Supplementary Material | Marine Biology

Ecophysiological responses of *Fucus virsoides* (Phaeophyceae, Fucales) to past and present nutrient conditions in the northern Adriatic

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Figure S1. Median values, 25th and 75th percentiles of survival (%) values between T1 and T4 measured in *F. virsoides* in the '*Germling experiment*'.

Table S1. Morphological features of *F. virsoides* germlings under R1= [DIN]:[P] ratio in 1996, R2= [DIN]:[P] ratio in 1996 and R3= [DIN]:[P] ratio in 2017. Mean values are expressed together with the standard deviation.

Table S2. Results of the Split-Plot ANOVA for differences in embryos density and survival and germling morphometry.

Table S3. Results of the Chi-square tests for adult photosynthetic performance analysis.

Table S4. *P*-value of pairwise comparisons between day 0 (T0) and day 12 (T3) of photosynthetic performance values for the different nutrient conditions.

Table S5. *P*-value of pairwise comparisons between nutrients conditions of photosynthetic performance values at day 0 (T0) and day 12 (T3).

Figure S2. Light response curves of electron transport rate (ETR) of dark-acclimated *F. virsoides* samples measured in the '*Adult experiment'*. Data points are an average of 6-9 independent measurements with error bars showing standard deviation.

Figure S3. Light response curves of quenching coefficient non-photochemical quenching (NPQ) of dark-acclimated *F. virsoides* samples measured in the '*Adult experiment*'. Data points are an average of 6-9 independent measurements with error bars showing standard deviation.

Table S6. Result of pairwise comparisons between nutrients conditions of RGR.

Table S7. Results of the Chi-Square tests for metabolic rate analysis.

Table S8. *P*-value of pairwise comparisons of metabolic rate values at day 0 (T0) and day 12 (T3).

Figure S4. Annual average of **a)** [DIN] and **b)** [P] concentrations (μM) on the Adriatic coast from northern Italy to southern Albania, northern sub-basin, central sub-basin and southern sub-basin, from 1993 to 2017 calculated from EMODnet.

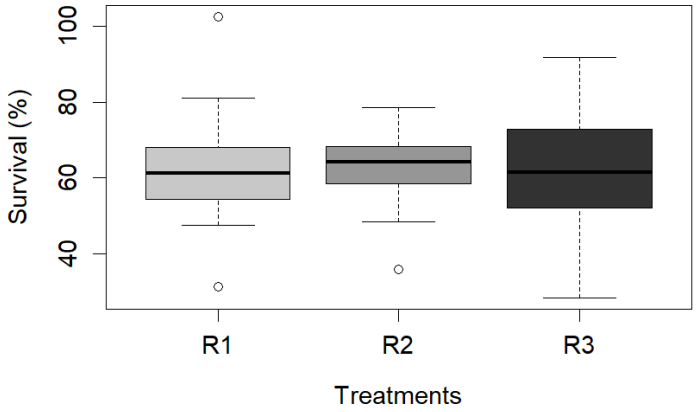

Figure S1.

Table S1.

	Embryo length (µm)			Embryo width (µm)			mean length hyalin hairs (µm)			mean length rhizoids (µm)		
	R1	**R2**	**R3**	**R1**	**R2**	**R3**	**R1**	**R2**	**R3**	**R1**	**R2**	**R3**
T1	114.77 ± 3.01	124.80 ± 0.97	111.73 ± 2.61	79.90 ± 1.89	84.80 ± 1.26	84.00 ± 0.55	-	-	-	164.10 ± 24.01	175.53 ± 8.34	201.17 ± 13.68
T2	163.53 ± 6.82	169.97 ± 4.05	167.40± 5.31	94.07 ± 7.61	97.57 ± 2.39	99.03 ± 0.66	71.52 ± 25.65	111.30 ± 36	59.74 ± 14.82	213.64 ± 12.72	148.04 ± 8.18	182.80 ± 20.76
T3	175.28 ± 8.31	182.20 ± 5.30	164.98 ± 8.69	110.71 ± 3.41	109.60 ± 1.19	105.37 ± 1.72	341.03 ± 47.29	278.81 ± 14.07	265.89 ±60.55	213.50 ± 47.15	256.51 ± 43.10	341.07 ± 26.17
T4	185.46 ± 9.62	198.80 ± 9.62	188.04 ± 4.02	118.86 ± 3.91	116.70 ± 1.00	118.02 ± 3.85	284.76 ± 45.42	337.92 ± 58.97	335.28 ± 7.49	215.06 ± 38.59	240.34 40.56	281.60 ± 17.15

Table S2.

	Effect	DFn	DFd	F	*p*
Embryo width	Treatment	2.00	6.00	1.10	0.39
	Time	1.26	7.57	76.46	**<0.001**
	Treatment:Time	2.52	7.57	0.45	0.70
Embryo length	Treatment	2.00	6.00	0.74	0.51
	Time	1.16	6.96	13.94	**<0.01**
	Treatment:Time	2.32	6.96	0.95	0.45
Number hyaline hairs	Treatment	2	6	0.55	0.60
	Time	3	18	199.60	**<0.001**
	Treatment:Time	6	18	0.75	0.62
Mean length hyaline hairs	Treatment	2	4	0.42	0.68
	Time	2	8	80.18	**<0.001**
	Treatment:Time	4	8	1.75	0.232
Length rhizoids	Treatment	2.00	6.00	0.66	0.551
	Time	1.43	8.55	5.89	**<0.05**
	Treatment:Time	2.85	8.55	0.62	0.61
Embryo density	Treatment	2	6	2.38	0.17
	Time	1	6	59.85	**<0.001**
	Treatment:Time	2	6	0.052	0.95

Table S3.

		Chisq	**Df**	**Pr(>Chisq)**
F_v/F_m	(Intercept)	4914.62	1	**<0.001**
	Treatment	2.54	5	0.77
	Time	55.25	3	**<0.001**
	Treatment:Time	52.76	15	**<0.001**
$rETR_{max}$	(Intercept)	407.95	1	**<0.001**
	Treatment	3.67	5	0.60
	Time	54.51	3	**<0.001**
	Treatment:Time	67.85	15	**<0.001**
α	(Intercept)	794.435	1	**<0.001**
	Treatment	93.53	5	**<0.001**
	Time	49.501	3	**<0.001**
	Treatment:Time	59.34	15	**<0.001**
NPQ_{max}	(Intercept)	144.09	1	**<0.001**
	Treatment	5.85	5	0.32
	Time	4.71	3	0.19
	Treatment:Time	27.66	15	0.02
E_k	(Intercept)	669.09	1	**<0.001**
	Treatment	42.83	5	**<0.001**
	Time	22.93	3	**<0.001**
	Treatment:Time	29.84	15	0.01

Table S4.

	F_v/F_m	$rETR_{max}$	α	NPQ_{max}	E_k
R1	**<0.001**	0.20	**<0.001**	0.46	0.39
R2	**<0.001**	0.97	**<0.001**	0.93	0.01
R3	**<0.001**	0.22	**<0.001**	0.84	0.86
C1	1.00	1.00	0.12	0.19	0.72
C2	**<0.001**	0.99	0.45	0.14	0.95
SW	0.99	0.73	**0.001**	0.17	0.78

Table S5.

	F_v/F_m		$rETR_{max}$		α		NPQ_{max}		E_k	
contrast	**T0**	**T3**	**T0**	**T3**	**T0**	**T3**	**T0**	**T3**	**T0**	**T3**
R1-R2	1.00	0.87	1.00	0.72	0.89	0.48	1.00	0.85	1.00	0.90
R1-R3	1.00	0.68	1.00	1.00	**<0.001**	0.01	1.00	0.99	1.00	0.93
R1-R4	0.94	**<0.001**	1.00	0.22	**<0.001**	**<0.001**	0.37	**<.0001**	**<0.001**	**<0.001**
R1-R5	0.97	0.49	0.67	1.00	**<0.001**	**<0.001**	0.90	1.00	0.17	0.75
R1-SW	1.00	**<0.001**	1.00	1.00	0.53	1.00	0.97	**0.001**	0.10	0.21
R2-R3	0.97	1.00	1.00	0.60	**<0.001**	0.47	1.00	0.99	1.00	0.35
R2-R4	0.80	**<0.001**	1.00	0.96	**<0.001**	0.11	0.61	**0.002**	**<0.001**	0.03
R2-R5	0.86	0.99	0.74	0.81	**<0.001**	0.04	0.98	0.97	0.05	1.00
R2-SW	1.00	**<0.001**	1.00	0.91	0.98	0.41	1.00	0.04	0.03	0.76
R3-R4	1.00	**<0.001**	1.00	0.15	1.00	0.96	0.34	**<0.001**	**<0.001**	**<0.001**
R3-R5	1.00	1.00	0.81	1.00	1.00	0.85	0.87	1.00	0.12	0.20
R3-SW	1.00	**<0.001**	1.00	1.00	**0.001**	**0.009**	0.96	**0.007**	0.07	**0.03**
R4-R5	1.00	**<0.001**	0.53	0.30	1.00	1.00	0.94	**<0.001**	0.20	0.06
R4-SW	0.95	1.00	0.99	0.49	**<0.001**	**<0.001**	0.93	0.99	0.63	0.69
R5-SW	0.97	**<0.001**	0.93	1.00	**0.003**	<**0.001**	1.00	**0.005**	1.00	0.90

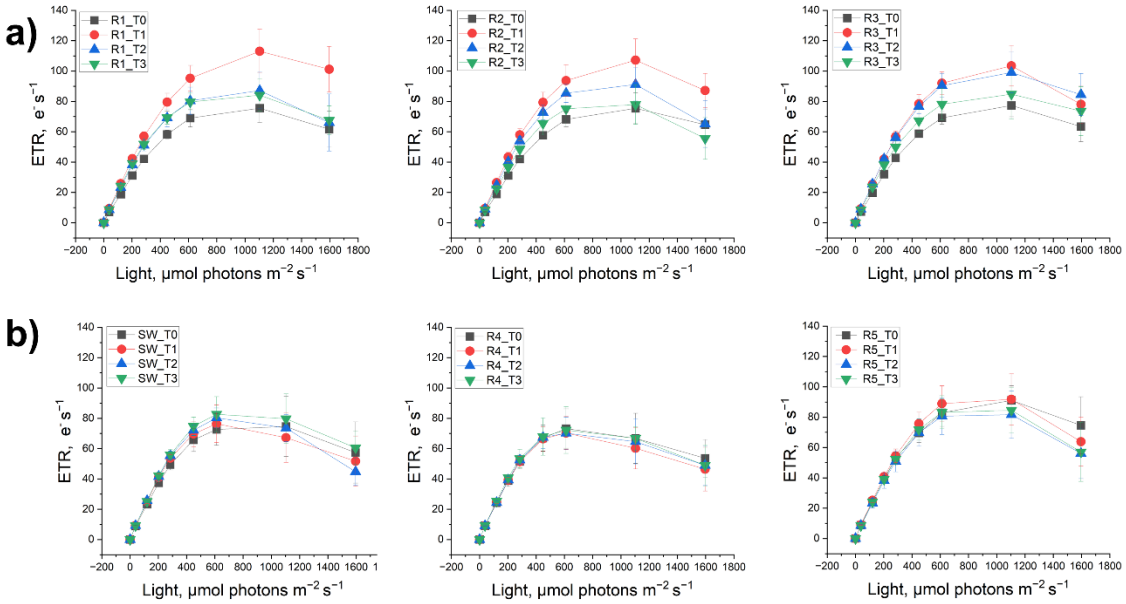

Figure. S2

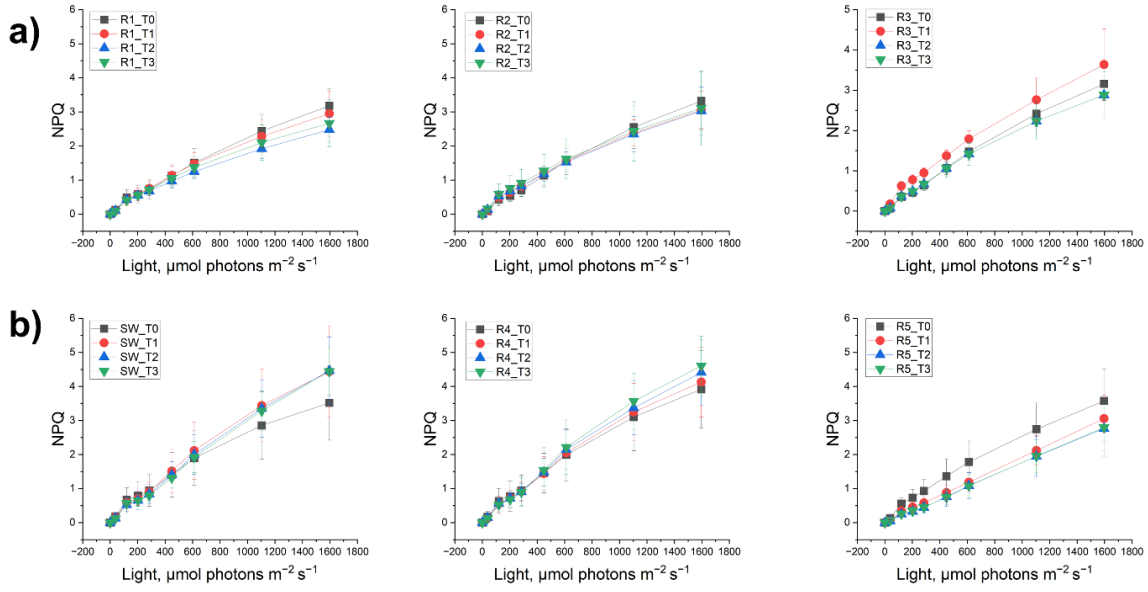

Figure. S3

Table S6.

Contrast	estimate	SE	df	*t*.ratio	*p*.value
C1 vs C2	1.04	0.29	107	3.65	**0.005**
C1 vs R1	0.70	0.27	107	2.55	0.12
C1 vs R2	0.15	0.27	107	0.53	0.99
C1 vs R3	-0.12	0.27	107	-0.45	1.00
C1 vs SW	-0.19	0.31	108	-0.62	0.99
C2 vs R1	-0.34	0.28	107	-1.21	0.83
C2 vs R2	-0.89	0.28	107	-3.18	**0.02**
C2 vs R3	-1.16	0.28	107	-4.13	**0.001**
C2 vs SW	-1.23	0.32	108	-3.86	**0.003**
R1 vs R2	-0.55	0.27	107	-2.05	0.32
R1 vs R3	-0.82	0.27	107	-3.04	**0.03**
R1 vs SW	-0.89	0.31	108	-2.88	0.05
R2 vs R3	-0.27	0.27	107	-0.99	0.92
R2 vs SW	-0.34	0.31	108	-1.10	0.88
R3 vs SW	-0.07	0.31	108	-0.23	1.00

Table S7.

		Chisq	**Df**	**Pr(>Chisq)**
GPP	(Intercept)	168.90	1	**<0.001**
	Treatment	37.05	5	**<0.001**
	Time	5.20	3	0.16
	Treatment:Time	39.39	15	**<0.001**
NP	(Intercept)	122.31	1	**<0.001**
	Treatment	19.38	5	0.002
	Time	3.37	3	0.34
	Treatment:Time	33.74	15	**0.004**
R	(Intercept)	71.57	1	**<0.001**
	Treatment	59.68	5	**<0.001**
	Time	6.94	3	0.07
	Treatment:Time	59.29	15	**<0.001**

Table S8.

	GPP		**NP**		**R**	
contrast	**T0**	**T3**	**T0**	**T3**	**T0**	**T3**
R1 - R2	0.21	0.68	**0.03**	0.74	0.95	0.98
R1 - R3	**<0.001**	0.99	**0.03**	0.98	**0.002**	1.00
R1 - C1	0.98	0.57	0.99	0.70	0.07	0.88
R1 - C2	1.00	0.66	1.00	0.45	1.00	1.00
R1 - SW	1.00	0.74	0.89	0.84	0.24	0.95
R2 - R3	0.29	0.95	1.00	0.98	**<0.001**	0.99
R2 - C1	0.05	**0.03**	0.14	0.08	0.42	0.47
R2 - C2	0.49	**0.04**	0.09	**0.02**	0.87	0.98
R2 - SW	0.28	0.07	0.46	0.14	0.73	0.62
R3 - C1	**<0.001**	0.22	0.15	0.30	**<0.001**	0.81
R3 - C2	**0.002**	0.23	0.09	0.12	**0.005**	1.00
R3 - SW	**0.001**	0.36	0.48	0.45	**<0.001**	0.91
C1 - C2	0.88	1.00	1.00	1.00	**0.04**	0.85
C1 - SW	1.00	1.00	1.00	1.00	1.00	1.00
C2 - SW	1.00	1.00	0.99	1.00	0.16	0.93

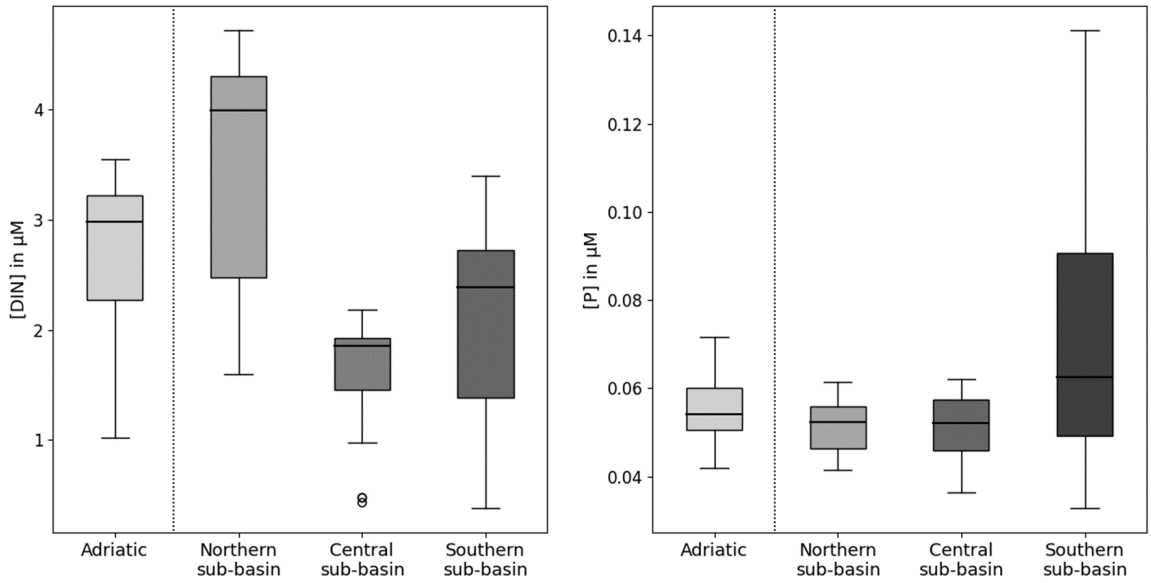
[DIN] in µM
4
3
2
1
Adriatic
Northern sub-basin
Central sub-basin
Southern sub-basin
[P] in µM
0.14
0.12
0.10
0.08
0.06
0.04
Adriatic
Northern sub-basin
Central sub-basin
Southern sub-basin

Figure S4.