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OF WILD FAUNA AND FLORA

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THE DISTRIBUTION, POPULATION CONDITION AND CONSERVATION STATUS OF *PTERAPOGON KAUDERNI* IN 2015

This document is submitted by the Fondation Franz Weber with respect to agenda item 25.*

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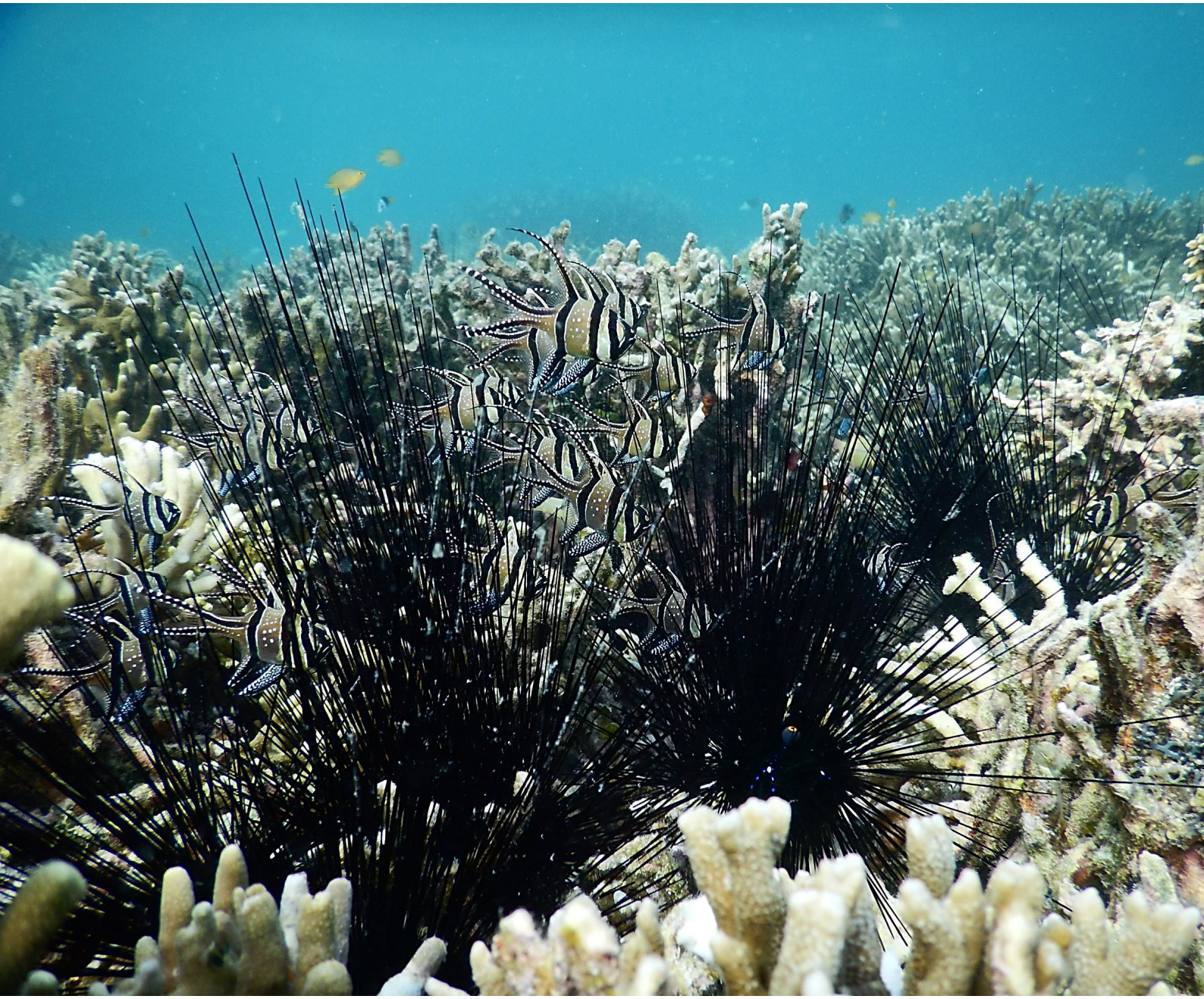

The distribution, population condition and conservation status of *Pterapogon kauderni* in 2015

Report for the 29th Animals Committee Meeting, Convention on International Trade of Endangered Species, CITES, 18 – 22 July, 2017

FONDATION FRANZ WEBER

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Abstract

*Pterapogon kauderni (*Banggai cardinalfish, Koumans 1933) is endemic to a small area of occupancy of 23 square kilometers in an archipelago off the coast of Eastern Central Sulawesi, Indonesia. It lives in shallow waters in coral reefs and sea grass beds commonly in sea urchins coral heads and anemones. It has unusual biological traits such as obligate commensalism with its hosts, sex-role reversal and long incubation period with advanced parental care and a very high level of population genetic structure. It is inscribed as "endangered" in the IUCN Red List due to its overexploitation through the aquarium trade. In 2015 the total individuals of the species within its natural habitat is estimated to be approximately 1.400.000 individuals. In 2015, the mean number of groups per census site was 26.6, representing a ~27% decline from 2007. Similarly, the mean group size of censused populations in 2015 showed a ~ 39% reduction from the mean size group of 2007. In both instances without including four populations that may be considered eradicated or at critical levels. The total maximum potential habitable area for this species has not significantly changed since the last survey. No population was found with a density near to the one considered the baseline data for the species, i.e., ~0.6 individuals/m^2. In 2007, censuses showed a mean density of 0.08 individuals /m^2. In 2015, the mean density of all censused populations declined to 0.05 individuals/m^2, and to an estimated 0.06 individuals/m^2 of all survey sites. Of the 43 populations surveyed, 33 showed abundance conditions from "vulnerable" to "critical" (i.e., with densities of about 0.11 to <0.01). Of the 31 populations revisited in 2015, 15 (48.4%) were found at a lower abundance than in the previous survey: five declined to a critical level, and three populations could not be found again, thus were likely extinct. Of the 13 populations that did not show a significant variation in abundance from the prior survey, 10 (77%) remained to a condition ranging from "vulnerable" to "critical". There has also been a severe and widespread decline in abundance of sea urchins, critical substrates of *P. kauderni*.

Introduction

P. kauderni is an coral reef teleost fish characterized by a series of biological traits that render its ecological function exceptional. It is an atypical apogonid with diurnal behavior. It displays obligated commensalistic relationships with several invertebrates with whom it must remain associated such as corals, sea urchins and anemones. Its ability to associate with anemones (and anemone-like Heliofungia corals) compares to that of anemone fishes (Vagelli & Erdmann, 2002; Vagelli, 2011). Its unusual reproductive biology includes the presence of a sex-role reversal, a long incubation (= embryonic development) period with advanced parental care where the male incubates the eggs and post-hatched embryos orally, very low fecundity, and absence of a larval period (direct development). The parental oral incubation of eggs and post-hatched embryos (and consequent absence of any planktonic dispersing mechanism) coupled with its adult sedentary behavior, precludes this fish of any meaningful dispersal during its entire ontogeny, including a within-parental microhabitat recruitment (Vagelli, 1999, 2004, 2011). This fish also has a highest level of population genetic structure (Hoffman, 2005) recorded in a marine fish. *P. kauderni* plays an important role in its environment by preying on larval stages of coral reef fish parasites, and by being a prey item of several teleosts and a sea snake (Vagelli & Erdmann, 2002; Vagelli 2002; 2005, 2011).

It is not possible to accurately know the historical abundance of *P. kauderni* given that the first quantitative surveys were conducted in 2001, after collection had begun (Vagelli, 2002; Vagelli & Erdmann, 2002). However, quantitative assessments of the only known unexploited population has

provided a reasonable estimate of individuals to compare to as baseline data (abundance). Such a population inhabits the "Pearl Farm" site, which lays within a protected bay off Banggai Island. In 2002, its density was calculated to be 0.63 individuals/m^2 (Lunn & Moreau, 2004), and in 2004 ~0.58 individuals/m^2 (Vagelli, 2005, 2008). Thus, the estimated baseline density of *P. kauderni* within its natural range has been considered to be ~ 0.6 individuals/ m^2, and any significant reduction in individuals has been considered to have been due to human extraction (Vagelli, 2008, 2011).

Significant widespread collection of *P. kauderni* began in the late 1990s. By 2004, the estimated mean density for the distributional range showed a reduction to ~0.07 individuals/m^2 (range: 0.028-0.21). This decline in density represented a reduction of about 90% of the species abundance, and was a critical component on the assessment that led to the species inclusion in the IUCN Red List as "endangered" (IUCN, 2007).

This remarkable fish has become emblematic of the exploitation of marine ornamentals for the international aquarium trade and the difficulties of associated conservation efforts (Roberts & Hawkins, 1999; Wabnitz et al., 2003; Helfman et al., 2009; Thornhill, 2012). Therefore, *P. kauderni* is found in a grave conservation situation. No effective conservation program has been implemented in the Banggai region since the inclusion of *P. kauderni* in the IUCN Red List as "endangered" and captures continue to be unregulated.

This study summarizes the results of the most recent population assessment of *P. kauderni* done in 2015 covering most of the species natural geographic range. These analysis were conducted as a continuation of assessments of the species in its natural range and for the member stated to the Conference of the Parties of the Convention on International Trade of Endangered Species of Fauna and Flora CITES which took place in September 2016 in South Africa, to underline the urgency of protecting the species from international trade. No protection status was agreed upon (Appendix I or II) but a series of decisions require Indonesia to put in place a conservation and management plan for the 30th Animals Committee meeting taking place in 2018.

Methods

The fieldwork within the Banggai Archipelago took place between March 6-March 24, 2015 and was carried out with the live-aboard boat mv Nusa Tara (Grand Komodo Diving & Adventure, Bali, Indonesia) equipped with air compressor, SCUBA gear for six people and a 4-m speedboat. Data on habitat condition as well on abundance of both fish population and microhabitat/host (sea urchin-anemones) was collected at 52 sites in 25 islands within the Banggai Archipelago (Figure 1).

Censuses were conducted following the same methods utilized in previous surveys: the census site was located following GPS coordinates, and the census began at one of the previously determined site limits.In case of a new census site, the limits, i.e., the population's geographic range, was determined by conducting a preliminary survey. Censuses were completed by two divers swimming perpendicular to the shoreline, from the mangrove-line to the reef crest or to a depth up to ~4 m, returning to the mangrove-line while covering a new transect adjacent to the previous one, and then repeating the same pattern. Divers swam parallel to each other, separated by ~4 m, and each diver plotts a ~4 m-wide strip (2 m to each side), totalizing an 8 m-wide transect. Net census time was 60 minutes; the swimming speed was maintained at ~10 m/minute, resulting in a total covered area of ~4800 m^2. At each encounter with *P. kauderni*, the timer was stopped and data was entered on prepared tables clipped to plastic slates. Data included time, depth, type of habitat/microhabitat, fish assemblages, demographics (group size, number

of individuals/size class, number of mating pairs and brooding males). All censuses were conducted by the same two researchers that participated in all previous census work.

Censuses were conducted in 11 sites (nine islands), including a site and island censused for the first time, i.e., Masepe. Thus, censuses were conducted in all populations previously censused, with the exception of the population inhabiting the "Pearl Farm" site in South West Banggai. The farm's owner was not present during the fieldwork period, and hence no permission to survey the site could be obtained. The population "Limbo3" was last censused in 2004. In 2007 it was surveyed but no actual census was conducted.

Surveys were done to establish where the populations are locatet. All surveys conducted in the remaining 41 sites covered a minimum area of that of the census site (~4800 m^2), and generally they covered larger surfaces. Surveys included all habitats present at the sites, from the coastline to depths of ~5m. Between three and four divers/researchers participated in the surveys, each assessing an approximately similar area of ~30 x 50 m. In each site, surveys included the approximate number of *P. kauderni* groups, average size of groups, host association, largest (counted) fish group, (counted) new recruits and host association, general status of coral cover, abundance of sea urchins and anemones, and evidence of destructive fishing. In several occasions, a diver encountered large fish groups, high anemones-urchin abundance/significant habitat degradation. In those instances, the diver communicated the finding to the rest of the team. Photographic documentation was done with digital still and video cameras. After each survey, the information was immediately shared among the team members and logged.

Of the 52 visited sites, 34 (21 islands) were previously surveyed, 30 sites during the last surveys conducted in 2007, three sites in 2004, and one site in 2002. In addition, 18 new sites were surveyed for the first time, including 15 sites located in 10 islands where *P. kauderni* was previously encountered, and three sites in Panteh Island (suspected of not harboring *P. kauderni*, but reported to be inhabited after the 2007 survey. With the exception of Taliabu, every island larger than 2.9 km^2 was included in this survey. In addition to Taliabu, eight islands harboring *P. kauderni* were not surveyed as these are all small islands (1.2-2.9 km in length) that previously contain very small populations.

In order to compare the condition of *P. kauderni* populations, substrates, and habitats encountered during this fieldwork with the previous assessment, a quantification system (Table 1) of such conditions was devised. It was largely based on data from censuses and photographic information including all previous surveys. Although acknowledged as arbitrary, it adequately characterizes the mentioned conditions, and allows an accurate comparison among sites and years.

Quantification of Population Condition

Condition	# Fish/site (4800m^2)	Density (ind/m^2)	Equivalent distribution*
6 = very good	3000-2000	(~0.6-0.4)	~ 85g x 20-30i (1g/60m^2)
5 = good	1900-960	(~ 0.39-0.20)	~50g x 25-30i (1g/90m^2)
4 = fair-vulnerable:	900-600	(~0.19-0.12)	~35g x 20i (1g/130m^2)
3 = vuln.-high risk :	350-240	(~0.11-0.05)	~20g x 15i (1g/240m^2)
2 = very high risk:	190-50	(0.04-0.01)	~10g x 12i (1g/480m^2)
1 = critical:	<50	(<0.01)	
0 = extinct	no fish found in searched site		
* Based on commonly encountered group distribution (~ average range of d/site). g: group; i: individual			

Quantification of sea urchin abundance

Condition	urchin clump size	occurrence
5	> 3 m (very large)	present
4	~2-2.5 m (large)	widespread
3	~1-1.5m (medium)	widespread
2	~0.5-0.8 m (small)	~ 4 -10 clumps/site
1	<0.4 m (very small)	1-5 clumps/site
0	Absent	

Quantification of anemone abundance

Condition	Ind./site (= ~census area)
3	> 15
2	4-10
1	1-3
0	Absent

Quantification of habitat condition

Condition	Characteristics
4 = good	No recent blast damage / high % coral cover / high abundance of substrates
3 = fair	Contains some good coral patches / monticules / substrates
2 = poor	Little coral cover / few monticules; issues: bleaching / crown thorns/ algae
1 = very poor	No/very reduced coral cover /substrates, most ruble; severe environ. conditions

Table 1: Quantification system to measurement for populations of *P. kauderni*, substrates and habitats.

The maximum potential habitat available (MAPHA) is calculated by multiplying the islands perimeters available for the species by a width of 80 m, which represents the approximate average distance from the coastline to depths of ~ 4 m (Vagelli, 2005, 2011). The total population of the species within its natural habitat was calculated by multiplying all censused fish by the MAPHA.

The assessment on the status of local conservation efforts and trade was carried out by conducting numerous interviews with regional/local authorities and other stakeholders. They included government officials: the Banggai Regional Governor (Bupati, Banggai Laut), Mr. Mohamad Hidayat; the Head of the Banggai Marine and Fisheries Service (Kadis Kelautan Perikanan), Mr. Abdullah Malida; Officers of the Fish Quarantine Office (Banggai Is.); Chiefs of Villages (towns) including: Latinbung, BoneBone, Kalupati (Bangkuru), Bone Baru (Banggai), Panapat (Bokan), Bentosi (Labobo), Toropot (Telopo), Limbo, Masepe, Masoni, and Melilis. Moreover, interviews were held with an ex-official of Fish Quarantine Office (Banggai), and fish collectors and traders throughout the Banggai region. In addition, the sites where conservation actions aimed to *P. kauderni* were reported as having been developed, such as the "Banggai Conservation Center", "Communities MPA" and "MPAs network" (Banggai; Togonglantan) were visited.

Results

Geographic distribution and area of occupancy

The natural geographic range of *P. kauderni*, i.e., the Banggai Archipelago, extends from 01° 24' 57.6" latitude South (Monsamat area, East Peleng Island, as its north most distribution point) to 02 ° 05' 53.5'' latitude South (Loisa A Island), and from 123 ° 0.3'04.2" of longitude East (Southwest Bangkuru Island, as its westernmost distribution), to approximately 124 ° 23' 30" longitude East (the southeast end of Taliabu Island). Within this range *P. kauderni* is limited to 34 out of the 67 islands (~51 %) with a maximum potential available habitat (MAPHA) of about 23 $km^{2.}$ The 2015 surveys included Panteh Island, the last small island not previously searched, and showed that *P. kauderni* was absent in this island. Thus, despite the availability of habitats and substrates similar to those found on islands where the fish occurs, the species is absent from the waters off 33 islands within the distributional area (~ 49%). The reduction with respect to the previous estimation is due to both declining of populations, and a more accurate estimation of potential habitable perimeter of all inhabited islands.

Population status

Surveys data comprises data from all surveyed populations including censuses. During the 2015 surveys 52 sites were visited in 25 islands, encompassing over 90% of the species natural geographic range. *P. kauderni* was present in 40 sites, in 22 islands. It was absent in Panteh, Togonglantan and Latitis Islands (most likely never inhabited by the species). In addition, *P. kauderni* was absent in seven sites located in islands inhabited by it, including three sites where the fish was present in 2007, and three where it was likely present in the past. No population was found at one site classified as in "very good" condition, i.e., with a density close to the one considered the baseline for the species (~0.5-0.6 individuals/m^2) (Table 2).

The data analysis of censuses conducted in March 2015 show that the overall abundance of *P. kauderni* within its entire region has further declined from the prior assessment. In 2007, censuses showed a mean density of 0.08 individuals/m^2. In 2015, the mean density of censused populations declined to 0.05 individuals/m^2 (range: 0.001-0.15).

The three populations that in 2007 had higher densities than in 2004 (Banggai4, Bokan, and Labobo) and the other three that had densities of at least 0.1 individuals/m^2 (Bangkuru5, Banggai4, and Seku) suffered a very significant decline in abundance (Table 5).

Also the mean number of groups per site,not including eradicated or at critical level sites, was 26.6, representing a ~27% decline from 2007, when the mean was 36.4 groups/site. Similarly, the mean group size of all sites *censused* in 2015 (excluding Limbo, Limbo3, Masoni, Peleng) was 14.1 individuals, which represents a ~39% reduction from the mean group size (23 individuals) of 2007 (Table 3).

The population at the census site in Masoni Island, drastically reduced in 2007, has likely become extinct. No individuals were found at the census site. Furthermore, a search on the remaining inhabitable sites (located on the west side of Masoni named ???) uncovered no more than ~50 individuals. The population at the census site in Peleng Island, drastically reduced in 2007, has virtually become extinct. Only one individual was localized at the census site. The remnants of the population inhabiting the census site in Limbo Island which had beenreduced to a critical level in 2004, and with only four fish found in 2007, did not recover. Only eight individuals were found at the census site. The small population inhabiting the census site Limbo3 in Limbo Island has likely become extinct. No specimens were found.

Of the 43 *populations surveyed* (22 islands), eight (18.6%) were found at a "fair" condition (see methods), two (4.7%; two islands) at a "good" condition, and 33 (76.7%; 17 islands) showed abundance

conditions from "vulnerable" to "critical" (i.e., with densities of about 0.11 to <0.01) (Table 3). Of the 31 populations (19 islands) revisited in 2015, three (9.6%) (3 islands) were found at a higher abundance than in the previous survey (Table 4); 15 (48.4%) (12 islands) at a lower abundance, and 13 (42%) (12 islands) at a similar abundance. Of the 15 populations in which the condition worsened, five declined to a critical level, and three had 0 presence at the census site (likely extinct) (Table 5). Of the 13 populations that did not show a significant variation from the prior survey, 10 (77%) remained in a condition ranging from "vulnerable" to "critical, while three (23%) maintained a "fair" condition (Table 6). Of the 18 (new) sites visited for the first time (in 10 islands inhabited by *P. kauderni*) none contained population at a "good" or better condition, four at "fair-vulnerable", seven contained populations "vulnerable" to "very high risk", one at "critical" condition, and three sites had 0 presence (Table 7).

Thus the estimated mean density for all populations is ~0.06 individuals/m^2 (cite range) and the total population of the species within its natural habitat is estimated to be approximately 1.400.000 individuals.

Table 2 Status of populations surveyed in 2005 and changes with respect to the previous assessment.
See Methods for condition equivalent to density. *: site surveyed for first time; **: last survey in 2002; ***: last survey in 2004.
In parenthesis: number of individuals; in bold: census sites. A: anemone; BC: branching coral; L/TBC: low/tall branching coral; U: urchin

			Population Condition		Main Association		Urchin Abundance		Anemone Abundance		Habitat Condition	
Is #	Site#	Is./Site name	2015	2007	2015	2007	2015	2007	2015	2007	2015	2007
1	1	Bakakan N	3	2	U/A	U	4	3	3	3	3-4	3-4
2	2	Bakakan S	0	1	n/a	U	2	3	0	1	2-3	3
3	3	Bandang W	5	4	U	LBC	4	4	2	2	3	3
4	4	Banggai N2*	3	n/a	LBC	n/a	1	n/a	1	n/a	4	n/a
	5	Banggai N **	3	3	U/LBC	U/LBC	2	2	0	1	3-4	3-4
	6	**Banggai 4**	3	4	BC	U	0	3	1	3	3	3
	7	Banggai 4 N cen*	3	n/a	BC/A	n/a	1	n/a	2	n/a	3	n/a
	8	Banggai 7 Toko	5	4	BC/A/U	U	4	4	3	3	3-4	3-4
	9	Banggai Matan*	0	n/a	n/a	n/a	1	n/a	0	n/a	1-2	n/a
5	10	Bangko NE bay	1	3	C	n/a	1	n/a	0	n/a	2-3	n/a
	11	Bangko 2 Out bay	1	2	TBC	A	1	1	1	2	2-3	2-3
	12	Bangko N 3*	0	n/a	n/a	n/a	1	n/a	1	n/a	2-3	n/a
6	13	Bangkuru BoneBone	3	3	U	U	3	3	1	1	3	3
	14	Bangkuru 3 stone	3	3	U	U	3	3	1	1	2	2
	15	**Bangkuru 5**	3	4	BC	U	1	4	1	1	2-3	2-3
	16	**Bangkuru 6**	4	5	BC	U	1	4	1	0	2-3	2-3
7	17	Bondoe N	2	2	U/C	U	2	2	2	2	3	2-3
	18	Bondoe E-S*	0	n/a	n/a	n/a	1	n/a	1	n/a	3	n/a
8	19	Bokan NW bay	4	4	U	U	2	3	3	2	3	3
	20	**Bokan**	3	5	BC	U	3	5	3	3	3-4	3-4
9	21	BuangBuang*	4	n/a	U	n/a	4	n/a	2	n/a	3-4	n/a
10	22	Kembongan *	4	n/a	U/A/BC	n/a	4	n/a	2	n/a	3-4	n/a
11	23	Kenau ***	3	3	BC/U/A	BC/U/A	2	2	3	2	2	2
12	24	Kokudan	4	4	BC/U		3	3	2	3	3-4	3-4
13	25	Latitis	0	0	n/a	n/a	2	2	2	2	3	3
14	**26**	**Labobo**	1	3	BC	BC	1	3	1	0	2-3	2-3
	27	Labobo Lalo	3	3	BC	U	2	3	2	2	2	2
	28	Labobo Pula *	3	n/a	BC	n/a	2	n/a	2	n/a	4	n/a

Table 3 **Variation in number of groups per site (4800 m^2), mean group size, and density (ind./m^2) between the 2015 and the previous census.**

Year	Is./site	# G/site	mean G size	Density
2007	Banggai 4	62	12.5	0.15
2015	**Banggai 4**	**18**	**18.5**	**0.07**
2007	Bangkuru 5	38	28.4	0.19
2015	**Bangkuru 5**	**13**	**19.4**	**0.05**
2007	Bangkuru 6	19	55.3	0.218
2015	**Bangkuru 6**	**41**	**15.2**	**0.13**
2007	Bokan	49	23.5	0.23
2015	**Bokan**	**41**	**13**	**0.11**
2007	Labobo	25	20.6	0.1
2015	**Labobo**	**14**	**2.4**	**0.01**
2007	Limbo	1	n/a	0.001
2015	**Limbo**	**3**	**2.3**	**0.001**

Year	Is./site	# G/site	mean G size	Density
2004	Limbo 3	15	10.4	0.03
2015	**Limbo 3**	**n/a**	**n/a**	**0**
2007	Masepe	n/a	n/a	n/a
2015	**Masepe**	**31**	**23.5**	**0.15**
2007	Masoni	1	n/a	0.001
2015	**Masoni**	n/a	**n/a**	**0**
2007	Peleng 3	5	5.4	0.005
2015	**Peleng 3**	**1**	**n/a**	**0.0002**
2007	Seku E	47	10.2	0.1
2015	**Seku E**	**28**	**6.9**	**0.04**

2007	**36.4***	**23***	**0.08***
2015	**26.6***	**14.1***	**0.05***

* Not including sites at critical level

Table 4 **Improved Condition**

Is./site	2015	2007
Bakakan N	3	2
Bandang W	5	4
Banngai 7	5	4

Table 5 **Worsened Condition**

Is./site	2015	2007
Bakakan S	0	1
Banggai 4	3	4
Bangko NE	1	3
Bangko 2	1	2
Bangkuru 5	3	4
Bangkuru 6	4	5
Bokan	3	5
Labobo	1	3
Limbo 3	0	3
Masoni	0	1
Melilis	1	4
Peleng Liang	1	3
Seku S bay	3	4
Seku	2	3
Tempaus	2	3

Table 6 **No Significant Change**

Is./site	2015	2007
Banggai N	3	3
Bangkuru Bone	3	3
Bangkuru 3	3	3
Bondoe N	2	2
Bokan NW Bay	4	4
Kenau	3	3
Kokudan	4	4
Labobo Lalo	3	3
Limbo	1	1
Masepe	4	4
Masoni 5	1	1
Peleng	1	1
Telopapaun	3	3

Table 7 **. New Sites**

Is./site	2015
Banggai N2	3
Banggai N cen	3
Banggai Mat	0
Bangko N 3	0
Bondoe E-S	0
BuangBuang	4
Kembongan S	4
Labobo Pula	3
Labobo Bontosi	4
Masoni bay S	1
Peleng farm	4
Peleng S Liang	3
Seku S corner	3
Seku N	2
Telopo SW	3

See Methods for condition equivalent to density. **:last survey in 2002; ***: last survey in 2004. In parenthesis: number of individuals.

Habitat and substrate condition affecting *P. kauderni*
Blast fishing remains widespread in the Banggai Archipelago. During this survey, we have witnessed several instances of this destructive fishing method and its devastating effects on coral reefs and associated fauna. Areas with severe substrate degradation included Matanga (Southeast Banggai) where the absence of the species may be related to the habitat condition. The same can be said forthe survey sites of Bangko3, West BuangBuang Southwest Labobo, Melilis , and South Telopo.

A widespread decline in abundance of sea urchins (*Diadema setosum*), critical substrates of *P. kauderni* was found. In 41 (79%) of 52 sites visited in 2015, the abundance value of *D. setosum* ranged between 0 and 2, including 26 (50%) sites with a value of 1, and three with 0. No site had the maximum abundance value of 5 (Table 1).

Of the 34 *sites* (21 islands) re-visited in 2015, 18 (53%) (11 islands) showed a decline in sea urchin abundance. In 25 (73.5%) sites the maximum abundance value was 2, including three sites with 0 presence. In contrast, during the previous survey only 13 sites (38.2%) had similar low abundance values (and no sites had 0) (Table 1).

Moreover, this study has shown a widespread low abundance as well as an important decrease in abundance, with respect to the previous survey, of anemones and anemone-like corals of the genus *Heliofungia*, another critical living substrate for *P. kauderni.* Thus, 26 sites (14 islands) of the 52 sites (25 islands) surveyed in 2015, contained anemones with a maximum abundance value of 1 (= up to 3 anemones encountered/site, Table 1). In addition, of the 31 sites re-visited in 2015 with known *P. kauderni* presence, 16 showed a maximum abundance value of 1, including four with 0 presence. In 2007, 11 sites had similar low values, including two with 0 presence (Table 1).

During the 2015 surveys significant habitat changes due to climatic factures such as storms were observed in the following sites harboring (or formerly harboring) populations of *P. kauderni*: West Limbo (including the census area surveyed since 2001), Kokudan, and west Masoni,particularly the census area, also surveyed since 200).

In-situ conservation efforts
No aquaculture or captive breeding projects are in place, and no village in the Banggai Archipelago is considering implementing such a project. No marine protected area (MPA) has been established and *P. kauderni* is absent from Togonglantan Island which was supposed to be part of a MPA network.

The collection of *P. kauderni* is not being tracked by local quarantine and fisheries authorities based on Banggai Island. They rely on the “voluntary” decision of a buyer to stop in Banggai island to comply with any regulation. In few occasions the buyers report to the fisheries department authorities and quarantine officers. The fish cargo is rearly checked, instead, samples are brought to them by the buyer for assessing fish health. Officers at the quarantine station in Manado, the capital of Sulawesi, told us that the never accurately estimate the number of individual fish being shipped out of the Banggai region, much less mortalities associated with collection and shipment. On those few occasions that shipments are checked, only a general estimation of the boxes and or bags are made. As we were told by an ex-quarantine officer and by collectors in BoneBaru,a main collection/shipping center in Banggai Island. In addition, collectors are now using the much increased “public transportation” to ship out fishes that they bag themselves bypassing collection centers.

Regarding collection methods, no meaningful change has taken place since our last survey in 2007 (Vagelli, 2008)Despite fishers being aware of the conservation importance of avoiding the capture of brooding males, they are not separated during the capture process and typically brooding males release the eggs and embryos during the netting and handling. This is not surprising since separating the brooding males would be a difficult and time consuming task given the fish group behavior, and the capture method employed corralling the entire group of fish into the nets in short–intense bursts of free-diving actions.

In 2007 the "Banggai Cardinal Fish Center" should have been established in BoneBaru to serve as a focus point for the conservation and management of the species. The buildings were never operated and are decying. The local villagers resent the investment of ~Rp 200.000.000 (about 15.000 US$).

As March 2015, the only tangible outcomes of all reported planned and implemented local conservation actions aimed to protect and manage *P. kauderni* in the entire Banggai Archipelago since 2007 are a sign identifying a 100m span of shallow reef area as a conservation site located in Buang Buang Island. However, no conservation activities take place, no personnel are assigned, and enforcement against destructive fishing and fish captures is absent. Furthermore, a sign reading'protection and conservation of endemic species' posted at the entrance of a village south of BoneBone, Southeast Bangkuru Island, alluds to conservation action towards *P. kauderni*. However, no conservation program is implemented in the entire Island

Discussion

The 2015 populations survey demonstrated that *P. kauderni* continues to be seriously imperiled primarily due to over-collection for the international marine ornamental fish trade. Since the first quantitative assessments, completed in 2001, no population has been near to what it is considered its historical density which was established at the site 'Perl farm' with 0.6 individual/m2 in 2002 (Vagelli, 2008, 2011) and has never been exploited due to a the owner prohibiting collection. There have been fluctuations on collection efforts on particular sites but 2015 is the lowest overall population size of just 0.06 individual/m2 ever measured, i. e. just 1.4 million specimens.
One goal of this survey was to investigate if any population that during the previous survey demonstrated a significant reduction in abundance due to overexploitation had since then not experienced further captures. If such populations were to be discoverd, then the new census would be particularly useful to estimate the capacity of *P. kauderni* population recovery. Moreover, such valuable data would advance estimations of sustainable yield and eventually,if captures were to be regulated, it would help to delineate stock assessment and management methods. Three populations with such characteristics were identified at Masoni, Limbo, and Peleng, and their censuses providing an unambiguous assessment, i.e., once populations of *P. kauderni* are reduced to ~ < 0.02 individuals/ m^2, they are not able to recover. The 2015 census of these populations supports our characterization of *P. kauderni* as a low-productivity species and populations reaching such low abundance are not able to recuperate even in absence of further collection pressure.

In 2007 this species was considered to be included in the appendecies of the Convention on International Trade of Endangered Species CITES to regulate its trade. But due, among other, to the FAOs negative evaluation, the proposal which did not include survey data fromthe March 2007 survey, negatively impacted the outcome and the species was not protected. The FAOs arguments were in part based on the reported significant increase bydoubling in density of the Masoni population over

two years (between 2002 and 2004) in response to halt in its collection. However, said increase occurred in a depleted population of only about130 individuals. By March 2007, the Masoni population had largely collapsed with only 38 fish remaining. As this study shows, during the 2015 census, no individuals were found in the census site of Masoni, thusthis population is likely to have become extinct. Furthermore, only ~ 50 fish were uncovered in the entire Masoni Island. The FAO has since re-examined the species and evaluates it as a low productivity species as of 2016.

Similar situations occurred with the populations of Peleng which isprobably extinct, and Limbo where only one individual was found in the census site. Both suffered intense declines prior to the 2007 survey.

The observed important general decline in the abundance of long-spine sea urchins (*Diadema setosum*), adds a new threat to *P. kauderni*. This fish is an obligated commensal with living benthic substrates, and sea urchins are significantly the most utilized host by this species, making them critical for its survival. This vital dependence on available substrates including anemones, which also were found at lower densities, emphasizes the high vulnerability of *P. kauderni*, even in absence of a heavy collection pressure.

The unique reproduction behavior with lack of planktonic dispersal coupled with its adult sedentary behavior precludes this fish from any meaningful displacement. Its populations are restricted to reef patches and seagrass beds and are isolated from other populations. The resulting extreme philopatry of *P. kauderni* is reflected by the possession of the highest genetic structure documented for a marine fish. Molecular studies have demonstrated that populations separated even only by a few km on the same islands are genetically distinct (Bernardi & Vagelli, 2004; Hoffman et al., 2005; Vagelli et al., 2009).

The significant decline, a highly restricted and fragmented distribution, low productivity, and persisting high demand by the ornamental fish trade led, in 2007, to the inclusion of *P. kauderni* on the IUCN Red List as “endangered” (Allen & Donaldson, 2007). Nonetheless, two attempts (2007, 2016) to include the species on the appendix II of CITES to regulate trade failed. In 2016 the CITES member states decided that Indonesia will have to implement protection and management schemes by the end of 2018 (CITES, 2016) otherwise the right is reserved to take further steps such as include the species on appendix II of CITES at the Conference of the Parties in 2019.

Since the last conservation and population assessment of *P. kauderni* and its inclusion in the IUCN Red List as “endangered” in 2007, several conservation actions have been reported although, generally in an unsubstantiated and sometimes even contradictory manner such as setting of harvest quotas, tracking of captures and exports by local quarantine and fisheries authorities, establishing of a “Banggai Cardinalfish Conservation Center” and “communities MPA”, and/or a “MPA network” in Banggai and Togonglantan Island. It has been also reported an improvement in collection methods, which supposedly decreases damage to capture fish and avoid the capture of brooding males (Moore & Ndobe, 2007; Ndobe & Moore, 2009; Moore et al., 2011; Ndobe et al., 2011, 2012). The findings of this study indicate that no coordinated or effective conservation program aimed to protect *P.n kauderni* has been implemented in the Banggai region. The above mentioned local conservation efforts either were never put in place, generally for lack of financial or technical support, or were without any enforcement measures that no positive effect on the conservation status of this species was felt.

Conclusion

The generalized decline in *P. kauderni* abundance, including a severe decline of several populations, and the further exterminations of others since the 2007 surveys, clearly demonstrates that capture pressure continues to be unsustainable, and that no local management action has made any positive impact on the species conservation status.
However, to date, despite statements that conservation actions had been planned or even implemented (Moore & Ndobe, 2007; Lilley, 2008; Ndobe & Moore, 2009; Ndobe et al., 2012), it remains without protection and it continues to be captured without regulations. It is clear that if no action is taken to decrease the current collection levels, the unregulated capture for the marine ornamental fish trade coupled with the loss of habitat and host substrates will lead to the extinction of more populations, resulting in further eradication of distinct genetic lineages and possibly the whole species.

The inclusion of *P. kauderni* in the IUCN Red List as "endangered" underscores its poor conservation status. However, this designation does not restrict international trade or collection. Thus it is imperative to provide meaningful protection measures and population management to *P. kauderni* such as the inclusion on the appendicies of CITES to regulate trade.

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Figure 1. Map showing the natural geographic distribution of *P. kauderni* (based on 275 sampling sites, 67 Islands). *P. kauderni* is restricted to an area of ~5500 km^2 (within green dashed polygon). However the maximum potential available habitat is about 23 km^2. Red perimeters indicate absence of the species. The 52 sites (on 25 islands) visited during the 2015 surveys are indicated by the arrows. Numbers in green indicate presences; in red: absences; in blue: census sites).