SECOND INTERNATIONAL CONFERENCE ON
PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS
UNIVERSITY OF ICELAND
DEPARTMENT OF ENGINEERING AND SCIENCE

CHANGES OCCURRING IN THE OCEANIC PORTION OF THE COLVILLE RIVER DELTA, ALASKA DURING SPRING FLOODING

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INTRODUCTION

Rivers which originiate outside the Arctic, e.g., the MacKenzie and the Yenisey, continue to flow during winter even though their surface waters are frozen. They contribute sediment-carrying water to the ocean throughout the year. In contrast, rivers which have their entire drainage basin within the zone of continuous permafrost virtually cease flow during winter. Thus, for a period of several months, no fresh water and no river transported sediment is added to the ocean.[1, 3] The Colville River (Fig.1), the longest river in arctic Alaska, is this type.

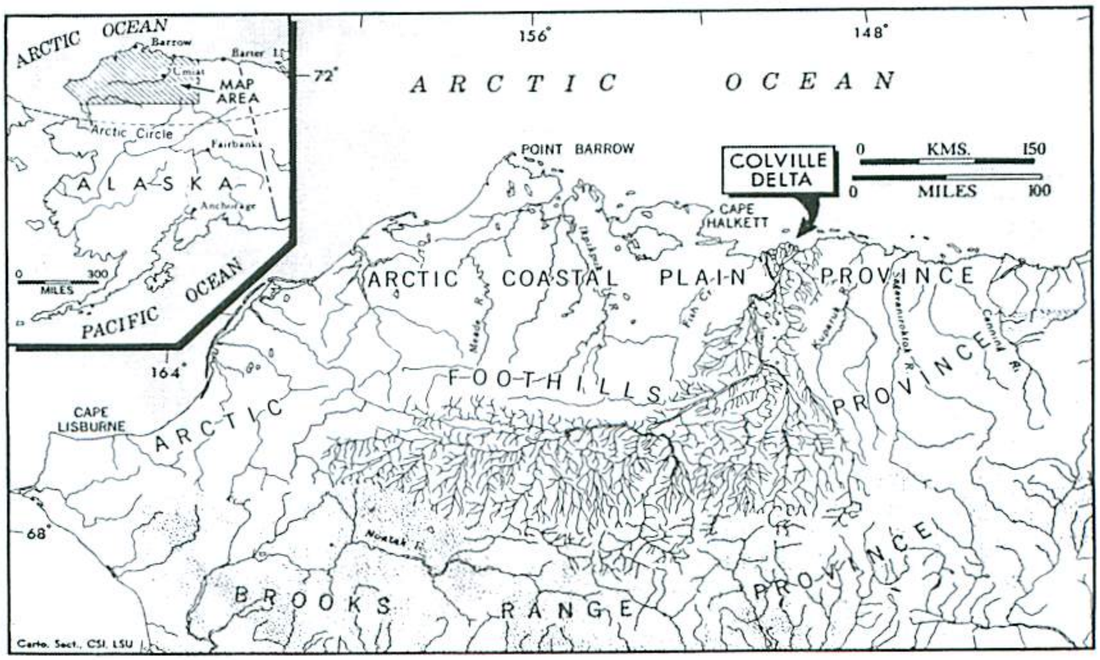

Fig. 1. Location map showing the Colville River and delta.

During 1971 and 1973 the effect of snowmelt, runoff and breakup on the oceanic portion of the Colville delta was investigated. With the aid of a helicopter it was possible to establish stations on the sea ice at the front of the delta during the flooding period and thus to monitor the flow of river water as it progressed seaward both over and under the sea ice.

METHODS

In 1971, 44 stations were established at 27 locations along three lines which extended seaward from the delta front.[4] The number of lines was doubled and the number of stations occupied was increased to over 150 during the 1973 season (Fig. 2). At each station a hole was drilled through the

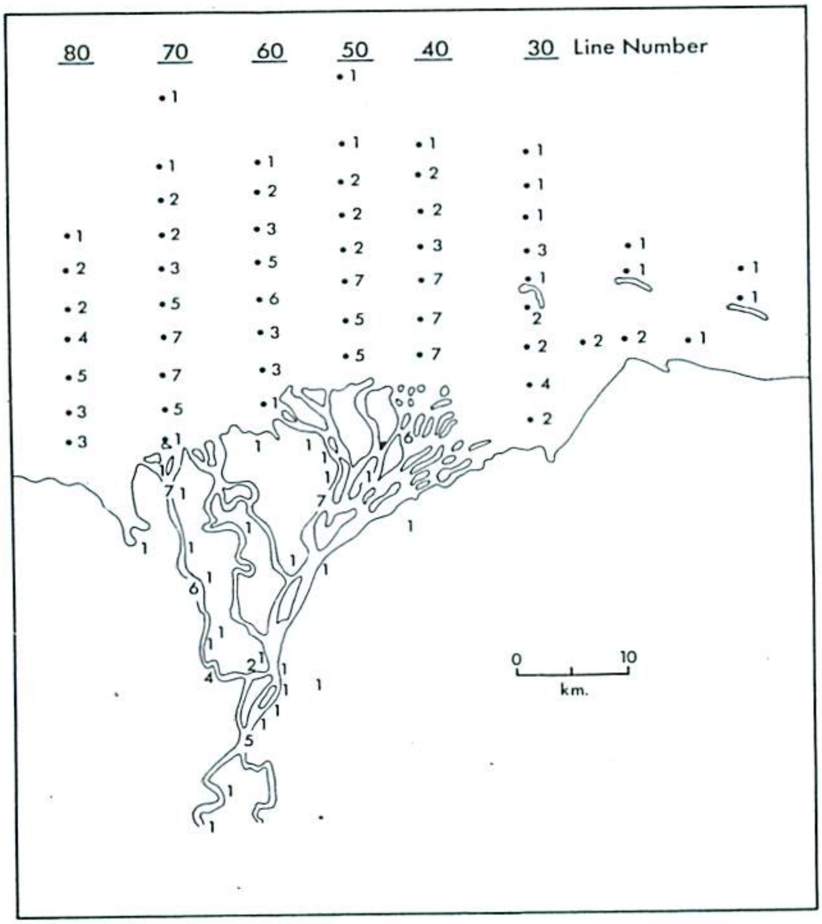

Fig. 2. Station location and number of occupations at each site during the 1973 field season, Colville River delta, Alaska.

2.0 - 3.0 meter-thick ice cover; in 1971 with a Sipre corer and in 1973 with a Hoffco power ice drill. During both seasons salinity and conductivity were measured at equal intervals in the water beneath the ice with a Beckman portable salinometer, Model RS5. In 1973 temperatures to 0.1° C were also recorded. In addition, in 1973 water samples, obtained from selected depths, were analyzed for suspended load by filtering, drying and weighing at the base camp in the delta.

SNOWMELT, RUNOFF AND BREAKUP

Prior to the initiation of snowmelt, the subaqueous portion of the delta is characterized by: (1) a band of bottomfast ice out from the delta front to a depth of approximately 2 meters; (2) a 2.0 to 3.0 meter ice cover seaward of the bottomfast ice; (3) hypersaline water in unfrozen pockets within the zone of bottomfast ice and in the channels near the front of the delta; (4) seawater of normal salinity seaward of the bottomfast ice (Fig. 3) and (5) a minimal amount of hydrologic, oceanographic and morphologic activity.

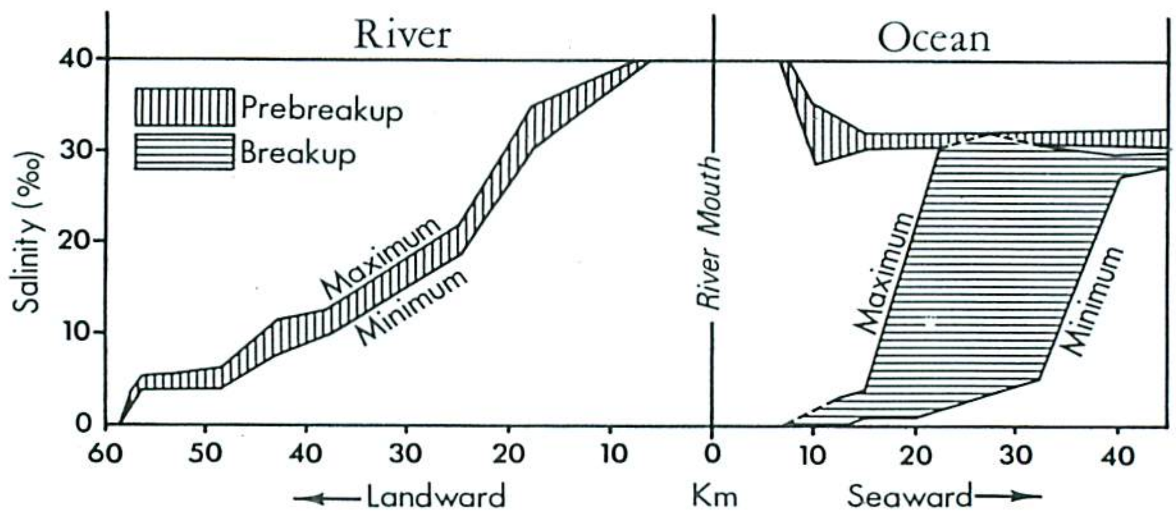

Fig. 3. Salinity changes in the Colville River delta, 1971.

In the Colville River, meltwater begins to accumulate on the river ice during the middle of May and shortly thereafter flows downstream on top of the bottomfast ice and beneath the floating ice. During this initial flow, the thawed portion of the active layer is thin or nonexistent. The frozen ground beneath prevents infiltration, and large quantities of meltwater flow to the numerous tributaries in the drainage basin (Fig. 1). The stage (Fig. 4) increases rapidly after downstream flow begins. Variation in quantity and timing are largely dependent on the amount of snow which has accumulated in the drainage basin and the rate at which it melts. Several years of observation in the Colville delta show that ice movement may occur just prior to, during or just after maximum stage is reached.[7]

At maximum stage floodwater covers river bars, mudflats, some of the low-lying tundra polygons and vast areas of the sea ice at the front of the delta. In 1971 404 square kilometers (65 percent) of the subaerial delta and 630 square kilometers of sea ice were flooded.[4] The water which flowed over the sea ice drained through moulins[2] and pressure ridge cracks, both of which were numerous near the outer limit of sea ice flooding (Fig. 5). Sediment

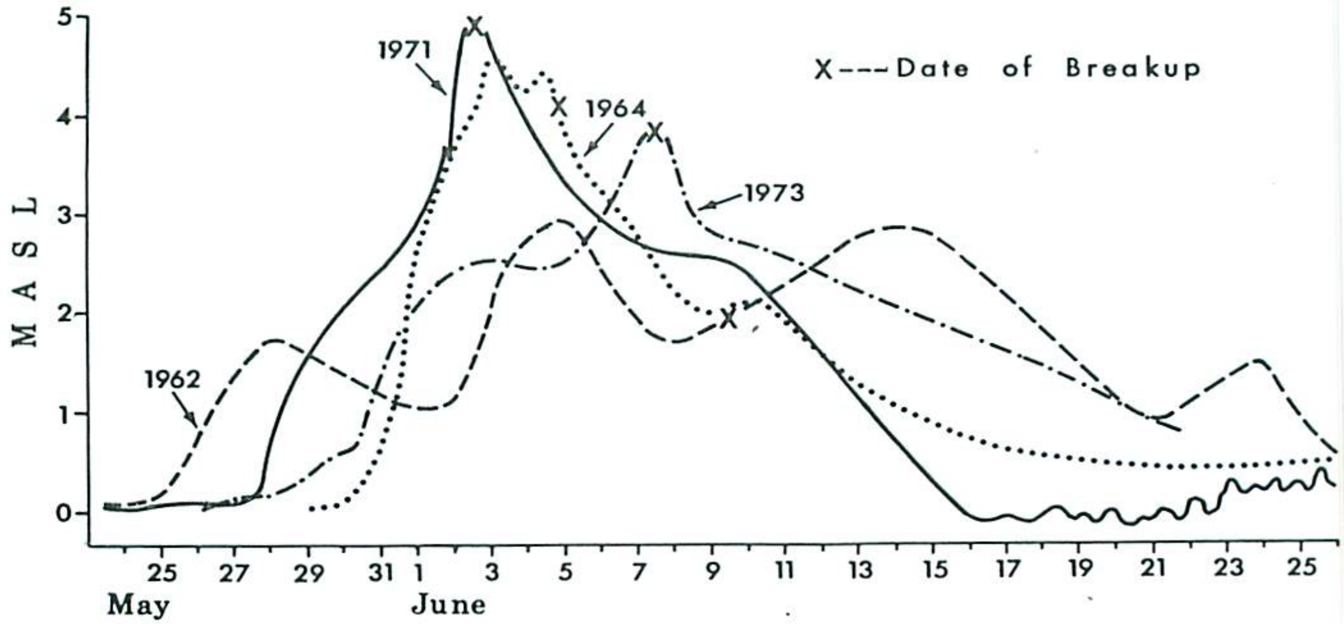

Fig. 4. Stage and breakup, selected years, Colville River delta.

deposited on the sea ice in 1971 ranged in thickness up to 17 cm.

Following removal of the ice from the distributaries the stage drops rapidly, although generally not so rapidly as it rises prior to the initiation of ice movement (Fig. 4). The total flood period usually averages about 3 weeks.[7]

SALINITY AND TEMPERATURE CHANGES DURING FLOODING

Floodwater has at least four characteristics which contrast with the winter water present in the subaqueous portion of the delta, namely: higher temperature, lower salinity, more suspended organic and inorganic matter and continuous flow. All four are very important in the modifications which occur in spring in the subaqueous portion of the delta.

The first water to accumulate on the ice of the delta is fresh. However, at about the time a noticeable flow downstream begins over the ice of the distributaries sufficient fracturing has occurred so that surface floodwater and sub-ice saline water begin to mix. As flood discharge increases the winter water of the channels is flushed seaward. Complete flushing of seawater from the deltas distributaries occurs within a couple of days after flooding begins. As in the case of the distributaries, the saline water beneath the sea ice is progressively replaced by floodwater.[6]

The Floodwater-Seawater Interface

The floodwater advances seaward as a wedge beneath the bottom of the sea ice.[5] The floodwater-seawater interface is a narrow transition zone that deepens and advances as flooding continues (Fig. 6). In 1973 the leading

Fig. 5. Contact between flooded and non-flooded sea ice, 8 kilometers offshore, Colville River delta, 1971. The sediment on the sea ice to the left was deposited as the floodwater drained through the moulin in the center of the photo.

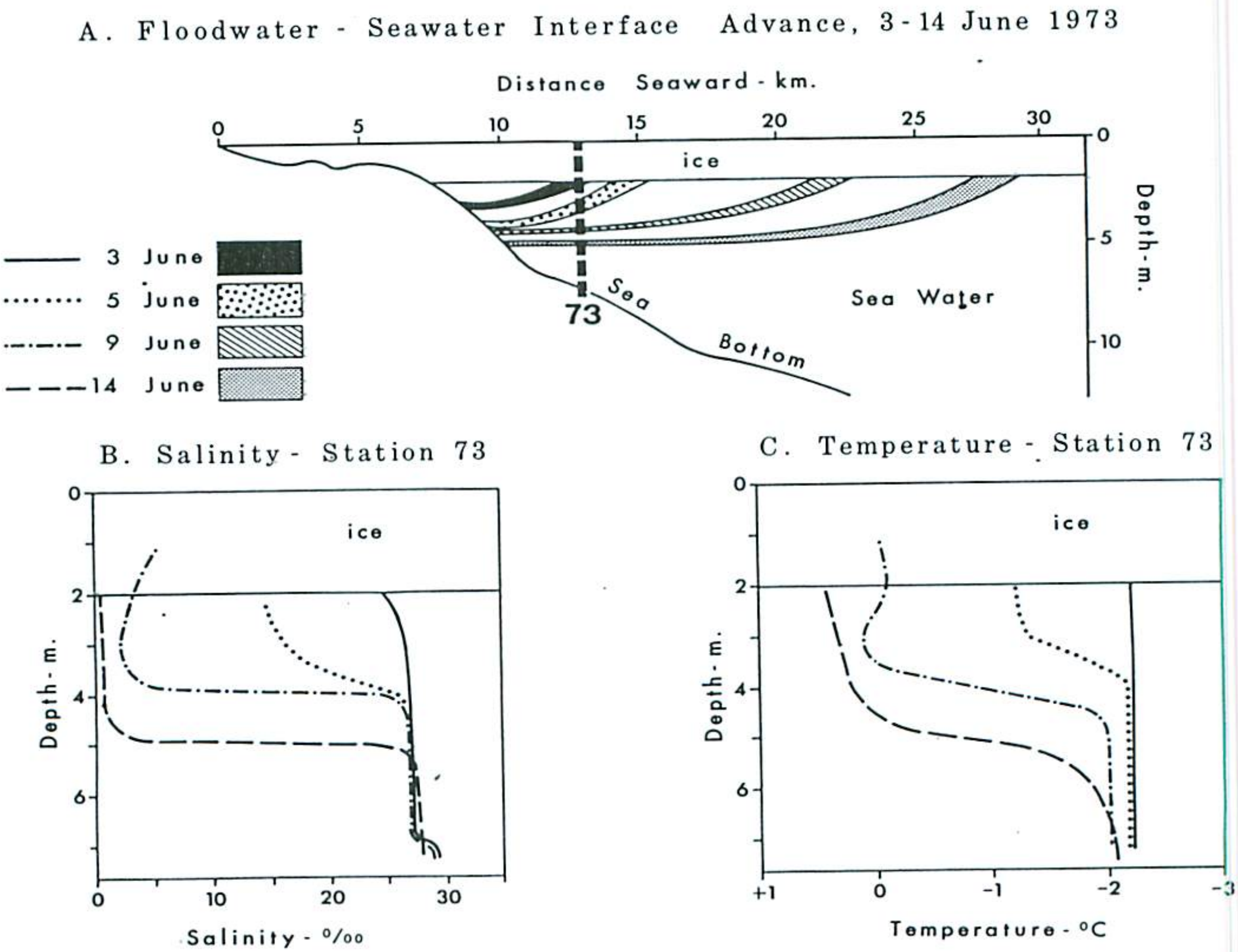

Fig. 6. Characteristics of the interface, Colville River delta, 1973.

edge of this interface had reached a distance of about 13 kilometers along Section 70 by 3 June. Eleven days later it had reached nearly 30 kilometers seaward. Vertical development did not progress as rapidly. For example, during the same period of time the wedge contact at the bottom only advanced about 3 kilometers (Fig. 6A).

Variations in the interface are reflected in the salinity and temperature profiles (Fig 6B and C). These two profiles are basically the same and show that the vertical column of water during preflood conditions was homogenous. Temperature, at -2.15°C, and salinity, at 27 ‰ (parts per thousand), were uniform. On 3 June the salinity profile shows that the first floodwater had reached that location. By 5 June mixing of the surface water had reduced salinity and raised temperature slightly in the upper 2 meters of the water column. By 9 June the mixed water had been removed and the interface narrowed. Quite fresh, warm water prevailed in the upper 2 meters. This narrowing of the interface was further accentuated by 14 June. Relatively little change occurred in either salinity or temperature in the water beneath the interface (Fig. 6B and C).

THE FLOODWATER WEDGE AND DISCHARGE

The sharpness of the floodwater-seawater interface and the fact that no freshwater exists in the subaqueous portion of the delta at the time flooding begins permit the calculation of river discharge during breakup. Discharge at any particular time during flooding will equal the amount of freshwater in the system plus any floodwater lost to the system by tidal or longshore currents minus that freshwater added from the melting of sea ice and the snow on top of the sea ice. In 1971, after 10 days of flooding, an area of the ocean nearly 3,000 square kilometers in area seaward of the delta was occupied by floodwater. The amount of floodwater present was 4.64×10^9 cubic meters which represented over 80 percent of the total flood discharge and nearly half of the total annual discharge for 1971.[4]

CHANGES IN SUSPENDED LOAD

At the same time the floodwater is bringing about changes in salinity and temperature it is adding both organic and inorganic material from the basin to the deltaic system. The leading edge of the advancing wedge has a relatively small amount of suspended material but as the wedge develops the quantity of sediment increases (Fig. 7).

Although the wedge advances with relatively little effect on the temperature and salinity of the seawater beneath the interface the same is not true of the suspended load. Samples collected from above, in and below the interface provide data for vertical profiles of material in suspension. For

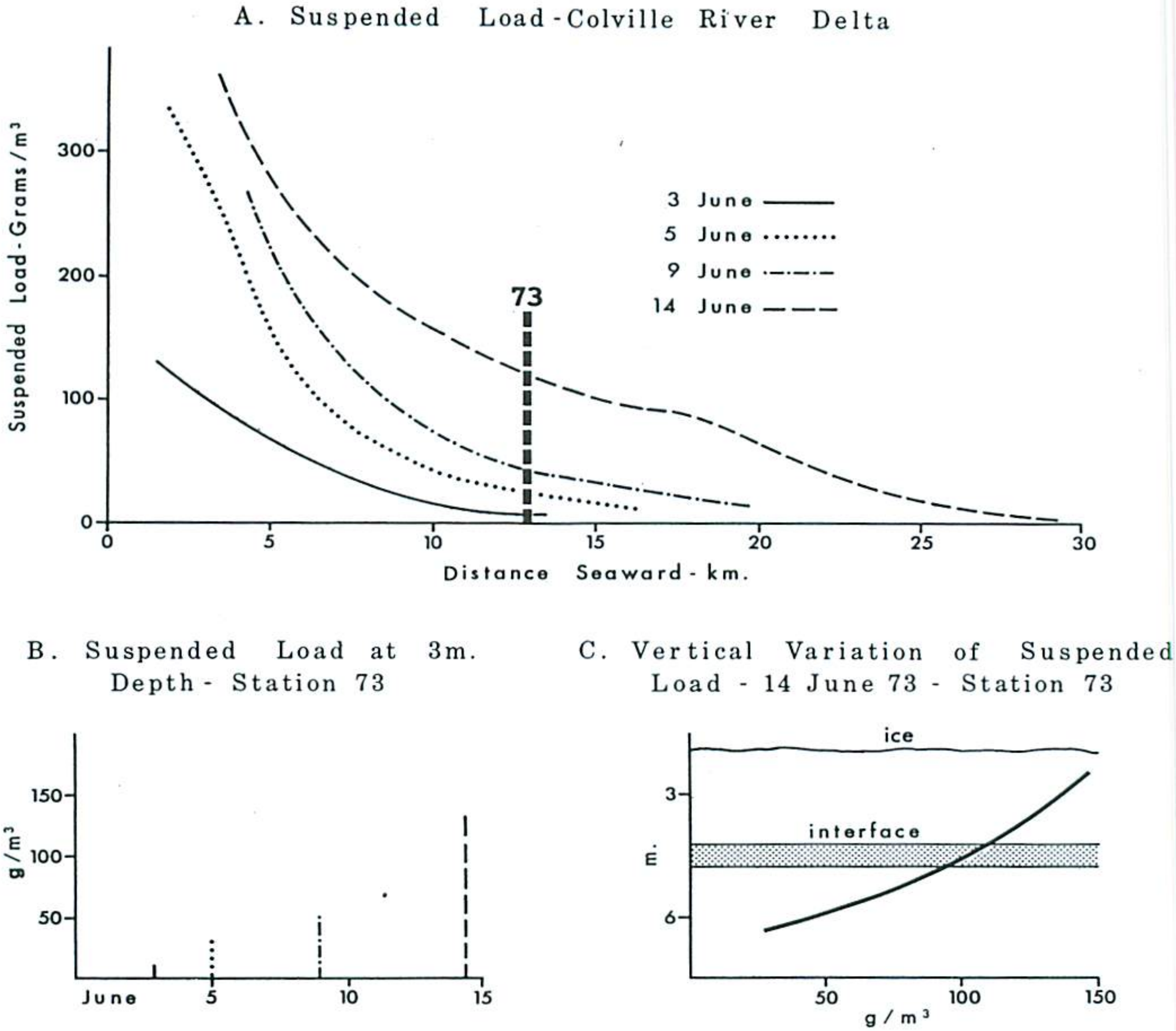

Fig. 7. Suspended load and flooding, Colville River delta, 1973.

example, at Station 73 on 14 June the quantity of suspended matter in the seawater at a depth of 6 meters (1.5 meters below the interface) was about one-third that in the floodwater at 3 meters (1.5 meters above the interface) (Fig. 7C).

One of the objectives of the present study is the determination of areal distribution of sedimentation in the Colville River delta. At the time this paper was being written data collected in May and June 1973 were being processed by computer for this purpose.

SUMMARY

The seawater which accumulates beneath the sea ice at the front of the Colville River delta during winter is replaced by fresh but turbid water during the flooding accompanying breakup. The wedge that initially forms is

very distinct and the floodwater within it has relatively little influence on the salinity and temperature of the seawater beneath the interface. Data show, however, that the suspended material transported seaward in the wedge settles through the interface and the seawater beneath the interface to be deposited on the bottom.

ACKNOWLEDGEMENTS

The research reported here was supported by the Arctic Program and Geography Programs, Office of Naval Research, under Contract N00014-69-A 0211-0003, Project NR 388 002, with Coastal Studies Institute, Louisiana State University. Logistic support was provided by the Naval Arctic Research Laboratory, Barrow, Alaska.

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