FINAL REPORT

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(Edinburgh University Coral Awareness and Research Expeditions
& Institut Halieutique et des Sciences Marines, Université de Toliara)

EUCARE & IH.SM COLLABORATIVE REEF RESEARCH EXPEDITION TO ANDAVADOAKA, SOUTH WEST MADAGASCAR

Project Madagascar

26th July- 8th August 2003

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Abstract

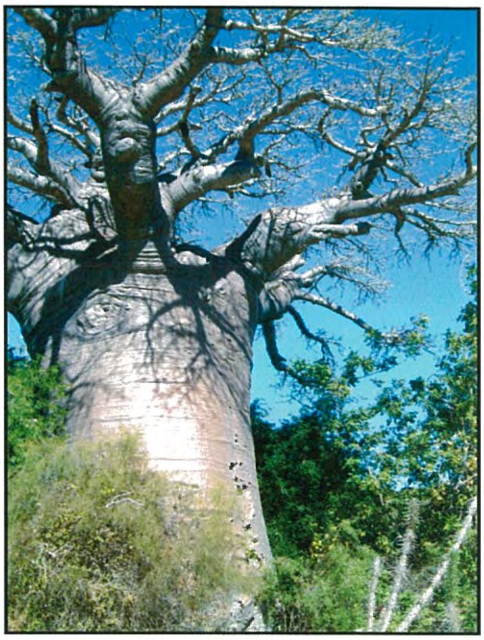
For 5 weeks from July to August 2003, a team of eight EUCARE (Edinburgh University Coral Awareness & Research Expeditions) SCUBA divers undertook an exploratory marine expedition to Andavadoaka, southwest Madagascar (43°13' E; 22°05'S). They had originally proposed to map the uncharted reefs of Belo-sur-Mer (43°50'E; 20°40'S), but due to logistical issues had to relocate the expedition to Andavadoaka. The team worked alongside scientists from the Institut Halieutique et des Sciences Marines (IH.SM) of the University of Toliara and collected baseline data from underwater surveys of the fringing coral reefs and offshore islands, of which there was none (to our knowledge) previously available. The project was termed 'Time Zero' due to its exploratory nature, and was followed up by a team from Oxford University (OUCARE), and then by Blue Ventures Conservation, a UK-based charity that intends to stay in the region for 2-3 years, enabling long-term monitoring.

Data collection utilised the methodologies outlined by 'Reef Check'; the Australian Institute of Marine Science (AIMS) (English *et al.* 1997); and the IH.SM (designed specifically for surveying the West Indian Ocean). Results showed a high level of hard coral (*Scleractinia*) mortality, possibly attributed to coral bleaching as a result of elevated water temperatures in the previous summer, and inner reefs were badly impacted at least in part by anthropogenic activities such as fine-mesh trawling nets and spear fishing for octopi. This report discusses scientific data from the EUCARE and OUCARE expeditions, outlines the logistical and administrative aspects of the project, and includes a brief section on the socio-economics of the region.

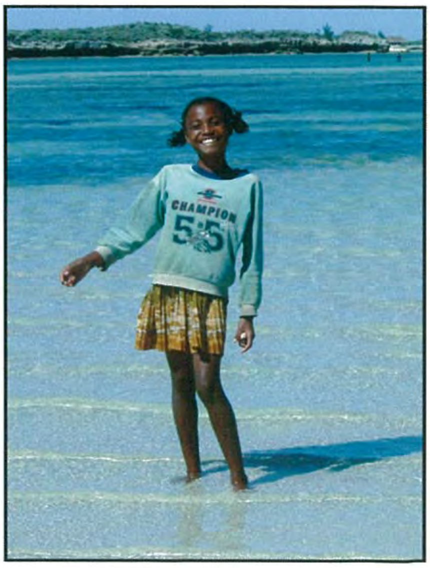
Some Photographic Memories of Madagascar

'Two Figures'

Dunes just south of Andavadoaka



Anticlockwise from above: Baobab Tree; Zebu on dusty road; road to Andavadoaka; beach girl; our 'private beach' at Coco Beach with pirogue in distance; Virgin Mary overlooking Andavadoaka; view from in a pousse pousse, Toliara; another beach girl.



Contents:

Acknowledgements

We would like to sincerely thank the people and organisations whose generous financial support made the expedition possible:

From the University of Edinburgh;
Davis Expedition Fund
Weir Fund for Field Studies
Barson Bequest
Student Travel Fund
Small Project Grant from the University of Edinburgh Development Trust

Ede & Ravenscroft Prize
The Gordon Foundation
College Vacation Scholarship (awarded to Anna Lewis);
the Carnegie Trust for the Universities of Scotland
The Royal Scottish Geographical Society

The EUCARE team would also like to thank the **Institut Halieutique et des Sciences Marines (IH.SM)** and **Cellule des Océanographes (COUT) de L'Université de Toliara** for its support and collaboration, particularly from the director, **Dr. Man Wai Rabenevanana** and the three scientists with whom we worked; **Jean-Charles Lope, Jasper Andriamanantsoa and Tsirivelo Ratovoson**. We are also very grateful to **Dr. Chris Inchley**, **Prof. Andrew Illius, Dr. Jill Lancaster** and members of the **University of Edinburgh Expeditions Committee**, particularly **Margaret Jackson**, for their expert advice and encouragement.

We also wish to thank all the people who supported the expedition in the field; **Dr. Andrew Cooke, Dave Razafinarivo, Olivier Delpierre,** the staff at **Coco Beach**, and all the people of **Andavadoaka village**, particularly the **President**, who welcomed us so warmly.

In addition, we would like to express our warm thanks to **OUCARE** for their financial and scientific collaboration; to **Blue Ventures** for valuable information that helped us with expedition planning and logistics, and for the beautiful AloAlo; to ***Aquapac*** for its generous donation of equipment (all EUCARE photographs in this report taken by or in water were taken through *Aquapac* protective casing); to **Dan Logan** for his pre-expedition PADI training; to **Kent Messenger Group Newspaper** and the **University of Edinburgh Development Trust Newsletter** for their informative articles; to **David Souter** for the donation of two highly informative books; the **Marine Conservation Society** for donation of Charles Sheppard's 'Guide to common corals'; to **Loic Lhopitallier** for his translation expertise; to **Bongo Club** and the **various artists** who very kindly performed for free at our club night, ***Gaijin***; and last but by no means least, to all the **friends and family** who supported us throughout this endeavour.

Section 1

Introduction

Edinburgh University Coral Awareness
& Research Expeditions

Project Madagascar 2003

Aims and Objectives

To describe the status of the unknown coral reef habitats of Andavadoaka and its offshore islands.

- To survey and chart the unexplored fringing coral reefs of Andavadoaka and its offshore islands, studying their biodiversity and health and assessing the potential threats these unknown ecosystems may be under. We also aimed to collect a range of oceanographic data from the region. In fulfilling this aim, we would achieve one of the priorities of the International Coral Reef Initiative (UNEP & IUCN), which is to improve the amount and availability of data on coral reefs in the West Indian Ocean.

- To identify strategies that the expedition team, local communities and local NGOs can work towards to develop sustainable local environmental management plans for the unique reef systems. These plans will focus on improving the quality of life of the local communties who depend on these marine resources while maintaining the biological diversity and productivity of the reefs.

Geographic Location

The EUCARE team originally proposed to map the uncharted reefs of Belo-sur-Mer (43°50'E; 20°40'S), but as the reefs lie so far offshore in such a exceptionally remote area of Madagascar the associated financial restrictions and safety issues meant we decided to relocate the expedition to Andavadoaka. Andavadoaka (43°13' E; 22°05'S) is situated approximately 45km south of Morombe, in the Toliara region and of the Befandefa Commune (see Fig.2).

Fig.1. Madagascar in relation to the rest of Africa

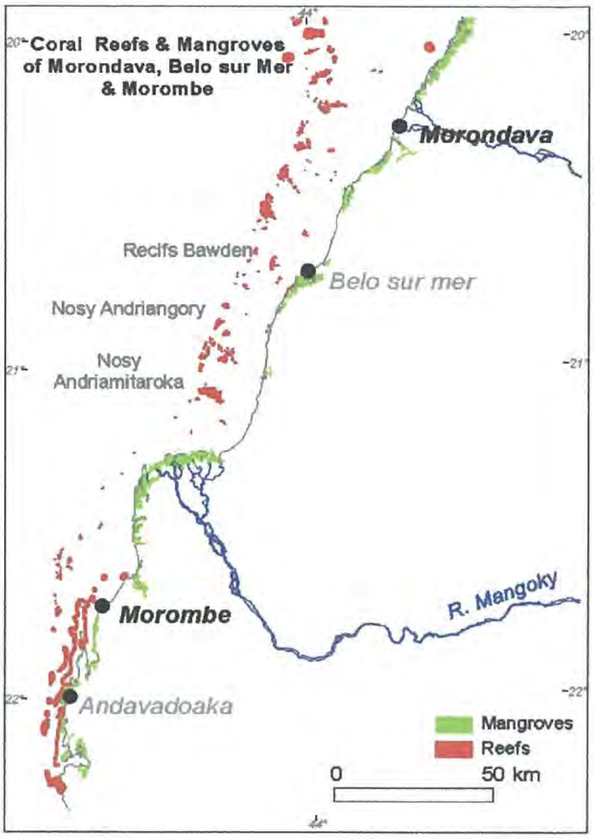


Fig. 2. Andavadoaka and Belo-sur-Mer shown in relation to Morombe and Morondava.
Coral reefs are shown in red and mangroves in green.

Fig.3. Satellite image of Andavadoaka and the offshore islands

Key:

1 – Nosy Hao

2 – Nosy Fasy

3 – Récif Parson [Nosy Masai]

4 – Nosy Andrahombava

○ Coco Beach Bungalows

Andavadoaka was recommended by Andrew Cooke, a former Advisor for Marine Conservation, Food and Agriculture Organisation (FAO), Madagascar, and is earmarked as an area with great potential for future tourist development.

The team stayed at **Coco Beach Bungalows** (Figs. 3 & 4); located between the villages of Andavadoaka and Ampasilava. The islands surveyed were approximately 4km to 8km offshore (Fig.3).

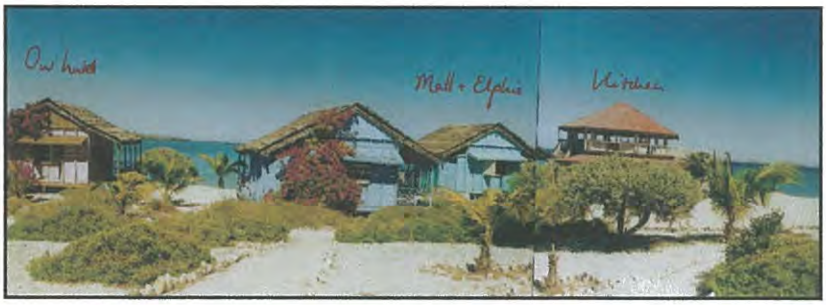


Fig. 4. Coco Beach Bungalows (Photo by Anna P)

Background & Justification

Healthy coral reefs are critical to the livelihoods and cultures of millions of people in tropical coastal environments, as well as forming part of the crucial life support system of the biosphere (Spalding *et al.* 2001). However, coral reefs throughout the world are increasingly exposed to over-exploitation and to degradation by anthropogenic and natural, particularly climatic, impacts (Sheppard, 2002). In Madagascar, the coral reefs act as a vital resource base for the growing coastal population (Cooke, 2001).

Coral reefs have the greatest diversity per unit area of any marine ecosystem with respect to higher taxa, which considering that marine waters are generally poor in nutrients and with low productivity is highly significant. Reefs are crucial on a global scale too, whereby calcium is taken up and bound into coral reefs in the form of calcium carbonate using huge quantities (approximately 700 billion kilograms of carbon per year) of carbon dioxide (Nybakken, 2001). Tropical reefs are formed from deposits of calcium carbonate produced primarily by hermatypic corals (phylum Cnidaria, class Anthozoa, order Scleractinia). Most hermatypic corals are colonial, consisting of individual polyp animals occupying corallites in the hard skeleton. Corals are thought to be primarily phototrophic (Wellington, 1982), for inside the polyps are minute symbiotic plant cells known as zooxanthellae that photosynthesise organic compounds, which, along with prey items caught in their nematocyst studded tentacles, provide sufficient nutrition for growth and recolonisation.

The number of threats faced by today's coral reefs is cause for considerable concern. Natural damage includes physical breakage caused by storms (Nybakken, 2001); predation by organisms such as the crown of thorns starfish (*Acanthaster plancii*) which has had a devastating impact on the Great Barrier Reef, Australia, at various times (Moran *et al.* 1992); salinity changes, such as freshwater influxes; coral bleaching, which probably reflects stress from many underlying causes such as climate change, for corals can only survive in a narrow temperature band of approximately 20-30°C (Maharavo, 1998; Norse, 1993; Nybakken, 2001). Elevated temperatures caused by the El Nino Southern Oscillation of 1997-8 resulted in coral bleaching that was considered the single largest threat to coral reefs ever documented in East Africa (Hoegh-Guldberg, 1999). Recovery rates of affected reefs have proven variable, and are likely to be influenced by other synergistic threats as well as the need for conditions such as a nearby source of larvae for recolonisation, favourable water currents, and a sufficient time lapse between major disturbances (Nybakken, 2001). Anthropogenic impacts include pollution that encourages algal growth to compete with and dominate over coral species; deforestation and land clearance (a common practise in Madagascar when creating rice paddies) that augments soil erosion and sedimentation, which, if too much settles for the coral's ciliary mucous mechanism to rid themselves of it, reduces light levels significantly and kills the coral through preventing the zooxanthellae from photosynthesising; physical destruction such as anchor damage; and unsustainable fishing practises, such as dynamite fishing .

Fisheries are the principal source of income for Madagascar's coastal communities. Artisanal (motorised; lakana fiara) and traditional (paddle or sail; lakana. Fig. 5) fisheries in Madagascar target a full range of exploitable resources in both shallow and pelagic waters. Principally sought are finfish, elasmobranchs, marine mammals, sea turtles, crustaceans, cephalopods, gastropods and echinoderms. In southwest Madagascar the total number of fishers has doubled or tripled, (Gabrie *et al.* 2000).


Fig. 5. Traditional Fisherman

In 1986 the local consumption of fish in Toliara reached 559 tonnes, which is nearly twice the reported consumption in 1983 (Vasseur, P. et al, 1988; cited in OUCARE final report), and this increase has lead to a dramatic decrease in certain high value stocks, notably sharks, sea turtles and numerous gastropods. In 1991, the yield of the artisanal fishery was estimated at 12 tonnes per km² per year for the reefs of Toliara (Laroche, J. *et al.* 1995; cited in OUCARE final report), this corresponds to the reported yields of the overexploited lagoons of Mauritius, and the Philippines.

The current over fishing of key species may result in ecological shifts in reef benthic communities (Johnstone *et al.* 1998), such as algae dominated areas where herbivores are heavily targeted. Effective management plans for these fisheries hinge on sufficient data being available. Future monitoring of the extensive artisanal fishery is therefore vital. Effective sustainable management requires community involvement and integration between scientists, managers and users of reefs, as well as the critical data from baseline surveys and monitoring of the status of reefs. Unfortunately, coral reef surveys are costly in terms of human and financial resources and are therefore commonly a limiting factor for management.

Collaboration

The team worked principally with the Institut Halieutique et des Sciences Marines (IH.SM) of the University of Toliara, and collaborated financially and scientifically with Oxford University Coral Awareness and Research Expeditions (OUCARE). Also, 'Blue Ventures Conservation' provided crucial information and guidance, as well as a dive boat ('Alo Alo') to hire in the field.

We would not have been able to import the equipment into the country and deploy it to the research site nearly so easily without the help and advice of **Dave Razafinarivo, (pictured below).**

We were also given advice and have full support from the following:

- **Dr. Chris Inchley** – Institute of Cell, Animal & Population Biology (ICAPB), University of Edinburgh
- **Dr. Man Wai Rabenevanana** – Director of the Institut Halieutique et des Sciences Marines, Madagascar.
- **Dr. Terry Dawson** - Senior Research Fellow with the Environmental Change Institute and team leader of the Ecology and Biodiversity Research Programme, at the University of Oxford.
- **Chlöe Webster** – Research and Project Coordinator of Frontier Operations, Madagascar, BP143, Toliara 601, Madagascar. frontiermadagascar@yahoo.co.uk
- **Andrew Cooke (pictured right)** – Former advisor for Marine Conservation, Food and Agriculture Organisation (FAO), Madagascar. He is currently a director of RESOLVE Consulting (advisory service in law and natural resources management) in Antananarivo, Madagascar.

Dissemination of results

- A hard copy of the final report is to be given to all major supporters of the expedition; to the IH.SM and Edinburgh University Darwin Library. An electronic version will be available on request, and depending on its size and feasibility, a copy will also be made available on the EUCARE website (www.eucarenet.com).

- A copy of raw data files will be archived with the IHSM with permission for their use as and when required, such as for addition to database(s) of coral reef status in Madagascar and East Africa, future IHSM studies, reports and publications.

EUCARE TEAM MEMBERS

Anna Lewis (21): Co-Leader / Treasurer
PADI Divemaster

Anna is a direct entry Zoology student now in her honours year at Edinburgh University, whose experiences of diving in a variety of conditions and enthusiastic participation in the 2002 Zanzibar expedition as Survey Coordinator provided her with the necessary background to co-lead the 2003 expedition to Madagascar. Anna's involvement with the expedition stems from a deep interest in marine biology and a great concern for the fast depleting reef ecosystems. She learnt to dive in 1997 in the Red Sea at Sharm-el-Sheikh, Egypt, and has since dived in Koh Toh, Thailand, the Great Barrier Reef, Scotland and Zanzibar, where, following the completion of the expedition, she worked for two months as a PADI Divemaster for 'Sensation Divers' based in Nungwi. She has also gained many experiences from travelling in Africa, Australia, S.E.Asia, Indonesia, North and South America and Europe. In 2002, members of the N.Berwickshire Lifeboat Association awarded her a Level 2 Powerboat-handling Certificate. She holds an up-to-date PADI Medic First Aid certificate and Oxygen Administration certificate, and completed Wilderness Medical Training (in conjunction with RGS/IBG) Part I prior to departure. Anna is also a keen photographer and musician of the French horn, alto saxophone and piano, playing for the Edinburgh University Symphony Orchestra and Symphonia. Apart from sections otherwise specified, she wrote this report and took the photographs.

Languages: French, German

Elizabeth Prins (23): Co-leader / Medical Officer
PADI Divemaster

Elizabeth is a 3rd year Biological Sciences student at Edinburgh University planning to take Zoology honours. In December 2002 she was a key research diver in EUCARE's Project Fiordland, which sent a team of divers to South Island, New Zealand to survey the largest known population of black coral in the world. Elizabeth has dived extensively throughout the world, particularly on the Great Barrier Reef and Australia's East Coast, and has dived in New Zealand, Hawaii, the USA and Scotland. Elizabeth's travels have taken her around Australasia, the USA, Europe, Africa and Asia. In 2000 she worked for five weeks, whilst in Namibia, with wildlife vets at the Africat Foundation, Okonjima. In 1996 she gained vital orienteering experience whilst hiking in the Rockies, Montana, and in 1999 Elizabeth completed her Gold 'Duke of Edinburgh Award' whilst hiking in the Drakensburg Mountains, Lesotho. She holds RYA Competent Crew Certificate, which she gained after a voyage on board the *STS Sir Winston Churchill* on return from the Tall Ships Race, on passage from Gothenburg to Dover in 1997, and in 2002 members of the N.Berwickshire Lifeboat Association awarded her a Level 2 Powerboat-handling Certificate. She undertook Wilderness Medical Training (in conjunction with RGS/IBG) Parts I & II and renewed her PADI Medic First Aid qualification and Oxygen Administrating certificate prior to departure. She is also secretary of Edinburgh University Polo Club.

Languages: French, Italian and Spanish

Hannah Dunstan (25): Survey Coordinator
PADI Rescue Diver

Hannah completed a triple major in ecological sampling and environmental toxicology, molecular and cellular biology, and applied microbiology before moving from Australia to the UK, which she now uses as a base for travelling around Europe and North Africa. She is currently working in the ICMB at the University of Edinburgh on the discovery and function of the starch proteome. She is a PADI Rescue diver with six years experience. She has dived in Indonesia, the Red Sea and Australia, which is where she gained experience in surveying coral reefs after partaking in a reef-monitoring program in Queensland. She also holds the PADI Medical First Aid certificate.

Languages: Basic French, Spanish and Indonesian

Dominic Jones (21): Communications Officer
PADI Rescue Diver

Dominic is now a 4th year History honours student at Edinburgh University with long-term interests in overseas aid and development. Having lived and travelled extensively in South East Asia and Africa, he has first hand knowledge of coral reef depletion and its effects. Dominic has dived in Borneo, Thailand, Indonesia and Egypt, and has a particular interest in underwater photography. He is also a member of the university's swimming team. In attaining his Duke of Edinburgh's Gold Award, he took part in an Inner Cities Young People's Project, which developed valuable interpersonal skills, and achieved first-aid and Bronze Medallion lifesaving qualifications. He hopes that his involvement in the project will further his interests in sustainable development and international cooperation. He took the PADI Rescue Diver course, PADI Medic First Aid and Oxygen Administering course in June, prior to departure.

Languages: English, Spanish, French

Ryan Knowles (27): Mechanic/IT Technician
PADI Divemaster

Ryan has a degree in scientific photography specialising in underwater UV. He is currently working as a website developer in Glasgow. Ryan started diving at the age of 12 and has been a PADI Divemaster for 9 years. He has worked as a professional diver in Australia and has dived around Australia, Fiji, Indonesia and the Red Sea. He holds various equipment servicing certificates. Since returning from the USA, where he worked as a graphics instructor, Ryan has worked as a website developer and computer network developer. Ryan is an avid rock climber and hill walker, and enjoys a passion for photography. He is also a compulsive traveller. He is medically trained to St. John's Level 1.

Languages: Basic French and Spanish

Matthew Linnecar (22): Dive Officer
PADI Divemaster

Matthew is a geography undergraduate at Edinburgh University, planning to continue his studies further in Marine Conservation. He has dived throughout South East Asia, the Caribbean and Scotland and is qualified as a PADI Divemaster. In 2000 Matt spent 3 months working as a research diver on a marine conservation project in Honduras. He was Science Officer on an exploratory diving expedition in 2001 to Southern Madagascar. In the EUCARE expedition to Zanzibar in July 2002, Matt undertook the role as Diving Officer with great skill and commitment, and ensured a high level of safety throughout the project. His responsibilities included overseeing that all diving standards were met and strictly maintained, supervising underwater surveys, and co-ordinating research dives on offshore coral reefs. He has been essential in keeping a strong socio-economic vein to this year's expedition, with dedicated and thorough research outlined in his report below. Matt holds up-to-date medic first aid qualifications, practical rescue management qualifications, oxygen administration qualifications, and DAN oxygen administration specifically for diving related injuries qualification.

Languages: fluent French

Adrian Mylne (20): Science Officer
PADI Rescue Diver

Adrian is a direct entry student, now in his 3rd year Biological Sciences at Edinburgh University. His enthusiasm for marine conservation is ever apparent, and he is an experienced diver, having undertaken a 10-week expedition to Fiji in 2002 with Greenforce, undertaking similar research methodologies towards data collection of the reef's status. He has dived extensively in a variety of conditions and has a good deal of fundraising experience. In addition, his hobbies include swimming, having competed since the age of 16, karate, squash and rugby. He took the PADI Rescue Diver course, PADI Medic First Aid and Oxygen Administering course in June, prior to departure.

Languages: Basic French

Anna Philips (22): Media Officer
PADI Rescue Diver

Anna completed a Zoology Honours degree at Edinburgh University, and is now doing Masters at the School of Tropical Medicine in London. She has undertaken a variety of expeditions, including working with tigers for a year in 1999 in India and tracking Orang-utans in Borneo, 2001. She has dived in Thailand, Indonesia and Egypt, and has a wide range of fieldwork experience relevant to the data collection methodologies to be used in Madagascar. She is trained as an RLSS Qualified Lifeguard and has a passion for photography, with some underwater experience. She took the PADI Rescue Diver course, PADI Medic First Aid and Oxygen Administering course in June, prior to departure.

Languages: Fluent English and French; basic Hindi, German and Spanish

IH.SM TEAM MEMBERS

Man Wai Rabenevanana

Director of the Institut Halieutique et des Sciences Marines
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Jean-Charles Lope

Lope is currently undertaking PhD studies in Fort-Dauphin.
E-mail : lopejcharles@yahoo.fr

Jasper Andriamanantsoa

Age :	29
Nationality :	Malagasy
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Tel :	33 (0) 6 71 33 79 78 261 (0) 032 40 024 25

STUDIES AND DIPLOMAS :
2003-04 : Current studies in "Aménagement du territoire"- IUP, University of Lorient (France).
2003 : "Diplôme d'Etudes Approfondies" in Applied Océanography – Theme : Biology and ecology of oyster *Crassostrea cucullata* (Born, 1778) and prefeasibility of oyster aquaculture in Toliara area (S.W. Madagascar) - IH.SM, University of Toliara.
1999 : "Attestation d'Etudes Approfondies" in Applied Oceanography.
1998 : "Maîtrise" in Marine biology researches – IH.SM, University of Toliara.
1997: "Licence" in Natural Sciences– Faculty of Sciences, University of Toliara.
1994: "Baccalauréat" (Scientific option) – Lycée Betroka.

TRAININGS AND ACTIVITIES :
2003-04 : Current training in Responsible of Aquaculture farming – CEMPAMA, Beg-Meil (France).
2003 : Histological studies of gonadal development of oster *Crassostrea cucullata* in Toliara area.
2003 : Reef survey in andavadoaka area with EUCARE project.
2003 : Founder and President of the IEC (IH.SM English Club).
2003 : Scientific guide in the "Mesée de la Mer" Rabesandratana-IH.SM Tolliara.
2002 : Reef survey and creation of artificial site for coral larvea settling in Anakao and Ifaty with Reef-Doctor.
2002 : Socio-economic studies in Ankilibe and Sarodrano for a future aquaculture activity.
2002 : Vice-Director of C.O.U.T NGO.
2001 : President of an Association of Bara students - University of Toliara.
2001 : Underwater sampling of coral reef speaces for a laboratory determination – Anakao.

2001 : Oyster beds studies in Toliara area.
2001 : Scuba diving traning. Frontier - Madagascar.
2000 : Protection and valorisation studies of Anakao Mangrove-Toliara.
2000 : Socio-économic fishery survey in Anakao-Toliara.
1999 : Quality control of halieutic products (fish, crustaceans, mollucs, etc...), IH.SM-Toliara.
1998 : Socio-economic studies in algoculture in Beravina-Toliara.
1998 : Socio-economic studies of lobster fisheries in Fort-Dauphin.
1998 : Hidrological and planctonic studies in Saline of Ankiembe and in the Great Reef of Toliara.
1997 : Several "travaux pratiques" in biology of Invertebrates and Vertebrates.

PROJECT :
2004-05 : - Settle and develop oyster farming in Fort-Dauphin area (Madagascar).
- Work for my PhD in oyster biology.

LANGUAGES :
Malagasy, French and English.

DIVERSE :
- I.T. : Word, Excel, Sphinx, .
- English certificate (High level).
- PADI Advanced Open Water Diver.
- Karate-ka : black belt.

Tsirivelo Ratovoson

Age : 28
Nationality : Malagasy
E-mail : rato_son@yahoo.fr

STUDY AND DEGREES :

Year	Classes	Degrees
2000-2003	5th and 6th year in the University of Toliara (IH-SM)	DEA (Master's degree) in Applied Oceanography
1998-1999	4th year in the University of Toliara (IH-SM)	Maîtrise in General Oceanography
1995-1998	1st , 2nd, 3rd year in the University of Toliara	Licence (Bachelor's degree) in Natural Sciences
1993-1994	High School	Baccalaureat (option : D)

SKILLS AND EXPERIENCES :

Marine biology and sea farming :
-Carried out a study about biology, ecology of Tropical Mussel, and the feasibility of mussel farming in the region of Toliara with ONE and IH-SM;
-Knowledge on phytoplankton farming and bivalve nursery.
Coral reef survey and coastal environment conservation :
-Fish and coral reef inventory in Ifaty and in Andavadoaka (Toliara) with EUCARE;
-Working with FRONTIER – Madagascar to sensibilise the fishermen in Anakao (Toliara) for coastal and marine environment conservation.
Socio-Economic Studies :
-Socio-organiser, certified by UNDP-Madagascar ;
-Participated on the establishment of Ambatosola PCD (Communal Development Plan) ;
-Socio-economical investigation into the fishermen of Toliara.
I.T. :
-Word, Excel, Sphinx, Internet
Languages :
-Malagasy, English and French
Diving :
- PADI Open Water diving certificate

FUTURE PLANS :
I want to work on marine activity (economic or environmental activity) in Madagascar and in parallel I will be carrying on my study : preparation of my Thesis on Marine Biology.

The Marine Science & Fisheries Institute (IH.SM) is a leading unit of the University of Toliara. It undertakes a wide range of educational, training and applied research work, including consulting services within Oceanography, Fisheries and Aquaculture.

In recent years, IH.SM has been involved in various environmental activities, such as Integrated Coastal Management.

The Institute offers a wide range of training courses dictated by the needs of the fishing industry and its administration, engineers, biologists (MSc, PhD) and qualified technicians.

Teaching is provided by about 25 teachers and visiting lecturers, who cover a wide spectrum of subjects ranging from fishing and aquaculture to Environmental Coastal Management.

Applied Research

The Institute's Applied Research includes:

Coastal Environmental Field Studies & Management: coral reefs, mangroves, seagrass beds, coastal erosion, marine parks and conservation, ecotoxicological and sewage problems and the impact of socio-economic activities and tourism.

Aquaculture: brine shrimp (*Artemia sp.*), algal culture (*Euchema spp.*), *Spirulina sp.*, Seacucumber (*Holothuria scabra*), Sea urchin (*Tripneustes gratilla*).

Marine Resource Assessment: rocky lobsters, marine turtles, sea cucumbers, crabs, elvers (*Anguilla sp.*), small pelagic fishes.

Fish Quality Assessment : HACCP (U.E norm.)

Biotechnology: Biogas, caragheenan (*Euchema sp.*).

Museum

A number of marine species have been accumulated over the years, including 60 floral and 600 faunal. In 1995 two specimens of coelacanthe fishes were added to the collection.

Training Achievements

1999-2003: 80 Biologist- Technicians
1984 –2003: 86 DEA
1987-1992: 50 engineers
1993-2001: 10 PhD
1994-2002: 110 MSc
1989-2000: 641 professional technicians
1995: 10 ecotourism guides

NODC
(National Oceanographic Data Centre)

Nominated last December 2000, the NODC for Madagascar is hosted by the institute and its activities are sponsored by UNESCO-IOC.

Collaboration

The institute collaborates with universities, organisations and private enterprises.

Universities: Laboratoire Ecologie Marine (University of La Reunion), ARVAM (La Reunion), University of Montpellier II, EUCARE (University of Edinburgh) ENSA de Rennes, Université Libre de Bruxelles (Belgium), University of Mons (Belgium), Aix-Marseille-III (France), STAVANGER University (Norway).

Organisations: National Program for Shrimp Research Activity (PNRC), IRD (La Reunion-Marseilles), CNRE (Mag), Frontier (UK), Blue Ventures (U.K); Reef Doctor (UK) , WWF-Mada, WCS, QMM.SA , School International Training (SIT/USA)… etc.

Fishing industry: *GEAPCM*
UNIMA/AQUALMA/ACB, AQUAMEN, REFRIGEPECHE (West & East), BIOMAD, COPEFRITO, SALINES d'IFATY.

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E-mail : manwai@dts.mg

Honouramy Team Members

Alexander Elphinstone (Elphie) – Blue Ventures Project Leader

He spent the majority of the expedition with the EUCARE and OUCARE teams to learn the ropes.

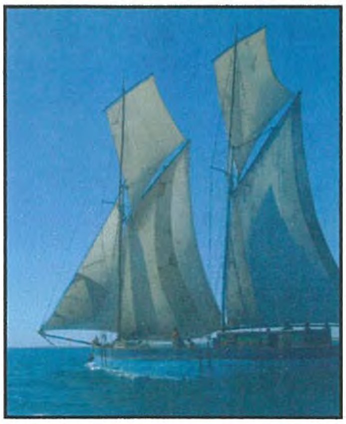
Pictured above with Matt and some ice cream.

Kiki, Coco Beach's 'pet' Ringtailed Lemur (*Lemur catta*)

Research Vessel & Driver

Initially, the EUCARE team used pirogues for reconnaissance (snorkelling) surveys...

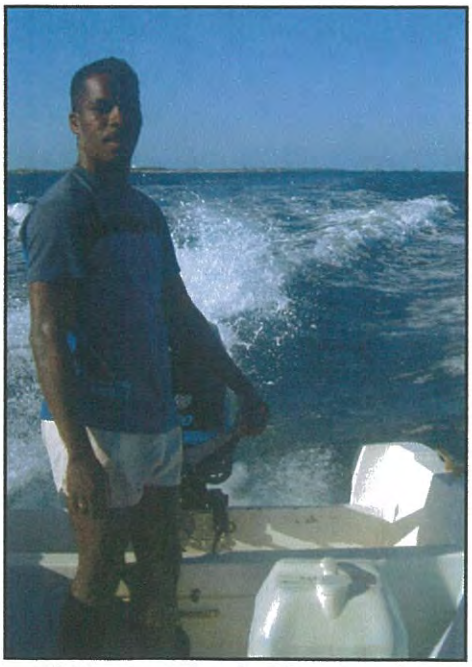
...We then used Olivier's boat...



... (joke!) until...

'AloAlo' (Malagasy for 'Barracuda') arrived with Elphie and Matt (pictured) on 22nd July.

Kindly provided for hire by Blue Ventures Conservation



Kalibra, our invaluable boat driver

Section 2

Fieldwork & Research

(i) Reconnaissance Surveys

Edinburgh University Coral Awareness
& Research Expeditions

Project Madagascar 2003

Materials & Methods

Our proposed methodologies were based on the AIMS Survey Manual (English *et al.* 1997) and Reef Check methods (www.reefcheck.org/methods.htm). However, after conferring with Andrew Cooke and the IH.SM scientists, we altered them slightly to correspond with those adopted by the IH.SM, specifically designed for reefs of the West Indian Ocean, always erring on the conservative and adhering to our safety protocol at all times (see Appendix 4).

(i) 'Time Zero' Reconnaissance Surveys

We had to first complete a series of reconnaissance surveys, as there was no available data or information describing location, type, or status of the reefs in the area. Local knowledge and an admiralty sound chart (Fig. 6 & 12) helped locate reefs ideally between 6 and 12m, though some were deeper. The EUCARE team carried out 11 reconnaissance surveys using a mixture of snorkelling and SCUBA diving depending on the reef depth. GPS points were taken for each site to aid in future relocation.

METHODS

- **Exploration Estimates** (as outlined by the IH.SM)

A number of surveyors (the higher the number of them the more powerful (human bias and error being diluted) the results) swim randomly about the site for exactly 5 minutes then write their estimate of percentage substrate cover using the codes outlined in Table 1. After completing this exercise the average of each substrate type is taken as an approximate quantification of the reef's health and state, and further comments added where necessary.

N.B. 'Debris' comprises dead and broken coral rubble (often the product of storms, reef walking or anchor damage).

DC	Dead Coral
DEB	Debris
CL	Living Coral
CA	Coralline Algae
AA	Algal Assemblage
SC	Soft Coral
RK	Rock
SA	Sand

Table 1. Codes used for Reconnaissance Exploration Estimates

- **Inventory**

Where possible, each surveyor also produces an inventory list of the fish and invertebrate (including coral) species seen and their approximate abundance according to the scale;

1-2	**= 1**
3-5	**= 2**
6-15	**= 3**
16-45	**= 4**
46+	**= 5**

'Seascape' by Dom Jones (unfortunately not an expedition photo. It was taken in Mozambique following project completion – see 'Limitations' below)

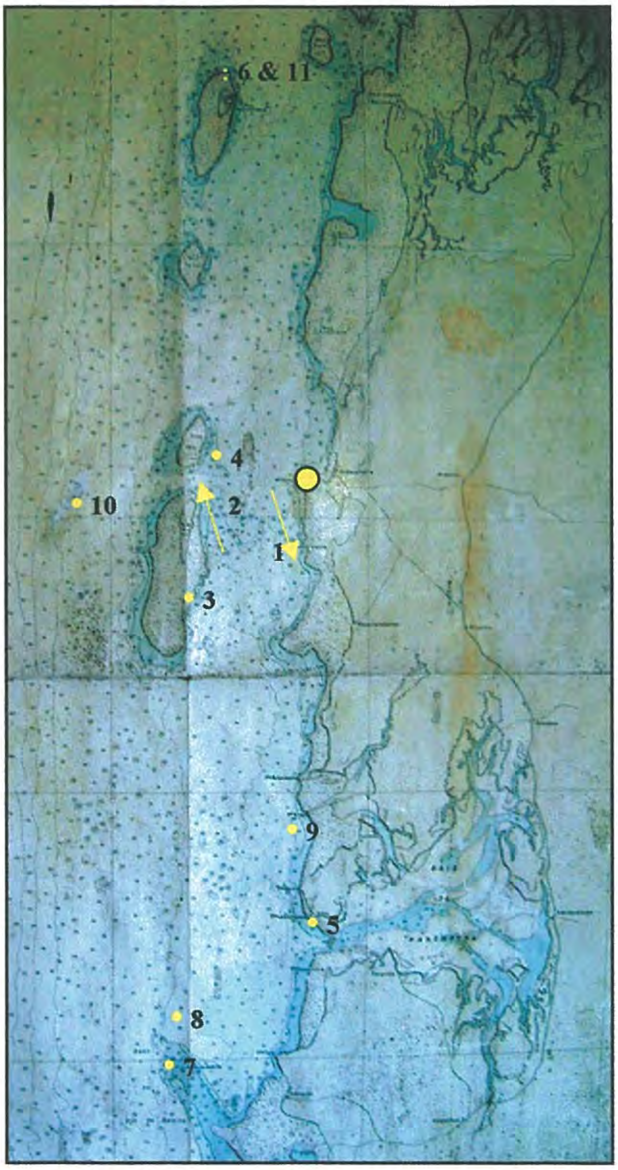
SITE DESCRIPTION

Site No.	Site Name
1	Ankareo (inner reefs of Andavadoaka)*
2	Nosy Hao / Nosy Fasy *
3	S. Nosy Hao
4	E. Nosy Fasy
5	Baie de Fanemotra
6	N. Nosy Andrahombava
7	Rock - S. Dos de Baleine
8	Baleine
9	N. Point Bevory
10	W of Nosy Hao
11	+ N. Nosy Andrahombava

* = snorkelled surveys (the rest were SCUBA dived)

Fig. 6. **SOUND CHART SHOWING (Approximate) LOCATION OF RECONNAISSANCE SURVEYS**

(17th July-5th August)



○ = Coco Beach Bungalows

INITIAL OBSERVATIONS

We unfortunately didn't find the reef (surveys 7 & 8) at Baleine as shown by results below (e.g. 100% SA), but were told that it is a particularly healthy reef that is frequented by whales, hence the name.

On first impressions, the inner reefs (1) and Nosy Fasy (2 & 4) had the unhealthiest coral reefs, with considerable physical damage and algae dominated.

The 'open ocean' sea mount (10) appeared to have the healthiest coral, and had a notably diverse and abundant array of fish and invertebrate species, though its depth (~23 – 28m) impeded it being chosen as a main (or permanent survey) site for logistical and safety reasons.

- **Table 2. EXPLORATION ESTIMATE AVERAGES FOR EACH SITE**

Site Number	1	2	3	4
Site Name	Ankareo	Nosy Hao / Nosy Fasy	S. Nosy Hao	Nosy Fasy
Date	17/07/2003	18/07/2003	20/07/2003	22/07/2003
GPS Position	22°05.471 S, 43°13.666 E	22°04.242 S, 43°11.528 E	22°07.463 S, 43°11.474 E	22°03.271 S, 43°11.810 E
DC	33.75%	45.00%	28.25%	27.50%
DEB	39.38%	25.00%	7.25%	56.50%
CL	6.25%	10.00%	13.75%	
CA		7.50%	20.83%	
AA	5.83%	5.00%	2.50%	7.50%
SC			10.75%	2.00%
RK			27.50%	
SA	16.25%	13.33%	15.00%	7.50%

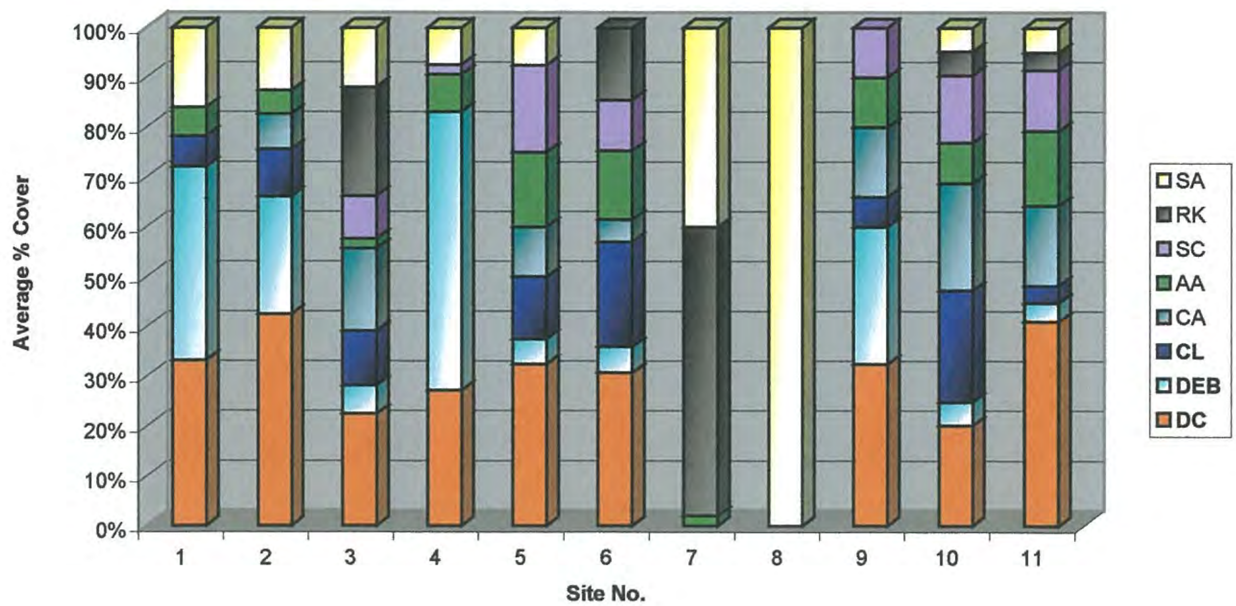
Site Number	5	6	7	8
Site Name	Baie de Fanemotra	N. Nosy Andrahombava	Rock - S. Dos de Baleine	Baleine
Date	24/07/2003	28/07/2003	02/08/2003	02/08/2003
GPS Position	22°12.726 S, 43°14.397 E	21°57.072 S, 43°11.623 E	22°15.301 S, 43°11.384 E	22°14.500 S, 43°11.499 E
DC	32.50%	31.88%		
DEB	5.00%	5.42%		
CL	12.50%	21.88%		
CA	10.00%	4.64%		
AA	15.00%	14.29%	2.00%	
SC	17.50%	10.63%		
RK		15.00%	58.00%	
SA	7.50%		40.00%	100.00%

Site Number	9	10	11
Site Name	N. Point Bevory	W. Nosy Hao	+ N. Nosy Andrahombava*
Date	02/08/2003	03/08/2003	05/08/2003
GPS Position	22°11.303 S, 43°13.534 E	22°04.681 S, 43°09.291 E	21°57.072 S, 43°11.623 E
DC	32.50%	21.00%	41.00%
DEB	27.50%	5.00%	3.75%
CL	6.00%	23.33%	3.50%
CA	14.00%	22.50%	16.00%
AA	10.00%	8.50%	15.00%
SC	10.00%	14.17%	12.25%
RK		5.00%	3.50%
SA		5.00%	5.00%

DC	Dead Coral
DEB	Debris
CL	Living Coral
CA	Coralline Algae
AA	Algal Assemblage
SC	Soft Coral
RK	Rock
SA	Sand

* Site 11 GPS position was not recorded. However, we dived approximately 10-20m due north from the previous survey site (6)

Fig. 7. Graph to Show Average Exploration Estimates of Recconnaissance Sites



- **INVENTORY DATA (Data displayed in Appendix 1)**

Inventories and relative abundance scores were made at a selection of the 11 reconnaissance sites. Where more than one inventory was produced out such as at the North of Nosy Andrahombava (6) and at the West of Nosy Hao (10), the average of abundance score was calculated (hence why there are not all whole numbers in Appendix 1).

Fig. 8. Barchart ShowingTotal Number of Different Fish Species Encountered at 6 Reconnaissance Sites

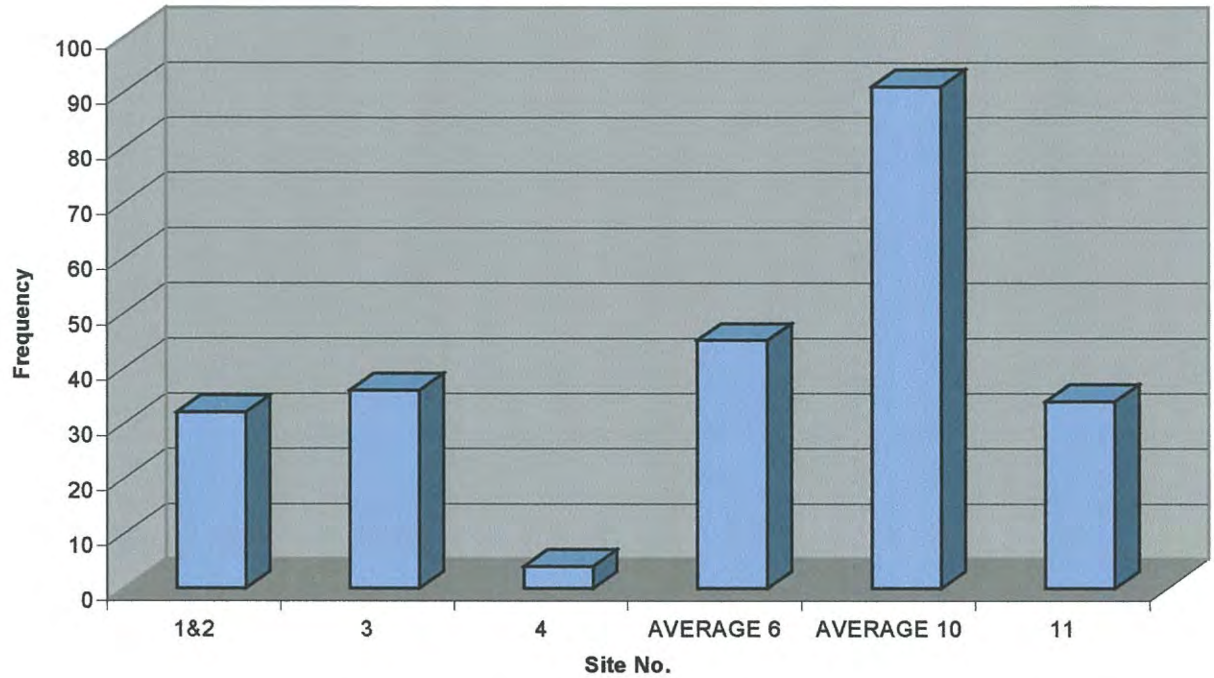


Fig.9. Abundance of Specific Fish Indicator Species on Reconnaissance Surveys Healthy Reef (+) / Absence due to High Fishing Pressures (-)

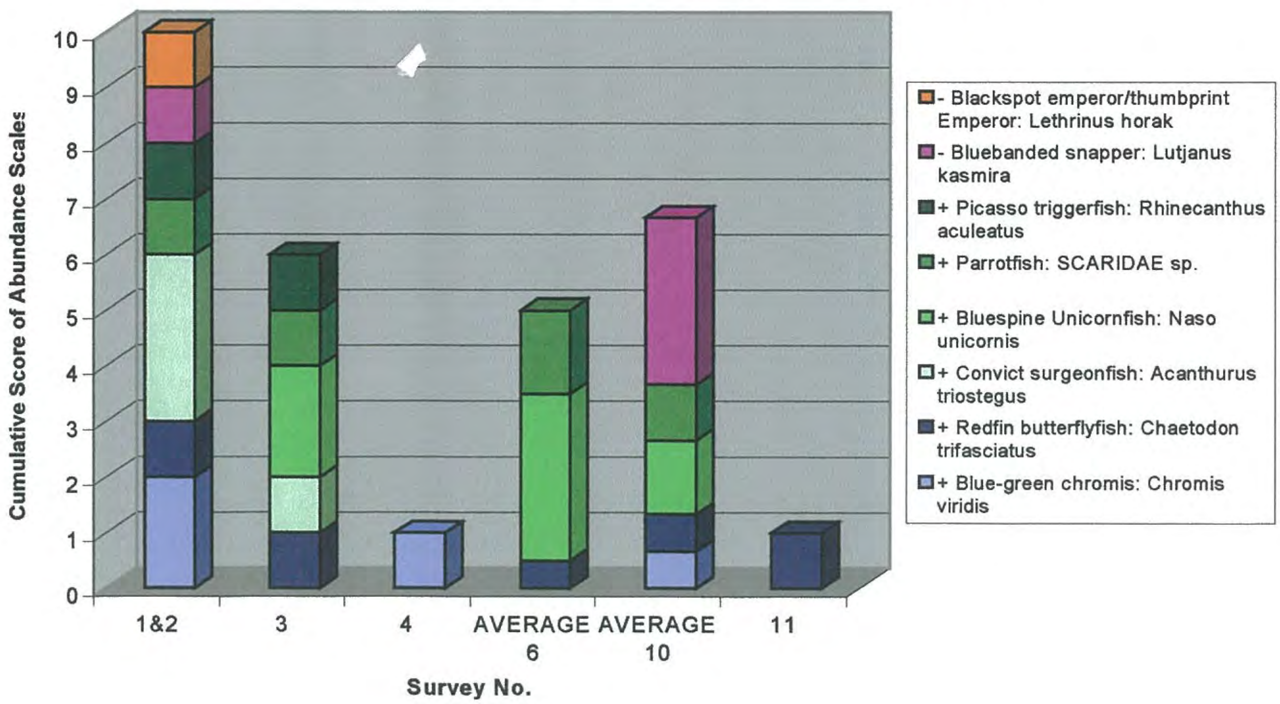


Table 3. ADDITIONAL RECONNAISSANCE DATA OBTAINED BY IH.SM SCIENTISTS:			Site No.	1&2 (snorkelling)	3 (diving)
			Location	Ankareo & Nosy Hao	South point - Nosy Hao
PHYLUM CNIDARIA; CLASS ANTHOZOA; SUBCLASS HEXACORALLIA					
ORDER SCLERACTINIA	**Acroporidae**	*Acropora*	*humilis*		1
(HARD CORALS)		*Acropora*	*sp.*		1
		Montipora	*sp.*		1
		Porites	*lobota*		1
		Porites	*nigresceris*	1	
	Agariciidae	*Pavona*	*cactus*	1	1
	Faviidae	*Favia*	*sp.*	1	1
		Favites	*sp.*	1	1
		Goniastrea	*sp.*		1
		Leptoria	*phlygia*		1
		Montastrea	*sp.*		1
		Platygyra	*daedalea*	1	1
		Platygyra	*sp.*	1	1
	Euphyllidae	*Physogyra*	*licheusteini*		1
PHYLUM CNIDARIA; CLASS ANTHOZOA; SUBCLASS OCTOCORALLIA					
SOFT CORALS	**Alcyoniidae**	*Lobophyton*	*sp.*		1
		Lobophyton	*venestum*	1	1
		Lobophyton	*crussum*	1	1
		Sareophytum	*sp.*	1	1
		Sareophytum	*geaucum*	1	1
		Sinularia	*sp 1.*		1
		Sinularia	*sp 2.*	1	1
		Sinularia	*abrupta*		1
PHYLUM RHODOPHYTA					
CORALLINE ALGAE		*Lithothamnion*	*sp.*	2	2
		Halimeda	*opuntia*	1	1
		Caulerpa	*sp.*	1	1
PHYLUM = multiple					
ALGAES		*Padina*	*gymnospora*	1	1
		Hyphea	*sp.*	1	1
		Galaxaura	elongata	1	1
		Tubinaria	*decurress*	2	2
		Thalaesodendron	*ciliatata*	1	
		Cynodocea	*serrulata*	1	
		Leptocesis	*sp.*	1	1
		Pocillopora	*verrucosa*	1	1
		Seratopora	*sp.*		1
		Stylophora	*sp.*		1

DISCUSSION (I)

The reconnaissance surveys provided us with sufficient information to make some basic assessments of the different reefs' health. They were vital in deciding where to carry out full survey work, though their scientific worth is open to speculation as there is undoubtedly a significant amount of surveyor bias /error. This will be particularly apparent on the exploration estimates, where percentage cover is based on opinion and can vary substantially with differing ability and experience. With more data it would be interesting to look into standard deviation values of exploration estimates for the same reef and perhaps see if sampling becomes more consistent over time as the amount of experience increases.

Exploration Estimates: Figure 7 shows the relative % cover of various benthos communities. It is interesting to note the high level of dead coral and debris at reefs closest to Andavadoaka, such as Ankareo (1) and Nosy Fasy (4), where fishing pressures such as fine mesh trawling and spearfishing for cephalopods at low tide, are high (based on personal observations and socio-economic research carried out. See below for report).

Living coral cover (Order *Scleractinia*) was relatively low throughout, though the deeper reefs at north Nosy Andrahombava (6) and west of Nosy Hao (10) had higher percentages of living coral. The minimal coral cover could be correlated with bleaching events as a result of elevated water temperatures, which are exacerbated in shallower water. This is discussed in more detail below (Part II). Site 11 was chosen to see if depth was having a substantial effect on living coral cover, and is situated just north of Site 6 at Nosy Andrahombava. In our surveys, Site 11 had a maximum depth of 20.7m verses 10-15m at Site 6. Surprisingly though, our reconnaissance survey showed Site 11 to have even less living coral than Site 6 (3.5% versus 21.88%). However, this could be that we simply missed the main part of the reef, as visibility was poor and it was too deep to view the reef before descending. One should not rule out the possibility of other variables affecting coral reef health. Another potential explanation for varying coral health is in anthropogenic activities. Even just 'eyeballing' the data above, a potential pattern emerges, whereby the reefs furthest from the village (Sites 6, 10, & 11) have generally the highest coral cover and number of fish species (Fig. 8).

Site 10 (approximately 2km off the west coast of Nosy Hao) is a seamount that slopes off steeply at the sides, making it notoriously difficult to locate, and relatively dangerous a site for potential surveys (depth of 22m - 25m+). It was our favourite reconnaissance site, with the highest living coral cover (23.33%) according to the exploration estimates and the highest number of fish species, which were on the whole noticeably larger than those seen elsewhere (Fig. 8).

Inventory: The abundance scale used to categorise numbers of fish simplified these results, but also took away some of the sensitivity of the analysis, whereby the difference in fish number between scales 1 & 2 (1-2 & 3-5 fish respectively) and 4 & 5 (16-45 & 46+ fish) is exponential and perhaps shouldn't be compared so readily. However, the scoring system is of less importance than the total number of species per site (Fig. 8) and key indictor species seen (Fig. 9), as these give more information as to fish diversity and reef health.

Figure 8 shows the number of fish species seen at six reconnaissance sites, and judging from this it would appear that the seamount (Site 10) is perhaps most diverse, followed by north Nosy Andrahombava (6 and 11), south Nosy Hao (3), the inner reefs around Andavadoaka (1 & 2), and lastly Nosy Fasy (4). However, there was little consistency in sampling methods for the inventories produced (e.g. looking for an equal amount of time per reef as with the 5 minute limit for exploration estimates), and more inventories were produced for 'popular' sites such as Nosy Andrahombava (6 & 11) and the seamount (10), so there is bound to be bias towards higher numbers of fish species encountered at these sites.

Figure 9 shows cumulative frequency of abundance scores for the key indictor species outlined by the IH.SM and detailed below in the 'Belt Transect methodology' section. Unexpectedly, the inner reefs around Andavadoaka (1 & 2) had the highest numbers of predatory fish species seen indicating relatively low fishing pressure, *Lutjanus kasmira* and *Lethrinus harak*. However, they also had the highest number of herbivorous fish such as *Chromis viridis* and *Acanthurus triostegus*, which when taken with the low scores for living coral and fairly high scores for algae cover would imply that they have been attracted to the plethora of algaes in the area. Presence of 'healthy' indicators on these unhealthy reefs is probably a result of unbalanced sampling and the pooling together of snorkelling sites 1 & 2, combined with high resilience to short term changes in substrate cover (Sheppard *et al.* 2002). It is later concluded that north Nosy Hao (Site 14 of the main surveys) had the healthiest reefs of all seen, so we perhaps encountered strays from this area.

Nosy Fasy (4), Nosy Hao (3) and Nosy Andrahombava (6 & 11) had none of the predatory fish indicator species, implying heavy fishing pressures here. The high numbers of snappers (*Lutjanus kasmira*) at the seamount (10) indicate that this is an area of low fishing pressure.

The three IH.SM scientists produced an inventory of coral and algae species encountered at Sites 1&2 and 3 (Table 3). Judging from the species and abundance scales described, there doesn't appear to be major differences between the sites, indeed, they almost overlap on the map. However, Table 3 shows a higher number of hard coral species at Site 3 (south Nosy Hao), plus the exploration estimates for living coral (1=6.25%; 2=10%; 3=13.75%) and debris + dead coral (1=73.13%, 2=70%, 3=35.5%) imply that the inner reefs are most impacted on and the least healthy.

Despite the obvious limitations of our sampling methods, the reconnaissance surveys provided us with valuable insight into the varying status of the reefs around Andavadoaka and its offshore islands. Our attempts at finding the reefs of Baleine were ill fated (Sites 5, 7 & 8), but the miscommunication with Kalibra as to its location meant we 'discovered' the reefs of Baie de Fanemotra. As a result we laid our first permanent transect there, for its position in the estuary opening and relatively shallow depth (6-10m) means it is vulnerable to impacts of sedimentation and bleaching events.

Section 2

Fieldwork & Research

(ii) Full Surveys

Edinburgh University Coral Awareness
& Research Expeditions

Project Madagascar 2003

(ii) Full Survey and Permanent Transect Methods

The entire survey length is **100m**, split in to **2x 50m lengths**. The central point (i.e. 50m into it) is classed as **point zero (See Fig. 11)**. This central position and the two end points were staked out for permanent surveying, taking care to hammer the iron stakes into previously dead coral. We tried to strengthen the stakes by placing plastic 2 litre bottles (with their base cut off) full of cement over the stakes, but with varying success. Either the cement was of particularly bad quality or we weren't very good at getting the correct mixture ratios, but we abandoned the cementing method on the second permanent transect (North Nosy Andrahombava) as we didn't wish to be one of the main factors attributing to sedimentation of the reefs! Permanent transects are marked with **coloured rope** running their length (with a different colour per 50m section) which can be viewed by snorkellers at the surface, and a surface marker buoy, such as a coloured plastic bottle attached to either the central or one of the end points.

METHODS

- **Line Intersept Transect (LIT)** (as outlined in English *et al.* 1997)

This technique is used to assess the sessile benthic community of coral reefs. They are characterised by lifeform categories (outlined below) and provide a quantitative description of the reef community and its morphology. Where possible (usually only with the IH.SM scientists) taxonomic information is given, though most of the surveyors were limited to identifying lifeforms and *Acropora* species. LIT allows reliable and efficient sampling by persons with limited experience in this field, and can provide valuable information about temporal changes. This is ideal for Andavadoaka's reefs as Blue Ventures Conservation is to carry on with research for sometime.

The LIT surveyor moves along the tape measure recording on a slate where the benthic lifeform changes to the nearest centimetre. The difference between transition points gives the total lengths of a different lifeforms and allows the calculation of percentage cover relative to total transect length.

Our LIT methodology followed 3 x 20m transects for each survey (outlined diagrammatically in **Fig.11)** from which a summarised % cover for '**hard corals, *Acropora* species, abiotic substrata** (including sand, rock, dead coral), **soft corals, algae** (including coralline algaes, fleshy algaes, Halimeda and sea grass) and **other** (such as tunicates)' per site allows for simple future comparisons. Also, we staked out permanent transects at **Baie de Fanemotra**, **Nosy Andrahombava** (EUCARE); and **Nosy Fasy** (OUCARE) so that future replicates and comparisons can be made with increased ease and accuracy.

LITs (T1-3) were carried out from point zero as outlined in Fig.11, with a 10m gap between T1 and T2.

Fig. 10. LIT procedure, courtesy of www.aims.gov.au

- **Belt Transect**

FISH VISUAL CENSUS is performed as diver 1 lays the line for the full 100m length so as to avoid disturbance. Species and abundance is noted for the entire 100m line for fish 2m either side, above and below it.

Particular significance was given to **key indicator species** (as recommended by the IH.SM);

- Indicators of a well-balanced, healthy reef include the herbivorous species, **Convict Surgeonfish (*Acanthurus triostegus*), Blue-Spine Unicornfish (*Naso unicornis*), Picasso Triggerfish (*Rhinecanthus aculeatus*), Bluegreen chromis (*Chromis viridis*) and Dick's damselfish (*Plectroglyphidodon dickii*)**
- Further indicators of a healthy reef include the corallivorous species, **Redfin butterflyfish (*Chaetodon trifasciatus*)**, and **Parrotfish (species of the family Scaridae)**.
- **Bluebanded / Yellowlined Snapper (*Lutjanus kasmira*)**, **Blacktip / Red-Banded Grouper (*Epinephelus fasciatus*)** and **Thumbprint Emperor (*Lethrinus harak*)** are all predatory fish and their absence is indicative of high fishing pressures.

INVERTEBRATE VISUAL CENSUS

The OUCARE team also used a belt transect for invertebrate surveying. They recorded invertebrate species and abundance 1m either side of the line along the three 20m LIT sections.

- **Quadrats for invertebrate surveying**

The EUCARE team employed the methodology for invertebrate surveys outlined by the IH.SM. This involves recording the invertebrate species and abundance within each of 3 x $1m^2$ quadrats randomly placed in each of the three 20m LIT sections (NB. only 1 section is shown in Fig.11). In addition, the invertebrate surveyor records percentage cover of 'Living coral, dead coral, algal assemblage (similar to 'turf' on the LIT codes), coralline algae, debris, rock and sand (LC, DC, AA, CA, DEB, RK, SA respectively) within each quadrat.

DIAGRAM OF TRANSECT DESIGN

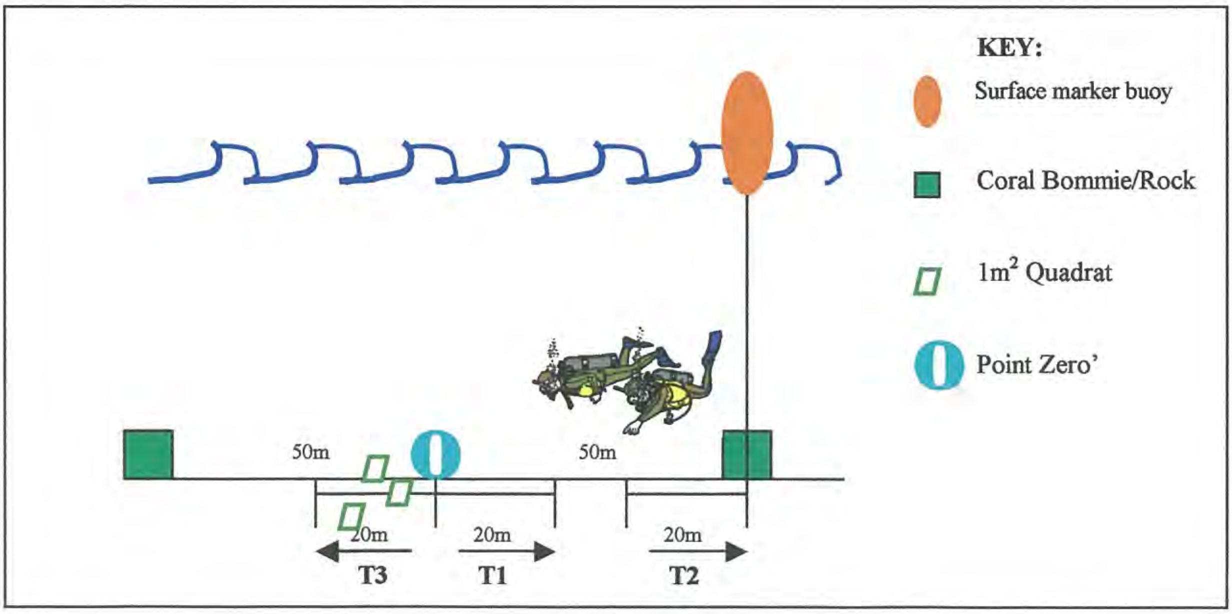


Fig. 11. Diagram of transect design employed by the EUCARE team 2003 (Pair of divers courtesy of http://www.abyss.com.au)

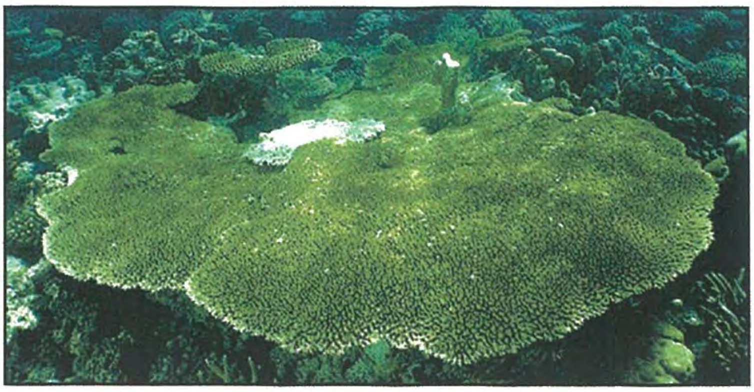
Table 4. LIT CODES

ABIOTIC SUBSTRATA	
RS	Small pebbles, rocks and /or coral rubble
RL	Large pebbles, rocks and /or coral rubble
SH	Shells
BRSH	Broken shells
SA	SAC = coarse sand
SA	SAF = fine sand, SA = sand
SI	Silt
DCB	DEAD coral - recently dead - bleaching,
DCR	DEAD coral - recently dead - other damage e.g.: anchor
DCO	Older dead - covered with other life form (encrusting algae, fleshy algae, hydroids)
RK	Rock/ hard substrate (e.g. solid fused parts of reef)
HARD CORAL	
CMT	Massive
CB	Branching
CC	Columna
CD	Digitate
CF	Foliate
CT	Plate/Tabulate
CE	Encrusting
CMR	Free living = 'mushroom'
(*Acropora* species have an additional 'A' is added to the start of the code.)	
OTHER	
SC	Soft corals
CME	Fire coral (millepora)
OTG	Gorgonians - fans, sea whips
OTH	Hydrozoa including hydroids etc
T	Turf -hydroids, algaes etc all mixed together
ZO	Zooanthids
SP	Sponges
OTT	Tunicates (sea squirts)
FA	Fleshy algae
HA	Halimeda and other calcareous algae
EA	Encrusting coralline algae
SG	Seagrass

PHOTOS OF LIFEFORMS (Courtesy of Jurg Brand unless specified otherwise)

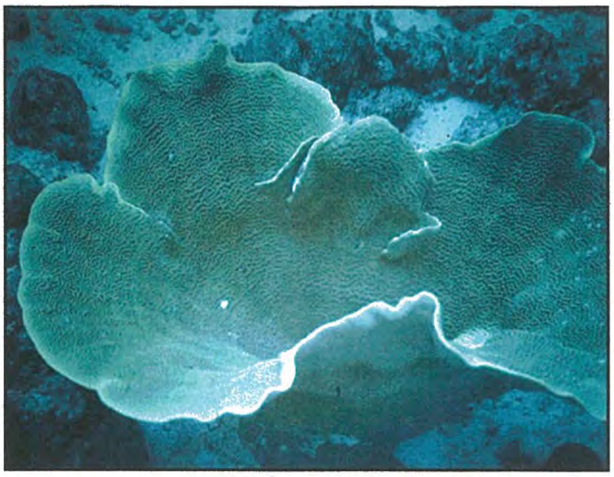
Acropora **- Digitate (ACD)**

Acropora **- Branching (ACB)**

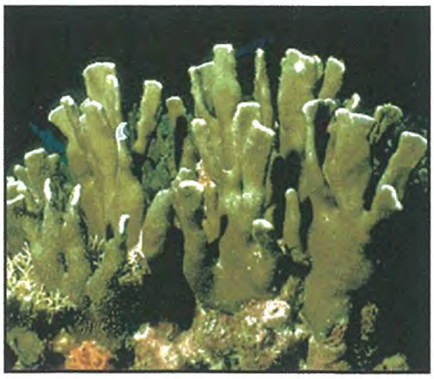


Acropora - **Tabulate (CT)**

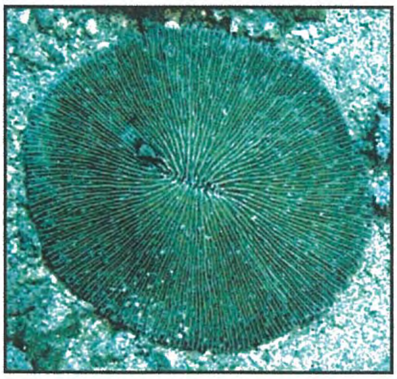
Coral Massive (CMT)



Foliate Coral (CF)



***Acropora* – Columnar (ACC)**



Mushroom Coral (CMR)

Encrusting Coral (CE)

Soft Coral - *Lobophytum* sp. (SC)

Soft Coral - S*arcophyton* sp. (SC)

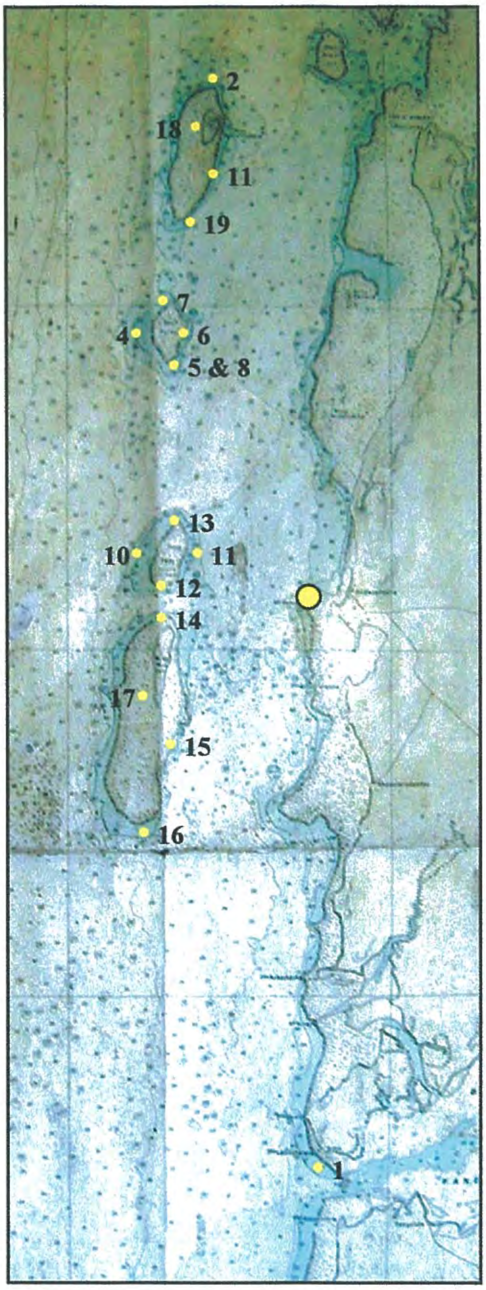
(The two pictures of soft coral courtesy of the OUCARE team 2003)

SITE DESCRIPTION

Site No.	Survey Description		GPS Position	
	Bearing	Area	South	East
1	-	Baie de Fanemotra *	22 12.726	43 14.397
2	N	Nosy Andrahombava *	21 57.072	43 11.623
3	-	Baie de Fanemotra (replicate) *	22 12.726	43 14.397
4	W	Récif Parson	22 00.546	43 10.921
5	S	Récif Parson	22 01.058	43 11.621
6	E	Récif Parson	22 00.676	45 11.773
7	N	Récif Parson	22 00.106	43 11.210
8	S	Récif Parson (replicate)	22 00.912	43 11.360
9	E	Nosy Andrahombava	21 57.330	43 12.544
10	W	Nosy Fasy	22 03.665	43 11.145
11	E	Nosy Fasy	22 03.689	43 11.939
12	S	Nosy Fasy *	22 04.268	43 11.621
13	N	Nosy Fasy	22 03.536	43 11.850
14	N	Nosy Hao	22 04.606	43 11.591
15	E	Nosy Hao	22 05.430	43 11.777
16	S	Nosy Hao	22 06.204	43 11.748
17	W	Nosy Hao	22 5.502	43 10.610
18	W	Nosy Andrahombava	21 07.305	43 11.600
19	S	Nosy Andrahombava	21 59.088	43 11.679

* = Permanent transect laid

Fig. 12. **SOUND CHART SHOWING (Approximate) LOCATION OF MAIN SURVEY SITES**
(26th July-30th August)



= Coco Beach Bungalows

Anna P & Anna L preparing to dive (Baie de Fanemotra [1], 26th July)

RESULTS

- **Table 5. Line Intercept Transects (See Appendix 6 for EUCARE raw data)**

Survey Completed	25.07.03	06.08.03	
Location	**BAIE DE FANEMOTRA**		**AVERAGE**
Site No.	**1**	**3**	
HARD CORALS	33.48%	23.67%	28.58%
ACROPORA	0.00%	0.33%	0.17%
ABIOTIC	58.32%	63.35%	60.83%
SOFT CORALS	7.53%	3.55%	5.54%
ALGAE	0.73%	4.75%	2.74%
OTHER	0.48%	6.27%	3.38%

Survey Completed	01.08.03	**OUCARE**			
Location	**NOSY ANDRAHOMBAVA**				
Bearing	**N**	**S**	**E**	**W**	**AVERAGE**
Site no.	**2**	**19**	**9**	**18**	
HARD CORALS	28.62%	33.67%	9.42%	33.00%	26.18%
ACROPORA	3.35%	1.67%	0.00%	0.00%	1.26%
ABIOTIC	55.60%	28.17%	79.58%	34.00%	49.34%
SOFT CORALS	5.63%	24.17%	1.83%	20.83%	13.12%
ALGAE	1.69%	12.33%	5.33%	11.17%	7.63%
OTHER	5.11%	0.00%	3.83%	1.00%	2.49%

Survey Completed	**OUCARE**				
Location	**NOSY HAO**				
Bearing	**N**	**S**	**E**	**W**	**AVERAGE**
Site no.	**14**	**16**	**15**	**17**	
HARD CORALS	32.92%	4.83%	0.00%	15.33%	13.27%
ACROPORA	2.83%	3.00%	0.00%	0.00%	1.46%
ABIOTIC	48.00%	76.33%	100.00%	60.00%	71.08%
SOFT CORALS	8.58%	2.33%	0.00%	14.67%	6.40%
ALGAE	0.00%	13.25%	0.00%	10.00%	5.81%
OTHER	7.67%	0.25%	0.00%	0.00%	1.98%

Survey Completed	**OUCARE**				
Location	**RÉCIF PARSON [NOSY MASAI]**				
Bearing	**N**	**S**	**E**	**W**	**AVERAGE**
Site no.	**7**	**5&8**	**6**	**4**	
HARD CORALS	28.50%	9.33%	1.50%	26.92%	16.56%
ACROPORA	0.00%	0.92%	0.00%	0.00%	0.23%
ABIOTIC	19.00%	50.79%	75.67%	10.25%	38.93%
SOFT CORALS	20.00%	2.29%	14.17%	22.58%	14.76%
ALGAE	14.67%	36.58%	8.00%	11.08%	17.58%
OTHER	17.83%	0.08%	0.67%	29.17%	11.94%

Survey Completed	**OUCARE**				
Location	**NOSY FASY**				
Bearing	**N**	**S**	**E**	**W**	**AVERAGE**
Site no.	**13**	**12**	**11**	**10**	
HARD CORALS	3.00%	1.67%	0.00%	4.00%	2.17%
ACROPORA	0.17%	0.00%	0.00%	0.00%	0.04%
ABIOTIC	94.33%	95.50%	54.42%	49.33%	73.40%
SOFT CORALS	2.17%	0.00%	0.50%	0.75%	0.86%
ALGAE	0.00%	2.17%	45.08%	45.92%	23.29%
OTHER	0.33%	0.67%	0.00%	0.00%	0.25%

Fig. 13. Total % Cover of Benthos Communities from LIT Surveys at Baie de Fanemotra, Nosy Andrahombava, Nosy Hao, Récif Parson and Nosy Fasy

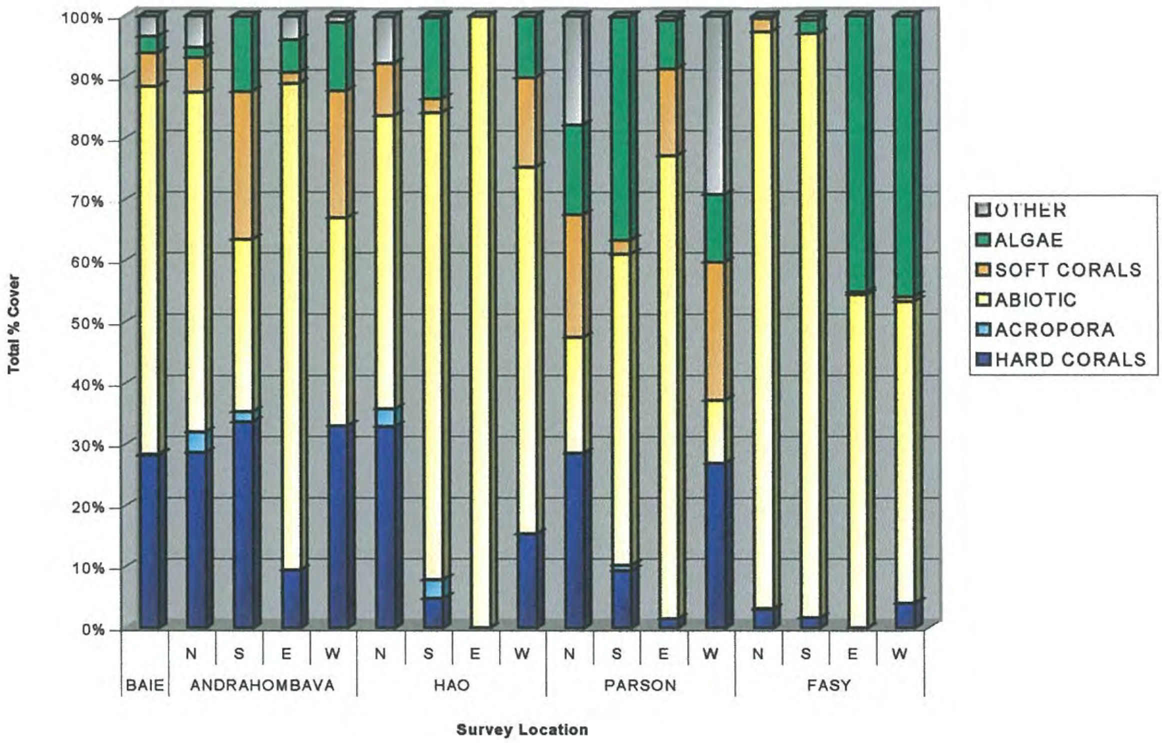
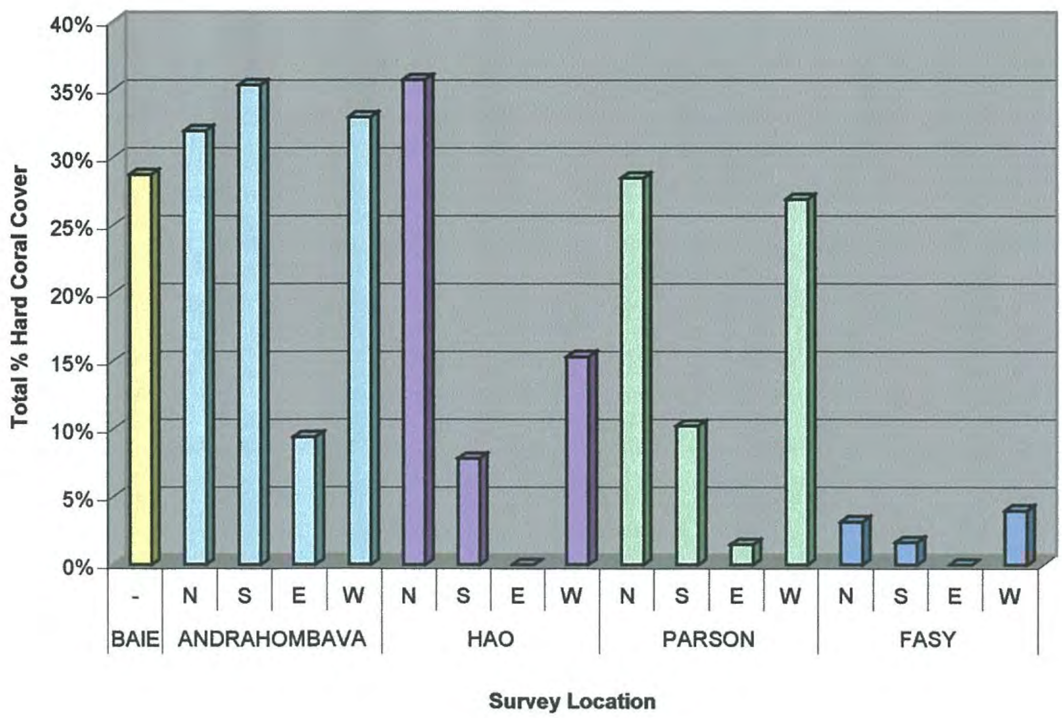
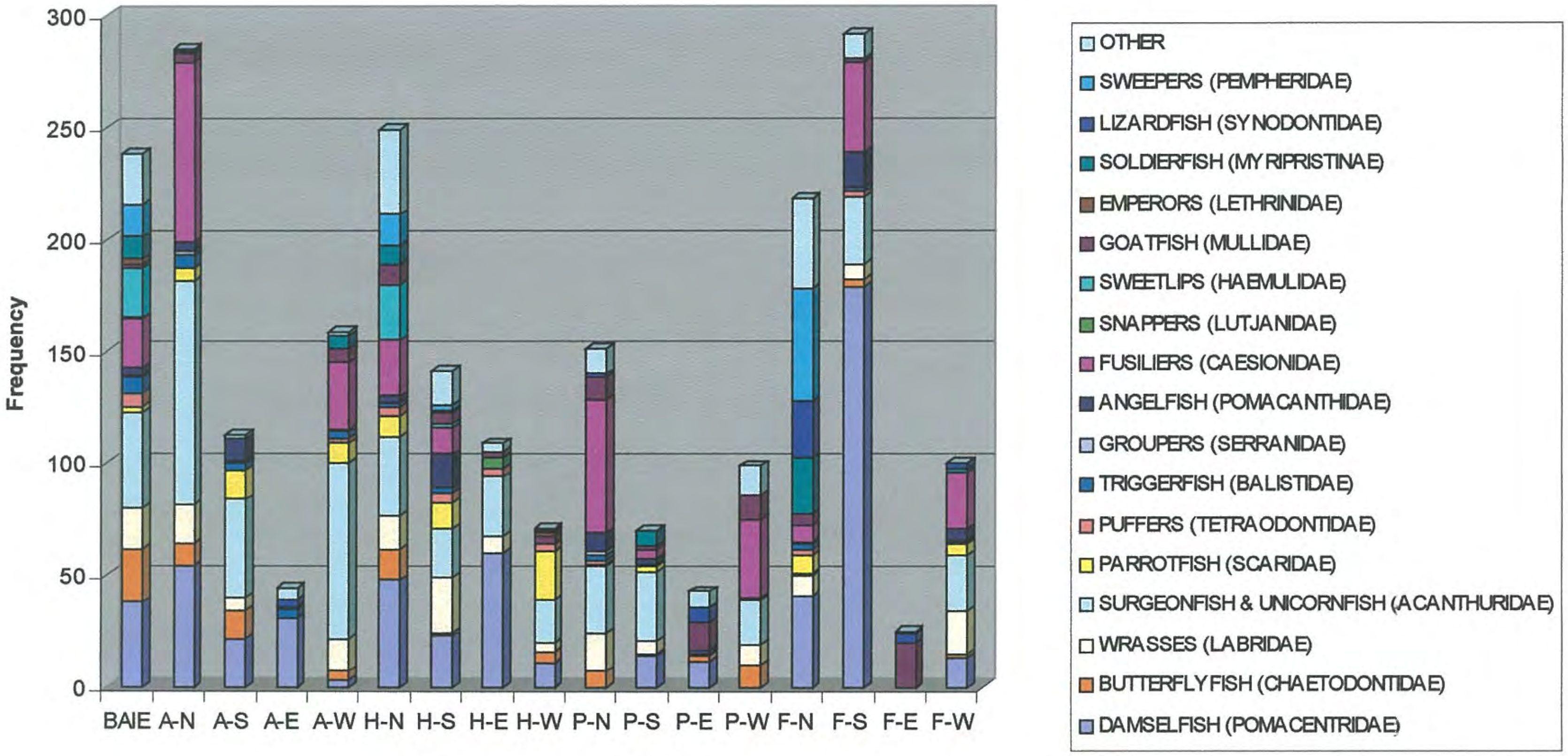


Fig. 14. Total % Hard Coral Cover from LIT Surveys at Baie de Fanemotra, Nosy Andrahombava, Nosy Hao, Récif Parson and Nosy Fasy



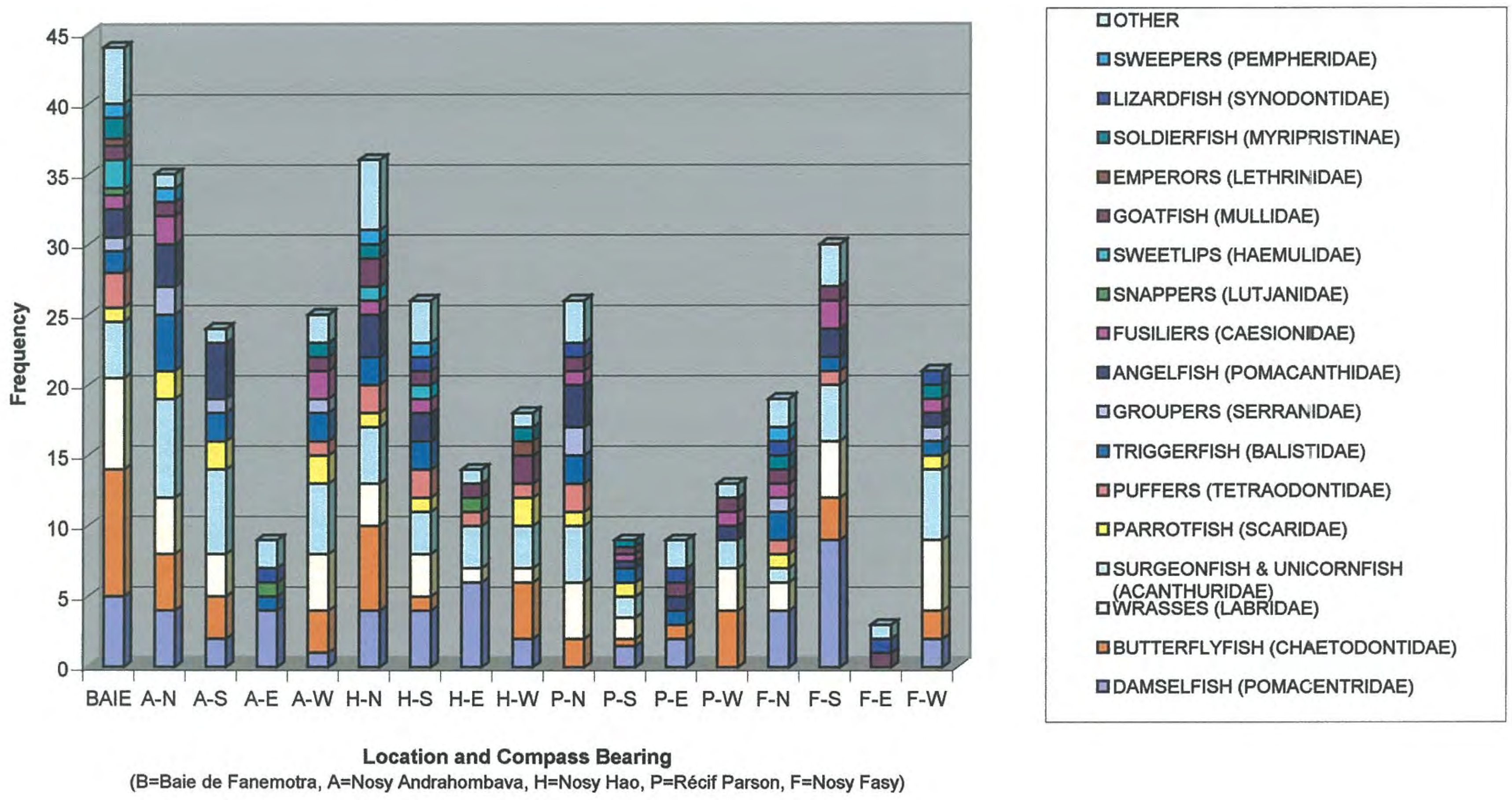
- **Fish Belt Transects** (Raw data can be viewed in Appendix 2, which also includes invertebrate survey data)

Fig. 15. Abundance (whole #) of Fish Belonging to a Selection of Families



Location and Compass Bearing
(B=Baie de Fanemotra, A=Nosy Andrahombava, H=Nosy Hao, P=Récif Parson, F=Nosy Fasy)

Fig. 16. Number of Species (whole #) Within a Selection of Fish Families



Comparison of Healthy Reef / Fishing Pressure Indicator Species

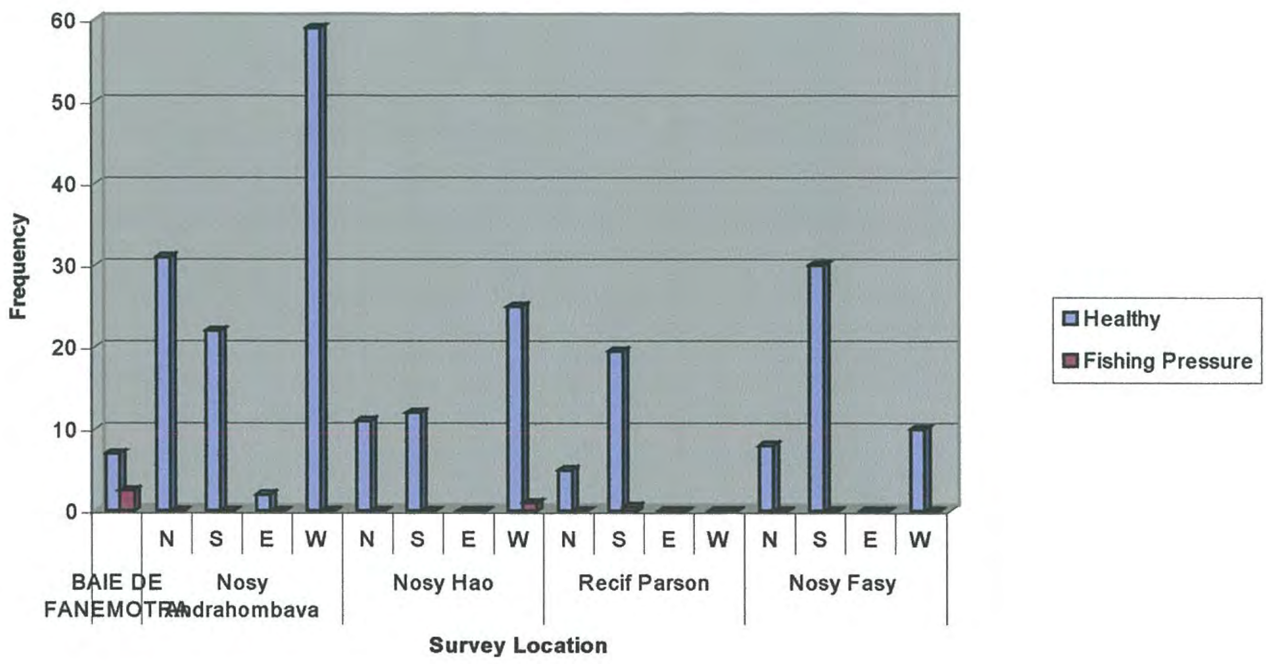


Fig. 18. Abundance of Specific Fish Indicator Species
Healthy Reef (+) [where present] / High Fishing Pressure (-) [where absent]

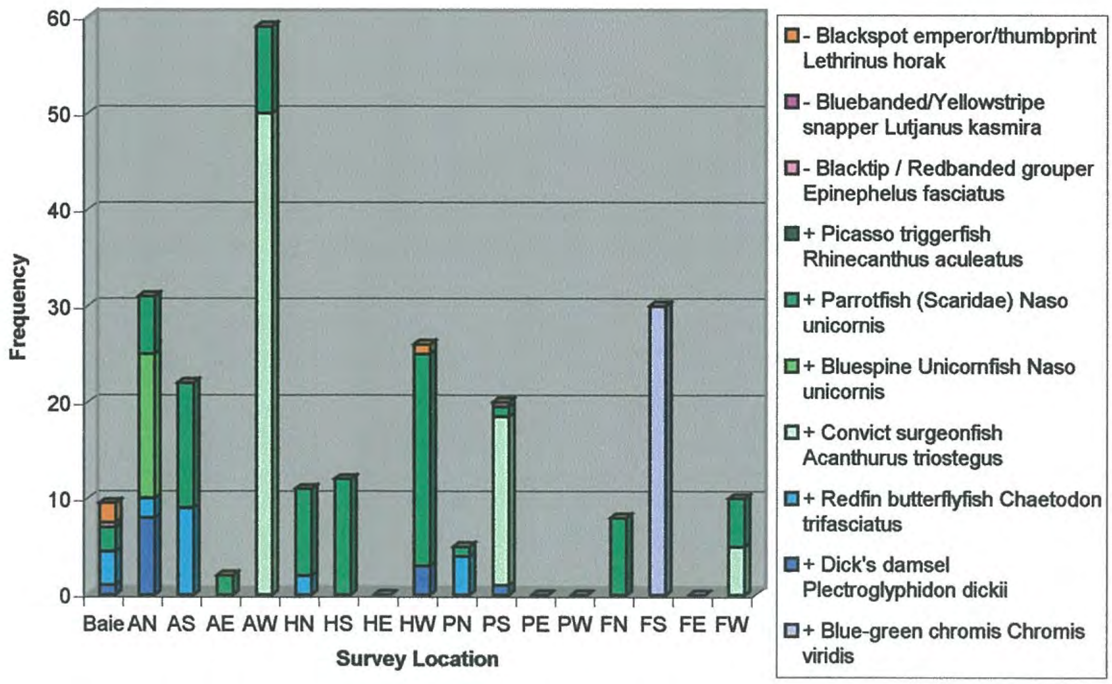


Table 6. FULL FISH INVENTORY
(EUCARE & OUCARE, RECCIES & SURVEYS)

DAMSELFISH (POMACENTRIDAE)		
Yellowtail sergeant	*Abudefduf*	*notatus*
Scissortail sergeant	*Abudefduf*	*sexfascialus*
False eye sergeant	*Abudefduf*	*sparoides*
Indopacific Sergeant	*Abudefduf*	*vaigieusis*
Skunk anemonefish	*Amphiprion*	*akallopiosis*
Seychelles anemonefish	*Amphiprion*	*fuscocaudatus*
Maldives anemonefish	*Amphiprion*	*nigripen*
Sebae anemonefish	*Amphiprion*	*sebae*
False Clown Anenomefish	*Amphiprion*	*ocellaris*
Madagascan Anenomefish	*Amphiprion*	*chrysopterus*
Twotone chromis	*Chromis*	*dimidiata*
Ternate chromis	*Chromis*	*ternatensis*
Blue-green chromis	*Chromis*	*viridis*
Humbug dascyllus	*Dascyllus*	*aruanus*
Indian dascyllus	*Dascyllus*	*carneus*
Threespot dascyllus	*Dascyllus*	*trimaculatus*
Creole damsel	*Pomacentrus*	*agassizi*
Baensch's damsel	*Pomacentrus*	*baenschi*
Carulean damsel	*Pomacentrus*	*caeruleus*
Sulphur damsel	*Pomacentrus*	*sulfureus*
Dick's damsel	*Plectroglyphido*	*dickii*
Jewel damsel	*Plectroglyphido*	*lacrymatus*
Pacific gregory	*Stegastes*	*fasciolatus*
Unknown	*Unknown*	*sp.*
BUTTERFLYFISH (CHAETODONTIDAE)		
Threadfin butterflyfish	*Chaetodon*	*auriga*
Bennett's butterflyfish	*Chaetodon*	*bennetti*
Saddleback butterflyfish	*Chaetodon*	*falcula*
Spotted butterflyfish	*Chaetodon*	*guttatissimus*
Klein's butterflyfish	*Chaetodon*	*kleinii*
Lined butterflyfish	*Chaetodon*	*lineatus*
Racoon butterflyfish	*Chaetodon*	*lunula*
Madagascar (redback)	*Chaetodon*	*madagascariensis*
Blackback butterflyfish	*Chaetodon*	*melannotus*
Meyer's butterflyfish	*Chaetodon*	*meyeri*
Latticed butterflyfish	*Chaetodon*	*rafflesi*
Chevroned Butterflyfish	*Chaetodon*	*trifascialis*
Redfin butterflyfish	*Chaetodon*	*trifasciatus*
Vagabond butterflyfish	*Chaetodon*	*vagabundus*
Yellowhead butterflyfish	*Chaetodon*	*xanthocephalus*
Zanzibar butterflyfish	*Chaetodon*	*zanzibariensis*
Longnosed butterflyfish	*Forcipiger*	*flavissimus*
Big longnosed butterflyfish	*Forcipiger*	*longirostrus*
Masked bannerfish	*Heniochus*	*monoceros*
Longfin bannerfish	*Heniochus*	*acuminatus*
WRASSES (LABRIDAE)		
Yellowtail wrasse	*Anampses*	*meleagrides*
Yellowbreasted/Twist's	*Anampses*	*twisti*
Axilspot hogfish	*Bodianus*	*axillarius*
Diana's hogfish	*Bodianus*	*diana*
Red banded wrasse	*Cheilinus*	*fasciatus*
Indian Ocean bird wrasse	*Gomphosus*	*caeruleus*
Bird wrasse	*Gomphosus*	*varius*
Checkerboard wrasse	*Halichoeres*	*hortulannus*
Barred thicklip wrasse	*Hemigymnus*	*fasciatus*
Bicolour cleaner wrasse	*Labroides*	*bicolor*
Cleaner wrasse	*Labroides*	*dimidiatus*
Ornate wrasse	*Macropharyngo*	*ornatus*
Twotone (Blunthead)	*Thalassoma*	*amblycephalom*
Hebrew (Goldbar) wrasse	*Thalassoma*	*hebraicum*

Six bar wrasse	*Thalassoma*	*jansenii*
Crescent (moon) wrasse	*Thalassoma*	*lunare*
Slingjaw wrasse	*Epibulus*	*insidiator*
Napoleon wrasse	*Cheilimus*	*undulatus*
Unknown	*Unknown*	*sp.*
SURGEONFISH & UNICORNFISH (ACANTHURIDAE)		
Orange socket surgeonfish	*Acanthurus*	*auranticaurus*
Eyestripe surgeonfish	*Acanthurus*	*dussumieri*
Powder blue surgeonfish	*Acanthurus*	*leucosternon*
Yellowfin surgeonfish	*Acanthurus*	*xanthopterus*
Blackstreak surgeonfish	*Acanthurus*	*nigricauda*
Eyestripe Surgeonfish	*Acanthurus*	*dassunieri*
Whitecheek surgeonfish	*Acanthurus*	*nigricans*
Thompson's surgeonfish	*Acanthurus*	*thompson*
Lieutenant surgeonfish	*Acanthurus*	*tennenti*
Convict surgeonfish	*Acanthurus*	*triostegus*
Twospot bristletooth	*Ctenochaetus*	*binotatus*
Goldring bristletooth	*Ctenochaetus*	*strigosus*
Striped bristletooth	*Ctenochaetus*	*striatus*
Humpback Unicornfish	*Naso*	*brachycentron*
Orangespine Unicornfish	*Naso*	*lituratus*
Bluespine Unicornfish	*Naso*	*unicornis*
Sailfin tang	*Zebrasoma*	*desjardinii*
Brushtail tang	*Zebrasoma*	*scopas*
Unknown	*Unknown*	*sp.*
ZANCLIDAE		
Moorish idol	*Zanclus*	*cornutus*
PARROTFISH (SCARIDAE)		
Bicolour parrotfish	*Cetoscarus*	*bicolor*
Blue humphead parrotfish	*Chlorurus*	*cyanescens*
Greenlip parrotfish-female	*Scarus*	*viridifucatus*
Russell's parrotfish	*Scarus*	*russelli*
Bullhead/Daisy parrotfish	*Scarus/chloruru*	*sordidus*
Unknown	*Unknown*	*sp*
PUFFERFISH (TETRAODONTIDAE)		
Crown toby (sharpnose	*Canthigaster*	*coronata*
Solander's sharpnose toby	*Canthigaster*	*solandri*
Bennett's sharpnose toby	*Canthigaster*	*bennetti*
Black saddled toby	*Canthigaster*	*valentini*
Star pufferfish	*Arothron*	*stellatus*
Black spotted pufferfish	*Arothron*	*nigropunctatus*
Spotted boxfish	*Ostracion*	*meleagris*
Unknown	*Unknown*	*sp*
TRIGGERFISH (BALISTIDAE)		
Indian triggerfish	*Melichthys*	*indicus*
Orange striped triggerfish	*Belistapus*	*undulatus*
Clown triggerfish	*Belastoides*	*consiculum*
Blue triggerfish	*Pseudobalistes*	*fuscus*
Picasso triggerfish	*Rhinecanthus*	*aculeatus*
Scythe triggerfish	*Sufflamen*	*bursa*
Titon triggerfish	*Balistoides*	*viridescens*
Wedge Triggerfish	*Rhinecanthus*	*rectangulus*
Flagtail (Halfmoon)	*Sufflamen*	*chrysopterus*
GROUPERS (SERRANIDAE)		
Peacock grouper	*Cephalophalis*	*argus*
Blacktip / Redbanded grouper	*Epinephelus*	*fasciatus*
Whiteblotched grouper	*Epinephelus*	*multinotatus*
Whitespotted grouper	*Epinephelus*	*caeruleopunctatus*
Brownmarbled grouper	*Epinephelus*	*fuscoguttatus*
Longspined grouper	*Epinephelus*	*longispinis*
Honey comb Grouper	*Epinephelus*	*merra*
Potato grouper	*Epinephelus*	*tukula*
Squaretail coral grouper	*Plectropomus*	*areolatus*

Spotted coral grouper	*Plectropomus*	*Maculatus*
Malabar grouper	*Epinephelus*	*malabaricus*
Lyretail grouper	*Varioloa*	*lonti*
Marbled coral grouper	*Plectropomus*	*punctatus*
Unknown	*Unknown*	*sp.*
ANGELFISH (POMACANTHIDAE)		
Manyspined/dusky angelfish	*Centropyge*	*multispinis*
Whitetail dwarf angelfish	*Centropyge*	*flavicanda*
Three spot angelfish	*Apolemichthys*	*trimaculatus*
Earspot angelfish	*Pomacanthus*	*chrysurus*
Emperor angelfish	*Pomacanthus*	*imperator*
Yellowbar angelfish	*Pomacanthus*	*maculosus*
Semicircle angelfish	*Pomacanthus*	*semicirculatus*
Regal/ royal angelfish	*Pygoplites*	*diacanthus*
FUSILIERS (CAESIONIDAE)		
Goldbanded fusilier	*Caesio*	*caerularae*
Yellowband fusilier	*Caesio*	*chrysozona*
Lunar fusilier	*Caesio*	*lunaris*
Yellowback fusilier	*Caesio*	*teres*
Yellowlined fusilier	*Caesio*	*varilineata*
Yellowback(scissortail)	*Caesio*	*xanthonota*
Twinstripe fusilier	*Pterocaesio*	*marri*
Bluestreak fusilier	*Pterocaesio*	*tile*
Unknown	*Unknown*	*sp.*
SNAPPERS (LUTJANIDAE)		
Red/Twinspot snapper	*Lutjanus*	*bohar*
Blackspot snapper	*Lutjanus*	*Fulviflamma*
Bluebanded/Yellowstripe	*Lutjanus*	*kasmira*
Lunulate snapper	*Lutjanus*	*lunulatus*
Bigeye snapper	*Lutjanus*	*lutjanus*
Humpback snapper	*Lutjanus*	*gibbus*
Onespot Snapper	*Lutjanus*	*Monostigma*
Bluestriped snapper	*Lutjanus*	*notatus*
SWEETLIPS (HAEMULIDAE)		
Silver sweetlips	*Plectorhinchus*	
Blackspotted sweetlips	*Plectorhinchus*	*gaterinus*
Diagonal banded sweetlips	*Plectorhinchus*	*linatus*
White barred sweetlips	*Plectorhinchus*	*playfairi*
Unknown	*Unknown*	*sp*
ANTHIASES (S/F ANTHIINAE)		
Threadfin anthias	*Nemanthias*	*carberryi*
Yellowback anthias	*Pseudanthias*	*evansi*
Lyretail (Scalefin) anthias	*Pseudanthias*	*squamipinnis*
MONOS (MONODACTYLIDAE)		
Mono	*Monodactylus*	*argenteus*
GOBIES (GOBIIDAE)		
Unknown	*Unknown*	*sp.*
GOATFISH (MULLIDAE)		
Dash and dot goatfish	*Parupeneus*	*barberinus*
Bicoloured goatfish	*Parupeneus*	*barberinoides*
Doublebar (barred) goatfish	*Parupeneus*	*bifasciatus*
Rosy goatfish	*Parupeneus*	*Rubescensis*
EMPERORS (LETHRINIDAE)		
Blackspot	*Lethrinus*	*horak*
Spangled emperor	*Lethrinus*	*nebulosus*
Unknown	*Unknown*	*sp*
SQUIRRELFISH (HOLOCENTRINAE)		
Crown squirrelfish	*Sargocentron*	*diadema*
Blackfin	*Neoniphon*	*opercularis*
Unknown	*Unknown*	*sp*
SPINE CHEEKS & MONOCLE BREAMS (NEMIPTERIDAE)		
Bridled threadfin bream	*Scolopsis*	*frenatus*
Arabian Spinecheek	*Scolopsis*	*ghanam*

RABBITFISH (SIGANIDAE)		
African Whitespotted	*Siganus*	*sutor*
Indian Coral Rabbitfish	*Siganus*	*corallinus*
SOLDIERFISH (MYRIPRISTINAE)		
Bigscale soldierfish	*Myripristis*	*berndti*
Bronze soldierfish	*Myripristis*	*adusta*
White edged soldierfish	*Myripristis*	*murdjan*
Whitetip soldierfish	*Myripristis*	*vittata*
Crimson soldierfish	*Myripristis*	*murdjan*
Unknown	*Unknown*	*sp.*
SCORPIONFISH (SCORPAENIDAE)		
Lionfish; turkeyfish	*Pterois*	*miles (volitans)*
Clearfin lionfish	*Pterois*	*radiata*
DARTFISH (MICRODESMIDAE)		
Fire dartfish	*Nemateleotris*	*magnifica*
Decorated	*Neruteleotris*	*decoratus*
Unknown	*Unknown*	*sp.*
MORAY EELS (MURAENIDAE)		
Balckspotted moray	*Gymnothorax*	*favagineus*
Unknown	*Unknown*	*sp.*
LIZARDFISH (SYNODONTIDAE)		
Indian lizardfish	*Synodus*	*indicus*
Reef lizardfish	*Synodus*	*variegatus*
Unknown	*Unknown*	*sp.*
BLENNIES (BLENNIDAE)		
Mozambique fangblenny	*Meiacanthus*	*mossambicus*
Bluestriped fangblenny	*Plagiotremus*	*rhinorhynchus*
SWEEPERS (PEMPHERIDAE)		
Vanicolo sweeper	*Pempheris*	*vanicolensis*
Schwenk's sweeper	*Pempheris*	*schwenkii*
Dusky sweeper	*Pempheris*	*adusta*
FILEFISH (MONOCANTHIDAE)		
Blacksaddle mimic filefish	*Paraluteres*	*prionurus*
Scrawled filefish	*Aluterus*	*scriptus*
Unknown		
SANDPERCHES (PINGUIPEDIDAE)		
Speckled sandperch	*Parapercis*	*hexaphthalma*
TRUMPETFISH (AULOSTOMIDAE)		
Trumpetfish	*Aulostomus*	*chinensis*
PIPEFISH (SYNGNATHIDAE)		
Banded pipefish	*Corythoichthys*	*intestinalis*
CORNETFISH (FISTULARIIDAE)		
Cornetfish	*Fistularia*	*commersonii*
?SETUREPANTS? (OUCARE)		
Indo-Pacific	*Unknown*	*sp*
FLATHEADS (PLATYCEPHALIDAE)		
Unknown sp	*Unknown*	*sp*
JACKS & TRAVALLYS (CARANGIDAE)		
Bluefin trevally	*Caranx*	*melampygus*
Big eye Trevally	*Caranx*	*sexfasciatus*
BARRACUDAS (SPHYRAENIDAE)		
Blackspot barracuda	*Sphyraena*	*forsteri*
REMORAS (ECHENEIDAE)		
Sharksucker	*Echeneis*	*naucrates*
STINGRAYS (DASYATIDAE)		
Bluespotted ribbontail ray	*Taeniura*	*lymma*

Table 7. FULL INVERTEBRATE INVENTORY		
(EUCARE & OUCARE, RECCIES & SURVEYS)		
Cone Shell	*Unknown*	*species*
Cone Shell	*Cornis*	*eburneus*
Cowrie Shell	*Cypraea*	*tigris*
Whelk	*Phos*	*senticosus*
Spindle Shell	*Pleuroploca*	*sp.*
Spider Shell	*Lambis*	*sp.*
Nudibranch	*Ardeadoris*	*egretta*
Nudibranch	*Phyllidia*	*coelestris*
Nudibranch	*Unknown*	*sp.*
Nudibranch	*Chromodoris*	*elizabethina*
Elongate Giant Clam	*Tridacna*	*maxima*
Unknown	*Unknown*	*sp.*
(Diadematidae) Regular urchin, intermediate-long black spines, dense and thicker than diadema sp.	*Echinothrix*	*diadema*
(Diadematidae) very long spined black urchin	*Diadema*	*setosum or savignyi*
Regular urchin	*Salmacis*	*bicolor*
Sea star	*Leiaster*	*species*
Blue Linckia	*Linckia*	*laevigata*
Brown Linckia	*Linckia*	*guildingii*
Crown of thorns starfish	*Acanthaster*	*planci*
Cushion star	*Cucita*	*schmideliana*
Star fish	*unknown*	*sp*
Feather star	*Unknown*	*sp.*
(Ophiuroidea) Brittle star	*Unknown*	*sp.*
	Topiometra	*sp.*
Sea cucumber	*Bohadschia*	*sp.*
Sea cucumber	*Holothuria*	*fuscopumctata*
Mantis Shrimp	*Unknown sp.*	
Lobster	*Unknown*	*sp.*
Vase sponge	*Unknown*	*sp.*
Sea squirt	*Unknown*	*sp.*
Polychaeta	*Unknown*	*sp. 1 & 2*
Tubeworm	*Sabellidae*	*sp.*
Flatworm	*Unknown*	*sp.*
Stinging hydrozoan	*Aglaophenia*	*cupressina*
Sea Anemone	*Heteractis*	*magifica*
Sea Anemone	*Stichodactylidae*	*sp.*
Sea Anemone	*Unknown*	*sp.*
Zooantharian	*Palythoa*	*sp.*
Zooantharian	*Protopalythoa*	*sp.*
Zooantharian	*Unknown*	*sp.*
Gorgonian Sea Fan	*Unknown*	*sp.*
Sea Whip	*Unknown*	*sp*
Green Algae	*Valonia*	*aegagropila*

- **Data Analysis**

(i) The different sampling methods for invertebrate surveys means that there will almost certainly be some bias between results. This will be considered in the discussion, but for simplicity they have been treated the same and compared with other sites. All EUCARE invertebrate data (Sites 1-3) or data calculated with this data is highlighted in orange to keep this in mind when interpreting results.

Table 8. Using the Shannon Index outlined in A.E.Magurran's book, 'Measuring Biological Diversity' the fish and invertebrate diversity (H) and evenness measures (J) were calculated;

Site No.	Fish H	Fish J	Invert H	Invert J	Hard Coral %	Algae %	Abiotic %
1&3	3.3109	0.8801	1.2269	0.5915	28.74	2.74	60.83
2	2.8550	0.8030	2.0681	0.7155	31.97	1.69	55.6
4	2.0338	0.7929	1.8933	0.8617	26.92	11.08	10.25
5&8	1.8109	0.8252	0.5623	0.8113	10.25	36.58	50.79
6	1.9325	0.8795	0.9503	0.8650	1.5	8	75.67
7	2.3270	0.7142	1.3322	0.9610	28.5	14.67	19
9	1.7236	0.8385	1.6609	0.9270	9.42	5.33	79.58
10	2.6099	0.8572	1.0397	0.9464	4	45.92	49.33
11	0.6005	0.5466	0.2712	0.3912	0	45.08	54.42
12	2.8619	0.8415	1.1732	0.8463	1.67	2.17	95.5
13	2.3966	0.8139	1.2215	0.5874	3.17	0	94.33
14	3.0919	0.8628	1.2725	0.7102	35.75	0	48
15	2.4332	0.9220	1.3954	0.7171	0	0	100
16	2.9197	0.8961	0.0000	0.0000	7.83	13.25	76.33
17	2.5251	0.8736	1.0397	0.9464	15.33	10	60
18	2.5364	0.7880	0.6931	1.0000	33	11.17	34
19	2.7920	0.8785	1.6300	0.9097	35.34	12.33	28.17
Min	0.6005	0.5466	0.0000	0.0000	0	0	10.25
Max	3.3109	0.9220	2.0680	1.0000	35.75	45.92	100
Mean	2.3977	0.8243	1.1430	0.7522	16.08	12.94	58.34

Key:

H	Shannon diversity index
J	Shannon evenness measure

The % values for Hard Coral, Algae and Abiotic substrate are taken from LIT surveys (shown above)

Fig. 19. Fish Diversity

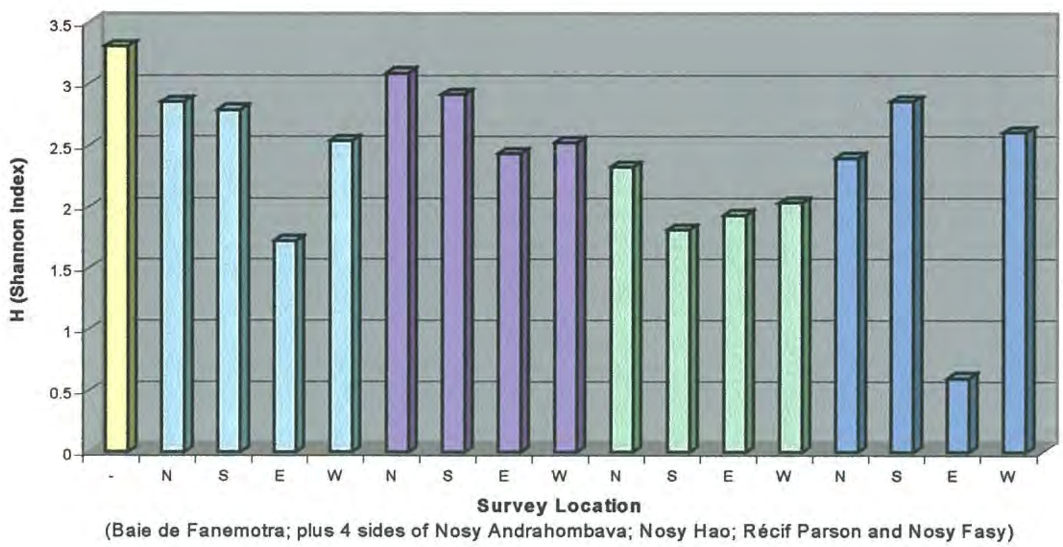


Fig. 20. Evenness Measure of Fish

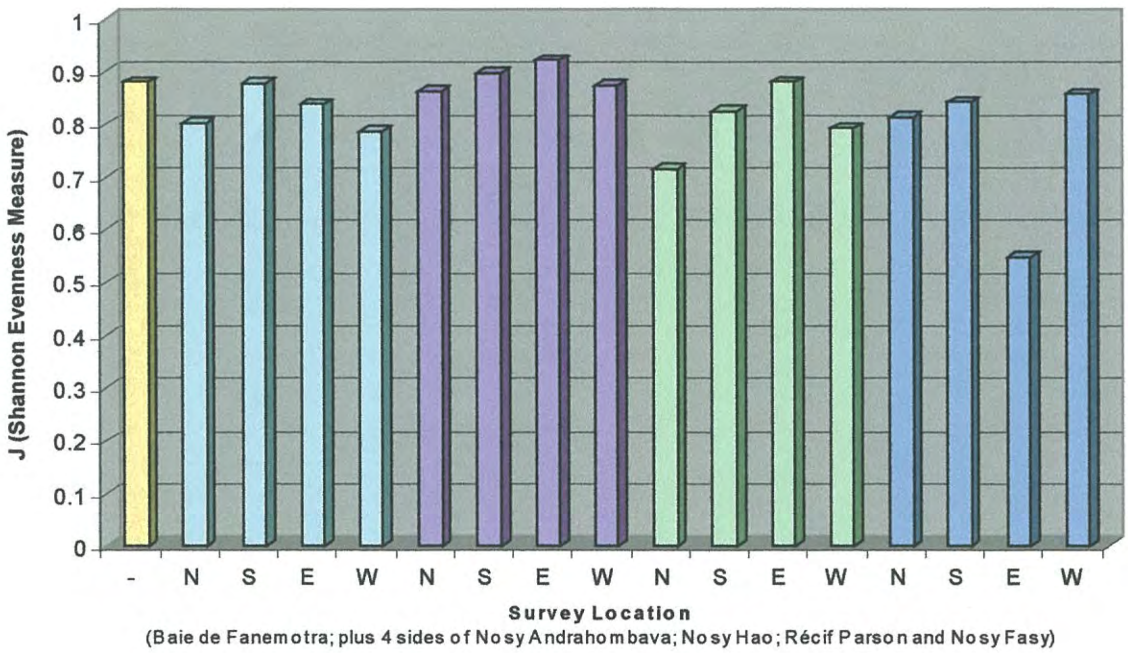


Fig. 21. Invertebrate Diversity

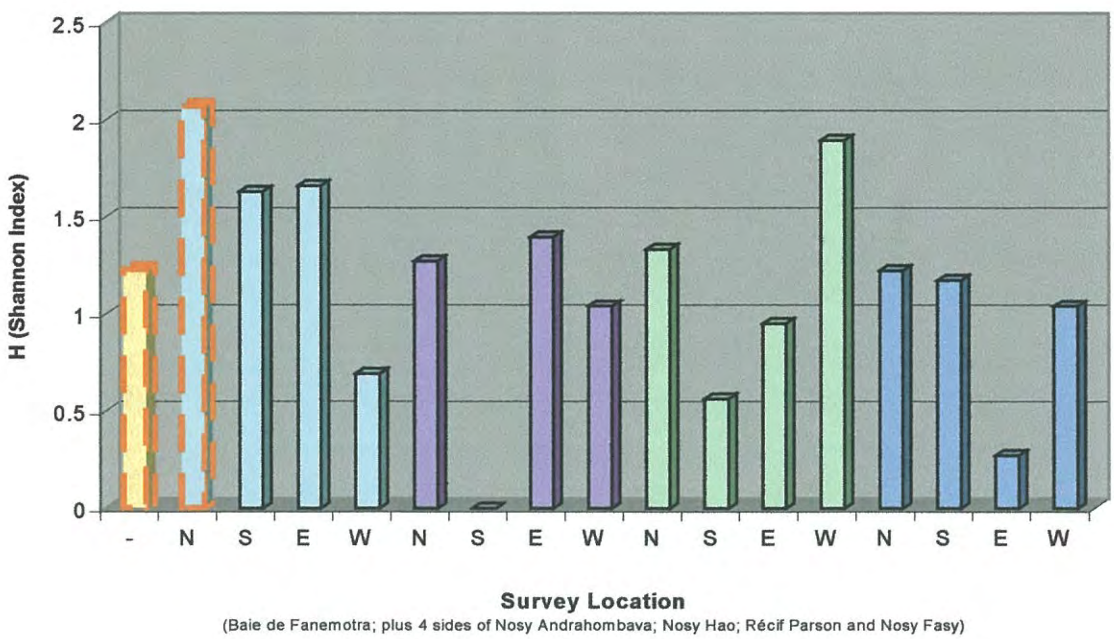
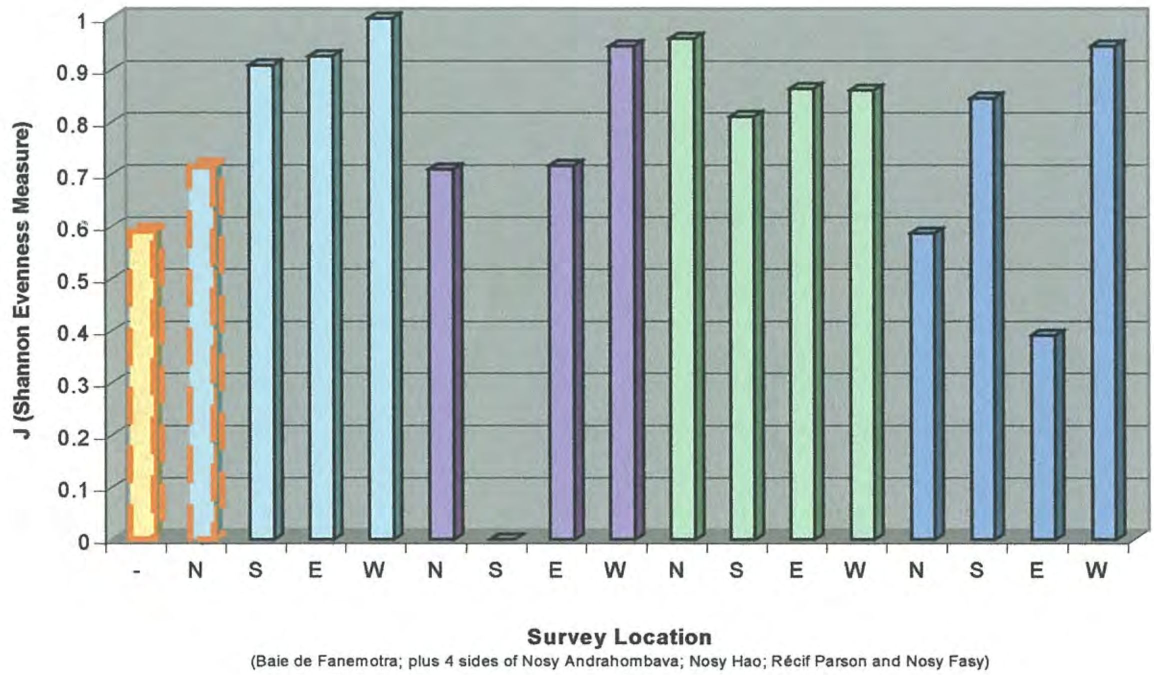


Fig. 22. Evenness Measure of Invertebrates



(ii) Despite the relative crudeness of this design (see Discussion II), the H and J values were ranked along with Hard Coral cover as signs of a 'healthy reef', while the negative values of algae and abiotic substrate were ranked as signs of an 'unhealthy reef' (Table 8). The reason for using the negative values for the 'unhealthy' variables was so they could be suitably combined with the other ranks, whereby the highest scores were consistently for the healthiest reefs (i.e. the highest H, J and % Hard Coral values combined with the lowest % Algae and Abiotic values).

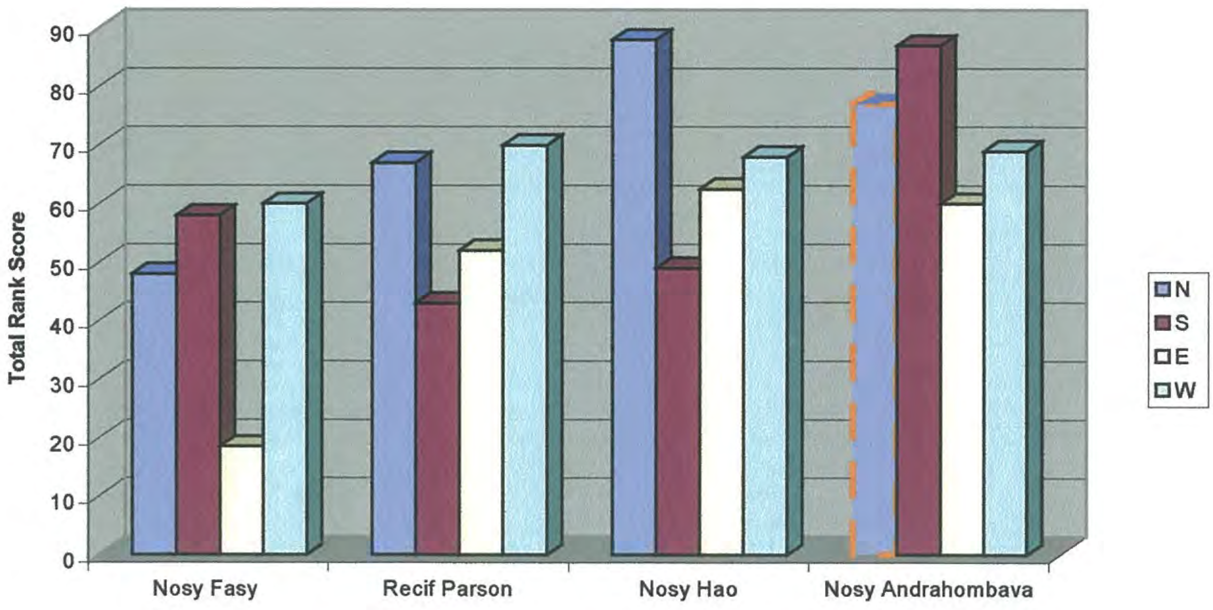
Table 9. Showing ranking scores of Diversity (H), Evenness (J) of fish and invertebrates, and Abiotic substrate and Algae cover

	Healthy					Unhealthy	
Site No.	**rank fish H**	**rank fish J**	**rank inv H**	**rank inv J**	**rank coral**	**rank abiotic**	**rank algae**
1&3	17	15	10	3	13	7	12
2	13	5	17	5	14	9	14
4	5	4	16	9	11	17	8
5&8	3	7	3	7	9	11	3
6	4	14	5	10	3	6	10
7	6	2	12	15	12	16	4
9	2	8	15	12	8	4	11
10	11	10	6.5	13.5	6	12	1
11	1	1	2	1	1.5	10	2
12	14	9	8	8	4	2	13
13	7	6	9	2	5	3	16
14	16	11	11	4	17	13	16
15	8	17	13	6	1.5	1	16
16	15	16	1	0	7	5	5
17	9	12	6.5	13.5	10	8	9
18	10	3	4	16	15	14	7
19	12	13	14	11	16	15	6

Table 10. Showing sums of ranks for 'Healthy' and 'Unhealthy' variables, and the subsequent ranking of the 4 compass bearings per islands, and the overall ranking of site.

Site No.	TOTAL (Healthy=h)	TOTAL (Unhealthy=u)	TOTAL (h+u)	Ranking (h+u)	Average (h+u)	Overall Ranking (Average h+u)	Bearing	Location
1&3	58	19	77	14.5	77	5	*	Baie de Fanemotra
2	54	23	77	14.5	73.25	4	N*	Nosy Andrahombava
19	66	21	87	16			S	
9	45	15	60	7.5			E	
18	48	21	69	12			W	
7	47	20	67	10	58	2	N	Recif Parson
5&8	29	14	43	2			S	
6	36	16	52	5			E	
4	45	25	70	13			W	
13	29	19	48	3	46.125	1	N	Nosy Fasy
12	43	15	58	6			S*	
11	6.5	12	18.5	1			E	
10	47	13	60	7.5			W	
14	59	29	88	17	66.875	3	N	Nosy Hao
16	39	10	49	4			S	
15	45.5	17	62.5	9			E	
17	51	17	68	11			W	
Key:	* = Permanent Transect							
Ranking Scores:	Highest = healthiest (h) ie. Highest Shannon index / evenness values and % living coral; and lowest % abiotic / algaes							
	Lowest = unhealthiest (u)							

Fig. 23. Rank Scores of 'Reef Healthiness' for the N, S, E & W Sides of the Four Offshore Islands



Survey Location (in order of increasing average rank score per site)

(iii) To see if there was a relationship between a selection of variables, 'Minitab' was used to calculate the Pearson Correlation and Regression Plot with line of best fit for Diversity (H) of fish and invertebrates compared to % cover of Hard Coral, Algaes and Abiotic substrate (detailed Regression Analysis given in Appendix 3).