1996: Nutrient and dissolved oxygen distribution in Mzinga Creek and Ocean Road beach. A Third Year Project Report. Department of Zoology and Marine Biology, University of Dar es Salaam. 34pp.

Aim of study: This study investigated the distribution of dissolved inorganic nutrients (nitrate, phosphate) and dissolved oxygen.

Area of study: Mzinga Creek and Ocean Road.

Methods: Sampling was carried out during November 1995 to February 1996 with the view to establish the nature, intensity and extent of these nutrients in the productivity.

Results: Concentration of nitrate in Mzinga Creek ranged from 0.18 to 0.53 µ mole Nl^{-1}, phosphate ranged from 0.47 to 1.10 µ mole Pl^{-1} and dissolved oxygen ranged from 5.20 to 12.75 cm^3l^{-1}. Higher phosphate but lower nitrate levels were observed at Ocean Road. At this site the concentration of phosphate ranged from 0.47 to 0.89 µ mole Pl^{-1} and that of nitrate ranged from 0.32 to 0.50 µ mole Nl^{-1}. Dissolved oxygen ranged from 6.97 to 7.20 cm^3l^{-1}. There was a general trend of seaward decrease of phosphate levels, with peak at the entrance of the river during high tides on rainy season. The horizontal gradient in nutrient concentrations was attributed to the interplay of tidal inundations and freshwater inputs. Seasonal distribution of nutrients in the fresh water was related to rainfall and the application of fertilisers to agricultural lands in the drainage basin. The observed concentrations of dissolved oxygen were attributed to a combined influence of water circulation and the bathymetry of the study sites.

Mwandya, A. W., 1996: Variability and morphometric relationships of lead and cadmium in *Saccostrea cucullata* and *Pinctada marginitifera* along the Dar es Salaam coast. A Third Year Project Report. Department of Zoology and Marine Biology, University of Dar es Salaam. 31p.

Aim of study: This investigation determined the concentrations of the heavy metals, lead and cadmium, in the soft tissues of oysters.

Area of study: Samples were taken at Ocean Road beach and Msimbazi Creek along the Dar es Salaam coast to see their variability and morphometric relationships in the oysters.

Methods: The study was conducted during November 1995 to February 1996. Samples of *Saccostrea cucullata* were taken in the area between Ocean Road beach and Msimbazi Creek while those of *Pinctada marginitifera* were taken in the area between Ocean Road beach and Mtoni mangrove swamps.

Results: Concentrations of the heavy metals varied between the two study areas. The mean concentrations of Pb and Cd at Msimbazi Creek were higher than those found at Ocean Road beach. The mean concentration of the metals in *Saccostrea cucullata* at Ocean Road beach were lead, 3.63 and cadmium 0.22 µg g^{-1} dry weight and at Msimbazi Creek were lead, 6.16 and cadmium 0.45µg g^{-1}. Concentrations of the metals in *Pinctada marginitifera* at Ocean road beach were 6.58 µg g^{-1} (Pb) and 0.94 µg g^{-1} (Cd) and at Mtoni mangrove swamps were 8.45 µg g^{-1} (Pb) and 0.69 µg g^{-1} (Cd). The high concentration of both Pb and Cd at Msimbazi Creek compared to those seen at Ocean Road beach may be due to differences in the source of discharge of these materials. Msimbazi River passes through major industrial areas of Dar es Salaam such as Tanzania Breweries Ltd and Ubungo textile mills. Furthermore, tributaries of the Msimbazi

River pass through the Tabata dumpsite and hence may contribute to the input of the heavy metals into the Msimbazi Creek.

Significant correlations between Pb and Cd with morphometric parameters were observed for samples from Ocean Road and Msimbazi Creek in *Saccostrea cucullata*. Pb and Cd in *Pinctada marginitifera* from Mtoni mangrove swamps showed significant correlation with morphometric parameters. By contrast, the heavy metals did not show any correlation with morphometric parameters in *Pinctada marginitifera* at Ocean Road beach.

Mamboya, F.A., 1996: Seasonal variation of nutrients and dissolved oxygen in Mbezi creek. A Third Year Project Report. Department of Zoology and Marine Biology, University of Dar es Salaam. 18p.

Aim of study: This report gives the results of an investigation whereby the seasonal variations (wet vs dry seasons) of dissolved nutrient concentrations and oxygen in Mbezi Creek were determined.

Area of study: The creek situated at Kawe Beach receives fresh water input from Mbezi River.

Methods: Water samples were collected during both low and high tides as well as during high and low river discharges. These were analysed for phosphate, nitrate and oxygen.

Results: There was a gradient in the horizontal distribution of nutrients, with concentrations decreasing towards the sea. Seasonally, both nitrate and phosphate showed higher concentrations during the rainy season probably due to input through enhanced agricultural activities, weathering processes, sewage effluent and other domestic waste, associated with high river discharge. The concentration of dissolved nitrate ranged from 0.06 to 0.14 $\mu molNl^{-1}$ during the wet season and that of phosphate ranged from 0.12 to1.14$\mu molPl^{-1}$ during the wet season and 0.11to 0.62 $\mu molPl^{-1}$ during the dry season. There was only a slight variation in oxygen concentration between seasons. During the rainy season concentrations ranged between 10.32 to 2.24 cm^3dm^{-3} and 6.0 to 1.61 cm^3dm^{-3} during the dry season. The author concludes by saying that a nutrient baseline level is not reliable in estuarine and intertidal waters as the concentrations fluctuate with tides, freshwater run-offs, plankton concentrations, and the effect of dilution of sewage input.

Chaggu, E.J., 1993: Ground water pollution Majumbasita, Tanzania. Final Research Report. Centre for Housing Studies, Ardhi Institute. Dar es Salaam. 107p.

Aim of study: This study was initiated in response to concerns over certain practices that posed pollution risks to ground water in the area. Such practices include the use of shallow dug wells as a source of water for every day use and pit latrines as a means of disposing excreta.

Area of study: This study was conducted at Majumbasita area, in Ilala district along Pugu Road in Dar es Salaam. It was hoped that results of this study will help formulate guidelines for the designing, construction and siting of wells relative to on-site waste disposal systems, particularly in unplanned peri-urban settlements.

Methods: The study used both questionnaires for user utilisation survey and laboratory analysis to assess pollution levels in the Majumbasita area. The study also prepared an environmental map that shows existing houses, pit-latrines, septic tanks, and hand-dug wells in the area. Laboratory analysis consisted of the measurement of pH, chlorides, sulphates and total and faecal coliforms in ground water (from boreholes) and piped water from the city network.

Results: All boreholes dug in the area with a maximum depth of 6.8m are heavily polluted with faecal matter. Similarly, piped water from the city's water supply system is also heavily contaminated with faecal coliforms with concentrations well above the Tanzania Temporary Standards (TTS).

The report gives recommendations on development guidelines. These include guidelines on siting wells and on-site disposal systems, and guidelines on design and construction of wells and pit-latrines. It also gives a number of recommendations that need to be taken to reduce pollution levels in the Majumbasita area. Among them are that study of the prevailing diseases in the research area related to the use of ground water should be done and that people should be discouraged from using shallow hand dug wells. Other recommendations included monitoring programme for the fluctuation of ground water level quality should be developed. Well water should be extracted from a depth of not less than 6.75 m but since the change to deeper wells may take a long time, the community should be advised to boil the water from shallow wells before drinking.

Munisi, J.J., 1998: A comparative study of polluted and unpolluted intertidal floral communities near Tanga Town. A report submitted for the fulfilment of the forth term programme at the University of Dar es Salaam. Department of Zoology and Marine Biology. 17pp.

Aim of study: The objective of this study was to determine the effects of pollution on intertidal floral communities by comparing two polluted areas, an area receiving discharges from the Tanga fertiliser Company and an area receiving sewage discharge from the municipality with an unpolluted control area (Mwambani).

Methods: The approach used in the study was setting up transect lines along the shore in the study areas during low spring tides and estimating percentage cover of each species found in the grid.

Results: Results are given in terms of abundance of the flora as well as that of associated fauna (See Appendix 5). Of the three sites, the sewage discharge site was the poorest in terms of floral cover compared to the other two areas with the fertiliser site boasting the highest diversity of flora. The most common floral species found at the fertiliser site but less common at the sewage discharge site were *Enteromorpha sp*., *Thalassia sp*., *Codium sp*., and *Boergescenia forbesii*. The Mwambani site had more vegetation cover and was also more dominated by seagrass species that include *Enhaulus sp*., *Thalassodendron sp*., *Cymodocea sp.*, *Thalasia sp*., *Halodule sp*., and *Halophila sp*.

Associated fauna was most abundant at the Mwambani site while the sewage discharge site was the poorest in terms of density and diversity of fauna. Most common fauna at the Mwambani site were sea cucumbers (*Synapta* and *Holothuria sp*.), seaurchins (*Diadema sp*. and *Echinmetra sp*.), crabs, hydrozoans, and jellyfishes.

The study suggests that the dominance of macroalgae at the fertiliser and sewage discharge sites is due to eutrophication. The fertiliser factory, though out of production for quite some times now, was still releasing ammonium nitrate into the environment thus enriching the area with nitrogen. The report gives recommendations on ways to reduce pollution in the affected areas.

Nzali, L., 1994: Nutrient concentration along the Msimbazi stream – Dar es Salaam. A Third Year Project Report, Department of Zoology and Marine Biology, University of Dar es Salaam. 20p.

Aim of study: This report describes the results of an investigation carried out in a section of Msimbazi creek (Salender Bridge to Jangwani area) in Dar es Salaam whereby concentration nutrients in the surface water of the creek were investigated. The objectives of this study were four folds. These were to investigate the nutrient concentrations along the creek. To find out if the mangrove ecosystem has any effects on the nutrient concentrations of the Msimbazi Creek. To investigate if there is any tidal effect on the nutrient and oxygen concentrations in the Msimbazi Creek, and to determine whether there is any seasonal variations on the nutrients and oxygen concentrations in the Msimbazi stream.

Methods: Water samples were collected from the stream during both rainy and dry seasons and were analysed for dissolved nitrate, nitrite, phosphate and oxygen according to the methods described by Parsons (1984). Results showed that there were spatial variations in nutrient concentrations along the creek with both nutrients – phosphate, nitrate plus nitrite- increasing from Jangwani area reach its maximum at Egypt air offices and thence decreasing to a minimum at Salender Bridge.

Results: Seasonally, higher concentrations of phosphates and nitrite were observed during the dry season than during the wet season. By comparison, wet season concentrations of nitrates were higher than that during the dry season. There were also variations over tidal cycles. Both nitrogen and phosphorus showed higher concentrations during ebb tides than during floods. By contrast dissolved oxygen showed an opposite trend. According to the report, the observed nutrient concentrations in the creek could be a result of input through effluent discharge from industries, such as the Tanzania Breweries, from sewers, from fertilisers applied to gardens, and from humic matter from terrestrial, non-cultivated land brought by surface run-off.

Mohammed, S.M., A. S. Ngusaru, and O.U. Mwaipopo, 1993: Determination of the effects of pollutants on coral reef areas around Zanzibar Town. NEMC. 27p.

Aim of study: The main objective of this study was to assess the impact of pollution, especially that emanating from the Zanzibar Municipality on the reefs fronting the Stone Town. The study set out to investigate spatial and seasonal distribution of nutrients, bacterial concentrations and BOD in the study area. Current patterns in the area were also studied with view to identify the distribution paths of domestic sewage from various discharge zones around the municipality.

Area of study: The study concentrated on the reefs around the coral islets of Chapwani, Kibandiko, Changuu, Bawe, Murogo and Nyange reefs. Other reef formations studied were Fungu Mapape, Mwamba Mapape, Pwakuu and Tambare and Boribo reefs.

Methods: Levels of pollution were assessed by measuring concentrations of nutrients (NO_3^- NO_2^-, PO_4^{3-}, NH_4^+), BOD_5^{20}, and levels of total and faecal coliforms. Other parameters measured were salinity, transparency, and water temperature. The analytical techniques used for nutrient analysis were those described by Parsons *et al* (1994). Coliform levels were measured by standard methods. In the measurements of current patterns, the study established a series of profiles perpendicular to the shore and sampling stations were located along the profiles. Current velocity and direction were then measured along these profiles. Nutrient levels are discussed in terms of their concentrations during the two monsoons.

Results: During the NE monsoon, phosphate levels were higher as compared to the other two nutrients except at Bwawani and at the harbour area where ammonia dominated. Nitrate plus nitrite were generally below detection limit at all stations except in front of the Peoples Palace where concentrations reached as much as 216 µmole N. Ammonia showed variable concentrations ranging below detection limit at most of the stations to a high of 500 µmole N at Bwawani. During the SE monsoon phosphate and nitrate/nitrite levels were significantly lower but there was an increase of ammonia levels in the water. Coliform levels were high at all stations and were highest at Bwawani where faecal coliform levels of up to 5,000 cells ml^{-1} were recorded. Bwawani also showed the highest levels of BOD.

There was a dominance of northward flowing longshore tidal currents during both the NE and SE monsoon except for the area between Bwawani and Mtoni where small eddies create southward streams along the shore. The study suggests that these northward flowing currents are ideal placed to carry pollutants northwards along the shore. However, because of their slow nature, the currents end up depositing their pollution loads along their paths as evidenced by the high nutrients loads and coliform levels along the shore thus threatening the near shore reef systems. In this regard, there are indications that the reefs around Chapwani and Kibandiko are heavily stressed.

In order to reduce pollution, the study recommends that the construction of discharge pipes is designed in such a way that sewage is discharged and flushed beyond the islets of Bawe and Changuu following the observed current patterns. Japan International Cooperation Agency, 1996: The study on solid waste management for Dar es Salaam City in the United Republic of Tanzania. Progress Report 2. Kokusai Kogyo Co., Ltd.

Aim of study: This progress report presents results of an assessment of current urban environmental sanitation and results of basic surveys for the formulation of the solid waste master plan for Dar es Salaam. The report also presents planning frameworks for the master plan.

Method: Environmental and sanitation conditions in Dar es Salaam were assessed through measurements of, among other things, water quality and soil contamination levels in the city. Water quality surveys were carried out during both rainy and dry seasons at various points in Msimbazi River and in wells situated near Vingunguti disposal sites. Samples from the study areas were analysed for dissolved oxygen, COD, BOD, faecal coliforms, total nitrogen, total phosphorus, tetrachloroethylene, trichloroethylene, 1-1-1 trichloroethane, lead, chromium (Cr, Cr^{6+}), cadmium and cyanide. Other parameters measured were water temperature, conductivity, chromatility, turbidity and pH. The report also discusses environmental sanitation situation in the City. Issues such as water supply situation, solid waste management and drainage and flood control are discussed.

Results: With regard to water supply situation, the report points out to the fact that most wells in the City suffer from pollution from pit latrines. Furthermore, the quality of water supply, other than the National Urban Water Supply (NUWA) is not assured at all. The paper further reports that domestic waste management is poor. It quotes a figure of 80% being the number of city households that rely on pit latrines which, due to limited emptying operations and a high water table, results in the pollution of rivers and the sea. Furthermore, the report points out that intensive cultivation in river catchment areas may possibly introduce toxic chemicals and heavy metals into the environment.

With regard to drainage and flood control the report enumerates environmental hazards associated with this sector. These include sewage overflow from pit latrines and cess pits as a result of

floods and poor drainage, pollution of surface water and ground water from overflow of sewage, the occurrence of retention pools of water where mosquitoes breed due to poor drainage. The report concludes by saying that improvement of solid waste management in the city is of importance since the present waste collection services are inadequate.

Machiwa, J., 1999: Distribution and remineralisation of organic carbon in sediments of a mangrove stand partly contaminated with sewage waste. *Ambio* 27:740-744.

Aim of study: The principal objective of this study was to assess the effect of sewage dumping on the levels and rate of mineralisation of organic carbon in mangrove soils. The influence of hydrological, biological and environmental conditions on organic carbon content of the mangrove soil was also considered.

Area of study: This study was carried out at Maruhubi mangrove stands in Zanzibar.

Methods: The study measured physiochemical factors in the soil (salinity, pH, redox potential), forest productivity, rate of organic carbon degradation, vertical distribution of organic carbon in sediment and carbonate carbon.

Results: Soil pH and redox potential were measured using appropriate electrodes while salinity of porewater was measured by a hand held refractometer. TOC was measured on a SHIMADZU TOC analyser. Results of organic matter decomposition rates indicated that mineralisation rates of organic matter in fine sediments were not significantly different in the different zones of the mangrove forest (Appendix 8). However absolute values show that mineralisation rates were higher in frequently inundated zones. Relative values indicated that mineralisation was slowest in sewage contaminated areas compared to areas not exposed to sewage. With regard to distribution of mangrove carbon in mangrove sediments, the paper shows that there is a seaward decrease in concentration. It appears that disposal of raw sewage increases the concentration of organic carbon in sediment but there was no peat formation.

Powell, C., 1997: Oceanic sewage pollution and composting toilets. SIT Fall Report. 29p.

Aim of study: The purpose of this study was to assess pollution levels along the coast of Zanzibar Town. In its introduction the report discusses the pollution situation in the Stone Town, Zanzibar especially with respect to the discharge of raw sewage into the sea. It also discusses proposals put forward by the Dorsch Institute to construct a sewage treatment plant about 7 – 10 km from the Stone Town. The other proposal was to repair the current sewage network so that leaks in the system are stopped and sewage does not spill in the street of the Stone Town. Secondly to extend the sea out-falls to a length of up to 170m into the sea. Dorsch Institute also proposed to introduce composting toilets The author argues that the idea of introducing composting toilets is more feasible than the other two alternatives since once the toilets are constructed they are easy to maintain.

Area of study: Zanzibar town.

Methods: Sampling points were selected in such a way as to assess both point sources and non-point sources of pollution. Sampling was carried out in the inshore waters off Bwawani Hotel, Shangani, Africa House, and Serena Hotel. Samples were also taken from point sources. Some sites were identified in Pemba to act as control. Parameters analysed were dissolved oxygen, biochemical oxygen demand (BOD), and faecal coliform. Dissolved oxygen and BOD were determined using methods recommended in *Standard Methods for Water and Wastewater Analysis*. Coliforms were determined using the Most Probable Number (MIN) technique.

Results: The areas studied were polluted as they had high levels of nutrients, BOD and faecal coliforms. The study recommended that composting toilets be implemented as they would help lower pollution in the water. It also recommended that since most people in the Stone Town are not aware of the pollution problem and associated health risks, they should be educated on these aspects.

Hogan, L. and D. Dahlke, 1998: An assessment of the west management program on Changuu Island. SIT Zanzibar Ecology. 46p.

Aim of study: The purpose of this study was to appraise the garbage accumulation situation in Changuu Island, Zanzibar with the view to assess the need for a disposal program and how it can be implemented. In its introduction the paper asserts that improper disposal of waste management has many detrimental effects on the environment as well as pose serious health risks. It further said that a major obstacle to adequate waste management in developing countries is the huge cost associated with the activity that many countries can hardly afford. Thus waste management is often found at the bottom of the list of the national priorities.

Area of study: This study was carried out at Changuu, a small island situated off the coast of the main Unguja Island. The islet is a popular tourist spot.

Methods: The study began with an initial assessment that consisted of continual assessment the solid waste scattered over the islet. This was followed with a series of interviews with members of the Zanzibar Ecotourism Association, members of staff of Changuu as well as with visitors to the islet.

Results: The study revealed that poor waste management was prevalent in much of Zanzibar including Changuu Island. On Changuu, garbage was contributed by both staff and visitors to the island The study concludes that waste management practices on Changuu led to unsanitary conditions, was environmentally degrading (Appendix 10) and had the potential to distract visitors to the island. The study recommended (and implemented the placement of rubbish cans on the island) with the hope that these will be used by staff/visitors to ease the garbage management problem.

The report recommends that an environmental awareness program aimed at both staff and visitors to Changuu be initiated to reduce the waste problem on the islet. Staff should also be taught different waste management techniques such as composting and waste separation. It also proposes that a study should be carried out in the waters surrounding Changuu and other islands to assess the effect of improper disposal of waste on marine life.

Huntoon, G., 1996:Tourism; impacts on environment and culture in Zanzibar. SIT Zanzibar. 36p.

Aim of study: Evaluate the impact of tourism on the environment and culture of Zanzibar.

Area of study: This study was carried out at Nungwi village situated at the extreme north of Unguja Island and at Changuu, a small island off Zanzibar Town.

Methods: Data collected for this study was through village and tourist surveys and through interviews with tour operators, hoteliers, a historian, and government agencies.

Results: The paper reports that results of fifteen interviews carried out with villagers indicate that villagers are very concerned with tourist behaviour especially their dress behaviour in public is disagreeable with the local culture. Of the tourists, the most common environmental problems frequently mentioned were poor waste management, structural danger in Stone town and overpopulation.

Interview with the Director of Planning and Development, Commission of Tourism had revealed that the number one focus of tourism development in Zanzibar is "appropriate development". Yet the island's infrastructure was not developed enough to handle this industry especially with regard to roads, electricity and communication. The island is yet to cope with tourist-villagers relations despite developing information booklets. It is hoped though that these information booklets will help ease conflicts between tourists and locals.

With regard to the environment, the report points out the fact that the improper waste disposal practices on the island is of great concern and is proposing an in depth assessment of the waste management problem in key areas of high tourist volume. The report further recommends that the authority use the revenues generated from tourism to establish a recycling centre so as to reduce the amount of waste from dumpsites. Finally, the study emphasises the need for environmental impact studies to be carried out on proposed tourism projects.

Kangwe, J.W., 1999: The effect of land based pollution on reef building calcareous algae in the reefs near Zanzibar Town. MSc Thesis. University of Dar es Salaam. 97p.

Aim of study: The purpose of this study was to investigate the impact of pollution (specifically of mercury, lead and cadmium) on calcification and photosynthesis rates of the reef building calcareous algae *Amphiroa tribulus* found in the reefs located off the Stone Town of Zanzibar.

Methods: Aspects that were investigated during this study included species composition and abundance with respect to associated physico-chemical factors and survival rates of the red alga exposed to varying conditions of physical and chemical factors. The effect of heavy metals on calcification and photosynthesis rates of the calcareous alga was also investigated. This study was carried out in the reefs around three islands off Zanzibar Town that receive various degrees of pollutants from the town. These are Bawe, Chapwani, and Changuu islands.

Assessment of environmental factors was carried out using standard techniques. Water temperature was measured using a hand held thermometer and that of turbidity by a secchi disc. A hand held refractometer was used to measure salinity. Dissolved inorganic phosphate was measured according to the spectrometric method of Parsons *et al* (1984). Algal abundance and diversity was assessed through SCUBA diving at the study sites. Rhodolith survival experiments were carried out at the study sites with algal nodules collected from the Bawe site. The effect of heavy metals on calcification and photosynthesis rates was studied outdoors in full sunlight and calcification rate was determined by estimating the rate of removal of CO_3^{2-} from the seawater using the total alkalinity method.

Results: According to this study, there are indications that in the near future Zanzibar marine waters will experience increased impacts from human activities. These may emanate from expanded tourism activities and the fast growing population of Zanzibar. Currently, Zanzibar is generating large quantities of waste (from hotels, households, harbour and transport activities and from commercial works) which is threatening the marine environment.

Results showed that there was a significant difference in composition and abundance of calcified red algae species with respect to distance from Zanzibar harbour, a polluted area . The study observed that species richness was highest at Bawe station, located about 6 km away from the harbour while Chapwani, locates 2.5 km from the harbour had the least number of species. Relatively higher temperatures, high turbidity, high phosphate and low pH values are among the factors that might have contributed to poor species richness at Chapwani. During the rhodolith survival experiment, it was found that individuals survived best at Bawe followed by Changuu and Chapwani stations. Results on the effects of short term exposure of mercury, lead, and cadmium on calcification and photosynthetic rates on *Aamphiroa tribulus* showed that mercury was the most toxic heavy metal used. Lead was the least toxic metal.

The study recommends that a comprehensive, long- term monitoring study be carried out in the waters off Zanzibar to assess the status of pollution and impacts on human health and critical ecosystem. This will help narrow the gap in knowledge about the status of pollution in this area and its ecological impacts. The study further recommends that proper pollution control regulations and public awareness campaigns should be instituted to help curb further pollution in the area. Waste effluents from domestic sewage systems and those from manufacturing industries should be treated before being discharged into the environment.

Maalim, M.K., 1995:Augmentation of Quantity and Improvement of water quality for Zanzibar Town. Diploma Project, Ardhi Institute, Dar es salaam. 72p.

Aim of study: The purpose of this study was to survey the yield capacity of existing water sources in the Zanzibar township and correlating with existing and future water demands. It was also aimed at examining the present quality of all water sources and to recommend the appropriate measures to be taken for improvement of both water quantity and quality.

Area of study: Zanzibar Town.

Methods: The study was conducted through interviews with several organisations and visiting water sources and network system. Water samples were also collected from all sources and within distribution network for laboratory analysis. Among the parameters measured were Temperature, pH, Chloride, Iron, Manganese, Total coliforms and Fecal coliforms etc. Water analysis for all parameters was done according to *Standard Method for Analysis of Water and Wastewater* 5th Edition published by APHA.

Results: It was observed that all water sources did not receive any treatment and was bacteriologically unsafe. However, chemical contents in the water were at acceptable levels except for one source that was found to have excess Iron concentration. In respect of quantity it was noted that there is an existing water shortfall of over 3,400 m^3 day^{-1} which shall increase to 13,400 m^3 day^{-1} in the year 2005 if appropriate measures are not immediately taken.

The study suggested mitigating the water shortfall through increasing the number of pumping hours presently followed by tapping of extra water through new boreholes. It was also proposed to establish disinfecting units and to arrest excess Iron by resorting to dilution from other sources. The study recommended permanent water source monitoring and routine water analysis for determination of both physico-chemical and bacteriological quality. It was also recommended to fence water sources in order to prevent human activities close to water sources with the view to avoid water pollution.

Bryceson, I., 1981: A review of some problems of tropical marine conservation with particular reference to the Tanzanian coast. *Biological Conservation*, 20: 163-171.

Aim of study: The purpose of this paper was to examine some principles of conservation theory in relation to the tropical marine environment and to review the main problems of conservation in Tanzanian coastal waters.

Area of study: Tanzania coastal waters.

Results: It was stated in this paper that coral reefs were predominant features along the whole of the Tanzanian coastline, except in the vicinity of river mouths. Unfortunately, coral reefs in the vicinities of urban centres, especially Dar es Salaam, Mtwara and Tanga, were subjected to frequent blasting by fishermen engaged in the illegal practice of using dynamite. Coral reefs were also damaged by excessive siltation caused by soil erosion due to deforestation and poor agricultural practices close to rivers. Trampling by visitors to the reefs crushed delicate growths. Other pressures on the coral reefs were the indiscriminate collection of shells, corals and aquarium fishes; and harpoon fishing.

The broken sewer pipe in the Dar es Salaam harbour on the sandy-muddy tidal flats of the area was also mentioned to be endangering invertebrates and fishes. In Msasani Bay (Dar es Salaam), a meat-processing factory was dumping untreated wastes into a seasonal stream. The foul-smelling wastes were a health hazard during rainy periods. Various industries also discharged organic and inorganic effluents into the sea. The effect of dumping vast quantities of gypsum into the sea by a fertiliser factory in Tanga was deleterious to seagrass beds and nearby isotopes. Seagrasses were also affected by trawling. Mangroves were threatened by intensive cropping for poles and firewood and by clearance of large areas for salt production.

Bryceson, I., 1982: Pollution of Dar es Salaam coastal environments by industrial and domestic effluents. In *Proceedings of the Workshop on the Current State and Development of Marine Sciences in Tanzania*. Institute of Marine Sciences, Zanzibar. 2-8 April, 1982, pp. 32-41.

Aim of study: The main objective of this paper was to briefly assess the impact of effluent disposal on the ecology of several habitats in the marine environment.

Area of study: In the vicinity of Dar es Salaam. Assessments were made at five places: The Dar es Salaam Harbour; the Ocean Road seafront; Msimbazi River Basin and Creek; Msasani Bay and Kunduchi area.

Results: At the Dar es Salaam Harbour, the assessment revealed that there were inflows of untreated sewage from storm-water that drained directly into the harbour from the City Centre, Keko, Shimo la Udongo, Kurasini and Mtoni. There was also oil pollution from the refinery at Kigamboni and inflows of industrial wastes from Keko, Chang'ombe, Kurasini, Mtoni and Temeke that included pesticides, paint wastes, mercury and organic wastes. Due to incomplete tidal flushing, many of these pollutants were considered to have long residence times in the harbour waters before dispersal to the sea, sedimentation or absorption by organisms.

At the Ocean Road seafront, a sewage pipe discharged onto the mud flats exposed at low tides due to break in the pipe. Due to this breakage, the immediate vicinity was deoxygenated, and the black sulphide mud was found to be completely devoid of natural macro-fauna and flora for a radius of several meters. Beyond this radius, there was prolific growth of algae and seagrasses

and an abundant fauna considered to be stimulated by the supply of organic detritus. In general, offensive smells, murky waters and muddy substrates from pollution of the harbour and the sewer pipe adversely affected the aesthetic quality of the Ocean Road area.

Msimbazi Valley and Creek were heavily polluted due to inflows of effluents from Vingunguti, Buguruni, Ilala, Kariakoo, Tabata, Kigogo, Magomeni, Mabibo, Mburahati, Manzese, Mwananyamala and Ubungo. Most of the industrial effluents were untreated and reached Msimbazi through ditches, channels and streams. The most noxious effluent included dyes and strong alkalis from textile factories, oils and tars from heavy vehicle depots and power stations, organic wastes, acids, pesticides, and other harmful chemicals. The results were deleterious to the Msimbazi Creek water quality and mangrove biota. Msasani Bay received domestic effluents from Regent Estate, Kijitonyama, Mwenge, University of Dar es Salaam, Mikocheni, Lugalo, Kawe and Mbezi through ephemerical streams and channels. Industrial effluents included organic wastes from the meat factory at Kawe causing deoxygenation, high turbidity and foul smelling. Wastes from the bicycle factory at Mwenge posed serious danger due to discharge of effluents containing acids, alkalis, cyanide, hexavalent chromium, nickel, zinc and copper. At Kunduchi area, factories were being constructed during the period of this study, and more others were planned. The paper singled out the asbestos factory, which started production in 1980 to be of particular concern.

Bryceson, I., De Souza, T.F., Jehangeer, I., Ngoile, M.A.K. and P. Wynter, 1990: State of the marine environment in the Eastern African region. ***UNEP Regional Seas Reports and Studies No. 113*****.**

Aim of study: The main goal of this study was to prepare a regional assessment of the state of the marine environment in the Eastern African region, following the general format of the second global review of GESAMP. Main issues discussed in this document included general characteristics of the region, marine contaminants, and human activities affecting the sea and biological effects, among others.

Results: Citing the example of Dar es Salaam, which had an estimated population of 1.3 million in 1990 and a growth rate of 6%, about 15% of the city population were estimated to be served by sewers, these conducted the sewage to the sea untreated. A major sewer extending from the Ocean Road seafront directly in front of the State House where untreated sewage spilled out of the broken sewer into intertidal flats; floatables and suspended solids from the sewer were conveyed to Banda Beach, the city's main fish market. Other sewers discharged into the harbour and into Msimbazi River and Creek. Most of the city's population used soak-away pits and septic tanks, severe problems occurred during the rain season due to overflow. Bryceson and Mwaiseje (1980), Gomile (1980), Bryceson (1981; 1983) and Mwaiseje (1983) were cited to describe the appalling situation in Dar es Salaam in detail.

The towns of Tanga and Lindi were also reported to have inadequate sewerage systems, and Zanzibar Town experienced acute problems during the rainy season as drains and sewers became flooded.

Industrial effluents, usually via streams and rivers also polluted the marine environment of Tanzania. The Msimbazi River was cited to receive large amounts of untreated or insufficiently treated wastes from industries in addition to the already overloaded state of domestic sewage effluents. The Msimbazi was being heavily polluted by noxious effluents which included dyes and strong alkalis from textile factories, oils and tars from various vehicle depots and power stations, organic wastes from breweries and meat plants, and various other industrial wastes such

as heavy metals, PCBs, cyanides, pesticides, herbicides, detergents, etc. Steinbach (1973), Madati et al. (1977), Bryceson and Mwaiseje (1980) and Bryceson (1981, 1983) described the polluted state of the Msimbazi River.

Pollution from rivers that flow long distances and later discharge into the sea was also mentioned. An example was given of the Mufindi Pulp and Paper Mill, which polluted the Kilombero River. However, the extent of this kind of pollution was not given. Mining activities in the study area were also discussed. However, few studies had been done to evaluate the mineral and mining potential in the study area. The studies due to Harris (1961) and Duyverman (1981) which gave an account of the extent of mineral deposits in the area were cited in the report. Salt works, which were cited as a major cause for the decline of mangroves, were also believed to compound beach erosion in the study area. Solar pans were found at Mbweni, Ras Kiromoni and Kunduchi/Mtongani and covered an area of approximately 165.5 ha (Semesi, 1991).

On beach erosion, a comprehensive list and review of literature was mentioned to be given in the report by Norman (1995). Similarly, Griffiths and Lwiza (1988) gave a detailed review of literature relevant to beach erosion along Kunduchi Beach. From these studies, it was generally found that the area north of Dar es Salaam had been experiencing severe erosion for the previous three decades.

Bwathondi, P.O.J., Nkotagu, S.S. and S. Mkuula, 1991: Pollution of the Msimbazi Valley. Report commissioned by National Environment Management Council, Dar es Salaam, 28p.

Aim of study: The main objectives of this study were to collect and compile all the available data on the pollution of Msimbazi River, and to advise if there was need for a more comprehensive multidisciplinary research on the pollution of the valley.

Area of study: Msimbazi River.

Methods: The methodology involved visits to key sources of information, and performing field and laboratory studies to compare the different concentrations of some elements. A study previously conducted by Ak'habuhaya and Lodenius (1986) was referred to on pollution by heavy metals on the valley.

Results: Mercury levels in most of the samples were within environmentally acceptable units. The samples had been taken from six sites (A to F) covering the whole length of the Msimbazi Valley from the textile mills to Selander Bridge. However, samples of an aquatic plant *Crotalaria laburnoides* taken just after the bridge contained higher quantities of mercury, which reflected a cumulative effect. Downstream of the valley at stations C, D and E, values of mercury greater that 0.1mg/kg dry weight were found in sediment samples. WHO's maximum permissible level of mercury in drinking water was mentioned to be 0.001 mg/l.

Chromium levels quoted from Ak'habuhaya and Lodenius (1986) were generally highboth in the sediments and in the bodies of aquatic plants and animals (0.2 to 2.7mg/kg dry weight). The allowable chromium in drinking water by Tanzania standards was 0.05mg/l. In this study, the chromium in water samples ranged from 0.02 to 0.19 ppm. This was seen to be an indication of reduced discharge of the chemical into the river.

A report by Haskoning and M-Konsult (1988) was referred to on the pollution due to solid wastes (domestic solid wastes, commercial solid wastes, institutional solid wastes and market wastes). The report gave sources of hospital wastes, car wrecks, slaughterhouses and industrial solid

wastes. Industrial hazardous wastes were produced from food and beverages, whereby a report by NEMC (1986) was referred to. Others were cotton and textile industries, and the SUKITA complex.

It was concluded in this study that there were high levels of bacteriological contamination of the Msimbazi River. The unpleasant odours that emanated from polluted waters of the Msimbazi Creek were notorious to the inhabitants. The foul smell was due to deoxygenation, which had been caused by chemicals that killed the natural flora, and by bacterial decomposition of concentrated organic wastes with the formation of hydrogen sulphide.

Chande, A. I., 1994: Inventory of destructive activities affecting the aquatic environment: Mtwara region. National Environment Management Council, Dar es Salaam, 38p.

Aim of study: The aim of this study was to make an inventory of all destructive activities affecting the aquatic environment in Mtwara region. One of the specific objectives of this study was to identify and assess the magnitude of destruction of activities that had an impact on the aquatic environment.

Area of study: Mtwara region.

Methods: Data were collected for a period of two weeks covering the four districts of Mtwara, namely Newala, Masasi, Mtwara Urban and Mtwara Rural.

Results: Destructive fishing methods such as beach seining and dynamite fishing were reported. Beach seines recorded the highest catch in 1993, and had the biggest number of fishing units. The seines were operated in sandy beaches such as Msimbati and areas between Pemba and Mgau. Areas reported to use dynamites included Mgau, Mikindani, Miseti, Msanga Mkuu, Naumbu, Mkungu, Mnete, Mkubiro and Ng'wale. Pemba was the only village that discouraged the use of dynamites.

42 companies, which had salt pans covering a total area of 1,169.2 ha operated salt production, out of which 516.5 ha were constructed within mangrove areas involving the total clearing of the forests. The remaining pans were situated behind mangrove forests on bare saline patches. The cleared area accounted for about 6% of the total area of 8,941 ha that was covered by mangroves (Semesi, 1991).

The production of lime from coral stone was practised at a large scale at Chumo, Mikindani, Mitengo, Mgau and Msimbati. The amount of coral used was not quantified as there was no monitoring by the Regional authorities, but the quantity of lime produced was large. Apart from destroying coral reefs, the process involved burning of mangrove as a source of fuel. Mangroves were also cut for boat and house building. The areas with the highest rate of poles collection were Mongo and Mana Hawanja Islands, and in the Ruvuma delta.

Industrial development in Mtwara was quite low. The only factory operating was a beverage factory situated at Mikindani. The effluents were being discharged into the Indian Ocean untreated. However, the effluents contained negligible amounts of pollutants. In Mtwaratown, sewage sludge was disposed of into the ocean at Shangani beach. Although no water quality analysis had been conducted, the area was polluted as was indicated by the unpleasant smell that came out. The report proposed various mitigation measures on these destructive activities.

Haskoning and M-Konsult, 1988: Study on: Solid waste management and pollution caused by sewerage system in Dar es Salaam. The Department of Sewerage and Sanitation, Ministry of Water, Dar es Salaam, 204p.

Aim of study: The main objective of this study was to differentiate the solid wastes according to the source of generation and to quantify the source of generation. The basic element of this approach was to come up with two kinds of waste: non-hazardous waste which could be collected and disposed off together, and hazardous wastes which required special collection and disposal facilities.

Methods and Results: This extensive study described and assessed the status of wastes generated by domestic sources, markets, commercial establishments, institutions, hospitals, industries, slaughterhouses, construction works, street drain and sewer cleanings, and car wrecks. Discussions and analyses were also made on the solid waste management system prevalent at that time, the Tipper Truck performance, impact assessment of Tabata Dump (now closed), maintenance of solid wastes collection, vehicles, forecasts of waste generation, recycling of wastes, etc. However, the report did not state specifically the amounts of waste disposed of into the sea.

HBT AGRA Limited (Engineering and Environmental Services, Consultants), 1994: Environmental Impact Assessment: Songo Songo Gas Development Project. Interim Assessment Summary Prepared for the Ministry of Water, Energy and Minerals, 33p.

Aim of study: The purpose of this study was to provide an environmental impact assessment and a mitigation management plan. Since Tanzania did not have environmental assessment guidelines or environmental discharge criteria, this environmental assessment followed international environmental protection guidelines from the World Bank and Canada.

Area of study: Songo Songo Island, approximately 200km south of Dar es Salaam.

Methods: The project involved production, processing and transportation of natural gas from Songo Songo Island to a thermal electric power generation facility in Dar es Salaam, connection to the existing electrical grid, and the local distribution of gas to industrial customers. The construction of facilities was expected to take approximately 10 to 12 months. The proposed development was expected to produce approximately 80 to 100 Mcf/d over a 20-year period from wells located on and near Songo Songo Island. The gas was to be processed at a plant on Songo Songo Island to remove produced water and condensates. The gas would be transported via a 30cm diameter pipeline, 24km to the mainland. The mainland buried pipeline, 186 km long, would occupy a 20m wide right-of-way during operations. Some of the right-of-way mainline would traverse coastal forest stands, up to the power plant in Dar es Salaam. The baseline biophysical information was collected from a variety of sources including literature review maps and air photos and an earlier feasibility study report. This was supplemented by a route reconnaissance using helicopter, fixed wing and truck transportation. Knowledgeable personnel in government agencies and private organisations were also interviewed.

Results: In general, the potential biophysical impacts of the proposed development were expected to be low to neutral. There would have been some short term impacts during construction consisting of minor erosion and siltation. The impact of the air emissions from the plant site was expected to neutral because the gas does not contain sulphur.

The marine pipeline route from SongoSongo Island to the mainland was to pass through shallow water and beside some coral reefs and eel grass beds. There was a large variety of fish species in the vicinity of the reefs. Pipeline construction would cause some temporary siltation in the vicinityof the reefs. The tidal and nearshore currents would however, disperse and dilute the suspended sediment thus minimizing any impact to the coral reefs, it was stated.

Johnstone, R. and M. Suleiman, 1997: Some aspects of the interaction between pollution and nutrient dynamics on coral reefs around Zanzibar. In (R.W. Johnstone, J. Francis and C.A. Muhando, eds.) *Proceedings of the National Conference on Coral Reefs*. Zanzibar, 2-4 December, 1997, pp. 45-50.

Aim of study: This paper was presented to mark the "International Year of the Reef", with the theme "Coral Reefs: Values, Threats and Solutions". The paper considered, in a wider perspective, some aspects of the interaction between pollution and nutrient dynamics on coral reefs around Zanzibar.

Area of study: Zanzibar.

Results: The paper first began with a review of global status of coral reefs, the destruction of coral reefs and the potential role of anthropogenic inputs. In Zanzibar, the majority of coral reefs around the islands of Unguja and Pemba were found not adjacent to large urban areas and so anthropogenic inputs were largely restricted to situations associated with particular village or hotel outlets. However, a possibility existed so that nutrient might reach coastal biotopes via groundwater that emanated from recharge areas to the coast. But no clear conclusion could be made about this potential for this effluent material to reach some of the nearby coral reefs.

An experiment was conducted to investigate different aspects of the nutrient dynamics and community response to nutrients at two reefs. One close to town and within the main current passing the town outflows (Chapwani Island), and the other more remote to town and considered to be outside of the main currents passing the town (Bawi Island). Comparisons were made in soluble reactive phosphate (SRP) and ammonium concentration. Results indicated no significant difference between the two reefs in PRP. However, there was an ammonium concentration of 0.8 Ml^{-1} during low tide at Chapwani while at Bawe, no ammonium was detected.

Another experiment was performed, to examine the development of epolithic communities after physical disturbance of coral. In these experiments, a mixture of terracotta tiles and pieces of cleaned dead coral were placed out to simulate the newly exposed surface of broken corals. Results showed that, after two weeks and four weeks, the respective specimens showed significantly higher gross community production on the specimens at Chapwani site compared to those of Bawe. Further, the communities which developed over the four week period on the Chapwani specimens had a much larger heterotropic component with respiration values approximately four times higher than for the communities that developed on the Bawe specimens.

Kondoro, J.W.A., 1997: Dispersion of heavy metals along Msimbazi River basin in Dar es Salaam, Tanzania. *Tanzania Journal of Science*, 23: 1-10.

Aim of study: This study presented preliminary results of a heavy metal distribution profile along Msimbazi River basin on a 15-km stretch, which pass through some industrial and residential zones of the City to the Indian Ocean. Several locations of the river were sampled for about six months.

Area of study: Msimbazi River.

Methods: The sampled specimens of water and sediments were investigated for the extent of heavy metal pollution using Atomic Absorption Spectrophotometry (AAS) and X-Ray Fluorescence analysis (XRF) techniques. The major elements of interest in this study were Pb, Cd, Zn, Cu and Cr. The report sought to identify the likely sources and sinks of the different heavy metals in the river system. A map showing the sampling locations and the region through which Msimbazi River passes was presented. The sampling was carried out five times at intervals of six months between 1994 and 1995.

Results: The Msimbazi River was mentioned as among the most prominent rivers that pass through the urban area of the City and end up into the Indian Ocean. The river has three tributaries: Sinza, Ubungo and Luhanga, which flow through the densely populated locations and the main industrial area of the City. The river was therefore a recipient of most of the city's garbage. The river is about 35 km long with a catchment area of 300 km^2. The valleys of these rivers hosted several squatter settlements, extensive vegetable production and sand mining. The river basin was also a major industrial area hosting several factories of different kinds such as textile mills, food-industries and power plant.

Results from this study indicated that most of the concentrations of heavy metals within the Msimbazi River occurred within a distance of 5-10 km along the river from the river mouth. Within this area/zone there is only one tributary (Luhanga River) which joins the Msimbazi at about 6 km from the river mouth. It was noted however that this tributary originates from the partly uninhabited and partly residential areas that were unlikely to contribute to the observed heavy metal profile. Although the industries spread out even beyond Vingunguti, most of them lied between Vingunguti and Buguruni along the Msimbazi valley. Since most of the observed heavy metals were used in technological processes, industries were likely to be linked to their presence in the river. Due to the intensity of human activities within the Msimbazi Valley, the concentrations of heavy metals could be higher than the registered values, it was noted.

Machiwa, J.F., 1992: Anthropogenic pollution in the Dar es Salaam Harbour area, Tanzania. *Marine Pollution Bulletin*, 24(11): 562-567.

Aim of study: The purpose of this study was to provide baseline information on the possibility of occurrence of toxic chemicals and pathogenic microbes in the marine sediments off Dar es Salaam. According to the author, the harbour area was suspected to be the most polluted of all places in the Tanzanian coast.

Area of study: Dar es Salaam harbours.

Methods: Samples were taken from ten sampling locations (stations 1-10) that were shown in a map. For the sediment cores, it was possible to get samples from only five stations (1, 2, 3, 5, and 10) since the remaining stations had coral rubbles. Samples for microbial analysis were collected and analyzed within 4h of sample collection. Coliform bacteria were counted using the most probable number multiple fermentation method as outlined in Franson *et al*. (1989). PCBs and petroleum hydrocarbons were analyzed using gas chromatography. The flame atomic absorption spectrophotometry (Perkin–Elmer model 2380) method was used to analyze sediments for heavy metals. Finally, the organic carbon content of the sediments was determined by dichromate oxidation technique (Gaudette *et al*., 1974).

Results: The organic carbon results showed high input of organic matter in sediments at stations 1 and 5. Organic substances in the harbour were found to derive from direct discharge of oil/fuel by boats and ships in the harbour, deliberate disposal of organic wastes and terrestrial input. A table of percentage organic carbon content in bulk sediment core samples at various depths for each station was included in this article.

Analysis of Total PCBs showed that the chlorinated organic compounds were t an alarming level at the port. They were enriched in sediments from station 1 in the inner harbour and relatively low outwards at station. The analyzed tri- to hepta-chlorobiphenyls could have resulted from Gerezani small industries (SIDO) area, from Kurasini area through stream runoff or from ship repair work at the port. Assessment of petroleum hydrocarbons, which was made on stations 1 and 3 only, showed that both stations were affected. Although station 1 was found to be more affected then station 3, there was no sufficient evidence to link the nearness of station 1 to the oil refinery plant which could potentially cause leakage or discharge of oil into the sea. It was urged however that heavy traffic of marine vessels in the area might significantly contribute to oil pollution.

The analysis on coliform bacterial count indicated that both total and faecal coliform counts were high at station. This station was the busiest fish-landing beach in the city. The bacteria resulted from disposal of offal and condemned fish at the beach. Locations on the outer harbour (stations 7 and 8) had intermediate numbers of bacterial count, and it was suspected that the sewer outfall contributed to microbial pollution in the area. Stations located far from the affected places were found to be least polluted.

Heavy metal concentrations in the geochemically available fraction (Fe, Mn, Cd, Cr, Pb, Cu, Zn and Ni) were presented in a table. Results showed that there was high input of some toxic metals viz. Pb, Zn and Cu at the port area. Also, there was a significant Cd pollution in sediments off the port, close to the ship's outer anchorage zone. The source of these heavy metals at the port was mainly deliberate disposal of unwanted goods or materials, ship repairs and terrigenous input.

Martinez, C., 1998: An assessment of the attempts to manage the sewerage/sanitation system of a growing East African coastal city – Dar es Salaam, Tanzania. University of Rhode Island, 18p.

Aim of study: The aim of the study was to describe the development of the sewerage system in Dar es Salaam, and the historical context within which this system evolved. The managerial processes involved were then evaluated and an attempt to determine the weaknesses of this development was made.

Area of study: Dar es Salaam.

Methods: The author reviewed the existing documentation on the development of the sewerage system that was built in 1948 and which she claimed was not consistent.

Results: Part of the initial construction was reported to consist of nine Waste Stabilization Ponds (WSP) installed in outlying areas to serve residential, industrial, and institutional wastes, along with one central sewage outfall pipe that was designed to discharge sewage just north of the harbour entrance. This sewage outfall pipe was connected to sewers that were constructed for the City Centre only. This information was gathered from Linden and Lundin (1995), UNEP (1982) and Uronu (1995). By the 1980's, seventeen pumping stations had been installed for the sewerage system in Dar es Salaam, but only two were in working order. Also, the condition of the existing sewers had significantly deteriorated, causing untreated domestic and industrial wastes to flow

directly into surrounding areas (UNEP, 1982). Of the nine WSP that had been installed, only one was operating with any degree of effectiveness by this time.

Of the eight projects remarked for addressing the sewerage/sanitation problems since 1945, only one was implemented. This was a World Bank Project geared towards rehabilitation and expansion of the sewerage/sanitation system in 1982, but some of the goals of this project were not met. An evaluation was done in 1990, which stated that the World Bank rehabilitation improved sanitary conditions by preventing direct discharge of untreated sewage. However, much of the system was inoperable by this time because, according to Lunden and Lundin (1995), there was no maintenance effort in place, and the system was considered inadequate because sufficient expansion had not occurred.

Conclusion: The author remarked that in Dar es Salaam, the population explosion at the coast caused an already inadequate and failing sewerage/sanitation system to become completely defunct, leading to innumerable health problems and risks to those living within the city and in surrounding areas. Figures were given of the population increase in Dar es Salaam since 1945 when the population was estimated at 145, 448 and would have reached 2 million by 1995.

Mashauri, D.A. and A. Mayo, 1989: The environmental impact of industrial and domestic waste water in Dar es Salaam. ***Symposium on Environmental Pollution and its Management in Eastern Africa*****. Faculty of Science, University of Dar es Salaam. 11- 14 September 1989, pp. 90-101.**

Aim of study: The main objective of this study was to discuss on the potential impact of discharging raw sewage into the Indian Ocean through a sea outfall.

Results: In this study, some indications of the levels of pollution were also given. The study gave an overview of pollution sources that finally lead into pollution of the sea. These were identified as domestic waste and industrial waste pollution. On domestic wastes, the main sources of pollution were considered to be non-point, e.g. Septic tanks/soak pits that leached into the ground water and quite often over flew to the nearby streams and eventually to the sea and the point loading from the industries. The domestic wastes were considered to be mainly responsible for deficiency in dissolved oxygen of receiving waters as a result of decomposition of the organic load. On the other hand, the industries were considered to pollute the streams and the ocean at a higher level than the domestic sources.

On industrial pollution, wastes generated were classified into food processing; textile mills; power generation; metal industries, and; petroleum industries. The potential impact of each of these polluting industries was then discussed separately. The Msimbazi stream was singled out as the main collector of most of the industrial waste in Dar es Salaam City. The stream, after traversing from the Pugu hills, discharged wastes at Salender Bridge. A table was given which showed typical concentrations of heavy metals in some fishes in the vicinity of this discharge. The table was adopted from Haskoning and M-Konsult (1988).

Mgana, S. and S. Mahongo, 1997: Land-based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment: Tanzania Mainland. Report presented at the ***UNEP Regional Workshop*****. Institute of Marine Sciences, Zanzibar. 6-9 October 1997, 50p.**

Aim of study: **The main objective of the study was to quantify all major human activities that contributed to land-based effluents and pollutants, namely the industrial, domestic and agricultural practices of the coastal area of Tanzania mainland.**

Area of study: Emphasis was made on Dar es Salaam and Tanga.

Methods: The qualification was made using the WHO manual on "Management and Control of the Environment (WHO/PEP/89.1 and WHO/PEP/GETNET/93.1-A)" as the major reference. The procedures followed were generally referred to as "Rapid Assessment of Air, Water and Land Pollution (WHO, 1982)".

Results: The report included information on many aspects of Tanzania's coastal environment such as natural conditions and processes, anthropogenic impacts, identification and assessment of problems, sources of degradation, contaminants, physical alterations, emerging and foreseeable problems, among other things. The report indicated that the Msimbazi Creek and Mzinga Creek were supposedly to be the heavily polluted sports of the Dar es Salaam coast. The breakdown and total pollution loads discharged into the sea by industries in Dar es Salaam were displayed in a table. The table showed that the pollutants consisted primarily of BOD_5 (2,715 tons/year) and SS (15,454 tons/year). It was noted that the city of Dar es Salaam had a total of 12 recognized streams that drained through the heavily inhabited areas of the city and later discharged into the Indian Ocean. These were shown in a map. In Tanga municipality, rivers Mkurumzi and Sigi passed through the heavily inhabited parts. However, the water quality of these rivers (Mkurumuzi and Sigi) was not bad. Data on BOD_5, DO, pH and PV from grab samples taken from these rivers were given to illustrate the quality of water in these rivers that later discharged into the sea.

Mohammed, S.M, 1990: Pollution by industry and other users of chemicals. *Zanzibar Environmental Study Series No. 2*. Commission for Lands and Environment, Zanzibar.

Aim of study: This study was intended to contribute towards the preparation of an integrated environmental policy for the Island of Unguja in Zanzibar. The report therefore outlined the results of a survey carried out during a month long period to assess the pollution problem in Zanzibar, specifically that emanating from the use of chemicals by different institutions in the Island. The specific objectives of the study were to assess the pollution problems of Zanzibar especially those that arose from the use of chemicals. To evaluate the perceptions of communities with regard to the potential hazards paced by chemicals, and to make an inventory of laboratory facilities and expertise in Zanzibar and Pemba.

Methods: The methodology involved identification and survey of potential polluting industries in Zanzibar Town and elsewhere. Questionnaire covering aspects such as pollution, types and amounts of wastes produced and disposal practices; visits to users of pesticides to assess the use, storage and disposal of the chemicals, and; interview with key informants.

Results: During the period of this study, there were over fourty small to medium scale industries operating in the Zanzibar Town area. The factories included small concerns such as garages, workshops, soap factories and printing works. Medium scale factories were Mahonda Sugar and Perfume Corporation, Mbweni Tractor Repair Workshop, Jitegemee Small Scale Industries, Cotex (Z) Ltd. and Afrochem Ltd.

The report indicated that the agricultural sector was presumably the main user of chemicals in the Island. Chemicals used were insecticides, fungicides and to some extent, rodenticides. The

herbicides included *Basagran PLZ, Paraquet (Gramaxone), Gesaprim (Atrazine*); insecticides were *Linden, Endosulfan (Thiodan), Malathion, Fenitrothion and Dimethoate (Rogor*); Fungicides - *Dithena* and Rodenticides -*Zinc Phospide*.

The study revealed that the Industrial sector discharged only a relatively small proportion of pollutants into the environment. However, little was known of the quality of the discharges directly into watercourses, mainly small streams. Affected streams that were mentioned included Zingwezingwe and Upepo, among others.

Mohammed, S.M., 1997: Assessment of land based sources of pollution in Zanzibar. Institute of Marine Sciences, Zanzibar, 12p.

Aim of study: The study's main objective was to assess the land-based sources of pollution in Zanzibar. Sources of pollution that were identified included agriculture, livestock development, industrial activities, tourism development, marine transport, vehicles repair workshops and municipal waste (liquid and solid waste).

Area of study: Zanzibar

Results: In this study, it was stated that the use of agricultural chemicals, such as fertilisers and pesticides, had remained relatively small. An example was cited whereby the use of fertilizers had chopped from 2,800 metric tonnes in 1988 to 406 tonnes in 1996 (source: Ministry of Agriculture, Zanzibar). However, potential pollution was expected from a proposed development of a pilot fish culture farm at Makoba, north east of the Unguja Island. This development would put more pressure on an area that already suffered from increased pollution from a sugar factory operating nearby.

A study was cited in this work which reported on pollution from livestock keeping (Allawi *et al*., 1994). In the study, chemicals such as *Steladone, Dekatix, Spotone* and other *organophosphates* that were being used in dips, were disposed of in simple pits dug in the vicinity of the dips after use. This accounted for about 70% of all pits. The rest of the dips did not have even such simple arrangements. As a consequence, there was a strong possibility of contamination of water sources located near the dips.

On industrial pollution, some industries such as Afrochem (foam mattresses and detergents), Cotex (T) Limited (yarn and printed fabrics), the milk factory (milk and butter) and the State Leather and Shoe Factory situated at the Mtoni industrial area were all reported to have been closed. Also, many of the small-scale industries which were housed under the Jitegemee Small Scale Industrial Complex (paint soap, aluminium utensils and hardware) at Amaan were also reported to have collapsed. Furthermore, the soap making cottage industries had also been closed down. However, new industries were reported to emerge as well. A flourmill at Mtoni, a feed mill at Maruhubi (1995) and soap manufacturing and edible oil making at Mombassa.

Tourism development was reported to grow fast in the island. The number of tourist hotels for instance, increased from 3 in 1987 to 104 in 1997. Likewise, the number of visitors grew from 16, 268 in 1985 to 56,415 in 1995. The tourist hotels, especially those located along rural beaches used septic tanks and soak pit latrines. In most cases, they were poorly designed and none of them had waste treatment facilities. Hence there was a potential of contamination of ground water sources and the coastal waters through leakage. Pollution due to incidences of oil discharge by ships at the harbour were reported to have increased in the previous few years. This was due

to the increase in the number of vessels from 40 in 1990 to 190 in 1995. Also, the number of vessels that were registered had increased from 2 to 14.

Vehicle repair workshops were reported to contribute to pollution as they dumped their wastes into the main sewers that emptied into coastal waters. Outside the Stone Town area, wastes containing oil, grease and metal scrap were dumped on street corners. During rains, such wastes found their way into the sea via storm runoff.

Domestic waste was mentioned as the main source of pollution in the coastal wasters of Zanzibar. The ever-increasing population of the coastal towns, especially that of Zanzibar Town, and the inefficiency of the sewerage system compounded the problem. People served by this system were connected to septic tank systems, which emptied into a combined sewerage storm-water system. This system discharged untreated waste into the sea by means of a series of short out-falls.

Of the solid waste generated in Zanzibar Town, over 80% of it were food waste mainly vegetable and fruit waste, which is organic biodegradable. The amount of hazardous collection on the municipality was however, reported to be not more than 30% (Dorsch Consult, 1993). The rest of the waste was burnt, buried or dumped at illegal sites thus contributing significantly to environmental pollution.

Shanmungam, A.T., 1981: Ports development in Tanzania and their impact on marine environment. Paper presented to *United Nations/East African Workshop on Resources Policy and Management in Coastal/Marine Zones*. October, 1981. Tanzania Harbours Authority, Dar es Salaam, 15p.

The paper first described briefly the history of port developments in Tanzania. Beginning with the Port of Dar es Salaam, it was reported that from the early 18th century, the open road step port of Bagamoyo (about 75km north of Dar es Salaam) was the principal port of Tanzania mainly trading with Zanzibar. Sultan Seyyid Majjid of Zanzibar set up the new port of Dar es Salaam along the tidal creek in 1867. Tanga Port development started later in 1891 when the German East African Company commenced construction of the Usambara railway and built a jetty in Tanga Bay to offload railway materials. The historically important port of Kilwa was the site of an Arab settlement and had a jetty constructed in the deepwater tidal basin. A similar jetty construction was situated in the inner tidal basin in Lindi during the writing of this report. Mafia Island was reported to have no berthing facilities and all cargo was carried in dhows and schooners on to the western side of the Island at Kilindoni.

From past developments of Harbours in Tanzania, the report says port constructions were mainly carried out inside tidal basins and that there was no record to show that such constructions had any significant impact on the marine environment.

By the time of writing of this report, there were proposed developments for nearly all the ports due to increased quantities of goods to be handled. A comprehensive masterplan for development of Dar es Salaam port was prepared in 1975. The principle recommendations were strengthening the Kurasini oil jetty, widening and deepening the entrance channel and modification of two alongside berths for container ships. The priority project was the deepening and straightening the entrance channel from the present depth of 6.7m to 10.0m in stages. This channel improvement work would have involved a major dredging project and the improved channel would have enabled ships up to 25,000 DWT to enter at high water. Disposal of dredging spoil would have been at sea beyond 40m-bed contour.

The recommended long-term masterplan for Tanga port included provision of two deepwater berths either inside the Inner harbour, or at Mwambani Bay at a new site facing the sea. There were no recommended development works for the Southern ports of Mtwara, Lindi and Kilwa. However, the expected increase in traffic by 1988 would have justified for harbour developments. Potential impacts of development on the marine environment in the Dar es Salaam Port that were considered to be of concern were: The effects on fish and wildlife resources due to modification of the landscape, waterways and offshore geology. The effects of dredging operations both at the source and point of deposition; the effects on the environment of spills or dumping of cargo chemicals or petroleum products, and the effects on the ecology of ship waste disposal and other sewage which was to be generated by development. A figure was given which showed the Dar es Salaam port and entrance channel improvements and another one on the marine environment around port area.

Shilungushela, J.M.S., 1993: Inventory of destructive activities to the freshwater bodies and the marine environment along the Tanga region coastal area. Report Commissioned by National Environment Management Council, Dar es Salaam, 57p.

Aim of study: The main objective of this study was to assess the current state of the aquatic ecosystem in the Tanga Region coastal area and prepare an inventory of all social and economic activities that were destructive to the freshwater bodies and the marine environment.

Area of study: Tanga region.

Methods: Study and evaluation of all existing literature and data that were available on the state of the aquatic ecosystems in the area, and; identification of all social and economic activities carried out in the study area that contributed to the destruction of the water bodies and the marine environment. Apart from describing the terrestrial activities that were considered destructive to the freshwater and the marine environment, the inventory also included information on geomorphology, hydrogeology and hydrology, among others.

Economic activities that were considered destructive to the marine environment included: Fishing and harvesting of other marine living resources; harvesting of mangrove poles and of firewood from coastal forests; agriculture (principally sisal); mining, construction and other civil works; salt production, and; industrial manufacturing and trade activities.

Results: Agricultural pollution was mainly caused by effluent from sisal decorticating plants. Most of these plants discharged their effluents into rivers and streams that finally flew into the Indian Ocean. The issue of pollution of rivers in areas with sisal estates in Tanga was reported to be on record for a long time. At the time of compilation of this inventory, 10, 4, 2 and 4 plants were discharging their wastes into the Pangani, Sigi, Mruazi/Mnyuzi and Mkurumzi rivers respectively.

Pollution of the coastal waters of Tanga Region was also due to industrial manufacturing, trade and other activities. Most of the industries were reported to be in Tanga municipality. Effluents from the industries were normally discharged directly either on open land, sea or rivers/streams. Effluents discharged on open land normally found their way to streams/rivers and eventually to the sea during the rainy season, when they were wasted into the overland flow.

In Tanga municipality, the refuse collection system was reported to be “non-existent”. Hence, dumps of refuse were variously found in the municipality, and they were accordingly washed by

overland flow directly to the sea or through the open sewer system to the sea. Moreover, sewage and domestic waste was also reported to be disposed of in a manner that it eventually found its way to the sea.

Shunula, J.P. and M.A.K. Ngoile, 1989: Consequences of human activities on the marine environment of Zanzibar. In (M.R. Khan and H.J. Gizjen, eds.) *Environmental Pollution and its Management in Eastern Africa*. University of Dar es Salaam, Dar es Salaam. 11-15 September, 1989. pp. 134-151.

Aim of study: The main aim of this study was to assess the consequences of human activities on the marine environment in Zanzibar Islands, and to suggest possible strategies to arrest the mounting problems.

Area of study: Zanzibar.

Methods: Interview with relevant ministries and departments, on site assessment of polluted areas, and review of published and unpublished manuscripts. Field visits were made at the Mahonda Sugar Factory, Mtoni Shoe Factory, Mbweni Tractor Repair Workshop, Cigarette Company and Clove Distilleries. Visits were also made to Funguni Creek, Gulioni and Maruhubi Hotel.

Results: The study reported that the sewerage in Zanzibar's Stone Town was not a centralized system. Only the main sewer whose outfall was at Funguni Beach served a portion of the town. The rest of the Stone Town was served by about 30 outlets that received sewage from septic tanks and their outclass discharged raw sewage on the beach areas (a figure was referred to show these areas but it was not seen). The outlets were also reported to collect storm waters. Since the flow of wastewater to the sea was mainly dependent on gravitation, the speed was slow and as a consequence, most of the Stone Town area was flooded during the rain season. By the time of writing of this report, the Zanzibar Government was reported to initiate a move to have a centralised sewerage system.

The pumping of raw sewage into the sea was reported to result into contamination of the coastal waters with pathogens and created high BOD especially in and within the vicinity of the outfall. A table was given to illustrate the characteristics of Zanzibar Town sewerage receiving water. Coliform ranged from 2-7/100 ml. The extent of damage was cited on the area facing Bwawani Hotel and Gulioni area, which received direct raw sewage from Funguni outfall. There was a strong smell of hydrogen sulphide in this area and there was a large population of a polychaete *Nereis*. There was also an overgrowth of *Ulva* and *Enteromorpha* to the exclusion of other species. These species were considered to have the tendency of favouring eutrophic areas.

Industrial effluent did not seem to constitute a problem in Zanzibar at the time of this study due to the fact that there were comparatively few industries of which only a small proportion were operating. The level of concentration of pollutants in the water, sediments and biota had not been determined in Zanzibar waters by the time of this report writing. Hence the impact of pesticides and other chemicals used in the Islands that reached the sea was not known.

Uronu, W.E.M., 1995: Sewerage issues in Dar es Salaam. Paper presented at *the National Workshop on Integrated Coastal Zone Management*. Reef Hotel, Zanzibar. 8-12 May, 1995, 11p.

Aim of study: This paper was a contribution by the Sewerage and Drainage Division in the above workshop. It was described in this paper that on the Tanzania Mainland, only seven municipalities had some form of sewerage system, and the condition of these systems were far from satisfactory.

Area of study: Dar es Salaam.

Results: The first sewage system in Dar es Salaam was constructed in 1948. Further extensions to the network continued to be made until 1977 when the Mikocheni sewerage system was constructed. Major rehabilitation of the system was carried outin 1980-1984. The collected wastewater were treated by use of waste stabilisation ponds and disposed of to rivers/streams. Most of these ponds were operational except those of Pugu road industrial area, Buguruni, Ukonga Prison and Ubungo. Other wastes were disposed of untreated through sea out fall after screening and removal of grit. Only 20% of the Dar es Salaam population were served by the conventional sewerage system. The remaining 80% were served by on site sanitation systems, which included the use of septic tanks, soak away systems, and traditional and ventilated pit latrines with unsatisfactory sanitary conditions. A sketch of the sewerage master plan was presented.

Pollution along the coast was described to originate from the sewer by sea out fall, the two storm water out falls, the Msimbazi Creek, waste stabilisation ponds and other sources such as oil spillage and solid waste dumping. The major sources of pollution over the Msimbazi Creek were two textile mills that discharged untreated textile and dye waste directly into the Msimbazi River. Others included an abattoir at Vingunguti, several small-scale factories and garages which discharged untreated toxic contents at Salender Bridge.

Wekwe, W.W., Othman, O.C. and M.R. Khan, 1989: Seaweeds as heavy metal pollution indicators. In (M.R. Khan and H.J. Gijzan, eds.) ***Environmental Pollution and its Management in Eastern Africa*****. University of Dar es Salaam, Dar es Salaam, pp. 241-248.**

Aim of study: The main objective of this study was to determine the heavy metal contents of seventeen species of marine and freshwater algae along the coast of Dar es Salaam.

Area of study: Dar es Salaam.

Method: The methodology employed the use of Perkin Elmer model 2380 atomic absorption spectrophotometer. Samples for analysis were collected at Mbudya Island and along Oyster Bay near Police Officers Mess.

Results: Many of the algae species studied were potential heavy metal pollution indicators as they concentrated metals to similar levels as the algae species elsewhere. An example was cited whereby the concentration of Zinc and Copper found in the marine algae *Ulva pertusa* and *Chaetomorpha crassa* (species also studied along the Tomo Island coast, Japan) showed the much lower level of pollution of the Dar es Salaam marine environment as compared to that of Japan. But it was noted however that the elements were accumulating and that pollution of the environment was taking place.

It was observed in this study that among the green seaweeds, *Halimeda discoidea* concentrated Cu, Ni, Fe and Mn; *Cladophora fascicularis* concentrated Fe, Cr and Co while *Chaetomorpha crassa* concentrated Cr and Zn. In the brown seaweeds *Sargassum polycystum* concentrated Zn

and Cd while *Padina tetrastromatica* accumulated Mn and Pb. These species could therefore be used for studying specific heavy metal pollution.

Bryceson, I., 1983: Pollution of Dar es Salaam Coastal environments by industrial and domestic effluents. *In:* Status and Problems of Marine Resources Development in Tanzania. Recommendations and selected papers from the workshop on " The Current State and Development of Marine Sciences in Tanzania." Zanzibar, 2-8 April, p. 32-41.

Aim of study: This paper provides a great overview of the severity of the marine pollution problems in Dar es Salaam at the time of his writing.

Area of study: Dar es Salaam.

Results: Good detail was given about problems associated with a few chosen areas of concern. These included the significant pollution problems in Dar es Salaam harbour, the broken sewage outfall pipe at Ocean Road (which was mentioned in many reports on pollution in Dar es Salaam during the 1980's), and the heavily polluted Msimbazi River basin and creek, among others (Bryceson, 1983). Bryceson (1983) also described some attempts to deal with the pollution problems (along with his involvement in them), including the formation of the Effluent Standards Committee in 1977 and the compilation of several reports by private consulting firms on the deteriorating sewerage/sanitation system in Dar es Salaam.

Ngoile, M.A.K., 1988: Marine pollution in Tanzania: Sources, dispersion and effects. In (J.R. Mainoya, ed.) *Proceedings of the Workshop on Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa,* Dar es Salaam. 18-20 January, 1988, pp.

Aim of study: In this paper Ngoile described the major sources of pollution and took a more detailed look at industrial wastes in Tanzania.

Results: Major industries in Tanzania and their associated wastes were described, and included a map designating the distribution of these industries along with their waste discharge receiving areas. Also included were general information on agricultural pollution such as pesticides and fertilisers, and the biological effects of some pollutants.

Semesi, A.K., and M.A.K. Ngoile, 1993: Status of the coastal and marine environment in the United Republic of Tanzania. In Proceedings of the Workshop and Policy Conference on Integrated Coastal Zone Management in Eastern Africa, Arusha Tanzania.

Results: This paper provides a synopsis of the Tanzanian government, along with a table listing the multitude of institutions involved in the planning and management of coastal resources in Tanzania and in Zanzibar. A bit of information on the inherent problems that exist within this complex system is described as well. Also included in this paper are brief

descriptions of the physical environment in Tanzania, and a good general overview of coastal resources and their socio-economic importance.

Machiwa, J.F., 1992: Heavy Metal Content in Coastal Sediments off Dar es Salaam, Tanzania. *Environmental International.* 18: 409-415 pp.

Aim of study: A study on anthropogenic input of Fe, Mn, Cu, Zn, Pb, Cr, Cd, and organic carbon in Dar es Salaam coastal sediments.

Area of study: Dar es Salaam.

Methods: Four sample sites were located within Dar es Salaam harbour channel and one sample site was located outside the harbour at the outer anchorage zone for ships waiting to unload cargo. Sediment cores were collected by SCUBA for sample sites within the harbour. Gravity sampler was used to collected core from the outer anchorage zone. All samples were collected between April and August 1991.

Results: The analytical techniques appear sound. Metals were analysed by flame atomic-absorption spectrophotometer, and organic carbon content was determined by the dichromate oxidation technique. Organic carbon and Fe content in sediment samples are presented as percentage, and other elements are presented in µg/g. Each sediment core was analysed at 2 cm depth intervals. Results show that the harbour channel sediments were enriched with iron and lead when compared with the location outside the harbour. Other elements such as Cu, Zn, Mn, Cd demonstrated moderate to weak signals when compared with the outer harbour sediment sample. The sediment sample collected at the outer anchorage zone was strongly contaminated with Cd and Cr, and the sediments in the harbour channel demonstrated a high flux of organic matter.

Machiwa, J.F., 1992: Anthropogenic Pollution in the Dar es Salaam Harbour Area, Tanzania. *Marine Pollution Bulletin.* 24:11, 562-567 pp.

Aim of study: Evaluation of petroleum hydrocarbons, PCB’s, and heavy metals in the sediments, and microbial pollution at the sediment-water interface, of the Dar es Salaam harbour and outer harbour area.

Area of study: Dar es Salaam harbours

Methods: Samples were collected for microbial analysis in this study, and were collected by SCUBA at the sediment-water interface using sterile glass bottles. There were nine sample sites for water collection for microbial analysis. Five sites were located within the harbour channel, three were at the mouth of the harbour, and one was located at the outer anchorage zone.

Results: Total and faecal coliform numbers were determined after 48 hr incubation at 37 and 44 degrees respectively. The highest faecal and total coliform counts were located at the mouth of the harbour, where the main sewerage outfall pipe was located. There were four sample sites for PCB and petroleum hydrocarbon sediment analysis. Three sites were located within the harbour channel and one was located just outside the harbour. PCB and petroleum hydrocarbon analyses were performed at the Department of Oceanography, University of South Hampton (UK) by the Marine consultant service section. PCB's were analysed in bulk sediment samples and on the clay/silt fraction. Results show that the sediments most contaminated with PCB's were those furthest in the harbour channel, with signals decreasing towards the mouth of the harbour. Petroleum hydrocarbon contamination was highest at the station furthest up the harbour as well, with another very high signal at a station located closer to the mouth of the harbour. Units of mg/kg dry weight were used for both PCB's and petroleum hydrocarbons.

MARINE FISHERIES

Narriman Jiddawi
University of Dar es Salaam, Institute of Marine Sciences, P.O.Box 668, Zanzibar.

Ardill, J.D. 1984. Tuna fisheries in the south west Indian Ocean. The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania. Mbegani, Tanzania, 6-8 March.

Aim of study: Tuna species and their distribution were discussed in this report in reference to geographic and oceanographic conditions such as temperature preference and oxygen tolerance.

Area of study: South West Indian Ocean.

Methods: Tunas are apparently caught more frequently in waters exhibiting particular oxygen and temperature characteristics that correspond to their high metabolic needs. Based on this information, predictions have been made as to where in the Indian Ocean various tuna species may be found during different times of the year. Artisanal and traditional methods of tuna fishing were described, as were commercial methods, and the state of exploitation of the tuna stocks were discussed. It was noted that the state of exploitation of the tuna stocks was considered only with respect to longline fisheries. The information included in this report came primarily from a workshop on the State of Tuna Fisheries and Tuna Stocks in the Pacific and Indian Oceans, held in Shimizu, Japan in 1979.

Results: In all the longline fisheries, the catch rate, in numbers and weight, has declined since the start of the fisheries in some cases very drastically. The general shape of the relation between the total longline catch and the total amount of fishing seems to be much the same for all species. A general flattening out to a level of catch which can be maintained over quite a wide range of

fishing efforts. Although the development of the fishery along these curves vary: Fishing effort on yellowfin in the Indian Ocean, southern bluefin and billfish could be decreased without any loss of sustained catch. The maximum level of albacore catch has been approached. Increased fishing for bigeye can be expected to give increased total catches, possibly at the expense of reduced catch rates.

Conclusion: The potential for expansion of the tuna fishery in SWIO waters was discussed and it was concluded that expansion of a fishery of this type would require facilities necessary to produce a high quality frozen product for the export market. This was considered a "doubtful proposition" at the time, and it was suggested that a market for local consumption would need to be established if expansion of a tuna fishery was to occur.

Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania. Mbegani, Tanzania, 6-8 March.

Nhwani (1984) wrote another paper appearing in the (1984) Proceedings. This report concentrated on the problems associated with data collection efforts in Tanzania and also provided suggestions for improvement. During the 1960's, stations were established in each region along the Tanzanian coast to record fisheries data. It was expected that the weight and value of all fish landed would be collected by species, as would the number of fishermen and the types of gear used in each vessel. This information was to be collected on a continuous basis, with monthly records sent to the regional fisheries office for analysis and estimation of the total catch. It was not until the 1970's that an attempt was made to standardize the data collection by providing weighing scales to most centers (previous weights had been estimated by age, but it was unclear what that meant), and by distributing lists of commercially important fish species groups to all regions. Short training courses on the collection of fish landing data were also conducted around this time. It was also during the 1970's that the Tanzanian Government chose to decentralize its authority, which affected fisheries statistics by vesting supervisory authority of data collection and analysis with the regional offices. This eventually resulted in the breakdown in the quality of data collected, which has caused this data to be viewed as unreliable.

The next couple of papers from the Proceedings (1984) discussed the fishing companies that were in operation in Tanzania during the early 1980's. A small Tanzanian fishing company called the Bagamoyo Fishing Company (BAFICO) was described by Nanyaro (1984), along with many of the inherent problems faced by these underfunded fishing efforts. One of the more difficult issues faced by these smaller fishing companies was the competition for fishing grounds with TAFICO, which was the larger fishing company in Tanzania at the time of this report. The equipment and boats of BAFICO were described as inadequate, poorly constructed, and in a constant state of disrepair. A great deal of time was spent repairing broken down vessels, and since there were no repair facilities, the work was done on the beach which meant additional problems such as having to work with the tidal cycles. Thus, fishing effort was often greatly reduced. BAFICO also lacked cooling and freezing facilities on the ships and on land, so fishing was limited by both time and distance from the harbor as well. This lack of freezing facilities caused the Bagamoyo fishermen to be at the mercy of "fishmongers" once in port, because it was well known that the catch would spoil if not sold to market quickly. In short, it appeared that the Bagamoyo Fishing Company would have a difficult time profiting from their work, although profit was not discussed in this brief report. The larger fishing company (TAFICO) did not appear to have such limitations.

The next paper on Tanzanian fishing companies was written by Killango (1984), and was a report on the large fishing company referred to in the previous summary – the Tanzania Fisheries

Corporation (TAFICO). It was stated in this report that TAFICO was begun in 1974 by the Tanzanian Government for the purpose of promoting the fisheries development industry in Tanzania. TAFICO inherited old assets such as boats, buildings, and fishing gears from the Directorate of Fisheries, and so had a difficult beginning. The TAFICO fleet was comprised of Japanese, British, Finnish, and Australian boats, with the largest boats being the Finnish and Australian. This fleet of boats totaled 16 in number, but only 10 were in operation at the time of this report. One of the main functions of TAFICO was to provide support in the form of expertise and materials to the smaller fishing companies such as Bagamoyo Fishing Company, Nyamifico, and Uvuvi Kigoma. TAFICO was a major shareholder in the smaller fishing companies (up to 60%) and acted as the holding company for loans from foreign donors through the Tanzania Rural Development Bank to help finance the new ventures. At some point the Tanzanian Government gave TAFICO a 4.5 million dollar loan to purchase engines and fishing gears because she was given authority to purchase these material for the local fishing market of Tanzania. As of the writing of this report the arrangements had still not been made to purchase the items. Other TAFICO business ventures included ice production (with two ice plants in Dar es Salaam), boat building, and consultancy services. The projected sales for TAFICO in 1983/1984 were 451 tons of fish for the local market and 144.8 tons of prawns, with some prawns sold locally, and the majority exported to Japan, the UK, and the USA. The long term plans for TAFICO were to expand their fishing operations and possibly attempt to enter into joint ventures. It appeared from the past two reports that TAFICO was doing well and making profit, while the smaller companies like BAFICO were struggling and could not compete.

In a short report by Wilkinson (1984) that was included in the Proceedings (1984), the Rural Development Programmes (RIDEP) in the Lindi and Mtwara regions were discussed, and it was noted that Lindi and Mtwara were the two poorest regions in the country. The RIDEPs typically encompass livestock development, agriculture, and fisheries, but this report discussed the fisheries component of the Lindi and Mtwara RIDEPs only. These programs were initiatives of the British Government, and were begun in 1980. Three main goals were identified for the Lindi/Mtwara regions and they were as follows (p. 153). (a) The resuscitation of the fresh water fisheries sector. (b) The establishing of a special revolving fund to enable fishermen to purchase fishing gear imported from the UK. (c) The evaluation of the marine resources not presently exploited by local artisanal fishermen.

By the time of this report, progress had been made on all three points listed above. Existing fresh water fishponds were rebuilt and were then stocked with tilapia. Several flocks of ducks were also established on the tilapia ponds to increase primary productivity and to decease the Bilhartzia vecting snail population that was endemic to the area. British fishing equipment was made available for purchase, which was considered a successful venture all around, and a small vessel fit with an echo sounder was used to evaluate the untapped marine resources in the coastal regions. In conclusion, it appeared that with a bit of support and technical assistance, conditions were improved in these very impoverished regions.

The last pertinent report of the Proceedings (1984) was a report by Jensen (1984) on the status of fisheries training in Mbegani. The projected development of improved training programs was described, with the target groups being technicians, mechanics, and artisanal fishermen. The main objective was to improve the traditional fisheries in Tanzania. A stock assessment was carried out in 1983/1984 as part of a training exercise, and the data collected during the trawl hauls can be found in Appendix O: Table 1 and Table 2.

The reports from the Proceedings (1984) that were summarized here provided a good overview of the fisheries industry in Tanzania in the 1970's through the early 1980's. Many references came

out of these summaries that could lead to more detailed information for certain regions, and they are listed in the literature cited section of this summary.

In the book titled *Integrated Coastal Zone Management in Tanzania* (Linden and Lunden, 1995), several tables of fishery data were provided, but it was noted that the circumstances under which the data was generated were "unsatisfactory," and so the data was considered unreliable (p. 69). I have included one of the tables in Appendix P. It is Table 7.2, and it lists artisanal fish landings by region and species group for 1992.

Conclusion

The information included in this summary consists of published or referenced materials only. With regards to the coral reef systems in Tanzania, extensive surveys have been conducted on the coral reefs around the Zanzibar and Mafia Islands. The reef systems that fringe the mainland coast of Tanzania appear to remain uncharted, with the possible exception of those in the Tanga region (Horrill and Kalombo, 1996).

No reliable reference was found that describes the fisheries data for Tanzania. The information that was available typically described the inshore fishery as overexploited and the exploitation potential of the offshore fishery as unexplored. The difficulties associated with obtaining imported gear, along with the lack of freezing facilities and adequate vessels for longer fishing trips, all contributed to the inability of the fishermen to venture into the deeper, offshore regions. The overexploitation of marine resources in the near shore regions, combined with the habitat destruction caused by destructive fishing practices, has led to declining catches overall. The large Tanzanian fishing company (TAFICO) has also apparently been out-competing with the smaller companies for accessible fishing grounds, although part of the initial mission of this larger company was to assist the smaller regional ventures.

The inshore fishery is an essential part of the lives of the coastal populations of Tanzania, but heavily exploited regions cannot be maintained in a productive state without effective management. One can only hope that adequate changes have been made to ensure the conservation of the inshore fishery for the sustained livelihood of the coastal populations of Tanzania.

Bagachwa, M.S.D., Hodd, M.R.V. and T.R. Maliyamkono, 1994*: Fisheries and Development in Tanzania*. MacMillan Press, Hong Kong, 185p.

Aim of study: This book was written with three objectives: to present the basic issues of fisheries economics together with the available statistical evidence for Tanzania; to enable sound Fisheries formulation, and; to consolidate information on Tanzania fisheries for aid support. The book began with a brief survey of Tanzania's fisheries. The main conclusion from this overview was the overwhelming importance of the artisanal fisheries sector. As a result, the book gave considerable emphasis to problems and issues related to small-scale fisheries.

Area of study: Tanzania coastal waters.

Results: The main result of the analysis on the economics of fisheries was that open access of fisheries could lead to a situation where there were falls in total output and output per worker if fish stocks were depleted by over-fishing. Already, direct surveys of fish stocks had indicated evidences of over-fishing in some fisheries, but that in many locations there was scope for considerable expansion of output without depleting the stocks. The book also examined the

performance of the industrial sector, and reviewed the potential for developing Aquaculture in view of the evidence that there were incidences of overfishing in some locations. The markets for Tanzania's fish, as well as the demand for fish, special issues of women in fisheries, the current state of fisheries regulation, training, extension and research were also examined.

Conclusion: The book concluded with a review of the prospects for Tanzania's fisheries and a series of policy recommendations directed toward enabling the fisheries sector to contribute in the most effective manner to Tanzania's development needs. Some of the recommendations included: the need for accurate assessment of fishing stocks and trends in fishing yields. Effective regulation to maintain output levels at a maximum in over-fished waters. Delivery of credit to expand fishing in waters where rates of return were high and yields were below the maximum sustainable. The encouragement of better fishing practices through short courses for small-scale fishers. The introductions of appropriate, efficient innovations in the small-scale sector. Equal access for women in training, jobs and credit, and equal rights over property ownership and inheritance.

Barnett, R., 1997: The shark trade in mainland Tanzania and Zanzibar. pp39-67. In (Marshall, N.T. and R. Barnett, eds.) The trade in sharks and shark products in the Western Indian and Southeast Atlantic Oceans. TRAFFIC East/ Southern Africa. 132 p.

Aim of study: This is one of several reports that assess the status of shark fisheries in the Western Indian and the Southeast Atlantic Oceans. The studies were carried out by the TRAFFIC Network, an IUCN/ WWF programme established to monitor trade in wild plants and animals.

Area of study: Western Indian and the Southeast Atlantic Oceans.

Results: A historical overview of shark fishery and summary of current fisheries in Tanzania is given. Shark fishery has been present in Tanzania for centuries. However this directed shark fishery is limited by small size of fishing vessels and moreover it is seasonal. Significant quantities of shark are caught for nine months of the year in mainland Tanzania and only from February through to May in Zanzibar. Fishing gears used in the artisanal directed shark fishery are large mesh gillnets ('jarife') and longlines ('cocho') and also drift gillnets and demersal gillnets. Main species of sharks being caught regularly are: the Silky Shark, Silvertip Shark, Hardnose Shark, Blacktip Reef Shark, Sandbar Shark, Blackspot Shark, Blacktail Reef Shark, Milk Shark, Whitetip Reef Shark, Milk Shark, Whitetip Reef Shark, Scalloped Hammerhead, Great Hammerhead and the Giant Guitar Fish. Statistics for shark landings and numbers of fishing gears and fishing units in the region are given. Both artisanal fishermen and the commercial (prawn) trawlers also catch sharks as bycatch. Sport fishermen do also catch sharks occasionally, however other large pelagics and demersal fish species are preferred.
The study found no domestic market for shark fin. Export figures are inaccurate due to illegal unmonitored exporting and overburdened regulatory and management frameworks. It is also likely that majority of shark fin exports are classified as fish offal, thus resulting in lower export taxes for the fin exporters. Shark meat is widely consumed in Tanzania by fishermen and liver oil is used for maintenance of traditional wooden fishing vessels. Trade in sharkskin exists on a small scale in Zanzibar only. Shark jaws are sold as tourist curios both on the mainland and in Zanzibar.

The author examines regulatory/ management frameworks in Tanzania. According to official statistics, the total shark landings for mainland Tanzania and Zanzibar in 1993 was 1261 mt and the export of dried fins was 1.3 mt. However shark fin traders give a figure that is more than double the amount officially recorded (3888mt). The large demand for shark products, especially

shark fin, and subsequent high prices have resulted in a substantial artisanal directed fishery. (In 1996, local prices for shark fin were approximately 70% higher than they were in 1991). Due to the recent increase in competition between shark fin traders and subsequent drop in profits, there is a possibility of the traders capitalising on the shark rich offshore waters of Tanzania by initiating a semi-industrialised shark fishery. The author suggests that if this happened, then the government regulatory and management mechanisms presently in place would be largely inadequate to control this fishery.

Bwathondi, P.O.J, 1991: The State of Fisheries Development in Tanzania: Problems and Prospects. *TAFIRI Research Bulletin*, 3: 2 – 13.

Aim of study: The paper reviewed the status of both marine and freshwater fisheries in Tanzania.

Results: It was reported in this paper that the marine waters of Tanzania extend for about 800km from latitude 04^{o} 039'S at the boarder with Kenya to latitude 10^{o} 028'S at the boarder with Mozambique. With inclusion of the EEZ, the total marine water of Tanzania was estimated at 100,000km^2. Within the marine habitat, the continental shelf of Tanzania is rather narrow, reaching merely 5km at places. This narrow continental shelf was considered to support more than 90% of the total marine fish production of Tanzania. It was therefore stressed that the importance of this area should not be underestimated.

The report stated that mainly artisanal fishermen carried out fishing in marine waters (more than 80%) using canoes, dhows and motorized boats. Several gears were deployed including gillnetting, beach seining, trawling and traps mainly basket traps (*madema*) done on the coral face habitat. Purse seining was also limited to near coastal waters and was operated during moonless nights using night attraction. The purse seine catches consisted mainly of pelagic fishes such as sardines (*Sardinella sp*.) and mackerel (*Rastreliger*).

The crustacean fishery, other than prawn, was reported to stagnate over the previous decade. Lobsters formed the major fishery followed by crabs (the swimming blue crab and mangrove crab – *Portunus spp*., *Scylla spp*.). Five species of spiny lobsters of great economic importance were reported. The main species caught were *Panulirus ornatus* and *P. longipes* (Bwathondi, 1993). Trawling for prawns was reported to gain much attention over the previous five years.

Bwathondi, P.O.J. and H.B. Pratap, 1981: The length-weight relationship of fishes in Kunduchi Creek, Dar es Salaam, Tanzania. *J.mar.biol.Ass.India* 23(182):161-163.

Aim of study: This study compared the length-weight relationships of 27 species of fishes caught at Kunduchi area, about 20 km north of Dar es Salaam.

Methods: Samples were obtained by beach seining every fortnight over the period January to August 1983. The total length and weight were measured to the nearest 0.1cm and 0.1g respectively. The equation $W = aL^n$ was used to calculate the length-weight relationship. More than 1000 specimens were analysed. 27 different species of fish were analysed and their n values ranged from 1.3932 to 4. 8356 with a mean of 3.0685 whereas that of the intercept 'a' ranged from 0.0001 to 0.3805, with a mean of 0.0574 (Table 1).

Results: The results suggested that not all fishes follow Allen's 'cube law' ($W = aL^3$). Fishes of different feeding habits had different values of 'n'. The size or type of food consumed also seemed to have influence on the value of 'n'. It is suggested that the value of 'n' may be influenced by the different developmental stages the fishes are in.

Bwathondi, P.O.J., and G. Mwaya. 1984. The fishery of crustacea and molluscs in Tanzania. The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania. Mbegani, Tanzania, 6-8 March.

Aim of study: The Tanzanian fishery of crustacea and mollusks was reviewed with information on artisanal as well as commercial catches, and this fishery was described in an historical context in this report.

Results: It was estimated that 50% of the documented prawn catches in Tanzania were accounted for by the artisanal fishers using stake traps, cast nets, and dragged scoop nets. It was mentioned that the documented catches for the artisanal fishery were not accurate, and should be viewed as "gross underestimates". The artisanal fishery for prawns is concentrated in the shallow coastal regions, such as estuaries, brackish lagoons, and the major river delta systems (the largest prawn fishing grounds being the Rufiji Delta). These coastal regions are nursery areas to the prawns, and Subramanian (1980) estimated that the artisanal catch was comprised of approximately 50% sub-adults. Targeting sub-adults in any fishery is a practice that is detrimental to the population, and it was suggested that this inshore fishery for juvenile prawns be restricted.

The first experimental trawling effort for prawns was conducted in 1959 by the East African Marine Fisheries Research Organization (EAMFRO) in the waters around Tanga, Zanzibar, Pangani, Bagamoyo, and Rufiji. This experiment demonstrated promise for the fishery, and commercial trawling for prawns was launched in the region. A Japanese firm joined the Tanzanian Government in this venture and formed a company called the New Mwananchi Ocean Products (NMOP), with the first production estimate of 150 tons shown for 1968. NMOP worked the region until around 1972, and a new company, the Tanzanian Fisheries Corporation (TAFICO), was formed in 1974 to resume this operation. The commercial fishery for prawns was also concentrated in shallow waters from 10-80 meters, which a much larger cause for concern regarding stock depletion than the smaller (in comparison – see Appendix I: Table 2) artisanal catch.

The continued use of traditional collection methods for lobsters was seen as a major hindrance to the advancement of the fishery, as was a lack of investment in the fishery itself. The traditional method for Tanzania was to scare the animal out of a hiding place with an octopus held in one hand, and to collect the frightened animal with a net held in the other hand. Traps and gillnets were also sometimes used to catch lobsters. Table 1 (Appendix I) lists lobster production between 1966 and 1975. Both crabs and lobsters were not considered popular food items of the local people, and therefore the commitment to the fisheries was not strong. Bivalves were also overlooked as a popular food item of the local people, and the meat was typically collected by the women and sold in the city. The seashells were harvested, possibly even over-harvested, for sale within the tourist industry.

Very little accurate information on crustacea and mollusk resources existed at this point in time, so it was suggested that studies be conducted on such things as breeding habits and population structure of the exploited organisms to assist with any future management efforts.

Bwathondi; P.O.J., Bayona, J.D.R. and E.D.S. Makwaia, 1988: Assessment of the Current status of the Coral Reef Fishery and the Impact of Dynamite to the Resources along the Dar es Salaam Coast. In *Investigations Related to the Protection and Conservation of Coastal Marine Resources in the Dar es Salaam Area*, pp. 65-89.

Aim of study: This study reviewed the trend in marine fish production and presented results and recommendations under which the status of the coral reef fishery in the study area could be assessed.

Study area: The study area extended from Ras Kiromoni (including Fungu Yasini) and outer Sinda. The area consisted of several islands, namely Mbudya, Bongoyo, Pangavini, Inner and outer Makatumbe, Kendwa and Inner and Outer Sinda. These areas were surrounded by coral reefs, some of which got exposed during low tides. Mostly madrepore corals constituted these coral reefs.

Methods: Study methods included beach seining, which were done either in the morning or afternoon depending on the timing of low tides. The seine net was set when the tides were receding. The total weight of fish was recorded for each haul and samples were taken for biometric studies. Sharknets were also used, these were placed on the bottom during the evening and left overnight. Laboratory studies were used to develop length-weight relationship, species composition, catch rates, maturity and size composition. A survey of dynamited fish was also made, which involved physical identification of blasted fish, recording weights of dynamited species and identification of responsible vessels.

Results: Results on beach seine catches indicated catch rates of 10.9, 17.9 and 27.3 kg/haul in Banda beach, Msasani and Kunduchi respectively. This suggested a progressive increase in relative abundance northwards along the Dar es Salaam coast. However, it was noted that the exceptionally high increase in catch rates at Banda Beach over the previous years was possibly due to an increase in landings from Mafia and Bagamoyo which were ferried there in search for higher prices offered at Banda beach.

The catch composition from beach seining operations was noted to be somewhat similar over the entire study area. It was mainly dominated by *Scaridae* (32.6% by weight; 15.4% by numbers), *Apogonidae* (11.3% by weight; 28.9% by numbers), *Labridae* (7% by weight; 5.8% by numbers), *Lutjanidae* (6.9% by weight; 5.8% by numbers) and *Siganidae* (6.5% by weight; 5.4% by numbers). It was observed from this study that the nearshore areas adjacent to coral reefs were not only important nursery ground for juvenile fish but also a biotope in which fish spawning was supported. Immature fish composed of 67.3% whereas mature fish contributed 16% to the landings. Spawning fishes were mainly *Apogonidae: Apogon nigripes, Labridae: Cheillio inermis, Scaridae: Colotomus spinidens* and *Cobidae: Gobius albomaculatus*. It was therefore confirmed by these results that beach seining in the near-shore was hazardous to the fisheries because of a big proportion of juveniles/immature fishes in the samples.

On dynamite fishing, the results showed that 611kg or 37.1% of dynamited fish was recorded at Kunduchi during 6 days of survey compared to 1,036 kg or 62.9% observed in Msasani area. Samples of dynamited fish were also fairly different from those recovered from inshore beach seining, as these were coastal pelagic dwellers. Other species reported were demersal coralline fishes, which were also noted to form aggregations on schools.

Coleman, E., 1998: Women of Nungwi and their contribution to economic development. Independent study project report. The School for International Training. 45 p.

Aim of study: This is a report of a study on the daily activities (both wage earning and non-wage earning) of women in a coastal village in Zanzibar.

Area of study: The study was carried out in Nungwi, located on the northern tip of Unguja Island, Zanzibar. Nungwi is a prime fishing location and the majority of its inhabitants participate in fishing activities.

Methods: Daily wage earning and non-wage earning activities were recorded after observation and active participation. Informal and formal interviews were conducted with members of different fishing cooperatives.

Results: Data collected on fishing activities indicate that the women were involved in octopus fishing, shellfish collection and collective net fishing. These activities were dictated by tides and were mostly undertaken during spring tides when the tidal range is greatest. The paper gives a good description of how the octopus is actually fished or hunted. Roughly 90% of the men in Nungwi participate in fishing. The women, unlike the men, do not have access to boats or advanced fishing gear so they concentrate on net fishing in shallow water. One fishing group consisted of 10 to 30 women, using 2 or 3 large hand held nets. A description of the net fishing activity is given. After fishing the women usually divide the fish between themselves, with the smaller ones being for home consumption and the larger ones for sale.

In the section on tourism, it is stated that tourism will have both positive and negative impacts on fishing activities. An increase in visitors to Nungwi will necessitate a bigger market for fish (hence generating more income), but this increase and the consequent rising demand may place strain upon Nungwi's fish population.

Since the mid 1980s when women in Nungwi formed the first female fishing cooperative the contribution of women to the economic development of Nungwi has been vital. At least 8 fishing cooperatives were active at the time of writing and the paper gives descriptions of these. The first two cooperatives formed were successful and no longer participate in fishing but depend solely on money from their buildings (purchased in the early 1990s to be rented out to tenants).
In conclusion, it is noted that the women of Nungwi are vital additions to all aspects of the welfare of the community and economy. It is recommended that the impact of tourism on this fishing village is negative and should be monitored.

Darwall, W.R.T., 1996: Report 7: Marine resource use in the Songo Songo archipelago. Current status and management recommendations. Marine biology and resource use surveys in the Songo Songo archipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar es Salaam, 41p. + Appendices.

Aim of study: The main objective of this study was to conduct surveys of the marine habitats and use of marine resources within the Songo Songo archipelago. The study was conducted from May 1995 to June 1996.

Area of study: The archipelago falls largely within Kilwa district. Songo Songo is the largest island, and there are additional 30 patch reefs. Approximately 40 km of fringing reef runs from north to south along the eastern edge of the archipelago thus protecting the islands and the patch reefs from the full force of the ocean.

Methods: The method used involved recording of catches at the fishing sites (as opposed to the landing sites). Therefore information could be provided on any catches sold at sea to the ice boats; the catch weights before processing which was often completed before return to the

landing site, and; those fish discarded at sea. By accompanying fishermen it was also possible to collect information on the fishing effort.

Results: Fishing in the Songo Songo archipelago was reported to constitute the following fisheries: finfish, shark and ray (*jarife*), seine net (*nyavu* and *juya*), handline, basket trap (*madema*), fence trap (*wando*), octopus, seacucumber, crayfish, and shell collection. The archipelago was described as one of the best remaining areas off the Tanzanian coast for small-scale artisanal fishing. Fishermen were reported to come to fish the area from as far away as Zanzibar and Mtwara. The more popular fishing sites were indicated (Appendix A5, Fig. 3). The catch yields recorded during this study in 1995 – 1996 and the relative importance of each fishery to the community economy was summarized in a table (Appendix A5, Table 6).

One of the main concerns for the shark and ray fishery was the incidental capture of turtles in the nets. The turtles got entangled in the *jarife* nets and either drawn or were later slaughtered in the boats. They were then eaten, or the carapace was removed for later sale as "Tortoise shell". Occasionally, if the fish caught had been good and the turtle was still healthy, it was returned alive. An additional problem for the turtles was the removal of eggs from nesting sites on the beaches. Few beaches, even those of the smallest and most remote islands such as Okuza and Simaya, were by then free from fishing camps throughout most of the year and the fishermen would take the eggs.

With regard to the seine net fishery, which mainly targeted reef fish, the nets were fished on spring tides as barrier nets over shallow coral, sea grass and algal habitats. This had two major concerns: habitat damage caused by nets being dragged through coral, and; the use of small mesh *juya* nets for catching undersized reef fish. The octopus fishery on Songo Songo was suspected to follow the same pattern of decline as that of Mafia due to high prices that were then offered, unless catch were monitored and regulated as necessary. The fishing pressure on crayfish was reported to be low due to both the lack of a local market and a lack of transport facilities to supply the lucrative Dar es Salaam market.

Dynamite fishing was reported to be commonly practiced in the waters surrounding Mafia and Songo Songo for many years. It was noted however, that with the current implementation of the Mafia Island Marine Park the dynamite fisherman were starting to avoid Mafia's waters and were moving south to further increase the pressure on the Songo Songo archipelago. Prawn trawling was also reported to be conducted on a major commercial scale in the area. The trawlers dragged nets along the seabed between the reefs and the mainland. Due to their highly unselective fishing technique, the trawlers not only badly damaged the seabed, but large numbers of fish were caught along with the prawns and discarded as an unwanted by-catch.

Another area of concern was the mining of corals on the Songo Songo Island, which involved both fossil and live coral. Fossil coral was used both as building blocks and as an aggregate. Live coral was mined from the numerous submerged reefs throughout the area. Live coral was also used as a building block or aggregate but its main use was for conversion to lime which was used as an alternative to cement. Live coral was collected from shallow reefs during low spring tides. The most popular reefs for mining were Imbi, Poiasi and Baniani. The scale of mining in the Songo Songo area (est. at 950 tonnes/year) was relatively low compared to that seen on Mafia.

Darwall, W.R.T., Choiseul, V.M., Guard, M., Whittington, M., and H. Kamwella, 1997: Report No. 5: Songo Songo Island. Marine Biology and Resource Use Surveys in the Songo

Songo Archipelago. Frontier-Tanzania marine Research programme. The Society for Environmental Exploration and the University of Dar es Salaam, 37p. + Appendices.

Aim of study: This report presented results of surveys that were conducted on Songo Songo Island and its intertidal and subtidal marine habitats between August 1995 and March 1996.

Area of study: Songo Songo Island.

Methods: SCUBA and Snorkel visual census was used in the subtidal habitat mapping. The subtidal benthic survey involved SCUBA visual census within 10m x 4m quadrats covering the full range of depths on the reef slope. The method of SCUBA census was also used on the subtidal habitat profile survey while SCUBA visual census was employed on the subtidal spot survey. The intertidal survey was carried out through survey of $0.5m^2$ quadrats along transects from the low water mark to the high water mark. Reef width measurements were taken from a boat on a low spring tide using a digital range finder to measure the distance to the two markers on the intertidal edge. Distance readings and depth soundings were taken at intervals from beyond the reef base to the intertidal edge. Lastly, a SCUBA and snorkel survey was used on the commercial fish census while a SCUBA visual census (as adopted from REEFWATCH) was used in the reef fish census survey.

The subtidal reef surveys were divided into sector A (east facing reef) and sector B (west facing reef). Sector A included the entire eastern reef face running from the mid-northern shore to the mid-southern point between two small islets. The majority of hard and soft corals in this sector were found to be undamaged and in a healthy condition. However, localized patches of coral damage were seen on the shallower reef slopes. This damage was attributed to seine netting and boat anchoring. In the northern part of the sector the reef occasionally deteriorated to patches of rubble and dead corals overgrown by macro-algae, soft corals and sponges. Evidence for dynamite damage, in the form of small craters, was seen in the north and east parts of the sector. Sector B included the entire western side of the island running from the southern inlet between the two islets to the northwestern point of Songo Songo Island. The majority of hard coral in sector B appeared to be undamaged. Occasional broken, overturned or bleached corals were seen. The coral damage was thought to be due to either anchors or boat groundings as the area was a popular handlining and octopus collection site. There was no evidence of dynamite damage. Sector C linked Sectors A and B at the northern end of the island running adjacent to Pumbavu Island. This sector was characterized by a sandy subtidal habitat with very sparse reef cover.

Three shallow patch reefs, locally named “Ulila ya Vikande”, “Ulila ya Msikitini”, and “Ulila ya Fungu” were located approximately one km west of Songo Songo Island within the 10m depth contour. Little damage was observed within the coral stands themselves but extensive areas of coral rubble were observed between coral stands. The cause of the damage was most likely from repeated boat grounding and net fishing.

Results: The fish surveys showed that diversity within sectors was related to the diversity and density of coral cover. 42 of the 56 species of reef fish were recorded as present. Greatest diversity was found in sector A (27 species) where coral cover was extensive (ROI: 0.48). In sectors B (17 species) and C (8 species) where coral cover was moderate (ROI: 0.30) and low (ROI: 0.14) respectively fish diversity was also lower. The most abundant species were the surgeonfish (*Acanthuridae*) followed by the butterfly fish (*Chaetodontidae*). Other species were only recorded in moderate abundance. The Songo Songo reef was found to support a diverse and abundant commercial fish population. The total number of all surveyed groups was higher in

sector A (348 fish/hr) than both sectors B (263 fish/hr) and C (28 fish/hr). The most abundant group consisted of snappers, emperors and grunts. In the intertidal survey, the eastern side had a higher diversity of brown algae (P*haeophyceae*) but a lower diversity of green algae (*Chlorophyceae).* However, the overall diversity was similar on both sides of the island.

Darwall, W.R.T., Dulvy, N.K. and M. Choiseul, 1994: Report 1. Preliminary studies on Nyuni Island. Marine biology and resource use surveys in the Songo Songo archipelago. Frontier-Tanzania marine Research programme. The Society for Environmental Exploration and the University of Dar es Salaam, 17p.

Aim of study: This report was a summary of two five-day trips to study the marine habitats in the proximity of Nyuni Island of the Songo Songo Island group south of Mafia Island. This work was conducted as a preliminary study to the initiation of full-scale surveys of the area in February 1994. These surveys were being conducted in order to collect information sufficient to formulate a management plan for marine resources in the area. This work was considered particularly important to enable both optimisation of management of the marine park planned for Mafia Island, and to protect the area from the anticipated redirection, away from Mafia Island, of pressures on marine resources.

Methods:
The surveys conducted included subtidal surveys of coral reefs, intertidal surveys of algae, seagrassess and molluscs, and surveys of the current patterns of resource use. The study area, the Songo Songo group of islands, is located approximately 100km south of Dar es Salaam and 20km south of Mafia (Appendix A4, Fig. 1 & 2). The island group includes four main islands (Fonjove, Songo Songo, Nyuni and Okuza) and 20 to 30 sandbars.

The survey techniques employed in the reef survey included both diving and snorkelling. The diving surveys were divided between the standard " Reef survey" technique, as used in the Frontier surveys on Mafia (Horrill & Ngoile, 1991), and " spot checks". The method applied in the survey of the abundance and distribution of the gastropod population was a modification of the one used in previous East African studies (Yaninek, 1976; Darwall, 1980) which was developed for an extensive survey of the Mafia archipelago (Frontier, 1993).

Surveys on algae and seagrasses were limited to the collection and identification of algal and seagrass species. Surveys were conducted of the intertidal flats by either walking a bearing from the high water mark toward the outer reef of by snorkelling over flooded intertidal areas. Information on the use of natural resources was collected by observations and through informal questioning of resource users.

Results: The area is very rich in marine resources and the supporting habitats remained in a relatively healthy state. There were large expanses of shallow coral, and together with the beautiful islands, were very appealing to future tourist development. The intensity of resource use appeared to be at a sustainable level but could easily became overexploited if there was an influx of fishermen previously operating in Mafia waters. The octopus, sea cucumber and gastropod fisheries were, however, already showing indications of over exploitation and warranted closer study. Of the finfish fishing techniques the shark netting and seine netting practices needed to be surveyed in depth. The use of sharknets had resulted in the incidental capture and drowning of numerous turtles around Mafia. Although the levels of live coral collection were unknown, it appeared that relatively low quantities of marine coral were used and the current impacts should be minimal. Currently, the most serious misuse of the marine resources was dynamite fishing. The prevention of this illegal practice therefore remained the

main priority for this area. Starting January 1994, a full programme of surveys was to be initiated to provide information on the biological characteristics, and patterns of resource use within the area stretching south from Okuza Island to Fonjove Island to the south of Songo Songo Island. It was anticipated that this work would be completed by April 1995.

Darwall, W.R.T., Guard, M., Choiseul, V.M. and M. Whittington, 1996: Report 6. Survey of thirteen patch reefs. Volumes 1-3. Marine Biology and Resource Use Surveys in the Songo Songo Archipelago. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar es Salaam, 321p.

Aim of study: The purpose of these surveys was to provide sufficient information to help ensure the future sustainable development of the use of marine resources within the archipelago. In this report, the physical and biological characteristics of the 13 main patch reefs in the archipelago (Jewe; Luala; Pweza; Pwajuu; Poiasi; Nyamambi; Baniani; Imbi; Machangi reef complex; Chocha; Miza, Membeuso and Banda reef complex; Bawara reef, and; Mwamba Mkuu reef complex) were described.

Methods: The methods used included subtidal habitat mapping, subtidal benthic survey, subtidal spot survey, intertidal survey, reef width measurements, commercial fish census, and reef fish census. The reefs were separated into distinct sectors, based on differences in biological cover and physical forms.

Results: Jewe Reef which is the largest patch reef within the archipelago was infrequently visited by fishermen from Songo Songo and Fanjove Islands. It was however, heavily fished by fishermen from Kilwa Kivinje on the Mainland, who utilized a wide range of methods. Dynamite fishing was also common practice at Jewe as its isolated position provided some security from unwanted observation. During the coral survey, 36 scleractinian and 8 non-scleractinian genera were recorded. The overall fish diversity on the reef was fairly high, with a total of 43 out of the 56 selected reef fish species recorded.

Luala Reef was a popular fishing site for fishermen from Songo Songo and Fanjove Islands. Diverse and abundant commercial and reef fish populations were found in the deeper parts of the reef. Reef fish diversity was very high over the entire reef with 53 of the 56 species of selected reef fish recorded.

Pweza Reef was regularly visited by octopus and seacucumber collectors and had a reputation among Songo Songo fishermen as a productive area for handline fishing. 40 of the selected reef fish were recorded. Greatest diversity was found in Sector A where the reef extended into deeper water and was more rugose (Appendix A3, Fig. 3.1).

Pwajuu Reef was within easy reach of both Songo Songo Island and the Mainland and was therefore subject to fishing activity. However, the relatively small intertidal area in comparison to nearby reefs and the steep surrounding reef slope appeared to limit the scale of these activities. The relative diversity of reef fish on Pwajuu Reef was not high (33), with approximately 65% of the "selected" reef fish species recorded.

Poiasi Reef, as with other reefs in the region, was subject to a wide range of fishing activities. The use of dynamite was less intensive on Poiasi than elsewhere due to a fairly rapid drop to deep water quite close to the reef. 37 hard coral genera and 6 non-seleractinian coral genera were recorded, and *Galaxea* was the overall dominant genera. The reef fish diversity for the whole reef was fairly high with a total of 42 out of 56 selected reef fish species observed.

Nyamambi Reef was fished extensively by local fishermen. The reef was also subject to dynamite fishing although on a lesser scale to those reefs further afield from Songo Songo Island such as Baniani, Msuagi and Nyuni. A total of 35 hard coral genera and 6 soft coral genera were recorded on Nyamambi. Reef fish diversity was not high, with 34 of the 56 selected reef fish species observed.

Baniani Reef's proximity to Songo Songo Island allowed it to be fished extensively. Visiting dynamite fishermen blasted the reef frequently. 33 hard coral genera and 6 coral genera were recorded from Baniani. Reef fish diversity was not high with just over half (32) the number of selected reef fish species recorded.

Imbi Reef, known locally as *Mwamba baba* (Father of reefs) because of its highly productive fisheries and the plentiful supply of coral suitable for lime production, was targeted by fishermen from Songo Songo, Nyuni, and Fanjove Islands. It was also a popular octopus, spiny lobster, and seacucumber collection site. A diverse and abundant commercial and reef fish population was found on the outer reef. 52 of the 56 survey species of reef fish were observed.

Machangi Reef Complex (Machangi reef, Msuagi reef and Machangi Moovu) was fished considerably by fishermen from the village of Somanga on the Mainland. On Machangi reef, the relative diversity of reef fish was poor (17), with less than one third of the "selected" reef fish species recorded. On Msuagi reef, diversity of reef fish was not particularly high with just over half (29) the number of selected reef fish recorded. 33 hard coral genera and 6 coral genera were also observed on Msuagi. On Machangi Moovu, the relative diversity of reef fish was poor (19), with fewer than half the "selected" reef fish species recorded.

Chocha Reef had quite low fish abundance in comparison to other reef sites. Minimal fishing activity was therefore observed on the reef at the time of surveying. Only 20 of the 56 selected fish species were recorded.

Miza, Membeuso and Banda Reef Complex were fished by fishermen from Somanga on the Mainland and transient fishermen who were based on Simaya Island for periods between 1 week and 6 months. Dynamite fishing was also observed at Banda reef. 31 species of hard coral genera were common to each of the reefs. 8 genera of non-scleractinian corals were recorded for Membeuso and 7 for Miza. Reef fish diversity was not high for any particular reef with a maximum of 55% of the selected reef fish species observed at Membeuso.

Bawara Reef was popular for collection of spiny lobsters, seine netting and madema trapping. 35 of the 56 censused species of reef fish were recorded on Bawara.

Mwamba Mkuu Reef's fishing activity involved fishermen from Simaya Island and Somanga Fungu on the mainland. Dynamite fishing was also observed whilst surveying the reef. 30 genera of scleractinian coral and 6 genera of non-scleractinian genera were recorded. On reef fish diversity, 34 of the 56 species censused were recorded. Of the fish recorded a large majority were juveniles (both reef and commercial species) and, as such, this site might have formed an important recruitment source for other reefs in the area.

Griffith, R. D. and N.S. Jiddawi, 1999: Traditional boat building and use in Nungwi. SIT Report, Coastal ecology. IMS, Zanzibar. 38p.

Aim of study: Traditional means of building boats used in fishing activities was studied in Nungwi village situated in North of Zanzibar Island.

Methods: The methods used for obtaining the information were direct observation and participatory method such as informal and semi-structured and structured interviews.

Results: The paper elaborates on the preferred wood for building, which was found to be mtondoo (*Alexandnas laurel*) with strips coming for mangrove wood and *Caesurina* trees. The building process was also elaborated which revealed that the popular period for building boats was during the period with less rain Therefore few boats were built between April -May which is the period of heavy rains (Masika). The ownership pattern of boats also indicated that most of the big vessels were owned by a middleman rather than by the captain and crew. The same case applied to fishing gears with the exception of fishing traps where the individual fishermen could afford on their own. The most expensive vessels are the dhow and *Mashua* that could cost up to 1.33 million TShs. The outrigger could fetch up to 180, 000 TShs. For durability the vessels need to be repaired after every 4-6 months. The vessels also were used for catching different types of fish. For example the outrigger canoes catch near shore species such as snappers, sardines due to its limitation where as the dhows catch the offshore larger fish such as marlin, kingfish, sailfish and tuna.. The boast elaborates on the traditional knowledge and terminologies used for each part of the fishing vessels, boat designs and uses. A thorough and longer study on this issue is suggested. Figures, and pictures are attached.

Hoekstra, T.M., M.A.K. Ngoile, N.S. Jiddawi, & C. Rotteglia. 1990: Census of the marine fishing units of Zanzibar in 1989.n FAO/UNDP: RAF/87/008/ DR/ 60/ 90/E. 118p.

Aim of study: This is a report of a joint exercise involving the Institute of Marine Sciences of the University of Dar es Salaam, the Department of Fisheries, the Statistics Division of the Permanent Planning Commission, and the FAO Regional Project for the Development and Management of Fisheries in the Southwest Indian Ocean (SWIOP). The objectives of the study were: to confirm the number and location of landing sites. To identify all principal artisanal fishery types. To determine the number of fishing units by fishery types and region; to determine the number, distribution, characteristics and mode of ownership of boats, engines and gears by fishery type and region, and to investigate the seasonality of use of fish landing sites by fishery type and region.

Area of study: The study was carried out on Zanzibar's two main islands of Unguja and Pemba as well as the lesser islands of Puza, Makongwe, Findo, Kojani, Uzi and Tumbatu.

Mathods: The basic unit of enquiry used was the fishing economic unit (FEU), defined as the combination of one or more currently active fishermen, operating together with fishing gear, and usually but not necessarily from a boat. An English version of the questionnaire used is given in Annex 5. Prior to data collection, training courses for the enumerators were held in Unguja and Pemba and a separate course for the supervisors. Interviews were taken at landing sites by the enumerators. The data were grouped in respect of 13 fishery types. The geographical stratifications used were the nine administrative regions, further subdivided into West and East Coast, plus Zanzibar Town.

Results:
The number of landing sites encountered during the census were 97 on Unguja and 109 on Pemba Island. The total number of fishing units recorded were 2,956 units on Unguja and 2,653 on Pemba, representing a total of 8,365 and 7,199 fishermen for the 2 islands respectively. The

fishery with most units was the 'other line' fishery (handlines and longlines) followed by the moveable traps fishery in Unguja and octopus fishing in Pemba. In Unguja the most common boat type was the *ngalawa* (44.1%) while on Pemba the *mtumbwi* was the boat most used (42.9%). With increasing value of the boat, the ownership pattern changed such that the percentage of boats owned solely by the fisherman-in-charge decreased and sharing of boats and ownership by middlemen increased. The quantities of fishing gears were quantified as number of units for some gear types (e.g. lines) and total length in the case of other gears (e.g. gillnets). The demersal gillnets were the most numerous nets used, with a total length (small mesh plus large mesh) of 52440 fathoms (95.9km) in Unguja and 35,249 fathoms (64.5km) in Pemba. A total of 141 units were encountered using engines, 133 in Unguja and 8 in Pemba. Apart from Zanzibar Fishing Company vessels, inboard engines were not recorded. There was indication of (inter and intra-regional) mobility of fishing units in the islands and between Unguja and mainland Tanzania.

The report gives detailed descriptions by fishery type, ranging from troll-line fishery to mosquito net fishery and octopus spearing fishery. The authors estimate that fishermen form 4.2% of the active population in Unguja and 4.8% in Pemba (for 1988 population figures, where 'active population' refers to people aged over 15 years). Most landing sites, fishing units and fishermen were found on the West Coast on both islands. It was found that as equipment costs increased due to size and complexity, the ownership by individual fishermen decreased. The figures on ownership indicated that fishermen in Pemba are generally more financially dependent than their colleagues in Unguja. The report has over 90 pages of diagrams, graphs, tables and appendices.

Horill, J.C., 1992: Status and issues affecting marine resources around the Fumba Peninsula. *Zanzibar Environmental Study Series No. 12*. Commission for Lands and Environment, Zanzibar.

Aim of study: This study was commissioned by the Zanzibar Division of the Environment in conjunction with the Zanzibar Department of Fisheries. It was in response to claims of the local communities in the Fumba Peninsular that visiting fishermen utilized fishing techniques that led to overfishing and destruction of underwater formations that supported the fishery.

Area of study: The study area included the coastal waters from Tele Island, south to Pungume Island and thence to a line between Niamembe, Miwi and Uzi Islands. This was a traditional fishing area for the villagers of Fumba, Dimani, Bweleo and Nyamanzi. A summary of the status of the coral reefs in the Fumba area was also shown.

Results: It was reported that during the previous three years the number of visiting fishermen had drastically increased (up to 1,800 camping on islands at any one time). Their length of stay similarly increased to virtual permanence with increasing use of gears namely small mesh seine nets (*Juya* and *Kojani*) and dynamite. Before this alarming situation, visiting fishermen only used the area during the Northeast monsoons only, and their presence did not cause any problems to the locals.

The fishing methods employed by visiting fishermen were thus a threat to fish productivity due to capture of juvenile and small sized fish. Reduced fish catches were therefore reported in all previously abundant fishing areas. Apart from diminishing the fishery resource, the destructive fishing methods destroyed underwater features such as coral reefs, which are important to the fishery.

Horrill, J.C. and M.A.K. Ngoile, 1991: Volume 1 (Text): Results of the physical, biological and resource use surveys: rationale for the development of a management strategy. Mafia Island Report No. 2. Second Edition. The Society for Environmental Exploration and the University of Dar es Salaam, 46p. + 20 Figures.

Aim of study: This study project was designed to collate information relevant to the formulation of a management plan for a proposed multi-user coastal management area at Mafia Island. Physical, biological and resource use surveys were made from July 1990 to September 1991. The study also included information on many other aspects such as the concept of developing and managing a Marine Regulated Area, and formulation of a Management Plan.

Area of study: Mafia Island.

Methods: Among others, the biological survey included a reef survey; subtidal algae, seagrass, sponge and soft coral bed survey; intertidal flats, and; mangrove survey. The reef survey used a modified version of "Reefwatch" which was employed in previous field phases (Gaudian and Richmond, 1990). The subtidal algae, seagrass, sponge and soft coral bed survey entailed the recording of bathymetry, species abundance, substrate type, as well as count of other invertebrate associated with the beds. Species abundance were recorded on a scale of 1-5 (Dahl, 1982). Surveys on intertidal flats were conducted at selected sites along a line transect from a conspicuous landmark to the spring low water mark. The intertidal area was zoned using predetermined criteria namely substrate type and presence/absence of indicator species groups. Within each zone 10 replicate $0.5m^2$ quadrats were randomly thrown within 5 meters of the transect line. Substrate type, species composition and abundance utilizing the 1-5 scale of Dahl (1982), with the numbers of invertebrate species were also recorded.

In areas of potential interest with regard to the zoning concept of the management plan, detailed studies were conducted. Studies were conducted along a 100m permanent transect line (PTL), following the reef profile, marked at either end and at 25m intervals by metal stakes. A detailed survey of the benthos along the transect line was undertaken with $1m^2$ quadrats. Within each quadrat, depth, rugosity index, substrate type, species composition and percentage cover of dominant biota including position and size were recorded.

The detailed study also involved fish counts to gain estimates of the abundance and distribution of a number of fish species. A total of 150 species were selected for visual assessment. On the use of natural resources, information was collected on artisanal activities such as: finfish fishing (vessel types, gear types, fishing areas and catch statistics); octopus fishing; shellfish, sea-cucumber and crayfish collection, and; fish processing and export to assess seasonal variability. All catch analyses were conducted using prepared forms. Other activities studied included "commercial activities" such as seaweed farming, coral collection for building, etc.

Results: Results from these surveys indicated that habitat types included exposed hard coral, soft coral and algae dominated reefs; sheltered back reef systems; intertidal flats with hard and soft substrate, and; mangrove forests and extensive seagrass, algal, sponge and soft coral subtidal beds. Species diversity within these habitats was also found to be high with over 380 species of fish, 45 genera of seleractinian coral, 3 genera of non-sederactinian coral, 12 species of seagrass, 7 species of mangrove and 134 species of algae. The number of species found during the course of this study showed an increase in the number of species previously found in Mafia (Talbot, 1965), coral genera in East Africa (Rosen, 1989) and algae and seagrass species in Tanzania (Semesi, 1989).

With regard to habitats, those in the western sector (where studied) showed greater levels of disturbance, were in comparably poorer condition and possessed lower species diversity than those in the eastern sector. In contrast, Chole Bay (north of the eastern sector) and the adjacent area had the greatest habitat diversity, species diversity within habitats, and was the least disturbed of all the areas studied with the condition of some systems still being pristine at the time of this survey.

Resource use surveys showed that, of the five fisheries found in the course of this study, the finfish and octopus fisheries were of primary importance. The majority of finfish caught in the waters surrounding Mafia Island were being exported to Dar es Salaam. Quantification of the fisheries trade was therefore very difficult to assess as many of the fish were being sold at sea and not landed.

Because of its isolation, Mafia Island had escaped the full effects of explosive fishing that had devastated a large proportion of Tanzania's coral reefs. It was mentioned in the study (without reference) that studies previous to this one had shown that the frequency of occurrence and amount of damage, caused by this activity was greatest in the Northwest sectors of the island. There was a gradual reduction in the frequency and effects of dynamite through the southern sector to Chole Bay where occurrence was rare.

Horrill, J.C. *et al.* 1994. Baseline monitoring survey of the coral reefs and fisheries of the Fumba peninsula, Zanzibar. Zanzibar Environmental Study Series, No. 16.

Aim of study: The purpose of this study was to assess the environmental effects of a nine month ban on the use of destructive fishing practices in the marine areas around the Fumba peninsula (Menai Bay), and to collect baseline data for subsequent assessments.

Area of study: Menai Bay.

Methods: A coral reef survey was conducted which included a survey of the benthos as well as the associated fish populations. Work was done by way of snorkeling and SCUBA, using 100 m transect lines which were marked at 25 m intervals by metal stakes. These stakes were left in place to make these transect sites permanent. The characteristics recorded in the benthic survey included live hard coral, dead hard coral, damaged coral attached and loose, soft corals, rock, macroalgae, sand, sand and rubble, rubble, sponge, and others.

Results: Damage to corals was considered high in five of the six sites examined, and three of these sites (Kwale West II, Pungume East, and Ukombe) were said to have been extensively damaged. Destructive fishing practices were considered to be the predominant cause of damage to the corals. The shallow regions adjacent to reefs and seagrass beds were the most important fishing areas, and a map of areas fished by artisanal fishermen was included.

An assessment was made of some of the landed fish catches over a 20 day period, and it was demonstrated that although the mean weight of fish per catch dropped markedly over this period, the catch per unit effort (CPUE) remained relatively constant (Appendix E: Figures 8 and 9). It was noted that a decrease in madema fish trap use (due to loss of gear) occurred over the course of the study period, and that this could have affected the catch weight data. The loss of fish traps was discussed, and was considered a significant issue that needed to be addressed. Once lost, the fish traps were believed to continue to fish for considerable periods of time before disintegrating, and thus were considered an "invisible fishing effort".

Fish densities varied among sites, but the damselfish was the dominant species at all sites. Kwale West II and Kwale East had relatively healthy fish populations with larger fish noted, whereas Pungume East and Ukombe had fish populations composed of small fishes. Ukombe was considered one of the most damaged areas, which could account for the low fish populations. Pungume was observed to have healthy coral growth and high coral cover, but habitat diversity was low. It was suggested that the monospecificity of the coral habitat at Pungume may have contributed to the low fish populations. The activities of the finfish fishermen (such as number of fishermen, boats, and gear arriving at Kwale Island) were also recorded in this study.

Horst, N., 1999: The status of Madema (basket trap fishing) on Tumbatu island, Zanzibar. SIT Report, Coastal ecology. IMS, Zanzibar. 43p.

Aim of study: The history and the use of moveable (basket traps) fishing at Tumbatu island and Mkokotoni was studied. Past research ranked *dema* basket trap as the second most important fishery in Unguja and the third in Pemba. The study was conducted to investigate on the current status of Madema trap fishing and to investigate potential reef damage.

Methods: The methodology used to obtain information on this fishery was through participatory method (following the fishermen during their fishing trips) and interviews. Underwater surveys and photography and statistics data collected from landing sites on boats landing catch caught with dema traps.

Results: The results indicated that Madema trap fishing is an old tradition which has been used for centuries and that very little change has occurred in the type, shape and sizes of madema used. The most common material used for making the dema is bamboo. For offshore fishing boats are used where as outrigger canoes are used for inshore fishing. Traps are normally left overnight. Common bait used is some species of green algae e.g. *Chaetomorpha* spp The results indicated that the most common fish caught with the traps as rabbit fish (*Siganus* sp) sizes 17-35cm, different types of parrotfish 17-39cm. The total catches ranged between 3.19-13.4kg /fishermen/day. Normally one fisherman owns an average of 5 traps. It was observed that about 85% of the fishermen place traps on or near corals. 13% on seagrass and 2% on sand. The landed statistics revealed that between 8-27 boats were dema vessels. The total catch from these boats was between 68-440kg of fish out of which 21-269kg of fish were from dema traps per day earning between 3200 - 1485001 and 29000-77200 T Shs respectively. The study revealed that the fishermen claim that in the past they were able to catch big fish the size stretching for the finger tips to the elbow and could fill their boats during good fishing days which indicates a decline in fish catches. The study also revealed that lost traps are not a serious issue as once thought as the traps can be destroyed to the point that fish are able to escape by wave action, however there was a potential for coral reef damage through placement of traps and careless use of pondos (long rods used for propelling the vessels). Suggestion is made for more research on this issue. Figures and tables are attached.

IUCN, 1993: Tanga region coastal ecosystem and analysis of benefits, threats, and management needs: A discussion paper, 28p.

Aim of study: The paper first presented “a legacy of lost benefits” by comparing past and present documented status of some resources. On coral reefs, Ray (1968) was quoted commenting that “some reefs adjacent to Tanga are among the best along Tanzania’s coastline". About two decades later, IUCN (1987) commented that reefs were extensively damaged throughout the Tanga region. In most areas, a percentage cover of live corals of less than 20% was recorded. On fisheries IUCN (1987) reported that fish landings in the Tanga region reached a peak between

1976 and 1981 (7,392 tonnes/year) with the catch per boat and per fisherman peaking in 1981 (11.8 tonnes/boat and 3.2 tonnes/fishermen). However, the total catch fell from 3,090 tonnes in 1981 to 930 tonnes in 1986.

Area of study: Tanga

Results: The paper identified major issues in the Tanga region that required management intervention. A project was thus proposed to address these management issues. The proposed project had three components: Coastal Zone Management; Sustainable Development Strategy, and; Awareness, Education and Training. A number of activities were proposed in each component.

Iversen, S.A. Myklevol, S., Lwiza, K. and J. Yonazi 1984: Tanzania Fish Resources in the Depth Region 10.500m investigated by R/V "Dr. Fridtjof Nansen". In (S.A. Iversen and S. Myklelvoll, eds.). ***Proceedings of the NORAD- Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania.*** **Mbegani, 6-8 March, 1984. Tanzania Fisheries Research Institute/NORAD/Institute of Marine Research, Bergen, Norway, pp. 45 - 83.**

Aim of study: Under agreement between the Tanzania Government and NORAD, the fishery research vessel "Dr. Fridtjof Nansen" carried out three surveys of the fisheries resources of Tanzanian waters in 1982-1983. During these surveys, the fish resources living in the depth region 10-500m were investigated, and the hydrographic situation was studied.

Methods: Hydrographic data such as temperature, salinity and oxygen content were collected using reversible Nankeen water bottles which were applied at the depths of 5, 10, 20, 50, 75, 100, 125, 200, 300, 400 and 500m. Samples from the surface were collected by a bucket. Fish abundance were investigated acoustically using three scientific sounders, two integrators, one sonar and one net sonde. The integrator readings were divided into the categories: plankton/fish larvae, mesopelagic fish, pelagic fish and demersal fish. Pelagic trawl hauls were carried out either to identify scattering layers or to investigate the surface layer for fish. However, rather few pelagic trawl hauls were carried out, because pelagic scattering layers of fish were scarce and poor. Demersal trawl hauls were placed at random in trawlable areas and fish biomass estimations were made according to the swept area method. The most important species were measured by length and weight. In selected areas, longlines and special fish traps were used.

Results: The species composition in the demersal trawl catches in different depth intervals for survey No. 1 (16 June - 8 July, 1982), survey No. 2 (12 Nov. to Dec. 1982) and survey No. 3 (11-26 May, 1983) were given in a table. From this table, the group of *Leiognathidae* was very abundant in waters shallower than 50m. About 20-40% of the catches in this depth belonged to this group. The most important species were *Leiognathus leuciscus, L. equulus, L. fasciatus, Secutor insidiator* and *Gazza minuta.*

Pelagic fish families such as C*lupeoidea, Engraulidae, Carangidae* and *Sphyraenidae* were most abundant in the demersal catches from waters shallower than 200m. In a typical pelagic community, various species of sardinella and scads contributed the main part. Thus amblygaster (*Sardinella*) *sirm, S. gibossa, S. albella* and to some extent the *Amblygaster* (*S. leiogaster* were most abundant and wide spread clupeoids in the shallower area. Some kingfish (*Scomberomorous spp*.) and large jacks (*Caranx spp*) were present throughout the area.

In deeper waters the demersal species were most abundant in the trawl hauls, but they were mostly of small size. The few larger specimens caught included mainly snappers (Luntjanidae)

and sweetlips (Pornadasyidae). Rock cods were present in small numbers in several catches. The most common species of sharks and rays caught were *Dasyatis* spp., *Rhizoprionodon acutus* and *Centrophorus moluccensis*. The catch rates of shrimp and crustacea were rather poor. The lobster and squid catches were also very small. The fish biomass estimates made in this report were in the order of 100,000-175,000 metric tonnes for the area investigated by R/V "Dr. Fridtjof Nansen". By the time this report was compiled, there was practically no fishery in this area. The potential yield, estimated using Gulland's formula, was 25,000 - 44,000 metric tonnes. During the period 1975-1980, the average catch in the inshore area was about 40,000 metric tonnes. Therefore, by extending the fishing area beyond the reef, it was considered that the yield would have increased by 60%.

Iversen, S.A., S. Myklevoll, K. Lwiza, and J. Yonazi. 1984. Tanzanian marine fish resources in the depth region 10-500 m investigated by *R/V "Dr. Fridtjof Nansen*." The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania. Mbegani, Tanzania, 6-8 March.

Aim of study: This report consists of very in-depth information collected during three scientific cruises that occurred from 1982-1983. The dates of the cruises were as follows: June 16-July 8, 1982; November 12-December 3, 1982; and May 11-26, 1983.

Area of study: The first two cruises surveyed the entire Tanzanian coast, while the third survey covered the area north of Kilva Kiwinje. During these cruises, information was collected regarding fish resources from the depth region of 10-500 meters, and the major hydrographical information of the regions was charted.

Methods: Maps depicting survey courses, hydrographical stations, fishing stations, and methods of collection can be found in Appendix K: Figures 2.1-2.4. Parallel trawling was carried out at four stations during the second survey in the western part of the Zanzibar Channel at stations 312-315.

This investigation was a joint venture between the Government of the United Republic of Tanzania and the Norwegian Agency for International Development (NORAD), and was carried out by a team that consisted of Norwegian and Tanzanian scientists. Cruise reports were submitted after each cruise, and were listed as Anon, 1982(a), 1982(b), and 1983.

The methods used to determine the distribution and abundance of fish were mainly trawling and acoustic investigation. Longlines and fish traps were also used in selected regions during the last two cruises. Acoustic investigations provided information on fish abundance, and the readings were divided into the following categories: plankton/fish larvae; mesopelagic fish; pelagic fish; and demersal fish. It was noted that it was impossible to separate pelagic from demersal fish in shallow regions, and so such readings from shallow waters were grouped into the category 'fish.' No areas within reefs were surveyed, and the majority of the biomass was observed in waters shallower than 50 m, and up to 200 m. Details about collection methods were included in this report, as was information regarding calculation of parameters for determining such things as average fish density and trawl efficiency. I chose not to include such details in this summary.

During each of the three cruises, measurements of temperature, salinity, density, and oxygen content were taken. Vertical profiles for many stations were included in this report, and I included one representative set of profiles (Appendix K: Figure 3.4.4). This set of profiles is for a region near Dar es Salaam, and measurements were taken between June 16-17, 1982. The salinity profile of Figure 3.4.4 (Appendix K) demonstrated that a salinity maximum of 35.4 $^{o}/_{oo}$ (parts per

thousand) occurred between the depths of 150-200 m, in a region of the water column where dissolved oxygen content dropped down to 2.5 ml/l. The thermocline was found between 50-200 m, and surface temperature remained relatively constant at 27 ^{0}C (80.6 ^{0}F) down to approximately 50 m. Surface temperatures and surface salinities were slightly higher (1-2 ^{0}C and 0.1-0.2 $^0/_{00}$ respectively) during the November-December cruise in 1982. During the third survey conducted in May of 1983, surface salinity distributions reflected the influence of increased freshwater input, especially off the mouths of the major rivers, e.g. Rufiji, Ruvu, and Pangani (Appendix K: Figure 3.6.1). There was some discussion on tidal amplitudes, as well as current and wind patterns of the Western Indian Ocean that I chose not to include in this summary.

Results: Information on species composition and distribution was given in a table. Approximately 20-40% of catches at depths shallower than 50 m were from the family Leiognathidae. In the trawl catches shallower than 200 m, small pelagic species dominated such as those from the families of Clupeoidea, Engraulidae, and Carangidae. In the deeper trawl hauls, demersal fish species dominated and were mainly of small size, with the main species being *Saurida undosquamis*, *S. tumbil*, and *Chloropthalmus agassizi*. Several species of ray and shark were caught, and the catches of crustacea and squids were small. The acoustical investigations resulted in estimations of fish biomass for the three survey cruises. From this table it is evident that the largest fish biomass was observed during the first cruise. Note that the area south of 9^{0}S was not surveyed during the last cruise. It was suggested that although acoustic estimates are typically underestimates since the equipment is not able to observe fish close to the bottom or in the surface layers, the poor trawl catches in the surface layers of this study indicated that the biomass was not seriously underestimated.

Through experiments with fish traps and longlines conducted during the last two survey cruises, it was determined that the traps and longlines fished very well when placed in the right areas (the best catch was taken about 25 nautical miles northwest of Mafia Island). It was concluded that the estimated potential yield was 25,000-45,000 tons for the regions surveyed, with a large portion of this biomass consisting of silver bellies, which were considered to be of little value on the fish market at the time of this report. This estimated potential yield was considered too low to support any significant trawl or purse seine fishery (p. 45), and so it was suggested that the traditional fishery be expanded outside the reef as an initial attempt to increase the fishery catch.

Jiddawi, N., 1997: The reef-dependent fisheries of Zanzibar. In (R.W. Johnstone, J. Francis and C.A. Muhando, eds.) *Proceedings of the National Conference on Coral Reefs.* Zanzibar, 2-4 December, 1997, pp. 22-35.

Aim of study: This paper was presented on a three day meeting with the theme "Coral Reefs: Values, Threats and Solutions". The meeting was conducted to mark the "International Year of the Reef". The specific objectives of the meeting were: To increase awareness on the issues pertaining to the management and sustainable use of coral reefs around Zanzibar. To help place the coral reefs of Zanzibar into a regional and global perspective, and to provide recommendations for coral reef management in Zanzibar and Tanzania at large.

Area of study: Zanzibar.

Results: The paper first described the reef fishery of Zanzibar by mentioning that a great proportion of the potential of demersal fisheries was within the coral reefs as noted by Ngoile (1991). In Zanzibar, the reef or demersal fishery contributed 41% of the total reported landings and ranked as the most important, followed by the small pelagic (27%) and large pelagic fishes (16%). The percent contribution of species in the total catch for 1995 – 1996 were given in a

table. The fishing gears used to exploit these resources were also described. It was stated that fish, lobsters, sea cucumbers, shells and octopus formed the basis of harvestable coral reef food resources. But despite the constant exploitation of these reef resources, there was very little information on potential yields as some of the harvested resources were rarely recorded. Diversity of the reef fish resources were also said to be high. The works of Mgimwa (1997), Jiddawi and Stanley (1997), Horrill *et al*. (1994) were referred to which described the abundance and diversity of these resources at various reef areas of Zanzibar. Major threats to coral reefs were given. These included: lack of proper management; over-fishing, habitat destruction; natural vulnerability, and; difficulties in data collection.

The management of fishery resources of Zanzibar was hampered for many reasons. Among these, was the lack of accurate harvest information and the data was not sufficient to monitor harvest rates. Over-fishing resulted from the increase in population so that more people were utilizing the environment as a source of food and employment as well as for recreation, tourism, education and research. This had increased pressure on the resources. Habitats were destroyed due to destructive resource exploitation techniques, including dynamite fishing. Dynamite fishing was still in use and occasionally observed in isolated islets. Collection of shells also involved breakage of pieces of corals. Natural factors that posed threat to the reefs and their associated fishery were such as currents, hard weather and food availability.

The problem of fishery data collection was due to the nature of the reef fishery, a multi-species fishery with fishing effort spread among a variety of gears, and an unevenly distributed effort. There were thus a frequently large number of artisanal fishermen landing their catch in a large number of landing sites spread over a wider area. Additionally, the fish taken home by the fishermen and the quantities purchased by middlemen at sea for sale in Dar es Salaam and Mombasa (Kenya) were not considered. This therefore created a problem in the collection of even the most basic information that could be used to assess stocks.

Conclusion: Several management initiatives were proposed so as to regulate and monitor the fishery so that destruction was minimized. Described at length, they were establishment of marine reserves; alternative employment; more research; community based management; education and awareness; installation of artificial reefs, and; increased control, monitoring and surveillance.

Jiddawi N.S. 1999: Status of the fishery resources of Chwaka bay. In (Mohammed, S., ed.) The ecology and socioeconomy of Chwaka bay. Report prepared for CARE, Tanzania. pp 24-31.

Aim of study: The paper elaborates on the artisanal fisheries of Chwaka bay, Unguja Island..

Area of study: Chwaka Bay, Zanzibar.

Methods: The methodology used to obtain the information was through literature survey and informal interviews.

Results: It was found that an estimated 47% of the population directly depends on fisheries as their only source of income, 42% as their second livelihood and 11% as their 3rd . The most important fisheries are the demersal fisheries followed by the small and large pelagic fisheries. The total fish production in Chwaka bay is currently less than 300 mt per year. The overall catches show a declining trend. This decline is also observed in most of the important fish groups landed. The only exception was the octopus and squid fishery. The small pelagics have declined

to almost 2 mt per year. Most of the catch in Chwaka bay is from *Dema* and *Towe* traps (47%) followed by net fishery (34.7%) and hand lines (15.4%) .The most common are the outrigger canoes (62.5%), followed by canoes (25%), boats and *mashua* (12.5%). The gears most commonly used in order of importance are basket traps, hand lines, spears, sharknets and gill nets and fixed traps (*uzio*). A total of 728 fishermen were recorded by the census of 1997 in Chwaka bay. Out of these 37% are fishermen on foot. About 77% of these fishermen on foot are women. The fishermen on foot normally operate during the springtides because their activities mostly involve collection of fishery resources or octopus spearing. According to the fishermen high landings are during the South East monsoon (April to September). There has been a serious fishing dispute in Chwaka bay in the last 4 years leading to physical aggression and the death of one fisherman. This is mostly between the fishermen of Marumbi and Chwaka village. Suggestions are lastly made on management strategies to be taken in order to minimise the decline in catches and the resource use conflicts. A monitoring programme was also suggested as a means of determining the status of the resources.

Jiddawi, N.S. and C. Muhando, 1990: Summary of Marine Resources in Zanzibar. *Zanzibar Environmental Study Series No. 1*. Commission for Lands and Environment, Zanzibar.

Aim of study: The aim of this report was to provide a summary of an assessment of the marine resources of Zanzibar emphasizing the need for rational exploitation, management and conservation of the fishery resources. The report discussed on marine resources exploitation in Zanzibar on resource surveys, on fisheries routine data collection and on fishery development plans. A number of activities were recommended for rational development and exploitation of marine resources of Zanzibar.

Results: The reef resources were being exploited using local traps (*dema, towe*) also handlines and anchoring nets. The principle species caught were mainly of the family Lethrinidae, Lutjanidae Siganidae, Serranidae, Nemipteridae, Mullidae and Labridae. Coral reefs reduced the trawlable area and hence commercial trawling was not common. Small pelagics such as sardines and scads were caught using light attraction. Important species caught were: *Sardinella gibossa, Amblygaster sirm, Rastrelliger kanagurta, Decapterus russelli* and *Selar crumenopthalmus*. Tuna and other larger pelagics such as marlin and kingfish were landed by artisanal fishermen using drift gillnets and lines. No data existed on the existence of sufficient deep sea resources adjacent to Zanzibar. Octopus and squid were caught around reef areas using iron rods and poking sticks. In 1988/1989, this fishery contributed 200 tonnes per year. The crustacea fishing was reported to be on a small-scale level. Lobster fishing was done by stone diving, harpooning and dema traps. Common species available were *Penaeus Latisulcatus, P. indicus, P. semisulcatus, P.monodon* and *parepeneopsis* sp., the most common being *P. indicus*. Commercial exploitation of mollusc shellfish was not important. Seacucumbers were mostly collected and dried for foreign market.

Mangroves and seaweeds were also briefly discussed. Various resource surveys that had been undertaken to qualify and quantify the Tanzania fishery resources since 1968 were also described. Lastly, on fisheries routine data collection, primary data collected included the number of boat landings, number and type of fishing gear, number of fishermen, and weight of catch. It was acknowledged, However that it was difficult to estimate the reliability of fisheries statistics of Zanzibar.

Knox. D., 1999: The status of the large pelagic fisheries in Nungwi. SIT Report, Coastal ecology. IMS, Zanzibar.35p

Aim of study: The status of the large pelagic fishery in Nungwi was studied. This was because very tittle information existed on this fishery despite its economic importance.

Methods: Data was collected through accompanying the fishermen during their fishing trips. The depth of the fish in the net and the direction the fish were swimming was recorded. The exact position of fishing was recorded using the GPS. The species caught were identified and measured. Interviews were also conducted with the fishermen while in the boat.

Results: During the 10 days of fishing about 118 fish were caught. Tuna accounted for 80% of the total catch. The average length of the frigate tuna was found to be 38.5cm with an average weight of 1.36kg. The average length of the yellowfin tuna was 83cm with a weight of 7.1kg. The average daily income ranged between 8200 to about 25333 T Shs. Most fish was caught between November and February. Most of the tuna were found in deeper waters. There was no correlation between the length of drift time and the number of fish caught. The bycatch was one unidentified dolphin. It was also observed that less fish were caught when it rained possibly due to the fish moving deeper where the net were unable to catch them. The catches were observed to be higher during the dark phases of the moon. Also there was a general con census that the fish catches were declining and also the sizes of the fish were decreasing. The maps in the report show where most of the fishing occurred as well as drift time and direction. Suggestion was made to monitor this fishery and set up better management strategies before the fishery collapse.

McClanahan, T.R., Muthiga, N.A., Kamukuru, A.T., Machano, H., and R.W. Kiambo, 1998: The effects of marine parks and fishing on coral reefs of northern Tanzania. *Biological Conservation*, ##: 1-22.

Aim of study: This study was undertaken to test the overfishing model developed in Kenya's fringing reef on Tanzanian patch reefs, triggered by the lack of quantitative data on many of the Tanzanian reefs. Another objective of this study was to acquire a baseline of information on coral reefs of northern Tanzania to determine their ecological status. Lastly, the study wished to determine if some of the previously gazetted but unprotected marine protected areas were in sufficiently good ecological condition to recover quickly and be retained as marine protected areas. The overfishing model was tested by comparing two protected reefs, one in northern Tanzania [Chumbe Island Coral Park (CHICOP)] and the other in Southern Kenya (Kisite Marine National Park). Another technique was by comparing coral surveys conducted in reefs off of Dar es Salaam in 1974 (Hamilton, 1975; Hamilton and Brakel, 1984) with present day studies.

Area of study: The fished sites in northern Tanzania included four patch reefs in the Tanga-Pangani region, four back-reef sites in the Mbudya and Bongoyo patch-reef islands, and two sites in Changuu and Chapwani patch reef islands situated off Zanzibar Town. Two of the fished sites (Mbudya and Bongoyo) were surveyed by Hamilton (1975) in 1974 and were established as marine reserves in 1975. Another marine reserve and survey site of Hamilton (1975), Fungu Yasini, was visited but no data were collected from this site.

Methods: Field measurements included quantitative studies of the cover of benthic macrobiota populations, sea urchin populations, and fish communities. Attached benthic communities were studied by the line-intercept method using seven to 24 (but usually nine) 10m line transects per site. Cover of benthic macrobiota under the line >3cm in length were classified into nine categories and their lengths were measured to the nearest Centimetre. Hard coral and fleshy algae were further identified to the genus. From these measurements the percentage cover of the various categories was calculated for each reef. A diversity index was calculated for corals and sea urchins using the Simpson's Index (Mugarran, 1988).

Results: Sea urchins were identified to species and counted in nine haphazadly placed 10 m^2 plots per site. The wet weight of each species was estimated by multiplying the population densities by an average wet weight per species from specimens collected off the Mbudya and Bongoyo reefs. Total sea urchin wet weight was estimated by summing the wet weights of each species. Fish communities were quantified using two methods in two 5m x 10m belt transects per site (McClanahan, 1994 and others). The first method was used to estimate the wet weight of fish while the second method was used to determine the numbers of species. Wet-weight estimates were made by classifying each individual encountered in the transect, estimating its length, and placing it into 10cm size-class intervals. No individuals < 3 cm in length were recorded. A second, more accurate method used a discrete-group sampling (DGS) method where one to three families were sampled with each pass through the belt transect and the line was passed four times to sample eight families. Using this method, the number of individuals per species and the number of species per transect were calculated and species-area relationships were determined by combining line-transect data.

Results from this study indicated that hard coral cover (37%) and algal turf cover (35%) were the dominant benthic cover types in all reefs followed by fleshy algae, sand, soft coral, coralline algae, and sponge. Although coral cover was 20% lower in unprotected than protected reefs there were no statistically significant differences found between protected sites. There were, however, large differences in the dominance and composition of coral genera at the studied sites. Most sites had high diversity, but a few sites had cover diversity, but dominance and diversity were not clearly related to management. Protected reefs did cluster together along with three unprotected sites. There were similarities in the number of genera encountered among regions by the search-sampling method for up to 100 min of searching. Each region had between 30 and 35 genera of coral in these shallow water sites.

Fleshy algae were also highly variable among sites. The fleshy brown algae were the most abundant genera but very uncommon in the Dar es Salaam and Zanzibar town area. The protected site of Chumbe Island had a high abundance of Sargassum as did a number of sites in the Tanga region and these sites clustered as outliers to a central cluster of sites with low fleshy macroalgal cover. High variability among regions produced high levels of variance for comparisons between protected and unprotected reefs such that none of the differences were statistically significant. The relationship between hard coral and fleshy algae cover was also highly variable and suggested some limitations of coral abundance by algal abundance but a highly variable relationship.

Comparison with Hamilton's 1974 reef profile studies at five sites showed that, at Fungu Mkadya reef, there was a very low cover by coral (<40%) but a high cover of algal turf (>85%) growing on consolidated rubble, and large numbers of sea urchins grazing on the turf and consolidated rubble. Hamilton had described this reef as having a fore reef dominated by *Acropora hyacinthus* and leeward slope dominated by *Galaxea clavus* with *Echinopora lamelossa* and *Acropora hyacinthus* colonies at the base of the slope.

Comparison of the Mbudya sites indicated the least change since Hamilton's survey but there were notable differences in the back reef crests he described and photographed. Comparison of the three Bongoyo reef profiles with transects studies in this investigation suggested a large changes in the coral community since 1974. The 1974 study described a cover of >70% of *Acropora hycinthus* and *A. formosa* on the reef crest. In the present study, only 28-36% of hard coral cover was found on the reef crest and much lower dominance of *Acropora* than found in 1974.

Estimates of fish wet weights on these reefs varied from 167 to 1,091 kg/ha with protected sites having around 3.5 times more fish biomass than unprotected reefs [Appendix A12, Table 1(d)]. By wet weight estimates, the most abundant groups in the protected reefs were the herbivorous parrotfishes and surgeonfishes (~247 and 161 kg/ha respectively) and scavengers (~190 kg/ha). The wet weight of these groups along with the triggerfish, angelfish and butterfly fish were significantly lower in unprotected compared to protected sites. The number of individuals and species per $500m^2$ belt transects determined from the discrete-group sampling method were shown in a table, the population densities of the studied fish species were also shown in another table. One of the concluding remarks was that, despite the damage of the gazetted but unprotected reefs of Mbudya and Bongoyo, the reefs still had high potential as marine protected areas due to the persistence of species and reef structure.

Mahongo, S.B. 1994. The coastal profile of Mafia Island: Tanzania. Report Commissioned by the National Environment Management Council.

Aim of study: A profile of Mafia Island was compiled which included information on many aspects of the Island such as the physical environment, the Island's natural resources, and the population of the island and socioeconomic activities, among other things. This profile provided detailed information about Mafia Island just prior to its designation and protection as a Marine Park.

Area of study: Mafia Island.

Methods: No survey of the coral reefs was conducted during this profile study, but a survey conducted by Horrill and Ngoile in 1991 was referred to. I have not seen the Horrill and Ngoile (1991) study, but it is on the ZIMS reference list. Species diversity was described as high within the habitats studied in the Horrill and Ngoile (1991) survey, and it was determined that there was a variation between the western and eastern sectors of the Island. Species diversity was found to be lower in the habitats of the western sector, and these habitats were observed to show greater levels of disturbance and appeared to be in poor general condition when compared to the eastern sectors (Horrill and Ngoile, 1991). The waters around Mafia Island were described as among the richest on the East African coast, and although widely utilized, the coral reefs and mangroves appeared to be healthy (Horrill and Ngoile, 1991).

Results: The fishery of Mafia Island was described as very difficult to quantify since a great deal of the catch was sold at sea (during spring tides), and the fish were transported to Dar es Salaam where the market for fish was very high. Also, there were many unregistered fishermen who visited the waters surrounding Mafia Island (Horrill and Mayers, 1992), and thus their landings were not included in any of the government fishery statistics. The types of fishing vessels used by the artisanal fishermen of Mafia Island included dhows, mashuas, outrigger canoes, and dugout canoes, and the various types of fishing gear used at the time included sharknets, seine nets, box traps, handlines, and fence traps. The fishes caught with these methods were diverse and included demersal and pelagic species, as well as those species that inhabited the coral reefs. Also exploited were shellfish, sea cucumbers, lobsters, squid, and prawns. There was a single working fish processing plant at the time of this report, and it was located in Kilindoni.

Mainoya, J.R. and H.B. Pratap, 1988: Marine Conservation Strategy for Sustained Bioproductivity of the Tanzanian coastal waters. In (J.R. Mainoya, ed.) *Proceedings of the Workshop on Bioproductivity of the Marine Coastal Waters of Eastern Africa.* Dar es Salaam, 18-20 January 1988, pp. 145-153.

Aim of study: The paper reviewed various conservation measures for the Tanzanian coastal ecosystems and discussed on the problems of implementation.

Results: It was reported in this paper that the need to establish marine parks in Tanzania was realized as far back as 1967. Observations made along the coast showed that in many places coral reefs and their associated rich fauna were being destroyed beyond recovery by destructive activities. Detrimental practices such as dynamiting of coral reefs, spear-gun fishing and excessive collection of shells was endangering certain species of molluscs. Referring to a paper by Ray (1968), the Tanzanian coast was surveyed and a number of sites earmarked for the establishment of Marine Parks and Reserves. These sites which were to serve as areas for conservation, control and management of marine resources and as control areas for scientific research and environmental protection were: Tanga; Maziwi Island; the islands around Dar es Salaam (Mbudya, Bongoyo and Sinda Island); Latham Island; Mafia Island and Rufiji Delta, and; Kilwa. Ecological problems that affected marine bioproductivity mentioned in this study included: destruction of ecosystems; human interference on coastal species through habitat loss or deliberate collection, and; pollution (oil pollution and land-based pollution). Whereas the broad guidelines recommended by Ray (1968) for designating marine parks and reserves in Tanzania were considered useful, a need for each conservation problem to be analysed in detail was recommended.

Mapunda, X.E., 1983: Fisheries economics in the context of the artisanal fisheries of the marine sector in Tanzania. *SWIOP Document* OISO RAF/ 79/ 065. 6p.

Aim of study: This document outlines the major constraints hindering the development of the small-scale fisheries of the marine sector in Tanzania and provides tentative development policies for the upgrading of artisanal fisheries through improvement of catch, distribution and marketing.

Results: The author describes the present state of the artisanal fisheries of the marine sector in Tanzania with regard to productivity (output/ fisherman), fishing capacity and fish export, international aspects and markets and distribution. Constraints and suggestions for improvement are also given. Among the suggestions are: usage of better fishing techniques such as purse seining; providing fishermen with incentives; improving distributional and marketing efficiency; and coordination of training between SWIO region countries, leading eventually to the establishment of a regional fisheries training centre. The author states that a genuine policy vehicle for improving markets, distribution and reinvestment would be for the artisanal fishermen to progress slowly, mastering simple techniques before they attempt to employ complicated ones, practising labour intensive fishing before proceeding to capital intensive fishing.

Mgaya, Y.D., G.D. Msumi, M.H.S. Muruke, and A.K. Semesi, 1999: Assessment of the Finfish Fishery in Bagamoyo Coastal Waters. In (Howell, K.M. and A.K. Semesi, eds.) *Coastal Resources of Bagamoyo District, Tanzania. Proceedings of a Workshop on Coastal Resources of Bagamoyo, 18-19 December 1997*. Faculty of Science, University of Dar es Salaam, Tanzania. pp 41–55.

Aim of study: The artisanal and commercial fisheries of Bagamoyo (specifically Mbegani) inshore waters were assessed.

Methods: Fishing gear and craft, fishing grounds, catch composition, catch per unit effort (CPUE) and monthly total catches were analysed and compared. Information about fish landings was obtained at the beach through observation, recording and interviews between January and

March 1997. Data on the commercial fishery were collected from three vessels (M/v Mafunzo, M/v Jodari and M/V Elimu) owned by Mbegani Fisheries Development Centre and which are on hire to private businessmen. The study also investigated the extent of dynamite fishing at five selected fishing grounds in Bagamoyo District.

Results: A description of the common traditional fishing gear and craft is given. The catch composition for the two types of fishery was found to be quite different, as did other aspects of the fisheries, with the exception of similar fishing grounds. Medium-sized demersal fish species of Lutjanidae (snappers, *kelea*) and Lethrinidae (emperors, *changu*) families made up the bulk of the landings, contributing about 40% and 34% respectively. The Leiognathidae (silverbellies and ponyfishes) accounted for about 30% and the Mullidae (goatfishes) accounted for 20% of the trawl fishery catch by weight. In some trips by Mbegani-based trawlers prawns made up over 50% of the catch. Data on dynamite fishing cases in Bagamoyo are given. (Tables 4&5). Dynamite fishing and beach seining were identified as major issues in fisheries management in Bagamoyo district. Recommendations are given for the control of these and for the management and improvement of fisheries and avoidance of local overfishing.

Msumi, G.D., 1992: Changes in relative abundance of demersal fishes in the Zanzibar Channel, Tanzania. MSc. Thesis. University of Kuopio, Finland. 45p., 2 annexes.

Aim of study: This study assessed relative abundance of demersal fishes in the Zanzibar Channel based on catch and effort data collected from stratified – random bottom trawl surveys carried out in 1984, 1986-1988 and 1991 using standardized vessel and methods. The objectives of the study were to assess the relative changes in the: Species composition of the catches with seasons and depth. Catch rates achieved with seasons and depth. Biomass, and Potential yield.

Area of study: The study area i.e. the Zanzibar Channel is approximately 1,650 square nautical miles and represents about 15% of the total Tanzanian marine area between shoreline and 400m depth.

Methods: A description of the survey area's geography, topography, physical and chemical characteristics is given. All the surveys were carried out onboard the training Vessel 'Mafunzo', a 22.0 metre long steel stern-trawler with gross tonnage of 115 tonnes, based at Mbegani Fisheries Development Centre. Average speed used during trawling was 3 knots. The fishing gear used during the research surveys is the standard trawl, North Sea 'Calypso' with 44.6m headline and 51.0 m footrope, 100mm stretched in the wings, 40mm stretched in the body and 18mm stretched mesh in the codend (Figs. 2 & 3). This gear is similar to that used in commercial fishery in the Zanzibar Channel. A stratified-random sampling design, adopted from Grosslein's (1982) method, was chosen for the survey. All tows were made during the day, between 06:00 and 18:00 hrs. The catch was sorted according to species and length and weight measurements were taken. Statistical analysis was carried out on the computer-based SPSS/PC+ data analysis system. Estimation of standing stock (biomass) was undertaken according to the 'swept-area' method as described by Pauly (1984).

Results: 11 tables are given which summarize the results for each survey conducted. A total of 182 hauls were made during the 10 surveys. Table 1 – 10 also gives the relative contribution of each family or species group to the catch in terms of biomass. Relatively few families dominated the catches. 10 families comprised about 80% of the total catches and there was insignificant seasonal variation in catch composition. Inshore waters had a greater number of species than offshore waters. The catches were consistently dominated in weight and numbers by the smaller-bodied Leiognathidae, Mullidae, Gerreidae, Nemipteridae and Carangidae in that order, the

abundance of which decreased with depth. The large fish made up a relatively small proportion of the total catch but showed increased abundance with depth. The mean catch rate varied from 100 to over 300kg/h, which generally declined with increasing depth and were higher during the Northeast Monsoons. The mean density varied between 2 and 15 tonnes per square nautical mile in depth strata, whereas the biomass ranged from 5,000 to 20,000 tonnes and potential yield was estimated at 2,000 – 8,000 tonnes between surveys. The estimates show a general decline over the successive surveys and years, probably as a result of increased commercial fishing effort. Recommendations are given for regulatory measures on trawl fishery. These include regulation of mesh size, limitation of number of commercial trawlers, promotion of offshore fisheries and a demersal fish stock assessment programme.

Muhando, C.A., Mndeme, Y.E.S. and A.T. Kamukuru, 1999: Mnazi bay and Ruvuma estuary environmental report, (draft). Institute of Marine Sciences, Zanzibar, 32p.

Aim of study: This study attempted to describe the important biophysical factors and processes in the Mnazi bay and Ruvuma area. It also described the location of various facilities that were likely to influence activities in the area. The investigation also described the status of the environment and its resource, the main ecological issues and recommended steps to be taken.

Area of study: Mnazi bay and Ruvuma.

Methods: The biophysical features were deduced from topographic maps, navigational charts, aerial photographs and documented reports. Various institutions and individuals holding information on habitat and resource distribution and status, including coastal communities, were consulted. Field observations were carried out to verify information gathered from the different sources. More data were gathered to fill in information gaps. Digital maps were constructed for different features.

Results: The study gave a qualitative description of the coastal land and coastline features of the area. This included the intertidal and nearshore waters, the hydrographic features, the coastal resource base and utilization patterns, mangroves and associated resources, rocky intertidal resources, seagrass beds and associated resources, other living and non-living resources, and corals and coral reef resources.

Coral reefs were found inside Mnazi bay, on the Msimbati (Ruvula) channel and on the exposed seaward side (Appendix A14, Map. 5). In total, coral reefs covered an area of approximately 8.6 sq. km. Three ecologically distinct coral reef zones were identified depending on the exposure to strong currents and ocean waves. The protected reefs inside Mnazi bay where water currents and waves were "friendly"; coral reefs located along the Msimbati Channel, which experienced strong reversing tidal currents, and; coral reefs located on the exposed seaside, which experienced full effects of oceanic waves and currents. Reef resource exploitation was concentrated on reefs inside the bay.

According to Guard *et. al* (1998), the exposed reefs formed continuous fringing coral reefs which extended beyond 30m with coral cover ranging from 85 to 95%, with about 36 genera of hard coral. The dominant coral assemblages included *Acropora, Porites, Favia, Favites, Echinopora*, etc. Reef fish diversity was high especially on the upper water column up to 10m. Habitat damage was minimal in this area. According to Guard et al. (1998), only the outer fringing reef sites remained in a pristine condition. In the Msimbati channel, fringing reefs were either continuous or broken and the coral cover was between 60 - 85%. This zone however, contained about 42 genera of hard coral, the highest coral species richness in the area. Habitat damage was

categorized as medium and was associated with destructive fishing and crown-of-thorn infestation.

In the protected inner parts of the bay (Chambo cha Chumba, Chambo cha Matenga, Msimbati inner reef, etc.), fringing and patchy reefs were observed. The substrate in this zone was composed of lots of coral rubbles and sandy patches. Coral cover estimates ranged from 40-50%, much lower compared to other reef zones. Only 26 hard coral genera were observed. Habitat damage was extensive in this zone and was associated with destructive fishing techniques and crown-of-thorn infestation. Reefs in this area formed the most common destination of all kinds of fishermen due to its friendly and accessible nature. A summary of the status of coral reefs in the three zones regarding fishing pressure, coral diversity, reef fish biodiversity, algal diversity, seagrass diversity, and crown-of-thorn starfish infestation was presented.

Myers, A., 1999: Artisanal fishing in the mangrove intertidal: Two methods in a rural village on Unguja. SIT Report Coastal Ecology, Zanzibar. 25p.

Aim of study: A survey was carried out on two common fishing methods in the mangrove intertidal zone.

Area of study: The study area was Kisakasaka, a small village on the Western side of Unguja Island, Zanzibar. Fishing in Kisakasaka takes place in Kiwani Bay, which is lined by mangrove forests.

Methods: Samples of fish were taken over two three-day fishing sessions during the spring tides of April 1999. Observations were made with regard to the tools and techniques used in the fishing (torch and *uzio* fishing). Random samples were taken and analysed in terms of species identification, length and mass. Interviews were conducted with various fishermen.

Results: A description of torch or *mwenge* fishery and *uzio* (fence trap) fishery is given, with illustrations and photographs. 13 species were present in samples from the *mwenge* fishery and 22 species in the *uzio* samples. 77% of species (or 70% of total mass) caught using *mwenge* were juveniles. 86% were juveniles in the *uzio* catch (or 58% of total mass). The most common species were *Lutjanus fulviflamma* for *mwenge* samples (31%) and *Gerres minuta* for *uzio* (52%). Interviews revealed that catches have decreased yearly in Kisakasaka and also size of individuals. Possible reasons given include the use of poison and small mesh sized nets, increased use of *dema* traps and influx of fishermen from other areas. Also the decline in number of *uzio* trap fishermen, as many young men are finding alternative employment. Possible reasons for the differences in catch of *uzio* and *mwenge* fishery are discussed. To reduce the fishing of juveniles the author proposes that closed seasons/periods be introduced and also adjusting of the spaces in an *uzio* (fence) trap so as to allow small fish to escape. The necessity for protection of the juvenile fishes' nursery grounds, the mangroves, and for the regulation of poison fishing, is stressed.

Nasser, S.M., 1995: Socio-economic consideration of villages around Menai Bay. Paper presented at the Workshop on the Conservation of Menai Bay, 2 - 4 May, 1995. CNR/WWF/IMS/DOC 4. 41p.

Aim of study: To provide information on socio-economic activities in Menai Bay, Zanzibar, to be used in the formulation of a management strategy for sustainable utilization of the resources. The objectives of the study were: to assess the socio-economic activities of the coastal communities in relation to the proposed establishment of a marine conservation area in Menai

Bay, and to identify alternative livelihoods which would promote sustainable use of the resource base.

Area of study: Menai Bay, Zanzibar. The survey covered a total of 53 households, which were randomly selected from inhabitants engaged in fishing activities. Both primary and secondary data were gathered during the survey, through interviews, direct field observation, informal discussions and questionnaires.

Results: The primary economic activity for men was found to be fishing using boats. Fishing in the intertidal area ranked high with both men and women. Absolute ownership of fishing vessels and gears was not common. The outrigger canoe (*ngalawa*) accounted for 66.7% of the total number of vessels surveyed. The hook and line was the most common fishing gear (36.4%). The survey revealed that there is an increase in number of nets with fine mesh size indicating that small fish were being caught and consequently stocks were being overexploited. It was found that fish landings were decreasing over time, except in Pungume and Kwale sites where there is a system of closed fishing season. The fisherfolk also collect shellfish and capture octopuses. The use of destructive fishing techniques such as dynamite fishing and use of poisons was reported. Recommendations include the shift of focus to offshore fisheries, ban or control of destructive fishing gears and techniques and control of fishery associated with single species exploitation.

Ndawula, L.M., 1988: Seasonal variation in size distribution, maturation and abundance of the Indian mackerel*, Rastrelliger kanagurta* Cuvier (Pisces:Scombridae) along the Zanzibar coast of East Africa. In (Mainoya, J.R. ed.) *Proceedings of Workshop on Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa. 18-20 Jan.1988*. UDSM and UNESCO/ ROSTA pp 85 – 93.

Aim of study: This paper examines seasonal variations in the catches of the Zanzibar Fishing Company (ZAFICO) during the period June 1982 to March 1983. The objectives were to investigate the catch rates and size composition of the Indian mackerel in monthly fishing operations of the commercial purse seiners and determine changes in maturity states, fish migrations, recruitment and food supply.

Area of study: Zanzibar.

Methods: Biweekly samples were collected from 10 stations located off the West Coast of Zanzibar. Fish were attracted by a strong light for about 5 hours and collected using a purse seine net. The net mesh was 20mm in the wings and 10mm at the bag. In the laboratory fork length and weight of each specimen was taken. The fish were sexed, their maturity stages were recorded and stomach contents analysed.

Results: Catch rates were lowest in the periods June to July (18.6 – 34.7 kg per night) and October to March (23.6 – 44.1 kg per night) and highest in August and September (25.0 – 102.9kg per night). Variation in terms of numbers of fish showed a similar pattern. Differences in size composition in fish from different sites during each month were negligible. The size range of the mackerel caught was 11.5 – 26.0 cm, but those greater than 14.1cm were mainly caught form June to August. Mackerel in all maturity states were encountered during the study period. Fig 3 indicates that most immature mackerel were caught between September and January, maturing fish in all samples, ripe-running fish in June – September samples and post-spawning fish in all samples except September and October. The most common food items ingested by mackerel were crustaceans (e.g. copepods, amphipods, decapod larvae) and fish larvae or post-larvae.

The trends in abundance of *R. kanagurta* observed off the coast of Zanzibar may be a result of spawning migrations or the seasonal distribution of its main prey items. The trends may also be due to seasonal changes in the environmental conditions induced by monsoon winds.
The author notes that there has been a tremendous development of mackerel fishery in East Africa and the magnitude of this resource and the impact of the purse-seine fishery are still largely unknown. There is therefore need to determine the stock sizes of these species and to assess the current pattern of exploitation and its possible effect on the stock size, recruitment and total yield.

Ngoile, M.A.K., P.O.J. Bwathondi, and E.S. Makwaia, 1988: Trends in the Exploitation of Marine Fisheries Resources in Tanzania. In (Mainoya, J.R. ed.) *Proceedings of Workshop on Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa. 18-20 Jan.1988*. UDSM and UNESCO/ ROSTA pp114 - 121.

Aim of study: This paper assesses the relationship between fish production and the different components of the artisanal fishing effort in Tanzania.

Results: Trends in marine fish catch landings (fish production) in Tanzania have been characterised by frequent rises and falls since 1970. Artisanal fishermen land more than 90% of the total marine fish production. Marine fisheries production including the catch per unit effort for 1970-1986 is given. Production was lowest in 1970 when the fishery data collection was launched, and highest in 1976. The catch is represented by a multiplicity of fish species caught by several types of gear. This multiplicity renders the application of resource assessment models complex, even for the surplus production model, which requires minimum variables (catch and effort). However, the authors try to obtain an insight into the status of the fishery by looking at the trend of the fishery production together with the different components of the fishing effort.

The most important gears used in fishery of pelagic species are gillnets sharknets and seine nets and for the demersal fisheries these are hook and lines and traps. Fig. 1 shows the deployment of these gears in relation to fish landings. In general the trend in annual fishery production was found to correlate well with the variation of the gears, although annual record quantities of these gears did not necessarily correspond to peak annual catches. This was so for both the demersal and pelagic fishery.

The variation in number of inboard and outboard engines was not consistent and related poorly to annual variation in fish catch landings, probably due to their low number in relation to the number of fishing vessels. The relationship between number of vessels vs. production and number of fishermen vs. production is shown. The optimum level of production was 47,000 and 43,000 metric tonnes using 5,500 vessels and 10,000 fishermen respectively. The authors conclude that the trend in annual fish production correlates with the annual fluctuations in the quantities of gillnets, sharknets, hook and lines, and traps. The results presented in this paper suggest that the fish stock which is accessible to the artisanal fishermen has reached or is just about to reach optimum production and that an increase in the number of vessels will not necessarily increase the catch of the individual fishermen or vessels. It is suggested that development of the artisanal fishery should incorporate expansion of the existing fishing grounds, introduction of more efficient gears, diversification of the fishery resources and installation of engines on the vessels. The report cautions against introduction of trawlers because the trawlable grounds are fairly limited and the mature fishes in the nearshore grounds are heavily fished.

Nhwani, L.B., 1982: The dagaa fishery of Tanga. *Tanzania Notes and Records no. 86 and 87.* pp 28 –33.

Aim of study: This paper attempts to assess the importance of the purse seine to the *dagaa* fishery of Tanga for the period 1971 to 1978. *Dagaa* here is taken to refer to any small fishes that are caught by various fishing gear such as beach seine, ring net, purse seine, lift net, dip net, scoop net, cast net and even trawl net and stake trap. Therefore catches of *dagaa* may consist of different types of fishes (both adult and juveniles of the bigger species) depending on the fishing method used.

Area of study: The study was carried out in Tanga Region. Monthly random samples were obtained from the Shirika la Uvuvi Mkoani Tanga (SHUMTA), a fishing corporation set up in 1974 by the District Development Corporations (DDCs) of Tanga Region.

Methods: The samples were analyzed for species composition, weight and other parameters. Catch rates were estimated as catch per boat-night, where a boat-night was taken to be the night a fishing boat (or unit) spends out at sea fishing. A 17.5m powered boat of 62 gross tonnage, a 12-m support boat and three 4m-lamp skiffs comprised the fishing unit in this study. The net used was 400m long and 64m deep with a 19mm stretched mesh bunt (bag). Due to the size of the net most fishing was done at depths greater than 40m. A sketch map showing the fishing grounds is given. There was a general increase in the annual catches of *dagaa* in Tanga Region from a total of 179.5 tons in 1971 to a maximum of 1200.8 tons 1976 followed by a gradual drop for the following years to 610.3 tons in 1978 (Table I). For the period 1971 – 1978 the annual average catch of *dagaa* in Tanga Region was 559.3 tons.

Summarizes of the average monthly percent species composition by weight of SHUMTA catches for the period October 1980 to March 1982 were presented in tables. The catches were dominated by sardinellas (*Sardinella* sp.), which contributed 72.6%. They were followed by the jacks and scads (*Carangidae*), the Indian Mackerel (*Rastrelliger kanagurta*), the slipmouths (*Leiognathidae*) and the anchovies (*Engraulidae*). Of the individual species, the spotted sardinella (*Sardinella sirm*) was the most dominant (51.4%). Another table shows the monthly catch rates for the SHUMTA unit. For the duration October 1980 to March 1981 the highest catch rates were in October and November (891.4 and 964.1kg per boat-night respectively) and these declined in February and March to 238.4 and 335.8kg per boat-night.

Results: Between 1971 and 1974 the mean annual catch of *dagaa* in Tanga Region was 286 tons. From 1975 to 1978 there was a dramatic increase in catch to an annual mean of 833 tons, which is almost triple the value of the previous period. This reflected the change in fishing method resulting from the introduction of the ring net and purse seine, which are more effective fishing gears than the traditional *juya* and *uzio*.

Conclusion: The author noted that there has not been a systematic study so far to assess the potential yield of *dagaa* fishery in Tanga Region. Nevertheless the catch records for the past 8 years show a trend which suggests that the present landings have not approached the value of the potential yield. It is suggested that it is therefore feasible to increase the annual catch by expanding the fishing effort and improving the efficiency and marketing of the catch. It is predicted that expansion of the inshore fishery of Tanga Region may depend on increased catches of the abundant small pelagic fishes or *dagaa*.

Nhwani, L.B., 1988: The pelagic fish resources of the East African coastal waters. In (Mainoya, J.R. ed.) *Proceedings of Workshop on Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa. 18-20 Jan.1988*. UDSM and UNESCO/ ROSTA pp 107 – 114.

Aim of study: This paper looks at the pelagic fish resources of the East African coastal waters and some related physical and biological phenomena. Previous fisheries surveys are mentioned and some of their results presented. The paper gives summary accounts for Somalia, Kenya, Tanzania and Mozambique.

Area of study: East African coastal waters.

Methods: The Tanzanian coastal waters are under the influence of the East African Coastal Current that flows northwards during the Southeast monsoon. This Current results in downwellings, thus the offshore waters are not usually very productive. However, the waters in the Zanzibar and Mafia channels, off Pemba Island and on the narrow continental shelf are quite productive. Consequently, the fishery of Tanzania (mostly artisanal) is limited to these areas.
FAO and NORAD have studied the marine resources of Tanzania in several surveys, from those of the East African Marine Fisheries Research Organisation in the 1950s and 1960s up to the surveys in 1976/77 and 1982/83 respectively. The FAO survey, using the research vessel Dr Professor Mesyatsev covered a limited area. A more extensive area was covered by the NORAD survey, using the R/V. Dr. Fridtjof Nansen. This difference in area covered led to very different estimates of the standing stocks and potential yields (Table 3). Both these surveys were made with a bottom trawl and acoustically at depths between 10 and 500m.The surveys were conducted during the Southeast monsoon period.

Results: The offshore waters of Tanzania seem not to be rich in fisheries resources because of the predominant downwelling. However there is possible upwelling in limited areas during the northeast monsoon. The author recommends that follow up studies are needed to 'fine tune' the estimates of potential yield and suggest methods for their practical exploitation especially of the vast mesopelagic fish resources.

Nhwani, L.B. and D.B.R. Chitamwebwa, 1987: Surveys of exploitable stocks of small pelagic fishes in the Tanzania waters of Lake Tanganyika and the Indian Ocean. *Tanzania Journal of Science*, 13:79-87.

Aim of study: This paper gives an account of the efforts made by Tanzania through various agencies to evaluate the fishery potential of marine and fresh water resources of Tanzania as a prelude to increasing their exploitation in order to raise their contribution to the food requirements of the nation.

Results: It was reported that from the outset, marine fisheries studies were directed at the pelagic fish species because it was believed that they held greater promise, economically, than demersal species because of the narrow and coralline continental shelf. The investigations (1956-1962) revealed the presence of the shoaling little tuna or kawakawa and frigate tuna in the coastal waters between 40m and 200m depth, in Zanzibar and North Mafia channels. Other pelagic fish found to be abundant were the Spanish mackerel or kingfish, various carangid species and small pelagics, including *Sardinella spp*., *Decapterus spp*., and the Indian mackerel, *Rastrelliger kanagurta* (Cuvelier).

Other investigations that followed on the distribution and abundance of demersals and pelagics were those of research cruises of RV *Professor Mesyatsev* in 1975 to 1977 (Birkett, 1978) and of RV *Dr. Fridtjof Nansen* in 1982 and 1983 (Iversen *et. al*., 1984). The two cruses covered the coastal waters from a depth of 10m to 500m. The surveys yielded estimates of between 100,000 and 210,000 tonnes in an area of 35,000 km^2. Most of the fish were in shallow waters at a depth

of less than 200m and they were abundant throughout the year. The estimated annual potential yield of these fishes was 200,000 tones. It was suggested in this paper that the figures could have underestimated the real values as acoustic methods that were used are not good at detecting scombroid fish which give weak echoes due to their reduced or absent gas bladders. Further, fish in the top water layers above the transducer were not detected, hence they were excluded from the abundance estimates.

Nhwani, L.B., Mwaiko, S.P., Chande, A.I., Mwamsojo, G.U. and H.A. Mhitu, 1993: Crustacea Resource Assessment in Rufiji and by-catch studies of Prawn Trawlers. Report Commissioned by National Environment Management Council, Dar es Salaam, 340p. + 15 Tables.

Aim of study: The main aim of this study was to obtain biological information and stock assessment that would be used to advise the Fisheries Division on how best to manage the prawn fisheries in the Rufiji Delta. The specific objectives were to determine the minimum size at sexual maturity of prawns *Penaeus* species in Rufiji channel. To determine the fecundity of prawns. To determine the breeding cycle of *Penaeus spp*. in Rufiji channel. To determine the by-catch composition of trawlers fishing for prawns in the Mafia channel off Rufiji, and to determine the stock of prawns in creeks around Dar es Salaam.

Area of study: The study area for the industrial fishery was the Rufiji/Mafia channel where the prawn trawlers operated. For the artisanal fishery, the study area was in the Rufiji delta at Nyamisati and Mchungu. In Dar es Salaam, the Kurasini creek was studied throughout the research period.

Methods: Sampling was done for seven days per month for both the industrial and artisanal fisheries. For the industrial fisheries, samples were obtained from prawn trawlers. After the catch was landed on board, two shovefuls of the catch were taken to represent the sample, which was then sorted into prawns and finfish, and later sorted into different species. Weights, numbers for each species and individual length, sex of the fish and their stages of maturity were recorded while on board. Catches of the prawns and finfish were then recorded. For the artisanal fishery, data from random samples of prawns and the finfish were obtained from catches of artisanal fishermen.

Results: The results showed that the industrial prawn fishery comprised five principal species. The most abundant was the Indian white shrimp *Penaeus indicus*, which accounted for an average of 74.8% of the total catch by weight. These were followed by the speckled shrimp, *Metapenaeus monoceros* (17.2%), the green tiger, *P. semisulcatus* (3.8%), the giant tiger prawn, *P. monodon* (3.8%) and *M. stebbingi* (0.4%). The by-catch consisted of more than thirty species. In the artisanal prawn fishery at Nyamisati, the dominant species were *P. indicus* (4.2.2%), followed by *M. monoceros* (36.0%), *P. monodon* (14.6%) and *P. semisulcatus* (7.2%). *P. japonicus* appeared very occasionally in the catches. In the artisanal prawn fishery, the study showed that all the prawn species caught in the seine net fishery both at Kurasini and Nyamisati were immature (maturity stage 1). In the industrial fishery, fish constituted a greater percentage in the sample (48.8-88.6%) than in the reported catch (16.9-68.7%). The differences (19.9-31.9%) were the fish discards that were thrown into the ocean, thus reducing the proportion of fish in the reported catches. Discards were higher during seasons of abundant prawn catches.

The maximum sustainable yield (MSY) was estimated using the Fox model due to Garcia *et al*. (1987) for exploited stocks (Sanders, 1987). The MSY value obtained was 543.5 tonnes, which was consistent with the reported total catch for 1992 of 527 tonnes. However the reported catch

was probably less than the true catch due to discards of small sized prawns. The fishing effort at MSY was 1,299 standard fishing days.

The study indicated a significant fall in biomass and potential yield of prawns in the industrial prawn fishery of more than 30% between the 1988 estimates (Sanders, 1989) and of this study. Sanders (1989) had estimated that the MSY of prawns for Rufiji ground was 740 tonnes. The length also indicated growth and over-fishing at maturity, indicating that prawns were being caught before maturity.

Nikundiwe, A.M., Maghimbi, S., Rumisha, C. and A.M. Haule, 1996: Report on Ecological and Marine Environmental Issues. The Dar es Salaam Beach and Management Project. National Environment Management Council (NEMC), 49p.

Aim of study: The main objective of the "Dar es Salaam Marine and Beach Management Project" was to identify and address environmental issues affecting the coastal belt north of Dar es Salaam.

Area of study: Mbezi River (Mbezi Beach) to Mpiji River (Boko) including the adjacent nearshore and Islands.

Methods: The methodology involved review of literature on marine resources in representative habitats of the area. Field observations were also made to validate the claims made by the stakeholders during the awareness workshops.

Results: It was reported in this study that resources within this coastal zone were under severe pressure of exploitation due to a rapid population growth, widespread poverty, lack of well thought out development plans, avarice and ignorance among resource users. Consequently, the environment was degrading rapidly and there was increasing incidents and severity of conflicts among stakeholders.

On fisheries, it was reported that literature on fisheries of the study area was not as extensive as one would have expected given the importance of this sector in the overall economy of Tanzania. Many of the previous studies were primarily concerned with establishing the basic biology of the species considered to be of commercial importance while others examined the parameters which yielded information on the fishery and mariculture potential of the species.

The nearshore waters of the study area were viewed to contain extensive outcrops of coral reefs, some of which were reasonably healthy while others had been destroyed extensively (Bryceson, 1981; Bwathondi *et al.*, 1988 and Pearson, 1988). Hamilton (1975) set the standards for present and future work and many of the selected transects formed the basis of future studies. Dynamite fishing and careless dropping of anchors and trampling destroyed the reefs in the study area. Also uncontrolled collection of shells and corals were also of concern.

A general description of the mangrove stands at Kunduchi and Mbweni together with physical a property, which sustained the respective stands, was reviewed from Banyikwa and Semesi (1986). Review on the past and the ongoing studies during the period of this study indicated that no comprehensive study on pollution was carried out in the study area, except for some survey to assess the problem. The works due to Jackson (1993), Haskoning and M-Konsult (1988), Bryceson (1982) and Mashauri and Mayo (1989) were referred to in reviewing the extent of pollution in Dar es Salaam.

Richmond, M.D. and G.R. Mganwa, 1994: Matemwe fishing co-operatives monitoring programme. Report No.1.IMS Library. 22 p.

Aim of study: The report is based on the outcome of the donation of 2 engine powered sailing dhows by the Netherlands embassy to two village fishing co-operatives in Matemwe, Northeast Zanzibar, Tanzania. Prior to this the fishermen co-operatives were using sail powered outrigger dugout canoes and simple fishing equipment and their income was very low. The two co-operatives are called in Swahili "*watoto tusikilizane"* and *"Sijachoka kuomba"*. One of the concerns was to raise their standard of living. Therefore this was a trial to improve and uplift the economic base of the two co-operatives by giving them efficient vessels to enabling them to fish in offshore waters for the large pelagic fish such as tuna. In addition to this the other objectives were to find out periodicity of fishing, fishing areas, species caught and methods employed in fishing. The method used for collecting the information was to provide a logbook to the fishermen themselves which they were supposed to fill on a daily basis.

Results: The results indicated that the common gear used was net fishery. Also it was observed that there was a lunar periodicity in the fishing activity i.e. more effort and catch occurred during the last quarter, new moon and first quarter covering approximately 20 days. The highest catch was during new moon. The common species caught were marlin, sailfish, tuna, kingfish, trevally and rainbow runner with tuna being the most common species. The data recording was very successful and it provided clear insight into the artisanal pelagic fishery off NorthEast of Unguja Island. Also there was an improvement in the catch landed by the two co-operatives. The authors suggest that monitoring programme be continued so as to get an insight on the status of the fishery for future management plans.

Rubindamayugi, M.S.T., 1983: The biology of the blue speckled parrotfish *Leptoscarus vaigiensis* (Family: Scaridae) occurring along the coast of Tanzania. MSc. Thesis, University of Dar es Salaam.

Aim of study: A study of the biology of the blue speckled parrotfish, *Leptoscarus vaigiensis,* the most commercially exploited parrotfish in Tanzania, was carried out. Attempts were made to evaluate the fishery potential of this species and of other scarids.

Area of study: The study sites were Banda Beach, Msasani and Kunduchi in Dar es Salaam (Fig.). Sampling was done over the period January to December 1981.

Methods: Analysis was carried out of gut content, length frequency distribution, length-weight relationships, spawning habits, fecundity, condition factor, sex ratio and size at first maturity.

Results: It was found that *L. vaigiensis* feeds primarily on seagrasses and their associated epiphytic algae. The length frequency distribution of the fish showed that there was continuous recruitment of juveniles to the fishable stock throughout the year, which was greatest between July and October. The length-weight relationship for *L. vaigiensis* was log W = -4.476 + 3.119 log L. There was no significant difference in regression lines between the sexes. The relationship between fecundity and length or weight could not be established. It was found that *L. vaigiensis* was the most commonly fished species in the study area, contributing 38% of the total catch by weight. The sex ratio (male: female) was 1:1.21 and the average size at first maturity was 14.4cm and 15.6cm for males and females respectively. The spawning season was found to be from April to September, with a peak in June/ July.

Recommendations include carrying out feasibility studies on the culture of *L. vaigiensis*. Investigation into the effect of high fishing pressure on this species. Assessment of standing stock and estimates of potential yield and devising new and more effective traps or other methods that could be used in the coralline habitats in which parrotfishes are abundant. It was not possible to obtain the relevant figures and data because of the stringent regulations at the University of Dar es Salaam, as far as photocopying of theses is concerned.

Scullion, J., 1989: Assessment of the demersal fish resources of the deeper reef slope in Lindi and Mtwara Regions, Tanzania. ODA Report. 79p.

Aim of study: This report summarises the results of a study undertaken by the ODA Fisheries Project on the demersal fish resources of the deeper reef slope in Lindi and Mtwara Regions of Southern Tanzania.

Methods: A short bottom-set long line (BSLL) technique was used to monitor reef fish populations on coralline or rocky substrates in water depths ranging from 40 to 100m at 26 sampling stations along 280km of coastline during the period January 1987 to April 1988. In addition, various small-scale experimental studies were undertaken to investigate the effects of changes in gear design on catch rate. To compare catch rates during night and daytime. To assess the performance of a local *ngalawa* using a BSLL technique, and to attempt to estimate fish density using a stock removal method on an isolated reef. An estimated 67km^2 of fishing grounds was fished repeatedly during five extensive surveys. Research activities involved 204 days fishing during 85,286 hooks captured 2,143 fish weighing 9.6 tonnes and comprising at least 122 species.

Results: Catch rates were initially high (22kg/ 100 hooks) but progressively decreased to low levels (7kg/ 100 hooks) as fishing effort increased during 1987. The decline in catch rate was attributed to the effects of increased fishing effort during the experimental programme. Catches were dominated by lethrinids, serranids and lutjanids (84% by weight) especially *Lethrinus elongatus*, *Epinephelus malabricus*, *Epinephelus tukula*, *Lutjanus bohar*, *Lutjanus sebae* and *Aprion virescens*. Poisonous species (e.g. the puffer fish) were rare, and there were no reports of ciguatera poisoning in the area. Using stock removal methods, fish density was estimated at 0.5 tonnes/km^2. Estimates of maximum sustainable yield (MSY) were calculated using the Gulland model and its modifications. Values of MSY ranged from 0.10 to 0.17 tonnes/ km^2 which, when applied to the area fished and the total area of available fishing grounds, resulted in an annual MSY ranging from 7 to 11 tonnes and 9 to 15 tonnes respectively. It was found that estimated sustainable yields would support the operation of only one mechanised *mashua* or 3 unmechanised *ngalawa*. Problems in supply of suitable bait at reasonable cost and the relatively high loss rate of gears by entanglement on the seabed were identified as potential constraints on development of a BSLL method. The effects of artisanal fishermen on the fish population of the deeper reef slope are discussed.

Recommendations given are that no attempts should be made to transfer the BSLL technique to the artisanal fishery. Future work should avoid further attempts to exploit the demersal fish stocks of the deeper reef slope but concentrate on the conservation of existing stocks by eradication of illegal dynamite fishing. Over 100 pages of figures, tables and appendices are provided, covering almost every aspect of the demersal fishery.

Semesi, A.K. and M.A.K. Ngoile. 1995. Status of the coastal and marine environment in the United Republic of Tanzania. Proceedings of the Workshop and Policy Conference on

Integrated Coastal Zone Management in Eastern Africa including the Island States. Olof Linden (Ed.). April 21-23. Arusha, United Republic of Tanzania.

Aim of study: Status of coastal fisheries industry in Tanzania.

Results: At the time this paper was written, it was estimated that approximately 75% of the fisheries catch in Tanzania were from freshwater lakes, reservoirs, and rivers, with the remaining 25% coming from the sea. The coastal fisheries were concentrated in the Zanzibar and Mafia channels, and along the narrow continental shelf. The main shrimp fishing grounds were to the north of Dar es Salaam (around Bagamoyo/Sandani) and the Rufiji Delta to the south, and it was estimated that the by catch consisted of 80%. It was also estimated that artisanal fishermen made up approximately 90% of the total marine catch. Increased landings were shown to correspond with seasonal runs of various kinds of pelagic fish during the northeast monsoon, such as kingfish, tuna, and sharks. Also exploited during this time were seashells and shark fins (which were exported), octopus, squid, prawns, and lobsters.

It was stated that between 1985 and 1989 there was a significant increase in exports of fish from approximately 400 tons (valued at 2.1 million $US) to approximately 2,300 tons (valued at 8.2 million $US), and that this reflected the higher value of the species being traded, especially prawns. It was believed that this export revenue value was low, but that it could be substantially increased if an efficient data collection system were introduced.

The estimated number of artisanal fishermen on Zanzibar islands as of a 1990 SWIOP report was 15,500, and the estimated number of artisanal fishermen on the Tanzanian mainland was the same (15,500) (Fisheries Report, 1989 - not listed in references section of this report). It was also estimated that 19 commercial trawlers and three commercial purse seiners operated along the Tanzanian coast at this time. As for local consumption, it was observed that anything that was caught was eaten, but not necessarily recorded. Shellfish (collected for consumption and the curio trade) were apparently overexploited at this time, as were sea cucumbers. Turtles were yielding a high price for their meat, and so females were often killed as they came ashore to lay eggs.

With the use of motorized boats and the storage of fish on ice, the trade of fresh fish was on the rise. Fish were also marketed as salted, sun dried, and frozen by the men, and the marketing of fried fish was mainly a trade of the women.

Conclusion: This report provided a good overview of the fisheries in Tanzania as of 1995, and It is interesting to learn that such a large number of artisanal fishermen worked the coastal regions at this time.

Semesi, A.K., Y.D. Mgaya, M.H.S. Muruke, G. Msumi, J. Francis, M. Mtolera. 1998. Coastal Resource Utilization and Conservation Issues in Bagamoyo, Tanzania. Ambio 27: 8. December, 1998.

Aim of study: The coastal resources and resource use of the Bagamoyo District of Tanzania were studied through an interdisciplinary team in collaboration with personnel of the Natural Resources Section in the Bagamoyo District. The purpose of this study was to collect baseline information to assist with management efforts. The findings on mangrove resources are outlined in the literature search summary on mangroves in Tanzania, so that discussion is omitted from this summary.

Methods: It was stated in this paper that the reefs of the Bagamoyo District had not been studied, so no documented information exists. Interviews with local fishermen provided information regarding fishing grounds and targeted species.

Results: It was determined from these interviews that the main fishing grounds for artisanal fishermen were located at Mwamba Kuni and Mshingwi, and that many species of fish, sea cucumber, octopus, and other marine organisms were caught at these locations. During the rainy seasons, several species of fish and prawns were also caught in the salt ponds. Many destructive fishing methods were used such as dynamite fishing, coral smashing to scare fish, and the trampling of the coral reefs while looking for shells and sea cucumbers.

A study of finfish resources was conducted from January – March 1997 at Mbgani, and the results were reported in this publication. The average daily catch rate for fishermen using hand lines was 10 kg/boat, with a range of 5-60-kg/boat. The average daily catch rate for fishermen using the beach-seining method was 50 kg/boat, with a range of 20-250-kg/boat. The various species that made up these catches are given. The catch composition from two fish trawlers was surveyed and the results can be found in a Table. It was interesting to note that prawns made up approximately 50% of the fish catch from the trawlers, although the months from December to February were officially considered closed seasons for prawn fishing in the Bagamoyo District. The open seasons for commercial trawling for prawns was from March to November, with the best catches from March to May.

Other exploited resources included mollusks, sea cucumbers, squid and octopus, and lobsters. Sea cucumbers were apparently overexploited, with the largest export market in Hong Kong (Appendix H: Table 11). It was stated that no reliable fishery statistics existed for the Bagamoyo District, so interviews with fishermen were conducted to obtain information. The information obtained indicated that there were overall declines in catches of targeted species.

No effective management practices currently exist in the Bagamoyo District, and it was concluded that a general lack of enforcement and lack of detailed information about local resources were key reasons. A compilation of fisheries information for Tanzania was put together in The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania, Mbegani, Tanzania, 6-8 March 1984.

Siegel, P.R., 1986: The exploitation of crustacean resources of Tanzanian mangrove habitats. In (J.R. Mainoya and P.R. Siegel, eds.) ***Proceedings of a Workshop on "Save the Mangrove ecosystems in Tanzania".*** **21-22 February, 1986. University of Dar es Salaam, pp. 59-69.**

Aim of study: This study was part of the work of Mangrove Study Team, which was established in recognition of mangrove forest destruction as a critical problem, and the death of information on environmental impacts of human intrusion into mangrove ecosystems.

Results: It was reported that many of the crustacea found in the Tanzanian estuaries were of significant economic importance. Most of these species spent most of their life circle in the mangrove habitat, and some portion in the open ocean. This in some cases, resulted in the development of two fisheries: an artisanal fishery capturing species within the estuary and during migrations from the estuary to the sea, and; a larger scale commercial trawling fishery in deeper waters offshore.

The most productive prawn grounds lied at the mouths of the Pangani, Wami, Ruvu and Rufiji rivers. About 80% of Tanzania's commercial prawn catch originated in the Rufiji delta. Tanzania prawn production reached peak in 1969 at about 555.6 tonnes, but had fallen to about half that figure. Sankarankuty and Subramaniam (1974) had estimated a potential harvest of 1,200 tonnes. The catch statistics therefore indicated an under-utilised resource.

Although prawns were currently the most important of the commercially exploited mangrove crustacea, there were also two species of mangrove crabs (*Portunus pelagicus* and *Scylla serrata)* which had high fisheries potential. However, these species remained virtually unexploited in Tanzania.

Soley, N., 1997: Socio-economic profile of the fisheries of Misali Island, Pemba. The Environment and Development Group, Oxford, England. 36p.

Aim of study: This is a report of surveys conducted on Misali Island, Zanzibar with the hope of gaining key socio-economic data specific to the fisheries of the island.

Area of study: Misali Island Conservation Area off the coast of Pemba, Zanzibar.

Methods: Misali Islands's spectacular coral reefs have long created interest in transforming it into a marine park or tourist resort but surprisingly, prior to these surveys the only work done specifically on Misali was by Horrill (1992, 1994). Three surveys were conducted: A shehia survey (n=34) on use of Misali fisheries by community. A shehia is the smallest administrative area in Zanzibar; a fisherman survey (n=96) on use of Misali fisheries by community; and a catch assessment for July 1997. These surveys failed to yield the following key data: an accurate estimate of the number of fishermen fishing in Misali and an accurate estimate of catch and value for the fisheries.

Results: The Misali fisheries are tropical multi species and multi technique. The report estimates 7260 people to be directly dependent on the Misali fisheries. The level of exploitation of the fisheries (taken as a whole) seemed to be such that catch and economic returns were currently falling, yet were still good enough to make fishing attractive to current fishermen and to potential entrants. In terms of the life cycle of an open access fishery, it was not too late to introduce management measures to save the fisheries from further decline. The benthic fisheries of Misali were identified as the fisheries most at risk from overexploitation. An appropriate management objective for the fisheries as a whole was to maintain its current state. In terms of management measures, this would imply primarily taking action to stop further net entrants to the fishery. It is recommended that development measures in support of management objectives should be investigated.

The resolutions adopted at the Second Misali Island Workshop are mentioned. Three of the fourteen resolutions pertain to fisheries. These included resolution 1 that provides support for management measures aimed at restricting access to the fisheries, possibly through a permit system. Resolution 9 which provides support for ongoing research initiatives, and Resolution 11 which provides support for management measures aimed at protecting specific fisheries from over exploitation, and may in particular be applied to the benthic fisheries.

SWIOP., 1985: Report on the National Workshop on Fish Handling in Zanzibar, United Republic of Tanzania.1985. *SWIOP Document* RAF/79/065/WP/22/85.

Aim of study: This is a report on the Workshop held in Zanzibar on 23-27 March 1985. The Workshop had 16 participants, 2 lecturers from FAO and 1 lecturer from the Fisheries Department. The participants learnt about pathways of fish spoilage, assessment of freshness fish, methods of handling fish on board and shore-use of fish boxes. Other techniques included ice and fish, insulated boxes for fish onboard the fishing vessel, fish landing facilities, fish handling during distribution, fresh fish in the market and production of publicity material on fish handling.

Results: The report gives summary notes of these subjects. Fish in this course was taken to include both finfish and shellfish such as shrimp, oysters, crabs and lobsters. The report has a section dealing with the handling of shellfish. Aspects dealt with are the capture, killing or handling alive, and storage of crabs, lobsters, shrimps, oysters and clams. Another section describes how to make a beam balance, the materials used, construction and calibration of the scale. At the end of the report is a conversion table.

Tarbit, J. 1984. Inshore fishery of the Tanzanian Coast. The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania. Mbegani, Tanzania, 6-8 March.

Aim of study: The East African Marine Fisheries Organization (EAMFRO) collected information on the marine fisheries of Tanzania from 1950-1977, mostly about the biology and taxonomy of the near-shore populations. The focus of these investigations was to determine the potential for the development of an offshore and coastal pelagic fishery, and for the potential exploitation of the demersal species on the North Kenya Banks.

Results: Several regions that were unexploited at the time were investigated such as the outer reef slopes and coral banks, and in 1968 EAMFRO conducted a study on the potential expansion of the artisanal fishery to the unexploited regions. Many references were listed pertaining to these investigations, and they were as follows. Losse, 1964; Merret, 1964, 1968; Morgans, 1958, 1959, 1964; Morris, 1971, 1972; Talbot, 1957, 1960; Tarbit, 1975, 1976; Wheeler, 1959, 1960 (a), 1960 (b); Williams, 1956, 1958 (a), 1959, 1975 (b) (Williams, 1975 (b) may be a misprint in the reference section of the report, and the actual date may be 1958). I have not read any of these reports, but have listed them in the literature-cited section of this summary for future reference. Fringing reefs and a narrow coastal shelf flank the Tanzanian coast. The outer edge of the reef usually lies within 1 km of both the mainland coast and the eastern coasts of the offshore islands. The artisanal fishery was concentrated in the smooth trawlable regions between the shoreline and the outer edge of the fringing reef, and also along the shallow shelves of the Mafia Island region and the Zanzibar Channel. The unexploited outer reef slopes extend to depths of 70-100 meters, with the steep slope of the seabed dropping off to depths of over 300 meters.

Catch statistics collected by the Tanzanian Fishery Department were stated as having been collected since 1967, but those records prior to 1970 were not considered accurate. These records were calculated by region, with Mtwara, Lindi, Coast, Tanga and the Islands of Zanzibar and Pemba recorded separately. Catch and effort statistics for the artisanal fishery from 1971-1981 are listed in Table 1 (Appendix J), and demonstrate that there was an increase in effort and catch until the late 1970's, when both appeared to decline. The increase in catch per unit effort (CPU) was considered a probable outcome of the introduction of the gill net, which apparently replaced the inefficient handline method to a great extent. The decline in total landings was attributed to a decrease in the actual number of artisanal fishermen. Several factors were suggested as the cause of this decrease in fishing effort from a socio-economic survey conducted by Hasset in 1983. Decreased effort was attributed to an overall shortage of gill nets due to some difficulties in obtaining imported gear. This caused fishermen to revert to traditional fish trap methods that

resulted in decreased productivity. Also, dynamite fishing was concentrated in the urban coastal regions such as Dar es Salaam, Mtwara, and Lindi. This destructive method of fishing led to widespread destruction of fish habitat, which was also attributed to decreased productivity in the regions affected. Although fishing effort had declined while CPU remained relatively constant in the mainland artisanal fishery from 1975-1981, effort appeared to increase during those years on the islands of Zanzibar, while CPU declined.

Note: An addendum to this publication indicated that fish landings dropped to 20,000 tons in 1982, while the number of fishermen increased to 7,870. The CPU was calculated to be 2.5 tons/vessel/year for 1982, which demonstrated a drop to 1971 CPU. It was suggested that the inability of the fishermen to obtain gill nets, along with the reluctance of the fishermen to return to traditional fishing methods were likely causes of this drastic decline in efficiency.

There is a table thatdemonstrates the catch per vessel, along with the proportion of landings and species composition of catches for artisanal fishermen of Zanzibar during a study conducted by EAMFRO from 1974-1976. The information was based on the type of fishing gear used. This data suggested that the topography of the region fished determined the type of gears deployed (e.g., gill nets were used in deeper waters to concentrate effort on larger pelagic species, and seines and scoop nets were used in shallower patch reef areas to collect smaller species). Relative and potential yields were calculated for each region based on this information, but I did not include these calculations in my summary. It was concluded that the fishery potential of the reef environment was probably fully exploited, and that the fishery should be expanded offshore. Suggestions were made to adapt traditional fishing gear for use in deeper waters, and to expand the gill net fishery. The difficulties in obtaining imported gear such as the gill nets were expected to hinder the possibility of expanding the gill net fishery.

Some potential was also observed for the expansion of the handline fishery (typically a shallow water fishery) to the reef slope areas. The strength of the East African Current was seen as a possible hindrance to this effort, so EAMFRO conducted studies during 1969-1976 to determine whether the use of handlines, droplines, and longlines would be possible in the Channels of Mafia and Zanzibar Islands. The gear was adapted and tested along the length of the Tanzanian coast (Tarbit, 1975, 1976), and it was determined that the potential existed for the expansion of this fishery to deeper waters.

Conclusion: The inshore regions of Tanzania appeared to have been heavily exploited from the information gathered from the EAMFRO studies, while offshore regions were barely explored for their exploitation potential. One would hope that any expansion of the Tanzanian fishery would have occurred in the offshore regions and that the inshore fishery would have been restricted to some extent.

Tiffney, P., 1984: An analysis of local and external marketing constraints and outlets for an expanded fishery in Zanzibar. Field document: URT/81/TOIUNO/URT/001/STD. FAO, Rome. 20 p.

Aim of study: This report was prepared for the Technology Transfer in Zanzibar Fisheries Project by a consultant assigned to analyse local and external marketing constraints and outlets for an expanded fishery in Zanzibar, with particular emphasis on small-scale fisheries. At the time, the Zanzibar Fishing Company (ZAFICO) was the only commercially integrated fishing operation in Zanzibar and it was about to undergo a major reinvestment and rehabilitation programme.

Methods: The consultant held discussions with GOPA Consultants of Germany, which was implementing the first phase of ZAFICO's rehabilitation programme. On arrival in Zanzibar the consultant visited many fish landing places and fishing villages in Unguja and Pemba, and examined vessels and gear, shore facilities, fish species caught and landed, methods of sale, prices and methods of distribution from these locations. Visits to market locations, both retail and wholesale, were carried out to review the present environment of handling practices, products and prices. Market locations in Dar es Salaam were also visited. A review of the situation at ZAFICO at the time is given. No radical change in operation of ZAFICO was planned in the reinvestment and rehabilitation programme, save for the improved handling and efficiency, and therefore viability, of the whole company.

Results: A description of Zanzibar Central Market is given as is that of the urban and rural district landing sites and markets (Table 2). In Dar es Salaam the possibility of a link between ZAFICO and the National Cold Chain Operations (NCCO) or/and the Tanzania Fisheries Corporation (TAFICO) was investigated. The NCCO were found to be in financial difficulties while TAFICO had no interest at the time, of developing local markets and wished only to concentrate on shrimp (and possibly lobster) export. The same applied to the other fish importers/ exporters visited.

There are two significant types of fishing in Zanzibar; (i) mechanized purse seine using light attraction, exclusive to Zanzibar Town and (ii) traditional line, trap and net fishing during daylight hours, using traditional sail powered craft. The price/demand relationship on Zanzibar is directly related to the purse seine fishery. Most of the heavier village landings in Zanzibar are landed in quantities in excess of the limited distribution available, smoking to preserve the excess thus rising the prise. Fish are very expensive in Zanzibar (as are other foodstuffs) in relation to average income.

Development prospects are examined in the report with regard to the internal market and rehabilitation of ZAFICO. Also discussed is the necessity for improvement of handling throughout the marketing system so as to reduce waste and spoilage and permit the movement of increased volume through the system. Zanzibar (and especially Pemba) has large stocks of shrimp and lobster currently under fished and this resource could be supplied to the mainland and further expansion would follow later on with direct exportation to external markets. Limited potential may also exist for developing of a tuna fishery. This capital intensive and specialised fishery would require a joint venture with an international organisation having existing technical and marketing expertise for tuna. However the tuna market had at the time undergone a recession so the short-term possibilities for a Zanzibar-based tuna fishery were remote, other than a limited expansion for the domestic market.

Conclusion: It is suggested that the situation is in need of improvement. Obstacles to be overcome include the inadequate and inaccurate fisheries data collection system and the run down marketing facilities. There is a need for the expansion of rural infrastructure in Zanzibar and the fish markets need to be improved. The author states that much of the market development prospects for Zanzibar would depend on the successful rehabilitation of ZAFICO. (It should be noted that ZAFICO is now defunct).

UNEP, 1989: Coastal and Marine Environmental Problems of the United Republic of Tanzania. ***UNEP Regional Seas Reports and Studies No. 106*** **+ Annexes 1-X**

Aim of study: This study was conducted by UNEP in collaboration with NEMC and in response to a request by the Government of Tanzania to assess the coastal and marine environmental

problems of the country. The study was also aimed at drawing up a national action plan for the protection, management and development of its marine and coastal environment.

Results: It was reported in this study that the main characteristics of reef formation of the Tanzania coastline were fringing reefs. Due to the narrowness of the continental shelf all the coral reefs were close to land and as a result were strongly subjected to natural and human influences and were particularly vulnerable to changes in land use and coastal development.

The use of explosive fishing methods was reported to cause severe damage to the coral reefs. Much of the substrates mostly suitable for recolonization had been reduced by extensive and continued practice of this fishing method to unconsolidated rubble. This rubble had then been extensively colonized by soft coral species, thus inhibiting the possible settlement of the more energetically important scleractinian species. In severely damaged areas, soft coral cover was estimated at 60-80%.

The exploitation of mangroves, the use of anchors by artisanal fishermen on reefs, walking on reefs during low tide, indiscriminate extraction and an unregulated collection of coral species and sedimentation were other sources of reef destruction. Coral reefs were also affected by the presence of *Acanthaster planci* (crown of thorns of Starfish), which caused mortality of reefs in Tanga region. In Annexes I to IV of the report, detailed results of surveys on reefs for all coastal regions were given (Tanga, Coast, Dar es Salaam, Lindi, Mtwara and the islands of Zanzibar).

In **Tanga Region**, coral reefs and fringing coral reefs around offshore islands were observed and their conditions were assessed. These were (from north to South): Boma Reef, Mwamba Shundo, Mwamba Wamba, Fungu Nyama, Niule Reef, Yambe Island, Karange Island and Fungu Tongone. Of these, Mwamba wamba, Fungu Nyama and Niule Reef were designated reefs that formed the Tanga Coral Gardens Marine Reserve.

The use of dynamite was reported to have severely damaged the reef at Boma Reef. The reef at Mwamba Shundo showed evidence of dynamite damage but had also been subjected to storm surge damage. The entire area of Mwamba Wamba had been severely damaged by explosive fishing and reduced much of the substrate normally suitable for recolonization to unconsolidated rubble. Explosive fishing damage was reported to be very extensive at Niule Reef, while the patch reefs at Yambe Island had also been exposed to explosive fishing. At Karange Island, the reef was reported to be subject to heavy sedimentation. Lastly, the back reef area at Fungu Tongone had been subjected to heavy explosive fishing, evident by distinct craters.

In **Coast Region**, the areas observed from north to south included Mbegani, the coastal area from Ras Ndege to Ras Buyuni, Sakuti Islands, Kwale, Koma, Mafia and Chole Bay.

At Mbegani Bay, there were no coral formations, but to seaward of it there was an extensive patch reef system. Since the surveyed area had no major reef formations, it was difficult to assess the degree of damage caused by fishing pressure, both artisanal and by explosive fishing technique. The area from Ras Ndege to Ras Buyuni consisted of a Pleistocene coral platform backed by a coastal slope with numerous beaches fronted by patch reef formations, water depths in the back reef areas were approximately one metre and the area was under intense fishing pressure by ambulant artisanal fishermen.

In the area from Ras Buyuni to Koma Island, artisanal fishermen had constructed many fixed traps throughout the intertidal area from Ras Buyuni to Samanga. From Koma Island to Mafia Island-Kilindoni, the reefs to the north of Kilindoni towards Ras Mkumbi in the north were

subjected to artisanal fishing pressure and explosive fishing had been reported. At Chole Bay, there was no observed damage that could be attributed to explosive fishing.

In **Dar es Salaam Region**, surveyed areas were: Fungu Yasini, Mbudya Island, Bongoyo Island, Msasani Bay to Ras Kiromoni and Ras Kankadya to Ras Ndege. Fungu Yasini, Mbudya Island and Bongoyo Island were reported to be gazetted marine reserves. Fungu Yasini, a sandbank drying to 3m at low water springs, had a well-developed fringing reef system extending from the east to the south. Fishing pressure was reported to be heavy and explosive fishing had been observed.

Mbudya Island was fronted by a high-energy fringing reef with back reef formations. Fishing pressure was reported to be heavy, and explosive fishing was common. Together with anchor damage, there was serious degradation of coral cover, and no coral recruitment was seen. Bongoyo Island was fronted to the east by a dissected fringing reef system with sheltered reefs of variable structure to leeward. Coral cover was estimated at 10 to 15%.

In the area from Msasani Bay to Ras Kiromoni, there was an extensive seagrass bed interspersed by patch reefs of massive *Porites* spp. and other lesser species on the seaward. The area was subjected to continuous explosive fishing. Lastly, the area from Ras Kankadya to Ras Ndege (including Outer and Inner Makatumbe and Inner and Outer Sinda Island) represented poorly developed fringing reef system and the most serious levels of pollution both urban and industrial in Tanzania.

In **Lindi Region**, surveyed areas were Okuza Island, Nyuni Island, Songo Songo Island, Kilwa Kisiwani and Kilwa Masoko. Songo Songo was reported to be a Pleistocene coral Island. By the time of writing of this report, there were plans to construct a natural gas recovery and ammonia cracking plant complex on the island. Okuza (Sand Island) was covered by casuarina trees on a Pleistocene coral platform and surrounded by a well-developed fringing reef on the seaward side and extensive patch reef formations on all remaining sides. Coral cover was reduced to leeward ta86dd(loped f)8(r)-3(i)7(n)1((cor 0 (and8u(a)0(in)1bl(casudu1(to)11(1(ri)8d9(e of n)122((onia)bil8(r)t(cas)6(

In **Zanzibar Island**, en extensive survey was made on the reefs fronting Zanzibar town and extending to the Southwest of the island. The reefs were arranged in loose formation. In the Islands of Chapwani, Kibandiko and Changuu, there was a poorly developed patch reef cover. Poor water quality increased productivity and heavy artisanal fishing pressure had resulted in continuous mortality of the reef fauna. At Pange reef, which dried to 2m, there was an extensive bank formation covered by shallow patch reefs in poor condition. To the west of Pange, there was a deep reef development to 30m that was undamaged. Bawi Island was fronted by a well-developed coral reef formation to the north and southwest. Being a naval base, no severe damage by artisanal fishing pressure was seen.

At Murogo Reef, a circular reef surrounding drying sand bank to the south of Bawi Island, the coral formations were continuous over the circumference of the reef extending from 1m to 10m. There were well-developed patch reefs to seaward. Coral cover varied from 60 to 100%. A mortality of 20 to 40% of shallow specimens was attributed to increase in water temperature by 1.5 to 2^{o}C in February-March, 1987. Nyange reef was similar to Murogo Reef, but with more extensive coral cover.

Chumbe Island (a Pleistocene island) had an extensive coral reef and seagrass towards the Southeast. Artisanal fishing pressure was found to be high, and damage due to shell collection, indiscriminate use of fish traps and stone anchors was identified. At Kwale Island, a bank and reef formation extended northwards to Ras Fumba. Damage to the reef was reported to be visible to the west of the island. Coral damage had reduced coral cover to less than 15% due to use of stone anchors and shell collection. At Pwakuu Reef, coral development had been stunted due to currents. The shallow reef had been damaged by shell collection and walking on drying reef flats.

At Mangapwani, a narrow ribbon of coral fronted the two beaches, separated by an exposed Pleistocene cliff formation, which was in poor condition. The coral fauna was under stress, and this was attributed to temperature and salinity fluctuations. At Nungwi, coral cover was poor, 15 to 30%, and those colonies present were encrusting a scoured coral substrate. Heavy pressure was observed, which was due to collection of octopus and molluscs.

On the East Coast Fringing Reef, access to the seaward reef was difficult. The back reef areas had been destroyed south of Chwaka Bay with those areas observed at Bwejuu being devoid of living coral. The observed area was subject to increasing fishing pressure, and an increase in the use of beach seines. Lastly at Chwaka Bay, no report was given whether corals occurred.

In **Pemba Island**, three areas were surveyed. At Misali Island, there was a unique reef flat area on the south of Uvinje Gap to the west that descended to the fore reef slope in a stepwise manner. Coral cover was 40 to 60% with 40 genera observed. Mortality of some species was observed.

The protected Inshore Area from Njao Gap to Port Cockburn had coral cover, which was restricted to very isolated patch reefs. Lastly, at Mtongani, the fringing reef fronting this area was found to be in poor condition. Coral cover was variable and never exceeded 15%. Diversity was poor with only 16 genera represented. Shallow back reef areas had been damaged by storm surge and stone archors. No resettlement was seen.

Latham Island was reported to be biologically important as reported by Cooper *et al*. (1984).

UNEP. 1989. Report on Zanzibar. Annex VI. Coastal and marine environmental problems of the United Republic of Tanzania. UNEP Regional Seas Reports and Studies No. 106.

Aim of study: Evaluation of the coastal and marine environmental problems of Tanzania.

Methods: Extensive surveys were conducted of the reefs and islands around Zanzibar, and although the data was not included in this report, it was stated that the data could be made available.

Results: Several select islands and reefs were described, and recommendations were made for the designation of certain regions as marine parks. A general description of the fishery around Zanzibar was included, with no statistical information or data. It was noted that the fishery statistics collected by the Zanzibar Ministry of Marine, Tourism and Forestry were available in another annex (annex IX), but that it lacked information on catch by species. Some sources of marine pollution were described, and this information was obtained by a survey conducted by NEMC. The information in this report (UNEP No. 106, 1989) was very similar to other reports described in my summary, so I did not feel the need to summarize this report any further.

Venema, S.C. 1984. Resource surveys other than those by *Dr. Fridtjof Nansen*. The Proceedings of the NORAD-Tanzania Seminar to Review the Marine Fish Stocks and Fisheries in Tanzania. Mbegani, Tanzania, 6-8 March.

Aim of study: This paper discusses some of the fisheries work that has been done in Tanzanian waters, and summarizes the Prof. Mesyatsev surveys conducted during the late 1970's. It was stated that no large systematic surveys of the marine resources had been carried out in Tanzanian waters prior to the *Dr. Fridtjof Nansen* surveys.

Methods: Japanese shrimp trawl surveys conducted from 1968-1970 were mentioned, and may be the same set of surveys discussed in the Bwathondi and Mwaya (1984) summary. Estimates of the fishery potential for Tanzania were made during an FAO/IOP workshop in 1978, and additional exploration of the shrimp fishery occurred in 1979 by TAFICO and others (the 'others' were not mentioned in this report).

Results: It was stated in this report that the marine resources of Tanzania required different methods for survey since their biotope and behaviors differed, and so these resources were divided into ten main groups. Group 1 consisted of large pelagic fishes such as tuna and sailfishes, Williams surveyed this group in 1956a. Group 2 encompassed all small pelagic fishes, which were the main targets of the surveys by the R/V *Dr. Fridtjof Nansen* as well as the Prof. Mesyatsev surveys. The small demersal fishes and shrimps (Groups 3 and 4, respectively) were also surveyed by the R/V Dr. Fridtjof Nansen and the Prof. Mesyatsev surveys, as well as by the Japanese shrimpers. Estimates for the remaining marine resources (Groups 5-10) were described as being largely based on statistics and extrapolations, with one exception being the spiny lobsters (Group 6a). Hall (1960) described the catch rates of spiny lobsters from eight regions around Zanzibar. Resource survey methods were divided into two main categories based on systematic and random surveys. Used to obtain a biomass estimate. Exploratory surveys. Trying out various types of gear on different grounds with the use of information obtained from an echosounder on larger vessels. It was noted that a third category of data collection may consist of data collected during trawl hauls for acoustic surveys when sampling for such things as size and species composition, or when attempting to identify traces on the echosounder.

The Prof. Mesyatsev surveys consisted of acoustic and trawl surveys (Birkett 1978; VNIRO 1978; Burczynski 1976). These results were used in an FAO/IOP workshop in Seychelles in 1979. The conversion methods for the acoustic surveys differed from the R/V *Dr. Fridtjof*

Nansen surveys, and from what I gathered from this report, were considered unreliable. It was stated that biomass values calculated with the methods used in the Prof. Mesyatsev surveys should be considered 'rough estimates' only due to incomplete coverage of the shelf area during the surveys. A map of sample stations was given. Estimates of biomass of demersal fishes from trawlable areas and from non-trawlable areas are presented in Table 3 (Appendix L), and come from the FAO/IOP workshop (1979). The information presented during this workshop may prove to be useful, but I have not seen the publication. The total estimated potential yield from the Prof. Mesyatsev surveys for the Tanzanian fisheries were considered very low at 15,260 tons, although the highest combined landings (from the artisanal fisheries and Mwananchi Ocean Products) for Tanzania were recorded in 1970, and totaled 706 mt (approximately 695 tons).

It was noted that Wijkstrom surveyed some reef areas in 1974, and that this report may provide information at least on fish species composition for the reefs surveyed. Tarbit conducted exploratory surveys for large demersal fishes in 1976 (1976 (a)) with longlines, handlines, and traps in Tanzanian and Kenyan waters. His methods were described as relating directly to the existing artisanal fishery.

Conclusion: Many small-scale surveys have been conducted in the Tanzanian waters, but even collectively, the information these surveys have provided was not considered sufficient to make accurate large-scale extrapolations for the fishery. The more valuable resources such as shrimp, lobster, and large demersal fishes had not been surveyed to any large degree, and so their rates of exploitation remained unknown at the time of this report.

CORAL REEFS

Greg Wagner
University of Dar es Salaam, Department of Zoology and Marine Biology
P.O.Box 35052, Dar es Salaam.

Guard, M. and Masaiganah, M. 1997. Dynamite fishing in southern Tanzania, geographical variation, intensity of use and possible solutions. Marine Pollution Bulletin 34 (10): 758-762.

Aim of study: Dynamite fishing has been practised in Tanzania since the 1960s and, because it has widespread and common use, virtually all coral reefs along the Tanzanian coast have been badly degraded. The factors that have led to its continual use is poverty, lack of law enforcement, inadequate legislation and lack of control of dynamite supplies. A typical dynamite blast kills all fish within 50-70 m radius. It also kills invertebrates, demersal plankton, larvae and eggs. Regeneration period of hard corals after a dynamite blast is minimal even after a period of 40 years.

Area of study: Kilwa and Lindi in Tanzania.

Methods: Marine biological and resource use surveys using SCUBA and snorkelling techniques have been conducted along the coast of southern Tanzania by the Frontier Tanzania Marine Research Programme. These surveys have shown that dynamite fishing has been practised all over southern Tanzania, but the way it is conducted and who is responsible differs from place to place.

Results: In Kilwa, fishermen who do most blasting come from Dar es Salaam and other outside areas. A single businessman or group in Dar es Salaam usually owns the boats that also procure the dynamite. Fishermen keep their catch in iceboxes and take it to Dar es Salaam for sale. What complicates the situation is that they also purchase fish from local fishermen to sell in Dar es Salaam. Since the local fishermen depend on this market for their fish, they don't report the fact that dynamite is being used. As a result, all coral reefs throughout the Songo Songo Archipelago are extensively damaged above a depth of 10 m, though below that level, the reefs are prolific with coral growth and abundant with fish. Shallow reefs, however, are almost completely destroyed.

In Lindi and Mtwara, on the other hand, dynamite fishing is practised by the local youth. The cost of dynamite has become very low in the area, so it has become much easier and cheaper to use dynamite than to purchase expensive nets for traditional way. Though many villagers are aware of the destructiveness of this practise, few are willing to do anything about it. The condition of the reefs in the area is similar to that already described for the Kilwa area.

Conclusion: It is recommended that an effective strategy be developed to confront the problem which should encompass a wide range of actions, such as continuous patrolling, police enforcement, improved legislation, increased fines, confiscation of vessels and jail sentences. Moreover, in the long term, the local communities themselves must be educated and empowered to combat and stop dynamite fishing.

Lindahl, U. 1998. Low-tech rehabilitation of degraded coral reefs through transplantation of staghorn corals. Ambio 27 (8): 645-650. [22]

Aim of study: In many tropical regions, the degradation of coral reefs poses a serious threat to human populations, many of whom depend upon reef fisheries for their livelihood. While coral reefs have an inherent capacity to recover from most natural disturbances, recovery from human impacts may be prolonged or hindered by consequent changes in the environment.

Area of study: The study was conducted at Tutia Reef in Mafia Island Marine Park. Staghorn coral (*Acropora formosa*) fragments were transplanted in plots in a fully orthogonal design with 3 factors, each of which had 2 levels as follows: attachment (unattached/tied on strings), density (30-40%/10-15% cover), and site (exposed/protected). There were 4 replicate plots for each combination of factors, making a total of 32 plots.

Methods: Experiments on rehabilitation of coral reefs through transplantation of corals have often involved methods that are too expensive for practical application in developing countries. This study aimed at developing simple, inexpensive methods for transplantation of corals to rehabilitate degraded coral reefs.

Results: The transplanted corals survived and grew well, with average cover (all treatments pooled) increasing from 22 to 30% over 23 months. Orthogonal three-way ANOVA showed that both low-density transplanting and attachment by strings had significant positive impacts on the increase of coral cover, while site and interactions between factors had no significant impacts (Table 1). The cover of soft corals and hard corals other than *Acropora formosa* increased markedly in the experimental plots (Fig. 2) in comparison with control plots.

Conclusions: It is concluded that, in areas that are moderately exposed to water movement, the transplantation of staghorn coral fragments at low density by tying them with string can be an effective, low tech method of rehabilitating damaged areas of reefs and enhancing the habitat.

Muhando, C.A. 1999a. Assessment of the extent of damage, socio-economic effects, Mitigation and recovery in Tanzania. *In* Linden, O. and Sporrong, N. (eds.), Coral Reef Degradation in the Indian Ocean: Status reports and Project Presentations 1999. CORDIO, SAREC Marine Science Programme, Stockholm: 43-47. [27]

Natural and anthropogenic factors affecting coral distribution are enumerated. Prior to the 1998 coral bleaching event, various surveys throughout Tanzania indicated widespread degradation of coral reef environments. In Zanzibar, hard coral cover ranged from 13.95% at Mnemba on the eastern coast to 53.11% at Bawe on the West Coast.

Seawater temperature on Zanzibar coral reefs in 1997 and 1998 are shown in Figure 1 which also indicates the coral bleaching period, March to May 1998. The bleaching period coincided with higher than normal temperatures and increased rainfall (lower salinity). 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 (Table 2), with *Acropora* being most affected; while a few corals such as *Diploastrea* and *Pachyseris* were seemingly unaffected.

After the bleaching event, filamentous algae colonized the dead corals. By November 1998, these were replaced by macroalgae and coralline algae. By January 1999, some areas showed the

recruitment of small corals, while corallimorpharia and soft corals colonized others. On the economic side, some dive operators reported a decline in tourist potential due to the bleaching event.

Various monitoring programmes and research activities have been on-going in Tanzania, while others have been launched specifically to determine the extent of damage to coral reefs brought about by the bleaching event. Moreover, various researchers are investigating possible techniques, which could be used to enhance the coral replenishment process on Tanzanian reefs.

Nzali, L.M., Johnstone, R.W., and Mgaya, Y.D. 1998. Factors affecting Scleractinian coral recruitment on a nearshore reef in Tanzania. Ambio 27 (8): 717-722. [30]

Aim of study: This study was conducted to examine possible impact of reef degradation on the recruitment pattern of hard corals.

Area of study: Two sites on Taa Reef, northern Tanzania, one of which had been severely damaged by dynamite fishing.

Methods: Terracotta (clay) tiles were placed on racks at an angle of 45^{o} approximately 20 cm above the seabed. Some of the tiles were retrieved for measurement and replaced every 8 weeks. Other tiles were left for a 12-month period before retrieval. Retrieved tiles were examined for coral recruits and data recorded on the location of recruits on the upper or lower surface. Their identification, diameter, and their number were also recorded. Seawater temperature, water transparency and sedimentation rates were measured.

Results: The highest densities of coral recruitment occurred in April, which also coincided with the lowest sedimentation, the highest rainfall, and the highest temperatures. No definite conclusion could be drawn about the relative importance of these three abiotic factors in relation to coral recruitment. Site 1, which had higher coral cover, had significantly higher densities of recruits than site 2, which had more damage from dynamite fishing, indicating that coral cover is an important factor affecting recruitment. Significantly greater densities of recruits on the lower sides of the tiles than on the upper sides was attributed primarily to differences in light intensity.

Conclusion: Overall, dynamite fishing at Taa Reef appears to have had a major impact due to the removal of viable seed populations of corals. This has decreased the supply of recruits for recolonization of the damaged areas. In addition, other factors such as sedimentation rates and competition for space with other organisms were also examined, but these did not appear to play a major role in determining recruitment levels at the study sites.

Ohman, M.C., Lindahl, U., and Schelten, C.K. 1999. Influence of coral bleaching on the fauna of Tutia Reef, Tanzania. *In* Linden, O. and Sporrong, N. (eds.), Coral Reef Degradation in the Indian Ocean: Status reports and Project Presentations 1999. CORDIO, SAREC Marine Science Programme, Stockholm: 48-52. [31]

Aim of study: In 1998, coral reefs of Tanzania were severely affected by bleaching. The coral mortality that followed caused a concern for coral reef degradation and overall resource depletion. This study investigated the effects of coral bleaching on the coral reef fauna.

Area of study: Tutia Reef in Mafia Island Marine Park.

Methods: Corals of the species *Acropora formosa* from adjacent reef patches were transplanted into plots in a back reef area on a substrate mixture of coral rubble and sand in 1995. Observations were made before and after the 1998 coral-bleaching event. Living coral cover was estimated through point sampling of randomly taken photographs. Reef structural complexity was estimated by measuring the heights of coral branches, in 10-cm sections of two parallel lines across the plots. Fish were identified and counted by a stationary SCUBA dive technique.

Results: Following the bleaching event, 88% of the corals died. A year after the event, a large proportion of the dead corals was still standing. As surviving and dead corals were from different clones, results suggested that genetic variation might influence bleaching tolerance. After the coral bleaching, there was a change in fish community composition and a 39% increase in fish abundance. In particular, there was an increase in the abundance of herbivorous fish, due to the growth of algae on the dead coral. Species diversity remained almost constant. There was a significant correlation (Spearman rank) between reef structural complexity and both fish abundance ($r = 0.86$, $p < 0.05$) and the number of fish taxa ($r = 0.76$, $p < 0.05$).

Conclusion: This study indicates that the reef may uphold an abundant fish population as long as the architectural structure remains intact. The impact that the coral bleaching event may eventually have on fisheries is difficult to anticipate. The Tutia Reef supports a multi-species fishery and a variety of fishing techniques are used. As broad ranges of species are targeted, including smaller fishes, catches may not be reduced as long as the reef structure is sustained. However, if dead coral is eventually degraded and turned into rubble, with consequent loss of structural complexity, fish abundance is likely to decrease greatly.

Solandt, J.L. and Ball, R. 1999 Coral mining in Mikindani Bay. Frontier-Tanzania Marine Research Programme. The Society for Environmental Exploration and the University of Dar es Salaam. 6 pp. [36]

Aim of study: Coral mining, which is common in many parts of the Indo-Pacific, is a destructive practise that involves denuding shallow reef areas of large hard corals, most commonly, *Porites* spp. This study reviews coral mining in Tanzania.

Area of study: Mikindani Bay in Mtwara Region.

Methods: Through discussions with indigenous people.

Results: It was found that at least three different communities in the area exist solely on income earned by selling lime gleaned from live and dead coral. The paper reports a case study of Mitengo Village, which is the oldest coral mining community in Mikindani Bay.

In Mitengo Village, out of approximately 100 inhabitants, 50-75 are involved in various stages of the lime industry, including men, women and children. Villagers reported that, before 1975, fish were plentiful in and around the bay. However, in the past two decades catches have dropped considerably due to the use of destructive fishing methods and small mesh nets. Reduced fish catches drove the community to seek for alternative sources of income, which led to coral mining.

Coral (most commonly *Porites lobata*) is broken from the reefs using an iron bar. Live colonies are preferred over dead colonies because they yield greater quantities of lime and are more easily converted into lime powder. Coral pieces brought from the reef are further broken into 5-20 cm diameter pieces and placed on kilns where they are burned. There are between 5 and 10 kilns that are active at any one time at the village. Within the community, there is mixed ownership of the

boats, kilns and stores, so the economics of the industry are somewhat complicated. The initial cost to the kiln owner to pay the boat owner for enough coral to construct one kiln is, on average, about Shs.60,000. The powder lime is sold by the kiln owner to a storeowner for approximately Shs.400 (1998 prices) for a 20-kg bag. The storeowner then sells the lime for Shs.800-1500 per bag to outside businessmen who collect the lime with trucks.

All *Porites* above a depth of 2 m have now been gleaned from nearby reefs. This has undoubtedly had an effect on the strength of waves impinging on the coast. This is likely leading to coastal erosion, though there is no documentation on this. Miners now have to go far from Mikindani Bay to get corals, sometimes as far as 15 km, and villagers estimate that all mineable coral in the area will be used up within the next 1-2 years.

Wagner, G.M. 1997. Impact of fishing (including dynamite fishing) on coral reefs. *In* Johnstone, R.W., Francis, J., and Muhando, C.A. (eds.), Coral Reefs: Values, Threats, and Solutions, Proceedings of the National Conference on Coral Reefs, Zanzibar, Tanzania, 2-4 December 1997. Institute of Marine Sciences, Zanzibar: 38-44.

Aim of study: Coral reefs exhibit a great diversity of microhabitats, a diversity of plant and animal life, and high primary and secondary productivity. They support a great variety and abundance of marine animals important in artisanal and commercial fisheries, including finfish, lobsters, prawns, crabs, squids, octopuses, shellfish and sea cucumbers. While there are a number of both natural and human threats to coral reefs, undoubtedly the greatest impacts are brought about by man through destructive fishing practices and overfishing. This study examines effects of fishing in coral reef areas.

Area of study: Coastal waters of Tanzania.

Methods: **Personal observation and review of existing literature on the dynamite fishing problem.**

Results: By far the most destructive type of fishing is dynamiting. Each blast of dynamite instantly kills all fish and most other living organisms within a 15-20 m radius and completely destroys the reef habitat itself within a radius of several meters. Besides these direct impacts, there are indirect impacts due to turbidity and sedimentation which adversely affect marine life in a much wide area.. Sedimentation clogs the feeding apparatus of coral polyps and, when substantial, kills the corals. With numerous blasts occurring daily on reefs all over the country, over a period of many years, the overall effect of dynamite fishing on coral reefs in Tanzania has been devastating and has reached an alarming state. Damaged reefs can take many decades to recover and some, in fact, may never recover.

The use of seine nets around coral reefs is destructive in three ways. Firstly, fishermen often hit the coral heads in order to scare the fish out of hiding; secondly, the net entangles with the corals, breaking them; and thirdly, the small-mesh size of seine nets results in the capture of many juveniles. In addition, there are several fishing methods that may be destructive to reefs, if carried out in an improper fashion. These include octopus fishing, collection of shellfish, and the use of basket traps. Other harmful activities related to fishing include the dropping of anchors and boat grounding.

Overfishing and the catching of juvenile fish result in the depletion of fish stocks, alteration in species composition, loss of species diversity, disruption of food webs, and disturbance of the

natural equilibrium of reef ecosystems. For example, overfishing of the triggerfish, results in a proliferation of sea urchins which are known to be bioeroders of reefs.

Socio-economic factors leading to the use of destructive fishing practices and overfishing include poverty, increased human populations in coastal areas, urbanisation, greed, lack of awareness, and the breakdown of traditional conservation practices.

One of the most important consequences of the degradation of reefs is a marked decrease in the diversity and abundance of fish and other commercially valuable marine animals. Such a decrease occurs not only in the vicinity of the reefs themselves, but in neighbouring nearshore and offshore waters, since reefs are important breeding and feeding grounds for fish occurring in a wide area. In addition, there is a decline in the aesthetic value of reefs which reduces their attractiveness to tourists. The end result is a decline in income to coastal communities and to the country as a whole.

Conclusion: It is imperative that strong and cooperative action be taken immediately to put a stop to the destructive and excessive practices that are taking place.

Wagner, G.M. 1999. Coral reefs: importance, threats, conservation and restoration. *In* Howell, K.M. and Semesi, A.K. (eds.), Coastal Resources of Bagamoyo District, Tanzania. Proceedings of a Workshop on Coastal Resources of Bagamoyo, 18-19 December 1997, Bagamoyo. Faculty of Science, University of Dar es Salaam: 27-32.

Aim of study: Review the importance of coral reefs, the existing threat and give suggestions for conservation and restoration.

Area of study: Tanzania coastal waters.

Methods: Personal observations and review of existing literature.

Results and recommendations: Coral reefs are very important, both ecologically and socio-economically. Although there have always been some natural threats to reefs (e.g., storms and the predacious Crown-of-Thorns starfish), in recent decades, reefs have been degraded at an alarming rate by various human threats. Man causes many types of pollution due to industrial, institutional, and domestic discharge; agro-chemical pollutants; and sedimentation brought about by deforestation, poor agricultural practices, and construction activities; all of which can be detrimental to the health of corals when carried by seawater to the reefs. Other threats include coral mining, uncontrolled tourism and fisheries activities. The most destructive human activities are due to fisheries, particularly, dynamite fishing. This practice causes great loss of habitat and reduces the diversity and abundance of marine life. The improper use of seine nets and basket traps is also harmful. Careless octopus fishing and shellfish collection cause breakage of coral colonies. Overfishing and capture of juveniles result in the depletion of fish stocks, particularly in nearshore waters, and a disturbance of the natural balance of reef ecosystems. All of these trends contribute towards the degradation of coral reef ecosystems. Boat grounding and anchoring also cause considerable damage.

The consequences of coral reef degradation include loss of valuable natural habitat, reduction in the diversity and abundance of marine organisms (many of which are of great commercial value). Others were loss of the aesthetic value of coral reefs as a tourist attraction (and thus loss of income and employment), and weakening of the natural role which reefs play as protectors

against coastal erosion. Severely degraded reefs take many decades to recover and some reefs never return to their original state.

Control of various types of pollution, the elimination of destructive and excessive fishing practices, proper management of tourism, and the elimination of coral mining are some of the measures which must be taken for the protection and conservation of coral reefs.

Conclusion: For severely degraded reefs, mere protection is insufficient. Deliberate human intervention is required in order to accelerate and ensure the recovery of coral reef ecosystems. The removal of sediments and rubble is one simple method of intervention. Another method is the transplantation of coral fragments, whereby, fragments are broken from healthy colonies and attached to a suitable substrate using cement or glue. Moreover, artificial substrates or reef structures can serve as fish sheltering devices and can also enhance coral larval settlement. Such methods can potentially greatly improve the recovery of degraded coral reef ecosystems.

Wagner, G.M., Mgaya, Y.D., Akwilapo, F.D., Ngowo, R.G., Sekadende, B.C., Allen, A., Price, N., Zollet, E.A., and Mackentley, N. 1999. An on-going project on restoration of coral reef and mangrove ecosystems by the local communities at Kunduchi and Mbweni, Dar es Salaam. *In* Proceedings of the Conference on Advances in Marine Sciences in Tanzania, 28 June - 1 July 1999, Zanzibar, Tanzania. Institute of Marine Sciences, Zanzibar (in press).
[39]

Aim of study: In recent decades, the diverse ecosystems along the Dar-es-Salaam coast, i.e., coral reefs, beautiful reef-fringed islands, seagrass beds, mangrove forests, estuaries and attractive sandy beaches, have become partially to severely degraded by various human activities. In badly degraded ecosystems, mere protective measures are insufficient. Active restoration is required in order to return such ecosystems to their original state in a reasonable length of time and to restore species composition.

An on-going project has been underway along the coast north of Dar es Salaam which has included several elements: socio-economic analyses, community participation, baseline studies, application of already known techniques in tangible restoration work, and monitoring of restored areas in comparison with control areas.

Participatory rural appraisal (PRA) and standardized interviews undertaken in Kunduchi Fishing Village and Mbweni Village showed that these communities have low education levels, poor infrastructure, and low incomes and are largely dependent on natural resources, particularly through fisheries and agriculture. Environmental problems, their causes, and solutions were also identified.

Area of study: A baseline study was conducted on the fringing coral reef around Mbudya Island, just offshore from Kunduchi.

Methods: The snorkelling visual census technique was used along eight 80-m transects on each side of the Island. There was significantly more hard coral cover on the landward side than the seaward side, but significantly more soft coral, seagrass, and algae on the seaward side. The fact that there was substantial area with no biocover (15-40%) was attributed to dynamite fishing and wave action. Of the hard coral cover, 40-60% was dead which was thought to be mainly due to coral bleaching (Figure 3.7). The live coral included 29 genera representing 11 families. Fish were generally more abundant on the landward side (Figure 3.1), while invertebrate groups showed varying results.

A preliminary trial was conducted on participatory restoration of the coral reef at Mbudya Island. Fishermen were involved in transplanting corals in dynamite blasted sites. Coral fragments from nearby healthy colonies were inserted into cement-filled, disposable plastic plates placed in the damaged areas. Approximately, 500 fragments of *Glaxea* sp., *Acropora* sp., *Porites* sp., *and Montipora* sp. were transplanted in 7 dynamited sites.

Monitoring was later carried out in the restored sites. Approximately 3 months after transplanting, 342 coral fragments could be located and their survival rates/health was status recorded.

Results: *Galaxea* sp. showed very significantly greater survival (100% complete survival) than *Porites* sp. (55.7% complete survival, 13.9% partial survival) ($\chi^2 = 37.010$, $p < 0.001$), but there was no significant difference between *Acropora* sp. and *Montipora* sp. survival ($\chi^2 = 2.200$, $0.50 > p > 0.25$). There was significantly greater survival in dynamited sites located at depths greater than 1 m (during low tide) than in shallow sites ($\chi^2 = 41.024$, $p < 0.001$). After another 5 months (i.e., 8 months after transplanting), survival rates were nearly the same. Heights of coral fragments of all species had increased significantly except for *Acropora* sp. whose slight increase was not statistically significant.

This paper also reported activities in the mangrove forest at Mbweni Village, including baseline studies, replanting trials involving the participation of the community, and monitoring of the replanted areas. However, since these aspects are outside the theme of these summaries, the results are not included here.

The potential for ecotourism in the area was also investigated. Tourists and residents of beach hotels in Kunduchi were interviewed, of whom, 92% said they would be interested in sailing to Mbudya on a traditional dhow with local fishermen and 15% would be interested in watching and/or learning coral transplantation. Of the villagers interviewed, 100% in Mbweni and most of those in Kunduchi said they were interested in participating in ecotourism.

Conclusions: The restoration work should be combined with ecotourism, whereby members of the communities receive payment from tourists for guided tours to coral reef and mangrove ecosystems while they carry on the restoration activities. It was also recommended that future projects/programmes in the region should combine involvement of local communities in the application of already developed restoration techniques, citizen monitoring of the success of the restoration activities, and research into improving techniques.

Permanent plots (10 m X 10 m) were established in which various environmental factors and the density and girth at breast height of all mangrove species were recorded. The density of macrofauna was also determined by sampling 0.25 m X 0.25 m quadrats. One site near Mbweni Village, which had previously been dominated by Rhizophora mucronata, has been heavily cut for firewood and building poles in recent years and is now dominated by *Ceriops tagal* seedlings and saplings. Another site which had been clear-cut a few years ago to build a hotel, which never materialized, is still almost barren, though there was some natural regeneration of *C. tagal* and *Avicennia marina*

MANGROVES

Jude P. Shunula
University of Dar es Salaam, Instutute of Marine Sciences, P.O.Box 668, Zanzibar

Banyikwa, F.F. and A.K. Semesi, 1986: Endangered mangrove ecosystems: The case of the Kunduchi and Mbweni mangrove forests. In (J.R. Mainoya and P.R. Siegel, eds*.) Proceedings of the Workshop on "Save the Mangrove Ecosystem in Tanzania"*.21-22 February, 1986. Faculty of Science, University of Dar es Salaam, 103-132.

Aim of study: The paper discussed on the status of mangroves of Kunduchi and Mbweni, and suggested recommendations that would provide a basis for their rational utilization.

Area of study: **Kunduchi fishing village is located approximately 20km north of Dar es Salaam while the fishing village of Mbweni is located 30 km north of Dar es Salaam.**

Methods: Real photographs were used to evaluate vegetation cover and extent of the mangroves. Two sets of photographs (1963 and 1981) were used for Kunduchi and one set for Mbweni (1981). The sketches of the two photographs were shown in a figure. Quantitative data of the mangrove vegetation at Kunduchi and Mbweni were collected using the point-centred quarter method (Cottam and Curtis, 1956). Since this technique has limitations when evaluating shrubby vegetation, all the sites visited were described qualitatively and the important species noted. At Kunduchi mangrove vegetation area, data were collected along three transects. At Mbweni mangrove vegetation site, data were also collected along three transects and then pooled together for analysis.

Results: A general description of the mangroves at Kunduchi and those of Mbweni were made. It was noted that the vegetation at Mbweni was by far better developed and more protected than that at Kunduchi. At Mbweni, Saltworks had not been established like the case with Kunduchi to such an extent that big areas had to be cleared.

Banyikwa, F.F. 1986: The Geographical Distribution of Mangrove Forests along the East African Coast. In (J.R. Mainoya and P.R. Siegel, eds*.) Proceedings of a Workshop on "Save the Mangrove Ecosystem in Tanzania*. 21-22 February 1986. Faculty of Science, University of Dar es Salaam, pp. 5-13.

Aim of study: The purpose of this article was to give an overview of mangrove forests and their distribution along the East African Coast. The trees forming the mangrove forests of the East African coast (Kenya and Tanzania) were described to consist of nine species belonging to six families.

Area of study: The mangrove vegetation occurring in East Africa was described in detail and examples were given for Tanga and the Rufiji delta.

Results: The geographical distribution of mangroves in Tanzania was described in detail. In Tanzania, mangroves were described to occur along the whole coastline from Tanga to Mtwara covering an area of 79,937 hectares. Mangrove forests were also well represented on the coasts of the main islands of Zanzibar (6,000 ha), Pemba (12,000 ha) and Mafia. Along the coast of Tanzania, mangrove forests occurred in coastal shores, on deltas, river estuaries, creeks etc. where a good combination of soil, and saline water converge in the right proportions suitable for

their establishment and growth. The degree of exposure to strong winds was also considered to govern their establishment.

It was stated that the largest continuous mangrove areas along the coast of Tanzania were to be found in the littoral zone of the coasts of Tanga district, the delta of the Rufiji river, in Kilwa, Lindi and in Mtwara where the Ruvuma river forms an estuary close to Mozambique. However, no figures were given for the specific forest areas.

Chale, F.M.M., 1993: Degradation of mangrove leaf litter under aerobic conditions. *Hydrobiologia*, 257(3): 177-183.

Aim of study: The main purpose of this investigation was to study leaf litter degradation of one mangrove species. Degradation of *Aviccennia marina* (Forsk) Vierh. Leaf litter was studied in the laboratory for three months.

Methods: The leaves were incubated in filtered estuarine water in erlenmeyer flasks for various number of days and the amounts of N, P and K super (+) remaining in the leaves determined.

Results: Weight loss was rapid within the first 24 hours (19%), but slowed down thereafter reaching 30% after six weeks. While P and K super (+) decreased with time, N decreased initially, then increased rapidly after six weeks. Leaching and microbial activities could be responsible for the nutrient changes. The increase in N may indicate that mangrove leaf litter provides the surface for microbial N synthesis and acts as a reservoir for N.

Francis, J., 1992: Physical processes in the Rufiji Delta and their possible implications on the mangrove ecosystem. *Hydrobiologia*, 247 (1-3): 1-10.

Aim of study: This paper was mainly based on studying the physical processes such as coastal currents, estuarine circulation and monsoon winds prevailing in the Rufiji delta located in the Southern Tanzania approximately in a N-S direction.

Area of study: Rufiji delta, which is the largest delta in east Africa containing the largest estuarine mangrove forest in the eastern part of the continent. The area covered is approximately 1022 km^2. The north-south extent of the delta is about 65 km and extends about 23-km inland.

Methods: The author observed the relationship between these processes and the occurrence of long-term trapping of the river discharge and the outflow of waters from the mangrove swamps into the nearshore zone. Salinity and conductivity of water were measured using salinometer and a WPA cm 35 conductivity metre respectively in two stations. Suspended sediment concentration was measured by using the Pertech Suspended Matter Monitor. Measurements were taken during ebb tide when there was maximum sediment concentration.

Results: It was observed that salinity values for surface waters were found to fluctuate slightly at tidal frequencies, being relatively high during flood tide and low during the ebb tide period. Measurements on the trapped waters in the near-shore zone showed a significant reduction in the mixing between the estuarine and offshore waters, leading to the two waters having distinctive properties. The trapping phenomenon is discussed in the light of its possible implications on the ecology of mangrove ecosystems. Trapping may explain the enhanced growth of the mangrove in the delta compared to other areas. The author mentioned that, this trapping effect may be providing more time for nutrient retention in the mangrove zone, incorporation of the decomposed leaf litter and fine sediments in the substrate, and settling of fruits and seedlings in

the swamps, thereby enhancing the regeneration of the mangrove. A setellite image and aerial photograph were used to interpret some information on the trapping effect in the near-shore waters off the delta.

Griffith, A.L., 1949: Reconnaissance on the forest problems of the Zanzibar protectorate. *Published by the government of Zanzibar*, Tanzania, 50p.

Aim of study: The objective of the report was to draw attention to the main forest problems and to obtain the views of the local administration thereon.

Area of study: Zanzibar.

Results: This was a general report based on a six-month survey. The report gave a description of the various areas, which were surveyed on both Pemba and Unguja Island. Also given is the background information on the climate, soil types and rainfall characteristics. The report gave fairly detailed descriptions of the various mangrove stands, with estimates of the areas covered by individual mangrove species. Described areas included Chwaka (Mapopwe creek; charawe; Ukongoroni; Kinani) also at Muungoni; Unguja Ukuu; kiwani; Kisakasaka, Makoba and Mwanda. In general the 48-page report available at the National archives in Zanzibar, described in fairly good details almost all the important mangrove stands in Pemba and Unguja.

Griffith, A.L., 1950: *Working scheme for the mangroves of Zanzibar Protectorate*. Published by the government of Zanzibar, Tanzania, 42p.

Aim of study: In this 42 page book, the author gives a summary of the facts on which the proposed working scheme are based and then gives details of the proposal for future management.

Area of study: Zanzibar.

Results: The report states that the mangroves of the Islands were divided into two working circles; the Zanzibar (Unguja) and Pemba working circles. The Pemba working circle was further divided into; the Northen District Felling series and the Southern District felling series. These divisions were based on the fact that mangroves in Northen Pemba grew faster than those in the south, which had a similar growth rate to those of Unguja. The author pointed out even at this time that the mangroves of the Island had been heavily, wastefully and ruthlessly exploited during the previous ten years, mainly for sustaining the mangrove bark export to America and Europe.

Jiddawi, N.S., J.P. Shunula and Z. Ngazy, 1999: Mangroves and associated fishery resources in the socio-economic setting of Kisakasaka village, Zanzibar. *Proceedings of the 20th anniversary of Institute of Marine Sciences.* 28 June - 1 July 1999, Zanzibar, Tanzania (In press).

Aim of study: Socio-economic setting of Kisakasaka village.

Area of study: Kisakasaka village in Zanzibar.

Methods: This socio-economic study was conducted between March 1998 and May 1999. It involved individual interviews, group discussions and participatory activities. The respondents formed 70% of the total village population of 200 families.

Results: The results which include the history of the village, the wealth grouping, preference of activities between men and women, poor and rich, give interesting indications of the groups whose activities tend to be destructive to the natural resources. These groups include the poor and landless who are always on the hunt for basic essentials for maintaining life. The immigrants and indigenous inhabitants are also potrayed having different impacts on the natural resources of the area. The solutions for reducing the wasteful use of the resources, as perceived by the villagers are highlighted. A map showing the study site and the (village) administrative demarcations of the mangrove resource is given.

Machiwa, J.F. and R.O. Hallberg, 1995: Flora and Crabs in a Mangrove Forest Partly Distorted by Human Activities, Zanzibar. *Ambio,* 24 (7-8): 492-496.

Aim of study: In this paper, the author presents a preliminary study on flora and fauna in Maruhubi area, a partly distorted mangrove ecosystem.

Area of study: Zanzibar.

Methods: Mangrove plants of different sizes were counted. A total of 18 belt transects were running perpendicular to the shoreline were selected for the entire forest. On each transect, several quadrants of 10-m x 10mm were constructed by using a rope and pegs. A hand magnetic compass was used for determining the direction of transects. Mangrove crabs and snails that permanently inhabit the forest were recorded during vegetation study. The crabs were randomly sampled using a 1 m^2 or 0.25 m^2 quadrant.

Results: The author pointed out that zonation of mangrove flora in the forest is clearly displayed by two dominant species, *Avicennia marina* and *Sonneratia alba*. *A. marina* forms an almost pure stand at the terrestrial edge of the forest. However, the species is ubiquitous in the area. *S. alba* almost exclusively occupies the marine fringe of the forest. The grapsid crabs occupy the terestrial edge of the mangrove area, which has a well-consolidated substrate. The ocypodid crabs, on the other hand, occur in mixed associations in sandy/muddy locations, mainly free of dense cover of mangrove trees and also in swampy open areas. The ocypodids are occasionally seen in areas with sandy bottoms at the edge of the terrestrial fringe mangroves. The mollusk *Cerithidea decollata* is ubiquitous in the *A. marina* zone, whereas in the marine-fringe and the shoreline-zone mangroves several other species of mollusks are represented. A conceptualized model for organic-carbon flux in the ecosystem is proposed based on distribution of mangrove flora and litter as well as grapsid crabs.

Machiwa, J.F., 1998: Distribution and Remineralization of Organic Carbon in Sediments of a Mangrove Stand Partly Contaminated with Sewage Waste. *Ambio,* 27 (8) 740-744.

Aim of study: This paper looked entirely on distribution and remineralization of organic carbon in sediments at Maruhubi mangrove stand Zanzibar, Tanzania. However, the author went into describing the mangroves in the area dividing them into sub-ecological zones to fit his study.

Area of study: Zanzibar

Methods: Forest productivity was estimated in terms of litter fall.

Results: He mentioned areas of mono-specific stands of *Sonneratia alba* and *Avicenia marina* as the marine and terrestrial zones respectively. Other zones included the land ward zone mainly with *A. marina* and *Ceriops tagal*, and sewage disposal &without sewage exposure. Sampling

stations are shown in appendix 18; figure 1. It was learnt that, the distribution of organic carbon in the surface soil of the mangrove forest generally shows a seaward decrease in concentration. Litter fall was highest in the terrestrial zone and lowest in the marine zone and the order of decrease in litter standing stock were in the order; Landward extending > Shoreline > Terrestrial > Marine.

Julius, A., 1998: A study on the microbial population and the decomposition of leaf litter in the mangrove ecosystem along the Dar es Salaam coast. MSc. Thesis, University of Dar es Salaam. 122p.

Aim of study: This thesis was entirely based at determining the rate of decomposition of different species of mangrove leaves found at Mtoni mangrove swamps in Dar es Salaam. Other objectives were to determine the macroalgae composition in the mangrove sediment and establish the distribution pattern of the microalgae in the mangrove sediments.

Area of study: Mtoni, Dar es Salaam.

Methods: Estimate were carried out for the amounts of methane and sulphide production and in-situ methane production from both continuous culture (fermentor) and batch cultures using mangrove leaf litter and other soluble materials as substrates.

Results: The thesis started by giving a broad description on the extent of the Tanzanian coastline from southern boarder of Kenya to the Southern boarder with Mozambique. Then she talked on area of mangrove coverage in Tanzania with reference to the previous work such as that of Semesi (1991) and those of Zanzibar Island. Six families and eight species of mangroves and their importance were discussed. The general characteristics and position of the study site (Mtoni, Dar es Salaam) was described in detail including the common species of mangroves present in the area. Thereafter the author went on telling about mangrove ecosystem and its constituents (organic matter, bacteria, sediments and other microbes). The process of leaf litter decomposition in a mangrove swamps was also reviewed in detail. Moreover, a broad description on the mangrove fauna (crabs, oysters, barnacles etc) was given. Litter bags were used for determining leaf litter decomposition of three mangrove species viz; Rhizophora mucronata, Avicernia marina and Sonneratia alba as described by Cundell, et al (1979), based on the probable number of bacteria present in the detritus material using the method described by ALPHA (1989). The rate of methane production was studied both in the field and *in vitro*. In the laboratory, batch and continuous (fermentors) cultures were carried out. In the field methane production from the mangrove sediments sediment was determined by static chamber techniques were used as described by Solomayor et al, (1994).

It was found that mangrove leaf litter was not good substrate for methane production (concentration of 1.5 or 2 gms of leaf litter inhibited methanogenesis in batch cultures. However, *in situ* value methane production was found to be variable along the mangrovearea. Higher values were measured in the middle part of the mangrove where Avicennia was dominant and decreased landward and also toward the sea. Mangrove sediments were found to produce limited quantities of methane and large amounts of sulphide varyingwithin the mangrove areas. Under batch cultures methane production using mangrove litter was affected by high concentration of leaf litter for all the three mangrove species tested. There was a low production of methane with increasing amounts of leaf litter. Microalgae composition in the mangrove sediments is shown in Appendix B_6, Table 3.9. Bacterial colonization was found to be higher in litterbags placed outside their respective mother trees than those placed under the trees.

The author observed that, the rate of leaf decomposition studied *in situ* using litter bag method had rapid loss in weight found to occur in the early days of incubation but slowed down with time. Difference in decomposition rates was observed among the three studied species of mangrove, being higher for *Sonneratia alba* followed by *Avicenia marina* and *Rhizophora mucronata* the least. It was also learnt that the presence of large populations of macro-invertebrates and microbial population facilitated the rate of leaf litter decomposition in the mangrove sediment. Moreover, it was further learnt that degradation and productivity in mangroves was influenced by many factors including the varying biological diversity and activities. The thesis also looked at the associated flora in the mangrove forest, and it was found that mangroves towards the sea had higher biomass of algae than the land ward mangroves and in tidal pools. Micro-algae species diversity in the mangrove sediment was found to be lower as compared to the open waters where hundreds of species have been reported. The author ended by putting emphasis on good management of mangroves, as they are important productive systems that support estuarine food webs and commercial fisheries. There is a need for the government to implement mangrove management policy and educating the general society on the importance of mangrove ecosystems.

Kangwe, J.W., 1994 (manusript). Some Ecological Parameters Affecting the Distribution and Abundance of *Terebralia palustris* and *Terebralia sulcata* in the Coastal Mangrove Forests at Kunduchi Dar es Saalam. BSc. student project, Department of Zoology and Marine Biology, University of Dar es Salaam, 15p.

Aim of study: The manuscript was entirely based on the distribution of the two common species of gastropods in three sites (namely; muddy, sandy/muddy and sandy) and the associated factors within the mangrove forest at Kunduchi in Dar es Salaam.

Area of study: Kunduchi, Dar es Salaam.

Results: The author gave a detailed description on species composition of mangroves at different zones in the area by doing a general survey by walking in the area identifying species and their coverage. Thus, mangrove species present in the area, vegetation coverage and zonation. He described six species found in the area and the way they are distributed. It was also learnt by the author that the mangroves at Kunduchi were not clearly distributed into defined zones. The author found that the two species of gastropods were more abundant in muddy areas dominated by *Sonneratia alba* a species in the outer margin above the low water level, followed by *Rhizophora mucronata*. Few species of gastropods were found on moving inland where *Ceriops tagal* zone was found.

Ludo Koenders, 1992: *Flora of Pemba Island*. A checklist of plant species. Wildlife Conservation of Tanzania. Publication No. 2: 104p.

Aim of study: In Arab literature, Pemba is described as the green Island (Jezirat al Khuthra). It is indeed rich in both wild and cultivated plants. The author of this 102-page book presents a database for the names of over a thousand plants in Pemba, including mangrove trees.

Results: The details of the list given presents among other things a genus -family list useful in many ways to any level of botanical understanding. The author also gives a local Swahili list of the plants described together with occasional remarks on the medicinal uses of some of the plants. The book has a map of Pemba's Ngezi forest deemed the area with the richest flora.

Machumu, E.M., 1996 (manusript): Comparison between mangrove stands at Mtoni Kijich and Kunduchi creeks. BSc. student project, Department of Zoology and Marine Biology, University of Dar es Salaam, 23p.

Aim of study: To compare the abundance of mangrove species in the mangrove stands at two sites; Mtoni Kijichi and Kunduchi creeks and also to identify and compare the abundance of benthic organisms (infauna and epifauna) in the two mangrove stands including studying environmental factors prevailing in the area.

Area of study: Two study sites were chosen for comparison purposes, Mtoni Kijichi andKunduchi. Mtoni Kijichi is a shallow creek situated at Mbagala suburbs, south of Dar es Salaam.

Results: Five mangrove species were found in both sides of the creek. The Kunduchi creek is a small tidal water body opening into the Indian ocean located about 18 km north of Dar es Salaam city.The mangrove forest at Kunduchi is confined to the estuarine mudflats and the sand banks inside the creek. Six mangrove species were found in the area. To compare aboundance of mangrove species in each study site, a sampling area of 1500 m^2 was marked off. Six random sampling points were selected using a random number table. A 10-m x 10-m area was examined for mangrove species by counting separately the number of mature and intermediates for each species. Other small quadrats were established to quantify the number of benthic organisms and laboratory procedures were followed for identification of organisms and other analysis.

It was learnt by the author that there was no significance difference in density of mangrove plants between sites for any of the age categories. The author found a significant difference in density of crustaceans between Mtoni kijichi and Kunduchi. The author concluded by mentioning that, some of the environmnental factors studied in the two sites (e.g organic matter content) were responsible for the differences in abundance of the benthic macroorganisms.

Mahongo, S.B. 1994. The coastal profile of Mafia Island: Tanzania. Report Commissioned by the National Environment Management Council.

Aim of study: A profile of Mafia Island was compiled which included information on many aspects of the Island such as the physical environment, the Island's natural resources, and the population of the Island and socioeconomic activities, among other things. This profile provided detailed information about Mafia Island just prior to its designation and protection as a Marine Park. A large portion of this report was outlined in the literature search summary on coral reefs/fisheries, so for this summary is on mangroves only.

Area of study: Mafia Island.

Results: The mangroves of Mafia Island were surveyed during the Semesi (1991) study, and area covered by mangroves was estimated to be 3,472.9 ha. It was stated in this report that several regions were not included in the Semesi (1991) inventory (the Chole Bay area, which includes several small islands), and so the actual area covered by mangroves was greater than the Semesi (1991) estimate for Mafia Island. It had been determined that the Mafia Island mangroves were utilized on a sustainable basis, and that regeneration was good at most sites.

Mainoya, J. R., 1986: Uses of Mangroves and their Products by the Local Community in Tanzania. In (J.R. Mainoya and P.R. Siegel, eds.) *Proceedings of a Workshop on "Save the Mangrove Ecosystem in Tanzania".* 21-22 February, 1986. Faculty of Science, University of Dar es Salaam, pp. 37-48.

Aim of study: The paper discussed on the uses of mangroves by the local community in Tanzania, which included poles, tannin extraction, charcoal, fuel wood and timber.

Area of study: Tanzania coastal area.

Results: It was reported that mangrove ecosystems were moderately represented on the Tanzania Mainland coast, as well as on the Islands of Zanzibar and Pemba. On the Mainland, large mangrove stands generally tended to be found at the mouths of rivers such as Ruvuma, Rufiji and Wami. The largest mangrove ecosystem in Tanzania was on the Rufiji delta, where it covered an area of about 50,000 ha.

Traditionally, mangrove ecosystems had played important role for rural populations who had exploited mangrove trees for building poles, firewood and charcoal without causing damage to the forests. Commercial and traditional products taken from the mangrove ecosystems were reported to range from construction materials to medicines. The paper also gave figures of the number and value of mangrove poles used locally and exported from Tanzania from 1950 up to 1967 and the mangrove bark (for tannin extraction) exported from Tanzania between the period 1923 to 1967.

It was recommended in this paper that all unjustifiable activities should be halted to prevent further destruction of mangroves. Resource planners should also view mangroves as an integral part of the coastal zone rather than as an ecosystem surviving in isolation. The Tanzanian government should ensure that adequate records were kept on the harvest and marketing of the mangrove products.

Mbwana, S.B. 1986: Mangrove Conservation and Utilization in Tanzania. In (J.R. Mainoya, and P.R. Siegel, eds.) *Proceedings of a Workshop on "Save the Mangrove Ecosystem in Tanzania".* 21-22 February, 1986. Faculty of Science, University of Dar es Salaam, pp. 49-58.

Aim of study: This paper explained the conservation policy and utilization of the Tanzanian mangroves. It highlighted various conservation problems, the role of the mangrove in the country's economy, and gave suggestions on what should be done to improve the management of this vital resource.

Results: It was stated in this paper that, of the 44.4 million hectares classified as forests on the Tanzania Mainland, the mangroves occupied less than 1%. The distribution for each district and region was given, and the total for the Mainland was 79,037 hectares.

The paper mentioned that the Forest Policy, which was then being revised, was the main basis for all forest conservation and management in the country, supported by the Forest Ordinance. The objectives of the policy were summarized, and part of the law pertaining to the protection of mangroves and other Forest Reserves was also presented.

Until the time of this study, no management plan was in place neither an inventory had been conducted. Harvesting was reported to be unsystematic resulting in over exploitation in some

areas and under exploitation in others. Mangrove species were used to produce poles, bark, timber, firewood and railroad. Some of the important felling and collection depots for poles and bark were Simbaulanga, Dima, Urange, Utikiti, Muhoro, Salale and Kikale in the Rufiji delta. Others were Bagamoyo, Pangani, Lindi and Kilwa Masoko.

Uncontrolled harvesting, encroachment and salt making were some of the factors cited that threatened the survival of the mangrove ecosystem. Some areas in Rufiji were being encroached for farmland particularly growing of rice in areas of freshwater. On salt making, the main areas that this activity had intensified were Tanga, Mtwara, Lindi and Coast regions.

McCusker, A., 1971: Ecological Studies of an area of Mangrove vegetation in Tanzania. PhD thesis, University of Dar es Salaam, 211p.

Aim of study: This study was based on the mangrove vegetation surrounding a tidal creek at Kunduchi, 18 Km north of Dar es Salaam.

Area of study: Kunduchi, Dar es Salaam.

Results: The thesis started by discussing the extent (coverage) of the Tanzania coastal line running from north to south. The author went into describing the Kunduchi creek and its mangrove vegetation dividing them into species and their distribution in the area in relation to the soil properties such as texture, colour, aeration, chloride content etc. She further did analysis of cell sap of mangrove leaves by collecting samples for extraction of sap (using sap extractor), analysis of sap and analysis of the sap results. Regeneration of mangroves based on reproductive mechanisms, flowering cycles, regeneration in undisturbed and disturbed communities was covered. It was found that regeneration after clearing was studied in three sample areas and usually favours the establishment of *Ceriops tagal*, especially where no adult plants are left standing. It was also learnt by the author *that Rhizophora mucronata* regenerates very rapidly

marine coastal resources exploitation and management and hence need for inventory and assessment.

Area of study: The study areas were Unguja-Ukuu, Kisakasaka, Chwaka and Muwanda in Unguja Island. In Pemba Island the areas were Micheweni, Chakechake and Wete.

Methods: Information collected at each site included a list of mangrove species, mangroves cut in sample plots of 5 x 5m, percentage cover by species, diameters and average lengths of randomly sampled poles, and the fauna associated with the mangroves. The fish species composition from the artisanal fishery was obtained by identification at landing sites and calculation of the percentage composition of species for each fishery according to the type of gear used.

Results: Results showed that about two thirds of mangrove forest stands on Zanzibar were located in Pemba Island and the remaining one third in Unguja Island. The various local use of mangrove species were enumerated in a table. The most destructive of the activities was firewood and charcoal production. Other destructive uses were salt production by boiling seawater, pole production, leather tanning, making of fixed traps for fishing and production of local medicines.

Three fishery types (based on gear type) were found to be associated with the mangroves and adjacent habitats. They included fixed stake traps, movable stake traps and hand line fisheries. A comparison of trap fishery landings at three stations indicated that more fish were caught from mangrove lined areas than elsewhere.

Salim, M.M. and Johnstone, R.W., 1995: Spartial and Temporal Variations in Water Column Nutrient Concentrations in a Tidally Dominated Mangrove Creek: Chwaka bay, Zanzibar. *Ambio*, 24 (7-8): 482-486.

Aim of study: The aim of this paper was to look at the variations of the dissolved inorganic Nutrients in the Mapopwe creek at Chwaka bay by the method described by Parsons et al., (1984).

Area of study: Chwaka bay, Zanzibar.

Results: The author gave a short description on area covered by mangroves in the bay (300 ha). He further gave a list of the seven species found in this forest. Photographs showing mangrove trees in the area were provided. It was learnt by the author that the Mapopwe creek had a elevated nutrient levels similar to that observed in mangrove swamps receiving a significant amount of groundwater input.

Semesi, A.K., 1986: Zonation and Vegetation Structure of Mangrove Communities in Tanzania. In (J.R. Mainoya and P.R. Siegel, eds*.) Proceedings of a Workshop on "Save the Mangrove Ecosystem in Tanzania".* 21-22 February, 1986. Faculty of Science, University of Dar es Salaam, pp. 15-36.

Aim of study: The main purpose of this paper was to examine current information about the structure and ecology of Tanzanian mangroves.

Area of study: Tanzania coast.

Results: The main species found in Tanzania were described in terms of their distribution and ecological features. The species (nine of them) were: *Ceriops tagal, Bruguiera gymnorrhiza, Rhizophora mucronata, Sonneratia alba, Avicennia marina, Lumnitzera racemora, Xylocarpus granatum* and *Xylocarpus moluccensis.*

Mangrove communities were also described on their adaptations to the environment, zonation, attributes of substrate and their forest structure (fringe, basin, riverine, overwash and dwarf). In Tanzania, all the four types of forests were observed. References were made for the Rufiji, Tanga, Kunduchi and Mbweni mangrove forests. A vegetation map of Kunduchi mangrove swamp after McCusker (1971) was given.

Conclusion: It was noted in this paper that the extent of exploitation as seen at Kunduchi and Mtoni, posed a threat of degradation and possible extinction of the mangrove resources. During the period of writing of this paper, it was revealed that a survey of the satellite imagery showed many small and big mangrove forests along the Tanzanian coast, which had not been studied. The studies that had already been conducted did not qualify for any sound mangrove utilization programme to be undertaken.

Semesi, A.K. 1988. Status and utilization of mangroves along the coast of Tanga, Tanzania. *In:* Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa. Proceedings of a workshop jointly organized by the University of Dar es Salaam and UNESCO/ROSTA. Dar es Salaam, Tanzania, January 18-20.

Aim of study: This is a study of the condition, extent, and exploitation of the mangroves in the Tanga region of Tanzania.

Area of study: Tanga coast.

Methods: In October of 1987, the mangroves along the Tanga coast from Boma Peninsula southward to Kipumbwi village were surveyed. Island mangroves were surveyed by boat, and ground surveys were conducted of the coastal mainland mangroves. Village interviews were also conducted to obtain information regarding status and utilization of mangroves. A map of mangrove distribution along the Tanga region coast was made.

Results: It was determined that all villages surveyed utilized mangroves, and that the rate of cutting had increased over the years. It was also determined that natural regeneration was sufficient in most places for the re-establishment of the forest, provided that the level of harvesting was regulated.

Conclusion: It appears that good baseline information has been collected on the mangrove ecosystems of Tanzania, and that detailed maps of the entire region can be obtained from the Tanzanian Ministry of Tourism, Natural Resources and Environment, Forest, and Beekeeping Division in Dar es Salaam (Semesi, 1991).

Semesi, A.K., 1991: Management Plan for the Mangrove Ecosystem of Mainland Tanzania. Vols. 1-10. Forestry and Beekeeping Division, Forestry Management Project, Dar es Salaam.

Aim of study: This book consists of two main parts. The "Mangrove Management Plan of Mainland Tanzania", and the "Mangrove Management Plan of (a coastal) District ".

Area of study: The coastal "districts" of Tanzania. Tanga and Muheza (1), Pangani (2), Bagamoyo (3), Dar es Salaam (4), Kisarawe (5), Mafia (6), Rufiji delta (7), Kilwa (8), Lindi (9), and Mtwara (10).

Results: The National Management Plan was prepared to ensure that a sustained yield management policy was implemented. This plan was prepared through extensive fieldwork in the mangroves and through aerial photography in 1989. A socio-economic study of coastal communities on how they used their mangrove environment was carried out. Discussions were also made with many individuals and organizations and finally, a workshop involving various stakeholders was conducted in order to arrive at a consensus on a future management policy.

The mangroves were then mapped into 30 map sheets depicting 10 administrative blocks (Appendix B6, Map sheets 1-30 showing the detailed forest types of mangroves in Tanzania) and this set of maps was complemented by a list showing the characteristics of each compartment (magnitude of forests and vegetation types). These were computerized for easy of information retrieval and update. The information provided by the map set and the computer system was reported to appear much more detailed than was available for any other mangrove forest in the world.

The mangroves in Tanzania were reported to occur along the coast and around many of the islands off the coast. According to the 1989 inventory, the mangroves of Mainland Tanzania covered a total area of about 115,500 ha. The largest area of mangroves was found in the Rufiji delta. Fairly large areas were also found in Tanga, Kilwa and at the estuaries of Ruvu, Wami, Pangani and Ruvuma rivers.

Eight common species of mangrove trees were observed to occur in Mainland Tanzania. The percentage composition of vegetation types of these mangrove forests was given and their uses were also described. Both natural factors and the un-regulated utilization threatened mangroves. Natural factors included river floods, sand deposition and the predicted sea level rise. Unregulated utilization of mangroves included production of salt (Tanga), production of lime (Bagamoyo, Lindi and Mtwara) and for drying of fish (Pangani). Others were demand for fuel wood and clearing for agriculture. Mangroves were also endangered by oil and industrial pollution, by excessive siltation due to man's degradation of catchment areas, by herbicides and insecticides coming from inland via rivers, and construction of dams or major irrigation schemes. Activities such as petroleum prospecting, oil pollution from ships, the damping of garbage and sewage and various types of industrial chemical pollution in the estuarine environment were also mentioned to have direct negative effects on mangroves.

In chapter II of this book, the management plan was described. The purpose of the plan was to identify a program with objectives and strategies in order to assist the government in its endeavor to rationally use and conserve the mangrove resources of Tanzania. For the purpose of management, mangroves were categorized into four zones for: total protection; production; recovery and rehabilitation, and; development.

Semesi, A.K. 1992. Developing management plans for the mangrove forest reserves of mainland Tanzania. *Hydrobiologia*. 247: 1-10.

Aim of study: The Forest and Bee-keeping Division in the Ministry of Natural Resources and Tourism is responsible for the management of the mangroves in Tanzania, although at the time of this report, management was not underway. As a step towards the conservation of the Tanzanian mangroves, the Forestry Division, with assistance from NORAD, conducted an assessment of the

state of all the mangrove reserves in Tanzania using aerial photography (photos were taken in 1988/89) and ground checks. The status of the mangroves with respect to area, distribution, and vegetation type were included, and mangrove fauna was catalogued.

Results: The area covered by mangrove vegetation was found to be 115,901 ha (this included bare saline areas, water bodies, and salt pans associated with the mangrove reserves). Table was made giving lists of mangrove area by district for Tanzania. The largest area of mangrove cover located was located in the Rufiji Delta. Some regions were mapped using a scale of 1:25,000, and others were mapped using a scale of 1:50,000. The maps were said to show stand density and height, vegetation types, and the area of each vegetation type. A map of the distribution of mangrove forests along the coast of mainland Tanzania was the only map included in this paper.

Common uses of mangroves in Tanzania were discussed, as were some of the problems associated with this use. Some social, economic and management issues were also reviewed with regard to mangrove ecosystems, and some of the problems encountered during management planning were listed. These problems included such issues as limited knowledge concerning ecological, botanical, and zoological matters, and the lack of laws and law enforcement.

Management strategies were reviewed along with the approaches to be used, and the participation of coastal people was identified as of 'paramount importance' for successful management of the mangrove resource (p. 8). Many different approaches were listed that would be used to seek participation of the local communities. The zoning of the mangrove forests according to various qualities and conditions was discussed as a management strategy, with four zones identified (p. 9). Zone I – All forests that will receive prime protection. Zone II – All ecologically stable areas with sufficient regeneration potential. They are considered productive forests suitable for controlled harvesting. Zone III – Degraded areas that will be closed for some time to allow for recovery and rehabilitation. Zone IV – Areas marked for development of different kinds. These zoning categories were selected with the idea of optimizing the direct and indirect uses of each mangrove forest. Semesi states on page 9 that the "survival of the mangrove forests in Tanzania is in doubt," and since she appears to be the authority on the subject, I would conclude that the mangrove destruction in Tanzania as of 1991 must have been significant.

Semesi, A. 1998. Mangrove Management and utilization in Eastern Africa. Ambio 27: 8. December, 1998.

Aim of study: The purpose of this paper was to discuss management issues, utilization, distribution, threats, and current condition of the mangroves in the Eastern African region. Current and future coastal management initiatives were mentioned, and management experiences from Tanzania, Kenya, and Mozambique were discussed.

Area of study: Eastern Africa coastal area.

Results: Mangrove distribution in Tanzania was described, and the mangrove area (ha) per region was listed in a Table 4. The mangrove system covering the largest area in Tanzania is located along the Rufiji Delta, with the forested area listed as covering 53,255 ha. It was mentioned that the coverage of mangrove in Tanzania was approximately double that of the mangrove coverage in Kenya, with a total coverage in Tanzania of 133,500 ha (115,500 ha on the mainland and 18,000 ha on Zanzibar). The information in Table came from the *Management Plan for the Mangrove Ecosystem of Mainland Tanzania*, written by Semesi in 1991. There are ten volumes to this Management Plan, and I have not seen them. They apparently include some very detailed

maps and can be obtained from the Tanzanian Ministry of Tourism, Natural Resources and Environment, Forest, and Bee-keeping Division in Dar es Salaam.

Some of the traditional uses of mangroves in Eastern Africa were discussed in this paper, and included the felling of trees for construction and firewood, and also the utilization of mangroves as inshore fishery habitat, where the collection of shellfish, prawns, and fish took place. Some plant products were also harvested in the mangroves. A list of the mangrove species present in Eastern Africa, along with the typical uses of each species was given in a Table.

Many destructive human activities were having significant detrimental effects on the mangroves of the Eastern African region. In some areas mangroves were overexploited for firewood and building materials, and clearance of mangroves for agriculture, Aquaculture, salt production, and development was a major problem in many urban areas. The conversion of mangrove stands for agriculture in the Rufiji Delta had not proven to be profitable over the long-term. Within seven years, crabs, grasses, and other invasive plants invaded the farms, and so farmers abandoned the land and moved to other sites. As an example of the extent of mangrove destruction, it was noted that 60% of the mangroves at Kunduchi in Tanzania had already been cleared. This, given the fact that all mangroves in Tanzania (and Kenya) were designated as Forest Reserves in 1928-1932.

Shrimp farming was discussed at length with regards to the three companies that had been given license to set up farms in Tanzania. Cencor Ltd. and Prawntan Ltd. were both designated to develop shrimp farms in the Ruvu mangroves (120 ha and 603 ha, respectively), and the African Fish Company (AFC) will develop in the Rufiji Delta, with 10,000 ha allocated. It appeared that there was a great deal of controversy over the proposed AFC shrimp farms. Some of the allocated land is located in Mafia Marine Park, and issues such as the lack of guidelines on Aquaculture in Tanzania, and the disregard for regulations at the time the land was allocated (among others) were listed as major concerns. Villagers, with the help of several environmental NGO's and academicians were working to ensure the development of the AFC project as it had been proposed.

The conflicting issues related to conservation and management of mangroves are not effectively being addressed at the present time in East Africa. Although a National Mangrove Management Plan was prepared for Tanzania (the first East African country to prepare such a Plan) in 1991, which emphasized the need to have close coordination among the various users of the mangrove ecosystem, the Plan has not been followed closely (p. 625). The concepts of this Management Plan have been useful with regards to other countries though, and awareness about the plight of the mangroves has been raised through the efforts involved. It was while this plan was being developed that the maps were constructed of all mangrove systems in Tanzania (Semesi, 1991), which has provided very good baseline information for the region.

This paper concludes with a discussion on the work currently in progress in other East African countries with regards to management of the mangroves, and general recommendations for mangrove ecosystem management.

Semesi, A.K., Y.D. Mgaya, M.H.S. Muruke, G. Msumi, J. Francis, M. Mtolera. 1998. Coastal Resource Utilization and Conservation Issues in Bagamayo, Tanzania. Ambio 27: 8. December, 1998.

Aim of study: The coastal resources and resource use of the Bagamayo District of Tanzania were studied through an interdisciplinary team in collaboration with personnel of the Natural

Resources Section in the Bagamayo District. The purpose of this study was to collect baseline information to assist with management efforts. Only the findings on mangrove resources are outline in this summary.

Results: The mangroves of Bagamoyo cover an area of 5,635 ha, and form a relatively continuous band along the coast from Saadani to the area near Kitame saltworks, and then from Ruvu River to Mpiji River. The mangroves are utilized locally for firewood, wood for charcoal making, and poles for the construction of houses. The mangrove wood is also sold as fuel wood and charcoal within the Bagamoyo District, and Zanzibar Island. Much of this trade is done illegally, and has resulted in overexploitation, which has contributed to the destruction of the mangroves.

Other sources of destruction to the Bagamoyo mangroves have been clearance for agriculture, salt production, and Aquaculture, and the digging of polychaete worms for fish bait. The most destructive activities were listed as clear cutting for the purpose of making charcoal and for salt production. Although a Management Plan for the mangroves of Tanzania was developed in 1991 (Semesi, 1991), no attempt has been made to implement any of these strategies in Bagamoyo. This paper concludes with discussions regarding the socioeconomic, and environmental problems that exist in the Bagamoyo District, and with recommendations for improvement of the poor conditions.

Shunula, J.P., 1990: A Survey on the Distribution and Status of Mangrove Forests in Zanzibar, Tanzania. *Zanzibar Environmental Study Series No. 5*. Commission for Lands and Environment, Zanzibar.

Aim of study: The purpose of this study was to assess the distribution and status of the mangrove forests of Zanzibar and Pemba Islands.

Area of study: Unguja and Pemba Islands.

Methods: The methodology employed analysis of soil type, mangrove use, associated fauna, extent of cutting and study on regeneration. Sampling areas were selected on the basis of the size of the mangrove stands and accessibility. Field studies were carried out in Unguja Island (Unguja-Ukuu and Uzi, Pete, Mwanda and Kisakasaka) and in Pemba (Micheweni, Wete Creek and Chakechake). Information collected earlier on the mangrove stand at Chwaka Bay was also included in this report.

Results: In Unguja Island at Unguja Ukuu and Uzi, the mangrove species found included the following: *Avicennia marina, Bruguiera gymnorhiza, Ceriops tagal, Lumnitzera racemosa, Rhizophora mucronata* and *Sonneratia alba*. The littoral distribution of these species was found to depend on the soil type. Cutting of mangrove trees for various purposes was seen to be rather intense. Regeneration was found to vary from place to place and between species. Mangroves were found to be used for charcoal, firewood, house construction, poles, boat building, dye making and leather tanning.

At Pete, the mangrove species were: *Cariops tagal, Avicennia marina, Xylocarpus granatum, Burguiera gymnorhiza, Sonneratia alba, Rhizophora mucronata* and *Lumnitzera racemosa*. Two major uses of mangrove use at Pete were house construction poles (and straps) and firewood. The Pete mangrove stand was found to be less intensively cut compared to the nearby Unguja Ukuu and Uzi stands. Regeneration was seen to be generally between poor and fair

The Mwanda mangrove stand consisted of *Heritiera littoraris, Lumnitzera racemosa, Avicennia marina, Ceriops tagal, Burguiera gymnorhiza, Rhizophora mucronata* and *Sorrenatia alba*. The mangroves were being used for firewood, ceiling boards, straps, boat building, house construction etc. Particularly intensive cutting of mangrove wood appeared to be in the *Avicennia marina* and *Ceriops tagal* zones. The degree of regeneration varied from very poor to fairly good.

At Kisakasaka, the mangrove species found were: *Heritiera littoraris, Lumnitzera racemosa Xylocarpus granatum, Avicennia marina, Ceriops tagal, Bruguiera gymnorrhiza, Rhizophora mucronata* and *Sonneratia alba.* The cutting of mangrove trees for various uses was seen to be quite considerable practised here, and the severely affected species included *Bruguiera gymnorhiza*. Regeneration was very variable, some places had good amount of regeneration and others very little.

Mangrove species found at Chwaka Bay were almost the same at Kisakasaha, except for the absence of *Lumnitzera racemosa* at Chwaka Bay. The major uses of mangrove wood in the Chwaka Bay area were in firewood both for general purposes and lime making, and poles for roofing. The cutting intensity appeared to be quite considerable especially for *Ceriops tagal* in Charawe area. Regeneration varied between poor to fair in Charawe and from fair to good in Michamvi.

In Pemba Island, The species found at Micheweni (Chaweni, Mtong'ombe, Kilindi and Jangwani) were: *Avicennia marina, Ceriops tagal, lumnitzera racemosa, Xylocarpus granatus, Xlocarpus molucensis, Heritiera littolaris, Bruguiera gymnoyrrhiza, Rhizophora mucromata* and *Sonneratia alba* (rare). The major use of mangrove wood at Micheweni was firewood, especially for lime making. Except in a few places, there appeared to be a low intensity of mangrove cutting. Regeneration was observed to be variable but generally fair. Some areas however were very poorly regenerating.

At Wete Creek (Uchozini, Limbani, Bogoa, Liafuu, Nyali and Makomani), the same species as those of Micheweni were observed, except for the absence of *Xylocarpus moluconsis* at Wete. The various species were locally being used for firewood, poles, boat building, medicine, dye making and tanning leather. Cutting was observed to be sporadic and localized while regeneration was found to vary between poor and fairly good.

Lastly at Chake-Chake (Tenga, Banda taka and Kwadobi) the mangrove species that were found in this stand were: *Sonneratia alba, Avicennia marina, Ceriops tagal, Lumnitzera racemosa, Rhizophora mucronata, Xylocarpus granatum* and *Heritiera littolaris.* It appeared from this survey that the major use of mangrove wood at Chake-chake were in house construction (poles) and in leather tanning. Cutting of mangrove trees was localized to small areas.

Shunula, J.P., 1996: Ecological studies on selected mangrove swamps in Zanzibar. PhD Thesis. University of Dar es Salaam, 270p.

Aim of study: The purpose of this thesis was to study and gather information on the ecology of mangroves in Zanzibar. Generally the study aimed at conducting a survey on the distribution and general status of the mangrove forests of Unguja and Pemba. Assessing the effects of human activities on mangrove forest structure and regeneration, studying the species composition of the mangrove vegetation at Chwaka bay and Maruhubi swamp. Studying the floral phenology of the dominant mangrove trees species at the two study sites. Evaluating quantitative and seasonal variations in litter production by the dominant species at the two study sites. Studying the leaf litter decomposition rate of selected species and determining C/N variations with time of

decomposition. Studying soil characteristics such as organic matter content, salinity and salinity at the Maruhubi site, and determining the extent of ultilization of mangrove products in Zanzibar.

Area of study: Zanzibar.

Results: The author gave a general survey listing mangrove species in both study sites and visual impression of the littoral distribution of the species. He classified all types of mangroves found from family to species levels (nine species identified) and their distribution in the study sites. Mangroves of Tanzania in general were described with reference to the previous works and went into listing mangrove species found in Zanzibar and Pemba and the potential commercial importance, floral phenology, regeneration of mangroves, factors governing their regeneration, seasonal variations in litter fall and decomposition. The ecological role of mangroves and direct uses were covered in detail. Threats to mangrove forests due to agricultural activities were explained.

Demographic studies based on height classes were carried out on *Avicennia marina* and *Sonneratia alba* at the Maruhubi mangrove stand, to show the size structure of the populations and to determine if generation was occurring. *A. marina* showed a considerable regeneration rate per plot while *S. alba* was poor. Phenology was strongly seasonal in *A. marina*. Litter trap data showed a seasonal trend in propagule shedding in *R. mucronata* and *B. gymnorrhiza*. Leaf litter production for these species was found to constitute 50-80% of the total litter production (including flower litter and propagule litter). Leaf decomposition rates were higher in *S. alba* and *A. marina* than in *R. mucronata* and *C. tagal*. Initial C:N ratios during decomposition were lower in *A. marina* and *S. alba* than in *C. tagal* and *B. gymnorrhiza*. Salinity between 10 and 25 ppt was found to have a positive effect on both root elongation and number in the seedlings of *A. marina*. The author ended by six recommendations for future research work.

Shunula, J.P. and Whittick, A., 1996: *The mangroves of Zanzibar*. Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania, 65p. ISBN 0-88901-308.

Aim of study: The purpose of this book was to provide a scientific account on aspects of the mangrove vegetation on Zanzibar island, which can be used by people at all, levels. The findings in this book were aimed at educating the common communities (including schoolchildren) who are not specialists with a detailed knowledge of botany and marine biology.

Results: The authors defined mangroves and their habitats, and then went further into their historical background and their uses in the past. Details on their distribution in the tropics and subtropics where the average temperature do not go below 19^{o}C and grow best in hot humid climates where the temperature fluctuations do not exceed 10^{o}C were given. Then the authors gave details on mangrove coverage in Zanzibar (total area 16,000 hectares) and their major ecological environmental and economic resource for tropical countries. The author went further giving details on the general characteristics of mangroves.

Ten species were found to occur on Zanzibar Island as listed on page 5 (Appendix G_1) of the book with their family name, species names and local Swahili names. Maps of Zanzibar (Unguja and Pemba islands) showing location of major mangrove forests were provided (Appendix G_2, Fig. 26). The use of different species of mangroves were also provided (Appendix G_3, Table 2). An identification key is provided for simple identification of species. The author went on describing each individual species morphologically and ecologically providing some diagrams of leaves and seeds structures for easy identification. Ways of adaptation of mangroves to the environment, leaf anatomy and morphology, root systems, water and salt relations of mangroves,

propagules and their dispersal were covered in detail by the authors. Factors governing the distribution and zonation of mangroves (such as soil types tidal, inudation, salinity and oxygen gradients) were given in detail. Biological factors such as competition between species were also given in detail. Other plants associated with mangrove communities were also mentioned. The use of mangroves as shelter and food source for animals' food chains in the mangroves was discussed in detail. Finally, the authors gave a list of the nine major mangrove stands in Zanzibar islands including the species found in these islands. The soils of these regions and use of mangroves on Zanzibar were described at length. At the end of the article, the author listed and defined some of the technical terms used in the article.

Shunula, J.P. and Whittick, A., 1999: Aspects of litter production in mangroves from Unguja island Zanzibar, Tanzania. *Proceedings of the 20th anniversary of Institute of Marine Sciences*. 28 June - 1 July 1999, Zanzibar, Tanzania (In press).

Aim of study: The purpose of this study was to determine the amount of litter that is produced by the dominant species belonging to different families (Avicenniaceae, Sonneratiaceae and Rhizophoraceae).

Methods: The litter trap method was employed in the study that ran between March 1991 to March 1993. The details of the methods used are available in the thesis deposited in the Library of the University of Dar es Salaam.

Results: The results showed that the total mangrove litter input ranges from 7-18 tons per hectare per year, depending on the species. Of the five species investigated, productivity was in the order (from most to least productive) Sonneratia alba, ca 18;*Bruguiera gymnorrhiza*, ca 16; *Rhizophora mucronata* ca14; *Avicennia marina* ca 12; and *Ceriops tagal* ca 7 tonnes per hectare per year. Flower and propagule production showed marked seasonality in *A. marina* and *R. mucronata*. the rates of production of the individual species per unit area were not significantly different at the two study sites (Chwaka and Maruhubi). Shown in the appendix are the relative quantities of leaves, propagules (fruits/seeds) for the years 1991-1993. in the two study sites, the figures are: 1a = *Avicennia marin*a at Maruhubi; b) at Chwaka; c = *Sonneratia alba* at Maruhubi & d) at Chwaka; e = *Bruguiera gymnorrhiza* at Maruhubi & f) at Chwaka; g = *Ceriops tagal* at Maruhubi, h = at Chwaka and I = *Rhizophora mucronat*a at Chwaka.

Shunula, J.P. and Whittick, A., 1999: Leaf litter degradation and nutrient release from three mangrove species in Zanzibar. *Proceedings of the 20th anniversary of Institute of Marine Sciences.* 28 June - 1 July 1999, Zanzibar, Tanzania (In press).

Aim of study: The aim of the study was to estimate the rate at which mangrove leaves of species belonging to three different families (Sonneratiaceae; Avicenniaceae; and Rhizophoraceae) decompose, as well as the behaviour of their C/N ratios during the process of decomposition. Nylon-mesh decomposition bags were deployed in the experiments conducted in the field, while milled remnants of decomposed leaves were used in the determination of C/N ratios.

Results: The results showed significant differences in decomposition rates between the species, with *Sonneratia alba* showing the highest rate, followed by *Avicennia marina* and lastly *Ceriops tagal*. C/N ratios also showed huge differences between the species.

Stromberg, H., Pettersson, C. and Johnstone, R., 1995: Spartial Variations in Benthic Macrofauna and Nutrient Dynamics in a Mangrove Forest Subject to Intense Deforestation: Zanzibar, Tanzania. *Ambio*, 27(8): 734-739.

Aim of study: This paper was aimed at studying the macrofauna and nutrients dynamic in the mangrove forest subjected to intense deforestation.

Area of study: Kisakasaka in Zanzibar, Tanzania.

Results: The authors looked upon the importance of mangrove leaf litter in forming the food web for many benthic organisms and nutrient enrichment in the soil after microbial decomposition. The dominant mangrove species on dense mangrove forest compared to deforested areas were studied. They found that *Rhizophora mucronata* was the most dominant species in dense forests. Moreover, it was learnt that areas with dense mangrove forests harbour more species of macrofauna than deforested areas. Thus it was observed that the increasing use of mangroves has led to rapid deforestation of large mangrove areas.

Conclusion: The absence of mangrove trees and associated flora in the areas examined, had a clear impact on nitrification. Generally, values obtained for all dissolved nitrogen species was much higher variation in values obtained from cut sites. The mean sediment concentrations of free dissolved NH_4^+ was higher in the cut sites than in uncut areas (Appendix 20; Fig. 3). NO_x concentration was also found to be higher in the cut sites with depth (Appendix 20; Fig. 4).

Wagner, G.M., Mgaya, Y.D., Akwilapo, F.D., Ngowo, R.G., Sekadende, B.C., Allen, A., Price, N., Zollet, E.A., and Mackentley, N. 1999. An on-going project on restoration of coral reef and mangrove ecosystems by the local communities at Kunduchi and Mbweni, Dar es Salaam. In: *Proceedings of the Conference on Advances in Marine Sciences in Tanzania*, 28 June - 1 July 1999, Zanzibar, Tanzania. Institute of Marine Sciences, Zanzibar (in press).

Aim of study: In recent decades, the diverse ecosystems along the Dar es Salaam coast, i.e., coral reefs, beautiful reef-fringed islands, seagrass beds, mangrove forests, estuaries and attractive sandy beaches, have become partially to severely degraded by various human activities. In badly degraded ecosystems, mere protective measures are insufficient. Active restoration is required in order to return such ecosystems to their original state in a reasonable length of time and to restore species composition.

Areas of study: Kunduchi and Mbweni, Dar es Salaam.

Methods: An on-going project has been underway along the coast north of Dar es Salaam which has included several elements: socio-economic analyses, community participation, baseline studies, application of already known techniques in tangible restoration work, and monitoring of restored areas in comparison with control areas.

Results: Participatory rural appraisal (PRA) and standardized interviews undertaken in Kunduchi Fishing Village and Mbweni Village showed that these communities have low education levels, poor infrastructure, and low incomes and are largely dependent on natural resources, particularly through fisheries and agriculture. Environmental problems, their causes, and solutions were also identified.

A baseline study was conducted in Mbweni Mangrove Forest. The transect line plots method (English *et al*., 1994) was used to determine mangrove species composition and abundance. Within each of three strata, four permanent transects were established and, along these, 10 m X 10 m permanent plots were surveyed.

The stratum nearest the village, which had formerly been dominated by *Rhizophora mucronata*, has been badly cut for firewood and building poles in recent years. It now consists mostly of saplings, dominated by *Ceriops tagal* (0.20 individuals/m^2), followed by *R. mucronata* (0.10 individuals/m^2), and *Avicennia marina* (0.02 individuals/m^2). Another stratum, which was clear cut several years ago for hotel construction, is now dominated by seedlings and saplings of *C. tagal* (0.52 individuals/ m^2), followed by *R. mucronata* and *A. marina* (0.11 and 0.04 individuals/m^2, respectively). In the third stratum, which was clear cut about two years ago, *C. tagal, A. marina,* and *R. mucronata* (mostly seedlings) are now found at densities of (0.23, 0.10 and 0.01 individuals/m^2, respectively). In addition, there were 0.32 stumps/m^2.

A preliminary trial in replanting mangroves was then carried out by the women of Mbweni village. More than 3,000 seedlings were planted in various parts of the Mbweni Mangrove Forest including some of the areas where permanent plots had been established. Most of the seedlings transplanted were *Rhizophora mucronata*, but a few were *Avicennia marina*. This mangrove replanting activity resulted in the spontaneous formation of a new Community-Based Organisation (CBO) known as Mbweni Environment and Women's Group.

Monitoring was carried out three months after the first mangroves were transplanted by assessing the health of the seedlings according to four categories. Perfect condition; Slightly wilted; Yellow leaves or only a bud, but likely to survive; No leaves or buds, but stemstill slightly green suggesting a chance of survival; and dead. It was found that 19-59% was in the first two categories. After another 5 months (8 months after transplanting), 35-38% were in perfect condition (category 1).

The potential for ecotourism in the area was also investigated. Of the villagers interviewed, 100% in Mbweni and most of those in Kunduchi said they were interested in participating in ecotourism.

This paper also reported activities on the coral reef fringing Mbudya Island near Kunduchi, including baseline studies, coral transplantation trials involving the participation of local fishermen, and monitoring of the coral transplants. However, since these aspects are outside the theme of these summaries, the results are not included here.

It is recommended that restoration work should be combined with ecotourism, whereby members of the communities receive payment from tourists for guided tours to coral reef and mangrove ecosystems while they carry on the restoration activities. It was also recommended that future projects/programs in the region should combine involvement of local communities in the application of already developed restoration techniques, citizen monitoring of the success of the restoration activities, and research into improving techniques.

OTHER MARINE LIVING RESOURCES

Yunus D. Mgaya
University of Dar es Salaam, Department of Zoology and Marine Biology
P.O.Box 35052, Dar es Salaam

Björk, M., Mohamed, S.M., Björklung, M. and A. Semesi, 1995: Coralline algae, important coral-reef builders threatened by pollution. Ambio, 24: 502-502.

Aim of study: This study examined coralline algae growing on the skeletons of reef-building corals on coral reefs.

Area of study: The reefs were located off the West Coast of the Island of Unguja.

Results: The cell walls of coralline algae were heavily impregnated with CaCO3. Encrusting coralline algae like Lithophyllum spp. grow over the reef structure cementing it together. Other types, like the different species of *Amphiroa* and *Jania*, are very brittle and disintegrate to fine calcareous sand when they eventually die.

Three types of habitats were chosen forthis study. Surveys were carried out by SCUBA diving. It was found that the cover of coralline algae decreased with decreasing distance to the sewage outlet area and increasing nutrient concentrations. From the control area to the area most exposed to sewage water, the total cover of coralline algae were found to decrease from 80% to 20%.

The results showed that the cover of coralline algae was reduced even at very low exposure to sewage water. Laboratory and field experiments showed that high phosphate levels negatively affected both the growth rate and the calcification of these organisms, but not by nitrate or ammonia.

Bryceson, I., 1981: A review of some problems of tropical marine conservation with particular reference to the Tanzanian coast. *Biological Conservation*, 20: 163-171.

Aim of study: This paper examined some principles of conservation theory in relation to the tropical marine environment and reviewed the main problems of conservation in Tanzanian coastal waters.

Results: The author reported that seagrass beds are highly productive and contribute mainly to the marine ecosytem through the detritus food chain. They stablise sublittoral sediments and provide a substrate for many epiphytic organisms, they support large population of fishes and invertebrates. They are also very important for the juvenile stages of many organisms. Seagrasses form the diet of the dugong. In Tanzanian coast dugongs are occasionally encountered around Kilwa, Rufiji, Mafia, Ruvu, Zanzibar and Moa. Its continued existence is threatened by hunting.

The small islands along the Tanzanian coast were reported to be critically important for the nesting activities of turtles and birds. Green turtles and hawksbill turtles were reported to be still fairly common but ridleys, loggerhead and leathery turtles were rare (Fraizer, 1974). The green turtles were hunted for meat and the hawksbills for their shell. The most important nesting grounds included Maziwi, North Funjove, ShunguMbili, Nyororo and Barakuni islands. The author reported that unless effective measures are taken to protect these animals, they might

continue on the path to extinction. Several shore birds, such as terns, boobies and noddies, depend upon small undisturbed islands for their nesting. Latham Island was considered to be critical as a sanctuary requiring specific protection. The author suggested that dugongs and turtles should be fully protected and certain small islands should be legislated as sanctuaries for breeding of turtles and birds.

Bryceson, I., 1982: Seasonality of oceanographic conditions and phytoplankton in Dar es Salaam waters. *University Science Journal (Dar Univ.)*, 8: 66-76.

Aim of study: This article described the oceanographic parameters and the synecology of the phytoplankton of the coast of Dar es Salaam.

Area of study: The sampling site was outside Mbudya Island. Samples were taken during 1973 to 1976 and from January 1975 to January 1976.

Methods: The oceanographic parameters investigated were: temperature, turbidity, salinity, oxygen, phosphate and nitrate. Chlorophyll level and phytoplankton cell counts were also determined.

Results: The annual cycle appeared to be divided into two main seasons: Northern monsoon (December-April) and the Southern monsoon (June-October). A clear seasonality in the standing stock of phytoplankton were observed. *Oscillatoria erythraea* was abundant during the northern monsoon but absent during the Southern monsoon. Diatoms and flagellates had higher values during the northern monsoon. During the southern monsoon conditions were reversed.

The Northen monsoon period was considered to be favourable to phytoplankton growth due to less mixing to depths of below optimal light intensity, greater residence time in neritic conditions because of the slower coastal current, greater runoff and nutrient input from rivers. Also, there was a greater availability of biologically assimilable nitrogen associated with the presence of *O. erythraea* attributed to its ability to fix nitrogen.

Colleen, J., Mtolera, M., Abrahamsson, K., Semesi, A. and M. Pederssen, 1995: Farming and physiology of the red algae *Eucheuma*: Growing commercial importance in East Africa. *Ambio*, 24: 497-501.

Aim of study: This paper tried to explain the background of algae cultivation in Zanzibar. The main purpose of the study was to investigate the physiology of red algae *Eucheuma*. These algae are cultivated for the production of carrageenan, a thickener used in many food products. The paper described an experiments performed with *Eucheuma* species mainly *E. denticulatum.*

Results: It was found that growing *Eucheuma* over seagrass beds is not advised because of the interference of seagrass with the carbon dioxide uptake of *Eucheuma*, which leads to poor growth. Similarly, if the algae are stressed by factors like grazing, high light intensities, stagnant water, epiphytes or seagrasses, the algae will begin to produce hydrogen peroxide, which in turn can cause the formation of hypochlorite, hypobromite, monochloroamine, hexachloroethane and other volatile halocarbons. These compounds were found to be toxic to the algae themselves and to other organisms in their vicinity. Stress often results in the *ice-ice* disease, which causes heavy losses to farmers in the Philippines. But this disease is not yet a problem in Zanzibar.

The results put emphasis on the importance of high water exchange for successful *Eucheuma* cultivation. Rapid water exchange not only improves the amount of CO_2 present in the seawater, but also reduces other nutrient limitations and, hence, stresses on the algae.

It was recommended in this paper that *Eucheuma* plants should be grown at medium densities. Extensive farms should be discouraged to avoid *ice-ice,* and the stressed condition of *Eucheuma* and to reduce the negative impact of *Eucheuma* on other marine plants and animals.

Hartnoll, R. G., 1976: The ecology of some rocky shores in Tropical East Africa. *Estuarine and Coastal Marine Science,* 4: 1-21.

Aim of study: The main objective of this study was to describe the rocky shore ecology around Dar es Salaam. This was the first general study of rocky shore ecology on the mainland of tropical East Africa. The shores were found to be predominantly coral limestone, with a wide erosion platform sloping up to mean low water neaps and backed by steep cliffs. A quantitative survey of the flora and fauna was made at 12 sites. The surveyed sites are given in a map.

Methods: At each site, transect was worked up the shore, starting from the inner edge of the erosion platform continuing upwards as far as the top of the limestone rock. Transects were levelled and within each vertical increment the biota was assessed, the algae as percentage cover, the fauna as number of specimens of each species per unit area. Both sessile and active mobile fauna included in the survey is listed in the table.

Results: The author conveniently divided the shore into 3 zones. A lower eulittorial with a dense cover of small algae and a fauna which does not extend to higher level. An upper eulittoral with algae only under shading overhangs and an abundant fauna dominated by *Pomatoleios, Chthamalus, Tetraclita, Lithotrya, Acmaea* and *Crassostrea*. A littoral fringe was characterised by littorinids and *Nerita*. Variation in the degree of wave action was reported to cause minimal effects on the height reached by the shore organisms, but it markedly affects abundance. *Pomatoleios, Chthamalus,* all limpets, *Nodolittorina*, *Dendropoma* and *Acanthopleura* preferred exposure, whilst shelter favours *Lithotrya valentiana, Cerithium, Planaxis* and *Gibbula*.

The slope of the substrate was found to be important. *Pomatoleios*, *Lithotrya* and *Acmaea* were much more abundant on steep and shaded surfaces, whereas *Chthamalus, Siphonaria* and *Brachiodontes* showed strong preference for gentle slopes. The author pointed out that the preferences of the various species for either shelter or exposure are mostly the same both at Dar es Salaam and the other areas that have been studied. Exceptions were *Pomatoleios kraussi* and *Lithotrya valentiana*.

Howell, K. M., 1988: The conservation of the coastal waterbirds of Tanzania. In (J.R. Mainoya ed.) *Proceedings of Workshop on Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa.* 18-20 January, 1988. Faculty of Science, University of Dar es Salaam, pp. 162-173.

Aim of study: This paper discussed the coastal waterbirds i.e. those which spend much of their time above or in coastal marine waters.

Results: It was reported in this paper that Tanzania with its islands (Pemba, Unguja, Mafia and numerous smaller ones) provide a variety of feeding and nesting habitats. The author also, reported that despite their large size, the variety of species and often-large numbers of individuals (Over 100 species in 25 families), the resident and migrant coastal waterbirds of Eastern Africa

have received little attention from biologists. Gerhart and Turner (1978) detailed the populations of birds found on Latham Island, the most important seabird breeding station along the entire Eastern Africa coast and the only known breeding ground of the Masked Booby and Crested Tern. Other birds on Latham included the Brown Noddy, 300-400 pairs nesting and the Sooty Tern with 10,000 nests estimated.

The waterbirds were reported to have an effect in nutrient cycling, the droppings (guano) produced by waterbirds is of economic importance as a fertilizer. Guano produced by waterbirds has been shown to be critical in maintaining forests on the coral rag. Several threats to coastal waterbirds were reported. These included, destruction of habitat such as intertidal sand and mud flats (feeding habitat), mangrove and cliff (roasting and breeding sites); pollution such as chemical pollutant and oil spill; human exploitation and introduction of predatory species such as the Indian House Crow, *Corvas splendens*.

Due to those threats the author suggested the following priorities for coastal waterbird conservation: Survey of seabird breeding sites, prevention or reduction of habitat destruction, establishment of nature reserve and parks. Other priorities include research on seabird breeding sites and population studies, studies on the ecology, numbers and habitat requirement.

Johnstone, R.W. and E. Ólafsson, 1995: Some environmental aspects of open water algal cultivation, Zanzibar, Tanzania. *Ambio*, 24: 465-469.

Aim of study: This research was undertaken to investigate the environmental effects of *Eucheuma spinosum* farming. The aspects investigated were population dynamics of benthic meiofauna, the primary and bacterial production in the associated water column in farmed area and non-farmed control areas.

Area of study: The study was conducted in the lagoon adjacent to the village of Paje on the East coast of Zanzibar.

Method: A modified version of the ^{14}C-isotope method was used to measure both benthic and water column primary production. Bacterial production in the water column and sediments was also determined. In addition to meiofauna sampling, grain size distribution, chlorophyll a, salinity and temperature was also measured within the farms.

Results: The results showed no significant difference in water-column bacterial production, bacterial abundance or primary production between the algal farm sites and the remote reference sites. It was revealed that *Eucheuma spinosum* cultivation does not affect water column microbial production to an extent that they could be detected. Butit showed clear effect on both benthic microbial processes and meiofauna populations. Thus, the presence of farms seems to have a significant impact on benthos. However, it was not entirely clear which particular aspect of the algal farming was responsible for the observed changes, but it was thought that mechanical alteration of the sediment surface and possible enhancement of local benthic fish grazing may play a role.

Khatib, A.A. 1998: Sea turtles nest recording program: Unguja Island. *Ambio*, 27: 763-764.

Aim of study: This article presented a one year nest recording program which was conducted between March 1997 and 1998 with the following objectives: to verify important nesting beaches, to identify the best conservation efforts and to allow community participation and education in the nesting program.

Area of study: The sites surveyed were Nungwi, Kizimkazi, Mkunguni, Jambiani, Kibigija, Uroa, Michamvi, Paje, Kiwengwa, Makoba, Pongwe, Mnemba and Matemwe.

Methods: The information recorded at 12 selected village sites were: species nesting, date and time of the nest find, place and name of the beach, and name of the finder. Others were remarks related to turtles attacks, hatchlings or information collected about other individuals like those caught in nets, dead turtle observed, turtle meat on sale etc.

Results: The results showed that a total of 229 entries were recorded for the whole period. The most frequent species recorded was the green turtle followed by hawksbill. Throughout the program 52 nests and 5 nesting attempts were recorded within the 12 village surveyed. The most important beaches were at Matemwe and Mnemba Island that show high numbers of nests. The summary of the nesting information is given in a table (Appendix E_8, Table 1).

Also this article revealed that most nests were recorded between April and July, species recorded nesting were green turtle and hawksbill. The latter was recorded at Mnemba and Makunduchi while green turtle nest at Mnemba, Makunduchi, Nungwi, Kizimkazi, Jambiani, Michamvi and Matemwe. Matemwe and Mnemba Island can be recognized as regionally important.

There are several threats affecting sea turtles in Unguja. These include natural threats especially erosion, egg collection by humans, killing of nesting turtles and incidental catches of sea turtles. Others are deliberate capture and coastal structure. Several recommendations were given; improvement of public awareness of sea turtle conservation needs, to recognise and support the conservation program by the government, zoning and conservation program should be established at several sites, intensive and proper monitoring is needed. Others are, research should be conducted on feeding habitats, and the community should be involved in all issues concerning sea turtles, furthermore, conservation committee should be formed.

Lirasan, T. and P.Twide, 1993: Farming *Eucheuma* in Zanzibar, Tanzania. *Hydrobiologia*, 261: 353-355.

Aim of study: This article presented data or history on the seaweed farming in Zanzibar. It described the farming technique, field survey, test planting and production of *Eucheuma* from 1987-1991.

Area of study: The location of Zanzibar island is given in the map.

Method: In mid 1988, the authors visited Zanzibar and conducted an aerial survey.

Results: It was reported in this paper that the government welcomed the idea of seaweed farming and promised issuance of the necessary permits. At the beginning of 1998, extensive surveys were conducted to assess the basic requirements in commercial seaweed farming with emphasis on size, accessibility and ecology of site; potential manpower; infrastructure and farming materials. Test plantings were initiated in July 1989.

For the planting purposes, 3kg of *E. cottonii* and 2kg of *E. spinosum* were transferred from the Philippines to Zanzibar in 1989. The farming method used was the fixed-bottom stake and

monoline technique. The harvest of plants was done after 25-35 days. According to the field survey conducted, about 750 ha of suitable farming sites were found situated along the East Coast of Zanzibar. The areas had relatively clear water and average salinity of 33-35‰. Temperature ranges from 22-32ºC. It was reported in this article that the test planting in Jambiani, showed daily growth rate (DGR) for *E. spinosum* of 6-7%. Furthermore, seedlings were found to grow relatively well, 4.5% DGR in the cold months (May-August).

Also this article gave out the production of *Eucheuma* from 1989-1991. At the end of 1990, 246 t dry *E. spinosum* had been procured from approximately 1200 farms (Appendix $E_{9,}$ Table 2), one of which, Jambiani area produced nearly 90%. In 1991 farming activity was spread to many areas and resulted in a total for that year of 1514 t (Appendix $E_{9,}$ Table 3). For 1992, production in Zanzibar of about 3000 t dry *E. spinosum* was foreseen and once fully exploited, the East Coast could yield 5000-6000 t (dry weight). The attempted farming trials with *E. cottonii* have so far failed.

Machiwa, J.F. andR.O. Hallberg, 1995: Flora and crabs in a mangrove forest partly distorted by human activities, Zanzibar. *Ambio*, 24: 492-496.

Aim of study: The aim of this study was to determine the organic carbon budget in Maruhubi forest. Inventory on mangrove flora and macrofauna was carried out during 1994.

Area of study: Maruhubi mangrove forest, within Zanzibar municipality.

Methods: During the study, crabs and snails were recorded. The crabs were randomly sampled using a $1m^2$ or $0.25m^2$ quadrat. The number of holes was assumed to be equivalent to the abundance of crabs and tree dwelling grapsid crabs and snails were physically counted.

Results: The results showed that the ocypodids crabs were about 55.2 ± 27.2 ind.m^{-2} in this area. It was noted that the ocypodid crabs prefer areas of relatively clear sandy floor in the sparsely growing mangroves. The tree climbing grapsids, *Metapograpsus messor*, *M*. thukuhar and *M. oceanicus* were found in the marine fringe. The snails' *Littorina scabra*, *Morula* sp., *Cerithium* sp. and *Turbo coronotus* were found in the fringe and shoreline zone.

In the shoreline zone, the grapsid crabs were only 1 ind.m^{-2}, usually *Metapograpsus* spp. other fauna population were *Uca* and *Dotilla spp*. and the snail *Terebralia palustris*. A37 411.45 TJı˝ Tfı anMele

for organic-carbon flux in the ecosytem was proposed based on distribution of mangrove flora and litter as well as the grapsid crabs.

Mshigeni, K.E. and E.V. Nzalalila, 1977: Contributions on the content and nature of the phycocolloid from *Laurencia papillosa* (Forssk) Greville (Rhodophyta, Ceramiales). *Botanica Marina*, 20: 443-447.

Aim of study: The objective of this study was to advance the knowledge on the quantity of phycocolloid in the fronds of *Laurencia papilosa*.

Methods: The content, infrared spectroscopy, total sulphate and optical rotation of the phycocolloid were investigated. The specimens of *L. papilosa* used in this study were collected from Oyster Bay and Msasani bay, Dar es Salaam. The pycocolloid yield of 33.6±0.6% was obtained on dry weight basis.

Results: The total sulphate content of the phycocolloid was 16.8±0.4% and the optical rotation was found to be negative. The phycocoloid was soluble in potassium chloride. Its IR spectra showed absorption peaks more akin to λ- than κ- or ι-carrageenan. Summary of the data is given in table and figure.

It was reported in this paper that in all tests the phycocolloid showed negative optical rotation suggesting it to be akin to agar rather than carrageenan. Yet, its IR spectra and total sulphate content were more closely related to carrageenan than agar. These findings thus cast doubt on the adequacy of positive or negative optical ratation as a valid criterion in the primary classification of red algal hydrocolloids into agar and carrageenan.

Mshigeni, K.E., Semesi, A.K., and T.M. Ngonyani, 1979: Studies on the phycocolloid from the red seaweed *Rhabdonia africana* Jaasund (Gigarttinales, Rhabdoniaceae). *Botanica Marina*, 22: 447-450.

Aim of study: This study was conducted on the phycocolloid from the red seaweed *Rhabdonia africana*. The study involved extracting the gel from *R. africana* and determining its percentage yield, optical rotation, sulphate level, infrared spectrum and solubility. The photo of specimen of *R. africana* is given.

Area of study: These specimens were collected during spring low tides from Salender Bridge, Dar es Salaam in May, 1977.

Results: The phycocolloid yield was found to be 31.7±0.5%, its optical rotation positive and its total sulphate content 18.6±0.1%. It was also insoluble in potassium chloride solution and showed infrared spectral peaks akin to those of ι-carrageenan.

It was considered that this study was a new contribution hitherto not reported in the literature. It added *R. africana* to the world list of ι-carrageenan bearing seaweeds: seaweeds that are currently in big demand as a result of expansion in the industrial usage of their colloids.

Mshigeni, K.E. and A.A. Kajumulo, 1979: Effects of the environment on polymorphism in *Ulva fasciata* Delile (Chlorophyta, Ulvaceae). *Botanica Marina*, 22: 145-148.

Aim of study: The main objective of this study was to investigate the growth form of *Ulva fasciata* raised from spores in two contrasting habitats.

Area of study: Two sites at Oysterbay were selected for the yield study. One was an area just beneath the Police Officer's Mess: a habitat subjected to strong surf. The other site was a habitat 200m away towards the Oysterbay hotel: a habitat that had relatively calm water.

Method: The seaweed was grown on planks of wood in calm water and wave exposed habitats for a period of ten weeks.

Results: By the end of experimental period, the mean height attained was 166.6±20.4mm and 34.2mm in the two habitats, respectively. The *Ulva* plants in the calm-water habitat had erect growth habitat whereas those from wave exposed habitats were dwarf and rosette-like. A summary presentation of the data on frond height as a function of age in two habitats is also shown.

Conclusion: The authors concluded that in suitable habitats, harvestable crops of *Ulva fasciata* could be raised within 10 weeks. Furthermore, the cultivation of this species would be profitable in calm-water than in wave exposed habitats. The finding that *Ulva* plants grown in surf-exposed habitats were grossly different from those grown under calm water suggests that the nature of the external environment had great influence on polymorphism in frondose algae.

Mshigeni, K.E. 1979: The economic algal genus *Eucheuma* (Rhodophyta, Gigartinales): Observations on the morphology and distribution ecology of Tanzanian species. *Botanica Marina*, 22: 437-445.

Aim of study: In this paper the author gave an account of his observations on the distribution of five species of *Eucheuma* occurring in Tanzania.

Method: The information was obtained through personal observations when the author visited the localities shown in a map. The data were compiled between April 1969 and March 1970.

Results: The results showed that among the species investigated (i.e. *Eucheuma spinosum*, *E. okamurai*, *E. platycladum* and *E. speciosum f. mauritianum*), *E. spinosum* showed the highest frequency of occurrence followed by *E. striatum*. *E. speciosum f. mauritanium* was the most restricted in its distribution. The two most abundant species also showed the widest range of morphological plasticity. The existence of polymorphic forms of these algae was depending on the habitat characteristic of small islands as compared to shores of big landmasses. In almost all localities where *Eucheuma* was present, populations of *E. spinosum* extended higher up the shore than the rest.

The ability of *E. spinosum* to extend higher up in the intertidal zone than the other species suggest that it was better adapted to withstand direct insolation, prolonged desiccation and possibly wider ranges of salinity. The observations that all Tanzanian species of *Eucheuma* are totally absent near river mouths suggest that the seaweeds probably can not tolerate silt and mud in such areas. *Eucheuma* plants grow thick and healthy in habitats that experience a good degree of water movement (Appendix E_{14}, Figs. 2-8) but remain slender and weak where the water is relatively calm.

The information from this study was considered as a useful guide in locating habitats in Tanzania where *Eucheuma* can be harvested for carrageenan production or natural beds from which

seeding material can be collected. They are also useful for locating areas along the West Indian Ocean where *Eucheuma* cultivation could be conducted most successfully.

Ndaro, S.G.M., Sjöling, S. and E. Ólafsson, 1995: Small-scale variation in major meiofaunal taxa and sediment chemistry in tropical sediments. *Ambio*, 24: 470-474.

Aim of study: The study was designed to investigate the variations in sediment biochemistry and abundance of meiofauna.

Area of study: The study area was in Unguja Island at 3 sites: Paje (intertidal lagoon, Maruhubi (mangrove forest) and Bawe (subtidal reef area). The study area is given in a map.

Methods: During sampling a quadrat of 1 m^2 was thrown into the sediment and plastic corers (10 cm^2) pushed 10 cm into the sediment and sealed with a rubber stopper. Chlorophyll samples were taken and redox potential discontinuity layer was estimated. The analyses were done in the laboratory at the Institute of Marine Sciences.

Results: Both the biochemical components of the pore water and meiofauna varied substantially over small distances in all three habitats. In the mangrove area, the colour of the pore water was found to be positively correlated with the major meiofaunal taxa, especially the nematodes. In the coastal lagoon, polychaetes showed negative correlation with particulate organic matter while other groups showed no correlation with any of the chemical components analysed.

In the subtidal reef area no chemical components were found to correlate with the meiofauna. When data from the three sites were taken together, two clear associations emerged. Firstly, grain size shows a highly significant relationship with both total fauna and nematode numbers. Secondly, there was a clear association between the amount of particulate organic carbon and particulate organic nitrogen in the pore water.

There was a high variation in nematode assemblage structure within and between sampling area indicating the absence of a well-defined nematode assemblage confined to mangrove areas. In a hypersaline area, diversity was much reduced and where salinity was over 100‰ the fauna was restricted to three nematode genera, *Microlaimus*, *Theristus* and *Bathylaimus*. Numbers of selective deposit feeders were negatively correlated with average grain size and positively correlated with silt content.

Newton, L.C., Parkes, E.V.H. and R.C. Thompson, 1993: The effects of shell collecting on the abundance of gastropods on Tanzanian shores. *Biological Conservation*, 63: 241-245.

Aim of study: The main purpose of this paper was to investigate the effects of shell collection. The abundance of gastropod was quantified on shores, which were subject to different levels of shell collecting.

Area of study: The study sites were at Dar es Salaam, Zanzibarand Mafia Island. Sites with similar aspects, wave exposure, rock type, flora and fauna were selected at each of these locations.

Methods: Surveys were conducted from the beginning of July to September 1990. Sampling was conducted for a period of 1hour. The total times spent sampling were Dar es Salaam, 32hrs, Zanzibar 24hrs; Mafia Island 37 hrs.

Results: The results showed that the shore of Dar es Salaam and Zanzibar were subject of severe exploitation of shells. The total number of gastropods (all species) found at Dar es Salaam was significantly higher than at either Zanzibar or Mafia. Overall, 106 species were recorded at Dar es Salaam, 80 at Zanzibar and 77 at Mafia, representing 18 famillies. Also it was reported in this paper that the three large cowries *Cypraea tigris*, *C. histrio* and *C. lynx* were heavily exploited compared to smaller ones, *C. carneota*, *C. annulas* and *C. moneta* and the cone shells *Conus ebraus* and *C. miliaris*.

This study revealed that some of the gastropods, which have commercial value because of the shell trade, were suffering from over-collection on shores at Dar es Salaam and Zanzibar. It was reported (Evance et al., 1977) that, commercially valuable cowries which were once common at Dar es Salaam have virtully disappeared from the gastropod fauna. *Cypraea arabica*, *C. carneola* and *C. erosa* were common when Spry carried out his survey but were found only occasionally in this study. Generally commercial valuable species which were rich in gastropod species diversity was found to be relatively poor compared with Zanzibar and Mafia.

Shell collecting and intensive fishing were reported in this paper as the two main factors which affecting gastropod populations and intertidal habitats at Dar es Salaam. Others include continued destruction of the reef by the use of dynamite for fishing, sediment outwash from nearby cement works, coastal erosion and sewage outflow.

Ólafsson, E., 1995: Meiobenthos in mangrove areas in Eastern Africa with emphasis on assemblage structure of free-living marine nematodes. *Hydrobiologia,* 312: 47-57.

Aim of study: The main aim of this paper was to give an account of the meiobenthos in mangrove swamps and to try to identify those factors responsible for differences in density and assemblage structure.

Area of study: The survey was confined within five mangrove areas on the West and East Coast of Zanzibar. The mangrove areas and sampling sites are given in a map.

Methods: A quadrat of 1 m^2 was located and the number of crab holes and prop roots within the frame counted. Water level, salinity and temperature were recorded. Grain size and identification of meiobenthos were done in the Laboratory.

Results: Meiofauna densities in surface sediments (0-5cm) ranged from 205 to 5263 ind.100cm^2 being on average 1493 ind.10cm^2. Of the 17 major taxa recorded, nematodes dominated (64-99%) in all samples while harpacticoid copepods were usually second most abundant. Within all areas the numbers of meiofauna were very variable and significant differences among areas were only detected for oligochaetes and turbellarians.

Densities of nematodes, harpacticoids, polychaetes and turbellarians were, however, significantly higher at low water stations compared with mid and high water stations. Harpacticoids were negatively correlated with the numbers of fiddler crab (*Uca* spp.) burrows. Other correlations between environmental factors (grain size, temperature, salinity, oxygen tension, prop root density, fiddler crab burrows) and major meiofaunal taxa were non-significant.

A total of 94 nematode genera were recorded from four mangrove areas. The most abundant and frequent genera were *Microlaimus* and *Spirinia*, followed by *Desmodora* and *Metachromadora*. Representatives of the genera most common in this study were found all over the world.

There was a high variation in nematode assemblage structure within and between sampling areas indicating the absence of a well-defined nematode assemblage confined to mangrove areas. In a hypersaline area diversity was much reduced and where salinity was over 100‰ the fauna was restricted to three namatode genera, *Microlaimus*, *Theristus* and *Bathylaimus*. Numbers of selective deposit feeders were negatively correlated with average grain size and positively correlated with silt content.

Semesi, A.K. and K.E. Mshigeni, 1977: Studies on the yield and Infrared Spectra of Phycocolloids from *Chondrococcus hornemanii* (Lyngbye) Schmitz and *Sarconema filiforme* (Sonder) Kylin from Tanzania. *Botanica Marina*, 20: 271-275.

Aim of study: The purpose of this study was to show whether *Chondrococcus hornemanii* and *Sarconema filiforme* contain agar or carrageenan and to make quantitative estimates of their phycocolloids.

Area of study: The specimens were harvested from the shores of Oyster Bay and Msasani Bay, Dar es Salaam, Tanzania.

Methods: Infrared spectroscopy, optical rotation tests, total sulphate content determination and solubility in potassium chloride were conducted to characterise the nature of the phycocolloids from these two seaweeds.

Results: Yield of 45.1±0.1 and 35.7±2.8% (of the dry weight) were obtained in *Chondrococcus hornemanii* and *Sarconema filiforme* respectively. The phycocolloid from *S. filiforme* showed a total sulphate of 18.3±0.5% and IR absorption peaks characteristic of ι-carrageenan. *C. hornemanii* showed a sulphate content of 24.7±0.3% and IR spectra and solubility properties akin to those of λ-carrageenan.

The authors reported that this study on *Chondrococcus hornemanii* was the first contribution on the nature of its phycocolloid. Furthermore, they concluded that studies on the nature of seaweed colloids can yield information which can be used in making decisions on the placement of taxonomically difficult genera into their appropriate taxa. These seaweeds and especially *S. filiforme* whose fronds attain a relatively large size, seems to be of economic potential as carrageenan sources on tropical shores.

Semesi, A.K., 1988: Seasonal changes of macrophytes on seagrass *Thalassodendron ciliatum* (Forssk) Den Hartog at Oysterbay, Dar es Salaam, Tanzania. In (J.R. Mainoya, ed.) *Proceedings of Workshop on Ecology and Bioproductivity of the Marine Coastal Waters of Eastern Africa*. 18-20 January, 1988. Faculty of Science, University of Dar es Salaam, pp.51-58.

Aim of study: The main objective of this study was to evaluate the standing crops of *Thalassodendron ciliatum* and of its epiphytic algae.

Area of study: The study area was in a lagoon on a rocky shore of Oysterbay, Dar es Salaam.

Methods: Sampling was done in August 1986 and in April 1987. Quadrats 50x50cm were used and thrown in areas with good cover of the seagrass *T. ciliatum*. The epiphytic algae were removed and identified using a key by Jaasund (1976). To get the biomass, the seagrass and

epiphytes were first weighed while fresh to get wet weight and then dried in the oven, cooled, and weighed.

Results: It was reported in this paper that seagrass together with the benthic algae, epiphytic algae and phytoplankton take part in primary productivity in the ocean. *T. ciliatum* harbour many species of epiphytic macroalgae (Appendix E_{17}, Table 2). This paper reported that in August there were more species of epiphytic algae than April thus showed a marked seasonality in species composition and biomass. Epiphytes *Ceramiella* and *Sphacelaria* were reported to appear only in August while in April they were completely missing. *Entoromorpha kylinii* was encountered only in trace quantities in August but it had 100% frequency of occurrence in all plants in April. Also it was reported that in April the number of epiphytic species were fewer but had a greater standing crop (Appendix E_{17}, Table 1).

The standing crop of the seagrass between April and August was not significantly different. Furthermore the epiphytic algae were found to show certain preference in terms of the parts of the seagrass on which they attach. The stems were found to harbour more species than the leaves due to the longer life of stem compared to the leaves, which are shed frequently. In this study, only macroscopic algae were analysed. However, diatoms and encrusting algae were assessed but it is important to note that they are also very important as primary producers.

Stensland, E., Berggren, P., Johnstone, R. and N. Jiddawi, 1998: Marine mammals in Tanzanian waters: Urgent need for status assessment. *Ambio,* 27: 771-774.

Aim of study: This synopsis reviews the existing information on marine mammals in Tanzanian waters, and reports on a reconaissance trip to Zanzibar.

Results: It was reported in this article that no direct research on marine mammals have been conducted in the coastal waters of Tanzania. It was further stated that the most threatened marine mammals in the region is dugong. The seagrass beds outside Kilwa and Mafia Island were known to be preferred habitats for dugong in Tanzania. But the true status of the dugong in Tanzania is uncertain although the lack of reported sightings indicated that the population might already be extinct.

Several species of dolphins were reported in the waters surrounding Zanzibar Island. Indo-Pacific humpback and bottlenose dolphins were reported in Menai Bay. Bottlenose and spinner dolphins (*Stenella longirostris*) were observed in Nungwi and Matemwe. Another dolphin species that has been reported in Tanzania is the rough-toothed dolphin (*Steno bredanensis*). Populations of dolphins have also been noted in the Rufiji delta, Saadani, around Latham Island, Tanga and Mtwara. This article reported that Humpback whale (*Megaptera novaeangliae*) was known to migrate outside the coast of Zanzibar Island.

This synopsis also described the threats on marine mammals. These include, incidental catches in fisheries, direct catches e.g. in Tanga, Bagamoyo, Dar es Salaam and Mtwara, Matemwe and Kazimkazi on Zanzibar. Overfishing particularly in the region of Zanzibar Tanga and Dar es Salaam, and dynamite fishing. Others are marine pollution e.g. PCBs and heavy metals.

Menai Bay was identified as an important area for dolphins. The Indo-Pacific humpback dolphin and the bottlenose dolphin were the most common cetacean species in Menai Bay. It was reported in this article that 14 boats were seen taking tourists out to watch, and swim with the dolphins.

The synopsis also described the marine mammal project, which was launched in 1993. The objective of this project was to investigate the status of marine mammals in Tanzania and to train local scientists. Initially the research was conducted in selected areas around Zanzibar. Under this project a three-week visit were done around Kizimkazi (Menai Bay) and Matemwe as a suitable sites to study dolphin.

Eleven humpback and 14 bottlenose dolphin individuals were identified with a photographic identification technique. Also the behaviour of these animals was observed, such as tail slapping. Furthermore a dolphin skeleton and 2 skull of bottlenose and a humpback dolphin were collected in Matemwe and the teeth were removed for age analysis. The authors advised that there is an urgent need to undertake research on the marine mammals of Tanzania in order to identify the needs for future conservation and management of these animals.

Subramaniam, S.P., 1990: Chwaka Bay (Zanzibar, East Africa) as a nursery ground for penaeid prawns. *Hydrobiologia*, 208: 11-122.

Aim of study: This study gathered information on a number of environmental factors affecting immigration of post-larval penaeids, their distribution, food habits, growth, and emigration in a typical prawn nursery ground in Zanzibar.

Methods: Year round incursions with a maximum during the warmer months of December to March were observed. The study area is given in a map. Post-larval samples were sampled by using a tow net while the juveniles were sampled by using a scoop net. The morphometric measurements were recorded in the laboratory.

Results: The results showed that the penaeids were recruited in the sheltered sandy beaches and mangrove areas at post-larval stage (7mm). February to March was considered as the peak recruitment period. Out of six species of penaeids found in the area, *Penaeus latisulcatus* (75%) and *Penaeus indicus* (15%) were dominant. The recruitment pattern indicated greatest incursions of the post-larvae with the flood spring tides of the night when the tidal flow was strong.

The author observed that, the juvenile population of *P. latisulcatus* was distributed in those intertidal sand flats with a rich growth of seagrass and *P. indicus* in the muddy areas of the mangrove forests. *P. indicus* showed affinity for euryhaline conditions, whereas *P. latisulcatus* showed no preference for lower salinity. Provision of flood and shelter were considered as important factors for their nursery dependence.

Furthermore, the author stated that, *P. latisulcatus* attained a size of 60-70 mm in five to six months and *P. indicus* 110-120 mm in six to eight months during their nursery phase. The juvenile penaeids were found to be omnivorous, feeding on animal products, plant material and detritus. The maturing *P. latisulcatus* were found to emigrate back to the sea when they are about 120mm. A positive correlation between post-larval recruitment and juvenile abundance was also observed.