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Contaminants in Bird Eggs

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5.2 Contaminants in Bird Eggs

5.2.1 Introduction

Since 1998, the parameter "Contaminants in Bird Eggs" has been implemented in the Trilateral Monitoring and Assessment Program (TMAP; Becker et al., 2001). Each spring, eggs of common tern Sterna hirundo and oystercatcher Haematopus ostralegus were sampled, at in total 16 breeding sites of the Wadden Sea (Figure 5.2.1). In these eggs concentrations of mercury and organochlorines, including polychlorinated biphenyls (ΣPCB) and some pesticides, were determined.

In the last QSR 2004, the main findings of spatial and temporal variation were presented (Becker and Muñoz Cifuentes, 2005). These showed that in the beginning of the 2000s, the Elbe estuary was still a hot spot for chemical contamination, but also some pollutant inputs in the western Wadden Sea were obvious. Even if levels of most contaminants had decreased since the beginning of the 1990s and seemed to remain more or less stable in the mid-1990s, concentrations of some substances had increased again in bird eggs, indicating new inputs of pollutants into the Wadden Sea.

In this contribution, we update the information presented by the last QSR 2004 (Becker and Muñoz Cifuentes, 2005) and by Becker and Muñoz Cifuentes (2004), and evaluate recent levels of contaminants in bird eggs from the Wadden Sea as well as their current trends. We focus on the geographical variation of bird egg contamination from The Netherlands to Denmark in 2008 and on temporal trends for three periods, viz. in the short term 2004–2008, medium term 1998–2008 and long term 1981–2008, the latter including data collected previously to the TMAP-project (Becker et al., 1991, 1992, 2001).

Furthermore, we present the geographical variation in the concentrations of dioxin-like PCBs, given as toxicological equivalents (TEQs). These TEQs give the summarized concentrations of 10 from 12 dioxin-like PCBs (Figure 5.2.6), each multiplied by a specific toxic equivalency factor (TEF, Van den Berg et al., 1998), depending on the toxicity of the substance in relationship to the most toxic substance "dioxin" (2,3,7,8-TCDD) for which TEF is defined as 1.

In addition, we address ecotoxicological aspects and compare the pollutant levels with the Wadden Sea Plan targets. Specific Ecological Quality Objectives (EcoQOs) concerning the concentrations of mercury and organochlorines in North Sea seabird eggs have been developed by ICES (2003, 2004) and OSPAR (2007). In 2008 and 2009, a pilot project has been carried out to analyze the status of contaminants in bird eggs in the North Sea and to evaluate the proposed EcoQOs (OSPAR 2007). We briefly mention this pilot project and relate the TMAP findings to the EcoQO.

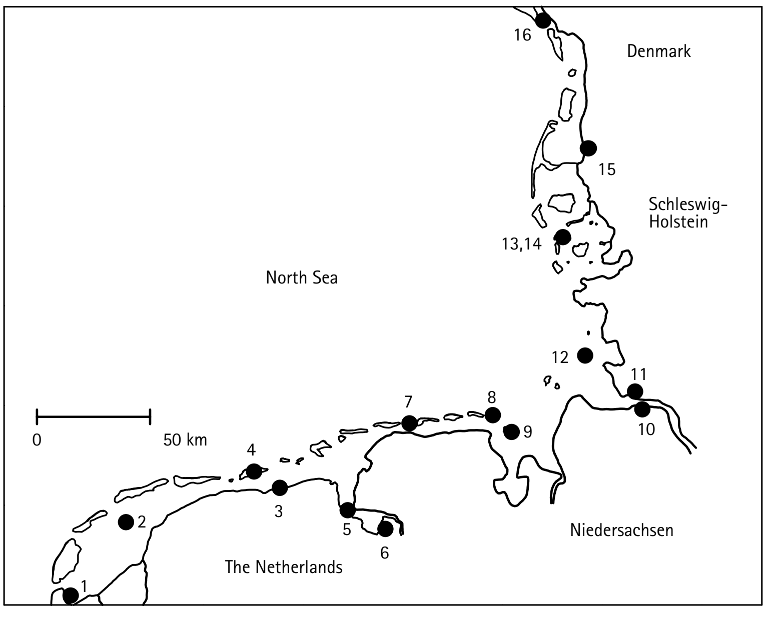


Figure 5.2.1: Sampling sites of common tern (CT) and oystercatcher (OC) eggs analyzed for contaminants. The Netherlands: 1 Balgzand, 2 Griend, 3 Julianapolder (CT until 2004), 4 Schiermonnikoog (CT since 2005), 5 Delfzijl; Germany, Niedersachsen: 6 Dollart, 7 Baltrum, 8 Minsener Oog, 9 Mellum, 10 Hullen; Germany, Schleswig-Holstein: 11 Neufelderkoog, 12 Trischen, 13 Norderoog (until 2006), 14 Hooge (since 2007); Denmark: 16 Langlie. At the sites 4 and 11, only common tern eggs, at the sites 3, 6, 7, 9 and 16, only oystercatcher eggs were taken; at all other sites, eggs of both species were collected.

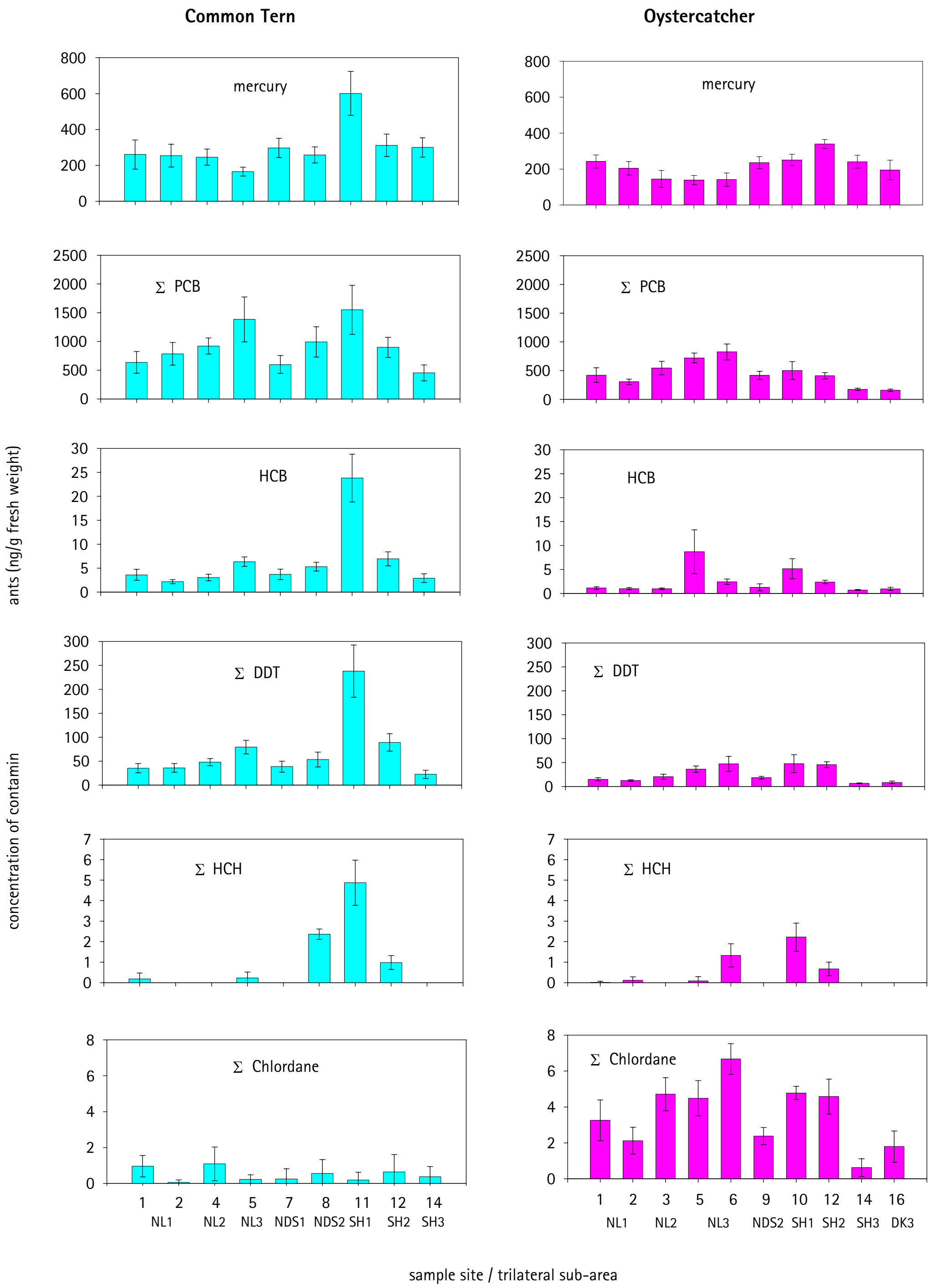


Figure 5.2.2: Geographical variation of the contaminants analyzed in common tern and oystercatcher eggs in 2008 in the Wadden Sea. See Figure 1 for location of sampling sites. Mean concentration (ng/g fresh weight of egg content) and 95% confidence intervals are presented for mercury, ΣPCB congeners, HCB, sum of DDT and its metabolites (ΣDDT), sum of HCH-isomers (ΣHCH), and sum of cis- and trans-chlordane and cis- and trans-nonachlor concentrations (ΣChlordane). At most sites, n=10 eggs were sampled.

5.2.2 Geographical trends

As in previous years also in 2008 the contaminants' levels showed distinct geographical patterns in both species (Figure 5.2.2; cf. Figure 5.2.1 for sampling sites). In common tern eggs, concentrations of mercury, ΣPCB, HCB, ΣDDT and ΣHCH were highest at the Elbe estuary. For ΣPCB, and to a lesser extent also for ΣHCB and ΣDDT, a second spatial peak was recorded at Delfzijl at the Ems estuary. Among the PCB congeners, exceptionally high levels were recorded for PCB64 in eggs from Minsener Oog (Mean±SD 35.7±11.1 ng/g). Concentration of ΣChlordane was highest at Schiermonnikoog.

In oystercatcher eggs, concentrations of mercury and ΣHCH were highest in the Elbe estuary, those of ΣPCB, HCB and ΣChlordane reached a maximum at the Ems estuary, where elevated

ΣHCH levels were also found. ΣDDT concentration showed peaks at both estuaries. Exceptionally high levels were recorded for PCB64 in eggs at Dollart (119.0±52.3 ng/g). Furthermore, high levels were found for TEQ component PCB126 at Neufelderkoog, Elbe estuary (see chapter 5.2.5). Mercury concentration showed increased values at Balgzand.

Summarizing, the results identify the estuaries of the two rivers Ems and Elbe as the sites where concentrations of most contaminant groups were highest. In the common tern, peaks of most contaminants were particularly pronounced at the Elbe estuary. In the oystercatcher, this was true for both the Ems and the Elbe estuary. For most pollutants and most sites, contamination was higher in the common tern than in the oystercatcher (Figure 5.2.2). However, contamination of ΣChlordane was clearly higher in the oystercatcher.

5.2.3 Temporal trends

An overview of middle-term (1998-2008) and short-term (2004-2008) temporal trends of contaminant concentrations is given in the Figures 5.2.3 and 5.2.4 and in Table 5.2.1. Between 1998 and 2008, concentrations of HCB, ΣHCH in common tern eggs decreased significantly at most or, for some of the compounds, even all sites. Concentrations of mercury, ΣPCB and ΣChlordane decreased significantly at 4 from 8 sites but no general geographical patterns in these decreases were detectable. On the other hand, significant increases were recorded for concentrations of ΣPCB and ΣDDT at Delfzijl.

During the last five years (2004-2008), concentrations of HCB and ΣPCB decreased significantly at 6 of 8 sites, those of mercury and ΣDDT did so at 5 of 8 and those of ΣHCH at 4 of 8 sites. During this period, significant increases were found for concentrations of ΣHCH at Minsener Oog.

In oystercatcher eggs, concentrations of HCB, ΣPCB and ΣHCH decreased significantly at most or for some compounds even at all sites between 1998 and 2008. The concentrations of mercury decreased significantly at 7 of 10 sites, those of ΣDDT and ΣChlordane did so at 4 of 10 sites. Significant increases during these 11 study years were recorded for mercury at Trischen, German Bight, and Norderoog/Hooge, and for ΣPCB and ΣDDT at Delfzijl.

During the last five years (2004-2008), concentrations of HCB, ΣPCB, ΣDDT decreased significantly at all or nearly all sites. Concentrations of ΣHCH decreased significantly at 6 of 10 sites. Significant increases were recorded for concentrations of mercury at Griend and Hullen and for those of ΣHCH and ΣChlordane at the Dollart.

Summarizing, most of the significant increases of contaminant concentrations were found at Delfzijl. Mercury in oystercatcher eggs was the most frequently increasing contaminant (apart from at Delfzijl, where no case of increase was found). In general, significant contaminant decreases in oystercatcher eggs occurred at a higher number of sites and were more pronounced than in common tern eggs.

Figure 5.2.5 shows the long-term-development of mercury, ΣPCB, HCB and ΣDDT concentration at three selected sites in the western (Griend), central (Trischen) and northern part of the Wadden Sea over a study period of 28 years. During that long period, the contaminants in eggs of both study species showed maximum concentrations in the 1980s. After strong decreases in the early 1990s they stabilized on a lower level with more or less pronounced inter-annual fluctuations until 2008.

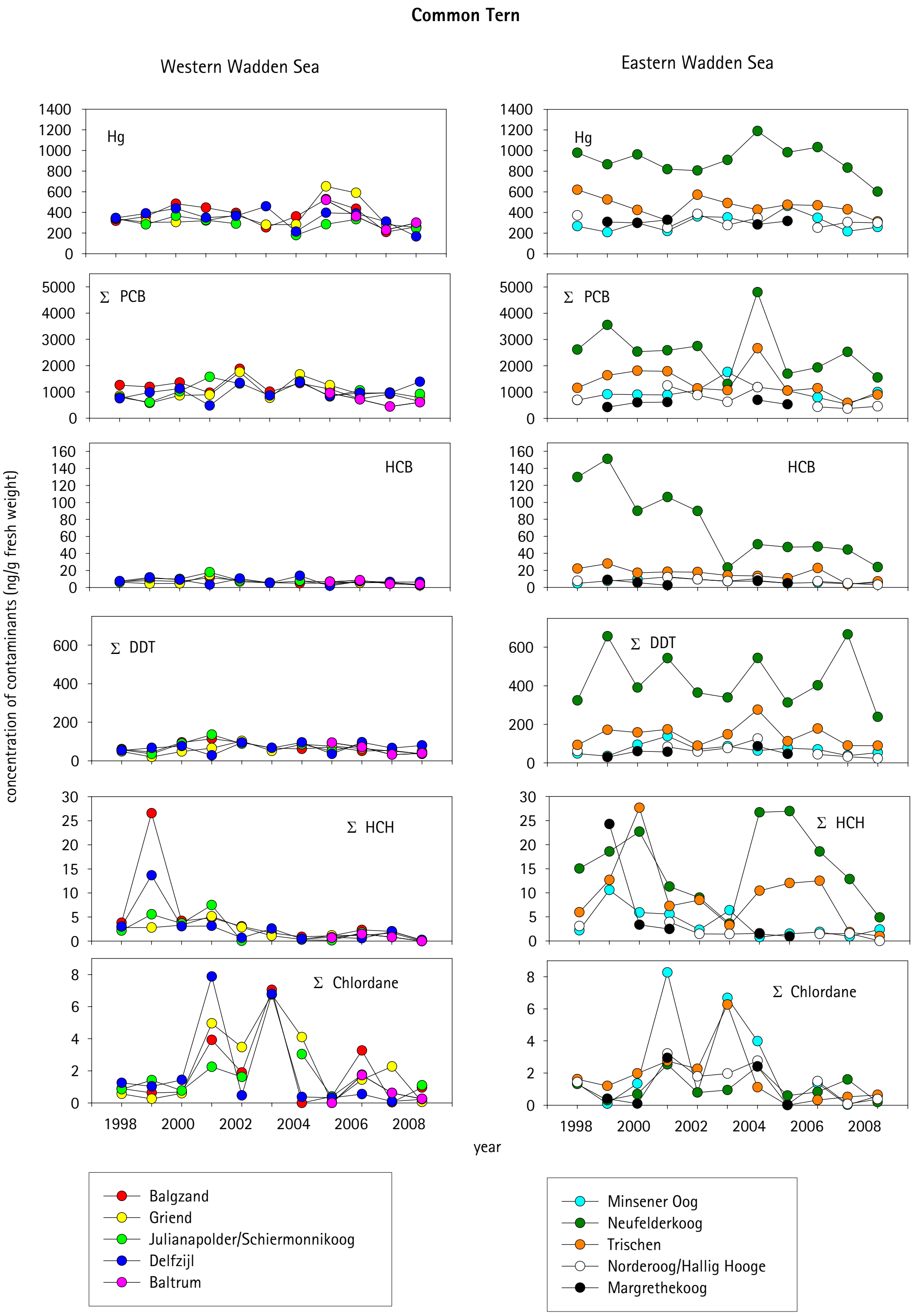
5.2.4 Ecotoxicological aspects

To date, monitoring of birds' breeding success is not included in the TMAP Common Package; consequently information on potential differences in the hatching success of coastal birds breeding in highly and lowly contaminated areas is lacking (cf. Thyen et al., 1998). Muñoz Cifuentes (2004) presented data from the mid 1990s suggesting that the reproductive success of common tern, common gull Larus canus and herring gull Larus argentatus was negatively affected by organochlorine contamination at the Lower Elbe. The current levels of most contaminants in bird eggs, however, are below the known threshold concentrations affecting birds' reproduction (cf. Becker et al., 2001; Muñoz Cifuentes, 2004).

Similar to most chemicals, also the TEQ-levels calculated for dioxin-like PCB-congeners (cf. Muñoz Cifuentes, 2004; see above) showed decreasing trends since 1998 in the Wadden Sea (Table 5.2.1).

However, similar to sporadic increases during previous periods, TEQ concentrations in 2008 were elevated in some areas between Dollart and inner German Bight (Figure 5.2.6; common tern: 152-442 pg/g; oystercatcher: 2-212 pg/g), deviating from the general spatial pattern of ΣPCB (Figure 5.2.2). Such TEQ-concentrations are in a range where negative effects on the hatchability of fish-eating bird species are reported (90-4,000 pg/g, Hoffmann et al., 1996; see for details Muñoz Cifuentes, 2004). Given a lipid content of 8,2%

Figure 5.2.3: Middle-term (1998-2008) trends of contaminant concentrations in common tern eggs from selected sampling sites (cf. Figures 5.2.1 and 5.2.2). Dots indicate arithmetic means (ng/g fresh weight of egg content).



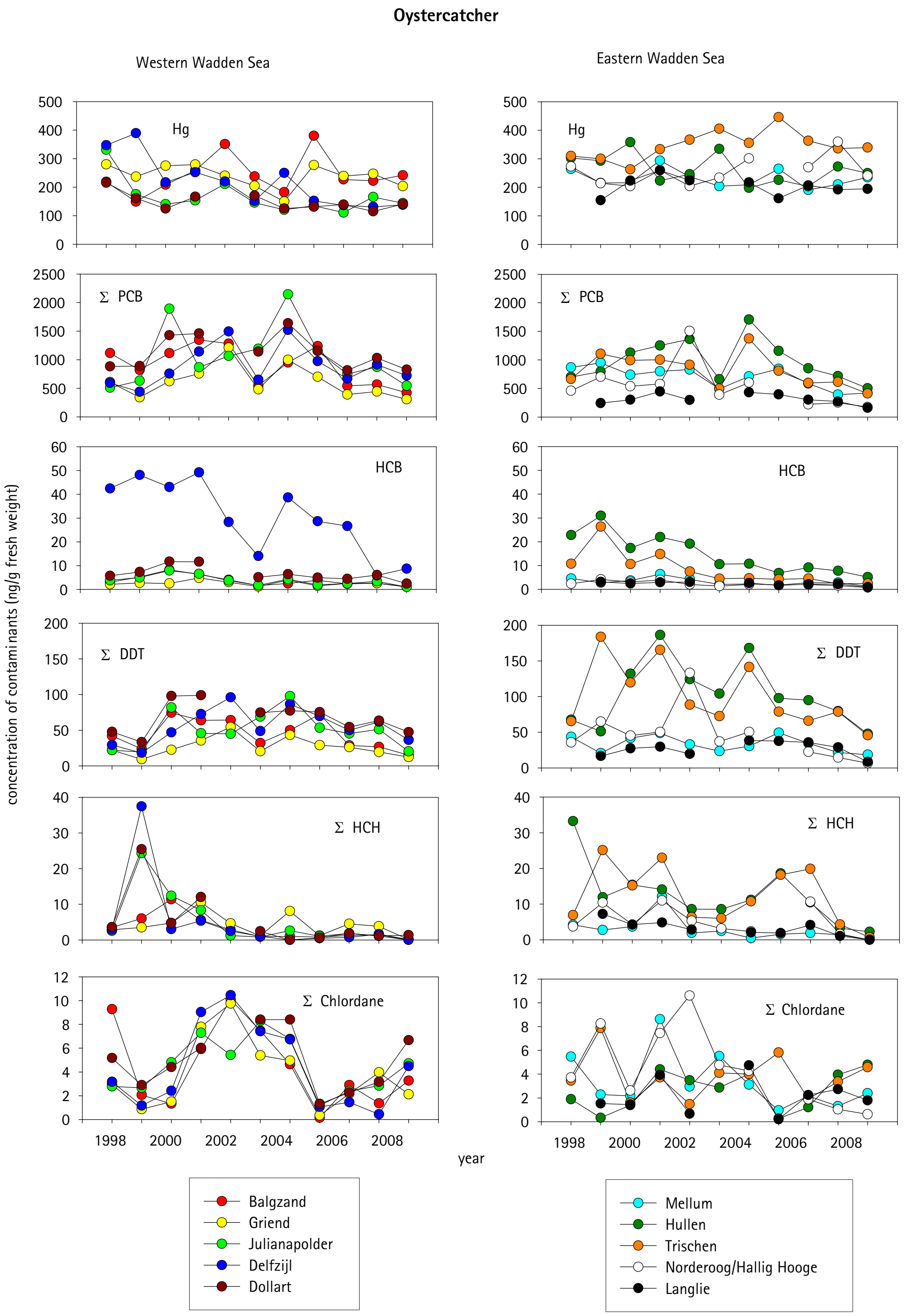
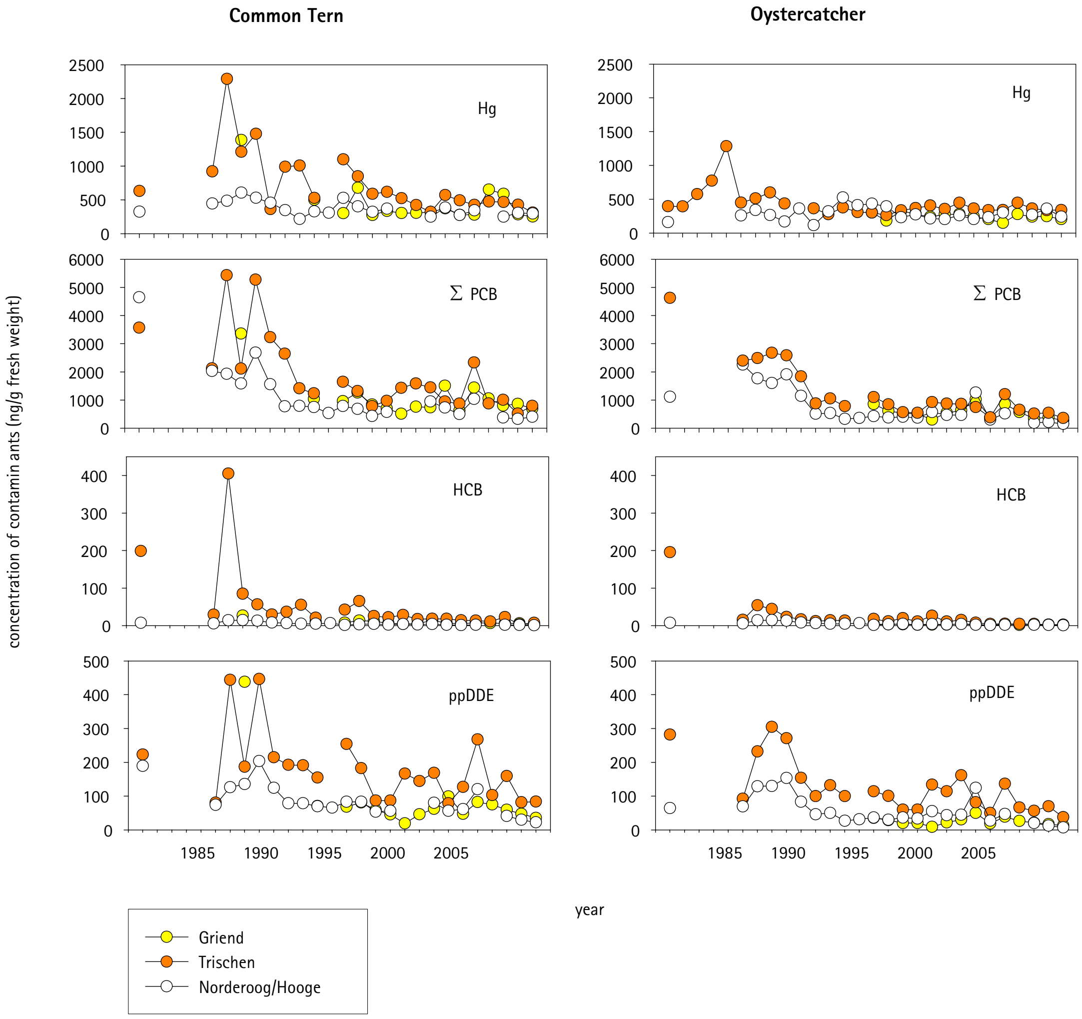


Figure 5.2.4: Middle-term (1998–2008) trends of contaminant concentrations in oystercatcher eggs from selected sampling sites (cf. Figure 1 and 2). Dots indicate arithmetic means (ng/g fresh weight of egg content).

Figure 5.2.5: Long-term (1981-2008) trends of concentrations of mercury, PCBs, HCB and ppDDE in common tern and oystercatcher eggs from three selected breeding sites in the Wadden Sea, Griend (NL1; CT since 1988; OC since 1995), Trischen (SH1) and Norderoog/Hallig Hooge (SH3). ΣPCB: sum of 32 PCB congeners; ng/g fresh weight; dots indicate arithmetic means. Data for 1981-1990 after Becker et al. (1991, 1992), for 1991-2003 after Becker & Muñoz Cifuentes (2005).



for the eggs of the study species (Mattig et al., 2000), TEQ concentrations recorded were up to about 2,500 times higher than the EU limits for chicken eggs destined for human consumption (2 pg/g fat; Chemisches und Veterinärmedizinisches Untersuchungsamt Freiburg, 2006).

5.2.5 Target evaluation

The concentrations of contaminants measured in bird eggs indicate that the burden of pollutants in the Wadden Sea is slowly decreasing towards the proposed Wadden Sea Plan targets, which are background concentrations of micropollutants such as mercury that occur naturally, and zero concentrations in the case of man-made substances such as organochlorines (TMAP, 1997). In 2008, the EcoQOs proposed for contaminants in seabird eggs (ICES, 2003, 2004; OSPAR, 2007) have already been reached for some substances at some sites in the Wadden Sea. For ΣHCH, this is true at the majority of sampling sites, but not for various other substances and locations (mercury, oystercatcher < 100 ng/g : no site; common tern < 200 ng/g: 1 site; ΣPCB < 20 ng/g: no site in both species; HCB < 2 ng/g: oystercatcher, 6 sites, common tern, no site; ΣDDT < 10 ng/g: oystercatcher, 2 sites, common tern, no site; ΣHCH < 2 ng/g: oystercatcher, 9 sites, common tern, 8 sites).

The stagnation of the levels of various substances and some recent increases point to local problems with environmental pollutants. Among these are several contaminants whose use has been prohibited a long time ago, such as ΣDDT and ΣChlordane. At the hot spots of contamination, the present concentrations of ΣPCB and ΣDDT, especially in the eggs of common tern, are still very high in comparison with the target levels.

In the framework of a pilot study on the EcoQO "Mercury and Organohalogens in Seabird Eggs", eggs were sampled at additional sites on the North Sea coast in 2008/2009 (Norway: Rogaland, Sweden: Skagerak, The Netherlands: Rhine-Scheldt

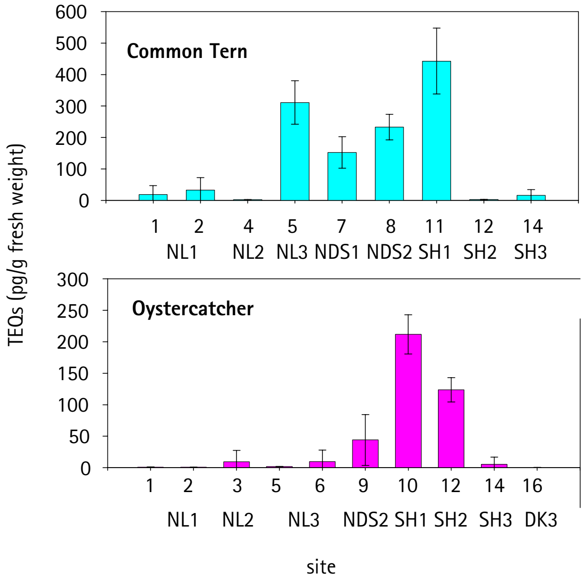


Figure 5.2.6: Geographical variation of TEQs (Toxic Equivalents) analyzed in common tern and oystercatcher eggs in the Wadden Sea in 2008. For location of sites cf. Figures 5.2.1 and 5.2.2. To calculate TEQs of non- and mono-ortho PCB congeners, bird-specific 2,3,7,8-TCDD toxic equivalency factors (TEF) proposed by the WHO (Van den Berg et al., 1998) were used. Non-ortho congeners detected were PCB126 and 169, mono-ortho congeners were PCB105, 114, 118, 123, 156, 157, 167 and 189). Mean concentration (pg/g fresh weight of egg content) and 95% confidence intervals are presented. At most sites, n=10 eggs were sampled.

estuary, Belgium: Zeebrugge, and in 2009 at three sites in the UK). The inter-site comparison of contamination levels indicates that, in most cases, concentrations were lowest at the proposed reference areas in Scandinavia, far distant from industrial hot spots. The tentative EcoQO of mercury (≤200 ng/g in the common tern and ≤100 ng/g in the oystercatcher, based on lowest values ever measured in the Wadden Sea) was reached by oystercatcher eggs at Rogaland (97 ng/g), as well as by Arctic/common tern eggs at Rogaland and Skagerrak respectively (173 ng/g). Nevertheless, the lowest ΣPCB-levels found (Rogaland: oystercatcher 132 ng/g, arctic tern 137 ng/g) were still clearly higher than the target level of 20 ng/g.

5.2.6 Discussion of trends and conclusions

During the last five years, the Elbe estuary persisted to be a hot spot of chemical contamination although the concentrations of most contaminants were decreasing. In comparison with the previous reporting period covered by the QSR 2004, the Ems estuary has emerged as an additional hot spot (Figure 5.2.2). Whereas the previously elevated HCB levels in oystercatcher eggs have decreased in this area (Figure 5.2.3 and 5.2.4), levels of ΣChlordane have increased. ΣPCB and ΣDDT have increased in both species studied. In 2008, levels of some contaminants recorded in bird eggs at the Ems estuary were similar or even higher than those at the Elbe estuary (Figures 5.2.3 and 5.2.4). The higher concentrations of all contaminants except ΣChlordane found in common tern compared to oystercatcher eggs may be a result of the higher trophic level and accumulation rates of the common tern.

Since the beginning of the 1990s (Figure 5.2.5), concentrations of most contaminants have decreased, with some fluctuations in the mid-1990s. These negative trends did continue during the first decade of the 2000s, with pronounced decreases occurring during the last five years. The results indicate that the general contaminant burden on the ecosystem has lowered. Despite this general development, the concentrations of some chemicals have increased in recent years. This may indicate new inputs or remobilization of these substances from sedimentary deposits through natural processes or human activities such as dumping harbour sludge. The increase of ΣPCB, ΣDDT, ΣHCH and ΣChlordane concentrations at the Ems estuary observed in both species (see above) is remarkable as these contaminants have been legally banned for decades (see Becker et al., 2001, for details).

Contrasting with the general long-term trends, sporadic and partly local instances of increased contamination with some substances have occurred since 2004 (Figures 5.2.3 and 5.2.4). In this respect also the exceptionally high levels of PCB64 at two sites in the Lower Saxon Wadden Sea are cause for concern.

The current levels of most contaminants in bird eggs are in general below the known threshold concentrations affecting birds' reproduction. However, the fact that TEQs reached biologically relevant levels at some sites in 2008 shows that the danger of intoxication of birds by environmental chemicals in the Wadden Sea is ongoing, and that even nowadays endangering of bird populations by chemical pollution cannot be excluded.

In 2008, the EcoQOs proposed for contaminants in seabird eggs (ICES, 2003, 2004; OSPAR, 2007) have already been reached for some substances at some sites in the Wadden Sea. The stagnation of the levels of various substances and some recent increases point to local problems with environmental pollutants. At the hot spots of contamination, the present concentrations of ΣPCB and ΣDDT, especially in the eggs of common tern, are still very high in comparison with the target levels.

5.2.7 Recommendations

Considering the current contamination status of bird eggs on the Wadden Sea coast and its recent development, we recommend:

(1) to continue monitoring of the TMAP parameter "Contaminants in Bird Eggs" in a long-term perspective, especially at the identified hot spots, and on an annual basis in order to dispose of the statistical power to separate short term fluctuations from long-term trends and to use the parameter as an early warning of marine pollution with chemicals;

(2) to include new toxic substances in the analytics;

(3) to carefully supervise the TEQs as indicators of toxic PCB congeners;

(4) to continue to pursue the one-lab-approach that has been the basis of the parameter "Contaminants in Birds Eggs" since 1991, in the process saving expensive intercalibration between laboratories and guaranteeing comparability, costs and time;

(5) to continue assessment of the EcoQO "Mercury and Organohalogens in Seabird Eggs" (OSPAR 2007) in order to supplement the geographical coverage of "Contaminants in Bird Eggs" by additional sampling sites and reference areas around the North Sea;

(6) to implement the parameter "Breeding Success" within the TMAP to provide a sensitive ecotoxicological indicator. This parameter should be adequately combined with the parameter "Contaminants in bird eggs", at least at the hot spots of chemical pollution (Elbe and Ems estuaries). The combination of both parameters will present an effective early warning against chemical pollution of the Wadden Sea (Thyen et al., 1998, Muñoz Cifuentes, 2004).

(7) to reinforce the need for continued effort to reduce anthropogenic atmospheric or riverine inputs of hazardous chemicals into the Wadden Sea, in order to avoid impacts on bird populations and the ecosystem. The elevated concentrations of some PCBs in 2008 at the estuaries of the rivers Ems and Elbe (PCB64 and some toxic PCB-congeners) are a warning of the importance of this work.

Table 5.2.1:
Middle (1998-2008) and short term (2004-2008) trends in pollutant levels and TEQs in common tern and oystercatcher eggs. Spearman rank correlation coefficients (rs) were calculated on the basis of n eggs, and p-values are presented. * <0,05, ** <0,01, ***0,001. Positive trends are given bold.

		n	Hg	ΣPCB	HCB	ΣDDT	ΣHCH	ΣChlordane	TEQs
Common Tern									
Balgzand	1998-2008	110	-0,194 *	-0,372 ***	-0,468 ***	-0,246 **	-0,709 ***	-0,92	-0,388 ***
	2004-2008	50	-0,543 ***	-0,546 ***	-0,191	-0,493 ***	-0,083 ***	**0,385 ****	-0,694 ***
Griend	1998-2008	110	0,069	0,146	-0,195 *	0,124	-0,703 ***	-0,23	-0,285 **
	2004-2008	50	-0,314 *	-0,630 ***	-0,606 ***	-0,698 ***	0,001	-0,253	-0,659 ***
Julianapolder/ Schiermonnikoog	1998-2008	69	-0,241 *	0,125	-0,621 ***	-0,077	-0,625 ***	0,038	-0,313 **
	2004-2008	36	0,194	-0,125	-0,359 *	-0,282	0,001	0,006	-0,589 ***
Delfzijl	1998-2008	110	-0,345 **	**0,191 ***	-0,195 *	**0,255 ****	-0,637 ***	-0,353 ***	-0,209 *
	2004-2008	50	-0,238	0,021	-0,059	0,094	0,047	-0,047	**0,340 ***
Minsener Oog	1998-2008	110	0,168	-0,018	-0,366 ***	-0,023	-0,438 ***	-0,250 ***	-0,078
	2004-2008	50	-0,412 **	-0,363 **	-0,419 **	-0,341 *	**0,465 *****	-0,264	0,177
Neufelderkoog	1998-2004	110	-0,083	-0,346 ***	-0,736 ***	-0,153	-0,145	-0,102	0,018
	2004-2008	50	-0,433 **	-0,450 ***	-0,406 **	-0,225	-0,787 ***	-0,654 ***	-0,157
Trischen	1998-2008	110	-0,312 ***	-0,416 ***	-0,559 ***	-0,110	-0,402 ***	-0,424 ***	-0,350 ***
	2004-2008	50	-0,284 *	-0,643 ***	-0,516 ***	-0,614 ***	-0,713 ***	-0,042	-0,838 ***
Norderoog/Hooge	1998-2008	75	-0,139	-0,598 ***	-0,540 ***	-0,584 ***	-0,569 ***	-0,395 ***	-0,409 ***
	2004-2008	35	0,035	-0,414 *	-0,824 ***	-0,785 ***	-0,672 ***	-0,680 ***	-0,789 ***
Oystercatcher									
Balgzand	1998-2008	110	**0,203 ***	-0,523 ***	-0,574 ***	-0,359 ***	-0,792 ***	-0,223 *	-0,375 ***
	2004-2008	50	0,040	-0,612 ***	-0,462 ***	-0,740 ***	-0,258	-0,087	-0,876 ***
Griend	1998-2008	111	-0,125	-0,238 *	-0,306 ***	-0,015	-0,390 ***	-0,037	-0,417 **
	2004-2008	51	**0,309 ***	-0,750 ***	-0,503 ***	-0,857 ***	-0,537 ***	-0,118	-0,901 ***
Julianapolder	1998-2008	108	-0,395 ***	-0,024	-0,638 ***	0,069	-0,719 ***	-0,089	-0,241 *
	2004-2008	50	0,167	-0,779 ***	-0,550 ***	-0,800 ***	-0,633 ***	-0,085	-0,776 ***
Delfzijl	1998-2008	110	-0,630 ***	**0,232 ***	-0,395 ***	**0,268 ****	-0,743 ***	-0,190 *	-0,537 ***
	2004-2008	50	-0,449 ***	-0,529 ***	-0,595 ***	-0,654 ***	0,183	-0,250	-0,720 ***
Dollart	1998-2008	85	-0,408 ***	-0,224 *	-0,564 ***	-0,155	-0,582 ***	-0,063	-0,671 ***
	2004-2008	49	-0,002	-0,561 ***	-0,549 ***	-0,485 ***	**0,591 *****	**0,335 ***	-0,711 ***
Mellum	1998-2008	110	-0,103	-0,554 ***	-0,523 ***	-0,316 ***	-0,677 ***	-0,370 ***	-0,465 ***
	2004-2008	50	0,014	-0,684 ***	-0,114	-0,672 ***	-0,193	-0,057	-0,344 *
Hullen	1998-2004	110	-0,292 **	-0,185	-0,627 ***	-0,132	-0,435 ***	0,149	0,057
	2004-2008	50	**0,365 ****	-0,762 ***	-0,284 *	-0,632 ***	-0,679 ***	0,247	-0,564 ***
Trischen	1998-2008	108	**0,272 ****	-0,459 ***	-0,876 ***	-0,424 ***	-0,391 ***	0,006	-0,170
	2004-2008	50	-0,303 *	-0,749 ***	-0,698 ***	-0,622 ***	-0,685 ***	0,022	-0,538 ***
Norderoog/Hooge	1998-2008	99	**0,244 ***	-0,587 ***	-0,578 ***	-0,579 ***	-0,553 ***	-0,587 ***	-0,393 ***
	2004-2008	40	-0,155	-0,688 ***	-0,705 ***	-0,863 ***	-0,664 ***	-0,821 ***	-0,862 ***
Langlie	1998-2008	84	-0,036	-0,231 *	-0,560 ***	0,056	-0,739 ***	0,125	-0,146
	2004-2008	44	-0,092	-0,807 ***	-0,540 ***	-0,750 ***	-0,592 ***	-0,422 **	-0,795 ***

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