

Influence of habitat condition on shallow rocky reef fish community structure around islands and headlands of a temperate marine protected area

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Table S1. Summary statistics for all fish species observed in mini-BRUVs stations deployed across 14 sites of the Port Stephens-Great Lakes Marine Park during autumn and spring 2016. Species in bold are those species contributing up to 70% dissimilarity from SIMPER. Rare species (highlighted in grey), which contributed 0.025% or less of the total MaxN abundance of all fish observed (7991) and appeared in only 1 or 2 sample stations, were excluded from the multivariate analyses. Note rare species had been observed across both island and headland sites (final column).

Fish species	Mean MaxN	SD	Sum of MaxN	No. stations with this species	Sample stations where rare species observed
<i>Atypichthys strigatus</i>	18.77	21.91	3154	122	
<i>Trachurus novaezelandiae</i>	3.92	10.70	659	52	
<i>Ophthalmolepis lineolatus</i>	3.29	2.57	552	151	
<i>Scorpius lineolata</i>	2.11	4.07	355	93	
<i>Notolabrus gymnogenis</i>	1.52	0.78	255	160	
<i>Gymnothorax prasinus</i>	1.50	1.22	252	126	
<i>Chromis hypsilepis</i>	1.17	5.63	196	33	
<i>Acanthopagrus australis</i>	1.04	3.32	175	54	
<i>Parupeneus spilurus</i>	0.88	1.79	147	76	
<i>Parma unifasciata</i>	0.86	1.47	144	62	
<i>Acanthistius ocellatus</i>	0.75	1.03	126	75	
<i>Chrysophrys auratus</i>	0.72	1.25	121	65	
<i>Pseudolabrus guentheri</i>	0.65	1.08	109	59	
<i>Parma microlepis</i>	0.61	0.76	102	79	
<i>Pelates sexlineatus</i>	0.58	3.75	98	10	
<i>Scorpaena jacksonesis</i>	0.52	0.70	87	69	
<i>Chironemus marmoratus</i>	0.45	0.90	76	47	
<i>Hypoplectrodes maccullochi</i>	0.45	0.74	75	56	
<i>Heterodontus portusjacksoni</i>	0.40	1.03	67	34	
<i>Coris picta</i>	0.38	0.93	63	31	
<i>Cheilodactylus fuscus</i>	0.37	0.58	62	55	
<i>Pictilabrus laticlavus</i>	0.37	0.63	62	51	
<i>Pseudocaranx dentex</i>	0.35	1.62	58	17	
<i>Rhabdosargus sarba</i>	0.35	0.88	58	33	
<i>Prionurus microlepidotus</i>	0.33	1.13	55	20	
<i>Dinolestes lewini</i>	0.30	1.53	50	17	
<i>Odax cyanomelas</i>	0.26	0.49	44	40	

<i>Brachaelurus waddi</i>	0.26	0.51	43	37
<i>Trygonorrhina fasciata</i>	0.26	0.62	43	29
<i>Meuschenia freycineti</i>	0.24	0.51	41	36
<i>Girella tricuspidata</i>	0.22	0.98	37	19
<i>Achoerodus viridis</i>	0.21	0.45	36	33
<i>Myliobatis australis</i>	0.19	0.46	32	28
<i>Austrolabrus maculatus</i>	0.18	0.51	30	24
<i>Upeneichthys lineatus</i>	0.18	0.41	30	28
<i>Microcanthus strigatus</i>	0.17	0.88	29	8
<i>Thalassoma lunare</i>	0.17	0.60	28	17
<i>Aplodactylus lophodon</i>	0.14	0.43	24	20
<i>Aulopus purpurissatus</i>	0.14	0.88	23	13
<i>Orectolobus maculatus</i>	0.14	0.45	23	19
<i>Monodactylus argenteus</i>	0.13	1.47	21	3
<i>Mecaenichthys immaculatus</i>	0.12	0.38	20	17
<i>Siganus nebulosus</i>	0.12	0.71	20	8
<i>Chaetodon guentheri</i>	0.10	0.39	17	12
<i>Eupetrichthys angustipes</i>	0.10	0.31	16	15
<i>Odax acroptilus</i>	0.08	0.29	13	12
<i>Pempheris affinis</i>	0.08	1.00	13	2
<i>Pseudolabrus luculentus</i>	0.08	0.38	13	9
<i>Meuschenia australis</i>	0.07	0.26	12	12
<i>Schuettea scalaripinnis</i>	0.07	0.93	12	2
<i>Enoplosus armatus</i>	0.07	0.25	11	11
<i>Meuschenia trachylepis</i>	0.07	0.27	11	10
<i>Acanthurus dussumieri</i>	0.05	0.48	9	4
<i>Anoplocapros inermis</i>	0.05	0.25	9	8
<i>Gymnothorax cribroris</i>	0.05	0.23	9	9
<i>Cheilodactylus vestitus</i>	0.05	0.21	8	8
<i>Eubalichthys bucephalus</i>	0.05	0.24	8	7
<i>Parupeneus multifasciatus</i>	0.05	0.21	8	8
<i>Pentapodus paradiseus</i>	0.05	0.39	8	3
<i>Trygonoptera testacea</i>	0.05	0.24	8	7
<i>Brachaluteres jacksonianus</i>	0.04	0.23	7	6
<i>Echeneis naucrates</i>	0.04	0.27	6	4
<i>Fistularia commersonii</i>	0.04	0.39	6	2
<i>Carcharhinus sp</i>	0.03	0.17	5	5
<i>Coris dorsomacula</i>	0.03	0.20	5	4
<i>Dicotylichthys punctulatus</i>	0.03	0.17	5	5
<i>Gymnothorax prionodon</i>	0.03	0.25	5	3
<i>Istigobius hoesei</i>	0.03	0.17	5	5
<i>Monacanthus chinensis</i>	0.03	0.17	5	5
<i>Pempheris multiradiata</i>	0.03	0.20	5	4
<i>Apogon limenus</i>	0.02	0.15	4	4
<i>Carcharias taurus</i>	0.02	0.15	4	4
<i>Thalassoma lutescens</i>	0.02	0.19	4	3
<i>Acanthaluteres vittiger</i>	0.02	0.13	3	3
<i>Argyrosomus hololepidotus</i>	0.02	0.13	3	3
<i>Centropogon australis</i>	0.02	0.13	3	3

<i>Meuschenia scaber</i>	0.02	0.13	3	3	
<i>Nemadactylus douglasii</i>	0.02	0.13	3	3	
<i>Pempheris compressa</i>	0.02	0.23	3	2	
<i>Pseudojuloides elongatus</i>	0.02	0.13	3	3	
<i>Suezichthys arquatus</i>	0.02	0.13	3	3	
<i>Cheilinus bimaculatus</i>	0.01	0.11	2	2	Dutchies Head 3, Fly Point 2
<i>Dasyatis brevicaudata</i>	0.01	0.11	2	2	Broughton Isl LG 6, North Rocks Isl 2
<i>Dasyatis kuhlii</i>	0.01	0.11	2	2	Fly Point 1 & 6
<i>Gerres subfasciatus</i>	0.01	0.11	2	2	Dutchies Head 4, Fly Point 4
<i>Halichoeres nebulosus</i>	0.01	0.11	2	2	Boulder Bay 5, Broughton Isl LG 1
<i>Lotella rhacina</i>	0.01	0.11	2	2	Boulder Bay 2, Cabbage Tree Isl N 3
<i>Macropharyngodon negrosensis</i>	0.01	0.15	2	1	Little Broughton Isl 3
<i>Meuschenia flavolineata</i>	0.01	0.11	2	2	Cabbage Tree Isl W 4, Broughton Isl LG 3
<i>Thalassoma janseni</i>	0.01	0.15	2	1	North Rocks 3
<i>Aptychotrema rostrata</i>	0.01	0.08	1	1	Cabbage Tree Isl W 3
<i>Chaetodon auriga</i>	0.01	0.08	1	1	Big Rocky Head 4
<i>Cheilio inermis</i>	0.01	0.08	1	1	Broughton Isl LG 1
<i>Chelmonops truncatus</i>	0.01	0.08	1	1	Fly Point 2
<i>Epinephelus daemeli</i>	0.01	0.08	1	1	Little Broughton Isl 3
<i>Kyphosus sydneyanus</i>	0.01	0.08	1	1	Fingal Head N 3
<i>Nelusetta ayraudi</i>	0.01	0.08	1	1	Broughton Isl CS 5
<i>Platycephalus fuscus</i>	0.01	0.08	1	1	Dutchies Head 1
<i>Pomacentrus coelestis</i>	0.01	0.08	1	1	Little Broughton Isl 5
<i>Scobinichthys granulatus</i>	0.01	0.08	1	1	Fly Point 6
<i>Seriola rivoliana</i>	0.01	0.08	1	1	North Rocks Isl 5
<i>Sillago ciliata</i>	0.01	0.08	1	1	Dutchies Head 3
<i>Stethojulis bandanensis</i>	0.01	0.08	1	1	Broughton LG 4
<i>Stethojulis interrupta</i>	0.01	0.08	1	1	Fingal Head N 3
<i>Tetractenos</i> sp.	0.01	0.08	1	1	Big Rocky Head 3
<i>Vincentia novaehollandiae</i>	0.01	0.08	1	1	Dutchies Head 3
Total			7991		

Table S2. Summary of PERMANOVA main test of reef fish community structure among zones (fixed: NTA and PPA), sampling seasons (random: autumn and spring), and sites (random: 14 sites nested within zones) within the Port Stephens-Great Lakes Marine Park, based on dispersion-weighted MaxN of abundant fish species (rare species excluded as per Table S1), arranged into a Modified Gower (base 2) resemblance matrix, with over 9600 permutations per term (except for the independent contrast of Geomorphology groups with 1268 unique permutations) for the full model with all terms included. An independent contrast of two groups of sites (islands vs headlands) was included to explore the influence of geomorphology within the significant terms involving the site factor. Significant terms ($p < 0.05$) are indicated in bold font. Note the very high p-value for the term zone, which had a negative component of variation estimate (square root -0.164) suggesting the need for pooling of this term in a re-run model (Anderson et al. 2008).

Source	SS	MS	df	Pseudo-F	P (perm)
Zone	1.569	1.569	1	0.538	0.986
Season	4.186	4.186	1	4.174	0.002
Site(Zone)	39.967	3.331	12	3.321	<0.001
Geomorphology(Zone)	6.317	3.159	2	3.511	0.087
Zone*Season	1.449	1.449	1	1.445	0.150
Site(Zone)*Season	12.034	1.003	12	1.912	<0.001
Geomorphology(Zone)*Season	1.799	0.900	2	1.227	0.136
Residual	73.449	0.525	140		
Total	132.51		167		

Table S3. Summary of PERMANOVA main test of effects for fixed factor of zone, random factor of sampling season, and random factor of site nested within zone for offshore sites only (i.e., excluding the two estuary headland sites of Dutchies Head and Fly Point), based on dispersion-weighted MaxN of abundant fish species (rare species excluded as per Table S1), arranged into a Modified Gower (base 2) resemblance matrix, with over 9700 permutations per term (except for the independent contrast of Geomorphology groups with 2465 or more unique permutations) for the (a) full model and with the (b) “zone” term pooled. An independent contrast of two groups of sites (islands vs headlands) was included to explore the influence of geomorphology within the significant site(zone) and interaction terms. Significant terms ($p < 0.05$) are indicated in bold font. Note the very high p-value for the term zone in (a), which had a negative component of variation estimate (square root -0.169) suggesting the need for pooling of this term in a re-run model (Anderson et al. 2008).

Source	SS	MS	df	Pseudo-F	P (perm)
(a) Full model					
Zone	1.851	1.851	1	0.587	0.954
Season	3.435	3.435	1	3.490	0.003
Site(Zone)	32.202	3.220	10	3.272	<0.001
Geomorphology(Zone)	5.655	2.828	2	3.206	0.081
Zone*Season	1.610	1.610	1	1.636	0.097
Site(Zone)*Season	9.842	0.984	10	1.644	<0.001
Geomorphology(Zone)*Season	1.764	0.882	2	1.126	0.259
Residual	71.855	0.599	120		
Total	120.74		143		
(b) “Zone” term pooled					
Season	3.435	3.435	1	3.490	0.002
Site(Zone)	32.202	3.220	10	3.272	<0.001
Geomorphology(Zone)	5.655	2.828	2	3.206	0.045
Zone*Season	1.610	1.610	1	1.636	0.090
Site(Zone)*Season	9.842	0.984	10	1.644	<0.001
Geomorphology(Zone)*Season	1.764	0.882	2	1.126	0.275
Pooled	73.706	0.609	121		
Total	120.74		143		

Table S4. Summary of PERMANOVA main test of effects for fixed factor of zone, random factor of sampling season, and random factor of site nested within zone for seven fishery target species, based on square root transformed data using Type III sum of squares and a maximum of 9999 permutations of resemblance matrix based on the modified Gower (base 2) dissimilarity resemblance matrix. Significant terms ($p < 0.05$) are indicated in bold font. The seven species (*Acanthopagrus australis*, *Cheilodactylus fuscus*, *Chrysophrys auratus*, *Notolabrus gymnogenis*, *Ophthalmolepis lineolatus*, *Rhabdosargus sarba* and *Scorpaena jacksoniensis*) are considered to be targeted by fishers based on commercial, recreational and compliance catch data.

Source	SS	MS	df	Pseudo-F	P (perm)
Season	1.974	1.974	1	3.116	0.0286
Zone	0.920	0.920	1	0.797	0.690
Site(Zone)	20.496	1.708	12	2.696	<0.001
Geomorphology(Zone)	1.948	0.974	2	1.863	0.136
Season*Zone	0.242	0.242	1	0.382	0.836
Season*Site(Zone)	7.602	0.633	12	2.624	<0.001
Season*Geomorphology(Zone)	1.045	0.522	2	1.419	0.158
Residual	33.795	0.241	140		
Total	65.049		167		