The impact of environmental variations on key fish stocks in the Northern Benguela Ecosystem

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Introduction

The small-pelagics (Sardines and anchovies but also horse mackerels) are considered as key species in the food web of upwelling systems. Due to their potential to build up large biomass in short time spans they are able to carry important fisheries. In the Northern Benguela a regime shift has occurred during the last 40 years showing a dramatic decline of sardines in the 1970ies and in the same time increase of horse mackerels being the most important pelagic fisheries resource in Namibia today. (Fig. 1; Cury et al. 2000, Cury & Shannon, 2004).

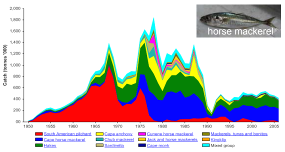


Fig.1: Development of fishery landings in waters of Namibia from 1950-2006 (©www.seaaroundus.org, 2011)

Early life stages are the bottleneck in the development of populations. They are most vulnerable to environmental changes such as increasing temperatures, decreasing oxygen or changing food.

This sub-project investigates distribution, diet, growth and metabolic parameters of key fish species (horse mackerel - HM, sardine - SAR, anchovy - ANC, pelagic goby and flatfish).

Subsequently we analyse to what extent relevant environmental factors and processes (phyto- and zooplankton composition, origin of surface waters, hypoxia) influence distribution, condition and survival of the fish and how physiological constraints of the species are linked to it.

Results

Distribution:

Results from GENUS cruises (2008 ff) confirm the trend in distribution patterns of small pelagics showing a decline in sardine and increase in horse mackerel and sardinella abundance since 2002 (Fig.2). In addition to the overall changes in abundance a shift of distribution towards the south could be observed in some species.

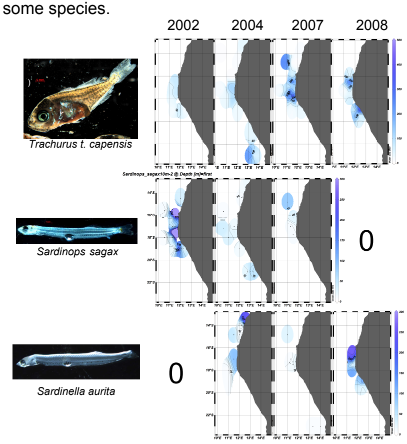


Fig.2: Horse mackerel, sardine and sardinella larvae distribution over the last 10 years. „0" no catch during that year.

Condition and growth:

Otolith analysis of young flatfish and pelagic gobies showed a strong correlation of growth with water masses. In general growth rate was low in larvae of both species investigated (see also Michalowski & Ekau poster). Analyses of growth and condition factors of small pelagics are in progress (Fig. 3) and will be tested against environmental factors.

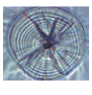


Fig. 3: Growth rings in otolith (Ø50µm) of a 4mm HM-larva

Trophy:

Different copepods dominated the stomach content of HM larvae (Fig. 4a). Phytoplankton (diatoms and dinoflagellates) occurred occasionally in HM, SAR and pelagic goby (Michalowski & Ekau poster). Spatial differences in HM stomach contents from 2009 coincided with microzooplankton dominance structure and suggest an opportunistic food choice (Fig. 4b and Schwinghammer & Ekau poster). δ13C- and δ15N-stable isotope signatures of HM and ANC were similar (Fig. 4c), but samples from 2010 were different from those caught in 2008 and 2009. The δ15N values indicated a trophic level of 2 to 3 both for HMC and ANC. Non-membrane fatty acid trophic biomarkers for diatoms and carnivory outweighed dinoflagellate markers. However, the proportion of trophic markers in total fatty acids of fish was low compared to that in copepods (Schukat et al. poster).

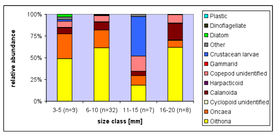
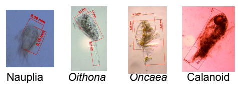


Fig. 4a: Stomach content of HM larvae from 2008 & 2009 by size classes



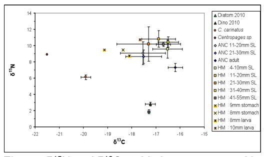


Fig. 4c: δ15N and δ13C stable isotope composition of HM and ANC larvae and potential food items

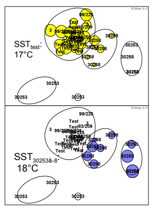


Fig. 4b: Spatial variability of stomach content of HM larvae from 2009. Yellow – *Oithona* dominated, blue – naupliae dominated. (SST: sea surface temperature at respective stations)

Physiology:

Experiments were conducted with the more robust HM, gobies and flatfishes. Respiration rates of larvae and juveniles were measured at different pO_2-levels using closed and intermittent flow systems. Swimming activity was recorded simultaneously (Fig. 5). Mass specific respiration rate of HM larvae and juveniles (fresh weight, FW: 0.1 to 4.6 g) ranged from 0.3-1.4 mg O_2 mg^{-1} FW*h (=8-43 µmol O_2 mg^{-1} FW*h) and decreased with body size. With pO_2 levels above 50% HM perfom as oxy-regulators, below 50% they become oxy-conformers.

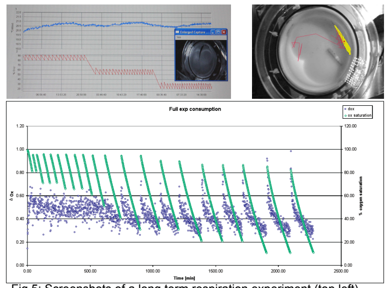


Fig.5: Screenshots of a long term respiration experiment (top left), analysis of swimming activity (top right) and of respiration data (bottom); green: O_2-saturation, blue: fish respiration as ΔpO_2)

Conclusions

- Strong indications of a southward shift and a decline in numbers of clupeid larvae over the last 10 years indicate a dramatic change in the ecosystem based on climatic changes.
- Opportunistic feeding mode and a good food supply in spawning regions indicate that no food limitation was apparent for early life stages. This implies that recruitment success is not primarily driven by food availability or quality.
- HM tolerates dissolved oxygen concentrations down to 10% oxygen saturation and recover fast from temporary hypoxia.

[1]Cury et al., 2000. Small pelagics in upwelling systems: patterns of interaction and structural changes in "wasp-waist" – ecosystems. ICES Journal of Marine Science, 57, 603-618.

[2]Cury & Shannon, 2004. Regime shifts in upwelling ecosystems: observed changes and possible mechanisms in the northern and southern Benguela. Progress in Oceanography, 60, 223-243.

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