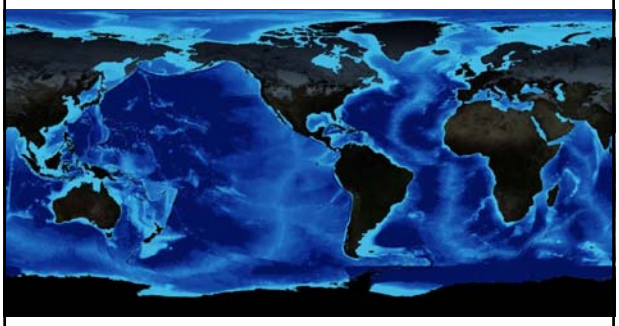
„Understanding the ocean, sustaining our future"

future ocean



Vice Speaker Kiel Excellence Cluster
Prof. Dr. Ralph Schneider
Christian-Albrechts Universitaet Kiel

Kiel, location for Marine Research

future ocean

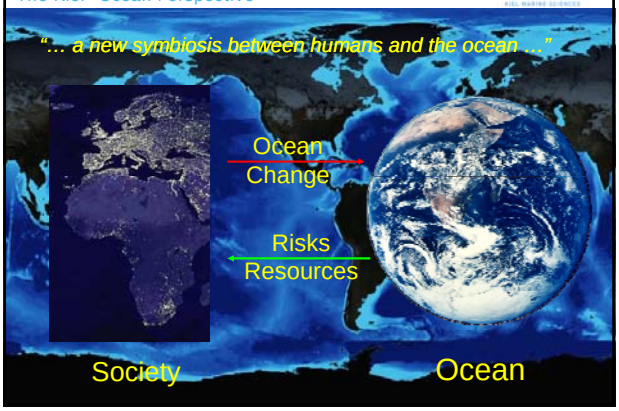
Kiel Institute
for the World Economy

IFM-GEOMAR

MUTHESIUS
Academy of Fine Arts

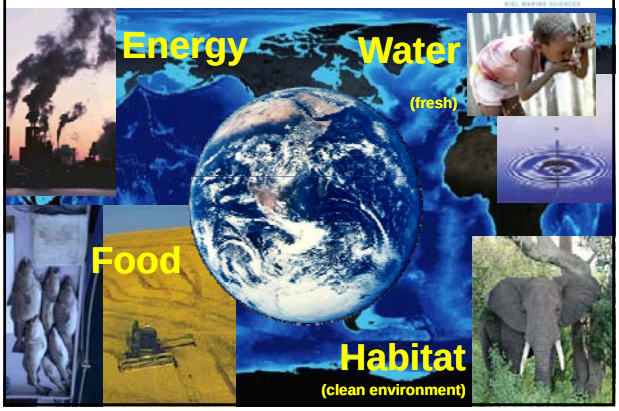
The Kiel "Ocean Perspective"

future ocean



Issues for the 21st Century => Resources

future ocean



Kiel Cluster of Excellence „The Future Ocean"

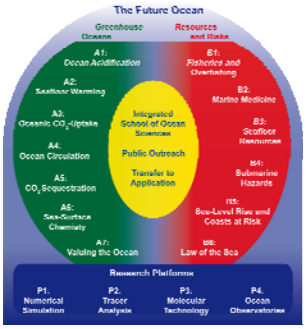
future ocean

Structure

The Cluster
140 Scientists from 6 Faculties of the Christian-Albrechts-Universität Kiel, the Leibniz Institute for Marine Sciences (IFM-GEOMAR), the Institute of the World Economy (IfW) and the Muthesius School of Fine Arts.

Multidisciplinary
Marine and Geological Scientists, Economists, Life Scientists, Mathematicians, Lawyers and Social Scientist jointly investigate Ocean Change and Marine Resources und Risks.

Innovative Research
13 junior Professorships cover a broad range of issues about „The Future Ocean"

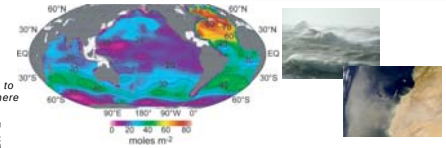


Kiel Cluster of Excellence „The Future Ocean"

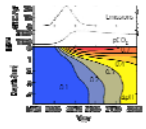
future ocean

Environmental Topics Include:

- Ocean Circulation Changes
- CO_2 Uptake of the Ocean
- Ocean Acidification
- Ocean O_2 loss



Decrease in pH-ocean due to CO_2 uptake from atmosphere



Today

pCO_2 280-380 ppmV

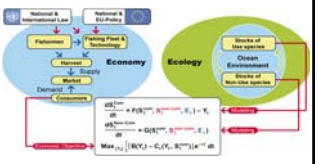
Increased CO_2 content

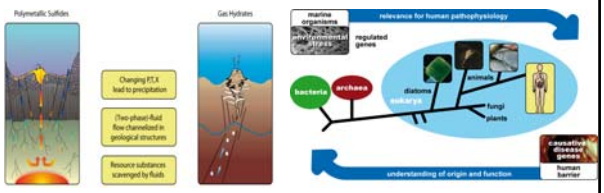
pCO_2 580-720 ppmV

Kiel Cluster of Excellence „The Future Ocean"

Resource Topics Include:

- Sustainable Fisheries
- Blue Medicine / Marine Substances
- Mineral und Energy Resources

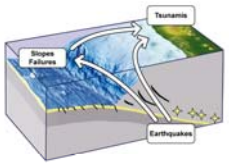


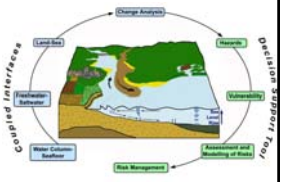


Kiel Cluster of Excellence „The Future Ocean"

Risk, Economic and Legal Topics Include:

- Marine Geo-Hazards
- Coastal Zone Management
- Law of the Sea





Kiel Cluster of Excellence „The Future Ocean"

Goals

Sustainability Science
develop options for global sustainable management of the oceans and their natural resources.

Knowledge Transfer
by public outreach, technology-transfer and the Integrated School of Ocean Sciences (ISOS)

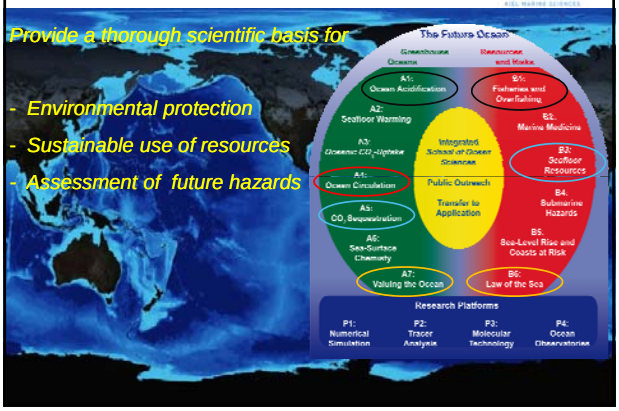
Highlight – The roving Exhibition „Ozean der Zukunft" allows to experience the Deep Sea and communicates all aspects of Marine Sciences

Enhance Profile
Kiel supports Excellence in Marine Sciences.

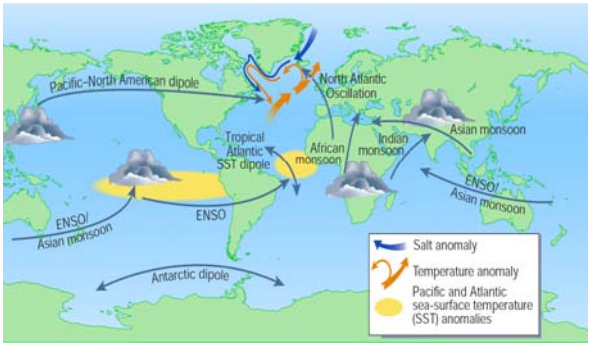
The Kiel "Cluster Future Ocean Challenge"

Provide a thorough scientific basis for

- *Environmental protection*
- *Sustainable use of resources*
- *Assessment of future hazards*



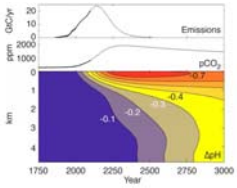
"Ocean Circulation and the Hydrological Cycle"



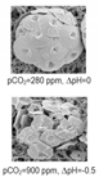
from Zahn, Nature 2003

Theme A1 "Ocean Acidification"

CO_2 Uptake & Biota Response



Projected future changes in ocean pH (Caldeira & Wickett 2003)



Acidification will stress calcareous microalgae

- Investigate the effect of ocean acidification on marine calcifying organisms and related ecosystems

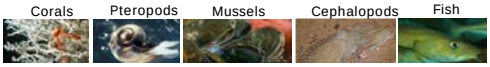
Cold-water corals at the European margin (photos IFREMER)

Theme A1 "Ocean Acidification"

1) Further study those organisms that cope well with elevated pCO_2 (e.g. cephalopods)

2) Place a research emphasis on sensitive marine invertebrates (e.g. bivalves, echinoderms)

Sensitivity to ocean acidification



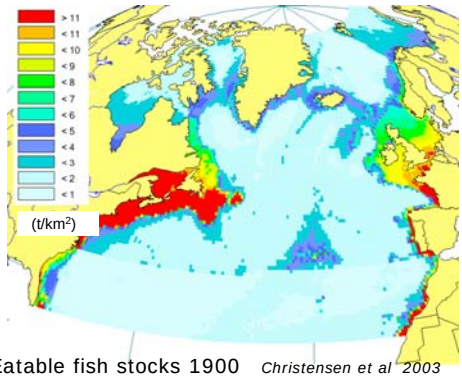
Metabolic rate & ion regulatory capacity

3) Place an emphasis on critical (early) life stages

4) Design experiments in a way to directly compare traits of sensitive and tolerant taxa

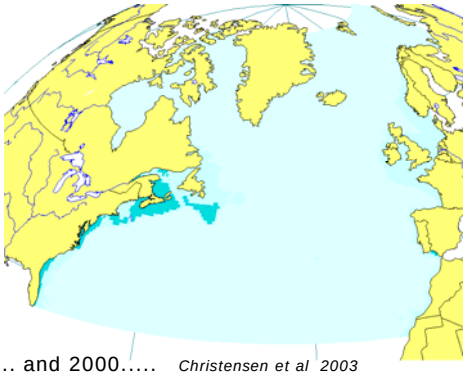
Courtesy F. Melzner

Theme B1 "Living Resources and Overfishing"



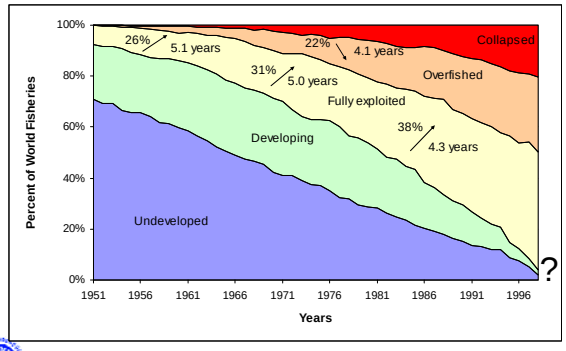
Eatable fish stocks 1900 *Christensen et al 2003*

Theme B1 "Living Resources and Overfishing"



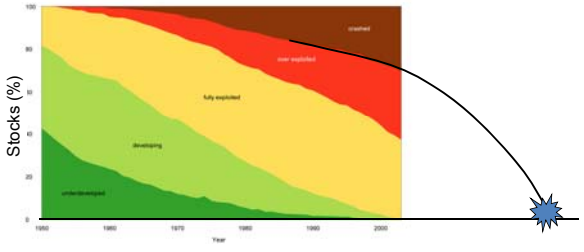
.. and 2000..... *Christensen et al 2003*

Theme B1 "Living Resources and Overfishing"



Froese and Kesner-Reyes, ICES 2002

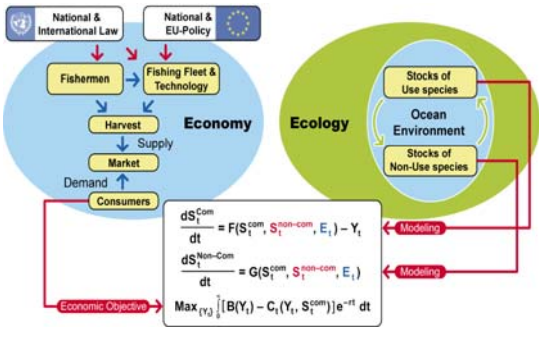
Theme B1 "Living Resources and Overfishing"



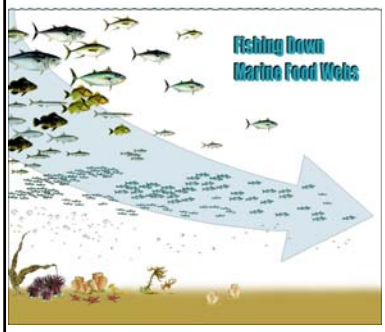
Worm et al., Science 2006

2048 ?

Theme B1 "Living Resources and Overfishing"



Theme B1 "Living Resources and Overfishing"



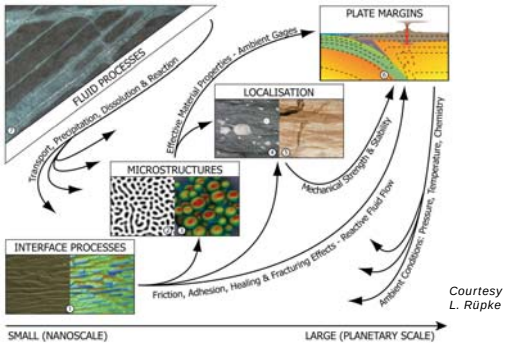
1) Which management options exist for a long-term sustainable fishery?

2) What are the costs and the benefits of different management options from an economic perspective?

3)How can sustainable and efficient management options be implemented in a market economy?

Theme B3 "Seafloor Resources"

Physics of Geological Processes

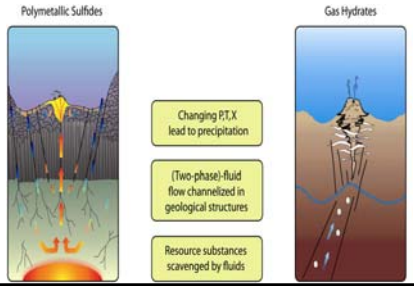


Courtesy L. Rüpke

Theme B3 "Seafloor Resources"

Fluid-Derived Ocean Resources

- Explore the formation of ocean resources
- Link computer sciences with geology
- Conduct applied research with industry collaboration
- Study reactive fluid flow through the Earth's crust



Theme B3 "Seafloor Resources"

petroleum / natural gas | deep sea ore deposits | gas / methane hydrate

Industry interests:

- Structural evolution of passive margins / basins
  - Subsidence, faulting, compaction
- Time-Temperature data
- Multi-phase porous flow
  - Reservoir processes, secondary migration

Research interests:

- Continental rifting
  - transition from rifting to drifting
- Fluid and melt migration through the Earth crust
  - feedbacks on phase transitions, rheology, chemistry

Courtesy L. Rüpke

Theme B3 "Seafloor Resources"

petroleum / natural gas | **deep sea ore deposits** | gas / methane hydrate

Industry interests:

- Deep sea ore deposits
  - which geodynamics settings are favorable
  - predictions

Research interests:

- Explore deep-sea hydrothermal systems
  - link between hydrosphere and solid Earth
- Mid-ocean ridge research
- Reactive transport through the Earth's crust

Theme B3 "Seafloor Resources"

petroleum / natural gas | deep sea ore deposits | **gas / methane hydrate**

Industry interests:

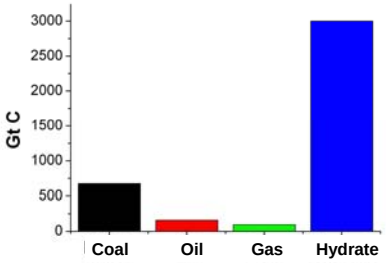
- Gas hydrates as an energy source

Research interests:

- Continental slope processes
- Reactive transport

Theme A5 "CO_2 Sequestration"

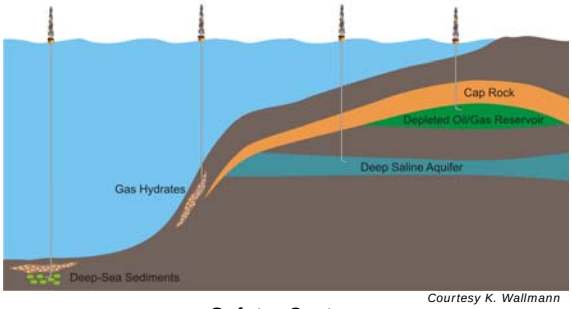
Global Methane Hydrate Inventory



Source: Energy Outlook 2007, Buffett & Archer (2004)
Coal, oil, gas: reserves economically exploitable at current market prices
Gas Hydrates: total marine inventory

Theme A5 "CO_2 Sequestration"

Storage of CO_2 below the Seabed



Courtesy K. Wallmann

Safety, Costs

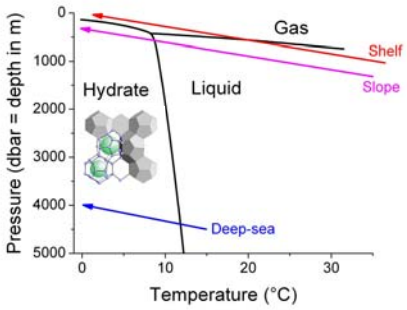
Theme A5 "CO_2 Sequestration"

CO_2-Storage und Methane Hydrate Exploitation

CO_2 →  → Natural Gas

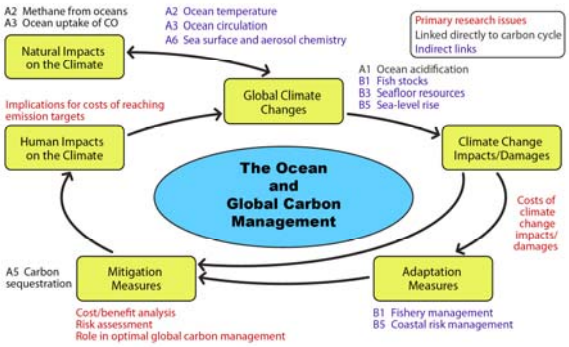
Theme A5 "CO_2 Sequestration"

Phase Diagram of CO_2



Theme A7 "Valuing the Ocean"

The Value of the Ocean for Global Carbon Management



Theme A7 "Valuing the Ocean"

Find Solutions for Optimal Control of CO_2 Emissions and Ocean Sequestration

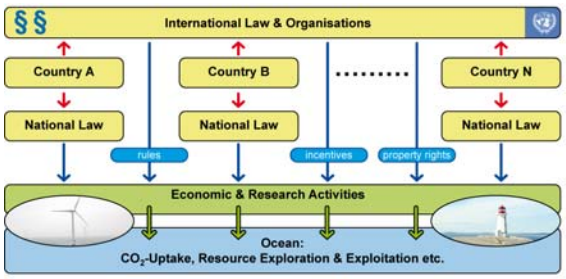
IfW Model			
State variables / Carbon Stocks		Equations of motion	
A	Atmosphere	$\dot{A} = (1-s)(e_c q + e_m \bar{m}) + \beta r(A,M) 1_{r>r(crit)} - o(A, O_U, O_D)$	[1]
O_U	Upper Ocean	$\dot{O}_U = o(A, O_U, O_D) - p(A, O_U, O_D$	[2]
O_D	Deeper Ocean	$\dot{O}_D = p(A, O_U, O_D) + l(S) + r(A,M) 1_{r \le r(crit)}$	[3]
S	Ocean Carbon Storage	$\dot{S} = s(e_c q + e_m m) - l(S)$	[4]
M	Methane Hydrates	$\dot{M} = -m - r(A,M)$	[5]
F	Fossil Reserves	$\dot{F} = -q$	[6]

Variable description	
e_i	emission coefficient for coal i=c and methane i=m
$l(S)$	leakage of sequestered carbon, with $l'(S) > 0$
$r(A,M)$	release of methane due to instability (diffusion or blow-out)
$o(A, O_U, O_D)$	Net carbon exchange with upper ocean, depending on the state of carbon in the atmosphere and in the upper ocean and deeper ocean
$1_{r>0 \le r(crit)}$	Indicator function, if r below critical value, release occurs in form of diffusion, if r above critical value, release occurs in form of blow out
β	conversion factor for methane in CO_2 equivalents
s	share of sequestered carbon
m	mined methane
q	mined fossil reserves

Courtesy M. Rickels

Theme B6 "Law of the Sea and Marine Resources"

„Beyond Mineral Resources - The International Legal Regime and Regulation of New Uses of the Deep Seabed - "



Walther-Schücking-Institute of International Law
Christian-Albrechts-University of Kiel

Common Heritage of Mankind

- The Deep Seabed is regarded the Common Heritage of Mankind
- Not susceptible to claims of national sovereignity
- Exploitation only through the global community of States
- Redistribution of Profits

Courtesy A. Proelß

UNCLOS Framework

- International Sea-Bed Authority
- Administration of Usage
- Redistribution of Profits
  - Royalties in Money
  - Royalties in Kind
- Transfer of Technology
- Modeled with a view to the mining of Manganese Nodules ("mineral" resources)

Theme B6 "Law of the Sea and Marine Resources"

Energy Resources

- Process of Exploitation is Mining and Drilling
- Most likely to fall under current UNCLOS
- Question of Non-State Parties

Courtesy A. Proelß

Genetic Resources & Bio-Prospecting

- Bio-Prospecting
  - Pharmaceutical Application
  - Agricultural Application (*e.g.* Aquaculture)
  - Industrial Application (Biological and Chemical Processes)
- May not fall under UNCLOS
  - No actual extraction of Resources from the Deep Seabed
  - Royalties in kind
  - Royalties in money based on amount taken
- Applicability of idea of redistribution?

CO_2 Sequestration

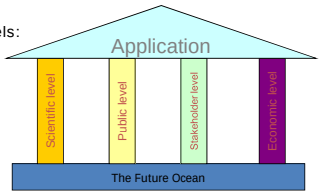
- Does not fall under UNCLOS
  - No exploitation
  - Actual use is for storage
- Legal Problems
  - anti waste dumping laws
  - Precautionary Principle of International Environmental law

Kiel Cluster of Excellence „The Future Ocean"

Transfer to Application

Realized at four different levels:

1. Scientific level
2. Public level
3. Stakeholder level
4. Economic level



maritimes cluster schleswig-holstein

Kiel Cluster of Excellence „The Future Ocean"

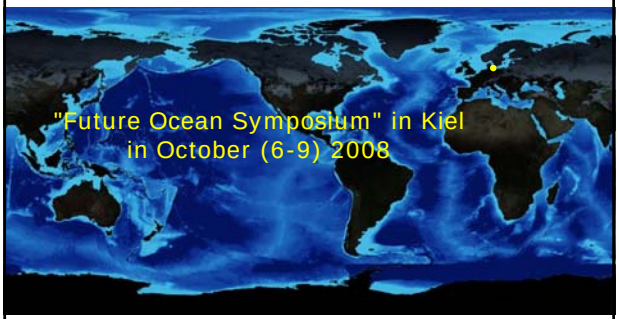
Outreach

Realized by many activities

1. Website (new design)
2. Monthly Newsletter
3. Press Releases
4. Feature Film (in progress)
5. Exhibitions
6. School Programs

www.future-ocean.de
www.ozean-der-zukunft.de

„What Next?



"The Future Ocean Global Research Alliance"