Supplementary materials

Table S1. Present species distribution data for Northeast Atlantic *Laminaria* spp. These data were manually added to a base map with Affinity Designer v1.9.1 (serif.com).

Species	References
L. digitata	OBIS 2015, GBIF 2019a, NBN 2017a, OSPAR unpubl. data
L. hyperborea	OBIS 2014, GBIF 2019b, NBN 2017b, Assis et al. 2009, Casado-Amezúa et al. 2019, OSPAR unpubl. data
L. ochroleuca	OBIS 2009, GBIF 2017, NBN 2017c, Schoenrock et al. 2019, Voerman et al. 2013, Casado-Amezúa et al. 2019, Giaccone 1969, OSPAR unpubl. data

Table S2. Pigments that were quantified via spectrophotometry and spectral deconvolution. Abbreviations, chemical formulae and colours were taken from (Jeffrey et al. 1997). λ_{max} refers to the absorbance maximum given in nm. α is the absorption coefficient (also specific extinction coefficient) at λ_{max} given in l g^{-1} cm^{-1}. In all cases acetone was used as a solvent to obtain the values given below.

Pigment	Abbr.	Formula	Colour	Conc.	α	λ_{max}	References
Chlorophyll *a*	Chl *a*	$C_{55}H_{72}MgN_4O_5$	#0d98ba	100%	112	430	Lichtenthaler 1987, Jeffrey et al. 1997
Chlorophyll c_1	Chl c_1	$C_{35}H_{30}MgN_4O_5$	#50c878	100%	348	446	Jeffrey 1972
Chlorophyll c_2	Chl c_2	$C_{35}H_{28}MgN_4O_5$	#50c878	100%	321	445	Jeffrey 1972
Phaeophytin *a*	Phytin *a*	$C_{55}H_{74}N_4O_5$	#808080	100%	206	418	Lichtenthaler 1987
β,β-Carotene	ββ-Car	$C_{40}H_{56}$	#ffae42	n/a	250	454	Jeffrey et al. 1997
Fucoxanthin	Fuco	$C_{42}H_{58}O_6$	#ffa500	n/a	166	443	Haugan & Liaaen-Jensen 1989
Violaxanthin	Viola	$C_{40}H_{56}O_4$	#ffff00	n/a	240	442	Jeffrey et al. 1997
Zeaxanthin	Zea	$C_{40}H_{56}O_2$	#ffae42	n/a	234	452	Jeffrey et al. 1997

Table S3. R packages used in the data analysis and visualisation procedure. All analyses were implemented in the integrated development environment RStudio v1.3.1093 (RStudio Team 2020).

Package	Functions	Purpose	References
car v3.0-10	Anova	omnibus hypothesis testing	Fox & Weisberg 2019
fitdistrplus v1.1-3	cdfcomp denscomp fitdist gofstat	probability distribution fitting and comparison	Delignette-Muller & Dutang 2015
ggplot2 v3.3.3	ggplot + add-ons	data visualisation	Wickham 2016
ggspectra v0.3.7	wl_guide	wavelength visualisation	Aphalo 2015
lme4 v1.1-26	lmer	mixed effects modelling	Bates et al. 2015
mgcv v1.8-33	gam	additive modelling	Wood 2001
nlme v3.1-151	gls	generalised least squares	Pinheiro et al. 2020
nnls v1.4	nnls	nonnegative least squares	Mullen & van Stokkum 2015
psych v2.0.12	describeBy	descriptive statistics	Revelle 2020
rworldmap v1.3-6	getMap	global map data	South 2011
vegan v2.5-7	adonis betadisper metaMDS ordiellipse permutest veganCovEllipse vegdist	permutational multivariate analysis of variance and nonmetric multidimensional scaling	Oksanen et al. 2014, Oksanen et al. 2020

Table S4. Linear model (LM) and generalised least squares (GLS) results obtained from omnibus sums of squares hypothesis tests and pairwise contrasts. When the interaction term was found to be significant, it is reported and statistics for the slope (i.e. the continuous explanatory variable detrital age) are given for each species. Details on the construction of each model can be found in the R code (github.com/lukaseamus/Laminaria-pigments).

Variables	Model	Test	n	df	*F*	X^2	*t*	p	
Decomposition rate (g d^{-1})									
Species	LM	Omnibus	81	2	6.5			0.002	**
Detrital age				1	49.77			< 0.001	***
Residuals				77					
L. digitata = *L. hyperborea*		Pairwise					0.76	0.45	
L. digitata < *L. ochroleuca*							2.67	0.009	**
L. hyperborea < *L. ochroleuca*							3.43	< 0.001	***
Total pigment (µg g^{-1})									
Species	GLS	Omnibus	81	2		64.56		< 0.001	***
Detrital age				1		0.12		0.73	
L. digitata = *L. hyperborea*		Pairwise					0.76	0.45	
L. digitata > *L. ochroleuca*							2.67	0.009	**
L. hyperborea > *L. ochroleuca*							3.43	< 0.001	***
Chlorophyll *a* (µg g^{-1})									
Species	GLS	Omnibus	81	2		58.82		< 0.001	***
Detrital age				1		0.06		0.8	
L. digitata = *L. hyperborea*		Pairwise					0.57	0.57	
L. digitata > *L. ochroleuca*							7.35	< 0.001	***
L. hyperborea > *L. ochroleuca*							5.61	< 0.001	***
Chlorophyll *c* (µg g^{-1})									
Species	GLS	Omnibus	81	2		11.8		0.003	**
Detrital age				1		2.21		0.14	
L. digitata = *L. hyperborea*		Pairwise					0.43	0.67	
L. digitata > *L. ochroleuca*							3.21	0.002	**
L. hyperborea > *L. ochroleuca*							2.82	0.006	**
Fucoxanthin (µg g^{-1})									
Species	GLS	Omnibus	81	2		63.33		< 0.001	***
Detrital age				1		2.51		0.11	
L. digitata = *L. hyperborea*		Pairwise					1.94	0.06	
L. digitata > *L. ochroleuca*							7.82	< 0.001	***
L. hyperborea > *L. ochroleuca*							5.71	< 0.001	***
Minor carotenoids (µg g^{-1})									
Species	GLS	Omnibus	81	2		26.87		< 0.001	***
Detrital age (*L. digitata*)				1		10.71		0.001	**
Detrital age (*L. hyperborea*)				1		0.002		0.97	
Detrital age (*L. ochroleuca*)				1		0.51		0.48	
Species × Detrital age				2		6.54		0.04	*
L. digitata = *L. hyperborea*		Pairwise					0.69	0.49	
L. digitata > *L. ochroleuca*							2.83	0.006	**
L. hyperborea > *L. ochroleuca*							4.83	< 0.001	***
Antenna to chlorophyll *a* ratio									
Species	GLS	Omnibus	81	2		10		0.007	**
Detrital age (*L. digitata*)				1		26.39		< 0.001	***
Detrital age (*L. hyperborea*)				1		0.003		0.95	
Detrital age (*L. ochroleuca*)				1		6.22		0.01	*
Species × Detrital age				2		14.43		< 0.001	***
L. digitata < *L. hyperborea*		Pairwise					2.31	0.005	**
L. digitata = *L. ochroleuca*							0.33	0.74	
L. hyperborea > *L. ochroleuca*							2.4	0.02	*

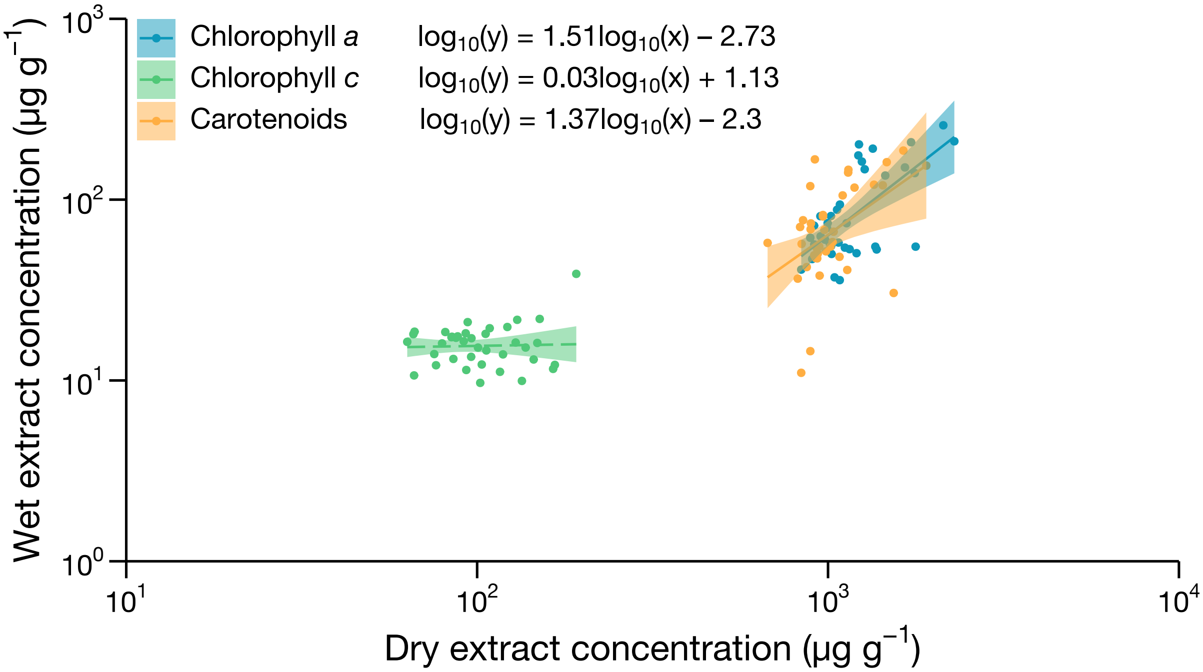

Figure S1. Relationship between pigment concentrations obtained by extracting fresh (response) and lyophilised (explanatory) *Laminaria* spp. tissue from Mount Batten (50.356222°N, 4.128055°W). Fresh kelp was cut up finely using a sterile razor blade and crushed with a pestle and mortar while lyophilised kelp was ground. Lines and shaded areas are model predictions and 95% confidence intervals. Solid lines represent significant slopes at the 95% confidence level, while dashed lines indicate no significant slope.

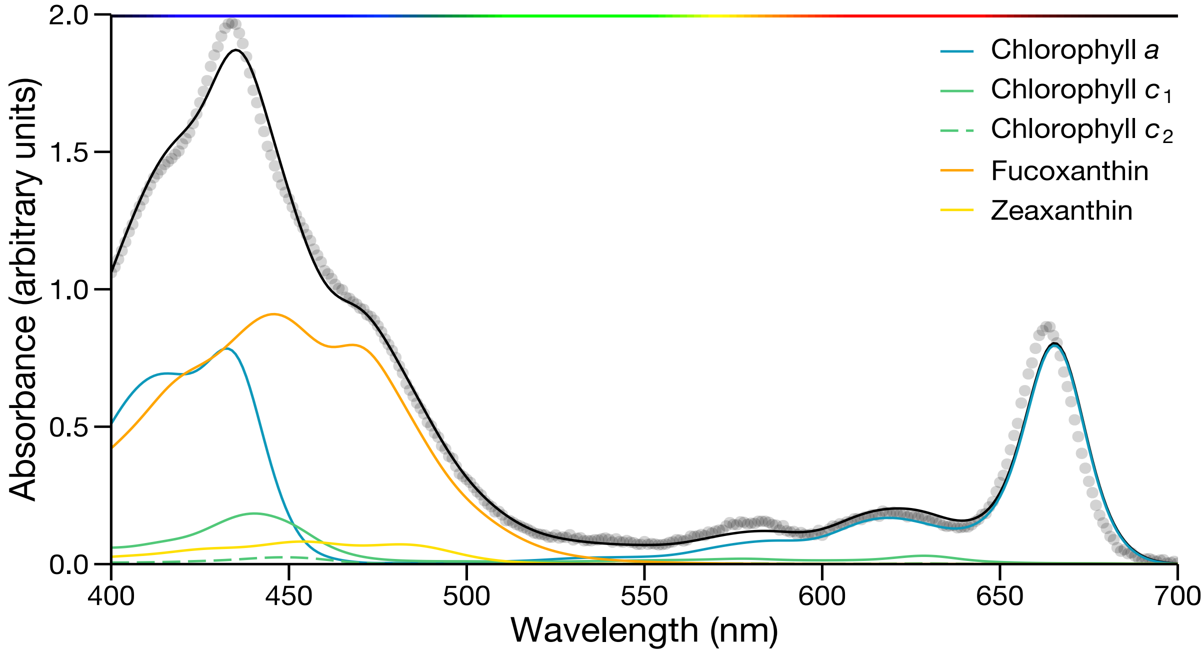

Figure S2. Spectral deconvolution using non-negative least squares fitting (Thrane et al. 2015). The plot shows the raw (grey points) and fitted (black line) absorbance spectra of one randomly selected, lyophilised *Laminaria digitata* sample from Mount Batten. Weighted spectra of individual pigments (coloured lines) are summed and then added to the background spectrum (not shown) to obtain the fitted absorbance spectrum (black line). Violaxanthin, pheophytin *a* and β,β-carotene are not shown because they are present in such low quantities that their absorbance is visually indistinguishable in this plot. Note the dominance of chlorophyll *a* and fucoxanthin as well as two conspicuous absorbance peaks due to the ability of chlorophyll *a* to utilise light energy in the blue and red wavebands (cf. colour bar).

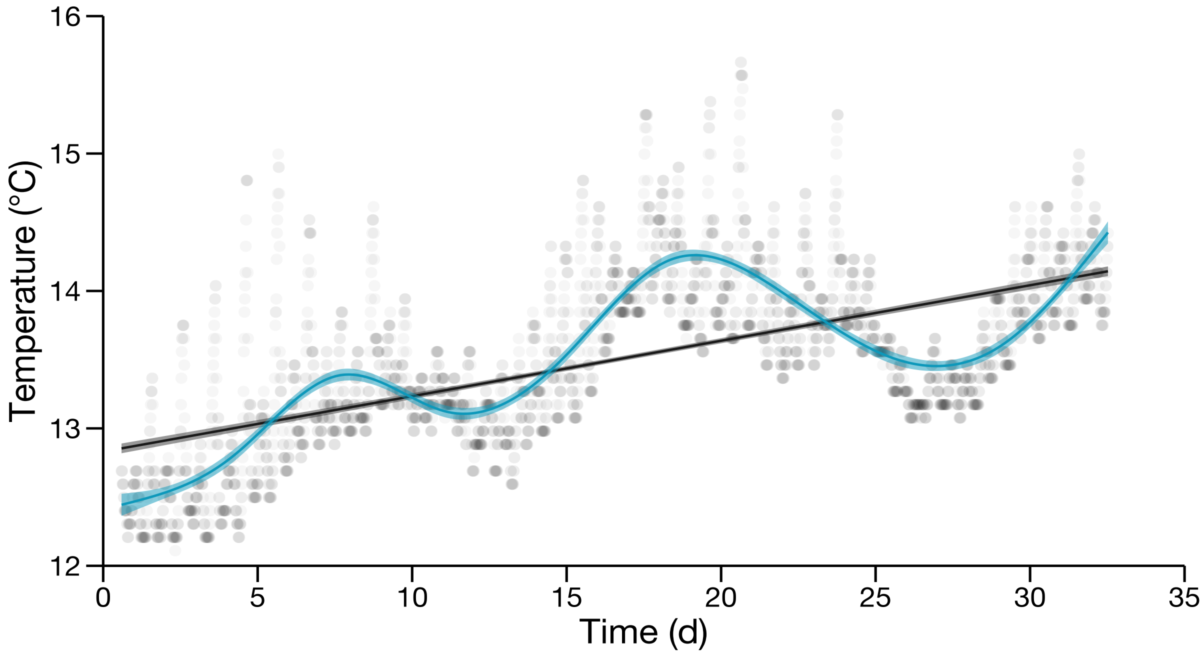

Figure S3. Ambient kelp forest temperature during the decomposition field experiment.
Lines and shaded areas are model predictions and 95% confidence intervals. The linear model (black) predicts an increase of 0.04°C d^{-1} over the 32-d period (y = 0.04x + 12.83). Because temperature clearly oscillated, we also fit a generalised additive model (blue), which explains 64% of the variance in temperature.

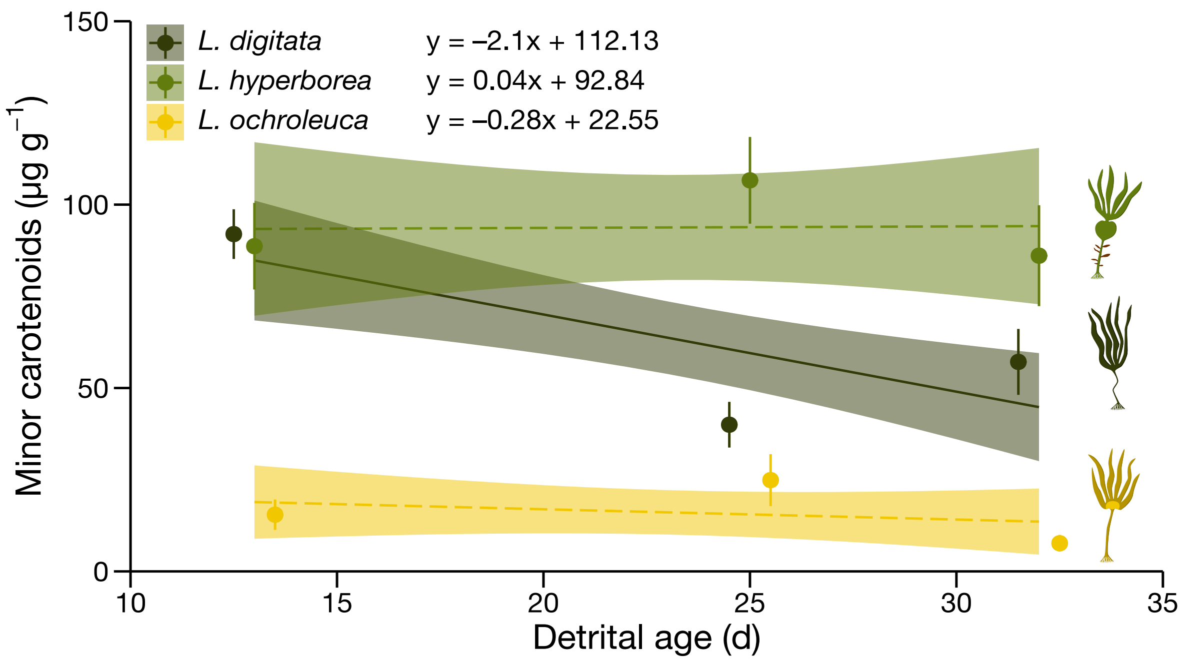

Figure S4. Relationship between detrital age and minor carotenoid concentration in different *Laminaria* spp. at West Hoe. Lines and shaded areas are model predictions and 95% confidence intervals. Solid lines represent significant slopes at the 95% confidence level, while dashed lines indicate no significant slope. Point ranges are means ± standard errors and are dodged to avoid overlap.

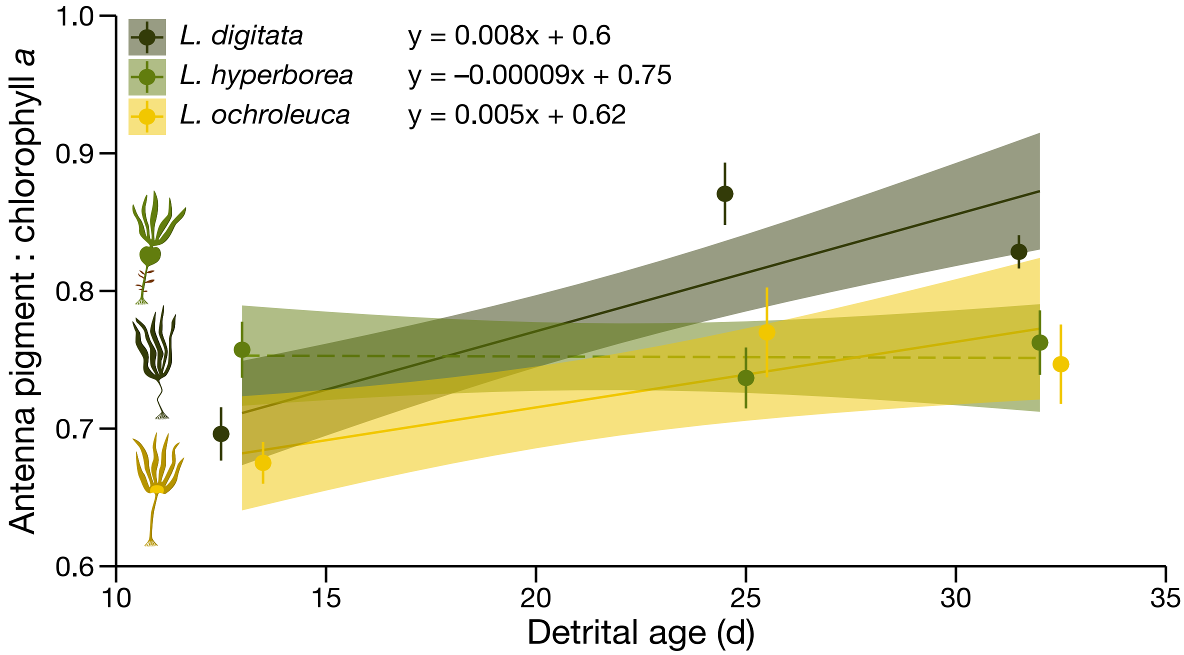

Figure S5. Relationship between detrital age and the antenna pigment to chlorophyll *a* ratio in different *Laminaria* spp. at West Hoe. Lines and shaded areas are model predictions and 95% confidence intervals. Solid lines represent significant slopes at the 95% confidence level, while dashed lines indicate no significant slope. Point ranges are means ± standard errors and are dodged to avoid overlap.

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