D-2.1.2 Studies on Seasonal and Spatial Distribution of Hazardous Chemicals in the East China Sea

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Total Budget for FY1998-FY1999: 9,887,000 Yen (FY1999: 4,878,000 Yen)

Abstract

An examination of the source and behavior of organic pollutants is essential in preserving environmental conditions in the East China Sea. The distribution of hazardous chemicals in the seawater, aerosol, and sediments of the East China Sea was studied based on samples taken during phase 1 (May 1996 and July-Aug. 1997) and phase 2 (Sept.-Oct. 1998 and Oct.-Nov. 1999). Organic halides such as hexachlorocyclohexane (HCH), chlordane, and nonachlore were detected in seawater and aerosol samples. α-HCH was more abundant than the other HCH isomers in the aerosol samples; β-HCH was more abundant in the seawater samples, with increased concentrations in low-salinity water. These results imply that α-HCH and β-HCH were transported mainly by air and river water, respectively, and suggest that the Changjiang discharge is one of the sources of hazardous chemicals in the East China Sea. Although the concentration distributions of chlordane and nonachlore in seawater were complex, their concentrations in aerosol samples were highest on days with rough weather, suggesting that they are carried into the area by rainfall and strong wind.

Key words: East China Sea, Organic Pollutants, Hazardous Chemicals, Route of Supply

Introduction

The ecology of the East China Sea is characterized by receipt of a large volume of materials from two large rivers, the Changjiang and the Yellow River, and by the influence of the Kuroshio Current. An examination of the source and behavior of pollutants will greatly assist in preserving environmental conditions in the East China Sea; however, because pollutant concentration is usually very low in the open ocean, there is a lack of observational data. The objective of this study is to

determine the distribution and behavior of hazardous chemicals in the East China Sea.

Method

Seawater, aerosol, and surface sediment samples were collected during phase 1 (May 1996 and July-Aug. 1997) and phase 2 (Sept.-Oct. 1998 and Oct.-Nov. 1999) in the region from the continental shelf to the Okinawa Trough using the *R/V Yoko-Maru* (Seikai National Fisheries Research Institute). A polyurethane foam solid phase extraction method[1] was used as the extraction sampling system. Water temperature, salinity, and turbidity were measured by CTD and TCTD; chemical concentrations were analyzed by GCMS-SIM. Locations of the sampling sites and observational details over the four-year period are shown in Fig. 1 and Table 1.

Results

Organic halides, such as hexachlorocyclohexane (HCH), chlordane, and nonachlore, were detected in seawater and aerosol samples, but were not detected in sediments. Concentrations of HCH isomers in surface water ranged from (with the point of highest concentration in parentheses) 8～144 pg/L (Stn. A12 during July-Aug. 1997), 6～458 pg/L (Stn. A12 during July-Aug. 1997), and 2～121 pg/L (Stn. T3 during Sept.-Oct. 1998), for α-HCH, β-HCH, and γ-HCH, respectively (Fig. 2). Concentrations of chlordane and nonachlore ranged from 2～112 pg/L (Stn. T3 during Sept.-Oct. 1998), 1～59 pg/L (Stn. T3 during Sept.-Oct. 1998), 1～35 pg/L (Stn. F6 during July-Aug. 1997), and to the detection limit of 17 pg/L (Stn. D11 during Sept.-Oct. 1998), for t-chlordane, c-chlordane, t-nonachlore, and c-nonachlore, respectively; blank values of chlordane and nonachlore were particularly high in Sept.-Oct. 1998 samples compared to the other observations (Fig. 3). Vertical distributions obtained at several stations are shown in Fig. 4; concentrations were highest in the middle layer during July-Aug. 1997. Concentrations in aerosol are given in Table 2.

Pollutant concentrations showed seasonal and spatial variations: HCH concentration at the sea surface was highest on the continental shelf in summer (July-Aug. 1997), became lower in early fall (Sept.-Oct. 1998), and was lowest in late fall (Oct.-Nov. 1999) and spring (May 1996). In summer, HCH concentrations increased from the continental slope towards the central shelf and became highest in the area offshore of Changjiang. The concentration distributions of chlordane and nonachlore were more complicated: concentrations became higher at the continental slope during July-Aug. 1997 and the concentration of t-chlordane was extremely high in the area off Goto during Sept.-Oct. 1998. The spatial distribution of

chlordane and nonachlore was random, in contrast to that of HCH, with no apparent trend.

The isomer composition of HCH in surface water over the four years was relatively stable, with 22 ± 9% α-HCH, 64 ± 11% β-HCH, and 15 ± 8% γ-HCH. Isomer composition of HCH in aerosol exhibited variability, with α-HCH as the dominant form (62 ± 5 %) in each sample (Table 2).

Discussion

HCH production in China consists of 65-70% α-HCH, 5-6% β-HCH, 13% γ-HCH, and 6% δ-HCH.[2] Our results, in which the composition in aqueous solution of α-HCH decreased and β-HCH increased compared to HCH production, suggest that β-HCH remains more stability than other isomers in the seawater samples, probably a result of the high volatilization of α-HCH and high absorption of β-HCH.[3]

Although the seasonal change in concentration was quite large, the highest concentrations of β-HCH in each observation period were determined in samples with low salinity (Figs. 1 and 2). Especially during the summer, there was a negative correlation between the surface concentration of β-HCH and the surface salinity in the East China Sea ($y = -58x + 2113$, $r^2 = 0.870$). These results imply that 1) β-HCH was supplied from the fresh-water Changjiang River, especially in the high discharge season, and were washed out into the continental shelf area. 2) During the spring and fall, vertical mixing above the pycnocline layer resulted in diffusion and dilution of the β-HCH at the surface.

The composition of HCH isomers in aerosol was different than in seawater; α-HCH was more abundant in aerosol than the other pollutants (Table 2), implying that α-HCH was transported mainly by air. Further, although the concentrations of chlordane and nonachlore in seawater were complex and we could not clarify any special trends, their concentrations in the aerosol samples were highest on days with rough weather (Table 2), suggesting that these pollutants are transported by rainfall and strong wind.

On the other hand, whereas Watanabe (1999) reported that sediments from the Changjiang estuary were still polluted by HCH that was supplied mainly from terrestrial soil,[4] we did not find these chemicals in sediments from the central shelf area; presumably, organic pollutants supplied from terrestrial soil have not extended direct influence and have not had much impact on our observation area.

We do not yet understand why the vertical distribution of these hazardous chemicals was highest in the middle layer during observations in July-Aug. 1997; further study is needed to address this question.

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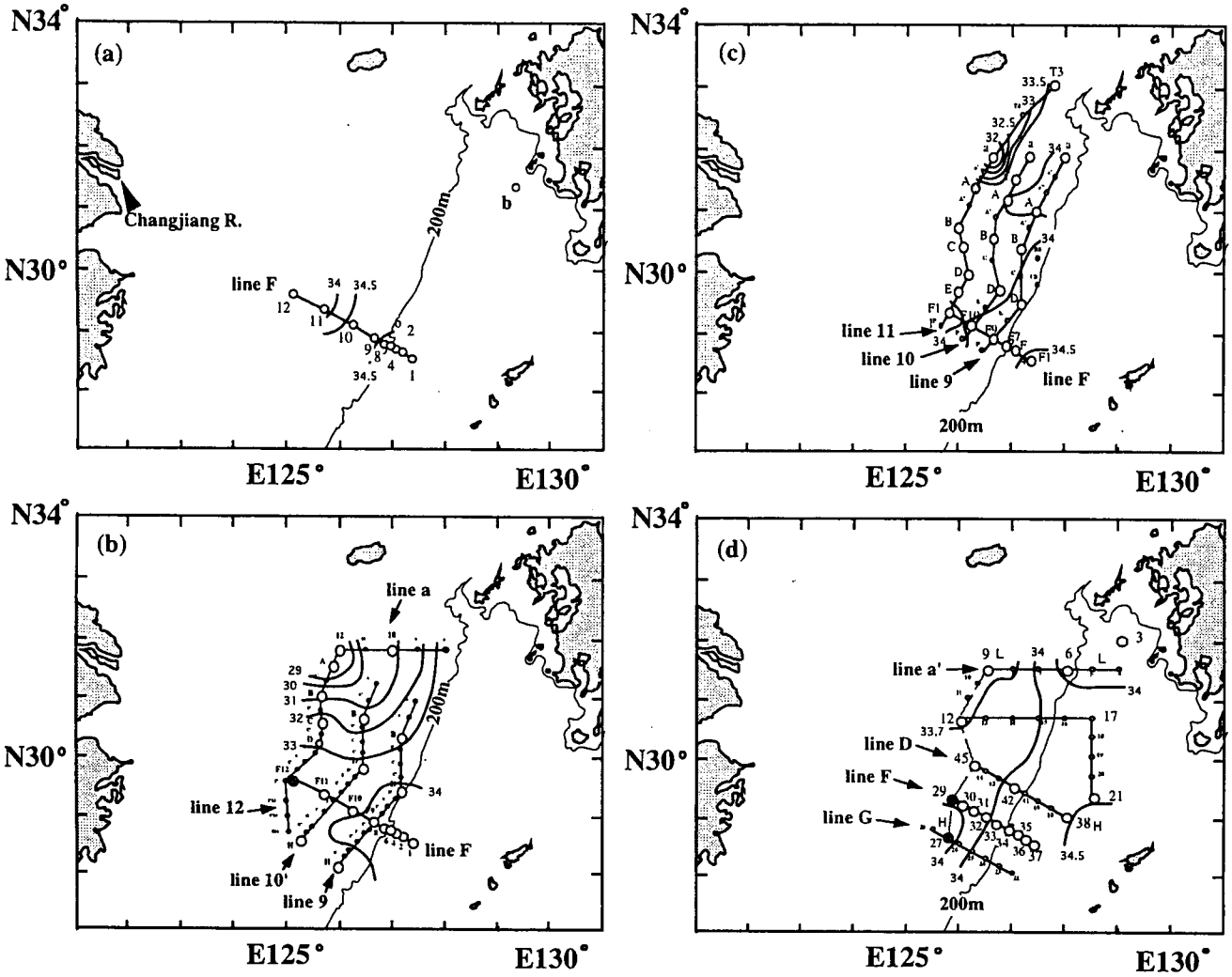

Figure 1 Locations of the sampling sites in the East China Sea during May 1996 (a), July-Aug. 1997 (b), Sept.-Oct. 1998 (c) and Oct.-Nov. 1999 (d). Distribution of surface salinity is also shown . —, Surface salinity; ○, CTD observation; ◯, Pump sampling (surface) and CTD observation; ●, Emphasis observation point (see Table 1).

Table 1 Observation details (1996-1999).

Sampling date	Pump (surface)	Short-term variation	Vertical distribution		Aerosol		Sediment	
	Number	Stn.	Stn.	Sampling depth (m)	Number	Stn.	Number	Stn.
18-19 May, 1996	10	–		–	–		–	
25 July - 5 Aug., 1997	20	F12	F12	2, 9, 26, 35	–		–	
30 Sept. -12 Oct., 1998	22	–	A11	2, 10	8	Continuous sampling on a voyage	1	A11
21 Oct. - 8 Nov., 1999	18	–	27, 29	2, 10, Bottom-10, Bottom-5	–		–	

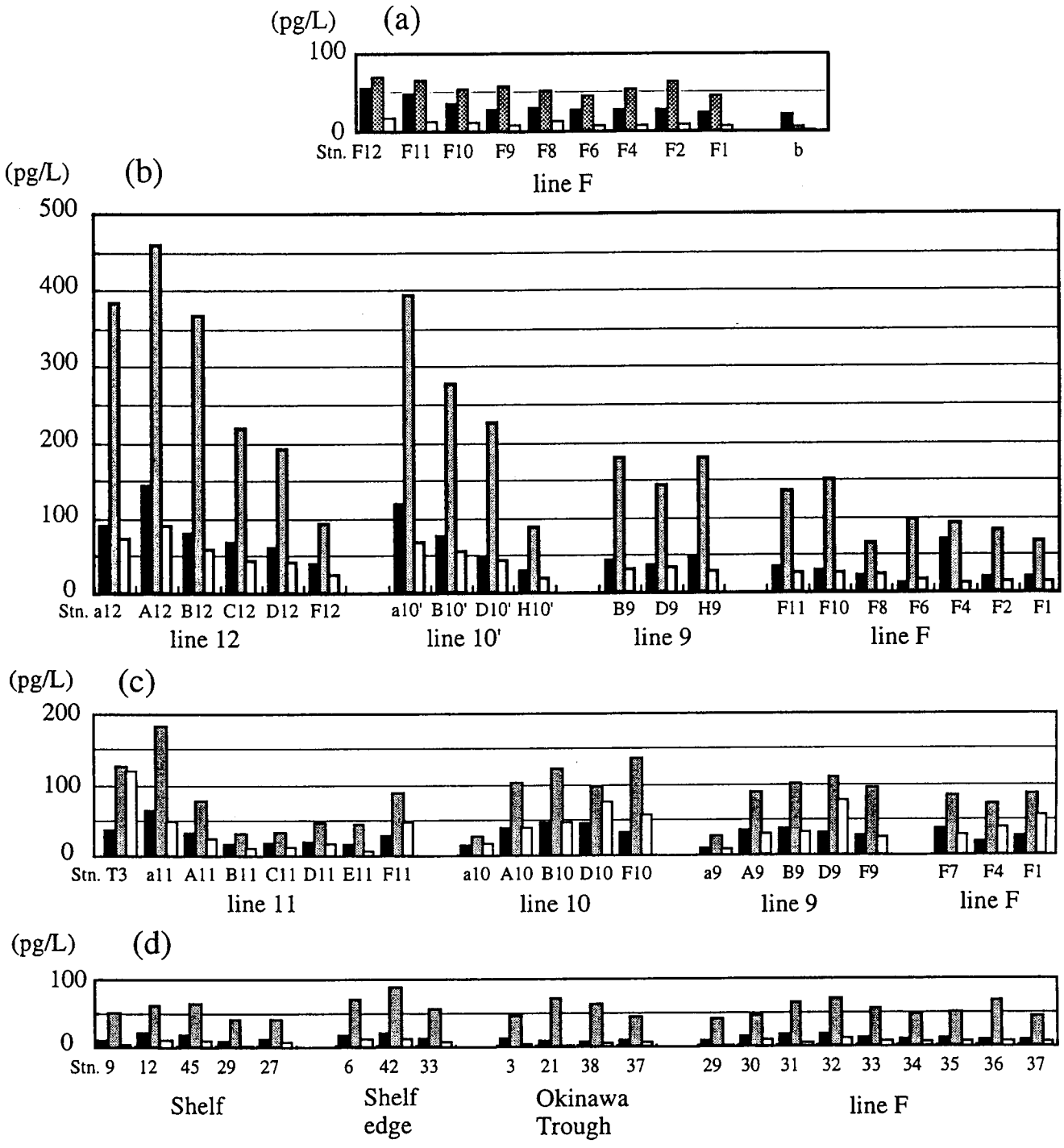

Figure 2 Horizontal distribution of HCHs in surface water during May 1996 (a), July-Aug. 1997 (b), Sept.-Oct. 1998 (c) and Oct.-Nov. 1999.
■, α-HCH; ▨, β-HCH; □, γ-HCH.

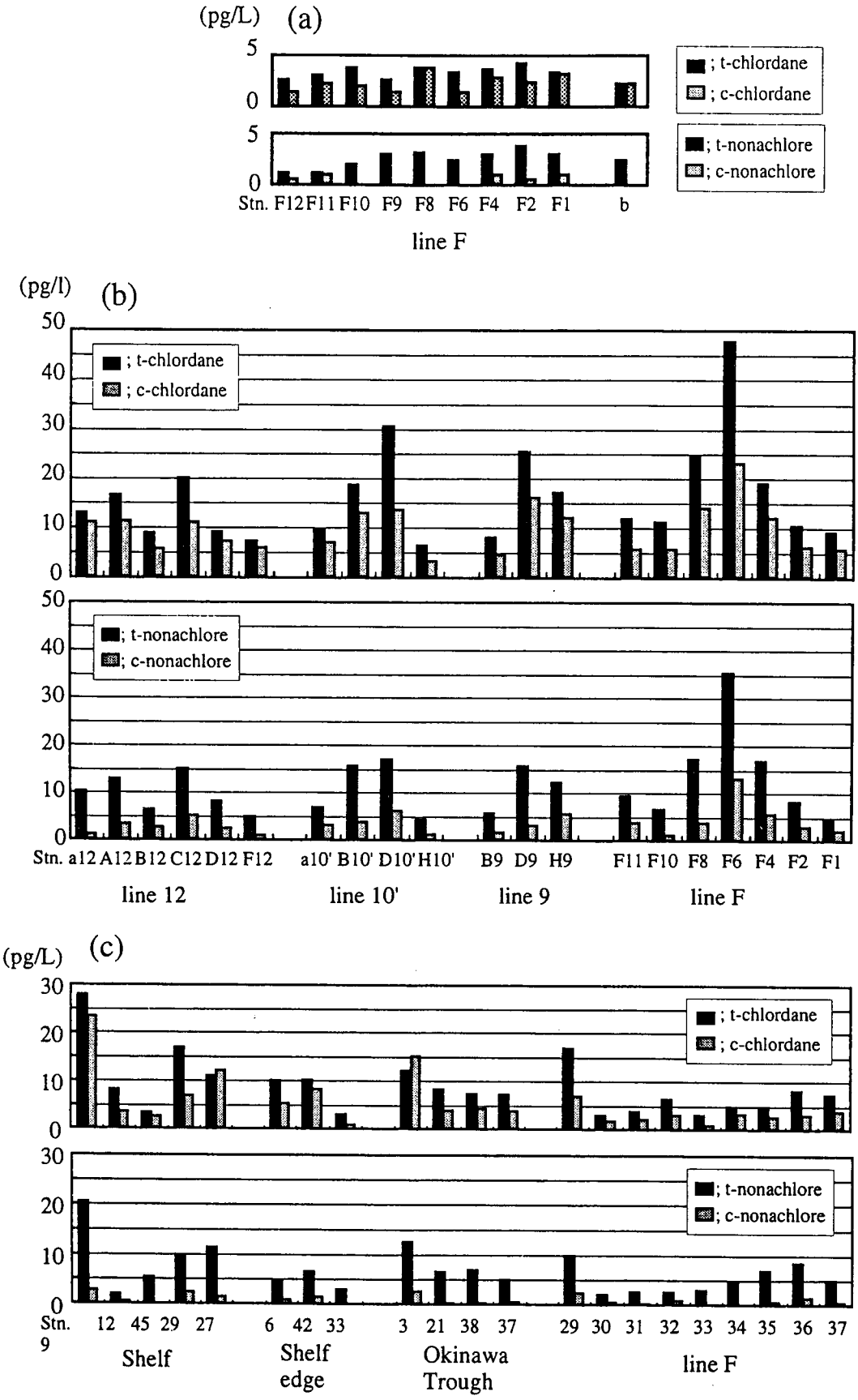

Figure 3 Horizontal distribution of chlordane and nonachlore in surface water during May 1996 (a), July-Aug. 1997 (b) and Oct.-Nov. 1999 (c).
We could not represent distribution during Sept.-Oct. 1998 because blank value of the abstraction columns was high compared to those of other observations.