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The use of optical properties of sea water for distinguishing water-masses along the Netherlands coast

by

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Summary

During a cruise in January-February 1967 in the southern North Sea off the Netherlands coast the relationship between natural fluorescence and salinity was found to vary in a systematical way when proceeding from the south to the north. The same appeared to be true for the relationship between the difference in attenuation coefficient for blue and for red light and salinity. These variations could be interpreted by assuming the existence of three different water-masses formed by mixing of water from the English Channel with, respectively, water from the Scheldt river, water from the Rhine and Meuse rivers, and water from the Wadden Sea. The location of these different water-masses and of their respective transition zones could thus be estimated.

Introduction

One of the main objectives of oceanographical investigations in the Southern Bight of the North Sea is to obtain information on the way of mixing of "fresh" water originating from the various rivers with the water having entered from the English Channel.

Most of the "fresh" water flowing from the continent into this sea area comes from the Rhine but also the Meuse and Scheldt rivers contribute their share as well as the IJsel lake, the water of which enters the North Sea via the Wadden Sea.

At any location at sea the fraction of the water that has come from these sources can be derived from the salinity as compared with that of the Channel Water. Salinity values alone, however, cannot tell us from which of the above mentioned sources the water has come. In the following communication the possibility to use optical characteristics for the determination of the relative contributions of the various sources to the water at different locations will be pointed out. It appeared to be possible, at least under certain conditions, to use with success the natural fluorescence of the water and the difference between the attenuation coefficients for blue and for red light.

Observations and results

The observations to be discussed were made during a cruise with the fisheries research vessel "Willem Beukelsz" from January 30 to February 3, 1967 in the area between the Netherlands-Belgian frontier and the island of Terschelling. The natural fluorescence was measured with a Turner fluorometer model 111 and expressed in mFl, the unit defined by Kalle (D.Hydr.Zeitschr. 16:153-166(1963)). The attenuation coefficients were measured with a beam transmittance meter and expressed as (decadic) coefficients relative to the clearest water encountered. The difference between the attenuation coefficients for blue and red light can be considered to be a measure of the concentration of "yellow substance".

The stations in the southern part of the region investigated near the entrance of the Scheldt estuary appeared to have a different fluorescence salinity relation as compared with the stations in the central and northern parts. It was assumed that this indicated the presence of two masses, one with admixtures of Scheldt water, the other with admixtures of Rhine and Meuse water[1]).

Two groups of stations were selected where the water was thought to represent approximately one of the two water-masses with negligible contributions of the other one. This selection was based on geographical considerations. The stations used for the definition of the "Scheldt water-mass" are situated in a section perpendicular to the coast, starting from the entrance of the estuary. The observations used to define the "Rhine-Meuse water-mass" were made on a section parallel to the coastline, from the Hook of Holland northeastwards.

The fluorescence-salinity relations were determined. They are (regression of fluorescence F over salinity S)

Rhine-Meuse water-mass (24 obs) $F = -2.16\ S + 75.0$ (corr.coeff. 0.98)
Scheldt water-mass (23 obs) $F = -2.53\ S + 88.8$ (corr.coeff. 0.99)

On this cruise no attenuation measurements could be made in the "Scheldt water-mass", but for the "Rhine-Meuse water-mass" the relation between the difference of the attenuation coefficients for blue and red light and salinity was found to be

$$C = -0.105\ S + 3.39 \quad (10 \text{ obs., corr.coeff. } 0.96).$$

However, in the northern part of the area investigated, a group of stations showed a quite different C - S relation. Because it may be safely assumed that the major part of the "fresh" water admixture in this region came via the Wadden Sea, another water-mass was thought to be present there which was appropriately called "Wadden Sea water-mass". The fluorescence-salinity relation did not differ much from that of the Rhine-Meuse water-mass. The relations found for this water-mass are:

$F = -1.98\ S + 69.6$ (11 obs., corr.coeff. 0.98)
$C = -0.258S + 8.29$ (6 obs., corr.coeff. 0.99)

1) The waters of Rhine and Meuse are mixed to a large extent before they flow into the sea.

Using these relations found for the different water-masses, it is now possible to give an interpretation to the observations made in the mixing zones between these water-masses. For instance the precentage of "fresh" Scheldt water in a given mixture with Rhine-Meuse water with salinity S and fluorescence F can be found from

$$\frac{F - F_R}{F_S - F_R} \times 100\%, \text{ where}$$

$F_R = -2.16\ S + 75.0$ and $F_S = -2.53\ S + 88.8$.

In this way for all stations the percentages of the "fresh" water originating from either Scheldt or Rhine-Meuse can be found. Fluorescencent and yellow substances, dissolved in the water, are of organic origin. Their concentration in the river water is not constant for longer periods, and in certain seasons biological processes may affect concentrations in the water. For these reasons more investigations are needed to find out whether relations as those found for this winter cruise also exist under other conditions.