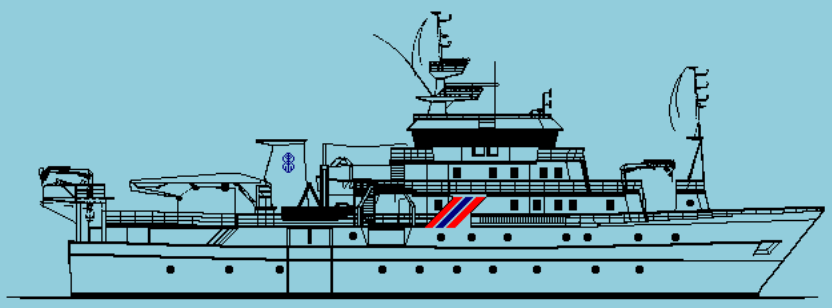

2007 BENEFIT SURVEY NO.5

SPAWNING AND EARLY LIFE HISTORY OF HAKES

Cruise Report No7/ 2007

14 September – 21 September 2007

by

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THE EAF-NANSEN PROJECT

FAO started the implementation of the project "Strengthening the Knowledge Base for and Implementing an Ecosystem Approach to Marine Fisheries in Developing Countries (EAF-Nansen GCP/INT/003/NOR)" in December 2006 with funding from the Norwegian Agency for Development Cooperation (Norad). The EAF-Nansen project is a follow-up to earlier projects/programmes in a partnership involving FAO, Norad and the Institute of Marine Research (IMR), Bergen, Norway on assessment and management of marine fishery resources in developing countries. The project works in partnership with governments and also GEF-supported Large Marine Ecosystem (LME) projects and other projects that have the potential to contribute to some components of the EAF-Nansen project.

The EAF-Nansen project offers an opportunity to coastal countries in sub-Saharan Africa, working in partnership with the project, to receive technical support from FAO for the development of national and regional frameworks for the implementation of Ecosystem Approach to Fisheries management and to acquire additional knowledge on their marine ecosystems for their use in planning and monitoring. The project contributes to building the capacity of national fisheries management administrations in ecological risk assessment methods to identify critical management issues and in the preparation, operationalization and tracking the progress of implementation of fisheries management plans consistent with the ecosystem approach to fisheries.

LE PROJET EAF-NANSEN

La FAO a initié la mise en oeuvre du projet "Renforcement de la base des connaissances pour mettre en œuvre une approche écosystémique des pêcheries marines dans les pays en développement (EAF-Nansen GCP/INT/003/NOR)" en décembre 2006. Le projet est financé par de l'Agence norvégienne de coopération pour le développement (Norad). Le projet EAF-Nansen fait suite aux précédents projets/ programmes dans le cadre du partenariat entre la FAO, Norad et l'Institut de recherche marine (IMR) de Bergen en Norvège, sur l'évaluation et l'aménagement des ressources halieutiques dans les pays en développement. Le projet est mis en oeuvre en partenariat avec les gouvernements et en collaboration avec les projets grands écosystèmes marins (GEM) soutenus par le Fonds pour l'Environnement Mondial (FEM) et d'autres projets régionaux qui ont le potentiel de contribuer à certains éléments du projet EAF-Nansen.

Le projet EAF-Nansen offre l'opportunité aux pays côtiers de l'Afrique subsaharienne partenaires de recevoir un appui technique de la FAO pour le développement de cadres nationaux et régionaux visant une approche écosystémique de l'aménagement des pêches et la possibilité d'acquérir des connaissances complémentaires sur leurs écosystèmes marins. Ces éléments seront utilisés pour la planification et le suivi des pêcheries et de leurs écosystèmes. Le projet contribue à renforcer les capacités des administrations nationales responsables de l'aménagement des pêches en introduisant des méthodes d'évaluation des risques écologiques pour identifier les questions d'aménagement d'importance majeure ainsi que la préparation, la mise en œuvre et le suivi des progrès de la mise en œuvre de plans d'aménagement des ressources marines conformes à l'approche écosystémique des pêches.

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1 Introduction

Given the importance of *Merluccius paradoxus* for the South-African and Namibian fisheries surprisingly little is known about the early life stages of the species. There are anecdotal information on spawning grounds (Crawford *et al*., 1987; Hutchings *et al*., 2002) and some information on peak spawning periods is also gathered from the fisheries (B. Rose, Irvin and Johnson, Cape Town, unpublished data and pers. comm.), but systematic collection of information on spawning and eggs and larvae are missing. It is well established through surveys that the area between Hondeklip Bay and Orange River holds large amount of juvenile fish and this is also the only area where small *M. paradoxus* less than 5 cm is encountered in the bottom trawl (Strømme *et al*., 2005). The survey carried out in February-March 2005 confirmed that the area north of Hondeklip Bay held the smallest fish, and as it grew bigger it migrated 'omnidirectional' from this site. That the area between Hondeklip Bay and Orange River forms the main nursery area for the *M. paradoxus* seems quite evident.

However, where the main spawning grounds are and what drift mechanisms the eggs and larvae utilises to reach the nursery ground are still not well understood. Also the annual spawning cycle of the stock needs an improved understanding. To put more light upon this question and to be able to describe the full lifecycle of the species was the overall objective of the survey.

This survey was planned to cover the area from Cape Agulhas to St. Helena Bay in order to complete the coverage that had to be abandoned in April 2007 due to engine problems of the vessel then.

Specific objectives of the cruise were:

1. To conduct a survey between Cape Agulhas and St Helena Bay to produce distribution maps of eggs and larval *M. capensis* and *M. paradoxus*.

2. To sample the adult population of *M. paradoxus* at the outer shelf and slope to check for maturity stages in order to localize spawning grounds geographically.

3. To check the gonadosomatic index of a representative sample of the females in order to back-calculate the main spawning period.

4. To collect relevant environment data to better understand the environment impact on the distribution of hakes and of the drift lanes for eggs and larvae.

5. To collect genetic samples of hake eggs and larvae to identify them to species.

6. To collect samples of hake larvae for analyses of diet and nutritional status.

2 Materials and methods

2.1 Registration of weather conditions

The underway weather data aboard Dr. Fridtjof Nansen are logged with the Aanderaa Weather Station unit fitted with the following sensors:

Sensor type	Measurement units
Air temperature	Degrees °C
Wind speed	M/s
Solar radiation	W/m^2
Wind direction	Degrees re. the magnetic N. Pole
Sea surface temperature	Degrees °C

All sensors but Sea surface temperature (SST) are mounted on a mast positioned midships, at about 20 meters above the sea level. The SST sensor is located at the intake of the water for cooling the engine and it readings are representative to a water layer at about 5 meters below the sea level.

The weather station data were logged continuously throughout the survey. The results presented in this report (wind data) are based on a standard output from the logging system comprising one nautical mile averages along the ship's track.

2.2 Hydrography

The data on temperature salinity and oxygen were collected with a CTD *Seabird 9 plus* probe between the surface and 10 meters off the bottom. CTDs were made at each plankton and trawl station.

2.3 Current measurements

Current measurements were carried out with vessel-mounted acoustic Doppler current profiler (ADCP) by RD Instruments, which operated 150 kHz in broad-band mode with 5 m vertical cells. Currents were measured from a depth of 25 m down to about 30 meters above the bottom. Only the bottom-tracked data were used in the data analysis. The ADCP unit used in the measurements had been mounted and calibrated by an RD Instrument specialist prior to the survey. The ADCP data were due to logistic problems not processed during the survey and are not presented here.

2.4 Plankton sampling and processing

Eggs, larvae and zooplankton were sampled with a Multinet plankton sampler from Hydrobios. The plankton sampler has 5 nets with a mesh size of 405 μm. The opening of the plankton sampler is 0.5 x 0.5 m. A flow meter was mounted in the opening of each net to measure the filtered volume. A Scanmar depth recorder with acoustic transmission to the vessel was mounted on top of the Multinet. The depth intervals used during this survey were 0 - 50 m, 50 - 100 m, 100 - 150 m, 150 - 200 m, and 200 - 250 m.

After removing the cups from the Multinet the samples were transferred into petri dishes and examined under a stereomicroscope. All fish larvae and fish eggs were removed from the sample. The fish larvae were identified using the key of Olivar and Fortuño (1991). All fish larvae were counted and the standard length of hake larvae was measured before they were preserved. Fish eggs were identified, counted and staged and all hake eggs were removed from the sample and preserved. Since it is not possible to distinguish between the two hake species on the egg and larval stage, all hake eggs and larvae were preserved in either liquid

nitrogen or 96% alcohol for genetic analyses. The larvae were in addition going to be used for analyses of diet composition and nutritional status.

2.5 Bottom trawls

All fish species in the trawl net were recorded for species composition by weight and numbers. The entire catch was sorted, species identified, length measured (total length) for key target species, weighed (kilograms), and recorded in the *Nan-Sis* database. Biological samples of target species were taken for some trawls, and included total length (cm), body weight (g), sex, reproductive stages and stomach samples. Reproductive stages were determined by an experienced person, and scored according to a five point classification scale. Genetic samples were taken from the target species (especially *Merluccius paradoxus*). These were placed in foil with labels (including: station number, species, date, sex and gonad stage). Genetic samples were immediately frozen for later analysis.

3 Narrative

The scientific staff consisted of:

From MCM, South Africa:

Marek R. Lipinski, Hans Verheye, Larry Hutchings, Jan van der Westhuizen,

From NatMIRC, Namibia:

Erasmus Kakonya, Nelda Katjivena, Paulus Mungeyi, Faye Brinkman

From IMR, Norway:

Erling Kåre Stenevik (cruise leader), Magne Olsen, Tore Mørk, Terje Hovland.

From University of Bremen, Germany

Britta Grote

The cruise tracks with fishing and hydrographical stations are shown in Figure 3.1. Due to engine problems the ship could not leave Cape Town as planned on 14th September. The vessel did not depart Cape Town until 12:00 on 17th September. After steaming southward,

the first station with CTD and Multinet were conducted on 17th September at 20:00. Distance between cross shelf sections were 15 nm while distance between stations varied between 5 and 15 nm. On the 7th line northwest of Cape Town, relatively high concentrations of hake larvae were observed and in this area stations were taken every 5 nm to try to estimate the size of the patch and get as many samples of larvae as possible. The last Multinet station was taken on 21st September at 22:20 UTC after which the vessel steamed to Cape Town. A total of 52 Multinet stations and 4 bottom trawls were conducted during the survey.

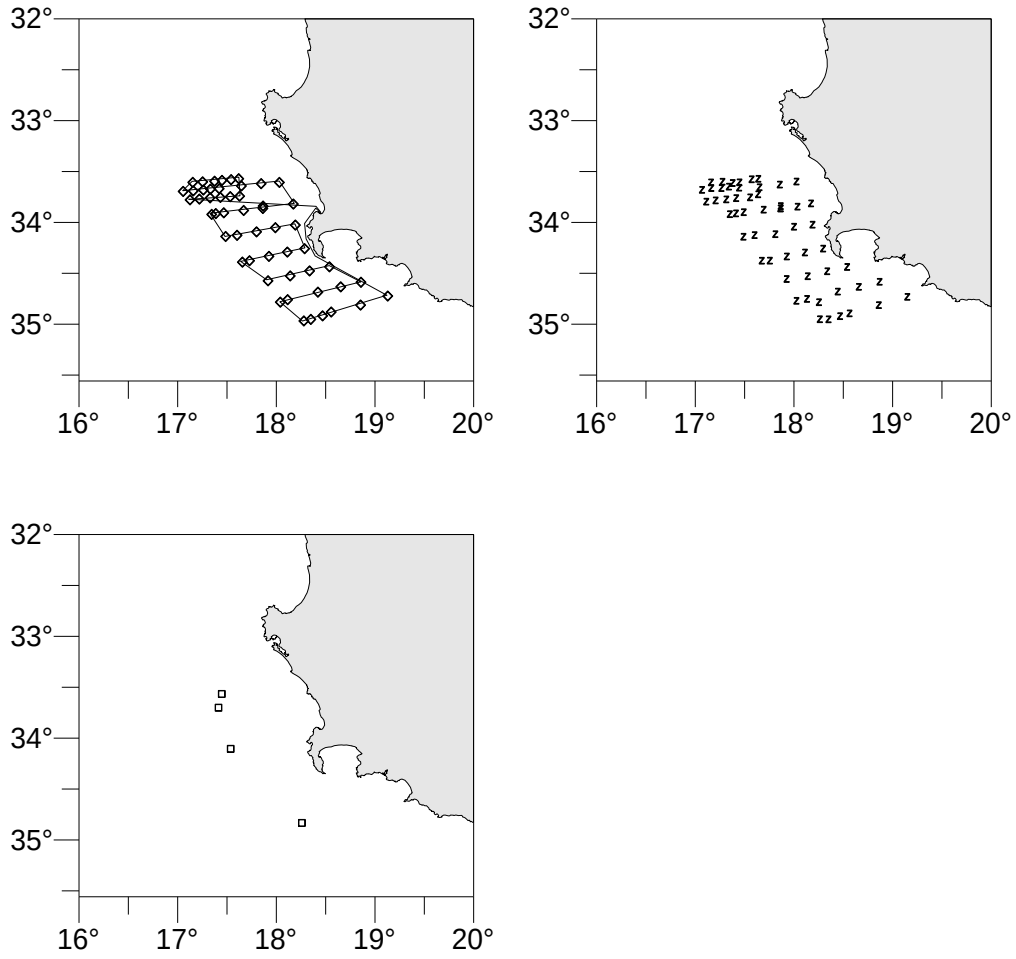


Figure 3.1. Plankton stations (upper left panel), hydrographic stations (upper right panel) and bottom trawl stations (lower panel) taken during the survey.

4 Results

4.1 Hydrography

The 3-day composite for sea surface temperature and chlorophyll a were downloaded from the site http//:www.rsmarinesa.org.za for the 17-09-2007. The thermal image (Figure 4.1.) indicates little active upwelling and moderate inshore offshore gradients through the study area. Temperatures were 15.4 ^{o}C inshore and 17.5 ^{o}C offshore, with isotherms parallel to the shore and slightly warmer water of Agulhas origin in a band stretching from the SE to the NW, with some indication of an eddy far offshore off Cape Columbine (32^{o}S).

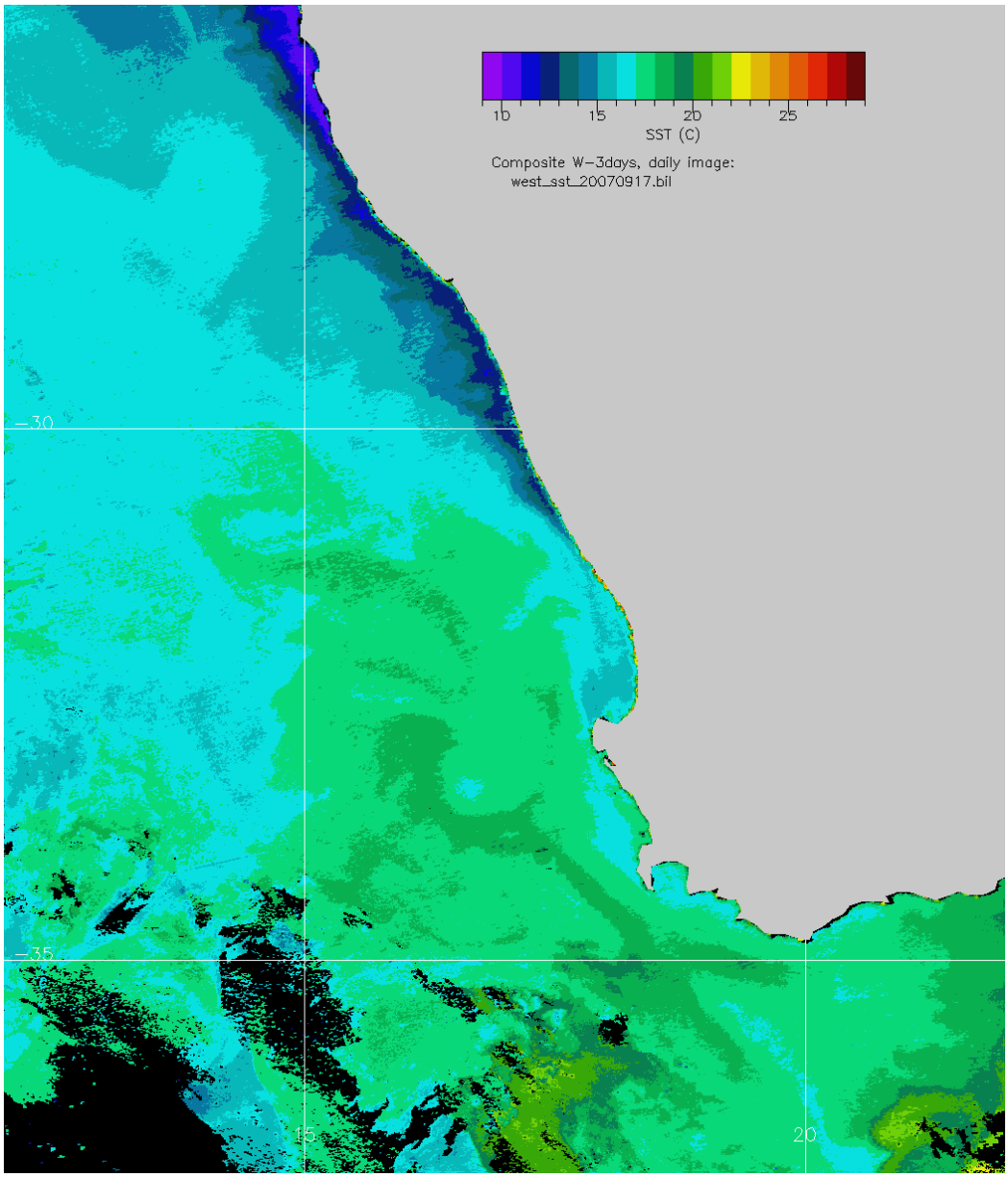


Figure 4.1 Sea surface temperature distribution from 3-day composite centred on 17 September. Courtesy of: http//:www.rsmarinesa.org.za.

The chlorophyll a image (Figure 4.2) showed some sharp discontinuities from different swathes, so the data should be treated with some caution as to absolute values. A narrow band of enhanced chlorophyll a extended from south of Cape Point to the NW, with an eddy-like

feature approximately over the Cape Canyon just south of Cape Columbine and a distinct clockwise eddy further offshore. A band of slightly lower chl a occurred in the warmer tongue of water extending to the NW. Both the thermal and the colour imagery suggested a gentle movement to the NW from the SE alongshore, with some eddying towards the northern edge of the survey area.

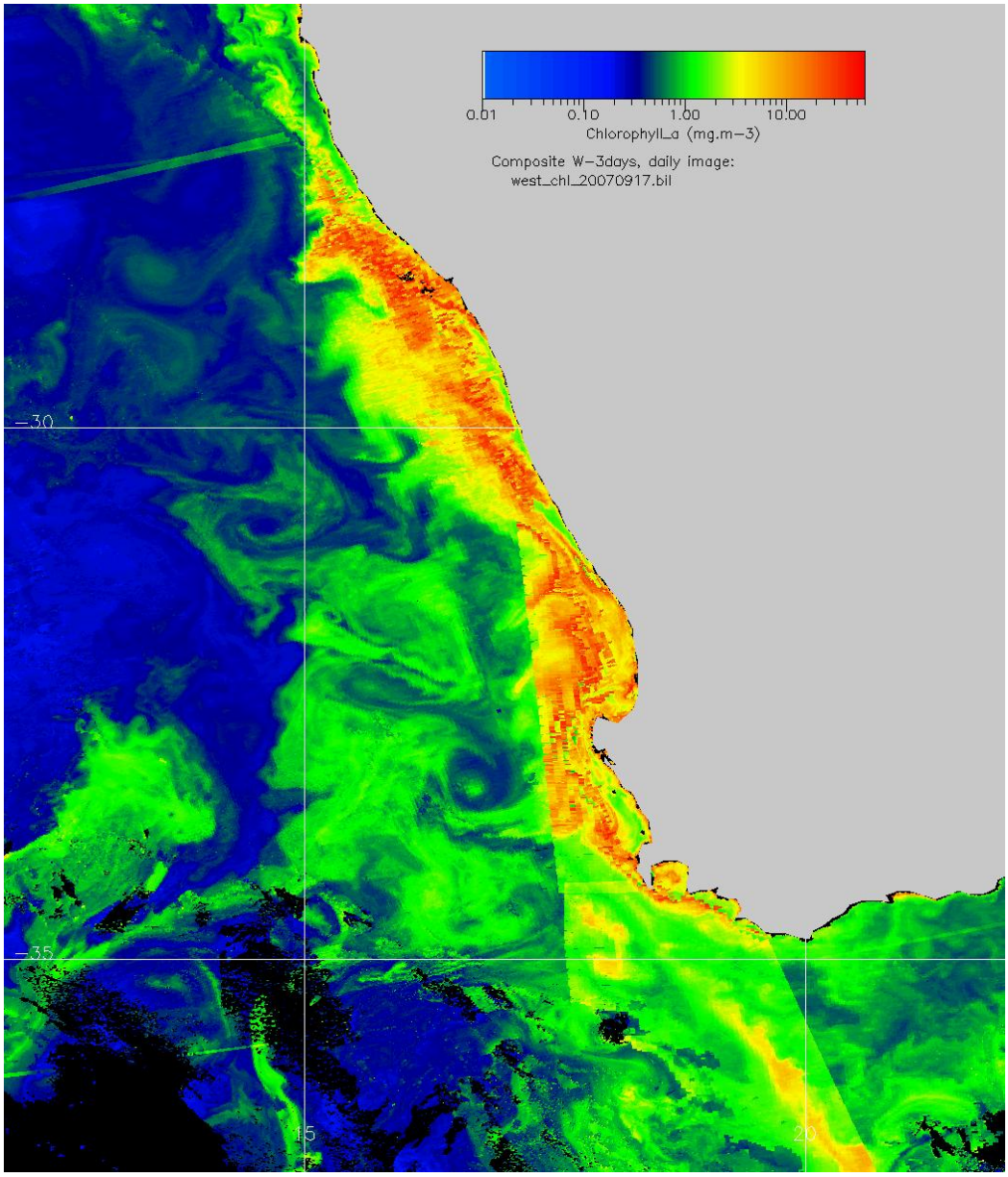


Figure 4.2. Surface chlorophyll a distribution from 3-day composite centred on 17 September. Courtesy of: http//:www.rsmarinesa.org.za.

Hydrographic sections (figure 4.3)

Line 01 Walker Bay
Very stable conditions occurred, with a deep upper mixed layer 80m deep. 8^{o}C water intersects the bottom at about 350m, while salinity and oxygen are uniform. There is no indication of upwelling.

Line 02 Cape Point Valley
Isolines dip in the centre, indicating an eddy or a belt of warm, less saline water moving to the NW. 8 ^{o}C water intersects the bottom at 400m.

Line 03 False Bay
The thermocline shallows, but isotherms indicate no active upwelling. Cold water of less than 8^{o}C is trapped at 250m at st 1219 on the midshelf.

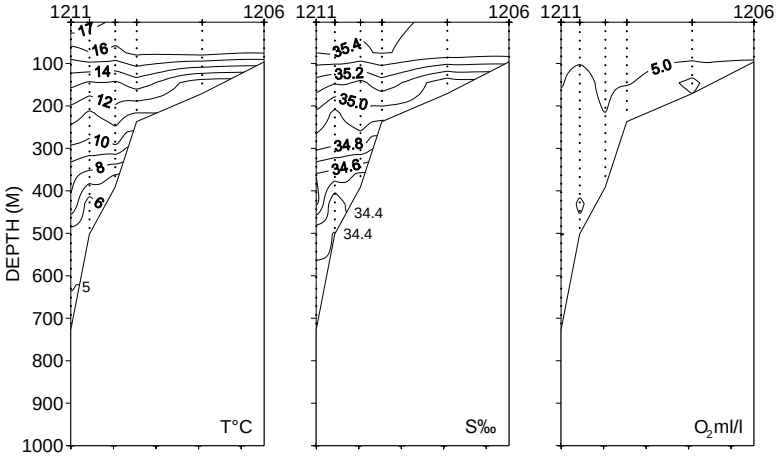
Line 04 Cape Peninsula south
Slightly sloping isotherms and isohalines indicate mild upwelling and a northward current, slightly cooler water inshore, the 8 ^{o}C isotherm is deeper at 470m

Line 05 Cape Peninsula north
Water column stratified inshore, patch of cold, fresher water <8 ^{o}C and <34.6‰ trapped at 200m and again at 460m. Some indication of upwelling and a northward drift of water above 400m, particularly between st 1228 and st1229.

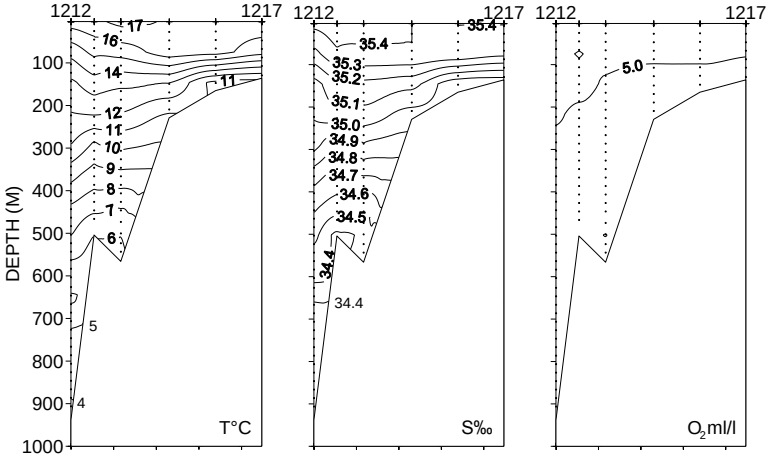
Line 06 Robben Island
Isolines stable inshore and dip steeply above the 250m isobath, then rise at the outside station, indicating an anticlockwise eddy offshore and a jet current to the north midway across the shelf.

Line 07 Cape Canyon
Isolines rise steadily across the transect, indicating northward flow across the whole transect.

All indications are of a slow current midway on the shelf, moving NW, parallel with the coastline, with minimal upwelling and perhaps an anticlockwise (downwelling) eddy just south of the Cape Canyon



Line 1



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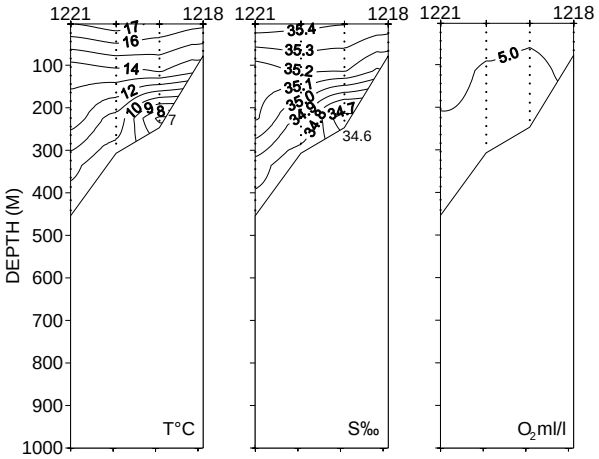

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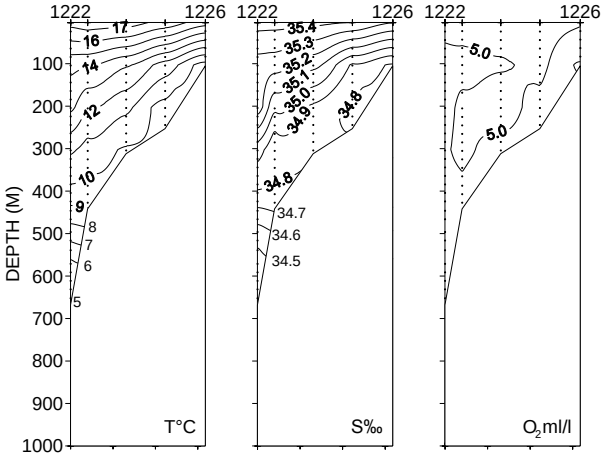

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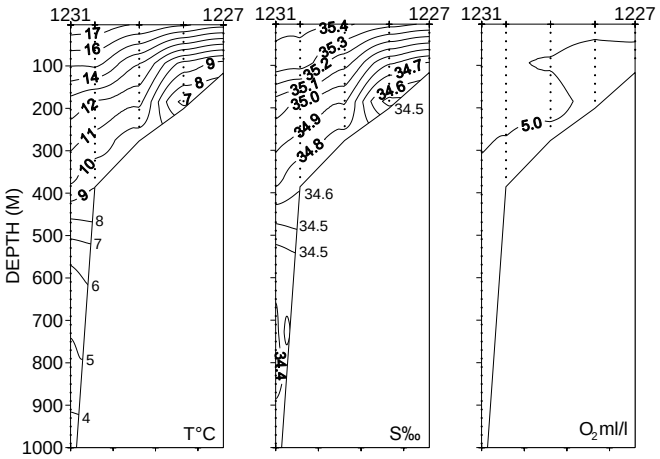

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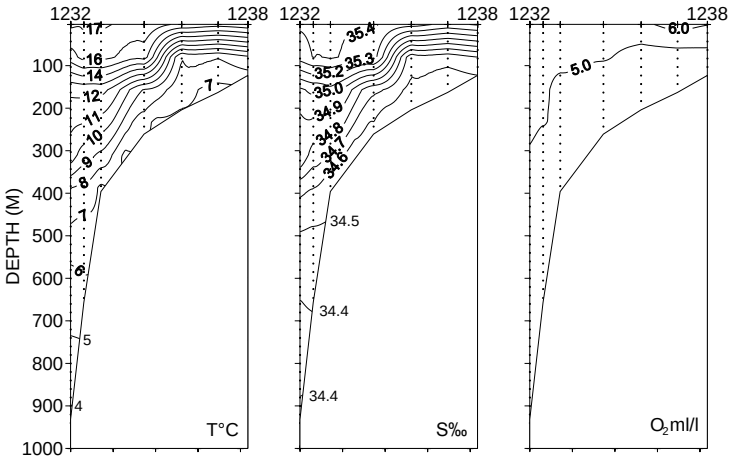

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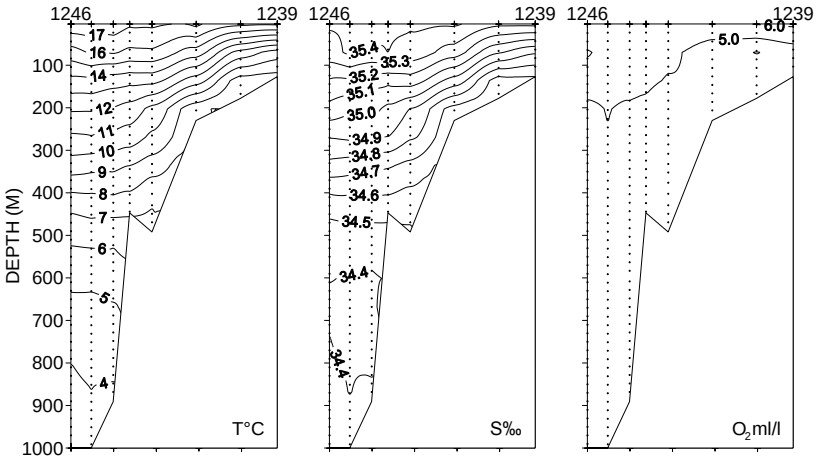

Line 7.

Figure 4.3. Hydrographic sections 1 to 7 showing temperature (left panel), salinity (mid panel) and dissolved oxygen (right panel).

Longshore transects (Figure 4.4)

Very uniform conditions occurred along the transect above the 400-500m isobaths. Water of less than 8 ^{o}C and slightly lower salinity occurred in the extreme north and south of the survey area, at slightly greater depths. Deepwater hake apparently prefer water of <8 ^{o}C and

so would have been slightly deeper at 470-500m off the Cape Peninsula. The water was well oxygenated and very uniform everywhere, with most values above 5.0ml/l, indicating little influence on the distribution of the two hake species.

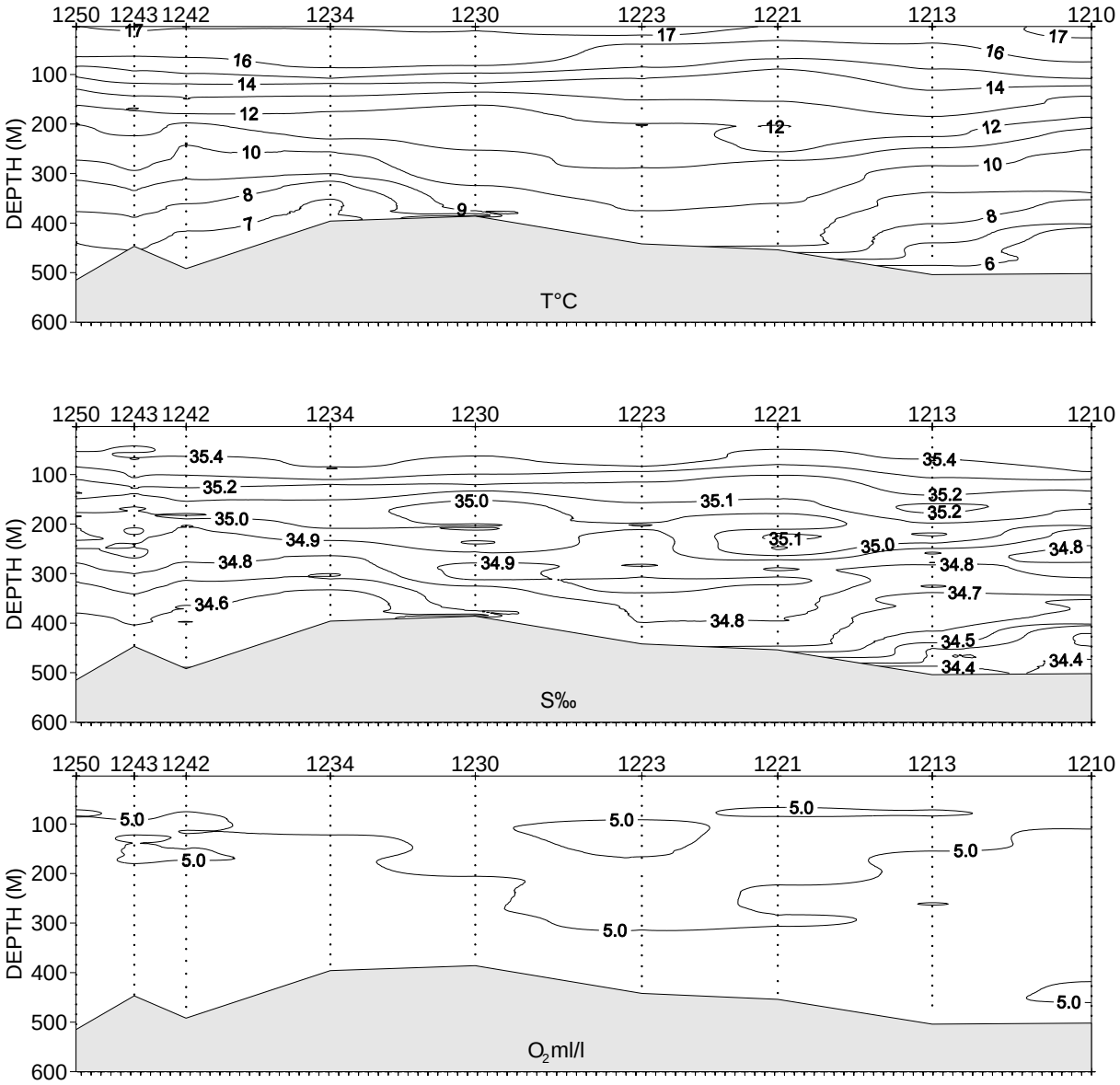

Figure 4.4. Alongshore temperature(^{o}C), salinity and dissolved oxygen(ml/l) section above the 400-500m isobaths. North is on the left side.

Wind data along track is presented in figure 4.5. Generally, the wind was stronger during the first half of the survey (around 20 knots, southeasterly) than during the second half (5-10 knots, southwesterly).

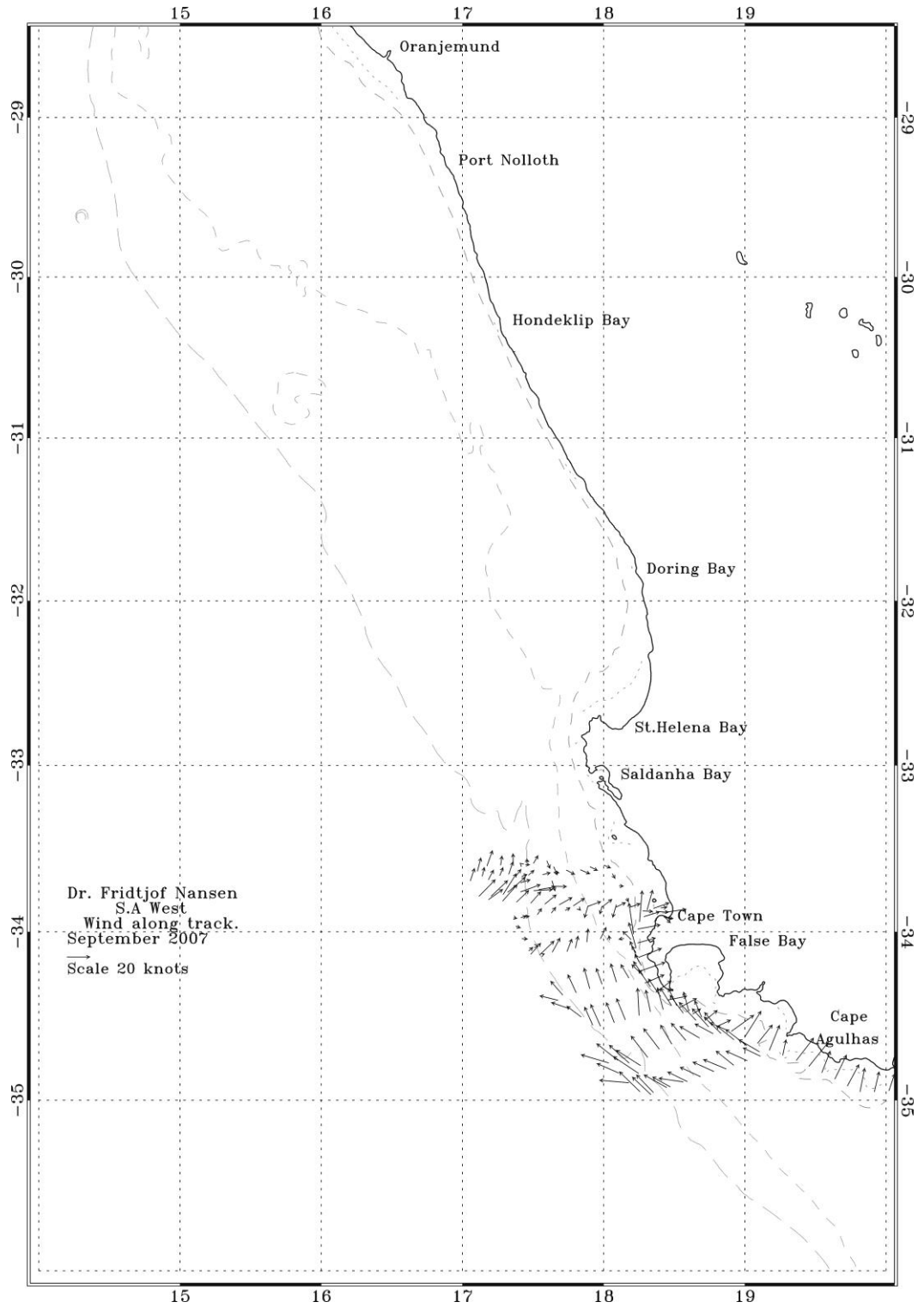

Fig. 4.5. Wind along track.

4.2 Ichthyoplankton

For the purpose of this cruise report, only results for hake eggs and larvae obtained from onboard microscope analysis of Multinet collections are considered. It is currently impossible to identify the eggs and larvae of the two hake species, *M. capensis* and *M. Paradoxus*, at sea without genetic analysis, hence the data presented here do not distinguish between the two species. In addition, it should be noted that it is highly likely that the area of distribution of both eggs and larvae was only partially covered owing to the survey being curtailed due to engine problems.

Hake eggs were found in relatively high concentration throughout the sampling area (figure 4.6) with highest concentrations found mid-shelf at depths between 150 m and 350 m. Highest concentration (ca. 100 eggs 10 m^{-2}) were observed south of Cape Point. Only minor concentrations of hake eggs were observed in the offshore part of the sampling area. Hake larvae were found in two patches (figure 4.6). One small patch south of Cape Town and a larger and high concentration patch in the northwestern part of the sampling area. This patch was not completely covered due to due to limited survey time, but concentrations of up to 200 larvae 10 m^{-2} were observed here, over bottom depths of up to 1800 m. This patch was associated with the anticyclonic eddy which was observed from the hydrographic data.

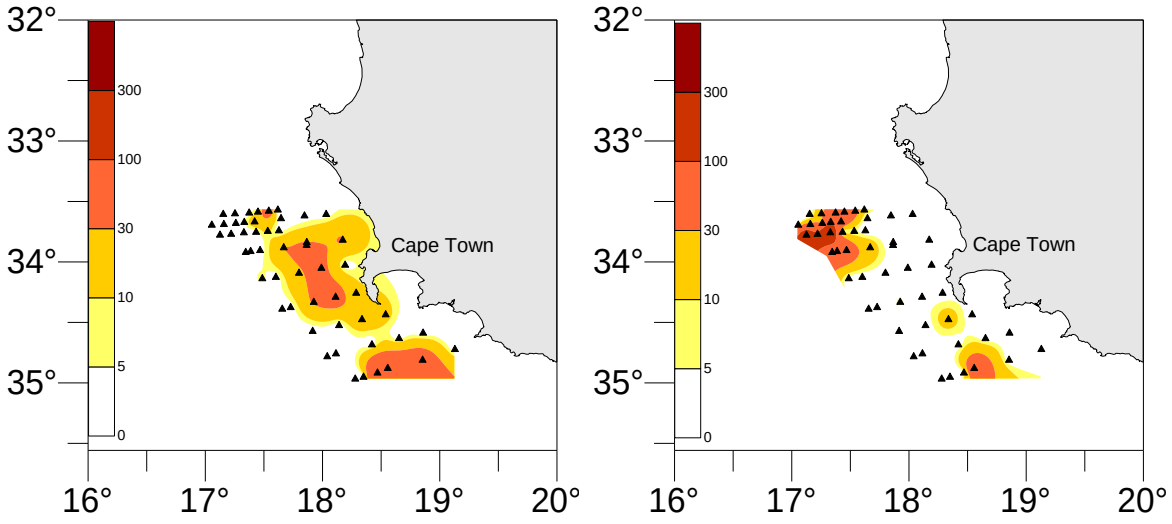

Figure 4.6 Hake eggs (left) and larvae (right) distribution.

4.3 Fish Biology

Only four bottom trawls were made as the main emphasis was on early life history investigation of hakes. The main reason for conducting trawling on such a small scale was to spot-check on maturities of *Merluccius paradoxus* in places of increased numbers of hake eggs and larvae. In practice, this was possible only during the last day of survey due to logistic reasons (stations with larvae at night in the deep water along the transect perpendicular to the shore). All trawls were conducted in depths greater than 500 m. *M. capensis* was not found at these depths. Mass measurement (n = 713) of *M. paradoxus* had three main peaks: most prominent at 35 cm, smaller at 43 cm and smallest, inconspicuous and very broad at 55-60 cm. Other species were occurring in small numbers and their measurements are not representative (*Helicolenus dactylopterus* n = 212; *Lophius capensis* n = 9; *Todaropsis eblanae* n = 26). Mesopelagic fauna in catches was well represented, by over 30 species of fish and invertebrates. It also constituted the main food category in hake stomachs. Hake-on-hake predation was noted only in one instance haul. Most often encountered prey were shrimps, *Photychthyis argenteus* and *Lycoteuthis lorigera*. In all catches female hake were dominant and males scarce (84%-16%, n = 300). There was large number of females in advanced preparatory stages of maturity, indicating the onset of maturation period. There were few post-spawning females with some remnants of mature eggs in gonads. Biological analysis confirms that the area of research is the maturation ground for *M. paradoxus*.

5 References

Crawford, R.J.M., Shannon, L.V. and D.E. Pollock 1987. The Benguela Ecosystem. Part IV. The major fish and invertebrate resources. *Oceanogr. Mar. Biol. Ann. Rev.* 25: 353-505.

Hutchings, L., Beckley, L.E., Griffiths, M.H., Roberts, M.J., Sundby, S., and C. van der Lingen 2002. Spawning on the edge: grounds and nursery areas around the southern African coastline. *Mar. Freshwater Res.* 53: 307-318.

Olivar, M.-P. and Fortuño, J.-M., 1991. Guide to Icthyoplankton of the Southeast Atlantic (Benguela Current Region). *Sci. Mar*., 55(1), 1991 (383 pp)

Strømme, T., Kainge, P., Lipinski, M., Ostrowski, M., Stenevik, E.K. and Alvheim, O. 2005. Transboundary survey between Namibia and South Africa with focus on spawning and the early life history of hakes. SURVEY NO.3 2005. Bergen 2005, 64 pp. Mimeo.