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Spatial variability in the structure of fish assemblages associated with Laminaria hyperborea forests in the NE Atlantic

Jackson-Bué, Mathilde; Smale, Dan A.; King, Nathan G.; Rushton, Aaron G.; Moore, Pippa J.

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tel: +44 1970 62 2400

email: is@aber.ac.uk

Supplementary Information

Table S1 Environmental conditions at the two survey sites (A, B) located within each of the four regions (1: N Scotland, 2: W Scotland, 3: S Wales, 4: S England) in the UK. 'Depth' is the average depth below chart datum. 'Mean SST' is the annual mean temperature calculated from satellite-derived sea surface temperature (SST) data (2005-2014). 'Log wave fetch' is the log of the sum of wave fetch values of sectors surrounding each site. 'Log chl a' is the average annual concentration of chlorophyll a ($\log_{10} \text{mg m}^{-3}$ from MODIS Aqua satellite data, 2002-2012). Kelp density is the mean density of canopy-forming *Laminaria hyperborea* plants found at each site, derived from multiple surveys conducted between 2014 and 2017.

Site	Latitude (°N)	Depth (m BCD)	Mean SST (°C)	Log wave fetch (km)	Log chl a (mg m^{-3})	Kelp density (inds m^{-2})
1A	58.98	2	9.7	3.8	0.21	9.3
1B	58.94	4	9.8	3.5	0.26	8.6
2A	56.37	5	10.8	3.3	0.59	9.3
2B	56.39	4	10.7	3.1	0.65	7.9
3A	51.76	4	11.7	3.7	0.43	9.7
3B	51.77	3	11.8	3.5	0.43	8.6
4A	50.29	3	12.4	4.1	0.28	9.1
4B	50.30	4	12.4	3.5	0.28	8.6

Table S2. Full model with the factor year not significant: results of PERMANOVA test for differences in fish assemblage structure based on BRUV data between factors Year (fixed), Region (fixed) and Site (random, nested in region). Permutations (999) were conducted under a reduced model and were based on a Bray-Curtis similarity matrix of square-root transformed data. Significant values ($P < 0.05$) are indicated in bold.

Source	df	MS	Pseudo-F	<i>p</i>
Year	1	3588.6	1.2463	0.336
Region	3	14128	4.5933	0.001
Site(Region)	4	3182.7	3.4307	0.001
Year x Region	2	3191.3	1.1008	0.445
Year x Site(Region)	3	2923.1	3.1509	0.002
Residual	47	927.71		
Total	60			

Table S3. Percentage contributions of individual taxa to observed differences in fish assemblages captured by BRUVs between regions as determined by SIMPER analysis with a cut-off at 70% cumulative contribution. Abundance values squared-root transformed prior to analysis.

	Taxa	Av. abund	Av. abund	Av. diss	Diss/SD	Contrib%	Cum%
Average dissimilarity = 66.42	<i>Pollachius</i> spp	3.86	Wales	21.72	1.57	32.70	32.70
	<i>Gobiusculus flavescens</i>	0.28		16.71	1.78	25.16	57.86
	<i>Pomatoschistus</i> spp	0.06	0.76	5.87	0.67	8.84	66.71
	<i>Scyliorhinus canicula</i>	0.21	0.51	5.27	0.76	7.94	74.65
			N Scot	W Scot			
	<i>Pollachius</i> spp	3.86	2.77	17.93	1.23	33.08	33.08
Average dissimilarity = 54.22	<i>Gobiusculus flavescens</i>	0.28	1.38	10.19	0.80	18.79	51.87
	<i>Ctenolabrus rupestris</i>	0.06	0.76	6.11	1.06	11.27	63.14
	<i>Labrus bergylta</i>	0.31	0.69	5.47	0.98	10.08	73.22
Average dissimilarity = 75.96			N Scot	S Eng			
	<i>Pollachius</i> spp	3.86	1.38	19.34	1.61	25.46	25.46
	<i>Ctenolabrus rupestris</i>	0.06	1.50	10.67	2.54	14.04	39.50
	<i>Gobiusculus flavescens</i>	0.28	1.61	9.96	1.15	13.11	52.62
	<i>Centrolabrus exoletus</i>	0.00	1.10	8.33	1.25	10.97	63.59
	<i>Ammodytes tobianus</i>	0.63	0.73	5.26	0.42	6.93	70.51
Average dissimilarity = 61.54			W Scot	S Eng			
	<i>Pollachius</i> spp	2.77	1.38	1.85	1.35	19.25	19.25
	<i>Gobiusculus flavescens</i>	1.38	1.61	1.36	1.18	18.45	37.70
	<i>Centrolabrus exoletus</i>	0.07	1.10	7.61	1.24	12.37	50.07
	<i>Ctenolabrus rupestris</i>	0.76	1.50	6.15	1.16	9.99	60.06
	<i>Labrus bergylta</i>	0.69	0.78	3.68	0.95	5.98	66.04
	<i>Scomber scombrus</i>	0.00	0.54	3.37	0.86	5.48	71.51
			Wales	S Eng			
Average dissimilarity = 61.93	<i>Ctenolabrus rupestris</i>	0.10	1.50	9.46	2.75	15.28	15.28
	<i>Gobiusculus flavescens</i>	2.13	1.61	8.97	1.40	14.49	29.77
	<i>Centrolabrus exoletus</i>	0.00	1.10	7.70	1.33	12.43	42.20
	<i>Pollachius</i> spp	1.52	1.38	6.18	0.79	9.99	52.18
	<i>Pomatoschistus</i> spp	0.76	0.00	4.39	0.63	7.09	59.28
	<i>Scyliorhinus canicula</i>	0.51	0.25	3.83	0.81	6.18	65.46
	<i>Labrus bergylta</i>	0.70	0.78	3.41	0.94	5.50	70.96
			W Scot	Wales			
Average dissimilarity = 58.66	<i>Gobiusculus flavescens</i>	1.38	2.13	16.12	1.75	27.49	27.49
	<i>Pollachius</i> spp	2.77	1.52	12.58	1.33	21.45	48.94

<i>Ctenolabrus</i>	0.76	0.10	5.56	1.12	9.49	58.42
<i>rupestris</i>						
<i>Pomatoschistus</i>	0.00	0.76	5.22	0.62	8.91	67.33
spp						
<i>Scyliorhinus</i>	0.00	0.51	4.35	0.67	7.42	74.75
<i>canicula</i>						

Table S4. Percentage contributions of individual taxa to observed differences in the presence of fish assemblages captured by combined techniques (BRUV and UVC) between regions as determined by SIMPER analysis with a cut-off at 70% cumulative contribution. Abundance were transformed into presence/absence prior to analysis.

	Taxa	Av. abund	Av. abund	Av. diss	Diss/SD	Contrib%	Cum%
		N Scot	W Scot				
Average dissimilarity = 49.89	<i>Ctenolabrus rupestris</i>	0.09	0.70	8.41	1.31	16.85	16.85
	<i>Labrus bergylta</i>	0.45	0.80	7.42	0.99	14.87	31.72
	<i>Gobiusculus flavescens</i>	0.73	0.70	6.08	0.79	12.18	43.90
	<i>Centrolabrus exoletus</i>	0.00	0.40	5.50	0.74	11.03	54.93
	<i>Scyliorhinus canicula</i>	0.27	0.00	3.76	0.59	7.54	62.48
	<i>Trisopterus minutus (luscus)</i>	0.00	0.30	3.34	0.64	6.70	69.18
	<i>Taurulus bubalis</i>	0.09	0.10	2.42	0.44	4.85	74.03
Average dissimilarity = 49.04	<i>Symphodus melops</i>	0.00	0.83	9.15	2.05	18.65	18.65
	<i>Labrus bergylta</i>	0.45	1.00	6.55	1.05	13.36	32.02
	<i>Dicentrarchus labrax</i>	0.00	0.50	5.55	0.96	11.32	43.34
	<i>Scyliorhinus canicula</i>	0.27	0.33	4.73	0.83	9.65	52.99
	<i>Gobiusculus flavescens</i>	0.73	1.00	3.44	0.59	7.01	60.00
	<i>Pomatoschistus</i> spp	0.09	0.25	3.25	0.63	6.63	66.63
	<i>Ctenolabrus rupestris</i>	0.09	0.17	2.19	0.54	4.47	71.10
Average dissimilarity = 46.84	<i>Symphodus melops</i>	0.10	0.83	7.51	1.69	16.03	16.03
	<i>Ctenolabrus rupestris</i>	0.70	0.17	5.98	1.26	12.76	28.78
	<i>Dicentrarchus labrax</i>	0.00	0.50	4.84	0.95	10.34	39.12
	<i>Centrolabrus exoletus</i>	0.40	0.17	4.28	0.84	9.14	48.26
	<i>Gobiusculus flavescens</i>	0.70	1.00	3.37	0.64	7.19	55.45
	<i>Scyliorhinus canicula</i>	0.00	0.33	3.13	0.68	6.69	62.14
	<i>Trisopterus minutus (luscus)</i>	0.30	0.08	2.87	0.70	6.13	68.27
	<i>Pomatoschistus</i> spp	0.00	0.25	2.37	0.56	5.06	73.33
Average dissimilarity = 59.50	<i>Ctenolabrus rupestris</i>	0.09	1.00	8.12	2.64	13.65	13.65
	<i>Centrolabrus exoletus</i>	0.00	0.91	7.75	2.64	13.02	26.67
	<i>Scomber scombrus</i>	0.00	0.64	5.12	1.25	8.61	35.28
	<i>Labrus bergylta</i>	0.45	0.91	4.85	1.03	8.16	43.44
	<i>Ammodytes tobianus</i>	0.09	0.55	4.33	1.03	7.28	50.72
	<i>Chelon labrosus</i>	0.00	0.55	4.32	1.05	7.27	57.99
	<i>Conger conger</i>	0.00	0.45	3.96	0.87	6.65	64.64
	<i>Scyliorhinus canicula</i>	0.27	0.45	3.92	0.92	6.59	71.23

		W Scot	S Eng				
Average dissimilarity = 46.26	<i>Scomber scombrus</i>	0.00	0.64	4.62	1.24	9.98	9.98
	<i>Centrolabrus exoletus</i>	0.40	0.91	4.54	1.12	9.81	19.79
	<i>Chelon labrosus</i>	0.00	0.55	3.91	1.05	8.44	28.23
	<i>Ammodytes tobianus</i>	0.00	0.55	3.91	1.05	8.44	36.67
	<i>Conger conger</i>	0.00	0.45	3.54	0.87	7.65	44.33
	<i>Labrus mixtus</i>	0.00	0.45	3.20	0.87	6.93	51.25
	<i>Symphodus melops</i>	0.10	0.36	3.09	0.77	6.67	57.93
	<i>Scyliorhinus canicula</i>	0.00	0.45	3.06	0.89	6.61	64.54
	<i>Parablennius gattorugine</i>	0.10	0.36	2.70	0.78	5.83	70.37