

## OBSERVATIONS OF SEVERE HYPOXIA AND OFFSHORE DISPLACEMENT OF CAPE HAKE OVER THE NAMIBIAN SHELF IN 1994

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In 1994, persistent and pronounced hypoxic conditions developed off the coast of central and northern Namibia, with oxygen levels  $<0.5 \text{ m}\ell^{-1}$  in bottom water over much of the continental shelf. These conditions apparently displaced juvenile Cape hake *Merluccius capensis* offshore from their typical inshore habitat, subjecting them to heavy mortalities from predation by larger hake and from commercial trawling.

Cape hake *Merluccius capensis* are abundant over the Namibian shelf. The population is typically segregated by size and their distributions are strongly related to depth (Botha 1985, Macpherson and Duarte 1991, Reiss 1997). Hake recruits (15–25 cm) generally inhabit the inner and midshelf, whereas medium-size (26–40 cm) and larger hake occupy the deeper waters of the outer shelf and slope. During 1994, this size-segregated distribution altered, when recruits moved offshore from their typical habitat of 100–200 m water depth to water up to 350 m deep. This move-

ment preceded an unusually widespread development of pronounced hypoxia in shelf bottom waters off central Namibia. In this note, the environmental changes in Namibian waters during 1994 and the associated responses of Cape hake are described. Data were collected on trawling and environmental surveys off Namibia on board the research vessels R.V. *Dr Fridtjof Nansen*, F. R. S. *Welwitschia* and *Matsuyama Maru* (Anon. 1994, Hamukuaya and O'Toole 1994, Kristmannsson 1995, O'Toole and Bartholomae 1995).

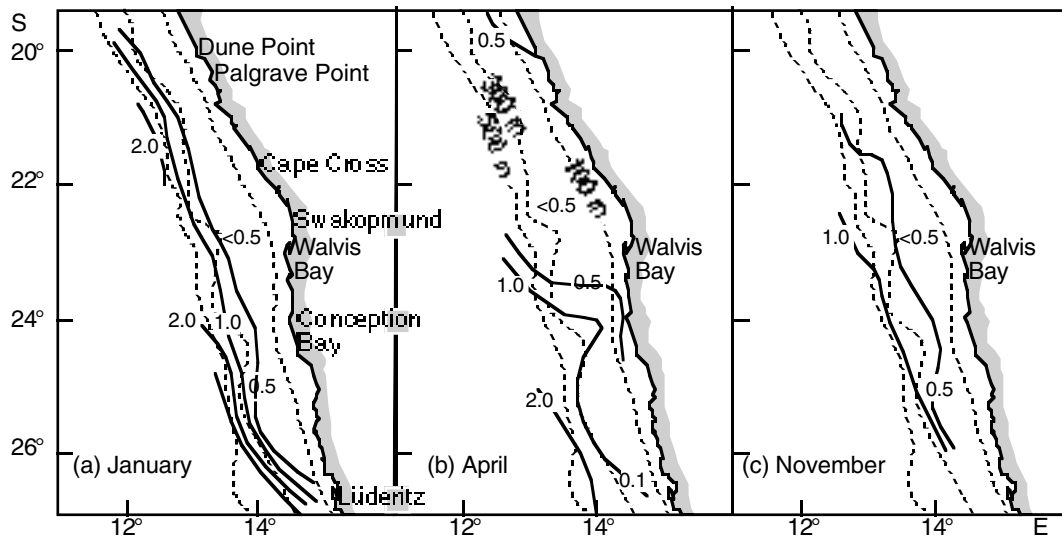


Fig. 1: Distribution of bottom dissolved oxygen ( $\text{m}\ell^{-1}$ ) over the Namibian shelf during (a) January, (b) April and (c) November 1994

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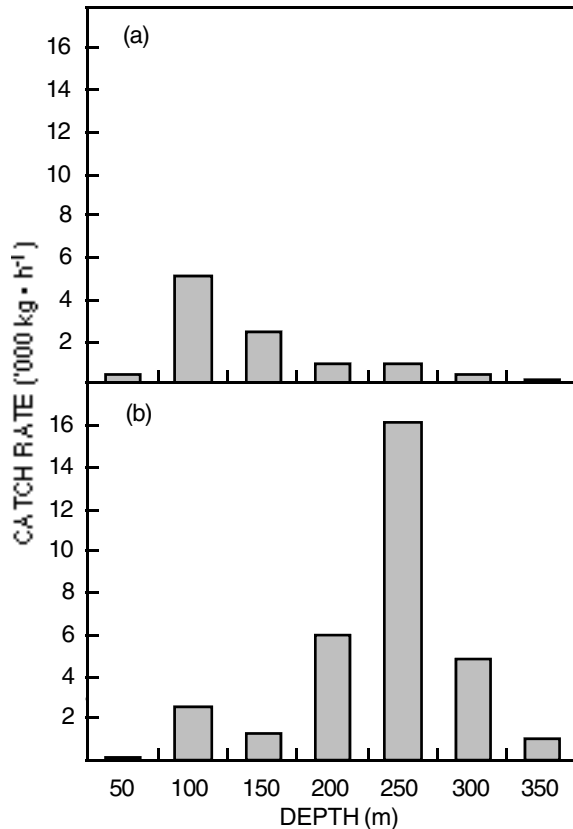


Fig. 2: Catch rate of Cape hake recruits by depth over the Namibian shelf during (a) January and (b) May 1994

## THE ENVIRONMENT

In summer 1994, oxygen depletion was very pronounced in bottom waters over the Namibian shelf, from 18 to 25°S. In January, bottom water of the inner and midshelf regions of northern and central Namibia was depleted of oxygen to levels as low as  $<0.5 \text{ ml} \cdot \ell^{-1}$ , with levels of between 1 and  $2 \text{ ml} \cdot \ell^{-1}$  at the shelf edge (Fig. 1a). By April, the oxygen depletion was widespread, covering more than 1 million hectares of the Namibian shelf. Bottom water oxygen concentrations of  $<0.5 \text{ ml} \cdot \ell^{-1}$  extended from 20 to 24°S, down to at least 300 m deep (Fig. 1b). Similar conditions were found in November (Fig. 1c).

Hydrographic data collected in March, June and September 1994, along transects extending across the central shelf between 22 and 24°S, showed very low oxygen levels of  $<0.5 \text{ ml} \cdot \ell^{-1}$  in bottom water to beyond

250 m. Pronounced hypoxia continued to be widespread over the central shelf, which persisted until October 1994. Hypoxia is normally restricted to small areas of the inner shelf in Namibian waters (Dingle and Nelson 1993).

## HAKE DISTRIBUTION AND MORTALITY

In summer 1994, Cape hake were most abundant over the midshelf off central Namibia. In January, highest densities of hake (up to 90%), consisting mainly of small (15–30 cm) fish, were at between 100 and 250 m of bottom depth (Fig. 2a). Larger, adult hake were distributed near the shelf edge and slope at between 250 and 450 m. By May, hake recruits were most abundant near the shelf edge in 200–300 m of water, having moved offshore from their more typical shallow-water habitat (Fig. 2b). Hake over the midshelf decreased in abundance by around 40% from January to May. By November, the size of the hake population was estimated to have decreased to  $<20\%$  of its summer abundance.

The offshore shift in hake recruits placed them with larger hake, which are voracious cannibals in Namibian waters (Hamukuaya 1993, 1994, Macpherson and Gordoia 1994, Traut 1996). This offshore movement by small hake appears to be substantiated by the high hake-on-hake predation found during the March and October surveys. Furthermore, commercial trawlers targeting larger hake caught many small hake in the slope region. Mortality of small hake by predation and trawling was estimated to be around 70% between February and November 1994.

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