Coastal erosion vs riverine sediment discharge in the Arctic Shelf seas

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Abstract This article presents a comparison of sediment input by rivers and by coastal erosion into both the Laptev Sea and the Canadian Beaufort Sea (CBS). New data on coastal erosion in the Laptev Sea, which are based on field measurements and remote sensing information, and existing data on coastal erosion in the CBS as well as riverine sediment discharge into both the Laptev Sea and the CBS are included. Strong regional differences in the percentages of coastal erosion and riverine sediment supply are observed. The CBS is dominated by the riverine sediment discharge (64.45×10^6 t a^-1) mainly of the Mackenzie River, which is the largest single source of sediments in the Arctic. Riverine sediment discharge into the Laptev Sea amounts to 24.10×10^6 t a^-1, more than 70% of which are related to the Lena River. In comparison with the CBS, the Laptev Sea coast on average delivers approximately twice as much sediment mass per kilometer, a result of higher erosion rates due to higher cliffs and seasonal ice melting. In the Laptev Sea sediment input by coastal erosion (58.4×10^6 t a^-1) is therefore more important than in the CBS and the ratio between riverine and coastal sediment input amounts to 0.4. Coastal erosion supplying 5.6×10^6 t a^-1 is less significant for the sediment budget of the CBS where riverine sediment discharge exceeds coastal sediment input by a factor of ca. 10.

Keywords Laptev Sea · Beaufort Sea · Coastal erosion · Fluvial sediment discharge · Sediment budget

Introduction

Shore dynamics directly reflecting the complicated land–ocean interactions play an important role in the balance of sediments, organic carbon, and nutrients in the Arctic Basin. Formerly the rivers were considered as the main suppliers of sediments into the World Ocean. With respect to the Arctic coast of Russia this opinion was already questioned by Suzdalsky (1974), who came to the conclusion that river sediment transport and coastal erosion input of sediments into White, Barents, and Kara seas were of the same order of magnitude. A decade later Shuisky (1983) concluded that coastal erosion supplied as much sediment into the World Ocean as the rivers to their mouths. The results of more recent investigations, however, showed pronounced regional differences in the ratio between riverine and coastal erosion sediment input. Thus, Are (1999) suggested that the amount of sediment supplied to the Laptev Sea by rivers and shores was at least of the same order, but that the coastal erosion input was probably much larger than the input...
of the rivers. Reimnitz et al. (1988) made calculations for 344 km of Alaska coast in the Colville River area. They found that coastal erosion here supplied seven times more sediments to the Alaskan Beaufort Sea than rivers. In the Canadian Beaufort Sea (CBS), on the other hand, the Mackenzie River input is the dominant source of sediments (MacDonald et al. 1998).

In this article we present new data on coastal erosion sediment input into the Laptev Sea and summarize the available data on riverine and coastal sediment input into the CBS and the Laptev Sea. In order to demonstrate the significance of coastal erosion for the sediment budget, a comparison between riverine and coastal sediment input into different Arctic seas is given.

Laptev Sea

The Laptev Sea is strongly influenced by continental runoff (Fig. 1). The main portion of water and sediment is transported through the Lena River, which is the second largest river in Russia and the eighth largest in the world in terms of water discharge (Milliman and Meade 1983). Due to the extreme continental climate of East Siberia (winter temperatures of −45 to −50° and summer temperatures of +30 to +35°), the water discharge of the Lena River exhibits strong seasonal variations. The surface waters are frozen each year from October to May. The river-ice breakup in spring proceeds from South to North starting in the beginning of May in the southern part of the Lena Basin and reaching the delta around 15–20 June in average years. The daily water discharge exceeds 100,000 m³ s⁻¹ during spring flood in June and decreases to less than 2000 m³ s⁻¹ during April (Rachhold et al. 1996).

The Laptev Sea is the region with the highest net-ice production rates in the Arctic Ocean and an important source region of the Transpolar Ice Drift system (Rigor and Colony 1997). Sea-ice formation is closely linked to freshwater discharge, mainly of the Lena River (Dmitrenko et al. 1998, 1999). A large-scale dynamic-thermodynamic sea-ice model has shown that the total net export of sea ice during winter (October to May) ranges between 3 and 7×10⁹ km² (Kassens et al. 1998). Ice export from the Laptev Sea is of great importance for sedimentary

![Fig. 1 Geographic location of the Laptev Sea. Key sites are indicated by dots](image)