BENTHIC INVESTIGATIONS ON THE RELATION BETWEEN SHELVES AND BASINS IN THE EASTERN ARCTIC

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Synopsis of research area

It is generally accepted since at least ten years that the Arctic houses very sensitive ecosystems which respond rapidly to global changes but have, in turn, concomitantly a profound effect on the global climate system itself. Furthermore, it is assumed that in this context both the land-ocean interrelationships and the connections between the shelves, slopes and deep basins of the Arctic seas are of special importance.

Therefore, various on-going/pending/planned research projects with German participation directly or indirectly address the physical and/or biogeochemical links between Eurasian shelf seas and the deep Arctic Ocean. They share the common basic assumption that the nature and extent of the interactions between the three major ecological subsystems of polar seas - sea ice, water column, and seabed - determine whether the shelf systems produce excess carbon which is available for export to the deep basins. Hence, the focus of the biological studies of these projects is on the concomitant assessment of the standing stock and production/respiration rates of sea-ice (i.e. sympagic), pelagic and benthic assemblages, as well as of the fluxes and relations between them.

Russian-German cooperation

In this context, one of the most prominent on-going investigations is the bilateral multidisciplinary research project "Russian-German Cooperation: The Laptev Sea System" which was launched in 1993 and is funded by the federal ministries of research and technology. [Similar in approach and content but geographically focussing on the Kara Sea is the Russian-German project "The Nature of Continental Run-Off from the Siberian Rivers and its Behaviour in the Adjacent Arctic Basin" which started in August 2000 after the successful completion of a pilot phase 1997-1999 (ref. Rüdiger Stein, Bremerhaven).] Besides contributing to the efforts to study the global issues related with the land-ocean and shelf-basin interactions, both the Laptev Sea and Kara Sea project also address the severe regional ecological problems which are related, for instance, to the exploitation of hydrocarbon resources and the pollution caused by radioactive fall-out and waste.

The research interests of the Russian and German participants in the Laptev Sea project are manifold. Because of the high ecological importance of the fluvial input of freshwater, sediments, plant nutrients and carbon to the sea, special focus is on the study of the interrelation between the marine shelf and the terrestrial ecosystems of the Siberian coast and hinterland. However, within the frame of a broader perspective, the results have implications for the export of sediments and organic matter, either northward via sea-ice transport or down-slope via density plumes, to the deep Arctic Ocean proper. Since 1993, a total of eight joint expeditions were conducted, the last one in August/September 2000. Taxonomic and zoogeographic issues, as well as the assessment of abundances, biomass, community structures and distribution patterns, have been addressed. In addition, process-oriented studies have been carried out to investigate the sources of organic carbon, its transformation in the water column and its degradation in the benthos. As the Laptev Sea proper is rather shallow, with water depths of up to 50 m at maximum, the interactions between the pelagic realm and the sea floor are very close. The Laptev Sea polynya, a narrow but 1800 km long zone of permanently open water between the fast ice and sea ice, located approximately 200 km north of the Lena delta over the mid-shelf, is of special ecological significance, primarily because pelagic primary production starts there very early (April/May) in the annual cycle. Annual pelagic primary production is rather low, ranging between 7 and 30 g C m^{-2} yr^{-1}. Comparatively high chlorophyll a contents in the sediment hint to a rapid sinking of phytoplankton blooms. Apparently, both pelagic and sea-ice primary production is hardly altered by zooplankton grazing during sedimentation and provides a high-quality food source for the benthos. Regional budgets

of pelagic primary production and zooplankton and benthos consumption indicate that allochthonous organic carbon has to be imported to the Laptev Sea shelf from either terrestrial, sympagic or adjacent marine sources to sustain the standing stocks of secondary producers. In conclusion, though these computations are based on a number of unproven assumptions and, hence, rather crude, the Laptev Sea shelf does not seem to be an important carbon source for the deep Arctic Ocean. It should be noted, however, that some carbon sources, such as terrigenous organic matter or sympagic primary production, are currently not included in these budgets.

Pan-European efforts

A number of European research initiatives focus on the Eurasian fringe of the Arctic Ocean, e.g. the pan-European research project " Arctic Ocean Grand Challenge - Ecology" (AOGC-ECO, submitted to the EU in 1999) which involves participants from Norway, Finland, Germany, the UK, Greece, and Poland. The project includes four work packages (i.e. studies on sea ice, plankton, benthos, as well as modeling). The objectives of the benthic investigations within this research effort are a) to describe and explain spatial differences in diversity and community patterns at different scales in a Eurasian shelf sea and along its continental slopes in relation to water depths, ice cover and productivity, b) to study reactions of different benthic community fractions (micro-organisms to megafauna) to organic input in terms of growth, energy storage, intensity of metabolic processes, and activity patterns such as mobility and bioturbation, and c) to relate these results to the productivity and sediment fluxes in the overlying waters and to build up budgets of energy transfer within the benthic subsystem from experimental and field data (and, thus, to contribute to the modeling of energy flow between the pelagic and benthic subsystems).

The field work concentrates on distribution patterns and processes across the marginal ice zone, especially that of the northern Barents Sea. The basic approach is to integrate complementary studies of various community fractions (micro-, meio-, macro- and megafauna) which are assumed to respond at different spatial and temporal scales to environmental forcing, such as oceanographic processes and the related patterns of benthic-pelagic coupling. Hence, the benthic assemblages can be used as indicators, each integrating over specific time scales, of the variability in the environmental conditions at the sea floor and/or the overlying water column, as well as, ultimately, also of potential global change impacts. A further aim is to describe the seasonality of benthic processes from spring to autumn. Comparative summer field studies will be carried out along a transect from the open waters across the marginal ice zone. The benthos task will also include experimental work on zoobenthos energy metabolism and large-scale community and biogeographical studies. Complementary to this, small-scale investigations will be carried out at a long-term benthic deep-sea station which was established in 1999 at 79° N and 4° E near Svalbard and will progressively grow during the next years (ref. Michael Klages, Bremerhaven).

The AOGC-ECO proposal has unfortunately not been accepted for funding in 2000. However, parts of the workplan are being conducted at a somewhat smaller scale within the framework of on-going national or bilateral cooperations. Currently, there are discussions whether a thoroughly modified proposal should be re-submitted in response to the second call in fall 2001.

Evaluation of current research methods and needs

The research conducted within the projects mentioned above is based on widely used standard benthological methods of sampling and analysis. Experience in the Laptev Sea project has shown, however, that due to methodological problems there are still gaps and uncertainties in our current knowledge, even with respect to basic parameters such as species composition, diversity, abundance and biomass. For instance, the elucidation of species identities and distributions would benefit from the (additional) use of modern methods, such as molecular genetics for taxonomic studies and Geographical Information Systems for biogeographic work. These novel technologies are just beginning to be used in most investigations in the eastern Arctic. The carbon budgets of the Laptev Sea systems mentioned above are only preliminary, as some presumably important sources are not included yet. Therefore, measurements of gross microbial and meiofaunal standing stock (DNA and ATP content of sediment

cores) and respiration (sediment core oxygen consumption) have recently been or are going to be carried out.

Ideas/goals for/of the development of national/international partnerships

The common prime objective stated in the introductory sections of almost each research project launched in the Arctic during the last years is a realistic assessment of the feedback interrelations between the Arctic and the global system. It is clear that this task requires a sound understanding of the physical and biogeochemical connections between Arctic shelves, slopes and basins which are commonly regarded to be crucial in this context. It is also commonplace in the scientific community that the Arctic system actually consists of several regional subsystems, differing in environmental conditions, extent of benthic-pelagic coupling, biological productivity, etc. Hence, a pan-Arctic perspective is needed to adequately tackle the global or large-scale issues addressed and to reach the quite ambitious ultimate research goal.

Naturally, the various European research initiatives focus on the Eurasian fringe of the Arctic Ocean, regionally complementing the American research efforts confined to western Arctic seas. The overall success of all projects - in the sense of eventually being able to draw general conclusions about the shelf-basin processes and their significance for the entire Arctic Ocean and the global climate system - will very much depend on a fruitful cooperation between them. Given the large spatial extent of the "Arctic System" as a whole and its compound composition, collaboration and data exchange would be of mutual benefit, as a broader spatial (and possibly also temporal) coverage of the relevant processes would foster the necessary pan-Arctic perspective.

Such a useful cooperation between the projects can be advanced by a number of measures whose ultimate goal could be to set up a loosely integrated program of spatial and temporal studies of shelf-basin interactions. A sound plan for collaboration of the various on-going and pending projects would foster valid synoptic and comparative analyses of data sampled in different Arctic regions. It would be helpful, for instance, to agree upon the use of standardized methods, possibly compiled in a sort of "handbook of methodologies", or to organize a regular series of joint workshops (for which the biennial SBI international Pan-Arctic meetings provide a useful model).