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CAPTIONS

Fig. 1 – Bathymetry (m) of the Coastal Zone of the Emilia Romagna (ERCZ) with the monitoring stations of ARPA-ER.

Fig. 2 – Total number (n) of hypoxic events recorded in 1977-2008: (a) spatial distribution in the ERCZ, (b) monthly distribution of hypoxia and strong hypoxia.

Fig. 3 – High-Low-Close plot of (a) monthly distribution (+ = median; box = 1°- 3° quartile; vertical bar = range of values) of daily average air temperature (T_A; C) at Porto Tolle in presence and absence of hypoxia in the coastal waters. (b) Difference between median values of temperature (ΔT_A) in the presence and absence of hypoxia.

Fig. 4 – Bar chart of daily-integrated precipitation (P; $dm^3\ m^{-2}\ d^{-1}$) at Porto Tolle in presence and absence of hypoxia in the coastal waters and frequency (%) of hypoxic events for each precipitation class.

Fig. 5 – Bar chart of daily average wind speed (W_S; $m\ s^{-1}$) at Porto Tolle in presence and absence of hypoxia in the coastal waters and frequency (%) of hypoxic events for each wind class.

Fig. 6 – Polar diagram of hourly wind direction (W_D; sectors of 45°) at Porto Tolle in concomitance to hypoxia in coastal waters.

Fig. 7 – Bar chart of the frequency of the days with hypoxia (%) in the coastal waters as a function of Po River flow (daily average; $m^3\ s^{-1}$) during the four seasons in the periods 1977-1988 and 1989-2008.

Fig. 8 – High-Low-Close plot of monthly distribution (median and 1° - 3° quartile) of oceanographic parameters in surface coastal waters in the absence and presence of hypoxia.

Fig. 9 - Annual integrated freshwater load of Po River (km^3 yr-1) and precipitation (P; $mm\ yr^{-1}$). High-Low-Close plot of annual median and 1° - 3° quartile of air temperature (T_A; C), wind speed (W_S; $m\ s^{-1}$), seawater temperature (T_{SW}, C) and salinity.

Fig. 10 - As in Fig. 9 for chlorophyll "a" (Chl a; $\mu g\ L^{-1}$), dissolved oxygen saturation (DO_{sat}; %), concentrations of nitrate (NO_3^-; $\mu mol\ N\ L^{-1}$), ammonium (NH_4^+; $\mu mol\ N\ L^{-1}$) and reactive phosphorus (PO_4^{3-}; $\mu mol\ P\ L^{-1}$) and N/P molar ratios.

Tab. 1 – Number (n), duration (days; median and range of values) and ratio of strong hypoxia (sHy; DO < 1 $mg\ L^{-1}$) and hypoxia (Hy; DO = 1-3 $mg\ L^{-1}$) in the ERCZ in 1977-1988 and in 1989-2008.

Tab. 2 – Inventory of river water (Q_y; $km^3\ yr^{-1}$) and nutrient ($t\ y^{-1} \cdot 10^3$) discharges of Po and the other ER rivers (TN = total nitrogen, TP = total phosphorus, DIN = dissolved inorganic nitrogen, SiO_2 = reactive silicon).

Tab. 3 - Difference (Δ) between monthly median value of oceanographic parameters in surface coastal waters in the presence and absence of hypoxia.

Tab. 4 - Median (med.), 1° - 3° quartiles (Q_1, Q_3) and range of values (min., max.) of meteorological (1990-2008), Po River flow (1977-2008) and oceanographic (1981-2008) datasets considered in this study. Mann Kendall Z-test (MKT) and Sen's test were applied to time-series of annual median data.

Table 1
Click here to download Table: Tab1-R1.doc

Tab. 1 – Number (n), duration (days; median and range of values) and ratio of strong hypoxia (sHy; DO < 1 mg L^{-1}) and hypoxia (Hy; DO = 1-3 mg L^{-1}) in the ERCZ in 1977-1988 and in 1989-2008.

	1977 – 1988					**1989 – 2008**				
Month	**Hypoxia**		**strong Hypoxia**			**Hypoxia**		**strong Hypoxia**		
	events n	**days** med. (range)	**events** n	**days** med. (range)	**sHy/Hy** ratio	**events** n	**days** med. (range)	**events** n	**days** med. (range)	**sHy/Hy** ratio
Jan	0	-	0	-	-	0	-	0	-	-
Feb	0	-	0	-	-	2	15 (2-28)	0	-	0.0
Mar	0	-	0	-	-	2	17 (3-31)	0	-	0.0
Apr	0	-	0	-	-	2	16 (2-30)	1	2	0.5
May	1	11	0	-	0.0	6	9 (2-17)	1	17	0.2
Jun	4	12 (1-16)	2	9 (1-16)	0.5	10	3 (1-11)	10	2 (1-9)	1.0
Jul	16	5 (1-18)	9	6 (1-20)	0.6	17	3 (1-31)	20	3 (1-16)	1.2
Aug	24	7 (1-31)	13	5 (1-22)	0.5	24	2 (1-16)	36	2 (1-31)	1.5
Sep	23	8 (1-27)	13	8 (1-30)	0.6	18	4 (1-18)	22	2 (1-18)	1.2
Oct	21	3 (1-29)	12	3 (1-18)	0.6	18	3 (1-22)	22	3 (1-22)	1.2
Nov	3	7 (3-8)	1	30	0.3	9	4 (1-15)	9	6 (1-15)	1.0
Dec	1	1	0	-	0.0	2	7 (2-12)	2	7 (2-12)	1.0

Table 2
Click here to download Table: Tab2-R1.doc

Tab. 2 – Inventory of river water (Q_y; km^3 yr^{-1}) and nutrient (t y^{-1} $\cdot 10^3$) discharges of Po and the other ER rivers (TN = total nitrogen, TP = total phosphorus, DIN = dissolved inorganic nitrogen, SiO_2 = reactive silicon).

Years	Q_Y	NO_3^-	NH_4^+	DIN	TN	PO_4^{3-}	TP	SiO_2	Reference
yyyy	km^3 yr^{-1}	t N $yr^{-1} \cdot 10^3$				t P $yr^{-1} \cdot 10^3$		t Si $yr^{-1} \cdot 10^3$	
Po River									
1968-1970	34-52	40	8.1	49	-	1.9	-	112	Fossato, 1971
1968-1970	34-52	50 [a]	-	-	-	2.0	-	-	Marchetti et al., 1989
1973-1974	40-45	60	9.4	70	71	3.3	-	113	Cioce et al., 1977
1974-1978	45-81	75	7.6	84	89	4.1	11.8	183	Provini and Pacchetti, 1982
1975-1978	55-81	67	12.9	-	-	3.5	10.9	-	Pettine et al., 1985
1976-1978	55-81	-	-	-	114	-	15.6	-	Chiaudani et al., 1980
1979-1984	46-54	84	-	-	94	5.4	14.7	-	Marchetti et al., 1985
1980-1987	45-52	100 [a]	-	-	-	5.0	13.0	-	Marchetti et al., 1989
1982-1987	45-52	100	-	-	110	4.9	12.9	-	Provini et al., 1992
1995-1996	53-65	-	-	-	155	-	-	-	Pettine et al., 1998
1996-2000	39-65	-	-	123	173	-	8.1	-	Palmeri et al., 2005
1985-2001	36-65	-	-	-	139	-	-	-	Salvetti et al., 2006
1995-2007	20-65	52 - 181	1.1 - 8.6	54 - 190	104 - 295	1.4 - 4.0	3.8 - 12.8	64-242	Cozzi and Giani, 2011
Emilia Romagna rivers (Po di Volano - Tavollo)									
1974-1976	-	-	-	-	-	-	5.7	-	Bressan, 1986
1976-1978	-	-	-	-	38.0	-	3.4	-	Chiaudani et al., 1980
1992	-	-	-	-	30.1	-	2.2	-	Marchetti and Verna, 1992
Savio River									
1978-1979	0.54	-	-	-	2.0	-	0.54	-	Haddrill et al., 1983

[a] *NH_4^+ included.*

Table 3
Click here to download Table: Tab3-R1.doc

Tab. 3 - Difference (Δ) between monthly median value of oceanographic parameters in surface coastal waters in the presence and absence of hypoxia.

Month	ΔT_{SW} C	ΔSal	ΔChl a µg L^{-1}	ΔDO sat %	ΔNO_3^- µmol N L^{-1}	ΔNH_4^+ µmol N L^{-1}	ΔPO_4^{3-} µmol P L^{-1}	ΔN/P mol/mol
Jan	-	-	-	-	-	-	-	-
Feb	1.9	-6.3	9.4	3.2	16.9	-0.33	-0.003	211
Mar	0.9	-1.7	18.7	31.5	1.35	-0.43	-0.005	227
Apr	0.6	-1.5	6.6	24.5	4.53	-0.65	-0.006	46
May	1.2	-2.7	2.8	3.0	3.32	-0.12	0.023	20
Jun	1.1	-2.9	2.9	2.3	0.59	-0.02	0.026	-9
Jul	0.6	-3.0	2.6	6.9	0.97	-0.02	0.019	11
Aug	0.7	-1.5	1.6	3.4	0.11	0.11	0.018	1
Sep	0.2	-2.4	2.8	3.3	2.49	-0.35	-0.003	25
Oct	0.1	-3.6	4.4	5.0	5.07	-0.54	-0.035	75
Nov	1.1	-5.2	5.4	1.2	6.35	-0.35	-0.065	126
Dec	1.1	-11.1	31.8	-4.7	9.39	-1.00	-0.132	100

Table 4
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Tab. 4 - Median (med), 1° - 3° quartiles (Q_1, Q_3) and range of values (min, max) of meteorological data (T_A = air temperature; P = precipitation; W_S = wind speed) for the period 1990-2008, Po River discharge (Q_{PO}) for the period 1977-2008, and oceanographic data (T_{SW} = seawater temperature; Sal = salinity; Chl a = chlorophyll a; DO_{sat} = dissolved oxygen saturation; NO_3^- = nitrate; NH_4^+ = ammonium; PO_4^{3-} = phosphate; N/P = nitrogen/phosphorus molar ratio) for the period 1981-2008. Mann Kendall Z-test (MKT) and Sen's test were applied to time series of annual median data.

Parameter	**med**	**Q1**	**Q3**	**min**	**max**	**MKT(Z)**	**Sen's annual slope**
T_A (C)	14.0	6.9	20.5	-6.9	29.5	3.3	+0.14 C yr^{-1} ($p < 0.01$)
P (mm d^{-1})	0.0	0.0	0.2	0.0	122	1.4	-
W_S (m s^{-1})	1.8	1.3	2.5	0.0	13.0	2.4	+0.03 m s^{-1} yr^{-1} ($p < 0.05$)
Q_{PO} (m^3 s^{-1})	1170	842	1810	168	9520	-2.2	-0.54 km^3 yr^{-1} ($p < 0.05$)
T_{SW} (C)	18.7	11.5	23.6	2.3	30.3	-0.8	-
Sal	32.5	29.1	34.7	6.0	38.7	2.6	+0.09 yr^{-1} ($p < 0.01$)
Chl a (µg L^{-1})	4.8	2.3	10.0	0.0	900	-1.9	-
DO_{sat} (%)	98.0	90.5	108.5	1.2	229	-3.5	-0.2 % yr^{-1} ($p < 0.001$)
NO_3^- (µmol N L^{-1})	8.4	2.2	22.4	0.0	550.0	1.1	-
NH_4^+ (µmol N L^{-1})	1.1	0.5	2.6	0.0	148.0	-3.0	-0.04 µmol N L^{-1} yr^{-1} ($p < 0.01$)
PO_4^{3-} (µmol P L^{-1})	0.10	0.05	0.20	0.00	20.0	-4.4	-0.004 µmol P L^{-1} yr^{-1} ($p < 0.001$)
N/P (mol/mol)	94	37	234	0	15000	2.6	+2.6 yr^{-1} ($p < 0.01$)

Figure 1
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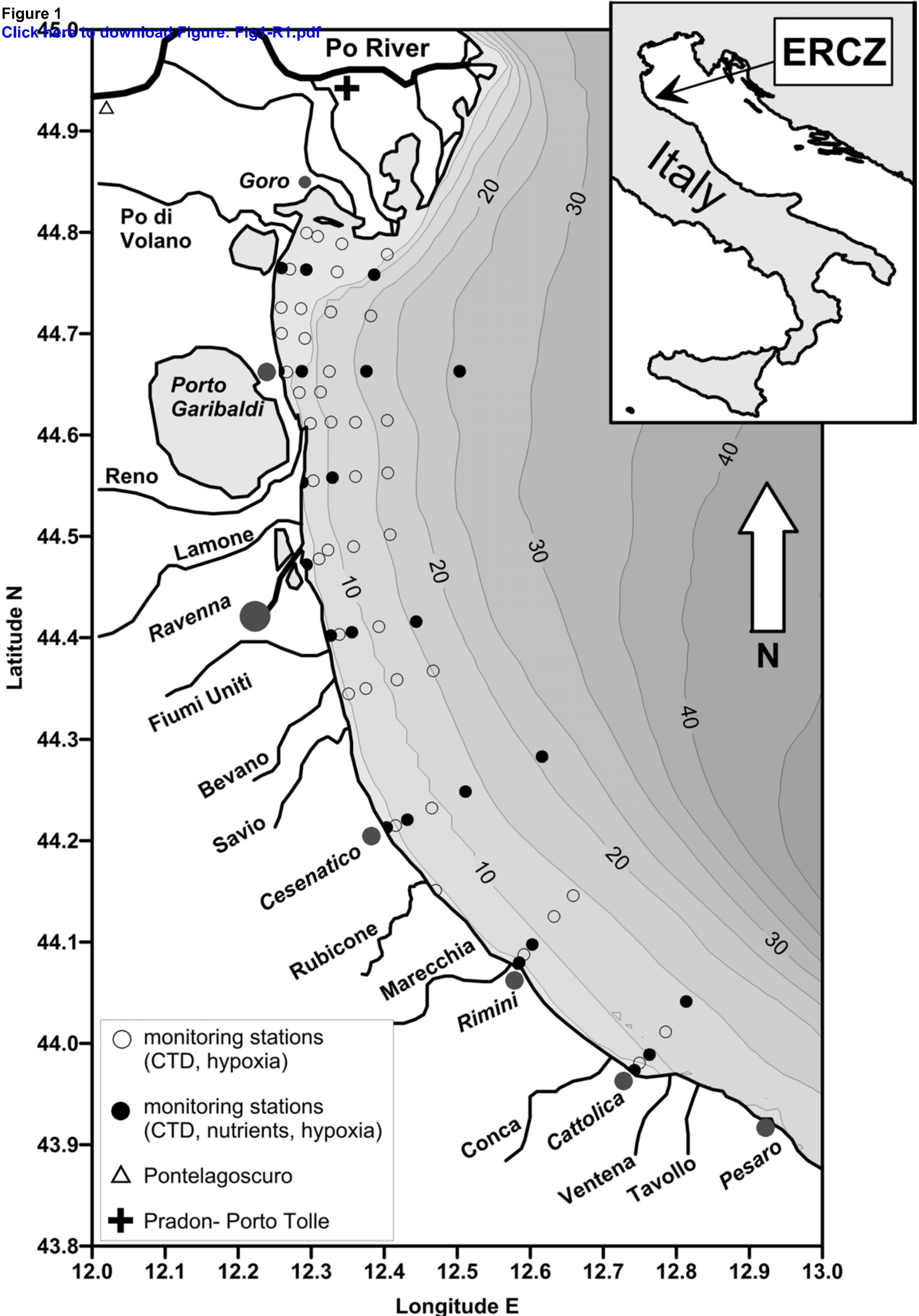


Figure 2

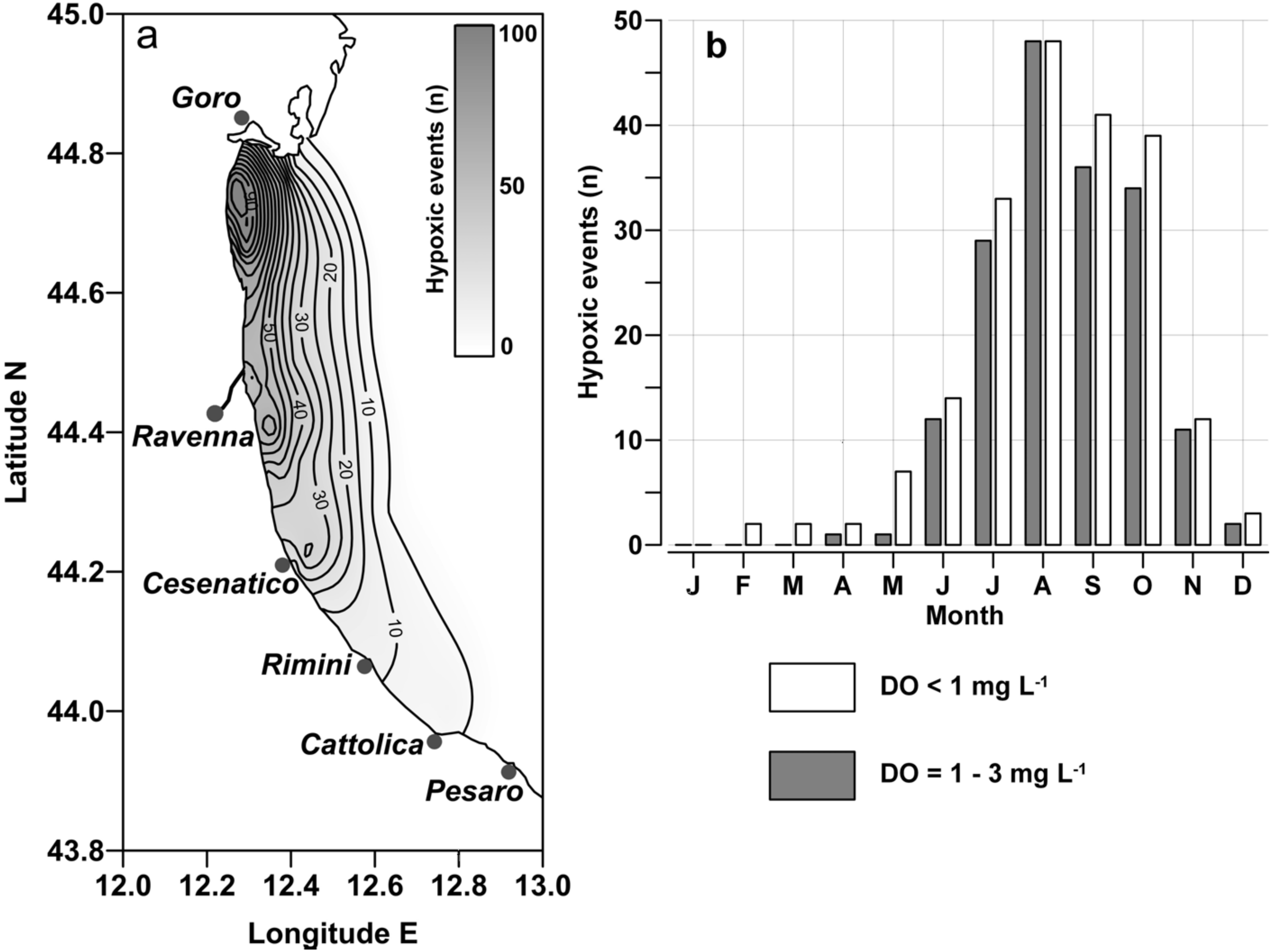

a
b
Goro
Ravenna
Cesenatico
Rimini
Cattolica
Pesaro
Hypoxic events (n)
100
50
0
Latitude N
Longitude E
45.0
44.8
44.6
44.4
44.2
44.0
43.8
12.0
12.2
12.4
12.6
12.8
13.0
10
20
30
40
50
90
Hypoxic events (n)
J F M A M J J A S O N D
Month
DO < 1 mg L-1
DO = 1 - 3 mg L-1

Figure 3

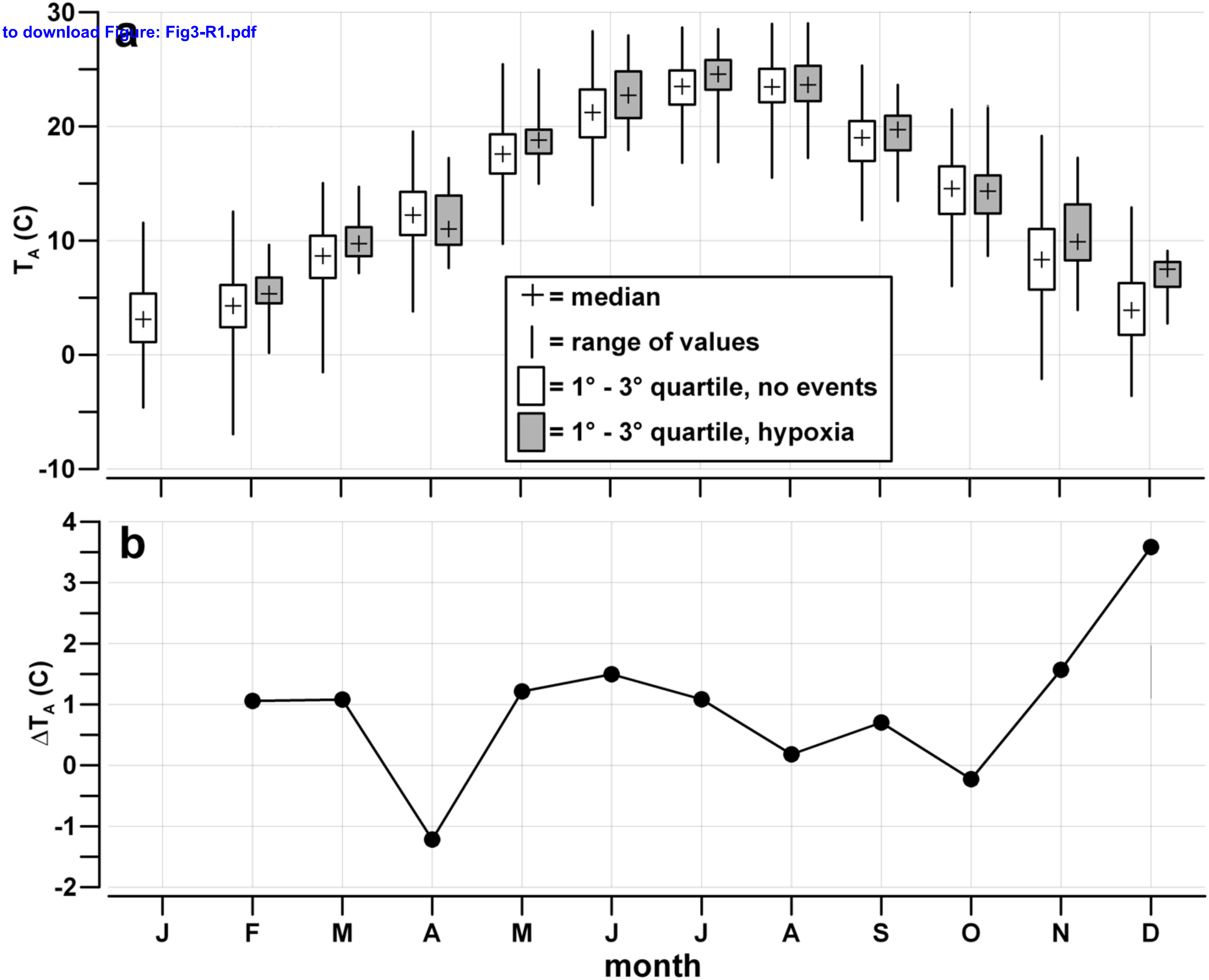
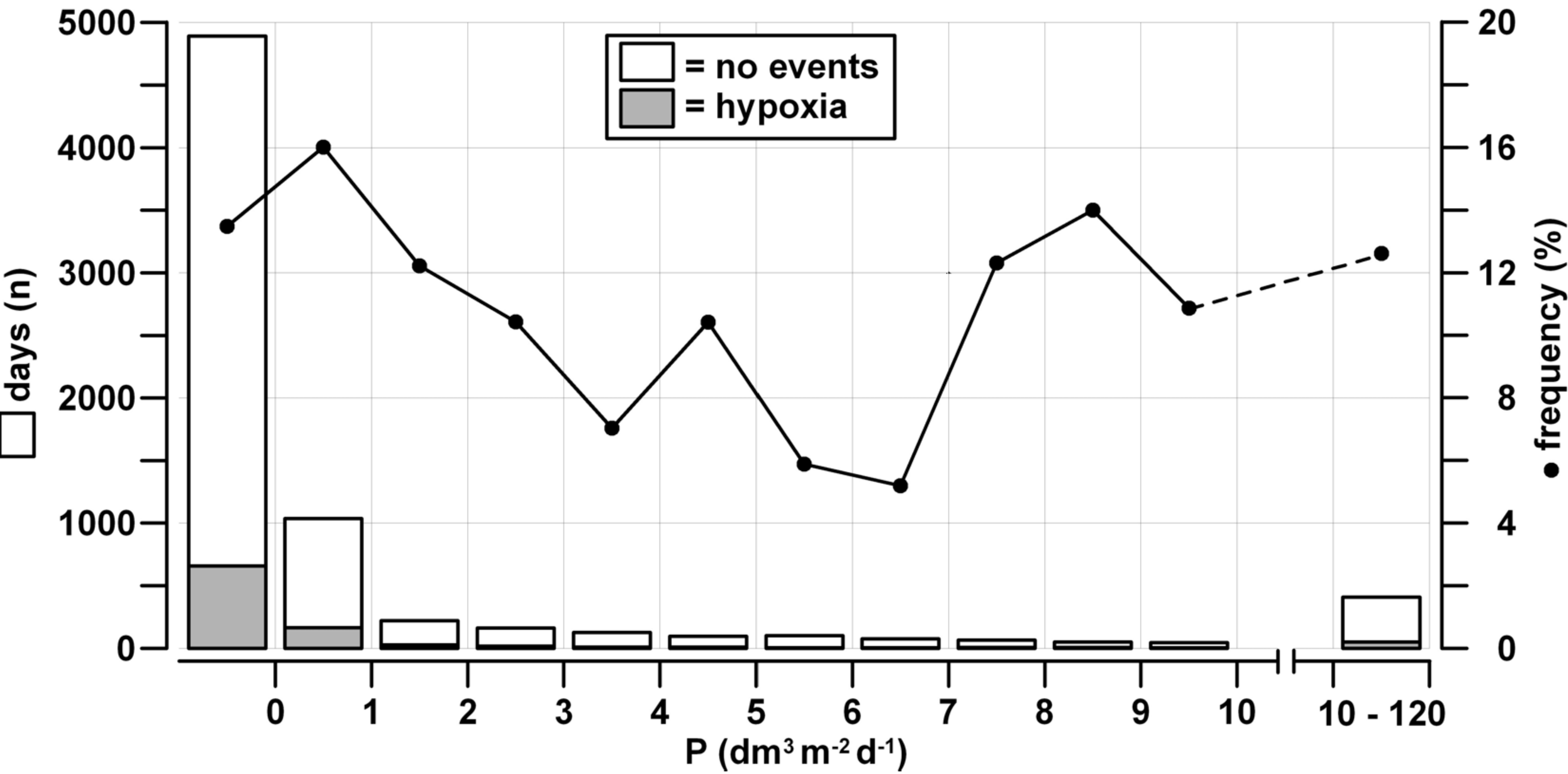
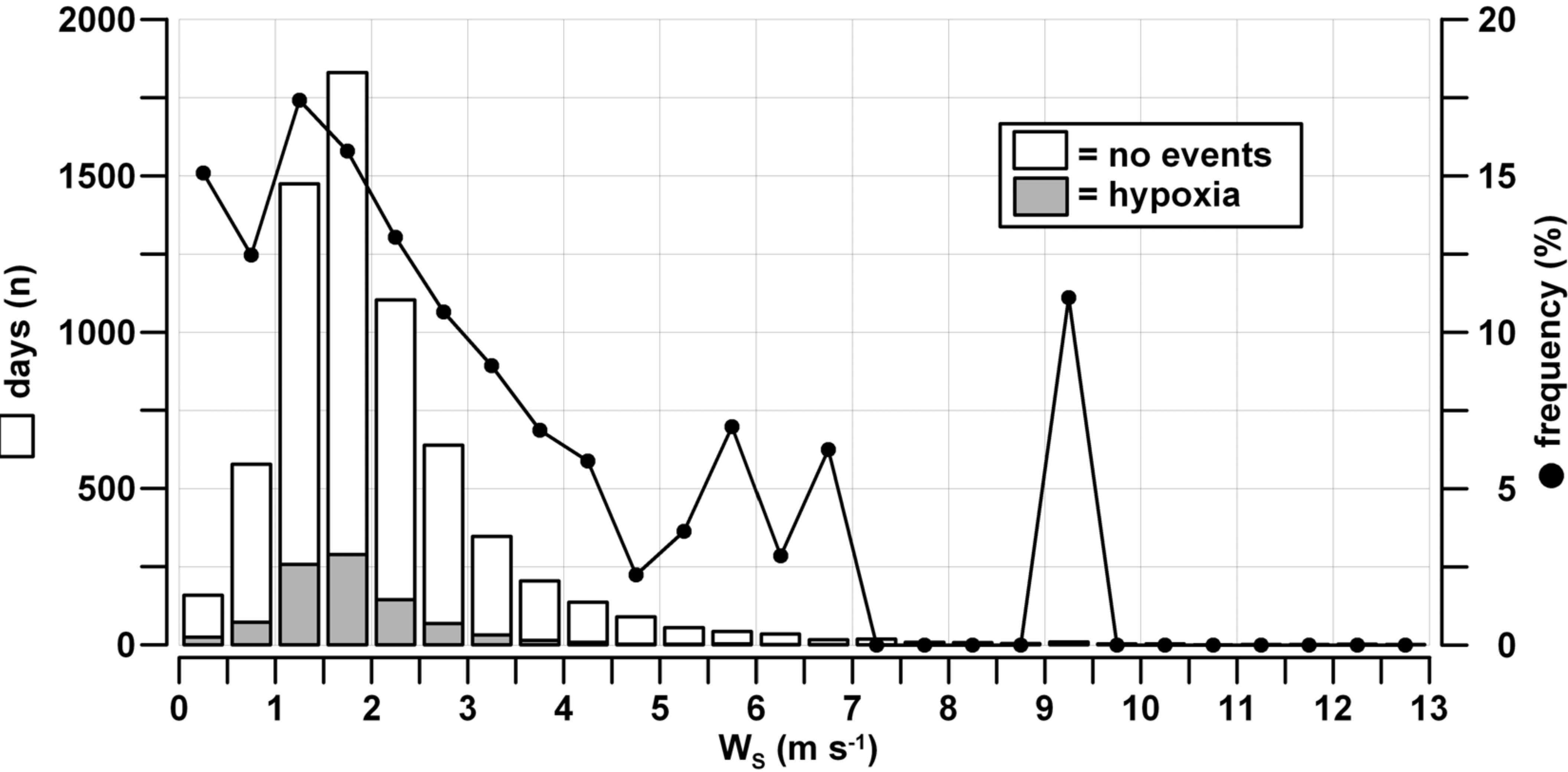

a
b
30
20
10
0
-10
T_A (C)
+ = median
| = range of values
= 1° - 3° quartile, no events
= 1° - 3° quartile, hypoxia
4
3
2
1
0
-1
-2
ΔT_A (C)
J
F
M
A
M
J
J
A
S
O
N
D
month

Figure 4



days (n)
5000
4000
3000
2000
1000
0
= no events
= hypoxia
20
16
12
8
4
0
● frequency (%)
0
1
2
3
4
5
6
7
8
9
10
10 - 120
P (dm³ m⁻² d⁻¹)

Figure 5



days (n)
frequency (%)
= no events
= hypoxia
W_S (m s^{-1})
2000
1500
1000
500
0
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13

Figure 6

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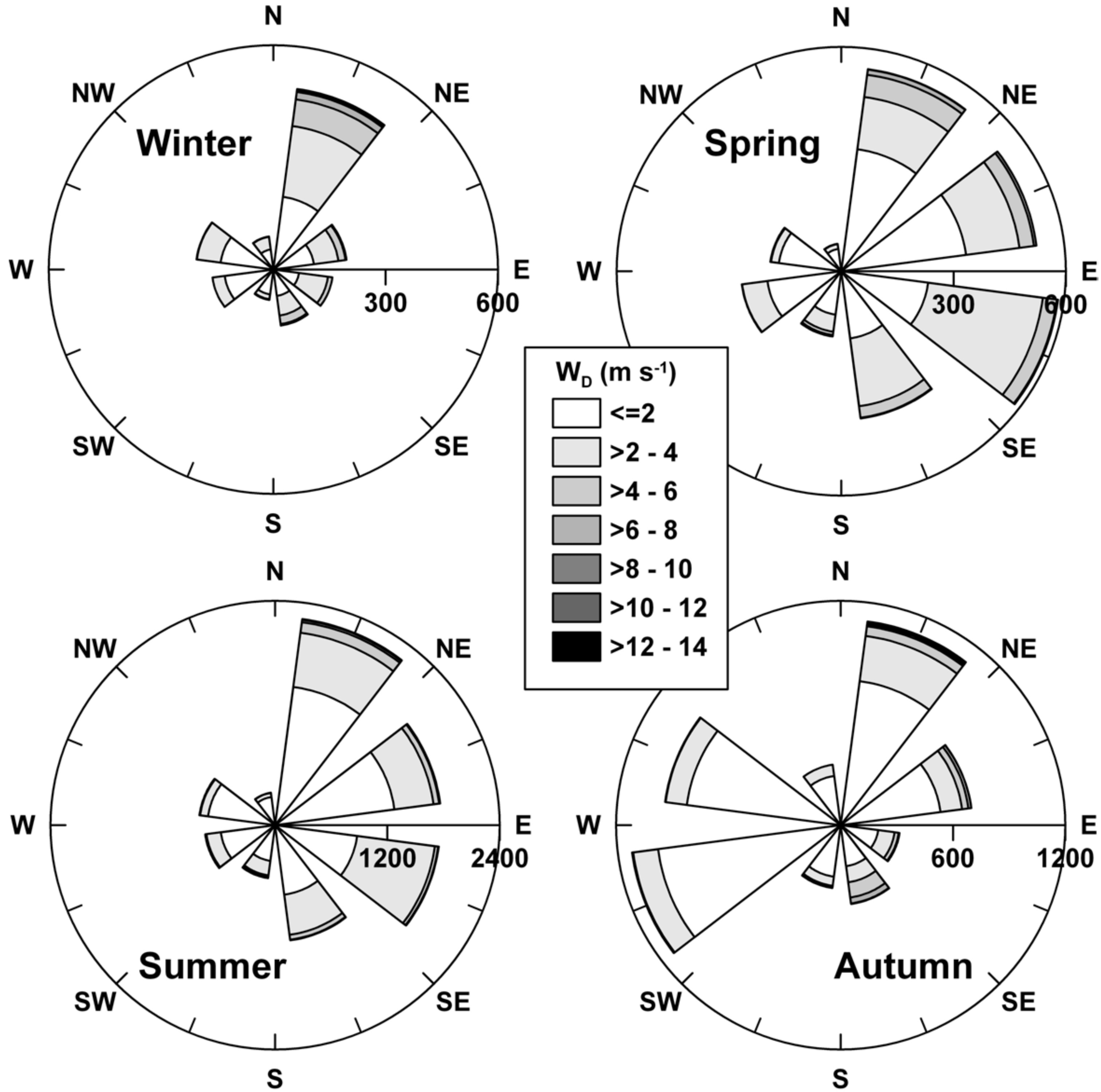

Figure 7
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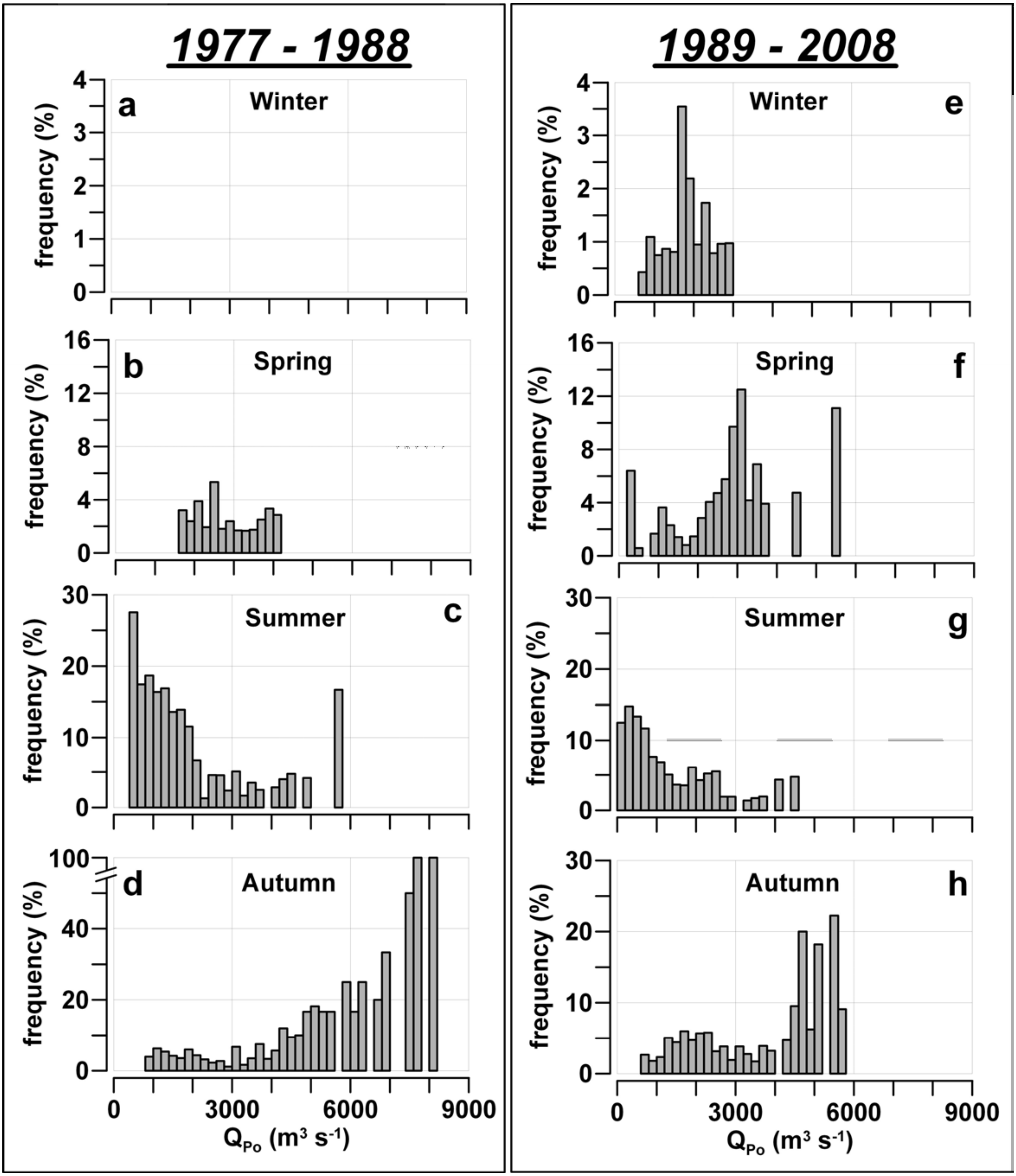

Figure 8
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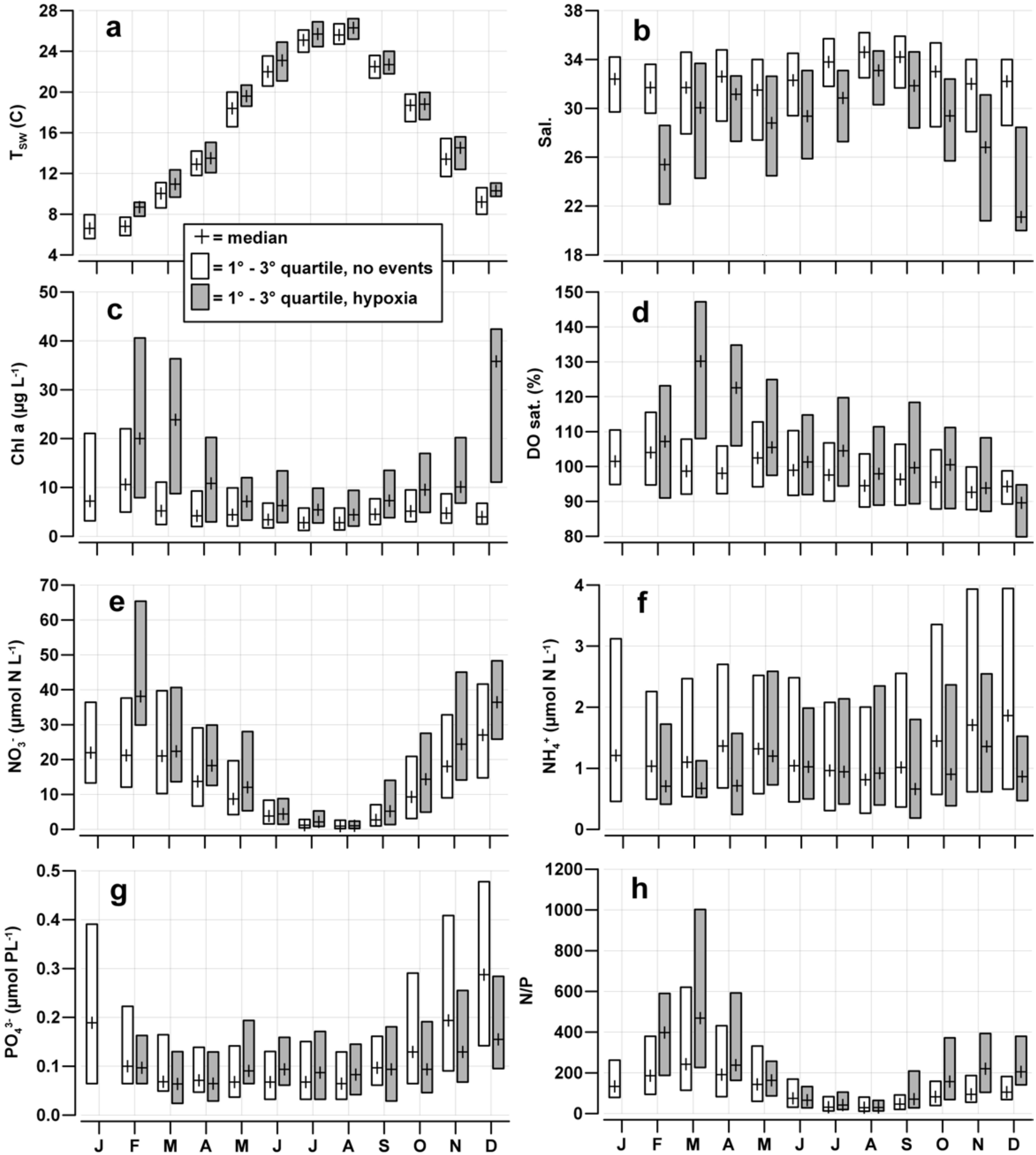

Figure 9

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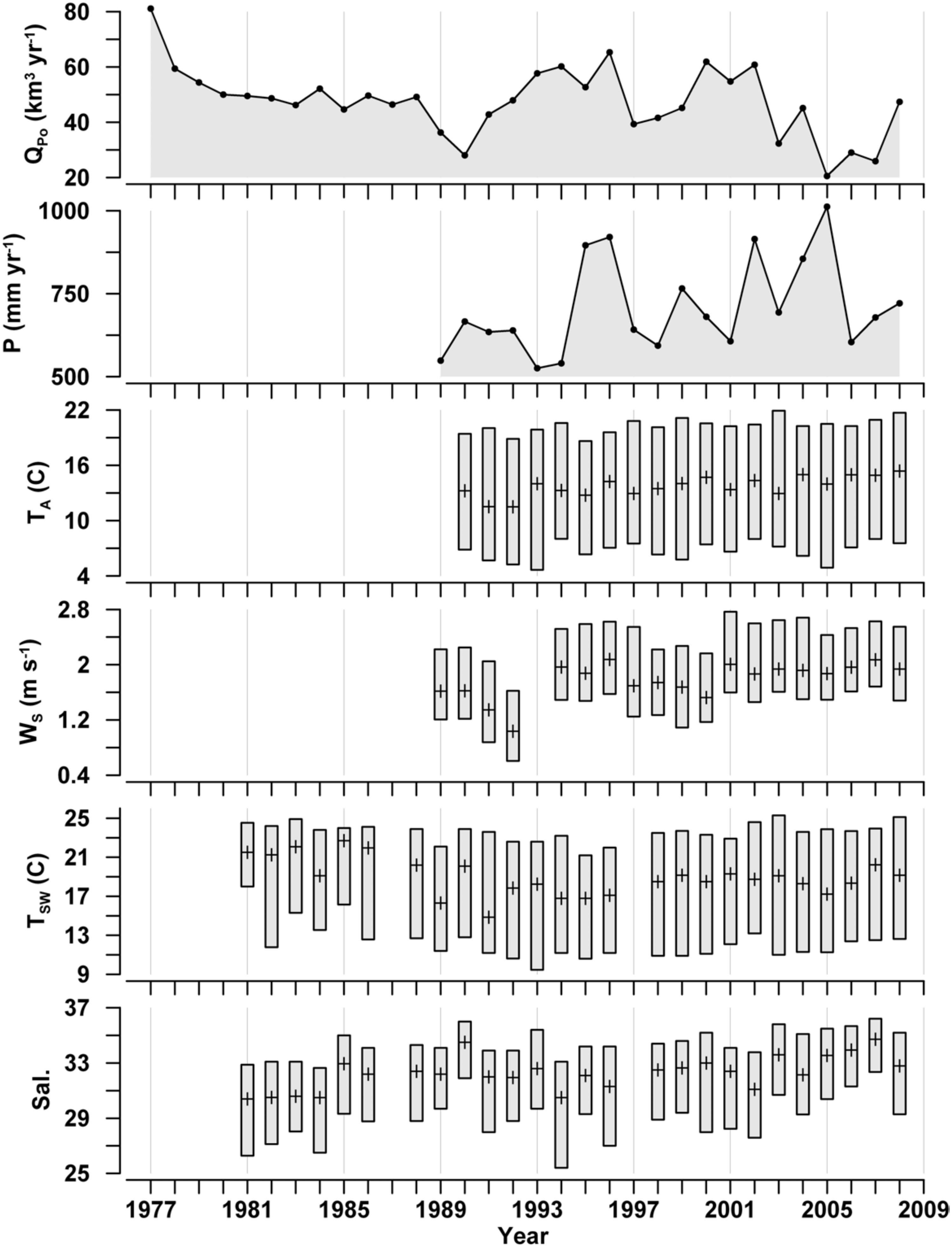

Figure 10
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