

The following supplement accompanies the article

Distributions of Indo-Pacific lionfishes *Pterois* spp. in their native ranges: implications for the Atlantic invasion

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Supplemental Material

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Table S1. *Pterois* spp. Characteristics of underwater visual reef-fish surveys used in the present study. Size = length $\times$ width of transects in m $\times$ number of sides counted (noted only if both sides are counted); Spec. = protocol specifically designed to census lionfish; Non-Spec.= protocol not specifically designed to census lionfish. NA: not available

Country or region	Island	No. transects	Size	Area (m ²)	No. fish observed	<i>Pterois</i>	UVC-type	Primary observers	Reference for method
PACIFIC OCEAN									
Fiji	Lakeba	180	50 $\times$ 5	45000	40358	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Fiji	Vanua-Levu	180	50 $\times$ 5	45000	71428	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Fiji	Viti-Levu	168	50 $\times$ 5	42000	80946	1	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Fangatofa	77	50 $\times$ 2	3850	7100	0	Non-Spec.	Galzin	Planes et al. 2005
Tuamotu	Haraiki	44	50 $\times$ 5	11000	8719	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Hikueru	72	50 $\times$ 5	18000	12868	1	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Hiti	52	50 $\times$ 5	13000	6593	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Kauehi	68	50 $\times$ 5	17000	31251	2	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Marokau	72	50 $\times$ 5	18000	26216	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Mataiva	16	50 $\times$ 2	800	6756	0	Non-Spec.	Galzin	Galzin & Bell 1990
Society	Moorea	28	50 $\times$ 5	7000	39629	0	Non-Spec.	Galzin, MouTham, Lison de Loma, Maihota	Labrosse et al. 2001
Society	Moorea	528	25 $\times$ 2	26400	78354	0	Non-Spec.	Galzin	Augustin et al. 1997
Tuamotu	Mururoa	28	50 $\times$ 5	7000	21974	0	Non-Spec.	Kulbicki, MouTham, Galzin	Labrosse et al. 2001
Tuamotu	Mururoa	96	50 $\times$ 2	4800	19625	0	Non-Spec.	Galzin	Planes et al. 2005
Tuamotu	Nihiru	76	50 $\times$ 5	19000	22395	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Australes Is.	Rapa	28	50 $\times$ 2	2800	16679	2	Non-Spec.	Galzin	Galzin et al. 2006
Tuamotu	Reka	24	50 $\times$ 5	6000	652	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Taiaro	72	50 $\times$ 5	18000	22916	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Tekokota	36	50 $\times$ 5	9000	4798	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Tepoto	40	50 $\times$ 5	10000	4257	0	Non-Spec.	Galzin, Harmelin-Vivien, Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Tikehau	35	50 $\times$ 5	8750	27669	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Tuamotu	Tikehau	48	25 $\times$ 2	2400	36558	0	Non-Spec.	Galzin, Chabanet, MouTham	Morize et al. 1990

Country or region	Island	No. transects	Size	Area (m ²)	No. fish observed	<i>Pterois</i>	UVC-type	Major observers	Reference for method
Marquesas	Eiao	36	25 × 2	1800	12851	0	Non-Spec.	Lison de Loma, Planes	Lison de Loma et al. 2008
Marquesas	Hatutu	36	25 × 2	1800	8783	1	Non-Spec.	Lison de Loma, Planes	Lison de Loma et al. 2008
Marquesas	Mohotani	33	25 × 2	1650	12121	1	Non-Spec.	Lison de Loma, Planes	Lison de Loma et al. 2008
Marquesas	Ua Huka	22	50 × 2	2200	1981	0	Non-Spec.	Planes	Lison de Loma et al. 2008
Marquesas	Ua Huka	30	NA		app.25000	2	Non Spec.	Planes	Lison de Loma et al. 2008
Micronesia	Pohnpei	NA	NA	36800	NA	10	Spec.	Hixon, Beets	
New Caledonia	Belep	50	50 × 5	12500	24022	2	Non-Spec.	Wantiez	Labrosse et al. 2001
New Caledonia	Chesterfield	33	50 × 5	8250	27097	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
New Caledonia	Isle of Pines	50	50 × 5	12500	16077	0	Non-Spec.	Wantiez	Labrosse et al. 2001
New Caledonia	Lifou	84	50 × 5	21000	27562	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
New Caledonia	Main Island	4827	50 × 5	12067 50	2137000	46	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
New Caledonia	Main Island	780	50 × 5	19500 0	145997	4	Non-Spec.	Wantiez	Labrosse et al. 2001
New Caledonia	Ouvéa	210	50 × 5	52500	272213	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Palau	Helen Reef	78	25 × 5	9750	10725	0	Non-Spec.	Green	Birkeland et al. 2000
Philippines	Cebu	NA	NA	61000	NA	55	Spec.	Hixon, Beets	
Indonesia	Raja Ampat	185	50 × 5	92500	NA	0	Non-Spec.	Green	Green et al. 2006
Samoa	Aunuu	5	50 × 3	750	1111	0	Non-Spec.	Green	Green 2002
Samoa	Ofu	30	50 × 3	4500	5258	0	Non-Spec.	Green	Green 2002
Samoa	Olosega	25	50 × 3	3750	3994	0	Non-Spec.	Green	Green 2002
Samoa	Rose	95	50 × 3	14250	15913	0	Non-Spec.	Green	Green 2002
Samoa	Swains	10	50 × 3	1500	9423	0	Non-Spec.	Green	Green 2002
Samoa	Ta'u	25	50 × 3	3750	2974	0	Non-Spec.	Green	Green 2002
Samoa	Tutuila	130	50 × 3	19500	16649	0	Non-Spec.	Green	Green 2002
Samoa	Upolu	45	50 × 3	6750	5567	0	Non-Spec.	Green	Green 2002
Solomons	Arnavons	10	25 × 5	1250	6437	0	Non-Spec.	Green	Green et al. 2006
Solomons	Choiseul	40	25 × 5	5000	22550	0	Non-Spec.	Green	Green et al. 2006
Solomons	Floridas	20	25 × 5	2500	10250	0	Non-Spec.	Green	Green et al. 2006
Solomons	Guadalcanal	20	25 × 5	2500	5725	0	Non-Spec.	Green	Green et al. 2006
Solomons	Isabel	60	25 × 5	7500	25050	0	Non-Spec.	Green	Green et al. 2006
Solomons	Makira	20	25 × 5	2500	6000	0	Non-Spec.	Green	Green et al. 2006
Solomons	Malaita	50	25 × 5	6250	15500	0	Non-Spec.	Green	Green et al. 2006
Solomons	New Georgia	45	25 × 5	5625	30600	0	Non-Spec.	Green	Green et al. 2006
Solomons	Russells	20	25 × 5	2500	13750	0	Non-Spec.	Green	Green et al. 2006
Solomons	Savo	5	25 × 5	625	4037	0	Non-Spec.	Green	Green et al. 2006

Solomons	Shortlands	20	25 × 5	2500	7750	0	Non-Spec.	Green	Green et al. 2006
Solomons	Three Sisters	10	25 × 5	1250	6312	0	Non-Spec.	Green	Green et al. 2006
Country or region	Island	No. transects	Size	Area (m ²)	No. fish observed	<i>Pterois</i>	UVC-type	Major observers	Reference for method
Solomons	Ugi	10	25 × 5	1250	8087	0	Non-Spec.	Green	Green et al. 2006
S. Marianas	Guam	NA	NA	75400	NA	54	Spec.	Hixon, Beets	
Tonga	Haapai	216	50 × 5	54000	45055	2	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Tonga	Tongatapu	237	50 × 5	59250	70365	1	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Tonga	Vavau	166	50 × 5	41500	44059	0	Non-Spec.	Kulbicki, MouTham	Labrosse et al. 2001
Futuna	Futuna	16	50 × 5	4000	NA	0	Non-Spec.	Wantiez	Labrosse et al. 2001
Wallis	Wallis	148	50 × 5	37000	NA	0	Non-Spec.	Wantiez	Labrosse et al. 2001
INDIAN OCEAN									
Îles Eparses	Glorieuses	39	50 × 5		29749	0	Non-Spec.	Chabanet	Chabanet et al. 2002
Îles Eparses	Geyser Bank	14 20	50 × 2 50 × 5		13172 13793	1 3	Non-Spec.	Chabanet	Chabanet et al. 2002
Kenya		132	50 × 5 × 2	66000	43123	25	Non-Spec.	McClanahan	McClanahan & Kaunda-Arara, 1996
Madagascar		59	50 × 5 × 2	29500	22220	5	Non-Spec.	McClanahan	McClanahan & Kaunda-Arara, 1996
Maldives		24	50 × 5 × 2	12000	14044	2	Non-Spec.	McClanahan	McClanahan & Kaunda-Arara, 1996
Mayotte		15	50 × 5 × 2	7500	16041	6	Non-Spec.	McClanahan	McClanahan & Kaunda-Arara, 1996
Mozambique		25	50 × 5 × 2	12500	17135	6	Non-Spec.	McClanahan	McClanahan & Kaunda-Arara, 1996
Tanzania		26	50 × 5 × 2	13000	22494	6	Non-Spec.	McClanahan	McClanahan & Kaunda-Arara, 1996
Maldives		21	50 × 2	12000	27030	3	Non-Spec.	Chabanet, Vigliola	Labrosse et al. 2001

LITERATURE CITED

- Augustin D, Galzin R, Legendre P (1997) Variation interannuelle des peuplements récifaux du récif-barrière de Tiahura (île de Moorea, Polynésie française). *Oceanol Acta* 20:743–756
- Birkeland CE, Green A, Guilbault M, Donaldson T and others (2000) Helen Reef marine resources in the year 2000: results of scientific and community monitoring surveys, 24 April to 3 May 2000. The Helen Reef Resource Management Program, Republic of Palau
- Chabanet P, Tessier E, Durville P, Mulochau T, René F (2002) 2002 Peuplement ichthyologique des bancs Geyser et Zélée (océan Indien occidental). *Cybiu* 26:11–26
- Galzin R, Bell J (1990) Interannual variation in the fish fauna in the lagoon of Mataiva atoll, French Polynesia. *Cybiu* 14:313–322
- Galzin R, Lecchini D, Williams JT, Planes S (2006) Diversity of coral reef fish at Rapa Island (French Polynesia). *Cybiu* 30:221–234
- Green A (2002) Status of coral reefs on the main volcanic islands of American Samoa: a resurvey of long-term monitoring sites (benthic communities, fish communities, and key macroinvertebrates). Department of Marine and Wildlife Resources, Pago Pago
- Green A, Lokani P, Atu W, Ramohia P, Thoma P, Almany J (eds) (2006) Solomon Islands marine assessment: technical report of survey conducted May 13 to June 17, 2004. Report No. 1/06, The Nature Conservancy, South Brisbane
- Labrosse P, Kulbicki M, Ferraris J (2001) Comptage visuel des poissons en plongée: conditions d'utilisation et de mise en œuvre. Secrétariat Générale du Communauté de Pacifique, Nouméa, New Caledonia
- Lison de Loma T, White TS, Planes S (2008) Inventaire des communautés benthiques et ichthyologiques de Hatutu (Archipel des Marquises, Polynésie française). Report RA 158, UMS 2978 CNRS-EPHE
- McClanahan T, Kaunda-Arara B (1996) Fishery recovery in a coral-reef marine park and its effect on the adjacent fishery. *Conserv Biol* 10:1187–1199
- Morize E, Galzin R, Harmelin-Vivien M, Arnaud H (1990) Organisation spatiale du peuplement ichthyologique dans le lagon d'atoll de Tikehau (Polynésie française). ORSTOM Tahiti, Notes et Documents d'Océanographie. 40:1–44
- Planes S, Galzin R, Bablet JP, Sale P (2005) Stability of coral reef fish assemblages impacted by nuclear tests. *Ecology* 86:2578–2585

Table S2. *Pterois* spp. Experimental fishing effort and catch in New Caledonia and Chesterfield Islands.
NA: not available

Gear	Region	No. stations sampled	Approximate area sampled	No. of fish caught	No. of <i>Pterois</i> caught
Rotenone	Chesterfield	15	3750 m ²	30100	0
	New Caledonia	58	14500 m ²	75900	9
Beam trawl	Chesterfield	32	12 ha	1357	1
Shrimp trawl	Chesterfield	12	14 ha	567	1
	New Caledonia	296	350 ha	319000	27
Fish trawl	Chesterfield	13	16 ha	379	0
	New Caledonia	71	100 ha	171000	6
Fyke net	New Caledonia	50	NA	30300	0
Gill net	New Caledonia	219	NA	12400	0
TOTAL			493 ha	641003	44

Table S3. *Pterois* spp. Results of GLMz relating *Pterois* density (log scale) to major geographical factors. Density D: log (D + 1); distribution: normal; link function: power. AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion

	df	Wald	p	Estimate
Intercept	1	0.538	0.46	-0.633994
Ocean	1	3.512	0.061	0.292974
Hemisphere	1	1.299	0.25	0.148508
Coast Type	1	10.56	0.0012	0.501370
Ocean* Hemisphere	1	4.69	0.031	0.276438
Ocean*Coast Type	1	14.38	0.00015	-0.685208
Hemisphere *Coast Type	1	0.098	0.75	-0.042738
Log-distance	1	4.90	0.026	0.234428
Latitude	1	27.29	< 0.0000001	0.074035

	df	Stat.	Stat./df
Chi-squared Pearson	36	19.2151	0.533753
P chi-squared normalized	36	45.0000	1.250000
AIC		109.4110	
BIC		127.4777	
Log likelihood		-44.7055	

Table S4. *Pterois* spp. Results of GLM relating *Pterois* density D (as log [D+1]) to species richness of other predator groups. Medium piscivore: 10–40 cm total length

	df	F	p
Intercept	1	0.439	0.52
Total richness	1	2.418	0.15
<i>Pterois</i> richness	1	0.334	0.57
Scorpaenidae richness	1	0.903	0.36
Piscivore richness	1	2.81	0.12
Medium-piscivore richness	1	0.0293	0.86
Error	10		

Table S5. *Pterois* spp. Results of GLM relating *Pterois* density D (as log [D+1]) to proportions of other predator groups. Medium piscivore: 10–40 cm total length

	df	F	p
Intercept	1	0.223	0.64
% Scorpaenidae	1	1.416	0.25
% Piscivores	1	1.510	0.24
% Medium piscivores	1	0.0472	0.83
Error	12		