Observations and simulations of a salt water intrusion into the Arkona Sea

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Offshore wind farms

According to a 2002 strategy paper of the German Ministry for Environment, renewable energies will be massively extended in Germany. One of the major generation principles will be wind turbines. Since space on land is already nearly exhausted, offshore wind farms are projected in the German EEZ (North Sea and Baltic Sea). Ecological aspects must be considered. The BSH is responsible for the approvals of erection, operation and use of offshore wind farms. Here, potential ecological impacts of these constructions will be studied.
Ostsee - Deutscher Festlandsockel/Ausschließliche Wirtschaftszone (AWZ)
All problems considered?
Offshore wind farms

Problem as formulated by Uli Lass (IOW) in 2002:

- The foundations of offshore wind turbines could lead to increased entainment of ambient water into medium strength dense bottom plumes flowing through the Arkona Sea.
- This could lead to decreased ventilation of the halocline in the Bornholm Basin and other Baltic Sea basins.
QuantAS Consortium

The international consortium QuantAS (Quantification of water mass transformation processes in the Arkona Sea) has been built to discuss questions of natural and anthropogenic mixing in the Arkona Sea.
QuantAS-Off Project

QuantAS-Off (QuantAS – Impact of Offshore Wind Farms, 2004-2007) will deal with the physical impact of wind turbine foundations.

Cooperation:

- University of Rostock, Fluid Mechanics Institute: small-scale laboratory experiments
- University of Hanover, Fluid Mechanics Institute: small-scale modelling studies
- Baltic Sea Research Institute Warnemünde: Coordination, in-situ observations, regional scale modelling, synthesis

Major aim: Give recommendations where and where not to build offshore wind farms.
Pathway of medium inflows?

Period / duration: \( \approx 5 \times \) per winter for \( \approx 1 \) week

Impact: Ventilation of halocline in Baltic Sea

Graphics by Toralf Heene (IOW)
Simulation with GETM

Idealised simulations with the General Estuarine Transport Model (GETM) are carried out for the Arkona Sea.

Some specifications:
- Background salinity: 8 psu, salinity at inflow: 25 psu.
- Sea level elevated by 2 cm at inflow boundary.
- Constant wind from south-west.
- 1/2 nm horizontal resolution.
- Bottom-fitted general vertical coordinates with 25 layers.
- One month simulation time until quasi-steady state.
Idealised simulation

Bottom salinity after 5 days

Simulation with GETM
Idealised simulation

Bottom salinity after 15 days

Simulation with GETM
Idealised simulation

Bottom salinity after 30 days

Simulation with GETM
Idealised simulation

Surface salinity after 30 days

Simulation with GETM
FWG cruise

From January 26 to February 13, 2004, FWG Kiel organised a research cruise into the Arkona Sea. Luckily, an inflow event occurred during this period.

Accumulated flux over Drogden Sill

Calculated from sea level differences according to Jakobsen et al. [1997]
Observed & simulated plume

South-north section south of Drogden Sill

Observed plume on Feb 1 (salinity)

Simulated plume after 7 days (salinity)
QuantAS: Inflow (observed)

ADCP in the ship's well.
Bottom layer affected by bottom interaction of sound beam side lobes.
Velocity in the plume in excess of 0.5 m/s.

Observations & Graphics by Jürgen Sellschopp & Michaela Knoll (FWG Kiel)
QuantAS: Simulated currents

Plume after 7 days (eastward velocity)

Plume after 7 days (northward velocity)
Observed & simulated plume

South-north section south of Drogden Sill

Observed plume on Feb 2 (salinity)

Simulated plume after 9 days (salinity)
18 hours later the salinity plume arrives at 55° 10' N.
The estimated velocity of the salinity front is 10 cm/s.
The salt water supply has momentarily ceased.
QuantAS: Simulated currents

Plume after 9 days (eastward velocity)

Plume after 9 days (northward velocity)
Observed & simulated plume

South-north section across Kriegers Shoal

- Observed plume on Feb 5 (salinity)
- Simulated plume after 30 days (salinity)
QuantAS: Inflow (observed)

Branches west and north of Krieger's Shoal

Observations & Graphics by Jürgen Sellschopp & Michaela Knoll (FWG Kiel)
QuantAS: Simulated currents

Eastward velocity in quasi-steady state

Northward velocity in quasi-steady state
24-hour station data
Observed & simulated profiles

Position: North of Kriegers Shoal

Observed salinity

Simulated salinity
Observed & simulated profiles

Position: North of Kriegers Shoal

Observed velocity

Simulated velocity
Research Questions

QuantAS tries to answer the following questions:

- Which are the major mixing mechanisms for Baltic Sea inflow events.
- Can we quantify those by combining observations with numerical models?
- Is there extra mixing due to offshore wind turbines? See energy budget calculation.
- How does increased mixing in the Arkona Sea affect the Baltic Sea ecosystem?
- Is additional vertical mixing due to projected offshore wind farms significant?