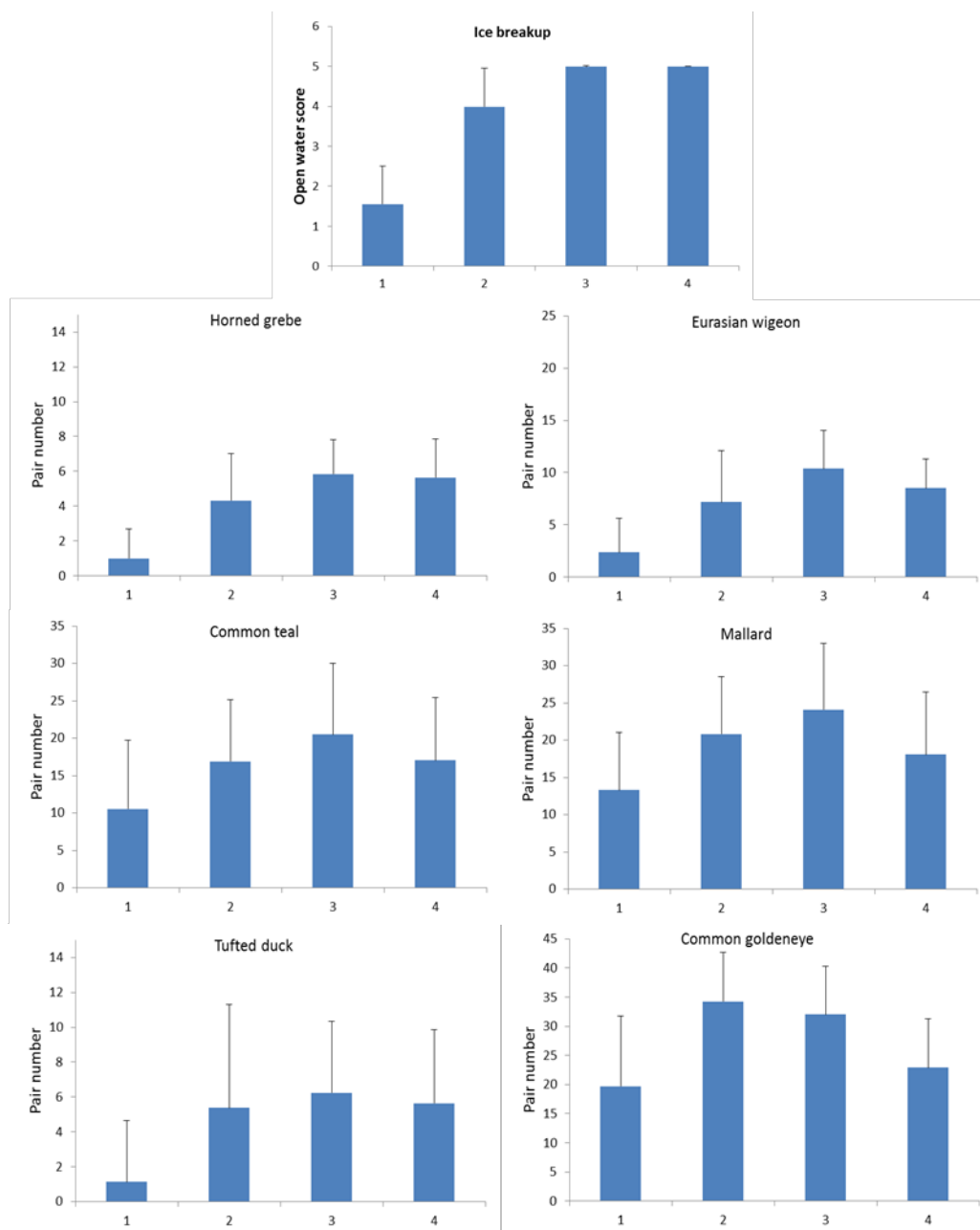


**Supplementary material**

## Appendix 1.



**Fig. A1.** Mean (+SE) open water scores (ice breakup; 0 = lake fully ice-covered, ..., 5 = lake fully open) and pair numbers of six waterbird species (horned grebe, Eurasian wigeon, common teal, mallard, tufted duck, common goldeneye) during four surveys (1, 2, 3 and 4) carried out at 37 lakes at intervals of seven days during April–May in 1991–2018.

**Table A1.** A hypothetical example of the calculation of annual population settling phenology indices (PSP) using survey-specific pair numbers as weighting factors; i.e., PSP is a weighted mean of the three survey dates for each year. Ice-out dates (IOD) and breeding pair survey dates are set fixed for clarity (1 = 1 April). Population settling phenology index, PSPA = (PSP-IOD).

Year	IOD	1st survey		2nd survey		3rd survey		PSP	PSPA
		Date	Pairs	Date	Pairs	Date	Pairs		
1	32	25	5	32	10	39	15	34.3	2.3
2	32	25	10	32	15	39	20	33.6	1.6
3	32	25	10	32	15	39	15	32.9	0.9
4	32	25	5	32	15	39	25	35.1	3.1
5	32	25	0	32	10	39	15	36.2	4.2

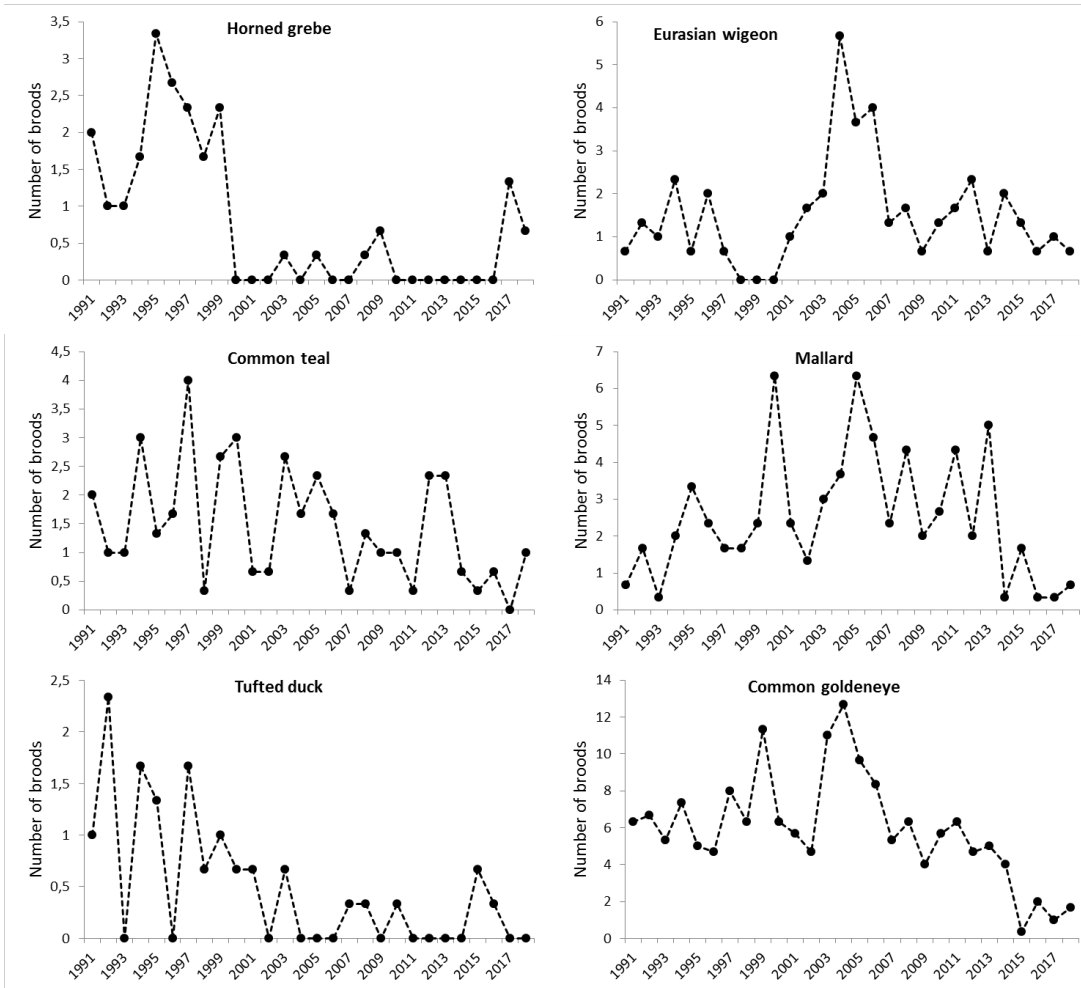
**Table A2.** Means, SDs and ranges of variables used in the analyses (n = 28 years). For further details, see the main text.

Variable	Mean	SD	Range
IOD	32.7	5.5	20.6–41.8
PSP, horned grebe	37.2	4.8	26.5–46.5
PSP, Eurasian wigeon	36.9	5.7	23.5–48.0
PSP, common teal	35.3	5.7	21.6–44.4
PSP, mallard	34.9	6.3	20.9–45.5
PSP, tufted duck	37.3	5.9	25.2–48.8
PSP, common goldeneye	34.7	6.1	21.6–45.6
PSPA, horned grebe	4.5	2.1	0.8–8.3
PSPA, Eurasian wigeon	4.2	2.0	0.6–7.6
PSPA, common teal	2.7	2.0	-1.2–6.5
PSPA, mallard	2.3	2.4	-1.0–8.7
PSPA, tufted duck	4.6	2.1	1.5–8.8
PSPA, common goldeneye	2.1	2.0	-1.5–5.9
Number of broods, horned grebe	0.8	1.0	0–3.3
Number of broods, Eurasian wigeon	0.2	1.3	0–5.7
Number of broods, common teal	1.5	1.0	0–4.0
Number of broods, mallard	2.5	1.7	0.3–6.3
Number of broods, tufted duck	0.5	0.6	0–2.3
Number of broods, common goldeneye	5.8	2.9	0.3–12.7
Number of pairs, horned grebe	5.6	1.9	2.0–9.5
Number of pairs, Eurasian wigeon	10.0	3.3	4.5–18.5
Number of pairs, common teal	20.0	7.3	9.0–38.0
Number of pairs, mallard	23.2	7.3	11.0–42.5
Number of pairs, tufted duck	6.5	4.5	0.5–19.5
Number of pairs, common goldeneye	33.8	7.6	14.5–50.0

**Table A3.** Pair-wise Pearson correlations or Kendall rank correlations for variables used to test for the effects of ice-out date (IOD) and population settling phenology asynchrony (PSPA) on annual breeding success for each species. In tufted duck and horned grebe breeding success was measured as a binary variable while it was a continuous variable in the other species. Significant ( $p < 0.05$ ) correlations are in bold;  $n = 28$  years in all cases. For additional information see the main text.

	Year	IOD	Breeding success	Number of pairs	PSPA
Horned grebe (Kendall rank correlation)					
Year	1.000				
IOD	<b>-0.319</b>	1.000			
Breeding success	<b>-0.387</b>	<b>0.615</b>	1.000		
Number of pairs	<b>-0.356</b>	<b>0.283</b>	<b>0.292</b>	1.000	
PSPA	-0.140	<b>-0.328</b>	-0.258	0.044	1.000
Eurasian wigeon (Pearson correlation; log-transformed number of pairs)					
Year	1.000				
IOD	<b>-0.461</b>	1.000			
Breeding success	0.071	-0.043	1.000		
Number of pairs	-0.178	0.019	0.053	1.000	
PSPA	<b>-0.430</b>	-0.088	-0.271	-0.133	1.000
Common teal (Pearson correlation; log-transformed breeding success and number of pairs)					
Year	1.000				
IOD	<b>-0.461</b>	1.000			
Breeding success	<b>-0.426</b>	0.188	1.000		
Number of pairs	0.038	-0.337	-0.008	1.000	
PSPA	<b>-0.407</b>	-0.110	0.228	0.366	1.000
Mallard (Pearson correlation)					
Year	1.000				
IOD	<b>-0.461</b>	1.000			
Breeding success	-0.027	-0.071	1.000		

Number of pairs	0.181	-0.270	0.219	1.000	
PSPA	<b>-0.528</b>	0.119	-0.099	-0.266	1.000
Tufted duck (Kendall rank correlation)					
Year	1.000				
IOD	<b>-0.319</b>	1.000			
Breeding success	<b>-0.306</b>	-0.089	1.000		
Number of pairs	<b>-0.598</b>	0.182	0.241	1.000	
PSPA	-0.074	-0.048	0.188	0.030	1.000
Common goldeneye (Pearson correlation)					
Year	1.000				
IOD	<b>-0.461</b>	1.000			
Breeding success	<b>-0.477</b>	0.148	1.000		
Number of pairs	<b>-0.545</b>	-0.026	<b>0.489</b>	1.000	
PSPA	<b>-0.536</b>	0.096	-0.004	0.214	1.000



**Fig. A2.** Annual numbers of broods for six waterbird species. The numbers are means of three surveys carried out at 37 lakes in mid June–early August.