GENUS – *Geochemistry and Ecology of the Namibian Upwelling System*

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Overview: Major upwelling areas

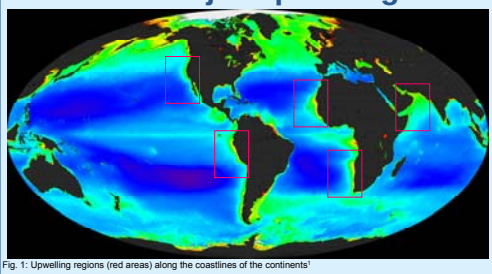

Fig. 1: Upwelling regions (red areas) along the coastlines of the continents[1]

Upwelling Areas are important:

- 7 % of the Earth surface
- 25 % of global biological productivity
- 90 % of organic carbon runoff from terrestrial sources
- 90 % of global fischeries
- Major regions for CO_2 uptake/release

What is upwelling?

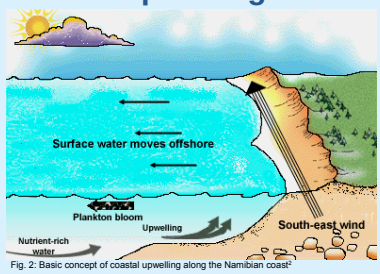

Fig. 2: Basic concept of coastal upwelling along the Namibian coast[2]

→ Winds from south-east blow along the Namibian coastline

→ Net surface water moves offshore

→ Deep and nutrient rich water comes to the surface

→ High primary productivity

→ Dolphins, Seals, **FISH**!

Benguela Upwelling Area

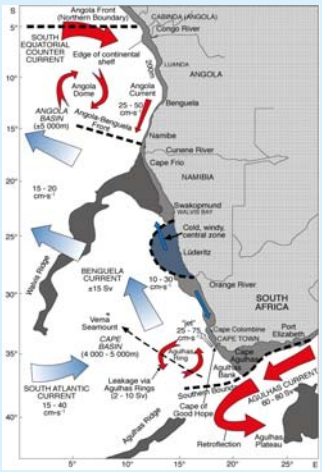

Fig. 3: The Benguela Upwelling System[3]

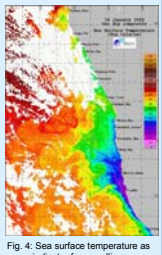

Fig. 4: Sea surface temperature as indicator for upwelling

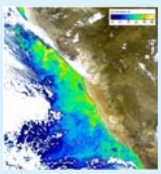

Fig. 5: Small-scale filament structure seen in chlorophyll distributions[4]

Why do we study the Namibian Upwelling System?

- Warm boundaries in the north and south of the upwelling region
  (Angola-Benguela Front and Agulhas Retroflection Area)
- Influence of tropical regime in the North and Antarctic regime in the South
- Seasonally variable trade wind fields modulated by regional influences, variable in space and time, generation of mesocale eddies and small-scale filament structures
- Second largest individual CO_2-source in the ocean (up to 5 Pg CO_2 a^{-1})
- Influence of several water masses (SACW, ESACW, AAIW, Angola Current)
- Causal chains between physical forcing and ecosystem response
- Characteristically short trophic chains
- Highly productive coastal area and thus economically extremely important!

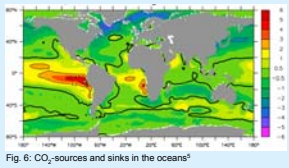

Fig. 6: CO_2-sources and sinks in the oceans[5]

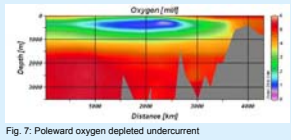

Fig. 7: Poleward oxygen depleted undercurrent

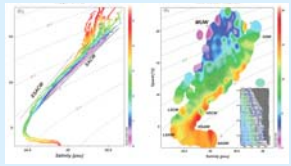

Fig. 8: Distinctive water masses along the Namibian shelf

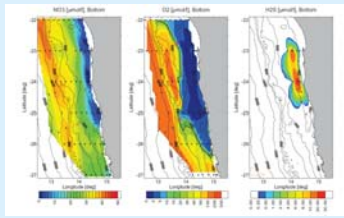

Fig. 9: Concentration of nitrate, oxygen and H_2S at the bottom along the coastline

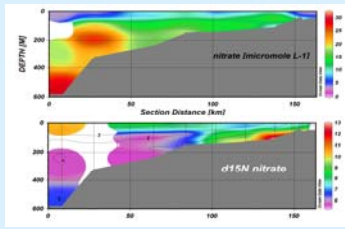

Fig. 10: Shelf-break upwelling discerned by nutrient and isotopic measurements

GENUS Project Structure

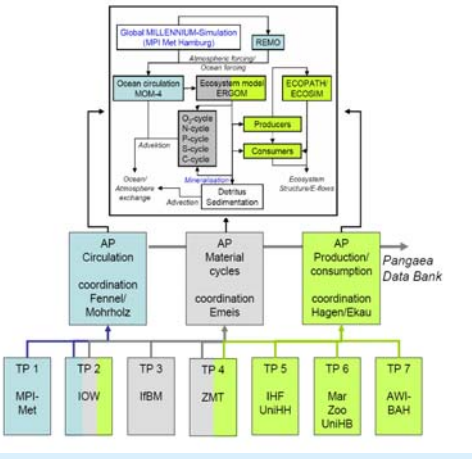

Fig. 11: Seven partner specific sub-projects (TP) report their results to three work packages (AP). All data are being imported to existing and updated model simulations. Results are also transferred to the Pangea Data Base.

Hypotheses and Approaches

Hypotheses

- Changes of atmospheric and hydrodynamic circulation impact on biogeochemical fluxes, steer the basis of food webs and determine status and stability of the ecosystem
- Changes at the basis of the food webs determine the structure and diversity of the pelagic ecosystems, initiate changes in the trophic relationships of the food web and their stability
- Structure, diversity and strength of the higher trophic levels feed back on lower trophic levels and are potential feed-back agents to external drivers
- Climate related changes in the biomass of phyto- and zooplanktivorous fishes lead to changes in phytoplankton production
- Effects of all these changes are exported to the adjacent ocean

Approaches

- (Retrospective) analyses of physical forcing and biogeochemical cycles
- Identification of key processes, rates, and species in physical, biogeo-chemical and biological processes
- Parameterisation and modeling of trophic relationships, feed-backs on biogeochemical fluxes
- Upscaling of the interactions between shelf ecosystem - open ocean - atmosphere with numerical models

GENUS Activities

Fig. 12: German RV Meteor on station work

Field Studies

- Joint Project between Germany, Namibia and South Africa
- 5 international ship expeditions
- 15 international research institutions

Fig. 13: Ecosystem Model MOM/ERCOM

Models and Simulations

MOM
ERGOM
REMO
↔
ECOPATH
ECOSIM

Fig. 14: GENUS workshop meeting

Capacity Building

- Fellowship programs (Master/Ph.D) for students from Namibia and South Africa
- Workshop and training sessions
- Summerschools

Summary and Outlook

- In upwelling regions climatic changes have a direct and very sensitive influence on the ecosystem structure.
- Physical changes cause immediate reactions in the chemical and biological inventory and thus have a direct impact on the food chain; Benguela is therefore a perfect area for testing ecological hypotheses.
- The Benguela upwelling region has been very variable in the past so that the current situation is only regarded as a snap shot of a long-term evolution.
- In times of climate changes it is crucial to distinguish between natural and anthropogenic effects. GENUS models will test the cause-and-effect chain for different scenarios.

References:

(1) SeaWIFS/NASA (http://oceancolor.gsfc.nasa.gov).

(2) http://disc.sci.gsfc.nasa.gov/oceancolor/images/Benguela_upwelling.

(3) Shannon, L.V. and O'Toole, M.J., 2003. Sustainability of the Benguela. In: G. Hempel and K. Sherman (Eds), Large Marine Ecosystems of the World: Trends in Exploitation, Protection and Research. Elsevier B.V., Amsterdam, pp. 227-253.

(4) R. Doerffer, GKSS (unpublished).

(5) Wetzel, P., Winguth, A. and Maier-Reimer, E., 2005: Sea-to-air CO2 flux from 1948 to 2003: A model study. Global Biogeochemical Cycles, 19. doi:10.1029/2004GB002339.

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