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Documentation of the TMAP Parameter "Pollutants in seabird eggs" in The Netherlands in 2009

1. Egg sampling

1.1 Sampling sites in the Wadden Sea in 2009

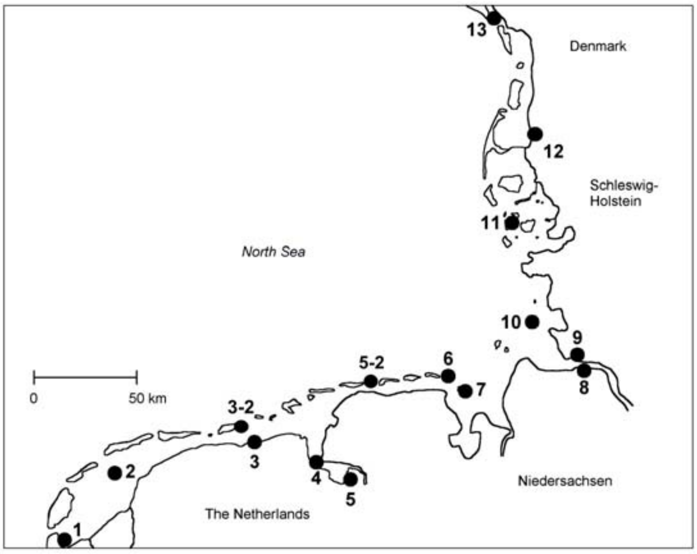

Fig. 1: TMAP parameter „Contaminants in bird eggs": Sampling sites of Oystercatcher and/or Common Tern eggs in the trilateral Wadden Sea. The Netherlands: 1 Balgzand, 2 Griend, 3 Julianapolder, 3-2 Schiermonnikoog, 4 Delfzijl; Germany, Lower Saxon: 5 Dollart, 5-2 Baltrum, 6 Minsener Oog, 7 Mellum (6 and 7 = Jade), 8 Hullen, 9 Neufelderkoog (8 and 9 = Elbe estuary); Germany, Schleswig Holstein: 10 Trischen, 11 Norderoog/Hallig Hooge; Denmark: 12 Margrethekoog, 13 Langli. At sites 3, 5, 7, 8 and 13 only Oystercatcher eggs, at sites 3-2, 6 and 9 only Common Tern eggs were taken. In 2009, eggs were sampled at all sites except Margarethekoog, at Langli, sample size was only 4 eggs.

1.2 The following egg samples were collected in The Netherlands in 2009:

	Species	
Site	Oystercatcher	Common Tern
Balgzand	10	10
Griend	10	10
Julianapolder	10	-
Schiermonnikoog	-	10
Delfzijl	10	10

1.3 Sampling: See OSPAR (1997), Becker et al. (2001) and VDI (2009) for methods

2. Chemical analytics

The samples were analyzed as shortly described by OSPAR (1997), Sommer et al. (1997) and Becker et al. (2001). You can get a detailed description of methods on request.

3. Documentation of data, description of the EXCEL-file and of the variables

The data from The Netherlands in 2009 are documented in an EXCEL-file (already sent on disk). The variables in the EXCEL-file are explained in the file-head.

4. Assessment of the results

To present a short assessment of the data, we prepared and present statistics for the following most important chemicals or chemical groups:

ORGANOCHLORINES:

PCB sum	62 congeners
6PCBs	6 PCB-congeners (PCB28, PCB52, PCB101, PCB138, PCB153, PCB180)
TEQs	Sum of concentrations of 10 of 12 dioxin-like PCBs PCB126, PCB169, PCB105, PCB114, PCB118, PCB123, PCB156, PCB157, PCB167, PCB189), each multiplied with a specific toxicity equivalence factor (TEF) 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 (Van den Berg et al. 1998)
HCB	
HCH sum	α-HCH, β-HCH, γ-HCH
DDT sum	p,p’-DDE, p,p’-DDT, p,p’-DDD
Chlordane sum	Sum of Chlordan and Nonachlor-compounds: trans-Chlordan, cis-Chlordan, trans-Nonachlor, cis-Nonachlor

HEAVY METALS:

Hg (mercury)

All concentrations are given in ng $\cdot g^{-1}$ fresh weight of the eggs.

Statistics:

For analysing temporal trends Spearman rank correlations were calculated (two-tailed) for the years 2005 - 2009. To identify potential differences in pollutant concentrations between 2008 and 2009, Mann-Whitney-U-tests were conducted. In the figures, arithmetic means ± 95% confidence intervals are presented. If the confidence intervals do not overlap, significance of at least $p < 0.05$ is indicated.

5 Results

5.1 Annual variation in pollutant concentration in the period 2005-2009

Balgzand

Temporal Trends 2005-2009:

Oystercatcher	Significant **decreases** were detected in Hg, PCB, HCB and DDT, **increases** in HCH.
Common Tern	Significant **decreases** were detected in Hg, PCB, DDT and HCH.

In 2009, significantly **lower** Chlordane levels and **higher** levels of HCB, DDT and HCH than in 2008 were found in Oystercatcher eggs. In Common Tern eggs, concentrations of PCB, DDT and Chlordanes were **lower**, concentrations of HCB were **higher** in 2009 compared to 2008.

Griend

Temporal Trends 2005-2009:

Oystercatcher	Significant **decreases** were detected in Hg, PCB and HCH.
Common Tern	Significant **decreases** were detected in Hg, PCB, HCB, DDT and HCH.

Between 2008 and 2009, Hg and Chlordane concentrations **decreased**, HCB and HCH levels **increased** in Oystercatcher eggs. In Common Tern eggs, the PCB level **decreased**, the HCB and HCH levels **increased** in that period.

Julianapolder/Schiermonnikoog

Temporal Trends 2005-2009:

Oystercatcher	Significant **decreases** in the concentrations of PCB and DDT were identified.
Common Tern	Significant **decreases** in the concentrations of PCB and HCH were identified

In Oystercatcher eggs from 2009, the level of Chlordanes was significantly lower, those of HCB, DDT and HCH significantly higher than in 2008. In Common Tern eggs from 2009, the concentrations of PCB and Chlordanes were significantly lower than in 2008.

Delfzijl

Temporal Trends 2005-2009:

Oystercatcher	PCB, HCB, DDT and HCH **decreased**, Chlordanes **increased**
Common Tern	Hg and Chlordanes **decreased** significantly, HCB **increased**

Between 2008 and 2009, no significant changes were detected in the levels of the six substance groups studied in Oystercatcher eggs. Between 2008 and 2009, levels of PCB and DDT decreased, the level of Hg increased in Common Tern eggs.

5.2. Spatial patterns of selected contaminants in the Wadden Sea in 2009

For the Oystercatcher, we identified areas with relatively high contaminations (in the order of mean contamination level, beginning with the highest):

Mercury:	Trischen, Halligen, Balgzand, Dollart
PCB:	Elbe, Julianapolder, Delfzijl
HCB:	Delfzijl, Elbe
DDT:	Trischen, Elbe
HCH:	Trischen, Elbe, Griend, Balgzand, Halligen
Chlordanes:	Delfzijl, Dollart

In the Common Tern concentrations of most pollutants were again higher than in the Ostercatcher. In the following areas relatively high contaminations of Common Tern eggs were detected (given in the order of contamination level, beginning with the highest average level):

Mercury:	Elbe, Trischen
PCB:	Elbe, Jade, Delfzijl
HCB:	Elbe
DDT:	Elbe
HCH:	Elbe, Halligen
Chlordanes:	Delfzijl, Jade, Balgzand, Baltrum

In the **Oystercatcher**, the geographical pattern of pollutant concentrations in 2009 was largely similar to that of 2007 (last report; Becker et al. unpubl.) in case of Hg, PCB, HCB and HCH. For Hg, peak values were recorded in the area of the Halligen and Trischen, comparatively low levels were recorded at Julianapolder, Delfzijl and at Langli. For PCB comparatively high concentrations were recorded at the river Elbe, at Julianapolder and at Delfzijl, but no more at Dollart. However, HCB reached the highest level of all areas sampled in 2009 at Delfzijl and was clearly higher there than in 2007. Again, HCH reached the highest average concentration at Trischen, followed by Elbe and Griend. For DDT and Chlordanes the spatial patterns of 2009 differed stronger from those in 2007: In 2009, the clearly highest levels of DDT were recorded at Trischen where they were about 3-times higher than in 2007. Among the other sites, rather high values were still found at the river Elbe. The spatial pattern of Chlordanes in 2009 was clearly different from that in 2007: Whereas in 2007, the lowest concentration was recorded at Delfzijl, the highest value was recorded there in 2009, Chlordane concentration was decreasing steeply from Delfzijl westward and slightly less steeply towards the east. Summarizing, for 3 out of 6 substance groups studied, the highest levels were found at Trischen and no more at the river Elbe. Hence, spatial patterns of substance concentrations were more substance-specific in 2009 than in 2007.

In contrast, the geographical pattern of pollutant concentrations in **Common Tern** eggs remained generally very similar to those of 2007: Clear peaks of Hg, PCB, HCB, DDT and HCH have been found again at the river Elbe, with concentrations decreasing more or less steeply towards the more western and northern parts of the Wadden Sea. Only for Chlordanes, peak concentrations were reached at Dollart and Jade in 2009 whereas at the river Elbe and at Griend, values were below the detection limit. The strong shift in the geographical pattern of Chlordanes is probably due to the fact that concentrations approach the detection limit, thus increasing the emergence of stronger relative errors of measurement.

5.3. Temporal trends and spatial patterns in TEQs

In Oystercatcher eggs, significant decreases of TEQs were recorded at the river Elbe and at Trischen. For Common Tern eggs, this was true for the sites Griend, Delfzijl, Baltrum, Jade and Elbe. At these sites (except Griend) the highest concentrations had been reached in 2008. Due to these considerable decreases the general spatial pattern of TEQ contamination has also changed: In 2009, highest TEQ levels were recorded at Jade and Delfzijl for Oystercatcher eggs and at Balgzand for Common Tern eggs. It has to be mentioned that the highest peak values recorded for TEQs in 2009 were about 3,5-times (Oystercatcher, Jade) and, respectively, about 26-times lower than peak values in 2008 which had been recorded ath the river Elbe for both species.

6. General Assessment

For the Common Tern, the clearly highest concentrations of all substance groups except Chlordanes and TEQs were recorded at the river Elbe. Similarly to the situation in previous years, the contamination was decreasing continuously with an increasing distance from the Elbe estuary towards the north and the west.
For the Oystercatcher, concentration peaks were found at the Elbe and at Trischen, but additional sites of comparatively high levels were identified in the western part of the Wadden Sea, which is also in accordance to the findings in previous years: In 2009, rather high values for Hg, PCB, HCB and HCH were found on one hand at Elbe and/or at Trischen and, on the other hand, at Balgzand (in case of Hg and HCH, in case of HCH also Griend) and, respectively, in the area of Julianapolder and/or Dollart (PCB) and Delfzijl (HCB). For DDT the clearly highest values were recorded at Trischen, for Chlordanes at Delfzijl in 2009.

In general, species-specific spatial contamination patterns which had already been suggested by the findings of 2007 became even more clear in 2009: The contamination pattern of the Common Tern with clear concentration peaks at the river Elbe has remained very similar to those in previous years. In contrast, concentration peaks of Hg, DDT and HCH in Oystercatcher eggs have shifted to Trischen. Further sites of comparatively high concentrations of all substance groups except DDT have been recorded for the Oytercatcher, but not the Common Tern, in the western Wadden Sea. For these differences the different foraging ecology of both species might be important: For the ground-feeding Oystercatcher, substances bound to sediment particles - which may have been transported in advance – could be of particular importance whereas the plunge-diving Common Tern may be stronger affected by the contamination of prey organisms in the water column. In addition, it is likely that Oystercatchers will additionally feed in terrestrial habitats. Furthermore, outside the breeding season, both species are likely to spent different amounts of time at the study sites - the Waddensea-population of the Oystercatcher partly is wintering in this area - which may have additionally affected the spatial contamination patterns. In general, data show as in previous years the importance of the large rivers Elbe and Ems, possibly also of the Rhine (Balgzand) for the transport of different environmental pollutants into the Wadden Sea. Pollutant concentrations in Common Tern eggs are still generally higher than in Oystercatcher eggs which is explained by the fact that the piscivorous Common Tern represents a higher trophic level than the Oystercatcher (stronger accumulation of contaminants).

Within the five-years-period 2005-2009, concentrations of many contaminants have continued to decrease. For the Oystercatcher it has to be mentioned that the PCB levels have decreased at all 10 study sites and that the DDT contamination has decreased at 8 of 10 study sites. In case of significant changes among the other substance groups, also mainly decreases have been recorded. The latter is also generally true for the Common Tern. Increases of contamination have been recorded in Oystercatcher eggs at Balgzand (HCH), Delfzijl (Chlordanes) and at Dollart (Hg) and in Common Tern eggs at Delfzijl (HCB). Comparing the values of 2009 with those of the previous year 2008, more increases than decreases of pollutant levels were recorded in Oystercatcher eggs (23 increases versus 15 decreases). In Common Tern eggs, 9 increases and 13 decreases were found. In

Oystercatcher eggs, the concentration of HCH has increased at 9 of 10 sites, for HCB and DDT this has been the case at 6 of the 10 sites. In Common Tern eggs, HCH has increased at 4 of 9 sites, HCB at 3 of 9 sites. In both species, HCB levels have increased at Balgzand, Griend and Halligen, those of HCH have increased at Griend, at Trischen and Halligen. The results indicate that both short-term analyses and fairly long-term analyses are necessary to describe adequately the changes in the contamination of the Wadden Sea with environmental pollutants.

The strong changes in TEQ concentration recorded between 2008 and 2009 may indicate that the comparatively high levels recorded in 2008 at Delfzijl, Baltrum, Jade and Elbe (Oystercatcher) and at Jade and Elbe (Common Tern) have resulted from a temporary and local input (cf. Becker & Dittmann 2009; Becker & Dittmann 2010). For instance, an input from the air is imaginable. On 31 July 2007, large amounts of plastics burnt during a blaze in a recycling facility for domestic waste at Eemshaven, NL which might have caused the emergence of dioxin-like substances. In the following year, besides the enhanced TEQ concentrations in bird eggs documented here, increased concentrations of dioxin have been found in livers of sheep in Northwest Germany. It seems imaginable – but of course is not proven – that the hazardous substances have been spread via a corridor over Northwest Germany by the western winds and rainfall occurring during that day.

Summarizing, the actual results indicate that the differences between the spatial contamination patterns of the two study species were even more pronounced in 2009 than in 2007. Whereas the Elbe river has proved to be still the most important source of contamination for Common Terns, the highest contamination of the Oystercatcher with several substances has been found increasingly at Trischen and at the Halligen. On the middle-term, a decrease has been determined for most of the studied substances at most sites. In contrast, between 2008 and 2009, increases of the contamination level have been recorded at many sites, in particular in case of HCB, HCH and, only for the Oystercatcher, also in DDT. However, between 2008 and 2009, concentration of TEQs have strongly decreased (both absolutely and proportionally) at least at those sites where levels have been particularly high in 2008. The results underline that statements concerning the development of the contamination of the Wadden Sea have to be differentiated in dependence of the spatial, temporal and species level. Only future data will be able to show if the actual increase in concentrations of some environmental pollutants marks the beginning of an undesirable trend reversal or not.

7. Literature

Becker, P.H. & T. Dittmann (2010): “Contaminants in Bird Eggs” in the Wadden Sea: Trends and Perspectives. Proc. 12th Intern. Scientific Wadden Sea Symposium, Wilhelmshaven. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

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8. Enclosures

8.1 Concentrations of selected contaminants in eggs of Oystercatcher and Common Tern at different sites of the Dutch Wadden Sea 2009
8.2 Spatial patterns in pollutant concentration in eggs of Oystercatcher and Common Tern in the Dutch, German and Danish Wadden Sea in 2009
8.3 Temporal trends of pollutant concentrations at different sites during 2005-2009
8.4 Temporal and spatial trends in TEQ concentrations

9. This report was compiled by Peter H. Becker, Tobias Dittmann and Ursula Pijanowska.

Wilhelmshaven, 22 January 2009

(Prof. Dr. Peter H. Becker)

8.1 Concentrations of selected contaminants in eggs of Oystercatcher and Common Tern at different sites of the Dutch Wadden Sea 2009

Table 8.1.1: Concentrations of chemicals in Oystercatcher and Common Tern eggs sampled in The Netherlands in 2009. Mean concentrations in ng · g^{-1} (fresh mass of egg content), standard deviations and number of samples are presented.

	Balgzand			**Griend**			**Julianapolder**			**Delfzijl**		
Oystercatcher	**(N=10)**			**(N=10)**			**(N=10)**			**(N=10)**		
Hg	231,1	±	72,5	166,4	±	51,2	128,7	±	23,4	127,7	±	40,3
6 PCB (law)	201,9	±	79,7	187,0	±	52,2	347,6	±	132,9	370,7	±	157,8
PCB sum	393,5	±	160,3	343,5	±	99,0	670,9	±	261,2	663,2	±	271,0
HCB	1,9	±	0,3	2,0	±	0,4	1,8	±	0,4	17,2	±	18,4
ppDDE	36,3	±	12,7	15,9	±	5,5	32,8	±	13,1	36,0	±	13,6
ppDDT	0,2	±	0,6	0,2	±	0,6	2,4	±	2,0	0,2	±	0,7
ppDDD	0,0	±	0,0	0,0	±	0,0	0,0	±	0,0	0,2	±	0,6
DDT sum	36,5	±	12,9	16,1	±	5,6	35,2	±	14,1	36,4	±	14,2
alpha-HCH	0,0	±	0,0	0,2	±	0,2	0,9	±	0,6	0,1	±	0,2
beta-HCH	3,1	±	1,0	3,1	±	1,1	1,1	±	1,2	0,7	±	2,3
gamma-HCH	0,0	±	0,0	0,0	±	0,0	0,0	±	0,0	0,0	±	0,0
HCH sum	3,1	±	1,0	3,2	±	1,1	1,9	±	1,4	0,8	±	2,3
Chlordane sum	0,4	±	0,4	0,3	±	0,3	0,3	±	0,3	2,7	±	1,9

	Balgzand			**Griend**			**Schiermonnikoog**			**Delfzijl**		
Common Tern	**(N=10)**			**(N=10)**			**(N=10)**			**(N=10)**		
Hg	242,5	±	45,0	232,7	±	38,1	255,2	±	56,8	233,6	±	27,2
6 PCB (law)	207,9	±	75,0	245,7	±	55,9	205,2	±	37,5	355,5	±	97,9
PCB sum	384,8	±	133,9	437,5	±	96,1	376,3	±	77,1	701,1	±	173,8
HCB	5,4	±	1,3	3,1	±	0,5	3,3	±	1,0	5,3	±	0,8
ppDDE	23,3	±	10,8	33,4	±	12,8	53,8	±	8,9	45,0	±	19,3
ppDDT	0,0	±	0,0	1,3	±	1,5	0,7	±	1,5	0,0	±	0,0
ppDDD	0,1	±	0,2	0,1	±	0,1	0,1	±	0,2	0,0	±	0,1
DDT sum	23,4	±	10,9	34,8	±	13,2	54,6	±	9,0	45,0	±	19,3
alpha-HCH	0,0	±	0,0	0,2	±	0,1	0,0	±	0,0	0,2	±	0,3
beta-HCH	0,3	±	0,5	0,2	±	0,3	0,0	±	0,0	0,3	±	0,2
gamma-HCH	0,0	±	0,0	0,0	±	0,0	0,0	±	0,0	0,0	±	0,0
HCH sum	0,3	±	0,5	0,4	±	0,3	0,0	±	0,0	0,5	±	0,4
Chlordane sum	0,2	±	0,5	0,0	±	0,0	0,0	±	0,0	0,5	±	1,1

8.2 Spatial patterns of pollutant concentration in the Wadden Sea in 2009

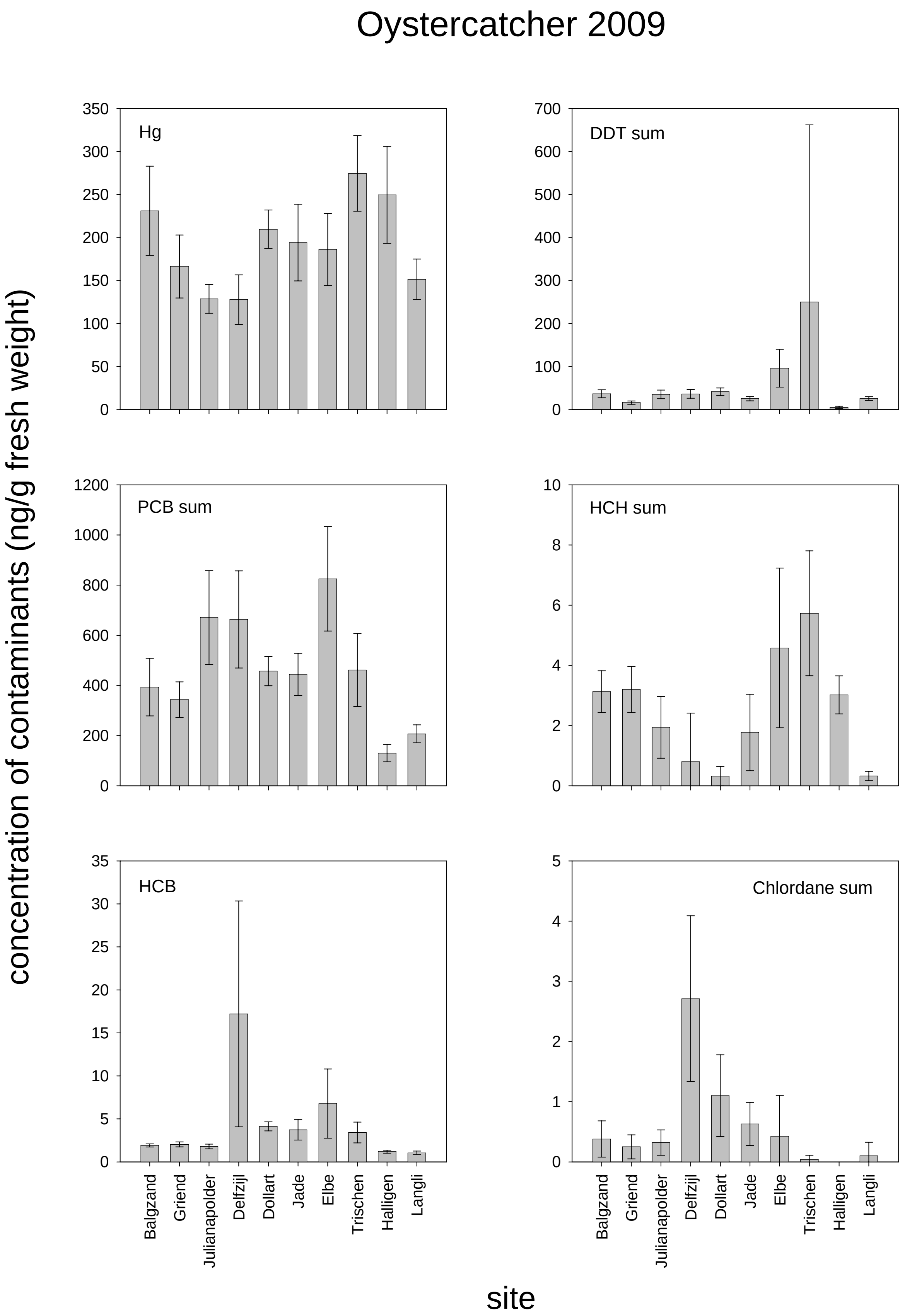

Fig. 8.2.1: Spatial patterns of pollutant concentrations in Oystercatcher eggs from the Wadden Sea in 2009

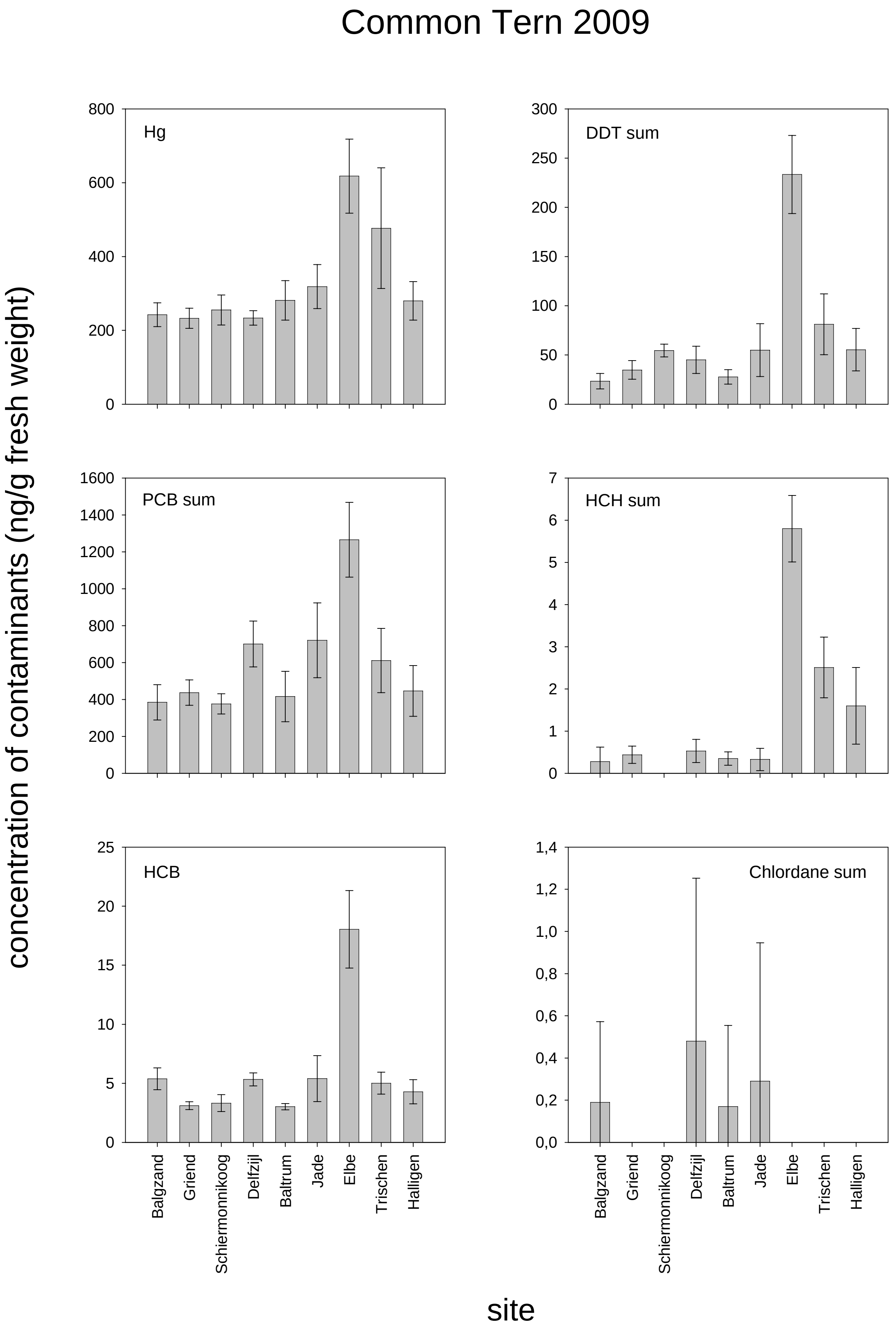

Fig. 8.2.2: Spatial patterns of pollutant concentrations in Common Tern eggs from the Wadden Sea in 2009

8.3 Temporal trends of pollutant concentrations at different sites during 2005-2009

Table 8.3.1: Overview over the development of selected pollutants in eggs of Oystercatcher and Common Tern in the Wadden Sea between 2005-2009 (Halligen 2006-2009), according to Spearman rank correlations. -: significant decline, +: significant increase.

	Oystercatcher										Common Tern								
	Balgzand	Griend	Julianapolder	Delfzijl	Dollart	Jade	Hullen	Trischen	Halligen	Langli	Balgzand	Griend	Schiermonnikoog	Delfzijl	Baltrum	Jade	Neufelderkoog	Trischen	Halligen
Hg	-	-			+			-			-	-		-	-	-	-		
PCB sum	-	-	-	-	-	-	-	-	-	-	-	-	-		-		-	-	
HCB	-			-	-			-	-	-		-		+	-		-	-	-
DDT sume	-	-	-	-	-	-			-	-	-	-			-	-	-	-	
HCH sum	+			-		-	-	-	-	-	-	-	-		-		-	-	
Chlordane Nonachlor sum				+				-	-					-			-		-

Table 8.3.2: Overview over the development of selected pollutants in eggs of Oystercatcher and Common Tern in the Wadden Sea between 2008-2009, according to Mann-Whitney-U-tests. -: significant decline, +: significant increase. Tendencies for Langli are given in brackets because sample of 4 eggs was too small to conduct pairwise tests.

	Oystercatcher										Common Tern								
	Balgzand	Griend	Julianapolder	Delfzijl	Dollart	Jade	Hullen	Trischen	Halligen	Langli	Balgzand	Griend	Schiermonnikoog	Delfzijl	Baltrum	Jade	Neufelderkoog	Trischen	Halligen
Hg		-			+		-	-						+					
PCB sum					-		+		-	(+)	-	-	-	-		-		-	
HCB	+	+	+		+	+			+		+	+					-	-	+
DDT sum	+		+			+	+	+		(+)	-			-					+
HCH sum	+	+	+		-	+	+	+	+	(+)		+			+	-		+	+
Chlordane Nonachlor sum	-	-	-		-	-	-	-	-	(-)	-		-						

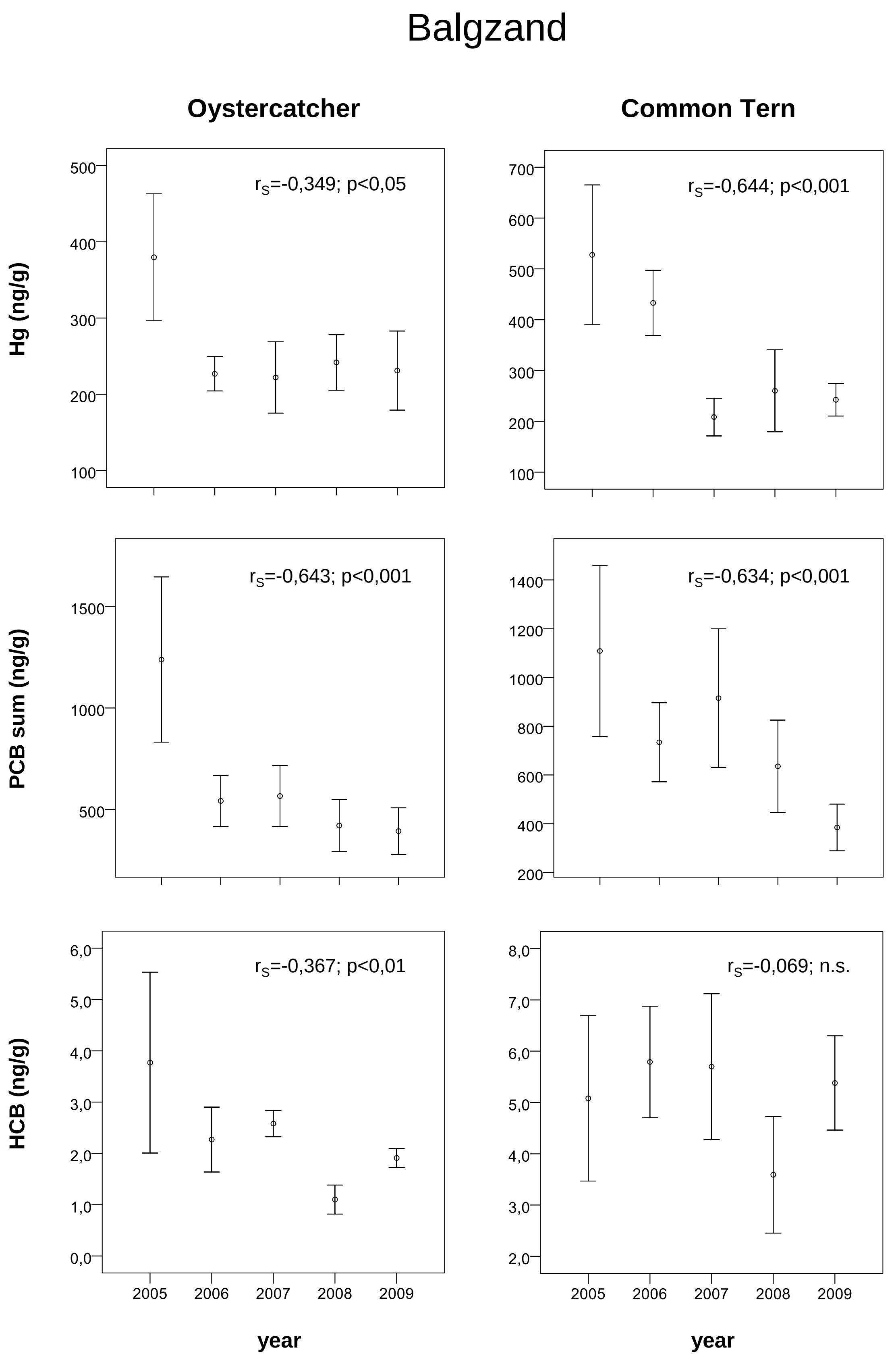

Fig. 8.3.1: Temporal development of pollutant concentrations in Oystercatcher and Common Tern eggs from Balgzand, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

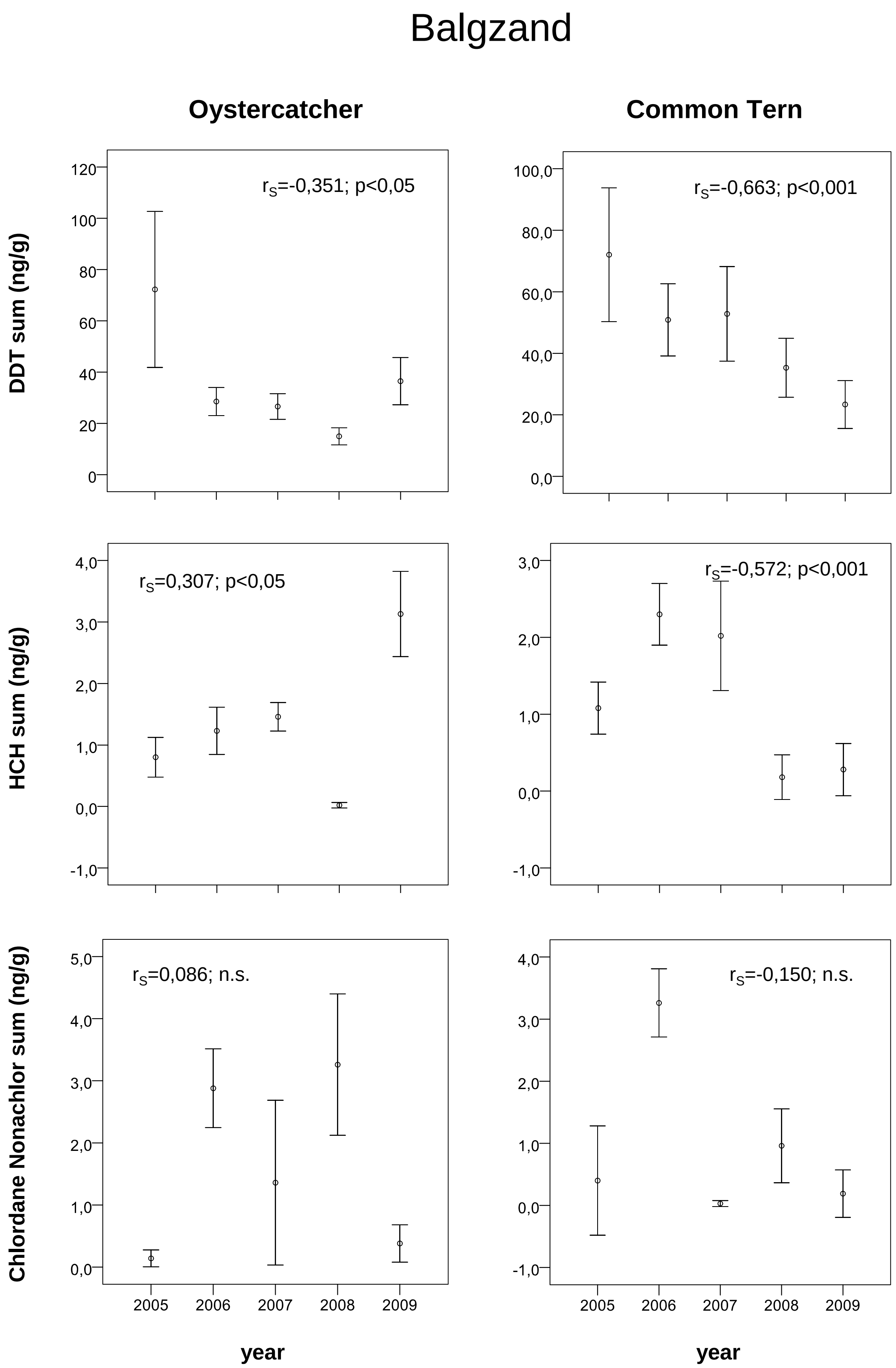

Fig. 8.3.1 (continued): Temporal development of pollutant concentrations in Oystercatcher and Common Tern eggs from Balgzand, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

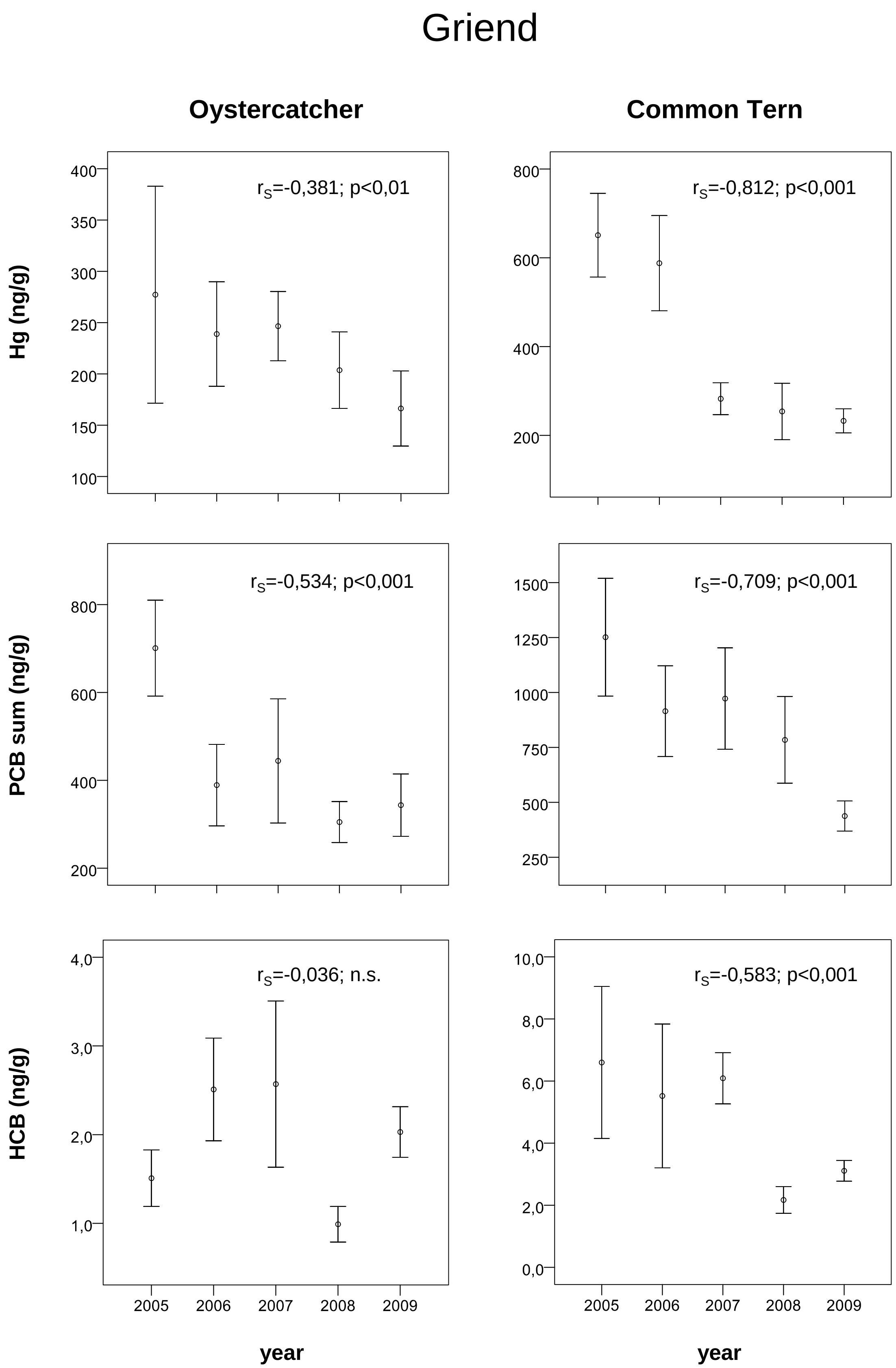

Fig. 8.3.2: Temporal development of pollutant concentrations in Oystercatcher and Common Tern eggs from Griend, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

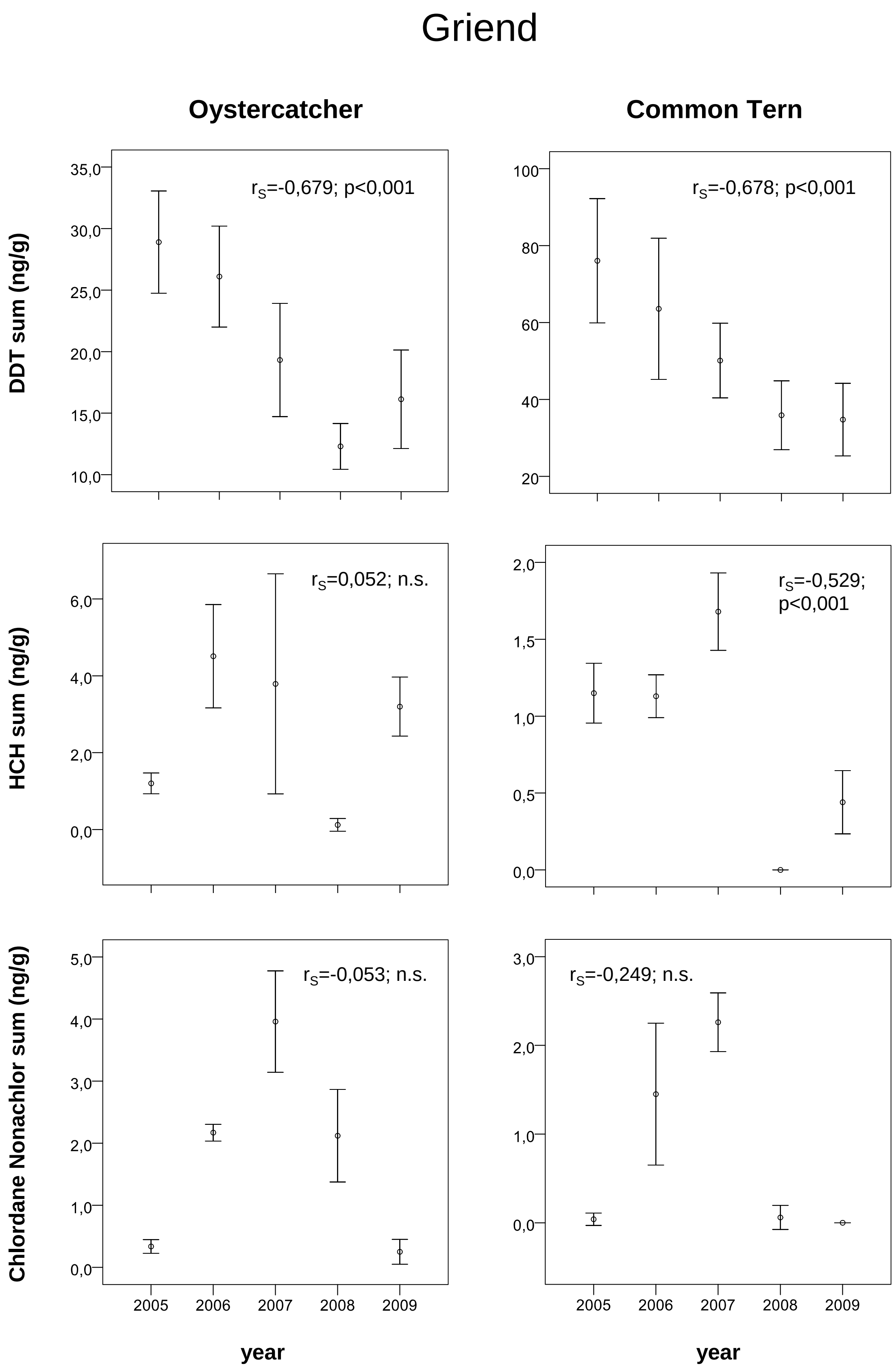

Fig. 8.3.2 (continued): Temporal development of pollutant concentrations in Oystercatcher and Common Tern eggs from Griend, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

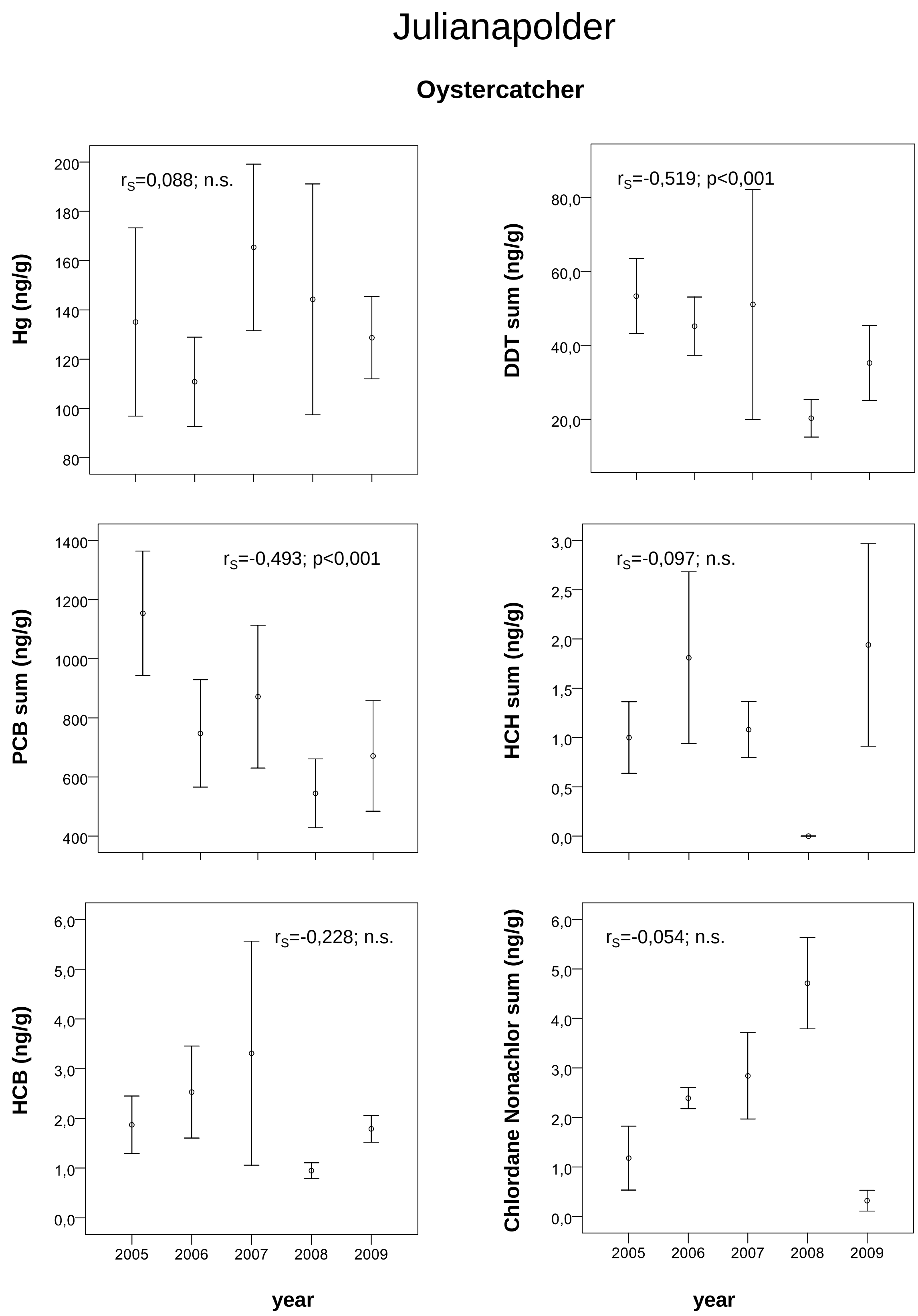

Fig. 8.3.3: Temporal development of pollutant concentrations in Oystercatcher eggs from Julianapolder, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

Schiermonnikoog

Common Tern

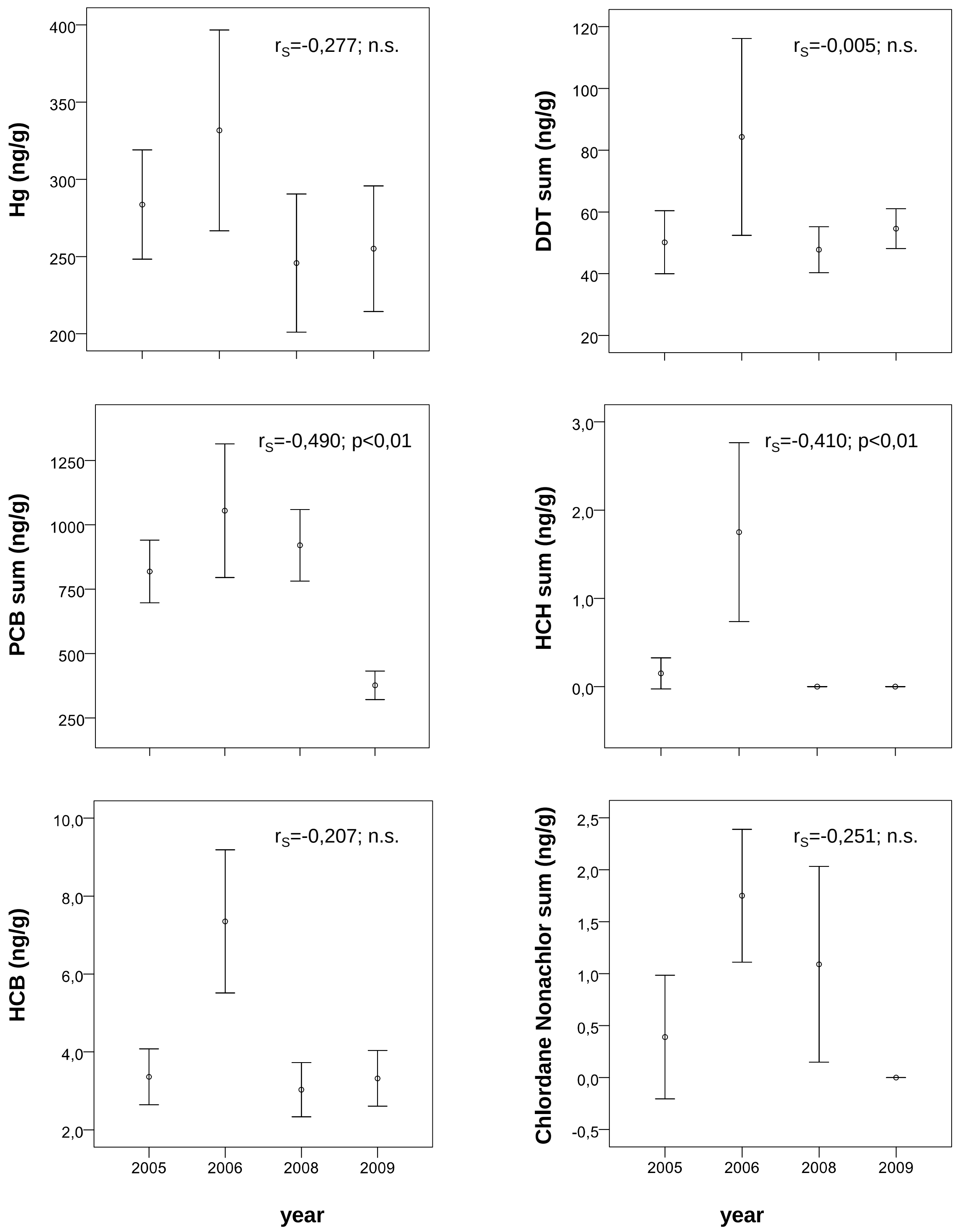

Fig. 8.3.4: Temporal development of pollutant concentrations in Common Tern eggs from Schiermonnikoog, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

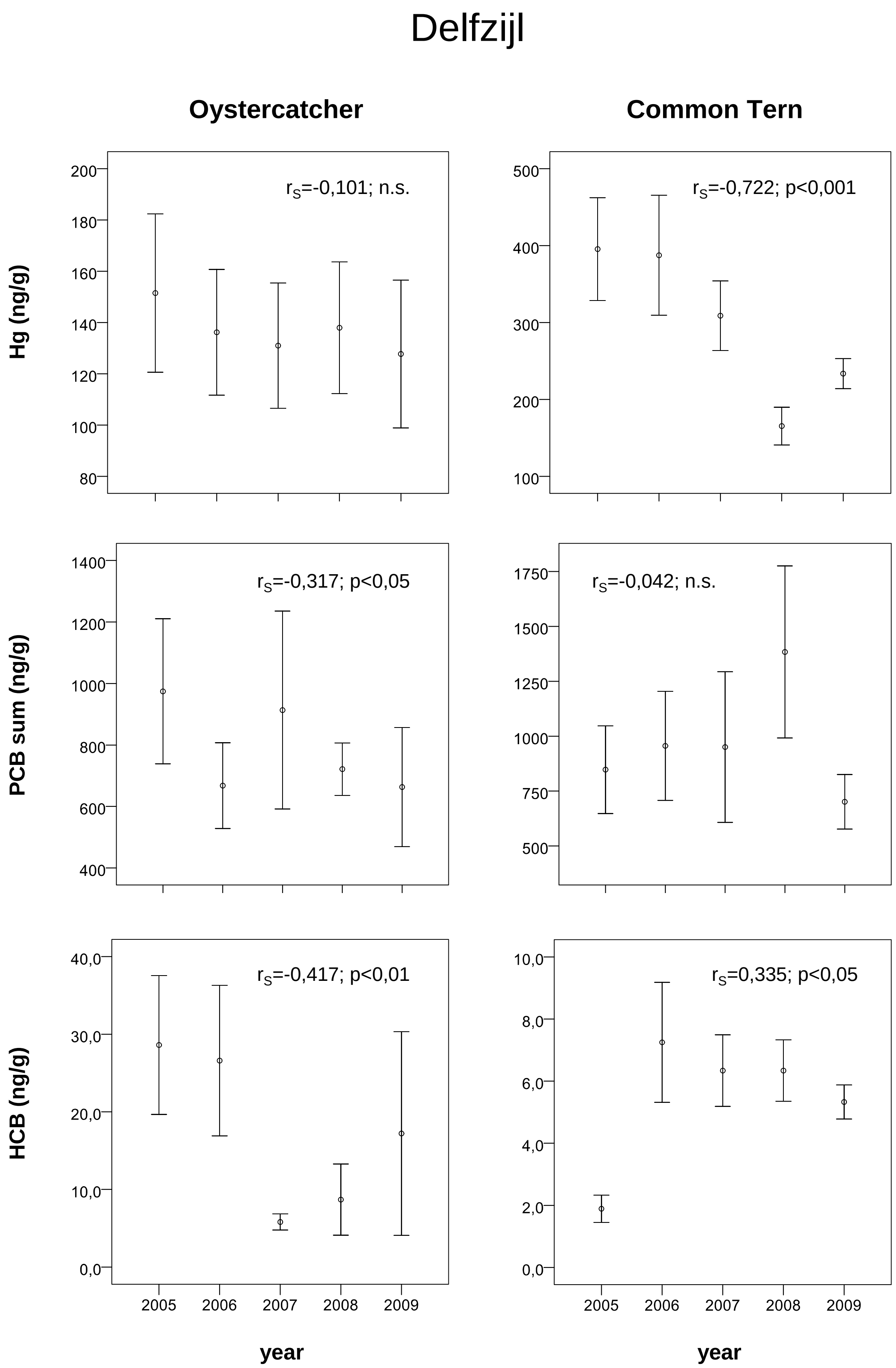

Fig. 8.3.5: Temporal development of pollutant concentrations in Oystercatcher and Common Tern eggs from Delfzijl, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

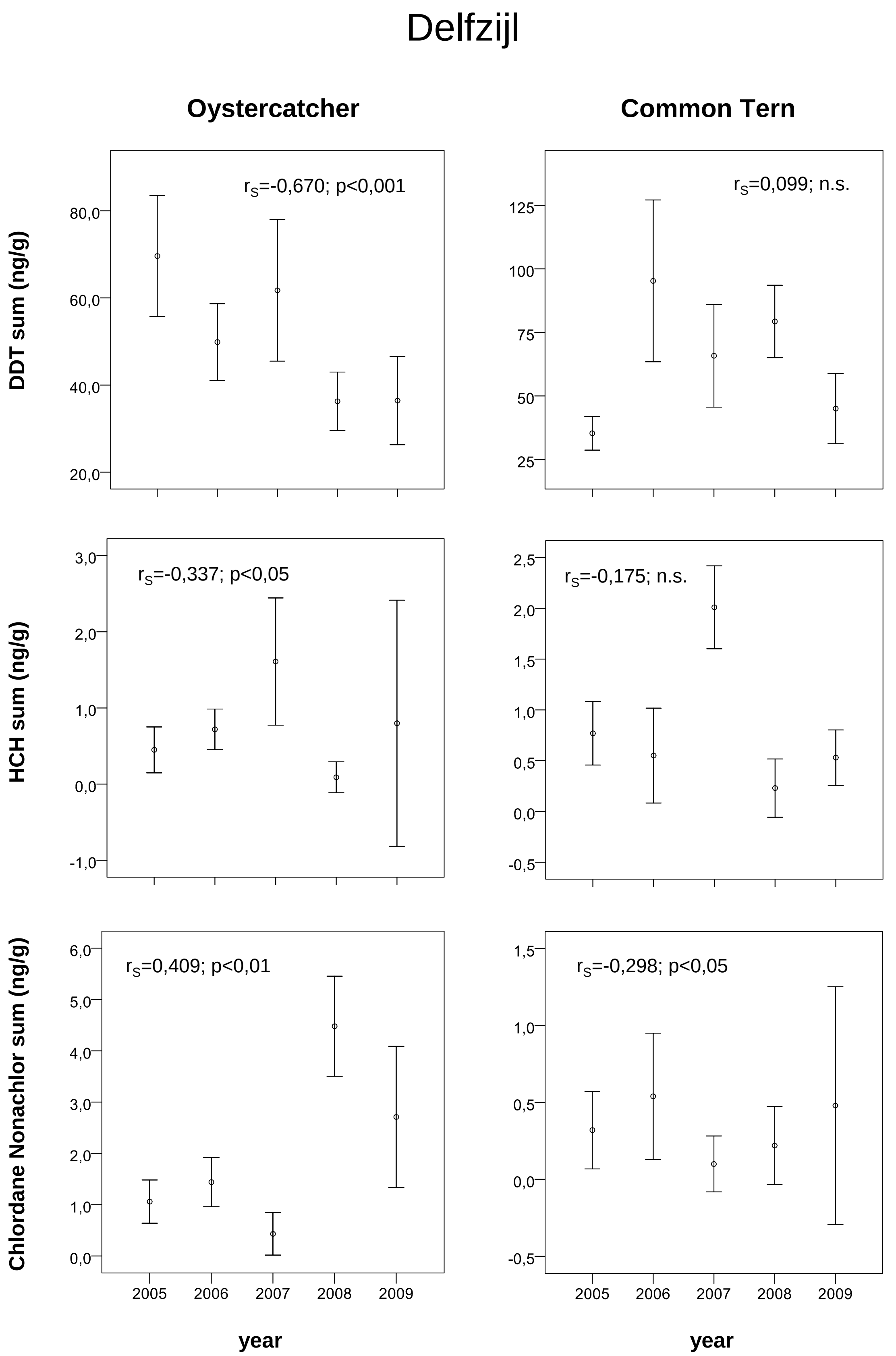

Fig. 8.3.5 (continued): Temporal development of pollutant concentrations in Oystercatcher and Common Tern eggs from Delfzijl, NL, in the period 2005-2009. Arithmetic means are given with the 95% confidence interval.

8.4 Temporal and spatial trends in TEQ concentrations

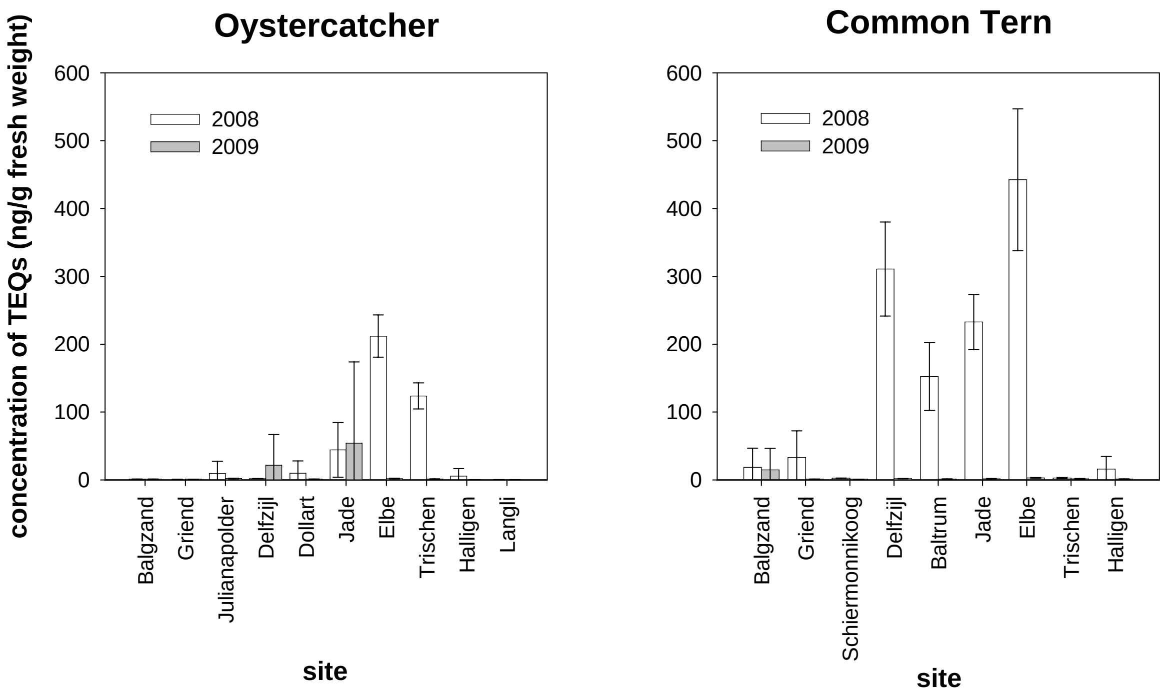

Fig. 8.4.1: Concentration of TEQs in Oystercatcher and Common Tern eggs in the Wadden Sea in 2008 and 2009