Supplementary Information

Table S1. Coral cover % and diversity on high-latitude reefs at locations above 26° N and below 26° S. Data are arranged in order of decreasing latitude.

Location and latitude	Latitude	Water depth (m)	Survey year	Mean coral cover (%)	Max. coral cover (%)	No. coral species	No. coral genera	Reference
Montague Island, eastern Australia	36.2°S	5–15	2014	42.0	80.0	1	–	Madin et al. 2015
Miyake-jima, eastern Japan	34°N	3–27	1979	17.6	36.8	80	36	Tribble & Randle, 1986
Tatsukushi, Shikoku Island, Japan	32.8°N	3–10	2011	60.0	–	73	40	Denis et al. 2013
Bermuda, USA	32.3°N	10	2001–2006	21.0	23.0	20	13	Jones, 2006
Minden Reef, southwest Australia	32.1° S	8–10	2013	6.0	–	16	12	Richards et al. 2016
Hall Bank, southwest Australia	32° S	13–15	2009	52.6	72.5	14	11	Thomson & Frisch 2010
Roe Reef, southwest Australia	32° S	10–25	2014	2.8	–	16	12	Richards et al. 2016
Kermadec Islands Marine Reserve, New Zealand	31°S	3–15	2004	5.3	18.0	16	16	Wicks et al. 2010
Amakusa, southwestern Japan	32°N	5	2001	28.3	–	54	30	Nozawa et al. 2008
Balls Pyramid, Western Pacific	31.8°S	30–40	2013	6.7	19.4	16	–	Linklater et al. 2016
Lord Howe Island, Western Pacific	31.6°S	<20	1992/93	29.9	50.6	83	33	Harriot et al. 1995
South West Rocks, eastern Australia	30.9°S	5–12	1997	15.2	42.6	5	5	Harriott et al. 1999
Solitary Islands, eastern Australia	30.3°S	5–9	1992	25.7	50.9	90	28	Harriot et al. 1994
Houtman Abrolhos Islands, Western Australia	28.9° S	<1	2018	21.7	–	184	42	Buckee et al. 2019
Houtman Abrolhos Islands, Western Australia	28.8° S	15–18	2010–2013	59.0	–	184	42	Bridge et al. 2014
Kure Atoll, Hawaiian Islands, USA	28.4°N	13	2008	13.1	28.0	9	5	Vroom & Braun, 2010
Flower Garden Banks, Gulf of Mexico	28.2°N	17–27	1989–2014	62.0	–	5	5	Johnston et al. 2016
Stetson Bank, Gulf of Mexico	28.2°N	<15	1993–2008	5.7	–	11	–	DeBose et al. 2012
Sodwana Bay, South Africa	27.4°S	15–20	1993–2006	26.9	58.3	93	21	Celliers and Schleyer 2008
Fort Lauderdale, Florida, USA	26.1°N	3–7	2001/02	14.3	28.0	17	11	Vargas-Angel et al. 2003

Table S2. Benthic survey methodology for each marine park.

Marine park	Jurien Bay marine park	Marmion Marine Park	Rottnest Island Marine Reserve	Shoalwater Islands Marine Park	Ngari Capes Marine Park	
Number of times surveyed	10 (1999-2016)	5 (2012-2019)	10 (2008-2017)	5 (2012-2019)	3 (2007-2018)	1 (2018)
Number of sites	43	8	26	8	20	10
Type of survey	50 m long transects: 0.25 x 0.25 m quadrats every 10 m	25 m long transects: ~0.5 x 0.5 m quadrats every 1 m	50 m long transects: ~0.5 x 0.5 m quadrats every 2.5 m	25 m long transects: ~0.5 x 0.5 m quadrats every 1 m	50 m long transects: 0.25 x 0.25 m quadrats every 10 m	Tow camera with 400 m long transects
Number of quadrats	5 quadrats per transect	25 photo quadrats per transect	20 photo quadrats per transect	25 photo quadrats per transect	5 quadrats per transect	120 photo quadrats per transect
Number of transects	4 transects	3 transects	2 – 3 transects	3 transects	4 transects	3 – 5 transects
Number of points	50 points per quadrat	6 points per photo-quadrat	5 points per photo-quadrat	6 points per photo-quadrat	50 points per quadrat	20 points per photo-quadrat
Analysis software	N/A (*in situ*)	EcoPAAS	Squiddle+	EcoPAAS	N/A (*in situ)*	Transect Measure

Table S3. Summary of sampling effort by Marine park, site and year with mean % cover of hard coral. A value of "0.00" denotes no coral detected and "-" denotes no survey completed.

Marine Park	Site	1999	2000	2003	2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Jurien Bay #denotes selective analyses	Australia Lump	0.00	0.20	0.00	0.00	0.00	-	-	-	-	-	-	0.10	-	-	0.50	-	-	-
	Big Wave Reef	-	-	-	-	0.00	-	-	-	-	-	-	0.10	-	-	3.30	-	-	-
	Cavanagh Reef	-	-	-	0.00	0.00	-	-	-	-	-	-	0.00	-	-	0.00	-	0.00	-
	Cavenagh Reef 2	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	-	0.00	-	-	0.40	-	-	-
	Escape Island#	0.00	0.00	0.00	0.00	0.10	-	-	-	-	-	0.20	0.00	-	-	0.00	-	0.00	-
	Fishermans Island#	0.67	0.50	0.50	2.90	7.10	-	-	6.10	-	-	2.80	3.60	-	-	4.60	-	1.60	-
	Fishermans Island 1#	0.70	11.20	6.50	0.10	10.53	-	-	6.30	-	-	5.60	8.90	-	-	15.60	-	5.60	-
	Fishermans Island 2#	7.47	11.80	7.10	3.50	18.00	-	-	8.00	-	-	23.50	32.70	-	-	22.20	-	32.10	-
	Flat Rock	0.70	0.00	0.00	0.00	0.00	-	-	0.00	-	-	-	0.00	-	-	0.20	-	-	-
	Flat Rock Reef	0.00	0.10	0.00	0.00	0.00	-	-	0.00	-	-	-	0.00	-	-	3.70	-	0.00	-
	Gazely Reef	0.00	0.00	0.00	0.00	0.00	-	-	0.10	-	-	-	0.00	-	-	0.00	-	0.00	-
	Inner Seaward Ledge#	0.00	0.00	0.00	0.00	0.00	-	-	0.50	-	-	0.00	2.20	-	-	0.00	-	0.00	-
	Inner Seven Foot Reef	0.40	0.00	0.00	0.00	0.30	-	-	-	-	-	-	0.00	-	-	0.00	-	0.00	-
	Inshore Boullanger Island	-	-	-	0.00	0.30	-	-	-	-	-	-	0.30	-	-	5.00	-	0.60	-
	Inshore Grey	-	-	-	0.00	0.00	-	-	-	-	-	-	0.00	-	-	0.00	-	0.00	-
	Inshore Grey North	-	-	-	0.00	0.00	-	-	-	-	-	-	0.20	-	-	0.00	-	0.00	-
	Juddy Reef#	0.00	0.00	0.10	0.00	0.00	-	-	-	-	-	0.20	0.10	-	-	0.90	-	0.00	-
	Kearn Reef	0.00	0.80	0.00	0.00	0.00	-	-	-	-	-	-	0.00	-	-	0.00	-	0.00	-
	Longman Reef (off Grey)	0.00	0.00	0.00	2.40	0.00	-	-	-	-	-	-	0.40	-	-	0.10	-	0.00	-
	Main Reef	-	-	-	-	0.50	-	-	-	-	-	-	0.50	-	-	2.50	-	1.90	-
	Middle Lumps#	1.10	1.10	0.10	0.10	0.00	-	-	-	-	-	0.00	2.10	-	-	1.00	-	0.00	-
	Midshore Boullanger Island	-	-	-	0.00	0.00	-	-	-	-	-	0.00	0.00	-	-	0.10	-	0.00	-
	Near Sandland Island	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	No Name Reef	0.40	0.00	0.00	0.00	0.60	-	-	9.50	-	-	-	0.10	-	-	0.00	-	0.00	-
	North Head 1#	0.00	0.00	0.00	0.00	0.00	-	-	-	-	-	0.50	0.00	-	-	0.00	-	1.40	-

	North Head Island	0.00	0.00	0.10	0.00	0.00	-	-	-	-	-	-	0.00	-	-	0.00	-	0.00	-
	North Lumps	0.50	1.10	0.00	0.50	0.40	-	-	-	-	-	2.50	1.10	-	-	0.10	-	-	-
	North Tail	0.00	0.00	0.10	0.00	0.60	-	-	-	-	-	-	0.00	-	-	1.80	-	0.00	-
	North Wedge	-	-	-	0.00	0.00	-	-	0.00	-	-	-	0.00	-	-	0.10	-	0.40	-
	Offshore Hill River	-	-	-	0.00	0.00	-	-	-	-	-	0.60	1.20	-	-	0.00	-	0.00	-
	Offshore Outer Gazaly Reef	-	-	-	-	0.00	-	-	0.00	-	-	-	0.20	-	-	0.00	-	0.00	-
	Offshore Outer Rocks	-	-	-	-	0.00	-	-	-	-	-	-	0.00	-	-	0.00	-	-	-
	Offshore Target Rocks	-	-	-	-	0.00	-	-	1.80	-	-	-	2.20	-	-	1.50	-	-	-
	Outer Green Islands	-	-	-	0.70	0.00	-	-	0.00	-	-	0.40	8.00	-	-	0.80	-	1.10	-
	Outer Rocks (North) 2#	0.00	0.00	3.50	0.00	0.00	-	-	0.50	-	-	0.00	0.00	-	-	0.00	-	7.10	-
	Outer Rocks, Inner Coffins	1.10	3.00	0.00	0.00	0.10	-	-	-	-	-	-	0.30	-	-	0.00	-	3.50	-
	Outer Seaward Ledge	-	-	-	3.10	0.10	-	-	-	-	-	0.30	0.20	-	-	0.70	-	0.00	-
	Outer Seven Foot Rocks	-	-	-	0.00	0.00	-	-	-	-	-	-	0.00	-	-	0.00	-	0.00	-
	Sams Reef	0.00	0.00	2.30	0.00	1.00	-	-	0.00	-	-	-	0.10	-	-	0.00	-	0.00	-
	Sandland Island#	0.20	0.50	0.00	0.00	0.10	-	-	-	-	-	0.40	0.00	-	-	0.10	-	0.00	-
	Sandy Cape#	0.00	0.00	0.00	1.00	0.00	-	-	-	-	-	0.00	0.00	-	-	0.00	-	0.00	-
	South East Green Island	-	-	-	0.00	0.00	-	-	0.00	-	-	-	0.00	-	-	0.30	-	0.20	-
	Wedge Island	-	-	-	1.50	0.30	-	-	0.80	-	-	-	0.10	-	-	3.50	-	-	-
	Jurien Bay mean	**0.46**	**1.21**	**0.78**	**0.43**	**0.90**	**-**	**-**	**2.10**	**-**	**-**	**2.34**	**1.54**	**-**	**-**	**1.65**	**-**	**1.63**	**-**
Marmion Marine Park	Burns Rocks	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-	-	-	-	0.00
	Burns Rocks Offshore	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	0.37	-	-	-	0.00
	Little Island	-	-	-	-	-	-	-	-	-	-	0.00	1.16	-	0.00	-	-	-	0.00
	The Lumps	-	-	-	-	-	-	-	-	-	-	1.71	0.00	1.11	-	-	-	-	0.00
	Three Mile Reef Inner	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	0.00	-	-	-	0.00
	Three Mile Reef Outer	-	-	-	-	-	-	-	-	-	-	0.00	0.89	-	1.18	-	-	-	0.66
	Watermans	-	-	-	-	-	-	-	-	-	-	0.00	0.22	-	0.00	-	-	-	0.00
	Watermans Outer	-	-	-	-	-	-	-	-	-	-	0.00	0.25	-	0.00	-	-	-	0.64
	Marmion Marine Park mean	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.21**	**0.34**	**0.56**	**0.26**	**-**	**-**	**-**	**0.16**
Rottnest Island	Armstrong Bay#	-	-	-	-	-	-	-	-	0.17	0.00	0.00	1.50	2.50	0.00	-	4.00	-	-

	Collindar	-	-	-	-	-	-	7.00	-	-	-	-	-	-	-	-	-	-	-
	Crystal palace#	-	-	-	-	-	-	1.00	2.33	4.50	-	-	2.00	0.00	0.00	4.67	2.50	-	-
	Duck Rock South	-	-	-	-	-	-	-	-	0.00	-	0.00	-	0.00	-	-	0.00	-	-
	Dyer Island	-	-	-	-	-	-	0.00	-	0.00	-	-	-	-	-	0.50	1.00	-	-
	Eagle Bay	-	-	-	-	-	-	-	0.33	0.00	-	0.00	-	-	0.00	-	0.00	-	-
	Fish Hook Bay	-	-	-	-	-	-	-	0.00	0.33	0.00	0.00	-	-	-	0.00	0.00	-	-
	Green Island Reserve 1#	-	-	-	-	-	-	0.50	0.00	0.33	0.00	0.00	0.00	0.00	-	0.67	0.00	-	-
	Green Island Wall	-	-	-	-	-	-	0.00	1.00	1.00	-	0.00	-	-	-	-	-	-	-
	Jackson Rocks#	-	-	-	-	-	-	0.00	5.00	0.00	-	2.00	0.50	3.50	1.00	-	1.00	-	-
	Kingston Reef	-	-	-	-	-	-	-	-	0.00	-	3.00	3.00	4.33	0.00	0.00	2.00	-	-
	Lionfishcave - Rottnest	-	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-
	Little Salmon Bay Rottnest	-	-	-	-	-	-	18.00	-	-	-	-	-	-	-	-	-	-	-
	Mini Swirl Stragglers	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-
	Parakeet	-	-	-	-	-	-	-	-	1.50	-	-	-	-	-	-	0.00	-	-
	Parakete Bay North	-	-	-	-	-	-	-	-	2.00	-	-	-	-	-	-	-	-	-
	Parker Point	-	-	-	-	-	-	0.33	-	-	-	-	-	0.50	0.00	0.00	0.00	-	-
	Pocillopora Reef#	-	-	-	-	-	-	9.00	7.33	2.67	-	-	2.50	6.00	-	0.00	1.67	-	-
	Roe Reef#	-	-	-	-	-	-	4.00	1.00	1.00	0.00	0.00	0.00	0.50	-	0.00	0.50	-	-
	Salmon Bay	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	0.00	0.00	-	-
	Swirl Reef Rottnest	-	-	-	-	-	-	-	-	-	-	1.00	-	-	1.00	-	-	-	-
	The Basin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.67	-	-
	The Count#	-	-	-	-	-	-	0.00	6.67	3.00	-	0.00	1.00	0.00	-	0.33	0.00	-	-
	The Grottos Rottnest	-	-	-	-	-	-	-	0.00	-	0.00	0.00	-	-	-	-	0.00	-	-
	West End Rottnest	-	-	-	-	-	-	-	-	-	-	0.00	-	-	-	-	7.50	-	-
	Rottnest Island mean	**-**	**-**	**-**	**-**	**-**	**-**	**1.95**	**2.19**	**0.89**	**0.00**	**0.36**	**1.36**	**2.25**	**0.29**	**0.78**	**1.00**	**-**	**-**
Shoalwater Marine Park	Becher Point	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	0.00	-	-	-	0.00
	Bird Island	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.40	-	-	-	-	0.00
	John Point	-	-	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-	-	-	-	0.00
	Penguin Island	-	-	-	-	-	-	-	-	-	-	0.00	0.21	-	-	-	-	-	0.00

	Peron North	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-	-	-	0.00
	Seal Island	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-	-	-	0.00
	Second Rock	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	-	-	-	-	0.00
	Sisters	-	-	-	-	-	-	-	-	-	-	0.00	0.00	-	0.00	-	-	-	0.00
	Shoalwater Marine Park mean	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.00**	**0.03**	**0.20**	**0.00**	**-**	**-**	**-**	**0.00**
Ngari Capes Marine Park * denotes deeper tow-camera sites	Bunker Bay (WA)	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Bunkers Offshore	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-	0.00	-
	Canal Rocks	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	-	-
	Cape Clairault	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	-	-
	Cape Clairault North East	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	-	-
	Cape Freycinet*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	-
	Cape Freycinet	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cape Freycinet Inshore	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.40	-
	Cape Leeuwin	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cape Leeuwin Inshore	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cape Nat Reef*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.88	-
	Cape Naturalist East, 10m	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cape Naturalist East, 5m	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cape Naturalist Island, Bommie	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	0.00	0.00	-
	Cape Naturalist North East	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cape Naturalist West	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cosy Corner	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.60	1.30	5.20	-
	Cosy Corner North	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cosy Corner Outer	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Cowaramup*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-
	Ellensbrook*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-
	Hamelin Bay*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00	-
	Isaacs Reef*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.62	-
	Prevelly	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-

	Seal Isle West	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00	-
	Smiths*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-
	Willyabrup*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	-
	Wright Bank*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.81	-
	Wyadup	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	0.00	0.00	-	-
	Ngari Capes Marine Park mean	**-**	**-**	**-**	**-**	**-**	**0.00**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.03**	**0.07**	**0.53**	**-**

Table S4. Mean % cover and 95% confidence intervals of hard-coral genera in 5 marine parks in south-western Australia. Transect replicates comprised of a series of *in situ* or photo-derived quadrats were used to derive percent cover from point-occurrences. A suite of sites were surveyed intermittently ranging across a temporal period from 1 to 22 years.

	Acropora		Dipsastraea		Favites		Paragoniastrea	
	% cover	95%CI	% cover	95%CI	% cover	95%CI	% cover	95%CI
Jurien Bay	-	-	0.12	0.053	-	-	0.018	0.019
Marmion Marine Park	-	-	0.084	0.080	0.035	0.039	0.094	0.12
Ngari Capes Marine Park	-	-	-	-	0.0030	0.0028	0.00052	0.00083
Rottnest Island	0.0041	0.0081	0.14	0.12	0.062	0.051	0.066	0.067
Shoalwater Marine Park	-	-	-	-	-	-	-	-

Table S4 cont.

	Coscinaraea		Montipora		Plesiastrea		Pocillopora		Porites	
	% cover	95%CI	% cover	95%CI	% cover	95%CI	% cover	95%CI	% cover	95%CI
Jurien Bay	-	-	0.28	0.13	0.03	0.013	0.063	0.028	-	-
Marmion Marine Park	-	-	-	-	-	-	0.013639	0.026	0.007092	0.0139
Ngari Capes Marine Park	0.0049	0.0038	0.0031	0.0043	0.0024	0.0047	-	-	-	-
Rottnest Island	0.020	0.021	0.30	0.11	0.0041	0.0081	0.36	0.24	0.020	0.040
Shoalwater Marine Park	-	-	-	-	-	-	-	-	-	-

Table S4 cont.

	Poritidae (only Alveopora or Goniopora)		Tubastraea		Turbinaria		Unidentified Hard coral		Total coral % cover per transect	
	% cover	95%CI	% cover	95%CI	% cover	95%CI	% cover	95%CI	% cover	95%CI
Jurien Bay	0.00033	0.00065	-	-	0.28	0.17	0.43	0.16	1.2	0.30
Marmion Marine Park	-	-	-	-	-	-	0.028	0.042	0.26	0.17
Ngari Capes Marine Park	-	-	-	-	0.15	0.13	0.024	0.023	0.19	0.14
Rottnest Island	0.058	0.034	0.033	0.041	0.079	0.066	0.025	0.023	1.2	0.37
Shoalwater Marine Park	-	-	-	-	-	-	0.022	0.031	0.022	0.031

References

Abdo D, Bellchambers LM, Evans SN (2012) Turning up the heat: increasing temperature and coral bleaching at the high latitude coral reefs of the Houtman Abrolhos Islands. PLoS One 7:e43878

Anderson MJ, Gorley RN, Clarke KR (2008) PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. [PRIMER-E]. Plymouth Marine Laboratory

Baird AH, Sommer B, Madin JS (2012) Pole-ward range expansion of Acropora spp. along the east coast of Australia. Coral Reefs 31:1063–1063

Bennett S, Wernberg T, Harvey ES, Santana-Garcon J, Saunders BJ (2015) Tropical herbivores provide resilience to a climate- mediated phase shift on temperate reefs. Ecol Lett 18:714–723

Benthuysen J, Feng M, Zhong L (2014) Spatial patterns of warming off Western Australia during the 2011 Ningaloo Niño: Quantifying impacts of remote and local forcing. Cont Shelf Res 91:232–246

Black R, Prince J (1983) Fauna associated with the coral *Pocillopora damicornis* at the Southern limit of its distribution in Western Australia. *Journal of Biogeography* 10:135–152

Bridge TCL, Ferrari R, Bryson M, Hovey R, Figueira WF, Williams SB, Pizarro O, Harborne AR, Byrne M (2014) Variable responses of benthic communities to anomalously warm sea temperatures on a high-latitude coral reef. PLoS One 9:1–20

Brock R, English E, Kenchington E, Tasker M (2009) The alphabet soup that protects cold-water corals in the North Atlantic. Mar Ecol Prog Ser 397, 355–360. https://doi.org/10.3354/meps08303

Burnham, KP, David RA (2002) Model Selection and Multimodel Inference: A Practical Information-Theoretical Approach. 2d ed. New York: Springer-Verlag.

Burton EA, Walter LM (1987) Relative precipitation rates of aragonite and Mg calcite from seawater: Temperature or carbonate ion control? Geology 15:111

Caputi N, Fletcher W, Pearce A, Chubb C (1996) Effect of the Leeuwin Current on the recruitment of fish and invertebrates along the Western Australian coast. Mar Freshw Res 47:147–155

Celliers L, Schleyer MH (2002) Coral bleaching on high-latitude marginal reefs at Sodwana Bay, South Africa. Mar Pollut Bull 44:1380–1387

Cheung WWL, Meeuwig JJ, Feng M, Harvey ES, Lam VWY, Langlois T, Slawinski D, Sun C, Pauly D (2012) Climate-change induced tropicalisation of marine communities in Western Australia. Mar Freshw Res 63:415

Clarke KR, & Gorley RN (2015) Getting started with PRIMER v7 [PRIMER-E]. Plymouth Marine Laboratory

Clarke KR, Gorley RN, Somerfield P, Warwick R (2014) Change in Marine Communities: An Apporach to Statistical Analysis and Interpretation (3rd Edition). PRIMER-E Ltd.

Clarke KR, Green RH (1988) Statistical design and analysis for a'biological effects' study. Marine Ecology Progress Series, 46, 213–226

Coles SL, Jokiel PL (1977) Effects of temperature on photosynthesis and respiration in hermatypic corals. Mar Biol 43:209–216

Coles SL, Lewis CR (1976) Thermal tolerance in tropical versus subtropical Pacific reef corals. Pac Sci 30:159–166

Cook C, Logan A, Ward J, Luckhurst B, Berg Jr C (1990) Elevated temperatures and bleaching on a high latitude coral reef: the 1988 Bermuda event. Coral Reefs 9:45–49

Couce E, Ridgwell A, Hendy EJ (2013) Future habitat suitability for coral reef ecosystems under global warming and ocean acidification. Glob Chang Biol 19:3592–3606

Cresswell G, Golding TJ (1980) Observations of a south-flowing current in the southeastern Indian Ocean. Deep Res 27A:449–466

Cure K, Hobbs JA, Harvey ES (2014) High recruitment associated with increased sea temperatures towards the southern range edge of a Western Australian endemic reef fish *Choerodon rubescens* (family Labridae) Env Biol Fish

Day PB, Stuart-Smith RD, Edgar GJ, Bates AE (2018) Species' thermal ranges predict changes in reef fish community structure during 8 years of extreme temperature variation. Divers Distrib 24:1036–1046

DeBose JL, Nuttall MF, Hickerson EL, Schmahl GP (2012) A high-latitude coral community with an uncertain future: Stetson Bank, northwestern Gulf of Mexico. Coral Reefs 32:255–267

DEC (2013) Ngari Capes Marine Park Management Plan 74 2013–2023.

Denis V, Mezaki T, Tanaka K, Kuo C, De Palmas S, Keshavmurthy S, Chen C (2013) Coverage, diversity, and functionality of a high-latitude coral community (Tatsukushi, Shikoku Island, Japan). PLoS One 8:e54330

Edgar GJ, Cooper A, Baker SC, Barker W, Barrett NS, Becerro MA, Bates AE, Brock D, Ceccarelli DM, Clausius E, Davey M, Davis TR, Day PB, Green A, Griffiths SR, Hicks J, Hinojosa IA, Jones BK, Kininmonth S, Larkin MF, Lazzari N, Lefcheck JS, Ling SD, Mooney P, Oh E, Pérez-Matus A, Pocklington JB, Riera R, Sanabria-Fernandez JA, Seroussi Y, Shaw I, Shields D, Shields J, Smith M, Soler GA, Stuart-Smith J, Turnbull J, Stuart-Smith RD (2020) Reef Life Survey: Establishing the ecological basis for conservation of shallow marine life. Biol Conserv 252:

Figueira WF, Booth DJ (2010) Increasing ocean temperatures allow tropical fishes to survive overwinter in temperate waters. Glob Chang Biol 16:506–516

Fowler AM, Parkinson K, Booth DJ (2018) New poleward observations of 30 tropical reef fishes in temperate southeastern Australia. Mar Biodivers 48:2249–2254

Gattuso J-P, Allemand D, Frankignoulle M (1999) Photosynthesis and calcification at cellular, organismal and community levels in coral reefs: a review on Interactions and control by carbonate chemistry. Am Zool 39:160–183

Gilmour J, Speed CW, Babcock R (2016) Coral reproduction in Western Australia. PeerJ 4:e2010. DOI 10.7717/peerj.2010

Goffredo S, Caroselli E, Mattioli G, Pignotti E, Dubinsky Z, Zaccanti F (2009) Inferred level of calcification decreases along an increasing temperature gradient in a Mediterranean endemic coral. Limnol Oceanogr 54:930–937

Greenstein B, Pandolfi JM (2008) Escaping the heat: range shifts of reef coral taxa in coastal Western Australia. Glob Chang Biol 14:513–528

Grigg R (1982) Darwin Point: a threshold for atoll formation. Coral Reefs 1:29–34

Harriott V, Banks S (2002) Latitudinal variation in coral communities in eastern Australia : a qualitative biophysical model of factors regulating coral reefs. Coral Reefs 21:83–94

Harrison PL, Dalton SJ, Carroll AG (2011) Extensive coral bleaching on the world's southernmost coral reef at Lord Howe Island, Australia. Coral Reefs 30:775–775

Hatcher BG (1991) Coral reefs in the Leeuwin Current -- an ecological perspective. Journal of the Royal Society of Western Australia 74:115-127.

van Hooidonk R, Maynard JA, Manzello D, Planes S (2014) Opposite latitudinal gradients in projected ocean acidification and bleaching impacts on coral reefs. Glob Chang Biol 20:103–12

Hutchins J, Pearce A (1994) Influence of the leeuwin current on recruitment of tropical reef fishes at Rottnest

Island, Western Australia. Bull Mar Sci 54:245–255

Huvenne, V.A.I., Bett, B.J., Masson, D.G., Le Bas, T.P., Wheeler, A.J., 2016. Effectiveness of a deep-sea cold-water coral Marine Protected Area, following eight years of fisheries closure. Biol. Conserv. 200, 60–69. https://doi.org/10.1016/j.biocon.2016.05.030

IPCC (2019) IPCC, 2019: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.

Johannes RE, Wiebe WJ, Crossland CJ, Rimmerl DW, Smith SV (1983) Latitudinal limits of coral reef growth. Mar Ecol Prog Ser 11:105–111

Kendrick A, Wilson S, Friedman K, Waples K, Whiting S, Holmes T, Rule M, Halford A, Quartermaine T, Bobojcov A, McCarthy A, Stevens D, Marshall R, Barnes P, Holley D, Jennings P, Evans M, Dasey M, Ossinger S, Holmes J (2016) Strategic marine ecological research priorities for CALM act marine parks and reserves 2016–2021. Conserv Sci West Aust 10:

Kleypas JA, McManus J, Menez L (1999) Environmental limits to coral reef development: Where do we draw the line? Am Zool 39:146–159

Lenanton RCJ, Dowling CE, Smith KA, Fairclough D V., Jackson G (2017) Potential influence of a marine heatwave on range extensions of tropical fishes in the eastern Indian Ocean—Invaluable contributions from amateur observers. Reg Stud Mar Sci 13:19–31

Le Nohaïc M, Ross CL, Cornwall CE, Comeau S, Lowe R, McCulloch MT, Schoepf V (2017) Marine heatwave causes unprecedented regional mass bleaching of thermally resistant corals in northwestern Australia. Sci Rep 7: 14999:

Lenth RV (2021) emmeans: Estimated Marginal Means, aka Least-Squares Means. https://CRAN.R-project.org/package=emmeans

Lin X, Zhang D (1999) Inference in generalized additive mixed models by using smoothing splines. J R Stat Soc Ser B Stat Methodol 61:381–400

Lough JM, Barnes DJ (2000) Environmental controls on growth of the massive coral Porites. J Exp Mar Biol Ecol 245:225–243

Madin J, Allen A, Baird A, Pandolfi J, Sommer B (2016) Scope for latitudinal extension of reef corals is species specific. Front Biogeogr 8.1:e29328

Markey KL, Abdo DA, Evans SN, Bosserelle C (2016) Keeping it local: Dispersal limitations of coral larvae to the high latitude coral reefs of the Houtman Abrolhos Islands. PLoS One 11:1–12

Marsh LM (1992) The occurrence and growth of *Acropora* in extra-tropical waters off Perth, Western Australia. Proc 7th Int Coral Reef Symp, Guam 2:1233–1238

Miller MW (1995) Growth of a temperate coral: effects of temperature, light, depth, and heterotrophy. Mar Ecol Prog Ser 122:217–225

Miller MW, Hay ME (1996) Coral–seaweed–grazer–nutrient interac- tions on temperate reefs. Ecol Monogr 66:323–344

Mizerek TL, Baird AH, Beaumont LJ, Madin JS (2016) Environmental tolerance governs the presence of reef corals at latitudes beyond reef growth. Glob Ecol Biogeogr

Moore JAY, Bellchambers LM, Depczynski MR, Evans RD, Evans SN, Field SN, Friedman KJ, Gilmour JP, Holmes TH, Middlebrook R, Radford BT, Ridgway T, Shedrawi G, Taylor H, Thomson DP, Wilson SK (2012) Unprecedented mass bleaching and loss of coral across 12 ° of latitude in Western Australia in 2010-11. PLoS One. e51807. 1-11.

Morgan KM, Perry CT, Smithers SG, Johnson JA, Daniell JJ (2016) Evidence of extensive reef development and

high coral cover in nearshore environments: Implications for understanding coral adaptation in turbid settings. Sci Rep 6:1–10

Muir PR, Wallace CC, Done T, Aguirre JD (2015) Limited scope for latitudinal extension of reef corals. Science (80-) 348:1135–1138

Mulders Y, Wernberg T (2020) Fifteen years in a global warming hotspot: changes in subtidal mobile invertebrate communities. Mar Ecol Prog Ser 656:227–238

NOAA Coral ReefWatch (2021) NOAA coral reefwatch daily global 5-km satellite coral bleaching degree heating week product. Available at https://coralreefwatch.noaa.gov/product/5km/index_ 5km_sst.php.

Orth RJ, Carruthers TJB, Dennison WC, Duarte CM, Fourqurean JW, Heck KL, Hughes AR, Kendrick GA, Kenworthy WJ, Olyarnik S, Short FT, Waycott M, Williams SL (2006) A global crisis for seagrass ecosystems. Bioscience 56:987–996

Pearce A, Lenanton R, Jackson G, Moore J, Feng M, Gaughan D (2011) The "marine heat wave" off Western Australia during the summer of 2010/11 Fisheries research report no. 222.

Pearce A, Hutchins B, Hoschke A, Fearns P (2016) Record high damselfish recruitment at Rottnest Island, Western Australia, and the potential for climate-induced range extension. Reg Stud Mar Sci 8:77–88

Pearse V, Muscatine L (1971) Role of symbiotic algae (zooxanthellae) in coral calcification. Biol Bull 141:350–363

Precht W, Aronson RB (2004) Climate flickers and range shifts of reef corals. Front Ecol Environ 2:307–314

Richards Z, Kirkendale L, Moore G, Hosie A, Huisman J, Bryce M, Marsh L, Bryce C, Hara A, Wilson N, Morrison S, Gomez O, Ritchie J, Whisson C, Allen M, Betterridge L, Wood C, Morrison H, Salotti M, Hansen G, Slack-Smith S, Fromont J (2016) Marine biodiversity in temperate Western Australia: Multi-taxon surveys of minden and Roe Reefs. Diversity 8:1–25

Ross CL, Falter JL, Schoepf V, McCulloch MT (2015) Perennial growth of hermatypic corals at Rottnest Island, Western Australia (32°S). PeerJ 3:e781

Ross CL, Schoepf V, DeCarlo TM, McCulloch MT (2018) Mechanisms and seasonal drivers of calcification in the temperate coral *Turbinaria reniformis* at its latitudinal limits. Proc R Soc B 285: 20180:

Smale DA, Wernberg T (2013) Extreme climatic event drives range contraction of a habitat-forming species. Proc R Soc B 280:20122829

Strydom S, Murray K, Wilson S, Huntley B, Rule M, Heithaus M, Bessey C, Kendrick GA, Burkholder D, Fraser MW, Zdunic K (2020) Too hot to handle: Unprecedented seagrass death driven by marine heatwave in a World Heritage Area. Glob Chang Biol 26:3525–3538

Stirling C, Esat T, McCulloch MT, Lambeck K (1995) High-precision U-series dating of corals from Western Australia and implications for the timing and duration of the Last Interglacial. Earth Planet Sci Lett 135:115–130

Szabo B (1979) Uranium-series age of coral reef growth on Rottnest Island, Western Australia. Mar Geol 29:M11–M15

Thomas L, Kennington WJ, Evans RD, Kendrick GA, Stat M (2017) Restricted gene flow and local adaptation highlight the vulnerability of high-latitude reefs to rapid environmental change. Glob Chang Biol 23:2197–2205

Thomson D (2010) Range extension of the hard coral *Goniopora norfolkensis* (veron & pichon 1982) to the south-east Indian Ocean. J R Soc West Aust 93:115–117

Thomson DP, Bearham D, Graham F, Eagle J (2011) High latitude, deeper water coral bleaching at Rottnest Island, Western Australia. Coral Reefs 30:775–775

Thomson DP, Frisch A (2010) Extraordinarily high coral cover on a nearshore, high-latitude reef in south-west Australia. Coral Reefs 29:923–927

Tribble G, Randall R (1986) A description of the high-latitude shallow water coral communities of Miyake-jima, Japan. Coral Reefs 4:151–159

Tuckett CA, de Bettignies T, Fromont J, Wernberg T (2017) Expansion of corals on temperate reefs: direct and indirect effects of marine heatwaves. Coral Reefs 1–10

Tuckett CA, Wernberg T (2018) High latitude corals tolerate severe cold spell. Front Mar Sci 5:1–6

Tweedie, M. C. K. (1984). An index which distinguishes between some important exponential families. Statistics: Applications and New Directions. Proceedings of the Indian Statistical Institute Golden Jubilee International Conference (Eds. J. K. Ghosh and J. Roy), pp. 579-604. Calcutta:Indian Statistical Institute

Vergés A, McCosker E, Mayer-Pinto M, Coleman MA, Wernberg T, Ainsworth T, Steinberg PD (2019) Tropicalisation of temperate reefs: Implications for ecosystem functions and management actions. Funct Ecol 33:1000–1013

Vergés A, Steinberg PD, Hay ME, Poore AGB, Campbell AH, Ballesteros E, Heck KL, Booth DJ, Coleman MA, Feary DA, Figueira W, Langlois T, Marzinelli EM, Mizerek T, Mumby PJ, Nakamura Y, Roughan M, van Sebille E, Gupta A Sen, Smale DA, Tomas F, Wernberg T, Wilson SK (2014) The tropicalization of temperate marine ecosystems: Climate-mediated changes in herbivory and community phase shifts. Proc R Soc B Biol Sci 281:

Veron J (1986) Corals of Australia and the Indo-Pacific. Angus and Robertson Publishers, North Ryde, Australia

Veron J, Marsh L (1988) Hermatypic corals of Western Australia. Records and annotated species list. Rec West Aust Museum 1–136

Veron JEN (1995) Corals in space and time: the biogeography and evolution of the Scleractinia. Cornell Univ. Press, Ithaca, London, pp 1-321

Veron JEN (2000) Corals of the world. Australian Institute of Marine Science, Townsville, Australia

Ward S (1995) The effect of damage on the growth, reproduction and storage of lipids in the scleractinian coral *Pocillopora damicornis* (Linnaeus). J Exp Mar Bio Ecol 187:193–206

Wernberg T, Bennett S, Babcock RC, Bettignies T De, Cure K, Depczynski M, Dufois F, Fromont J, Fulton CJ, Hovey RK, Harvey ES, Holmes TH, Kendrick GA, Radford B, Santana-garcon J, Saunders BJ, Smale DA, Thomsen MS, Tuckett CA, Tuya F (2016) Climate-driven regime shift of a temperate marine ecosystem. Science (80-) 353:169–172

Wernberg T, Russell BD, Thomsen MS, Gurgel CFD, Bradshaw CJA, Poloczanska ES, Connell SD (2011) Seaweed communities in retreat from ocean warming. Curr Biol 21:1828–32

Wilson SK, Kendrick A, Wilson B (2019) The North-Western margin of Australia in World Seas: an Environmental Evaluation, Chapter 14, 303-331.

Wood SN (2011) Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. Journal of the Royal Statistical Society (B), 73(1), 3–36

Wood SN (2017) Generalized Additive Models: An Introduction with R (2nd ed.). Chapman and Hall/CRC

Wyrwoll K, Greenstein B, Kendrick G, Chen G (2009) The palaeoceanography of the Leeuwin Current: implications for a future world. J Royal Soc WA 92:37–51

Yamano H, Sugihara K, Nomura K (2011) Rapid poleward range expansion of tropical reef corals in response to rising sea surface temperatures. Geophys Res Lett 38:1–6