AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Summary of results of population density surveys of the Banggai cardinalfish in the Banggai Archipelago, Sulawesi, Indonesia, from 2007 – 2012

[1]Yunaldi Yahya, [1]Andri Mustain, [1]Nengah Artiawan, [1]Gayatri Reksodihardjo-Lilley, and [2]Michael F. Tlusty

[1] Yayasan Alam Indonesia Lestari, Jl. Tirta Nadi II/21, Denpasar, Bali 80227, Indonesia.
[2]John H Prescott Marine Laboratory, New England Aquarium, Boston MA 02110.
Corresponding author: G. Lilley, gayatri@lini.or.id

Abstract. The unique endemic Banggai cardinalfish (*Pterapogon kauderni*)(BCF) is still among the top 10 imported species of marine aquarium fish in the US. The fish has been classified as an endangered species due to concerns over its collection for the aquarium trade. The fish was only re-discovered in 1995, and only limited studies have been undertaken in the field. In an effort to complement these studies, surveys on the the distribution, population density, and current levels of trade of the BCF were conducted from 2007 to 2012. Using the belt transect method, three classes of BCF (recruits, juveniles, and adults) encountered along each transect were counted, as well as BCF habitats including soft corals, hard corals, sea grasses, sea urchins and anemones. Some areas were surveyed more than once, and showed a decline in population densities. The causes of these declines were most likely due to overexploitation, habitat destruction and extensive removal of microhabitats and species for human consumption. A number of measures have been taken to prevent BCF populations from further declines, to ensure that they are being collected in a more sustainable manner. However, control and enforcement of these measures are still lacking in the field. An initiative to include the BCF in the protected species list under Indonesian law has not yet been realized. There is a call for the aquarium industry to actively support the work in Indonesia by promoting and supporting the purchase of BCF from sustainable collection areas and methods only.
Key Words: fishery, ornamental fish, sustainability.

Ikhtisar. Ikan endemik Capungan Banggai (*Pterapogon kauderni*) merupakan salah satu dari 10 jenis ikan terbanyak yang diimpor di negara Amerika Serikat. Capungan Banggai masuk dalam kategori jenis langka karena kekuatiran pemanfaatan yang berlebih untuk perdagangan ikan hias.Ikan ini baru dimunculkan kembali pada tahun 1995, dan penelitian mengenai jenis ini masih sangat terbatas. Sebagai salah satu upaya untuk menambah informasi mengenai ikan Capungan Banggai, survey mengenai penyebaran, kepadatan populasi dan tingkat pemanfaatan untuk perdagangannya dilakukan dari tahun 2007 sampai 2012. Dengan menggunakan metode transek, ikan Capungan Banggai yang berada dalam transek dihitung berdasarkan tiga kategori ukuran (bayi, anakan dan dewasa), termasuk juga habitatnya, yaitu karang lunak dan keras, lamun, bulu babi dan anemon. Dibeberapa lokasi survey dilakukan lebih dari satu kali, dimana terlihat adanya penurunan dari kepadatan populasi. Penyebab dari penurunan kepadatan populasi akibat dari pemanfaatannya yang berlebih, kerusakan habitat dan pengambilan mikro habitat untuk konsumsi manusia. Beberapa upaya untuk mencegah semakin menurunnya populasi Capungan Banggai telah dilakukan, yaitu dengan mengupayakan pemanfaatan yang lebih berkelanjutan. Akan tetapi, kontrol dan pengawasan dilapangan dirasakan masih kurang. Upaya yang dilakukan agar ikan Capungan Banggai menjadi jenis yang dilindungi di Indonesia belum terlaksana. Sangat diharapkan industri ikan hias secara aktif mendukung upaya yang sedang dilakukan oleh Indonesia yaitu mempromosikan dan mendukung perdagangan Capungan banggai yang berasal dari perikanan berkelanjutan.
Kata-kata kunci: perikanan, ikan hias, berkelanjutan.

Introduction. The Banggai cardinalfish (BCF)(*Pterapogon kauderni* Koumans, 1933), a unique and endemic fish species belonging to the family Apogonidae. The fish has a limited geographical distribution, and was orginally found in the Banggai Archipelago situated in the western part of central Sulawesi, on the boundary between the Banda Sea in the South, and the Mollucan Sea in the north.

It has become one of the most talked about marine ornamental fish among hobbyists, researchers, conservationists and traders because of its status in the wild (endangered in native range, but introduced to new areas), yet continued availability to hobbyists. The BCF is suspected of being the carrier of an unknown iridovirus, which has puzzled scientists and breeders (Weber et al 2009).

As the fish was only re-discovered in 1995, only a handful of studies have been undertaken in the field, including studies on its distribution, behavioural aspects, reproduction, genetics, trade surveys and the exploitation of the species (G.R. Allen 2001; Lunn & Moreau 2002; Kolm & Berglund 2003; Bernardi & Vagelli 2004; R. Lilley 2008).

The BCF used to be one of the high-value species in the USA in mid 1990s. Increased supply has decreased price, and currently it is in the top 10 ten imported species in the US (Rhyne et al 2012).

However, the collection of this species continues to provide additional income for local communities in the Banggai islands. Harvest data from only one location (Bone Baru) showed that, in 2010 and 2011, 99,898 and 99,719 (respectively) BCF shipped to major cities in Indonesia for distribution internationally. There are a number of other gateways within Banggai Islands and throughout Indonesia through which BCF have been sent from Banggai to the international market, but trade figures from these gateways remain unreported. Since the BCF was proposed for listing in Appendix II of CITES in 2007 and included on the IUCN Endangered Species list, Indonesian Authorities have started to recognize the importance of this species (G.R Allen & Donaldson 2007).

Various efforts have been implemented to more effectively conserve and manage the BCF as a sustainable resource for trade. These include the development of a BCF management plan and training for the collectors and middlemen. Non-governmental organization initiatives have included shortening the supply chain, the establishment of No-Take Areas, and surveys to monitor the population densities of the BCF throughout its restricted range (G. Lilley 2012). However, a number of problems remain, and these threaten the survival of the BCF and the habitats in which it lives (R. Lilley & Lilley 2010; G. Lilley 2011).

In an effort to complement the studies on the BCF, here we report on surveys on the distribution, population density, and current levels of trade, conducted from 2007 to 2012. We characterize the abundance of three size classes of fish (recruits, juveniles, and adults) to better identify population dynamics.

Ideally, these data will form a basis for not only additional studies on native populations, but to identify if the enacted management plan is being effective, and how it can be tuned to assure the long term coexistence of BCF, local fishers reliant on this species, and increased anthropogenic stressors from an ever increasing human population.

Materials and Methods. The BCF population surveys were conducted in 54 areas, consisting of small coastal villages or islands from 2007 to 2012. Not all areas were surveyed equally, with Teropot (n=5) and Bone Baru (n=4) being explored the most. Liang, Popisi, and Tinakin Laut were surveyed twice, and all other locations a single time. These surveys utilized the belt transect method, with the length of each transect being 100 meters long and 5 meters wide. Most of the sites were laid with two transect replications. The fish were categorised into three size classes: recruits smaller than 1.8 cm (<1.8 cm), juveniles between 1.8 cm and 3.5 cm, and adults over 3.5 cm in length. Each BCF encountered along a transect was counted and sized. Other organisms observed and noted in the belt transects included soft corals, hard corals, sea grasses, sea urchins and anemones. These are all habitats of the BCF.

Results and Discussion. Of the 54 areas surveyed, BCF were found in only 28 areas (Fig 1). The sites were surveyed based on information from local communities including fishermen, and from previous surveys conducted by various researchers (Balai Riset Perikanan Laut, Pers. comm, Wijaya 2010; Vagelli 2011; G. Lilley 2012). The BCF were most abundant around Banggai Island, and the smaller islands to the South. While surveyed extensively, it was for the most part absent from Peleng Island to the Northwest of Banggai Island (Fig 1).

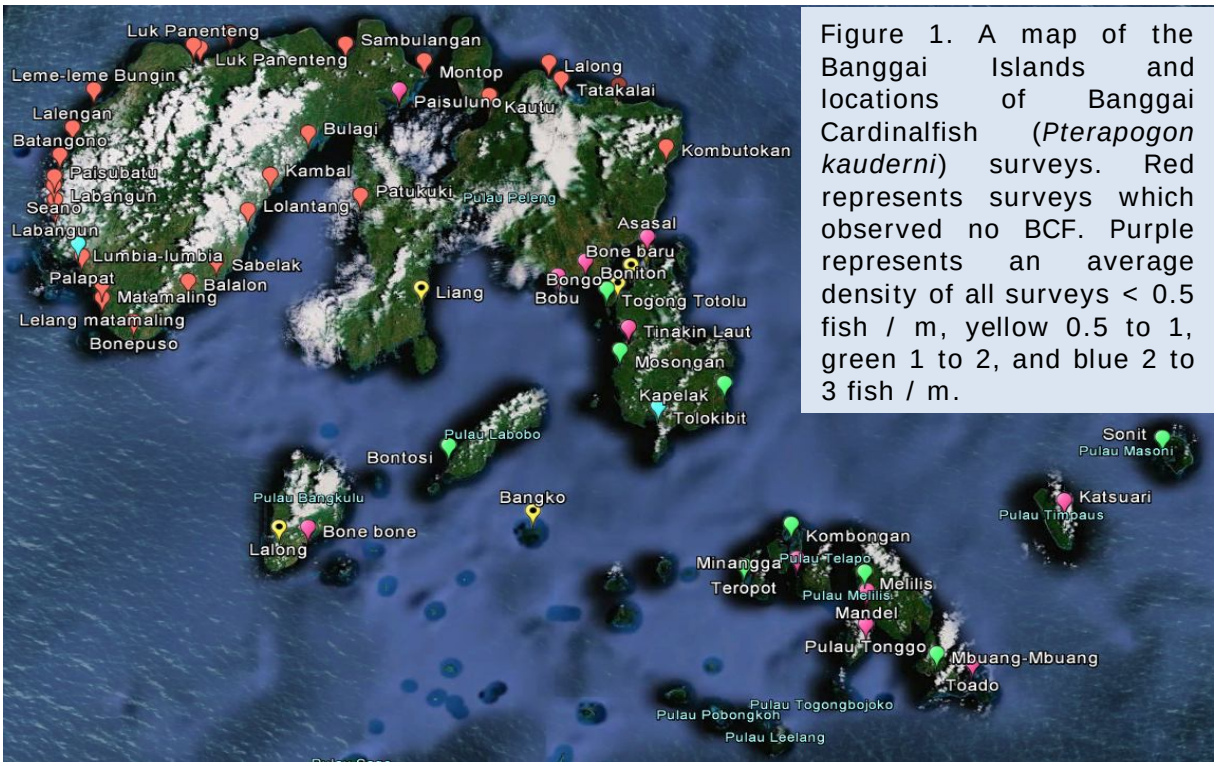

Figure 1. A map of the Banggai Islands and locations of Banggai Cardinalfish (*Pterapogon kauderni*) surveys. Red represents surveys which observed no BCF. Purple represents an average density of all surveys < 0.5 fish / m, yellow 0.5 to 1, green 1 to 2, and blue 2 to 3 fish / m.

Although not a strict statistical design, there was no difference in density between the sample dates (one-way ANOVA, $F_{6,31} = 2.1$, $p > 0.08$, Fig. 2). Likewise, there did not appear to be seasonality, as there was no significant association (linear $r^2 = 0.07$, or second order $r^2 = 0.09$) between density and calendar month number. There did seem to be a population low in September of 2011, however, the large variation within and between sample locations and times preclude the statistical confirmation of this trend.

Three areas were surveyed more than once between 2007 and 2012, these being Teropot, Bone Baru and Popisi. Comparing the change in population of recruits, juveniles, and adults between June 2009 and July 2012 (approximately matched for time of year), recruits and adults decreased leading to an overall decrease in population density (Fig 2). However, juveniles were more abundant in 2012 compared to 2009. This change in age structure needs to be further understood in the context of animals growing to adults and recruiting to the fishery.

The overall density in Bone Baru showed a decline from 2007, and only started to increase again in in 2012 (Fig 2a). The cause of the declines in BCF populations in Teropot and Bone Baru are likely to be due to the collection and sales of the species to the aquarium trade since the mid-1990s. These two places have experienced higher collection pressures than any other areas in the Banggai Archipelago, and they are the main villages where BCF are aggregated before being shipped on to the next buyers in the trade chain. Middlemen from Teropot and Bone Baru have been trading with middlemen from Tumbak (North Sulawesi), Kendari (Southeast Sulawesi), and from as far away as Bali and Banyuwangi in East Java. The increase in density may be the result of the closure of sites that used to be collection areas, and these sites becoming No-Take Areas. Two No-Take Areas were established, one in Bone Baru in 2010, and another in Bongo Beach in 2012. These No-Take Areas were established by local community groups

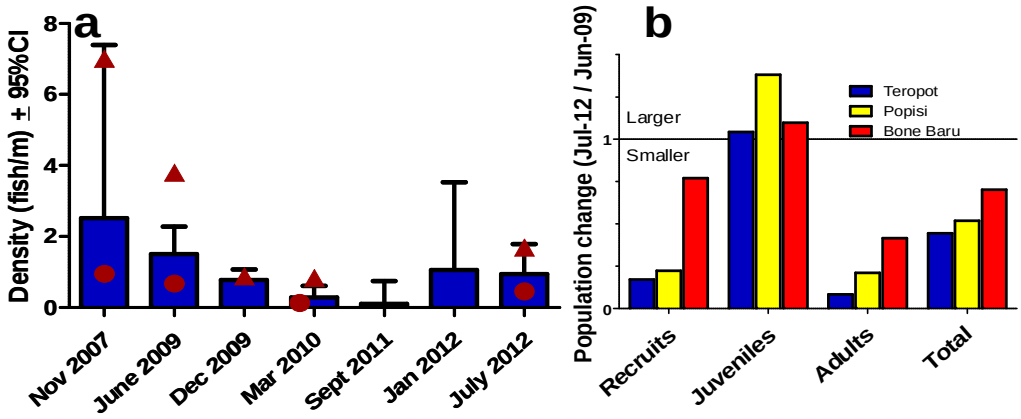

Figure 2. a: the average density for all sites (blue) with data for Teropot (triangle) and Bone Baru (circle) listed individually as these were the most surveyed sites. b: The difference in density for July 2012 compared to June 2009 for three size classes of fish for three sites. Values > 1 indicate density was greater in 2012 compared to 2009.

from Bone Baru. It is important to survey populations within these No-Take Areas to determine if population density and structure differ significantly from the fished areas. Furthermore, the marine aquarium industry has encountered several drastic changes in the past five to ten years, including changes in technology allowing home hobbyists to keep smaller marine tanks (Rhyne & Tlusty 2012), and the global economic recession which caused a contraction of the trade. BCF imports into the US in 2009 were 89% the number imported in 2005 (Rhyne & Tlusty, unpublished data).

There are also other causes of declines in BCF population densities outside of simple fishing pressure. These include anthropogenic stressors (coastal development, effluent discharge into critical habitat, changes in terrestrial water run-off), as well as habitat destruction and the removal of sea urchins and anemones for human consumption. Sea urchins and anemones create important micro-habitats and refuges for recruits and juveniles (Fig. 3), and their removal can lead to significant declines of BCF, especially recruits. From observations in the field, immediately after recruits are released, they seek refuge in anemones. With the disappearance of anemones, recruits become more exposed to predators. Habitat destruction caused by destructive fishing methods still occurs in many parts of the Banggai archipelago, and this includes the use of dynamite for food fish, and cyanide for live food fish and for the aquarium trade. Cyanide fishing targets high-value species such as groupers and napoleon wrasse for human consumption, and blue tang for the aquarium trade.

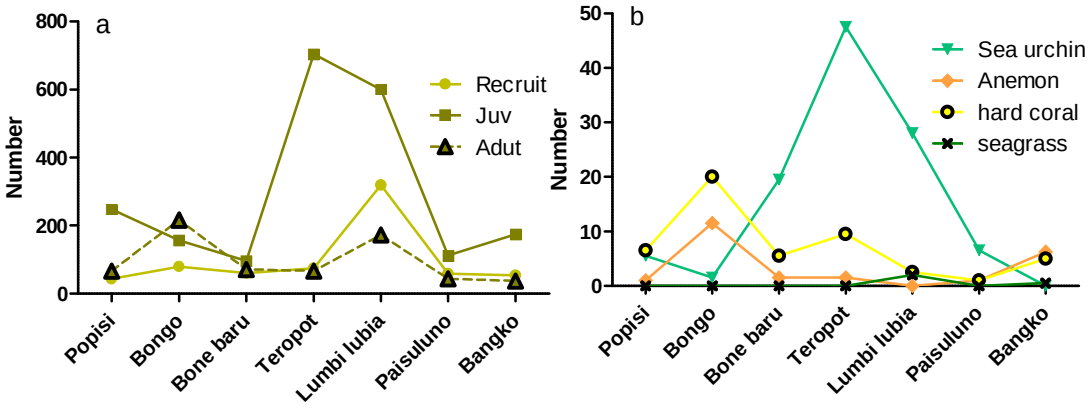

Figure 3. Counts of BCF (a) as they relate to habitat scores (b). Soft corals were only observed at Bangko.

Conclusions. The work to save the BCF and its habitats from further declines still requires further support. The BCF requires greater protection, and its habitats need to be more sustainably managed. So far, little attention has been paid to the problem of over-exploitation of sea urchins and anemones, even though there is evidence to show that some stages of life of the BCF depend on these organisms for their survival. Another problem is that thousands of BCF are still being harvested and exported without being reported, and with no proper documentation. Measures to monitor and control the trade have not yet been enforced effectively. The trade quotas proposed by the local stakeholders during the meeting in 2010 have not been continued, largely because of a lack of legal support. This does not allow for sufficient management. A lack of sufficient stock assessment does not allow for the application of relevant fishery management tools such as calculation of maximum sustainable yields, or the application of size limits or seasons (Charles 2008).

The plan to include this species in the Protected Species list under Indonesian law has not yet been realized. Some people argue that, as the species no longer has a limited geographic distribution because of releases outside its original home range, and because it is even thriving in non-native habitats, that it is doubtful whether this species is actually still threatened. Another issue to be concerned about is that the BCF is perceived by some people as an invasive species, because of releases ('dumping') of unsold fish by traders in areas outside its origin. Although the fish is small, it is a predatory species, and such introductions could have significant ecosystem impact. This survey did observe BCF in areas such as Lumbia-lumbia on the western edge of the study area (Fig. 1) largely separate from the main BCF population. These populations appear to not be explained by human induced relocation, and point to the need to better understand dispersal potential and mechanisms.

In the absence of credible efforts by the authorities to enforce conservation measures for the BCF, it is hoped that the marine aquarium industry can be encouraged to play a more active role in preventing further threats to the BCF. It is possible for buyers to choose to purchase BCF from managed, sustainable collection areas, and this opportunity needs to be taken if the trade does not want to be blamed for the decline of the BCF in its natural environment. The on-going work on the iridovirus will hopefully shed some light on the origins and causes of the infection. The Government authority, local communities and NGOs will need to work together closely, and continue to collaborate their efforts more intensively. Measures to effectively control and monitor the collection and trade of BCF need to be implemented as a priority, and the problem of extensive destructive fishing, which is causing so much habitat degradation, must be controlled if the BCF and its habitats are to be saved.

Acknowledgements. The surveys were made possible with the grants we received from Yayasan KEHATI, the Mohamed bin Zayed Species Conservation Fund and PADI Foundation. All works in Banggai have been kindly supported by Banggai Islands District Government, Local communities of Banggai Islands, Community groups in Bone Baru, Indonesian marine aquarium industry and fishermen of Banggai islands. A Rhyne provided comments on a draft of this manuscript.

References

Allen G. R., 2001 Reef fishes of the togean and banggai islands. In G. R. Allen & S. A. McKenna (Eds.), A marine rapid assessment of the togean and banggai islands, sulawesi, indonesia. Rap bulletin of biological assessment 20 (Washington, DC: Conservation International. pp. 44-53.

Allen G. R., Donaldson T. J., 2007 *Pterapogon kauderni* IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1.

Bernardi G., Vagelli A., 2004 Population structure in banggai cardinalfish, *Pterapogon kauderni*, a coral reef species lacking a pelagic phase. Mar Biol 145:803-810.

Charles A. T., 2008 Sustainability in fishery systems Sustainable fishery systems. Blackwell Science Ltd. pp. 183-202.

Kolm N., Berglund A., 2003 Wild populations of a reef fish suffer from the "nondestructive" aquarium trade fishery. Conserv Biol 17(3):910-914.
Lilley G., 2011 Update on banggai cardinalfish project by lini in banggai islands, sulawesi, indonesia. OFI Journal 65:22-24.
Lilley G., 2012 Update on banggai cardinalfish project by lini in banggai islands, sulawesi, indonesia. OFI Journal 69:20-21.
Lilley R., 2008 The banggai cardinalfish: An overview of conservation challenges. SPC Live Reef Fish Information Bulletin 18:3-12.
Lilley R., Lilley G., 2010 Update on banggai cardinalfish project by lini in banggai islands, sulawesi, indonesia. OFI Journal 62:32-35.
Lunn K. E., Moreau M.-A., 2002 Conservation of banggai cardinalfish populations in sulawesi, indonesia: An integrated research and education project. SPC Live Reef Fish Information Bulletin 10:33-34.
Rhyne A. L., Tlusty M. F., 2012 Trends in the marine aquarium trade: The influence of global economics and technology. AACL Bioflux 5:99-102.
Rhyne A. L., Tlusty M. F., Schofield P. J., Kaufman L. E. S., Morris J. S., Bruckner A., 2012 Revealing the appetite of the marine aquarium fish trade: The volume and biodiveristy of fish imported into the united states. PloS one:DOI:10.1371/journal.pone.0035808.
Vagelli A., 2011 The banggai cardinalfish: Natural history, conservation, and culture of *Pterapogon kauderni*. New York: John Wiley and Sons, LTD.
Weber E. S., Waltzek T. B., Young D. A., Twitchell E. L., Gates A. E., Vagelli A., et al., 2009 Systemic iridovirus infection in the banggai cardinalfish (*Pterapogon kauderni* Koumans 1933). J Vet Diagn Invest 21:306-320.
Wijaya I., 2010 Analisis pemanfaatan ikan banggai cardinal (*Pterapogon kauderni*, Koumans 1933) di pulau banggai, sulawesi tengah. Sekolah Pasca Sarjana, Institute Pertanian Bogor.

Received: 25 August 2012. Accepted: 06 September 2012. Published online 07 September 2012.
Authors:
Yunaldi Yahya, Yayasan Alam Indonesia Lestari, Jl. Tirta Nadi II/21, Denpasar, Bali 80227, Indonesia, yunaldi@lini.or.id
Andri Mustain, Yayasan Alam Indonesia Lestari, Jl. Tirta Nadi II/21, Denpasar, Bali 80227, Indonesia, andre@lini.or.id
Nengah Artiawan, Yayasan Alam Indonesia Lestari, Jl. Tirta Nadi II/21, Denpasar, Bali 80227, Indonesia, artinengah@gmail.com
Gayatri Reksodihardjo-Lilley, Yayasan Alam Indonesia Lestari, Jl. Tirta Nadi II/21, Denpasar, Bali 80227, Indonesia, gayatri@lini.or.id
Michael Tlusty, John H Prescott Marine Laboratory, New England Aquarium, Boston MA 02110, mtlusty@neaq.org

How to cite this article:
Yahya Y., Mustain A., Artiawan N., Reksodihardjo-Lilley G., Tlusty M., 2012 Summary of results of population density surveys of the Banggai cardinalfish in the Banggai Archipelago, Sulawesi, Indonesia, from 2007-2012. AACL Bioflux 5(5):303-308.