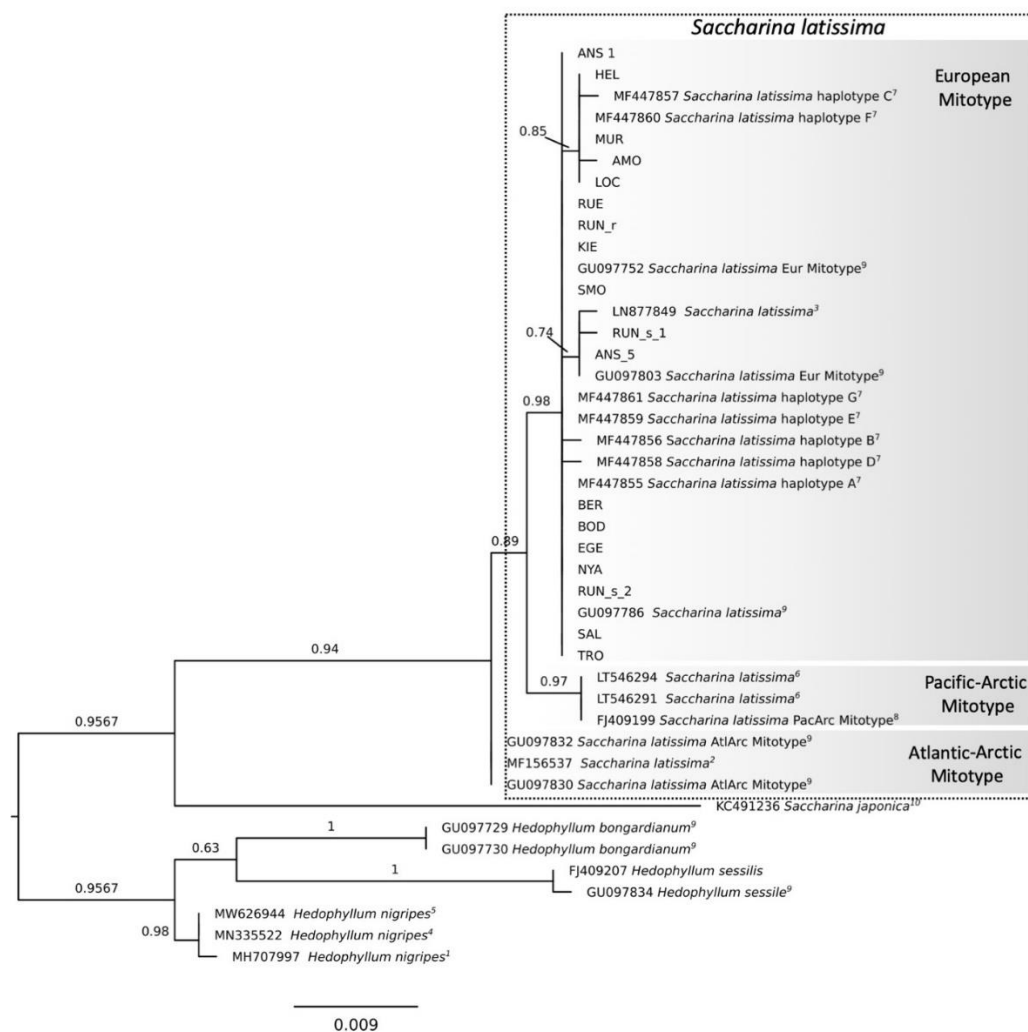


Supplementary Material

1 Supplementary Figures and Tables

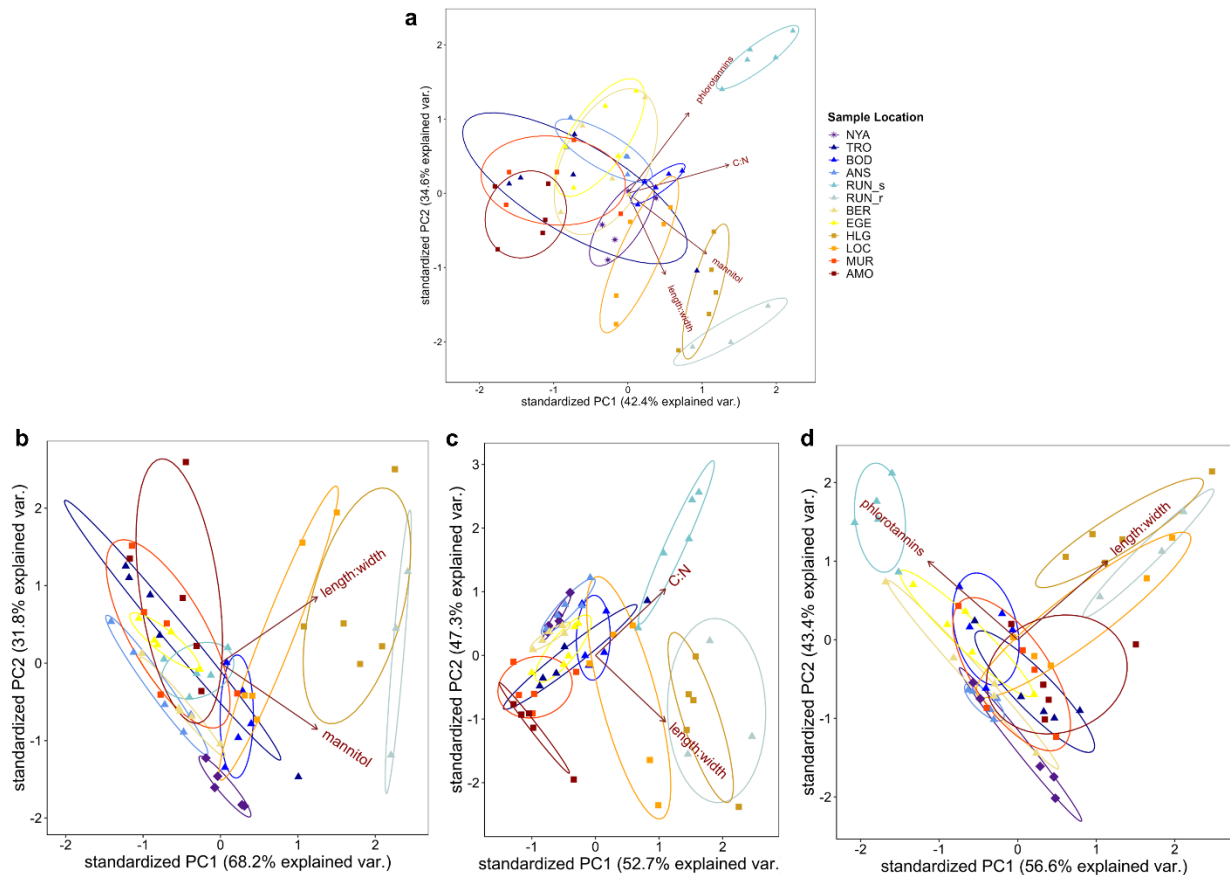
1.1 Supplementary Figures



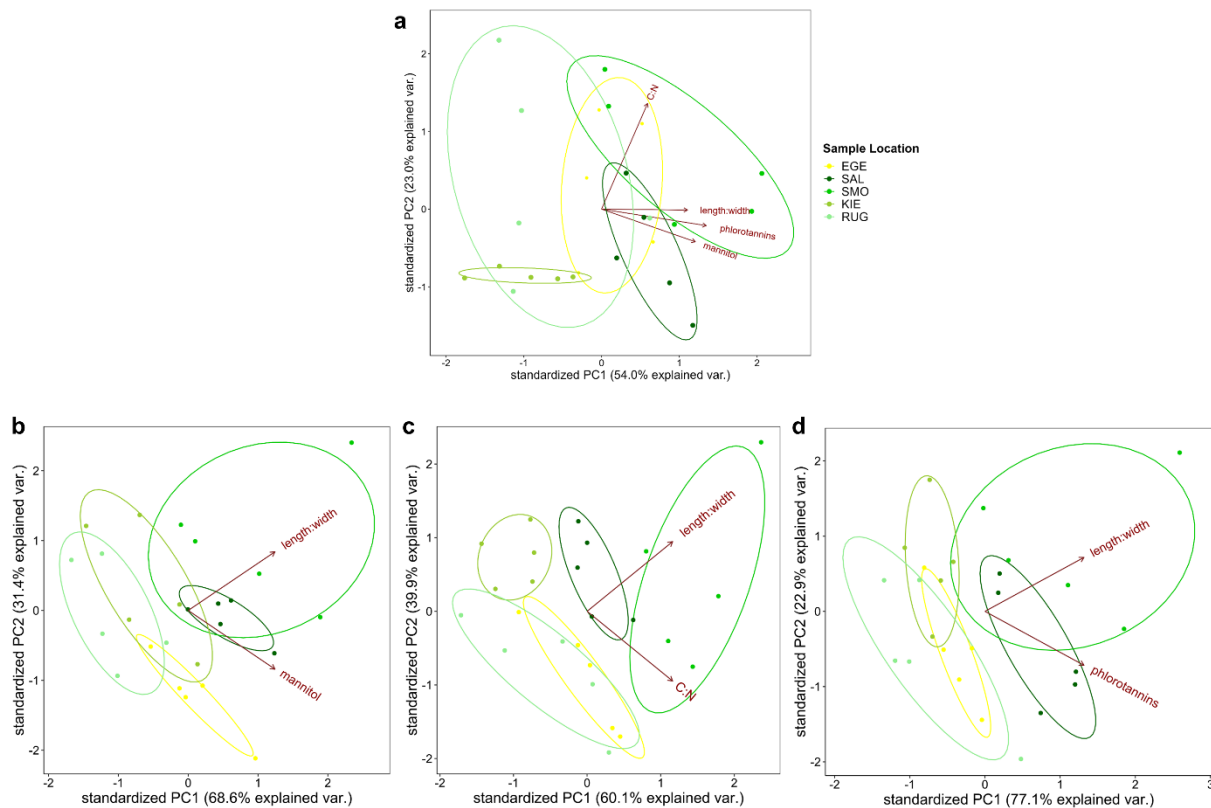
Supplementary Figure S.1. Maximum Likelihood phylogram based on COI-5P sequences of the genera *Saccharina* and *Hedophyllum*. Values above nodes indicate ML bootstrap support, with values lower than 60 % not reported. The scale indicates substitutions/site. Published sequences are indicated by their GenBank accession number, the species name, haplotype (where applicable) and a number specifying the reference: 1 - Aizen et al., unpublished; 2 - Augyte et al., 2018; 3 - Biancarosa et al., 2016; 4 - Bringloe et al., 2020; 5 - Franke et al., 2021; 6 - Kuepper et al., 2016; 7 - Luttikhuisen et al., 2018; 8 - McDevit & Saunders, 2009; 9 - McDevit & Saunders, 2010; 10 - Zhao et al., 2013.

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Supplementary Figure S.2. Combined score- & biplots of the first two principal components (PC) of the principal component analyses (PCA) performed on samples of *Saccharina latissima* from different sample locations along the European coast – Latitudinal data-set. Plotted are the length to width ratio (length:width) and biochemical compounds (mannitol, carbon to nitrogen ratio [C:N], phlorotannins). The arrows represent the loadings of each PCA. Sampling locations are indicated by different colors. Different shapes represent hydrographic regions of the samples: ♦ = Arctic (Spitsbergen), ▲ = Norwegian Sea, ■ = North Sea/North Atlantic. Each point represents one individual. For coding of collection sites see Fig. 1.



Supplementary Figure S.3. Combined score- & biplots of the first two principal components (PC) of the principal component analyses (PCA) performed on samples of *Saccharina latissima* from different sample locations along the European coast – Baltic data-set. Plotted are the length to width ratio (length:width) and biochemical compounds (mannitol, carbon to nitrogen ratio [C:N], phlorotannins). The arrows represent the loadings of each PCA. Sampling locations are indicated by different colors. Each point represents one individual. For coding of collection sites see Fig. 1.

1.2 Supplementary Tables

Supplementary Table S.1. Overview of the morphology and biochemical parameters of all *Saccharina latissima* samples. Frond length, frond width and length to width ratio (length:width). Mannitol, phlorotannins, carbon to nitrogen ratio (C:N), total carbon content (total C) and total nitrogen content (total N). DW = dry weight.

location				morphological parameters			biochemical parameters				
				length [cm]	width [cm]	length:width	mannitol [mg g ⁻¹ DW]	phlorotannins [mg g ⁻¹ DW]	C:N	total C [mg g ⁻¹ DW]	total N [mg g ⁻¹ DW]
Ny-Ålesund	NYA	Norway	latitudinal	142	59	2.4	210.96	1.467	22.56	287.02	14.84
				107	40	2.7	196.46	1.705	23.85	315.28	15.42
				110	45	2.4	162.06	2.487	21.45	263.81	14.35
				105	38	2.8	208.98	2.119	19.67	262.64	15.57
				80	44	1.8	208.16	1.980	22.09	319.07	16.85
Tromsø	TRO	Norway	latitudinal	113	25	4.5	123.86	6.019	23.20	272.41	13.70
				130	19	6.8	280.88	3.392	37.58	312.95	9.71
				80	14.5	5.5	102.12	10.184	19.41	266.27	16.01
				115	23	5.0	71.78	4.697	17.36	252.52	16.97
				84	16	5.3	64.24	4.095	16.15	219.15	15.83
Bodø	BOD	Norway	latitudinal	252	36	7.0	183.81	8.493	23.95	303.24	14.77
				309	43	7.2	214.10	9.403	27.11	311.03	13.39
				237	38	6.2	215.27	11.856	24.58	289.19	13.72
				130	26	5.0	230.37	10.170	31.78	329.51	12.10
				110	35	3.1	223.97	7.587	29.82	325.98	12.75
Ansnas	ANS	Norway	latitudinal	54	23	2.3	80.15	-	-	-	-
				73	30	2.4	109.96	6.737	23.05	225.29	11.40
				120	55	2.2	155.68	6.288	33.55	230.65	8.02
				92	42	2.2	190.40	8.193	27.82	359.88	15.09
				140	43	3.3	178.25	6.837	29.57	338.49	13.35

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Runde (sandy)	RUN_s	Norway	latitudinal	104	27	3.9	133.98	14.579	53.52	348.06	7.59
				146	25	5.8	173.53	17.677	48.98	354.81	8.45
				258	33	7.8	172.20	18.017	33.60	319.43	11.09
				128	25	5.1	163.02	17.040	44.57	333.95	8.74
				107	28	3.8	169.15	17.800	55.12	399.76	8.46
Runde (rocky)	RUN_r	Norway	lat.	223	12.5	17.8	278.31	5.514	25.66	310.57	14.12
				147	11.5	12.8	344.64	6.330	40.38	375.29	10.84
				196	9.5	20.6	259.91	5.987	34.86	304.56	10.19
Bergen	BER	Norway	latitudinal	64	23	2.8	169.27	14.730	23.09	309.20	15.63
				113	30	3.8	212.01	7.401	24.62	314.49	14.90
				77	24	3.2	179.69	7.033	25.22	365.81	16.92
				79	28	2.8	140.42	3.621	19.29	344.71	20.85
				103	36	2.9	116.13	9.763	21.35	304.42	16.64
Egersund	EGE	Norway	latitudinal & Baltic	191	35	5.5	163.11	10.834	21.19	322.15	17.74
				109	27	4.0	122.82	13.629	27.28	360.95	15.43
				137	26	5.3	126.11	5.605	22.67	343.01	17.65
				136	34	4.0	97.69	11.078	26.52	360.70	15.87
				125	31	4.0	118.40	9.258	16.70	331.12	23.13
Helgoland	HLG	Germany	latitudinal	345	14.5	23.8	203.27	6.238	15.00	-	-
				205	12.5	16.4	277.14	7.355	28.14	-	-
				167	11.5	14.5	270.38	7.239	32.20	286.59	10.38
				138.5	10.8	12.8	214.35	8.888	37.09	337.37	10.61
				227	15	15.1	240.17	8.634	32.12	349.00	12.68

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Locmariaquer	LOC	France	latitudinal	250	13	18.9	183.66	5.572	16.80	287.13	19.94
				168	25	6.7	225.84	8.231	30.07	346.75	13.46
				139	20	7.0	206.01	6.840	24.24	313.73	15.10
				350	22	15.9	174.23	5.202	20.72	288.54	16.25
				228	31	7.4	211.41	5.927	33.25	353.67	12.41
Muros	MUR	Spain	latitudinal	70	11	6.4	59.00	6.389	12.40	267.48	25.17
				86	13	6.6	200.12	7.460	21.82	326.16	17.44
				75	14	5.4	119.10	11.270	14.67	282.11	22.43
				56	24	2.3	148.12	6.927	15.77	328.32	24.28
				52	11.5	4.5	98.22	3.423	12.82	304.21	27.69
Amorosa	AMO	Portugal	latitudinal	50	4	12.5	56.80	3.464	9.97	241.33	28.25
				42.5	9	4.7	-	4.401	11.23	286.10	29.71
				41.5	7.2	5.8	63.51	4.899	10.99	274.59	29.14
				40	6.5	6.2	149.95	5.582	11.98	292.62	28.49
				36	5	7.2	118.17	8.729	10.92	278.61	29.76
Saltø	SAL	Sweden	Baltic	127	13	9.5	115.56	17.855	17.32	352.41	23.73
				125	17	7.1	102.07	16.775	20.71	334.76	18.86
				140	16	8.8	111.66	10.093	23.01	362.57	18.39
				130	16	8.2	117.51	10.614	17.88	330.66	21.58
				143	14	9.9	144.24	17.506	15.95	336.51	24.62
Smøgen	SMO	Sweden	Baltic	218	18	11.8	119.23	14.361	20.76	334.01	18.77
				294	14	20.9	120.62	16.624	22.13	338.35	17.84
				158	16	9.8	88.02	7.132	28.10	382.07	15.86
				239	18	13.4	152.05	18.925	26.44	354.57	15.64
				166	17	9.6	78.80	10.187	25.73	380.99	17.28

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Kiel	KIE	Germany	Baltic	57	10	5.7	119.01	6.948	16.12	313.06	22.66
				47	10	4.8	44.67	3.869	11.85	271.34	26.72
				40	10	3.8	83.28	8.214	14.49	306.87	24.70
				45	6	7.9	61.42	3.182	13.37	281.00	24.52
				42	6	6.8	97.84	7.082	14.97	294.80	22.97
Rügen	RUG	Germany	Baltic	25.5	8.6	3.0	47.67	3.702	27.37	341.08	14.54
				23.5	5	4.7	57.21	5.710	23.62	361.21	17.84
				13	6.4	2.0	77.02	7.663	17.60	323.43	21.44
				5.6	4.1	1.4	92.82	6.831	13.82	332.05	28.04
				5.4	1.1	4.9	-	17.077	-	-	-

Supplementary Table S.2. Pearson correlations of morphological (frond length, frond width, length to width ratio [length:width]) and biochemical parameters (mannitol, phlorotannins, total carbon [C], total nitrogen [N], C to N ratio [C:N]) of European *Saccharina latissima* and abiotic factors: sea surface temperature (SST), salinity and sampling depth. $p < 0.05^*$; $p < 0.01^{**}$; $p < 0.001^{***}$

data-set	correlated factors	<i>t</i>	<i>df</i>	<i>p</i>	<i>r</i>
latitudinal	length – SST	1.396	56	0.168	0.183
	width – SST	-4.385	56	< 0.001	-0.506***
	length:width – SST	3.275	56	0.002	0.401**
	length – salinity	-2.442	56	0.018	-0.310*
	width – salinity	-2.947	56	0.005	-0.366**
	length:width – salinity	-0.221	56	0.823	-0.030
	length – sampling depth	1.060	56	0.294	0.140
	width – sampling depth	1.435	56	0.157	0.188
	length:width – sampling depth	0.731	56	0.468	0.097
	mannitol – SST	-0.580	55	0.564	-0.078
	mannitol – salinity	-2.878	55	0.006	-0.362**
	mannitol – sampling depth	1.994	55	0.051	0.260
	phlorotannins – SST	0.958	55	0.342	0.128
	phlorotannins – salinity	-1.625	55	0.110	-0.214
	phlorotannins – sampling depth	-2.590	55	0.012	-0.330*
	C:N – SST	-0.940	54	0.351	-0.127
	total C – SST	2.294	53	0.026	0.301*
	total N – SST	2.733	53	0.009	0.351**
	C:N – salinity	-4.786	54	< 0.001	-0.546***
	total C – salinity	-1.960	53	0.055	-0.260
	total N – salinity	6.870	53	< 0.001	0.686***
	C:N – sampling depth	-1.432	54	0.158	-0.191
	total C – sampling depth	0.039	53	0.969	0.005
	total N – sampling depth	0.673	53	0.504	0.092
	mannitol – length	3.629	55	< 0.001	0.440***
	mannitol – width	1.047	55	0.230	0.140
	mannitol – length:width	2.904	55	0.005	0.365**
	phlorotannins – length	0.900	55	0.373	0.120
	phlorotannins – width	0.905	55	0.370	0.121
	phlorotannins – length:width	-1.000	55	0.322	-0.134
	C:N – length	2.256	54	0.028	0.293*
	total C – length	1.265	53	0.211	0.171
	total N – length	-3.610	53	< 0.001	-0.444***
	C:N – width	1.992	54	0.051	0.262
	total C – width	0.837	53	0.407	0.114
	total N – width	-3.875	53	< 0.001	-0.470***
	C:N – length:width	0.446	54	0.658	0.061
	total C – length:width	-0.201	53	0.841	-0.028
	total N – length:width	-0.357	53	0.723	-0.049
Baltic	length – SST	0.685	23	0.500	0.141
	width – SST	-2.855	23	0.009	-0.512**
	length:width – SST	2.610	23	0.016	0.478*
	length – salinity	3.650	23	0.001	0.606**
	width – salinity	8.751	23	< 0.001	0.877***
	length:width – salinity	0.981	23	0.337	0.200
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length – sampling depth	0.001	23	0.999	0.000
width – sampling depth	0.009	23	0.993	0.012
length:width – sampling depth	-0.590	23	0.561	-0.078
mannitol – SST	-1.461	22	0.158	-0.297
mannitol – salinity	4.166	22	< 0.001	0.664***
mannitol – sampling depth	0-196	22	0.847	0.042
phlorotannins – SST	-0.171	23	0.866	-0.036
phlorotannins – salinity	1.695	23	0.104	0.333
phlorotannins – sampling depth	1.192	23	0.246	0.241
C:N – SST	0.297	22	0.769	0.063
total C – SST	-0.049	22	0.961	-0.010
total N – SST	-0.222	22	0.826	-0.222
C:N – salinity	1.029	22	0.315	0.214
total C – salinity	1.165	22	0.257	0.241
total N – salinity	-1.173	22	0.253	-0.243
C:N – sampling depth	2.741	22	0.012	0.505*
total C – sampling depth	3.915	22	< 0.001	0.641***
total N – sampling depth	-2.114	22	0.046	-0.411*
mannitol – length	4.1806	22	< 0.001	0.665***
mannitol – width	3.4177	22	0.002	0.589**
mannitol – length:width	1.8978	22	0.071	0.375
phlorotannins – length	3.338	23	0.003	0.571**
phlorotannins – width	1.050	23	0.305	0.214
phlorotannins – length:width	3.101	23	0.005	0.543**
C:N – length	2.350	22	0.028	0.448*
total C – length	2.176	22	0.041	0.421*
total N – length	-2.578	22	0.017	-0.482*
C:N – width	2.266	22	0.034	0.435*
total C – width	1.740	22	0.096	0.348
total N – width	-2.472	22	0.022	-0.466*
C:N – length:width	0.975	22	0.340	0.203
total C – length:width	1.00	22	0.328	0.209
total N – length:width	-1.158	22	0.260	-0.240