Benguela Current Large Marine Ecosystem Programme

BENEFIT

EV/PROVARE/04/01: Characterizing the spawning habitat (temporal, spatial and in terms of physical and biological attributes) of harvested pelagic species (*Sardinops sagax, Trachurus sp., Engraulis encrasicolus*) using Continuous Underwater Fish Egg Sampler (CUFES) and net sampling

Contracted to: BENEFIT
Completion date: 31st May 2007
Principle Investigator: Anja Kreiner (NatMIRC)

EXECUTIVE SUMMARY

Objectives:

Almost all available information on spawning habitat of commercially important pelagic fish (*Sardinops sagax, Trachurus sp., Engraulis encrasicolus*) in the northern Benguela region comes from a time period when the stocks were in a much healthier state than at present. It is likely that these data are not representative of current spawning behaviour due to changes in stock structure and thus their validity is questionable. In order to improve management recommendations it is of utmost importance to know where and when fish are spawning in order to relate recruitment success to environmental conditions. The distribution and density of fish eggs provides information of spawner biomass as well as adult fish distribution and recruitment success. It is thus critical to monitor the dynamics of fish egg distribution as an added element of the overall stock status assessment. This information will be used in combination with other assessment tools such as acoustics, which give indices of abundance and distribution.

Specific aims of the project were:

- Build and deploy a Continuous Underway Fish Egg Sampler (CUFES) for the northern Benguela
- Apply the CUFES method for fish egg sampling on regular fish assessment surveys and dedicated CUFES/environmental monitoring surveys
- Analyses of data obtained and comparison with existing data.
- Training of staff in the running of the CUFES as well as egg identification.

Recommendations:

1. CUFES should be routinely used on the environmental monitoring surveys in Namibia.
2. CUFES should be run during hydro-acoustic surveys on a regular basis to get hydro-acoustic independent information on fish distribution, especially with the currently very low biomass of pelagic stocks like sardine and anchovy.
3. It must be ensured that logistical problems experienced with the '*RV Welwitchia'* in Namibia are minimized and regular environmental surveys (with CUFES) can be done.

4. Technical problems occurring with the CUFES should be dealt with by the management of the '*RV Welwitchia'*.
5. A feasibility study in Angolan waters should be done to ensure that CUFES samples are analysed for identification of eggs of pelagic species in the Angolan system before a CUFES is considered for regular monitoring in Angola.

FINAL REPORT
EV/PROVARE/04/01

A. Title

Characterizing the spawning habitat (temporal, spatial and in terms of physical and biological attributes) of harvested pelagic species (*Sardinops sagax, Trachurus sp., Engraulis encrasicolus*) using Continuous Underwater Fish Egg Sampler (CUFES) and net sampling.

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H. Introduction

To improve management recommendations it is of utmost importance to know where and when fish are spawning in order to relate recruitment success to environmental conditions. The distribution and density of fish eggs provides information of spawner biomass as well as adult fish distribution and recruitment success. It is thus critical to monitor the dynamics of fish egg distribution as an added element of the overall stock status assessment. This information is used in combination with other assessment tools such as acoustics, which give indices of abundance and distribution. Almost all available information on spawning habitat of commercially important pelagic fish (*Sardinops sagax, Trachurus sp., Engraulis encrasicolus*) in the northern Benguela region comes from a time period when the stocks were in a much healthier state than at present. It is likely that these data are not representative of current distribution due to changes in stock structure and thus, their validity is questionable.

Pelagic fish spawn in aggregations which result in contagious distributions of eggs that are often best sampled continuously. That this is the case in the northern Benguela became very clear when the CUFES was tested during an ichthyoplankton survey on board the "*Dr. Fridtjof Nansen"* in February 2003 (see Appendix 1). Sampling for fish eggs with nets on stations spaced 10 nm or more apart, would thus result in undersampling of eggs of pelagic fish species.

The Continuous Underwater Fish Egg Sampler (CUFES) (Checkley *et al.* 1997) allows for continuous, real-time underway sampling which reduces the need for sampling stations. With reduced stock sizes, the problem of accurately sampling a patchy distribution of fish eggs is exacerbated and thus continuous sampling will improved the efficiency of surveys by reducing the rate of false-negatives (missing egg dense areas).

The CUFES is used on a routine basis for many in several countries (e.g South Africa, US and Spain) and other countries have acquired the system and used it on one or more surveys (e.g. France, Peru, Chile; Checkley *et al*. 2000). Under the GLOBEC -SPACC programme a working group (WG8) was formed to evaluate the hypothesis that changes in the productivity of small pelagic fish may be caused by climate-induced changes in the extent of the spatial and temporal location of suitable spawning habitat (Hunter and Alheit 1997). The approach of WG8 was to use the same methods (CUFES) in each participating region to map the spatial and temporal dimensions of the spawning habitat of small pelagic fish and to compare between them between ecosystems. The same species occur in many ecosystems around the world and thus inter-ecosystem comparison is a powerful tool in gaining new insight (Checkley *et al.* 2000).

Evidence exists that the described spawning behaviour of several pelagic species in the northern Benguela has changed with the changes in stock size and structure. With the advent CUFES a method has been developed that can assist in rectifying our state of knowledge regarding the distribution of pelagic species in a more efficient manner than has been possible in the past. Using a method that is also used in other ecosystems will allow for ecosystem comparisons and insights gained from longer time series in other regions might help in explaining observations from the northern Benguela.

The CUFES system is interchangeable between vessels and can be used at speeds of up to 10 knots, which enables the system to be used on vessels of opportunity. This enormously increases the amount of data that can be collected and will make a significant contribution to improving the amount and quality of information for management. For this contract a CUFES system was built and commissioned for deployment and testing initially in Namibia. The work was conducted mainly on the "*RV Welwitchia"*. The regular NatMIRC research cruises were used as a platform for the work and the funding for the activity was incremental to that committed to survey work by the MFMR.

I. Aims and Objectives

The project aimed to achieve the following:

- Build and deploy a CUFES for the northern Benguela
- Apply the CUFES method for fish egg sampling on regular fish assessment surveys and dedicated CUFES surveys
- Analysis of the data obtained and comparison with existing data.
- Training of staff
- Recommendations for further applications of the CUFES methodology

J. METHODS

The Continuous Underwater Fish Egg Sampler (CUFES) consists of a pump, concentrator, and sample collector (Plate 1; Checkley *et al.* 1997). The pump is originally mounted outside the hull at approximately 3m depth. This is the standard configuration but due to reoccurring problems with the submersible pump on the "*RV Welwitchia*", the pump was mounted on board the ship in January 2007 and now draws water via a sea chest. Water flows from the pump to a concentrator in the ship's laboratory. The concentrator (Plate 2) contains a 400µm mesh which oscillates. Eggs and other large particles are retained in ca 3% of the flow; the filtrate is discharged overboard. The concentrate flows to a sample collector (Plate 3) where eggs and other large particles are retained on sample meshes of 400µm. Samples are collected continuously during sequential intervals (usually about 30min). Target eggs are counted in these samples prior to preservation. Spatial resolution of sampling is determined by ship's speed and CUFES sample interval and is either constant during a cruise (e.g. 10kt. x 30min ~ 5nm) or varied (depending on egg densities).

In order to calibrate the number of eggs collected with CUFES, a CalVET net (Plate 4) is deployed at regular intervals to sample eggs to 100m depth in order to relate the number of eggs collected with CUFES (at fixed depth) to the number of eggs in the water column.

Mr. Mike Patterson was contracted to:

1. Design and supply a CUFES system comprising a stainless steel concentrator box with motor, speed control, filter basket oscillating assy, clear perplex door with round porthole inspection hatch and interior hoses.
2. Design and supply of a mechanical sample collector consisting of stainless steel frame sliding 3 way valve, two sample collection beakers for fish eggs and reservoir tank.
3. Supply of two double CalVET 25 cm diameter with stainless steel swivel / coupling between the rings.
4. Assist with deployment and training of appropriate staff at NatMIRC in the operation of above devices.

Mr. Mike Paterson visited Swakopmund in March 2005 to board the research vessel "*Welwitchia*" and get the measurements and give advice on the requirements for fitting the CUFES on the vessel

WESCO from Walvis Bay was contracted to build the pipes for the CUFES and fix these to the vessel. Apart from giving the cheapest quotation for the job, this company was chosen as they had a standing contract with the Ministry for Fisheries and Marine Resources to do all maintenance work on the '*Welwitchia*" and thus were familiar with the vessel.

Two Zeiss Stemi DV 4 microscopes were purchased for analysing CUFES samples at sea and in the laboratory.

The concentrator and sample collector were mounted in the laboratory on the "*RV Welwitchia"* (Plates 5 and 6).

Mr. Jan van der Westhuizen from M&CM participated on the first CUFES dedicated cruise in late August 2005 on board the "*Welwitchia"* to help set up the CUFES and train Namibian staff in running the system. Due to incorrect mounting of the pipes, the pipes bent on the second day of the survey. The submersible pump was damaged and could not be used during the remaining part of the survey.

Mr. Mike Patterson participated in the CUFES test run on 1st November 2005 to assist with the smooth running of the system after the problems that occurred during the first CUFES survey. No problems were encountered during the trial.

A GPS screen was purchased and mounted in the CUFES lab by Radio Electronics, the only company supplying this equipment in Walvis Bay at that stage.

Due to the problems that occurred with the pipes mounted on the side of the vessel and the submersible pump the water inlet was changed to a hull mounted inlet with a pump on board (Plates 7 and 8).

Table 1: Summary of all CUFES surveys during the project period

Date	Type of survey	Area	Number of CUFES samples taken	Problems
29th August to 2nd September 2005	BiMOM	20°S to 23°S	45	Intake pipe bent after two days and no more samples could be taken
1st November 2005	CUFES test run	Walvis Bay harbour	N/A	None
3 – 9 November 2005	BiMOM	20°S to 23°S	118	At 22°S the pump of the system was giving problems and the system was switched off.
December 2005	BiMOM	20°S to 23°S	218	None
February 2006	Horse mackerel	17°15'S to 25°S	32	The pump of the CUFES tripped after one week and the system could not be used for the rest of the survey. Eggs were collected using the CalVET net for the entire survey
23rd August to 12th September 2006	BENEFIT Mesopelagic survey	23°S to 34°S	448	None
31st October to 6th November 2006	BiMOM	20°S to 23°S	199	None
February 2007	Horse mackerel	17°15'S to 25°S	627	None
May 2007	BiMOM	20°S to 23°S	34	Problems occurred with the pump on the second day and no more samples were collected for the rest of the surevy

Sample analysis

Samples are scrutinized for fish eggs and eggs are counted immediately after collection at sea before being preserved in formalin. Once the survey is finished, samples are brought to the laboratory where all samples are reanalyzed. Fish eggs are counted a second time in the laboratory. If there is a big difference between counts (roughly more than 20%), fish eggs are counted a third time in the laboratory. Data is punched into an Access database, which is stored at NatMIRC.

K. Results and Discussion

Technical

Several problems with the system have occurred since it was installed on board the "*Welwitchia*".

1. When the pipes with the submersible pump were fitted to the side of the vessel for the first time, they were mounted the wrong way, with the stabilizing fin pointing forward. This caused the pipe to bend and the pump was damaged in the process.
2. The engineering company (WESCO) admitted their mistake in mounting the pipes wrong and replaced the damaged pump with a new one. During the November 2005 survey, the new pump started leaking and the system could not be used on the entire survey. After rewiring of the pump, a successful survey was completed during December 2005. During the horse mackerel survey in February 2006 the pump started leaking water again and tripped. The engineering company claimed that the pump was not made to sustain the pressure, even though an identical pump is used successfully in other systems.
3. A new design was subsequently developed with a new pump mounted on deck and the pipe mounted on the side. Even though the vessel was available for repairs in the harbour for four weeks, the new construction was only finished by the engineering company on the day the survey was scheduled to leave and hence could not be tested before the survey. Once the survey left (delayed in order to finish the mounting of the new pump), the pipe banged against the hull, because it was not mounted correctly and the survey had to be stopped and the pipe removed. The CUFES could not be used during the survey.
4. While the "*Welwitchia*" was on dry dock during early 2007, the CUFES inlet was changed from a pipe mounted on the side of the vessel to a hull mounted water inlet. During the horse mackerel surveys in February 2007 the new system was running smoothly, but during the following survey problems were encountered with the pump again and these are currently being attended to.
5. Problems were experienced with the availability of the "*Welwitchia*" and several environmental surveys during which the CUFES was supposed to be run, were cancelled. Due to this, the envisaged training of Angolans could not be conducted during the project period.

Lack of cooperation from the "*Welwitchia*" management as well as the contracted engineering company (WESCO) has led to the reported problems and hence less data than was anticipated during the setup of the project was collected with the CUFES. The data that was collected during the project period has, however, been used for management recommendations and has shown the value of using the CUFES in Namibian waters.

Scientific

Even though the system is still not running smoothly, valuable results have been acquired from the project. In early November 2005 the CUFES was run and samples collected between 20°S and 22°S. No pelagic eggs were found in the samples, confirming the results of the hydro acoustic survey in October 2005, which failed to detect any adult sardine between 20ºS and 22ºS.

During a survey in early December 2005 sardine eggs were found between 20ºS and 21ºS, around 22ºS and in a very small area around 23°S. Eggs were rather widely distributed but very patchy and in low numbers (Figure 1). Egg distribution during this survey suggests that the sardine stock was widely distributed throughout the survey area, but very patchy.

In February 2006 ichthyoplankton samples were taken during the horse mackerel survey using the CUFES and CalVET net between 25°S and 17°15'S. Sardine eggs were only found between 23°S and 24°30'S (Figure 2), confirming the sardine distribution detected during the March 2006 acoustic survey. It is likely that the sardine stock moved further south and concentrated in a smaller area compared to December 2005 due to warmer sea surface temperatures in the northern areas.

During February 2006 horse mackerel eggs were found mainly north of 21°S, with the exception of one station inshore at around 24°40'S (Figure 3). Total number of horse mackerel eggs was rather low and eggs were sparsely distributed. Although it is clear that horse mackerel eggs were found in lower numbers and more sparsely distributed in 2006 compared to previous years, the data should not be directly compared as different gear and different units of measurement were used. Nevertheless the horse mackerel egg distribution data confirms that the distribution in 2006 was different to that of 2005, as is seen from the horse mackerel biomass survey acoustic information.

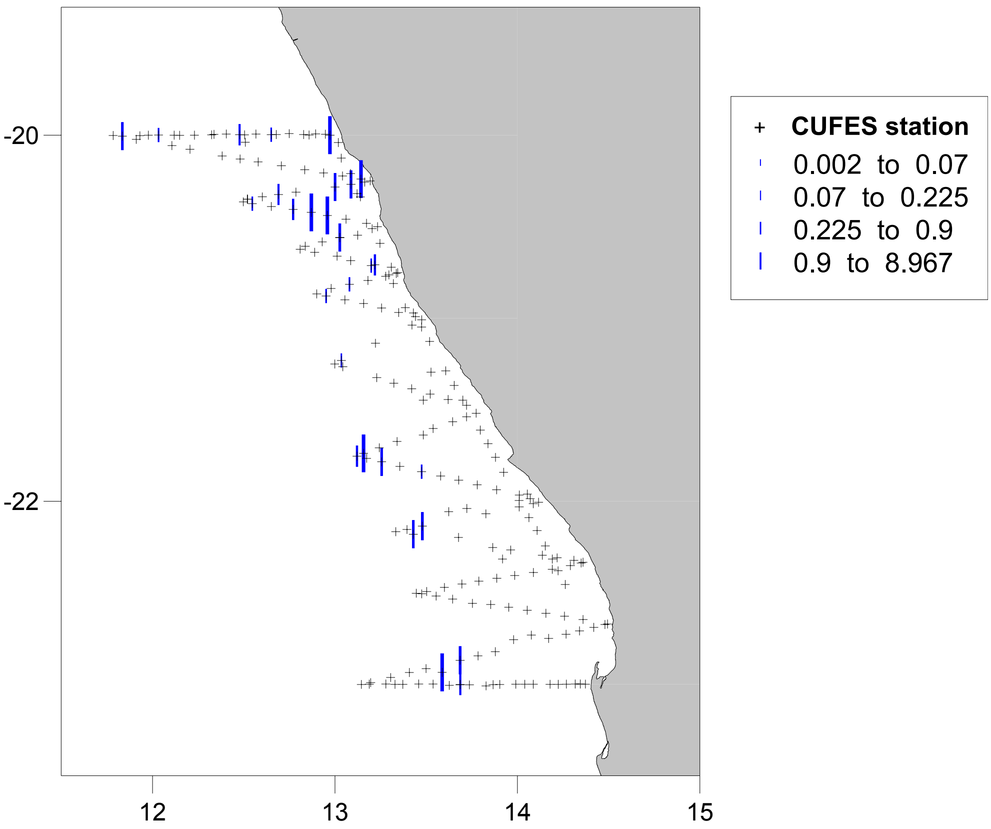

Figure 1: *Map showing all CUFES stations (+) and the number of sardine eggs (blue bars) sampled per minute during the December 2005 survey.*

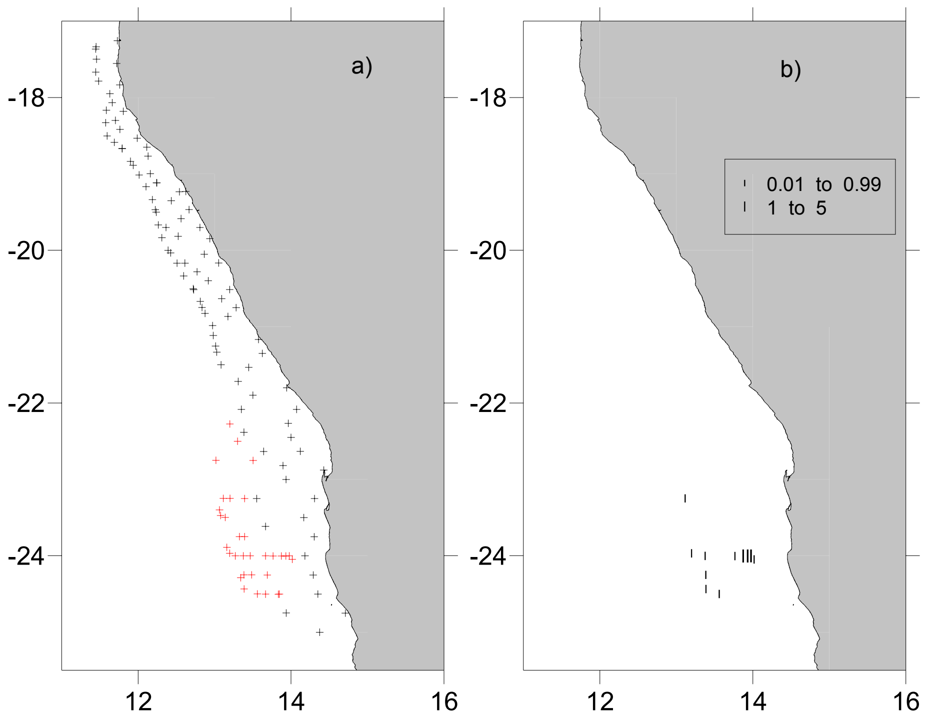

Figure 2: *a) Map showing all CUFES (red) and CalVET stations (black) sampled during February 2006 b) the number of sardine eggs sampled per minute with CUFES during the February 2006 survey.*

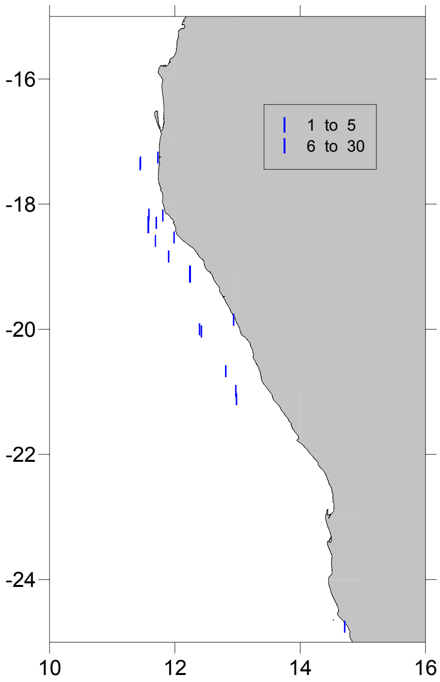

Figure 3: *Number of horse mackerel eggs found per CalVET hawl during the horse mackerel cruise February 2006.*

The CUFES system was mounted on board the "*Dr Fridtjof Nansen"* for the mesopelagic survey during August 2006. Eggs of lightfish, lanternfish, red eye, hake and other species were collected during the cruise. Maps of egg distributions of this survey are not available yet as samples have only been counted on land once and big differences in number of eggs between the counts one and two were observed. The numbers of eggs in table 2 are a simple average of counts one and two and are likely to change.

During November 2006 CUFES samples were collected on transects 20ºS and 23°S and on a zigzag grid between the two transects. CUFES samples were taken approximately every 30 minutes and a total of 199 samples were taken. Fish eggs were found in only 5 samples and no sardine eggs were found on this cruise. CalVET samples were taken at every station on the 20ºS and 23ºS transect a total of 33 samples. No pelagic eggs (*Sardinops sagax, Engraulis encrasicolus*) were found in the samples and only very few other, unidentified eggs were recorded. This data confirms the results of the sardine acoustic survey done in October 2006, which failed to detect any significant amount of sardine along the northern Namibian coast.

CUFES was run during the entire horse mackerel survey in March 2007 that covered the northern Benguela from 25°S to 17°15'S between 30 and 1000m depth. No sardine eggs were found during the survey, confirming the results of the hydroacoustic survey conducted during April 2007 that failed to detect any measurable amounts of sardine in the northern Benguela.

The distribution of sardine eggs, as assessed with CUFES, gives information of the distribution of the adult stock. The value of this information is that it is independent of the acoustic data that is collected to assess abundance and distribution the sardine stock. Results from CUFES surveys so far support the results from the acoustic surveys with regard to sardine abundance and distribution and thus give valuable information to strengthen management recommendations.

Due to the extremely low stock levels of sardine and anchovy in the northern Benguela, few eggs were collected with the CUFES during the project period. It is therefore not possible at this stage to compare observed spawning behaviour of sardine with historic observations.

Table 2: Approximate number of eggs of different species collected with CUFES during the project period

Survey date	Approximate number of eggs	Species
29th August to 2nd September 2005	0	N/A
3rd to 9th November 2005	0	N/A
December 2005	288	Sardine
3rd to 28th February 2006	204	Sardine
	51	Anchovy
	60	Horse mackerel
	426	Other
23rd August to 12th September 2006	2	Sardine
	1	Anchovy
	74	*Bathylagus* spp
	360	Hake
	1377	Lanternfish
	707	Lightfish
	1936	Red Eye
	1	Sole
	109	*Zeus faber*
31st October to 6th November 2006	275	Other
28th February to 22nd March 2007	48	Horse mackerel
	1400	Other
7th to 12th May 2007	0	N/A

L. Capacity building

Two graduates from the University of Namibia (UNAM), Mr Twalinohamba Akawa and Ms Tupohole Shiwanapo were employed on a contract basis with effect from 1st March 2005. Both participated on a training cruise on board the South African research vessel "*Africana*" offered by M&CM and BENEFIT in August 2005. During the cruise they were exposed to both environmental and fish sampling. While the CUFES was not yet operational in Namibia, Mr Akawa and Ms Shiwanapo participated on several monthly environmental monitoring cruises of the Ministry of Fisheries and Marine Resources on board the RV "*Welwitchia*" to get hands-on training in environmental sampling. While in the laboratory they received training in zooplankton sampling analysis and soon took over most of the analysis of the zooplankton samples collected during routine monitoring surveys.

Mr Akawa and Ms T Shiwanapo participated in a zooplankton identification workshop hosted at NatMIRC in October 2005, run by Susan Jones from M&CM.

After Ms Shiwanapo resigned on 31st December 2005 to take up a permanent position at another company, Mr Erasmus Kakonya took up his position to replace her on 1st March 2006.

Mr Kakonya participated in several routine environmental monitoring cruises of the Ministry of Fisheries and Marine Resources on board the RV "*Welwitchia*" to get hands-on training in environmental sampling and the running of the CUFES. He received training in zooplankton sampling analysis and soon assisted with most of the analysis of the zooplankton samples collected during routine monitoring surveys.

Mr Akawa and Mr Kakonya from the CUFES project, as well as Ms Kakuuai, Ms Katjivena, Mr Hashoongo and Ms Christof from NatMIRC participated in an egg identification workshop from 6th to 10th March 2006 organized by the CUFES project leader and run by Cecil Giddey from M&CM at NatMIRC.

During the mesopelagic survey in August 2006 on board the "*Dr. Fridtjof Nansen"* Mr Akawa and Mr Kakonya ran the CUFES that was mounted on board the "*Dr. Fridtjof Nansen"* and received further hands on training in egg identification, focusing mainly on mesopelagic species.

Both Mr Kakonya and Mr Akawa resigned from the CUFES project with effect from 30th November 2006 in order to take up a permanent post at the Ministry of Fisheries and Marine Resources in Swakopmund. While employed by the CUFES project they received training in ichthyo-/and zooplankton sample collection and identification and now work in the plankton section of the Ministry of Fisheries and Marine Resources. Their job description is to run the CUFES and analyze the samples as well as analysis of zooplankton samples. They were not replaced in the project as the staff compliment within the biological oceanography section at NatMIRC is such that no more external assistance is needed to run the CUFES and analyse the samples.

Two Angolans will be invited to join a CUFES survey on board the "*RV Welwitchia*" in the near future in order to introduce them to the CUFES system. They will be shown how to operate the CUFES, analyse samples at sea (under the microscope) and preserve samples for further analysis in the laboratory.

M. Conclusions

Despite the problems encountered during the setup phase of the CUFES system, valuable data was collected within the project period. The results of the CUFES surveys were used to support management recommendations for sardine and horse mackerel. Data collected with CUFES gives important additional and acoustic-independent insights on stock abundance and distribution, which is especially important at current low stock levels of sardine and anchovy.

The envisaged comparison with historical data could not be done yet, due to the low numbers of eggs caught during the project. This is an important result in itself as it confirms the low abundance of sardine and anchovy, as assessed with hydroacoustics, in the northern Benguela.

Two Namibians have been trained in using CUFES and analysing data and CUFES surveys are now an integrated part of the environmental monitoring programme at

NatMIRC. Staff recruited and trained within the project is permanently employed in the Biological Oceanography section within NatMIRC. The envisaged training for Angolans that could not take place during the time period of the project due to technical and logistical problems will be done on a routine environmental monitoring survey on board the "*Welwitchia*".

N. Recommendations

It is recommended that the CUFES is routinely used on the environmental monitoring surveys in Namibia. Furthermore the CUFES should be run during hydroacoustic surveys on a regular basis to get acoustic independent information on fish distribution especially with the low biomass of pelagic stocks like sardine and anchovy.

It must be ensured that logistical problems experienced with the research vessel at NatMIRC are minimized and regular environmental surveys (with CUFES) can be done. Furthermore, technical problems occurring must be dealt with by the management of the research vessel.

O. References

CHECKLEY, D. M., JR., J. R. HUNTER, L. MOTOS, and C. D. VAN DER LINGEN 2000 - Report of a workshop on the use of the Continuous Underway Fish Egg Sampler (CUFES) for mapping spawning habitats of pelagic fish. *GLOBEC Report* 14: 1-65pp.

CHECKLEY, D. M., JR., P. B. ORTNER, L. R. SETTLE, and S. R. CUMMINGS 1997 - A continuous underway fish egg sampler. *Fish. Oceanogr.* 6(2): 58-73.

HUNTER, J. R. and J. ALHEIT 1997 - International GLOBEC small pelagic fishes and climate change program. Implementation plan. 11: 1-36.

Plate 1: Schematic presentation of a CUFES system with the intake pipes mounted on the side of the vessel.

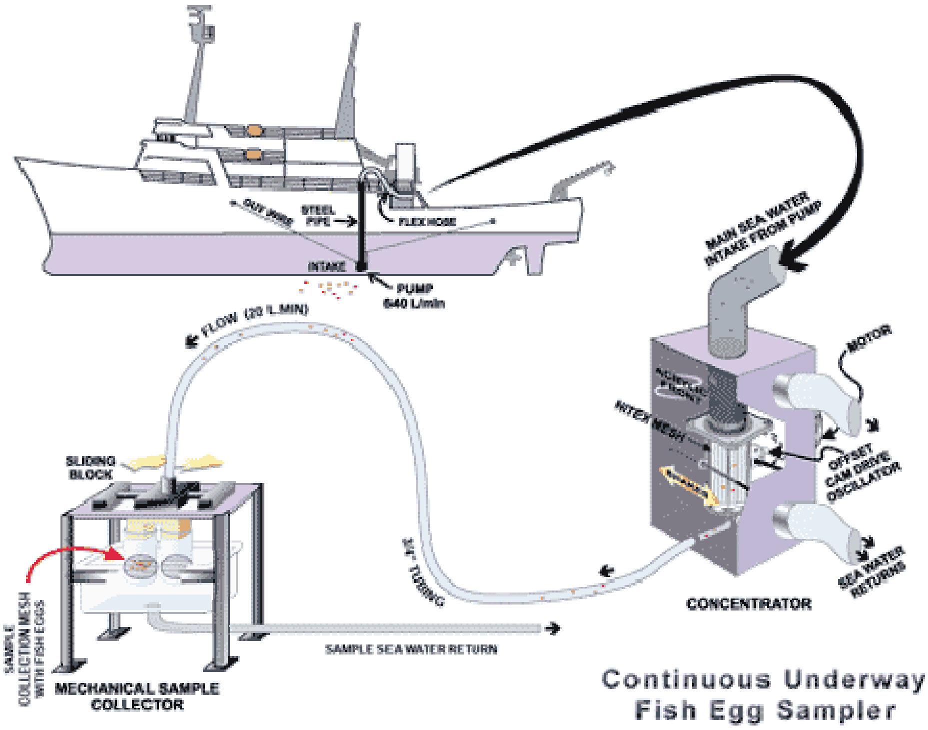

Plate 2: Stainless steel concentrator of the CUFES

Plate 3: Mechanical sample collector for the CUFES

Plate 4: Double CalVET 25 cm diameter with stainless steel swivel / coupling between the rings.

Plate 5: The concentration set-up in the laboratory on the "*RV Welwitchia*"

Plate 6: The concentration and sample collector in the laboratory on the "*RV Welwitchia"*

Plate 7: The pump for the CUFES on the "*RV Welwitchia"*

Plate 8: The water intake pipe for the CUFES on the "*RV Welwitchia"*

APPENDIX 1

Selected results of the Continuous Underway Fish Egg Sampler (CUFES) from the August 2003 test survey
By Dave Checkley (Jr)

The CUFES system is used to sample pelagic fish eggs. A complete description is given in Checkley *et al.* 1997 (*Fish. Oceanogr.* 6:58-73). CUFES was provided for the present cruise by MCM of Cape Town, South Africa. It consists of a metal pipe fitted external to the hull starboard amidships. Attached to the bottom of this pipe, at 2-m depth, is a submersible, semi-vortex pump, powered by a 440 VDC (4 ampere) motor. Water flows at ca. 500 liters/min through a 3"-diameter plastic tubing in the metal pipe on board to a concentrator. The concentrator consists of an oscillating mesh (500 μm) which serves to continuously backflush, hence clean, itself. Fish eggs and other large particles are concentrated in approximately 5% of the total flow, hence 25 liters/min, while the filtrate is discharged overboard. Particles in the small flow are retained on a 500-μm mesh in a sample collector. Such samples are collected over defined intervals, e.g. every 30 min between stations and for the duration of the ascent of the Multinet (ca. 6-10 min). An acoustic flowmeter is placed between the pump and the concentrator and readings are recorded periodically to allow computation of the volume of water filtered for each sample. Flow is approximately 480-500 liters/min on station and 520-530 liters/min underway at 12 kts. Sensors that monitor a small portion of the pump flow prior to the concentrator continuously record temperature, salinity and fluorescence (recorded as volts), and these data are logged to computer, together with GPS-derived time, latitude and longitude, using the Environmental Data Acquisition Software (EDAS) developed at the Scripps Institution of Oceanography. Mean values for each of these parameters are computed and stored at the end of each CUFES interval. CUFES samples are examined under a microscope immediately after collection, and fish eggs (and larvae) are identified and enumerated. This on-board examination of samples permits near-real-time assessments of egg (and larva) distributions.

CUFES Results

490 CUFES samples, with associated environmental data, were acquired. Each sample was analyzed on at sea prior to collection. Careful reanalysis on shore is advised, although the general patterns of occurrence of eggs is expected to be the same.

Whereas numerous zooplankton (including copepods, euphausiids, amphipods, and others) were collected by CUFES, particularly at night, few pelagic fish eggs or larvae were collected during the first leg of the survey. Some anchovy larvae (±20mm *TL*) were taken in samples from the outer shelf along Line 1, south of the Orange River. Low concentrations (<5 eggs.m^{-3}) of round herring *Etrumeus whiteheadi* eggs were collected offshore along Line 2. Occasional patches of lanternfish *Lampanyctodes hectoris* eggs were collected during transects sampled off Lüderitz, particularly from sample 022a (the first interval after multinet station #22) where >100 eggs were collected. Low numbers of horse mackerel *Trachurus trachurus capensis*, deep water smelt *Bathylagus spp.*, saury *Scomberesox spp.* and dory *Zeus spp*. eggs, and the occasional horse mackerel larva were collected from CUFES samples taken in transects from Sandwich harbour northwards.

CUFES collected pelagic eggs of a variety of species during Leg 2, to the north of Walvis Bay, particularly sardine (*Sardinops sagax*), anchovy (*Engraulis encrsicolus*), and horse mackerel (*Trachurus trachurus capensis*). Larvae of these three species, and eggs and larvae of other species were also collected, although fewer in number. Several general conclusions can be made.

- CUFES collected eggs of sardine at stations where the Multinet collected sardine eggs. In addition, CUFES collected eggs between Multinet stations, while underway. Frequently, the concentration of sardine eggs estimated from CUFES was higher between Multinet stations than at those stations. Hence, it appears at the distribution of sardine eggs is highly aggregated and, therefore, that continuous sampling is useful for estimating the spatial distribution of sardine eggs and their overall abundance. In this regard, a biomass estimate for sardine by means of the Egg Production Method might benefit from the use of CalVET nets deployed at CUFES stations positive for sardine eggs, i.e. using adaptive sampling, as is done off Calfornia.

- Anchovy eggs were not collected by CUFES at stations where the Multinet collected those eggs. Eggs of the anchovy population off Namibia appear to be smaller than elsewhere in the world (e.g. off California, Peru, Chile, Spain, and South Africa). A comparison of 405 and 505 μm mesh sizes showed >95% extrusion of anchovy eggs through 505 μm mesh. Hence, it is proposed that CUFES be equipped with 405 μm mesh to sample anchovy eggs in Namibian waters. This will result is faster clogging of the concentrator and sample collector meshes by small plankton and hence the need for more frequent cleaning of the concentrator mesh and the use of more mesh in the sample collector cod ends. These options are considered feasible.

- Round herring (*Etrumeus whiteheadi*) and horse mackerel eggs appeared in CUFES samples. Round herring may be reasonably sampled by CUFES. It is unlikely; however, that horse mackerel is adequately sampled by CUFES, due to the deep distribution of this egg type.

- Eggs of other fish species dominant off Namibia, including hakes (*Merluccius capensis, M. paradoxis*) and goby (*Sufflogobius bibaratus*) are not adequately sampled by CUFES. Hake eggs are deep dwelling and goby eggs are benthic.

- Further use of CUFES on the *Dr. Fridtjof Nansen*, or its routine use on the Namibian fisheries vessel *Welwitchia*, might benefit from the permanent installation of the pump and associated plumbing within the hull, as has been done elsewhere (e.g. ships in France, Mexico, Norway, South Africa, and United States).

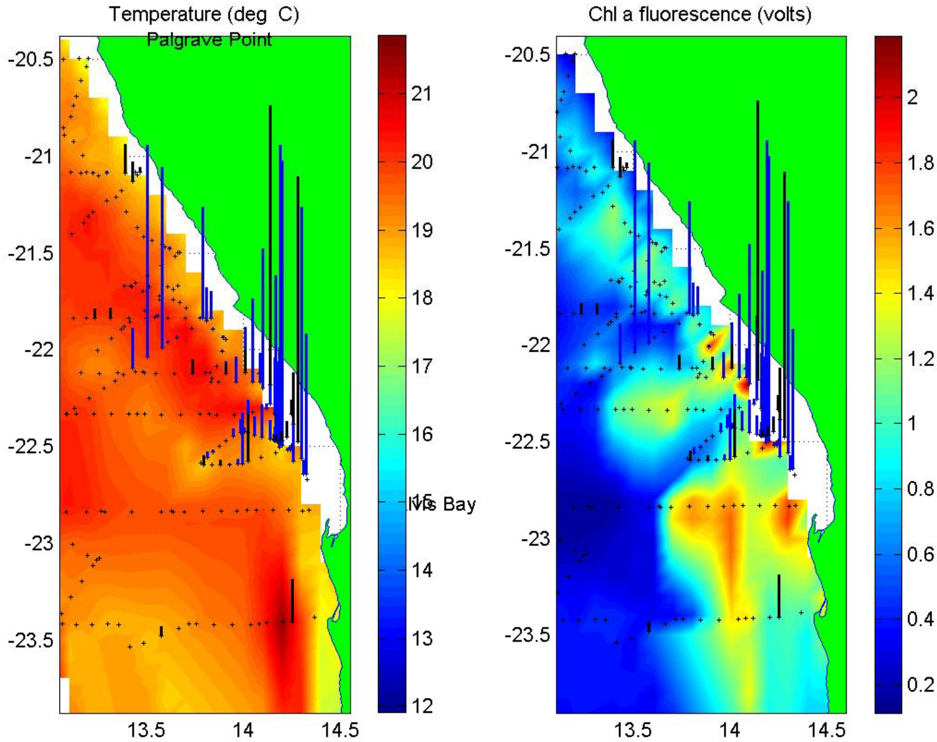

Figure 1: Sardine eggs (blue) and horse mackerel eggs (black) samples with CUFES during February 2003 plotted on sea surface temperature (left) and chl a fluorescence (right).