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Distribution of Noah's giant clam, *Tridacna noae*

P. Borsa · C. Fauvelot · J. Tiavouane · D. Grulois · C. Wabnitz · M.R. Abdon Naguit · S. Andréfouët

P. Borsa (✉)
Institut de recherche pour le développement (IRD-UR 227), c/o Indonesian Biodiversity Research Center, Universitas Udayana, Jl Raya Sesetan Gang Markisa no. 6, 80322 Denpasar, Indonesia
e-mail: philippe.borsa@ird.fr

C. Fauvelot · J. Tiavouane · D. Grulois · S. Andréfouët
Institut de recherche pour le développement (IRD-UR 227), LabEx Corail, Nouméa, New Caledonia

C. Wabnitz
Secretariat of the Pacific Community, Nouméa, New Caledonia

M.R. Abdon Naguit
Jose Rizal Memorial State University, Dapitan City, Philippines

Abstract Previously confused with the small giant clam *Tridacna maxima*, the recently-resurrected Noah's giant clam, *Tridacna noae* has been reported from the Taiwanese and the Ryukyu archipelagoes. Our recent underwater observations now extend its distribution to Dongsha (northern South China Sea), Bunaken (Sulawesi Sea), Madang and Kavieng (Bismarck Sea), the Alor archipelago (Sawu Sea), Kosrae (Caroline Islands), New Caledonia, the Loyalty Islands and Vanuatu (Coral Sea), Viti-Levu (Fiji), Wallis Island, and Kiritimati (Northern Line Islands). Published mitochondrial DNA sequences retrieved from open-access databases also indicate its presence in eastern Negros (Philippines), in the Molucca Sea, at Ningaloo Reef (Western Australia), and in the Solomon Islands. Noah's giant clam is thus a widely distributed Indo-West Pacific species. Wherever research has been done on small giant clams throughout *T. noae*'s range, the inadvertent confusion of *T. noae* with *T. maxima* might have led to overestimating actual *T. maxima* densities and to errors in estimating demographic parameters.

Keywords Indo-West Pacific; Reef survey; DNA barcode; Cytochrome oxidase 1; 16S ribosomal RNA; *T. maxima*; *T. crocea*

Introduction

Giant clams (Cardiidae: Tridacninae) are distributed throughout the Indo-West Pacific, from the Red Sea and East Africa to the central Pacific Ocean (Rosewater 1965, bin Othman et al. 2010). The Tridacninae sub-family includes two extant genera, *Hippopus* and *Tridacna*, with two and nine extant species, respectively (ter Poorten 2014a,b). Extant species in the genus *Tridacna* are *T. crocea* Lamarck, 1819, *T. derasa* (Röding, 1798), *T. gigas* (Linnaeus, 1758), *T. maxima* (Röding, 1798), *T. mbalavuana* Ladd, 1934, *T. noae* (Röding, 1798), *T. rosewateri* Sirenko and Scarlato, 1991, *T. squamosa* Lamarck, 1819, and *T. squamosina* Sturany, 1899.

Röding (1798) initially distinguished *T. noae* from the small giant clam, *T. maxima* on the basis of shell morphology in a plate by Chemnitz (1784) representing various shell forms of giant clams. Noting the high variability in shell morphology in *T. maxima*, Rosewater (1965) treated the *T. noae* form as a variant of the latter, leading to the confusion of the two species until recently. New evidence from mitochondrial DNA sequences, together with differences in mantle morphology in small giant clams from Taiwan and the Ryukyu Islands indicated a sympatric, cryptic species within *T. maxima* sensu Rosewater (Tang 2005; Kubo and Iwai 2007; Su et al. 2014). Kubo and Iwai (2007) first mentioned that the cryptic species was possibly *T. noae*. Su et al. (2014) compared the shells of the cryptic species with the drawings of Chemnitz (1784) referred to by Röding (1798) and resurrected *T. noae* as a valid species.

It has been emphasized that shell morphology is only partly diagnostic between *T. noae* and *T. maxima* (Su et al. 2014). Live Noah's giant clams are better diagnosed by the discontinuous disposition of the hyaline organs, and by the large, easily recognizable, ocellate spots with a thin, white contour on the mantle's edge (Fig. 1) (Su et al. 2014). Mitochondrial-DNA phylogenies identify *T. noae* as a distinct clade separated from *T. maxima* by 17-26% nucleotide divergence at the cytochrome-oxidase 1 (*CO1*) gene locus and 4-5% nucleotide divergence at the ribosomal RNA subunit 16S (*16S*) locus (Su et al. 2014).

Noah's giant clam has been reported from the Taiwanese and the Ryukyu archipelagoes (Kubo and Iwai 2007; Su et al. 2014). Here, we update the distribution of *T. noae* by providing new records of this species, either from underwater observations of live individuals or from published mitochondrial DNA sequences of specimens assigned to *T. maxima* or *Tridacna* sp. in the recent literature.

Methods

Observations of giant clams were made opportunistically between January 2012 and July 2014 by snorkeling or SCUBA diving at Dongsha (northern South China Sea); at the Bunaken marine reserve area (Sulawesi Sea); off Madang and Kavieng (Bismarck Sea); in Kosrae (Caroline Islands); in New Caledonia, in the Loyalty Islands and at Efate, Vanuatu (Coral Sea); in northeastern Viti Levu (Fiji); at Wallis Island; and in Kiritimati (Northern Line Islands). At Dongsha, photographs of giant clam specimens were taken after they had been collected on the reef and stored alive in aquaculture tanks prior to studying their reproduction (P.-W. Su, pers. comm.). In Kosrae, adult small giant clams (22-28cm) were collected as aquaculture broodstock. At Efate, adult small giant clams ($N = 10$) were collected in the Mangaliliu marine protected area, to be transferred to the Vanuatu Fisheries Department facilities in Port-Vila for experiments on their larvae (Dumas et al. 2014). At Bunaken and Madang, reef surveys focused on habitat mapping but benthic macro-species considered important for fisheries (e.g., sea cucumbers, giant clams) were counted and photographs taken. In New Caledonia and the Loyalty Islands, photographs were taken as part of a dedicated giant clam sampling programme for genetic purposes. In Kiritimati, giant clams were photographed opportunistically during a series of dives aimed at monitoring aquarium fish collecting practices. When Su et al.'s (2014) article describing the mantle characteristics of *T. noae* was published, we started browsing through our collections of

giant clam pictures with the aim to distinguish possible *T. noae* from *T. maxima* individuals and thus obtaining additional *T. noae* records.

Details on the sites visited in New Caledonia and the Loyalty Islands were recorded on the divers' logbooks. This dataset was examined more closely because it came from our only survey specifically dedicated to sampling giant clams. This information is summarized in Supplementary Material, Table S1. To determine the main characteristics of Noah's giant clam's habitat in New Caledonia and the Loyalty Islands, correspondence analysis (Benzécri 1982) was run on the site x habitat matrix derived from Table S1, using the FACTOMINER package (Lê et al. 2008). In this matrix, rows represent survey sites (N = 98) and columns represent environmental variables. The latter were: medium diving depth, reef geomorphology, latitude (Table S1), and the number of individual giant clams encountered by species. Correspondence analysis suggested that the relative abundance of *T. noae* was correlated with that of *T. maxima*. To formalize this observation, Spearman's test of correlation was run between these two variables, and between the abundance of *T. noae* and the other environmental variables (using the Social Science Statistics online calculator; http://www.socscistatistics.com/). Statistical error rate was adjusted by applying the Bonferroni correction (Sokal and Rohlf 1995).

We also searched for possible nucleotide sequences of *T. noae* in publicly accessible databases. All partial cytochrome-oxidase 1 (*CO1*) gene nucleotide sequences of *Tridacna* spp. available in GENBANK (http://www.ncbi.nlm.nih.gov/; accessed 04 June 2014) were entered into a single FASTA file under BIOEDIT (Hall 1999). The accession numbers for these sequences were: AB076920, DQ155301, DQ168140, DQ269479, EU003606-EU003616, EU341350-EU341379, EU346361-EU346368, FM244476-FM244485, FM244513-FM244619, FM253431-FM253562, GQ166591, HE995439-HE995532, HM187782-HM188392, JN392020-JN392066, JX974903-JX974957, KC456021-KC456025, KF446283-KF446591, and KJ202107-KJ202117 (N = 1529). All nucleotide sequences at the 16S ribosomal RNA (*16S*) locus, GENBANK accession nos. AM909726-AM909764, AF122975-AF122980, DQ115320, DQ119339, EU341331-EU341349, JX974838-JX974902, KC456034-KC456042, and KJ508349-KJ508358 (N = 150) were treated similarly. The nucleotide sequences were aligned by eye. The alignment of sequences, trimmed to 548 bp (*CO1*) or 443 bp (*16S*), was used as an individual x nucleotide site matrix subjected to Neighbor-Joining (NJ) analysis under MEGA5 (Tamura et al. 2011). The GENBANK accession numbers for nucleotide sequences at the *CO1* and *16S* loci for reference specimens of *T. crocea*, *T. derasa*, *T. gigas*, *T. maxima*, *T. mbalavuana*, *T. noae*, *T. squamosa* and *T. squamosina* (Plazzi and Passamonti 2010; Lizano and Santos 2014; Su et al. 2014) are listed in Table 1. Nucleotide distances between haplotypes clustering with *T. noae* on the NJ trees, and the homologous sequences of reference specimens of the foregoing *Tridacna* species were estimated according to the Kimura-2 parameter model algorithm implemented in MEGA5 (Tamura et al. 2011).

Results

Underwater reef surveys revealed the occurrence of Noah's giant clam at Bunaken National Park, Madang, New Caledonia and the Loyalty Islands, and Kiritimati; Noah's giant clams were also collected along with *T. maxima* at Dongsha Atoll, Kosrae and Efate (Supplementary Material, Figs. S1-S6). Noah's giant clam was also observed at Kavieng (02°33'S 150°48'E), at Moon Reef, off northeastern Viti Levu (17°30'S 178°32'E) and off Wallis Island (see Supplementary Material, Fig. S7). In addition, two pictures of live individuals labeled '*T. maxima*' in Tisera et al. (2012; their figures 2E and 2F), now presented with details of date and location in Supplementary Material., Fig. S8, provided evidence of the occurrence of *T. noae* in the Sawu Sea. In New Caledonia, *T. noae* was observed only in Hienghène, northeastern coast, despite equivalent sampling effort all along New Caledonia's Grande Terre, from d'Entrecasteaux Reefs to Isle of Pines (Supplementary

Material, Table S1). *T. noae* was also observed in the Loyalty Islands except Maré, the southernmost island of the Loyalty archipelago.

. The sites where Noah's giant clam was present in New Caledonia and the Loyalty Islands had moderate depth (average 10 m), were mostly on the reef slope (Supplementary Material, Table S1), and tended to have the same characteristics as those with *T. maxima* as indicated by correspondence analysis (Supplementary Material, Fig. S9). The abundances of the two species were correlated (Spearman's correlation coefficient, ρ = 0.292; $P < 0.004$; significant after Bonferroni correction). Sites where Noah's giant clam was recorded in the Alor archipelago, at Bunaken and off Wallis Island were characterized by shallow depth (1 m to 3 m) and were either on the reef flat or in shallow lagoon (Supplementary Material, Figs. S2, S7 and S8). Those at Kavieng, Kosrae, Efate, and Kiritimati were the reef flat, the reef crest and the outer reef slope at depths ranging from ca. 1 m to ca. 15 m (Supplementary Material, Fig. S6). The site where Noah's giant clam was sighted at Moon Reef, Viti Levu was a lagonal patch reef, characterized by pavement reef flat with scattered coral heads, at 2 m depth at high tide.

The NJ tree of *Tridacna* spp. *CO1* haplotypes displayed a distinct haplogroup (Supplementary Material, Fig. S10A) clustering with the reference sequence for *T. noae* (GENBANK KC456023; Su et al. 2014). Published *CO1* sequences labeled '*Tridacna* sp.' from Ningaloo Reef (Western Australia), Sibulan (Negros, Philippines) and the Solomon Islands (Huelsken et al. 2013; Lizano and Santos 2014), and one published *CO1* sequence labeled '*T. maxima*' from Doi Island (Molucca Sea) (DeBoer et al. 2014) were identified as *T. noae*. Published *16S* sequences from '*Tridacna* sp.' individuals from Ningaloo Reef, Sibulan, and the Solomon Islands (Huelsken et al. 2013; Lizano and Santos 2014) were similarly identified as *T. noae* (Supplementary Material, Fig. S10B). The nucleotide distances between *T. noae* haplotypes and the reference sequences for seven other *Tridacna* species are given in Table 1.

Discussion

Two types of data were used to identify Noah's giant clams: the ornamentation patterns of the mantle of live individuals observed underwater, and published mitochondrial DNA sequences. Unlike shell morphology, both mantle ornamentation patterns and mitochondrial DNA sequences are diagnostic of this species (Su et al. 2014). The new records reported here allow us to extend the distribution of Noah's giant clam from the Ryuku archipelago to Western Australia, and from the Coral Triangle (as defined by Veron et al. 2009) to the Coral Sea and to the Northern Line Islands (Fig. 2). Noah's giant clam is thus a widely distributed Indo-West Pacific species. It may occur naturally on the same reef habitats as *T. maxima*, and also *T. crocea* as reported from the Solomon Islands (Huelsken et al. 2013), and as observed at Bunaken and in New Caledonia (this survey).

Wherever research has been done on small giant clams throughout *T. noae*'s range, the inadvertent confusion of *T. noae* with *T. maxima* may have led to erroneous results. For instance, actual *T. maxima* densities (bin Othman et al. 2010, and references therein; Tisera et al. 2012) may have been overestimated, thus potentially leading to underestimating the risk of local extinction in this species. In ecological and physiological experiments on the small giant clam (e.g., Ambariyanto and Hoegh-Guldberg 1999; Dumas et al. 2014), inadvertently mixing specimens of different species might lead to artefactually inflated variance in response to stimuli. Juvenile production of small giant clams (e.g., Gomez and Mingoa-Licuanan 2006) might be affected by lower fertilization success and higher embryo mortality if individuals of different species are induced to spawn in the same batch. Genetic analysis of small giant clam samples (e.g., Campbell et al. 1975, Benzie and Williams 1997) when these include two different species might produce artefactually high estimates of genetic diversity, generate heterozygote deficiencies through the Wahlund effect, and bias estimates of genetic differentiation between populations. Last, understanding population dynamics, including

variability of recruitment and mortality is essential for assessing ecological change and for informing conservation plans (Van Wynsberge et al. 2013). In natural populations of giant clams, demographic parameters are derived from estimates of population density and size-frequency distributions (e.g., Black et al. 2011): inadvertently lumping data relative to different species could blur our understanding of their population dynamics. To help improve our knowledge and management of these species, thorough reassessments of small giant clam demographics, population ecology, physiology, and population genetic structure, this time by distinguishing *T. maxima* from *T noae*, are warranted.

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Table 1 Nucleotide distances [Kimura-2 parameter distances; MEGA5 (Tamura et al. 2011)] separating haplotypes clustering with *Tridacna noae* from reference *Tridacna* spp. specimens (Plazzi and Passamonti 2010; Lizano and Santos 2014; Su et al. 2014), based on nucleotide sequences at mitochondrial loci *CO1* and *16S*. *DB* DeBoer et al. (2014); *HU* Huelsken et al. (2013); *LI* Lizano and Santos (2014); *SU* Su et al. (2014). *Dash* no data

Locus, GENBANK accession no.	Sampling location	Original identification (reference)	Species							
			T. crocea	*T. derasa*	*T. gigas*	*T. maxima*	*T. mbalavuana*	*T. noae*	*T. squamosa*	*T. squamosina*
CO1			EU341379	GQ166591	KJ202113	DQ155301	-	KC456023	EU346364	-
DQ168140	Taiwan	*T. noae* (SU)	0.196	0.243	0.319	0.187	-	0.007	0.145	-
JX974903 [a]	Ningaloo Reef	*T.* sp. (HU)	0.193	0.210	0.275	0.213	-	0.008	0.139	-
JX974904	Ningaloo Reef	*T.* sp. (HU)	0.201	0.214	0.281	0.216	-	0.014	0.147	-
JX974909	Ningaloo Reef	*T.* sp. (HU)	0.199	0.230	0.292	0.227	-	0.009	0.144	-
JX974911	Ningaloo Reef	*T.* sp. (HU)	0.210	0.235	0.307	0.232	-	0.016	0.153	-
JX974912	Ningaloo Reef	*T.* sp. (HU)	0.211	0.230	0.319	0.227	-	0.009	0.144	-
JX974913	Ningaloo Reef	*T.* sp. (HU)	0.199	0.230	0.306	0.227	-	0.009	0.144	-
JX974914	Ningaloo Reef	*T.* sp. (HU)	0.211	0.242	0.312	0.239	-	0.016	0.154	-
JX974915	Ningaloo Reef	*T.* sp. (HU)	0.199	0.236	0.299	0.227	-	0.006	0.144	-
JX974916	Ningaloo Reef	*T.* sp. (HU)	0.216	0.242	0.319	0.233	-	0.009	0.149	-
JX974917	Ningaloo Reef	*T.* sp. (HU)	0.199	0.218	0.306	0.227	-	0.009	0.144	-
JX974918 [b]	Solomon Is.	*T.* sp. (HU)	0.181	0.192	0.299	0.172	-	0.024	0.148	-
JX974919	Solomon Is.	*T.* sp. (HU)	0.190	0.201	0.299	0.180	-	0.019	0.148	-
JX974921	Solomon Is.	*T.* sp. (HU)	0.195	0.196	0.305	0.185	-	0.021	0.152	-
JX974922	Solomon Is.	*T.* sp. (HU)	0.195	0.201	0.305	0.185	-	0.022	0.152	-
KF446463	Doi I.	*T. maxima* (DB)	0.188	0.223	0.310	0.178	-	0.000	0.144	-
KJ202114	Bolinao	*T.* sp. (LI)	0.180	0.241	0.322	0.173	-	0.002	0.141	-
KJ202115 [c]	Bolinao	*T.* sp. (LI)	0.184	0.240	0.316	0.176	-	0.000	0.145	-
16S			EU341349	AF122976	AF122975	DQ115320	AF122977	KC456036	KC456038	AM909741
DQ119339	Taiwan	*T. noae* (SU)	0.051	0.088	0.142	0.043	0.134	0.000	0.035	0.034
JX974873 [d]	Ningaloo Reef	*T.* sp. (HU)	0.049	0.086	0.168	0.055	0.127	0.005	0.030	0.049
JX974874 [e]	Ningaloo Reef	*T.* sp. (HU)	0.044	0.081	0.168	0.049	0.127	0.000	0.025	0.044
JX974895	Solomon Is.	*T.* sp. (HU)	0.049	0.086	0.161	0.044	0.134	0.005	0.030	0.049
JX974896	Solomon Is.	*T.* sp. (HU)	0.049	0.086	0.176	0.055	0.134	0.005	0.030	0.049
KC456040	Taiwan	*T. noae* (SU)	0.058	0.094	0.149	0.049	0.133	0.005	0.040	0.037
KC456041	Taiwan	*T. noae* (SU)	0.051	0.088	0.142	0.043	0.134	0.000	0.035	0.034
KJ508355 [f]	Bolinao	*T.* sp. (LI)	0.052	0.088	0.148	0.043	0.140	0.000	0.035	0.034
KJ508357	Bolinao	*T.* sp. (LI)	0.052	0.088	0.148	0.043	0.140	0.000	0.035	0.034

[a] nucleotide sequence identical with JX974905-JX974908, JX974910; [b] nucleotide sequence identical with JX974920, JX974923; [c] nucleotide sequence identical with KJ202116; [d] nucleotide sequence identical with JX974876, JX974879, JX974887; [d] nucleotide sequence identical with JX974875, JX974877, JX974878, JX974880-JX974886, JX974888-JX974894, JX974897, JX974898; [f] nucleotide sequence identical with KJ508356.

CAPTIONS TO FIGURES

Fig. 1 Detail of the mantle of a Noah's giant clam, *Tridacna noae* photographed on the Madang barrier reef, Bismarck Sea, November 2012 (courtesy of M. Hamel). The ocellate spots visible on the mantle's edge which are diagnostic of the species (Su et al. 2014) were used to identify it in the wild.

Fig. 2 Noah's giant clam, *Tridacna noae*. Geographic distribution of the species, compiled from various sources including published records (squares), publicly accessible *CO1* and *16S* sequences (hexagons), and new observations of live individuals (circles). *BS* Bismarck Sea; *MS* Molucca Sea; *Sa* Sawu Sea; *Su* Sulawesi Sea.

Fig. 1

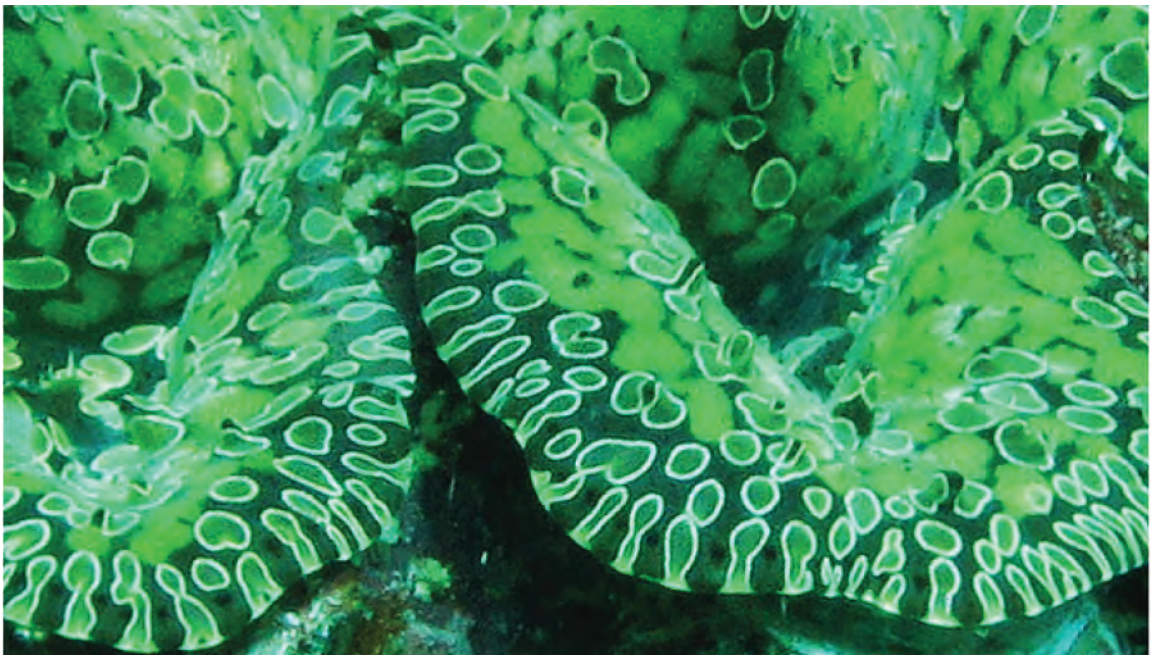
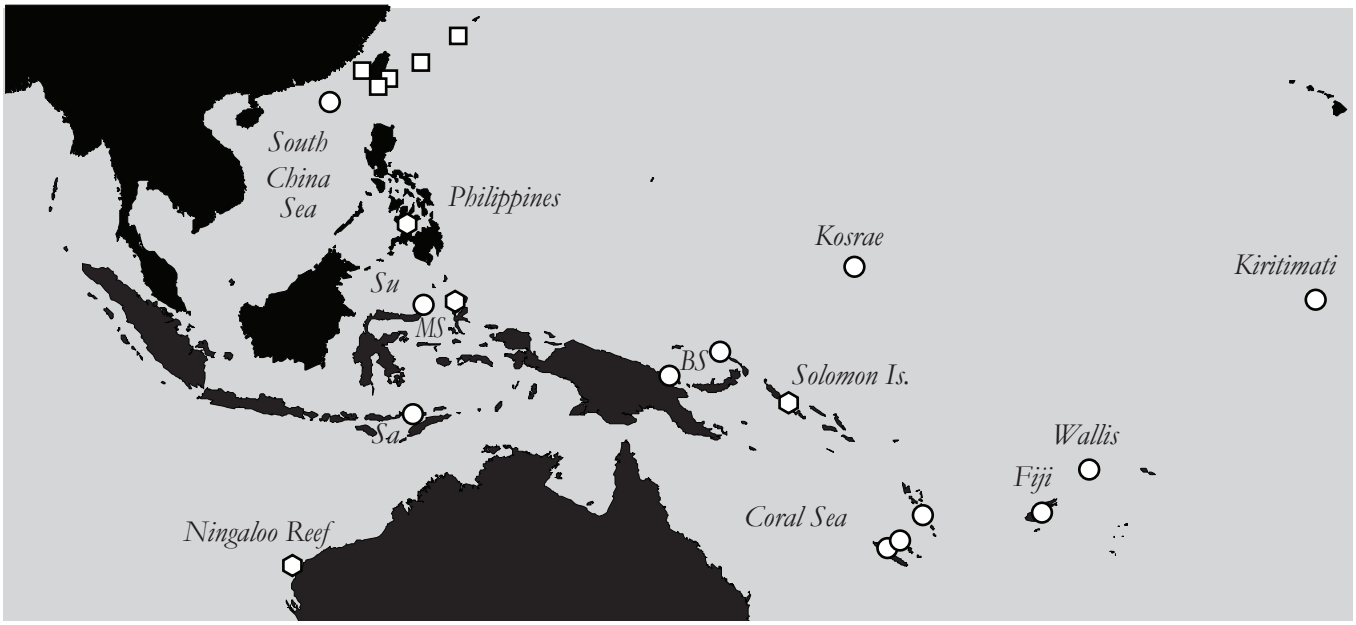


Fig. 2


South
China
Sea
Philippines
Kosrae
Kiritimati
Su
MS
BS
Solomon Is.
Sa
Wallis
Fiji
Coral Sea
Ningaloo Reef

Supplementary material to:

Distribution of Noah's giant clam, *Tridacna noae*

P. Borsa · C. Fauvelot · J. Tiavouane · D. Grulois · C. Wabnitz · M.R. Abdon Naguit · S. Andréfouët

Table S1 and Figs. S1-S10 here appended

Authors of photographs

M.R. Abdon Naguit (MRAN)
S. Andréfouët (SA)
P. Borsa (PB)
P. Bosserelle
C. Fauvelot (CF)
D. Grulois (DG)
J. Tiavouane (JT)
C. Wabnitz (CW)

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Table S1 Habitat characteristics of the diving sites surveyed for giant clams in New Caledonia and the Loyalty Islands during the period October 2013-February 2014 (extracted from the divers' logbooks: CF, DG and JT). *z* diving depth; *Tn Tridacna noae*, *Tm T. maxima*, *Td T. derasa*, *Tc T. crocea*, *Ts T. squamosa*, *Hh Hippopus hippopus*; + species present (<10 individuals), ++ species abundant (≥ 10 individuals); *RS* reef slope, *LA* lagoon, *IB* internal barrier reef, *FR* fringing reef, *BR* barrier reef

Region, Station	Locality	Latitude	Longitude	z (m)	Abundance						Habitat
					Hh	Tc	Td	Tm	Tn	Ts	
New Caledonia											
NCIP1	Isle of Pines	22°40'S	167°21'E	1-12	0	0	+	+	0	0	RS
NCIP4	Isle of Pines	22°30'S	167°22'E	1-12	0	0	0	+	0	0	RS
NCPI5	Isle of Pines	22°31'S	167°25'E	1-12	0	0	0	+	0	0	RS
Sn_af	Isle of Pines	-	-	1- 3	0	0	0	+	0	0	LA
NCPI7	Isle of Pines	22°38'S	167°34'E	1-12	0	0	0	++	0	0	RS
NCPI8	Isle of Pines	22°36'S	167°33'E	1-12	0	0	0	++	0	0	RS
Sn_af	Brosse I.- Isle of Pines	-	-	1- 3	0	0	0	+	0	0	LA
NCNE11	Isle of Pines	22°34'S	167°12'E	1-12	0	0	0	+	0	+	RS
Sn-PI13	Isle of Pines	22°35'S	167°19'E	1- 3	0	0	0	++	0	0	LA
Chenea	Oro Bay - Isle of Pines	-	-	1- 3	++	0	0	+	0	+	LA
NCPI17	Isle of Pines	22°28'S	167°18'E	1-12	0	0	0	+	0	+	RS
NCPI18	Isle of Pines	22°29'S	167°14'E	1-12	0	0	+	0	0	+	RS
NCPI21	Isle of Pines	22°31'S	167°27'E	1-12	0	0	+	0	0	0	RS
Sn_mo	Prony Bay	-	-	1- 3	+	0	0	+	0	0	LA
NC125	Pelotas Atoll, d'Entrecasteaux Reefs	18°36'S	163°14'E	3-15	0	0	0	+	0	+	RS
NCCR27	Cook Reef	18°57'S	163°34'E	3-15	0	0	0	+	0	+	RS
NCCR29	Cook Reef	18°50'S	163°29'E	3-15	0	0	0	+	0	+	RS
NCCR30	Cook Reef	19°06'S	163°34'E	3-15	0	0	+	+	0	+	RS
NCCR31	Cook Reef	18°59'S	163°30'E	3-15	0	0	+	+	0	+	RS
NCCR32	Cook Reef	18°53'S	163°25'E	3-15	0	0	+	0	0	+	RS
NCCR33	Cook Reef	19°03'S	163°41'E	3-15	0	0	0	+	0	0	RS
NCCR34	Cook Reef	19°04'S	163°38'E	3-15	0	0	+	++	0	0	RS
NCCR36	Cook Reef	18°51'S	163°32'E	3-15	0	0	0	+	0	0	RS
NCCR37	Cook Reef	18°51'S	163°27'E	3-15	0	0	0	+	0	0	RS
NCCR38	Cook Reef	18°51'S	163°26'E	3-15	0	0	0	+	0	+	RS
NCPO39	Portail Atoll, d'Entrecasteaux Reefs	18°30'S	162°55'E	3-15	0	0	+	+	0	+	RS
NCPO40	Portail Atoll, d'Entrecasteaux Reefs	18°27'S	162°53'E	3-15	0	0	0	++	0	+	RS
NCHU43	Huon Atoll, d'Entrecasteaux Reefs	17°53'S	162°54'E	3-15	0	0	0	++	0	0	RS
NCHU44	Huon Atoll, d'Entrecasteaux Reefs	17°56'S	162°54'E	3-15	0	0	0	++	0	0	RS
SnHu-1	Huon Atoll, d'Entrecasteaux Reefs	17°54'S	162°54'E	1- 3	0	0	0	++	0	0	LA
SnHu-1b	Huon Atoll, d'Entrecasteaux Reefs	17°54'S	162°54'E	1- 3	0	0	+	0	0	+	LA
NCHU49	Huon Atoll, d'Entrecasteaux Reefs	18°14'S	162°53'E	3-15	0	0	0	+	0	+	RS
NCHU50	Huon Atoll, d'Entrecasteaux Reefs	18°12'S	162°50'E	3-15	0	0	0	++	0	+	RS
SnHu-2	Huon Atoll, d'Entrecasteaux Reefs	18°03'S	162°57'E	1- 3	0	0	0	+	0	0	LA
NCHU54	Huon Atoll, d'Entrecasteaux Reefs	17°58'S	162°56'E	3-15	0	0	+	+	0	+	RS
NCHU55	Guilbert Atoll, d'Entrecasteaux Reefs	18°00'S	163°07'E	3-15	0	0	0	++	0	+	RS
NCHU56	Guilbert Atoll, d'Entrecasteaux Reefs	18°01'S	163°08'E	3-15	0	0	0	++	0	0	RS
NCHU58	Guilbert Atoll, d'Entrecasteaux Reefs	18°01'S	163°05'E	3-15	0	0	0	+	0	+	RS
NCHU59	Guilbert Atoll, d'Entrecasteaux Reefs	18°03'S	163°05'E	3-15	0	0	0	+	0	+	RS
SnSu_41	Surprise Atoll, d'Entrecasteaux Reefs	18°29'S	163°05'E	1- 3	+	0	+	++	0	+	LA
NCSU63	Surprise Atoll, d'Entrecasteaux Reefs	18°26'S	163°14'E	3-15	0	0	0	+	0	0	RS
SnSu_42	Surprise Atoll, d'Entrecasteaux Reefs	18°29'S	163°05'E	1- 3	+	0	+	+	0	+	LA
NCSU66	Surprise Atoll, d'Entrecasteaux Reefs	18°28'S	163°01'E	3-15	0	0	0	++	0	+	RS
SnSu_43	Surprise Atoll, d'Entrecasteaux Reefs	18°29'S	163°05'E	1- 3	+	0	+	+	0	0	LA
NCSU69	Surprise Atoll, d'Entrecasteaux Reefs	18°18'S	162°59'E	3-15	0	0	+	+	0	+	RS
NCSU70	Surprise Atoll, d'Entrecasteaux Reefs	18°24'S	162°59'E	3-15	0	0	0	+	0	0	RS
NCSU71	Surprise Atoll, d'Entrecasteaux Reefs	18°30'S	163°06'E	3-15	0	0	0	++	0	+	RS
NCPO72	Portail Atoll, d'Entrecasteaux Reefs	18°29'S	162°51'E	3-15	0	0	0	++	0	0	RS
NCPO73	Portail Atoll, d'Entrecasteaux Reefs	18°31'S	162°52'E	3-15	0	0	0	++	0	+	RS
NCPO74	Surprise Atoll, d'Entrecasteaux Reefs	18°28'S	163°05'E	3-15	0	0	+	++	0	+	RS
NC175	Pelotas Atoll, d'Entrecasteaux Reefs	18°32'S	163°15'E	3-15	0	0	0	++	0	+	RS
NC176	Pelotas Atoll, d'Entrecasteaux Reefs	18°36'S	163°11'E	3-15	0	0	0	++	0	+	RS
Cobelo1	St Vincent Bay	21°59'S	165°54'E	1- 3	+	0	+	++	0	0	IB
Cobelo2	Testard I.	21°56'S	165°54'E	1- 3	++	0	0	0	0	0	IB
Cobelo3	Beco Reef	21°24'S	164°57'E	1- 3	0	0	0	++	0	0	IB
Cobelo4	Grimault I.	21°23'S	165°00'E	1- 3	++	0	0	0	0	0	IB
Cobelo5	Mathieu Reef	20°47'S	164°16'E	1- 3	++	0	0	++	0	0	IB
Cobelo6	Deverd I.	20°46'S	164°19'E	1- 3	++	0	0	0	0	0	IB
Cobelo7	Teewa I.	20°38'S	164°17'E	1- 3	+	0	0	0	0	0	IB
Cobelo8	Poum Reef	20°17'S	163°53'E	1- 3	+	0	+	++	0	0	IB
Cobelo9	Neba I.	20°10'S	163°56'E	1- 3	++	0	0	0	0	0	IB

Table S1 (continued)

Region, Station	Locality	Latitude	Longitude	z (m)	Abundance						Habitat
					Hh	Tc	Td	Tm	Tn	Ts	
Cobel10	Art I.	19°40'S	163°37'E	1- 3	0	0	0	+	0	+	IB
Cobel11	Art I.	19°40'S	163°38'E	1- 3	+	0	0	++	0	+	FR
Cobel12	Voh	21°02'S	164°37'E	1- 3	+	+	+	++	0	0	IB
Cobel13	Bourail Bay	21°41'S	165°28'E	1- 3	0	0	0	++	0	+	IB
Cobel14	Koregan I.	21°38'S	165°26'E	1- 3	+	0	0	+	0	0	RS
Cobel15	Bourail Bay	21°41'S	165°28'E	1- 3	0	0	+	0	0	0	IB
Cobel16	Larégnère Reef	22°20'S	166°20'E	1- 3	++	0	0	0	0	0	IB
Ptb1	Port-Bouquet – Niaouato Reef	21°36'S	166°25'E	5-20	0	0	0	++	0	++	RS
Ptb2b	Port-Bouquet – Nenii Reef	21°41'S	166°25'E	1- 5	+	++	0	0	0	++	RS
Kua1	Kuakué Bay	21°48'S	166°38'E	5-20	0	0	+	++	0	+	RS
Kua2b	Kuakué Bay	21°54'S	166°37'E	1- 2	0	+	0	0	0	0	LA
Gor1b	Goro Bay	22°20'S	167°01'E	0- 1	+	0	0	++	0	+	LA
Gor2b	Goro Bay	22°20'S	167°01'E	0- 1	+	++	0	0	0	+	LA
Pb1	Pouébo	20°12'S	164°25'E	0- 5	0	+	0	++	0	0	LA
Hg1	Hienghène: Hiengu I.	20°41'S	165°06'E	0- 5	0	+	0	++	+	+	LA
Loyalty Islands											
LOY-01	Maré I.	21°25'S	167°49'E	3-10	0	0	0	++	0	+	RS
LOY-02	Maré I.	21°25'S	167°25'E	0- 3	0	0	0	++	0	+	FR
LOY-02b	Maré I.	21°29'S	168°07'E	15	0	0	0	+	0	0	RS
LOY-03	Maré I.	21°20'S	168°59'E	0- 3	0	0	0	+	0	0	IB
LOY-05	Tiga I.	21°07'S	167°50'E	8-15	0	0	0	++	+	0	RS
LOY-06	Tiga I.	21°05'S	167°48'E	0- 3	+	0	0	+	0	0	LA
LOY-07	Chateaubriand Pt, Lifou I.	20°51'S	167°17'E	6-15	0	0	0	++	+	+	RS
LOY-08b	Namamate, Lifou I.	21°02'S	167°25'E	6-15	0	0	0	++	+	0	RS
LOY-08b	Namamate, Lifou I.	21°02'S	167°25'E	0- 3	+	0	0	++	0	0	LA
LOY-09	Escarpé Cape, Lifou I.	20°41'S	167°14'E	3-15	0	0	0	0	0	+	RS
LOY-10b	Lifou I.	20°42'S	167°10'E	8	0	0	0	0	0	+	RS
LOY-12	Martin Cape, Lifou I.	20°55'S	167°04'E	10-20	0	0	0	+	0	0	FR
LOY-11b	S Santal Bay, Lifou I.	20°47'S	167°07'E	1- 6	+	0	0	++	0	0	LA
LOY-12b	S Santal Bay, Lifou I.	20°56'S	167°04'E	1- 3	0	0	0	+	0	0	LA
LOY-13	S Ouvea I.	20°44'S	166°24'E	5-20	0	0	+	++	0	++	BR
LOY-14b	S Pleiades, Ouvea I.	20°37'S	166°17'E	5-20	0	0	0	++	0	0	BR
LOY-15	N Pleiades, Ouvea I.	20°25'S	166°29'E	5-20	0	0	0	++	+	++	RS
LOY-16b	N Pleiades, Ouvea I.	20°25'S	166°29'E	1- 5	+	0	+	0	0	+	RS
LOY-17	S Beautemps-Beaupré I.	20°25'S	166°08'E	5-20	0	0	+	++	0	+	RS
LOY-18	Motu 1, Beautemps-Beaupré I.	20°25'S	166°08'E	5-20	0	0	+	++	0	++	RS
LOY-19	E Astrolabe Reef	19°53'S	165°50'E	5-20	0	0	0	++	+	+	RS
LOY-20	W Astrolabe Reef	19°52'S	165°33'E	5-20	0	+	+	++	0	+	RS

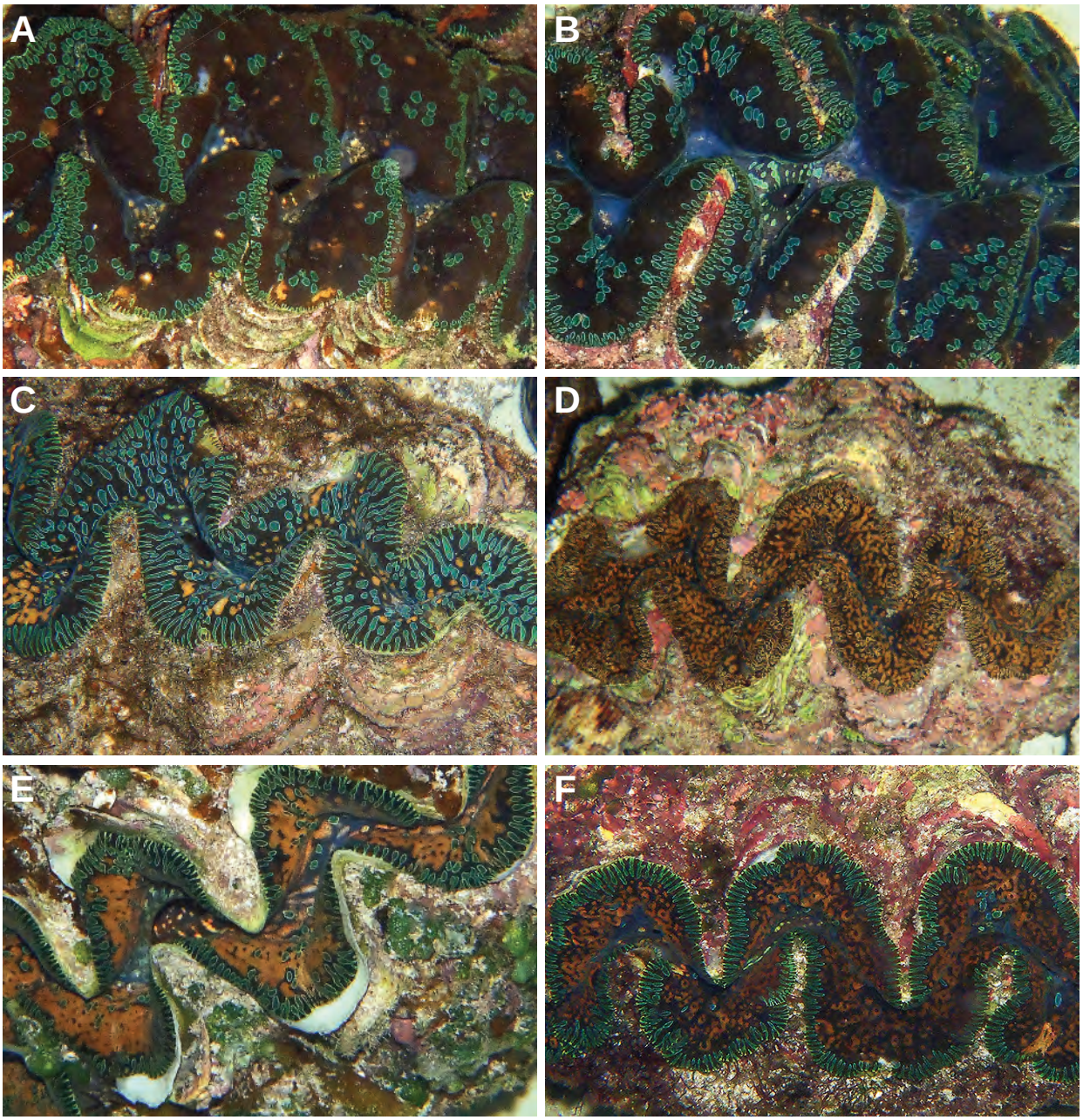

Fig. S1 A-F *Tridacna noae* specimens from Dongsha reef (20°43'N 116°44'E), northern South China Sea, April 2013 (PB).

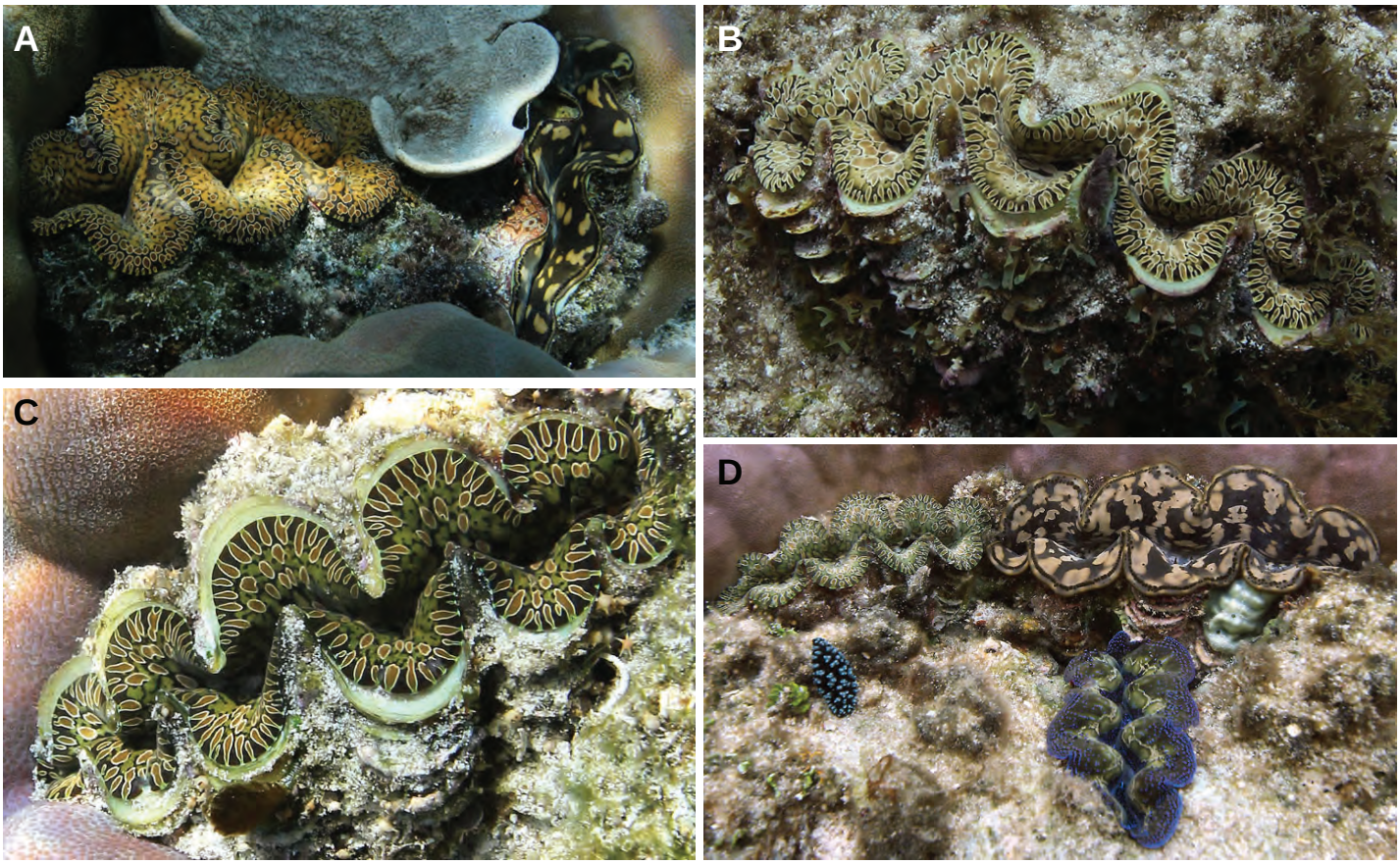

Fig. S2 *Tridacna noae* specimens from the Bunaken marine reserve area, Sulawesi Sea (SA). **A** Nain Island, 01°47'N 124°49'E, shallow lagoon, depth 2.5 m; 10 May 2014; size ca. 14 cm. **B** Nain Island, 01°47'N 124°49'E, reef flat, depth 1.5 m; 10 May 2014; size ca. 12 cm . **C** Siladen Island, 01°38'N 124°48'E, reef flat with sparse *Porites* micro-atolls, depth ca. 1 m (mid-tide); 09 May 2014; size ca. 10 cm. **D** *T. noae* together with *T. maxima* (right) and *T. crocea* (foreground), Mantehange Island, 01°44'N 124°46'E, reef flat with sparse small *Porites* colonies; 17 May 2014.

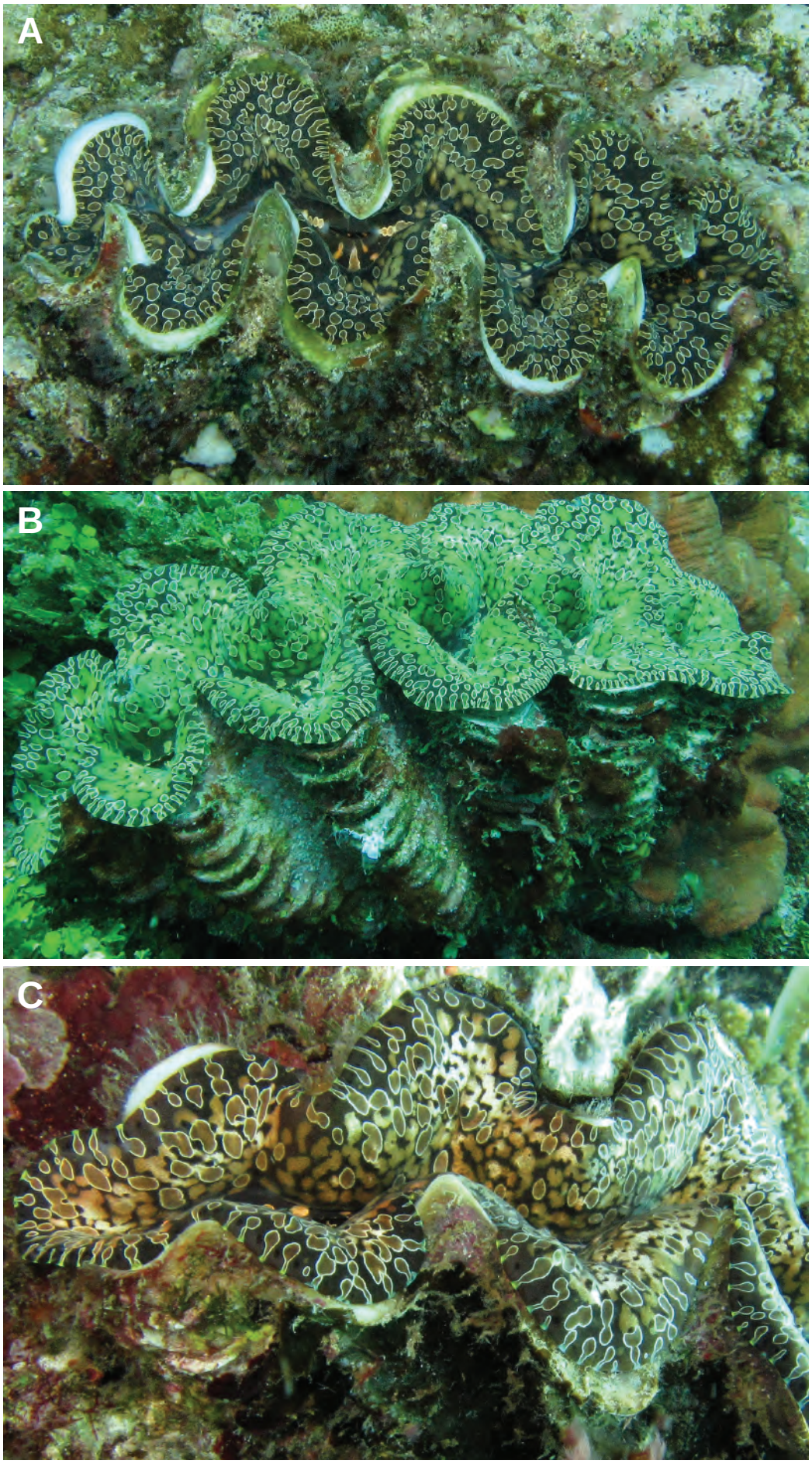

Fig. S3 A-C *Tridacna noae* individuals from the Madang barrier reef, Bismarck Sea (05°10-11'S 145°50'E), photographed uring expedition CORAL TRIANGLE 1, November 2012. Photographs courtesy of IRD / M. Hamel.

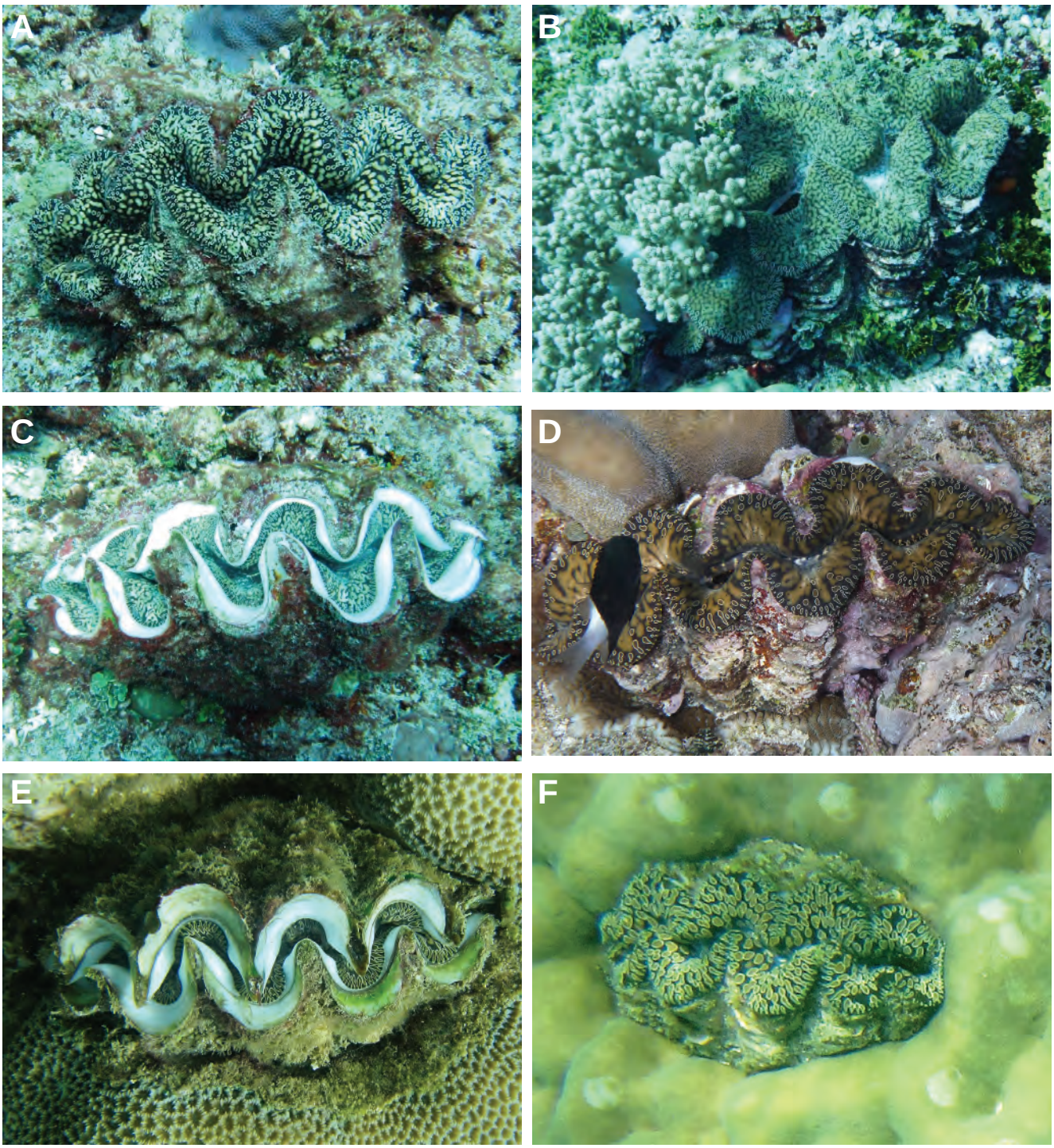

Fig. S4 *Tridacna noae* specimens from the Loyalty Islands and New Caledonia, Coral Sea. **A** From Tiga reef, ca. 10 m depth, photographed during cruise BIBELOT of RV *Alis*, 17 February 2014 (DG). **B** Idem, ca. 15 m depth (CF). **C** Idem, ca. 10 m depth (DG). **D** From Ouvea atoll, 20°26'S 166°29'E; ca. 8 m depth; cruise BIBELOT of RV *Alis*, 22 February 2014 (CF). **E, F** Individuals photographed at Ilot Hiengu, Hienghène, eastern coast of New Caledonia, 05 March 2014 (JT).

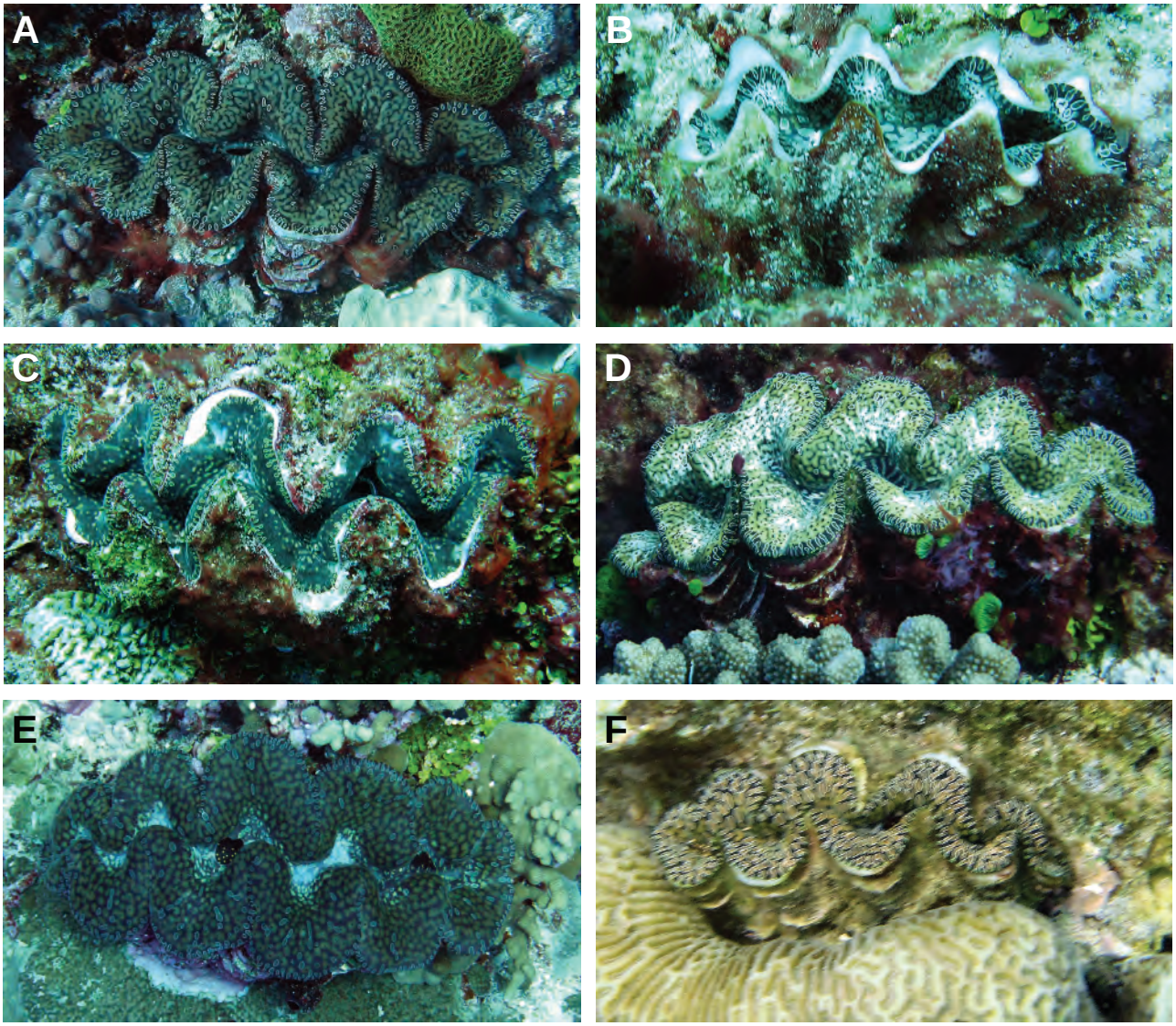

Fig. S5 *Tridacna noae* specimens from the Loyalty Islands, Coral Sea. **A, B** From Tiga reef, ca. 10 m depth; photographed during cruise BIBELOT of RV *Alis*, 17 Feb. 2014 (DG). **C** From Lifou Island, 20°51'S 167°17'E, ca.10 m depth; cruise BIBELOT of RV *Alis*, 18 Feb. 2014 (DG). **D** Idem, ca. 15m depth (CF). **E** From Astrolabe reef, 19°53'S 165°50'E, ca. 12 m depth; cruise BIBELOT of RV *Alis,* 24 Feb. 2014 (CF). **F** From Ilot Hiengu, Hienghène, eastern coast of New Caledonia, 05 March 2014 (JT).

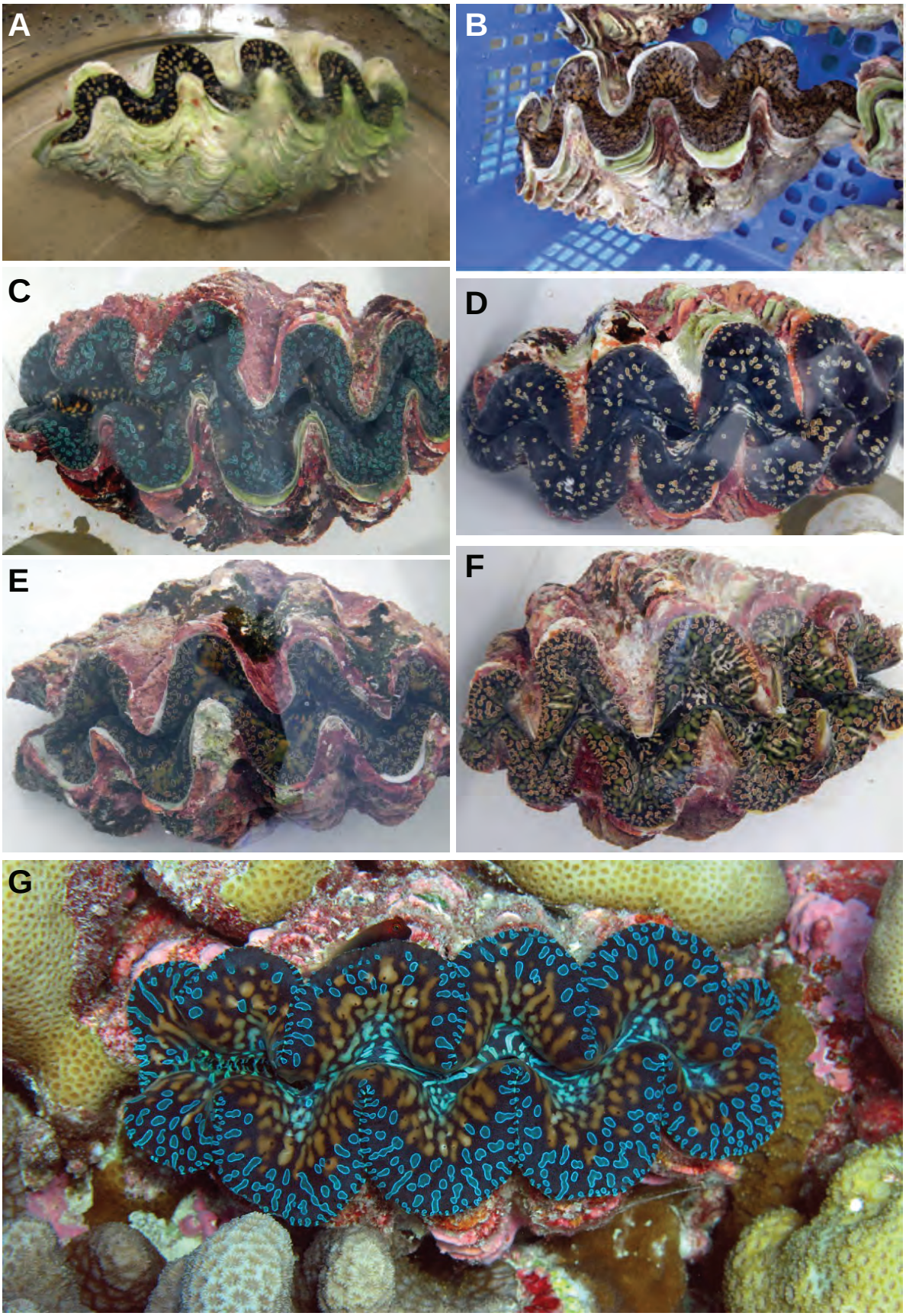

Fig. S6 *Tridacna noae*. **A,B** Specimens collected from the Mangaliliu protected reef area, Efate Island, Vanuatu (17°38'S 168°12'E), 1-5 m depth, during expedition COMPO, 16 January 2012 (JT). **C-F** Specimens collected from the reef off Kosrae (05°18'N 163°02'E), ca. 8-10 m depth (courtesy of M. Selch). **G** Specimen sighted on the reef slope off Paris, Kiritimati (01°56'N 157°31'W), ca. 15 m depth in a habitat characterized by live coral and large coral rubble covered with encrusting red algae, July 2014 (CW).

Fig. S7 *Tridacna noae*. Specimen sighted on the reef flat along Honikulu pass close to Fenuafo'ou Islet off Wallis Island (13°23'S 176°13'W), ca. 1.5 m depth, among a high diversity of live corals in a habitat characterized by strong hydrodynamism, 24 April 2014 (courtesy of P. Bosserelle).

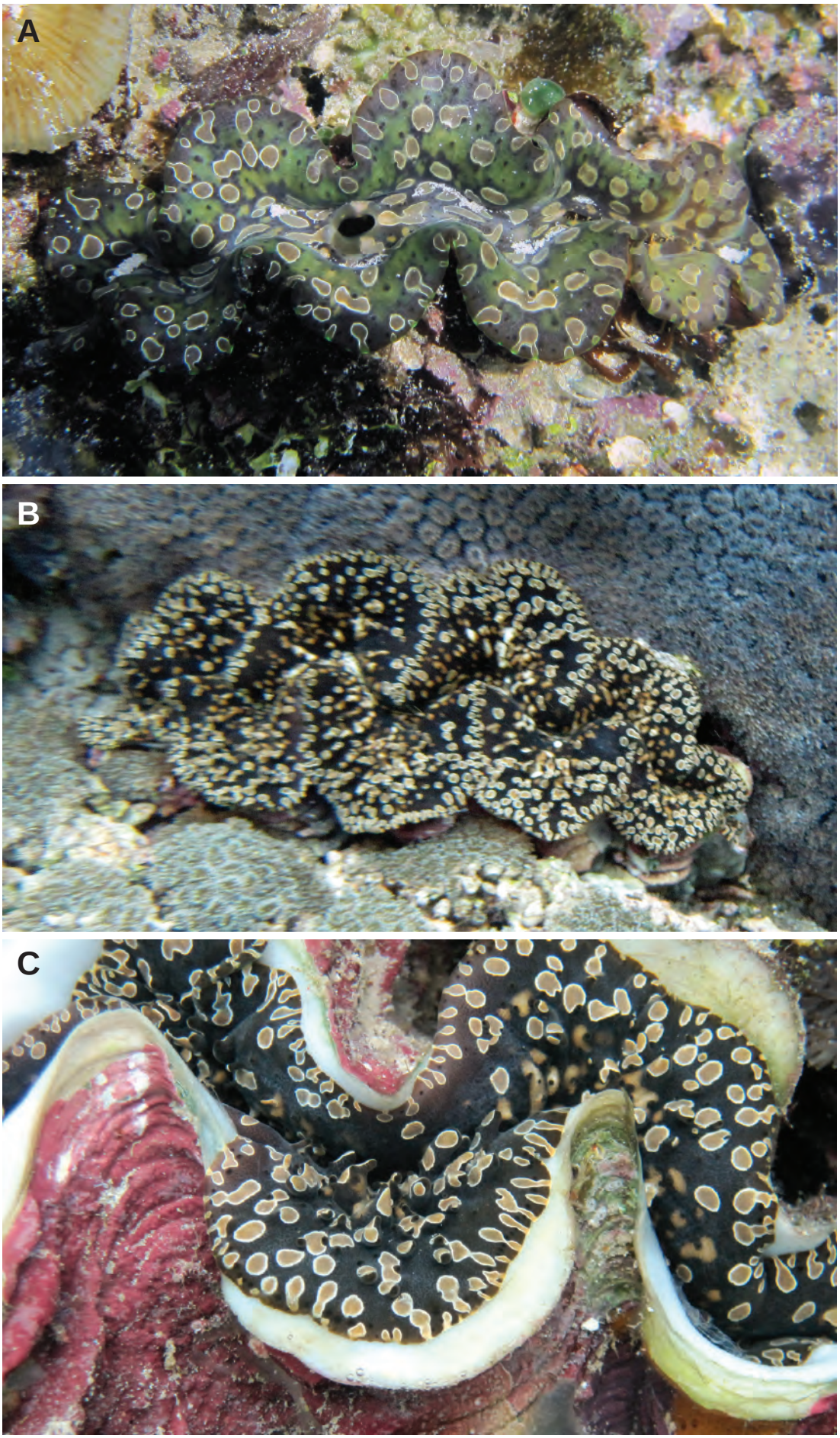

Fig. S8 *Tridacna noae* from the Sawu Sea (MRAN). The two individuals photographed here have been previously presented by Tisera et al. (2012)(their Figs. 2E and 2F). **A** Individual sighted on the reef flat off Pura Island (08°18'S 124°22'E), ca. 2 m depth, 28 October 2010. **B** Individual sighted on the reef off Ternate Island (08°14'S 124°22'E), ca. 3 m depth, 28 October 2010. **C** Close-up on the mantle of the same individual.

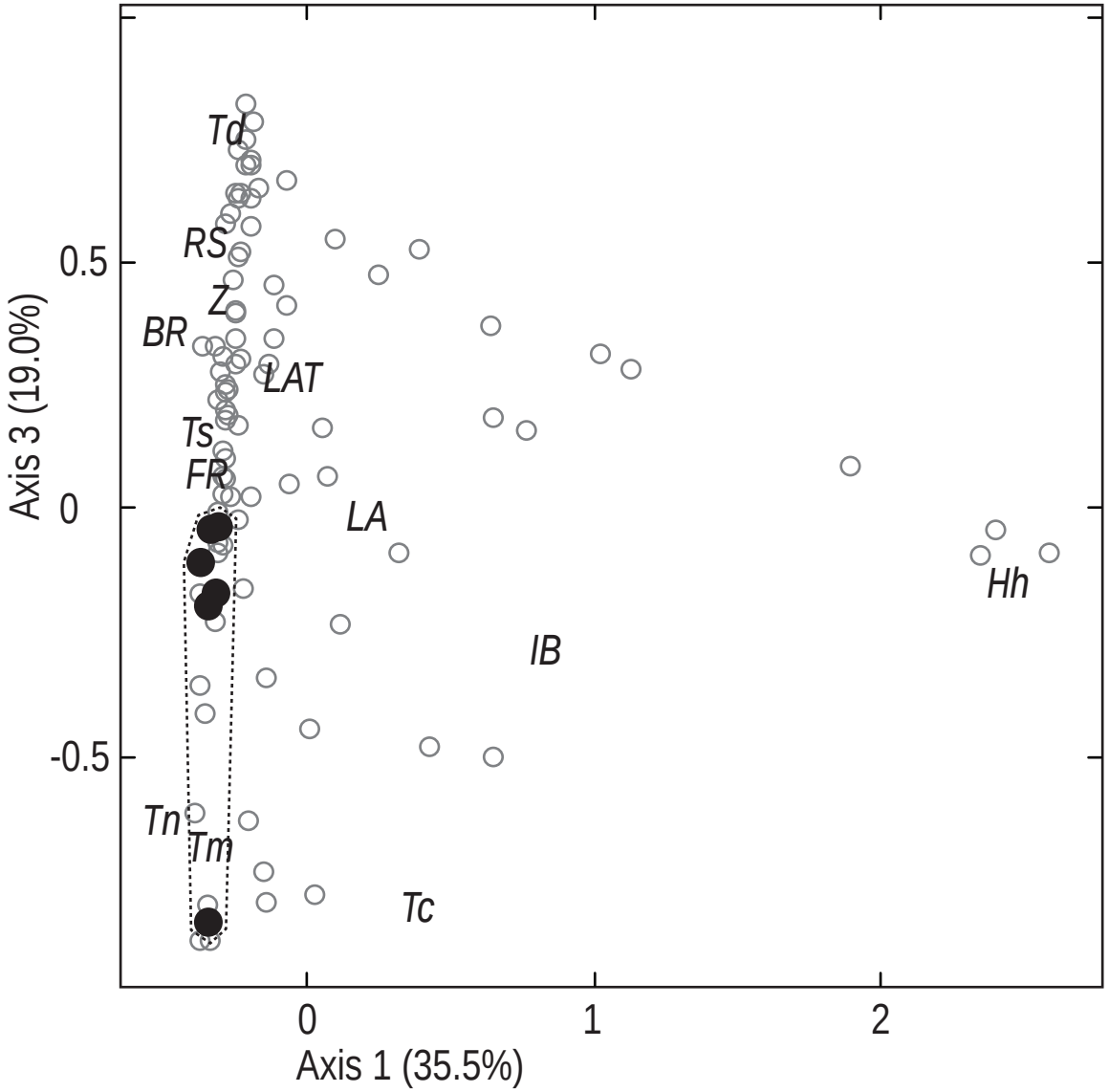

Fig. S9 Characterizing the habitat of Noah's giant clam, *Tridacna noae*, in New Caledonia and the Loyalty Islands. Projection on the second plane of correspondence analysis (Benzécri 1982) of 98 underwater stations surveyed by snorkelling or Scuba diving. Each underwater station was defined by its latitude (*LAT*), rounded to nearest degree, its geomorphology (*BR* barrier reef; *FR* fringing reef; *IB* internal barrier reef; *LA* lagoon, *RS* external reef slope), its average depth (*Z*), and the numbers of *Hippopus hippopus* (*Hh*), *T. crocea* (*Tc*), *T. derasa* (*Ts*), *T. maxima* (*Tm*), *T. noae* (*Tm*) and *T. squamosa* (*Ts*) individuals encountered during the dive. *Solid black circles* designate the 6 underwater stations where *T. noae* was observed; *grey circles*, the other stations.

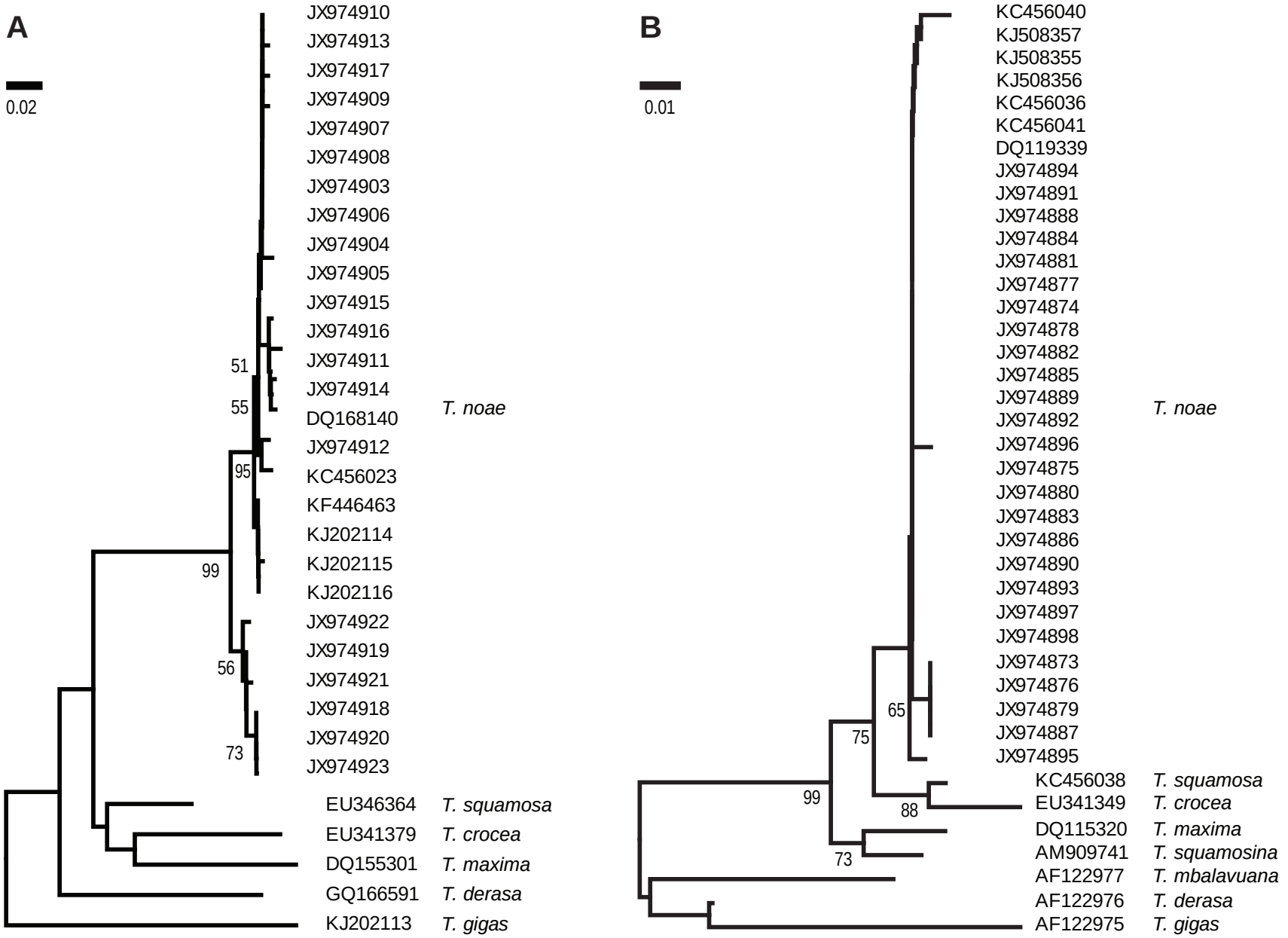

Fig. S10 Neighbor-joining (NJ) trees of giant clam (*Tridacna* spp.) nucleotide sequences retrieved from GENBANK (see Table 1), computed using MEGA5 (Tamura et al. 2011). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches; bootstrap scores ≤ 50% are not shown. Nucleotide distances were estimated using the Kimura 2-parameter method. **A** NJ tree of partial *CO1* gene sequences. All sequences clustering with *T. noae* (KC456023) in a preliminary analysis have been retained in this NJ analysis, together with reference sequences for the other *Tridacna* spp. species. **B** NJ tree of partial *16S* gene sequences. All sequences clustering with *T. noae* (KC456036) in a preliminary analysis have been retained in this NJ analysis, together with reference sequences for the other *Tridacna* spp. species.