CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Seventeenth meeting of the Conference of the Parties
Johannesburg (South Africa), 24 September – 5 October 2016

CONSIDERATION OF PROPOSALS FOR AMENDMENT OF APPENDICES I AND II

A. Proposal

Inclusion of *Pterapogon kauderni* in Appendix II, in accordance with Article II, paragraph 2(a) of the Convention and satisfying Criteria A and B in Annex 2a of Resolution Conf. 9.24 (Rev. CoP16).

B. Proponent

The European Union*

C. Supporting statement

1. Taxonomy

1.1 Class: Actinopterygii

1.2 Order: Perciformes

1.3 Family: Apogonidae

1.4 Genus, species or subspecies, including author and year: *Pterapogon kauderni* Koumans, 1933

1.5 Scientific synonyms:

1.6 Common names: English: Banggai Cardinalfish
French: Poisson-cardinal de Banggai
Spanish: Pez cardenal de Banggai

1.7 Code numbers:

2. Overview

Pterapogon kauderni is a small marine fish endemic to the Banggai Archipelago off Central Sulawesi, eastern Indonesia (Allen and Steene, 2005; Vagelli and Erdmann, 2002). The species has an extremely restricted range of c. 5,500 km^2 and occurs as isolated small populations in the shallows of 34 islands (Vagelli, 2011). The species has been subject to heavy collection pressure for the aquarium trade, with annual harvests reportedly having reached 900.000 fish/year in 2007 (Vagelli, 2008; 2011). The species' biological characteristics make it vulnerable to overexploitation (low fecundity, extended parental care, and a lack of planktonic phase that precludes dispersal). A reported widespread decline in the abundance of

* *The geographical designations employed in this document do not imply the expression of any opinion whatsoever on the part of the CITES Secretariat (or the United Nations Environment Programme) concerning the legal status of any country, territory, or area, or concerning the delimitation of its frontiers or boundaries. The responsibility for the contents of the document rests exclusively with its author.*

sea urchins (*Diadema setosum*), a critical habitat for *P. kauderni,* also poses a significant threat to the species (Vagelli, 2015).

The population was estimated at 1.4 million individuals in 2015, representing a decline of 36% with respect to the estimated population in 2007 and a decline in abundance of over 90% with respect to the estimated pre-harvest level (Vagelli, 2008, 2011, 2015). The extirpation of several populations has been documented (Allen and Donaldson, 2007, Ndobe *et al.,* 2013a, Vagelli, 2015). Given the extreme microgeographic genetic structure of the species (with high levels of divergence in distances as small as 2-5 km) (Hoffman *et al*., 2005, Vagelli *et al*. 2009), such extirpations signify the loss of entire distinctive genetic lineages.

P. kauderni is categorised as Endangered in the IUCN Red List on the basis of a very small area of occupancy, severe fragmentation, (due to lack of suitable habitats between subpopulations and lack of dispersal mechanisms) and “the ongoing continuing decline (local extirpations and marked decrease in population size in recent years) due to exploitation for the international aquarium trade” (Allen and Donaldson, 2007). The species qualifies for inclusion in Appendix II by satisfying both Criteria A and B of Annex 2a of Resolution Conf. 9.24 (Rev CoP16).

3. Species characteristics

3.1 Distribution

Pterapogon kauderni is endemic to the Banggai Archipelago, Indonesia (Allen and Steene, 1995; Allen, 2000). The natural geographic range extends from 01^{o}24’57.6” Lat South to 02^{o}05’53.5’’ Lat South, and from 123^{o}0.3’04.2” Lon. East to 124^{o}23’ 30” Lon. East (Vagelli, 2011). Within this range, isolated populations are limited to 34 out of the 67 islands (Vagelli, 2011, 2015), of which 21 are less than 6 km in length and 16 are less than 3 km in length (Vagelli, 2011). The maximum potential available habitat[1] was estimated at 23 km^2 (Vagelli, 2015). The area of occupancy was reported to have declined from a previous estimate of 30 km^2 (Vagelli, 2011) based on declining populations and more accurate estimations of the maximum potential habitat of inhabited islands (Vagelli, 2015).

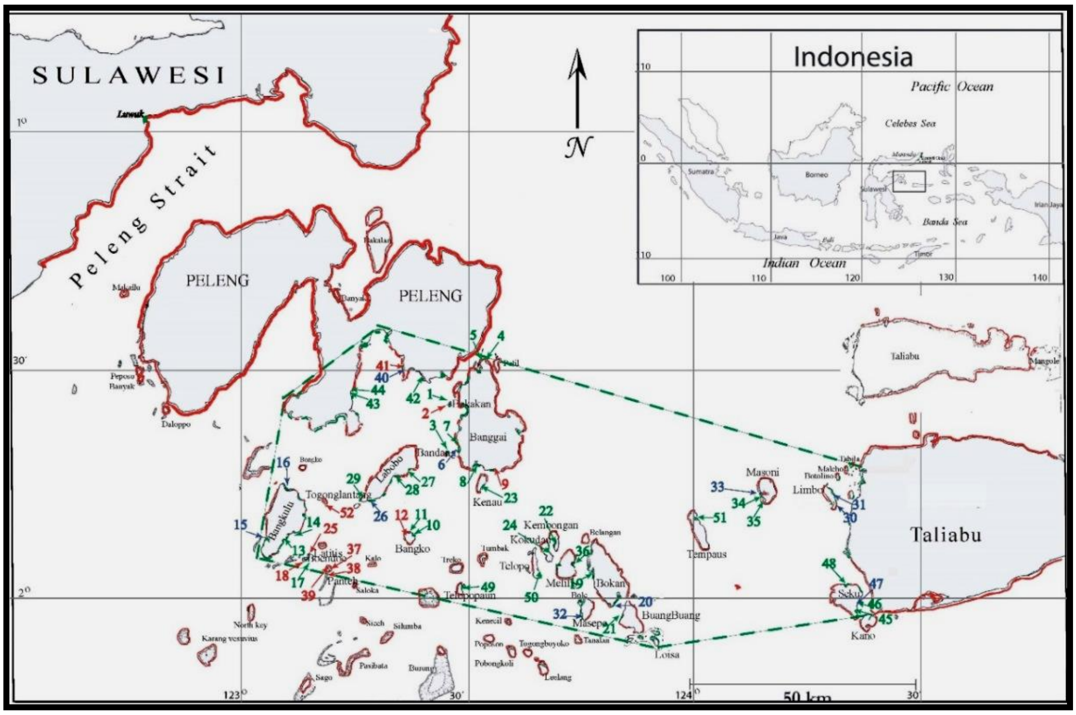

Figure 1. Natural geographic distribution of *P. kauderni.* Red perimeters indicate absence of the species (Vagelli, 2011). 52 sites (on 25 islands) visited during surveys in 2015 are indicated by the arrows. Numbers in green indicate presence; in red: absence; in blue: census sites (Vagelli, 2015).

1 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 ~ 4m (Vagelli, 2005, 2011; pers. comm. to UNEP-WCMC, 2016).

The artificial introduction of *P. kauderni* has resulted in several small populations establishing along trade routes (Moore *et al*., 2012). Introduced populations occur in Luwuk, central Sulawesi (Vagelli and Erdmann, 2002), Palu Bay in northwest Sulawesi (Moore and Ndobe, 2007); Lembeh Strait in north Sulawesi (Erdmann and Vagelli, 2001); Tumbak in north Sulawesi (Vagelli, 2011); Kendari in southeast Sulawesi (Moore *et al.*, 2011), and north Bali (Lilley, 2008). However, with the exception of the Lembeh population, all introduced populations are highly restricted geographically and composed of a few hundred to a few thousands individuals. For instance, the small population introduced in Luwuk is confined in an area of 0.6 km^2, within the Luwuk harbor (Vagelli, 2011). All introduced populations account for less than 1% of the entire species (Vagelli, 2011, 2016).

3.2 Habitat

P. kauderni is an atypical diurnal apogonid that occurs in shallow (<6 m), sheltered waters, most commonly between 1.5-2.5 m depth, in coral reefs, seagrass beds, and less commonly in open areas (Vagelli and Erdmann, 2002; Vagelli, 2005; 2011). It is most common in calm habitats on the protected side of larger islands (Vagelli, 2004a), however, it can occur also in environments with a strong surge (Vagelli and Erdmann, 2002). The average water temperatures of these habitats is 28°C (ranging from 26°C to 31°C) (Vagelli and Erdmann, 2002). The oceanographic characteristics of the Banggai region (deep channels between islands and strong currents) have contributed to *P. kauderni's* extreme philopatry (Bernardi and Vagelli, 2004; Vagelli, 2011). This is a benthic, site-attached species, and an obligated commensal with *Diadema setosum* sea urchins, anemones (and anemone-like *Heliofungia* corals) and living branching corals (Vagelli and Erdmann, 2002; Vagelli, 2005, 2011). It displays ontogenetic shift in microhabitat association, with sea anemones considered especially important as a microhabitat for new recruits (Vagelli, 2004a).

3.3 Biological characteristics

P. kauderni possesses a number of biological characteristics that make it vulnerable to overexploitation, including extremely limited geographic range, low productivity, and the absence of dispersal mechanisms (Vagelli, 2008; 2011). In addition, some of its ecological characteristics greatly facilitate its capture, including preference for shallow habitats, a highly site-attached behaviour, and the formation of groups (Vagelli, 2005; 2011); whereas others magnify the detrimental effects of its indiscriminate collection, including a synchronised reproduction with the moon cycle (Vagelli and Volpedo, 2004), the occurrence of an ontogenetic shift in microhabitat use and high early post-recruitment mortality (Vagelli, 2004a, 2011).

P. kauderni has the lowest recorded fecundity of any species within the family Apogonidae, with clutch sizes of approximately 60 eggs (Vagelli, 2011). Sexual maturity is attained at about nine months, with species longevity of 3-5 years (Vagelli, 2011). There is a high degree of parental care, with males brooding the egg clutch for about 20 days and retaining the hatched embryos for about a week before release of recruits (Vagelli, 1999; 2011).

This species presents sex–role reversal. Males limit the females' reproductive output and mating requires females to successfully compete for a receptive male (Vagelli, 2011). Consequently, not all mature females in a population are able to mate at a given time resulting in a reduction of the potential population fecundity (Vagelli, 2011). In addition, males fast during the incubation period (~28 days), which inhibits their ability to brood (mate) immediately after releasing a cohort of juveniles and thus limiting their availability. Thus, males are restricted to just a few brooding cycles per year constraining the population's reproductive rate and maximum recruitment (Vagelli, 2011).

A lack of a planktonic dispersing egg and larval period, and a highly sedentary adult behaviour result in very limited dispersal capacity and within parental habitat recruitment (Vagelli 2011).

Unlike most apogonids, *P. kauderni* has diurnal feeding habits (Vagelli, 2005). It is a generalist planktivore that preys mainly on copepods, but it is an opportunistic forager that consumes a variety of taxa (Vagelli and Erdmann, 2002; Vagelli, 2005, 2011). The size range of food items varies from about 0.1 mm to 14 mm. Diet composition is similar between size classes but important variations were found among sites (Vagelli, 2005; 2011).

Pterapogon kauderni was described by Koumans (1933) creating the monotypic genus *Pterapogon*. Recent phylogenetic molecular and morphological analysis support the monotypy of *Pterapogon*

(Fraser and Allen, 2010; Mabuchi et al., 2014). *P. kauderni* is unique at the generic level and represents a unique phylogenetic lineage (Vagelli, 2011).

3.4 Morphological characteristics

P. kauderni is a small fish (55-57 mm standard length) with a distinctive contrasting pattern of black and light bars with white spots (Vagelli, 2011). White dots on the silvery body are unique to each individual and can be used to identify specimens (Vagelli, 2002). The species is distinguished from others apogonids by its tasselled first dorsal fin, elongated anal and second dorsal fin rays, deeply forked caudal fin, and colour pattern (Allen, 2000). Sexual dimorphism has not been demonstrated for *P. kauderni*, but males can be distinguished from females by a conspicuous enlarged oral cavity, which is apparent only during brooding (Vagelli and Volpedo, 2004).

3.5 Role of the species in its ecosystem

P. kauderni associates with various anemone fishes when sheltering in anemones. When found among long-spined sea urchins and branching corals, it associates with several other cardinalfishes (Vagelli and Erdmann, 2002, Vagelli, 2005). The species serves as food source for several species of lionfish (*Pterois* spp.), Honeycomb Grouper (*Epinephelus merra*), Crocodilefish (*Cymbacephalus beauforti*), Snowflake Moray (*Echidna nebulosa*), Estuarine Stonefish (*Synanceia horrida)*, and Banded Sea Krait (*Laticauda colubrina*) (Vagelli, 2005, 2011). The species itself preys on the larval stages of coral reef fish parasites, thereby controlling parasite loads in other reef fishes (Vagelli, 2011).

4. Status and trends

4.1 Habitat trends

Widespread degradation of coral reef ecosystems throughout the Banggai Archipelago has been observed since 2001 (Allen and McKenna, 2001; Allen and Werner, 2002; Vagelli, 2005). Habitats occupied by *P. kauderni* (seagrass beds and coral reefs) are especially susceptible to anthropogenic stressors as they are close to shore (Allen and McKenna, 2001). Surveys of coral reef conditions in the Banggai Archipelago, from 2001 to 2007, found the average conditions of the reefs to be poor (Ndobe and Moore, 2008). Surveys conducted around Banggai Island from 2004 to 2011 observed a decline of coral reef cover from 25%t to 11% (Moore *et al.*, 2011; 2012). Surveys in 2011-2012 by Ndobe *et al*. (2013c) found that, at most sites, the rate of degradation of coral reef ecosystems had increased due to human activities.

Sea urchins and anemones were reported to be experiencing intensive and increasing harvest pressure with negative impacts on *P. kauderni* (Moore *et al.*, 2012). In 2015, a survey to assess the conservation status of *P. kauderni* reported that the most significant finding regarding habitat/substrate condition was the severe and widespread decline in abundance of sea urchins (*Diadema setosum*), which are considered a critical substrate for *P. kauderni* (Vagelli, 2015): 53% of the sites re-surveyed in 2015 (previous survey in 2007) in 11 islands showed a decline in sea urchin abundance (Vagelli, 2015). Furthermore, the mentioned survey uncovered a widespread low abundance and decrease in abundance of anemones (and anemone-like corals of the genus *Heliofungia*), another critical living substrate for *P. kauderni* (Vagelli, 2015).

4.2 Population size

Based on surveys in 2011 and 2012, Ndobe *et al*. (2013c) estimated the total population in 2011-2012 at 1.5-1.7 million, using an assumption that the estimate for available habitat area was 30-34 km^2 [this was later revised by Vagelli (2015) to 23 km^2]. In 2015, the total wild population of *P. kauderni* within its natural habitat was estimated at 1.4 million individuals (Vagelli, 2015). This estimate was based on surveys of 52 sites in March 2015 covering 90% of the species' natural geographic range, with many sites resurveyed, plus 18 new sites (Vagelli, 2015). Based on the reported population of 2.2 million individuals estimated in 2007 (Vagelli, 2008), this represents a population decline of 36% over the eight years between the two estimates.

4.3 Population structure

P. kauderni form stable groups of varying size, typically less than 25 individuals (maximum observed was a group of 500 individuals in 2002) (Vagelli and Erdmann, 2002). Smaller groups are common and vary by age class and habitat (Vagelli, 2011). Population sex ratios show slight male-bias of 1.04 males (Vagelli and Volpedo, 2004). Most fish encountered in groups are large juveniles or young adults, whereas new recruits are rare (Vagelli and Erdmann, 2002; Vagelli, 2011). Vagelli (2011) reported that new recruits stay within parental habitat and are often observed alone, but commonly form small groups; the size of new recruit groups may be related to habitat type (Vagelli, 2004; 2011).

P. kauderni exhibits the highest degree of population subdivision ever documented for a marine fish over such a small geographic scale (Hoffman *et al.*, 2005). Genetic structure of populations varies over distances as small as 2 km; even populations occurring on reefs of the same islands are genetically isolated from one another, suggesting limited gene flow between reefs within individual islands. For instance, assignment tests performed on 12 populations within the island of Bangkulu showed a significant self-reassignment for 10 (Vagelli *et al.*, 2009), and other study reported populations displaying a strong phylogenetic breaks with lack of gene flow between populations of Bangkuru Island (Bernardi and Vagelli, 2004). This is thought to be due to 1) a lack of a pelagic larval stage; 2) a sedentary, site-attached nature of all life stages; 3) an association with shallow substrates; and 4) the presence of deep channels and strong currents between islands isolating populations (Bernardi and Vagelli, 2004; Hoffman *et al.*, 2005, Vagelli, et al., 2009). These characteristics mean that *P. kauderni* has a very limited ability to recolonise areas where it has been extirpated (Vagelli, 2011). This high degree of genetic structure has profound conservation implications, given the importance to protect all intraspecific diversity (Palumbi, 2003).

4.4 Population trends

P. kauderni is categorised as Endangered in the IUCN Red List on the basis of a very small area of occupancy, severe fragmentation, a continuing population decline and local extirpations due to exploitation for trade (Allen and Donaldson, 2007). The first quantitative surveys of the species were conducted in 2001, about five years after collection of the species had begun (Vagelli and Erdmann, 2002; Vagelli, 2005). Thus the historical abundance of the species is unknown, but quantitative assessments of the only known unexploited population have been used to provide an estimate of the baseline abundance (Vagelli, 2008, 2011). This population inhabits a protected bay, and its density was calculated to be 0.63 fish/m^2 in 2002 (Lunn and Moreau, 2004) and 0.58 fish/m^2 in 2004 (Vagelli, 2011). Thus, the estimated baseline density of *P. kauderni* within its natural range has been considered to be ~0.6 ind/ m^2, and any significant departure is deemed to be related to human intervention (Vagelli, 2008, 2011).

In 2001, the population size of *P. kauderni* was estimated to be around 1.7 million individuals based on surveys conducted in a limited number of sites which were extrapolated over the species range (Vagelli, 2002). Following additional surveys in 2002 and 2004 across the entire Archipelago (50 islands, 159 sites), the population was estimated at approximately 2.4 million individuals (Vagelli, 2005). In 2007 the estimate of population size was given as 2.2 million (Vagelli, 2008).

Negative effects of captures on populations were first observed in 2000, following the establishment of an export fishery in the 1990’s (Kolm and Berglund, 2003). Dramatic declines as a result of fishing pressures were observed between 2001 and 2007, including the virtual extinction of a Limbo Island subpopulation by 2004. Four individuals had been located at one census site in Limbo Island in 2007 (Allen and Donaldson, 2007), and eight were found in 2015, suggesting that the population was unable to recover (Vagelli 2015). No specimens were located at the second census site in Limbo Island in 2015 and the population was considered extinct (Vagelli, 2015).

The small subpopulations of Bakakan Islands (total ~6000 individuals estimated for north and south islands) in 2001 were reduced to ~ 350 individuals for both islands in 2004 (Vagelli, 2008). These populations never recovered: in 2007, ~200 fish were localised in the north island and ~20 in the south island (Vagelli, 2005, 2008). In 2014, it was reported that local fishers characterised the population of Bakakan Island as “small and declining” (Moore, 2014 pers. comm. to Conant, 2014). In 2015, 350 individuals were found to inhabit the entire north island, while no fish was found in the south island (considered likely extinct by the author) (Vagelli, 2015, 2016).

Vagelli (2008) reported that in 2007 the population at the census site off Masoni to be reduced to only 38 individuals, and the population at the census site off Peleng to be practically eliminated, with only

27 individuals encountered. In 2015, only one individual was located at the Peleng Island census site, with the population considered virtually extinct; no individuals were located at Masoni census site, which was considered likely to be extinct and a search for all potentially inhabitable sites at the island uncovered only 50 individuals (Vagelli, 2015).

Site assessments undertaken by Marine Aquarium Council Indonesia in 2007 at Banggai, Bone Baru, Bone Bone, Liang, and Teropot also showed that population sizes were smaller than previously; it was also reported there was general agreement from collectors that the populations were suffering from overexploitation, with collection sites being abandoned following population collapse (Lilley, 2008). Yahya *et al.* (2012) surveyed 54 sites from 2007-2012, with site selection based on previous known distribution or information from local communities and fishermen. Occurrence of *P. kauderni* was confirmed at 28 of the 54 sites surveyed, with the species being most common around Banggai Island and mostly absent from Pelang Island. Overall, the population was considered to be declining (Yahya *et al.*, 2012).

Site visits and interviews with local communities in 2011 and 2012 suggested that the overall population of *P. kauderni* was declining in the Banggai Archipelago (Ndobe *et al.*, 2013a). Survey activities undertaken in 2011 (10 stations, Banggai) and 2012 (14 stations) by Ndobe *et al*. (2013c) found population declines in six (of eight) sites, declining habitat extent in seven sites, and declines in the density of *P. kauderni* at four sites. It was concluded that stocks appeared to have declined sharply over the past decade (Ndobe *et al*., 2013c). Ndobe *et al*. (2013c) considered habitat degradation the main cause of population declines, including the over-exploitation of the species' microhabitat.

Vagelli (2015) showed that the mean density of censused populations declined from 0.08 individuals/m^2 in 2007 (range 0.001-0.22) to 0.05 individuals/m^2 in 2015 (range 0.001 to 0.15 individuals/m^2), with no populations found near to the baseline density for the species. Of the 43 populations surveyed (22 islands), the abundance condition of 33 (76%) was described as being 'vulnerable' (less than 350 fish at the site) to 'critical' (less than 50 fish/site) (Vagelli, 2015). Of the 31 populations revisited in 2015, 15 (48%) were found at a lower abundance than the previous survey, five had declined to a 'critical' level, three sites had zero presence and these populations were thought likely to be extinct (Vagelli, 2015.). No population censused in 2015 had a higher abundance than in 2007. Furthermore, the only three populations (from three different islands) that had higher densities in 2007 than in 2004 (Banggai4, Bokan, and Labobo), and the three populations (from three islands) that in 2007 had densities of at least 0.1 ind./m^2 (Bangkuru5, Banggai4, and Seku), showed significant declines in abundance in 2015 (see Table 2). Declines in the number of groups of fish per site had declined from 36.4 in 2007 to 26.6 in 2015 (excluding four populations that were considered eradicated or at a critical level); similarly the mean group size of censused sites was observed to have declined by 39% from 23 in 2007 to 14 in 2015 (Vagelli, 2015).

Table 2. 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 (data from Vagelli, 2015):

Year	Census site	Groups per site	Mean Group 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	Seku E	47	10.2	0.1
2015	**Seku E**	**28**	**6.9**	**0.04**

Three populations that had undergone significant reductions due to overexploitation until 2007 when collection ceased (Masoni, Limbo and Peleng) had not recovered in 2015; it was therefore concluded that once populations are reduced to abundance levels of ~0.02 individuals/m2, they are unable to recover, even in the absence of further collection pressures (Vagelli, 2015). These findings support the characterisation of *P. kauderni* as a low-productivity species, and which is also affected by Allee' effect (Kolm and Berglund, 2003; Vagelli, 2011).

Populations monitored over several years showed a significant decline in the catch per unit effort. Between 2000 and 2004, the reported mean catch in Banggai declined from over 1000 fish/hour to 25-330 ind/hour (Vagelli, 2011). Prior to 2003, fishers from the BoneBaru collection centre typically required one day to capture ~2000 specimens (Vagelli, 2011). In 2007, they reported requiring one week for capturing the same number (Vagelli, 2011). Similar declines were recorded in other sites (EC-Prep Project EP/RO3/R14, 2004).

The FAO (2007) considered the species to have a 'high' productivity level, based on its age at maturity and lifespan and noted that the Masoni population density had doubled over three years following a locally imposed collection ban during 2001-2004 (FAO, 2007). However, this increase occurred in a depleted population of ~130 individuals. Thus, after three years without collection, this population increased by only ~150 fish. Furthermore, by 2007 the Masoni population largely collapsed with only 37 individuals recorded in the census site (Vagelli, 2008). In 2015, Vagelli (2015) did not record any individuals in the census site, and considered this population to have become extinct, while a total of ~ 50 individuals were localized in the entire Masoni island (Vagelli, 2015).

The fecundity and overall productivity of *P. kauderni* is density dependent, and hence the removal of individuals results in a much higher cumulative loss of fish due to the effects of this removal on annual production. (Vagelli, 2016).

P. kauderni possesses a very low fecundity (females produce batches of only ~ 60 mature oocytes), and a frequent reduced fertility (fertilized eggs are lost during the egg-clutch transfer, resulting in even fewer numbers of recruits). However, not all ova produced in a population will become zygotes because males limit the reproductive output of females, ultimately determining the population fecundity. In this species, where the sex roles are reversed, mating requires females to successfully compete for a receptive male. Hence, not all mature females in a population are able to mate at a given time resulting in a reduction of the potential population fecundity. In addition, males incubate each brood for about 28 days while fasting, which inhibits their ability to brood (mate) immediately after releasing a cohort of juveniles, thus limiting their availability. Thus, males are restricted to just a few brooding cycles per year, which in turn constrains the population's reproductive rate and maximum recruitment (Vagelli, 2011).

4.5 Geographic trends

The historic geographic distribution of *P. kauderni* within the Banggai Archipelago is unknown; the first broad surveys aiming to determine its distribution were conducted in 2001, about five years after intensive collection of this fish had begun. During subsequent years, additional surveys were completed and included new islands and many new sites (Vagelli & Erdmann, 2002, Vagelli, 2005, 2011, 2015; Yahya *et al.*, 2012). The species was reported from 34 out of the 67 islands of the Banggai Archipelago. It was present off eight of the 10 large islands, 10 of the 11 medium sized islands and 16 of the 45 small islands and islets (Vagelli, 2011,2015).

The extirpation of a subpopulation off Limbo Island in 2004 was reported by Allen and Donaldson (2007). Ndobe *et al.* (2013a) reported that a population off Liang had been extirpated by 2012. In 2015, the populations at the census sites in Masoni, Peleng, Limbo3 and Bakakan Islands (all of which had drastically declined in 2007), were considered to be extirpated, as no individuals were encountered in the former three and only one individual in Peleng 2015 (Vagelli, 2015*).*

P. kauderni has suffered a ~90% reduction in abundance, due principally to the overexploitation for the aquarium trade during a decade (Vagelli, 2008; 2015); populations are spatially isolated with virtually no connectivity, as demonstrated by its high degree of genetic differentiation (Bernardi & Vagelli, 2004; Hoffman et al., 2005; Vagelli et al., 2009). According to Vagelli (2016), the persistence of *P. kauderni* is undoubtedly in question as evidenced by the extirpations of populations already occurred, which affect a significant portion of its range (the area occupied by the remnants of depleted populations inhabiting Masoni and Limbo Islands, the small and highly restricted population found in East Tempaus, and the small populations found east to Limbo unquestionably encompass a significant portion of the species range- see map-) (Vagelli, 2008, 2011, 2015).

5. Threats

The main threat to the species was considered to be heavy collection for the international marine ornamental trade (Allen, 2000; Allen and Donaldson, 2007; Marini & Vagelli, 2007) and has been heavily exploited since its introduction to the aquarium community in 1995 (Vagelli, 2011). The first estimations of the trade showed that by early 2000s at least 600,000-700,000 fish/year were exported (Vagelli, 2002; Vagelli & Erdmann, 2002; Lunn & Moreau, 2004).

P. kauderni is relatively easy to collect due to its sedentary nature and tendency to form groups in shallow habitats (Vagelli, 2008). Collection methods were reported to result in high mortality (Lilley, 2008). Methods of corralling fish groups into nets were also considered to affect recruitment, as they do not separate out brooding males which typically release eggs/embryos during handling (Vagelli, 2011, 2015). Rates of mortality in holding pens and in transit were also reported to be high (Lilley, 2008; Vagelli, 2011).

Other threats to *P. kauderni* habitat have been reported to be increasing, in particular the intensive harvesting of benthic invertebrates for consumption locally, including *Diadema* urchins (often used to feed carnivorous reef fish such as the Appendix-II listed Humphead Wrasse *Cheilinus undulatus* for illegal export) and sea anemones, which are important microhabitat species (Moore *et al.*, 2012; Ndobe *et al.*, 2013b). Habitat loss and harvesting of sea urchins and anemones was reported to result in a loss of refuges for recruits and increase vulnerability of *P. kauderni* to predation (Yahya *et al.*, 2012). Decreases in abundance of sea urchins (*Diadema setosum*) (see section 4.1), anemones and corals of the genus *Heliofungia*, all critical substrates for *P. kauderni,* were reported by Vagelli (2015).

Further anthropogenic threats to *P. kauderni* were reported to include habitat destruction caused by destructive fishing practises (explosives, cyanide, and coral destruction through netting fish) (Allen, 2000; Allen and McKenna, 2001; Moore *et al.*, 2012). Vagelli (2015) reported that blast fishing remained widespread throughout the Banggai Archipelago. Coastal development, effluent discharge, and terrestrial water run-off were also reported as threats (Lilley, 2008; Moore *et al.*, 2012; Yahya *et al.*, 2012). Coral mining and predation by the starfish *Acanthaster plancii* were also reported to have impacted on the species (Ndobe *et al.*, 2013b). Coral reef degradation was noted at several sites in the Banggai Archipelago during surveys in 2004 and 2006 (Moore and Ndobe, 2009), and coral cover had declined from 25% to 11% in *P. kauderni* habitat in Bone Baru from 2004 to 2011 (Moore *et al.*, 2012). A *Megalocytivirus* virus, likely contracted at export/import centres, was reported to be causing high mortality in imported specimens, further increasing the loss of wild-caught specimens (Weber *et al*., 2009, Vagelli, 2011). Frequent earthquakes were reported to affect several zones within the Banggai Archipelago, with the potential to impact on localised *P. kauderni* populations (Allen and Donaldson, 2007).

Thus, demographic risks of *P. kauderni* are influenced by both depensatory processes (intimately related to its reproductive biology, including pair formation, sex role reversal, Allee effect), as well as stochastic catastrophic processes. The latter include both of natural origin (such as significant habitat destruction by earthquakes/tsunamis, Niño events, etc.) and the mentioned anthropocentric induced habitat and substrates degradation.

6. Utilization and trade

6.1 National utilization

The local economy has not traditionally depended on the capture and trade of *P. kauderni*; exports did not begin until the late 1990s (Vagelli, 2011). In terms of economic value, it is estimated that the annual contribution of the sale of *P. kauderni* to the local economy is <0.03 % of the region's annual GDP (Vagelli, 2008, 2011; 2016), with the vast majority of Banggai people making a living through agriculture, seaweed culture and fisheries (Vagelli, 2008, 2011). *P. kauderni* fisheries were reported from all of the major islands within the species range (Lunn and Moreau, 2004; Vagelli, 2011). *P. kauderni* is shipped out of the Banggai Archipelago by boat to national exporters via Tumback to Manado and to Bali exporters via Luwuk, Palu and Kendary, and also direct to Bali. Aquarium fish export companies operate in Bali; others exist in Kendary and Manado (Sulawesi) (Vagelli, 2016).

6.2 Legal trade

The first trade estimations were conducted in 2001 and 2002 and indicated a minimum of at least 600,000-700,000 fish/year being shipped out of the Banggai Archipelago (Vagelli & Erdmann, 2002, Lunn & Moreau, 2004). By 2007, collection was organised by three main collection centres in

Banggai, Bokan and Bangkuru Islands, and a minimum of about 900.000 specimens were captured per year (Vagelli, 2008). Catch data for 2008 indicated that catches from two of three main harvest sites totalled 236,373 individuals (Moore *et al*., 2012). Combined catch data for three main sites was 330,416 in 2009 (Moore *et al*., 2012). Shipments of *P. kauderni* for 2009 and 2010 were 215,950 and 148,800, respectively (Moore *et al*., 2011; 2012). Whilst these figures were not considered a complete trade record; they were thought to show a reduction in trade volumes compared to previous years (Moore *et al*., 2011).

The reported shipping time from the collection centers to the buyers' centers in North Sulawesi, South Sulawesi and Bali is 2-5 days, and the reported conservative mortality' estimate is 25-50% (Vagelli, 2008, 2011). Thus, in the case of *P. kauderni*, the number of specimens officially reported in trade greatly underestimates the actual number of specimens removed from the wild, thereby making it difficult to assess the true impact of trade on the species (Vagelli, 2011).

P. kauderni was reported to be destined for the United States (US), as well as Europe and Asia (Kolm and Berglund, 2003). The species was listed in Annex D of the EU Wildlife Trade Regulations (EC No. 338/97 and EC No. 865/2006 and its amendments) on 11 April 2008. Since that date, imports to the EU have been monitored. Reported direct exports to the EU from Indonesia primarily comprised live individuals (Table 3). The majority of this trade was reported without a purpose or source specified, and is assumed to be of wild origin. Direct imports of live fish (reported in number) in 2014 represented the highest volume of reported trade since 2008 (26,687). According to Rhyne *et al.* (2012), *P. kauderni* was among the top 10 marine aquarium fish imported to the United States of America during May 2004-May 2005, and ranked 10th, 11th and 8th of the most imported fish into the U.S during 2008, 2009, and 2011, respectively, according to preliminary data presented by Rhyne *et al.* (2015). Based on the data presented by Rhyne *et al*. (2012), U.S imports over the period 2004-2005 appeared to be in the region of 180,000 fish.

Table 3. Direct imports of *Pterapogon kauderni* from Indonesia to the EU-28 (EU) 2008-2014.

Term (unit)	Purpose	Source	2008	2009	2010	2011	2012	2013	2014	Total
live (blank)	T	C		60					13	73
		U		744	1561	4795	6885	6139	4763	24,887
		W		77						77
		(blank)	1010							1010
	-	I	86		6					92
		-		10,217	11,226	439	7034	12,233	8315	49,464
Subtotal live (blank)			**1096**	**11,098**	**12,793**	**5234**	**13,919**	**18,372**	**26,687**	**62,512**
live (kg)								2.4		2.4

Source: CITES Trade Database, UNEP-WCMC, Cambridge, UK, downloaded on 25 February 2016.

During a field survey completed in 2015, the collection center located in Bokan was found not to be active, but increased capture and buyer activities were found in the nearby Topopot area (Telopo Island) (Vagelli,2016). The shipment of *P. kauderni* out of the Banggai Archipelago was found to be less centralized than in the past, with less traffic through the collection centers due to increased "public" transportation (small and medium size boats, and speed boats) for shipping *P. kauderni* directly outside the Archipelago, particularly to Luwuk (central Sulawesi). According to Vagelli (2016), this new shipping method was observed in islands with high collection activity, including Banggai and Bangkuru, and as a consequence, captures were not being reported to the local (Banggai) fisheries/quarantine office. It was reported that assessment of trade volumes and shipping mortality had become more challenging, since there are less opportunities for meeting buyer's boats at different areas within the Archipelago. Nevertheless, in 2015, holding nets containing thousands of *P. kauderni* were encountered in several islands, including Banggai and Bangkuru and Telopo, and collection pressure seems to have not decreased from previous years (Vagelli, 2015, 2016).

6.3 Parts and derivatives in trade

According to the CITES Trade Database, all reported trade is in live specimens.

6.4 Illegal trade

Indonesian fishermen from outside Banggai Islands have been reported to illegally fish (without proper permits) for this species and export them to nearby islands (Moore *et al.*, 2011; 2012).

6.5 Actual or potential trade impacts

Collection for the international trade has resulted in local extirpations and marked population declines which have contributed to the species being categorised as Endangered in the IUCN Red List (Allen and Donaldson, 2007). Following surveys in 2015, Vagelli (2015*)* concluded that the population of *P. kauderni* continues to be seriously imperilled, primarily as a result of over-collection for the international ornamental fish trade, which will result in extinction of additional populations and eradication of distinct genetic lineages if the trade remains unregulated.

Collection methods for *P. kauderni* of pushing sea urchins into a cage, which the fish then follow, may also impact on urchin populations (Kolm and Berglund, 2003). The introduced population at Lembeh Strait, resulting from releases along trade routes, was considered invasive and may be impacting local biodiversity through interspecific competition (Vagelli, 2011).

Populations of species with extreme microgeographic genetic differentiation should be conserved as reproductively distinct units (Rocha et. al., 2007; Hauser & Carvalho, 2008; Reis et al., 2009). Vagelli, (2016) considered that if no action was taken to decrease the current collection levels, the unregulated capture for the marine ornamental fish trade coupled with the loss of habitat could lead to the extinction of more populations. Various authors have highlighted the need for protection of *P. kauderni* and/or restrictions on collection (e.g., Allen, 2000, Allen and Werner, 2002; Kolm and Berglund, 2003; Lunn and Moreau, 2004, Marini and Vagelli, 2007; Rainer, 2000; Vagelli, 2011, 2013; Vagelli and Volpedo, 2004; Vagelli and Erdmann, 2002; Wabnitz *el al.,* 2003).

7. Legal instruments

7.1 National

P. kauderni is not a protected species in Indonesia under Government Regulation No. 7/1999 on Preservation of Wild Flora and Fauna.

7.2 International

P. kauderni was included in Annex D of Commission Regulation (EU) No. 318/2008 in April 2008 and most recently, in Commission Regulation (EU) No. to 1320/2014.

8. Species management

8.1 Management measures

Management actions for *P. kauderni* were reported to include a multi-year Banggai Cardinalfish Action Plan (BCF-AP) (2007-2012), developed by local and national stakeholders (Ndobe and Moore 2008); inclusion of the species conservation within the Indonesian National Coral Triangle Initiative plan; and a district Marine Protected Area (MPA) (Ndobe *et al*., 2012). The BCF-AP was developed to focus on conservation, trade and management (Moore *et al.* 2011) and included the establishment of the Banggai Cardinalfish Centre (BCFC) in Banggai Island to coordinate conservation and management actions (Lilley, 2008). However, as of 2011, no integrated or comprehensive monitoring system was in place and data sets were lacking (Moore et al. 2011). Moreover, it was reported that, as of 2011, the BCFC had no electricity, no operational budget, and was operated on a voluntary basis (Moore *et al.* 2011).

Trade quotas that were proposed by local stakeholders in 2010 were not continued, mainly due to a lack of legal support (Yahya *et al*., 2012). Furthermore, following the end of the BCF-AP in 2012, there was no effective long-term conservation or management mechanism in place for *P. kauderni* (Ndobe *et al*., 2013c). In addition, the region was split into two Administrative Districts in 2013, and the BCFC was reported to need official approval under the new Districts to maintain its legality (Ndobe, pers. comm. to Conant, 2014).

Other reported management actions included the drafting of legislation in the form of a BCF Fisheries Management Plan, the establishment of a district protected area network in 2007, and habitat conservation/restoration activities at community level (Moore and Ndobe, 2013). However, by 2012, the MPA was still in a planning phase (Ndobe et al. 2012). In addition, only two islands were designated for the conservation of the *P. kauderni*, and one (Togong Lantang) does not harbour the species. Further, the authors recognize that the MPA network design was poor from *P. kauderni* population and genetic diversity aspects, with the vast majority of the known *P. kauderni* and most of the known genetic diversity are outside the MPA boundaries" (Ndobe et al. 2012).

Ndobe *et al.* (2012) considered that threats to habitat and microhabitat loss remained unaddressed, as did Yahya *et al.* (2012). Lilley (2008) also noted the lack of no-take zones as part of a coordinated regional plan and problems with near shore no-take zones set up by villagers destroyed by people from elsewhere. Yahya *et al*., (2012) considered that enforcement of management measures was lacking, harvest and export was continuing to occur without being reported, and measures to monitor trade were not being effectively enforced. Based on survey activities in 2011-2012, Ndobe *et al.* (2013c) considered that the species was not yet being harvested sustainably.

In 2015, a broad survey on local management and conservation efforts on *P. kauderni* was completed (Vagelli, 2015), comprising interviews with regional/local authorities such as government officials and other local stakeholders, including over a dozen of head of villages; fish collectors and traders throughout the Banggai region (Vagelli, 2015). The survey included visitation to the sites where conservation actions aimed at *P. kauderni* were reported, including the BCFC and Communities MPA/MPAs (Vagelli, 2015). The survey found that no coordinated, effective conservation program had been implemented in the Banggai region since *P. kauderni* was classified as Endangered in the IUCN Red List in 2007. Local conservation efforts were not implemented (generally for lack of financial/technical support), or were poorly designed so that no positive effect was had on improving the conservation status of *P. kauderni* (Vagelli, 2015).

As of March 2015, no MPA has been physically established and the fishery of *P. kauderni* was not being tracked in any meaningful way by local authorities (Vagelli, 2015). The results of this conservation survey were summarised in a report shared with the Indonesian CITES Authorities and the Indonesian Institute of Science (LIPI) (Vagelli, 2016).

8.2 Population monitoring

Specific activities outlined in Indonesia's National Plan of Action for the Coral Triangle Initiative for *P. kauderni* included population assessments and monitoring of trade (National Secretariat of CTI-CFF Indonesia, 2009). However, no comprehensive monitoring system had been implemented and few types of data have been collected on a regular, long-term basis (Moore *et al.*, 2011). Moreover, a number of weaknesses were identified with local monitoring activities, including a lack of monitoring protocols, coordination between organisations, and baseline data (Moore *et al.* 2011). Vagelli (2015) considered monitoring of the fishery by the local quarantine/fisheries authorities based on Banggai Island to be inadequate, since there was poor compliance with any reporting requirement.

8.3 Control measures

8.3.1 International

None, though imports into the EU are monitored (see section 7.2)

8.3.2 Domestic

Thornhil (2012) reported that authority for management of marine resources in Indonesia was designated to regional governments. However, it was reported that this has not yet been successfully implemented due to the lack of a legal framework, resulting in the need for clarification of the roles of various governing bodies (Indrawan and Suseno, 2008).

In 1995, a regulation prohibiting the collection of all ornamental fishes without a government permit was issued for the Banggai District. The species' natural distribution falls outside of the Banggai District covered by this regulation.

All trade in *P. kauderni* was reported to be required by law to go through Fish Quarantine procedures before crossing internal administrative borders or prior to export (Moore *et al.*, 2011). However, the vast majority of the trade is not reported to that agency (Vagelli, 2016). Yahya *et al*. (2012) noted that unreported trade in *P. kauderni* accessed the international market through a number of gateways in the Banggai Archipelago and throughout Indonesia. Vagelli (2015) found that in 2015 the fishery of *P. kauderni* was not being tracked in any meaningful way by local quarantine/fisheries authorities, who were reported to rely on the "voluntary" decision by buyers to comply with any regulation. Vagelli (2015) indicated that in the few occasions when buyers reported to the fisheries authorities, actual checks of the fish cargo by quarantine officers were rare; instead, samples are brought to them by the buyer to assess fish health. According to Vagelli (2015), accurate estimates of the number of individuals being shipped out of the Banggai region were not made by officers, and mortalities associated with collection and shipment were not recorded. When shipments were checked, only a general estimation of the boxes and or bags were made (Vagelli, 2015).

8.4 Captive breeding and artificial propagation

Captive breeding of the species was reported to be a viable alternative to wild harvest (Ross and Pedersen,1998; Marini and Vagelli, 2007; Vagelli, 2004b, 2011). *P. kauderni* was considered to be hardy in captivity and could be bred and reared in captivity throughout its entire life cycle for commercial purposes (Ross and Pedersen,1998; Marini and Vagelli, 2007; Roozbehfar *et al*., 2012). In 1997, the New Jersey Academy for Aquatic Sciences began a captive breeding program, and all aspects of the reproductive biology of this species were described (Vagelli, 1999, 2004b). Ongoing research programmes as part of the BCAP were reported to exist at aquaculture research agencies in Ambon and Bali (Moore and Ndobe, 2013). In 2012, a large-scale aquaculture facility in Thailand was reported to begin breeding *P. kauderni* in captivity for export (Talbot *et al.*, 2013).

It was noted that although captive breeding of this species is possible, wild caught fish are much cheaper and are therefore still widely traded (Vagelli, 2011).

8.5 Habitat conservation

The Indonesian government prohibits the use of chemicals or explosives to catch fish (Fisheries Law No. 31/2004, Art. 8(1)). However, the practice was reported to continue (Vagelli, 2011), and damage to coral reefs from blast fishing was considered widespread in the Banggai Archipelago, including in protected areas (Talbot *et al.*, 2013; Vagelli, 2015).

In 2007, a marine protected area (MPA) consisting of 10 islands was declared with conservation of *P. kauderni* as the primary aim for two islands (Ndobe *et al.*, 2012). However, it was reported that three of the islands had *P. kauderni* populations but were not specifically designated for protection of the species, whereas the species was actually absent from one island designated with the specific aim of its protection (Ndobe *et al.*, 2012). The MPA was considered to have been poorly designed from a conservation perspective in terms of maintaining the intraspecific genetic diversity; 15 of the 17 distinct genetic stocks were reported to remain outside of MPA boundaries (Ndobe *et al.*, 2012). Ndobe *et al.* (2013c) reported that the MPA had not yet been implemented and that there was no MPA management plan. The separation the Banggai Archipelago into two districts in 2013 was reported to have made the made the MPA invalid (Ndobe and Moore, 2013b). Vagelli (2015) reported that by March 2015 no MPA has been established in the Banggai region.

8.6 Safeguards

P. kauderni was one of the first entrants into the Frozen Ark Project, which is a programme to save the genetic material of imperilled species (Williams, 2004).

9. <u>Information on similar species</u>

There are no similar species. *P. kauderni* is easily distinguished from other fish, including other apogonids.

10. <u>Consultations</u>

A consultation was launched in 2015 by the European Union and its Member States to Indonesia as only range State. The authorities of Indonesia indicated in April 2016 that, based on consultations carried out at national level, the species did not deserve a CITES listing. Indonesia indicated furthermore that support was welcome to strengthen efforts for the conservation of the fish and community participation.

11. Additional remarks

A proposal to list *P. kauderni* in CITES Appendix II under Criterion B of Annex 2a of Resolution Conf. 9.24 (Rev. CoP13) was submitted to CoP14 (CoP 14 Prop. 19) by the United States of America. The proposal was withdrawn.

Based upon a review of published literature and research from 2004-2013, Ndobe and Moore (2013b) found that *P. kauderni* fulfilled five criteria (endangered; rare; restricted range [endemic]; sharp decline in wild population(s); and low reproductive capacity) for limited protected status under the provisions of law PP No. 60/2007. In 2011, a proposed listing of *P. kauderni* for restricted protected status under Indonesian domestic law failed (Ndobe and Moore, 2013b).

In 2014, the United States National Marine Fisheries Service (NMFS) carried out a status review of *P. kauderni* to determine if the species warranted protection under the Endangered Species Act (ESA). The review concluded that the species was at moderate risk of extinction (Conant, 2014). Subsequently, *P. kauderni* was proposed for listing as an endangered species under the ESA in 2014. On 20 January 2016, the species was listed as “Threatened” under the ESA, effective as of 19 February 2016. No changes in regulations governing trade or possession of the species have been made (National Oceanic and Atmospheric Administration, 2016).

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