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

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STUDY TO ASSESS THE IMPACT OF INTERNATIONAL TRADE ON THE CONSERVATION STATUS OF *PTERAPOGON KAUDERNI* (BANGGAI CARDINALFISH)

This information document has been submitted by the Secretariat at the request of the International Union for Conservation of Nature in relation to agenda item 21*.

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A study to assess the impact of international trade on the conservation status of *Pterapogon kauderni* (Banggai cardinalfish)

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This study was conducted by the authors on behalf of the International Union for Conservation of Nature (IUCN)[v].

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I. Background

Pterapogon kauderni (Banggai cardinalfish) is a small fish, endemic to the Banggai Archipelago in Indonesia, which is internationally traded for aquarium display. Additional uses within Indonesia include as broodstock for culture operations, as research specimens, and for educational displays. Their extremely restricted geographic range (with an estimated area of occupancy by native populations of approximately 20 km^2) and specialized life history (mouth brooders with no dispersal phase), combined with pressure from international trade, have led to severe populations declines, such that the species has been twice proposed for listing in Appendix II of the Convention on International Trade in Endangered Species (CITES). The first listing proposal was presented to the fourteenth meeting of the Conference of the Parties to CITES (CoP14) in 2007, and the most recent proposal was presented to CoP17 in 2016[1]. The CoP17 proposal was withdrawn[2], with the CoP instead adopting six Decisions on *P. kauderni* in support of improving the sustainability of the international trade in this species.

Decision 17.260, directed to the Secretariat, calls for a study to assess the impact of international trade on the conservation status of *Pterapogon kauderni* (Banggai cardinalfish) and to advise on suitable conservation and management measures. This study serves as input for the Animals Committee, which is directed to formulate recommendations, as appropriate, pursuant to Decision 17.262. The study will also support Indonesia in implementing conservation and management measures to ensure the sustainability of international trade in *P. kauderni*, in accordance with Decision 17.259.

Indonesia's submission of an initial progress report[3] to the 29th meeting of the CITES Animals Committee (AC29), and subsequent discussions in a working group, allowed the Committee to develop additional guidance for the content of this study, which can be found in document AC29 Com. 10[4], to ensure that the study is not duplicative of, but complimentary to, Indonesia's 2017-2018 Banggai Cardinal Fish National Plan of Action (NPOA).

This study is therefore mostly focused on providing new and up-to-date information to the Secretariat and Animals Committee, that is complementary to but not repetitive of that contained in previous documents such as the proposal to include *P. kauderni* in Appendix II at CoP17[1], the Food and Agriculture Organization of the United Nations (FAO) Expert Panel's review of the same proposal[5], and Indonesia's progress report to AC29 (AC29 Doc 25.2 and its Annex 2[3], and AC29 Inf. 21[6]).

The information compiled in this report was provided by a number of international experts on behalf of the International Union for Conservation of Nature (IUCN), as follows. Dr. Sarah Foster, Ph.D. (independent consultant, Honorary Research Associate at The University of British Columbia, Canada, and member of the IUCN SSC Seahorse, Pipefish and Stickleback Specialist Group) acted as the coordinating author. Dr. Samliok Ndobe, M.Si (independent consultant, Tadulako University, Palu, Central Sulawesi, Indonesia), Dr. Inayah Yasir, M.Sc. (independent consultant, Hasanuddin University, Makassar, South Sulawesi, Indonesia) and Abigail M. Moore, M.Sc. (independent consultant, Ph.D Candidate in Fisheries Science, Hasanuddin University) provided all information related to the species in Indonesia (Sections II, III, IV and VI). Monica V. Biondo, M.Sc. (independent consultant, University of Bern, Switzerland) provided information on international trade (Section V), with support in study design and data analysis from the coordinating author. All authors contributed to the recommendations found in Sections VIII and

IX.

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II. Information on the biology and population status of the species

(i) Range

Pterapogon kauderni is a rare example of a marine fish with an extremely limited geographic range. It is found only in Indonesia, with a native distribution (hereafter referred to as endemic distribution or range, for consistency with the majority of existing literature on the species) spread over approximately 5000 km^2 (extending from 01^o 24' 57.6" to 02^o 05' 53.5'' South and from 123^o 0.3'04.2" to 124^o 23' 30" East[7]; Figure 1). Within this range, *P. kauderni* has been found around 34 out of 67 islands with a maximum potential available habitat area (area of occupancy) of approximately 20 km^2 [(8)]. Over 90% of native *P. kauderni* populations are within the Banggai Archipelago, administratively Banggai Kepulauan and Banggai Laut Districts in Central Sulawesi Province, Indonesia. The remaining native *P. kauderni* populations are in Taliabu Island District, North Maluku Province.

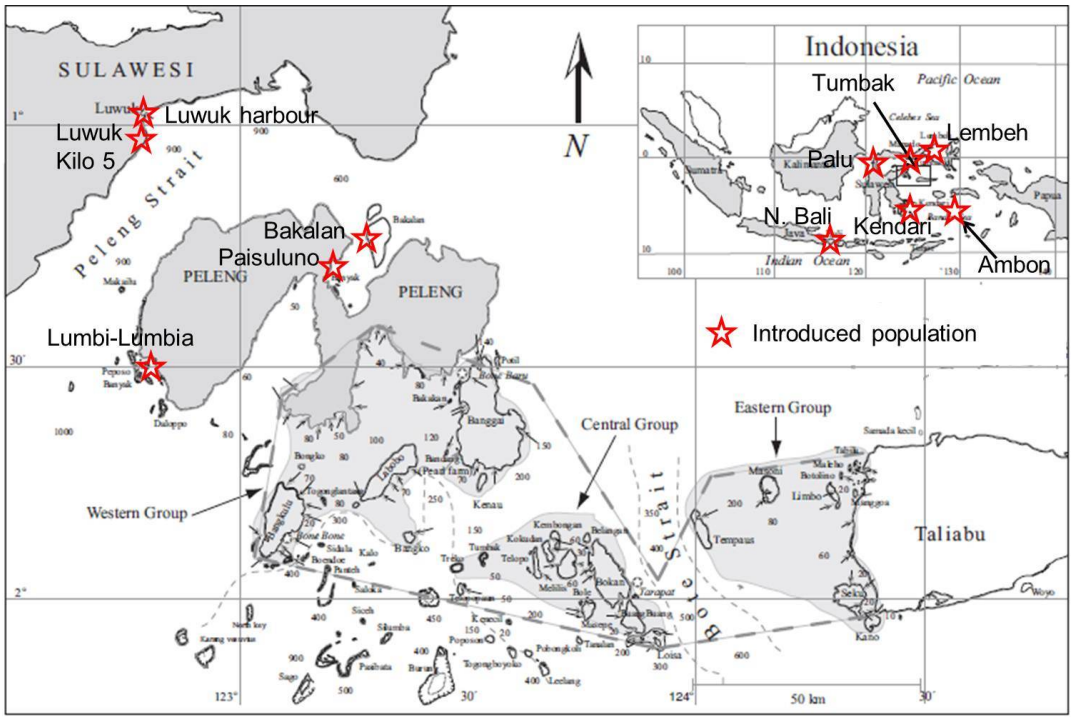

Figure 1. Banggai cardinalfish (*Pterapogon kauderni*) endemic (native) distribution according to Vagelli[7] (dotted lines indicate the external boundaries of the endemic range of ≈ 5000 km^2, within which potential *P. kauderni* habitat extent ≈ 20-24 km^2 around 34 of the islands in the relatively shallow sea areas shaded in grey), and known (published) introduced populations (stars) in the Banggai Archipelago (Lumbi-Lumbia, Bakalan[9], Paisuluno[10]); Central Sulawesi (Luwuk[11,12], Palu Bay[13,14]); North Sulawesi (Lembeh Strait[7,15]); Southeast Sulawesi (Kendari[16]) and North Bali[17] (Gilimanuk, possible other sites), and Maluku (Ambon[18]).

In addition to the native populations, a growing number of introduced *P. kauderni* populations have become established over the past 20 years along ornamental fishing trade routes within Indonesia, mostly due to purposive or accidental release by traders (Figure 1). Introduced population sites reported in the scientific literature include Lembeh Strait[15,19] and Tumbak[20] in North Sulawesi; Luwuk harbour[11,12,14,21]; Luwuk Kilo 5[22], Mamboro and Kadongo in Palu Bay[14,23] in Central Sulawesi; Kendari[16] in Southeast Sulawesi; and North Bali[17]. In addition, traders are known to have released *P. kauderni* in at least three sites in the Banggai Archipelago but outside the *P. kauderni* endemic distribution (Lumbi-Lumbia and Pulau Bakalan[24,25]; Paisuluno[10]). Around 10,000 individuals of *P. kauderni* are reported to have been released in Ambon, Maluku Province, by the MMAF Ambon Mariculture Centre during 2017[18]. Anecdotal information indicates that there may be further introduced population sites, e.g. in the Parigi area of Tomini Bay (Ansarudin, trader, pers. comm. to A. Moore, July 2017) as well as Java and Sumatra (A. Green, The Nature Conservancy, pers. comm. to M. Beger, Leeds University, February 2018).

(ii) Life history

Pterapogon kauderni is a paternal mouth brooder like the majority of cardinalfishes, however it is unusual in having direct development[26,27]. The male parent broods the clutch and then the free embryos, until the yolk sac has been nearly or completely absorbed. Released offspring settle immediately and do not go through a pelagic dispersal phase. After settlement *P. kauderni* exhibits exceptionally high site fidelity throughout its life[28]. Key *P. kauderni* life history parameters show that, for a marine fish, this species is relatively short-lived, has low fecundity, and is subject to a high level of exploitation (Table 1). Furthermore, the fecundity and overall productivity of *P. kauderni* is density dependent[29]. While low densities can reduce overall production[29], reproductive success in terms of post-release survival seems to correlate negatively with adult *P. kauderni* density, most likely related to cannibalism[14,30].

Table 1. *Pterapogon kauderni* life history parameters (based on Ndobe et al 2013[a], unless otherwise indicated).

Parameter	Units/Remarks[b]	Value
Age at first maturity	months or years	< 1 year
Asymptotic length (L_∞)	SL and TL	71 mm SL/107 mm TL
Length at first maturity (L_m)	SL	≈ 40 mm
Growth pattern	$W(g) = a \cdot SL\ (cm)^b$	Allometric negative, $b \approx 2.15$
Growth in length	SL, in cm	$L_t = 7.1 \cdot (1 - \exp^{-(0.74(t + 0.11))})$
Growth in weight	W in grams	$W_t = 12.2 \cdot (1 - \exp^{-(0.74(t+0.11))})^{2.15}$
Fertility	eggs (in egg mass)	mean: 59 (observed range 20-102)
Effective fecundity	eggs brooded	mean: 59 (observed range 45-99)
Sex ratio	Male:Female	≈ 1:1[c], tendency towards male bias (> 1:1)
Breeding pattern	Seasonality	Year round, peak September-November
Breeding cycle	Lunar cycle	Major peak full moon, secondary at new moon[c]
VBGF parameter: K	$years^{-1}$	0.74
Growth performance ø'	non-dimensional value	1.928
Longevity t_{max}	years	3-5 years
Minimum population doubling time	years	1.4 – 4.4[d]
Natural Mortality M	based on water T° 28ºC	2.2
Total Mortality Z	based on L/F data	4.4
Fishing Mortality F	F = Z - M	2.2
Exploitation Rate E = F/Z	range 0-1, ideally < 0.4	0.5
Maximum length Lmax	SL and TL	66 mm SL/86 mm TL

[a] Ndobe S, Soemarno, Herawati EY, Setyohadi D, Moore A, Palomares MLD, Pauly D (2013) Life History of Banggai Cardinalfish, *Pterapogon Kauderni* (Actinopterygii: Perciformes: Apogonidae), from Banggai Islands and Palu Bay, Sulawesi, Indonesia. Acta Ichthyologica et Piscatoria, 43(3):237–50.
[b] SL = standard length, TL = total length
[c] See also Vagelli AA, Volpedo AV (2004) Reproductive ecology of *Pterapogon kauderni* , an endemic apogonid from Indonesia with direct development. Environmental Biology of Fishes, 70:235–45.
[d] Froese R, Pauly D (Editors) (2018) FishBase. World Wide Web electronic publication (www.fishbase.org, 02/2018) https://www.fishbase.de/summary/Pterapogon-kauderni.html [accessed 6 June 2018]

(iii) Habitat and microhabitat

Pterapogon kauderni habitat is limited to shallow (0-5 m, mostly less than 3 m, depth) coastal waters including coral reefs and reef flats, seagrass meadows and lagoons, where it lives associated with protective microhabitat, especially sea urchins, sea anemones and hard corals[7,11, 14,16,20,31,32,]. The extent of suitable habitat within its endemic range is limited; the most recent estimate of 20 km^2 made in 2015[8] is a substantial reduction on an initial estimate of 34 km^2 made in 2005[33].

While many taxa have been reported as *P. kauderni* microhabitat (Annex I), the majority of *P. kauderni* are associated with the microhabitat provided by one of three main taxonomic groups: sea urchins of the genus *Diadema*, sea anemones, and scleractinian corals. Data collected in 2017/2018 shows *P. kauderni* associated with at least two species of the genus *Diadema*: *D. setosum* and *D. savignyi*[34,35]. Published literature prior to 2017, however, refers only to *D. setosum*[7,11] or, more conservatively, *Diadema sp.* (e.g. [20,31,32,36]).

Several studies report statistically significant differences in microhabitat association among different *P. kauderni* age/size classes, indicating an ontogenetic shift in microhabitat

selection[31,32,24,37]. While new *P. kauderni* recruits and small juveniles are commonly found in sea anemones, they are rarely observed in coral (other than the anemone-like *Heliofungia* sp.), and vice-versa. All age/size classes associate with *Diadema* urchins. *Pterapogon kauderni* population abundance and age structure (parameters indicative of reproductive success) appear to be strongly correlated with the abundance of key microhabitat, sea anemones and *Diadema* sea urchins in particular[7,16,14,20,24,30,32,36].

Human activities are exerting heavy pressure on the shallow coastal ecosystems in which *P. kauderni* populations are found, through a variety of direct and indirect anthropogenic impacts. These include destructive fishing practices (use of explosives, crowbars, etc) [7,10, 24, 34,35,38,39,40], coral mining[7,24,38], overfishing (fish and invertebrates)[10,24,34,35,38,40,41], pollution[10,24,39], sedimentation[10,24,39,34], coastal development and sea filling/land reclamation[10,24], and coral bleaching[34,40]. Reported threats to habitat at an ecosystem level have changed little over the past two-three decades, although there have been shifts in spatial distribution and/or severity. Data on habitat typology and condition at 16 *P. kauderni* native population sites surveyed in 2011/2012 and again in 2017/2018 are presented in Table 2. The 2017/2018 data are unpublished, and were collected by scientists from Hasanuddin and Tadulako Universities using belt transect and swim survey methods. The researchers noted a decline in the condition of overall habitat at five of the 16 sites, stable conditions at four sites, some recovery in just two sites, and no data on trends were available for a further five sites (Table 2).

Exploitation levels of sea anemones and sea urchins have increased sharply over the past decade, resulting in sharp declines in abundance[8,10,16,31,32,34]. These species are mostly exploited for human consumption, though urchins are also used as feed for carnivorous fish grow-out operations. Data on *P. kauderni* microhabitat density and status in 2011/2012 and trends through 2018 across 19 sites are shown in Table 3, and qualitative data on *P. kauderni* microhabitat abundance (2004-2018) at nine of these sites are shown in Table 4. The general condition of habitat at the 19 sites ranged from good (one site) to severely degraded (three sites). Microhabitat densities were noted to have declined in eight sites, increased in two sites, remained the same in one site, and there were no data on trends available for a further eight sites (seven were not sampled again after 2012, and for one site the exact area sampled differed between periods such that data were not comparable) (Table 3).

Table 2. Data on the typology and condition of *Pterapogon kauderni* habitat at 16 sites across the Banggai Archipelago, Indonesia, in 2011/2012[a] and notes on habitat condition trends when sites were re-visited in 2017/2018 (new data, see text).

Survey Site				Ecosystem[b]		Condition[c]		
						2011/2012		2017/2018
No.	Name	Geography		Main type	Extent	State	Trend	Trend
1	Popisi 1	bay	protected	RF	stable	poor-average	signs of degradation	decline
	Popisi 2			CR				
2	Bone Baru	bay	semi-open	RF	reduced	average	decline[d]	decline
3	Paisulimukon	strait	semi-open	CR	stable	average	improving	no data
4	Tinakin Laut	strait	protected	RF	reduced	poor	decline	stable
5	Monsongan	bay	semi-open	CR	reduced	average	stable	decline
6	P. Bandang Besar & Kecil	small islands/strait	semi-open	CR	-	poor to good	signs of degradation	no data
7	Tolokibit	bay	protected	RF & SG	reduced	poor-average	decline	decline
8	Matanga	bay	semi-open	SG	reduced	poor-average	no data	no data
9	Toropot	bay/lagoon	protected	SG	reduced	poor-average	decline	stable
10	Kombongan 1 &2	bay	protected	RF	unclear	poor-good	signs of degradation	stable
11	Tanjung Nggasuang	lagoon	protected	SG	greatly reduced	severely degraded	sharp decline	some recovery
12	Mbuang-Mbuang	bay	semi-open	RF	reduced	poor	signs of degradation	some recovery
13	Toado	shoal	protected	MG	-	good	no data	stable
14	Bone Bone 1	coast	semi-open	SG	unclear	poor-average	signs of degradation	no data
	Bone Bone 2	bay	semi-open	RF		poor		
15	Tolobundu	small island	semi-open	RF	reduced	severely degraded	no data	no data
16	Liang jetty	bay	protected	CR	stable	poor	decline	decline
	Liang Bajo		protected	SG	stable	poor	no data	decline
	Liang Island	small island	semi-open	RF & SG	reduced	severely degraded	decline	decline

[a] Ndobe S, Moore A, Salanggon AIM, Muslihuddin, Setyohadi D, Herawati EY, Soemarno (2013). Pengelolaan Banggai cardinalfish (*Pterapogon kauderni*) melalui konsep Ecosystem-Based Approach. Marine Fisheries, 4(2):115–26

[b] Main type: CR = coral reef; SG = seagrass beds; RF = reef flat; MG = mangrove (*Rhizophora* sp.), habitat among prop roots.

[c] Trend for 2011/2012 is compared to observations before this period, for some sites as early as 2004, and for 2017/2018 is compared to 2011/2012.

[d] Overall condition declining, almost total destruction of one patch reef, but significant (albeit still partial) recovery within the community MPA.

Table 3. Data on *Pterapogon* microhabitat (*Diadema* urchins and all species of anemones) at 16 sites across the Banggai Archipelago, Indonesia in 2011/2012[a] and trends in density from 2012-2018.

Survey Site		Density (individuals/m²)				Trend 2012-2018
		Belt Transect		Swim Survey		
No.	Name	*Diadema*	Anemones	*Diadema*	Anemones	
1	Popisi	-	-	0.180	0.002	slight decline[c]
2	Bone Baru	4.123	0.010	0.072	0.008	sharp decline[b]
3	Paisulimukon	-	-	0.348	0.002	no data
4	Tinakin Laut	2.558	0.020	-	0.002	decline[c]
5	Monsongan	-	0.005	-	-	sharp decline[c]
6	P. Bandang Besar	-	-	0.508	0.018	no data
	P. Bandang Kecil	0.435	0.020	-	-	no data
7	Tolokibit	0.175	0.023	-	-	sharp decline[b]
8	Matanga	0.245	0.105	-	-	no data
9	Toropot	1.418	0.005	-	-	slight increase[c]
10	Kombongan	3.260	0.018	0.490	0.004	slight decline[c]
11	Tanjung Nggasuang	0.318	0.080	-	-	signs of recovery[c]
12	Mbuang-Mbuang	4.360	0.007	-	-	decline in *Diadema*[c]
13	Toado	-	-	0.000	0.009	unknown[d]
14	Bone Bone	4.280	-	-	-	no data
15	Tolobundu	-	-	0.018	0.004	no data
	Liang jetty	-	-	0.122	0.000	decline[b, c]
16	Liang Bajo	-	-	0.218	0.002	decline[b, c]
	Liang Island	-	-	0.002	0.000	no data

[a] Ndobe S, Moore A, Salanggon AIM, Muslihuddin, Setyohadi D, Herawati EY, Soemarno (2013) Pengelolaan Banggai cardinalfish (*Pterapogon kauderni*) melalui konsep Ecosystem-Based Approach. Marine Fisheries, 4(2):115–26

[b] Ndobe S, Moore AM, Jompa J (2103) Status of and threats to microhabitats of the endangered endemic Banggai Cardinalfish (*Pterapogon kauderni*). Coastal and Ocean Journal, 1(2):73–82

[c] Trends based on data collected in 2017/2018 by A. Moore, unpublished data.

[d] Coordinates of site surveyed were different.

Table 4. Qualitative data on *Pterapogon kauderni* microhabitat abundance at nine sites in the Banggai Archipelago, Indonesia, across three time periods from 2004-2018 (DD = *Diadema* spp.; AN = sea anemones, all species)[a].

Site	2004/2006	2011/2012	2017-2018
Bone Baru	• AN fairly abundant on reef flat and in seagrass beds • DD: mainly associated with corals all around the bay, moving to seagrass beds in poor weather	• DD and AN still quite numerous • Reduced distribution area, partly due to coral mining	• DD greatly reduced, higher proportion of juveniles • AN reduced by at least 50%
Tinakin Laut	• DD and AN abundant around and between the small islands • DD abundant around and under stilt houses	• DD patchy, less abundant • AN greatly reduced since 2004, but more than in 2007 (almost 100% collected for consumption in 2007)	• DD mostly juveniles, few large adults, mostly around houses • AN: still very few
Monsongan	• AN very abundant • DD abundant among corals, groups of many hundreds of individuals, mostly adult size	• AN: drastic reduction, only 2 individuals in 4 transects (400m^2) • DD in small groups and further apart	• AN: still few, but more than 2012 • DD absent from extensive areas, high proportion of juveniles
Tolokibit	• AN: relatively few • DD extremely abundant, in corals, seagrass, and rubble areas damaged by abalone collection	• DD and AN: drastic reduction, sea urchins dominated by the genus *Echinothrix*	• AN: rare but present • DD: some recovery in 2017 but very few in 2018
Matanga	• AN: extremely abundant in fringing reef, including rubble areas damaged by abalone collection • DD: abundant but mainly in seagrass	• AN: still abundant but far fewer; decline possibly mitigated by increase in *Heliofungia actiniformis* • DD far less abundant	• No data, but in Kapela (same bay) some recovery in area now protected by the community
Toropot	• AN: abundant • DD: extremely abundant in lagoon	• AN and DD: drastic decline, absent from extensive areas of the lagoon	• AN: slight recovery • DD: many more than in 2012 but still < 5% compared to 2004
Tanjung Nggasuang	• AN abundant • DD extremely abundant in lagoon, and abundant in fringing reef	• DD and AN absent from extensive areas of the lagoon • Severe damage to fringing reef	• AN: slight recovery, still few • DD (and corals) more abundant than in 2012
Liang jetty and bay to Bajo village	• AN and DD abundant among the remains of the old jetty (destroyed by earthquake in 2000) • DD extremely abundant in the bay as a whole	• AN: absent near jetty, few elsewhere • DD: sharp decline, few adult sized urchins • Old jetty disintegrated, new jetty already collapsing	• AN: present, but rare • DD: even fewer than in 2012, very few adult urchins • New jetty further collapsed
Liang Island	• Source of corals for rebuilding since the earthquake in 2000 • DD and AN still present but very few, one anemone hosting only remaining group of *P. kauderni* (11 fish)	• Continued degradation due to ongoing use as source of materials • AN: none found • DD: 1 urchin found • Intensive search: no *P. kauderni* (extirpated population)	• Not surveyed in 2017/2018 but informed that coral mining is reduced • Designated as rehabilitation zone in Banggai Dalaka MPA (section 2.2.2)

[a]Data for 2004-2012: Ndobe S, Moore A, Salanggon AIM, Muslihuddin, Setyohadi D, Herawati EY, Soemarno (2013) Pengelolaan Banggai cardinalfish (*Pterapogon kauderni*) melalui konsep Ecosystem-Based Approach. Marine Fisheries, 4(2):115–26; data for 2017-2018 A. Moore, unpublished data.

(iv) Population structure

The life history traits of *P. kauderni* (mouth brooder, no pelagic dispersal, high site fidelity at all life stages, see Section II.ii) result in low dispersal and thus low connectivity, with at least two consequences. First, the species is especially vulnerable to local extinction (extirpation), which is known to have occurred since the early 2000's in at least two sites[7,32]. Second, a high potential for reproductive isolation leads to little or no gene flow between populations.

Studies reveal fine-scale genetic population structure in *P. kauderni* at the level of the Banggai Archipelago[19,42,43], and even individual islands[12,19,21]. Population structure in *P. kauderni* has been studied based on analysis of the mitochondrial control region[42] and on a set of polymorphic microsatellites developed in 2004[44]. Together, these studies indicate a minimum of 21 genetically distinct populations[35], some separated by as little as 2-5 km[12,19,21] (Figure 2). Genetic diversity is accompanied by phenotypic diversity (morphometric[45] and/or colour pattern[7]) in some populations.

There are many sites in the Banggai Archipelago for which no genetic data exist, but existing data suggest that every small island and each bay (or stretch of coast delimited by areas without suitable *P. kauderni* habitat) on larger islands could be treated as separate Evolutionarily Significant Units (ESUs) for the purposes of *P. kauderni* conservation and management – at least until information gaps are filled.

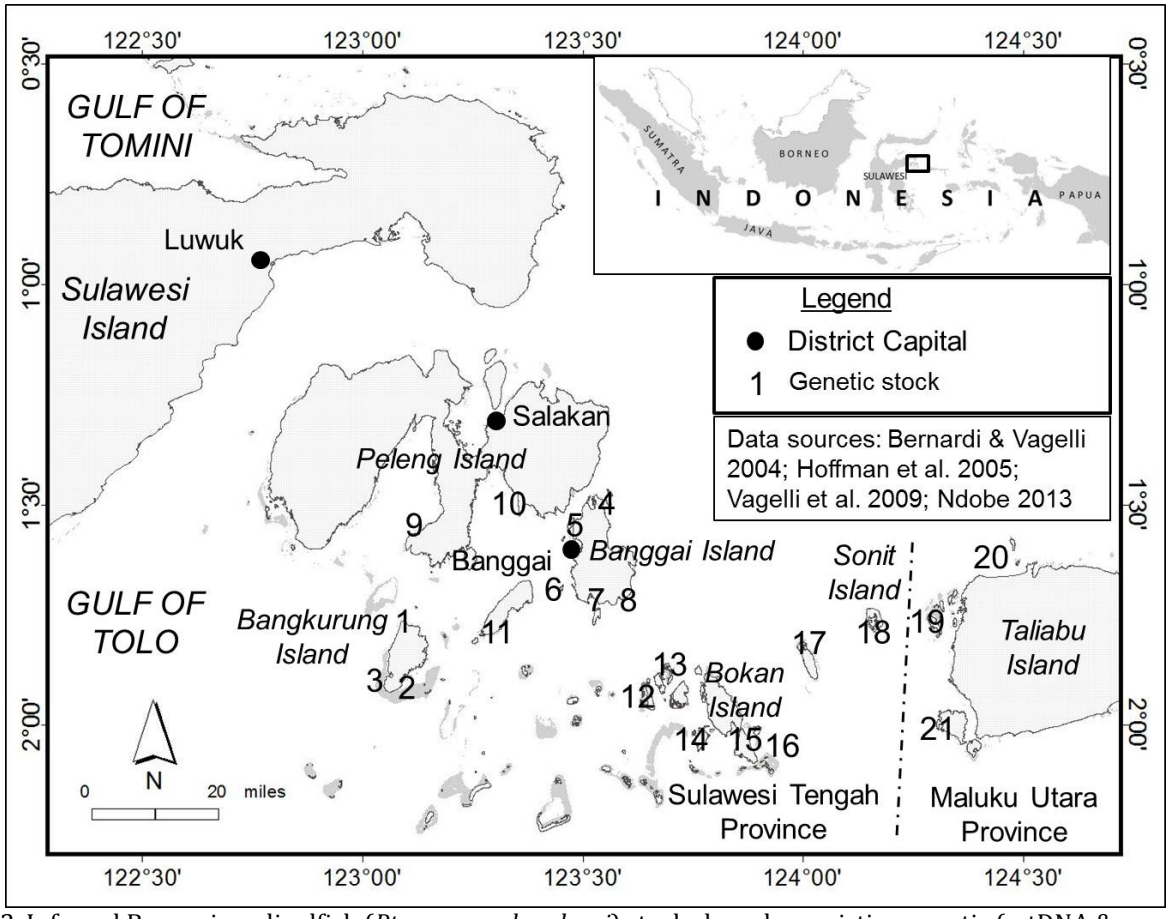

Figure 2. Inferred Banggai cardinalfish (*Pterapogon kauderni*) stocks based on existing genetic (mtDNA & microsatellite) data (adapted from Moore et al.[35], compiled from several studies[12,19,21,42]).

(v) Population status – Endemic

The overall status of *P. kauderni* within its endemic range is one of conservation concern; the species is listed as Endangered on the IUCN Red List of Threated Species (assessed in 2007)[46], and is listed on the US Endangered Species Act (ESA, added in 2016)[47]. All surveys since 2000 have reported declining trends in native *P. kauderni* populations at a majority of sites surveyed (estimated total population declines range from 36 to 90%), and there has been extirpation of several populations (as many as six; this information is presented in CoP17 Prop 46[1]). Although there is little doubt that the total native population has declined substantially since the late 1990's and even the late 2000's[7,8,14], there is some doubt about the total native population figure at any period in time, due to the way in which estimates have been calculated. Estimates to date have been based on multiplying an average density by a total habitat area, and thus are dependent on the assumptions made in calculating both densities and total habitat area. For example, the latter has been revised several times from around 34 km^2 [(33)] to around 20 km^2 [(8)]. These methods have produced estimates ranging from a maximum of 2.4 million fish[11] to the most recent estimate of around 1.4 million fish[8].

Within its endemic range, the status of various known or inferred ESU's varies greatly, from sites with high densities to sites now nearly void of fish. The most recent wide-ranging survey – carried out in 2017 under the NPOA (Table 5, see also map in Annex 1 of AC29 Doc 25.2[3]) – suggests over-exploited conditions in several sites. The survey covered 24 sites proposed as permanent monitoring sites by the Indonesian Ministry for marine Affairs and Fisheries (MMAF) and the Indonesian Institute of Science (LIPI), and included counts of key *P. kauderni* microhabitats. The survey took place about a week after the peak spawning (full moon) period, during the peak reproductive season (in October)[14], which accounts for the high number of (mostly recent) recruits at most sites.

Table 5. *Pterapogon kauderni* counts and density from the T_0 survey carried out in October 2017 at 24 sites across the Banggai Archipelago, Indonesia [a].

Survey site			**Density in (600 m²) transect area (fish/m²)**	***P. kauderni* and key microhabitat recorded in T_0 transects (number of individuals)**					
No.	Approximate Coordinates	Name		Total	Recruits (<18 mm SL)	Juveniles (18-35 mm SL)	Adults (>35 mm SL)	Sea urchins	Sea anemones
1	02 04' 52.4" S 123 54' 28.7" E	Toado 1	2.60	1558	359	646	553	1	9
		Toado 2	5.21	3123	838	1558	727	11	18
2	02 04' 37.5' S 123 52' 19.7" E	Melilis 1	0.59	353	202	114	37	294	4
		Melillis 2	0.51	303	124	83	96	187	0
3	02 04' 19.0" S 123 52' 10.4" E	Mbuang Mbuang 1	0.67	401	258	98	45	199	0
		Mbuang Mbuang 2	0.27	159	104	18	37	100	0
4	01 59' 51.9" S 123 50' 32.8" E	Mandel 1	0.09	51	25	0	26	706	2
		Mandel 2	0.05	28	20	0	8	200	0
5	02 00' 41.6" S 123 46' 22.0" E	Tj. Nggasuang 1	1.59	953	521	203	229	796	0
		Tj. Nggasuang 2	0.61	367	172	81	114	464	0
6	01 55' 31.9" S 123 42' 28.7" E	Minanga 1	1.95	1167	640	355	172	0	5
		Minanga 2	3.28	1965	821	419	725	4	13
7	01 52' 47.4" S 123 41' 23.0" E	Kombongan 1	0.38	229	103	51	75	36	6
		Kombongan 2	0.43	255	41	88	126	21	4
8	01 56' 33.6" S 123 38' 03.5" E	Toropot 1	2.56	1534	761	470	303	277	2
		Toropot 2	4.13	2475	1189	765	521	1164	0
9	1.53944° S, 123.48197° E	Bongo	3.48	2089	733	911	445	422	23
10	1.71474° S, 123.57911° E	Kapela	0.67	404	86	69	249	72	3
11	1.71639°S, 123.53017° E	Tolokibit	0.49	296	165	41	90	505	1
12	1.63711°S, 123.48248° E	Monsongan	0.37	222	126	45	51	181	3
13	1.60268°S, 123.48826°E	Tinakin Laut	1.13	675	293	149	233	771	2
14	1.49923°S, 123.51510°E	Popisi	2.51	1503	141	468	894	155	11
15	1.53193°S, 123.49397°E	Bone Baru	8.27	4961	1265	2532	1164	351	24

Survey site			Density in (600 m²) transect area (fish/m²)	*P. kauderni* and key microhabitat recorded in T_0 transects (number of individuals)					
No.	Approximate Coordinates	Name		Total	Recruits (<18 mm SL)	Juveniles (18-35 mm SL)	Adults (>35 mm SL)	Sea urchins	Sea anemones
16	1..49330˚S, 123.51348˚E	Asasal	2.18	1308	187	426	695	579	3
17	1.88531˚S, 123.10294˚E	Bone Bone	1.69	1013	200	656	157	2035	0
18	1.77019˚ S, 123.10045˚ E	Dungkean	0.51	304	94	92	118	391	1
19	1.78366˚S, 123.26972˚ E	Bontosi	0.80	478	2	273	203	113	3
20	01.27281˚S, 123.21318˚ E	Paisuluno[b]	0.38	228	8	121	99	228	0
21	1.48968˚S, 122.82118˚E	Lumbi-Lumbia[c]	1.93	1159	444	266	449	1133	0
22	1.55329˚ S, 123.24296˚ E	Liang	0.09	53	28	11	14	2	1
23	1.52276˚S, 123.40159˚ E	Bobu	0.22	131	21	27	83	888	2
24	1.73814˚S, 123.33696˚E	Lipulalongo	0.15	90	10	20	60	16	0

[a] The survey data were collected from a minimum of six belt transects (20x5 m) at each site. For sites 1-8, two sets of six transects (12 in total) were placed in locations with *P. kauderni* microhabitat, where *P. kauderni* was known to be or to have been present. Transect placement for sites 9-24 is not known (see Section VIII.iii). Sites 1-8 were surveyed by a team from Tadulako University (UNTAD), Hasanuddin University (UNHAS), Palu Fisheries and Marine Science College (STPL-Palu), and the Central Sulawesi Marine and Fisheries Service (Dislutkan Sulteng). Sites 9-24 were surveyed by teams from the Indonesian Institute of Science (LIPI), MMAF technical agencies (the Luwuk-Banggai Fish Health and Quarantine Station (BKIPM Kelas II Luwuk-Banggai) and the Palu Branch of the Makassar Coastal and Marine Resources Management Agency (BPSPL Makassar Satker Palu)), the national NGO LINI and local NGO Kali.

[b] This is most probably an introduced population, situated outside the endemic range according to: Vagelli AA (2011) The Banggai Cardinalfish: Natural History, Conservation, and Culture of *Pterapogon kauderni*. First Edition. Chichester, UK: John Wiley & Sons, Ltd. 219 p.

[c] There are strong indications (including anecdotal evidence from fishermen who released *P. kauderni* at this site) that this is an introduced population, situated outside the endemic range according to Vagelli (2011), reference in [b].

The T_0 surveys provided evidence of overfishing at several sites. Some sites with low or very low *P. kauderni* densities also had a very low proportion of juvenile fish – the cohort of marketable sizes – suggesting the low densities are the result of collection pressure (see site 3 – Mbuang Mbuang 2; site 4 – Mandel 1 and 2 in Table 5). Also likely the result of collection pressure, the ratio of juveniles to adults at 14 out of 24 sites was low compared to previous population age-size structure data that indicated juvenile to adult ratios between 1:1 and 2:1[14,20,32] (similar to those at the apparently unfished sites of Toado and Minanga during the T_0 survey). Furthermore, the majority of juveniles observed at sites in the Bokan Islands (sites 1-8) were below 25 mm SL, while the marketable cohort size range (≈25-35mm SL) was visibly depleted with the exceptions of Toado (site 1) and Minanga (site 6).

The 2017 survey is referred to as the T_0 or baseline survey; it is the "baseline" for the purposes of monitoring the effect of newly proposed *P. kauderni* conservation and management activities (see Section VII), and not a "baseline" for evaluating population status. Many of the sites surveyed have densities that are well below historic densities, and thus below what might be appropriate targets for rebuilding. Unfortunately it is challenging to compare the T_0 survey results to some previous population surveys due to uncertainty about survey locations and differences in the methods used. For example, the most recent comprehensive population survey prior to the T_0 survey, carried out in 2015, covered 43 sites[8] – but the contributing authors struggled to compare those results to the T_0 results due to uncertainty about some survey locations in both cases, as well as the differences in survey methods, data analysis and data presentation.

(vi) Population status – Introduced

The T_0 surveys did not include introduced *P. kauderni* populations, and so data on *P. kauderni* densities are not yet available for these sites. Brief information on the exploitation and status of each is given in Table 6 (see Figure 1 for site locations). The majority of these populations were established after ornamental fish traders released fish that appeared damaged and/or unlikely to survive further travel, released fish that remained unsold, or released them with the deliberate intention of forming introduced populations in order to exploit them (particularly to fulfil smaller orders near their homes). These populations are thus true introductions, defined in the IUCN Guidelines for Reintroductions and Other Conservation Translocations[48] as "the intentional movement and release of an organism *outside its indigenous range*".

At many of these sites, population abundance and age structure can be expected to vary over short time periods, as individuals are removed for aquarium trade and other uses (broodstock, research, display), and added through release activities. These activities are not currently regulated outside a new *P. kauderni* fishery closure during two time periods in three districts (Banggai Laut, Banggai Kepulauan, Banggai), which includes the Luwuk introduced populations and those within the Banggai Archipelago (Lumbi-Lumbia, Bakalan and Paisuluno) – see Section VII.iii for regulation details.

Table 6. Notes on the status of introduced *Pterapogon kauderni* populations across Indonesia.

Introduced population		Estimated date of establishment	Status
No.	Name/Location		
1	Lembeh Strait, North Sulawesi	Prior to 2001[15]	Possibly exploited, expanding[7].
2	Tumbak North Sulawesi	Between 1998 and 2003[20]	Exploited – rate/status unknown.
3	Luwuk harbour Central Sulawesi	2000 or earlier[11]	Social survey and genetic analysis data both point to introduced origin[49]. Abundant, no sign of expansion.
4	Luwuk Kilo 5 Central Sulawesi	2017	Increasing. Fish released as juveniles in early 2017, and again in 2017. Substantial numbers of sub-adults seemed well established in October 2017 but not yet fully mature or breeding[22].
5	Palu Bay Central Sulawesi	2005	Two populations known to have become established: Mamboro and Kadongo[50]. Exploited (ornamental fishery, research, promotion/expositions). Repeat monitoring revealed recent habitat degradation at both sites, especially severe at Kadongo.
6	Parigi Central Sulawesi	early 2000's[51]	Exploited – rate/status not known.
7	Kendari Southeast Sulawesi	probably late 2000's, ongoing in 2011[16]	Exploited – rate/status unknown.
8	Sites in North Bali (including Gilimanuk)	unknown	Exploited[17].
9	Lumbi-Lumbia Peleng Island Banggai Kepulauan District	unknown[52] thought to be post 2004	In 2013, population still concentrated around release site and few in number. Surveyed in 2017 (Table 5). Exploitation – no data.
10	Bakalan Island Banggai Kepulauan District	unknown thought to be post 2004	In 2016, population had spread around 100m from the release site, still few in number, coral and anemone microhabitat affected by bleaching[40]. Exploitation – no data.

(vii) Disease

Wild *P. kauderni* individuals are known carriers of internal parasites, ectoparasites and pathogens – particularly *Vibrio alginolyticus*; whereas an iridovirus not present in wild fish has been documented to cause significant mortality once fish enter the supply chain. Precautionary measures are needed to minimize risks of disease in captive populations, and to prevent transfer from captive to wild populations, or between wild populations.

Internal parasites found in *P. kauderni* specimens include trematodes and nematodes (digestive system); incysted isopods (external stomach wall, internal body wall); pleurocercoid cestode larvae; and unidentified parasite eggs[7]. Macroscopic external parasites seem relatively rare, however a cymothid isopod has been reported[7]. Smaller potentially pathogenic ectoparasites of the following genera are reported from routine inspection of wild-caught fish being traded from the Banggai Archipelago: *Chilodonella, Trichodina, Amyloodinium, Vorticella, Zoothamnium*, and *Ichthyopthirius*, with a higher frequency and severity of infestation during the rainy season[53]. Mortality due to infestation with one or more of these parasites has occurred in holding cages

and tanks; these outbreaks are thought to be related to the lowered resistance of fish under stressful conditions, such as poor water quality or nutrition[53].

Pathogens which can affect *P. kauderni* include bacteria of the genus *Vibrio*[54,55], which can cause symptoms including subcutaneous haemorrhage, fin erosion, ulcerated wounds, abnormally protruding eyes, and death. Wild-caught fish collected (live) from fishers (Banggai Archipelago), a middleman (Luwuk), and exporters (Bali, Jakarta, Manado) were tested for parasites, pathogenic bacteria, viruses, and fungi[55]. No ectoparasites or fungal infections were found. The following bacteria were identified in the fish collected from fishermen: *Alcaligenes faecalis, Micrococcus luteus*, *Acinetobacter* spp., *Plesiomonas shigelloides, Yersinia enterocolitica*, and *V. alginolyticus*, although composition and prevalence varied between collecting sites. Of these, *V. alginolyticus* and *P. shigelloides* were prevalent at the middleman's facility. These results indicate that *Vibrio* sp., omnipresent in the environment, have the potential to become a major problem in the *P. kauderni* trade chain.

An iridovirus causing significant mortality in the *P. kauderni* trade chain (called the Banggai cardinalfish iridovirus or BCIV) was identified as a virus of the genus *Megalocytivirus*, family Iridoviridae[56]. To date, this virus has not been found in wild fish, though it has been identified at all levels of trade from middlemen to Indonesian exporter facilities[55], and overseas from importers through to consumers[7,39]. It is thought likely that the virus originated in a captive environment, possibly through transmission from other species followed by mutation to adapt to the new host, and that its emergence may be related to (poor) environmental conditions and other stress factors[7,39,55].

III. Sustainable harvest levels

There is empirical evidence that *P. kauderni* can be harvested sustainably under the right conditions. For example, the highest population density during a survey in 2004 was recorded at a site where collection had been carried out for some years, with a between-site rotation period of approximately 3 months[20,57] (the density exceeded that recorded at the Monsongan pearl farm, a site suggested as a baseline[7]). There are, however, at least two caveats. Firstly, that habitat condition and microhabitat abundance are conducive to reproductive success; and secondly, that harvest patterns are conducive to regular replenishment of the target size/life-stage. Various ways to achieve these conditions are explored in this section and Section VIII.

A study on *P. kauderni* life history published in 2013[14] included an analysis of population dynamics using the FISAT II[58] software. Data spanning the period 2004-2012 were used to calculate an approximate exploitation rate of E = 0.5 (Table 1). Based on guidelines in the FAO fish stock assessment manual[59], an exploitation rate of 0.2 would be more appropriate for a fish with low productivity[7] such as *P. kauderni*. This proposed rate accounts for the fact that productivity of *P. kauderni* is density dependent[29], and that population growth at many sites will be significantly hindered by the status of habitat/microhabitat (see Section II.iii), in addition to extremely limited to no movement of individuals between sites.

The authors have determined sustainable harvest estimates (potential quotas) for the native *P. kauderni* populations within the Banggai Archipelago based on the T_0 survey results (Table 7). An exploitation rate of 0.2 was used for the commercial trade in predominantly juvenile fish (SL

range 25-35 mm), and a lower maximum rate of 0.1 was used for adult (presumably reproductively active) fish. Several assumptions were made: (i) surveyed sites are representative of sites not surveyed; (ii) the actual number of fish per site is on average five times greater than the number recorded in the sample transects (based on observations at a limited number of sites, A. Moore, unpublished data); (iii) cohorts will graduate from recruits/small juveniles to target size in approximately three months (based on empirical field observations, S. Ndobe and A. Moore, unpublished data; the growth curve derived from data on wild populations[14]; information from fishermen, e.g. [20]; and captive growth rates, e.g. [60]); and (iv) fishing effort can be allocated in accordance with the suggested protocols (Table 7, and see also Section VIII.iv).

Table 7. Proposed *Pterapogon kauderni* quota volumes and mechanisms in support of fisheries management in the Banggai Archipelago, Indonesia. See text for details.

Parameter	Juveniles (SL 25-35mm)	Adults (SL > 35mm)
T_0 number of individuals (Table 5)	11,056	8,798
Estimated available fish per 3 months	55,280	35,192
Estimated available fish per year	221,120	175,960
Estimated allowable harvest per year across all sites	44,224	17,596
Estimated allowable harvest per month across all sites, with 3 monthly rotation at each site	3,685	1,466
Proposed total monthly quota across all sites, with 3 monthly rotation at each site	4,000	1,500
Proposed total quarterly quota across all sites, with 3 monthly rotation at each site	12,000	4,500
Proposed allowed uses	Trade, Research, Broodstock	Broodstock, Research
Proposed mechanisms for ornamental trade	Sites and associated quotas allocated to fisher groups; Harvest rotation between sites	Not permitted
Proposed mechanisms for broodstock (aquaculture), research, and any other permitted use (e.g. for display at expositions or educational purposes)	By permit; Indemnity to fisher group(s) holding quota(s) for the site(s) of origin	By permit (time and site limited quota); Dependent on volume, proposed use, and quota availability
Monitoring - administrative	Routine procedures	
Monitoring - field surveys	Yearly + spot checks	
Review of quota	Annual evaluation; Revision as part of 5 year management cycle (NPOA and general fisheries management plans) or when monitoring and evaluation indicate an urgent need	

This analysis is highly precautionary, which the authors consider appropriate given the Endangered status of *P. kauderni*, and documented population declines to date (see Sections II.v and VI). The total suggested quota of ~66,000 fish per year (Table 7) is significantly less than a quota determined in 2007 of 15,000 individuals per month (182,000 per year)[5], but similar in scale to annual trade in *P. kauderni* reportedly consigned from within its endemic range in recent years (see data for Luwuk-Banggai 2016-2017 in Section IV; though it is worth noting that some of the trade from Kendari reported in Section IV may include stock extracted from the endemic area, as discussed in Section IV(ii)). In the spirit of adaptive management, as populations (stocks) recover, the quotas suggested in Table 7 could be increased. Conversely, where monitoring shows continued declines, quotas could be reduced. No quota is suggested for recruits and small

juvenile *P. kauderni* (SL < 25 mm). This is the most vulnerable life stage, and survival of these young fish is critical to *P. kauderni* conservation including sustainable use.

The authors have proposed a total quota across all sites (Table 7), but the population structure of *P. kauderni* suggests that quota implementation should be site specific. Setting a limit on the total volume of *P. kauderni* harvested is unlikely to prevent the serial extinction of fish within specific sites. The genetic structure of *P. kauderni* (Section II.iv) calls for management at a fine spatial scale – at the ESU level. Management should aim to prevent the overfishing of individual ESUs as well as the unnatural movement of individuals between ESUs. A number of measures that could be implemented as part of and/or complementary to the proposed quotas are considered in Section VIII.

The authors have not estimated sustainable take from introduced populations, in part because current density estimates are not known (see Section II.vi). It will be important to establish the size of introduced populations for two reasons. For one reason, this information will help determine if reported trade out of introduced regions includes illegal take of native populations (for example, see discussion of reported trade out of Kendari in Section IV.ii). For a second reason, increased exploitation of introduced populations may provide a source of fish while overexploited native populations are allowed to recover. The authors are concerned, however, that a lack of traceability systems will make it challenging to determine if fish are indeed from introduced populations, rather than from native areas. There is additional concern that increasing the focus on introduced populations will reduce incentives for conservation and management within the species endemic range (see Section VI).

Finally, the contribution of cultured animals to overall trade in *P. kauderni* in Indonesia is not yet significant in terms of numbers (see Section IV.iii).

IV. Trade – inter-island/national, regional

The near-shore shallow habitat and sedentary lifestyle make *P. kauderni* extremely easy to catch[17,20]. By 2001 the trade volume was estimated to be around 700,000-1.4 million fish/year[61], more recent estimates vary depending on methods and data sets used[7,16,24]. Nevertheless, the estimated annual volume in recent years has been lower than in the late 1990's and early 2000's[24].

(i) Sizes in trade

The target size-range for the ornamental trade has remained fairly stable over the last decade, at approximately 25-35 mm standard length (SL)[24,62]. Oversized (and more rarely undersized) fish have been released as rejects and to start or replenish introduced populations (e.g. in Kendari[16]). In recent years there has been some in-country demand for larger fish as broodstock, for example by aquaculture and research facilities in Ambon and elsewhere (S. Ndobe and A. Moore, unpublished data).

(ii) Sources and volumes

Pterapogon kauderni typically pass through two-four trade levels from point of capture to point of export. Fish are typically hand caught using simple fyke or scoop nets (respectively called cang and bundre). Originally the majority of fishers were fisher-traders coming from provinces outside the *P. kauderni* native area by sea, but nowadays almost all fish recorded as leaving the Banggai Archipelago are caught by local fishers or fisher/traders operating within their own jurisdiction. Fishers who are not also first level traders sell to such traders (mostly fisher/traders) operating near where they live. These first-level traders consign their fish to larger traders (some of whom are also exporters) based in trading and export centres – most commonly Denpasar (Bali) or Java (Jakarta/Surabaya).

Movement of fish between jurisdictions is supposed to be regulated and monitored. Legally, fishing vessels and traders require special permits to operate outside their own jurisdiction, and are subject to mandatory reporting requirements. Furthermore, along trade routes, fish volumes, sources and destinations are supposed to be reported to the local Fish Health and Quarantine Service by fishers and/or traders when shipping fish outside a jurisdiction. Consignments are also supposed to be recorded on arrival in a jurisdiction. Consignments by sea are still frequently under-reported or unreported, while for air transport (increasingly common since the Luwuk airport has been upgraded) evasion is more difficult, due to routine (e.g. X-Ray) procedures. Fish head overseas from major export centres, with minimal and variable tracking of volumes at point of import (see Section V).

The Fish Health and Quarantine Service has a statistics section in its website with data on *P. kauderni* (reported as "capungan") from mid-2008[63]. For this section of the report, A. Moore analysed data for *P. kauderni* from 2008-2018 (data were accessed between 28 May and 1 June 2018). A synopsis of the reported transit of *P. kauderni* shipments through a number of key origin and destination stations is presented in Table 8 and Figure 3, based on detailed data in Annex II Tables II.1 through II.7. The way the data are organized makes it challenging to search out information on a particular commodity across time and reporting stations, and so it is possible that some stations with data were missed (i.e. *P. kauderni* may have been sent from or received in Denpasar from stations other than those included in the tables), and does not include consignments that were not reported through the Fish Quarantine procedures. It is also possible some consignments were counted twice if they were sent to an intermediate destination before being sent on to a final destination in Indonesia. Current trade routes, however, suggest double counting would apply to a very small percentage of total trade – likely much smaller than the volume of missed data or underreporting.

Table 8. Fish Health and Quarantine Service statistics on total reported *P. kauderni* consignments from regions across Indonesia. Details for each region, including breakdown by reported destinations, in Tables II.1 through II.6 of Annex II. Data for 2018 are partial data only (data accessed between 30 May and 1 June 2018).

Year	Luwuk-Banggai	Kendari	Manado	Makassar	Palu	Ambon	Total
2008	40,799	126,435	438,430	200	1,192		607,056
2009	158,280	66,616	207,635	500	2,173	-	435,204
2010	143,200	88,615	183,500	-	2,875	-	418,190
2011	136,065	71,416	99,885	1,000	6,450	-	314,816
2012	65,172	66,108	81,600	200	1,950	20	215,050
2013	137,090	92,790	25,650	1,150	2,750	2,760	262,190
2014	137,730	147,477	1,400	15,900	14,800	8,450	325,757
2015	165,750	351,164	30,815	17,550	2,105	1,990	569,374
2016	45,710	445,830	46,632	15,250	1,425	800	555,647
2017	62,400	402,378	58,680	10,460	200	653	534,771
2018	13,550	142,843	14,699	2,350	-	80	173,522

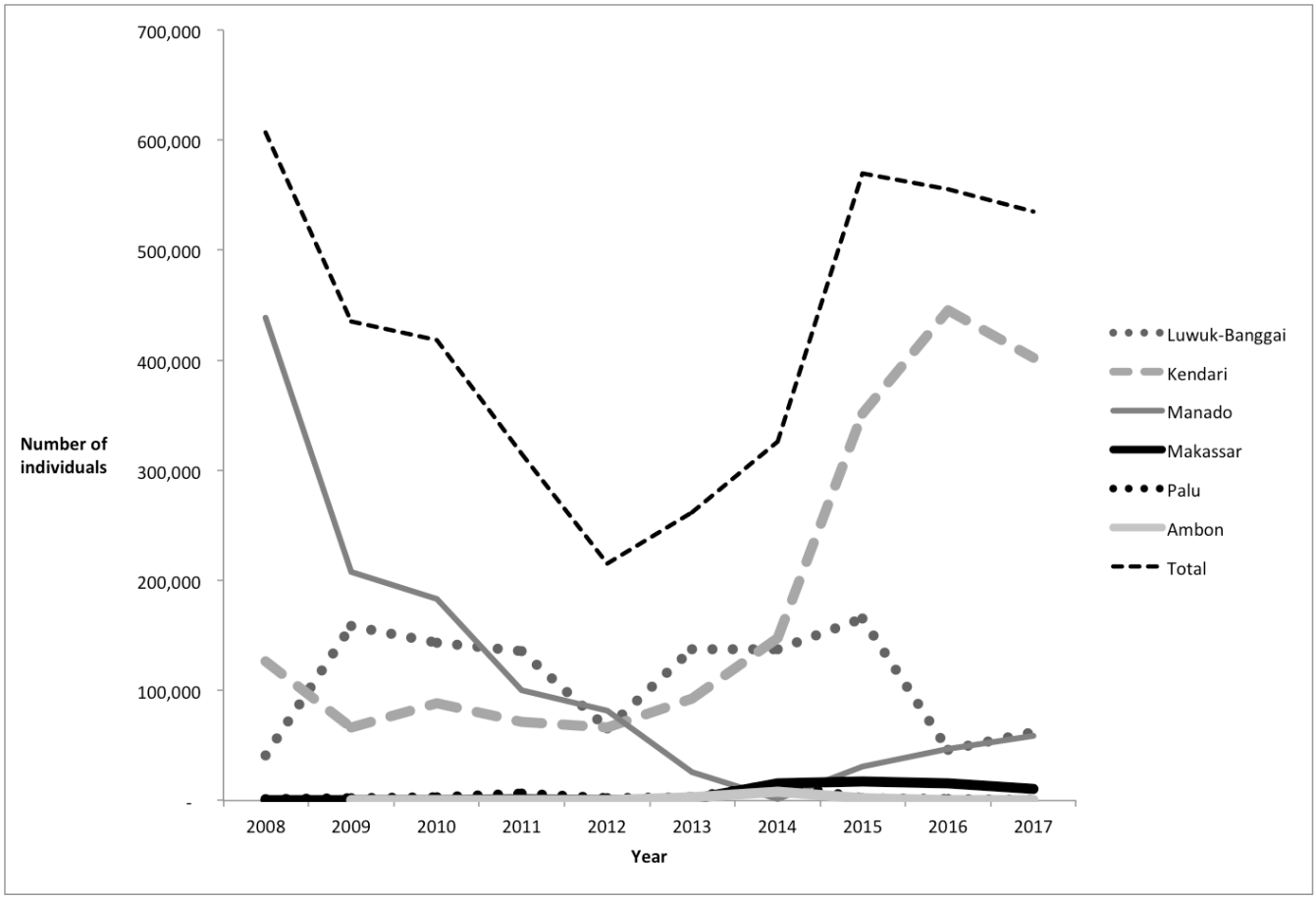

Figure 3. Fish Health and Quarantine Service statistics on total *Pterapogon kauderni* consignments from regions across Indonesia reportedly dispatched into major destinations/trading centres (data in Table 8, destinations for each region in Annex II, Tables II.1-ii.6).

The most notable patterns in the data are the substantial decrease in reported consignments from Manado and increase in reported consignments from Kendari (Table 8, Figure 3). Reported consignments from all other regions have been variable but stable over time. The declines in reported consignments from Manado likely reflect a shift in trade routes, with boats that previously transported fish from the Banggai Archipelago to Tumbak in North Sulawesi (with overland transport to Manado) no longer in operation (A. Moore, personal observation).

The recent increase in apparent consignments from Kendari (mostly to Denpasar and Jakarta) was unknown to the contributing authors of this report until analysis of the Fish Quarantine data. The authors consider it unlikely that the introduced populations in and around Kendari can support the reported levels of trade – and hypothesize the volume indicates an ongoing unrecorded fishery in the endemic area (Banggai Laut District, Central Sulawesi Province, and Luwuk-Banggai Fish Quarantine area) with transport by boat to Kendari. This hypothesis would help explain the observed condition of several *P. kauderni* populations in the more remote southern part of the Banggai Archipelago during the T_0 survey (Table 5 – sites 3-4 in particular, but also sites 2 and 7). These populations had low densities (in particular when compared to habitat condition), and were also depleted in tradable sized fish – consisting almost entirely of recruits/small juveniles (SL < 25 mm) and adult fish mostly over 40 mm SL (A. Moore, personal observation). It is not currently possible to differentiate between fish from endemic area and introduced populations, and doing so in the future would require genetic analysis (see also Section VIII.ii).

Decentralization and diversification of shipping opportunities from the archipelago is evident from the tables in Annex II – with multiple consignment and destination regions, many of which overlap. The main reported consignment destination according to available data is Denpasar. Analysis of Tables II.1-II.6 (Annex II) estimates that 67% of total consignments from 2009-2018 were reportedly dispatched there. Denpasar (capital of Bali Province) is the main export airport for ornamental fish from Indonesia, and is where most exporters are based.

The dispatch data into Denpasar reflect the patterns in reported trade consigned from key regions (in Figure 3) – indicating a decrease in reported consignment volumes from Manado and an increase from Kendari over time (Table 9, Figure 4). It is notable that the recorded volume of arrivals in Denpasar is much lower than the volume of consignments dispatched to Denpasar (24% of fish reportedly dispatched to Denpasar are reported in the arrival data for 2015-2018, Table 9). Indeed dispatch and arrival data do not match across all of Tables II.1-II.6. Some shipments may not be recorded on arrival – fish transported by sea or overland from some destinations may not be reported to or detected by Fish Quarantine officers, or may be recorded incorrectly, particularly in cases of mixed consignments of fish destined for the ornamental trade.

Table 9. Fish Health and Quarantine Service statistics on total *P. kauderni* consignments reported as dispatched to Denpasar from regions across Indonesia (data compiled from Tables II.1 through II.6 of Annex II). Includes reported data on consignments arriving in Denpasar (data from Table II.7). Data for 2018 are partial data only (covering the period up to the dates when data were accessed, between 30 May and 1 June 2018).

Year	Reported Consignments							Reported Arrivals
	Luwuk-Banggai	Kendari	Manado	Makassar	Palu	Ambon	TOTAL	TOTAL
2009	50	37,191	159,585	0	1,418		198,244	
2010	3,300	47,595	151,500	0	1,750		204,145	
2011	26,150	45,946	81,625	1,000	4,640		159,361	
2012	3,780	47,143	72,250	0	1,400	0	124,573	
2013	81,640	71,930	17,350	150	1,600	800	173,470	
2014	115,900	112695	1,000	0	11,600	1,850	243,045	
2015	123,200	294,671	25,840	500	985	260	445,456	169,023
2016	31,310	390,351	24,584	0	725	400	447,370	62,157
2017	52,170	348,710	31,518	0	0	315	432,713	47,480
2018	10,650	113,888	5,480	0	0	0	130,018	67,799

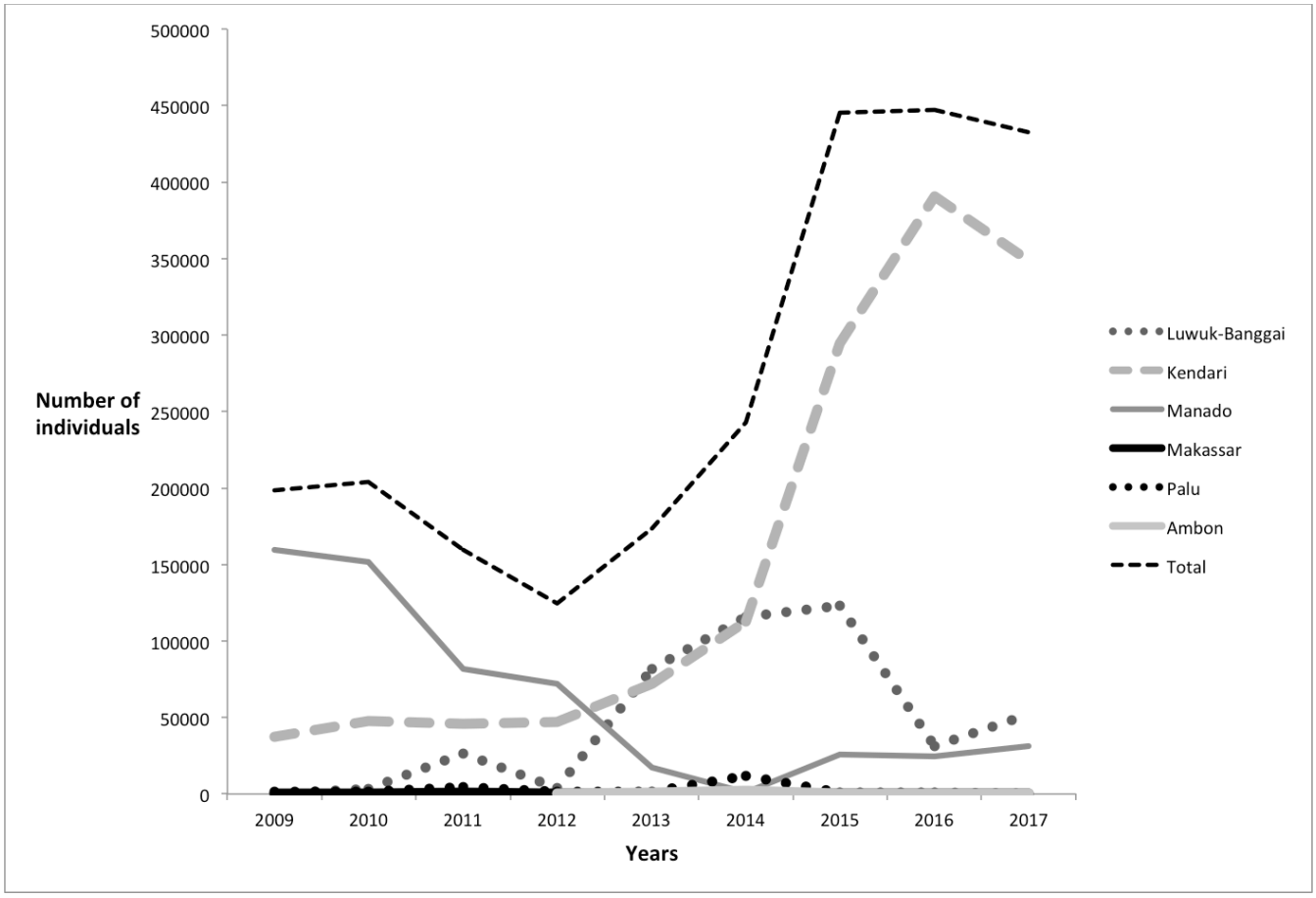

Figure 4. Fish Health and Quarantine Service statistics on total *Pterapogon kauderni* dispatched to Denpasar (Bali, main export centre/airport) from six regions across Indonesia (data in Table 9).

The Fish Health and Quarantine Service data provide a useful proxy for tracking exploitation levels of *P. kauderni* in Indonesia, but may underestimate total exploitation. This is due to (i) under-reported or unreported consignments (discussed above), (ii) unknown levels of mortality between point of capture and recorded consignment, and (iii) unknown volumes being collected for reasons other than trade. With respect to ii, there is evidence that fishers or traders may discard unwanted fish (wrong size or poor condition, especially fin damage or scale loss) prior to consignment, but the extent of this practice is unknown. The authors consider that mortality and discard rates within the Banggai Archipelago were higher in the past when large volumes of fish were collected and kept in holding pens waiting for requests from traders. Now it seems that fish are collected on demand such that most caught fish are eventually traded. Most rejected fish are released alive, in itself a potential problem (see Sections II.iv and VIII.iii). Collection patterns are unknown, however, for collection by fishers from outside the Banggai area – for example fishers operating from Kendari, and for collection from introduced populations. It is also unknown to what extent mortality occurs due to disease (e.g. Iridovirus contracted while being held at various points along the supply chain). Finally, with respect to iii, there are no data on the volume of *P. kauderni* being collected for uses within Indonesia (e.g. as broodstock, for research or for display).

(iii) Trade from culture operations

The supply of *P. kauderni* to the export market from outside the endemic distribution includes fish from introduced populations as well as those produced through breeding. There are known government and private sector *P. kauderni* breeding facilities supplying fish for trade in Ambon, Makassar, Bali and the Jakarta area. It is also possible there are traders in Manado and elsewhere breeding some fish, as well as trading in fish from native and/or introduced populations (various pers. comms. to S. Ndobe and A. Moore).

The contribution of cultured animals to overall trade in *P. kauderni* in Indonesia is not yet significant in terms of numbers. Aquaculture production of *P. kauderni* for commercial purposes seems to be mostly (in terms of volume) in Bali and Ambon, with relatively small contributions from other sites. Fish Health and Quarantine Service data for Ambon and at least some of the shipments from Makassar since 2013 likely reflect consignments of captive-bred specimens (Table 8, Figure 3) – together shipments from these two sites average just 3% of total consignment volumes across 2013-2018.

It is not known what proportion of offspring produced in captivity is captive-born (born to wild caught parents, defined by CITES as "first-generation offspring"[64]) versus captive-bred (born to parents also born in captivity, defined by CITES as "offspring of second…or subsequent generation"[64]), but inferences can be made about reliance on wild broodstock. The data for Ambon suggest approximately 3.5 fish are produced and expedited for every individual provided as broodstock (Table 8 and Annex II). This estimate is based on the fact that the volume of fish reportedly dispatched out of Ambon, which mostly reflect captive-born or captive-bred specimens for trade, is 3.5 times the volume of fish reportedly consigned to Ambon, which are either known or inferred wild broodstock (Annex II, Table II.6). This estimate increases to ~7 fish produced per individual provided as broodstock after accounting for the approximately 10,000 fish reportedly released in and near Ambon Bay[18]. During a visit to the installation in 2014, staff working in the facility gave an estimate of 20 recruits on average per pair per breeding cycle,

with several cycles per year[65]. The technology used in Ambon is briefly described in brochures[66,67].

Culture for *P. kauderni* within Indonesia is mostly outside the endemic range of this species, except for a breeding facility set up in Bone Baru with support from MMAF and the NGO LINI, which began operations in February 2018. By the end of April 2018, this facility had succeeded in producing large numbers of offspring, but there had been problems with high levels of broodstock mortality for which solutions were being sought. This facility applies some good practices such as maintaining broodstock and offspring from different source populations in separate tanks, thus ensuring traceability and enabling the use of offspring for re-stocking the sites of origin of the broodstock as is proposed under the NPOA (see Section VII.i).

(iv) Prices

The price paid to fishers within Indonesia per wild-caught fish in 2004 varied between IDR 200-300[20], and remained fairly static for over a decade (2000-2009) with an increase to IDR 500 around 2010[16]. Currently, wild fish are typically sold for IDR 1,000 (less than USD 0.1 at current rates of exchange, IDR 14,000 for USD 1 on 9 June 2018). This recorded price increase mirrors increases in local living costs[vi].

The low prices paid for wild fish are in sharp contrast to the prices proposed in economic business analyses for cultured fish produced in Indonesia. An economic business analysis presented in one brochure[66] proposes a sale price per cultured fish of IDR 7,000/USD 0.5. Another brochure[67] proposes IDR 10,000/USD 0.7. These prices are 7-10 times the price currently paid for wild-caught fish. They are, however, well below the sale price of USD 7 proposed based on a breeding trial in Hawaii, US in 2005[68]. This suggests that, if developed to an appropriate scale, captive breeding in Indonesia might be competitive at an international level. As far as is known, however, no small-scale aquaculture installations in Indonesia dedicated to *P. kauderni* breeding have been in operation long enough to evaluate their chances of making a sustained profit.

V. Trade – international

The following analysis of the international trade in *P. kauderni* is based on existing datasets, an online survey and stakeholder interviews. Existing datasets included the CITES trade database[69], EU annual reports, the EU TRAde Control and Expert System (TRACES)[70], and the US Law Enforcement Management Information System (LEMIS)[71]. The online survey (questions in Annex III) was sent out to 161 stakeholders (importers, wholesalers, exporters, retailers), with 20 responses representing 16 countries received in the time available. Online surveys were supplemented with stakeholder interviews – but time constraints meant information was obtained from just 2 of the 11 businesses contacted. Additional information was obtained from two reports prepared in support of the FAO Expert Advisory Panel assessment of the CoP17 proposal to list *P. kauderni* on Appendix II: a report from Tropical Marine Centre Ltd (the largest

[vi] For example, traditional cakes (home-made or from mostly informal sector micro-enterprises) widely sold and consumed throughout Sulawesi (and indeed much of Indonesia), including the Banggai Archipelago, have consistently cost around the same as the price paid locally for a Banggai cardinalfish, rising from around IDR 200-250 to IDR 500 and now IDR 1000.

marine fish wholesaler in Europe) and another from Nautilus Park (*P. kauderni* breeder in Thailand)[72].

(i) CITES and EU data

Pterapogon kauderni is not listed on any CITES Appendix, and as such Parties are not required to include trade in this species in their annual report to CITES. The species is, however, listed on Annex D of EU Wildlife Trade Regulations (EC No. 338/97 and EC No. 865/2006 and its amendments). The latter requires member States to record their imports of this species, reports of which are submitted annually to CITES and compiled by UNEP-WCMC in the CITES trade database. As a result, all records of trade in *P. kauderni* in the CITES trade database are reported by EU Member States (Table 10).

Table 10. Volume of trade in *P. kauderni* (number of individuals) reported in the CITES trade database as imports by EU member States, according to declared origin country (CITES trade database), from 2008 to 2016.

	CITES trade database			
Year	**Indonesia**	**Thailand**	**Other**	**Total**
2008	1,096		0	1,096
2009	11,098		14	11,112
2010	12,890		136	13,026
2011	5,700		38	5,738
2012	15,071	8,327	139	23,537
2013	18,372	5,024	10	23,406
2014	13,091	9,376	77	22,544
2015	10,236	8,064	76	18,376
2016	20,051	6,720	159	26,930
Total	**107,605**	**37,511**	**649**	**145,765**
Annual average				**16,196**

Eighty-two (82) records of trade in *P. kauderni* were downloaded from the CITES trade database on 28 June 2018, spanning the years 2008-2016. All trade was reported as live specimens, and all but four records were reported as individuals (unit = "blank"); the remaining four records were reported as kg for a total of 74 kg across all years, and were excluded from further analyses[vii].

EU member States are not required to report purpose and source codes of trade in Annex D species, and so the data extracted from the CITES trade database provided limited information on the purpose of trade, and almost no information on the source of specimens (e.g. whether the specimens were reportedly wild sourced, captive-born, captive-bred, or otherwise). EU member States reported total imports of 145,765 individuals across the nine-year period up to 2016 (~16,200 individuals per year, Table 10). Of these, 23% (33,546) were reported with purpose code T (for commercial trade), with the remainder (77%, 112,219 individuals) reported without a purpose code specified. The source of nearly all (~99%) reported specimens was reported as

[vii] The weight is likely that of the fish in addition to the water in the bag in which they are shipped, so it is not possible to convert the kg to number of individuals. The volume, however, is likely negligible compared to the overall volume in trade.

code U (unknown) (32,218) or without a source code specified (111,567), as to be expected given the lack of requirement to report source. A small proportion of imports reportedly sourced from Indonesia were reported as captive-born (source F; 1290 individuals), captive-bred (source C; 353 individuals) and wild (source W; 245 individuals).

Two countries were the declared exporters of nearly all the trade in *P. kauderni* reported by EU member States– Indonesia and Thailand – accounting for 74 and 26% of the trade, respectively, across all years (Table 10).

Two EU member States were the declared importers of the vast majority of reported trade in *P. kauderni* – the UK and Germany. More than half (57%) of imports reportedly originating from Indonesia were reported by the UK (61,871 individuals, with trade reported in 2008-2010 and 2012-2016) and nearly a third (30%) by Germany (32,187 individuals, with trade reported in 2009-2014 and 2016). All imports reportedly originating from Thailand were reported by the UK.

(ii) EU TRAde Control and Expert System (TRACES)

TRAde Control and Expert System (TRACES) is an electronic database used by EU customs to monitor animal diseases. TRACES gathers some species-level data, but reporting is not compulsory. Indeed, across all marine ornamental fishes, the percentage of specimens entering the EU without a species name ranged from 22-40% by volume from 2014-2017 (M.V. Biondo, unpublished data); before 2014 almost all fish were reported as "otra pesca". TRACES reported at least 195,294 *P. kauderni* specimens imported across 2014-2017, with an annual average of 48,824 specimens (Table 11). Another 56,654 specimens, with an annual average of 14,164 individuals across the four years, were reported only as belonging to the cardinalfish family Apogonidae, of which *P. kauderni* is one of approximately 350 species (Table 11). Approximately 79% of trade across 2014-2017 was reportedly exported by Indonesia and 20% by Thailand.

Table 11. Data on import volumes (number of individuals) of *Pterapogon kauderni* and Apogonidae into EU and non-EU countries reported in the EU TRAde Control and Expert System (TRACES) by reported country of origin.

	P. kauderni							**Apogonidae**
		Reported origin						
Year	**Volume**	**Indonesia**	**Thailand**	**Singapore**	**Sri Lanka**	**Malaysia**	**United States**	**Volume**
2014	43,982	31,265	12,064	593	32	16	12	12,470
2015	38,169	28,352	9,572	209	9	27		13,155
2016	56,494	46,973	9,408	79	10		24	16,022
2017	56,649	48,009	8,328	169	143			15,007
Total 2014-2017	**195,294**	**154,599**	**39,372**	**1,050**	**194**	**43**	**36**	**56,654**

TRACES and CITES trade data are divergent in terms of volumes and destinations for purportedly Indonesian specimens, but mostly align for specimens reported from Thailand. TRACES data reported 106,590 specimens imported from Indonesia for 2014-2016 (the years for which the two datasets overlap), whereas CITES data reported volumes from Indonesia that were 60% lower than those in TRACES for the same time period (43,348 specimens). The reported destinations for purportedly Indonesian specimens also differed. TRACES data reported the Netherlands as the major reported destination of *P. kauderni* from Indonesia, followed by France, Italy, Denmark and then Germany (Table 12). On the other hand, CITES data reported the UK and Germany as the major destinations for purportedly Indonesian specimens. In terms of specimens from Thailand, TRACES data reported 31,044 specimens and CITES data reported 24,160 individuals imported from Thailand over 2014-2016 (~22% lower than TRACES). Similar to CITES data, TRACES reported the UK as the major destination for *P. kauderni* supposedly sourced in Thailand (Table 12).

Table 12. Data on import volumes (number of individuals) of *P. kauderni* into EU and non-EU countries reported in the EU TRAde Control and Expert System (TRACES) by reported country of origin and destination.

Year	**Reported origin = Indonesia**						**Reported origin = Thailand**
	Reported destination						**Reported destination**
	Netherlands	**France**	**Italy**	**Denmark**	**Germany**	**Other[b]**	**UK**
2014	15,070	7,347	3,156	-	1,086	4,480	12,064
2015	6,041	9,549	3,728	2,874	312	5,848	9,572
2016	19,876	5,964	3,851	5,450	4,737	6,999	9,408
2017	19,343	5,450	4,108	5,746	5,665	5,376	8,328
Total (2014-2017)	60,330	28,310	14,843	14,070	11,800	22,703	39,372
% Total (2014-2017)	40%	19%	10%	9%	8%	15%	100%
Total (from all sources)[a]	60,330	28,449	15,340	16,370	11,800	63,005	

[a]Total across all source countries: Indonesia, Thailand, Singapore, India, Sri Lanka, Malaysia, US.
[b]Other source countries = PL, BE, SE, GR, ES, LU, NO, HU, UK, CZ, CH, MT, CY, BG, RO, AT, SM, SI, PT, SK (in descending order of reported import volumes), see https://www.worldatlas.com/aatlas/ctycodes.htm for ISO Alpha-2 country codes.

(iii) US Law Enforcement Management Information System (LEMIS)

The US Fish and Wildlife Service collects data on flows of wildlife and wildlife products that enter the US through the Law Enforcement Management Information System database (LEMIS). Most marine ornamental fishes are recorded as MATF (marine aquarium tropical fish) and not at species level. LEMIS has had a species-specific code for *P. kauderni* since 2016, when the species was listed on the US Endangered Species Act (ESA); before 2016 there was only a code for *Pterapogon* sp. In spite of the ESA listing, however, it is not compulsory to report *P. kauderni* imports at the species level. So while species-level records have increased over time, this may not reflect an actual increase in trade since some imports will have been reported at the genus level, and others still as 'marine tropical fish'.

LEMIS data reported 5,520 *P. kauderni* entering the US from 2007-2018 (data as of 14 May 2018), just 99 of which were reported from 2008 to 2015 (before the species was listed on the ESA). The

countries of origin were reported as Indonesia (5,136 specimens), Thailand (96 specimens), Japan (40 specimens), US (34 specimens), Palau (23 specimens) Hong Kong (1 specimen) and 'XX' (unknown, 190 specimens). The data also recorded 139 specimens being re-exported from the US (135 specimens to Canada and 4 specimens to Nigeria).

Additional, albeit patchy, information on imports of *P. kauderni* into the US is available from published reports. For example, Rhyne et al (2012)[73] reported import volumes from 2004-2005 of 180,000 fish, and the report prepared for ESA consideration cited imports for 2005 and 2009 of approximately 200,000 and 160,000 fish, respectively[25]. Rhyne et al. (2017)[74] reported imports in 2013 of ~120,000 *P. kauderni* specimens from a breeding facility in Thailand (see also Section V.v).

(iv) Stakeholder survey and interviews

Some inferences can be made from the results of the surveys and interviews, but the number of participants was too small and representation across sectors too diffuse to draw any significant conclusions. The online survey (Annex III) to 161 enterprises resulted in 20 responses from participants in 16 different countries: USA (3), Indonesia (2), Italy (2), Taiwan (2), UK (2), Czech Republic (1), France (1), Kenya (1), Netherlands (1) and Sweden (1). Ten participants were importers, nine wholesalers, seven exporters, two retailers and six marked 'other'. M.V. Biondo further spoke to one UK importer/exporter and one Czech Republic retailer.

Reported annual acquisition/purchase volumes of *P. kauderni* varied greatly – ranging from just one to 15,600 specimens per enterprise. Across respondents, six reported acquiring hundreds of individuals a year, four reported thousands, and one reported tens of thousands – with a mean of 2,995 individuals (stdev = 4,681) and a median of 475 specimens per enterprise per year (n = 11). Enterprises based in the US reported total annual imports of 15,600 individuals (n = 1), those based in the EU reported a total of 12,540 individuals (n = 7), and those based in the Asia-Pacific region reported a total of 7,800 individuals (n = 3). There was no clear trend in the reported volumes over time across the limited sample size (data not shown).

When asked about the source of *P. kauderni*, 40% replied that they were wild-caught or mostly wild-caught (n = 6), one-third (27%) reported purchasing captive or mostly captive-bred specimens (n = 4), and one-third (33%) reported the source as unknown (n = 5). One respondent reported acquiring captive-bred *P. kauderni* from Thailand and all others (n = 8) reported buying them from Indonesia.

The respondents indicated a preference for captive-bred and larger sized specimens (within the size range of traded fish, which would mean larger sub-adults but not mature individuals). When purchasing *P. kauderni*, respondents said they considered whether the specimens were wild or captive-bred (n = 10), the size (n = 4) and the colour (n = 2) (n = 4 indicated "other"). Three survey respondents and two interview respondents commented that the size of *P. kauderni* mattered as, within the range of traded fishes, bigger fish were sturdier and seemed to survive better in the aquarium than smaller individuals.

The most frequently reported trends in *P. kauderni* trade over time by respondents were decreases in the volume of trade and demand for wild-caught fish, and increases in the demand

for captive-bred fishes (Figure 5). Interestingly, high numbers of respondents also reported overall availability and availability of wild-caught fish had not changed, while an equal number of respondents reported availability of captive-bred fishes to have increased or not changed. Most respondents reported that prices of wild or captive-bred fishes had not changed over time. Regarding source countries, an equal number of respondents reported purchase volumes from Indonesia had decreased or stayed the same, whereas most respondents did not give an answer for Thailand, and most reported no change in volumes sourced from other countries.

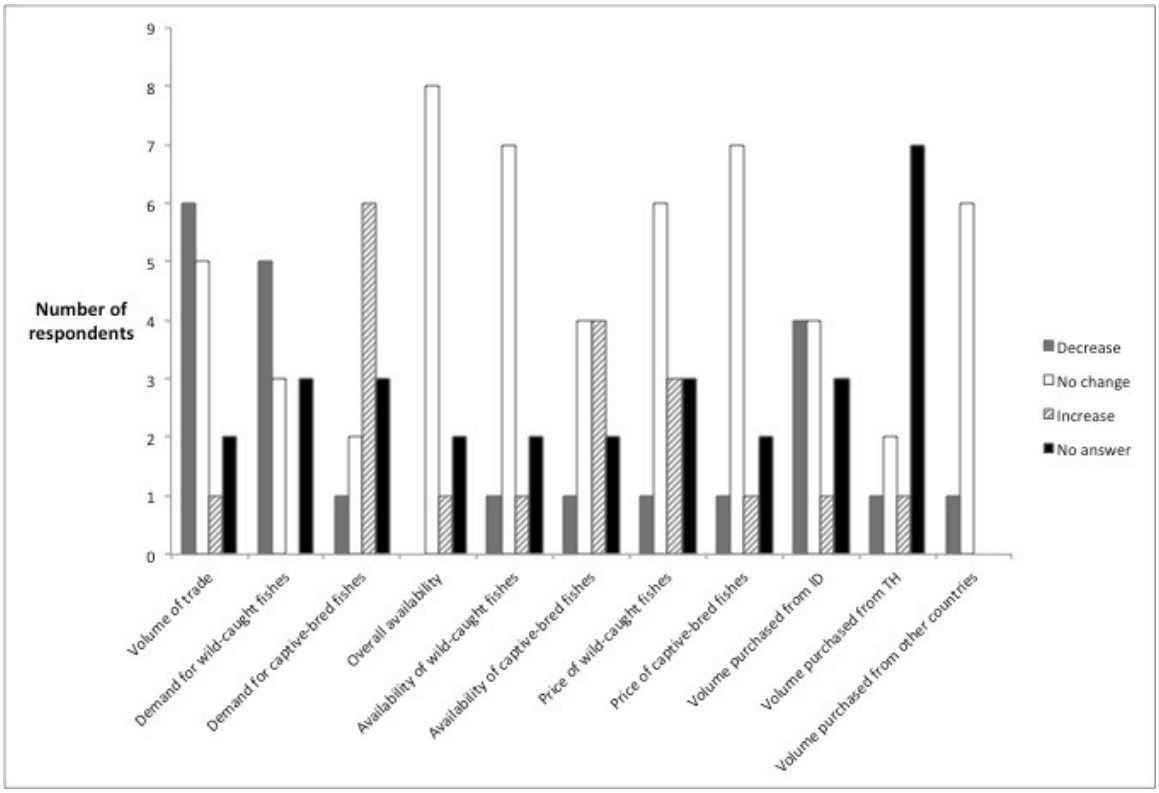

Figure 5. Number of online survey respondents (total n = 20 importers, wholesalers, retailers) reporting changes in various components of international *P. kauderni* trade over time.

Reported prices paid for wild-caught and captive-bred fish were similar. Prices for wild-caught fish ranged from USD 1-6, with an average reported price of USD 2.23 (stdev = 1.60, n = 9 respondents); for captive-bred fish prices ranged from USD 2-4, average = USD 2.37 (stdev = 1.18, n = 8). Reported sale prices of *P. kauderni* ranged from USD 2.25-15, with an average of USD 6.5 (stdev = 4.48, n = 8).

A European importer/exporter interviewed as part of this study (the first of the two interviews) responded that he had started importing *P. kauderni* in 2010 and would import at least 1,700 specimens per year. He only buys wild-caught specimens, and had no knowledge of breeding facilities. He reported overall trade volumes to have increased and had observed no change in the demand for wild-caught fishes or overall availability. He further reported that there was no demand from his buyers in Germany, Austria and Switzerland for captive-bred specimens. He purchases all *P. kauderni* from Indonesia, paying USD 3.70 per fish and selling them for at least double that price.

A European retailer interviewed (the second of the two interviews) has reportedly been buying *P. kauderni* since 1993 but has only sourced captive-bred specimens since 2000, purchasing about 200 per year. As a retailer, he does not know from which country his wholesaler buys the fishes. He pays USD 10-12 for a specimen and sells them for at least double the price.

(v) Additional information

Tropical Marine Centre (TMC) reported a decline in their sales of wild-caught *P. kauderni* from Indonesia and an increase in sales of tank-bred fish from Thailand from 2007-2014 (Figure 6). Indeed by 2014 almost all their reported sales were of captive-bred fish sourced in Thailand. TMC reported to the FAO Expert Advisory Panel that, according to public record, captive-bred fish sourced in Thailand account for 60-70% of all ornamental fish imported into the UK and up to 9-12% of ornamental fish imported into the EU. TMC reported similar wholesale prices for both tank-bred fish from Thailand and wild-caught fish from Indonesia – with a mean sale value of each just under GBP 10/USD 13.4 (based on the exchange rate on 9 June 2018) from 2008-2014.

Nautilus – a *P. kauderni* captive-breeding operation based in Thailand – reported export of nearly 500,000 P. kauderni during 2011-2015 – with 84% of reported exports being sent to the US and 16% to the EU.

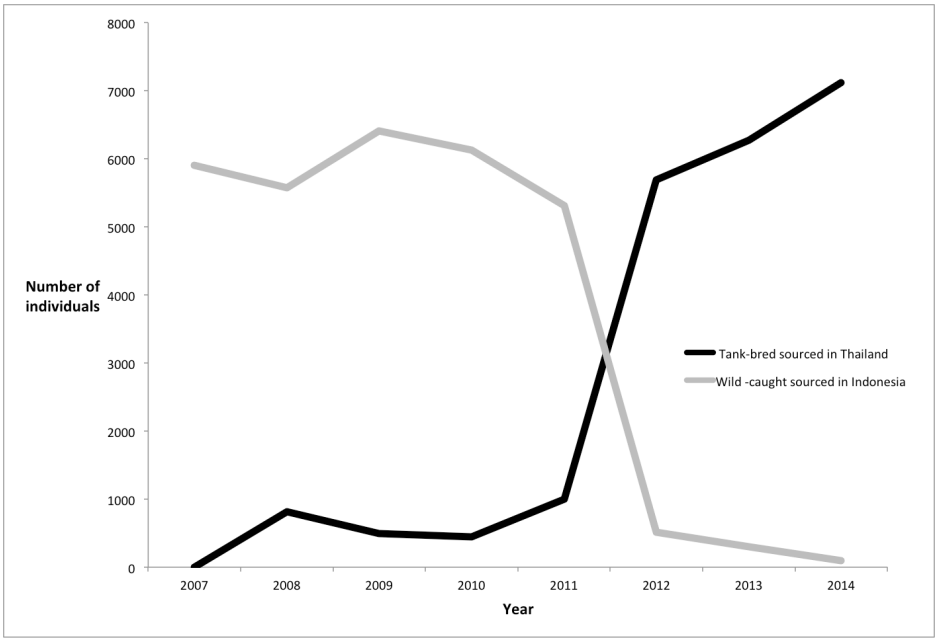

Figure 6. Evolution of sales of tank-raised Banggai cardinalfish (*P. kauderni*) from Tropical Marine Centre Ltd (UK)

(vi) Summary

Existing importing country datasets are limited in the information they provide – being generally restricted to information on reported export countries and volumes. It can be inferred, however, that the majority of trade in this species is of wild-caught, mostly native, fish from Indonesia. CITES and TRACES data reported 26% and 20% of total EU-reported imports to be of Thai origin, respectively, which one can assume are captive-bred (given that this country is outside the

geographic range for this species, though it is possible some are re-exports). Existing data give no information on the relative proportion of wild or captive-bred specimens being exported from Indonesia – but the authors are not aware of large-scale production of cultured *P. kauderni* in Indonesia. It is interesting, therefore, that most survey respondents reported getting their captive-bred fish from Indonesia.

A few survey respondents indicated a preference for captive-bred specimens and also larger wild fish – in both cases due to the likelihood of a higher survival rate. Respondents also reported an apparent increase in demand for captive-bred fish and decrease in demand for wild-caught fish. Although the survey sample size is limited, one might infer that there would be an uptake in the international market should the availability of captive-bred specimens increase. The limited data also suggest Indonesia could be a competitive supplier of captive-bred fish, being able to produce them at a lower cost than proposed out of Hawaii (see Section IV.iv) and lower than the prices reportedly paid by survey respondents.

The EU and US import volumes reported in existing databases are significantly lower than the volumes reportedly exported out of Indonesia, which could be due in part to post-export mortality – conservatively estimated at 25-50%[75]. The ~16,200 individuals per year reported as EU imports in the CITES trade database, and ~40,000 individuals per year reported in TRACES, can be compared to export estimates reported in CoP17 Prop 46 which ranged from 148,800 in 2010 to as many as 900,000 in 2007. EU member States reported imports of 37,511 individuals from Thailand from 2012-2016 according to the CITES trade database, whereas the Thai breeding company Nautilus reported exporting 66,288 individuals to the EU from 2012-2015. There are further discrepancies in reported information regarding imports into the US. For example LEMIS data reported 5,520 fish entering the US from 2007-2018 (the vast majority reportedly sourced in Indonesia) whereas one US-based survey respondent reported importing 15,600 specimens in a single year while Nautilus reported exporting ~100,000 fish per year to the US from 2011-2015. Furthermore, the role of other importing countries in *P. kauderni* trade is unknown.

VI. Conservation risks and benefits from international trade

The conservation risks of unmanaged international trade in *P. kauderni* are clear, and are already well documented for CITES purposes. The CoP17 proposal to list the species on Appendix II (CoP17 Prop. 46) and the FAO Expert Advisory Panel assessment of the proposal both reported a widespread decline in abundance of *P. kauderni* – as high as 90% with respect to pre-harvest levels, and extirpation of several populations has been documented (references in CoP17 Prop. 46, see also Section II.v of this report). Population declines due to exploitation have resulted in *P. kauderni* being listed as Endangered on the IUCN Red List of Threated Species[46] and in the US Endangered Species Act[47]. There is a clear need to manage the take and trade in this species.

Stopping or significantly limiting the trade in wild-caught *P. kauderni* within their endemic range is expected to have a limited impact on local livelihoods, however, a sustainable fishery and trade would most certainly have benefits for those involved. The remaining fishers are few in number and most do not rely solely on *P. kauderni*. That said, the Fish Health and Quarantine data indicate fishing on a scale that is likely to be a main livelihood for several fishers (individuals or

groups). These fishers are currently almost certainly operating illegally[viii] and may well be based outside the Banggai Archipelago, as indicated when discussing the Fish Quarantine data for Kendari. There is a limited understanding, however, of the (mostly unreported and frequently illegal) fisher movement in the southern part of the region that appears to have increased markedly since 2014. One factor driving this increase is the (hopefully temporary) vacuum created by the implementation of the new regional autonomy law (UU 23/2014), which transfers jurisdiction over waters 0-4nm offshore from district to provincial level, in addition to the previous 4-12 nm provincial remit. This has effectively left district and city governments with no jurisdiction seaward of the coastline.

Furthermore, the indirect benefits of a well-managed trade in *P. kauderni* are at least as important as the direct, economic, benefits. With *P. kauderni* highly dependent on habitat quality, one of the most important steps would be conserving/managing its habitat and microhabitat. In addition to benefiting *P. kauderni*, this would also revive food fisheries of economic and subsistence value. Experience in Kapela has shown that where habitat has recovered, food fisheries have returned; villagers in Kapela stopped using destructive fishing methods only around three years ago, and have already seen a rebound of food fish (M. Takbir, pers. com to A. Moore, June 2016, October 2017 and April 2018).

A sustainable trade in *P. kauderni* could also restore potential for tourism and recreation. Tourism, especially community-based tourism, could provide economic benefits directly and indirectly[ix]. The charisma of *P. kauderni*, and even interest in its trade, can serve as promotion for local tourism. At present, tourism in the Banggai Archipelago is relatively limited when compared with more developed areas of Indonesia (e.g. Bali). A number of studies have identified potential sites for both land and marine nature-based tourism, and both districts have strategic and/or sectoral development plans that include tourism as an important component. The potential of *P. kauderni* as a tourist attraction is in evidence in Mbuang-Mbuang, where visitors snorkel in *P. kauderni* habitat as well as with non-stinging jellyfish. In Bone Baru most visitors come for *P. kauderni* – with a *P. kauderni* statue in the gateway to the village now mirrored by another underwater as part of an artificial reef.

Noting the increased efforts to increase *ex-situ* breeding, it is unclear if or how increasing *ex-situ* breeding of *P. kauderni* in Indonesia would confer conservation benefits to wild *P. kauderni* inside their endemic range. The NPOA (Section VII.i) includes proposed activities related to community-based aquaculture in Indonesia, however the activities are mostly suggested for areas outside the endemic range for the species. In this case, a shift in export of *P. kauderni* from wild to cultured fish would move any benefits of trade away from local communities in the Banggai archipelago.

[viii] Movement of any fisheries product, including ornamental fish, within a jurisdiction does not need to be reported - but any movement outside a jurisdiction should be reported to the Fish Health and Quarantine Service and be accompanied by a certificate of health, whatever the mode of transport used (land, sea or air). For example, in the case of reported consignments out of Kendari, those fish should have also been reported leaving the jurisdiction in which they were caught, but such catch volumes are not reflected in data reported from jurisdictions within P. *kauderni* endemic range – see Section IV.ii. Thus the fish, if indeed taken from within the endemic range of the species, were moved to Kendari illegally. Relevant laws include: *Undang-Undang Nomor 16 Tahun 1992 tentang Karantina Hewan, Ikan, dan Tumbuhan* and *Peraturan Menteri Kelautan dan Perikanan Republik Indonesia Nomor PER.32/MEN/2012 Tentang Jenis, Penerbitan, dan Bentuk Dokumen Tindakan Karantina Ikan*.

[ix] e.g. marine and land-transport providers, guides, equipment rental, accommodation and food/drink providers, souvenir makers, shopkeepers, farmers and fishers, trip organisers, cultural groups, etc.

This scenario, in turn, could reduce incentive for *in situ* conservation of wild native fish populations and their habitat by local people. Increasing community-based *ex situ* breeding activities within the endemic range of *P. kauderni* would ensure benefits are realized for local communities, but may still reduce incentives for conservation of wild fish and habitats. On the other hand, a global demand for well-managed wild fish could increase incentive for *in situ* conservation of *P. kauderni* in its endemic range, as well as its associated microhabitats and habitats.

Locals in the endemic range are increasingly taking pride in "their" fish, across an expanding cross-section of society. Recognition could be a powerful tool for conservation. *Pterapogon kauderni* has strong potential to be a local "flagship" species, driving a "sea change" in attitudes and coastal resource stewardship. Pride of individuals, communities and local governments in their achievements can be bolstered by recognition of efforts taken toward improved conservation and management of *P. kauderni*.

VII. Existing *P. kauderni* conservation and management

At present there are three main avenues for *P. kauderni* conservation and management pursued by Indonesia, each of which is related to the other: (i) a National Plan of Action (2017-2021) (NPOA), (ii) spatial management in the form of a decreed marine protected area (MPA), and (iii) a decreed temporal fisheries closure.

i. National Plan of Action (NPOA)

The Banggai Cardinalfish NPOA (2017-2021), shared with CITES in AC29 Doc 25.2 and AC29 Inf. 21, has six major targets:
1) availability of information on *P. kauderni* population in its natural habitats and other geographic areas;
2) implementation of protection and preservation of *P. kauderni* and its natural habitats;
3) sustainable use and trade of *P. kauderni*;
4) improvement of human resources capacity to conserve and manage *P. kauderni*;
5) improvement of conservation governance; and
6) implementation of re-stocking of *P. kauderni* populations.

These six targets are in turn broken down into 11 strategies each with several associated activities – progress against which was reported in AC29 Doc 25.2, with another update expected at AC30[76].

Section VIII of this report endeavours to make research, conservation and management recommendations relevant to the proposed activities of the NPOA, which are summarised against the various NPOA components in Table 13.

ii. Spatial management - MPA

A key component of the NPOA is achieving *P. kauderni* conservation through implementation of the new provincial coastal and small island marine protected area (MPA) – KKP3K Banggai Dalaka or Banggai Dalaka MPA. Established by a decree of the Governor of Central Sulawesi

Province (Keputusan Gubernur Nomor: 523/635A/Dis.Kan GST/2017 dated 27 December 2017), the total area within the MPA boundaries is 869,060 ha.

It is estimated that around 90% of *P. kauderni* endemic distribution is within the proposed Banggai Dalaka MPA boundaries, with some populations in each zone and sub-zone. In effect, the Banggai Dalaka MPA includes the habitat of almost all known *P. kauderni* native populations in waters under the jurisdiction of Central Sulawesi Province. All or part of at least 10 *P. kauderni* populations – all of which are known or inferred ESUs – are included in core zones, with the remainder in tourism, traditional fishery, aquaculture sub-zones or rehabilitation zones.

The four conservation targets of the Banggai Dalaka MPA are:

1. Key coastal habitat (coral reefs, seagrass beds, mangrove forests).
2. *Pterapogon kauderni* conservation, including habitat and microhabitat.
3. Other priority conservation species (designated in each MMAF 5-year strategic plan, currently 20 species – 18 of which are marine and two live in fresh water).
4. Economically important fishery species/stocks (finfish and invertebrates).

Conservation of native *P. kauderni* populations is one of the key priorities in the draft Zonation Management Plan (RPZ) (Figure 7) – which would, if effectively implemented as proposed, be an important tool for management and conservation of *P. kauderni*. This category of MPA has three allowable zones: core zone, restricted use zone, and a rehabilitation zone (allowed and prohibited activities under each zone are in Annex IV). The restricted use zone can be further subdivided into traditional fishing, mariculture and marine tourism zones.

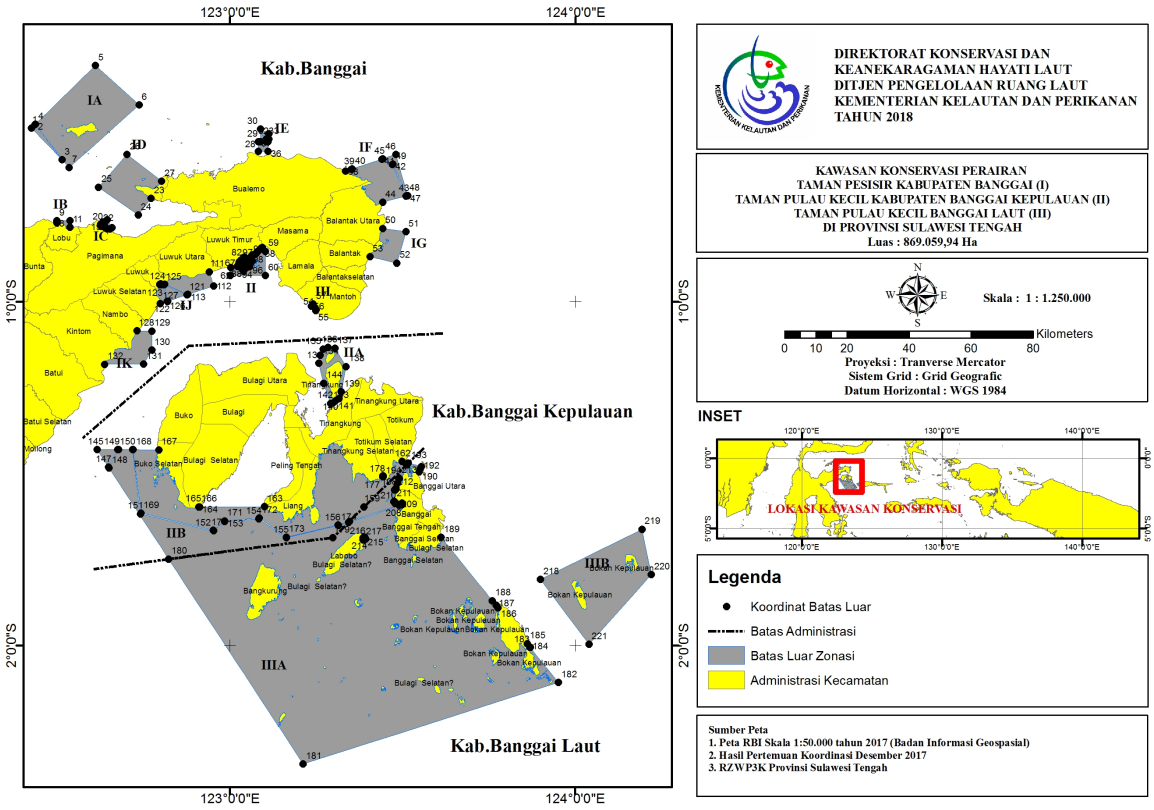

Figure 7. Map of the Banggai Dalaka MPA showing the MPA boundaries (MPA areas in grey, land in yellow)

iii. Temporal management

The most recent policy development with respect to *P. kauderni* is the promulgation of Ministerial Decree Kepmen 49/2018 by the Minister for Marine Affairs and Fisheries dated 4 April 2018 and socialised in early May. This decree applies to *P. kauderni* populations within the Banggai Dalaka MPA and imposes a ban on the fishery during the months of February-March and October-November corresponding to peak breeding periods[x].

VIII. Research, conservation and management considerations

There is an established need to manage the take and trade of *P. kauderni* in order to improve the conservation status of the species in its endemic range. What follows are recommendations in support of different conservation and management options for the species, as well as filling gaps in understanding, that Indonesia may wish to consider as it moves forward with its NPOA and other planned activities in support of *P. kauderni* conservation and management.

(i) Habitat and microhabitat

Conserving *P. kauderni* microhabitat through protection and/or restoration is vital to conserve the native *P. kauderni* populations/stocks, even in the absence of fishing, and to enable sustainable fisheries of wild *P. kauderni* and microhabitat populations. A holistic approach to restoring the *P. kauderni* habitats would have many benefits for coastal communities including restoring valuable but depleted food fisheries (as has been demonstrated in Kapela village, Section VI).

Effective implementation of proposed zonation within the Banggai Dalaka MPA (Section VII.ii) should protect habitat, and where necessary recovery could be assisted (e.g. through ecosystem rehabilitation technologies). Including regulations to manage the take of the two *P. kauderni* microhabitats (sea urchins and sea anemones), which are subjected to increasingly heavy unregulated fishing pressure, would be advisable to prevent overexploitation. In some cases assisted recovery of *P. kauderni* microhabitats would be advisable[35].

(ii) Population structure

The genetic structure of *P. kauderni* (Section II.iv) makes ESU-based management necessary for sustainable take and trade, and sufficient information exists on which to delineate temporary management units (see Section II.iv). Extirpation is likely to entail the loss of genetic diversity including genotypes (and possibly phenotypes) not found elsewhere. It is therefore recommended that each known ESU, or each small island or bay within a larger island where genetics are unknown, be considered as a separate "stock" for conservation and fisheries management purposes. For example, ESU's (known or inferred) could be taken into consideration during the design of permit and quota systems (see Section VII.iv). As current data do not allow the assignment of individuals from introduced populations or captive-bred

[x] The October-November peak is well documented and widespread, whereas the February-March peak may be at a limited number of sites protected from the west monsoon.

specimens to a source population, it is recommended that such individuals not be released in native *P. kauderni* population sites except in exceptional circumstances (see VIII.vi). Indeed releases should be possibly limited to sites where population genetic integrity has already been compromised (e.g. Bone Baru and possibly other trade centers).

Although enough is currently known to delineate temporary management units in support of site-based management within the Banggai Archipelago, it is recommended that existing information be updated and knowledge gaps filled should resources allow. The studies on *P. kauderni* population genetics to date have each used different methods, do not cover all populations of concern, and are unlikely to reflect the full intra-species genetic structure in terms of evolution and relatedness. Furthermore, the methods used to date are not necessarily the most appropriate for management purposes such as stock delineation and traceability of wild-caught fish. This points to a need for research to delineate and characterize stocks – the results of which would provide a strong scientific basis for *P. kauderni* conservation and management, and provide the basis for a meaningful evaluation of introduced population genetic characters (a key component of the NPOA).

(iii) Population status

Monitoring the effectiveness of implemented conservation and management activities requires establishing baseline population levels (T_0) and stock structure (discussed in the previous section), in addition to regular monitoring of population and harvest levels in support of adaptive management (see Section VIII.v). Baseline data were collected in 2017 in fulfilment of the NPOA and provide a good starting point for managed take. However, practical application of the survey methods initially developed under the NPOA revealed challenges in the proposed approach to monitoring that the government may wish to consider before the next surveys are carried out (S. Ndobe and A. Moore, personal observations).

To give one example, it is important that the same sites/ESUs are monitored each year to allow data to be compared and trends tracked. But it was not always easy to understand where surveys were to be carried out – site names are not applied consistently among stakeholders, and the coordinates provided sometimes pointed to areas without suitable *P. kauderni* habitat. In these cases researchers made their best inferences about where to survey, but the same inferences may not be made in following years. This matters as population densities could vary widely between *P. kauderni* patches in a single bay.

As another example, the patchy and shifting (e.g. with *Diadema* groups) distribution of *P. kauderni* suggests that the proposed approach of laying 20x5 m transects parallel to shore may not be the most appropriate way of obtaining consistent data. Instead one might consider roving diver swims over the locations of known populations or patches of suitable habitat/microhabitat. This approach is suggested for other patchily distributed and site-specific fishes such as seahorses[77].

Although the T_0 surveys give a useful basis on which to monitor the effectiveness of conservation and management actions, it is not clear what the goal of such actions are in terms of population status. As mentioned previously, the T_0 "baseline" shouldn't necessarily be the level to aim for since many populations are already severely depleted. It would be useful if the NPOA articulated

the anticipated outcomes or impact of proposed activities on *P. kauderni* populations – such as preventing further declines, rebuilding populations to a particular level, and/or enabling on-going and sustainable trade.

(iv) Sustainable harvest

The NPOA includes regulating *P. kauderni* harvest through site-specific quotas to be implemented on a rotational basis, an approach strongly supported by the information gathered for this report. This study estimated a precautionary total quota to be distributed across different sites (ESU's where known or inferred), which can be revised based on monitoring data. A rights-based approach to fisheries management may be a practical way to implement site-specific quota restrictions. In this case, fisher groups would be allocated a number of fishing grounds (based on known/inferred ESUs) and a number of site-specific quotas that could be based on T_0 data for the sites included in this survey (to be updated based on T_1 surveys). Harvest could be rotational – for example each group could be allocated ~six fishing grounds, enabling a three monthly rotation with (on average) two fishing grounds per month. Of course the status of some sites might suggest a complete moratorium on fishing pressure until the stocks have had a chance to rebuild.

In the experience of the contributing authors, fishers can grasp the notion of genetic stocks or ESUs relatively easily. This is because most have noticed minor but consistent differences between fish from different fishing grounds. If the mechanisms can be put in place for an ESU and rights-based management scheme, informal consultations suggest that fishers will be able and willing to implement such an approach – particularly if they are included in any decision-making regarding quota allocations.

Implementing a robust quota system for *P. kauderni* requires establishing stock structure (Section VIII.ii) and baseline population levels (T_0) (Section VIII.iii), as well as repeat monitoring of populations and harvest levels in support of adaptive management. With respect to repeat fisheries monitoring, mobile phone technologies may offer a mechanism for gathering site-specific catch information from fishers. The enumerator system that ran from 2008/2009 to 2011/2012 demonstrated that fishers could make usable records of their catches, in terms of numbers and fishing grounds[16]. Nowadays, with the ubiquity of mobile phones (even in areas with no signal as yet), a mobile app would be a low-cost way of collecting and sharing data. This approach is being used for fisheries in other parts of the world, such as ABALOBI in South Africa[78] and WWF's e-logbook that has been implemented in Ecuador[79].

At some sites, simply reducing fishing pressure on *P. kauderni* may be sufficient to enable sustainable exploitation and/or rebuild *P. kauderni* population abundance. At most sites, however, habitat degradation and/or declines in microhabitat abundance are likely to prevent such recovery – requiring a holistic approach to conservation and management. The most feasible way to do this in the current situation would be a combination of regulations for *P. kauderni*, microhabitat (*Diadema* urchins and anemones) and general habitat (corals and seagrasses) within the new Banggai Dalaka MPA (see also Section VIII.i). Regulations could apply across the MPA or by zone, or even by site within zones as well as village regulations. The latter have the advantage that they can be directly implemented by communities, and would be an

effective mechanism for empowering community coastwatch groups (*Pokwasmas*) in villages where they have been established.

One potential model for community-based management is the "BCF Gardens" concept[24,35]. Inspired by the Locally Managed Marine Areas (LMMA) movement, the idea is to select a (relatively small) area of potentially "prime" *P. kauderni* habitat within village waters where the species is still present but where habitat has been degraded and/or microhabitat abundance has been greatly reduced. *Pterapogon kauderni* and its habitats would be completely protected within this small area. The area should be selected to minimize logistical challenges of management, for example it should be easily monitored (to guard against intruders). Once recovery is well under way, there should be spillover into less protected areas of the MPA, and eventually the "garden" itself could be harvested at sustainable levels.

(v) Trade – regional/national

There is a considerable amount of data on the movement of *P. kauderni* within Indonesia provided in the records of the Fish Health and Quarantine Service. The remarks made to A. Moore by Fish Quarantine officers on the difficulty (time and effort involved) in providing data on the *P. kauderni* trade, as well as the time necessary to access data through the on-line system, indicate a need for improved data collection and management practices. A redesign of the software interface to make it user-friendly (for fish quarantine officers and other interested stakeholders), and ideally mobile enabled to reduce the need for paperwork, could resolve data management and access challenges.

One key information gap related to *P. kauderni* trade routes is the consignment of large volumes of fish out of Kendari reported in the Fish Quarantine data. The reported consignments from this region have increased substantially over the past years, and it is not clear how the fish are being sourced (i.e. from local or other introduced populations, native populations, or a combination thereof). A field survey on the trade through Kendari would be a useful approach for filling this urgent gap in understanding.

With respect to reducing mortality along the supply chain – both nationally and internationally - consideration could be given to best-practice guidelines for capture methods, post-harvest husbandry and transportation, such as those developed by the NGO LINI[80], and to CITES guidelines for transport of live animals by air[81] or by other non-air means[82].

With respect to *P. kauderni* aquaculture, consideration should be given to how community-based aquaculture being developed outside the endemic area could still provide benefit to the fish and stakeholders within the endemic area. For example, a proportion of the revenue from selling cultured fish outside the endemic area could go to funding conservation of *P. kauderni* within the endemic range. Furthermore, it would be useful to establish best practice approaches to *P. kauderni* culture in Indonesia, in support of the training proposed in the NPOA – such as those being employed in Bone Baru to prevent mixing of broodstock and related offspring sourced from different known or inferred ESUs (see Section IV.iii). This is of particular importance if breeding is carried out in part to enable re-stocking efforts proposed in the NPOA (but see section VIII.vii).

(vi) Trade – international

Internationally, several publications have reported on the lack of an adequate management and control mechanism to monitor the trade in marine ornamental fishes[73,83,84]. The analysis of available international trade records for *P. kauderni* in Section V suggests that improving importing country record collection, particularly ensuring data are collected at the species level and noting whether specimens are wild sourced or captive-born/bred, would be of value in tracking the international trade in *P. kauderni*. This information might be available on customs import records, but it is not systematically collected into accessible databases.

Given the estimated rates of post-export mortality, however, it seems that improved tracking of exports as they leave Indonesia would better reflect exploitation levels and populations trends over time (see Section VIII.v). Furthermore, as stated in the previous section, consideration could be given to CITES guidelines for transport of live animals by air[81] or by other non-air means[82] in an effort to bring down rates of post-export mortality.

(vii) Existing management

NPOA:

The information compiled in this report supports the need for most aspects of the NPOA for *P. kauderni*, as presented in AC29 Doc 25.2 and AC29 Inf. 21, and the authors have endeavoured to provide some specific considerations and recommendations relevant to most proposed actions in Table 12. There are, however, two recommendations to expand on here. The first is related to the proposed locations of the various activities, and the second is related to Target 6 – re-stocking of *P. kauderni*.

With respect to the locations of proposed activities – it is noted that many of the activities are proposed to take place within but also outside the endemic range of *P. kauderni*. Where it does not end up feasible to carry out activities at all proposed locations, it is recommended priority be given to support *P. kauderni* conservation and management within its endemic range to ensure benefits to native fish populations. Attention could be turned to introduced populations at such time that native populations and their habitats are well managed with adequate resources.

Second, with regard to Target 6: re-stocking, the authors support comments made in AC29 Com 10 (Rev by Sec): "noting, among other actions, re-stocking activities are proposed, it was suggested Indonesia provide updated reintroduction protocols it will be using to support the re-stocking activities and avoid genetic mixing. It was further noted that the IUCN Reintroduction Guidelines may be useful for Indonesia to consider this this regard". IUCN, in its Guidelines for Reintroductions and Other Conservation Translocations[48], synonymizes re-stocking with reinforcement, which it defines as "the intentional movement and release of an organism into an *existing population* of conspecifics." This is in contrast to reintroduction – "the intentional movement and release of an organism *inside its indigenous range from which it has disappeared*", and conservation introduction – "the intentional movement and release of an organism *outside its indigenous range*." As these three approaches to translocations necessitate different risk assessments and approaches to implementation, it would be valuable for them to be distinguished in any guidelines and activities in support of Target 6.

In any case, some recommendations that could be included in the best practice guidelines for re-stocking, reintroductions and/or introductions could include:

- that there should generally be strong evidence that the threat(s) that caused any previous declines or extirpations have been correctly identified and removed or sufficiently reduced[xi];
- that the release of fish from one site (known or inferred ESU) at another site (known or inferred ESU) only be allowed if genetic data are available and indicate very close relation between donor and receiving population/site – or at sites where genetic mixing has already occurred (e.g. Bone Baru);
- that fish released at a site (known or inferred ESU) from captive breeding be the offspring of broodstock from the same site – or be released as sites where genetic mixing has already occurred (e.g. Bone Baru);
- that releases to the wild outside the endemic range should be reported, wherever they occur, whether purposive or accidental; and
- that overall releases of any kind be tightly regulated by the appropriate authorities (i.e. only carried out on recommendation from the appropriate scientific authority and with a permit from the appropriate management authority).

Banggai Dalaka MPA:

Effective implementation of the Banggai Dalaka MPA (Section VII.ii) would provide conservation gains for *P. kauderni* and its associated habitats (see also Sections VIII.i and iv). The findings of this report strongly support the proposed multi-zone approach to implementation of the Banggai Dalaka MPA, such that protection/conservation of *P. kauderni*, its habitat and microhabitat vary among zones and sub-zones, and also among sites within each zone/sub-zone. In this way "no-take" zones can be balanced by "managed zones" in which sustainable exploitation can be achieved by integrated science and community-based approaches (e.g. the "BCF Garden" approach, see Section VIII.iv) along with routine monitoring.

Key to MPA implementation will be stakeholder support and empowerment, as proposed in the NPOA. The authors suggest partnerships with local schools, women's groups, and other civil society actors as possible mechanisms to garner stakeholder buy-in. Again, "BCF Gardens" (Section VIII.iv) are an example initiative that could be implemented with a community-based approach. The re-establishment/revitalization of the multi-stakeholder BCFC (Banggai Cardinalfish Centre)[xii] also has wide stakeholder support. The BCFC will be particularly effective if it is empowered not only in matters directly related to *P. kauderni* trade and direct conservation of the species, but also in the role of *P. kauderni* as a flagship species for holistic and sustainable coastal resource management.

[xi] Recommendation from the IUCN guidelines

[xii] The BCFC was established in 2007 under the first *P. kauderni* NPOA (2007-2012) as a multi-stakeholder umbrella organisation for all aspects relating to the conservation (including sustainable use) of *P. kauderni* and other ornamental fish. The BCFC, as constituted under Decree 168/2007 of the Banggai Kepualuan District head, included members of national/provincial/district/sub-district government, NGOs, academia, private sector and community/civil society. In particular, the BCFC was expected to lead on and provide a forum for *P. kauderni* conservation and management efforts, including: conservation and recommendations; statistics, monitoring and surveillance; production and marketing; and community development/empowerment.

Temporal management:

Temporal restrictions on fishing pressure are a useful compliment to spatial management, particularly when they coincide with peaks in reproduction and/or recruitment. The currently decreed closure imposes a ban on the fishery during peak breeding months of February-March and October-November on *P. kauderni* populations within the Banggai Dalaka MPA. Complimentary regulations, such as quotas, will be necessary to prevent unsustainable fishing practices when the closure is not in effect, and to manage *P. kauderni* microhabitats (e.g. prevent overexploitation of the microhabitat organisms themselves).

IX. Conclusions and summary recommendations

The need to manage the take and trade of *P. kauderni* to improve the conservation status of this species is well established, and Indonesia has already proposed and begun many relevant activities to this end. This report aimed to provide additional information in support of assessing the impact of international trade on the conservation status of *P. kauderni* and to advise on suitable conservation and management measures. The previous section elaborated on several such recommendations, which are summarised in this section and matched to proposed NPOA activities in Table 13.

The recommendations account for the unique life history of *P. kauderni*, which in turn leads to genetically isolated populations (ESU's), density dependent productivity, and a high dependence on exploited microhabitats and vulnerable nearshore marine habitats. Taken together, these facts necessitate a site-specific and holistic approach to conservation and management of *P. kauderni*. That said, accounting for these factors in conservation and management activities (whether they be quotas, spatial/temporal management, or relocations, *inter alia*), together with the involvement of local communities in activity implementation, enforcement and monitoring, should allow for an ongoing and sustainable harvest of *P. kauderni* within Indonesia. Conserving and managing this unique species and its habitat/microhabitats could revive food fisheries of economic and subsistence value, while restoring potential for tourism and recreation. In this way *P. kauderni* can become a flagship species for holistic and sustainable coastal resource management. Given the Endangered status of the species, it is recommended that any initial management efforts err on the side of precaution, and then are adjusted as monitoring data come in and management effectiveness is known.

Regarding trade, there appears to be a need to fill some gaps in the understanding of trade routes – particularly where individuals are reportedly being consigned in large volumes through trade centers outside the endemic range. Finally, while it appears Indonesia could become a competitive supplier of captive-bred *P. kauderni* to the international market, consideration should be given to ensure that the growth of this sector maintains or increases incentives for wild population conservation and benefits for local communities.

Table 13. Summary of relevant report recommendations (from Section IX) against the strategies and activities of the Banggai Cardinalfish National Plan of Action (2017-2021).

STRATEGY	ACTIVITY	RECOMMENDATIONS
TARGET 1. Availability of and information on *P. kauderni* population in its natural habitats and other geographic areas.		
Development of database, information, and documentation of BCF both at its natural habitats and introductions areas.	1. Development of survey and monitoring manual for BCF. 2. Training on survey and monitoring of BCF population 3. Conduct survey and monitoring of BCF population at its major habitats. 4. Conduct a genetic test for BCF population outside Banggai as its natural habitat. 5. Updating BCF population status.	• Revisit and consider revising the *P. kauderni* monitoring protocol based on stakeholder experience after practical application during T_0 surveys, to ensure data can be compared among years and a wide range of stakeholder groups can consistently apply the methodology. • Clarify the anticipated outcomes/impacts of the various activities outlined in the NPOA on *P. kauderni* populations in Indonesia. This will provide a useful framework for considering how best to implement any one activity, and will be useful for measuring effectiveness of the proposed activities. • Determine the goal of NPOA actions in terms of population size, taking into consideration that the T_0 "baseline" shouldn't necessarily be the level to aim for since many populations are already severely depleted. Example goals include preventing further declines, rebuilding populations to a particular level, and/or enabling on-going and sustainable trade. • Should funds and/or partnerships become available, carry out a comprehensive genetic study of the native *P. kauderni* populations, of which the aims should be to (i) identify the ESUs within the endemic range and their (relative) relatedness; and (ii) develop diagnostic tools for assignment of origin to support management of native, introduced, and captive-bred *P. kauderni*, including traceability.
TARGET 2. Implementation of protection and preservation of *P. kauderni* and its natural habitats.		
Habitat protection	1. Identification of potential habitats for conservation 2. Rezoning existing MPA to cover all BCF major habitats 3. Establishment of new MPA under the provincial government. 4. Establishment of locally managed MPAs	• Regulate the exploitation of urchins and anemones (key P. kauderni microhabitats), particularly through implementation plans for the Banggai Dalaka MPA. The status of these key microhabitats at some sites may justify a temporary moratorium on their take, and perhaps activities for assisted recovery. • Implement the planned zonation of the Banggai Dalaka MPA, using a community-based approach that empowers stakeholders to be stewards of *P. kauderni* and its habitats, and to identify with *P. kauderni* as a flagship species for holistic and sustainable coastal resource management. Consider the aforementioned "BCF Garden" concept as a

STRATEGY	ACTIVITY	RECOMMENDATIONS
		possible tool to achieve this recommendation.
Re-initiating the proposal to apply protection status for BCF	1. Formulation of policy paper	• Recommendations as under Target 3, below
	2. Regulation on limited protection status (options include: limit on size, number of harvest, and catch sites/areas)	
TARGET 3. Sustainable use and trade of *P. kauderni*.		
Designation of area/habitats which allowed for harvest	1. Conduct population survey at all potential harvest sites	• Population survey recommendations as above under Target 1. • Work with stakeholders to determine site-specific quotas for initial implementation, explore the practicality of rights-based fisheries, and follow up with population monitoring and quota adjustment as needed. • Identify suitable sites for piloting the "BCF Garden" concept, as a tool for ensuring sustainable harvest of *P. kauderni*. • Take into account known or inferred ESUs in implementation of a quota system for native *P. kauderni* within its endemic range. The status of *P. kauderni* at some sites may justify a temporary moratorium on take. • In order to monitor take over time, implement fisher reporting of fishing ground(s) (known or inferred ESUs) and number of fish from each site, in addition to the current requirements for total volume, general origin, and destination. • Explore whether technological solutions (such as mobile phone technologies) could facilitate robust fisher reporting and data management. • Improve monitoring of trade within Indonesian with measures to further improve Fish Health and Quarantine data collection, enhance data management and make the data access portal more user-friendly. • Carry out a study on *P. kauderni* trade through Kendari. • Consolidate best practice guidelines for the catch and trade of *P. kauderni* to minimise mortality along the supply chain, based on existing resources provided by LINI and CITES.
	2. Dissemination on harvest rotation system and open-close system.	
Setting up quota for BCF harvest from wild	1. Conducting level of exploitation at each market chain.	
	2. Quota allocation	
Conducting monitoring and surveillance of BCF exploitation	1. Socialization on BCF regulation	
	2. Surveillance on harvest, distribution, and trade.	
	3. Enforcement	
Application of CITES approach to regulate trade of BCF (although this species is not yet listed in CITES Appendix)	1. Development of SOP for BCF trade outside main habitats in Banggai Islands and trade from aquaculture	
	2. Data collection of international trade	
	3. Development of NDF (Non Detrimental Finding) for BCF	
	4. Registering BCF exporter and setting up association	
TARGET 4. Improvement of human resources capacity to conserve and manage *P. kauderni*.		
Community empowerment	1. Community based surveillance program.	• Relevant recommendations under Targets 1, 2, 3 and 6
	2. Sustainable use of BCF for community welfare.	
	3. Training and technical assistance to community (aquaculture, re-stocking, trade-chain, disease management)	
	4. Socialization, education, and awareness campaign.	

STRATEGY	ACTIVITY	RECOMMENDATIONS
TARGET 5. Improvement of conservation governance.		
Improving BCF conservation and management governance	1. Optimizing Banggai Cardinal Fish Center	• Relevant recommendations under Targets 1, 2, 3 and 6
	2. Development of ex situ conservation and training center	
	3. Increasing natural habitat coverage	
	4. Development of national trade network and promotion of BCF.	
	5. Improving the role and function of national task force on ornamental fish to support BCF conservation and management.	
TARGET 6. Implementation of re-stocking of *P. kauderni* populations.		
Strengthening brood stock center for BCF culture	1. Community training on BCF culture	• Consider how to ensure the growth of community-based aquaculture activities as proposed in the NPOA, either inside or outside the endemic distribution of *P. kauderni*, increases incentives for wild, native fish conservation and benefits stakeholders within the species' endemic range. • Take into account the need to conserve the genetic structure of *P. kauderni* in activities related to culture or re-stocking, as proposed in the NPOA. • Establish best practice guidelines for culture of *P. kauderni* that mitigate against impacts on genetically distinct wild populations of the species. • Revisit and consider revising protocols for *P. kauderni* translocations, distinguishing among re-stocking/reinforcement, reintroduction and introduction activities, which reflect best practice approaches such as those provided in the IUCN Guidelines for Reintroductions and Other Conservation Translocations.
	2. Increasing of BCF culture activities	
	3. Re-stocking of adult	
	4. Assessment of habitat rehabilitation sites	
Re-stocking program	1. Updating manual for BCF re-stocking	
	2. Community education and training on BCF restocking.	
	3. Conducting re-stocking activities	
	4. Evaluation on re-stocking effectiveness	

Recommendations

(i) Habitat and microhabitat

- Regulate the exploitation of urchins and anemones (key *P. kauderni* microhabitats), particularly through implementation plans for the Banggai Dalaka MPA. The status of these key microhabitats at some sites may justify a temporary moratorium on their take, and perhaps activities for assisted recovery.
- Identify suitable sites for piloting the "BCF Garden" concept, as a tool for habitat and microhabitat conservation and management.

(ii) Population structure

- Take into account known or inferred ESUs in implementation of a quota system for native *P. kauderni* within its endemic range. The status of *P. kauderni* at some sites may justify a temporary moratorium on take.
- Take into account the need to conserve the genetic structure of *P. kauderni* in activities related to culture or re-stocking, as proposed in the NPOA.
- Should funds and/or partnerships become available, carry out a comprehensive genetic study of the native *P. kauderni* populations, of which the aims should be to (i) identify the ESUs within the endemic range and their (relative) relatedness; and (ii) develop diagnostic tools for assignment of origin to support management of native, introduced, and captive-bred *P. kauderni*, including traceability.

(iii) Population status

- Revisit and consider revising the *P. kauderni* monitoring protocol based on stakeholder experience after practical application during T_0 surveys, to ensure data can be compared among years and a wide range of stakeholder groups can consistently apply the methodology.
- Clarify the anticipated outcomes/impacts of the various activities outlined in the NPOA on *P. kauderni* populations in Indonesia. This will provide a useful framework for considering how best to implement any one activity, and will be useful for measuring effectiveness of the proposed activities.
- Determine the goal of NPOA actions in terms of population size, taking into consideration that the T_0 "baseline" shouldn't necessarily be the level to aim for since many populations are already severely depleted. Example goals include preventing further declines, rebuilding populations to a particular level, and/or enabling on-going and sustainable trade.

(iv) Sustainable harvest

- Work with stakeholders to determine site-specific quotas for initial implementation, explore the practicality of rights-based fisheries, and follow up with population monitoring and quota adjustment as needed.
- Identify suitable sites for piloting the "BCF Garden" concept, as a tool for ensuring sustainable harvest of *P. kauderni*.
- In order to monitor take over time, implement fisher reporting of fishing ground(s) (known or inferred ESUs) and number of fish from each site, in addition to the current requirements for total volume, general origin, and destination.
- Explore whether technological solutions (such as mobile phone technologies) could facilitate robust fisher reporting and data management.

(v) Trade – regional

- Improve monitoring of trade within Indonesian with measures to further improve Fish Health and Quarantine data collection, enhance data management and make the data access portal more user-friendly.
- Carry out a study on *P. kauderni* trade through Kendari.
- Consolidate best practice guidelines for the catch and trade of *P. kauderni* to minimise mortality along the supply chain, based on existing resources provided by LINI and CITES.
- Consider how to ensure the growth of community-based aquaculture activities as proposed in the NPOA, either inside or outside the endemic distribution of *P. kauderni*, increases incentives for wild, native fish conservation and benefits stakeholders within the species' endemic range.
- Establish best practice guidelines for culture of *P. kauderni* that mitigate against impacts on genetically distinct wild populations of the species.

(vi) Trade – international

- Importing countries should endeavour to collect more complete information on *P. kauderni* imports (e.g. collecting data at the species level, and on whether imported individuals are wild caught or captive-bred).
- Consideration should be given to whether the online survey of *P. kauderni* importers, wholesalers and retailers piloted for this report should be repeated, but with sufficient time allowed to gather a larger sample size of responses.

(vii) Existing management

- Consider the above recommendations in context of the NPOA strategies and actions, as summarised in Table 13.
- Consider prioritizing NPOA activities within the endemic range of the species, when prioritization is needed due to limited resources or capacity.
- Revisit and consider revising protocols for *P. kauderni* translocations, distinguishing among re-stocking/reinforcement, reintroduction and introduction activities, which reflect best practice approaches such as those provided in the IUCN Guidelines for Reintroductions and Other Conservation Translocations.
- Implement the planned zonation of the Banggai Dalaka MPA, using a community-based approach that empowers stakeholders to be stewards of *P. kauderni* and its habitats, and to identify with *P. kauderni* as a flagship species for holistic and sustainable coastal resource management. Consider the aforementioned "BCF Garden" concept as a possible tool to achieve this recommendation.

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Annex I. Reported microhabitat associations of *P. kauderni* (endemic habitat)

Taxon	Prevalence	Remarks	References
Sea urchins (Echinoidea, Echinodermata)			
Diadema setosum	widespread	Main microhabitat, all size classes	a, b, c, d
Diadema sp.			e, f, g, h
Diadema savignyi			c, d
Echinothrix sp.	common		i, j
Astropyga sp.	rare	Isolated occurrences	k
Tripneustes sp.	rare	Other urchins absent	a, b
Sea anemones (Actinia, Cnidaria)			
Heteractis sp.[1]	common	Often in anemones inhabited by clownfishes (genera *Amphiprion* and *Premnas*)	a, b, c, d, e, l
Stichodactyla sp.[2]	common		a, b, c, d, l
Entacmea quadricolor	common		a, b, c, d, l
Macrodactyla doreensis	rare		a, b, c, l
Actinodendron sp.[3]	common		a, b, c, d, l
Hard corals (Scleractinia, Cnidaria)			
Acropora sp.	widespread		a, b, c, e, l
Other Acroporidae	common		a, b, c, e, l
Porites sp.	widespread	Mostly branching forms	a, b, c, l
Heliofungia actiniformis	widespread	Recruits/small juveniles	a, b, e, g, j
Goniopora sp.	rare		a, b, k, l,
Echinopora sp.	rare		a, b, k
Montipora sp.	common		a, b, k
Other or unspecified genera (mainly branching or foliose forms)	common		e, f, g, k, m
Other microhabitat associations			
Rhizophora sp. prop roots	locally common	Few sites, but *P. kauderni* density can be high	a, b, i
Cassiopea sp.	rare	Isolated occurrences (temporal & spatial)	a, e, k, n
Nephthea sp.	rare		a, b
Other/unspecified soft corals	rare		e, k, o. p
Millepora sp.			a, b, e, k, l
Proteaster nodosus	rare		a, b
Tridacnidae	rare	One site (Toado)	k, n

[1] *H. crispa, H. magnifica, H. aurora, H. malu*
[2] *S. gigantea, S. haddoni, S. merteensis*
[3] Species unidentified, varied in form and colour

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Annex II. Fish Health and Quarantine Service data

Table II.1. Fish Health and Quarantine Service data on consignments from Luwuk-Banggai

Data for		Destinations - Main (volume)						Other		Total	Letter six*	
Year	Months	Denpasar	Jakarta	Makassar	Manado	Kendari	Surabaya	Volume	Name	Volume	Volume	Destinations
2008	7-12	No data on destinations								40,799	0	None recorded
2009	all	50	2,100	700	106,030	0	700	0		158,280	14,060	D J M S
2010	all	3,300	12,000	0	117,400	10,000	500	0		143,200	13,400	D J M S
2011	all	26,150	24,600	15	47,500	37,500	300	0		136,065	14,828	D J K M S
2012	all	3,780	9,400	1,000	33,992	17,000	0	0		65,172	4,199	D J K M
2013	all	81,640	12,700	0	31,500	11,000	10,500	250	P	137,090	58,339	D J K M P S
2014	all	115,900	18,300	0	3,500	0	450	390	A Ba P	137,730	59,092	D J M S
2015	all	123,200	7,700	0	2,500	31,200	500	700		165,750	80,192	D J K
2016	all	31,310	9,400	0	2,000	3,000	0	110	Bk Y	45,710	12,128	D J K
2017	all	52,170	10,030	150	0	0	0	50	P	62,400	31,820	D J S
2018	1-5	10,650	2,900	0	0	0	0	0		13,550	19,449	D J S

A = Ambon; Ba = Batam; Bd = Bandung; Bk = Bengkulu; D = Denpasar; J = Jakarta; K = Kendari; M = Manado: P = Palu; S = Surabaya; U = Makassar (formerly Ujung Pandang), airport code UPG; Y = Yogyakarta

2014: A = 300; Ba = 60; P = 30; 2015: Bd = 50; Bk = 50; P = 600; 2016: Bk = 60; Y = 50

*Letter six is the trade name for *Paracanthus hepatus*. These are also the destinations for other ornamental fish, especially angelfishes

Table II.2. Fish Health and Quarantine Service data on consignments from Kendari

Year	Months	Denpasar	Jakarta	Medan	Surabaya	Makassar	Manado	Mataram	Padang	Total
2008	1 - 11	Data on destination began during November 2008								59819
2008	11 - 12	7040	7040	4465	1425	310	0	0	0	73,059
2009	all	37,191	23,725	0	5,000	700	0	0	0	66,616
2010	all	47,595	35,120	0	5,000	700	200	0	0	88,615
2011	all	45,946	23,770	0	750	950	0	0	0	71,416
2012	all	47,143	18,840	0	0	125	0	0	0	66,108
2013	all	71,930	20,335	0	225	300	0	0	0	92,790
2014	all	112695	34482	0	200	100	0	0	0	147,477
2015	all	294,671	53,034	0	3,459	0	0	0	0	351,164
2016	all	390,351	53,454	0			0	2,025	0	445,830
2017	all	348,710	52,276	0	1,242	0	0	0	150	402,378
2018	1 - 5	113,888	28,535	30	0	0	0	0	390	142,843

Table II.3. Fish Health and Quarantine Service data on consignments from Manado[a]

Year	Denpasar	Jakarta	Surabaya	Ternate	Makassar	Ambon	Medan	Pekanbaru	Total
2008	1 to 7	Data on destination starts during July 2008							230,795
2008	7 to 12	55,673	12,053				750		68,476
2009	159,585	45,950			550	400	1,100	50	207,635
2010	151,500	31,200	400			400			183,500
2011	81,625	18,160		100					99,885
2012	72,250	8,750	0	100	500				81,600
2013	17,350	6,150	1,100	1,050	0				25,650
2014	1,000	400							1,400
2015				200[b]					200

	Denpasar	Jakarta	Surabaya	Other	Total		
2015	25,840	3,502	690	583	30,615	Medan as main destination for ornamental fish other than Denpasar, Jakarta, and Surabaya during period 2015-2018	Mixed marine ornamental fishes
2016	24,584	13,767	2,554	5,727	46,632		
2017	31,518	16,616	2,152	8,394	58,680		
2018	5,480	5,233	375	3,611	14,699		

[a]From 2015 onwards data for all species dispatched from Manado seem to be generally aggregated as marine ornamental fishes, with some exceptions such as the one consignment of *P. kauderni* in December 2015 shown above, and a few consignments of "Letter six". This means that in effect there is no record of the volume of *P. kauderni* traded/dispatched from Manado over the past 4 years.
[b]Dispatched during December 2015

Table II.4. Fish Health and Quarantine Service data on consignments from Makassar

Year	Months	Denpasar	Jakarta	Timika	Surabaya	Total
2008	10 to 12	200	0	0	0	200
2009	all	0	0	0	500	500
2010	all	0	0	0	0	0
2011	all	1,000	0	0	0	1,000
2012	all	0	100	0	100	200
2013	all	150	1,000	0	0	1,150
2014	all	0	15,900	0	0	15,900
2015	all	500	17,050	0	0	17,550
2016	all	0	15,200	0	50	15,250
2017	all	0	10,410	50	0	10,460
2018	1-5	0	2,350	0	0	2,350

Table II.5. Fish Health and Quarantine Service data on consignments from Palu (statistics website)

Year	Months	Denpasar	Jakarta	Ambon	Makassar	Batam	Lampung	Manado	Total
2008	5 to 12	No data on destination							1192
2009	all	1418	675	0	0	0	0	80	2173
2010	all	1750	370	700	0	0	55	0	2875
2011	all	4640	400	1,240	50	120	0	0	6450
2012	all	1400	250	300					1950
2013	all	1600	300	850					2750
2014	all	11600	3200						14800
2015	all	985	1,120	0	0	0	0	0	2105
2016	all	725	700	0	0	0	0	0	1425
2017	all	0	0	0	200	0	0	0	200
2018	1-5	0	0	0	0	0	0	0	0

Table II.6. Fish Health and Quarantine Service data on consignments to and from Ambon

Year	Consignments from Ambon									Consignments to Ambon			
	Denpasar	Jakarta	Mataram	Batam	Lampung	Surabaya	Sorong	Manado	Total	Palu	Luwuk	Manado	Total
2009									0			400	400
2010									0	700		400	1100
2011									0	1240			1240
2012	0	10	0	0	0	0	10	0	20	300			300
2013	800	1960	0	0	0	0	0	0	2760	850			850
2014	1850	6150	0	400	50	0	0	0	8450		300		300
2015	260	900	700	0	130	0	0	0	1990				0
2016	400	50	0	200	0	150	0	0	800				0
2017	315	108	150	80	0	0	0	0	653				0
2018	0	0	0	50	0	0	0	30	80				0
Total	3625	9178	850	730	180	150	10	30	**14753**	3090	300	800	**4190**

Table II.7. Fish Health and Quarantine Service data on consignments arriving in Denpasar

Year	Months	Kendari	Luwuk	Makassar	Total
2015	all	160088	5705	3230	169023
2016	all	60542	0	1615	62157
2017	all	41140	6340	0	47480
2018	1 to 5	62899	4900	0	67799

Annex III. Online survey

Country of your company/headquarter	
Country	
Your function (please tick all that apply)	
Importer	
Exporter	
Wholesaler	
Retailer	
Since when do you buy Banggai cardinalfish (Pterapogon kauderni)?	
Please give the year:	
How many Banggai cardinalfish do you buy per year? Please give the year:	
Amount:	
How many Banggai cardinalfish have you purchased in the last years? Approximate volumes.	
2017	
2016	
2015	
2014	
2013	
2012	
Do you know the source of your Banggai cardinalfish? Wild-caught = from the coral reef; Captive-bred = from a breeding farm/aquaculture	
All wild-caught	
Mostly wild-caught	
Unknown	
Mostly captive-bred	
All captive-bred	
If you purchased captive-bred fishes which country/company/farm did they come from?	
Country:	
What considerations do you take into account when sourcing Banggai cardinalfish?	
Size	
Colour	

Sex				
Wild				
Captive-bred				
Other				
Have you noticed any changes? Multiple possibilities apply.				
	Decrease	No change	Increase	No answer
Volume of trade				
Demand of wild-caught fishes				
Demand of captive-bred fishes				
Overall availability				
Availability of wild-caught fishes				
Availability of captive-bred fishes				
Price of wild-caught fishes				
Price of captive-bred fishes				
Volume of purchase from Indonesia				
Volume of purchase from Thailand				
Volume of purchase from other countries				
What is the average price (US$) you pay for wild versus captive-bred Banggai cardinalfish? Average price you sell for? (Optional)				
	US$			
Wild				
Captive-bred				
Average price of sale				
Your comments:				

Annex IV. MPA Zones and associated activities

Activities which are permitted and forbidden under the KKP3K MPA category zonation scheme are defined under MMAF ministerial regulation 17/2008 (Peraturan Menteri Kelautan dan Perikanan Republik Indonesia Nomor PER.17/MEN/2008 Tentang Kawasan Konservasi di Wilayah Pesisir dan Pulau-Pulau Kecil). These activities are briefly described in this table. The MPA Zonation Management Plan (RPZ) includes far greater detail on the activities permitted and not permitted by zone and sub-zone (e.g. types of fishery/fishing gear, types of tourism activity, etc), some of which can vary between sites within a given zone.

Core Zone	
Permitted	Not Permitted
1. Surveillance 2. Monitoring 3. Diving and/or collection of marine organisms for research and/or 4. Research, development, and education <u>Note:</u> The above activities must be reported to and be authorised by the management authority	1. Capture fisheries and/or mariculture 2. Damage to or collection of corals and other marine organisms whether live or dead 3. Tourism 4. Commercial diving 5. Passage of vessels or other marine transport 6. Anchoring
Restricted Use Zone (General)	
Permitted	Not Permitted
1. Research, development, and education, benchmarking, knowledge building 2. Mariculture 3. Traditional fisheries 4. Nature-based tourism 5. Recreational/sport fishing 6. Watersports 7. Passage of vessels	1. Damage to marine habitats (coral and sand mining, collection of live or dead corals, pulling up or cutting seagrasses, other) 2. Capture, collection, disturbance, or holding in captivity, of any protected species as well as sea snakes and seabirds, specifically turtles and their eggs and all marine mammals 3. Catching fish with explosives, synthetic or natural chemicals, and carrying explosives and/or chemical substances used to capture fish on land or at sea 4. Capture, collection, disturbance, or holding in captivity, of any species managed under specific site or zone/sub-zone regulations
Restricted Use Zone – Traditional Fishery Sub-zone	
Permitted	Not Permitted
1. Research, development, and education 2. Fishing with traditional gear which is environmentally benign 3. Recreational/sport fishing 4. Longline fishing – with restrictions	1. Damage to marine habitats (coral and sand mining, collection of live or dead corals, pulling up or cutting seagrasses, other) 2. Capture, collection, disturbance, or holding in captivity, of any protected species as well as sea snakes and seabirds, specifically turtles and their eggs and all marine mammals

5. Purse seine and other gear targeting pelagic fish – with restrictions 6. Fixed or floating lift nets for pelagic fish - with restrictions 7. Other nets and fishing gear - with restrictions 8. Free passage of vessels 9. Construction of piers/jetties and other fisheries infrastructure - with restrictions 10. Tourism - with restrictions 11. Mariculture - with restrictions 12. Activities to protect or restore the marine environment/ecosystem(s)	3. Catching fish with explosives, synthetic or natural chemicals, and carrying explosives and/or chemical substances used to capture fish on land or at sea 4. Capture, collection, disturbance, or holding in captivity, of any species managed under specific site or zone/sub-zone regulations
Restricted Use Zone – Aquaculture (mariculture) Sub-zone	
Permitted	Not Permitted
1. Research, development, and education 2. Environmentally benign mariculture 3. Traditional fishing - with restrictions 4. Nature-based tourism - with restrictions 5. Recreational fishing - with restrictions 6. Watersports- with restrictions 7. Free passage of vessels	1. Damage to marine habitats (coral and sand mining, collection of live or dead corals, pulling up or cutting seagrasses, other) 2. Capture, collection, disturbance, or holding in captivity, of any protected species as well as sea snakes and seabirds, specifically turtles and their eggs and all marine mammals 3. Catching fish with explosives, synthetic or natural chemicals, and carrying explosives and/or chemical substances used to capture fish on land or at sea 4. Capture, collection, disturbance, or holding in captivity, of any species managed under specific site or zone/sub-zone regulations
Restricted Use Zone – Tourism Sub-zone	
Permitted	Not Permitted
1. Research, development, and education 2. Environmentally benign tourism 3. Watersports 4. Recreational fishing 5. Fishing with traditional low-impact gear -with restrictions 6. Passage of vessels within designated lanes and with restrictions 7. Construction of piers/jetties and other tourism infrastructure - with restrictions 8. Activities to protect or restore the marine environment/ecosystem(s)	1. Damage to marine habitats (coral and sand mining, collection of live or dead corals, pulling up or cutting seagrasses, other) 2. Capture, collection, disturbance, or holding in captivity, of any protected species as well as sea snakes and seabirds, specifically turtles and their eggs and all marine mammals 3. Catching fish with explosives, synthetic or natural chemicals, and carrying explosives and/or chemical substances used to capture fish on land or at sea 4. Capture, collection, disturbance, or holding in captivity, of any species managed under specific site or zone/sub-zone regulations
Other Zone (Rehabilitation Zone)	
Permitted	Not Permitted

1. Activities to protect or restore/rehabilitate the marine environment/ecosystem(s) 2. Research, development, and education 3. Tourism - with restrictions 4. Passage of vessels - with restrictions	1. Damage to marine habitats (coral and sand mining, collection of live or dead corals, pulling up or cutting seagrasses, other) 2. Capture, collection, disturbance, or holding in captivity, of any protected species as well as sea snakes and seabirds, specifically turtles and their eggs and all marine mammals 3. Catching fish with explosives, synthetic or natural chemicals, and carrying explosives and/or chemical substances used to capture fish on land or at sea 4. Capture, collection, disturbance, or holding in captivity, of any species managed under rehabilitation zone regulations

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