Laboratory Benchmark for Models of the Transport in the Kara Sea

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LONG-TERM GOAL

Our long-term goal is to provide a well-controlled laboratory benchmark for the development and validation of numerical models of shelf-sea transports.

OBJECTIVES

Our objectives are to combine available field data and laboratory model results to provide a consistent description of the transport and spreading of water masses and contaminants in the Kara Sea, and to make the laboratory results accessible in the form of electronic data files for the scientific community.

APPROACH

The dynamics of the ocean circulation in a small-scale topographical model of the eastern Barents and Kara seas are simulated in a 5-m diameter rotating laboratory basin, fulfilling Froude-Rossby similitude. A map of the model domain is shown in Figure 1. The ocean circulation is obtained by forcing the inflows of various water masses. A weak tidal excitation simulates the background circulation driven by the tides in the absence of and in conjunction with the through-flows. Surface outflows are directed to the northern Barents Sea and the Vil'kitsky Strait to the east, and deeper outflows are directed to the Arctic Ocean in the north. Late summer field measurements from the Kara Sea, obtained by NRL-SSC and FFI (Norwegian Defense Research Establishment) during 1993-1996, together with preliminary laboratory simulations of the transport processes are available from the ANWAP program. The present work is a follow-on study to simulate the events from 1991-1995, using a tracer in the coastal water inflow and particles to study the transport times through and around the Kara Sea. The forcing conditions and the responses are documented as data files for use in numerical model studies.

WORK COMPLETED

A five-year simulation of the circulation in the Kara Sea was run for climatic monthly inflows of modified Atlantic Water, coastal water and polar water, and measured monthly averaged inflows of river discharges. Data files have been prepared for public use.

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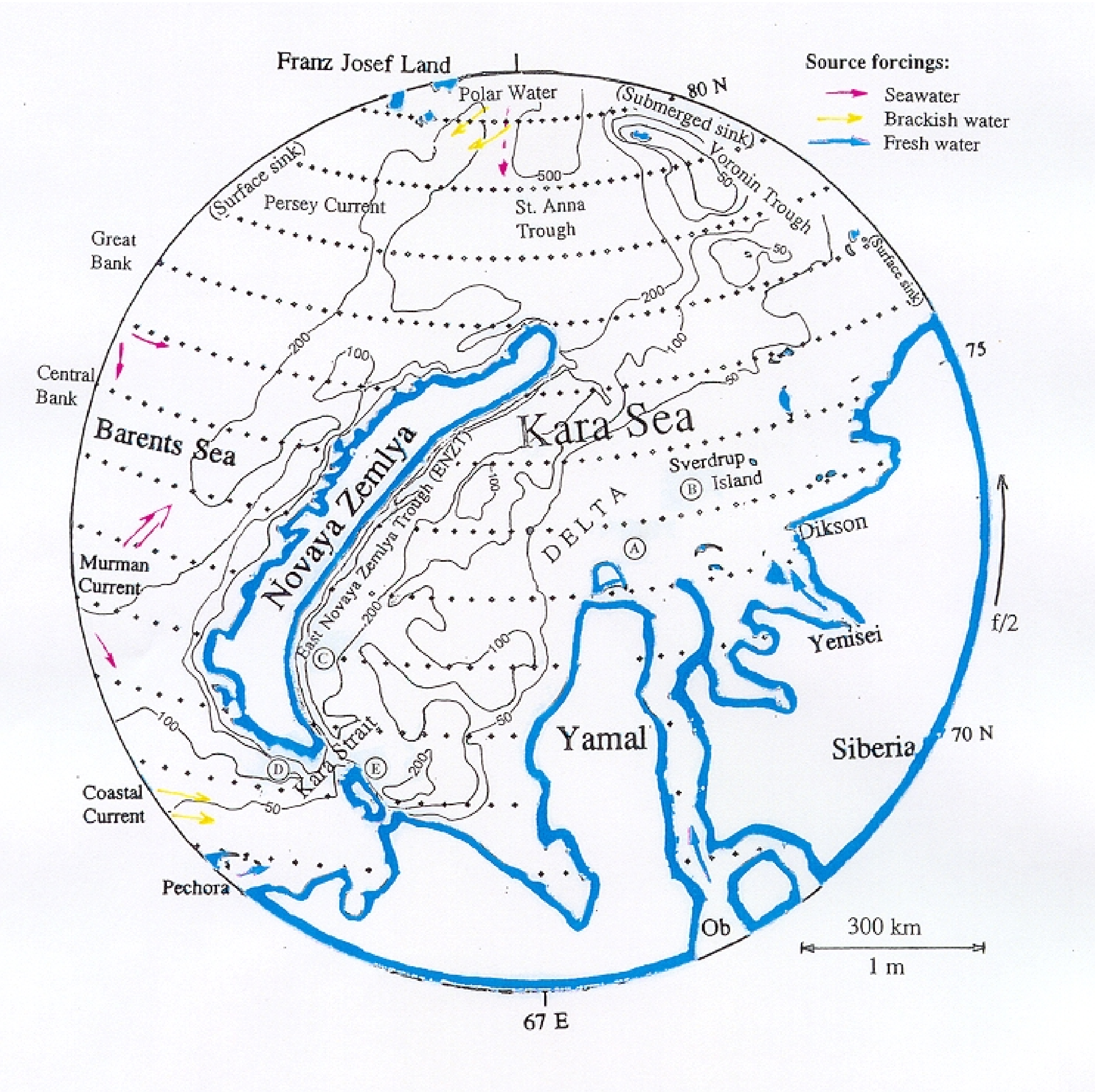

Figure 1. The laboratory domain (UTM 67 projection) with sources and sinks noted.

RESULTS

Weak tidal excitation, without inflows (or wind) produce a weak anticyclonic circulation on the river delta to the north of the major estuaries in the Kara Sea, and a significant outflow in the northern portion of the Kara Strait (Litke Current). With inflow forcings, these circulations are enhanced. Most of the flow of coastal water from the Barents Sea flows outside the Kara Sea, to the west and north of Novaya Zemlya, reaching the Voronin Trough within about 8 months. The coastal water that flows east through the Kara Strait follows the tortuous topography through the Kara Sea. Some of this is entrained to the river plumes in the estuaries, while most of it flows along the slope, reaching the Voronin Trough within about 2 years.

The river water flows first to the northwest toward the delta slope, and then to the northeast toward Voronin Trough. Residence times for the water masses in the deep East Novaya Zemlya Trough are long. Some results from the laboratory simulations are shown in Figure 2. These results are documented digitally by particle traces, Eulerian velocity fields and by the time development of tracer and salinity fields in chosen sections.

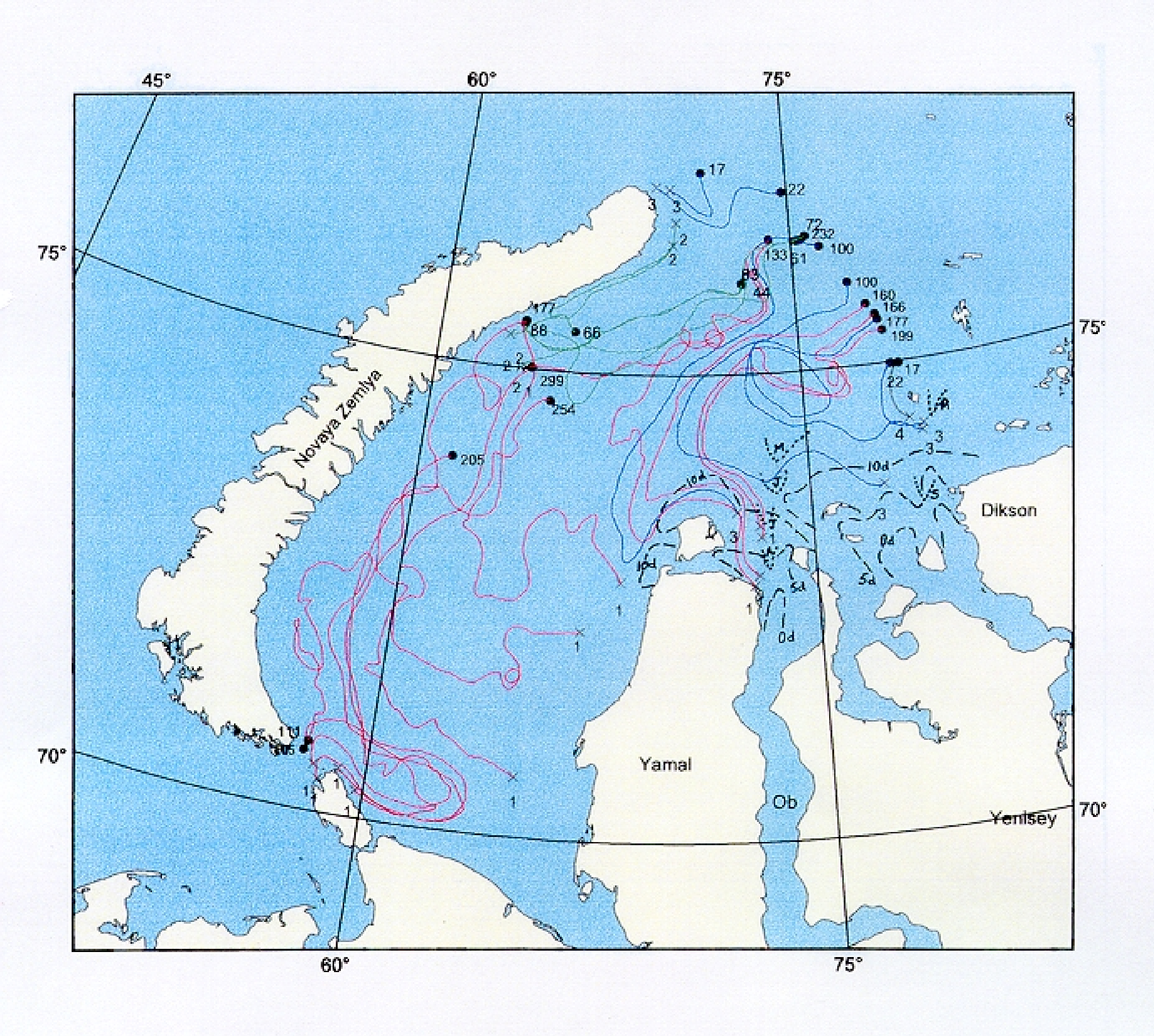

Figure 2. Color traces show surface particle paths from the laboratory model simulation. Here, the initial particle position is a cross, where the season is noted (1 = spring, etc.), and the number by the dot at the end of the path gives the number of days of travel. The outflows of color fronts from the rivers are shown with dashed lines, where the numbers of days of travel are noted. The simulated compensation flow of slope water, originating at the 50 m isobath directly north of Yamal in January is shown by dotted lines where the letters refer to the months (M = May, etc.).

IMPACT/APPLICATIONs

The results demonstrate, by means of a well-controlled alternative reality without wind forcing, the synoptic transport fields over several years. This has proven to be valuable for interpreting the available, sparse field data and is expected to help in the development of relevant and useful numerical models of the region, as well as similar shelf seas.

TRANSITIONS

The results show the most robust transport features and give a basis for choosing more reliable locations for monitoring the transport of water masses and contaminants. With the present climate, these waters are ice-covered most of the year. Monitoring the transports of the surface waters can thus in principle be done with satellite SAR data, using PIPS to account for local wind effects. There are, however, no concrete plans yet to use this approach for monitoring.

RELATED PROJECTS

ANWAP was the first phase of the laboratory studies and field work, to find the transport routes for potentially dangerous discharges of radioactive contaminants in the region. The Royal Norwegian departments of Foreign Affairs and Environment supported this and their newer project "Transport in the North". The results from these projects are quite complementary, and are still being prepared for publications. The present results can serve projects in at least two of ONR's program areas: High Latitude Dynamics and Ocean Modeling and Prediction. There are also several environmental studies connected to AMAP which can use the results of the present research.

PUBLICATIONS

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