Export of dissolved metals from the North Sea to the Channel: additional field evidence

Channel
North Sea
Export
Dissolved Co
Dissolved Ni

Manche
Mer du Nord
Transfer
Co dissous
Ni dissous

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ABSTRACT

Longitudinal distribution of dissolved nickel and cobalt along the English coast of the Channel is similar to that previously observed for dissolved aluminium. The exponential decay, as a function of salinity, of the concentration of a relatively conservative element such as nickel strongly supports the hypothesis that significant amounts of dissolved trace elements could be exported from the North Sea to the Channel.

RÉSUMÉ

Transfert de métaux dissous de la Mer du Nord vers la Manche: observations complémentaires.

La distribution longitudinale du nickel et du cobalt dissous dans la Manche, le long de la côte anglaise, est similaire à celle observée antérieurement pour l'aluminium dissous. La décroissance exponentielle de la concentration d'un élément relativement conservatif comme le nickel en fonction de la salinité, confirme l'hypothèse selon laquelle des quantités importantes de métaux dissous en trace pourraient être transferées de la Mer du Nord vers la Manche.

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INTRODUCTION

In a recent paper published in *Oceanologica Acta* (Chou and Wollast, 1993), it was suggested that export of North Sea water to the Channel along the English coast, as predicted by circulation models (Salomon and Breton, 1991; Salomon and Breton, 1993) and observed by HF radar measurements (Prandle, 1993) could constitute a significant source, for the Channel, of trace elements strongly enriched in the southern bight of the North Sea. It was shown that there exists a strong gradient of dissolved Al from the Dover Strait. This element exhibits an exponential decrease from Dover to the entrance of the Channel, which has been attributed to transport with the residual currents oriented westward along the English coast. This may be especially important during northeasterly wind events. During one of the *Belgica* cruises (September 1989 and July 1990), samples were also taken for dissolved Co and Ni and analysed by cathodic stripping square-wave voltammetry according to the method described in Zhang *et al.* (1989).

The results of these measurements are given in Table 1. As with the results for dissolved Al published previously, a strong gradient of the concentrations of both Co and Ni in the vicinity of the Strait of Dover has been observed. The relative decrease in concentration is, however, less marked in the case of Co and Ni compared to Al, due to the smaller difference in concentrations between the North Sea and the North Atlantic waters. In a manner analogous to that relating to dissolved Al, the evolution of the concentrations of dissolved Co and Ni as a function of salinity follows an exponential decay function as shown in Figure 1. The most striking fact is the similarity of the exponential decay constants which are -3.37, -3.67 and -4.28 for Ni, Co and Al respectively. The slight differences of the values of these constants may reflect the reactivity of these metals in the oceanic system, as shown by their mean oceanic residence times (Martin and Whitfield, 1983).

Table 1

Summary of results of concentrations of dissolved Co and Ni obtained for surface sea water samples collected in the English Channel.

	Station	Salinity (psu)	Cobalt (nM)	Nickel (nM)
September 1989				
	00	35.117	0.081	4.75
	01	35.288	0.076	4.29
	02	35.307	0.076	3.95
July 1990				
	S1	34.960	0.127	6.73
	S2	35.098	0.095	5.50
	S3	35.085	0.080	4.26
	S4	35.072	0.090	4.63
	S5	34.988	0.105	6.22
	S6	35.228	0.075	3.73
	S7	35.197	0.070	3.66
	S8	35.227	0.073	4.14
	S9	35.336	0.073	4.04
	S10	35.393	0.063	3.29
	S11	35.400	0.061	3.54
	01	35.293	0.070	3.73
	02	35.412	0.062	3.59
	03	35.610	0.055	2.52
	10	35.450	0.060	3.32

In our previous paper on the longitudinal distribution of dissolved Al (Chou and Wollast, 1993), we have suggested that this exponential decay function can be explained either by the advection/dispersion of the outgoing North Sea water or by the non-conservative behaviour of dissolved Al due to its high reactivity. On the other hand, dissolved Ni has been accepted as a rather refractory element with a very long residence time in marine systems evaluated at 14,000 years (Martin and Whitfield, 1983). This element can thus be considered as behaving more or less conservatively during the time necessary to mix the North Sea and Channel waters. The fact that the exponential decay constants observed for the three elements investigated are similar strongly reinforces the hypothesis that the decay can be explained by the advection of outgoing North Sea water along the English coast submitted to lateral dispersion with the central water masses of the Channel originating in the North Atlantic (Pingree and Maddock, 1985).

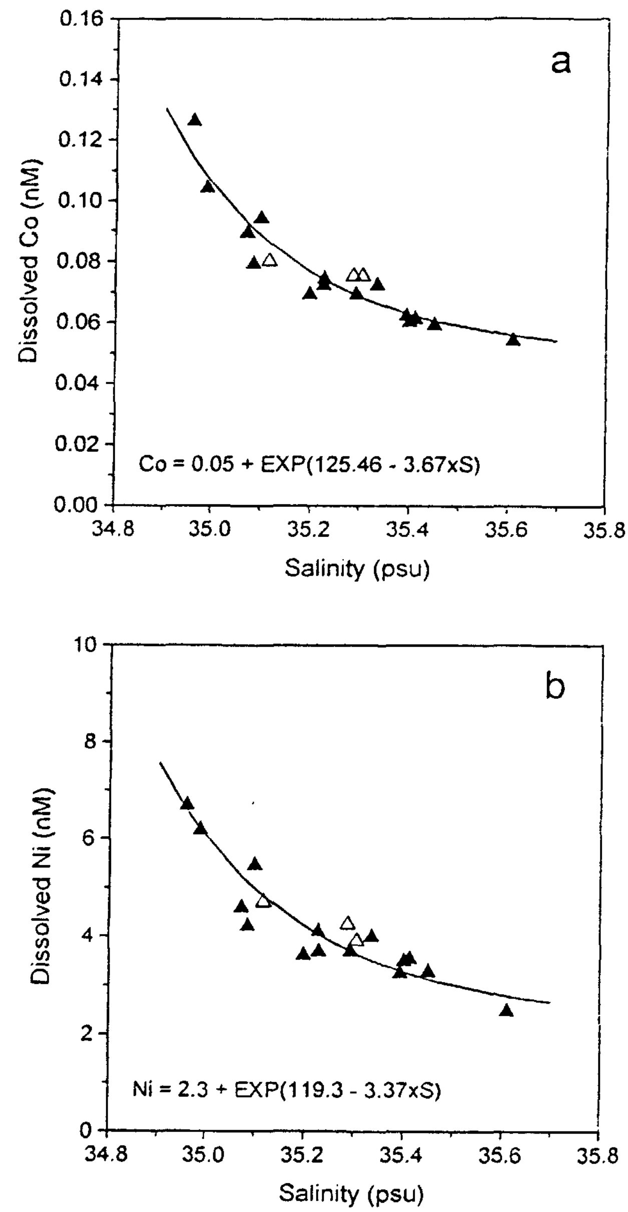

Figure 1

Dissolved Cobalt (a) and Nickel (b) as a function of salinity for surface waters taken in the Channel. Curves represent the best fits of the data points with exponential decay functions. Data from the September 1989 cruise are represented by open triangles and those from the July 1990 cruise by solid triangles.

The spatial and temporal distribution of dissolved Ni across the Dover Strait observed by James *et al.* (1993) during the FLUXMANCHE study indicates that the lowest dissolved Ni concentrations are always obtained for the central Channel (3 - 4.4 nM). Concentrations increase towards the coastlines and are consistently greater along the English coast than along the French coast, which is strongly influenced by the river Seine plume. It is very unlikely that the high concentrations of Co and Ni occurring along the English coast are due to the limited discharge of fresh water in that area.

Similar to dissolved Al, export of North Sea water to the Channel, although restricted in flow, could thus be responsible for a significant transfer of other dissolved metals such as Ni and Co that are enriched in the southern bight of the North Sea. As a consequence, fluxes of these trace elements through the Strait of Dover into the North Sea may well be overestimated if the reverse fluxes have not been taken into consideration.

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REFERENCES

Chou L., R. Wollast (1993). Distribution and origin of dissolved aluminium in the English Channel. *Oceanologica Acta* **16**, 5-6, 577-583.

James R.H., P.J. Statham, N.H. Morley, J.D. Burton (1993). Aspects of the geochemistry of dissolved and particulate Cd, Cu, Ni, Co and Pb in the Dover Strait. *Oceanologica Acta* **16**, 5-6, 553-564.

Martin J.-M., M. Whitfield (1983). The significance of the river input of chemical elements to the ocean. In: *Trace Metals in Sea Water* (eds. Wong C.S., E. Boyle, K.W. Bruland, J.D. Burton and E.D. Goldberg), p. 265-296.

Pingree R.D., L. Maddock (1985). Stokes, Euler and Lagrange aspects of residual tidal transports in the English Channel and the southern bight of the North Sea. *J. Mar. Biol. Ass., U.K.* **65**, 969-982.

Prandle D. (1993). Flow through the Dover Strait: results from year-long HF radar measurements. *Oceanologica Acta* **16**, 5-6, 457-468.

Salomon J.-C., M. Breton (1991). Courants résiduels de marée dans la Manche. *Proceedings of the International Colloquium on the environment of epicontinental seas, Lille, 20-22 March 1990, Oceanologica Acta* **Spec. Vol. n°. 11**, 47-53.

Salomon J.-C., M. Breton (1993). An atlas of long term currents in the Channel. *Oceanologica Acta* **16**, 5-6, 439-448.

Zhang H., R. Wollast, J.-C. Vire, G.J. Patriarche (1989). Simultaneous determination of cobalt and nickel in sea water by adsorptive cathodic stripping square-wave voltammetry. *Analyst* **114**, 1597-1602.