ENDANGERED SPECIES ACT

DRAFT STATUS REVIEW REPORT

Banggai Cardinalfish, *Pterapogon kauderni*

Source: Jens Peterson ©

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August 2014

PRE-DECISIONAL DOCUMENT

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National Marine Fisheries Service
National Oceanic and Atmospheric Administration

ACKNOWLEDGEMENTS

I thank Dwayne Meadows for the distribution map. Review by Heather Coll, Kimberly Maison, Lisa Manning, Dwayne Meadows, Margaret Miller, Marta Nammack, and Kerry Whittaker greatly improved the document. I also thank Abigail Moore, Samliok Ndobe, and Alejandro Vagelli for serving as peer reviewers and providing helpful and expert insights.

This document should be cited as: Conant, T.A. 2014. Endangered Species Act Draft Status Review Report: Banggai Cardinalfish, *Pterapogon kauderni*. XX pages

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INTRODUCTION

Background

On July 15, 2013, the National Marine Fisheries Service (NMFS) received a petition from WildEarth Guardians to list 81 species, including the Banggai cardinalfish, of marine organisms as endangered or threatened species under the Endangered Species Act (ESA) and to designate critical habitat. NMFS evaluated the information in the petition to determine whether the petitioner provided "substantial information" as required by the ESA to list a species.

The petitioner asserted that the Banggai cardinalfish's restricted range (endemic only to the Banggai Archipelago in Indonesia) and genetic isolation render the species vulnerable to local threats, which include habitat degradation; harvest of its habitat (corals and anemones) for the aquarium trade; coral bleaching; inability of the species to move to new areas on its own when sea temperature rises; disappearance of corals because of global climate change; pollution and contaminants; harvest of individuals for the aquarium trade; disease and predation; the inadequacy of regulatory mechanisms (e.g., no concerted effort to replace wild-caught fish with captive-bred fish for the aquarium industry); and other natural or manmade factors (e.g., low fecundity; lengthy oral incubation period by males; susceptibility to indiscriminate collecting; lack of dispersal mechanisms; frequent earthquakes). The petitioner adds that synergistic effects of these threats also contribute to the species' risk of extinction. The petitioner argued that the United States represents one of the largest importers of wild-caught Banggai cardinalfish, making an ESA listing particularly effective.

Under the ESA, if a petition is found to present substantial scientific or commercial information that the petitioned action may be warranted, a status review shall be promptly commenced (16 U.S.C. §1533(b)(3)(A)). NMFS determined that the petition presented substantial scientific information that listing may be warranted and that a status review was necessary for the Banggai cardinalfish (*Pterapogon kauderni*) (79 FR 10104; February 24, 2014). Experts and members of the public were requested to submit information to NMFS to assist in the status review process from February 24 through April 25, 2014. We received information from three parties in response to our request for information in the 90-day finding. One submitter recommended working with the aquarium hobbyists to prevent marketing wild populations and to restock depleted populations in the wild. Defenders of Wildlife and WildEarth Guardians strongly supported listing the Banggai cardinalfish under the ESA and requested NMFS to consider the IUCN's species assessments and classifications as equivalent to those made under the ESA. They also provided information, which is incorporated, where appropriate, in this status review report. Another submitter strongly supported listing the Banggai cardinalfish under the ESA and provided information, which is incorporated, where appropriate, in this status review report.

ESA Listing Overview

Under the ESA, a listing determination may address a species, which is defined to also include subspecies and, for any vertebrate species, any distinct population segment (DPS) that interbreeds when mature (16 U.S.C. 1532(16)). A joint NMFS-U.S. Fish and Wildlife Service (FWS) (jointly, "the Services") policy (DPS Policy) clarifies the agencies' interpretation of the phrase "distinct population segment" for the purposes of listing, delisting, and reclassifying a species under the ESA (61 FR 4722; February 7, 1996). A species, subspecies, or DPS is "endangered" if it is in danger of extinction throughout all or a significant portion of its range, and "threatened" if it is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (ESA sections 3(6) and 3(20), respectively; 16 U.S.C. 1532(6) and (20)). Pursuant to the ESA and our implementing regulations, we determine whether species are threatened or endangered based on any one or a combination of the following five section 4(a)(1) factors: the present or threatened destruction, modification, or curtailment of habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; and any other natural or manmade factors affecting the species' existence (16 U.S.C. 1533(a)(1); 50 CFR 424.11(c)).

As noted above, the definitions of both "threatened" and "endangered" under the ESA contain the term "significant portion of its range" (SPR) as an area smaller than the entire range of the species which must be considered when evaluating a species risk of extinction. The phrase has never been formally interpreted by NMFS. Recently, the Services published a policy on interpretation of the phrase (79 FR 37578; July 1, 2014). The Policy provides that: (1) If a species is found to be endangered or threatened in a SPR, the entire species is listed as endangered or threatened, respectively, and the ESA protections apply to all individuals of the species wherever found; (2) a portion of the range of a species is ''significant'' if the species is not currently endangered or threatened throughout its range, but the portion's contribution to the viability of the species is so important that, without the members in that portion, the species would be in danger of extinction, or likely to becomes so in the foreseeable future, throughout all of its range; (3) the range of a species is considered to be the general geographical area within which that species can be found at the time the Services make any particular status determination; and (4) if the species is not endangered or threatened throughout all of its range, but it is endangered or threatened within a significant portion of its range, and the population in that SPR is a valid DPS, we will list the DPS rather than the entire taxonomic species (or subspecies).

Approach to the Status Review

For the purposes of this status review, I reviewed the best available information, acquired as a result of the public comment period and a literature search that included *Google Scholar*, *Science Direct*, and *Aquatic Sciences and Fisheries Abstracts*. I organized the information based largely on McElhany *et al.* (2000) (i.e., abundance/population size, growth rate/productivity, spatial

structure and connectivity, and diversity) to determine the population status. Finally, I examined whether a particular portion of the Banggai cardinalfish range was significant in accordance with the SPR Policy.

For the risk assessment, I used a qualitative reference level of relative extinction risk modified from reference levels commonly used in status reviews (e.g., rockfish in the Puget Sound, Washington: http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/rockfish.pdf). I did not make recommendations as to whether the species should be listed as threatened or endangered. Rather, I drew conclusions about the overall risk of extinction faced by the species based on an evaluation of the species' demographic risks, as well as present and future threats to the species and how the species is responding to those threats.

According to the ESA, the determination of whether a species is threatened or endangered should be made solely on the basis of the best scientific information available regarding its current status, after taking into account efforts being made to protect the species. During the extinction risk assessment, likely or possible effects of conservation measures are taken into account to the extent they are reflected in the ESA section (4)(a)(1) factor—inadequacy of existing regulatory mechanisms. Conservation measures that have not yet been implemented or shown to be effective are taken into account in a separate process by NMFS prior to proposing any listing determinations.

LIFE HISTORY AND ECOLOGY

Taxonomy

Kingdom:	Animalia
Phylum:	Chordata
Class:	Actinopterygii
Order:	Perciformes
Family:	Apogonidae
Genus:	*Pterapogon*
Species	*kauderni*
Common:	Banggai cardinalfish

The species was "discovered" in 1920 by Walter Kaudern and described by Koumans (1933). The genus *Pterapogon* contains one other species, *P. mirifica*, from northwestern Australia. However, analyses of biology and molecular studies indicate that it is distantly related to the Banggai cardinalfish and may merit separate generic status (Allen and Donaldson 2007). The species, *Pterapogon kauderni*, constitutes a valid "species" eligible for listing under the ESA because it is considered a valid taxonomic species.

Physical Appearance

The Banggai cardinalfish is a relatively small marine fish. Offspring that are just released from the oral cavity (see Diversity/Resilience-Reproduction and Related Parameters below) measure about 6-8 mm standard length (SL), and juveniles measure up to about 40 mm SL (Vagelli 1999, 2004, 2011). Adults generally do not exceed 55 to 57 mm SL (Vagelli 2011); however, the largest known specimen was a female that measured 66 mm SL (86 mm in total length) and weighed 11.3 g (Ndobe *et al.* 2013).

The species is distinguished from all others in the Apogonidae family by its tasseled first dorsal fin, elongate anal and second dorsal fin rays, and deeply forked caudal fin (Allen 2000). It is brilliantly colored with contrasting black and light bars with whitish spots over a silvery body. The dot pattern is unique to individual fish and can be used to identify specimens (Vagelli 2002, cited in Allen and Donaldson 2007). Sexual dimorphism is not reported for this species; however, on average, males have a larger mouth gape to their total body length (Ndobe *et al.* 2013) and can be distinguished during brooding when their oral cavity becomes enlarged (Vagelli 2011).

Diversity/Resilience—Reproduction, and Related Parameters

Sexual maturity has been estimated at about 8-9 months at approximately 40 mm SL (Vagelli 1999) or up to 12 months (Ndobe *et al.* 2013). Generation length (the age at which half of total reproductive output is achieved by an individual) is estimated to be 1.5 years (Vagelli, personal communication cited in Allen and Donaldson 2007) to 2 years (Ndobe *et al.* 2013). Its life span in the wild has been estimated at approximately 2.5-3 years (Vagelli 2011) and a maximum life span up to 3-5 years (Ndobe *et al.* 2013).

The Banggai cardinalfish possesses several unique reproductive traits. Like many apogonids, sex roles are reversed and males provide parental care and brood eggs in their mouth. It lacks a planktonic larval stage and extends the brooding of larvae after hatching, which results in the release of fully formed juveniles. Spawning occurs year round but peaks around September through October, which is a period of fewer storms in the region (Ndobe *et al.* 2013). Spawning also appears to be related to the lunar cycle, with major peaks during the full moon and smaller peaks during the last quarter and new moon (Ndobe *et al.* 2013; Vagelli 2011; Vagelli and Volpedo 2004). Prior to courtship and spawning, a pair will separate from the main group and establish a spawning site, where both male and female defend their territory against intruders (Kolm and Berglund 2004; Vagelli 1999). Females actively court males through several mating displays (Kolm and Berglund 2004). Upon spawning, a female produces 54-90 eggs at a time and requires about 1 month between each spawning event (Kolm and Berglund 2004; Ndobe *et al.* 2013; Vagelli 2008). The female exudes the egg mass, which the male fertilizes then pulls from the female to take the clutch up into his mouth. Significant egg loss can occur during the clutch transfer as some eggs are cut off from the main clutch (Vagelli 2013). The number of eggs incubated by males varies. Ndobe *et al.* (2013) reported an average of 59 (range = 45-99),

while others reported approximately an average of 41 (range = 12 to 73) at a time for about 20 days (Vagelli 1999, 2013; Vagelli and Volpedo 2004). The incubation period last about 25-28 days at 26°C, and upon hatching, the embryos remain within the oral cavity for about a week until their release as juveniles (about 8 mm SL, often referred to as new recruits post-release from the oral cavity) (Figure 1). Generally it is thought that males do not feed during incubation (Vagelli 2008, 2011). Males are limited to just a few brooding cycles a year (Vagelli 2008).

Several studies indicate a female will produce larger eggs if her mate is large, presumably resulting in higher reproductive fitness (e.g., larger eggs produce larger offspring and increase the chance of survival) (Kolm 2001, 2002; Kolm and Olsson 2003). However, other studies indicate egg size is related to female size and females do not differentiate egg production based on male size (Vagelli 2011, 2013; Vagelli and Volpedo 2004). There is some evidence that fecundity may be positively correlated with female size (Ndobe *et al.* in press).

The Banggai cardinalfish has the lowest fecundity reported for any apogonid (Vagelli 2011). Based on a conservative estimate, a male could incubate/brood ~400 to a maximum of 640 offspring over his lifespan (Vagelli, New Jersey Academy for Aquatic Sciences (NJAAS), personal communication 2014), of which less than 5% may survive to adulthood (Vagelli 2007 as cited in CITES 2007). High mortality occurs during the first days after release from the brood pouch due to predation, including parental and non-parental cannibalism (Vagelli 1999). New recruit and juvenile survival is negatively correlated with adult density, most likely due to increased levels of cannibalism (Ndobe *et al.* 2013) and availability of microhabitat (Moore *et al.* 2012).

Figure 1. Parental care in male Banggai cardinalfish with juveniles in the mouth cavity. *Source*: Daniel Knop used with permission.

Population sex ratios are slightly male-biased and vary from 1.04 males (Vagelli and Volpedo 2004) to 1.67 males (Ndobe *et al.* 2013) for every female.

Banggai cardinalfish form stable groups. Natural group size is difficult to know because group size decreases with fishing pressure, and most populations are not pristine. However, one bay in private ownership in the Banggai Island had, until 2006, never been fished, and group size averaged about 13 fish, but varied from 2-33 fish per group (Lunn and Moreau 2002). At the same site in 2004, group size varied from 1 to over 200 fish per group (Moore, Sekolah Tinggi Perikanan dan Kelautan (STPL), unpublished data). Generally, group size is typically less than 25 individuals, although smaller groups are common and vary by age class and habitat type (Vagelli 2011). Groups consist of a mix of age classes, with the majority of the group being large juveniles or young adults. New recruits stay within parental habitat and are often observed alone, but commonly form small groups of about 2-4 individuals (Vagelli 2011). New recruit group size may be related to habitat type. Moore *et al.* (2012) found group size of new recruits

to be about 2-4 in sea urchin microhabitat and about 20 in just one sea anemone. In 2001, the largest single group (approximately 500 fish) was observed in Tempaus Island within seagrass habitat located in a calm, protected bay (Vagelli and Erdmann 2002). Surveys conducted in 2012 in Tempaus found groups less than 20 individuals (Talbot *et al.* 2013) and over 50 (Moore, STPL, unpublished data). The larger group sizes were often found in sites where microhabitat had decreased and the fish were crowded into the remaining habitat (Moore, STPL, personal communication 2014).

The Banggai cardinalfish exhibits strong homing ability, which is based on location rather than individuals being related to each other (Kolm *et al.* 2005). Olfactory cues may be a mechanism that allows them to return to familiar territory ((Kolm *et al.* 2005). Indeed, individual fish return to their home territory after capture, even when separated by distances up to 100 m (Kolm and Berglund 2003). However, ecological barriers (e.g., strong currents and depth) limit their ability to travel great distances if displaced from their home territory (see Spatial Structure/Connectivity below).

Spatial Structure/Connectivity

The Banggai Archipelago, Indonesia, (Figure 2) is considered the natural range for the Banggai cardinalfish. The Banggai Archipelago is part of the Sula Platform (a microcontinental crust), which likely has remained intact since at least the Oligocene epoch (approximately 34 million to 23 million years before the present) (Vagelli 2011). Sea level rise and fall has occurred over geological time within the region, affecting population distribution in the Banggai Archipelago, but deep oceanic trenches that separate island groups have naturally prevented distribution over a broader range (Vagelli 2011). Currently, the Banggai cardinalfish has an exceptionally restricted range (approximately 5,500 km^2) within the Banggai Archipelago (Table 1; Figure 2). Isolated populations may occur in habitat that is no wider than 10 m, but can exceed 200 m in width (e.g., Monsongan reef flat; Moore, STPL, personal communication 2014). The total inhabited area encompasses approximately 30 km^2 around 34 islands (Vagelli 2008, 2011). The species is reported absent from 32 islands and 5 shallow reefs within the Banggai Archipelago, even though these islands may contain suitable habitat in some sites. It is absent in most of the southern portion of the Banggai Archipelago and from the northern and western coast of Peleng Island and southwestern Taliabu Island, despite suitable habitat occurring in these areas (Vagelli 2011). It is unknown whether the absence of Banggai cardinalfish in these areas indicates a loss of local populations. Distances between non-introduced populations range from less than 1 km (Vagelli 2011) up to 153 km (Vagelli *et al.* 2009). Distribution of populations is discontinuous, with deep water, strong currents, or coast exposed to severe weather serving as effective ecological barriers to migration (Bernardi and Vagelli 2004; Ndobe and Moore 2013; Ndobe *et al.* 2012).

Table 1. Known Banggai cardinalfish geographic locations within its natural range (*source:* Vagelli 2011).

LOCATION	ISLAND LENGTH (KM)	MAP NO. (FIGURE 2)	LOCATION	ISLAND LENGTH (KM)	MAP NO. (FIGURE 2)
Taliabu	115	1	Kenau	4.5	18
Peleng	86	2	Bangko	2.9	19
Banggai	28	3	Toluon	2.9	20
Bangkulu	18.5	4	Botolino	2.7	21
Labobo	18	5	Telopopaum	2.7	22
Bokan	16.6	6	Tabija	2.5	23
Tempaus	10	7	Manggoa	2.3	24
Seku	9.4	8	Maleho	2.0	25
Mbuang Mbuang	8.7	9	Labobo Kcl	1.5	26
Melilis	6.7	10	Boendoe	1.5	27
Telopo	6.5	11	Loisa a	1.3	28
Masepe	6.3	12	Loisa b	1.3	29
Limbo	6.2	13	Bole	1.25	30
Masoni	6.0	14	Loisa c	1.2	31
Kokudan	5.2	15	Bandang	0.95	32
Kembongan	5.2	16	Bakakan S	0.51	33
Kano	4.5	17	Bakakan N	0.48	34

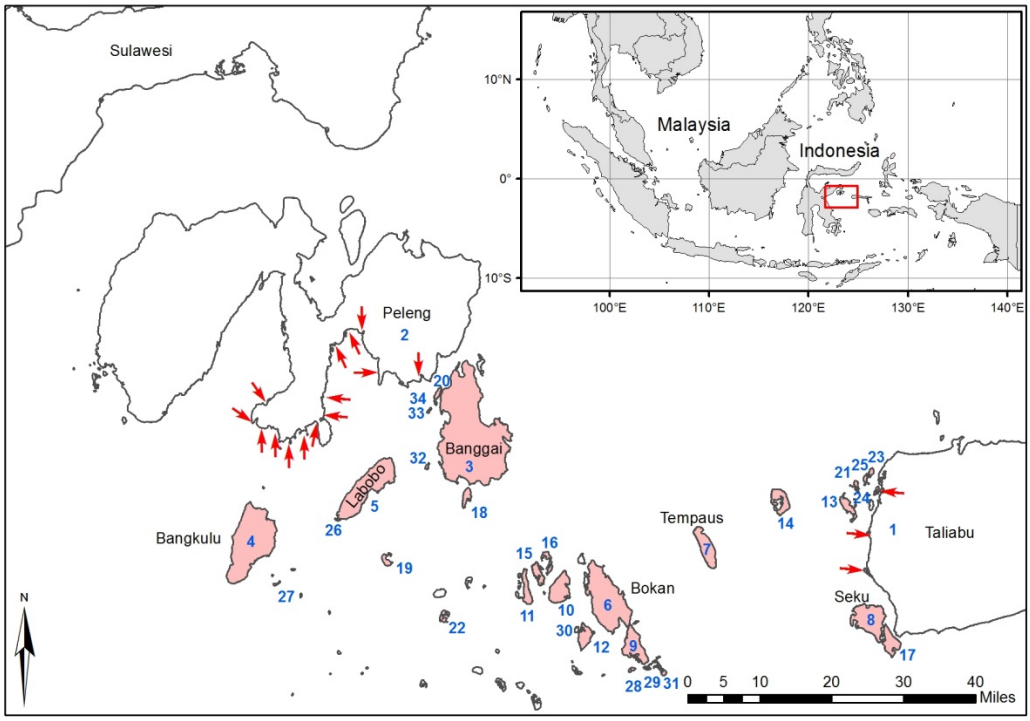

Figure 2. Banggai cardinalfish geographic locations within its natural range. Red arrows represent individual populations found in waters around Peleng and Taliabu Islands. Islands in pink indicate individual populations occur at several sites within the island's shallow coastal waters. See Table 1 for corresponding locations (*source:* Vagelli 2011).

Populations have been introduced in areas outside of the Banggai Archipelago, including Luwuk harbor (Bernardi and Vagelli 2004), Palu Bay (Moore and Ndobe 2007), Lembeh Strait (Erdmann and Vagelli 2001), Tumbak (Ndobe and Moore 2005), Kendari Bay (Moore *et al.* 2011), and north Bali (Lilley 2008). Populations have also been introduced at two sites outside of the cardinalfish's natural distribution on Peleng Island—Lumbi-Lumbia and Bakalang Island (Moore, STPL, personal communication 2014). Although the Luwuk harbor population cannot be definitively ruled out as part of the species' natural range, it is 75 miles (120 km) from the nearest population located within the Banggai Archipelago and is separated by the 17-mile (27-km) wide and 900-m deep Peleng Strait, which makes it highly improbable (Vagelli 2011). A more simple and likely explanation is that all of these populations were introduced through the

practice of high-grading (i.e., discarding live specimens determined to be of low quality/non saleable) or escapement near trade centers for the ornamental live reef market. Indeed, locals have reported releasing cardinalfish in Luwuk harbor (Moore, STPL, personal communication 2014). Also, at some sites (e.g., Lembeh Island), cardinalfish are known to be introduced by dive-resort operators to support the tourist industry (Vagelli 2011). The introduced population at Lembeh Strait is considered invasive and may be impacting local diversity through interspecific competition for resources in the area, but specific data on ecological impacts are lacking. The introduced populations are an artifact of the commercial ornamental live reef trade and are not part of any conservation program to benefit the native populations. Because we interpret the ESA as conserving species and the ecosystems upon which these species depend, we consider the natural range to be biologically and ecologically important to the species' viability to persist in the face of threats.

The Banggai cardinalfish exhibits the highest known degree of genetic structure of any marine fish (Bernardi and Vagelli 2004; Hoffman *et al.* 2005; Vagelli *et al.* 2009). Populations occurring on the same reef, separated by only a few kilometers, are genetically isolated from one another (Bernardi and Vagelli 2004; Hoffman *et al.* 2005; Vagelli *et al.* 2009). For example, 10 out of 12 populations on Bangkulu Island were found to be genetically differentiated from one another (Vagelli *et al.* 2009). Population differentiation within the Bangkulu Island[1] (Fst = 0.15, Nm = 2.92) indicates low migrants per generation, as well as at the Archipelago level (average Fst = 0.258, Nm = 15) (Vagelli *et al.* 2009). Populations within the Banggai Archipelago diverge into two distinct clades, a southwestern clade restricted to the southwest area around Bangkulu Island, and a northern and eastern clade distributed throughout the remainder of its range, with approximately 40% of the 'within clade' pairwise comparisons indicating that less than one individual per generation is exchanged (Bernardi and Vagelli 2004; Vagelli 2011). Reproductive isolations between islands may have occurred around 800,000 to 160,000 years ago when sea level rose and eliminated shallow water habitats between islands (Bernardi and Vagelli 2004). The lack of dispersal mechanisms, high site fidelity, and other ecological barriers are the most likely reasons for the high degree of genetic subpopulation structure (Bernardi and Vagelli 2004; Vagelli 2011).

Genetic analysis of six sites in Banggai Island revealed distinct subpopulations consisting of four closed populations (i.e., no meaningful exchange of individuals and highly localized dispersal distances) and one metapopulation (i.e., a network of partially closed populations with nontrivial supply from other populations) (Ndobe *et al.* 2012). Population structure is also indicated by differences in morphology among populations in the Banggai Island. Populations in the northern and southeastern extremities differed significantly in morphology. The northern population (Popisi) had short/high head shape compared to the southeastern population (Matanga), which exhibited elongated and pointed heads (Ndobe and Moore 2013).

[1] Current official name is Bangkurung

Genetic data suggest that Banggai cardinalfish populations have experienced bottlenecks; however, limited genetic variability in the species, as well as small sample sizes, prevented a definitive conclusion (Bernardi and Vagelli, 2004), and Hoffman *et al.* (2005) found no evidence of a historical loss of genetic diversity as a result of a severe reduction in population size.

Habitat or Ecosystem Conditions

The Banggai cardinalfish occurs in an area rich in diversity supported by coral reefs (Allen 2008; Allen and Werner 2002). It is generally found in calm waters of sheltered bays or on the leeward side of islands; however, isolated populations also occur in areas affected by strong surge and moderate currents (Allen and Donaldson 2007). It inhabits a variety of shallow (average depth is 1.5 to 2.5 m, but ranges from about 0.5 to 6 m) habitats including coral reefs, seagrass beds, and less commonly, open areas of low branching coral and rubble. Suitable habitat can sometimes be a small patch that is no wider than 10 m (Vagelli 2011). Banggai cardinalfish are found in waters ranging from 26 – 31 °C, but averaging 28 °C (Ndobe *et al.* 2013).

The Banggai cardinalfish lacks a defense mechanism and must avoid predators by associating with other organisms that have protective mechanisms, such as sea urchins and anemones (Vagelli 2011). For example, small cardinalfish may hide in close proximity to sea anemone tentacles without triggering a feeding reaction from the anemone or succumbing to its toxicity (Moore *et al.* 2012; Randall and Fautin 2002; Vagelli 2011). In addition to sheltering in sea anemones, the Banggai cardinalfish associates with branching corals, including: *Acropora* sp., *Anacropora* sp., *Echinopora horrida*, *Goniopora* sp., *Heliofungia actiniformis*, *Montipora digitata*, *Seriotopora hystrix*, *Nephthea* sp., and species of *Millepora*. The Banggai cardinalfish also associates with *Diadema setosum* and other sea urchins (Allen 2000; Vagelli and Erdmann 2002; Vagelli 2004, 2011). Both juveniles and adults are known to associate with sea stars and submerged mangrove roots (Ndobe *et al.* in press; Vagelli, 2004).

New recruits (less than 45 days old post release) associate more often with sea anemones within sea grass beds than with sea urchins within coral reef and sand/rubble habitat (Vagelli 2004, 2011) (Figure 3). Juveniles and adults are found more commonly associated with sea urchins in coral reef habitat (Vagelli 2004, 2011). The ontogenetic shift in habitat occurs at about 2-months of age and, although the processes governing the shift are unclear, it may be a result of differential survival, but further studies are needed to determine the role of post-settlement processes involved in this ontogenetic shift (Vagelli 2011). Although sea urchin microhabitat host all size classes of the cardinalfish, recruits comprised 80% of the cardinalfish associated with sea anemones. Recruits and small juveniles were not observed in the hard coral microhabitat, though a few isolated recruits have since been seen in corals of the genus *Heliofungia* (Moore *et al.* 2012).

Figure 3. Banggai cardinalfish new recruits associated with sea anemones shortly after expulsion from male brood patch. *Source*: Daniel Knop used with permission.

The sea urchin, *Diadema setosum*, is a natural component of the coral reefs within the Banggai Archipelago, and cardinalfish have always associated with this microhabitat as evidenced by the names for the Banggai cardinalfish in the two main local languages, which are loosely translated as 'little sea urchin fish' (Moore, STPL, personal communication 2014). However, *Diadema setosum* becomes prominent in degraded coral reef habitat, and anecdotal observations of the Banggai cardinalfish indicate it may be able to survive in degraded habitat by seeking refuge among these urchins (Lilley 2008). In the absence of a healthy coral reef, the Banggai cardinalfish also will associate with large objects, including wood, walls of piers, and rubbish (Lilley 2008). However, the extent to which the cardinalfish can survive or adapt, if any, to degraded habitat is unknown.

Unlike any other Apogonidae, the Banggai cardinalfish forages during the day. It feeds primarily on copepods, but is also opportunistic, taking advantage of high concentrations of planktonic organisms that occur sporadically in localized areas (Vagelli 2011). It feeds on a variety of taxa, including seven phyla: Ciliophora, Foraminifera, Annelida, Mollusca, Arthropoda, Chaetognatha, and Chordata (Vagelli 2011). It also preys on the larval stages of coral reef fish parasites, thus controlling parasite loads in other reef fish (Vagelli 2008).

POPULATION ABUNDANCE AND GROWTH

Population surveys were conducted in 2001, 2002, 2004, 2007, 2011, and 2012, but the area covered was not consistent over the years. Thus population trends are difficult to interpret given the expansion in the survey area over time and the inherent patchy distribution and variability of density at sites. However, many sites were censused repeatedly; thus, density could be compared for specific sites overtime (Vagelli 2005, 2008). Although density changes overtime are provided for several sites (see discussion below), I was unable to find a systematic comprehensive comparison of site-specific density.

In 2001, the earliest known population survey, Banggai cardinalfish populations were found on 16 out of 37 islands searched within the Banggai Archipelago. Estimated total population was 1.7 million, with a mean density of 0.03 fishes per m^2 based on a census at three sites (Vagelli 2002; Vagelli and Erdmann 2002). Additional surveys between 2001 and 2004 covering the entire Banggai Archipelago expanded the range to 17 major islands and 10 minor islands (34 sites). In 2004, the total population size was estimated at 2.4 million and a mean density of 0.07 fishes per m^2 (CITES 2007). By 2007, population surveys indicated a mean density of 0.08 fishes per m^2 (Vagelli 2008). By 2011-2012, Ndobe *et al.* (in press) estimated the population abundance at 1.5-1.7 million with a mean observed density of 0.05 fish per m^2 reportedly for the sites that were surveyed in 2004. The 2011-2012 estimate does not include locations in Toado where the habitat was limited and density was very high (Ndobe *et al.* (in press); thus, the estimate is biased low. However, 7 of the major sites surveyed in 2004 have declined in abundance and mean density (Ndobe *et al.* in press), indicating the population has likely decreased from the 2.4 million estimated in 2004. Thus for purposes of this review, I accept the more recent estimate of 1.5 -1.7 million as the possible overall population abundance. A set of surveys were conducted at 54 sites from 2007 to 2012, but not all areas were surveyed with equal effort (Yahya *et al.* 2012). Of the 54 sites, the Banggai cardinalfish was found in 28 areas. Bone Baru and Popisi (Banggai Island) and Teropot (Telopo Island) were the most frequently surveyed sites. Overall density decreased at these sites between 2009 and 2012. However, juvenile density increased over the same period, indicating a change in population age structure. Density at Bone Baru appears to have begun to increase in 2012 (Yahya *et al.* 2012), likely due to replenishment from released unsold and unsaleable fish on a regular basis and the presence of a functional marine protection area (Moore, STPL, personal communication 2014).

Historical data on population abundance are lacking as surveys were done after harvest began in the early to mid-1990s. However, one population (private oyster pearl farm) exists within a privately owned bay in Banggai Island and fishing has been prohibited since trade began, although illegal poaching in the bay was reported in 2006 (Talbot *et al.* 2013). The habitat in the bay may be similar to other sites that support the Banggai cardinalfish; thus, this population may be used as a proxy for a baseline of population abundance (Allen and Donaldson 2007; Vagelli 2008). However, several researchers (Moore STPL, personal communication 2014; Ndobe,

Tadulako University, personal communication 2014) caution the use of this bay as a baseline for population trends. Banggai cardinalfish populations are inherently patchy and density is highly variable between and within sites of the Banggai Archipelago, including this bay (Moore, unpublished data, 2004). They also question whether the bay is comparable to other sites. The bay has been protected from habitat degradation and consists of a great deal of sheltered habitat and good quality microhabitat/habitat with limited suitable habitat for predators of the cardinalfish, such as groupers and other larger reef fish. While acknowledging the debate on the use of the site as a baseline, I accept the oyster pearl farm site as a proxy to the historical baseline given it is the only historical abundance metric available. Further, the more recent declines observed in surveys through 2012 lend support for historically higher abundance. In 2001, densities of fish in the private oyster pearl farm averaged 0.63 $\pm$ 0.39 fish per m^2 (range: 0.28 to 1.22 fish per m^2) (Lunn and Moreau 2002). If we accept the 0.63 per m^2 density value from the protected population as the historical density of all populations within the Banggai Archipelago, then a reduction of up to approximately 90% in density took place since the start of the fishery in the early to mid-1990s (Vagelli 2008; 2011).

Declines and extirpations of local populations have been observed across years, likely due to heavy harvest and, more recently, habitat destruction. In 2001, Bakakan Island had about 6,000 fish, but by the 2004 census, only 17 fish remained at Bakakan Island (Vagelli 2008). However, in 2007, 350 individuals were found at Bakakan Island, but still well below the 6,000 fish found in 2001 (Vagelli 2008). More recently, Moore (STPL personal communication 2014) reported that local fishers characterize the cardinalfish population on Bakakan Island as small and declining.

Between 2001 and 2004 the population density at Masoni Island doubled from 0.03 to 0.06 fishes per m^2 (an increase in approximately 150 fish in 3 years) (Vagelli 2005). This increase is thought to have occurred in response to a collecting ban that the local people imposed in early 2003. However, in 2007, the population declined to 0.008 fish per m^2, with 38 fish recorded over the entire census site (the largest group consisted of 2 individuals). An extensive search around the entire island identified only 150 fish (Vagelli 2008). A population in southeast Peleng Island had 159 and 207 fish in 2002 and 2004, respectively (Vagelli 2005). However, by 2007, it had been practically extirpated with only 27 fish found (Vagelli 2008). Over harvest of microhabitat such as *Diadema* and sea anemones and coral mining has resulted in local population depletions on an island off Liang, which was surveyed in 2004, and was extirpated by 2012 (Ndobe *et al.* 2013). Extirpation of local populations has been documented in areas of increased harvest of microhabitat combined with fishing pressure, and interviews of locals and visits to several sites in 2011 and 2012 indicate populations are declining in the Banggai Archipelago (Ndobe *et al.* 2013).

Group size also decreases in sites where fishing pressure is high. For example, mean group size of fish was 5.7 fish per group in areas of high-intensity fishing compared to 11.5 fish per group at low-intensity fishing sites (Kolm and Berglund 2003). Interviews with local collectors indicate they will abandon a collection site after it is severely depleted of the Banggai cardinalfish and wait for the site to recover. Recovery time is unknown (Lilley 2008). Kolm and Berglund (2003) scored fishing pressure at eight sites with similar habitat using a scale of 1 to 3 (3 = close to a fishing village and fished frequently; 2 = recently fished but away from the main fishing village and fished less frequently; 1 = never fished or only fished once over several years past). They found that heavy fishing pressure is correlated with lower population density, but no significant difference was found in population density between lightly and moderately fished sites (Kolm and Berglund 2003; Moore *et al.* 2011).

As stated earlier, the Banggai cardinalfish has been introduced through the aquarium trade to areas outside of its natural range. Populations established by humans outside of the species' natural range at or before the time of listing are considered members of the species that is considered for listing under the ESA. The ESA listing regulations specify that protections apply to all populations and individuals of the species, wherever found (50 CFR 223.102 and 224.101). In 2000, 31 adults and 18 newly released juveniles were observed in Lembeh Strait in North Sulawesi approximately 400 km from their core distribution in the Banggai Islands. A census conducted in 2001 documented 644 individuals, of which the majority were immature juveniles in Lembeh Strait (Erdmann and Vagelli 2001). Group size was smaller (5.8 $\pm$ 7.9 individuals) compared to groups observed in the Banggai Islands (21.3 $\pm$ 57.2 individuals) (Erdmann and Vagelli 2001). By 2004, the population had spread along the Lembeh coasts, and by 2007, it was found about 4 km north of its original location (Vagelli 2011). Group size ranged from 120-150 individuals. In 2009, approximately 2,000 individuals were estimated to occur in one 500 m patch in Lembeh Strait (Vagelli 2011). Vagelli (2011) characterized the Lembeh Strait population as invasive. Vagelli (2011) expressed concern for detrimental effects on natural species composition in the area. Banggai cardinalfish competition with anemonefishes in the introduced area is a particular concern because sea anemones host a limited number fishes (Vagelli 2011). However, studies on possible ecological impacts of the introduced population have not been conducted. Other introduced populations are small and not doing well, such as the Luwuk Harbor population, likely due to pollution and habitat degradation (Vagelli 2007 as cited in CITES 2007).

ANALYSIS OF THE ESA SECTION 4(A)(1) FACTORS

As discussed earlier, pursuant to the ESA and our implementing regulations, we determine whether species are threatened or endangered based on any one or a combination of the following five section 4(a)(1) factors: the present or threatened destruction, modification, or curtailment of habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; disease or predation; inadequacy of existing regulatory mechanisms; and

any other natural or manmade factors affecting the species' existence. The following provides information on threats from each of the five factors as they relate to the Banggai cardinalfish.

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Significant changes in living coral reef habitat and fish diversity on reefs within the Banggai Archipelago have been observed since 2001 (Allen *et al.* 2001; Vagelli, 2005). Multiple factors are responsible for the degradation of the Banggai cardinalfish's habitat.

The illegal use of fish bombs (typically made with fertilizer and phosphorus) and cyanide to catch fish (unrelated to the Banggai cardinalfish fishery) has resulted in significant loss of coral reef habitat within the Banggai cardinalfish range (Allen and Werner 2002). A typical bomb can leave a 1-2 m diameter crater in the reef, which is then covered with algae and fungus (Vagelli 2011). Damage to coral reefs due to fish bombs is prevalent, even in protected areas (Talbot *et al.* 2013). Cyanide is used to catch fish for the live reef fish trade. It is squirted on coral heads to stun and capture fish—a practice that kills corals (e.g., see Jones and Steven 1997; Mous *et al.* 2000). Boats have degraded the coral reefs in the area, and clear-cutting of wooded slopes and mangroves has occurred, increasing sedimentation, which degrades coral reef habitat (Lilley 2008). Other upland activities, such as agriculture and human population growth, have increased the amount of waste and nitrates in the marine environment, promoting algal blooms (Lilley 2008), which may destroy coral reefs by outcompeting them for vital resources such as light and oxygen (reviewed by Fabricius 2005). Significant plastic, styrofoam, and other human made debris occur in the area (Lilley 2008). Human population density is high – the most recent census (2010) yields 53 people/km^2 with over 100/km^2 for some of the key Banggai cardinalfish areas. Most of the population lives on the coast, and the density is likely 3-10 times the overall estimate. The census also reports a rate of population increase well above the national average (Moore, STPL, personal communication 2014). This information indicates destruction of habitat is occurring within the Banggai cardinalfish's range. Although quantitative data on impacts to cardinalfish populations are lacking, considerable qualitative information exist indicating where habitat has been degraded (e.g. at Tanjung Nggasuang and Toropot in the Bokan Archipelago, which were surveyed in 2004 and 2012 and at Mbuang-Mbuang, on Bokan Island, surveyed in 2012), large and thriving Banggai cardinalfish populations spread over large areas can be reduced to isolated remnants crowded into small remaining patches of habitat with some protective microhabitat (Ndobe, Tadulako University, personal communication 2014).

Coral reef conditions in the Central Sulawesi Province, including the Banggai Archipelago, were examined from 2001 through 2007 in seven Districts in the region (Moore and Ndobe 2008). Average condition of the reefs was poor and major impacts included coral mining, sedimentation, fishing, and predation (Moore and Ndobe 2008). Population explosions of the crown-of-thorns starfish *(Acanthaster planci*), a coral predator, have been observed in the area, indicating an ecological imbalance likely due to overharvest of natural predators, and changes in

hydrology and water quality (Moore *et al.* 2012). Surveys conducted at five sites around Banggai Island from 2004 through 2011 showed a decline of coral reef cover from 25% to 11% (Moore *et al.* 2011, 2012). Major causes of the coral reef decline around Banggai Island were attributed to destructive fishing methods and general fishing pressure, coastal development, and the replacement of traditional homes with concrete and breeze-block dwellings, which increases the demand for mined coral and sand. The use of illegally mined coral and sand by both public works and local communities was observed at several sites over the period 2004-2011 (Moore *et al.* 2011, 2012). Loss of coral reef cover may increase mortality of recruits due to cannibalism. In the absence of adequate coral cover, sea urchins have been observed to will lock their spines together to form a flattish dome, a shape with good stability and wave resistance in the exposed environment. All age classes of the Banggai cardinalfish were forced to crowd under this dome, including the recruits, which had been sheltering nearby where the spines are too close for adults to penetrate. As the smaller recruits dashed out occasionally to catch small prey, adult cardinalfish were able to prey with ease on the smaller recruits, resulting in considerable mortality from cannibalism (Moore, STPL, personal communication 2014; Ndobe *et al.* in press).

Climate change may also impact Banggai cardinalfish habitat. Warmer water temperatures cause corals to expel algae (zooxanthellae) living in their tissue. The coral turns white (called 'bleaching') and may survive the event, but it is more susceptible to mortality. Coral bleaching events due to warming temperatures are anticipated to increase by 2040 in areas of the Indian Ocean, including waters of Indonesia (van Hooidonk *et al.* 2013). Coral bleaching due to elevated water temperatures has not been observed around Banggai Island up through December 2011; however, extensive bleaching was observed in nearby Tomini Bay in 2010 (Moore *et al.* 2011, 2012). The Banggai cardinalfish is restricted to shallow waters with ambient temperatures ranging from 28 to 31 °C. Thus, warming temperatures may render habitat unsuitable, but specific data on impacts to the Banggai cardinalfish are lacking.

As discussed earlier, the Banggai cardinalfish associates with sea urchins (*Diadema* spp.) and sea anemones. Urchins and anemones are experiencing intensive and increasing harvest pressure (Moore *et al.* 2012; Ndobe *et al.* 2012), which negatively impacts the Banggai cardinalfish (e.g., interferes with reproductive activity and diminishes recruitment; Vagelli, NJAAS, personal communication 2014). Sea anemones were once abundant but were drastically reduced from Tinakin Laut, Banggai Island, which resulted in a collapse of the Banggai cardinalfish population in the area (Moore *et al.* 2012). Heavy harvest of sea anemones at Mamboro, Palu Bay, resulted in a drastic reduction of new recruits and juvenile Banggai cardinalfish (observed since 2006) in 2008 (Moore *et al.* 2011). Moore *et al.* (2011, 2012) report that intensive harvesting of shallow water invertebrates, including sea anemones and sea urchins, had increased by 2010/2011 and continues to increase. They state the expanding microhabitat harvest is linked to socio-economic trends associated with consumption by local seaweed farmers and use as feed for carnivorous fish destined for the live reef trade. They conclude that it would be difficult to establish and enforce local regulations for controlling the overharvest and that raised awareness of the

ecological impacts, especially to the Banggai cardinalfish, is needed to ensure protection of habitat in the future (Moore *et al.* 2011, 2012).

In addition, a disease of unknown origin may be damaging hard corals in habitat occupied by the Banggai cardinalfish. The disease affects the top sections of long-branched *Acropora* species as well as species of *Porites*, both of which are important microhabitat for the Banggai cardinalfish (Vagelli 2011). Data are lacking on the extent of impact the disease may pose to Banggai cardinalfish habitat.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The Banggai cardinalfish is traded internationally as a live marine ornamental reef fish. The fish has been collected in the Banggai Islands, Indonesia, since 1995 (Marini and Vagelli 2007). The United States, Europe, and Asia are the major importers of the Banggai cardinalfish for the aquarium trade (CITES 2007). The Banggai cardinalfish is the tenth most common ornamental fish imported into the U.S. (Rhyne *et al.* 2012).

The ornamental live reef fish trade has resulted in decreases in cardinalfish population density and extirpation of local populations (see Population Status and Trends). By 2000 (less than a decade of trade), negative impacts on the Banggai cardinalfish from the trade were observed. Roberts and Hawkins (1999) surveyed 235 scientists about possible extinctions in the sea. The scientists believed the Banggai cardinalfish was most at risk of extinction due to overexploitation from the ornamental live reef fish trade. Kolm and Berglund (2003) examined the effects of the ornamental live reef fish trade at eight sites in the Banggai Archipelago. They found that the density and group size of fish and sea urchins were negatively impacted by the trade. However, they found no effect on the ratio of juveniles to total population at the sites. Ndobe and Moore (2009) also found that populations were exploited, but observed high population density in areas where collection had been ongoing for some years with rotation between sites, indicating some harvest sustainability. Unfortunately, habitat destruction and collection and consumption of microhabitat not related to the Banggai cardinalfish fishery have now greatly reduced the cardinalfish populations at sites, which had previously sustained periodic collection for more than a decade (Moore, STPL, personal communication 2014; Ndobe *et al.* in press).

The ornamental live reef fish trade also results in high mortality of fish collected. The Banggai cardinalfish is easy to collect given its sedentary nature and tendency to form groups in shallow habitat (Vagelli 2008). Collection methods can result in damage to scales, fins, and eyes, and result in high mortality rates (Lilley 2008). All size classes, including male brooders, are collected (Vagelli 2011); however, by 2006 most fishers ceased collecting brooding males (Moore, STPL, personal communication 2014; Ndobe, Tadulako University, personal communication 2014). The fish are then held in floating pens until sold. Fishermen rarely feed the fish or maintain the pens, which increases mortality (Vagelli 2011). Mortality in holding pens is estimated to be about 50% (Lilley 2008). Once sold, the fish are transported to trade

centers, where at least 25-30% mortality is reported for transport and another 15% of fish are discarded due to condition (Vagelli 2008, 2011, 2013). Since 2010, some trade centers such as Bone Baru have collected cardinalfish based on demand and not on market speculation, which may decrease mortality with less holding time (Moore, STPL, personal communication 2014). Based on interviews with collectors, Lilley (2008) estimated that only one out of every four to five fish collected makes it to the buyer for export. Banggai cardinalfish also die from iridoviruses due to stress from captivity during the trade process (see Disease and Predation).

Banggai cardinalfish exports for the ornamental live reef fish trade may be decreasing, although systematic data are lacking. In 2001, up to 118,000 Banggai cardinalfish were sold each month with a total estimate of 700,000-1.4 million fish traded (Lunn and Moreau 2002, 2004). From 2004 through 2006, around 600,000-700,000 fish were traded each year (Moore *et al.* 2011). In 2008 and 2009, 236,373 and 330, 416 fish, respectively, were traded at three trade centers (Moore *et al.* 2011, 2012). However, these numbers do not include capture data from Bone Bone in 2008 and from Panapat for 2008 and 2009. These collections centers each reported about 15,000 fish per month in 2007 (Vagelli 2008, 2011). In 2005 and 2009, approximately 200,000 (Rhyne *et al.* 2012) and 160,000 fish (Talbot *et al.* 2013), respectively, were exported to the U.S. alone. Collection data from just one trade center showed approximately 200,000 fish were exported over two years from 2010-2011 (Yahya *et al.* 2012). By 2012, a multi-stakeholder group working in conjunction with the Fish Quarantine and Inspection Agency reported only 120,000 cardinalfish were exported (Talbot *et al.* 2013). This number is likely low, given the export numbers to the U.S. in 2009 (Talbot *et al.* 2013), and could be referring just to the Banggai cardinalfish from Bone Baru exported with support from Yayasan Alam Indonesia Lestari (LINI) (Moore, STPL, personal communication 2014). Vagelli (NJAAS, personal communication 2014) estimates that 1,000,000 Banggai cardinalfish are collected each year for the ornamental live reef trade.

Information suggests the number of active participants in the trade may have dropped. In 2001, there were 12 villages that collected the Banggai cardinalfish and only 3 were active by 2011 (Moore *et al.* 2011, 2012). The fluctuations in the number of active villages may be an artifact of reporting requirements and the definition of what constitutes a collecting village. The authors point out that lack of data reported for one village (Mbuang-Mbuang) under the government participatory monitoring program was because it is actually a fishing ground (for Panapat fishers working with Balinese roving collectors). Thus, collection occurs, but not by the fishermen of that village; thus, data were not collected. Also, at least 5 villages (Bone Baru, Tolokibit, Bone Bone, Toropot, and Panapat) were active in 2014 (Moore, STPL, personal communication 2014). Reported as number of collectors, the data indicate a decline in participation as well—from about 130 in 2001 (Lunn and Moreau 2004) to about 80 in 2007 (Vagelli 2011) and 2012 (Vagelli, NJAAS, personal communication 2014).

U.S. imports were 11% lower in 2009 compared to 2005 data (Rhyne and Tlusty, unpublished data cited in Yahya *et al.* 2012). However, Talbot *et al.* (2013) report that overall imports to the U.S. of all aquarium species dropped by 25% during the same period. Thus, relative to the market, the Banggai cardinalfish trade was strong. The decrease in exports may be partly due to fewer fish being available to collect and export. Surveys have shown a significant decline in the catch per unit effort (Vagelli, NJAAS, personal communication 2014). In Bone Baru, from 1993-2000 fishers were catching an average of 1,000-10,000 fish per day, but by 2003 they only averaged 100-1,000 with most between 200-300 fish (EC-Prep Project 2005). Vagelli (2011) reports similar declines for Banggai Island, where between 2000 and 2004 the reported mean catch declined from about 1,000 fish/hour to 25-330 fish/hour. Prior to 2003, collectors from Bone Baru typically required one day to capture approximately 2,000 specimens. In 2007, they reported requiring one week for capturing the same number (Vagelli, 2011).

In 2012, a large-scale aquaculture facility based in Thailand began to breed Banggai cardinalfish in captivity for export, which may alleviate some of the pressure to collect fish from wild populations (Rhyne, Roger Williams University, unpublished data 2014; Talbot *et al.* 2013). In 2013, approximately 120,000 Banggai cardinalfish were imported into the U.S. from the Thailand facility. The volume represents a significant portion of overall U.S. imports of the cardinalfish and may even exceed the number of wild fish currently imported (Rhyne, Roger Williams University, unpublished data 2014). Efforts to captive-breed in the U.S. are also ongoing to alleviate dependence on wild-caught cardinalfish (e.g., Hopkins *et al.* 2005; Marini and Vagelli 2007; Vagelli 2002). In the U.S., the Florida Department of Agriculture and Consumer Services has certified eight aquaculture facilities that are beginning to culture and market farm-raised Banggai cardinalfish (Knickerbocker, Florida Department of Agriculture and Consumer Services, personal communication 2014). In Hawaii, a facility implemented an experimental captive-breeding program for the Banggai cardinalfish (Hopkins *et al.* 2005). Sustainable Aquatics, a large aquarium facility in Tennessee, also captive breeds the Banggai cardinalfish (Talbot *et al.* 2013), although a check on their website http://sustainableaquatics.com/current-availability/ in July 2014 does not show the Banggai cardinalfish as currently available. Results of research in 2006 (Indonesian Sea Partnership, unpublished data) indicated that *in-situ* breeding by the fishing communities in the endemic area may also alleviate pressure on the natural population, but the concept requires further research before it can be implemented at a local community level (Ndobe, Tadulako University, personal communication 2014).

Disease or Predation

The sea snake, *Laticauda colubrina*, may prey upon the Banggai cardinalfish (Lilley 2008; Vagelli 2011). Other predators include several species of lionfish (*Pterois* spp.), grouper (*Ephinephelus merra*), crocodilefish (*Cymbacephalus beauforti*), moray eel (*Echidna nebulosa*), and stonefish (Scorpaenidae) (Moore *et al.* 2012). Mortality is high in new recruits due to cannibalism and predation (Moore *et al.* 2012). Data are lacking on whether predation pressure

is increasing or impacting the Banggai cardinalfish population growth. However, as discussed earlier, loss of habitat cover may increase mortality in new recruits (see Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range).

A virus known as the Banggai cardinalfish iridovirus (genus *Megalocytivirus*) is linked to high mortality of wild-caught fish imported for the ornamental live reef fish trade (Vagelli 2008; Weber *et al.* 2009). The virus causes necrosis of spleen and renal tissue, which appears as darkened tissue. Other symptoms are lethargy and lack of appetite. Surveys of wild populations have not reported symptoms of the disease. Necropsies of over 100 fish collected in the wild and at holding facilities showed no indication of the virus (Talbot *et al.* 2013). Thus, the virus is likely transmitted from other specimens at containment centers, or is carried by the Banggai cardinalfish and is only expressed as a result of stress incurred during the long transport process (Talbot *et al.* 2013; Weber *et al.* 2009).

Parasites occur naturally in the Banggai cardinalfish with up to 70% of sampled individuals showing endoparasitism (Vagelli 2011). Main parasite groups were trematodes, nematodes, isopods and pleurocercoid larvae of cestodes (Vagelli 2011). Data are lacking on whether these naturally occurring parasites have a negative impact on the Banggai cardinalfish populations.

Inadequacy of Existing Regulatory Mechanisms

Indonesia delegates authority for the management of marine ornamental fish to regional governments (USAID Democratic Reform Support Program 2006 cited in Indrawan and Suseno 2008). This decentralized governance structure has yet to be successfully implemented because there is no central legal framework and the roles of various governing authorities are not clear (Indrawan and Suseno 2008). The Banggai District, outside the cardinalfish's endemic distribution (however it covers the introduced Luwuk population), issued a regulation in 1995 that prohibited collection without a government permit for all ornamental fishes. Current legislation requires all trade in Banggai cardinalfish and all other fishes and fish produce go through Fish Quarantine procedures before crossing internal administrative borders or prior to export (Moore *et al.* 2011). Past compliance has been low, but is improving (Moore *et al.* 2011). However, reported collection through the Fish Quarantine Data was well below the total reported from Bone Baru, Toropot, and Bone Bone for 2008 and 2009. In 2008 and 2009, the Fish Quarantine Data was 35% and 65% of the total reported catch, respectively (Moore *et al.* 2011). Enforcement is weak, and illegal, unregulated, and unreported capture and trade are still a major problem, especially in remote areas such as the Bokan Archipelago (Ndobe, Tadulako University, personal communication 2014). Indonesia prohibits the use of chemicals or explosives to catch fish (Fisheries Law No. 31/2004, Article 8(1)). However, the practice continues (Vagelli 2011), and damage to coral reefs due to fish bombs is prevalent, even in protected areas (Talbot *et al.* 2013). In 2011, Indonesia had proposed to list the Banggai cardinalfish for restricted protected status under domestic law. But the proposal stalled when the Indonesian Institute for Science argued that the introduced populations meant the species was no

longer endemic and did not meet protection status (Moore, STPL, personal communication 2014; Ndobe, Tadulako University, personal communication 2014). In 2007, the Banggai cardinalfish was proposed for listing under CITES Appendix II. However, the proposal failed. The species is listed in Annex D of the European Wildlife Trade Regulations, which only requires monitoring through an import notification. Currently, there are no international instruments protecting the Banggai cardinalfish, except for conservation efforts underway through the Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF) (see Conservation Measures discussion below).

Other Natural or Manmade Factors Affecting Its Continued Existence

Climate change is unequivocal and global averaged combined land and ocean surface temperatures show a warming of 0.85 °C (0.65 to 1.06 °C) over the period 1880 to 2012 (Intergovernmental Panel on Climate Change (IPCC) 2013). As discussed earlier (see Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range), warming temperatures may destroy or modify habitat, but data are lacking on specific impacts to the Banggai cardinalfish.

The Banggai Archipelago sits at the junction of three tectonic plates (Eurasian, Indian-Australian, Pacific-Philippine Sea) and is vulnerable to earthquakes. Frequent earthquakes within the Banggai Archipelago may have impacted localized Banggai cardinalfish populations (CITES 2007), but specific data are lacking. An earthquake measuring 7.6 on the Richter scale occurred in 2000 destroyed coral reefs in the region (Vagelli 2011).

ASSESSMENT OF EXTINCTION RISK

According to section 4 of the ESA, the Secretary determines whether a species is threatened or endangered as a result of any (or combination) of the following factors: (A) destruction or modification of habitat, (B) overutilization, (C) disease or predation, (D) inadequacy of existing regulatory mechanisms, or (E) other natural or man-made factors. Collectively, we simply refer to these factors as “threats” (albeit conservation efforts as an outcome of regulatory mechanisms are inherent when considering factor D). In addition to reviewing the best available data on threats to the Banggai cardinalfish, we considered demographic risks to the species similar to approaches described by Wainwright and Kope (1999) and McElhany et al. (2000). The approach of considering demographic risk factors to help frame the consideration of extinction risk has been used in many status reviews including Pacific salmonids, Pacific hake, walleye pollock, Pacific cod, Puget Sound rockfishes, Pacific herring, scalloped hammerhead sharks and black abalone (http://www.nmfs.noaa.gov/pr/species). In this approach, the collective condition of individual populations is considered at the species level according to the four demographic viability risk criteria: abundance, population growth, spatial structure/connectivity, and diversity/resilience. These viability criteria reflect concepts that are well-founded in conservation biology and that individually and collectively provide strong indicators of

extinction risk. We then describe the likely extent of extinction risk faced by the Banggai cardinalfish based on its current status and how likely it will respond to projected threats. Projected threats are considered those that we can reasonably predict. We do not have a definitive time horizon as predictability of threats may vary depending on the threat and sufficiency of data. Because the information is often non-quantitative and sometimes sparse, we use qualitative reference levels modified from reference levels commonly used in status reviews (e.g., rockfish : http://www.nmfs.noaa.gov/pr/pdfs/statusreviews/rockfish.pdf) and expressed along a continuum of decreasing relative risk of extinction (Table 2) in the synthesis and finding.

Table 2. Definitions of relative levels of extinction risk used in the assessment.

Qualitative 'Reference Levels' of Relative Extinction Risk	
Continuum of decreasing relative risk of extinction ↑	Not at Risk: A species is not at risk of extinction if it exhibits a trajectory indicating that it is not at a low risk of extinction (see description of "Low Risk" below). A species is not at risk of extinction due to projected threats and its likely response to those threats (i.e., long-term stability, increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience). Low Risk: A species is at a low risk of extinction if it exhibits a trajectory indicating that it is more likely not to be at a moderate level of extinction (see description of "Moderate Risk" below). A species may be at low risk of extinction due to projected threats and its likely response to those threats (i.e., stable or increasing trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience). Moderate Risk: A species is at moderate risk of extinction if it exhibits a trajectory indicating that it is more likely not to be at a high level of extinction (see description of "High Risk" below). A species may be at moderate risk of extinction due to projected threats and its likely response to those threats (i.e., declining trends in abundance/population growth, spatial structure and connectivity, and/or diversity and resilience). High Risk: A species is at high risk of extinction when it is at or near a level of abundance, spatial structure and connectivity, and/or diversity and resilience that place its persistence in question. Demographic risk may be strongly influenced by stochastic or depensatory processes. Similarly, a species may be at high risk of extinction if it faces clear and present threats (e.g., confinement to a small geographic area; imminent destruction, modification, or curtailment of its habitat; or disease epidemic) that are likely to create such imminent demographic risks. Extinct: A species is extinct when there are no longer one or two living individuals who can breed and produce offspring.

Qualitative Risk Analysis of Demographics

The life history characteristics (i.e., low fecundity, high degree of parental care and energetic investment in offspring, high new recruit mortality, no planktonic dispersal, high site fidelity) of the Banggai cardinalfish render it less resilient and more vulnerable to stochastic events than marine species that are able to disperse over large areas and recolonize sites that have been lost due to these events. Because the Banggai cardinalfish has an exceptionally restricted natural range (approximately 5,500 km^2) and occupies only about 30 km^2 of shallow water habitat within the Banggai Archipelago, these demographic traits become more important in terms of the extent the threats are appreciably reducing the fitness of the species. Although overall population estimates are 1.5 to 1.7 million, estimates of annual fish collection and trade are likely up to 1,000,000 fish per year. Local extirpations have occurred, especially in areas where harvest was heavy. Group size has declined. However, where moderate fishing occurs, the population appears to persist, and some harvest may be sustainable. The Banggai cardinalfish lacks dispersal ability and exhibits high site fidelity and new recruits stay within parental habitat. Thus, recolonization is unlikely once a local population is extirpated. Local populations off Liang and Peleng Island are reported extirpated, and interviews with local fishermen indicate extirpation of local populations throughout the Banggai Archipelago. One population (private oyster pearl farm) is protected, but illegal poaching has been reported since 2006. Only one other population --Bone Baru, although depleted, appears to have stopped declining, likely due to replenishment of released unsold/unsaleable fish on a regular basis and the presence of a functional marine protective area.

Observations of the Banggai cardinalfish indicate it may be able to survive or adapt to degraded coral reef habitat; however, these observations are anecdotal and studies are lacking on the extent to which the cardinalfish can adapt to degraded habitat. Significant damage to coral reef habitat and fish diversity is likely to negatively impact the Banggai cardinalfish. Damage to coral reef habitat and fish diversity on these reefs has been observed in the Banggai Archipelago within the natural range of the Banggai cardinalfish. Coral reef cover in Banggai Island decreased by over 50% (from 25% to 11%) from 2004 through 2011. Causes of coral reef decline include devastating fish practices (e.g., cyanide, bombs), coral mining, upland clear-cutting, agriculture, and coastal development. Overharvest of sea urchins and sea anemones are a concern as these species provide habitat and protection for the Banggai cardinalfish. The Banggai cardinalfish exhibits high genetic population substructuring and lacks dispersal mechanisms; thus, extirpation of local populations from overharvest and/or loss of habitat can result in loss of genetic diversity and further fragmentation of spatial distribution.

In considering the demographic risks to the species, its growth rate/productivity, spatial structure/connectivity, and diversity are assigned a category of the likelihood of a high risk of extinction. However, the overall population abundance (estimated 1.5 to 1.7) is assigned a category of the likelihood of a moderate risk of extinction because the abundance may allow some resilience against stochastic events.

Qualitative Risk Analysis of Threats

Regarding habitat threats to the species, habitat degradation has occurred/is occurring and is anticipated to continue in the foreseeable future. Although Indonesia prohibits the use of chemicals or explosives to catch fish, historically compliance has been low and data indicate compliance is not improving. Destructive fishing practices continue, and damage to coral reefs due to fish bombs is prevalent, even in protected areas. Data also indicate increased harvest of sea urchins and sea anemones in the future, which negatively impacts the Banggai cardinalfish and its ability to avoid predators. Coastal development and upland activities have also negatively impacted coral reef habitat and fish diversity in the Banggai Archipelago. Although specific data are lacking on impacts to the Banggai cardinalfish, it is reasonable to anticipate that coastal development and upland activities will continue and may further damage habitat within the species' range. For these reasons, I conclude the Banggai cardinalfish is at moderate risk of extinction due to destruction, modification and curtailment of habitat, particularly from destructive fishing practices and harvest of microhabitat.

As for impacts from overutilization the greatest impact to the Banggai cardinalfish, to date, has been direct collection for the ornamental live reef fish trade, which likely resulted in a marked decrease (possibly as high as 90% based on one survey site) in the population density since the mid-1990s. Currently, the only legislation that covers the Banggai cardinalfish within its natural range is Fish Quarantine regulation that requires all trade in Banggai cardinalfish go through quarantine procedures before crossing internal administrative borders or prior to export. Recent efforts under the Banggai Cardinalfish Action Plan indicate improved compliance with trade regulations and raised awareness for improving sustainability of the Banggai cardinalfish trade. Data indicate that participants in the Banggai cardinalfish trade may be decreasing. However, lack of enforcement of illegal fishers and traders remains a concern. Data also indicate where harvest is light to moderate and assuming suitable habitat, Banggai cardinalfish populations are able to recover, indicating some harvest sustainability. Aquaculture facilities in the U.S. and abroad may alleviate fishing pressure on the wild populations, but data are lacking on the extent, if any, of the benefit to wild populations. We assume efforts to sustain the ornamental live reef fish trade will continue in the future, and the Banggai cardinalfish will respond favorably. However, the extent of benefit is unknown and given the known impacts to populations from heavy harvest, I consider the Banggai cardinalfish is at moderate risk of extinction due to overutilization from the ornamental live reef fish trade.

With respect to disease and predation, high mortality of new recruits (note: considered as a demographic risk factor above) from predation, high mortality from disease of wild-caught fish imported for the ornamental live reef fish trade, and disease affecting the Banggai cardinalfish habitat are all plausible threats. However, data are lacking on how these threats impact the population and what, if any, impacts will occur in the future. Thus, I consider the Banggai cardinalfish to be at low risk of extinction due to disease and predation.

With respect to inadequacy of existing regulatory mechanisms, the only legislation that covers the Banggai cardinalfish within its natural range is Fish Quarantine regulation that requires all trade in Banggai cardinalfish go through quarantine procedures before crossing internal administrative borders or prior to export. Recent efforts under the Banggai Cardinalfish Action Plan indicate improved compliance with trade regulations and raised awareness for improving sustainability of the Banggai cardinalfish trade. Thus, I consider the Banggai cardinalfish to be at a moderate risk of extinction due inadequacy of existing regulatory mechanisms.

Regarding other natural or manmade factors, data indicate ambient temperatures will continue to rise in the future, but data are lacking on specific impacts to the Banggai cardinalfish. However, given the species is reef-dependent and is restricted to a narrow temperature and depth regime, it is reasonable to assume the Banggai cardinalfish will be negatively impacted in the future as a result of climate change. Frequent earthquakes within the Banggai Archipelago may have also negatively impacted localized Banggai cardinalfish populations. Although I was unable to find data that predicted earthquake frequency and magnitude in the region, it is reasonable to expect that earthquakes will occur in the future and may negatively impact the Banggai cardinalfish populations and/or habitat. For these reasons, I consider the Banggai cardinalfish to be at moderate risk of extinction due to other natural or manmade factors.

Overall Extinction Risk—Synthesis and Finding

In determining the overall extinction risk of the Banggai cardinalfish, I first analyzed the demographic risks to the species. Following this analysis, I assessed the threats to the species to determine if these threats are appreciably reducing the fitness of the species.

In considering the demographic risks to the species, its growth rate/productivity, spatial structure/connectivity, and diversity contribute to the likelihood of a high risk of extinction. However, the overall population abundance (estimated 1.5 to 1.7 million) contributes to the likelihood of a moderate risk of extinction because the abundance may allow some resilience against stochastic events.

In considering the threat risks, habitat degradation has occurred and is anticipated to continue in the foreseeable future. Although Indonesia prohibits the use of chemicals or explosives to catch fish, historically compliance has been low and data indicate compliance is not improving. Data also indicate increased harvest of sea urchins and sea anemones in the future, which negatively impacts the Banggai cardinalfish and its ability to avoid predators. Overutilization from direct harvest for the ornamental live reef fish trade has significantly impacted the Banggai cardinalfish and remains a concern. However, an increase in compliance with the Fish Quarantine regulations and improved trade practices likely will continue in the future, which may mitigate impacts through sustainable trade. Predation of new recruits is high. Mortality from disease of wild-caught fish imported for the ornamental live reef fish trade, and disease affecting the Banggai cardinalfish habitat are all plausible threats. However, data are lacking on how these

threats impact the population and what, if any, impacts will occur in the future. Improved compliance with the Fish Quarantine regulation and raised awareness for improving sustainability of the Banggai cardinalfish trade are likely to continue into the future. Climate change within the Banggai cardinalfish range will continue to affect coral reefs in the future, and it is reasonable to expect future earthquakes that may destroy or modify habitat within the species' range.

The Banggai cardinalfish is exposed, and negatively responds to some degree, to the five threat factors discussed above. Although quantitative analyses are lacking, it is reasonable to expect that when these exposures are combined, synergistic effects may occur. For example, the ornamental live reef fish trade likely causes the expression of the iridovirus in the Banggai cardinalfish, which results in increased mortality. The indiscriminate harvest of sea anemones and sea urchins and destruction of coral reefs eliminates important cardinalfish shelter and substrate and increases the likelihood of predation. Interactions among these threats may lead to a higher extinction risk than predicted based on any individual threat.

In sum, based on the life history characteristics of the Banggai cardinalfish, which indicate high vulnerability to demographic risks (due to trends in population growth/productivity, spatial structure and connectivity, and diversity), coupled with ongoing and projected threats to habitat and microhabitat, commercial use, inadequate regulatory mechanisms, disease and predation, and natural or manmade factors, I found that demographic risks and threats to the species may contribute to the overall vulnerability and resiliency of the Banggai cardinalfish. The Banggai cardinalfish has experienced a dramatic decline in abundance due to overharvest, and its demographic characteristics put it at a high risk of extinction. However, the threat of overharvest has been and will likely continue to be reduced in the future. Further, the overall population abundance (1.5 to 1.7 million) may allow some resilience against stochastic events; thus, placing the Banggai cardinalfish at an overall moderate risk of extinction.

CONSERVATION MEASURES

The Banggai cardinalfish is listed as 'endangered' by the World Conservation Union (IUCN; Allen and Donaldson 2007), which is an international organization that publishes the IUCN Red List of Threatened Species. The "endangered" status, a category meant for species "considered to be facing a very high risk of extinction in the wild," was due to its small range, the fragmentation of its distribution, and its continuing decline due to exploitation for the international aquarium trade (Allen and Donaldson 2007). In 2007, due to overharvest concerns, it was proposed to be listed under CITES Appendix II. Appendix II includes species that are vulnerable to overexploitation, but not at risk of extinction under CITES criteria; trade must be regulated to avoid exploitation rates that are incompatible with species survival. Indonesia did not support the proposal and it was withdrawn (Vagelli 2008). The Banggai cardinalfish was one

of the first entrants into the Frozen Ark Project, which is a program to save the genetic material of imperiled species (Clarke 2009; Williams 2004).

Indonesia rests within the Coral Triangle, a rich and biologically diverse region that equals that of the Amazon and Congo basins. Indonesia is a signatory to the CTI-CFF, which consist of a multilateral partnership of six countries (Figure 4) working together to protect the rich and diverse coral habitat in the region.

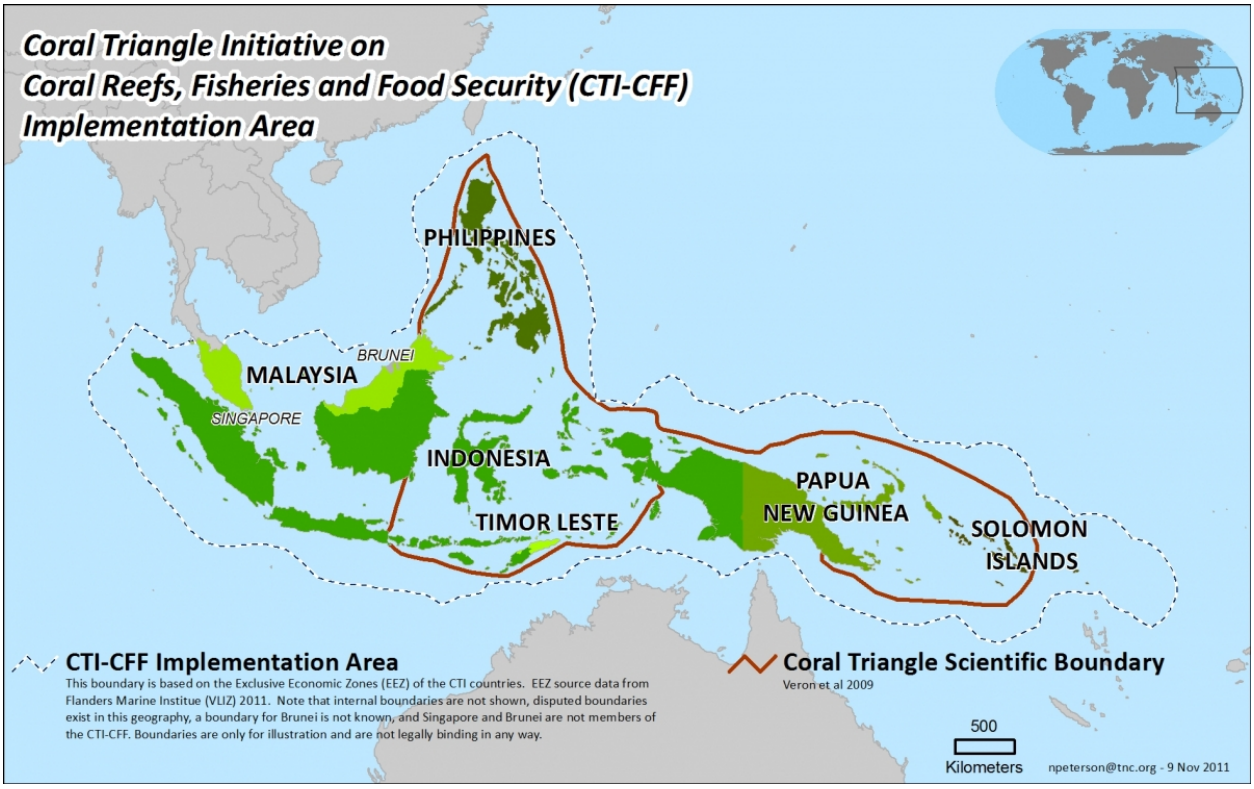

Figure 4. CTI-CFF implementation area including Banggai Archipelago, Indonesia.

Indonesia developed a national plan of action under the CTI-CFF (http://www.coraltriangleinitiative.org/library/national-plan-action-indonesia). The national plan includes a goal to use an ecosystems-based approach to managing fisheries (EAFM) including a more sustainable trade in live reef fishes. A priority action is to develop a comprehensive management plan for the Banggai cardinalfish. In 2013, World Wide Fund for Nature (WWF) in partnership with STPL implemented a pilot project in Central Sulawesi Province under the ecosystems-based approach and chose the Banggai cardinalfish as one of five fisheries case studies in Banggai Laut District. The goal is to draft local regulations for an EAFM for two Districts--Banggai Laut District (which encompasses the majority of the endemic Banggai cardinalfish populations) and Banggai Kepulauan District (which includes the Peleng Island

Banggai cardinalfish populations). The STPL EAFM Learning Centre team will be facilitating this component under an agreement with the WWF through January 2015. These efforts could introduce local measures to sustain the Banggai cardinalfish trade (Moore, STPL, personal communication 2014; Ndobe, Tadulako University, personal communication 2014).

In 2007, a national multi-stakeholder Banggai cardinalfish action plan (BCF-AP) was developed, which focused on conservation, trade, and management (Ndobe and Moore 2009). As part of the BCF-AP, annual stakeholder meetings are held to share data, review progress, and set goals (Moore *et al.* 2011). The BCF-AP called for biophysical and socio-economic monitoring of trade, population status, and habitat, and several organizations have begun to report on these activities. However, there is no integrated or comprehensive monitoring system and long-term data sets are lacking (Moore *et al.* 2011). Several aspects of the BCF-AP appear to have improved the sustainability of the Banggai cardinalfish trade. Fishermen groups have gained legal status (which allows them access to various benefits such as funding or loan support), which has led to socialization of sustainable harvest in Bone Baru. The legally established fishermen's group (Kelompok BCFLestari) in Bone Baru implemented collection practices designed to prevent capture of brooding males (Moore *et al*. 2011). Workshops have been held on improving capture methods and post-harvest care, and several community members have become active in conservation efforts. However, the BCF-AP officially ended in 2012 and so did the funding. Some of the stakeholders are still active and are likely to continue to be so despite lack of government support (Moore, STPL, personal communication 2014).

Compliance with the Fish Quarantine regulations (see Inadequacy of Existing Regulatory Mechanisms) has increased since the development and implementation of the BCF-AP (Moore *et al.* 2011). In 2004, one Banggai cardinalfish trader followed Fish Quarantine procedures. By 2008, there was a marked increase in legal trade (Moore *et al.* 2011). Illegal and unreported fishing still occurs. A key component of data sharing was the establishment in 2007 of the Banggai Cardinal Fish Centre (BCFC) to serve as a central point for sharing information and managing the species over a wider community area (Lilley 2008; Moore *et al.* 2011). As of 2011, the BCFC had no electricity, no operational budget, and was operated on a voluntary basis (Moore *et al.* 2011). Further exacerbating the continued operation of the BCFC is that in 2013 the region was split into two Districts (Banggai Kepulauan and Banggai Laut) by constitutional law (UU No. 5/2013). The BCFC will need to be officially approved under the new Districts to maintain its legality within the boundaries of the Banggai Laut District (Ndobe, Tadulako University, personal communication 2014). Legislation is needed to support and restart the goals described in the BCF-AP, and although efforts have been ongoing to establish fishing quotas and size limits, no legally binding regulations have been passed or implemented (Moore *et al.* 2011). Moore *et al.* (2011) point out many weaknesses with local monitoring activities including lack of monitoring protocols, overall strategy/plan, coordination between organizations, and baseline data. Nonetheless, they concluded that, although continued monitoring and vigilance is needed

to ensure the conservation of the Banggai cardinalfish, the decrease in illegal trade and destructive collection practices indicate the fishery was well on the way to being sustainable.

A marine protected area (MPA) consisting of 10 islands was declared in 2007 with conservation of the Banggai cardinalfish as the primary goal of the Banggai and Togong Lantang Islands (Ndobe *et al.* 2012). However, Banggai cardinalfish populations are not found at Togong Lantang Island while for three other islands within the proposed MPA with known populations, Banggai cardinalfish conservation is not included as a conservation goal in the designation (Ndobe e*t al.* 2012). In addition, based on genetic analysis, only 2 of 17 known populations occur within the MPA, which led Ndobe *et al.* (2012) to conclude the MPA design was ill-suited for conserving the Banggai cardinalfish. White *et al.* (2014) conducted an evaluation of MPAs for all countries under the CTI-CFF. They found that several of Indonesia's MPAs show positive impacts on fish and coral reef conditions, but that less than 15% of Indonesia's MPAs are meeting their management objectives. In response, Indonesia developed a monitoring and effectiveness system to apply to all MPAs (White *et al.* 2014). Data are lacking on whether the national system has improved MPA management in Indonesia.

Although no longer active, the Marine Aquarium Council (MAC), an international non-governmental organization, developed a certification system to improve the management of the marine aquarium trade. MAC developed best practices for collectors and exporters, including those in Indonesia. Best practices include improvement of product quality, reduction in mortality rates, safer practices for collectors, and fairer prices paid to collectors. By applying the MAC standards, traders could be certified as meeting these international standards (Lilley 2008). Training of collectors and government officials was done by LINI. LINI focused on surveys, capacity building and training of local suppliers and reef restoration (Lilley 2008). They conducted an assessment of the Banggai cardinalfish trade in 2007 and found many 'farmers' who trade the species without reporting to the government. It is clear that the trade of the fish is largely unmonitored and undocumented (Lilley 2008). Building on the MAC efforts, LINI has worked in the Banggai Islands to promote a sustainable fishery and to protect habitat (Talbot *et al.* 2013). LINI's training and education efforts may raise awareness of needed conservation efforts to benefit the Banggai cardinalfish. For example, more benign collection methods have been implemented at Bone Baru, the species has been adopted as a mascot, and local citizens craft and market items related to the fish. LINI is also trying to set up a mechanism for hobbyist to only buy from distributors who use best practices and are sustainable (Talbot *et al.* 2013).

Although established for commercial purposes, captive breeding facilities may result in conservation benefits for the Banggai cardinalfish. As stated earlier, in 2012, a large-scale aquaculture facility based in Thailand began to breed Banggai cardinalfish in captivity for export (Rhyne, Roger Williams University, unpublished data 2014; Talbot *et al.* 2013). In theory, should the Thailand facility succeed, other aquaculture facilities in Southeast Asia may follow and drive the price of the Banggai cardinalfish down and possibly alleviate fishing pressure on

the wild population (Talbot *et al.* 2013). However, data are absent on how this operation will impact the Banggai cardinalfish. Raising Banggai cardinalfish in captivity may result in hardier specimens (Vagelli 2011) and lessen the impact of harvest on natural populations. Regulation, enforcement, and certification are needed for any such operations, and buyers would need to support the added costs for the resources needed to maintain a sustainable aquaculture operation. In the U.S., the Florida Department of Agriculture and Consumer Services has certified eight aquaculture facilities that are beginning to culture and market farm-raised Banggai cardinalfish (Knickerbocker, Florida Department of Agriculture and Consumer Services, personal communication 2014). In Hawaii, a facility implemented an experimental captive-breeding program for Banggai cardinalfish (Hopkins *et al.* 2005). Sustainable Aquatics, a large aquarium facility in Tennessee, also captive-breed the Banggai cardinalfish (Talbot *et al.* 2013), although a check on their website http://sustainableaquatics.com/current-availability/ in July 2014 does not show the Banggai cardinalfish as currently available.

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