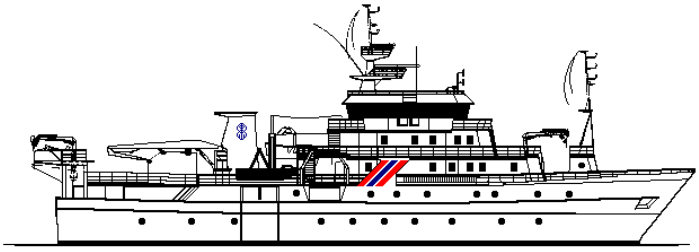

Mauritius Ecosystem Survey

ASCLME / FAO 2008 Cruise 2

04 - 07 October 2008

Preliminary report

Institute of Marine Research (IMR)
Norway

CRUISE REPORTS "DR. FRIDTJOF NANSEN"

Mauritius Ecosystem Survey

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Preliminary report

by

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Institute of Marine Research
Bergen, 2008

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1. INTRODUCTION

This survey is the second survey of the GEF funded "Agulhas and Somali Current Large Marine Ecosystem" (ASCLME) project. The survey is conducted jointly with the Food and Agriculture Organisation of the United Nations (FAO) Nansen Programme.

The main objective of fisheries surveys in the 1980s was to find new resources. Today, when most of the world's fish resources are located, and in many instances overexploited, the main focus is not on finding new resources, but to monitor the ecosystem and ensure that resource exploitation does not exceed the carrying capacity of the system. Hence an ecosystem approach - a holistic approach encompassing not only the targeted fishery species but the entire physical, chemical and biological environment - to the management of marine resources is advocated.

This new baseline will enable the countries within the region to monitor subsequent changes in the resources and in the environment. This is especially important today as we are in a crucial period of global warming with likely heavy impact on the coastal areas over time. The new Nansen EAF (Ecosystem Approach to Fisheries) programme with the full backup from the FAO and other UN agencies such as UNEP and the IOC will assist the coastal states in the SW Indian Ocean in following up on this important task in the years to come.

1.1 Aims and Objectives

Following discussion between the ASCLME project, the Nansen Programme coordinator and FAO, the following aims and objectives were decided for the survey.

1.1.1 Aims

Mauritius is a representative example of an island under the influence of the South Equatorial Current system in the South West Indian Ocean. The aim of the survey is to establish how the deep-sea currents influence the island's Exclusive Economic Zone and its ecosystem. Since Mauritius has a very narrow shelf this requires transect lines into deep water. Since the Mauritius EEZ extends some way over the Mascarene Ridge, two lines in this direction will be included in the next cruise (Cruise 3: Mascarene Plateau). This will be the first multi-disciplinary, quasi-synoptic cruise that is focused directly on the ecosystem of the island and that will act as bench-mark of knowledge for the informed management of local marine ecosystems.

1.1.2 Objectives

- To determine the nature of the South Equatorial Current as a driving force for the marine ecosystem by establishing the physical/chemical environment of Mauritius that will affect the nature and motion over the continental shelf of the island.
- To determine the on- and offshore distribution of organisms on a number of trophic levels and how these are affected by the reigning current system.
- To determine the biodiversity of the island's marine ecosystem and its surroundings
- To establish, as far as possible, the productivity, biodiversity and biomass of the pelagic ecosystem.
- To do preliminary investigations on species diversity on the demersal fish fauna over the Mascarene Plateau section.
- To fulfil the data management agreement contained in Appendix V.

1.1.3 Key questions

- What is the physical, chemical and biological nature of the offshore environment of Mauritius?
- How does the offshore oceanic environment affect the shelf regions of the island?
- How does the South Equatorial Current affect the waters over that part of the Mascarene Ridge that forms part of the EEZ of Mauritius?
- What influence does the South Equatorial Current have on the distribution of organisms and thus on the local ecosystem?
- What are the cross-shelf characteristics of the current and its biota?
- What are the biodiversity of the pelagic ecosystem and the main fauna of the demersal fish community over the Mascarene Plateau?

1.2 Participation

A total of 16 scientists and technicians participated in the three legs of the survey. The full list of the participants, their affiliations and the stages of the survey where they participated is given in Table 1.1 below:

Table 1.1 List of participants

Participants	Institution	Period
Sigbjørn Mehl (Cruise Leader)	IMR	04.10-07.10
Raymond Roman (Local Chief Scientist)	UCT, South Africa	04.10-07.10
Inger Marie Beck	IMR	04.10-07.10
Tore Mørk	IMR	04.10-07.10
Ole Sverre Fossheim	IMR	04.10-07.10
Bradley Flynn	UWC, South Africa	04.10-07.10
Jonathan Durgadoo	UCT, Mauritius	04.10-07.10
Oocheetsing Sadasing	OMI, Mauritius	04.10-07.10
Tommy Bornman	ACEP, South Africa	04.10-07.10
Angus Paterson	SAEON, South Africa	04.10-07.10
Kim Bernard	SAEON, South Africa	04.10-07.10
Pavs Pillay	MA-RE, South Africa	04.10-07.10
Claire Attwood	ASCLME, South Africa	04.10-07.10
Duncan Graham-Rowe	Reporter, Britain	04.10-07.10
Barbara Hoareau	SCMRT, Seychelles	04.10-07.10
Vikash Muibodhe	OMI, Mauritius	04.10-07.10

List of institution abbreviations:

ACEP; African Coelacanth Ecosystem Programme
ASCLME; Agulas and Somali Current Large Marine Ecosystems project
IMR; Institute of Marine Research, Norway
MA-RE: Marine Research Institute, UCT
OMI: Mauritius Oceanographic Institute
SAEON: South African Environmental Observation Network
SCMRT: Seychelles Centre for Marine Research & Technology
UCT; University of Cape Town
UWC; University of Western Cape

1.3 Narrative

The first environmental transect northwest of Mauritius was taken 1 October at the end of the Madagascar survey steaming towards Port Lois for change of crew and scientific personnel. The vessel left Port Lois in the morning of 4 October, and the first station on the second transect was reached at noon the same day. The last environmental transect was finished in the morning of 7 October and the vessel docked in Port Louis in late afternoon the same day.

Continuous acoustic recording and analysis were carried out along and between the environmental transects throughout the survey. Due to limited survey time and few registrations only 1 pelagic blind trawl haul was carried out. Environmental transects consisting of CTD-stations were planed to be taken to the bottom or to a maximum of 3000 m depth on predefined stations along selected hydrographical transects and water samples were collected with Niskin bottles at predefined depths on these. Due to lack of time the CTD-stations were taken to a maximum of 1500 m on the first transect and from the middle of the third transect and further. Zooplankton samples were taken from 500 m depth to the surface (100 m depth interval per net) with Hydrobios Multinet plankton sampler on the hydrographical stations. Bongo nets were planed to be taken to 200 m depth on three stations (far offshore, mid transect and shelf break) along each environmental transect. Due to lack of time no zooplankton samples were taken on the first transect and bongo nets were only taken on the second and the beginning of the third transect (see Figure 1.1 for details).

1.4 Survey effort

Figure 1.1shows the cruise tracks with hydrographic stations, plankton stations and pelagic trawls. Table 1.2 summarises the survey effort.

Table 1.2 Number of hydrographic (CTD), plankton (P), pelagic trawl (PT), bottom trawl (BT) stations and distance surveyed (NM) during the survey.

Region / transect	CTD	P	PT	Distance surveyed (NM)
Transect 1	5			205
Transect 2	6	9		100
Transect 3	5	5	1	100
Transect 4	5	4		100
Transect 5	5			60
Transect 6	4			40
Steaming				45
Mauritius	30	18	1	650

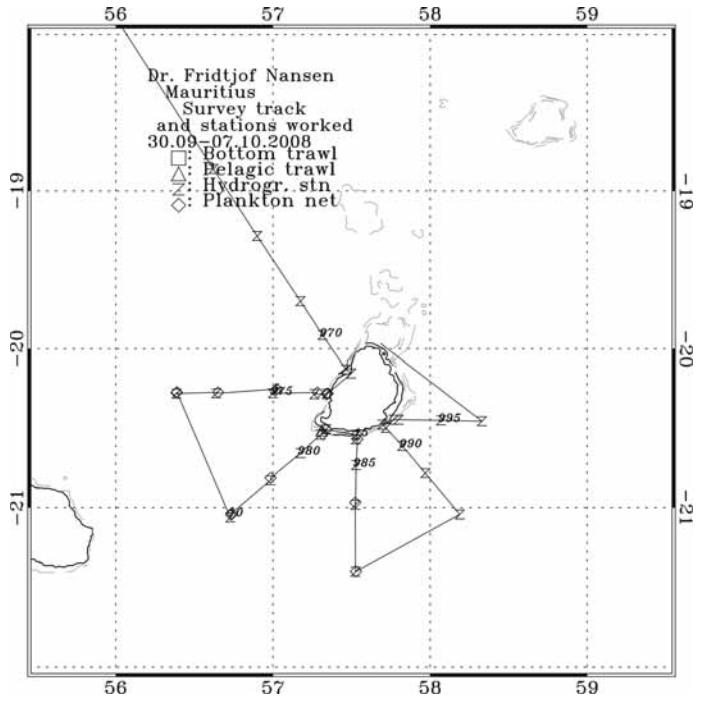

Figure 1.1. Course tracks with pelagic trawl, plankton and hydrographic stations. The 100, 500 and 1000 m depth contours are indicated.

2. METHODS

2.1 Meteorological and hydrographical sampling

2.1.1 CTD profiles

A total of 30 CTD stations were conducted along selected hydrographical transects (Figure 1.1). A Seabird 911plus CTD plus was used to obtain vertical profiles of temperature, salinity and oxygen. Real time plotting and logging was done using the Seabird Seasave software installed on a PC. The profiles along the shelf of Mauritius and slope were usually taken down to a few metres above the bottom, whilst offshore, due to limited survey time, the maximum sampling depth was 1500 m on most stations. Water samples were normally taken at 10 standard depths; 1500, 1250, 1000, 800, 500, 300, 100, 85, 50, surface (4-5 m) for nutrient

analysis as well sensor calibrations of oxygen and salinity. Nutrient samples were frozen onboard for analysis on land.

The oxygen sensor calibration showed a slope and offset of: what?

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Salinity calibration with the Portsal salinometer showed a slope and offset of: what?

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Also attached to the CTD was a Chelsea Mk III Aquatracka fluorometer. It measures chlorophyll a concentration in micrograms per litre with an uncertainty of 3%. Factory slope and offset were 0.921 and -0.02.

Fluorescence: Chl-a

Water samples were taken from up to 5 depths from Niskin bottles on the CTD rosette, dependant on other hydrographic sampling priorities. An ideal sampling regime was to have a sample from below fMax, one at fMax (maximum fluorescence noted during the CTD downcast), two between fMax and the surface, and one at the surface. Frequently, only 3 or 4 of these depths were available.

500 ml of water from each depth was filtered through a 2.5 cm diameter Whatman GF/F filter. This paper was then placed in a labelled plastic tube and 10 ml of 90% acetone was added; this sample was then stored in a refrigerator for approximately 24 hours. After this 24 hour extraction period, the samples were allowed to warm to room temperature in a dark place and the acetone solution was decanted into a borosilicate glass tube and its fluorescence measured on a Turner Designs Fluorometer, both before and after the addition of one drop of 10% HCl acid. A one minute period was allowed to elapse between the addition of the acid and the subsequent reading being taken. The sensitivity of the machine was adjusted to ensure a mid-scale reading. If the reading was off the scale at minimum sensitivity, the sample was diluted, the dilution factor noted, and a reading taken. 90% acetone blanks at all sensitivities were taken at least once every time the machine was turned on, and the machine was left on for at least 30 min prior to taking any readings. All procedures were performed in subdued light.

As some uncertainty exists around the accuracy of the fluorometer, duplicate samples from fMax were taken once per transect, wrapped in tinfoil, labelled and deep frozen for later analysis on shore.

Fluorescence readings were converted with the following formula:

$$\text{Chlorophyll a } (mg.m^{-3}/\mu g.l^{-1}) = F_D * (T/T\text{-}1)*(R_B\text{-}R_A)*(v/V)$$

Where

v = volume of acetone used for extraction (10ml)
V = volume of seawater filtered (500ml)
R_B = fluorescence reading prior to adding acid
R_A = fluorescence reading after adding acid
Acid ratio T = R_B/R_A
T = 2.19
T/T-1 = 1.84

F_D was a calibration factor determined prior to the cruise, dependent on the sensitivity of the fluorometer:

1x sensitivity on Min and 3.16 settings: 25.792
1x sensitivity on 20 and 31.6 settings: 2.7948
100x sensitivity on Min and 3.16 settings: 0.2876
100x sensitivity on 10 and 31.6 settings: could not be determined.

2.1.2 Phytoplankton

At each CTD station, water samples from fMax (maximum fluorescence noted during the CTD downcast) and the surface were taken. An attempt was made to assess flagellate abundance using a Leitz phase contrast microscope by placing one drop of seawater on a slide and placing a coverslip over it and examining. If flagellates were found, an attempt to categorise them into taxa and an estimate of abundance was made (noting the dominant taxa), along with sketches. If no flagellates were apparent in the first drop, a second drop was examined in the same manner.

Those aboard the first leg had no familiarity with flagellate identification, and were unable to definitively identify flagellates.

500 ml of water from each of fMax and the Surface Niskin bottles was placed in separate Ütermohl settling chambers with 10 ml of prepared formalin solution (equal volume of 40% formaldehyde solution to distilled water with 100 g/l hexamine added). After settling for 24 hours in a fume cupboard, the supernatant layer was drained by slowly separating the baseplate, and the settled plankton remaining in the well were transferred using a glass micropipette into a labelled 50ml dark amber plastic bottle and stored in a plastic bin.

When the Vaseline for sealing the chambers ran out, a slight modification of the method was employed; 500 ml of sample water was placed in a 600 ml jar with 10ml of formalin solution and stored in a bin for later settling.

The samples will be analysed on shore for species composition.

2.1.3 Bongos

A bongo net with 300 µm and 500 µm mesh nets was due to limited sampling time only deployed on the second and parts of the third transect. The bongo tows was planed to be made at the shelf break, midway out along the CTD line and at the furthest station from shore.

The bongo was deployed to 200 m and retrieved. Flow meters were mounted inside the mouth of each net, and the meter readings before and after each tow, along with the time down, were recorded. Tows generally lasted 20-30 minutes.

The 500 µm sample was preserved in a 500 ml jar using 40 ml of 40% formaldehyde with the remainder of the bottle being sample and seawater. The jar was labelled and stored for later analysis.

The 300 µm sample, intended for stable isotope analysis, was size-fractioned through a 4 mm, 2 mm, 1mm and 500 µm sieve series. The 4mm sample was frozen so that large taxa could be identified and separately analysed. The other 3 size classes were individually washed from the respective sieve into a 300 µm sieve, concentrated, and then transferred without water into separate labelled sterile sample jars. The sample was pressed against the side of the jar, and then left in an oven at 50º C for 48 hours before being capped and stored. Labelling was restricted to the outside of the bottle only.

2.1.4 Thermosalinograph

The SBE 21 Seacat thermosalinograph was running routinely during the survey, obtaining samples of sea surface salinity and relative temperature and fluorescence (5 m depth) every 10 seconds. An attached in-line Turner Design SCUFA Fluorometer continuously measured Chlorophyll A levels [RFU] at 5 m below the sea surface while underway during the entire cruise.

2.1.5 Current speed and direction measurements (ADCP)

A vessel-mounted Acoustic Doppler Current Profiler (VMADCP) from RD Instruments was run continuously during the survey in broadband mode shallower than about 400 m and in narrow band mode in deeper waters. The frequency of the VMADCP is 150 kHz, and data were averaged and stored in 3 m or 4 m vertical bins. All data were stored on files for post survey processing.

2.1.6 Meteorological observations

Wind direction and speed, air temperature, air pressure, relative humidity, and sea surface temperature (5 m depth) were logged automatically every 1 min. on an WIMDA meteorological station.

2.2 Zooplankton sampling

Zooplankton samples (Figure 1.1) were collected with Hydrobios Multinet zooplankton sampler that takes up to five discrete samples at predefined depths while measuring the water flow through the net. The aim was to collect depth-stratified information on the abundance and distribution of zooplankton and to collect zooplankton for genetic analysis. The obliquely-hauled multi-net configuration was 5 nets, fitted with 180 um mesh. Nets were deployed using standard protocols and were retrieved at a rate of ~ 1.5 m per second. The ship's personnel deployed the net at each environmental station except when severe wind prevented deployment. The nets were triggered at 100 m intervals starting at a maximum depth of 500 m. No adjustments to the sampling protocols were made for day or night.
The samples collected were rinsed into the cod end and thoroughly washed into a sieve with a 100 micron mesh. The contents of the sieve were then washed into a sample jar using a water bottle filled with ambient seawater. Labels showing full station details, net number and fishing depth range were placed into the sample jars, which were topped up with 40 ml of 40% formalin. The lids of all sample jars were labelled with station details – including net and station number. The main types of zooplankton observed in each sample were identified and recorded in the log. Any medusa or other obstructions found in plankton samples were fixed and preserved separately (with full labels). Large specimens of other interesting taxa were removed, fixed and preserved separately, with full labels.

Jars were placed in the plastic fish box provided for 24 hours. At the end of each haul, after the samples had been processed, the cod ends were inspected for damage, repaired if necessary, and replaced on the nets. After 24 hours, the approximate volume of zooplankton in each sample was recorded and entered into the logbook. Thereafter, the samples were stored for further analysis on land.

Every 10th zooplankton haul were stored in sample jars filled with 96% ETOH. Samples were labelled and stored in the freezer. After 24 hours, the ETOH was replaced; and then again after a further 48 hours.

2.3 Biological fish sampling

The trawl catches were sampled for species composition by weight and number. The deck sampling procedure is described in more detail by Strømme (1992). Length measurements were planned to be taken for target species. An Electronic Fish Meter (SCANTROL) coupled to a customised data acquisition system (Nansis) running on a Windows PC is used for length measurement, and the total length of each fish is recorded to the nearest 1 cm, rounding down when this was between sizes. Due to limited survey time and only one pelagic blind trawl catch consisting of just a few juvenile non target species, no length measurements were taken

on the present survey. Basic information recorded at the only one trawl haul is presented in Annex I.

2.4 Multibeam echo sounder for bottom mapping

The EM 710 multibeam echo sounder is a high to very high-resolution seabed mapping system. Acquisition depth is approximately 3 m below the transducers, and the maximum acquisition depth is in practice limited to 1500 m on *Dr. Fridtjof Nansen*. Across track coverage (swath width) is up to 5.5 times water depth and may be limited by the operator either in angle or in swath width without reducing the number of beams. The operating frequencies are between 70 to 100 kHz. There are 128 beams with dynamic focusing employed in the near field. The transmitting fan is divided into three sectors to maximize range capability and to suppress interference from multiples of strong bottom echoes. The sectors are transmitted sequentially within each ping, and use distinct frequencies or waveforms. The along track beam width is 1 degree. Ping rate is set (manually) according to depth. The receiving beam width is 2 degrees.

2.5 Biomass estimates

2.5.1 Acoustic abundance estimation

A SIMRAD ER 60 Echo sounder was used to survey the water column and the echograms were stored on files. The acoustic biomass estimates were based on the integration technique. The Large Scale Survey System (LSSS) from MAREC was used for integration and allocation of the integrated s_A-values (average area back scattering coefficient in m^2/NM^2) The splitting and allocation of the integrator outputs (s_A-values) was based on a combination of a visual scrutiny of the behaviour pattern as deduced from echo diagrams and LSSS analysis. The mean integrator value in each sampling unit (s_A-values) was planed to be divided between the following standard categories/groups of fish: PEL 1 (Clupeoid species), PEL 2 (Carangids, Scombrids and associated pelagic), ODFI (mainly demersal species), MESFI (Meseopelagic species) and PLANK (Plankton). Only the groups ODFI, MESFI and PLANK were applied during the present survey.

The following target strength (TS) function is normally applied to convert s_A-values (mean integrator value for a given area) to number of fish by category:

$$TS = 20 \log L - 72 \, dB \qquad (1)$$

or in the form

$$C_F = 1.26 \cdot 10^6 \cdot L^{-2} \qquad (2)$$

where L is the total length and C_F is the reciprocal back scattering strength, or the so-called fish conversion factor. Generally, in order to split and convert the allocated s_A-values (m^2/NM^2) to fish densities (number per length group per NM^2) the following formula was used

$$N_i = A \cdot s_A \cdot \frac{p_i}{\sum_{i=1}^{n} \frac{p_i}{C_{Fi}}} \qquad (3)$$

where: N_i = number of fish in length group i
A = area (NM^2) of fish concentration
s_A = mean integrator value (echo density) in area A (m^2/NM^2)
p_i = proportion of fish in length group i in samples from the area
C_{Fi} = fish conversion factor for length group i

$$N = \sum_{i=1}^{n} N_i \qquad (4)$$

Further, the traditional method is to sum the number per length group (N_i) to obtain the total number of fish:

The length distribution of a given species within an area is computed by simple addition of the length frequencies obtained in the pelagic trawl samples within the area. In the case of co-occurrence of target species, the s_A value is split in accordance with length distribution and catch rate in numbers in the trawl catches. Biomass per length group (B_i) is estimated by applying measured weights by length (W_i) when available or theoretical weights (calculated by using condition factors), multiplied with number of fish in the same length group (N_i). The total biomass in each area is obtained by summing the biomass of each length group:

$$B = \sum_{i=1}^{n} N_i \overline{W}_i \qquad (5)$$

The number and biomass per length group in each concentration are then added up to obtain totals for each region.

A description of the fishing gears used, acoustic instruments and their standard settings is given in Annex II.

3. OCEANOGRAPHIC CONDITIONS

3.1 Background

3.2 Results

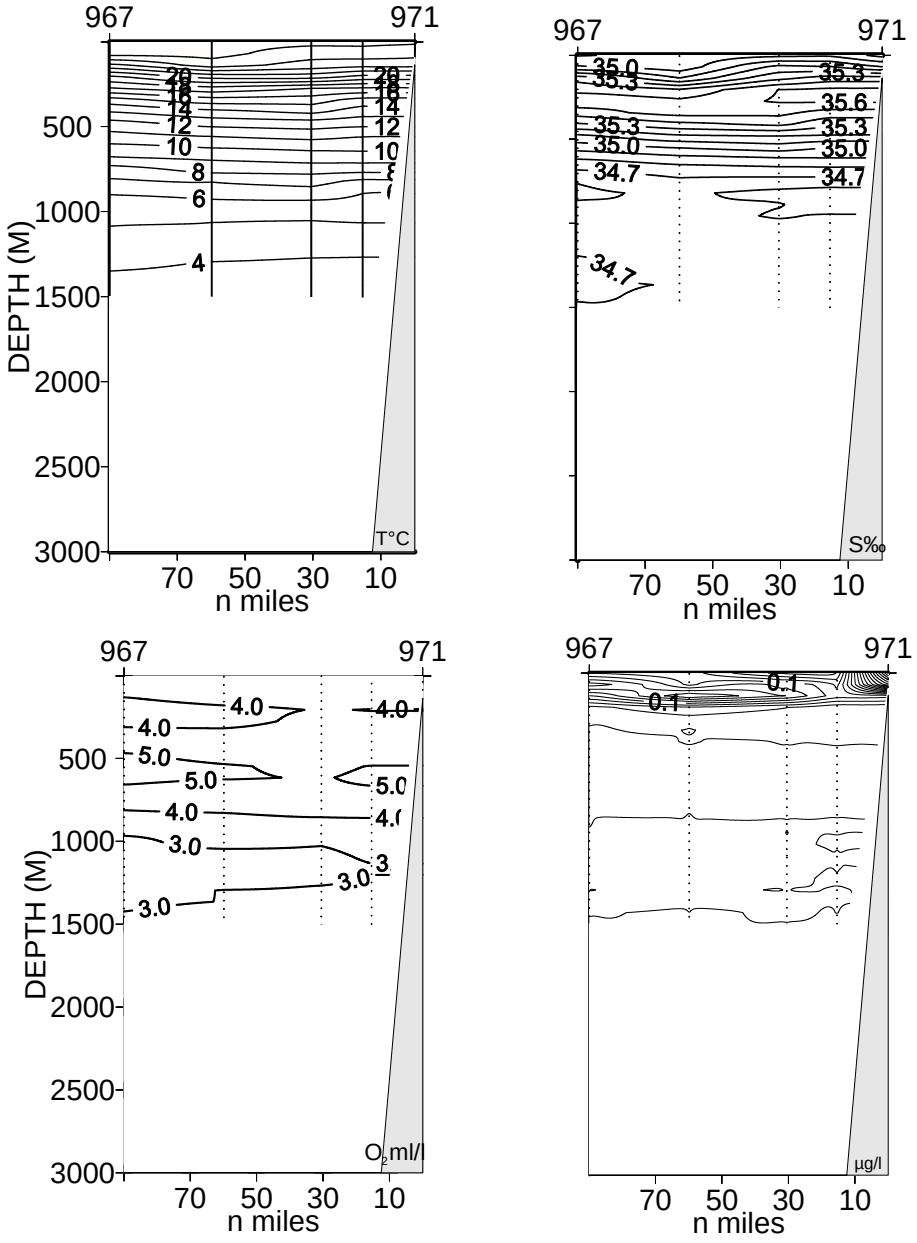

Figure 3.1 Vertical sections of temperature, salinity, oxygen and fluorescence

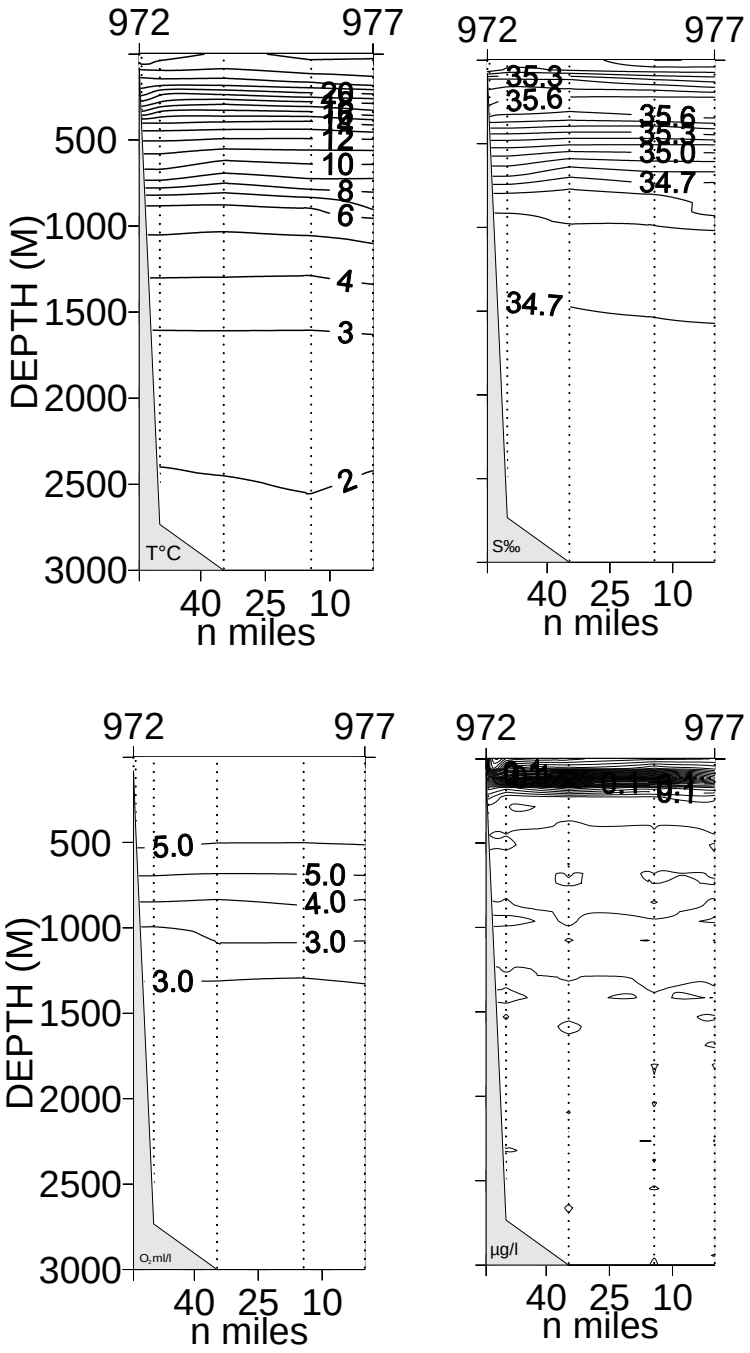

Figure 3.2 Vertical sections of temperature, salinity, oxygen and fluorescence

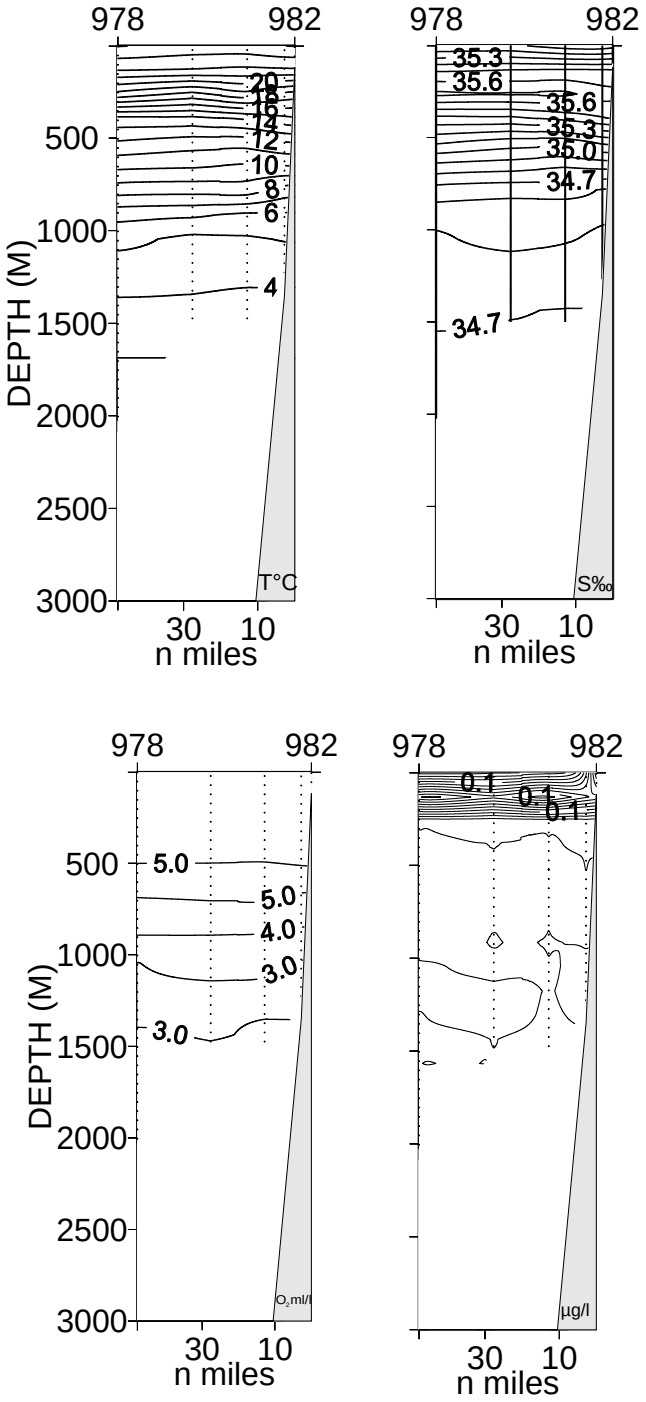

Figure 3.3 Vertical sections of temperature, salinity, oxygen and fluorescence

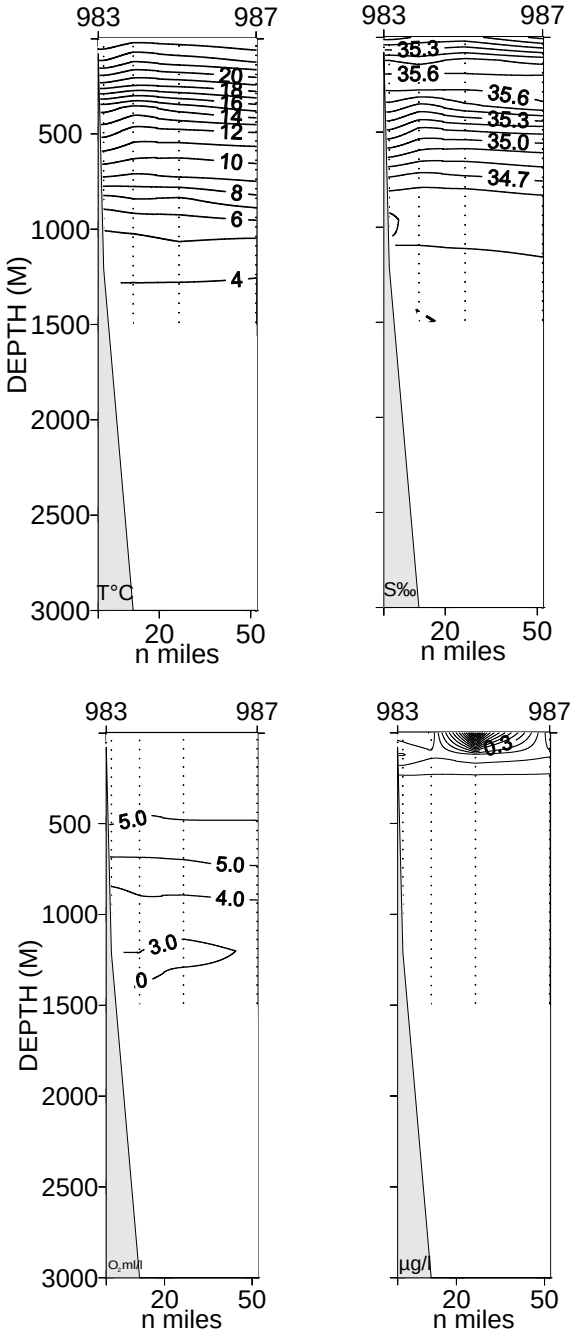

Figure 3.4 Vertical sections of temperature, salinity, oxygen and fluorescence

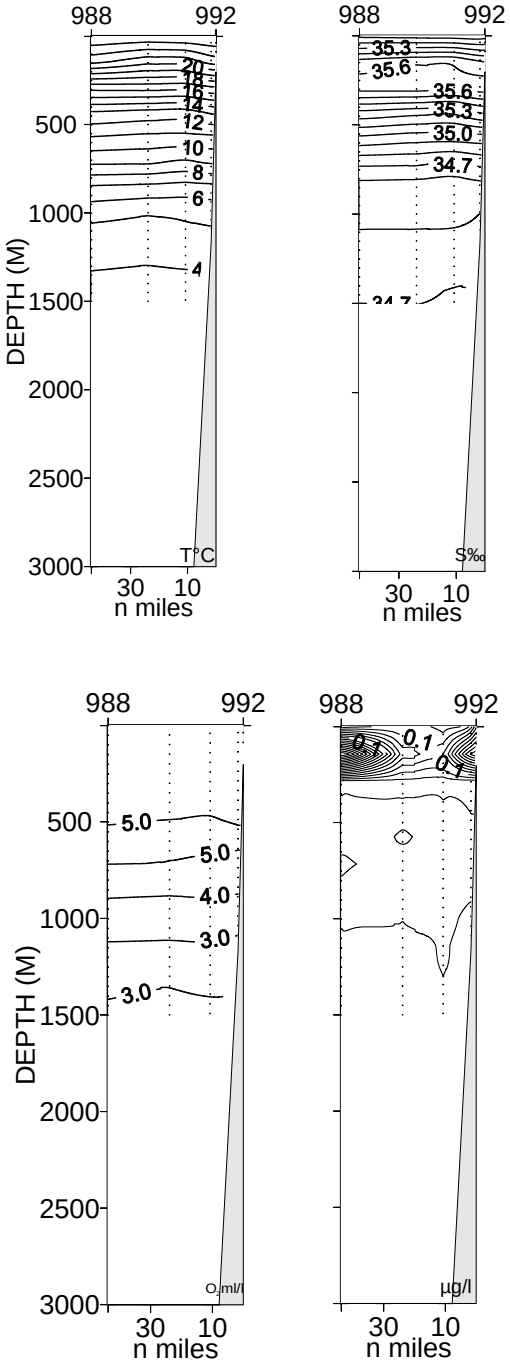

Figure 3.5 Vertical sections of temperature, salinity, oxygen and fluorescence

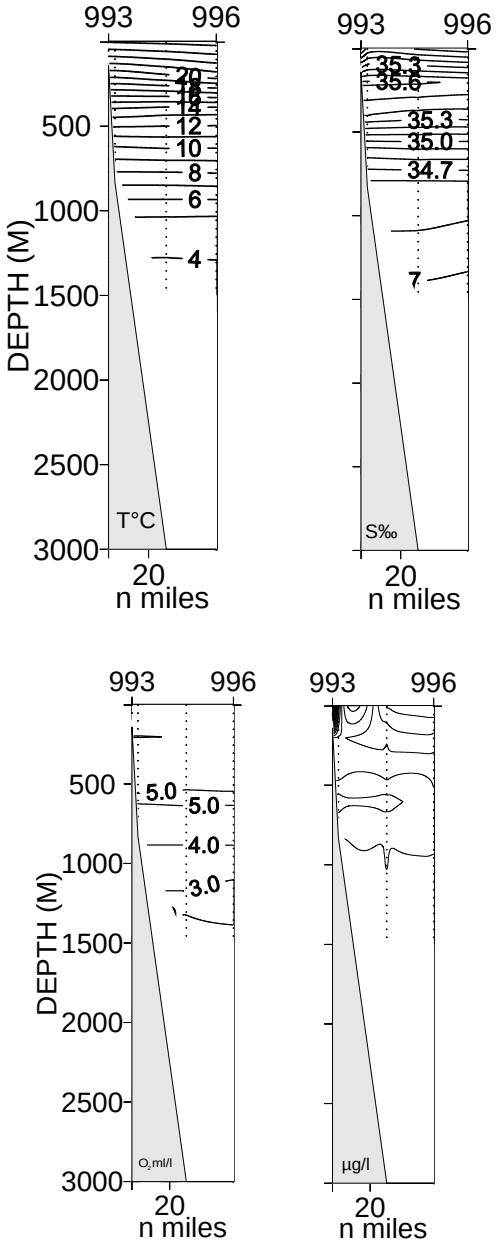

Figure 3.6 Vertical sections of temperature, salinity, oxygen and fluorescence

Figure 3.7 Horizontal distribution of sea temperature at 5 m on the shelf of Mauritius based on data recorded underway.

Figure 3.8 Horizontal distribution of salinity at 5 m on the shelf of Mauritius based on data recorded underway.

4. RESULTS OF THE FISH SURVEY

The hydroacoustic survey covered only the shelf and slope along the environmental transects (Figure 1.1). Continuous acoustic recording and analysis was carried out throughout the survey. Due to limited survey time and almost no visible registrations only one pelagic blind trawl haul was carried out. In a few shelf areas scattered recordings were made of demersal species close to the rough bottom, while plankton and a few low density mesopelagic fish schools were found in the water column from the shelf break and further offshore. No acoustic biomass estimates were calculated for any species or groups.

The catch in the pelagic blind trawl haul is presented in Annex 1. The only fish species caught were some lantern fishes (Myctophidae) and a few juvenile barracudas Sphyraenidae), tobies (Lagocephalus) and flounders (Bothidae).

5. SUMMARY AND CONCLUSIONS

6. REFERENCES

Strømme, T. 1992. NAN-SIS: Software for fishery survey data logging and analysis. User's manual. *FAO Computerized Information Series (Fisheries*). No. 4. Rome, FAO. 1992. 103.

Annex I Records of fishing stations

R/V "DR. FRIDTJOF NANSEN" SURVEY:2008406 STATION: 1
DATE :05.10.2008 GEAR TYPE: PT NO: 5 POSITION:Lat S 20°30.92
start stop duration Lon E 57°18.48
TIME :21:09:14 21:39:05 29.9 (min) Purpose : 1
LOG : 7388.58 7390.00 1.4 Region : 7600
FDEPTH: 5 5 Gear cond.: 0
BDEPTH: 629 639 Validity : 0
Towing dir: 0° Wire out : 125 m Speed : 2.9 kn
Sorted : 0 Total catch: 0.48 Catch/hour: 0.96

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
C R U S T A C E A N S	0.17	0	0.00	
SQUILLIDAE	0.03	8	0.00	
J E L L Y F I S H	0.50	0	0.00	
MYCTOPHIDAE	0.12	54	0.00	
Sphyraena sp.	0.06	14	0.00	
Lagocephalus sp.	0.00	2	0.00	
Unidentified fish	0.07	26	0.00	
BOTHIDAE	0.00	6	0.00	

Annex II Instruments and fishing gear used

Echo sounder

The SIMRAD ER60/38 kHz scientific sounder was used during the survey for fish abundance estimation. The lowering keel was not submerged during the survey. The LSSS Integrator system was used to scrutinise the acoustic records. System calibration experiment using a standard copper sphere was performed 23.06.2008. The settings of 38 kHz echo sounder were as follows:

Transceiver-1 menu (38 kHz lowering keel)

Transducer depth	5.50 m
Absorbtion coeff.	6.7 dB/km
Pulse length	1.024ms
Bandwidth	2.43 kHz
Max power	2000 Watt
2-way beam angle	-20.6 dB
Transducer gain	25.82 dB
Angle sensitivity	21.9
3 dB beamwidth	6.95º alongship
	6.99º athwardship
Alongship offset	0.11º
Athwardship offset	0.04º

Display menu

Echogram	1 (38 kHz)
Bottom range	15 m
Bottom range start	10 m

Fishing gear

The vessel has both small and medium sized "Åkrahamn" pelagic trawls. The SCANMAR system was used on all trawl hauls. This equipment consists of sensors, a hydrophone, a receiver, a display unit and a battery charger. Communication between sensors and ship is based on acoustic transmission. The doors are fitted with sensors to provide information on their distance. The pelagic trawl can be equipped with a trawl eye that provides information on the trawl opening and the distance of the footrope to the bottom.

Annex III Samples collected and storage location

Annex IV Data management agreement