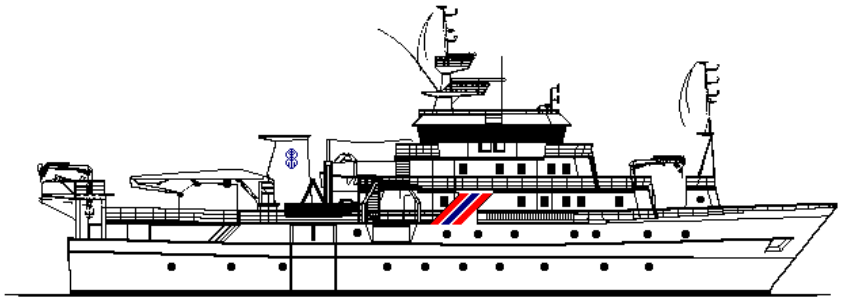

Mauritius Ecosystem Survey

ASCLME / FAO 2008 Cruise 2

04 - 07 October 2008

Preliminary report

Institute of Marine Research (IMR)
Norway

CRUISE REPORTS "DR. FRIDTJOF NANSEN"

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Preliminary report

by

S. Mehl[1], R. Roman[2], T. Bornman[3], K. Bernard[4], B. Flynn[5] and I. M. Beck[1]

[1] Institute of Marine Research
P.O. Box 1870 Nordnes
N-5817 Bergen, Norway

[2]Department of Oceanography
University of Cape Town
Private Bag X3, Rondebosch 7700, South Africa

[3]African Coelacanth Ecosystem Programme

[4]South African Environmental Observation Network

[5]Department of Biodiversity and Conservation Biology
University of Western Cape
Private Bag X17, Bellville, South Africa

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 IV.

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 planned 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 planned 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) and pelagic trawl (PT) 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 to/from transects				45
Mauritius total	30	18	1	650

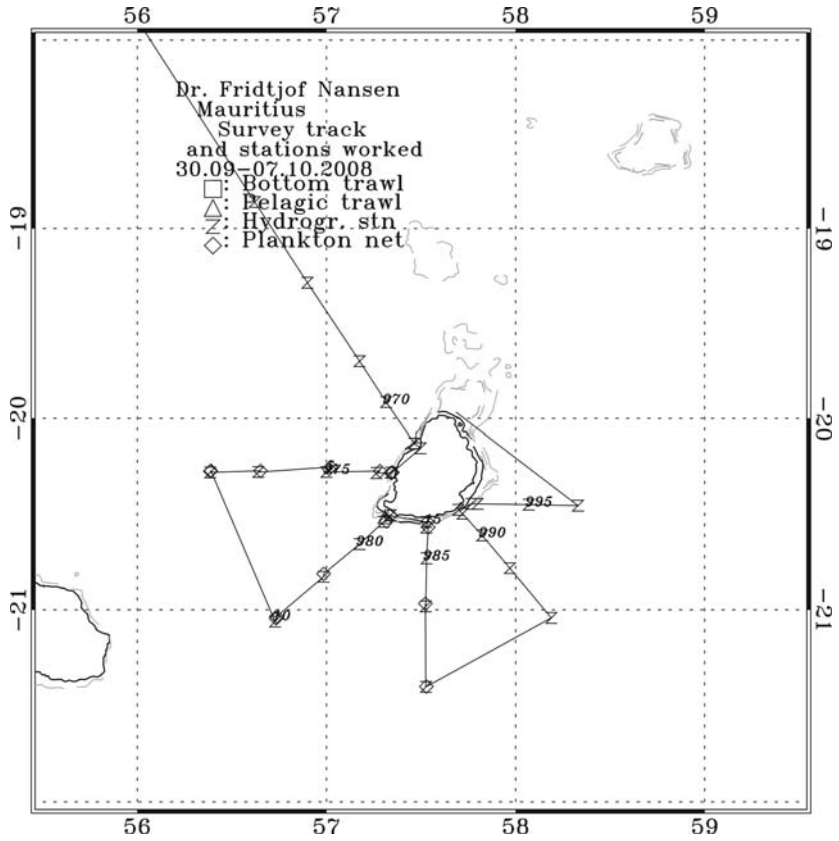

Figure 1.1. Course tracks with plankton and hydrographic stations along six transects. The 100, 500 and 1000 m depth contours are indicated.

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 y = 1.0568x + 0.091

Salinity calibration (Portsal salinometer) showed a slope and offset of: y = 1.0091x - 0.3308

Also attached to the CTD was a Chelsea Mk III Aquatracka fluorometer. It measures chlorophyll a concentration in microgrammes 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:

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

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 Microzooplankton Community Structure

Microzooplankton are defined as phagotrophic organisms that are <200 μm in length. For the sake of operational convenience, the microzooplankton include the pico- and nanozooplankton (0.2-2 and 2-20 μm, respectively) although due to time constraints, we have only focused on the true microzooplankton (20-200 μm). Microzooplankton are abundant in the surface mixed layer of the oceans, forming a significant stock of organic carbon. Furthermore, microzooplankton have been shown to form a major trophic pathway linking phytoplankton to the higher trophic levels. The study of microzooplankton thus provides important information on the flux of organic carbon in the surface waters.

The methods described in the JGOFS Protocols (1994) for microzooplankton biomass have been used. Microzooplankton biomass (mg C L-1) is defined as the quantity of microzooplankton organic carbon per unit volume of sea-water. In addition to biomass, the microzooplankton samples will be identified to the finest taxonomic level possible and counted to give abundance (ind. L-1).

Vertical profile samples were taken through the surface mixed layer and deep chlorophyll-a maximum using a CTD and Niskin bottle rosette. Between 225 mL and 2 L of seawater were taken from the Niskin bottles triggered at the following depths: surface; fmax, 1 to 2 depths between the surface and fmax; and 2 to 3 depths below fmax. Samples were pre-filtered through a 200 μm sieve and concentrated on a 20 μm sieve. The sample was then gently washed into a 50 mL bottle that had been covered in dark tape to reduce light degradation of the preservatives. Approximately 3 mL of Lugol's solution and 80 mg of strontium sulfate were added to the concentrated sample. Samples were stored in the refrigerator for analysis in the home laboratory. Fixed samples will be counted and analysed using inverted microscopy. Microscopic analysis involves counting and sizing of microzooplankton. Geometrical shapes are assigned to each microzooplankton taxon and organism volumes are calculated. These are converted to organism biomass through appropriate volume to organic carbon ratios. Biomass of the microzooplankton community is the sum of biomass of individual organisms divided by the original water volume.

2.1.4 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.

2.1.5 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.

2.1.6 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.

2.1.7 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 is 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

Mauritius a small volcanic island is situated at the southern boundary of the Mascerene Plateau that runs northwards to the Seychelles. Because of its volcanic origin the island has almost no shelf on the west and southern parts of the island. Oceanic circulation around Mauritius is strongly influenced by the southern core of the South Equatorial Current (SEC) that flows through a gap in the Plateau just to the north of it. This core is strengthened by northward flows from the subtropical gyre to the south of Mauritius. Flow speed of the SEC to the north of Mauritius is typically 30-40 cm/s. This core of the SEC eventually hits Madagascar where it forms the northward and southward flowing East Madagascar Currents (New et al., 2007).

The surface water around Mauritius consists of relatively fresh Tropical Surface Water (TSW) originating in the tropics (~0-100 m). This water mass is formed as a result of excess precipitation over evaporation (Read and Pollard, 1993). Below the TSW layer there is the highly saline, low oxygen, high nutrient Subtropical Surface Water layer (STSW) (~100-400 m). It is believed this water mass gets its high nutrient values from in situ bacterial breakdown of organic matter (Donohue and Toole, 2003). Around the thermocline depth, South Indian Central Water (SICW) or Sub-Antarctic Mode Water (SAMW) with its characteristic oxygen maximum is the major water mass (~400-800 m). In this region SICW is recognised by its relatively linear Θ/S relationship between approximately 8°C and 15°C (Gründlingh et al., 1991, New et al., 2007). Intermediate waters (800-1500) in this area consist of fresh Antarctic Intermediate Water (AAIW) of southern origin; saline, low oxygen Red Sea Intermediate Water (RSIW) with Red Sea and Persian Gulf influence and high silicate Indonesian throughflow Intermediate Water (IIW) originating in the east (You et al. 2003, New et al., 2007). The Deep waters around Mauritius are highly saline southward flowing North Indian Deep Water (NIDW) with its formation region in the Arabian Sea as well as Circumpolar Deep Water (CDW) of southern origin flowing northward (New et al., 2007).

3.2 Results

3.2.1 Transect 1

The isolines along this section indicate north eastward flow offshore with a surface intensified eddy along the slope of Mauritius. Surface water in the eddy core is both warmer and more saline than the surrounding TSW. This is due to upwelling upwelling in the core of the eddy. The freshest warmest TSW is found along the coast of Mauritius with salinities of 34.861 psu and temperatures as high as 24.16°C. Sub surface the most saline water was found in the eddy with salinity values in access of 35.5 psu. The higher oxygen values would indicate this to be STSW of southern origin. The STSW offshore of the eddy has lower oxygen values (~3.38 ml/l) that would indicate circulation from the north. Below this layer, ICW is clearly distinguishable with it oxygen maximum near 500m across the entire section. The highest oxygen values in this layer is observed at the extreme offshore station with a maximum value of 5.13 ml/l. Intermediate circulation indicates the relatively cool, fresh AAIW flowing along the slope of Mauritius whilst offshore the relatively warm, salty, low oxygen RSIW dominates (Figure 3.1).

3.2.2 Transect 2

The surface intensified eddy observed along transect 1 is not evident along this transect. The isolines do however indicate weak cyclonic motion along the slope of Mauritius. As was the case along transect 1 there was some upwelling of sub surface water at station 3 with the fresher warmer TSW dominating the surface waters outside the eddy. The freshest warmest TSW variety was 34.900 psu and 24.14°C, found at the extreme offshore station. Below this layer a band of STSW of southern origin can be observed. The lowest oxygen values associated with this layer was 4.03 ml/l. The most saline STSW was found at station 4 with a maximum salinity of 35.67 psu. No northern origin STSW was observed along this line. At intermediate level both AAIW and RSIW is observed. Their distribution has however changed with RSIW found along the slope and far offshore with AAIW flowing between the two RSIW cores. Although not conclusive indications from the oxygen values would suggest the majority of the deep waters to be CDW along this section. This will only be fully answered once the nutrients has been analysed (Figure 3.2).

3.2.3 Transect 3

Flow as indicated by the isolines indicates northward flow along the coast of Mauritius and cyclonic flow further offshore. Sub-surface upwelling in the isolines suggests the presence of a cyclonic eddy centred at station 4. The freshest TSW was found to the side of the eddy with salinities of 35.02 psu and a temperature of 24.04°C. Sub-surface of this STSW with its

characteristic high salinity and lower oxygen is found as a band across the whole section. The highest salinity of 35.745 psu was found at station 3 with the lowest oxygen found at station 2 (~ 3.77 ml/l). This low oxygen value would indicate the STSW found along the slope to be of northern origin. The ICW layer is observed below this with its characteristic oxygen maximum. The maximum oxygen concentration for this layer was 5.14 ml/l centred at station 4. Intermediate water circulation for this section is similar to that along transect 2 to with the AAIW core flanked by two RSIW cores along the slope and further offshore. This can be clearly observed in the distribution of salinities and oxygen at this level (Figure 3.3).

3.2.4 Transect 4

The doming of the isolines indicating cyclonic circulation along this section with the freshest warmest TSW found on the edges. The freshest warmest TSW along this section was 35.05 and 23.97°C respectively. STSW is found as a band across the section with the most oxygen depleted variant (3.84 ml/l) found along the slope of Mauritius. The most saline STSW was found at the extreme offshore station with a maximum salinity of 35.749 psu. In the ICW layer the maximum oxygen concentration was 5.15 ml/l at stations 3 and 5 centred at around 600 m. At intermediate level the circulation is completely different compared to the other sections so far described. It appears as if the low salinity oxygen rich AAIW is sliding across the high salinity low oxygen RSIW. The freshest AAIW is however still found in the middle of the section and the lowest oxygen was still observed along the slope below the salinity minimum (Figure 3.4).

3.2.5 Transect 5

Similar to transect 4 the flow as indicated by the doming of the isolines is cyclonic along the slope of Mauritius along this section. As was the case along the other sections with similar circulation the freshest warmest TSW was found at the edges of the section. The freshest warmest TSW observed were 35.038 psu and 23.97°C respectively. Sub-surface of the TSW the most saline STSW was now found in the middle of the section with salinities as high as 35.736 psu. The most oxygen depleted northern variant of this water mass is however still observed along the slope. As is the case along all the sections ICW was observed along the whole section just below STSW layer. The maximum oxygen concentration observed in this layer was 5.17 ml/l in the middle of the section. At intermediate layer depth the freshest AAIW is found just offshore of the slope. The freshest salinities were of the order of 34.513 psu at around 900 m depth. It would appear as if the AAIW overlay the RSIW core layer at around 1250 m where there is a oxygen minimum layer. The most oxygen depleted water in this layer was again found along the slope (Figure 3.5).

3.2.6 Transect 6

The cyclonic motion observed along the other lines is not evident in the isolines of this section. It would appear as if the flow along the coast is southward and would explain the much fresher warmer TSW found along the coast of Mauritius. TSW salinities and temperatures at station 1 were 34.910 psu and 24.00°C respectively. Also different from the previous sections are the fact that the most saline STSW (35.676) is now found along the slope of Mauritius with the most oxygen depleted variant (3.94 ml/l) found offshore. At the ICW level the most oxygen rich water was found in the middle of the section with oxygen values greater than 5 ml/l. Similar to the above section the freshest AAIW was found along the slope at around 1000 m with RSIW/NIDW centred at around 1250 m found further offshore. This is shown by the offshore oxygen minimum (Figure 3.6).

3.2.7 Conclusions

Along the west and south coast of Mauritius the circulation appear to be cyclonic with south and south eastward movement of surface water along the coast. Further offshore the circulation is north north-eastward. The freshest warmest TSW was almost always found along the coast and at the northern most section of the west and east coast. As expected in the case of STSW the most saline water was found top the south of the island with the freshest found in the north western corner of the island. In the ICW layer the highest oxygen values are observed in the south eastern corner of the island. At intermediate level the circulation indicates the northward moving AAIW to sliding over the southward moving RSIW/NIDW core. The freshest AAIW seemed to be transported offshore of the slope of the island whereas the RSIW/NIDW core was mostly observed along the slope. Along transect 2 the deep waters appear to be made up of only the northward spreading CDW. This however can only be positively concluded when we have the nutrient data.

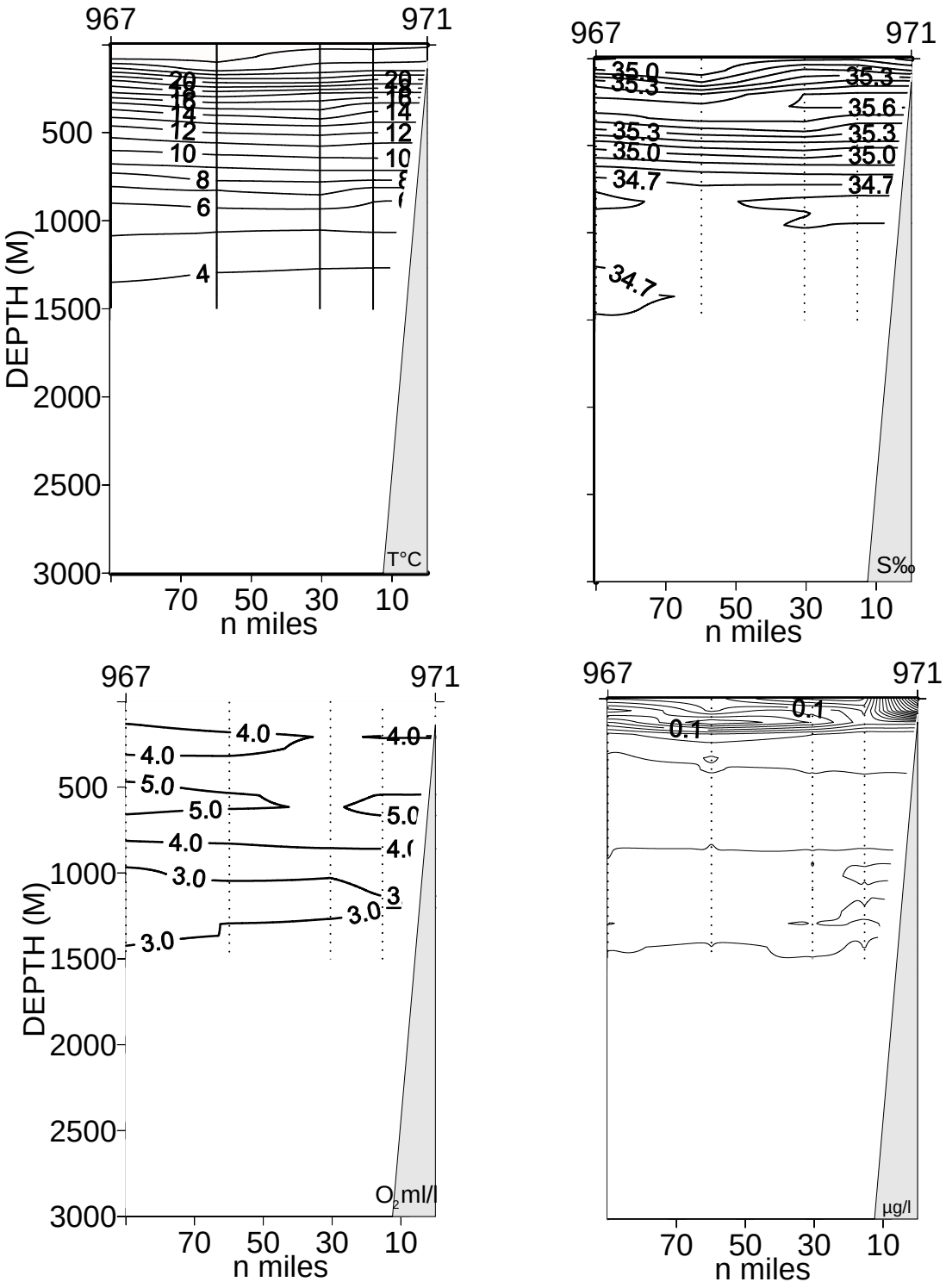

Figure 3.1 Transect 1. Vertical sections of temperature, salinity, oxygen and fluorescence

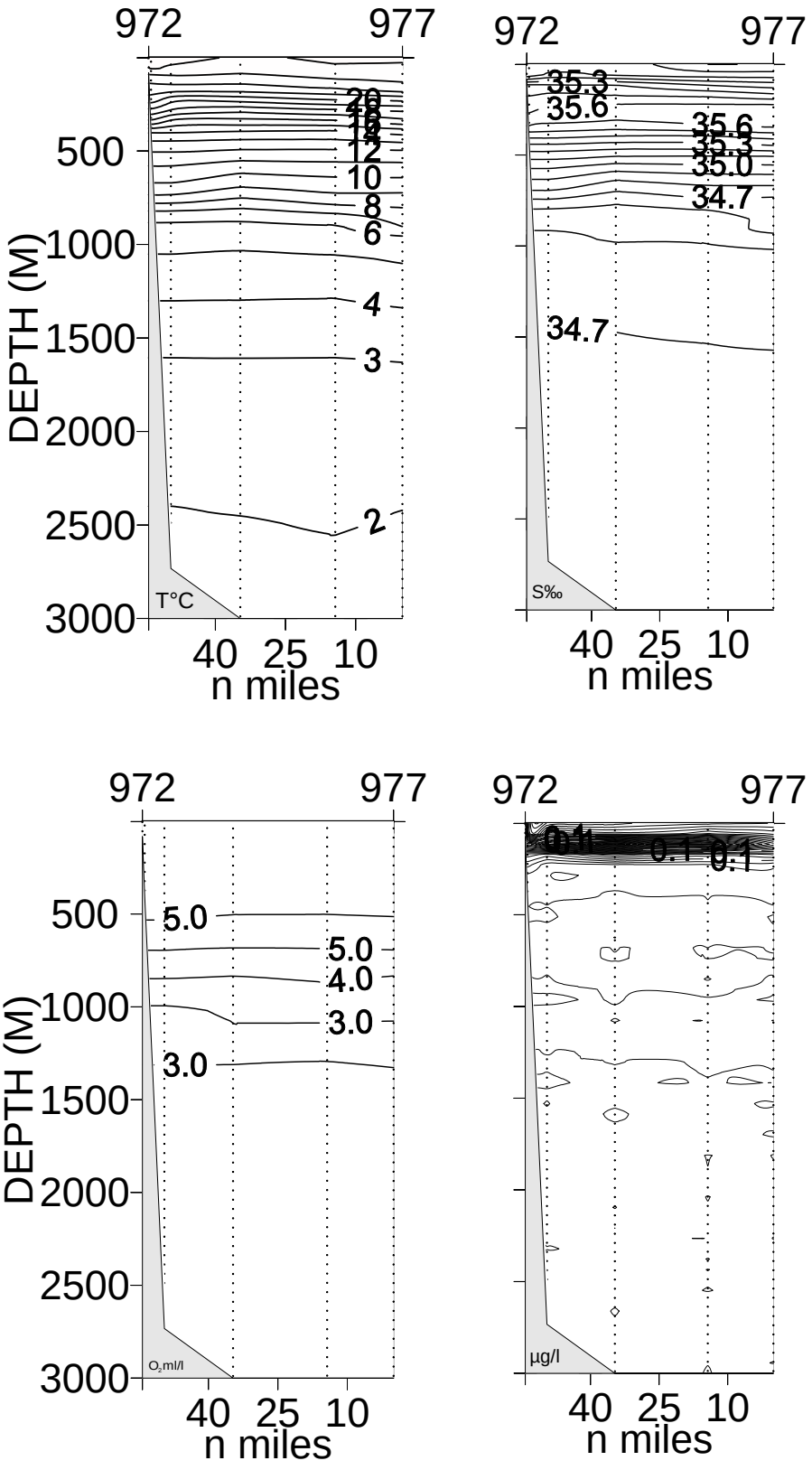

Figure 3.2 Transect 2. Vertical sections of temperature, salinity, oxygen and fluorescence

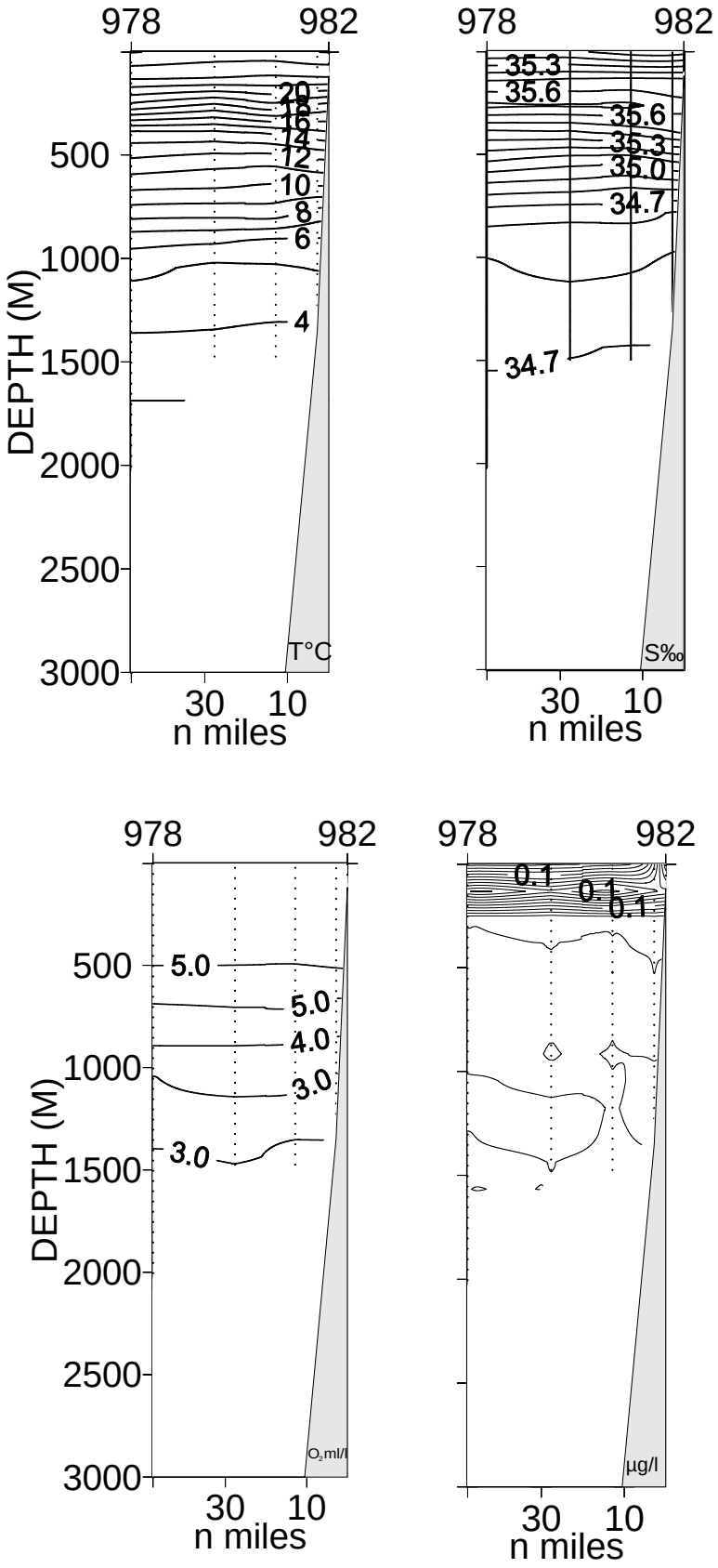

Figure 3.3 Transect 3. Vertical sections of temperature, salinity, oxygen and fluorescence

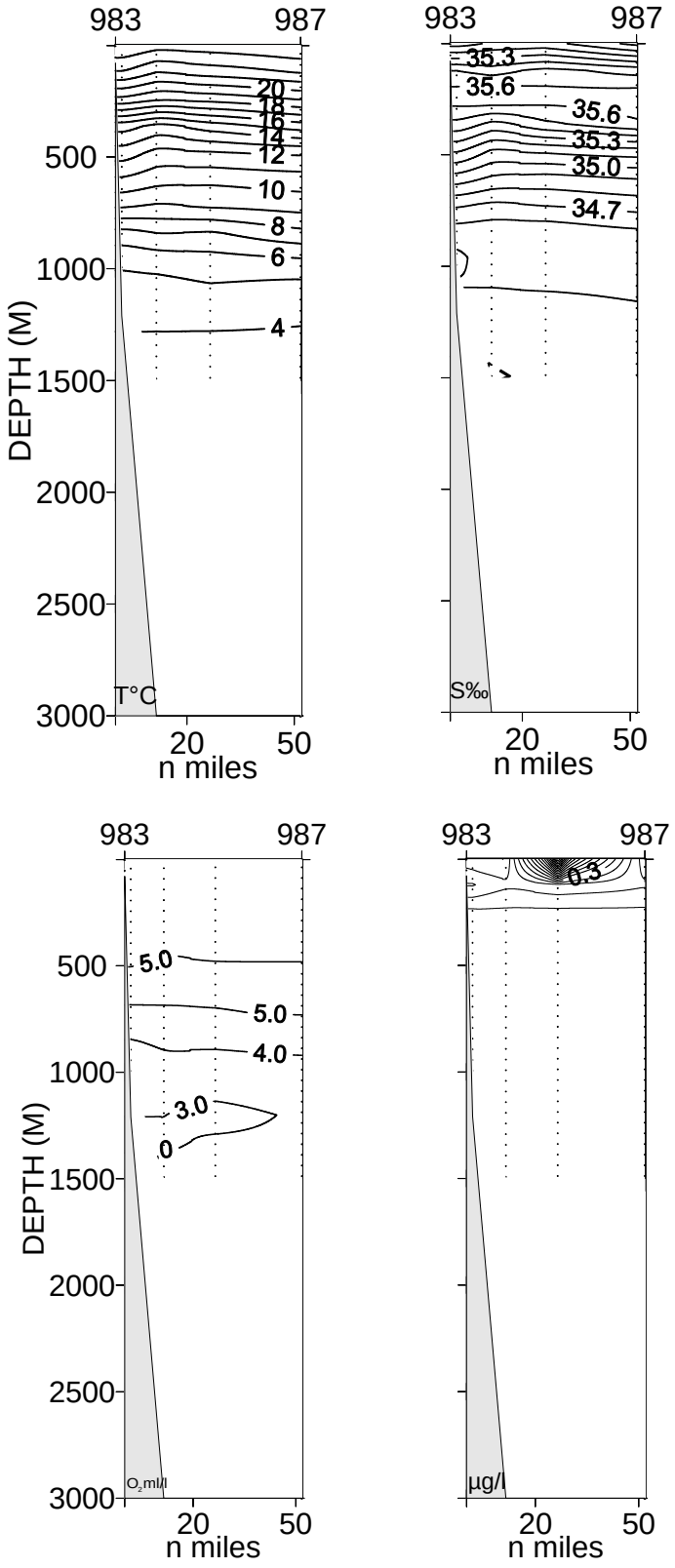

Figure 3.4 Transect 4. Vertical sections of temperature, salinity, oxygen and fluorescence

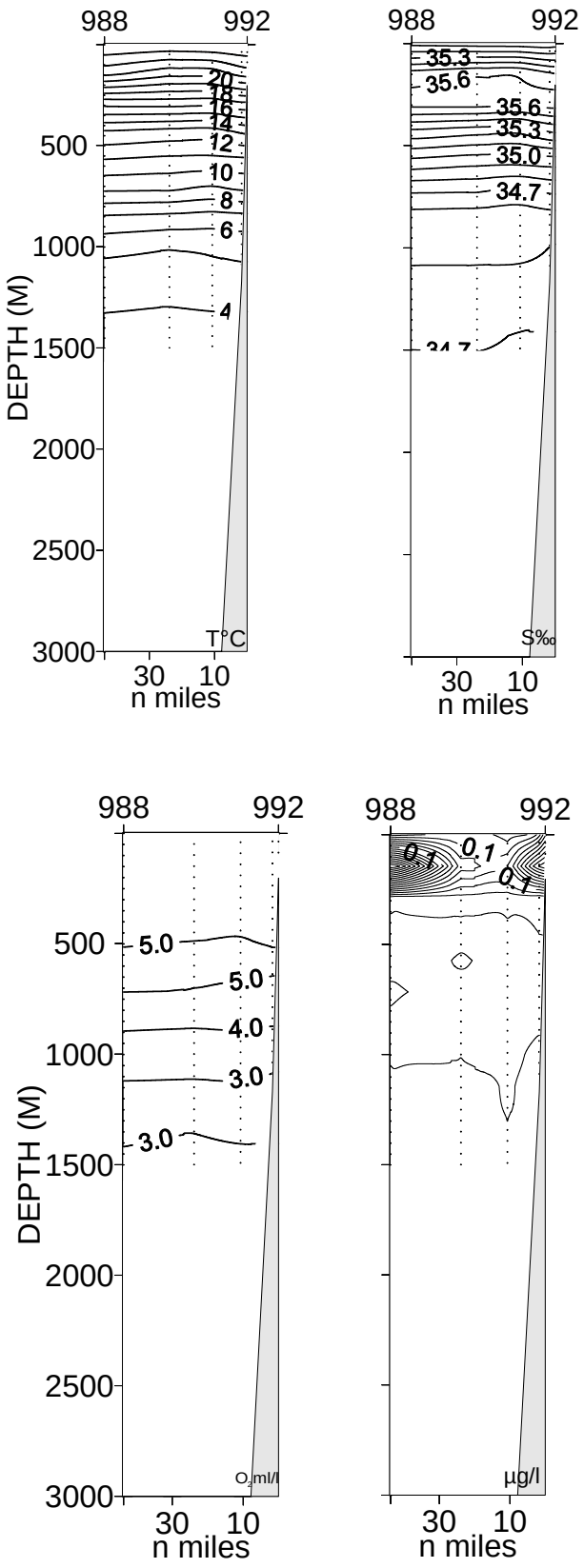

Figure 3.5 Transect 5. Vertical sections of temperature, salinity, oxygen and fluorescence

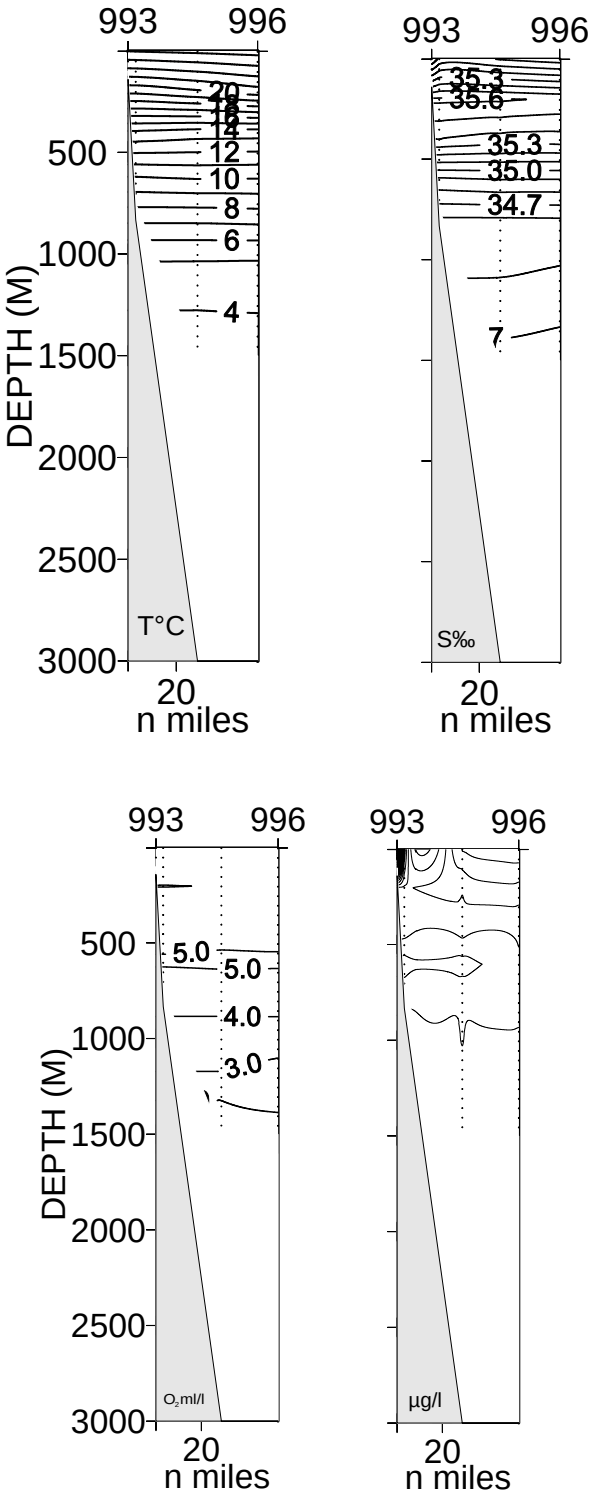

Figure 3.6 Transect 6. Vertical sections of temperature, salinity, oxygen and fluorescence

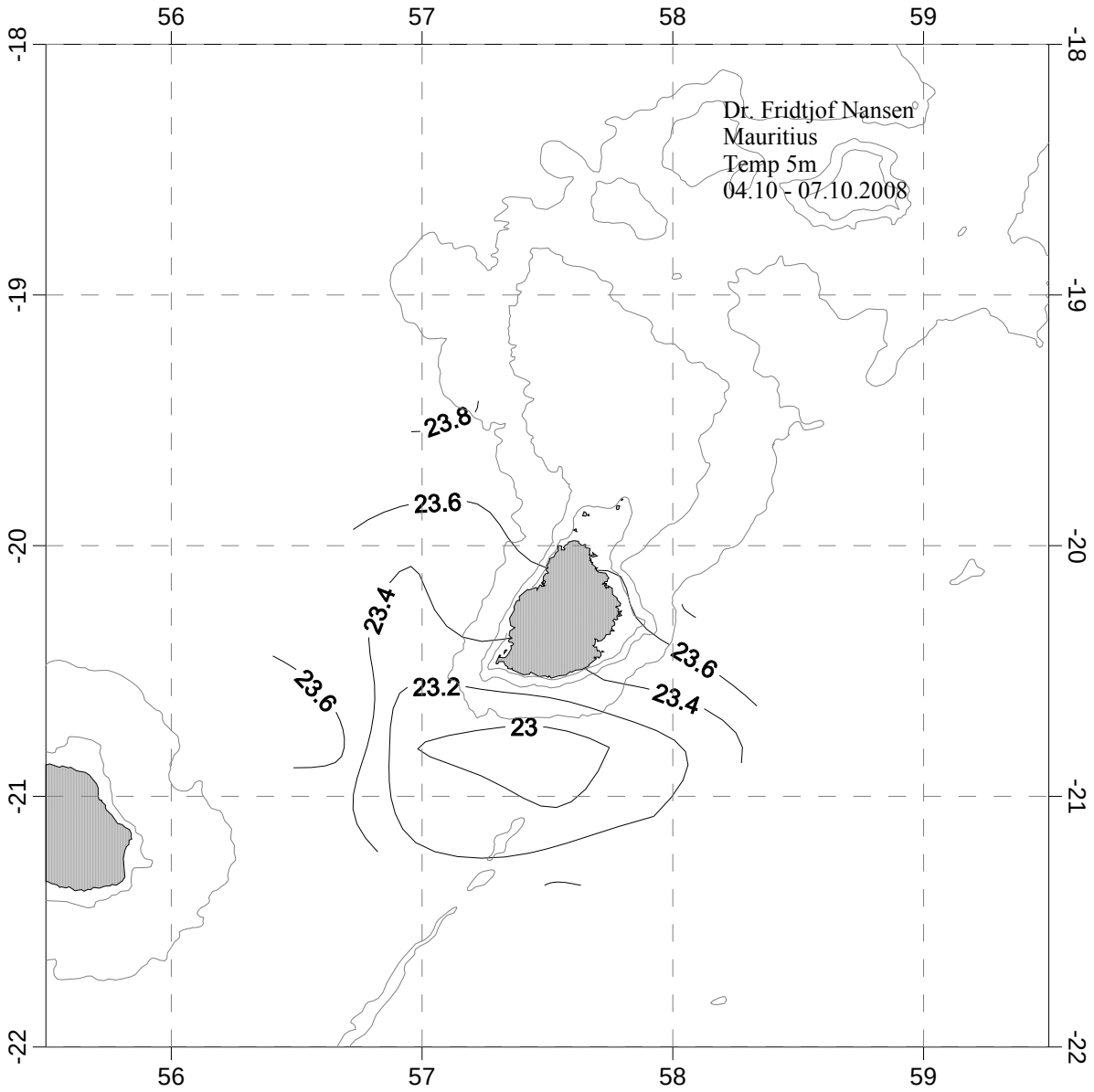

Figure 3.7 Horizontal distribution of sea temperature at 5 m on the shelf of Mauritius based on data recorded underway. The 100, 1000 and 3000 m depth contours are indicated.

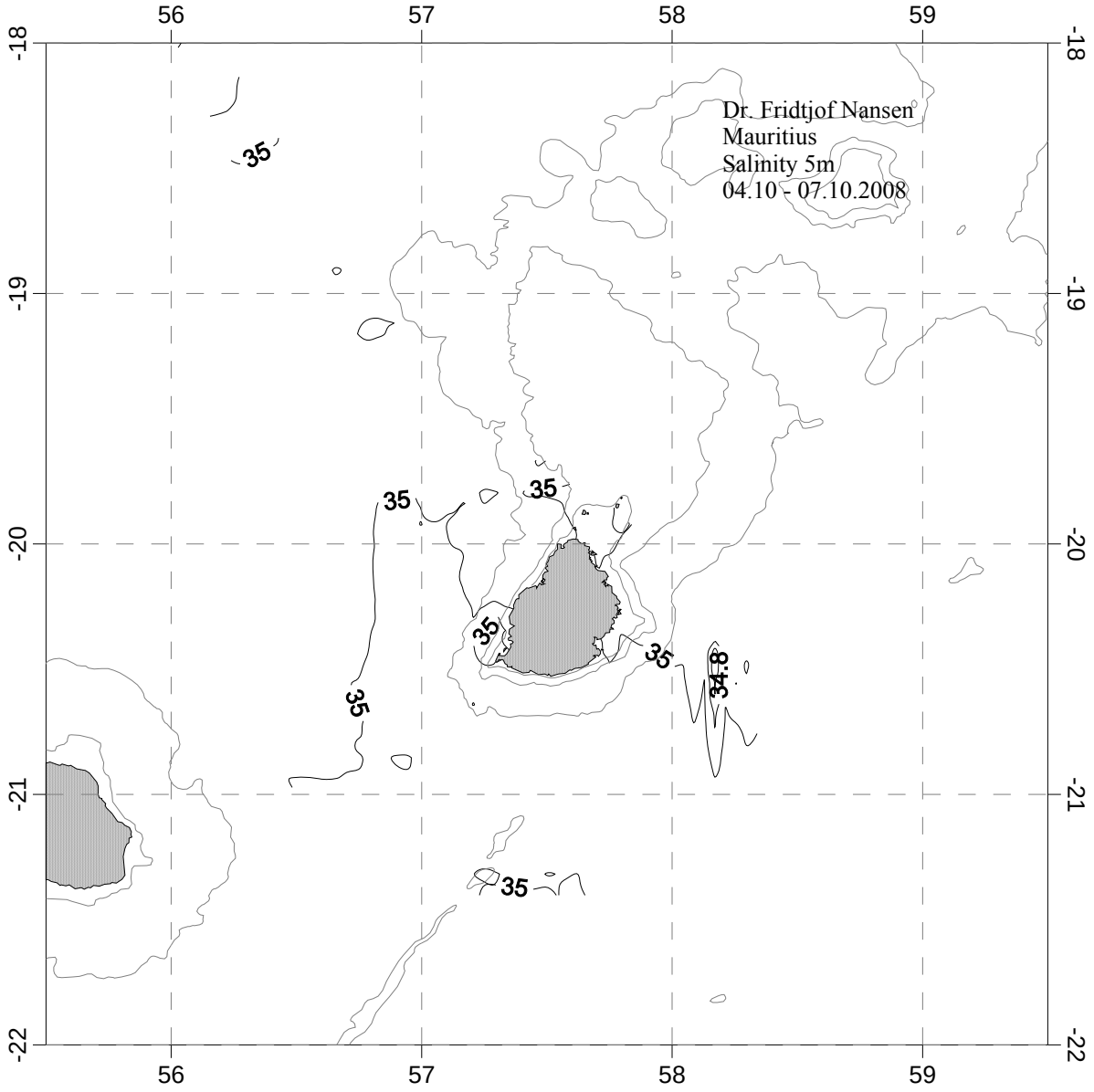

Figure 3.8 Horizontal distribution of salinity at 5 m on the shelf of Mauritius based on data recorded underway. The 100, 1000 and 3000 m depth contours are indicated.

4. RESULTS OF THE FISH SURVEY

The hydro acoustic 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

Donohue, K.A. and Toole, J.M. 2003. A near synoptic survey of the Southwest Indian Ocean. Deep-Sea Research II 50, 1893-1931.

Gründlingh, M.L., Carter, R.A. and Stanton, R.C. 1991. Circulation and water properties of the southwest Indian Ocean, spring 1987. Progress in Oceanography 28, 305-342.

New, A.L., Alderson, S.G., Smeed, D.A. and Stansfield, K.L. 2007. On the circulation of water masses across the Mascarene Plateau in the South Indian Ocean. Deep-Sea Research I 54, 42-74.

Read, J.F. and Pollard, R.T. 1993. Structure and transport of the Antarctic Circumpolar Current and Agulhas Return Current at 40°E. Journal of Geophysical Research 98, 12281-12295.

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.

You, Y., Lutjeharms, J. R. E, Boebel, O. and de Ruijter, W. P. M. 2003. Quantification of the interocean exchange of intermediate water masses around southern Africa. Deep-Sea Research II 50, 197-228.

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

Station	Date	Longitude	Latitude	CTD	Oxygen	Nutrients	Multinet	Bongo
967	30.09.2008	56.6207	-18.8599	*	*	*		
968	01.10.2008	56.8994	-19.286	*	*	*		
969	01.10.2008	57.1751	-19.6997	*	*	*		
970	01.10.2008	57.3154	-19.9148	*	*	*		
971	01.10.2008	57.4643	-20.1299	*	*	*		
972	04.10.2008	57.498	-20.1548	*	*	*	*	
973	04.10.2008	57.3409	-20.2832	*	*	*	*	*
974	04.10.2008	57.2647	-20.2844	*	*	*	*	
975	04.10.2008	57.0006	-20.2793	*	*	*	*	*
976	04.10.2008	56.6405	-20.2796	*	*	*	*	
977	05.10.2008	56.3855	-20.2816	*	*	*	*	*
978	05.10.2008	56.7282	-21.0617	*	*	*	*	*
979	05.10.2008	56.9855	-20.8275	*	*	*	*	
980	05.10.2008	57.1755	-20.6565	*	*	*		
981	05.10.2008	57.3028	-20.5398	*	*	*	*	
982	05.10.2008	57.339	-20.5057	*	*	*	*	
983	06.10.2008	57.5285	-20.5406	*	*	*	*	
984	06.10.2008	57.528	-20.5699	*	*	*	*	
985	06.10.2008	57.5292	-20.7317	*	*	*		
986	06.10.2008	57.5255	-20.982	*	*	*	*	
987	06.10.2008	57.526	-21.4028	*	*	*	*	
988	06.10.2008	58.1892	-21.0424	*	*	*		
989	06.10.2008	57.9696	-20.7829	*	*	*		
990	06.10.2008	57.8232	-20.6114	*	*	*		
991	06.10.2008	57.72	-20.4975	*	*	*		
992	06.10.2008	57.6977	-20.4775	*	*	*		
993	07.10.2008	57.7668	-20.4465	*	*	*		
994	07.10.2008	57.7995	-20.4463	*	*	*		
995	07.10.2008	58.0697	-20.4502	*	*	*		
996	07.10.2008	58.3307	-20.4552	*	*	*		

Annex IV Data management agreement

Data Management Agreement for the FAO/ASCLME Cruises

The intention of this Data Management Agreement is to clarify and protect the interests of all scientists and countries. This Agreement is appended to the ToRs for all scientists that are working on the Nansen as part of the 2008 ASCLME Cruise Schedule.

Introduction

Participating countries in the ASCLME Project, and their designated representatives, have the mandate to develop a comprehensive document on principles and guidelines for ASCLME data and information management so that it facilitates the effective collection, use and dissemination of information in support of TDA/SAP development in the short term and the ecosystem approach in the long term. National Data and Information coordinators in particular, have a responsibility for developing mechanisms for reliable long-term storage and use of information collected under the ASCLME Project.

This Agreement is intended to govern the collection, storage and access to data on the ASCLME 2008 Cruises as an interim measure prior to agreement of a more detailed MoU on data access and management which is currently under development as part of the overall ASCLME Programme (particularly as a joint MoU between the ASCLME and SWIOFP projects and their respective countries). In this context, data collected will be shared freely between the ASCLME and the SWIOFP Project with due note being taken of SWIOFP's own MoU with each of its countries regarding Transboundary Marine Scientific Research in Support of the South West Indian Ocean Fisheries Project (SWIOFP). Nothing in this current agreement should jeopardise the ability of SWIOFP scientists on joint research cruises from abiding by their terms of agreement as specified in this SWIOFP MoU.

Bearing in mind that access to new data, associated metadata, information collection **activities and resulting products funded by the FAO/ASCLME Project** shall be free and unrestricted;

The primary owner of data sets shall be the UNDP GEF ASCLME Project, the FAO and the member-countries of the ASCLME Project, and the primary contact points and archive locations for ASCLME-generated data shall be at nationally appointed data centres as well as through the ASCLME Project Coordination Unit and the FAO.

The first right to publish findings from new data, associated metadata, information collection activities and resulting products funded by the ASCLME Project resides with the principal investigator

and her/his associated team (in the case of a scientific investigation), the participating country and the ASCLME Project and FAO.

These guidelines for intellectual property assume that adequate opportunity has been given to regional scientists to collaborate on research projects (data collection, processing and paper-writing), particularly from countries in whose territorial waters the research cruises have taken place.

Interim data management guidelines with specific reference to 2008 ASCLME/EAF-Nansen cruises

Detailed documentation will be made of all measurements and samples collected during each cruise. Documentation will include the cruise track, timing, geo-referenced and time-referenced records of every sampling site and station. All specimens and samples collected will be described and documented electronically during each cruise.

Wherever possible, duplicate or triplicate voucher specimens of macrofauna will be preserved.

The IMR Cruise Leader and the ASCLME Chief Scientist will be jointly responsible for ensuring the accurate documentation of activities, preservation of samples and backup of electronic data.

The primary custodians of data sets shall be the Institute of Marine Research, Bergen (on behalf of the FAO EAF-Nansen project,) the UNDP/GEF ASCLME Project and the member-countries of the ASCLME Project. The primary contact points and archive locations for the survey data shall be at nationally appointed data centres as well as through the ASCLME Project Coordination Unit. The intellectual property of new data, associated metadata, information collection activities and resulting products resides with the principal investigator (in the case of a scientific investigation), the Institution to which the scientist belongs, the participating countries, the ASCLME Project and FAO.

Timing of cruise data reports and products

Specimens

Morphological specimens which are preserved as voucher specimens will be fixed in formalin during the cruises. These will be transferred to ethanol after fixing, also during the cruises. At least one voucher will be lodged at each of:

1) the South African Institute of Aquatic Biodiversity in South Africa (SAIAB). This is an African collection where specimens will be preserved for the use and study by scientists throughout the region.
2) The National collection or National focal point institution for the ASCLME Project of the country from which the collection was made. This will ensure that countries also keep voucher collections. Where feasible, appropriate support will be provided by the ASCLME Project to the countries that do not currently have good capacity for specimen curation.

Specimens will be lodged at institutions *within three months of the conclusion of the 2008 cruises (18 March 2009)*

Electronic data from the cruises

A provisional cruise report and completed data report (containing documentation of all measurements and samples collected during each cruise, include the cruise track, timing, geo-referenced and time-referenced records of every sampling site and station) will be provided to the ASCLME PCU *within 21 days of end of that particular cruise*. It is accepted that biological samples may not be identified and sorted before the end of the cruises, but those data that are captured must be included in the report. Together with this, an electronic version (in Excel) of all activity/site/station records, and video & photographic inventories will be given to the PCU.

The provisional cruise reports and completed data reports will be made available to the ASCLME participating countries *within six weeks of the conclusion of the 2008 cruise schedule (21st February 2009).*

A final draft cruise report will be made within three months of the completion of the survey. The Cruise Leader and the Chief Scientist are responsible for finalising the report which will be distributed to ASCLME and FAO for final editing and approval. After approval this will be named the Final Cruise Report and will be printed and be available in electronic copies in pdf format.

Processed data from the cruises

A complete set of all processed data collected on the 2008 ASCLME cruises will be made available to the PCU *within three months of the conclusion of the cruise (18 March 2009).* Examples of these data will include CTD, ADCP, multibeam data sets, as well as inventories of identified specimens. It is recognized that some data sets may not be processed by this time. In that case, any raw electronic data must be provided to the PCU together with a report on the steps (and timing) that will be taken to process the data.

The provision of flagged (data to be published) data sets to the PCU will be safely retained offline until either

a) Chief scientists agree to the dissemination of data sets OR
b) Publications are submitted OR
c) Eighteen months has passed since the conclusion of the cruise, whichever is the soonest.

As soon as processed data sets are distributable, they will be lodged at nationally appointed data centres for the ASCLME.

Raw OR processed data collected by scientists under the ASCLME Project shall be immediately available to the Regional Information Working Group (made up of national D&I Coordinators) for the sole purpose of (*internally*, not for distribution) informing the TDA/SAP, should it be necessary.

Proposed time line for delivery of data products

During each cruise	All sampling activities are carefully documented, geo-and time-referenced.
	Voucher specimens are fixed.
Final day of the 2008 cruise schedule. 18 December	Provisional cruise reports, and final data report (containing a record of sampling activities) is delivered to the PCU. Electronic inventories are provided to the PCU.
After completion of the 2008 cruise schedule (ongoing)	Public domain data sets are reviewed, checked and made available to the PCU and National data centres.
Six weeks after that. 21st February	Provisional reports, and the final data reports are sent to ASCLME countries.
Three months from the conclusion of the 2008 cruise schedule. 18 March 2009	Voucher specimens are lodged at National Collections.
	All processed data (or raw data sets + report if not yet processed) provided to the PCU.
	Draft Final Cruise Report submitted to FAO and ASCLME
Eighteen months from the conclusion of the 2008 cruise schedule. 11th June 2010.	The last of the processed data sets are made available to National data centres.