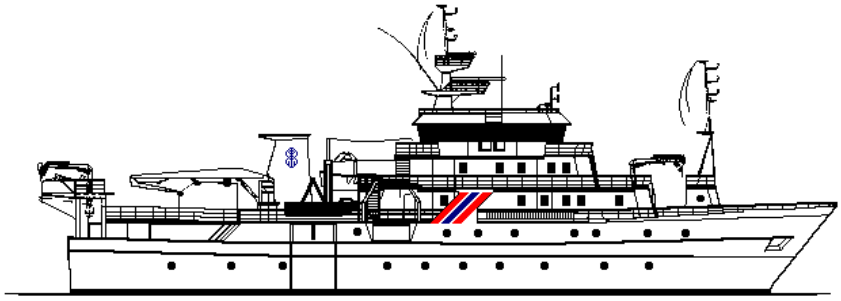
PRELIMINARY

Cruise Report "Dr. Fridtjof Nansen"



Survey of the Comores Gyre

(ASCLME & SWIOFP 2009 Cruise 3)

5 October – 3 November 2009

By

***R.Roman*[1)], *S. Kaehler*[2)], *K. Michalsen*[3)], *M. Olsen*[3)] *and Morgane Perri*[4)]**

[1)]University of Cape Town
Private Bag X3
Rondebosch 7701, South Africa

2)Rhodes University
PO Box 94
Grahamstown
6940

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

[4)] Megaptera, France

Text from old report. If not used in the new report this texts will be removed

Text/figures that must be checked and possibly changed

Text without color is the text that in the end will represent our preliminary cruise report

Table of Contents

1 Introduction

This is a ***preliminary*** cruise report made at the end of the 2009 FAO/ASCLME /SWIOFP survey of the Comoroes Gyre. Not all results (eg. Zooplankton data) are ready at the time of writing and the analyses presented are *initial* and conclusions may therefore change as the data is analyzed more thoroughly.

To fully understand the processes in Comoros Gyre the design of the 2009 survey encompassed the Comoros Gyre and its three inflow regimes; the East Madagascar Current, along the African coast sub-surface of the East African Coastal Current and the southern Mozambique Channel. Although the Comoros Gyre shows no distinct flow pattern intermediate depth floats do however indicate the overall flow in the basin to be to the south (Di Marco et. al., 2002). The northern branch of the East Madagascar Current is formed between 18-20°S where the South Equatorial Current hits the coast of Madagascar. The current flows around the northern tip of Madagascar towards the east African coast from where the water flows south into the Comoros Basin and northwards as part of the East African Coastal Current. At intermediate level it appears that most of the flow is towards the Comoros Basin along the African shelf break. The East African Coastal Current is a shallow current that flows between 11 and 3°S where after it becomes the eastward flowing Equatorial Counter Current. Sub-surface of the current to flow is overall to the south, towards the Comoros Gyre. Flow in the southern Mozambique Channel is also overall to the south but it has been shown that at deeper levels there is some flow into the Comoros Basin. Eddies across the narrows of the Mozambique Channel further enhances the interaction allowing for surface level transport between the southern part of the channel and the Comoros Basin.

1.1 Aims & Objectives

To establish for the very first time the physical, chemical and biological characteristics of the Comoros Gyre. The Gyre is an anti-cyclonic eddy that is generally located from 10°S to 15°S and between the north-east coast of Mozambique and the north-west coast of Madagascar (Figure 1). The location of the Gyre is not constant (Figure 1) necessitating the long transects depicted in Figure 2. A number of recent exploratory cruises, satellite tracking and remote sensing studies have shown that the northern Mozambique Channel to be a generally oligotrophic environment that nonetheless supports a large number of fisheries, a high biodiversity and high densities of ecologically important top predators. To date, the processes that sustain the biomass and diversity of this ecosystem are not well understood. It has been acknowledged, however, that the region at a global scale, is physically unusually dynamic and it has been suggested that the observed spatial and temporal variability of the physical environment may well play an important role in enhancing both pelagic and coastal production and the distribution of fish, zoo & phytoplankton and coral larvae.

SWIOFP has identified small pelagic fishes (scads, mackerels, herrings and sardines) as a potential future resource in the Comoros islands. The R/V *Dr Fridtjof Nansen* survey around the islands will undertake acoustics transects to determine the distribution and abundance of small pelagic fish shoals. Mid-water trawls will be undertaken on fish aggregations to determine species and size composition. Biological sampling to determine the length, weight, sex, and reproductive condition of random samples of selected species will be undertaken. Otoliths for age/growth determination and genetic samples for population genetic studies will be collected from selected species.

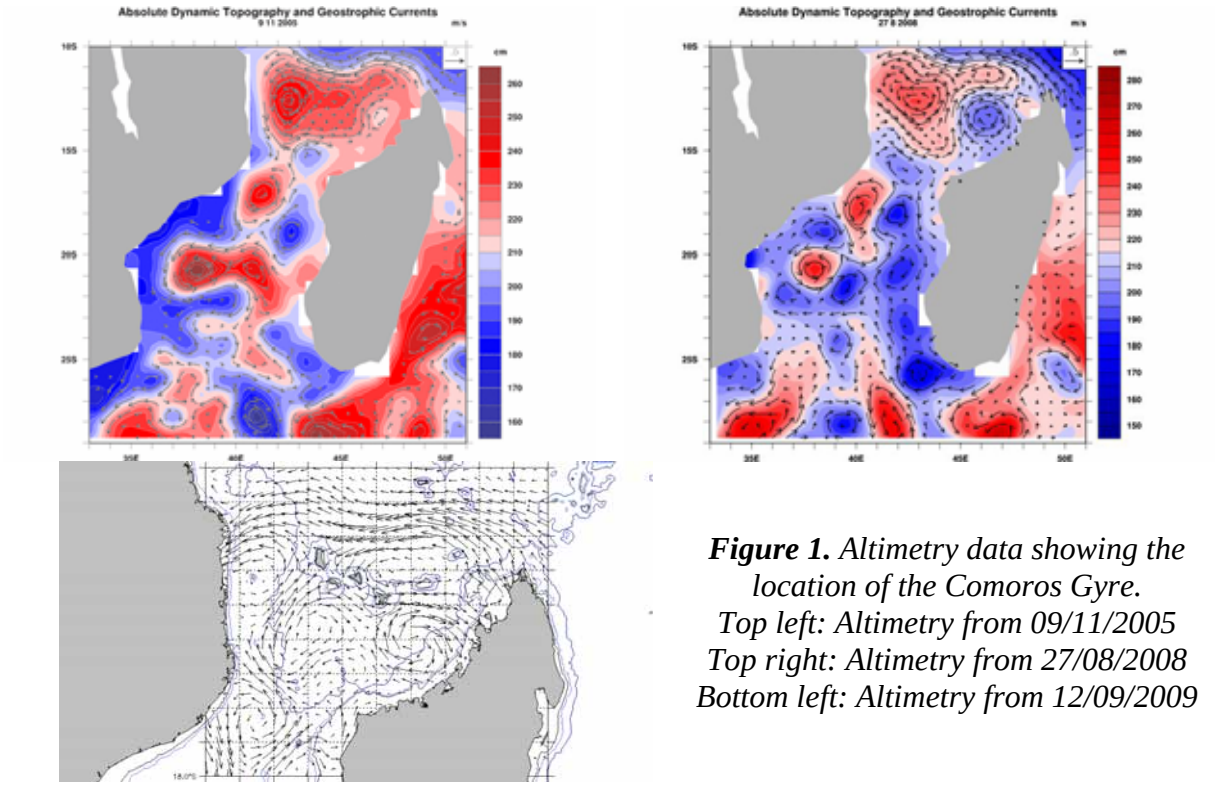


Figure 1. *Altimetry data showing the location of the Comoros Gyre.*
Top left: Altimetry from 09/11/2005
Top right: Altimetry from 27/08/2008
Bottom left: Altimetry from 12/09/2009

Objectives are:

1. To carry out a multi-disciplinary cruise that investigates the physico-chemical processes and fisheries potential of small pelagic fishes in the Comoros Basin.
2. To establish the distribution, abundance and composition of organisms at a number of trophic levels in the Comoros Basin.
3. To establish, as far as possible, the productivity, diversity and biomass of the pelagic ecosystem.
4. To establish the role of the island shelf region and terrestrial input in linking coastal and pelagic biomes (coupling).
5. To investigate the role of the Comoros Gyre as a dispersal agent.
6. To investigate mesopelagic and, if trawlable conditions exist, demersal fish species diversity and abundance.
7. To determine the distribution and abundance of small pelagic fish shoals around the islands of the Union of Comoros and Mayotte using acoustics methods and a systematic grid survey strategy.
8. To use regular surface and midwater trawls on target fish aggregations for species composition, biological information and genetic material of selected small pelagic fishes for fisheries resource assessment purposes.

9. To link various sources of energy and nutrition to different food-web compartments.
10. Capacity building of ASCLME and SWIOFP trainees & young scientists.
11. To fulfil the data management agreement contained in Appendix A.

1.2 Key Questions & deliverables

1. What are the processes that drive production in the region?
2. What is the phytoplankton, zooplankton, ichthyoplankton diversity of the pelagic ecosystem and the main mesopelagic fish fauna?
3. What is the distribution and abundance of the marine flora and fauna including the avifauna, marine turtles and mammals in the Comoros Basin?
4. What determine the relative abundance and assemblage composition of larvae/juveniles in relation to hydrographic features?
5. What are the main energy and nutrient sources that subsidise the pelagic food-web?
6. What are the cross-basin characteristics of the current and its biota?
7. How important is coastal-pelagic coupling in supporting fish biomass?
8. What is the relative importance of the Comoros Gyre in producing and/or relocating biomass?
9. What are the species composition, abundance and distribution of small pelagic fishes of potential importance to fisheries?
10. What are the biological characteristics (size composition; length-weight; age-length; size at maturity) of selected small pelagic fish species captured during the survey?

Deliverables will be:

1. Cruise reports
2. Data reports
3. Genetic samples and otoliths
4. Electronic inventories
5. Scientific publications in peer reviewed international journals
6. Training and capacity building

1.3 Participation

Field	**Names**	**Affiliation & nationality**	**Gender**
Cruise Leader	Kathrine Michalsen	IMR, Norwegian	Female
Cruise Leader (Local)	Raymond Roman	UCT, South African	Male
Physical Oceanography	Nicolas Rascle	UCT, South African	Male
Oceanography	Charine Collins	UCT, South African	Female
Oceanography	Kate Munnik	UCT, South African	Female
Oceanographic	Caren George	SAEON, South	Female
Biological	Sven Kaehler	RU, German	Male
Zooplankton	Ali Binty Soafia	IHSM, Malagasy	Female
Fisheries biology	Abdallah Youssouf Ben	Comores	Male
Fisheries biology	Jaffar Mohidone*	Comores	Male
Fisheries biology	Ahmed Soifa	Comores	Male

Fisheries biology	Jessica Escobar*	ORI, South African	Female
Marine mammals	Morgane Perri*	Megaptera, France	Female
Technician	Magne Olsen	IMR, Norwegian	Male
Instrument Chief	Terje Hovland	IMR, Norwegian	Male
Instrument Operator	Ole Sverre Fossheim	IMR, Norwegian	Male

* SWIOFP Scientists

List of abbreviations
ASCLME: Agulhas Somali Current Large Marine Ecosystem
RU: Rhodes University
UCT: University of Cape Town
IMR: Institute of Marine Research, Norway
SAEON:
IHSM:

Land based personnel:
MCM Scientific Advisor: Mike Roberts (squid@metroweb.co.za)
Ocean Modeling: C Reason, P Penven
Phytoplankton: R Barlow, T Bornman, M Kyewelanga
Remote Sensing: H Demarcq
Zooplankton: J Mwaluma, N Strydom
Acoustics: M Soria, E Josse
Fisheries : F Marsac, F Menard, N Bodin, E Romanov, T Filippi
Nansen-EAF Project Research Coordinator: Dr Tore Strømme (Tore.Stromme@fao.org)
ASCLME Coordinator: Tommy Bornman (t.bornman@ru.ac.za)

1.4 Overview of the cruise and study area

Logistics

R/V *Dr Fridtjof Nansen* did dock in Moroni, Comoros, on 5 October 2009. The ship did remain in port for two days to take on the scientific crew. The ship departed on the afternoon of 6 October, but due to problems with licences to enter any of the 6 EEZ that was involved, the order of the transect had to be changed. First all the stations around the Comoros Island were conducted. Then transect 10 was sampled. The vessel sailed south east along transect 3 to the coast of Madagascar, followed by Transect 2 due north from the northern tip of Madagascar. The Comoros Gyre cruise did encompass a period of 27 days of environmental stations, acoustic surveys, trawling and steaming. The cruise did end in Anjouan, Comoros, on 3 November 2009.

Survey Design

The survey will sample 10 environmental transects as show in Fig. 1 and 3. Steaming along the coast will be required between Transects 2 & 3 and 8 & 9. The cruise design given in Fig. 1 & 3 shall be followed closely, but flexibility is allowed in order to adjust for delays due to weather or technical problems and to accommodate findings at sea and satellite information relayed from the shore base. The acoustic tracks around the islands are not shown due to the narrow shelf.

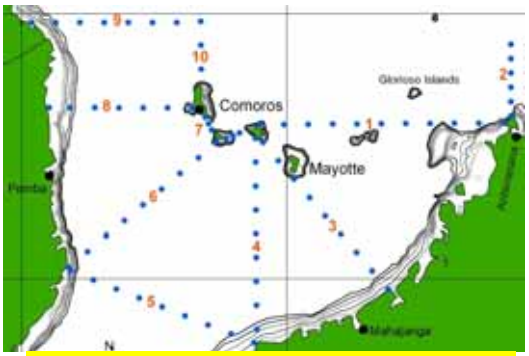


Figure 2. *Environmental survey design*

Scientific work

The principal tasks will be to carry out using the station grid shown in Fig 1 & 3 as closely as possible, but being guided at all times by the time available, by new satellite information and suggestions relayed by the shore-based teams. At each environmental station *CTD profiles* and Niskin bottle *water sample collection* will be carried out to near the bottom or as deep as the CTD cable can go (3000 m). In addition to CTD casts, multi-nets and, if necessary, oblique bongo nets (200 micron mesh) will be deployed at the stations shown in Figure 4. Underway hydro-acoustics will be used to locate midwater trawl stations, which may be independent of the above full environmental stations. Details of the proposed acoustic coverage is shown in Figure 5 below. Acoustic coverage of the southern reefs will be carried out during Transect 1 and the northern reef after completion of Transect 2. Demersal/bottom trawling will only take place where the seafloor is suitable for trawling. A map of all trawlable ground/areas will be produced. Approximately two surface trawls per transect are planned (Figure 4).

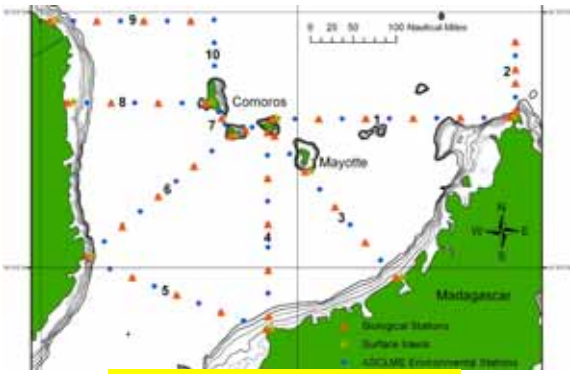


Figure 3 *Biological stations*

In each of the transects, a number of physical or full environmental stations were completed (Fig. 1.3.1). These varied in composition depending on requirements of the survey. Full environmental stations typically included CTD, multinet, bongo, as well as water samples for size-fractionated chlorophyll, phyto-pigments, particulate organic matter (POM), primary production, nutrients and nitrate isotope analysis. A detailed summary of samples taken at each station are provided in Table 1.3.1. Additionally, surface and meso-pelagic trawls were conducted in areas of interest, hydro-accoustics were used to identify areas of high zooplankton and fish biomass and bird and marine mammal observations were carried out during daylight hours.

Summary of Survey effort

For the purpose of establishing the physical, chemical and biological characteristics of the Comoros Gyre the sampling was conducted along 10 straight transects. Figures 1.1-1.3 show the cruise tracks with bottom trawls, pelagic trawls, hydrographical stations and plankton stations. Table 1.1 summarises the survey effort in each transect.

Table 1.1 Number of hydrographic (CTD), plankton (PL), pelagic trawl (PT) and bottom trawl (BT) stations as well as the distance surveyed (NM) during the survey, by transects.

Region	**CTD**	**PL**	**PT**	**BT**		**NM**
Line 1						170
Line 2						
Line 3						150
Line 4						202
Line 5						211
Line 6						214
Line 7						
Line 8						150
Line 9						
Line 10						
Acoustic survey, Grand Comore						
Acoustic survey, Moheli						
Acoustic survey, Anjouan						
Acoustic survey, Mayotte						
Total						

Table 1.3.1: Stations and samples collected (grey)

Station #	Instrument	Date	Time	Lat	Long	DO	Salinity	Nutrients	Tot Chl	Pigm	Abs	Fract Chl	Prod	Isonitr	POM	Micro-zoo	V
1176	CTD	28/11/2008	11:36	-13.093	40.719												
1177	CTD	29/11/2008	6:52	-14.467	42.670												
1178	CTD	29/11/2008	14:20	-14.916	43.329												
1179	CTD	29/11/2008	15:44	-14.913	43.323												
XBT1	XBT	29/11/2008	18:57	-15.211	43.097												
1180	CTD	29/11/2008	20:43	-15.480	42.866												
1181	CTD	29/11/2008	22:36	-15.487	42.868												
XBT2	XBT	30/11/2008	0:10	-15.58	42.762												
XBT3	XBT	30/11/2008	1:02	-15.685	42.655												
1182	CTD	30/11/2008	2:04	-15.800	42.531												

2 Methods, Instruments, Calibrations:

2.1 Conductivity, Temperature and Depth Instrument (CTD):

A Seabird 911 plus CTD was used to obtain vertical profiles of temperature, salinity, pressure and oxygen. Real time plotting and logging was carried out using the Seabird Seasave software installed on a PC.

2.1.1 CTD sensor calibrations:

Three calibrations were completed for this survey:

a) Dissolved Oxygen:

The dissolved oxygen calibration shows a very stable sensor with little to no correction needed to the raw data (Fig. 2.1.1 a). Calibrations were done using the Winkler Titration on a manual 725 Dosimat system.

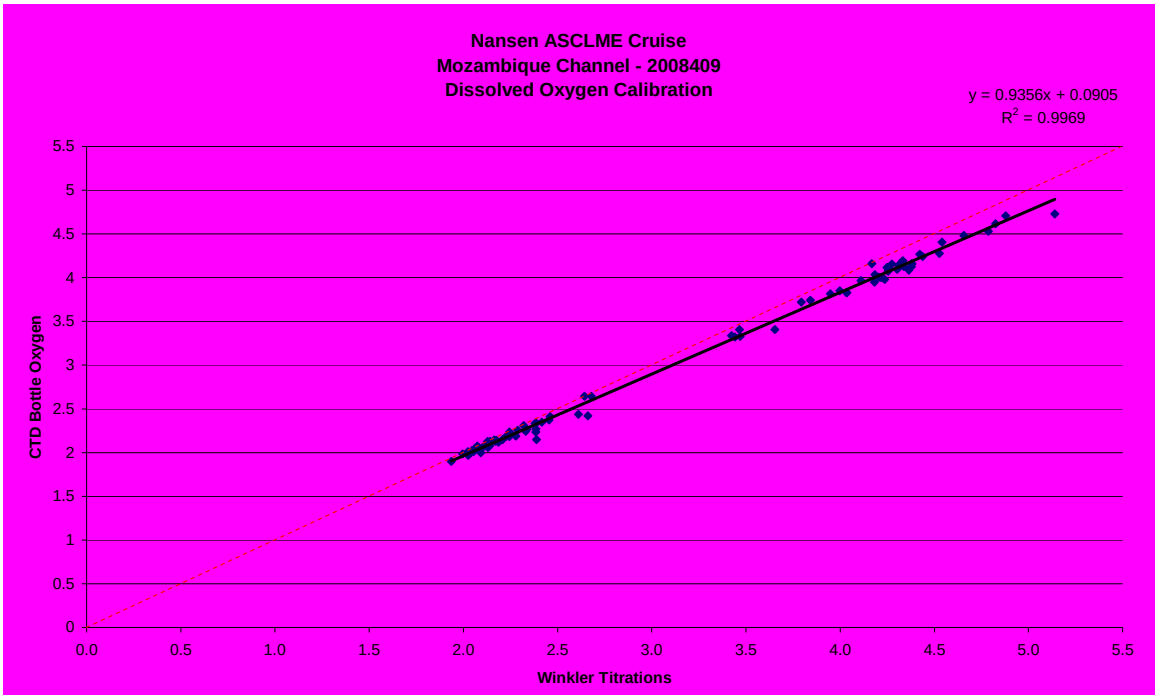


***Figure 2.1.1 a**: Dissolved oxygen linear regression plot – CTD bottle oxygen vs. Winkler Titrations.*

b) Derived Salinity:

The calibration of the conductivity cell using derived salinity from the CTD compared to samples analyzed on a Guildline Portasal system proved to be a bit tricky. The Guildline Autosal gave numerous problems and was eventually dismantled to fix leaking capillary tubes and service the pump motor. However, a calibration was made with the samples that remained stable enough (Fig. 2.1.1b). It is recommended that the Guildline Autosal onboard the vessel be sent back to the manufacturer for a factory calibration and a general service.

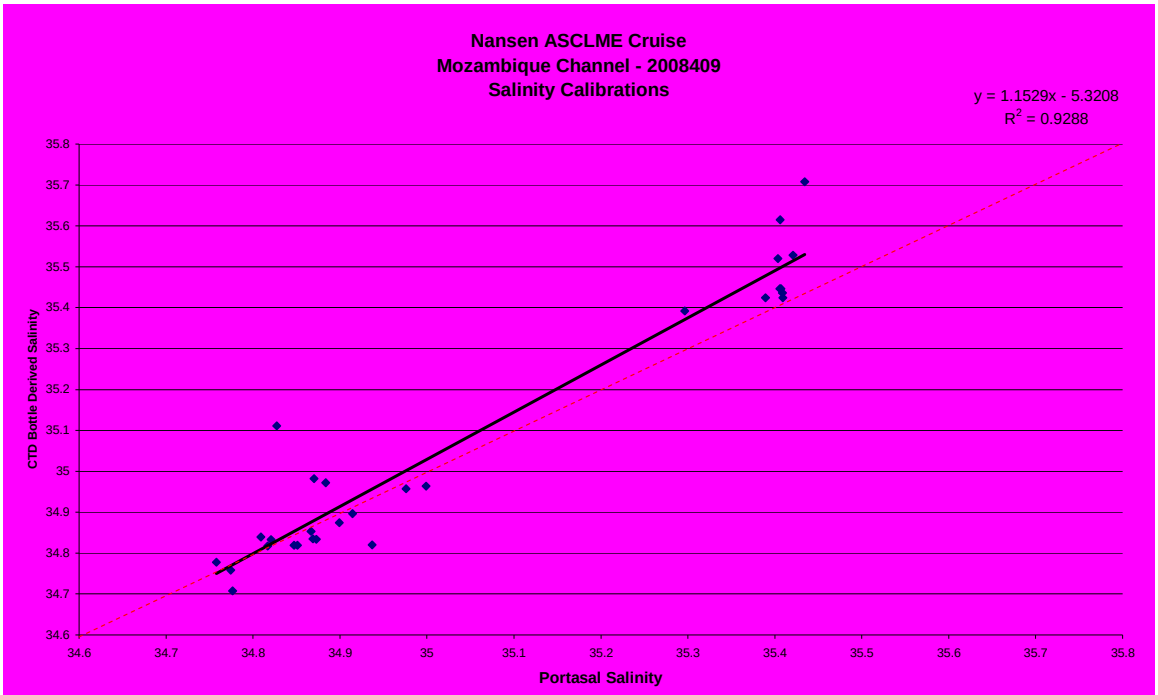


***Figure 2.1.1 b**: Derived salinity regression plot – CTD bottle salinity vs. Portsal Salinity readings.*

2.2. Methods for water samples:

2.2.1 Dissolved Oxygen

Two dissolved oxygen samples were taken at all full hydrographic stations, usually at the bottom and from an oxygen minima bottle sample. Seawater was tapped from the Niskin bottle using a PVC pipe that fits over the tap. Water was allowed to flow for 20 seconds before the pipe was removed, without entrapping any bubbles within the glass container. Two reagents were then added to the bottle, Manganous chloride and Potassium Iodide with Sodium Hydroxide (1 ml each). The lid was replaced onto the bottle and shaken to capture all the dissolved oxygen out of the seawater. This precipitate was titrated against Sodium thiosulphate, after mixing in 2 ml of concentrated hydrochloric acid. The titrated volume was then used to calculate dissolved oxygen..

2.2.2 Salinity

Two salinity samples were taken at most full stations for calibration purposes. This was eventually stopped to allow for the servicing of the Guildline Portasal. Sample bottles were washed out three times with seawater from the Niskin bottle, before being filled to the bottle neck. These samples were stored alongside the Portasal and analyzed once they reached room temperature.

2.2.3 Total Chlorophyll

At each full environmental station, five samples were taken for total chlorophyll *a*. One sample was taken at the fluorescence maximum (Fmax), one below Fmax, one at the surface and two samples in between the surface and Fmax, in order to get a description of the fluorometric profile. At physical stations additional filtrations were taken at any bottles that were within the photic

zone (usually three). 250 ml of seawater was filtered for each depth, onto 25 mm glass fibre GF/F filters. These filters were frozen , labelled and await analysis in Cape Town.

2.2.4 Phytoplankton samples

1000ml phytoplankton samples were collected at the surface and Fmax at all environmental stations and at physical stations, where possible. Storage was in plastic bottles and fixation occurred with Lugols solution. Samples were then stored in the dark.

2.2.5 Nutrients

Samples were collected at all water depths where Niskin bottles were triggered. The test tubes were rinsed three times and filled to ¾ volume to allow space for freezing. Test tubes were marked with a pencil (station # and depth), and trays of samples were stored in plastic bags in the freezer once the samples had frozen properly.

2.2.6 Size fractionated POM

Water samples for particulate organic matter were collected at the surface (20 l) and from Fmax (20 l) at all full environmental stations. For the determination of the smaller POM size fraction (pico and nano), 10 l from each depth was pre-screened through a 20µm mesh and the resulting water filtered onto precombusted GFF filters. For the determination of total POM (pico, nano and micro), 10 l of water from each depth was prescreened through 64µm mesh (to remove zooplankton but maintain the micro POM size-fraction) and the resulting water filtered onto precombusted GFF filters. Attempts were also made to isolate the micro size fraction of the POM, but concentrations were too low for this to work.

The GFF filters were then labelled, packed, dried at 50^{o}C for 24 hrs and stored for analysis in South Africa.

2.3 Underway Acoustic Doppler Current Profiler

The 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 was stored in 3 m or 4 m vertical bins for post survey processing.

2.4 Biological sampling methods

2.4.1 Multinet sampling

Oblique multi-nets (190µm mesh size) were deployed at all full environmental stations; with the exception of transect 2. During the latter transect windy conditions and high swell did not allow for multi-net deployments. At each station, the multi-net was lowered while steaming at 0.3-0.5 $m.s^{-1}$ to 200 m depth. The five nets were then opened sequentially at 200-120m, 120-80m, 80-50m, 50-25m, 25m to surface. Between 50-60 m^3 of water were filtered per stratum.
After deployment, the nets were rinsed into 250 ml jars and fixed in 8% formalin. Jars were labelled on the inside and outside and stored for analysis in South Africa.

2.4.2 Bongo sampling

Oblique bongos were deployed at each full environmental station to a depth of 200m with 190 & 370µm nets. Flowmeter readings on both nets were noted before and after each dip and allowed for the determination of water volume filtered. Between stations, the flow-meters were washed in distilled water. The bongo was lowered to 200 m while steaming at 2 to 3 knots. Thereafter it was retrieved at a rate of 10m per minute. From each Bongo, the 190µm sample was washed into 250 ml plastic jars and fixed in 8% formalin for future investigation. These samples will be used to work on fish larval abundance and zooplankton composition patterns. The 370 µm samples were size-fractionated by washing through serial 2mm, 1mm, 500 µm and 250 µm sieves. Each size fraction was touch dried on a paper towel and then weighed to the nearest 0.1 g. Subsamples for stable isotope analysis were extracted from the 250µm size fraction (copepods) and the 1 and 2 mm size fraction (euphausids). These samples were dried at 50^{o}C for 24hrs in Eppendorf vials, before storage. The largest size fraction from the 370um net was also sorted and all fish larvae removed under a dissecting microscope. Fish larvae from each Bongo were stored in labelled Eppendorf vials, in 70% alcohol. Larvae will be described and barcoded for identification in South Africa / Canada.

2.4.3 Acoustics

Dr Fridtjof Nansen use ER-60 echo sounders (with ER-60 software) and LSSS ("Large scale survey system", also called "El-trippel-S") for scrutinizing of echoes. The acoustic transducer is attached to an adjustable keel that can be lowered in rough weather to avoid the damping effect of bubbles. Echo intensities per nautical mile are integrated continuously, and mean values per 1 nautical mile are recorded for mapping and further calculations. The echograms, with their corresponding s_A-values, are scrutinized every day. Contributions from the seabed, false echoes, and noise are deleted. Data was stored on raw data files. Acoustic recordings were carried out along all the transects, as well as around the three Islands of Comoros and around Mayotte, zigzagging between bottom depths of 50 to 500 m. Four frequencies are being used (18, 38, 120 and 200 kHz). The acoustic surveys were pursued at a cruising speed of 10 knots or less.

The survey targeted firstly plankton, mesopelagic fish and pelagic fish aggregating in the upper 200 m of the water column. Secondly, an acoustic survey around the Comoros Island and Mayotte was conducted in order to determine the distribution and abundance of small pelagic fish shoals. Secondly, the dynamics of the migrating scattering layer and the pelagic layer communities was studied in more detail using fisheries acoustic and mulinet trawling. The corrected values for integrated echo intensity were allocated to species according to the trace pattern of the echograms and the composition of the trawl catches. Data from pelagic trawl hauls and bottom trawl hauls were not considered to be 100 % representative for the pelagic component of the stocks. The reason is that we did see several schools of tuna and mackerel jumping in the surface, but these were not possible to catch in the trawl, nor did they show up on the acoustical recordings. Fishing rods were tried, but these attempts did not give any successful output. The schooling fish was obviously avoiding the ship.

The echo sounders were watched continuously, and trawl hauls in addition to the predetermined hauls were carried out whenever the recordings changed their characteristics and/or the need for biological data made it necessary. Trawling was carried out both for identification purposes and to obtain biological observations, i.e., length, weight, maturity stage, stomach data, and age.

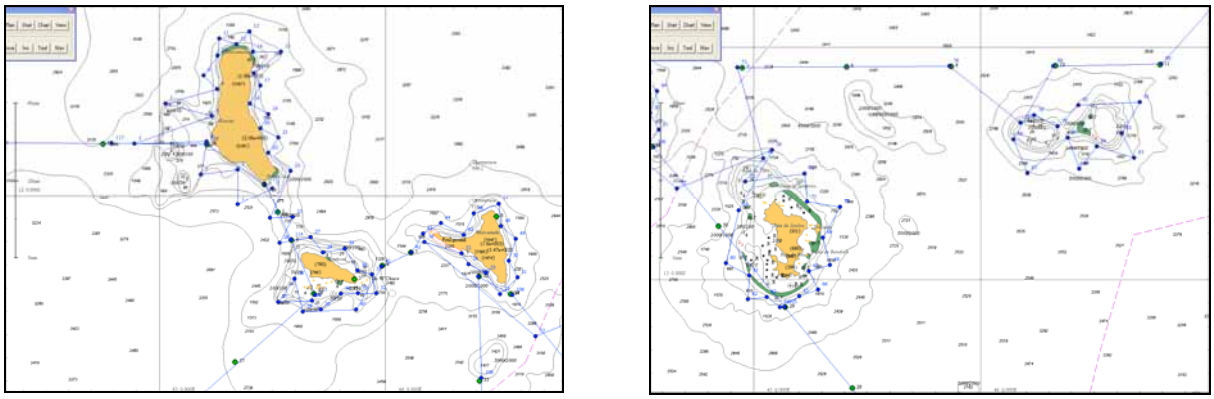


Figure 2.4.1. *Approximate acoustic cruise track where the vessel is* zigzagging between depths of 50 to 500 m. The panel to the left shows the 3 Comoros Island while the panel to the right shows cruise track around Mayotte

2.4.4 Acoustic zooplankton calibrations

In one station several Multinets were conducted to attempt to calibrate underway acoustic data with zooplankton abundance estimates. Well defined scattering layers were specifically targeted for composition and size frequency distribution with the Multinet. The surface and deep scattering layers were targeted both before and after dark and the migrating layer investigated.

2.4.5 Surface trawls

Surface trawls were carried out at the end of each transect (on or close to the shelf) and in a few additional locations; where time permitted. Daytime surface trawls using a xxx net, were carried

out specifically for the collection of juvenile life-stages of coastal fishes. Each trawl occurred for approx 30min at a speed of ~ 3 kn. Juvenile fish and all other trawl contents were immediately sorted, counted and weighed to the nearest 0.1g. Representative photos were taken of all new juvenile fish and a juvenile larval inventory (with photos) was constructed. Representative samples were collected (3 individuals per species) and individually packed in 70% alcohol for identification using barcoding. All remaining larvae were also kept, but stored mixed in alcohol in one container for each trawl.

2.4.6 Mesopelagic trawls

Mesopelagic trawls were carried out in locations where the acoustics suggested fish aggregations. Each trawl occurred for approx 30min at a speed of ~ 3 kn. All fish and other trawl contents were immediately sorted, counted and weighed to the nearest 0.1g. For larger fish specimen, length was determined. Representative photos were taken of adult and juvenile fish. Representative samples of fish were collected (3 individuals per species per trawl) and frozen for further processing at the South African Institute for Aquatic Biodiversity (SAIAB). Fish juveniles were individually packed into vials with 70% alcohol for identification using barcoding.

2.4.7 Demersal trawls

Demersal trawls were carried out wherever the substratum allowed. Unfortunately, due to the steep slopes of the volcanic Comoros islands, only one demersal trawl was performed. Fish samples (3 individuals per species) were photographed, identified and weighed. Thereafter they were stored in large plastic bags and frozen.

3 Results

3.1 Water masses Raymond

3.2.1 Current Structure

3.2.2 Hydrographic structure

3.7 Biology

Only partial and preliminary results will be presented here as more detailed data and laboratory analyses are required for most biological studies and additional background information needs to be acquired.

3.7.1 Nutrients and total Chlorophyll

Total chlorophyll and nutrients samples were collected at 135 stations. Both nutrient and chlorophyll analysis will be carried out upon return to South Africa and cannot be further commented on in this preliminary report.

3.7.2 Fish juveniles

Juvenile stages of fish were collected in a total of 19 trawls (surface or near surface), on or near the shelf of the Comoros, Mayotte, Magagascar and Mozambique. Some 151 taxa were distinguished, photographed and prepared for bar-coding and identification (see appendix 1). The taxa ranged from species with potential commercial importance such as scombrids (2 or 3 tuna species), anchovies and carangids (10 kingfish species) to coral reef inhabitants such as parrot fish, rock cods and surgeon fishes.

In terms of juvenile species richness, distribution and abundance the current cruise data must be interpreted with great care. The number of trawls was relatively low and no attempts have yet been made to link our sample compositions to the physical environment. In order to strengthen the data, samples from previous ASCLME cruises as well as upcoming regional cruises need to be added to the analysis. Nonetheless some patterns do seem to emerge. The number of species caught in each trawl did not vary dramatically between locations (Fig 3.7.2a). On average 21 species were distinguished per trawl. The fact that this is only a tiny fraction of the total number of species identified, suggests that we have under sampled the representative taxa and/or or that different species are to be found in different localities (apparently true in some cases). Only a more complete analysis of all data sets will allow for a less subjective interpretation.

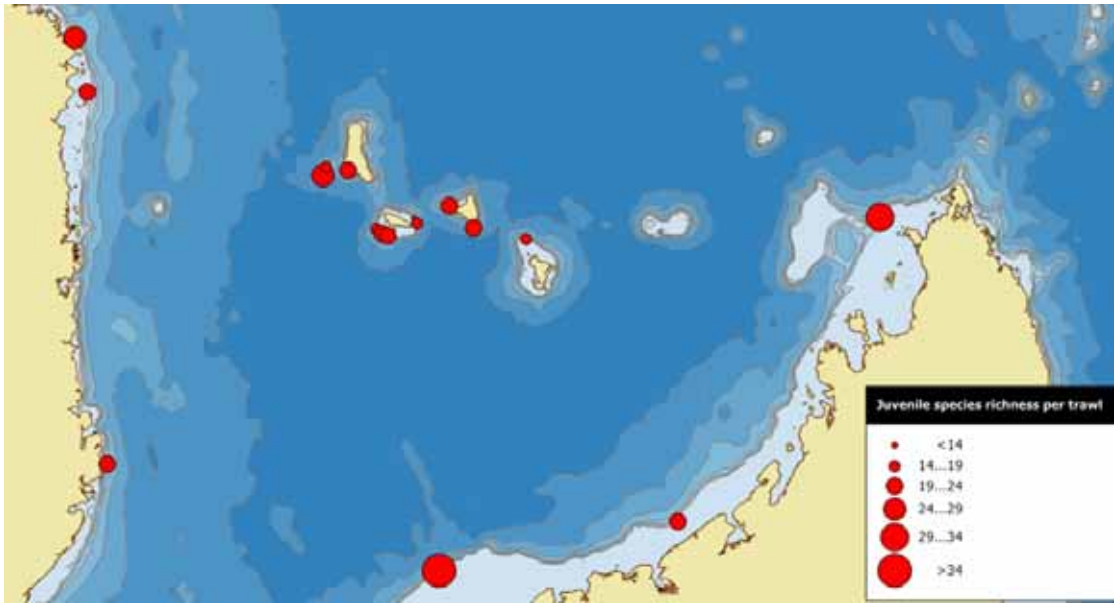


Fig. 3.7.2a: Map of juvenile species richness in the region

While the number of taxa collected show little variation between locations, the number of individuals per unit water volume vary more dramatically (Fig. 3.7.2b). The highest densities of juveniles were generally caught along the Madagasi shelf, with fewer being observed in the Comoros region and the lowest overall abundances along the Mozambique coast. Again, additional samples need to be added to this analysis to see whether this pattern stands up to scrutiny. At the time the cruise, the eastern Comoros Basin was dominated by a cyclonic eddie,

while the western part was dominated by a large anti-cyclone. Both physical and nutritional aspects of these features might have affected the survival and distribution of juvenile fish stages.

The juveniles caught during this cruise will add to a regional juvenile identification guide, will allow us to better understand larval and juvenile origins and dispersal (with the help of genetics) and should eventually allow for more informed regional management strategies (pertaining to commercial fisheries as well as coastal ecosystem health).

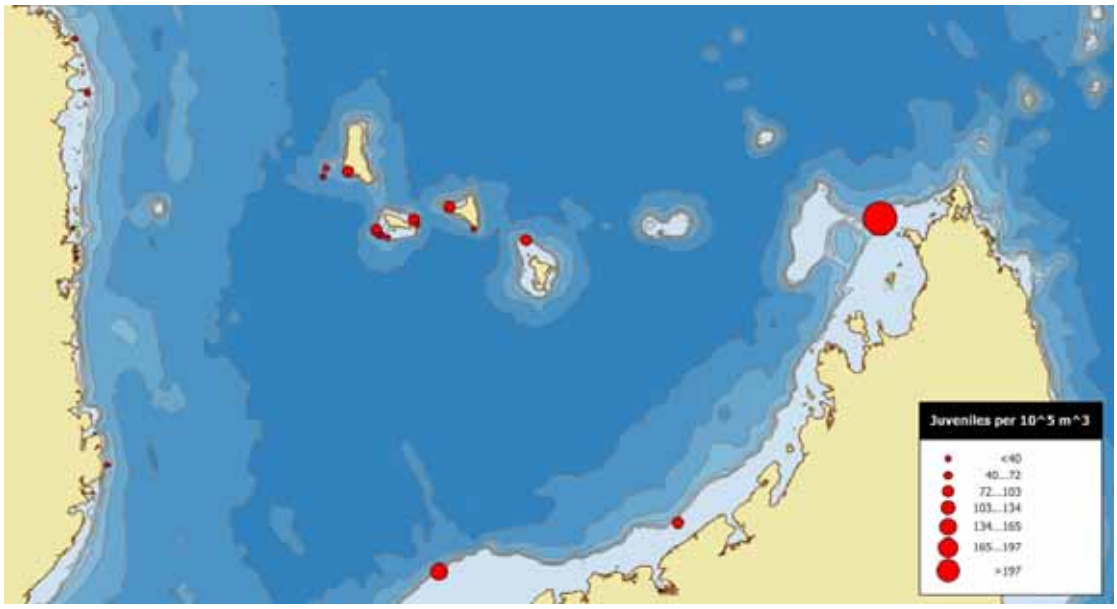


Fig. 3.7.2b: Map of juvenile species abundance (individuals per 10^5 cubic meters)

3.7.3 Zooplankton

Zooplankton results as presented here comprise data from only the 370µm net of the Bongo. The 180µm net and the Multinet samples require analysis after the cruise before they may be commented on.

a) Bongo samples

The main aims of the Bongo sampling were to:

a) provide samples for stable isotope analysis and investigation of trophic links
b) provide samples for fish-larval identification and abundance estimates
c) provide an estimate of size-fractionated biomass distribution

Of the three aims, only the biomass estimates can be discussed at this stage as the other samples require further lab-based analysis.

During the Comoros survey, at total of 47 Bongo trawls were conducted at transect-linked full biological stations (Table 3.7.3.a) as well as a further 14 around the Comoros for a comparative study (Comoros vs Madagascar) by Soafia Binty Ali.

Table 3.7.3a.: Position of oblique Bongo stations.

DATE	TIME (GMT)	LON	LAT	Bottom Depth	STA	corrCTD
07-Oct-09	12:35:30	43.9191	-12.3238	314	PL1	1080
07-Oct-09	18:52:42	44.0472	-12.263	1971	PL4	1082
08-Oct-09	01:13:14	44.1865	-12.1678	270	PL7	1084
09-Oct-09	05:22:12	43.6065	-12.2115	86	PL10	1087
09-Oct-09	09:24:00	43.5459	-12.0752	828	PL13	1089
09-Oct-09	12:14:10	43.4812	-11.9567	216	PL15	1091
10-Oct-09	11:46:51	43.3562	-11.3557	146	PL18	1093
10-Oct-09	22:32:26	43.3435	-10.6833	3329	PL21	1096
11-Oct-09	07:00:14	43.311	-10.1579	3376	PL24	1099
14-Oct-09	03:32:33	44.529	-12.3945	156	PL26	1102
14-Oct-09	09:08:15	44.7345	-12.515	3203	PL29	1105
14-Oct-09	16:31:43	44.9266	-12.6366	218	PL32	1109
15-Oct-09	09:52:26	45.1612	-13.074	264	PL35	1110
15-Oct-09	14:13:13	45.3385	-13.3394	3483	PL37	1113
16-Oct-09	03:39:56	45.8056	-14.1918	3327	PL40	1116
16-Oct-09	09:52:06	46.1275	-14.7073	2736	PL41	1119
16-Oct-09	19:54:36	46.4839	-15.3061	276	PL44	1123
18-Oct-09	23:02:44	49.2538	-11.8776	222	PL45	1124
19-Oct-09	05:53:46	49.2951	-11.5235	2114	PL46	1128
19-Oct-09	13:08:14	49.2884	-10.8545	3930	PL47	1130
20-Oct-09	13:17:25	48.1562	-13.0019	355	PL48	1133
20-Oct-09	21:07:26	47.7647	-13.0165	2400	PL51	1136
21-Oct-09	04:57:17	46.9315	-13.0072	3426	PL52	1139
21-Oct-09	19:04:37	45.9146	-13.0278	3509	PL56	1142
22-Oct-09	00:48:36	45.3963	-13.0095	2182	PL57	1145
22-Oct-09	05:04:03	45.2825	-13.0081	974	PL59	1148
22-Oct-09	15:15:56	44.4859	-12.3894	323	PL63	1149
23-Oct-09	02:13:18	44.492	-13.3102	3551	PL64	1152
23-Oct-09	16:41:07	44.5089	-14.3529	3518	PL67	1155
24-Oct-09	01:47:47	44.4837	-15.3139	3371	PL68	1158
24-Oct-09	09:20:31	44.4645	-15.6394	660	PL71	1160
24-Oct-09	19:28:44	43.9815	-15.9123	740	PL75	1162
24-Oct-09	23:59:50	43.5637	-15.751	3025	PL76	1165
25-Oct-09	13:40:52	42.5756	-15.3833	3095	PL79	1168
25-Oct-09	22:16:26	41.6443	-15.0205	2276	PL80	1171
26-Oct-09	10:42:37	40.8955	-14.72	404	PL83	1176
26-Oct-09	16:07:18	41.2469	-14.4451	2773	PL84	1178
27-Oct-09	05:33:55	42.039	-13.7343	3002	PL87	1181
27-Oct-09	13:49:54	42.8007	-13.092	3410	PL88	1184
28-Oct-09	05:47:18	43.5184	-12.4821	715	PL92	1189
28-Oct-09	13:26:30	43.2391	-11.6852	716	PL94	1191
29-Oct-09	02:46:42	42.3794	-11.6843	2897	PL97	1194
29-Oct-09	10:25:39	41.4776	-11.6946	1989	PL98	1197

29-Oct-09	21:59:58	40.7121	-11.677	384	PL101	1202
30-Oct-09	09:35:58	40.5707	-10.4507	319	PL102	1203
30-Oct-09	19:53:22	41.2097	-10.4243	2427	PL105	1206
31-Oct-09	04:41:43	42.2159	-10.4452	2672	PL106	1209

At each of the biological stations, both Copepod and Euphausid samples were collected for isotope analysis. Additionally, an estimated 300 fish larval samples were collected for barcoding.

b) Bongo composition and biomass:

Only partial and preliminary biomass estimates will be provided in this section as additional work is required to separate abundance estimates at the taxonomic group level (i.e. copepods, euphausids, decapods etc). Furthermore, any interpretation of zooplankton distributions must at this stage be tentative as mesoscale anomalies cannot yet be positioned with certainty.

Total mesozooplankton wet biomass in the top 200m of the water column (as sampled by the 370µm Bongo) ranged from 11 to 94 mg m^{-3}. The predominant taxa in the smaller size fractions from most stations were:

280µm – 500µm:	copepods (also some gastropods, ostracods and amphipods)
500µm – 1mm:	copepods (also some amphipods, ostracods and euphausiid nauplii)
1mm – 2mm:	small euphausiids and chaetognaths (also some large copepods, amphipods, decapods)

The larger size fractions were more variable in composition, with euphausids, decapods, fish larvae and gelatinous zooplankton making up the bulk of the biomass. These larger size fractions of the zooplankton tended to make up a large proportion of the total biomass only during night-time stations. Particularly obvious in their temporal variability were the larger euphausids and decapods which occurred primarily during night time stations.
Preliminary results suggest that mesozooplankton biomass was highly variable throughout the survey. Total zooplankton wetmass (mg m^{-3}) was highest south-east of the Comoros and lowest south west of the islands. Spatially this pattern coincided closely with the position of a cyclonic and anti-cyclonic eddie in the vicinity of the Comoros.
As in previous cruises in the region, horizontal (geographical) distribution of zooplankton suggests that warm-core eddies contain overall very little zooplankton when compared to cold-core eddies and frontal boundary regions. While this result needs to be reinvestigated once updated altimetry data is available, current data suggest that biomass increases drastically outside of the warm-core eddies.

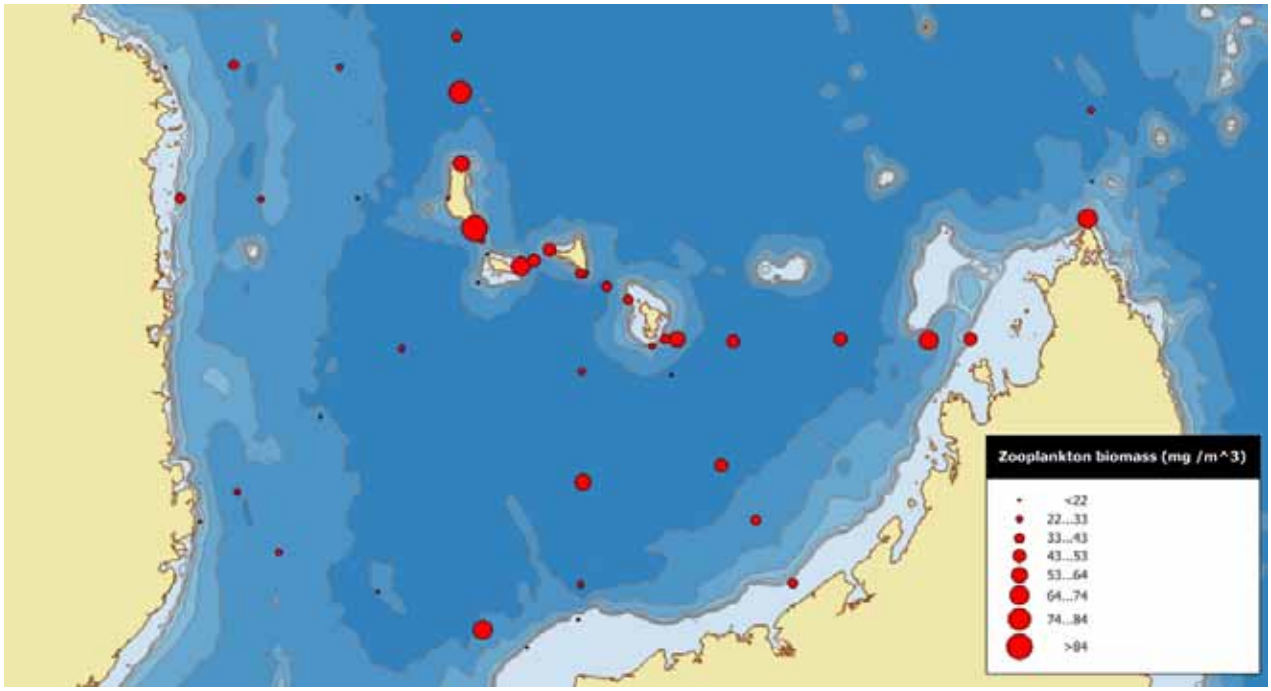


Fig. 3.7.3.: Horizontal distribution of mesozooplankton biomass

c) Multinet zooplankton

Multinets were deployed at all full biological stations with the exception of transect 10 (north of Madagascar). A total of 46 multinet stations were sampled all of which require further analysis before comments can be made.

Table 7.3.3.b: Position of multinet stations

DATE	TIME (GMT)	LOG	LON	LAT	Bottom Depth	STA
07-Oct-09	15:53:44	4369.35	43.9471	-12.3145	509	PL2
07-Oct-09	21:07:42	4384.91	44.0467	-12.2399	1859	PL5
07-Oct-09	23:56:17	4397.47	44.1868	-12.169	213	PL6
09-Oct-09	05:54:54	4624.26	43.6086	-12.2125	77	PL11
09-Oct-09	07:48:06	4632.73	43.5449	-12.0867	786	PL12
09-Oct-09	12:48:20	4647.25	43.481	-11.9514	92	PL16
10-Oct-09	12:22:40	4844.71	43.3493	-11.3554	104	PL19
11-Oct-09	00:45:22	4895.33	43.338	-10.6681	3349	PL22
11-Oct-09	04:20:26	4925.01	43.3378	-10.1875	3383	PL23
14-Oct-09	04:09:31	5334.3	44.5335	-12.3902	122	PL27
14-Oct-09	11:44:47	5355.1	44.7624	-12.5306	3201	PL30
14-Oct-09	17:06:57	5372.94	44.9246	-12.6288	127	PL33
15-Oct-09	08:56:54	5520.75	45.1608	-13.0718	91	PL34
15-Oct-09	17:00:47	5548.1	45.3914	-13.3634	3508	PL38
16-Oct-09	00:48:22	5602.33	45.8058	-14.1549	3347	PL39
16-Oct-09	12:04:40	5646.69	46.1219	-14.7227	2718	PL42
16-Oct-09	19:00:13	5689.25	46.4954	-15.2909	184	PL43
20-Oct-09	14:10:08	6243.64	48.1559	-13.0015	354	PL49
20-Oct-09	18:38:06	6266.59	47.7917	-13.002	2150	PL50

21-Oct-09	07:34:13	6321.68	46.9175	-13.0117	3400	PL53
21-Oct-09	12:45:54	6351.92	46.4291	-12.9991	516	PL54
21-Oct-09	16:23:31	6381.43	45.9266	-13.0129	3511	PL55
22-Oct-09	02:35:35	6418.42	45.3798	-13.0076	2097	PL58
22-Oct-09	06:56:05	6427.63	45.2596	-13.0133	416	PL61
22-Oct-09	14:18:44	6492.53	44.4983	-12.3972	372	PL62
23-Oct-09	05:07:17	6563.42	44.5214	-13.3689	3551	PL65
23-Oct-09	13:38:53	6611.11	44.4915	-14.3047	3520	PL66
24-Oct-09	04:39:30	6677.77	44.4655	-15.3291	3326	PL69
24-Oct-09	08:06:54	6696.41	44.4853	-15.6177	924	PL70
24-Oct-09	18:34:31	6741.57	43.9754	-15.9026	1160	PL74
25-Oct-09	02:20:02	6774	43.5625	-15.7356	2959	PL77
25-Oct-09	10:56:49	6834.79	42.6134	-15.3816	2514	PL78
26-Oct-09	00:03:42	6900.05	41.6396	-15.0056	2284	PL81
26-Oct-09	09:22:04	6949.09	40.9263	-14.7465	800	PL82
26-Oct-09	18:25:04	6986.75	41.2539	-14.4379	2774	PL85
27-Oct-09	02:53:59	7047.2	42.0188	-13.7744	2916	PL86
28-Oct-09	03:51:40	7170.95	43.509	-12.4775	910	PL90
27-Oct-09	16:12:58	7113.29	42.8412	-13.0749	3422	PL89
28-Oct-09	03:51:40	7170.95	43.509	-12.4775	910	PL90
28-Oct-09	13:59:21	7233.2	43.2376	-11.6754	900	PL95
28-Oct-09	23:55:00	7284.16	42.4224	-11.6898	2938	PL96
29-Oct-09	12:12:21	7342.96	41.4536	-11.6846	2001	PL99
29-Oct-09	20:44:42	7387.64	40.7419	-11.6784	584	PL100
30-Oct-09	10:33:07	7477.41	40.5647	-10.4487	304	PL103
30-Oct-09	17:10:17	7516.43	41.1935	-10.4388	2318	PL104
31-Oct-09	06:50:35	7583.93	42.2191	-10.434	2662	PL107

3.7.4. Other Fish samples

Due to the lack of suitable ground for demersal trawls, an effort was made to obtain bottom fish by hand-line as well as from fish markets. Approx 40 individuals were caught and photos and ids can be viewed on the Comoros 2009 data CD.

3.7.4 Acoustics

The aim of the acoustic assessment was to study the spatial distribution of fish and zooplankton biomass continuously along the cruise track. Firstly, the objective was to look for the total "acoustic population", including micro organisms and fish. Secondly, an acoustic survey around the Comoros Island and Mayotte was conducted in order to determine the distribution and abundance of small pelagic fish shoals. Mid-water trawls have been used on fish aggregations to determine species and size composition. However, very few pelagic shoals have been recorded. Thirdly, the dynamics of the migrating scattering layer and the pelagic layer communities was studied in more detail using fisheries acoustic and Mulinet trawling.

Oceanographic measurements and trawl fishing were carried out during the day as well as at night. The cruise track was designed in order to conduct detailed description of different mesoscale features in the area. The strategy, for acoustics/fisheries, consisted of conducting trawling according to the scattering structures observed during the acoustic survey.

Mid-water trawls have been used on fish aggregations to determine species and size composition. However, very few pelagic shoals have been recorded acoustically. Schools of fish have been observed in the surface a couple of times, and we have tried to catch them by rod fishing, but we have had no success. These fish aggregations have not been recorded acoustically (se section 3.7.6 visual observations). The reason for this could either be that they are too close to the surface (the ecosounder can only record fish deeper than 6 m depth, or that the fish swim so fast and avoid the research vessel. Strong scatters of mesopelagic fish have been recorded, but no schools which could have any resembling to mackerel, sardines, anchovy or tuna were seen. The conclusion is that there is very little fish in this area.

Design of the acoustic survey

Most of the acoustic data have been collected along straight transects designed to explore the mesoscale eddies field of the studied area. This strategy, linked to the "environmental" objectives of the cruise, differs from the classical shape of acoustic survey (gridding coverage of the prospected area) and results in limited goals in the acoustic survey, particularly in terms of fish aggregates prospecting. Therefore, data collected cannot be processed by the usual gridding methods which require a gridded horizontal survey of the area by means of radial transects that are geostatistically spaced. Hence, we only got vertical profiles which provide us with a rough idea of the biomass spatial distribution in the studied area. However, around the island of Comoros and Mayotte, the R/V *Dr Fridtjof Nansen* were zigzagging between depth of 50 to 500 m around the islands will undertake acoustics transects to determine the distribution and abundance of small pelagic fish shoals. Due to the large avoidance behaviour discovered horizontal sonar would have been a more appropriate tool to map the distribution of these fast swimming fishes.

Data processing

Acoustic data were collected with four synchronized SIMRAD split-beam ER60 echo sounders with hull-mounted transducers. The frequencies used were 18, 38 (Fig. 3.7.4 d), 120 and 200 kHz; the pulse durations were all set at 1 ms. The water column was sampled down to a depth of 500 m.. A –82 dB threshold was applied on data to reject noise and non-micronekton organisms.

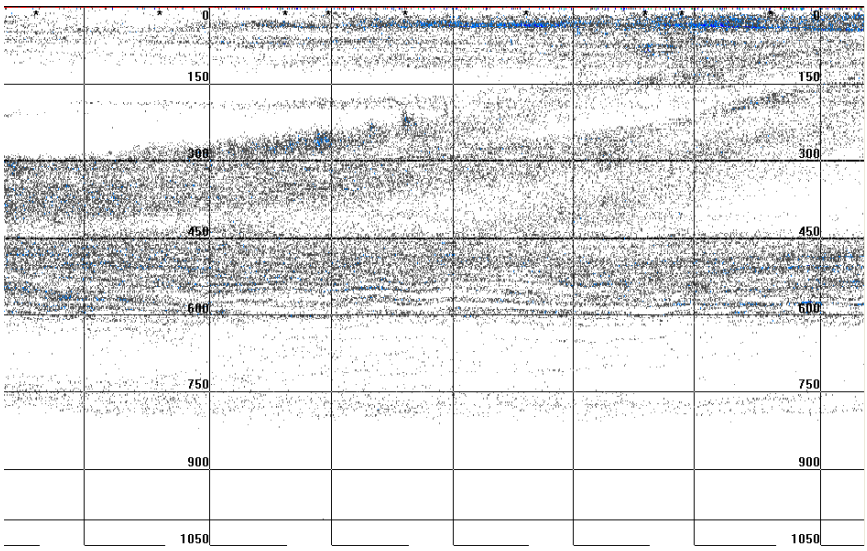
Frequency:	38000 Hz	Beam Type:	Split
Gain:	25.82 dB	Two-way Beam Angle:	-20.60 dB
SaCorrection:	-0.53 dB	Absorption:	7.90 dB/km
Bandwidth:	2425 Hz	Sound Velocity:	1503 m/s
Sample Interval:	0.1924 m		

Angle Sensitivity,	Alongship:	21.90	Athwartship:	21.90
3dB Beam Width,	Alongship:	6.95°	Athwartship:	6.99°
Angle Offset,	Alongship:	0.11°	Athwartship:	0.04°

Figure 3.7.4 d: *The 38 kHz transceiver settings*

The 38 kHz echo-sounder is the best suited for general observation purposes (visual acoustic survey, biomass assessment). Other frequencies are more useful for discrimination purposes in the data analysis process (see below)

The total acoustic back-scattering energy per surface unit (s_A) values were calculated along the full survey track. The next step of the data processing could be post processing of three of the four frequencies. Considering that organisms do not have the same acoustic response at different frequencies, the multi-frequency analysis, performed using frequency masks (by overlapping and comparison between these frequencies), allow us to discriminate plankton and fish.

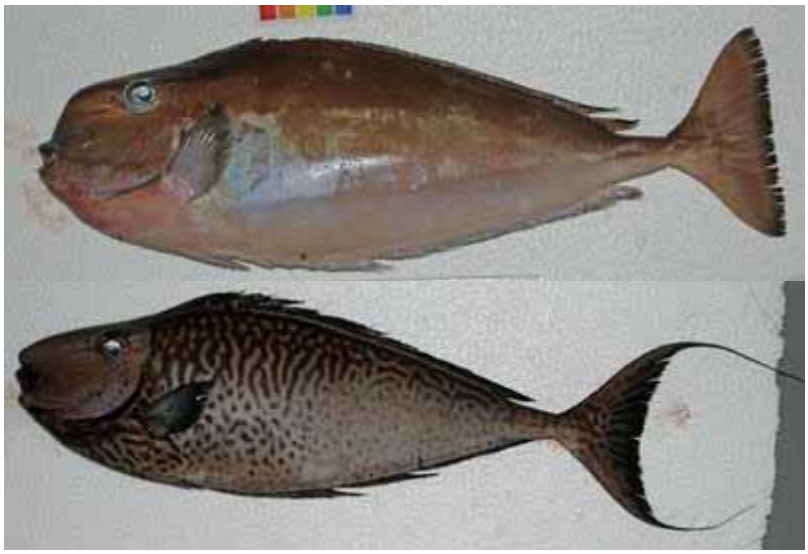


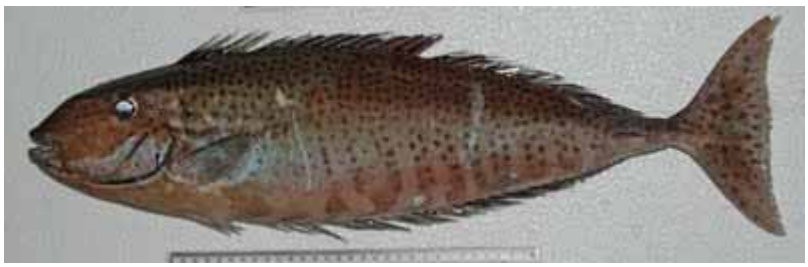
3.7.5 Fish trawls

17 trawls (7 at daytime and 10 at night) were performed during the cruise (Table 3.7.5 a, Fig. 3.7.5 a). Night trawls were performed at the surface between 10 to 20 m depth were a DSL was detected (Fig. 3.7.5 b).

Part of the cruise strategy is to assess the bottom (demersal) fauna and biodiversity of shallow shelf areas. This is typically done by demersal trawls in areas that are neither too steep and rough nor covered in vulnerable species such as corals. To date, around the Comoros, such habitat has only been found once as the volcanic origin of the islands have resulted in very steep and uneven

slopes. To visualise the extreme of the slopes, imagine the ship anchored outside the port of Moroni. While the bow (front) anchor was in 35m of water, the stern (back) of the ship was floating 300m above the bottom.
Our first demersal trawl at 90m depth therefore caused much excitement. Highlights of this trawl were the capture of what appear to be six species of Unicorn fish (*Naso* sp). While some species such as the humpback unicornfish were easy to identify, others did not agree with all characteristics as provided by species keys. Are there more species in this genus than currently accepted? Only a closer examination of the specimen back at the museum will tell! Below are shown some examples.





257 unidentified Flying fish were observed. A further 196 were recognized as looking different. These were categorized into 12 different types of flying fish. Differences were based on, i) whether the fish had one or two pectoral fins; ii) differing colour of pectoral fins, iii) differing lengths of pectoral fins or iv) distinctive body colour. All very small flying fish were categorized as unidentified. I would suspect that those I called "Type 1" which had a single transparent pair of pectoral fins would probably represent more than one species, as the detail on the pectoral fins was not always obvious. It cannot also be ruled out that the different colour pectorals fins of the other types may be males and females of a same species.

1marine turtle or was seen close to the coral reef just outside Moroni. Svimming crabs were observed during the last CTD- station on line 9. Cephalops was during the survey but no sharks

3.7.7 Predator observations

SEABIRDS

Sooty Tern	*Sterna fuscata*	4494
Common Noddy	*Anous stolidus*	83
Crested Tern	*Sterna bergi*	4
Lesser Crested Tern	*Sterna bengalensis*	7
Common Tern	*Sterna hirundo*	360
Black-naped Tern	*Sterna sumatrana*	70
Little Tern	*Sterna albifrons*	2
Unid. Tern	*Sterna spp.*	2
Audobon's Shearwater	*Puffinus Iherminieri*	3
Wedge-tailed Shearwater	*Puffinis pacificus*	6
Jouanin's Petrel	*Bulwaria fallax*	5
Black-bellied Storm Petrel	*Fregetta tropica*	1
Wilson's Storm Petrel	*Oceanites oceanicus*	3
Great Frigatebird	*Fregata minor*	7
Red-footed Booby	*Sula sula*	16
White-tailed Tropicbird	*Phaethon lepturus*	2
Red-tailed Tropicbird	*Pheathon rubricuada*	2
Parasitic Jeager	*Stercorarius parasiticus*	3
Pomerine Jaeger	*Stercorcarius pomarinus*	2
Brown Skua	*Catharacta lonnbergi*	1

Madagascar Squacco Heron	1
Cattle Egret.	2

CETACEANS

Cetaceans were scarce, and when seen showed a tendency to avoid the vessel. This behaviour may be a consequence of acoustic equipment running continually to locate fish and uncharted topography. Only one feeding association between cetaceans, tuna and seabirds was observed. This was with False Killer Whales.

Sperm Whale	*Physeter macrocephalus*	5
Minke Whale	*Balaenoptera acutororostrata*	3
Bryde's Whale	*Balaenoptera edeni*	1
Cuvier's Beaked Whale	*Ziphius cavirostris*	5
Short-finned Pilot Whale	*Globicephala macrorhynchus*	2
False Killer Whale	*Pseudorca crassidens*	5
Bottle-nosed Dolphin	*Tursiops truncatus*	130
Common Dolphin	*Delphinus delphis*	50
Spinner Dolphin	*Stenella longirostris*	118
Pan-tropical Spotted Dolphin	*Stenella attenuata*	400
Unid. Dolphin		25
Unid. Whale		6

20 Risso's Dolphin *Grampus griseus*, 20 Melon-headed Whale *Peponocephela electra*, was seen together with 100 Spotted Dolphin and 10 Short-finned Pilot Whale, the morning after the survey was completed off Maputo.

4 Summary and Conclusions

4.1 Summary of results

While much of the sample analysis remains to be done and data need to be put into context with the help of updated satellite imagery, preliminary results already suggest that the cruise as a whole was a success in terms of meeting its objectives.

id-water trawls have been used on fish aggregations to determine species and size composition. However, very few pelagic shoals have been recorded acoustically. Schools of fish have been observed in the surface a couple of times, and we have tried to catch them by rod fishing, but we have had no success. These fish aggregations have not been recorded acoustically. The reason for this could either be that they are too close to the surface (the ecosounder can only record fish deeper than 6 m depth, or that the fish swim so fast and avoid the research vessel. Strong scatters of mesopelagic fish have been recorded, but no schools which could have any resembling to mackerel, sardines, anchovy or tuna were seen. The conclusion is that there is very little fish in this area.

4.2 Logistics

Overall, the cruise was successful in achieving most of its objectives and to a large extent; this was due to the professional handling of the logistics by both the crew and the scientists. For future purposes, however, a number of possible further improvements were discussed during a wash-up meeting on the last day of the cruise. The following should be regarded as an idealised wish-list.

1) One important lesson learned from this cruise is that all **fishing licenses** must be received before the cruise starts. Only this way can the cruise be conducted in the most efficient way.
2) **Trawling and acoustics**: Trawling and acoustics were performed without any problems. However, the cruise strategy of sampling along straight lines did not facilitate the ideal sampling grid as required for fisheries surveys. On future cruises this could be improved upon by: a) increasing the time available and then gridding the biological transects, b) reducing the number of hydrographic and biological stations to allow for more acoustic time, c) realistically, slightly more time and an overall gridded sampling design would most likely optimise the situation as even for hydrographic measurements, a grid survey is preferable to simple straight lines, d) more focuses on processes/features would have increased the ecological outcome of the survey, but then more time must have been made available for staying in one to follow features, e) a towed undulator (or similar) could be used to reduce the number of required hydrographic stations and thereby free up time for a more detailed gridded sampling strategy. Use of sonar and other types of equipment for fishing would have increased the possibility of getting more fish samples.

d) **Trainees**: The trainee's involvement in both the underway science and the analysis and interpretation of the data for this report was exemplary. Nonetheless, it was felt that in some cases our regional collaborators could have gained more from the cruise had individual projects of interest been developed and made available to them. Due to time-constraints, this was not possible during this past cruise. For future purposes, however, this possibility should be investigated in more detail. Requests from two of the trainees were also made to remain part of the science team during the upcoming analysis and write-up of the research. Additional funding might have to be sought to facilitate their continual involvement. Even though the trainees on this cruise was very dedicated it could have been

advantageous to have had more scientist onboard, especially those that are supposed to work with the sampled data in the near future

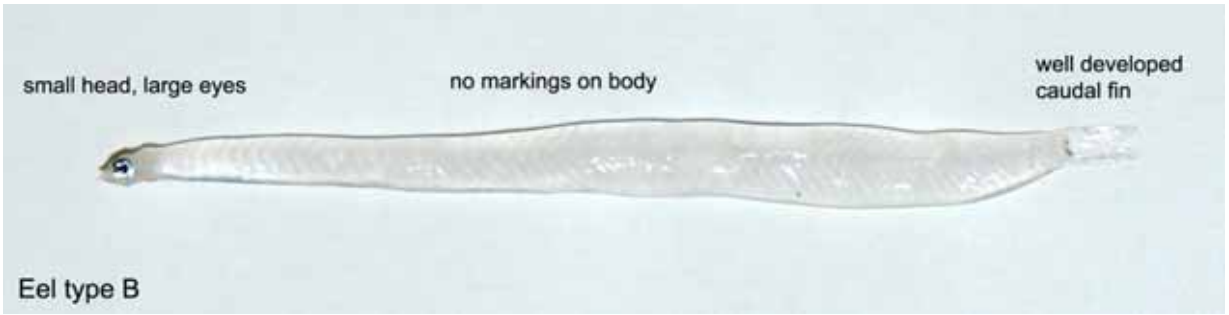
e) The survey has been conducted very well thanks to the skill of the crew and the scientists on board. In terms of the acoustic survey and fishing trawl strategy, the general strategy of the cruise corresponding to a "physical oceanography cruise" was not optimal. Better results would have been achieved with a "gridding oriented" approach as well did around the Comoros islands and Mayotte. Due to the very steep slopes around the islands the noise in the data might be very large.

4.3 Acknowledgements

Many thanks are due to the officers, scientists and crew of the RV Dr. Fridtjof Nansen for their continuous support and for generally making this cruise a successful and enjoyable one.

Last, but certainly not least a great many thanks to all those who made this cruise possible in first place. Specific thanks must go to the GEF/UNDP funded ASCLME programme and all of its regional representatives and the EAF Nansen project. Personally, I would like to thank David Vousden (ASCLME director), Tore Strømme (EAF Nansen research coordinator) and Tommy Bornman (ASCLME cruise coordinator) for their insights, financial and management support and generally for making this cruise possible.

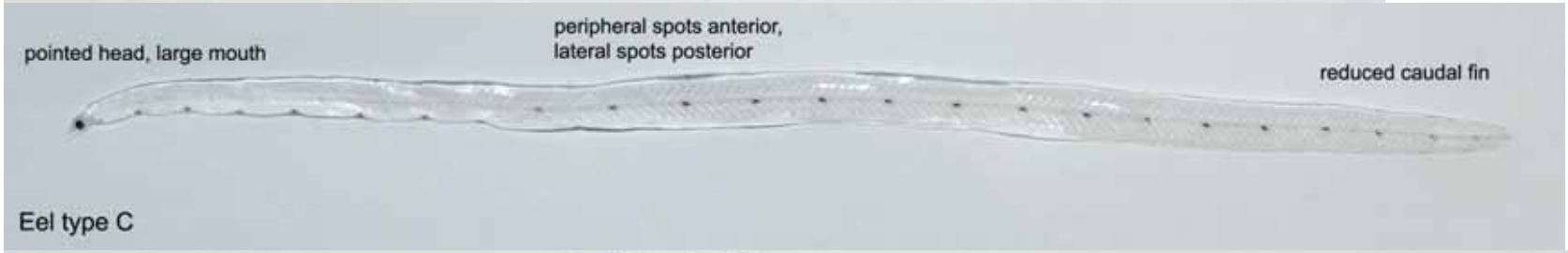
1. ELOPIFORMES



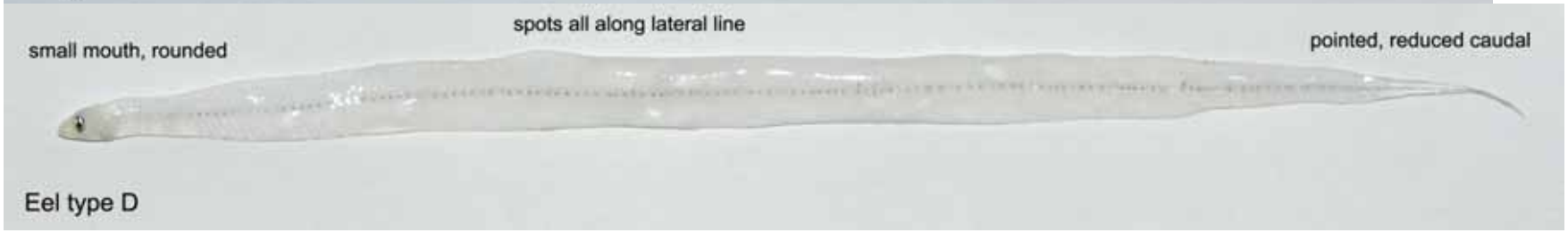
UNIDED2

2. ANGUILLIFORMES

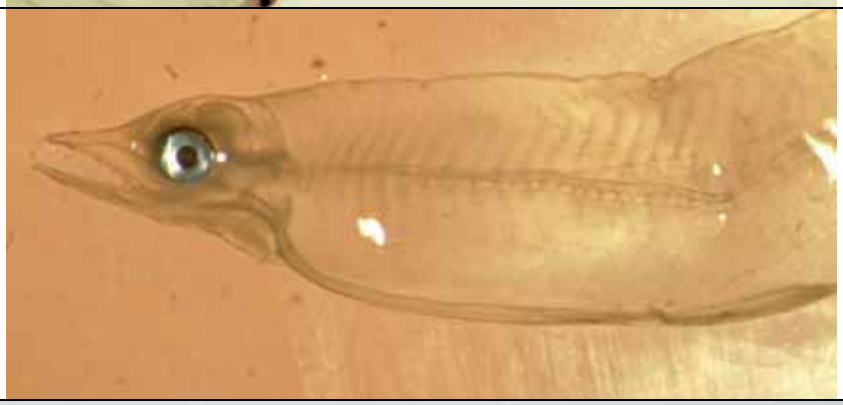
UNIDEQ3



UNIDEO3 = UNIDEE9?



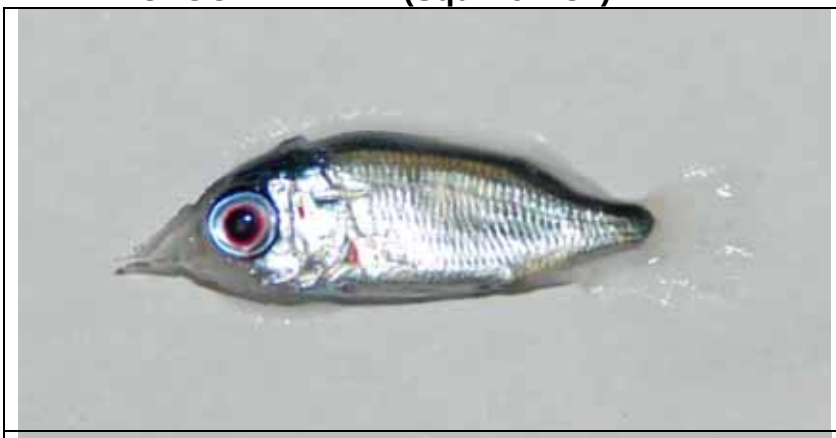
UNIDEQ4

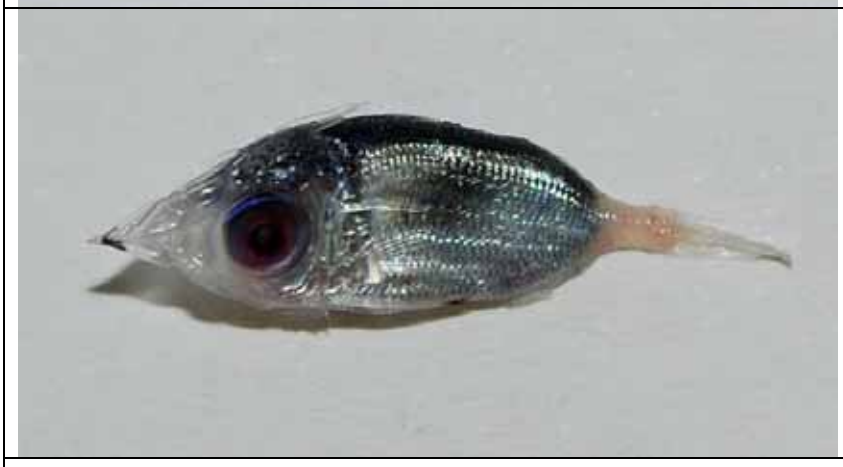
	**UNIDED9**
	**UNIDEE9 = UNIDEO3 ?**
	**UNIDEX5** (pointed head, diagonal marks along lateral line)

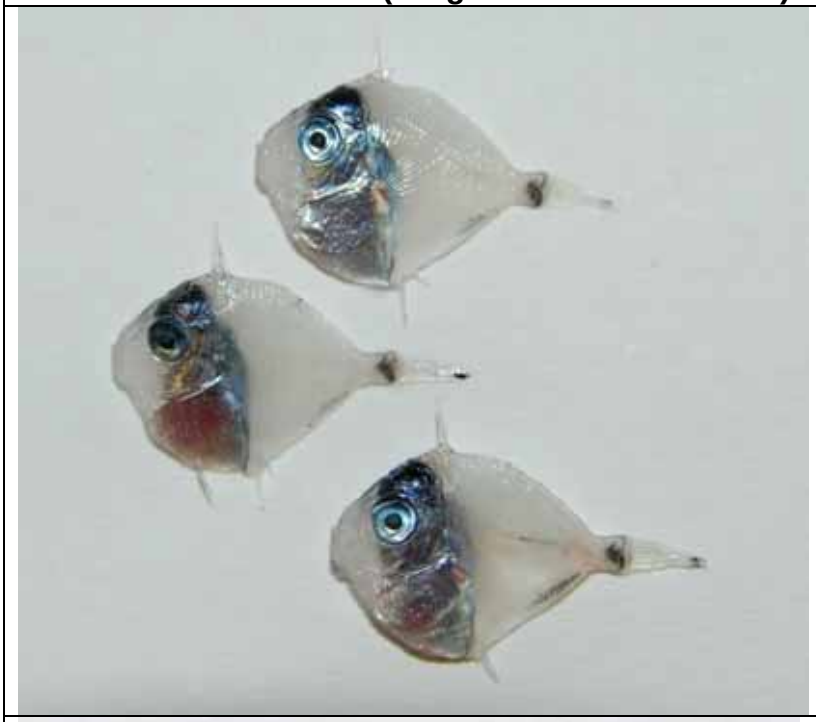
3. ANTENNARIIDAE (Anglers) ?

	**UNIDEP5**

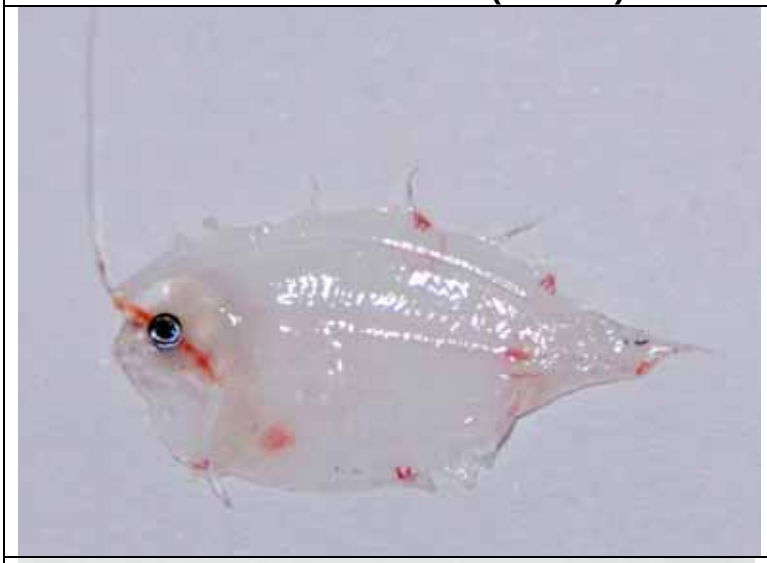
4. HOLOCENTRIDAE (Squirrel fish)

	**UNIDEG1 = UNIDEN1 ?** (no markings, no yellow dorsal, silver to caudal fin)
	**UNIDEN1 = UNIDEG1?** (no markings, no yellow dorsal, silver to caudal fin)
	**UNIDEG2** (black bar on peduncle, tail pink)
	**UNIDEJ3** (yellow dorsal, no markings, tail pink)

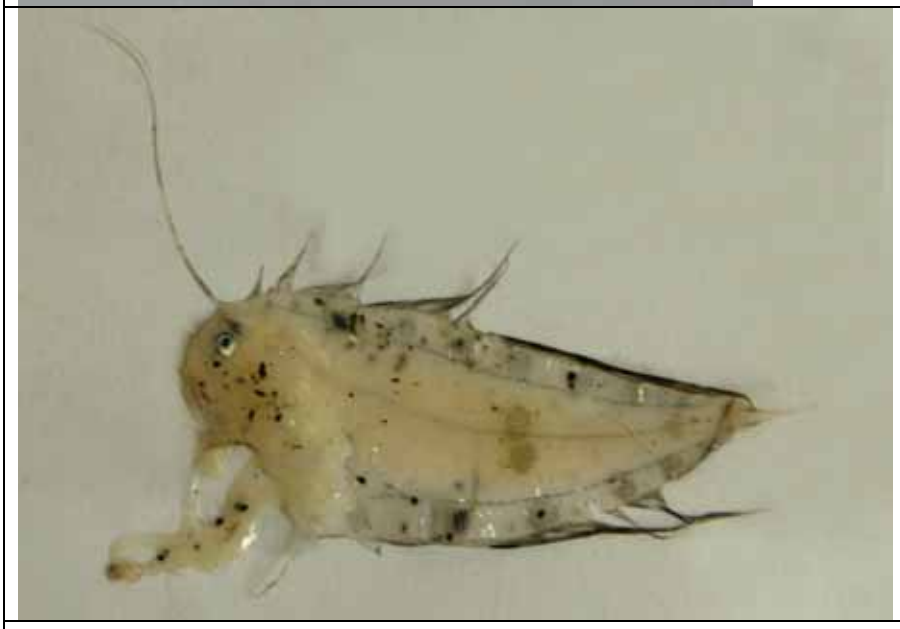
	**UNIDEL7** (red bar on nose, tail pink)
	**UNIDEL8** (yellow with black bar on nose, tail pink)
	**UNIDEM2** (not yellow with black bar on nose, tail pink)

5. ACANTHURIDAE (Surgeon and unicorn fish)	
	**UNIDED3** (black peduncle, black caudal tips, blunt nose)
	**UNIDES9** (black peduncle, no black caudal tips, blunt nose)
	**UNIDES4** (black markings on peduncle and caudal fin, black markings on body, blunt nose)

	**UNIDES8** (black peduncle, no black caudal tips or body markings, pointed nose)

6. PLEURONECTIFORMES (Flatfish)	
	UNIDEA7
	UNIDEV8
	UNIDEC8
	UNIDEP3

	UNIDER4
	UNIDEF3 = UNIDEJ9 ?
	UNIDEJ9 = UNIDEF3 ?

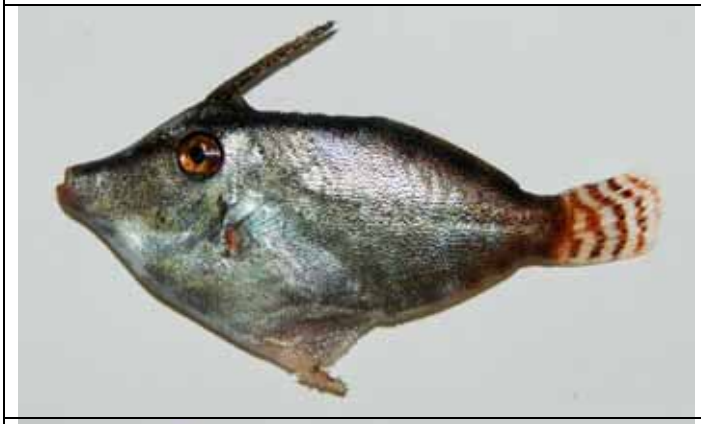
	UNIDEJ7
	UNIDET8

7. CARANGIDAE	
	**UNIDET4**
	**UNIDEC2**
	**UNIDEC3**
	**UNIDET5**

	**UNIDEW2** (*Gnathanodon speciosus*?)
	**UNIDER5**
	**UNIDET6**
	**UNIDES3** (narrow scutes)

	**UNIDER6** (wide scutes)
	**UNIDEG5** (narrow scutes)

8. BALISTIDAE	
	**UNIDEA6 = UNIDEN2**
	**UNIDET3**

MONACANTHIDAE (Filefish)	
 ??	**UNIDEA5** (wrong body width)
	**UNIDET1** (*Pervagor janthinosoma*?)
	**UNIDET2** (*Paramonacanthus cingalensis*?)

	**UNIDEB5** (*Pseudalutarius nasicornis*?)
TETRAODONTIDAE (Pufferfish)	
	**UNIDEA3** (black around dorsal)
	**UNIDEC4** (blue around pectoral)
	**UNIDEN9** (spiky)

	**UNIDEN1** (warty)
	**UNIDEU3** (*Arothron stellatus*?)
DIODONTIDAE (Porcupinefish)	
	**UNIDEC5**

OSTRACIIDAE (Boxfish)	
	**UNIDEO1**
	**UNIDEO2**

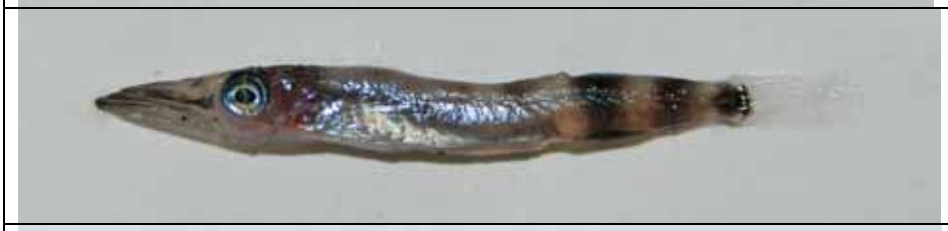
SCORPINIDAE	
	**UNIDEN7**
	**UNIDEM1**
	**UNIDEB3**
	**UNIDEB4**

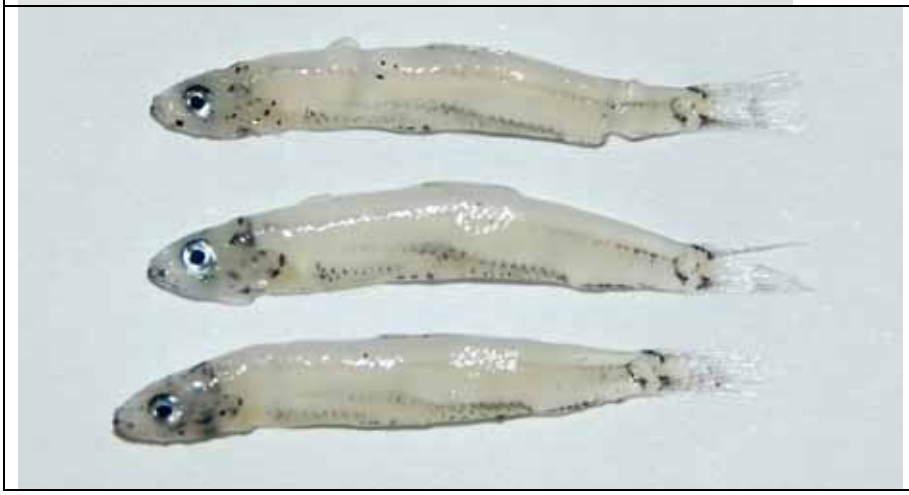
	**UNIDEE6 = UNIDES7?**
	**UNIDES7 = UNIDEE6?**
	**UNIDEU4**
	**UNIDEW8**

	**UNIDEB2** (horizontal black spots above lateral line, dark lateral line)
	**UNIDER7 = UNIDEX2** (no black spots above lateral line, dark lateral line)
	**UNIDEO5** (vertical black bars dorsally, no black lateral)

	**UNIDEG9 = UNIDEX8** (no black dorsally or laterally)

SCOMBRIDAE (Tuna)	
	**UNIDET9**
	**UNIDEW9**
	**UNIDEJ1 = UNIDEX1?**
	**UNIDEX1 = UNIDEJ1?**

SPHYRAENIDAE (Barracudas)	
	**UNIDEB6**
	**UNIDED1**
	**UNIDER3**
	**UNIDEU2**

	**UNIDEA1**
	**UNIDEC1**
	**UNIDEX7**
	**UNIDEX6**

	**UNIDER2**
	**UNIDEA9**
	**UNIDEB7**
	**INIDEG7**
	**UNIDEL9**

	**UNIDEQ1**
	**UNIDEQ2**
	**UNIDEN3**
	**UNIDEP4**

	**UNIDEA4 = UNIDED6**
	**UNIDEM5**
	**UNIDEO4**

	**UNIDEB1 = UNIDEX9** (orange marks, red dorsal and pectorals)
	**UNIDEF8 = juv UNIDEB1?**
	**UNIDEE8**
	**UNIDEU8**

	**UNIDER8**
	**UNIDES1**
	**UNIDER9**
	**UNIDEN6 = juv. UNIDER9?**

	**UNIDEU7**
	**UNIDEV2**

	**UNIDEA2**
	**UNIDEO8**
	**UNIDEY1**

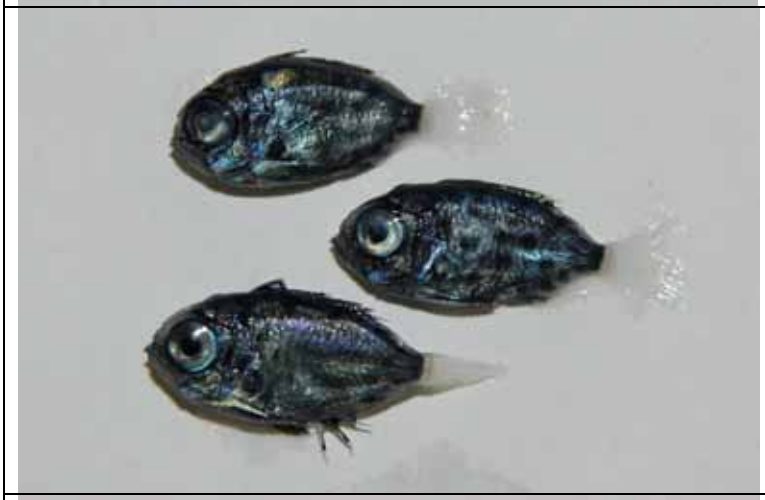
	**UNIDED4**
	**UNIDEE7** (orange, black caudal tips)
	**UNIDEF9** (orange hind body)
	**UNIDEU9** (orange peduncle, yellow face)

	**UNIDEV1** (black peduncle)
	**UNIDEC9** (lateral line pigments below skin)
	**UNIDEG6** (lateral line pigments on skin, black tip caudal)
	**UNIDEW7**

	**UNIDEV6**
	**UNIDER1**

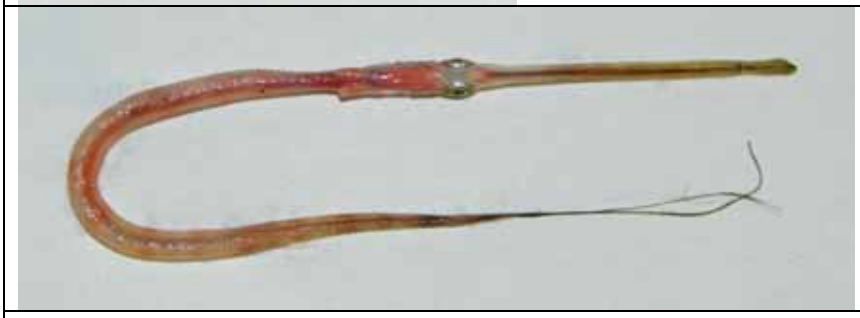
	**UNIDEM4**
	**UNIDEP6**
	**UNIDEG8** **= juv. UNIDEP6?**
	**UNIDES6**

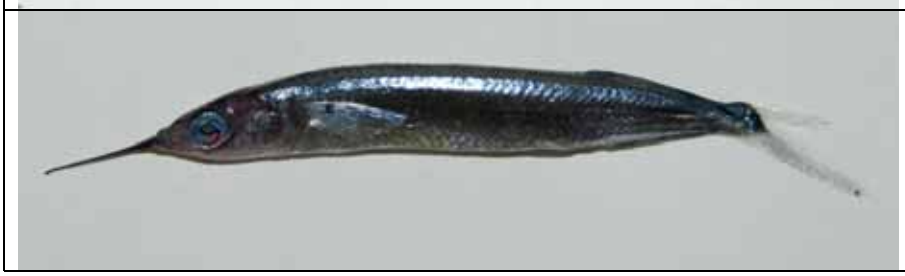
	**UNIDEE5**
	**UNIDED7**
	**UNIDEU5**

	**UNIDEW5**
	**UNIDEC7**
	**UNIDEP1**
	**UNIDEP2**

	**UNIDEF7**
	**UNIDEO7**
	**UNIDEN4**

	**UNIDEV5**
	**UNIDEA8**
	**UNIDES2** **= INDEV3?**
	**UNIDEV3** **= UNIDES2?**

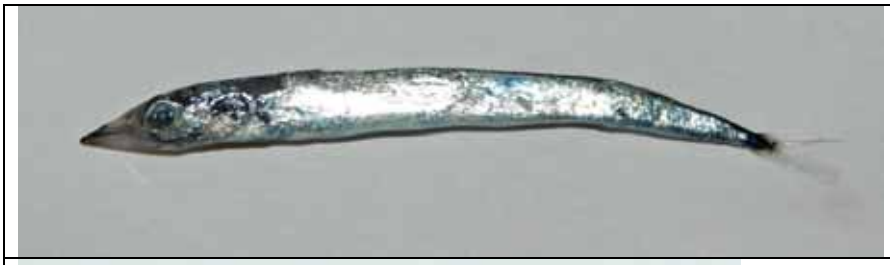
	**UNIDEW4**
	**UNIDEX3**
	**UNIDEC6**

	**UNIDEL1**
	**UNIDEL2**
	**UNIDEU6**
	**UNIDEL3**

	**UNIDEW1**
	**UNIDEV7**
	**UNIDEF4**
	**UNIDEF5**

	**UNIDET7**
	**UNIDEU1**
	**UNIDEV4**
	**UNIDEB8**

	**UNIDEN5**
	**UNIDEN8**
	**UNIDEO6**
	**UNIDEO9**

	**UNIDEJ5**
	**UNIDEW3**
	**UNIDEX4**