SPATIAL DISTRIBUTION OF ICHTHYOPLANKTON SPECIES IN THE NORTHERN BENGUELA CURRENT ECOSYSTEM

BY:

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Declaration

I hereby declare that this work is the product of my own research efforts, undertaken under the supervision of Mr. F.P. Nashima and has not been presented elsewhere for the award of the degree. All the sources have been duly and appropriately acknowledged.

Candidate Signature: ……

Date: ……..

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Certification

This is to certify that this report has been examined and approved for the award of the degree of Bachelor of Science in Fisheries and Aquatic Science of the University of Namibia.

External Examiner…….....

Internal Examiner…….....

Head of Department…….....

Acknowledgement

First of all I would like to thank the Almighty God for giving me the strength to complete this work and secondly the Department of Fisheries and Aquatic Sciences, University of Namibia, for allowing me the opportunity to take part on the cruise Maria S Merian, where I was able to collect part of my data for this project. This project could not have been possible without the help, understanding and technical support of all students and scientists that were with me on the cruise. I would also like to thank the Ministry of Fisheries and Marine Resources for allowing me the opportunity to use their data. I extend my handful thanks to my supervisors Mr F.P Nashima and Mr R. Haraeb for their support and dedication toward the completion of this project. I am appreciative of the support and tremendous help from the KIFI staff, MFMR colleagues and all my class mates toward the success of this project.

Dedication

I dedicate this work to my lovely family the Mokanya's especially my parents for their support and encouragement throughout my studies and my ever supportive friend Ndapewa Iipinge, all relatives and other friends for their encouragement and word of strength.

Table of Content

LIST OF FIGURES

Abstract

A study to compare the spatial distribution of ichthyoplankton species in the northern Benguela current was conducted. Systematic sampling was used to collect samples whereby a total of thirty sampling stations were sampled with one haul per station. Fish larvae Samples were collected aboard the Maria S Merian and they were analysed for species diversity using primer 5.0 and SPSS statistical package together with egg samples collected onboard the RV Welwitchia a Continuous Underway Fish Egg Sampler (CUFES). Species abundance and distribution depicted non significant differences with regard to depth and latitudes. Trends depicted that ichthyoplankton diversity was high in the north than the south. This is because of the intrusion of the warmer Angolan water. In addition ichthyoplankton species tend to be closer to the shore than off due to distribution of zooplankton. Eggs distribution (anchovy, horse mackerel and sardines) tends to have increased from 2005 and reached a peak in 2010 and declined in 2011.

Key words: Ichthyoplankton, CUFES, Species diversity, northern Benguela current.

CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

1.1 General introduction

Commercial fishery is a fast growing industry in the world, and to date quality research has been conducted and still ongoing in the marine environment. Numerous nations have adopted the necessary sustainable utilization of marine fisheries and efforts are being made to implement these (FAO, 1995). Angola, South Africa and Namibia making up the coastal states of the Benguela Current Large Marine Ecosystem (BCLME) are committed to making progress in carrying out research in the Benguela current ecosystem in helping to manage the fishery sustainably (BCLME, 2002). Namibia, like any other coastal bordering country has a 200 nautical mile Exclusive Economic Zone (EEZ) which enables effective management of the fisheries, proper and efficient monitoring of the Namibian waters and ensures effective stock assessment and allocation of fish quotas (Klingelhoeffer, 2005).

The early life history of fish is often considered critical for recruitment to the adult population (Ekau and Verheye, 2005). Thus, understanding how larval fish populations vary through time, distance from shore and vertical distribution is important for answering questions related to both vertical and horizontal distribution of larvae.

The Benguela region is extremely productive and rich in fishing resources that have been subjected to intense exploitation in recent years (de Villiers, 1985; Crawford *et al*., 1987,

Crawford *et al.,* 1989). Human influence on marine biota has increased dramatically, threatening the stability of coastal ecosystems. These human factors have been superimposed on the complex ecosystem that transcends national/country boundaries (that has a highly variable environment) (BCLME, 2002). Some species has been overharvested (MFMR, 2009); others have been transported inadvertently to areas where they are not indigenous, sometimes resulting in detrimental effects on native species.

According to Ekau and Verheye, (2005) a large portion of the Benguela region, is dominated by larvae of small pelagic-spawning fishes including the semi-pelagic goby (*Sufflogobius bibarbatus),* the lantern fish (*Lampanyctodes hectoris),* and the anchovy (*Engraulis capensis).* On the other hand Hake (*Merlluccius* species), and horse-mackerel (*Trachurus capensis),* Pilchard (*Sardinops sagax)* are also relatively abundant components. Some of these ichthyoplankton are ecologically and economically important components of the Benguela upwelling ecosystem and their importance has resulted in substantial research effort directed towards understanding their population dynamics, with much of this effort going into ichthyoplankton surveys. The spatio-temporal distribution pattern of larvae of these and other fish species is strongly influenced by hydrographic conditions.

Hydrographic conditions tend to influence the seasonal distribution, migration, spawning behaviour and early life stages of many pelagic fish particularly fish larvae. According to Kreiner *et al.,* (2009) the driving forces behind successful recruitment of pelagic species in the northern Benguela Current system are still unclear.

Oceanographic parameters that include temperature, dissolved oxygen, and salinity, play a major role in the distribution of ichthyoplankton and it is important to understand how these factors affects the distribution and availability of fish larvae in the Benguela current ecosystem and to determine their relative abundances (relation between these factors and ichthyoplankton is not described in this report) . A better understanding of the ecology of marine organisms is urgently needed to prevent irreversible damage to the living marine resources including ichthyoplankton by creating protected areas for spawning grounds. Namibia has a long history of overfishing during the pre-independence years, yet it has one of the most thriving marine ecosystems in the world, supported by the rich Benguela current upwelling system. It is to our advantage to understand and study this system because its productiveness depends on our willingness to manage and use it sustainably.

1.1.1 Problem statement

Past studies that were done in the Benguela were aimed mainly at describing spawning locations and distributions of larvae of *Sardinops ocellatus* and *Engraulis capensis.* Substantially, less is known about other species, especially those that are not commercially fished. The Benguela Current region (northern, central and southern) is vast and intensive studies of different intensities have been done in the three areas (north, central and southern) with the central (Ekau and Verheye, 2005) Benguela system being the least studied. However, due to the dynamic nature of the Benguela ecosystem more studies need to be done to update and detect possible prevailing changes in the distribution and abundance of ichthyoplankton species. Knowledge of ichthyoplankton distributions may also be used to provide information on species interactions during early life history. Additionally, fish larvae

distribution provide insight on factors influencing fish populations and communities, and understanding spatial and temporal variation in larval fish distributions gives us an overall health of the system. Ichthyoplankton studies can give indication of the abundance of eggs and larvae of several fish species which provide information on the spawning population size of adult fish (International Oceanic and Atmospheric Administration, 2007). Despite of all the research that was done in the Benguela current, more research still need to be done to understand the continuous dynamic changes of the ecosystem. Taking these findings into consideration, this study tried to access the distribution of ichthyoplankton species in the northern Benguela current region.

1.1.2 Significance of the study

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The aim of the study is to collect and compile information on the early development stages of ichthyoplankton that inhabit the northern Benguela region and their spawning areas. The study on ichthyoplankton is a key component in research into the biology, systematic and even population dynamics of fishes. Combination of ichthyoplankton location with information of the surrounding environment can help make inference based on environmental effects. The study is of great importance to the Namibian fisheries industry, as it would provide data and information pertaining commercial sustainable fishery management. The Namibian fisheries industry contributes a great value to the Gross Domestic Product (GDP) (MFMR, 2008). Therefore, there is a need to know and identify major spawning grounds for ichthyoplankton in the Benguela current ecosystem to ensure a productive and yet a self-sustained ecosystem. Moreover, knowledge about the distribution of fish larvae is important to understand the future stock recruitment, allocation of fish quotas and because this stage of

life is the most vulnerable in the whole life history of fishes it needs to be critically studied. The study will contribute to the knowledge of the system which will yield both economical and environmental benefits in the future to the country. Ichthyoplankton surveys will make a substantial contribution toward identifying key mechanisms impacting on recruitment success and hence management of these small pelagic species. This will help in providing sound and solid information on the spatial distribution of ichthyoplankton in the Benguela current off the Namibian coast. Climate change is the most pressing challenges of our time and oceanographic factors are changing on a considerable rate. However, in order to implement effective climate protection policies, scientists and politicians need models that allow them to make reliable forecasts and take targeted actions based on allocation of marine resources that includes fish, to ensure a sustainably managed environment. Therefore, a sound understanding of the system is required to make high quality decisions and predictions.

1.1.3 Research objectives

(a) To determine and compare diversity of fish larvae species in the Benguela ecosystem region.

(b) To determine and compare the abundance of ichthyoplankton (CUFES) distribution along the Namibia coastline in the year 2012.

(c) To determine changes in abundance and distribution of ichthyoplankton species (i.e. anchovy, sardine and horse mackerel) over the years, 2005-2011.

1.1.4 Specific research questions

(a) Are there significant differences in diversity of ichthyoplankton (larvae) species in the Benguela ecosystem region?

(b) Are there significant differences in the abundance of ichthyoplankton (CUFES) distribution along the Namibia coastline in the year 2012?

(d) Are there significant changes in abundance and distribution of ichthyoplankton species (i.e. anchovy, sardine and horse mackerel) over the years, 2005-2011?

1.1.5 Research hypothesis:

a) There are significant differences in diversity of ichthyoplankton (larvae) species in the Benguela ecosystem region.

b) There are significant differences in the abundance of ichthyoplankton (CUFES) distribution along the Namibia coastline in the year 2012.

c) There are significant changes in abundance and distribution of ichthyoplankton species (i.e. anchovy, sardine and horse mackerel) over the years, 2005-2011.

1.2 Literature review

1.2.1 Benguela ecosystem

The Namibian coastal waters are unusual in several ways. Despite a subtropical latitude the shape and orientation of the coastline, depth and narrowness of the continental shelf and the prevailing southerly wind all contribute to make the northern-Benguela one of the major upwelling system in the world and with very rich fish resources that have been subjected to intense exploitation in recent years (the others are off northwest Africa, California and Peru) (BCLME, 2002). The region is influenced by upwelling and water masses of tropical, subtropical, south Atlantic, and Antarctic origins, making it one of the most hydrologic complex regions in the world (Oliver, 1987). This system support large stocks of demersal, mid-water and small pelagic species (Axel, 1998).

The Benguela current ecosystem exhibit large annual and inter-decadal variability caused by variation in environmental forcing (Shannon & Nelson, 1996). This variability results in large fluctuation in fish stock and growth and cause economic loss in fisheries for the bordering countries. Benguela current is bordered equator ward by the Angolan current and pole wards by the Agulhas current, both warm water currents and hence its uniqueness (Shannon,1996). Offshore, the Benguela current is bounded by a circulation of warm subtropical water associated with the South Antlantic Gyre. Apart from the two outflow of water from the Cunene River at the northern edge of Namibia and Orange River down south there is little inflow from inland waters which its influence is known to be minimal. The Benguela Current flow north-north westerly along the coast from the vicinity of Cape Point (34°20’S) to Cape Frio (18°30’S). This current is driven by the prevailing winds, which produce the upwelling

of deep South Antlantic Central water from 100 to 300m. Upwelling occurs in the coastal areas of the entire Benguela Current region but exhibit varying geographically related intensity and marked seasonal fluctuations.

1.2.2 General description of ichthyoplankton (Eggs and Larvae)

Ichthyoplankton studies in the southeast Antlantic dates back to the 1900s around the Cape Peninsula whereby Obtained data was only partially analysed and never fully documented. Ichthyoplankton studies off the Namibian coast commenced later in the 1970's. Surveys of pilchard and anchovy spawning have been carried out intermittently since 1960 (Le Clus, 1990), mainly during September to April. Oliver (1987, 1990) later studied the ichthyoplankton distributional patterns and species assemblages in the Benguela region.

Ichthyoplankton presents a greater indicator of population size of adult fish. The International Oceanic and Atmospheric Administration, (2007) defined ichthyoplankton as the eggs and larvae of fish found mainly in the upper 200 meters of the water column, also called the near-surface waters. The eggs are passive and drift in the ocean along with the water currents. Most fish larvae have almost no swimming ability initially, however, by half way through their development they are active swimmers. Ichthyoplankton are relatively small but vital component of total zooplankton, which feed on smaller plankton and are prey for larger animals. For species that are not captured by a fishery, monitoring their population trends by monitoring their eggs or larvae can provide an indication of a healthy or stressed ecosystem (International Oceanic and Atmospheric Administration, 2007). It is unlikely that we would have an idea of the abundance, growth or decrease of these species.

Pelagic eggs of fish are highly aggregated in time and space. Such aggregation affects both the ecology of fish and our ability to study and manage them. In particular, estimates of egg abundance in time and space are used to estimate the spawning biomass of populations of pelagic fish and are thus needed to understand the status and dynamic of fish population in order to best manage them.

1.2.3 Oceanographic parameters influence on ichthyoplankton

The marine environment presents major oceanographic parameters that affect the spatial distribution of ichthyoplankton. Dissolved oxygen is one of the key environmental variables influencing the habitat suitability in biologically productive systems such as the northern Benguela region (MFMR, 2008). Furthermore, it highlighted that species that are not adapted to hypoxic (<2.0 ml/l) and even anoxic (0.0 ml/l) conditions would be constrained both vertically and horizontally by oxygen poor water. It is hypothesised that low oxygen concentrations have a strong impact on the development and survival of the early life-cycle stages of fish, and that recruitment of sardine and other pelagic species relies more on the upward extension of the oxygen minimum layer than was previously thought (Kristmannsson, 1999).

An extensive study done by Ekau and Verheye, (2005) showed that the Benguela current has been characterised by a presence of an extensive and almost permanent Oxygen Minimum Layer (OML) at 100-500m at. Kristmannsson (1999) states that this layer extends between at least 18°S and 28°S and up to 60 km from the shore. The hypoxic conditions on the Namibian shelf have been discussed by (Hagen, 1991, and Duncombe Rae, 2005). There is a pronounced poor mixing of oxygen rich Antarctic Intermediate Water (AAIW) and South

Atlantic Central Water (SACW). Robinson *et al*., (2007) suggested that adult *Sardinops sagax* do not leave areas with unfavourable DO concentrations but migrate towards the surface where DO concentrations are higher than in the deeper layers. Although fish larvae, like adults, have the ability to migrate up and down the water column and hence can avoid waters with less favourable DO concentrations, their mobility is limited and newly hatched larvae, typically caught in plankton nets, are likely to be found close to the areas where they were spawned, hence giving an indication of spawning habitat selection. A study carried by Kreiner *et al*., (2009) shows that the concentration of DO in the water column might be an environmental variable that is crucial for the successful spawning and subsequent development and survival of eggs and larvae of pelagic fish species. However, there is no concrete data to support the hypothesis that low DO has negative effects on the abundance and survival of recruitment on pelagic species in the Benguela Current.

According to Gammelsrød *et al*., (1998), some areas off northern Namibia, oxygen concentrations of <1ml L^{-1} are found at 50–this presents a limiting factor for many pelagic species, particularly for their early developmental stages. However, fish species occurring in coastal upwelling regions, such as the Benguela system, have adapted either physiologically or behaviourally to survive in this extreme conditions. According to Dethlefsen & Westernhagen, 1983 oxygen depleted waters and sulphur eruptions results from local and remote forcing, restricting the habitat available for demersal and pelagic fish species. Other studies carried out from other parts of the world, showed that low oxygen levels are known to have severe impacts on the different life stages of fish. For example, catches of herring (*Clupea harengus),* sprat (*Sprattus sprattus)* and Atlantic cod (*Gadus morhua)* in the North Sea declined from 720–900kg h–1 under hypoxic conditions (2.7–3.0ml L–1) to 2–10kg h–1,

because they moved from the area following a large-scale intrusion of low-oxygen (1.2–1.5ml L–1) water (Dethlefsen & Westernhagen, 1983).

Ekau and Verheye, (2005) carried out a study on the northern Benguela and concluded that there is no discrete evidence on the effect of oxygen depletion on the pelagic species in the Benguela current, particularly in terms of their recruitment and pattern of migration and distribution. Based on a triad hypothesis of Bakun *et al.,* (1996), fish recruitment depends on a combination of enrichment, concentration and retention processes. Thus, a species' success to adapt its larval distribution and behaviour to physical environmental constraints is crucial for its population development.

Temperature and salinity are the two primary parameters widely used for water-mass characterisation, and they widely affect fish recruitment. Dethlefsen & Westernhagen, 1983 noted that warm water intrusion into the northern Benguela are an annual event and southerly winds diminish during austral summer and autumn off central and northern Namibia and upwelling weakens. Off the coast of Namibia the Benguela Current is bounded by a circulation of warm subtropical water associated with the South Atlantic Gyre (Oliver & Shelton, 1993). The coastal strip is extremely arid, with the Namib Desert north of the mouth of the Orange River (28°38'S) (Shannon and Nelson 1996). Except for the outflows of the Cunene River at the northern edge of Namibia and the Orange River, where there is little influx of inland waters, the influence of which can therefore be regarded as minimal. Upwelling occurs in the coastal area of the entire Benguela Current region but exhibits varying geographically related intensity and marked seasonal fluctuations. Increase solar radiation and the southward movement of warm and more saline Angolan current water, causes mixing with the cooler waters of the Benguela current, resulting in warm water

conditions in the northern regions (Boyd, 1987). The area is highly productive at the frontal area where the two currents converge and this is known to be productive for pelagic recruitment.

Salinity is an important factor in the survival, metabolism, and distribution of many fish. Water of different salinity on eggs and larvae may be a result of several factors. These are the effect of the total osmotic concentration, the incidence and concentration of particular ions, the availability of oxygen and the specific gravity has an effect on the eggs and larvae of fish. Wind induced coastal upwelling is the dominant oceanographic process along the Namibian coast, as it stimulate primary production in the sunlit zones through the enrichment of the surface water with nutrients (MFMR, 2008). Thus, there is a need for us to understand larval distribution as they can provide an insight on the factors influencing recruitment dynamics such as the location and suitability of spawning habitat. Nutrient concentration also proves to be an important factor that affects the survival and growth of ichthyoplankton.

CHAPTER TWO

MATERIALS AND METHODS

2.1 Study area

The sampling was carried out in the Benguela ecosystem on the continental shelf and slope off Namibia. The study area for fish larvae was located between 21^0S, 22^0S and 23^0S from a 100 to a 3000 depth (*Figure 1*). Whereas for fish egg sampling, the study area was between 17^0S and 24^0S, (*Figure 2*). Both the study sites fall within the Northern Benguela current ecosystem which is one of the four major current systems which exist at the eastern boundaries of the world oceans (Shannon and Nelson, 1996). Like other coastal currents the Benguela current is highly characterized by upwelling of nutrient-rich cold water and it is among the most productive in the world and ranges from the Orange River in the south to the Kunene River in the north and extends 200 NM offshore.

2.2 Study design

2.2.1 Fish Larvae

Fish larvae samples were collected from sampling stations indicated in (*Figure 1)*. Sampling followed a systematic design whereby a total of thirty (30) stations were sampled with one haul per-station and five water samples from multi-nets with respective to depth. The depths

sampled were; surface 0m, 20m, 40m, and 60m depending on the bottom depth of the station. Fish larvae analysis was carried out and identified on-board the vessel according to (Oliver and Fortuno, 1991) guide book.

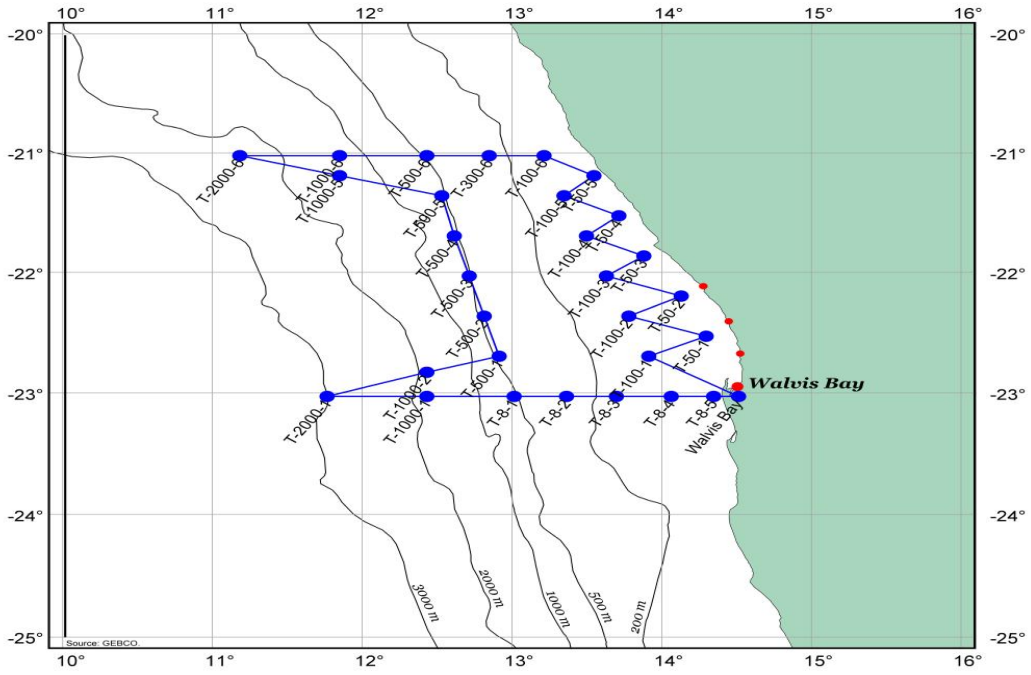

Figure 1: Layout design for the fish larvae sampling between 21^0S and 23^0S latitude (Source: Ekau, 2011).

2.2.2 Continuous Underway Fish Egg Sampler (CUFES)

Samples were collected using **CUFES.** Eggs samples were collected from sampling stations set on different cruises e.g *(figure 2)* for a period between 2005 and 2012. Sampling stations were pre-determined and they followed a zig-zag line format along the coast this is to cover both the horizontal and vertical distribution of ichthyoplankton along the Namibian coast.

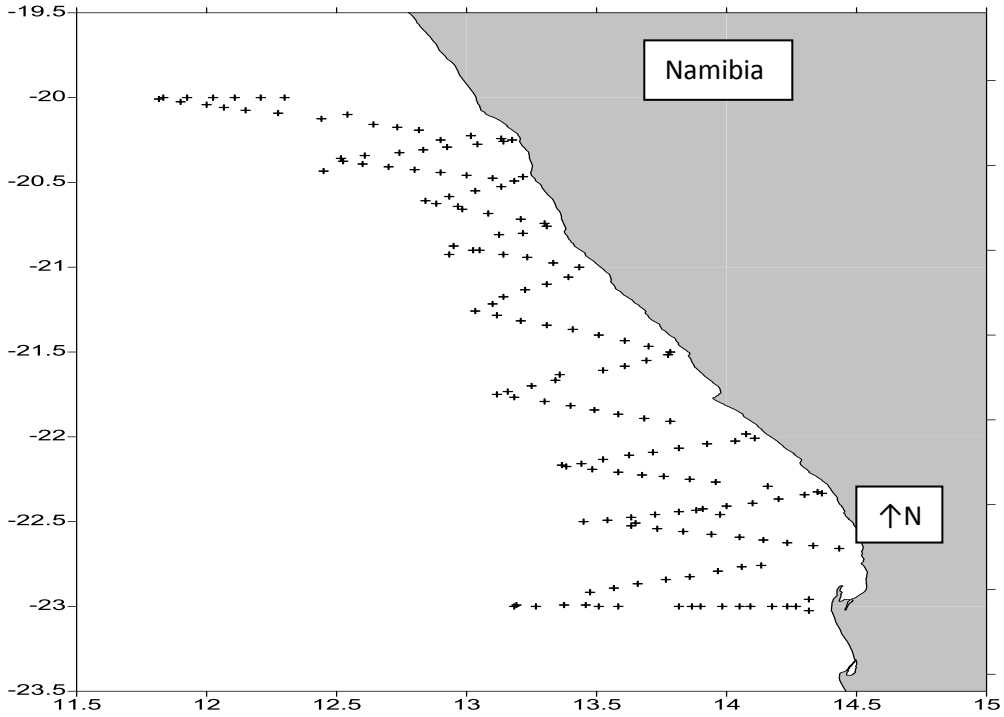

Figure 2: Layout design for Fish egg sampling sites between 17^0S and 24^0S latitudes.

2.3 Data collection

2.3.1 Larvae sampling

Larvae - The data collection duration ran for a period of ten (10) days during September 2011. Samples were collected on-board the *Maria S Merian research vessel* to determine the abundance and distribution of fish larvae within the study area. This allowed ease and ensured comparisons between different stations, whilst identifying hot spots / spawning grounds within the sampled area.

Samples were collected using a multinet (5 nets, 500µ mesh size). Multinet containing 1-5 (500µm) nets and Inlay Nets 4a and 5a (55µm) were used (net 1 contains the samples from the deepest depth while net 5 contains samples collected closer to the surface). Collected water samples containing fish larvae were placed in numbered buckets for clear identification to carefully avoid evacuation of fish larvae guts.

2.3.2 CUFES sampling

CUFES - Egg samples were collected on board the RV *Welwitchia*. Samples were collected for a period between 2005 - 2012 using CUFES (Continuous Underway Fish Egg Sampler). These Samples were collected within the first 3m depth.

The CUFES pumping system consist of three elements (*Figure 3*), i) an insitu submersible pump fixed to the ship's hull; ii) a device to concentrate large particles including fish eggs; iii) analysis devices and Mechanical Sample Collector (MSC). The first element enables 640 l/min of water to be pumped from a nominal depth of 3m, ii) the second element concentrate large particles in a flow of 20l/min and iii) and the third element electronically sense and physically collect particles for real time assessment of the concentration of the target particles types.

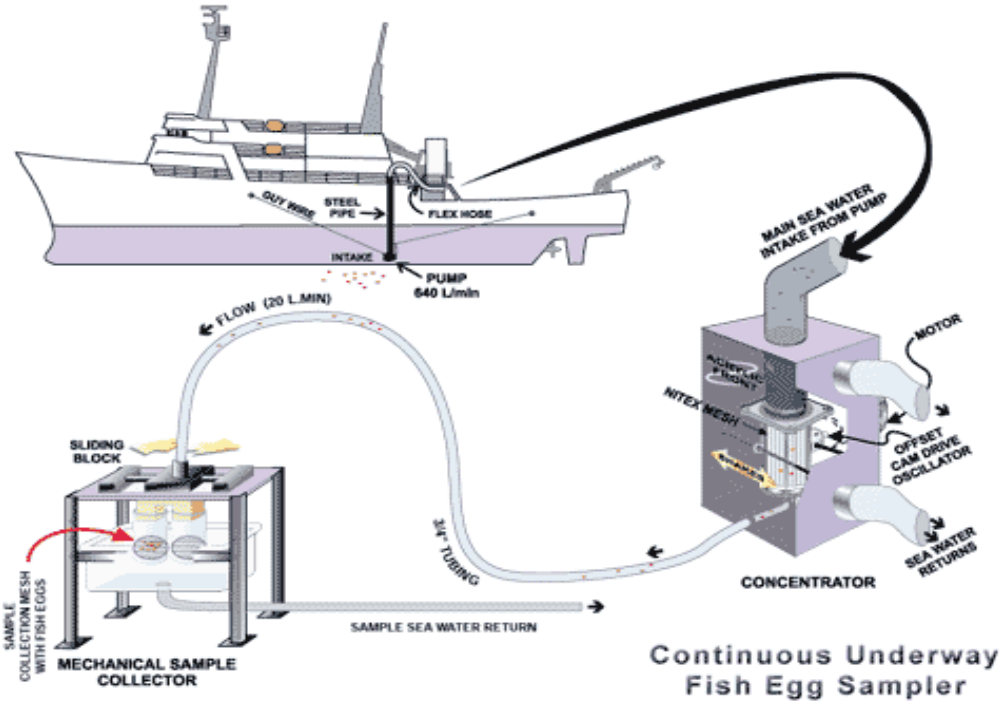

Figure 3: Sampling procedure for CUFES (Source: SWFSC, 2010).

The procedure for collection of CUFES is outlined in *Figure 3*, above. When the pump is switched on sea water will immediately start to flow into the concentrator. Pipes above and below the concentrator need to be adjusted nicely for proper seawater discharge from the concentrator, if they are not properly adjusted then the concentrator will either over flow or dry out. Seawater from the pipe above the concentrator will flow into the mechanical sample collector through the separator. Water discharging from the separator only collects in one cup at a time so that the other one remain unused or empty. Once the first interval is over (usually 30min) cups are switched by simply sliding the block so that seawater will now flow into the empty cup for a new sample. It is very important to watch the clogging of the nitex net and ensure it is cleaned accordingly. After sampling is done recording of the date, sample number, position, grid, start time, start position and the name of the recorder in the log book. Samples are then collected into the mesh provided, checked using a microscope to identify

and count eggs. These samples are then poured and thoroughly washed into the labelled bottles and preserved by adding formalin using the dispenser.

2.3.3 Laboratory analysis

Larvae: Caught larvae were removed from the samples and identified according to Oliver and Fortuno, (1991) using dissecting microscopes. Fish larva/juvenile were identified using magnifying lens or/and dissecting microscope. Strong light source was mounted on a stand and black trays were used for sorting the fish larvae, as most fish larvae appeared whitish after catching. Measurement on the specimens was done using a graph paper (mm) and plastic/glass pipettes were used to transfer water into the Petri-dish to avoid drying of samples while identifying them to species level. Larval pictures were taken with a dissecting microscope for further references. Each sample was fixed with 5% formaldehyde and labelled by station number; depth (m), haul number and the cruise name. This information was then recorded in the recording sheet.

CUFES: Egg samples were identified to species level and counted on board the vessel using microscopes and identification guide (Oliver and Fortuno, 1991). In each case samples were recounted twice off board at the Ministry of Fisheries and marine resources laboratory following the same procedures to enhance accuracy of the data.

2.4 Data analysis

The statistical packages *SPSS 14.0,* and *Primer 5.0* for Windows were used to analyze the data pertaining to species diversity, abundance and distribution of fish larvae species. The species diversity of fish larvae was calculated using *Shannon – Weiner Index* of diversity (*H*'), this analysis was carried out using *Primer 5.0* for Windows. To compare the diversity of larval species a Kruskal-Wallis test was used. To determine and compare the abundance of ichthyoplankton (CUFES) distribution along the Namibia coast, an F – test from the One-Way ANOVA was used. To determine for significant changes in abundance and distribution of ichthyoplankton species over the years 2005-2011, the One-Way ANOVA was used.

CHAPTER THREE

RESULTS

3.1 Diversity of fish larvae species

A total of 12 species of fish larvae were investigated during the present study. Observed ichthyoplankton species comprises of varieties of species of different body sizes and lengths. The diversity of fish larvae species were investigated between 21-23^{o}S off the Namibian coast. No 'new' ichthyoplankton species were recorded during this study.

Composition sampled comprised of several species belonging to different families such as Myctophidae (*Symbolophurus boobs*, *Lampanyctodes hectoris*, and Diaphus species), Sternoptychidae (*Maurolicus muereli*), Gobidae (*Sufflogobius birbatus*), Merlucidae (*Merlucius species*), Gonostomatidae (*Cyclothone*), Carangidae *(Tranchurus capensis*), Scoperlachidae (*Scoperlachus analis*), Paralepidae (*Paradiplopus gracilus*), Macrouridae (*Coelorhynchus occa*) and Green palylus species.

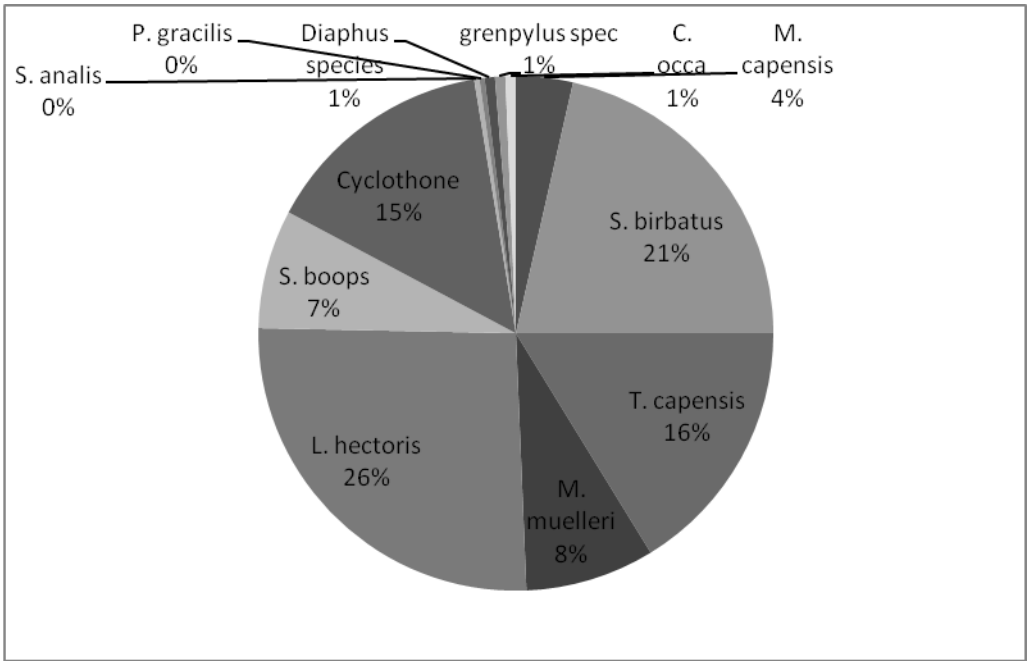

Figure 4: Percentage (%) composition of fish larvae species sampled during the survey.

The percentage composition of fish larvae species was dominated by the *Lampanyctodes hectoris* followed by S*ufflogobius birbatus* and then *Trachurus capensis* respectively, as shown in *Figure 4*.

The comparison of means in larval species diversity is depicted in (*Figure 5)*. The results indicated non-significant differences in means of larval species diversity between latitudes.

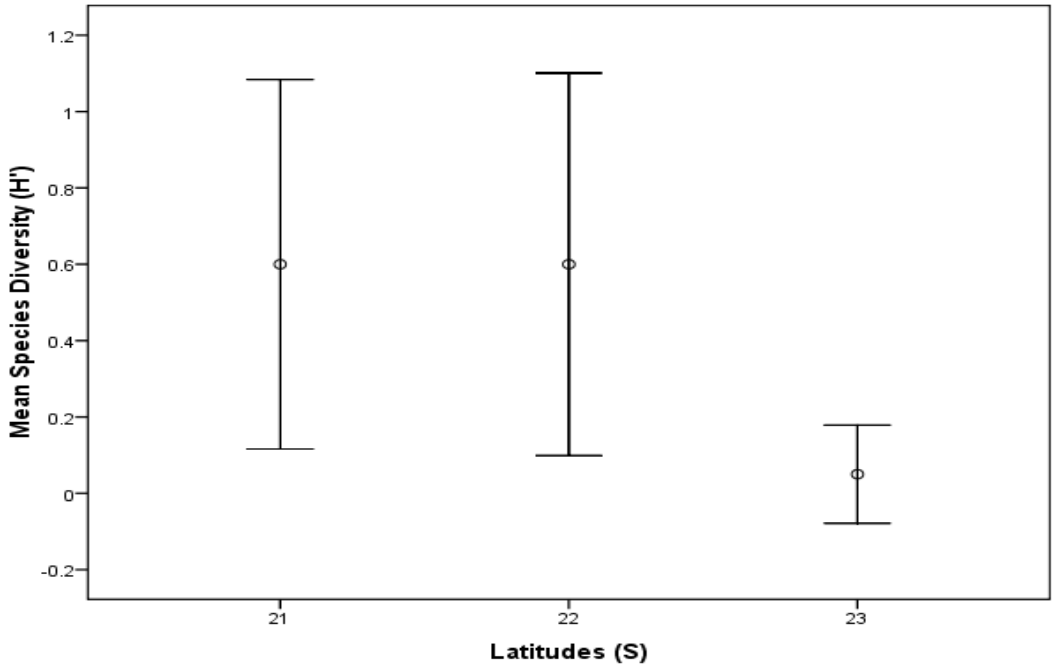

Figure 5: Comparison of means in species diversity of fish larvae between 21°S, 22°S and 23°S. Error bars indicate 95% confidence interval of the mean.

An analysis of variance (ANOVA) indicated a non-significant differences in means of larval species diversity between the selected localities (F = 4.414, $d.f$ = 2, p> 0.05). Although no-significant differences was observed in means of larval species diversity (*Figure 5*) it is evident that the means in larval species diversity was high at 21°S followed by 22°S and lowest at 23°S with H' = 6, 3.6 and 0.3, respectively.

The comparison of means species diversity with regards to depths is depicted in (*Figure 6).* The results indicated a non-significant difference in means of species diversity between depths.

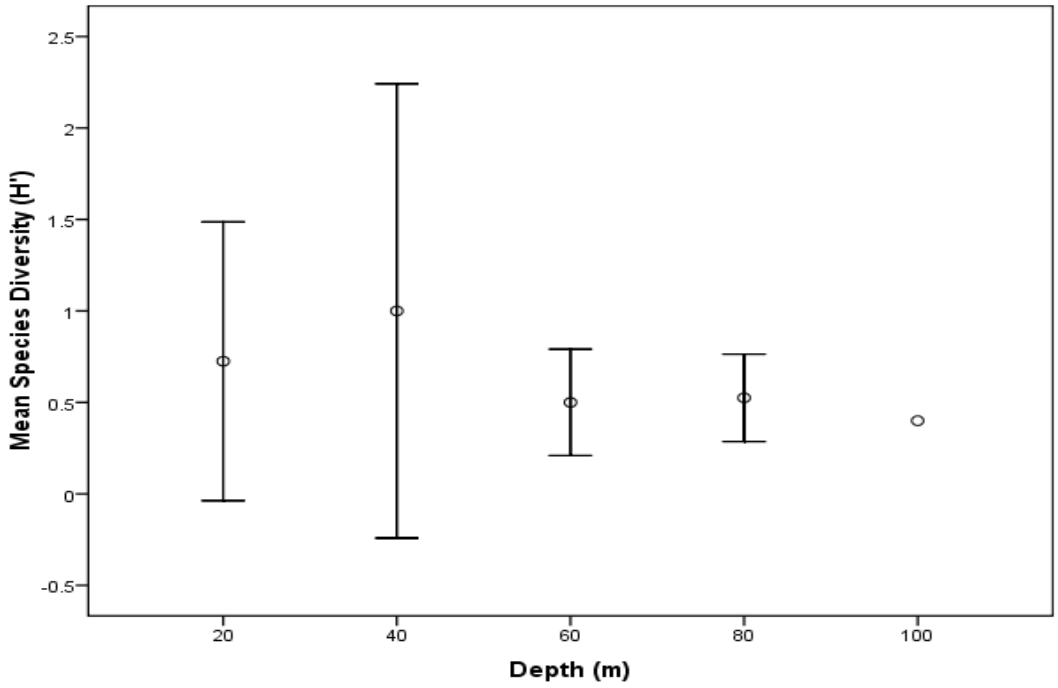

Figure 6: Comparison of means in species diversity of fish larvae between depths. Error bars indicate 95% confidence interval of the mean.

A Kruskal Wallis test indicated a non-significant differences in means species diversity between different depths (Chi-square = 3.00, $d.f = 4$, $p > 0.05$). A non-significant difference in species diversity was observed. The graph depicts the highest mean species diversity at 40m depth and low at 100m depth with $H' = 1.03$ and 0.4 respectively.

3.2 Abundance and distribution of ichthyoplankton species for the year 2012

The abundance and distribution of fish egg fluctuated along the northern benguela area. The comparison in abundance of fish egg along latitudes indicated relatively high abundance at 19°S and lowest at 21°S latitude (*Figure 7*).

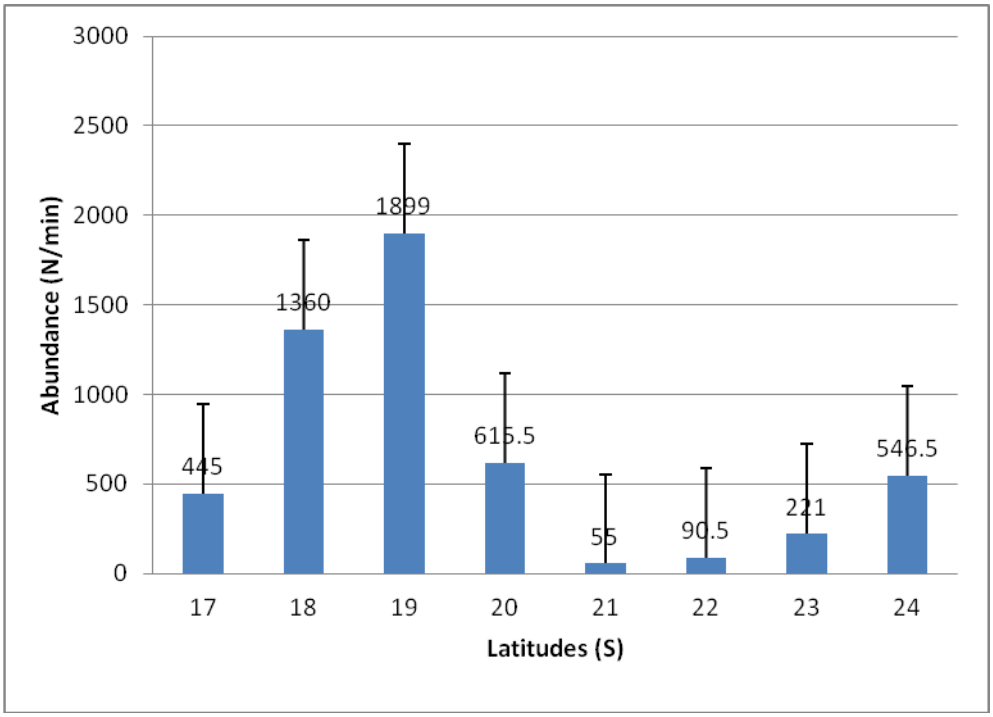

Figure 7: Comparison of ichthyoplankton abundance between (17°S) and (24°S) latitudes. Error bars indicate 95% confidence interval of the mean.

An analysis of variance (ANOVA) indicated non-significant differences in the ichthyoplankton abundance along the Namibian coastline with regard to latitudes (F = 1.4, $d.f$ = 7, $p > 0.05$). It is evident from (*Figure 7)* that the abundance of CUFES was highest at 19°S latitude and lowest at 21°S latitude.

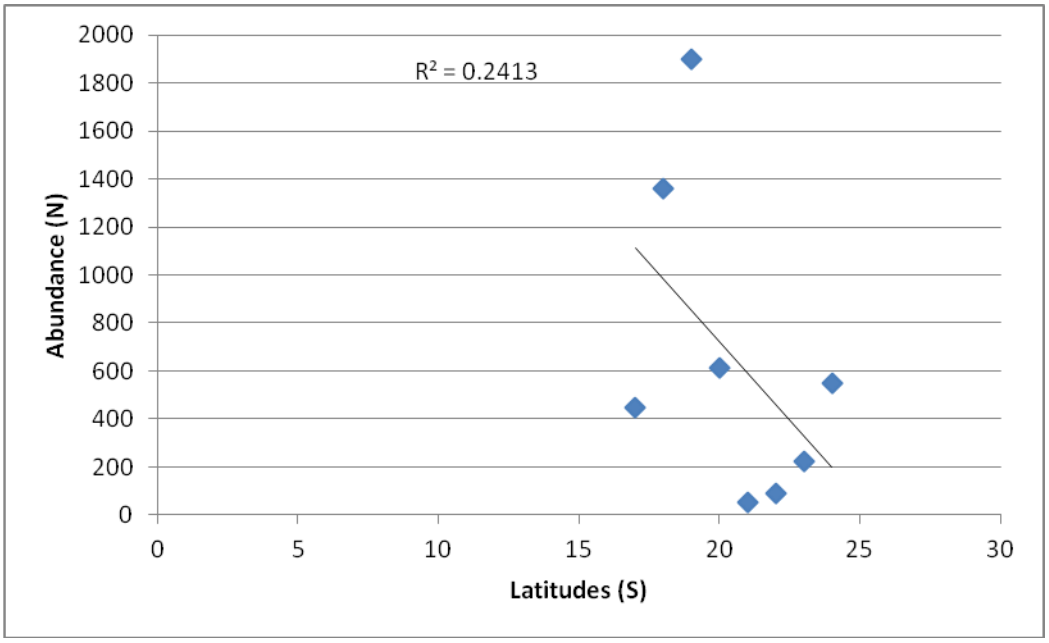

Figure 8: Scatter plot showing the association between ichthyoplankton abundance and latitudes (i.e. 17°S and 24°S).

The straight line shows the degree of linear association between latitudes and abundance of CUFES samples. R^2 = 0.2413 indicates that only about 24% variation in the data can be accounted for. It is however, evident from the graph that there is a non-linear association between latitudes; this is clearly shown by the inverse straight line in (*Figure 8).*

3.3 Changes in abundance and distribution of ichthyoplankton species

The comparison of means abundance of CUFES data sampled over the years between 2005 and 2011 is depicted in (*Figure 9).* The results indicated a non significant difference in the means of abundance over a 6 year period.

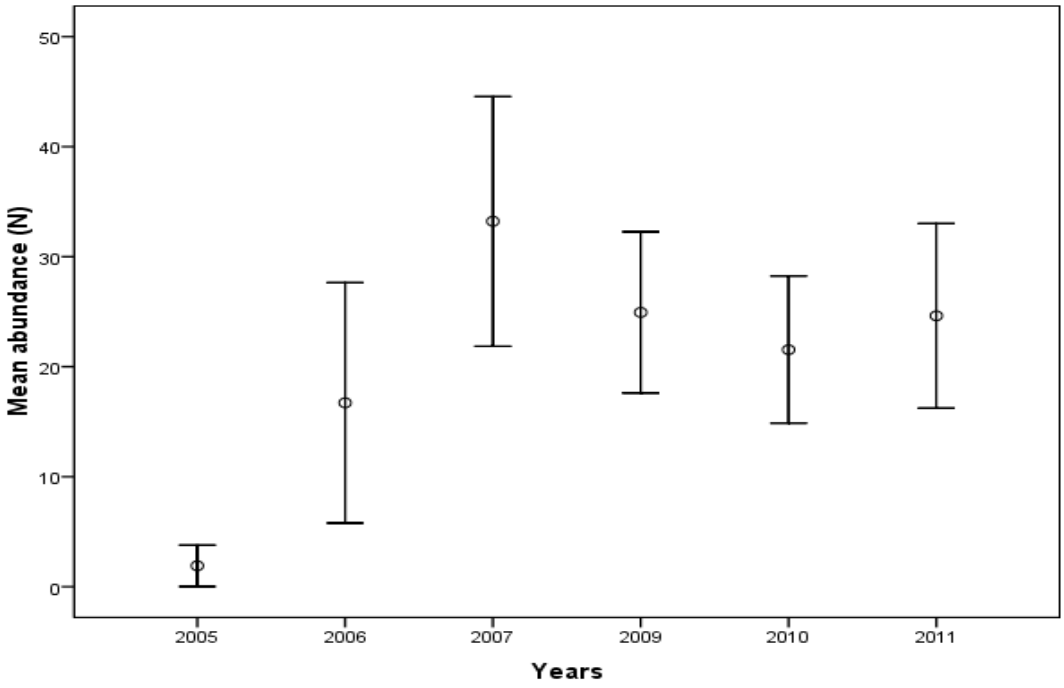

Figure 9: Comparison of means in abundance of CUFES data over the year between 2005 and 2011. Error bars indicate 95% confidence interval of the mean.

An analysis of variance (ANOVA) indicated a non significant differences in means abundance over the years (F = 1.148, $d.f$ = 5, p> 0.05). A non significant difference in the mean abundance of CUFES data was observed (*Figure 9*) the graph depicts the highest mean abundance in 2007 and the lowest in 2005.

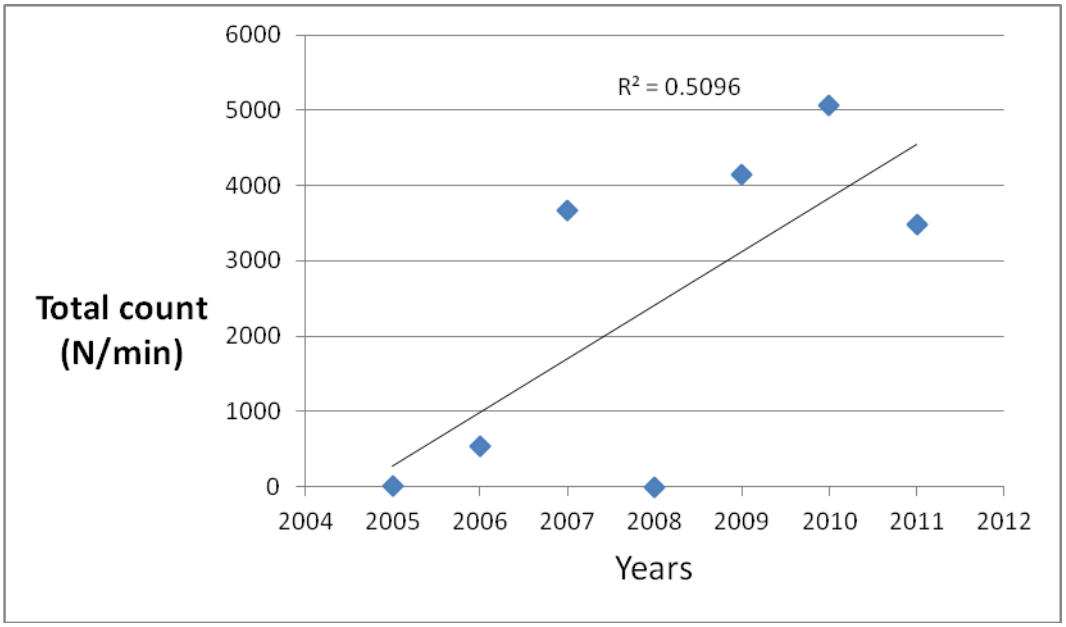

Figure 10: Showing the association between collected CUFES samples with years (2005-2011).

The straight line shows the degree of linear association between years and total recorded CUFES samples. R^2 = 0.5096 indicates that about half the sample variation could be accounted for. Thus, there is a linear association between years and total recorded CUFES samples.

The trend line shows anchovy, Sardines and Horse mackerel from 2005-2011. The abundance fluctuated among the years. Results show that 2010 had the highest count for all the species and no count for sardines.

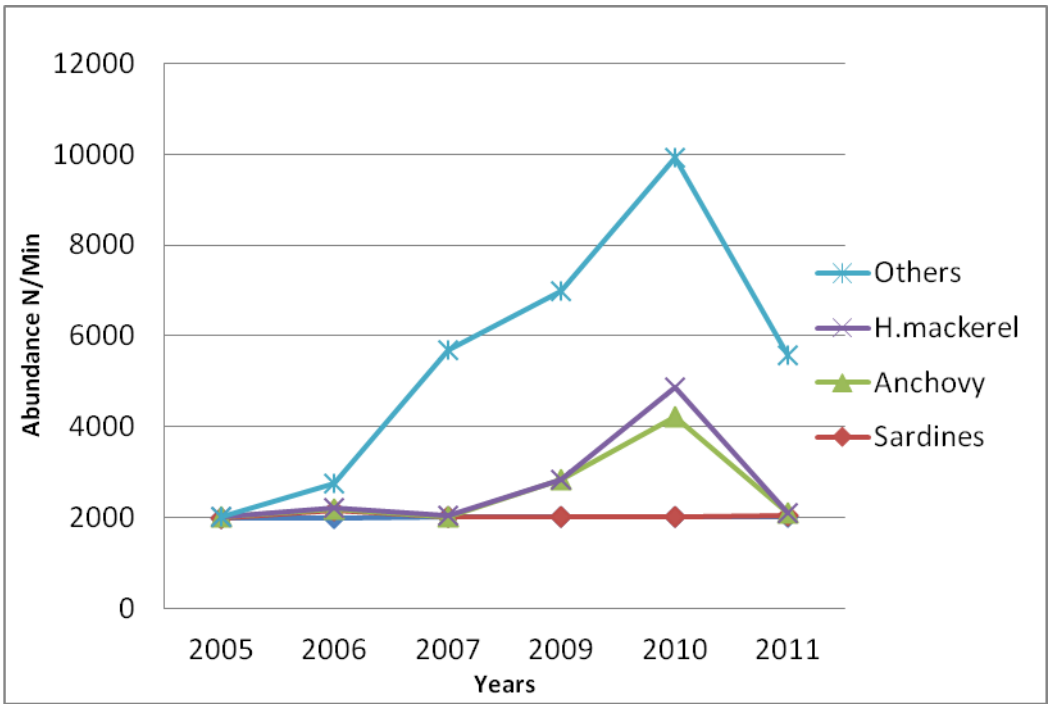

Figure 11: Comparisons of change in the Sardines, Anchovy and Horse mackerel CUFES samples from the year 2005-2011.

Results shows that anchovy was the most abundant eggs collected over the 6 year period followed by horse mackerel and then sardines with 17%, 3.9%, and 1.1% respectively. The general pattern showed in Figure 10, indicated that there has been a slight increase in abundance of CUFES samples collected over the years which reaches the peak in 2010; notably for anchovy and horse mackerel, unlike for sardines they were high in 2006 but remained low until 2011 *(Figure 10).*

CHAPTER FOUR

DISCUSSION, CONCLUSION AND CONTRIBUTION TO KNOWLEDGE

4.1 Discussion

4.1.1 Diversity of ichthyoplankton species

This study is aimed to identify the spatial distribution of ichthyoplankton species diversity in the northern Benguela current ecosystem. In total, about 12 species of ichthyoplankton were identified. *Lampanyctodes hectoris* was the most abundant species recorded with 26.3%. This observation is in conferment with literatures that states that *L. hectoris* is a pseudo oceanic latern fish which is in abundant quantity in the Benguela region (Oliver, 1987). *L. hectoris* was followed by *Trachurus capensis* and *Cyclothone* species (*Figure 4*). These species belong to the Myctophidae family and contributed about 33% to the total sampled larvae. Another important group was the mesopelagic fishes, represented by three families (Gonostomatidae, Scoperlachus, and Sternoptychidae, which contributed about 23% to the total samples. Other species such as *Merluccius* larvae, *Sufflogobius birbatus,* Carangidae and Cyclothone contributed about 4%, 21%, 16% and 15%, respectively. There were also two specimens that could not be identified to family level. Based on Ekau and Verheye, (2005) highlighted that the fish fauna of the Benguela region can be represented by endemic species and those common to other oceans. Many species are common to the entire Benguela area, while others are present only in the southern or northern area.

Results have indicated non-significant differences in means of species diversity with regards to latitudes and depths. The observed trends in species diversity investigated between 21^{o}S-23^{o}S off the Namibian coast indicated that diversity tend to lower toward the 23^{o}S. This limited spatial observation is not in confinement with other fishery studies carried out in the Benguela (Nashima, 2012; Van Zyl, 2000), thus it align with the global trends in species gradient where diversity tend to increase toward the equator (Sakko, 1998). Therefore, larval diversity was highest in the northern most part of the sampled area than the south. According to Oliver, (1990) intrusion of warmer, more saline water facilitated penetration by species that generally dwell further north, which, in combination with the indigenous Benguela species accounted for the increased species diversity.

In addition, high species diversity and abundance in the north correspond to a study carried out by Oliver in 1990 were larvae accumulates along the Benguela current (which flows N-NW) and then retained at the confluence where these waters meet the Angolan water. Both stations on the 23^{o}S line had diversity score of zero except station 1041 (Appendix 1). Low breeding grounds are around this area as compared to 21^{o}S and 22^{o}S transect line. Parish *et al.*, (1983) noted that low diversity levels are characteristics of the southern zone. Several studies have pointed out that certain species may avoid using this area of perennial upwelling as a spawning area because of the strong offshore transport.

Species diversity based on depth was also carried out and showed a non significant difference with depth. This implies that different depths could have similar species diversity regardless of the conditions. This is mostly because of the nature of the species however, most species spawn in areas and depths with favourable conditions were growth and

survival can be high (Southward and Barret, 1983). Subsequently, from an energy availability standpoint, the most efficient strategy would be to remain close to the surface, because of the higher zooplankton densities found there. Additionally, other authors have indicated that vertical distribution is determined by feeding conditions (Munk *et al*., 1989), and certain species or zooplankton have sometimes been reported to remain within a particular depth range because suitable food organisms aggregated there Results showed that at 40m species diversity was highest with the lowest being at 100m. According to Oliver, (1990) due to vertical distribution patterns species that spawn in period of weak upwelling, when stratification of the water column is more marked, eggs and larvae distribution are more confined to the surface layers i.e. the uppermost 50 m. Generally, hydrographic feature appears to be the main factors that control the spatial distribution of ichthyoplankton. According to literature, species diversity is greatest in the offshore areas than elsewhere, as a result of increased influenced by the larvae of deep water forms. These situations persist during diverse hydrographic conditions, as has been observed in other geographic areas (Richardson *et al.*, 1980).

4.1.2. Abundance and distribution of fish eggs along the Namibian coast in the year 2012

Fish eggs were spatially distributed along the Namibian coast, and the result showed a non significant difference in abundance of sampled eggs at those localities for the year 2012. Nevertheless, abundance trends showed that fish eggs were relatively more abundant between 17^0S and 20^0S latitude compared to the other latitude further south (21-24^0S). Species such as *Engraulis capensis* and *Sardinops ocellatus* have coastal distribution for their eggs and yolk sac larvae. This distribution pattern for eggs and larvae indicate that adult spawn mainly near the coast with larvae then drifting seawards. This is in agreement with a study carried

out by Oliver, (1987) that indicated that during quiescent upwelling period pelagic species (anchovy, pilchard, round herring), demersal species (hake) and semi pelagic species spawn in the coast-shelf area, along the length of the Namibian coast. However, offshore Ekman transport off Namibia is responsible for the displacement of larvae away from the coast. Oliver and Shelton, (1993) noted that chlorophyll-a and zooplankton concentrations are lower offshore than in the upwelling zones (Kruger and Boyd, 1984; Shannon and Pillar, 1986), and the survival of larvae there would probably be lower than in the rich, near shore areas. The highest abundances were recorded at latitude 19°S, whereas the lowest were recorded at 21°S. The variability (as indicated by the error bars) within the abundance recorded across the latitudes is relatively larger *(figure 7).* Several reasons explain this, such as latitudes 17-20°S being closer to the vicinity of the Angola Benguela frontal region where abundances are usually higher owing to warmer water due to the influence from the warm Angola current. This area present a reduced wind induced transport and turbulence and continental width tend to be greater. Shown in the results (*figure 8)* R^2 showed a non linear association in abundance between latitudes meaning there is no linear association between the sampled latitudes.

4.1.3. Abundance and distribution of ichthyoplankton species over the years

CUFES has proven to be a reliable system with which to sample pelagic eggs of fish. It provides data on the distribution and abundance of eggs under virtually all sea conditions as opposed to when nets have to be used under high winds and heavy seas (Checkley *et al*, 1997). Conventional methods, nets towed at discrete stations are limited in their accuracy, precision and sensitivity, and are labour intensive and hence, costly. Additionally, such method requires a dedicated use of a ship and is limited by adverse conditions and produce samples which await analysis ashore. Results on egg samples over a six year period showed

non-significant differences, the pattern in the change and comparisons in the ichthyoplankton over the years did not differ much irrespective of the years. The introduction of CUFES in Namibia was mainly to analyse if pilchard were recovering and to see the effect of fishing on pilchard substitutes (Horse mackerel and Anchovy). After pilchards were overfished, it was a great loss in terms of employment and revenue generation for the country's economy.

Based on the results, year 2010 recorded the most eggs sampled, with a total of 5059 followed by year 2009 with a total of 4149 eggs. The year 2010 was a very productive year, conditions were stable and production increased in terms of total zooplankton biomass which is the food for larvae. There was more zooplankton in terms of abundance than any other year since 2005 to recent, thus more larvae were collected due to some of these reasons this. The results further showed that there is a linear association between years and total egg count. R^2 *(Figure 9)* depicts that about 0.51 variability of the data is accounted for. Based on the obtained results the egg samples collected increased from 2005 to 2007. The trend started picking up thereafter reaching a peak in 2010 and slightly dropped in 2011. Anchovy contributed about 17% to the total recorded CUFES samples followed by Horse mackerel with 3% and then sardines amounting to 1%. A section of others contributed a total of 78% making it the largest contributor to the composition (*Figure 10*).

According to literature anchovy and horse mackerel increased as sardines species started to disappear. Thus there is an assumed relation in this three species. Based on the result *(Figure 11)* in the year 2010 anchovy and horse mackerel recorded the highest abundance unlike for sardines. Sardines showed a peak in 2006 until then it has been recorded in lower numbers. Changes in the spawning area are partly due to changes in the population structure of the sardine's population. There have been several changes in biological indicators that were

observed since the stock collapsed. Based on the Sing Parameter Quotient (SPQ) analyses carried out on several surveys, it has been shown that recently there has been a shift in the preferred latitudes of spawning towards more southerly regions. le Clus, (1989) noted that a decrease in length in comparison with the 1980s leads to a lower fecundity of sardines stock, as large sardines spawn more larger eggs which have a better chance of survival. A decline in the maturity of sardine spawners was also observed thus producing weaker eggs with little survival rate. Le Clus (1989) further discussed that the spawning stock currently consist of only smaller females, the total number of spawning as well as the number and quality of eggs per spawning are greatly reduced. This does not only mean that fewer eggs will be produced but, probably more important, the chance of a spawning during a period of favourable oceanographic conditions is also reduced. Thus the productive potential of the sardines stock is currently greatly reduced.

Sardines recovery may however be hampered by the ecosystem function observed in the northern Benguela. Fossen *et al.,* (2001) added that due to the low biomass of sardines, predation pressure has increased and may prevent the stock from recovering; this is in line with the predator pit explained by (Bakun, 1996). Several authors suggested that the ecological niche opened up by the collapse of the sardine stock have been taken over by other species such as gobies, jellies, mesopelagic fish and horse mackerel, hampering the recovery of the sardine stock.

CUFES samples were only collected within the first 3m and it was mainly to sample pelagic species however, others species that were collected along the way could not be ignored hence they were just placed under the ‘others’ section. Others also meant that either the samples could not be identified because it was damaged during preservation or samplers could not be

identified to species level at all. These samples could contain any of the other species such as sardines, anchovy or horse mackerel.

4.2. Conclusion

To understand the Benguela system it is necessary to have a wider knowledge of the biology of the component species (e.g. fecundity, resistant time in the plankton, food requirement etc). However, from the available information it is apparent that, species diversity is higher up north compared to the south. The variability within the abundance recorded across the latitudes is relatively larger. There is a fluctuation in the distribution of ichthyoplankton over the years 2005-2011 this may be due to changing environmental factors. CUFES data coupled with hydrographic data in future studies will produce more clearly and reasonable results as their abundances can be correlated to oceanographic data.

4.3. Contribution to knowledge

This study has provided insight knowledge in the sense that the investigator has gained a depth understanding of conducting a research and working together with other people. Knowledge gained includes research design, data collection, analysis and interpretation. This study can be used as a management tool by the ministry in relation to decision making pertaining ichthyoplankton and egg distribution along the Namibian coast and to see the status of some ichthyoplankton species such as sardines and their substitutes. In particular, estimates of egg abundance in time and space can be used to estimate the spawning biomass

of populations of pelagic fish and thus needed to understand the status and dynamics of fish population in order to best manage them.

4.4 Limitation of the study

- **Sampling -** This may have been the major constraints of the survey. The types of sampling methods used are likely to have affected the results and since this was a onetime sampling survey this does not really provide a concrete species richness of the area. Using more specified sampling equipments for larvae sampling will provide accurate and non-biased results. Species richness may not really relate to the area size but rather be a statistical artefact. More species could be recorded if sampling was done over a longer period.

- **Expertise** - Sampling and larval identification was done by different people, most of them were students and they did not have training and experience on this. Thus this might have affected the species composition in a way.

- **Inconsistency** - Identifying samples was done by different people over the 5 year period and this could have impacted on the results, experienced people at the job leave the ministry and new recruits use new skills and strategies and thus, resulting to irregularities.

- **Funding** – There is limited funding and personnel to do this kind of studies and it is quite expensive and risky working at sea, however, good results always pays off.

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APPENDICES

Appendix 1: Species diversity at respective depths and Station plus species diversity calculations

Station	Latitude	Richness (s)	Total (N)	H(LOG e)
1019	22	3	16	0.9
1021	22	4	37	1.0
1023	22	2	14	0.7
1025	21	2	12	0.3
1027	21	2	13	0.5
1029	21	1	1	0.0
1030	21	5	6	1.6
1031	21	1	3	0.0
1032	21	5	25	1.2
1033	21	1	13	0.0
1034	21	6	10	1.7
1035	21	0	0	0.0
1036	21	2	52	0.7
1037	22	0	0	0.0
1038	22	0	0	0.0
1039	22	4	81	1.0
1041	23	2	25	0.3
1042	23	0	0	0.0
1043	23	0	0	0.0
1044	23	0	0	0.0
1045	23	0	0	0.0
1046	23	0	0	0.0
Total			308	9.8

H’ = (P) (logP)

Where H = diversity index

P = Proportion of taxa (number of species/taxon divided by the total number of organisms)

Total # of taxon = 12 Total # of organisms = 308

Total value (diversity index) = -1.869484

Multiply by -1 = 1.869484

Diversity index = 6.484952

Appendix 2: ANOVA tables for Species diversity, Depth and Distribution of ichthyoplankton along the coast respectively.

(a) ANOVA table for species diversity

	SS	**Df**	Mean Square	**F**	**Sig**
Between Groups	1.021	4	.255	1.982	.187
Within Groups	1.417	11	.129		
Total	2.438	15			

(b) ANOVA table for depth

	SS	**Df**	**Mean of square**	**F**	**Sig**
Between groups	1.021	4	.255	1.982	.167
Within groups	1.417	11	.129		1.982
Total	2.438	15			

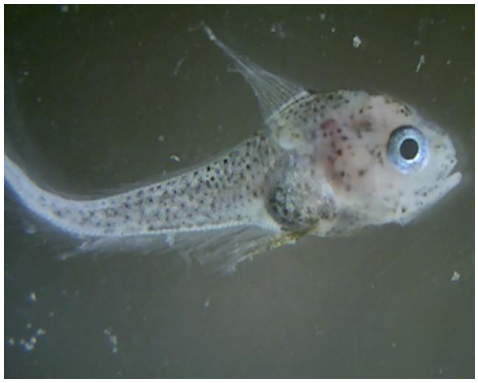
(c) ANOVA table for distribution and abundance along the coast

	SS	**Df**	**Mean Square**	**F**	**Sig**
Between Groups	45273.482	7	6467.640	1.400	.206
Within groups	1025503.393	222	4619.385		
Total	1070776.875	229			

(d) ANOVA table for different years

	SS	**Df**	**Mean square**	**F**	**Sig**
Between groups	14974.028	5	2994.806	1.148	.333
Within groups	1773436.726	680	2607.995		
Total	1788410.754	685			

Appendix 3: Laboratory samples and some identified larvae



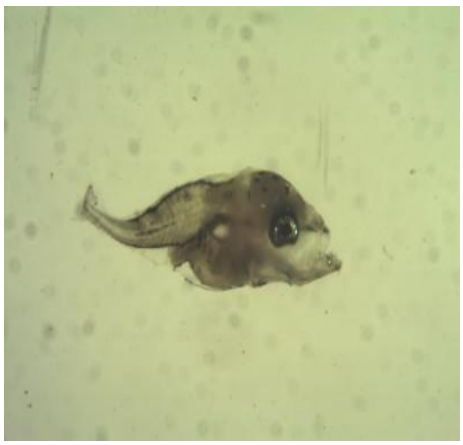
Macrouridae X100Mg

Merlucidae X100Mg

Maurolicus Muereli X100Mg

Gobidae X100Mg

Sternoptychidae X100Mg



Trachurus capensis X100Mg

Appendix 4: Data collection sheet for samples

Station	Latitude	Species	0
1019	**-22.66**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
			0
1021	**-22.33**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0

		paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
			0
1023	**-22.03**	*merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
1025	**-21.66667**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus	0

		analis	
		paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
			0
1027	**-21.333**	*merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
			0
1029	**-21**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0

		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
			0
1030	**-21**	*merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus s capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
1031	**-21**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1032	**-21**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
1033	**-21**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus s capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1034	**-21.17**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1035	**-21.33**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		grenpylus spec	0
		Coelorhyanchus occa	0
1036	**-21.67**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1037	**-22**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1038	**-22.33**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1039	**-22.66**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1041	**-23**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1042	**-23**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1043	**-23**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1044	**-23.00002**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1045	**-23**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0
		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		Paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0
1046	**23.218**	*Merlucius capensis*	0
		Sufflogobius birbatus	0
		Trachurus capensis	0
		Coelorhyanchus occa	0
		Maurolicus muelleri	0
		Lampanyctodes hectoris	0

		Symbolophorus boops	0
		Cyclothone	0
		Scopelarchus analis	0
		paradiplospuus gracilis	0
		Diaphus spec	0
		Grenpylus spec	0
		Coelorhyanchus occa	0