Habitat degradation alters trophic pathways but not food chain length on shallow Caribbean coral reefs

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Supplementary information

Supplementary tables

Supplementary Table S1. Summary of stable isotope information by reef. Mean ± SD $\delta^{15}N$ and $\delta^{13}C$ values (in parts per mil) of basal carbon sources and 48 species of consumers (invertebrates and fishes) on Limones and Bonanza reefs. Trophic position (TP) estimated for consumers according to Hussey et al.[1].

	Trophic		Limones Reef				Bonanza Reef			
Sources/species	**category**	**Reference**	**n**	**$\delta^{15}N$ ± SD**	**$\delta^{13}C$ ± SD**	**TP**	**n**	**$\delta^{15}N$ ± SD**	**$\delta^{13}C$ ± SD**	**TP**
Basal carbon sources										
Particulate organic matter (POM)			3	2.85 ± 0.17	-18.39 ± 0.49		3	2.80 ± 0.56	-13.12 ± 1.89	
Algal turf			9	1.40 ± 0.87	-15.83 ± 2.76		10	1.78 ± 0.65	-18.76 ± 3.01	
Epiphytes			5	2.09 ± 0.51	-14.62 ± 1.27		5	2.19 ± 0.19	-11.97 ± 1.08	
Amphiroa tribulus			5	2.57 ± 0.19	-16.43 ± 0.51		5	0.50 ± 0.35	-8.78 ± 0.58	
Caulerpa racemosa			5	1.01 ± 0.11	-18.37 ± 0.30		5	0.96 ± 0.26	-18.35 ± 1.30	
Dictyota cervicornis			5	0.56 ± 0.22	-16.64 ± 0.76		5	0.95 ± 0.12	-15.22 ± 0.32	
Halimeda tuna			5	1.32 ± 0.08	-18.74 ± 0.77		5	0.52 ± 0.16	-18.62 ± 0.71	
Consumers										
Invertebrates										
Barbatia domingensis (B)	Ov	2	5	3.72 ± 0.22	-16.15 ± 0.07	1.60	5	3.63 ± 0.20	-14.53 ± 0.10	1.66
Calcinus tibicen (C)	Ov	3, 15	5	4.30 ± 0.50	-14.89 ± 1.43	1.77	5	3.39 ± 0.20	-15.00 ± 0.76	1.59
Caribachlamys ornata (B)	Ov	2	5	3.48 ± 0.28	-14.56 ± 0.33	1.53	5	4.23 ± 0.29	-13.59 ± 0.24	1.84
Cerithium litteratum (G)	Hv	2	5	4.11 ± 0.20	-14.87 ± 0.56	1.72	5	4.37 ± 0.28	-15.73 ± 0.45	1.88
Columbella mercatoria (G)	Hv	2	5	3.77 ± 0.16	-15.36 ± 0.87	1.61	5	3.98 ± 0.22	-15.01 ± 1.80	1.77
Coralliophila erosa (G)	Ov	2	5	5.06 ± 0.72	-10.47 ± 0.54	1.99	5	3.85 ± 0.40	-12.32 ± 0.87	1.73
Ctenoides mitis (B)	Ov	2	5	4.35 ± 0.81	-14.27 ± 0.47	1.79	5	4.91 ± 0.63	-13.22 ± 0.83	2.04
Cyphoma gibbosum (G)	Cv	2	5	5.98 ± 0.19	-13.54 ± 0.47	2.26	5	6.69 ± 0.41	-13.67 ± 0.36	2.56

Diadema antillarum (U)	Hv	4	5	5.37 ± 0.41	-13.51 ± 0.59	2.08	5	5.68 ± 0.64	-13.04 ± 1.39	2.26
Echinometra viridis (U)	Hv	5	5	5.35 ± 0.31	-15.01 ± 0.42	2.08	5	5.76 ± 0.61	-15.57 ± 0.38	2.29
Echinometra lucunter (U)	Hv	6	5	4.71 ± 0.47	-14.12 ± 0.19	1.89	5	5.13 ± 0.27	-15.05 ± 0.81	2.10
Eucidaris tribuloides (U)	Cv	6	5	8.50 ± 0.34	-13.63 ± 0.10	3.01	5	8.91 ± 0.56	-14.27 ± 0.65	3.22
Eupolymnia sp. (A)	Ov	7	5	3.57 ± 0.43	-15.87 ± 1.09	1.55	5	2.83 ± 0.72	-15.76 ± 0.90	1.43
Hemitoma octoradiata (G)	Hv	2	4	4.09 ± 0.20	-15.28 ± 1.21	1.71	5	3.94 ± 0.26	-12.62 ± 1.66	1.75
Holothuria floridana (H)	Ov	8	5	4.30 ± 0.54	-13.56 ± 0.51	1.77	4	5.00 ± 0.85	-13.93 ± 0.57	2.07
Lima caribaea (B)	Ov	2	5	4.67 ± 0.46	-15.02 ± 0.41	1.88	5	4.76 ± 0.29	-13.87 ± 0.52	1.99
Lithopoma caelatum (G)	Hv	2	5	3.43 ± 0.42	-14.75 ± 0.92	1.52	5	3.53 ± 0.31	-16.07 ± 0.43	1.63
Lithopoma tectum (G)	Hv	2	5	3.41 ± 0.38	-13.88 ± 0.83	1.51	5	3.76 ± 0.47	-16.82 ± 0.52	1.70
Mithraculus coryphe (C)	Hv	9	5	4.40 ± 0.22	-13.60 ± 0.42	1.80	5	5.33 ± 0.38	-11.90 ± 1.01	2.16
Mithrax aculeatus (C)	Ov	17	5	5.91 ± 0.32	-14.45 ± 0.41	2.24	5	5.66 ± 0.48	-15.60 ± 0.18	2.26
Morula nodulosa (G)	Cv	2	5	7.98 ± 0.33	-13.25 ± 0.41	2.85	5	7.58 ± 0.35	-13.48 ± 0.27	2.82
Octopus briareus (Ce)	Cv	10	4	6.46 ± 0.36	-12.81 ± 0.90	2.41	5	5.69 ± 0.63	-13.42 ± 1.06	2.27
Ophiocoma echinata (O)	Cv	11	5	6.87 ± 0.28	-13.19 ± 0.56	2.53	5	6.48 ± 0.26	-15.28 ± 0.62	2.50
Ophiocoma wendtii (O)	Cv	11	5	7.48 ± 0.51	-13.68 ± 0.52	2.70	5	7.48 ± 0.66	-15.24 ± 0.26	2.79
Paguristes anomalus (E)	Ov	12	5	3.65 ± 0.26	-14.60 ± 0.43	1.58	5	3.85 ± 0.15	-14.93 ± 0.56	1.73
Paguristes puncticeps (E)	Ov	12	5	3.73 ± 0.21	-14.17 ± 0.68	1.60	5	3.68 ± 0.24	-14.98 ± 0.95	1.68
Paguristes tortugae (E)	Ov	12	4	3.42 ± 0.54	-15.71 ± 0.84	1.51	5	4.71 ± 0.36	-14.63 ± 0.20	1.98
Pagurus brevidactylus (E)	Ov	12	5	3.05 ± 0.51	-13.55 ± 0.72	1.40	4	3.36 ± 0.45	-13.65 ± 0.72	1.58
Panulirus argus (L)	Ov	13	5	5.30 ± 0.55	-12.05 ± 0.90	2.22	5	5.59 ± 0.42	-12.70 ± 1.10	2.33
Panulirus guttatus (L)	Ov	13	5	6.83 ± 0.27	-12.42 ± 0.41	2.51	5	6.97 ± 0.16	-13.15 ± 0.49	2.64
Teleophrys ruber (C)	Hv	9	5	4.83 ± 0.41	-13.90 ± 0.40	1.93	4	4.59 ± 0.22	-14.48 ± 0.69	1.95
Stenoplax purpurascens (P)	Ov	2	4	3.99 ± 0.25	-14.04 ± 1.03	1.68	5	3.65 ± 0.36	-14.84 ± 1.56	1.67
Fish										
Acanthurus coeruleus	Hv	14, 16	3	6.17 ± 0.46	-15.50 ± 0.35	2.32	3	6.08 ± 0.20	-18.28 ± 0.77	2.38
Batrachoides gilberti	Cv	16	3	8.29 ± 0.07	-14.21 ± 0.63	2.94	5	7.82 ± 0.47	-13.66 ± 0.65	2.89
Cephalopholis cruentata	Cv	14, 16	5	9.12 ± 0.26	-13.42 ± 0.25	3.19	3	8.74 ± 1.04	-12.72 ± 0.74	3.16

Chaetodon capistratus	Cv	14, 16	3	7.66 ± 0.31	-12.46 ± 0.14	2.76	5	8.59 ± 0.35	-12.29 ± 0.47	3.12
Haemulon carbonarium	Cv	14, 16	5	9.23 ± 0.30	-13.11 ± 0.32	3.22	4	9.22 ± 0.25	-13.54 ± 0.28	3.31
Haemulon sciurus	Cv	14, 16	5	9.03 ± 0.56	-13.16 ± 1.02	3.16	5	8.17 ± 0.24	-13.01 ± 0.53	3.00
Lutjanus apodus	Cv	14, 16	3	9.41 ± 0.25	-12.77 ± 0.49	3.27	3	9.12 ± 1.18	-13.27 ± 0.33	3.28
Lutjanus griseus	Cv	14, 16	4	9.28 ± 0.60	-11.58 ± 1.52	3.24	5	9.14 ± 0.15	-13.08 ± 0.39	3.28
Ocyurus chrysurus	Ov	14, 16	3	7.62 ± 0.46	-13.50 ± 0.45	2.75	3	8.65 ± 0.17	-13.83 ± 0.09	3.14
Pempheris schomburgkii	Cv	14, 16	4	9.17 ± 0.16	-15.52 ± 0.49	3.20	5	9.14 ± 0.39	-14.33 ± 0.53	3.28
Pomacanthus paru	Ov	14, 16	3	7.40 ± 0.44	-18.39 ± 0.52	2.68	3	7.10 ± 0.78	-20.70 ± 0.87	2.68
Sargocentron vexillarium	Cv	14, 16	5	8.70 ± 0.12	-12.72 ± 0.71	3.06	4	8.80 ± 0.54	-13.52 ± 0.96	3.18
Scarus iseri	Hv	16	5	6.79 ± 0.21	-15.13 ± 0.99	2.50	3	5.51 ± 0.93	-14.71 ± 0.96	2.21
Sparisoma aurofrenatum	Hv	14, 16	3	6.14 ± 0.14	-16.31 ± 0.92	2.31	4	5.97 ± 0.39	-16.57 ± 0.51	2.35
Sparisoma viride	Hv	14, 16	3	5.47 ± 0.20	-14.83 ± 0.62	2.11	4	5.26 ± 0.36	-16.26 ± 0.42	2.14
Stegastes diencaeus	Ov	16	5	8.30 ± 0.31	-13.98 ± 0.92	2.95	5	8.12 ± 0.43	-14.91 ± 0.88	2.98

A: annelid, B: bivalve, C: crab, Ce: cephalopod, E: hermit crab, G: gastropod, H: holothurian, O: ophiurid, L: lobster, P: polyplacophora, U: urchin, Hv: Herbivore, Ov: Omnivore, Cv: Carnivore.

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Supplementary Table S2. Stable isotopes comparisons between reefs. Results of Student's *t* test of the null hypothesis of no significant differences in the mean $\delta^{15}N$ and $\delta^{13}C$ of basal carbon sources and consumers between Limones and Bonanza reefs.

	$\delta^{15}N$			$\delta^{13}C$		
	t	**df**	**p**	***t***	**df**	**p**
Basal carbon sources						
POM	0.14	4	ns	-4.68	4	**
Algal turf	-1.08	17	ns	2.21	17	*
Epiphytes	-0.40	8	ns	-3.54	8	*
Amphiroa tribulus	11.72	8	***	-22.03	8	***
Caulerpa racemosa	0.41	8	ns	-0.03	8	ns
Dictyota cervicornis	-3.59	8	**	-3.88	8	**
Halimeda tuna	9.63	7	***	-0.26	8	ns
Consumers						
Invertebrates						
Barbatia domingensis	0.72	8	ns	-29.40	8	***
Calcinus tibicen	3.80	8	**	0.15	8	ns
Caribachlamys ornata	-4.15	8	**	-5.40	8	***
Cerithium litteratum	-1.70	8	ns	2.71	8	*
Columbella mercatoria	-1.77	8	ns	-0.39	8	ns
Coralliophila erosa	5.28	8	***	4.04	8	**
Ctenoides mitis	-1.21	8	ns	-2.49	8	*
Cyphoma gibbosum	-3.22	7	*	0.47	7	ns
Diadema antillarum	-0.92	8	ns	-0.70	8	ns
Echinometra viridis	-1.34	8	ns	2.21	8	ns
Eucidaris lucunter	-1.73	8	ns	2.49	8	*
Eucidaris tribuloides	-1.40	8	ns	2.19	8	ns
Eupolymnia sp.	1.97	8	ns	-0.18	8	ns
Hemitoma octoradiata	1.39	7	ns	-3.60	7	**
Holothuria floridana	-1.53	7	ns	1.02	7	ns
Lima caribaea	-0.39	8	ns	-3.86	8	**
Lithopoma caelatum	-0.40	8	ns	2.96	8	*
Lithopoma tectum	-1.28	8	ns	6.74	8	***
Mithraculus coryphe	-4.70	8	**	-3.45	8	**
Mithraculus ruber	1.04	7	ns	1.60	7	ns
Mithrax aculeatus	0.96	8	ns	5.72	8	***
Morula nodulosa	1.83	8	ns	1.03	8	ns
Octopus briareus	2.17	7	ns	0.90	7	ns
Ophiocoma echinata	2.29	8	ns	5.58	8	***
Ophiocoma wendtii	-0.01	8	ns	6.03	8	***
Paguristes anomalus	-1.47	8	ns	1.06	8	ns
Paguristes puncticeps	0.29	8	ns	1.55	8	ns

Paguristes tortugae	-4.36	7	**	-2.83	7	*
Pagurus brevidactylus	-0.97	7	ns	0.20	7	ns
Panulirus argus	-0.92	8	ns	0.64	8	ns
Panulirus guttatus	-1.03	8	ns	2.58	8	*
Stenoplax purpurascens	1.49	7	ns	1.52	7	ns
Fishes						
Acanthurus coeruleus	0.02	6	ns	1.71	6	ns
Batrachoides gilberti	2.72	2	ns	-1.03	2	ns
Cephalopholis cruentata	0.82	6	ns	-2.05	6	ns
Chaetodon capistratus	-3.51	4	*	-0.90	4	ns
Haemulon carbonarium	0.78	8	ns	1.09	8	ns
Haemulon sciurus	2.50	9	*	-0.56	9	ns
Lutjanus apodus	0.42	4	ns	1.49	4	ns
Lutjanus griseus	0.55	6	ns	1.76	6	ns
Ocyurus chrysurus	-4.01	5	*	1.26	5	ns
Pempheris schomburgkii	-0.39	6	ns	-4.29	6	**
Pomacanthus paru	-0.22	5	ns	-0.14	5	ns
Sargocentron vexillarium	-0.43	7	ns	1.45	7	ns
Scarus iseri	1.38	6	ns	0.02	6	ns
Sparisoma aurofrenatum	1.08	4	ns	0.66	4	ns
Sparisoma viride	-0.18	7	ns	3.38	7	*
Stegastes diencaeus	1.16	9	ns	1.50	9	ns

n.s. = not significant ($p > 0.05$); *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$