CROSS-MARGIN EXCHANGES IN THE BENTHIC LAYERS OF ARCTIC SEAS

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1. Introduction

Cross-margin exchanges have a substantial influence in setting up environmental conditions in the Arctic seas. Many of the Arctic seas are shallow so that benthic layers (the zone spanning up to 20 m above the sea bed) occupy larger proportion of the water column than in the deep water. A significant fraction of all shelf transport may occur in the benthic layers, hence they play a greater role in shelf-wide exchange processes. The improvements that occur in our understanding of exchange processes in the benthic layer will also enhance the prospects for success in realistic assessment of the potential responses of Arctic to global change.

A few research projects are run jointly by the University of Plymouth (UK) and Shirshov Institute of Oceanology (Russia). In a broad context the following fundamental aims were posed: (i) To achieve a better understanding of exchange processes within the benthic layer on the outer shelf and continental slope; (ii) To develop specialist 'process models' capable of quantifying and predicting exchange, transformation and storage of materials; (iii) To collect and analyse archived and newly obtained data in the Russian Arctic; (iv) To enhance the quality of prediction of biochemical and sediment fluxes through developing numerical algorithms based on 'process models' for embedding into general circulation models;

The results of this study can be used within the Shelf-Basin Interaction mission by applying the developed methodology to estimate connections between the Arctic shelves and deep basin through exchanges in the benthic layer, and thus contribute to realistic assessment of potential responses of the Arctic system to global change.

2. Research topics in the context of pan-Arctic exchange and needs for further study

Many benthic processes are forced by processes originating within other regions, including the nearshore, the surface layer, the thermo/halocline, and the interior. Thus study of the benthic layer often needs measurements/modelling in these other regions. On the other hand, benthic processes exert influence in these other regions. In the current studies, the shelf exchange is examined on the basis of fundamental principles of fluid dynamics supported by analysis of observational data. The research focuses on three key processes, influential in cross-shelf exchanges: mesoscale eddies, dense water cascades, and internal waves.

Meso-scale physical and biogeochemical processes in coastal waters of the Russian Arctic.
The aims of this study are to quantify meso-scale physical and biogeochemical processes in immediate coastal waters of the White and Barents Seas and to assess environmental impact of these processes. Main specific objectives include collation of existing observations of physical, chemical and biological conditions in the White and southern Barents Seas; and investigation into physical and biogeochemical processes, governing the material fluxes in the study area.

The observations in the Pechora Sea (South Western Barents) in August 1988 revealed that high intensity internal waves (IW) contribute to both vertical and horizontal mixing in the area of strong thermocline (Shapiro et al, 2000). It is believed that internal waves originate in the deep

water and at the shelf break and then transport their energy onshore. While entering shallower waters, IW increase their amplitude.

Most intense internal bores and packets of internal solitons were identified in the shallow southern area. In the deeper north-western part of the Sea, the SPM profiles featured a maximum just above the thermocline that is typical for the Arctic waters. On the contrary, the vertical profiles in the shallow area were rather smooth with max/min ratio as small as 1.6 as compared to 6.5 in deeper waters. It was found that intense the vertical mixing in this area was generated by braking IW rather than storm events. Estimated oscillatory current velocity in the benthic layer were high enough and may have contributed to re-suspension of fine grained sediment and the increase of the SPM concentration within the neopheloid layer. Figure 1 shows the effect of IW on the vertical mixing of suspended matter and temperature distributions. There are very limited observations of IW in the Arctic. New field observations are necessary to identify the significance of the above process in the pan-Arctic context.

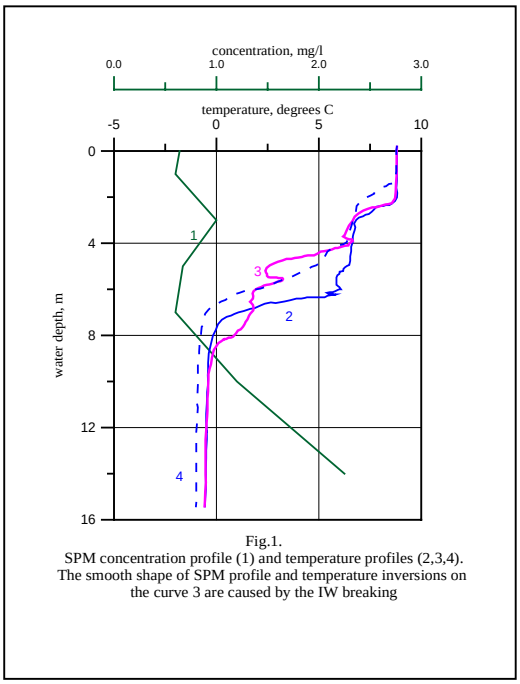

Fig.1.
SPM concentration profile (1) and temperature profiles (2,3,4).
The smooth shape of SPM profile and temperature inversions on the curve 3 are caused by the IW breaking

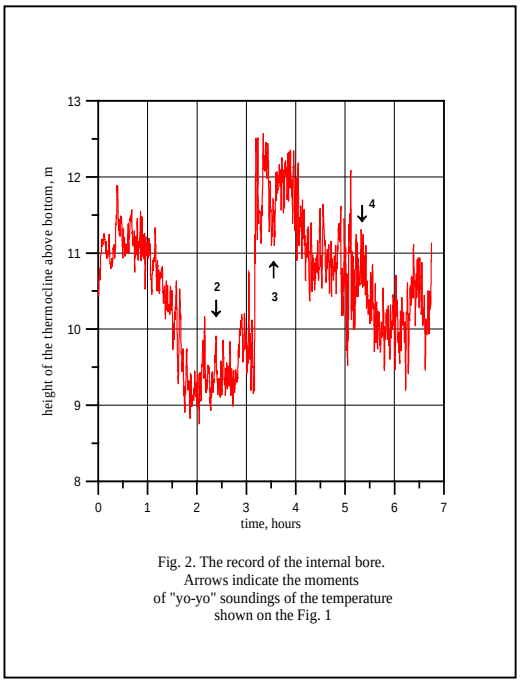

Fig. 2. The record of the internal bore.
Arrows indicate the moments
of "yo-yo" soundings of the temperature
shown on the Fig. 1

Dense water overflows off continental shelves (cascading).

Dense water overflows from Arctic shelves are believed to be important in the formation of Arctic Ocean (salinity) stratification and hence climate. From all Arctic shelves, the flux of cold saline water into the polar basin is estimated as 2.5 Sv (Aagaard et al. 1981). Evidence of cascading at the East-Siberian and Laptev Sea slopes (typical shapes of isopycnal surfaces) were reported by Golovin and Polyakov and in the Chukchi Sea by Weingartner et. al (1998). The "Cascading" project aims to improve understanding and modelling of dense water overflows from continental shelves into deep waters, as a meso-scale process, using observations and models. It was found that general purpose models do not do well over complex topography and specialist models, in particular related to sediment transport, are necessary. The specialist models (Shapiro and Hill,1997, Hill et al, 1998) did well on the European continental slope. However they need further development for Arctic conditions (canyons, ice cover).

Sediment transport by mesoscale eddies.
Mesoscale eddies were found an important mechanism in re-distribution of sediment off Northern California (Washburn et al, 1993), in the Mediterranean Sea (Evans et al, 1995) and on the Black Sea shelf (Shapiro et al, 2000). The presence of numerous mesoscale eddies in the Arctic implies that they may contribute significantly to cross-margin material transport. However further observational and modelling studies are necessary to estimate relative importance of this mechanism over the basin scale.

3. Development of national and international partnership.

As there is expertise in the above areas in more than one country, the international partnership will bring extra strength and value to the study of Shelf-Basin exchanges. I see the potential collaboration particularly helpful in the following areas.

- Process –oriented analysis of archived observational data (USA, Russia, Germany)
- Study of sediment redistribution by intensive internal waves (USA, UK, Russia)
- Cross-shore sediment transport by long-lived eddies (UK, USA)
- Dense water cascades in the Arctic environment (USA, Russia, Germany, UK)

I also think that the great level of expertise gained in the course of Land-Ocean Interaction Study (UK, 1992-1998) can be partially transferred to the Arctic region.

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