

Effects of climate and eutrophication on the diversity of hard bottom communities on the Skagerrak coast 1990-2010

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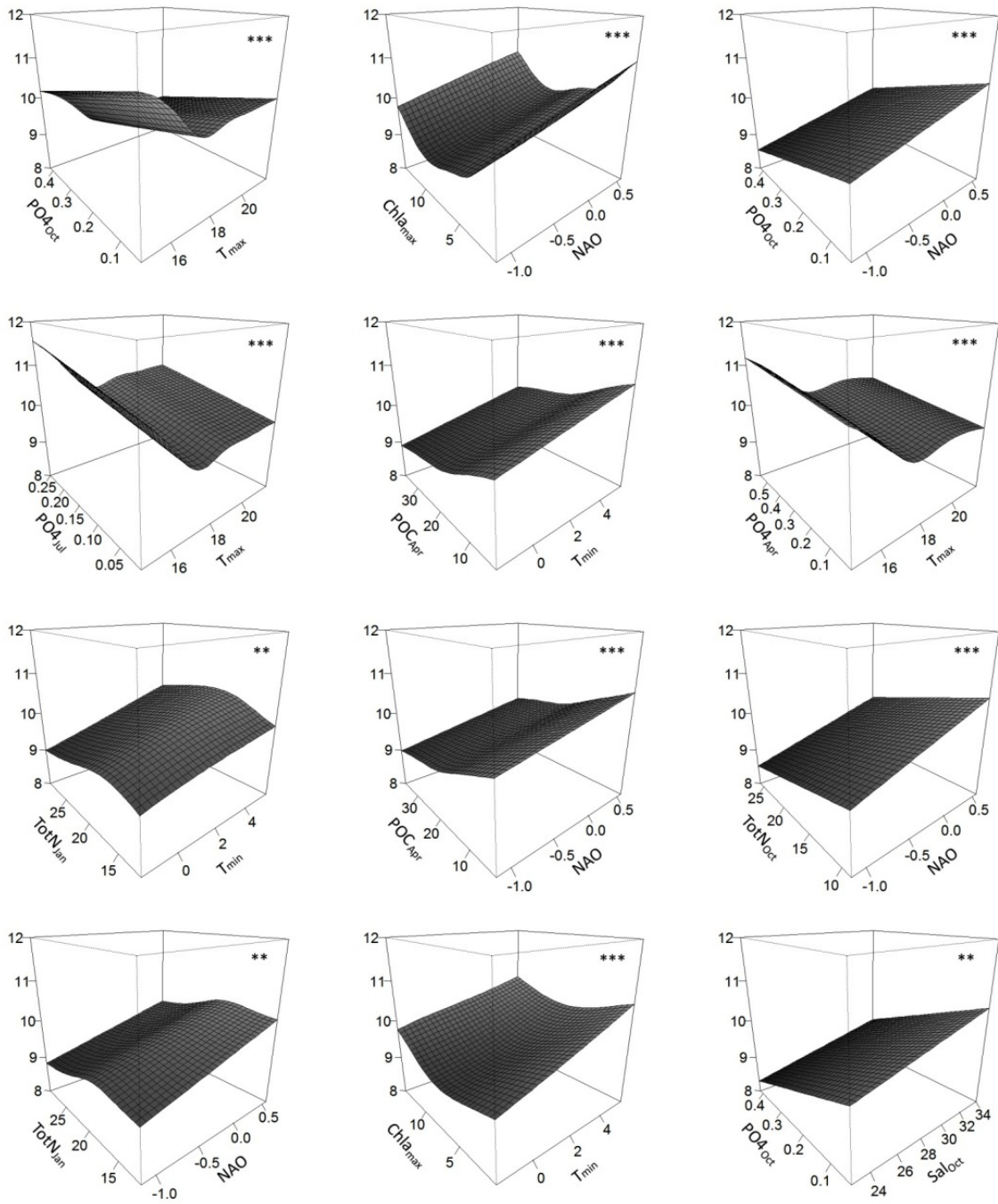
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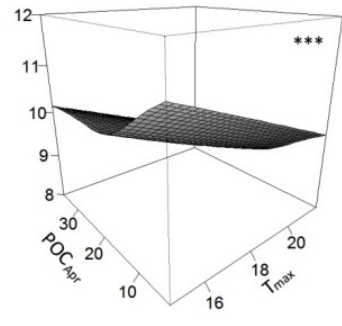
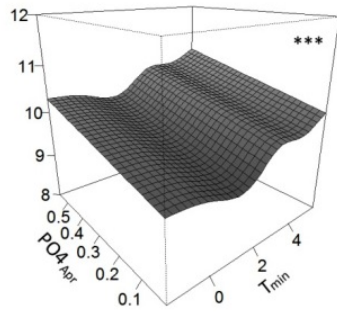
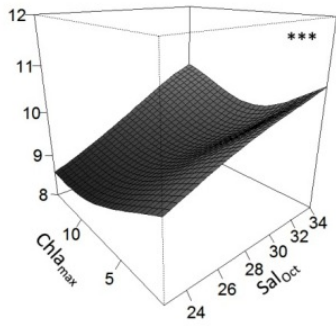
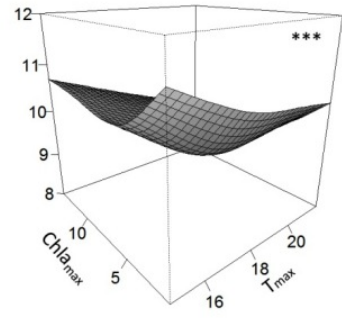
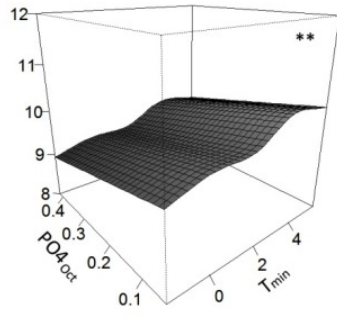
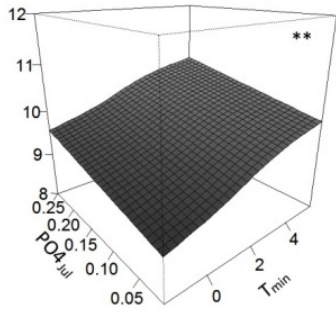
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Supplement 1.

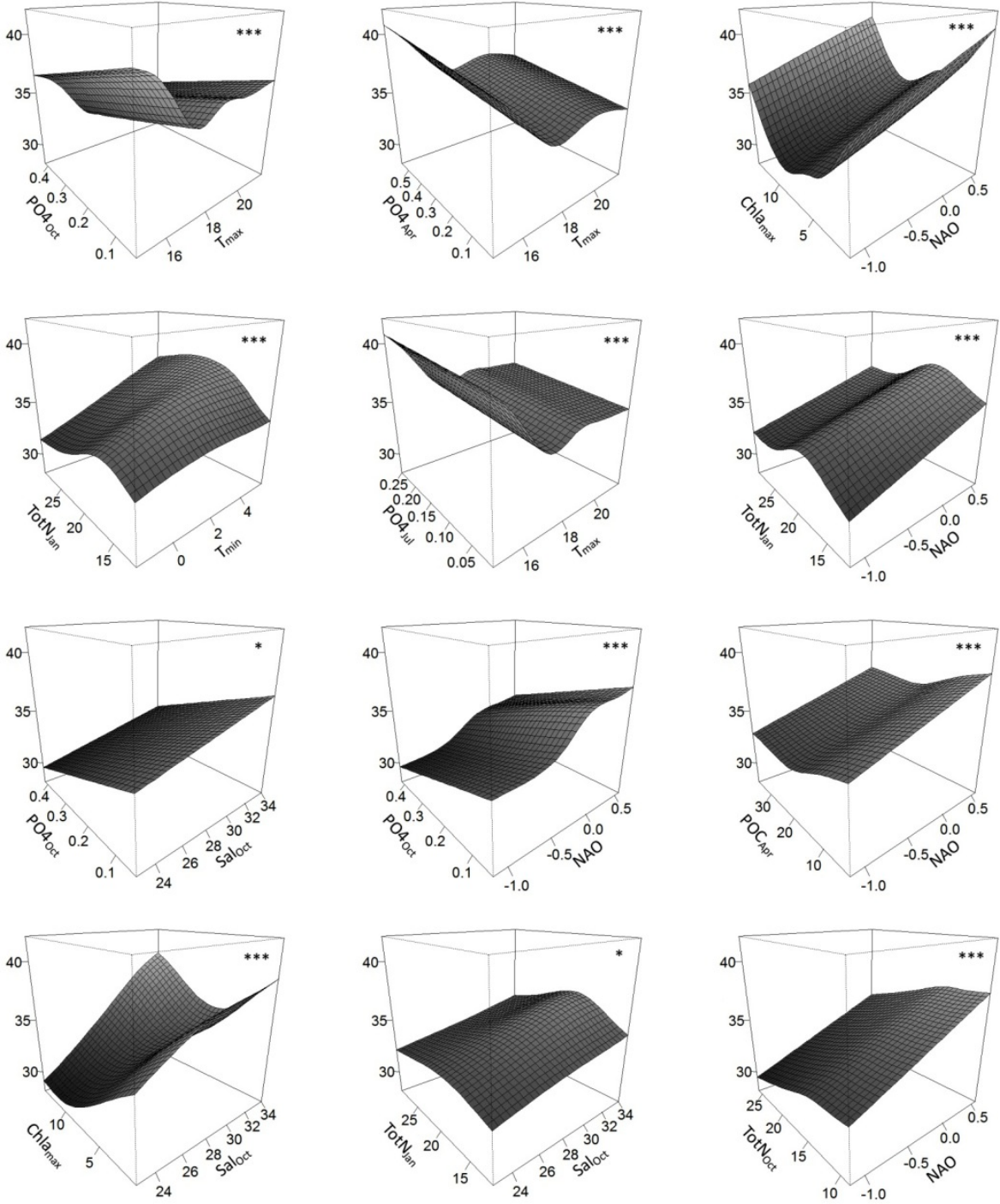
Partial response curves from the Mixed GAMs of the relationship between (A) diversity and (B) species richness and the most important explanatory interactions between eutrophication and climate variables: NAO (North Atlantic Oscillation index), T_{\max} (maximum temperature), T_{\min} (minimum temperature), Sal_{\min} (minimum salinity), Sal_{\max} (maximum salinity), $PO4_{\text{Jan}}$ (average phosphate concentration in January), $PO4_{\text{Apr}}$ (average phosphate concentration in April), $PO4_{\text{Jul}}$ (average phosphate concentration last July), $PO4_{\text{Oct}}$ (average phosphate concentration last October), $TotN_{\text{Jan}}$ (average total nitrogen in January), $TotN_{\text{Oct}}$ (average total nitrogen in October), POC_{Jan} (average particulate organic carbon concentration in January), POC_{Apr} (average particulate organic carbon concentration in April), Chl_{\max} (maximum chlorophyll *a* concentration during spring). Symbols indicate significant levels at $p < 0.001$ (***), $p < 0.01$ (**), $p < 0.05$ (*), and $p < 0.1$ (·).

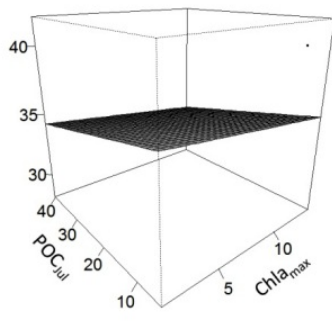
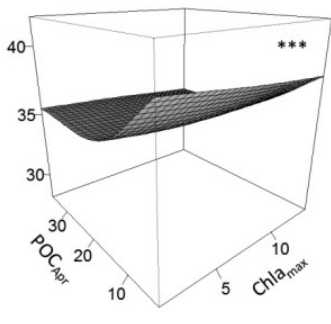
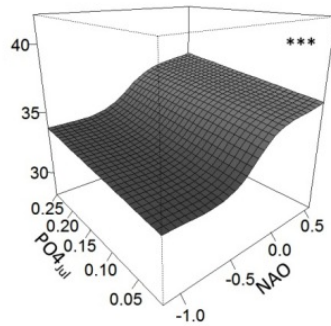
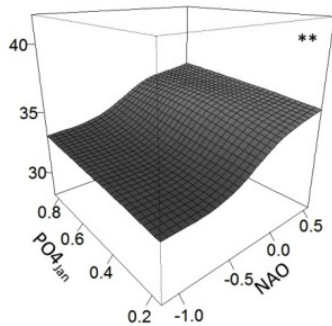
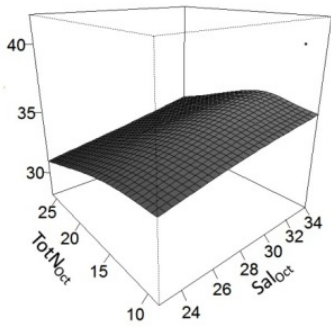
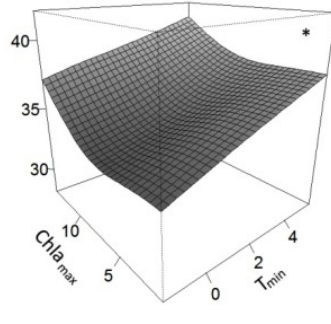
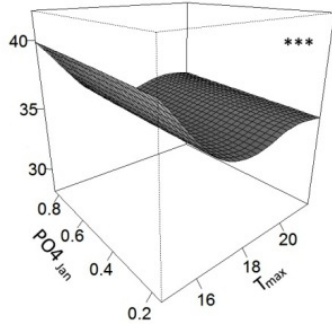
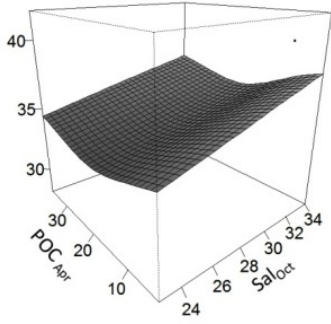
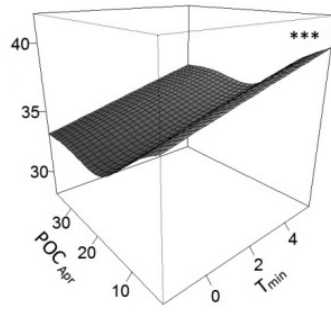
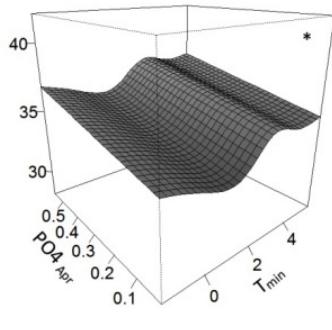
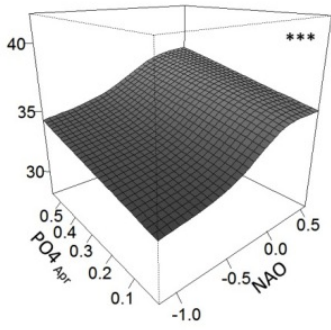
A) Diversity





B) Species richness





Supplement 3.

Species accounting for 90% of the total variation within the depth zones 0–3 m, 4–15 m and 16–24 m according to SIMPER analysis.

	0–3 m	4–15 m	16–24 m
Annual filamentous algae	<i>Ceramium rubrum</i> (Agardh) <i>Polysiphonia stricta</i> (Dillwyn) <i>Chorda tomentosa</i> (Lynbye) <i>Chordaria flagelliformis</i> (Müller) <i>Dumontia contorta</i> (Ruprecht) <i>Spongomorpha aeruginosa</i> (Linn.) <i>Ectocarpus fasciculatus</i> (Harvey) <i>Polysiphonia fibrillosa</i> (Dillwyn) <i>Scytosiphon lomentaria</i> (Lynbye) <i>Polysiphonia brodiei</i> (Dillwyn) <i>Desmarestia viridis</i> (Müller) <i>Bonnemaisonia hamifera</i> (Hariot) <i>Mesogloia vermiculata</i> (Smith) <i>Cystoclonium purpureum</i> (Hudson) <i>Spongomorpha pallida</i> (Linn) <i>Derbesia marina</i> (Lyngbye) <i>Elachista fucicola</i> (Velley)	<i>B. hamifera</i> <i>P. stricta</i> <i>Lomentaria clavellosa</i> (Gaillon) <i>Audouinella purpurea</i> (Lightfoot) <i>D. viridis</i> <i>Sphacelaria radicans</i> (Agardh) <i>Sphacelaria caespitula</i> (Agardh) <i>C. melagonium</i> <i>E. fasciculatus</i> <i>Bonnemaisonia asparagoides</i> (Agardh) <i>Derbesia marina</i> (Lyngbye) <i>Callithamnion corymbosum</i> (Lyngbye) <i>C. rubrum</i> <i>Pterothamnion plumula</i> (Ellis) <i>Sphacelaria cirrosa</i> (Agardh) <i>Spongomorpha aeruginosa</i> (Linn.) <i>Audouinella membranacea</i> (Magnus)	<i>B. hamifera</i> <i>P. stricta</i> <i>P. plumula</i> <i>S. radicans</i> <i>B. asparagoides</i> <i>Pterosiphonia parasitica</i> (Hudson) <i>S. cirrosa</i> <i>Lomentaria orcadensis</i> (Harvey) <i>Lomentaria clavellosa</i> (Gaillon) <i>D. viridis</i> <i>Bryopsis plumosa</i> (Agardh) <i>D. marina</i>
Annual sheetlike algae	<i>Ulva lactuca</i> (Linn.)	<i>U. lactuca</i>	
Calcareous algae	<i>Corallina officinalis</i> (Linn.)	<i>C. officinalis</i> <i>Pneophyllum limitatum</i> (Foslie)	<i>C. officinalis</i>
Encrusting non-calcareous algae	<i>Hildenbrandia rubra</i> (Sommerfelt)	<i>Cruoria pellita</i> (Lyngbye) <i>Pseudolithoderma extensum</i> (Lund)	<i>P. extensum</i> <i>C. pellita</i>

Perennial red algae	<p><i>Chondrus crispus</i> (Stackhouse)</p> <p><i>Palmaria palmata</i> (Linn.)</p> <p><i>Delesseria sanguinea</i> (Hudson)</p> <p><i>Phyllophora truncata</i> (Turner)</p> <p><i>Furcellaria lumbricalis</i> (Hudson)</p> <p><i>Rhodomela confervoides</i> (Hudson)</p> <p><i>Ahnfeltia plicata</i> (Hudson)</p> <p><i>Polysiphonia elongata</i> (Hudson)</p> <p><i>Mastocarpus stellata</i> (Stackhouse)</p>	<p><i>D. sanguinea</i></p> <p><i>Phycodrys rubens</i> (Linn.)</p> <p><i>C. crispus</i></p> <p><i>Dilsea carnosa</i> (Kuntze)</p> <p><i>P. truncata</i></p> <p><i>P. palmata</i></p> <p><i>Phyllophora pseudoceranoides</i> (Phypps)</p> <p><i>Brongniartella byssoides</i> (Schmitz)</p> <p><i>Ptilota plumosa</i> (Agardh)</p> <p><i>Apoglossum ruscifolium</i> (Turner)</p> <p><i>Odonthalia dentata</i> (Linn.)</p> <p><i>Porphyropsis coccinea</i> (Agardh)</p> <p><i>F. lumbricalis</i></p> <p><i>R. confervoides</i></p> <p><i>Membranoptera alata</i> (Hudson)</p>	<p><i>D. sanguinea</i></p> <p><i>B. byssoides</i></p> <p><i>D. carnosa</i></p> <p><i>P. truncata</i></p> <p><i>O. dentata</i></p> <p><i>P. pseudoceranoides</i></p> <p><i>P. rubens</i></p> <p><i>R. confervoides</i></p> <p><i>Heterosiphonia plumose</i> (Lyngye)</p>
Perennial green algae	<p><i>Cladophora rupestris</i> (Linn.)</p> <p><i>Chaetomorpha melagonium</i> (Kützing)</p>		
Perennial brown algae	<p><i>Desmarestia aculeata</i> (Linnaeus)</p> <p><i>Petalonia fascia</i> (Müller)</p>	<p><i>D. aculeata</i></p> <p><i>Sphacelaria plumosa</i> (Lyngbye)</p>	<p><i>Cutleria multifida</i> (Smith)</p>
Kelp	<p><i>Laminaria hyperborea</i> (Gunn Foslie)</p> <p><i>Laminaria digitata</i> (Hudson)</p> <p><i>Saccharina latissima</i> (Linn.)</p> <p><i>Alaria esculenta</i> (Linn.)</p> <p><i>Fucus serratus</i> (Linn.)</p> <p><i>Halidrys siliquosa</i> (Linn.)</p>	<p><i>L. hyperborea</i></p> <p><i>S. latissima</i></p> <p><i>H. siliquosa</i></p>	<p><i>L. hyperborea</i></p> <p><i>S. latissima</i></p>
Seaweed			
Macroinvertebrates	<p><i>Halicondria panacea</i> (Pallas)</p> <p><i>Laomedea geniculata</i> (Linn.)</p> <p><i>Balanus balanoides</i> (Linn.)</p> <p><i>Balanus crenatus</i> (Bruguère)</p> <p><i>Asterias rubens</i> (Linn.)</p> <p><i>Electra pilosa</i> (Linn.)</p> <p><i>Membranipora membranacea</i> (Linn.)</p>	<p><i>Alcyonium digitatum</i> (Linn.)</p> <p><i>Leucosolenia complicata</i> (Montagu)</p> <p><i>Sycon ciliatum</i> (Fabricius)</p> <p><i>U. felina</i></p> <p><i>M. membranacea</i></p> <p><i>E. pilosa</i></p> <p><i>L. geniculata</i></p> <p><i>C. eburnea</i></p> <p><i>A. rubens</i></p>	<p><i>C. parallelogramma</i></p> <p><i>A. digitatum</i></p> <p><i>Parasmittina trispinosa</i> (Johnston)</p> <p><i>A. mentula</i></p> <p><i>Halecium halecinum</i> (Linn.)</p> <p><i>Hymedesmia mammillaris</i> (Fristedt)</p> <p><i>C. eburnea</i></p> <p><i>M. glacialis</i></p>

	<p><i>Mytilus edulis</i> (Linn.) <i>Nucella lapillus</i> (Roding) <i>Littorina littorea</i> (Linn.) <i>Umbonula littoralis</i> (Hastings) <i>Patella sp.</i> <i>Scrupocellaria reptans</i> (Linn.) <i>Urticina felina</i> (Linn.) <i>Metridium senile pallidum</i> (Linn.) <i>Crisia eburnea</i> (Linn.) <i>Campanularia johnstoni</i> (Alder) <i>Dendrodoa grossilaria</i> (Van Beneden)</p>	<p><i>Leptasterias muelleri</i> (Sars) <i>Marthasterias glacialis</i> (Linn.) <i>Corella parallelogramma</i> (Müller) <i>Halichondria panicea</i> (Pallas) <i>Celleporella hyalina</i> (Linn.) <i>Callopora craticula</i> (Alder) <i>Callopora linearis</i> (Alder) <i>Laomedea longissima</i> (Pallas) <i>C. johnstoni</i> <i>D. grossilaria</i> <i>S. reptans</i> <i>Spirorbis borealis</i> (Daudin) <i>Spirorbis spirillum</i> (Linn.) <i>Pomatoceros triqueter</i> (Linn.) <i>Botryllus schlosseri</i> (Pallas) <i>Ascidia mentula</i> (Müller)</p>	<p><i>A. rubens</i> <i>A. virginea</i> (Müller) <i>L. complicata</i> <i>L. longissima</i> <i>P. triqueter</i> <i>M. membranacea</i> <i>Scrupocellaria scabra</i> (Van Beneden) <i>Flustra foliacea</i> (Linn.) <i>L. muelleri</i> <i>E. pilosa</i> <i>S. ciliatum</i> <i>Caryophyllia smithii</i> (Stokes & Broderip) <i>Kirchenpauria pinnata</i> (Pallas) <i>L. geniculata</i> <i>Crania anomala</i> (Müller) <i>Bugula purpurotincta</i> (Norman) <i>Securiflustra securifrons</i> (Pallas) <i>Boltenia echinata</i> (Linn.)</p>
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Supplement 4.

The 20 most important species in explaining variation in community composition according to SIMPER for NAO (North Atlantic Oscillation during December-February), T_{\max} (maximum temperature), T_{\min} (minimum temperature), S_{\min} (minimum salinity), S_{\max} (maximum salinity), P_{Jan} (average phosphate concentration in January), P_{Jul} (average phosphate concentration last July), P_{Oct} (average phosphate concentration last October), TotN_{Jan} (average total nitrogen in January), TotN_{Oct} (average total nitrogen in October), POC_{Jan} (average particulate organic carbon concentration in January), POC_{Apr} (average particulate organic carbon concentration in April), Chla_{\max} (maximum chlorophyll *a* concentration during spring). Each variable was grouped as “high”, “medium” and “low” level prior to analysis, and the table shows results when comparing groups “high” versus “low”. +: increased amount of species when the variable is high, -: increased amount of species when variable is low.

		NAO	T_{\max}	T_{\min}	S_{\min}	S_{Oct}	P_{Jan}	P_{Jul}	P_{Oct}	TotN_{Jan}	TotN_{Oct}	POC_{Jan}	POC_{Apr}	Chla_{\max}	
Annual filamentous and sheet-like algae	<i>B. hamifera</i>	-		+		-	-	-	+	-	-	-	+	-	
	<i>S. radicans</i>	+			+		+	-	+			-		-	
	<i>C. rubrum</i>	+	+	-	-	+	+	+	+	+		+	-		
	<i>P. stricta</i>								+						
	<i>P. plumula</i>				+									-	
	<i>B. aspargoides</i>					+									
	<i>C. tomentosa</i>		+	-	-		+		-		+	+			
	<i>E. fasciculatus</i>	-	+		-		-	+	+	+	+	-	-	-	
	<i>C. flagelliformis</i>		+	-	-		+		-						
	<i>D. contorta</i>			-											
	<i>S. aeruginosa</i>		+	-	+			+		+					
	<i>D. viridis</i>	-		-	-	-				+		+	-	+	+
	<i>M. alata</i>		+	-											
	<i>S. pallida</i>								+	+		-			
	<i>P. parasitica</i>								+						
<i>U. lactuca</i>													-		
<i>L. clavellosa</i>					+			+		+	+			+	
Encrust. algae	<i>C. officinalis</i>		+			+	+	+	+	+				+	
	Brown encr. indet.	+			+	+	+	-	-	+	+		-	-	
	<i>C. pellita</i>										-	-			
	<i>P. extensum</i>							-					+	-	

Perennial red and green algae	<i>D. sanguinea</i>			+	+		+	-				-		-
	<i>P. rubens</i>			+	+		-	-			-	-		-
	<i>C. crispus</i>	+	+	-	-	+	-	+			+	+		+
	<i>P. palmata</i>		+				-				+			-
	<i>P. truncata</i>	+			+		-		-		-	-	+	-
	<i>P. pseudoceranooides</i>				+			-	-		+	+	-	-
	<i>D. carnosa</i>				+							-	-	-
	<i>B. byssoides</i>								+		-			
	<i>C. rupestris</i>					-			+			-		-
	<i>R. confervoides</i>		-	+		-		+	-		+	+		-
	<i>C. melagonium</i>						-	+	+					-
Perennial brown algae	<i>L. hyperborea</i>	-	-	+		-	-	-	+		-	-	-	
	<i>L. digitata</i>		-											
	<i>S. latissima</i>	+	-			-							-	
	<i>A. esculenta</i>		-											+
	<i>H. siliquosa</i>			-	-		+	+	-	+	+	+	-	
<i>D. acuelata</i>		+			-	-	+		+	-		-		
Macroinvertebrates	<i>A. rubens</i>	+		-		+					+	+	+	+
	<i>M. membranacea</i>	-		+		-							-	
	<i>E. pilosa</i>			+		-								
	<i>C. parallellogramma</i>		-		+									
	<i>P. triqueter</i>	+		+		+	+						-	-
	<i>M. edulis</i>	+	+	-										+
	<i>H. panicea</i>	-		-		+					+			+
	<i>B. balanoides</i>		+											
	<i>L. geniculata</i>	-		+		-	-				-			
	<i>C. eburnea</i>	-			+	-		+		-			-	
	<i>L. mulleri</i>	-				-		+						
	<i>L. longissima</i>	-				-		+	-				+	
	<i>C. parallellogramma</i>	-			+								+	-
	<i>A. digitatum</i>		-		+								+	
<i>D. grossilaria</i>		+												