CRUISE REPORTS "DR. FRIDTJOF NANSEN"

BENEFIT SURVEYS

Cruise Report No 1/2000

Recruitment and reproduction study on horse mackerel
16 February - 8 March 2000

by

Institute of Marine Research
Bergen, Norway

National Marine Information and Research Centre
Swakopmund, Republic of Namibia

Institute of Marine Research
Bergen, 2000

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

1.1 General objectives

An overall goal of BENEFIT is to improve the knowledge and understanding of the important commercial stocks, their environmental condition and the linkage between environmental processes and growth, distribution and abundance of the fish stocks.

The present survey is part of a project that was initiated during the BENEFIT Annual Meeting in Swakopmund, April 1999. It resulted in a BENEFIT project proposal "Horse mackerel, *Trachurus trachurus capensis* and *T. t. trecae* recruitment surveys". The objective of the project is to augment the understanding on the reproductive biology and early life stages of horse mackerel and to explain the spawning and recruitment dynamics of the two horse mackerel species and thereby improve management recommendations.

1.2 Specific objectives of the survey

The cruise is the first field investigation of the horse mackerel project, and is a pilot survey geographically limited to mid and northern Namibian waters and to southern Angolan waters. The specific objectives of the survey are to identify spawning areas of horse mackerel, map the spatial distribution of its eggs and larvae and to investigate the physical properties of eggs with respect to buoyancy. Further it will be studied how the circulation features in combination with the vertical distribution of the eggs influence the spreading and advection.

1.3 Participation

The scientific staff during the cruise was:

From Namibia:
Hilma Asino, Rudi Cloete and Graca D'Almeida.

From Norway:
Berit Endresen, Erik Kvaleberg, Tore Mørk, Marek Ostrowski, Laura Rey, Svein Sundby, Erling Kåre Stenevik and Jan Frode Wilhelmsen

1.4 Narrative

The vessel left Walvis Bay 16 February, 19:00 hours, and headed for Conception Bay where the survey started 17 February, 03:00. East-west sections for every degree latitude were made from Conception Bay (24 °S) and northwards. Cross sections from southwest to northeast were made between the east-west sections. Stations were taken every 20 nautical miles, and CTD and Multinet plankton sampler were used on all station. Methot plankton trawl were taken occasionally and only during night time. Pelagic trawl were used in regions where there were indications of horse mackerel. ACDP was run all through the cruise. Weather conditions were very good during the survey. We encountered problems with noise in the transfer of signals from the CTD

underwater unit during the first days. The cause of the problem was searched for during most of the time of the survey, and several unrelated malfunctions were identified. At position 21 °S, 13 ° 03' E repeated CTD and Multinet stations were taken for a 12 hours period on 21 February. The vessel was anchored at Baia dos Tigres on 26 February and the density gradient columns were refilled. Thereafter the survey continued further northwards along the Angolan coast to Ponta Grossa (14 ° 15' S) where the first part of the survey was terminated 1 March 00:40. The region from Ponta Albina and southwards to 20 °S, where horse mackerel eggs and larvae were found to be most abundant, was covered once more during the last week of the survey. The investigation was terminated at Palgrave Point on 6 March … and the ship headed for Walvis Bay where it arrived 7 March ….. The work on reporting continued onboard until 8 March.

CHAPTER 2 MATERIAL AND METHODS

2.1 Physical measurements

The survey started 17 February 2000, 03:00 hours, at Conception Bay and the Namibian coast was covered northwards in east-west section at every degree of latitude, and with cross sections towards northeast between. Generally, CTD stations were taken at 20 nautical miles intervals. The ADCP was operational more or less continuously from Conception Bay (24 °S) to Ponta Grossa (14° 15'S).

2.1.1 Wind data

Wind speed and direction was measured continuously underway by the Aanderaa weather station. In addition, at each CTD station the wind speed was entered manually from the bridge. By using the programme LOG2UMS, the files were converted to UMS format and then plotted in a similar manner to the current data, described below. The direction was given in tens of degrees, and because this was interpreted as degrees by UMS, each directional value had to be multiplied by 10 in order to obtain the correct result. Wind speed and direction is shown in figure (Figures 3.1 – 3.3).

2.1.2 Current data

2.1.2.1 Data collection and calibration

The ADCP was set up in Walvis Bay, and the heading adjusted to the ships gyro-compass. The offset for the transducer misalignment was maintained at minus 3 degrees. This was done to compensate for various electronic factors, and as they have appeared to be relatively constant for a number of cruises they are compensated in the misalignment field. The bias between ADCP and gyro heading was checked when leaving Walvis Bay, and displayed a maximum deviation of ±0.5 degree. Given that the data was collected at a cruising speed of approx. 8 - 9 knots, errors due to heading

bias was regarded as minimal. The velocity-smoothing interval used for navigational referenced data was 300 seconds.

To simplify data processing, and allowing for continuous current vector plotting during the cruise, the ADCP data was divided into several smaller files instead of a few large ones. The ship was cruising mainly along fixed sections; offshore parallel to lines of latitude, and with cross sections towards northeast between. Generally, each ADCP-file contained the data stored along one or two of these sections.

The bottom-referenced ADCP data appeared somewhat chaotic and noisy, especially in the upper layers between 34 and 58 m depth. Large fluctuations in velocity combined with sudden shifts in direction complicated the hydrographic interpretation, as areas of coherent readings were sparse and scattered. Further down, between 58 and 98 m, the conditions improved, and clearer current patterns became discernible.

As the shelf north of 19°S is narrow and steep, navigational-referenced data was initially utilized, given that bottom tracking was not allowed for. Data collected with navigational reference exhibited some features similar to bottom-referenced data, as well as an extra curiosity. It became clear that the ship's heading influenced the readings, given that current vectors were persistently pointing to the left, perpendicular to the path. These data therefore had to be rejected and substituted with the limited supply of bottom-referenced data available.

The main generator of noise in the measurements was probably the ship itself. When stopping for CTD- and Multinet-stations, the main- and side-propellers create bubbles of air that interfere with the ADCP readings. Other sources of error may be dense distributions of fish, plankton or jellyfish, obstructing the path of the beams and thereby causing misreadings.

A way of eliminating the errors that occur when stopping for CTD- and Multinet-stations may be to simply suspend the ADCP measurements until the ship is again moving at regular speed. This was not done during this cruise, and it is therefore uncertain what impact it would have on the readings, but it would certainly exclude a number of the flawed peak values

2.1.2.2 Processing

Processing of the ADCP data was done by converting the data to ASCII files using the playback menu in the ADCP Transect program. Thereafter, velocities at selected depths were extracted into UMS "external files" using ADCPUMS, a programme written by Martin Dahl. The current vectors in depths of 34–58 m, 58-82 m and 98 m were chosen, i.e. the two first levels were averaged over 3 bins (24 m), while the third set of vectors corresponded to the current in the 1 bin layer from 98 to 106 m.

The South-African programme UMS (Underway Mapping System) was then employed to plot the current vectors. This programme allows both individual vectors to be plotted in a geographic frame of reference, as well as enabling averaging to take place on any spatial scale. The data were generally averaged in a grid of size 2.3 by 2.3 minutes latitude and longitude. When the ship follows set lines of latitude, it

alternates from being slightly north and south of these lines. By adding the fraction 0.3 to the grid size, the risk of splitting data from the same station into different blocks was minimized.

Because the data exhibited some highly improbable values of current speed and direction, the UMS-files were manually edited in Microsoft Excel. The presumed erroneous values were identified and then deleted, even though this is an absolute subjective method. However, by removing single values of obvious error, the final results portrayed more plausible hydrographic conditions, hence the manual editing was to a large extent justified.

Averaged currents at 34-58 m, 58-82 m and 98 m depth (Figures 3.4–3.12) are shown to describe the circulation patterns. A comprehensive analysis of the currents in the first level is carried out by comparison with CTD-derived information (Figure 3.13).

2.1.2.3 User details for plotting horizontal ADCP maps

In the following, a brief user's guide is included to help in future employment of the ADCPUMS and UMS programmes.

ADCPUMS
The ADCP files already converted to ASCII format should be given the extension ".001", in our case they were named 001.001, 002.001 etc. They should then be copied into the directory G:\UMS\ADCPUMS where the programme files are situated. The programme can either create a new UMS-file, or data from ADCP-files can be added to an existing file.

If an existing UMS-file is to be modified, first select the ADCP-file containing the desired data to be added using the browser option. Then insert the name of the UMS-file, or use the browser to locate it. Depth is selected using the scroll-bar. Click "Append UMS File". The data will then be shown in the Clipboard window.

If a new file is to be created, select an ADCP-file as previously, and assign a suitable name of your choosing for the UMS-file, though with the extension ".ext" and a path identical to the ADCP-files. (For example 1-034.ext, where "1" denotes the section number and "034" the depth of the current data). Select depth, click "New UMS File" at the bottom of the window, and the data will be shown.

The "File" menu offers the opportunity to open and save an UMS-file, in which case it can be edited with the usual Windows commands under the "Edit" menu. By choosing "Bottom" in the scroll-bar for depth, the programme selects every reading from the ADCP with Bottom Reference. It also selects the deepest vector with 100% good quality. All ADCP-measurements with a vector angle less than 0 and larger than 360 degrees are rejected.

UMS
The UMS-files with the extension ".ext" created by ADCPUMS are copied into the directory G:\UMS\DATA. Execute the programme, and use the arrow keys to move around.

To select the area in which the ADCP-data are taken, press F2, move to "Main menu" and select "Coastal files". For the coasts of Namibia or Angola, select "Other" and choose the appropriate file, e.g. "Namibia.dat" or "Angola.dat". Then select "Setup Options", and "Main options" from "Main menu" and enter the desired positions for the map frame.

The converted ADCP-files are inserted under "Properties", then "External files". Write the name(s) of the UMS-files created by ADCPUMS.

To plot the data, move to "Averaging". Select the option "To screen (& file)". "Gridsize" determines the size of the cells in which the data are averaged; a suitable value must be adjusted to match the amount of data. Select "Mean position" to ensure that the vectors in a section are arranged in a straight line, then choose between wind or current data. To plot the data, select "Start", and follow the instructions at the bottom of the screen.

To create a plot file of the displayed map, press F7 and move to "Plotfile name". Choose any name for the file, as long as it carries the extension ".plt". Press escape, and select "Draw plot" under the "Main menu". Press F7, and the plotfile is created. To print it open a MS-DOS window, and write: "copy *.plt lpt1" at the dos prompt "G:\ums\data" (here * denotes the preceding file name. lpt1 is the default printer).

2.1.3 Hydrography

A Seabird 911 CTD was deployed to collect data on temperature, salinity and oxygen. CTD were taken on all stations. Rosette bottle samples for calibration of oxygen and salinity were taken in two depths on each station. Some of the oxygen samples were analysed on board. Unfortunately, the salinity samples could not be analysed on board because of problems with stabilizing the conductivity cell of the laboratory salinometer (Portasal from Guildline). We encountered problems with noise in the transfer of signals from the CTD underwater unit during the first days. The cause of the problem was searched for during most of the time of the survey, and several unrelated malfunctions were identified.

2.2 Plankton sampling

2.2.1 Multinet plankton sampler

Eggs, larvae and zooplankton were sampled with Multinet plankton sampler from Hydrobios. The plankton sampler has 5 nets with a mesh size of 405 micrometers. The opening of the plankton sampler is 0.5 x 0.5 m. A flow meter was mounted in the entrance of each net. A Scanmar depth recorder with acoustic transmission to the vessel was mounted on top of the Multinet. At most of the stations the nets sampled in 50 m depth intervals when bottom depths were more than 260 m. When bottom

depths were less the deepest net sampled from 10 or 20 m above the bottom to the nearest 50 m depth interval (e.g. from 180 to 150 m depth). The plankton sampler was retrieved at a speed of 0.5 -1.0 m/sec while the vessel maintained a speed of 2 - 2.5 knots.

2.2.2Methot fish larvae sampler

A Methot fish larvae sampler was fabricated at Globe Engineering in Walvis Bay. The equipment was produced in stainless steel according to the description of Methot (1986). The opening of the sampler is 2.24 x 2.24 m. The nets for the Methot sampler were kindly provided for the present cruise from MCM, Cape Town. The mesh size of the inner nets were 7 mm. The Methot sampler was deployed from the stern gate using a 12 mm cable on one of the trawl net winches.

The experience with operating the Methot net onboard "Dr. Fridtjof Nansen" was good. The deploying and retrieving through the stern gate seemed to work quite well and the large net winch was perfect for running the cable. However the sea was calm while using the net throughout the cruise and it is probably sensitive to weather conditions. Also, one has to be careful and not use to much force with the drum while retrieving the net especially when it approaches the ship.

The Methot sampler was only used during night time. A Scanmar depth sensor was mounted on top of the frame, and depth was monitored on the bridge during tows. The sampler was towed horizontally at discrete depth from 40 m to about 10 m. From Methot stations 1 –22 the depth sensor was –10 m off calibration. Thereafter it was calibrated to show correct depth.

2.2.3 Processing of samples

Juvenile fish were counted and length measured.

2.3 Trawl sampling

2.4 Buoyancy measurements of fish eggs and larvae

The onboard equipment from Martin Instrument Co. Ltd. (MIC) was used to measure specific gravity of plankton. The equipment consists of three glass cylinders, 50 mm internal diameter and 700 mm high, submersed in a temperature-controlled transparent water container. The temperature was kept constant by a ship-mounted cooling unit. A linear salinity gradient is set up in each column by filling the column from two conical flasks. One of the flasks is filled with (each filled with 830 ml salt water solutions) connected by a plastic tube at the bottom, one with low-salinity and the other with high-salinity. The two solutions were made from natural seawater. The filling of each column takes about 25 min.

The salinity gradients in the three columns were first made before departure on 16 February when the ship was in harbour in Walvis Bay. It is of important to do the filling in calm conditions because too much motion of ship will cause errors in the filling procedure due to unwanted mixing between the two flasks. During the first filling the low-salinity solution was made by adding 740 ml distilled water to 1900 ml natural seawater. The high-salinity was made by adding 18 g sodium chloride to 2500 ml natural seawater. This made the salinity of the low-salinity solution about 25, and the salinity of the high-salinity solution about 42. The temperature was kept constant at 11.5 °C during the first experiments onto 26 February. Then the eggs and the newely hatched horse mackerel larvae were taken out and studied, and the columns were drained and refilled on 26 and 27 February when the ship was anchored in Baia dos Tigres, Angola. The new stock solutions were made from natural sea water (salinity 35.94) filtered through 90 microns mesh. The low-salinity solution was made by adding 810 ml distilled water to 1850 ml sea water, and the high-salinity solution was made by adding 15.1 g sodium chloride to 2500 ml sea water. This made the low-salinity solution 25,00 and the high-salinity solution 42.00. The temperature was increased to 14.0 °C.

The columns were calibrated by inserting five glass floats in each column, the specific gravities, □, ranging from about 1.021 to 1.027 g/cm3. The table shows the Id. number for each float and the exact specific gravities, □, at 11. 5 °C and 14 °C . The absolute specific gravity of the floats was given with an accuracy of +/- 0.0002 g/cm3.

Column I			Column II			Column III		
Id. No.	□□at		Id. No.	□□at		Id. No.	□□at	
	11.5 °C	14.0 °C		11.5 °C	14.0 °C		11.5 °C	14.0 °C
23744	1.0214	1.0214	23743	1.0210	1.0210	23742	1.0203	1.0203
22635	1.0233	1.0233	23745	1.0228	1.0228	22633	1.0218	1.0218
20381	1.0243	1.0242	20377	1.0248	1.0247	20380	1.0241	1.0240
20375	1.0255	1.0254	20372	1.0262	1.0261	20374	1.0256	1.0255
20366	1.0270	1.0269	20358	1.0281	1.0280	20362	1.0276	1.0275

The fish eggs to be measured were introduced into the columns with a pipette just below the surface water in the columns, and eggs were allowed to settle for 3-4 hours before first reading of the vertical position in the column. Neutral buoyancy of the eggs was expressed in salinity units by calculating the salinity gradient in the column from the absolute densities of the floats and from the temperature in the columns.

CHAPTER 3 RESULTS

3.1 Physical measurements

3.1.1 Weather

Figure 3.1 shows the wind velocities during the first part of the survey along the Namibian coast from 24 °S to 18 °S (16-25 February). During the first three days (16-19 February) winds were weak (1 – 6 m/s) and predominantly from north and northwest. For the period 19 – 25 February winds were more steadily from south and southeast and the wind speed increased and varied between 5 and 12 m/s. Hence, the forcing behind the upwelling was rather moderate compared to October situations when stronger winds from southeast dominate.

Figure 3.2 shows wind velocities during the second part of the survey along the Angolan coast from 17 °S to 14 °S (25 February – 1 March). Winds were moderate and mainly from south - southeast varying between 1 and 7 m/s.

Figure 3.3 shows wind velocities during the third part of the survey, from Baia dos Tigres to Palgrave Point (1 – 6 March).

3.1.2 Currents

ADCP currents were recorded both on the first part of the survey from 24 °S to 14 °S and during the second part when covering once more the region from 16 °S to 20 °S. Along the Angolan coast the nearshore currents had a strong southerly component and in some of the sections an onshore component. Because of the narrow Angolan shelf the more offshore parts of the ADCP sections were lost, since the bottom was beyond the reach ADCP bottom track function. Along the Namibian coast the currents below 34 m depth were predominantly towards southeast. Figure 3.4 shows the currents between 34 and 50 m depth along the Namibian coast. There is a strong and steadily current coming from the Angolan coast and directed towards southeast across the entire sections from 18 °S to 20 o 30'S. A small cyclonic eddy is located onshore at 19 °S. A band low currents at the midshelf occurs between 21 °S and 22 °S. In the southernmost region southerly current component was reduced and two cyclonic eddies dominate the current pattern. The largest eddy of these two are located between 22 °S and 23 °S (to the west of Walvis Bay-Cape Cross) and had a diameter of approximately 100 km. The other southernmost eddy was found with the centre at 23 ° 30' S (off Sandwich Harbour) and had a diameter of approximately 50-60 km.

(Figures 3.4–3.12)

3.1.3 Hydrography

3.2 Plankton sampling

3.3 Trawl sampling

3.3.1 Horizontal distribution and species composition

3.3.2 Experiments on spawning horse mackerel

Horse mackerels were caught in both pelagic trawl and bottom trawl. However, large and mature individuals were never caught in pelagic trawl hauls from the upper layers or from mid water layers. Only in pelagic trawl hauls near the bottom ripe and running individuals were caught, and the large abundance of such individuals was only caught in the bottom trawl.

Mature horse mackerels of both the *T. t. capensis* and *T. t. trecae* were found at BT557 (17 °S, 11° 24’ E) 200 m depth. Several running males were found, but no female with running eggs.

At trawl station BT559 (18° 48’ S, 11° 36’ E) a large fraction of the horse mackerel, all *T. t. capensis*, was mature, especially among the largest fish most of the males were running and a large part of the females were spawning. However, fully hydrated eggs were difficult to find, but in one of the females artificial fertilisation was tried. The result was, however, unsuccessful.

The latter position was revisited later same day and a series of seven trawl hauls were made through the night from 3 March 23:30 to 4 March 10:30. In these trawl hauls the maturation status of all the largest horse mackerel (>25 cm) were inspected. Nearly all of the individuals were prespawning or spawning. The large mature horse mackerels were caught at the bottom trawl stations (BT560 and BT565) and at the pelagic trawl station (PT564) where the trawl was towed with the footrope 5 – 10 m above the bottom. In the pelagic trawl hauls from the upper layers and from mid water (PT561 – PT563) taken during night only small and immature horse mackerels were caught. One female with fully ovulated eggs were also found at PT564. Also here the artificial fertilisation was unsuccessful. At BT565 four running females were found. However, again the artificial fertilisation was unsuccessful. Inspection of the eggs after several hours showed segmentation within the eggs and a large fraction of the eggs had 2-5 small oil globules instead of one. Also many of the eggs deviated from the spherical shape. During all of the experiments on artificial fertilisation the

eggs were incubated in water taken from the sea surface of salinity ~35.5 and temperature of 19 – 20 °C.

3.4 Buoyancy and development of horse mackerel eggs and larvae caught in the Multinet planktonsampler

Horse mackerel eggs sampled from Multinet stations 48, 55 and 56, all from the upper net (50 – 0 m depth) were introduced in column I and column II during the first experiment on buoyancy.

Ten stage 4 eggs from station 55 were put in column I on 24 February. The staging was according to King *et al*. (1977). Three of the ten eggs were viable and two of them hatched before the column was drained 26 February (Appendix xx). Mean buoyancy was high when they were inserted, 36.73. Twelve hours after the eggs were inserted two of them had hatched. The larvae were found at neutral buoyancy 32.30 in salinity units.

One stage 1 egg and eleven stage 3 eggs from station 48 were put in column II on 23 February (Appendix xx). Nine of them were alive. Later on the 24 February another batch of 16 eggs, all stage 4, from station 56 were put in the column. Eight of them were alive. The mean neutral buoyancy of the eggs increased through development from 34.30 salinity units for the stage 3 eggs when they were inserted to 35.08 prior to hatching. The mean neural buoyancy of the larvae was 33.36 in salinity units.

The larvae were floating with the yolk sac up, quite similar to hake larvae. Every 30 – 60 seconds they were swimming upwards 1-2 cm in bursts of 2 – 4 seconds duration, and thereafter slowly sinking back to their level of neutral buoyancy.

The horse mackerel larvae were taken out of the column 26 February 13:00, about 24 hours after hatching, and transferred to a 250 ml plastic jar. The temperature was then gradually increased from 11.5 °C to 19 °C over 3-4 hours, and they were kept at that temperature until the two surviving larvae were closer inspected under microscope 27 February 23:00, about 2.5 days after they were hatched in the column. They were then 3.3 mm long. **Figure xx** displays the features of the larvae. The oil globule was positioned at the very front end of the yolk sac. There was some pigmentation in this area. Other parts of the larvae were only slightly pigmented with small dots mainly along the upper and lower lines of ……. This is differently from the hake larvae. They have more pigmentation and the pigment spots are star-formed and cross-formed rather than small dots.

Ten eggs from station 89 (50-0) m were inserted in column II 2 March 09:15. Six of them were stage 4 eggs and four of them were stage 5 eggs. All the eggs were quite heavy. Six sank to the bottom and the remaining four eggs were all heavier than …… Four of the eggs hatched around 18:00 on the same day and were observed higher up in the column. The first larva was removed from the column three hours after hatching. The total length was 2.2 mm (**Figure xx).** It had a relatively large yolk and the oil globule was positioned at the front of the yolk and it was some small dots of pigment at the front end of the oil globule. The second larva was removed from the

column 18 hours after hatching (**Figure xx**). The length was 2.6 mm, and the yolk was considerably smaller. The oil globule was positioned at the very front of the yolk sac, almost bulging out it. A third larva, 3.5 mm long, was removed from column III about 48 hours after hatching (**Figure xx**).