*Aceh Journal of Animal Science (2019) 4(2): 89-98*
*DOI: 10.13170/ajas.4.2.14571*
*Printed ISSN 2502-9568 Electronic ISSN 2622-8734*

RESEARCH PAPER

# Shallow-water hard corals (Hexacorallia: Scleractinia) from Bangka Belitung Islands Waters, Indonesia

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Received : 07 September 2019
Accepted : 30 October 2019

## ABSTRACT

Bangka Belitung Islands (Sumatra, Indonesia) has various coastal resources, e.g., coral reefs, seagrass beds, mangrove forests. However, the coral community has been threatened by anthropogenic activities, i.e., tin mining and illegal tin mining. Threatened species assessment is important for mitigation of coral losses and management. The ojective of the present study was to examine the status of Scleractinian corals in Bangka Belitung Islands, Indonesia. A line intercept transect was performed for the coral reef survey. Live and dead coral cover were recorded in the three locations. Corals species were identified following taxonomic revisions. The results showed that there were 142 species of Scleractinian corals recorded from Bangka Belitung Islands. Of these, 22 species are the new report from the areas of the the eastern part of Belitung Island. Family of Merulinidae, Acroporidae, and Poritidae were predominant group in this region. It is concluded that the condition of the coral reef ecosystem in the Belitung Islands is relatively good, but fair in Gaspar Strait and Bangka Island.

**Keywords**: Coral cover, coral diversity, hard coral, Scleractinia

## INTRODUCTION

Indonesia has various tropical coastal ecosystems, such as mangrove forests, seagrass beds, coral reefs, sandy shore (Dsikowitzky *et al.*, 2019). The variety of coastal ecosystem present high marine biodiversity in the marine region around Indonesia. Indonesia is one of the coral triangle regions because of the highest number of zooxanthellate corals compare with other areas in the world (Veron *et al.*, 2011). Delineation of the region also takes account of other taxa besides corals, including mangroves, seagrasses, algae, mollusks, crustaceans, and fishes (Hoeksema, 2007). Coral reef is playing the important role as spawning, nursery, feeding of aquatic animals, for example fish, shrimp, mollusk etc. (Rudi *et al.*, 2005; Rudi *et al.*, 2012; Fadli *et al.*, 2012; Fadli *et al.*, 2014; Akbar *et al.*, 2019).

The coral reefs of the Bangka Belitung Islands were reported experienced to anthropogenic disturbances (Putra *et al.*, 2018). Somehow, this condition was also found in the other coastal area in Indonesia (Heery *et al.*, 2018; Annas *et al.*, 2017; Fadli *et al.*, 2014; Fadli *et al.*, 2012; Baird *et al.*, 2012; Kusuma *et al.*, 2016). Reef degradation in Indonesia mainly was caused by land-based pollution and human activities (Edinger and Risk, 2000; Baum *et al.*, 2015; Annas *et al.*, 2017; Putra *et al.*, 2018; Suparno *et al.*, 2019). The degradation also affected seagrass meadows (Short *et al.*, 2014) and mangrove forests ecosystem (Das-Gupta and Shaw, 2013).

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The main problem of the Bangka Belitung Islands coral is anthropogenic impacts (Putra *et al.*, 2018). Bangka Island is well known for tin mining activity (Schwartz *et al.*, 1995). The mining activity is occurred in both the mainland and coastal area. This activity was reported changing the coastal community (e.g., mangrove forests, coral reefs) in the surrounding area (Sari and Rosalina, 2016; Putra *et al.*, 2018). Several studies on the coral reef have been done in Bangka Belitung Islands (Siringoringo *et al.*, 2006; Siringoringo and Hadi, 2013, 2015). Mainly, these studies were conducted on Bangka Island and Gaspar Strait. The previous reports showed that coral coverage was in fair condition (less than 50 %), except for a prior survey in 2006 (Siringoringo *et al.*, 2006). While, the study on the coral reefs fish has been reported by Akbar *et al.* (2018). This present study provided additional information on the other side of this area (Belitung Island). Therefore, the objective of the present study was to describe coral diversity and conditions in Bangka Belitung Islands.

## MATERIALS AND METHODS

### Time and Site

The current study was conducted on November 2012 in the reef formations of three small islands in the coastal waters of East Belitung Regency, Bangka Belitung Islands, Indonesia (Figure 1). Those islands are Pekandis Island (02º37'08,7"S 108º12'10,4" E), Keran Island (02º32'57,0" S 107º58'40,1" E), and Gosong Semut (02º34'03,8" S 108º02'23,3" E).

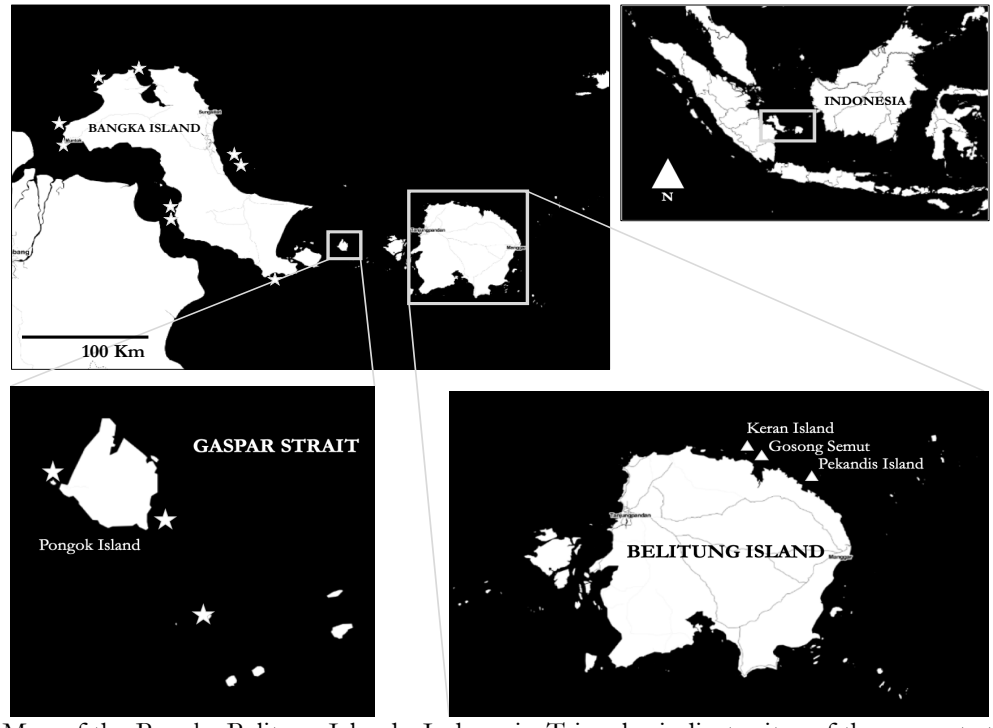


Figure 1. Map of the Bangka Belitung Islands, Indonesia. Triangles indicate sites of the current study. Stars indicate sites from the previous studies (Siringoringo *et al.*, 2006; Siringoringo and Hadi, 2013).

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**Data Collection**

The survey was done by applied a line intercept transect method (Hill and Wilkinson, 2004). Fifty meters transect line lied in the shallow at 4-5 m depth, parallel to the coastline. We identified all encountered live colonies found under the transect. We also review previous papers that also study on coral diversity in the adjacent area, e.g., Bangka Island, Gaspar Strait (Siringoringo *et al.*, 2006; Siringoringo and Hadi, 2013, 2015). Only valid names were presented, any synonymies from previous studies were not included.

**Data Analysis**

The Identification and classification were updated following taxonomic revision in the World list of Scleractinia (Hoeksema and Cairns, 2019) and Corals of the world (Veron *et al.*, 2016). Coral percent cover was calculated as poor (<25%), fair (25-50%), good (51-75%), and excellent (>75%) condition. Coral mortality index (CMI) also calculated as a ratio of dead coral cover to the sum of dead and hard coral cover (Gomez *et al.*, 1994). Coral cover (live coral cover, dead coral cover) and coral mortality index presented as descriptive statistics (e.g., tabulate, standard deviation, average, and frequency).

## RESULTS

### Hard Corals (Scleractinia)

From the current survey, we found 35 species of Scleractinian corals in the eastern part of Belitung Island. The genus of *Acropora* was found dominantly, with ~40% of total species described. *Montipora turtlensis* Veron & Wallace, 1984 and *Porites lutea* Milne Edwards & Haime, 1851 are the most abundant species found in the East Belitung Island. A total of 142 Scleractinian corals were recorded from Bangka Belitung Islands (Table 1). Merulinidae Verrill, 1865 was the dominant family of Scleractinian in this area, consisted of 39 species such as, *Favites halicora, Astrea curta, Dipsastrae* spp.*, Echinopora* spp.*, Goniastrea* spp., *Hydnopora* spp.*, Leptoria phrygia, Merulina* spp., *Mycedium elephantotus*, *Oulophyllia bennettae*, *Pectinia* spp., and *Platygyra* spp.

Table 1. List of hard corals (Hexacorallia: Scleractinia) recorded from Bangka Belitung Islands, Indonesia.

| Taxa | Distribution |
|---|---|
| **Acroporidae Verrill, 1902 (34)** | |
| *Acropora acuminata* (Verrill, 1864)* | Belitung |
| *Acropora aspera* (Dana, 1846) | Gaspar St. |
| *Acropora clathrata* (Brook, 1891)* | Belitung |
| *Acropora cytherea* (Dana, 1846)* | Belitung |
| *Acropora digitifera* (Dana, 1846)* | Belitung |
| *Acropora donei* (Veron and Wallace, 1984)* | Belitung |
| *Acropora florida* (Dana, 1846) | Gaspar St. |
| *Acropora gemmifera* (Brook, 1892) | Bangka |
| *Acropora humilis* (Dana, 1846) | Bangka, Belitung |
| *Acropora hyacinthus* (Dana, 1846) | Gaspar St., Belitung |
| *Acropora kimbeensis* Wallace, 1999* | Belitung |
| *Acropora latistella* (Brook, 1892)* | Belitung |
| *Acropora microphthalma* (Verrill, 1870) | Gaspar St. |
| *Acropora millepora* (Ehrenberg, 1834) | Bangka, Belitung |
| *Acropora muricata* (Linnaeus, 1758) | Gaspar St., Belitung |

| Taxa | Distribution |
|---|---|
| *Acropora robusta* (Dana, 1846) | Gaspar St., Bangka, Belitung |
| *Acropora tenuis* (Dana, 1846) | Gaspar St., Bangka, Belitung |
| *Acropora valenciennesi* (Milne Edwards, 1860)* | Belitung |
| *Astreopora myriophthalma* (Lamarck, 1816) | Gaspar St., Bangka |
| *Isopara palifera* (Lamarck, 1816)* | Belitung |
| *Montipora aequituberculata* Bernard, 1897 | Gaspar St., Belitung |
| *Montipora australiensis* Bernard, 1897 | Gaspar St. |
| *Montipora capricornis* Veron, 1985 | Gaspar St. |
| *Montipora danae* Milne Edwards and Haime, 1851* | Belitung |
| *Montipora flabellata* Studer, 1901* | Belitung |
| *Montipora floweri* Wells, 1954* | Belitung |
| *Montipora foliosa* (Pallas, 1766) | Gaspar St., Belitung |
| *Montipora hispida* (Dana, 1846) | Gaspar St. |
| *Montipora incrassata* (Dana, 1846) | Bangka |
| *Montipora informis* Bernard, 1897 | Bangka |
| *Montipora peltiformis* Bernard, 1897* | Belitung |
| *Montipora spumosa* (Lamarck, 1816) | Bangka |
| *Montipora turtlensis* Veron and Wallace, 1984* | Belitung |
| *Montipora undata* Bernard, 1897 | Bangka |
| **Agariciidae Gray, 1847 (6)** | |
| *Gardineroseris planulata* (Dana, 1846) | Gaspar St. |
| *Pavona cactus* (Forskål, 1775) | Gaspar St., Bangka |
| *Pavona decussata* Dana, 1846 | Gaspar St., Bangka, Belitung |
| *Pavona explanulata* (Lamarck, 1816) | Gaspar St. |
| *Pavona frondifera* (Lamarck, 1816) | Bangka |
| *Pavona varians* (Verrill, 1864) | Bangka |
| **Dendrophyllidae Gray, 1847 (4)** | Bangka |
| *Tubastraea faulkneri* Wells, 1982 | Gaspar St., Bangka |
| *Turbinaria frondens* (Dana, 1846) | Bangka |
| *Turbinaria peltata* (Esper, 1794) | Bangka |
| *Turbinaria reniformis* Bernard, 1896 | Bangka |
| **Diploastreidae Chevalier and Beauvais, 1987 (1)** | |
| *Diploastrea heliopora* (Lamarck, 1816) | Gaspar St., Bangka |
| **Euphylliidae Alloiteau, 1952 (6)** | |
| *Euphyllia glabrescens* (Chamisso and Eysenhardt, 1821) | Bangka, Belitung |
| *Fimbriaphyllia ancora* (Veron and Pichon, 1980) | Gaspar St., Bangka |
| *Fimbriaphyllia divisa* (Veron and Pichon, 1980) | Gaspar St. |
| *Galaxea astreata* (Lamarck, 1816) | Gaspar St., Bangka |
| *Galaxea fascicularis* (Linnaeus, 1767) | Gaspar St., Bangka |
| *Galaxea longisepta* Fenner and Veron, 2000 | Bangka |
| **Fungiidae Dana, 1846 (10)** | |
| *Ctenactis echinata* (Pallas, 1766) | Gaspar St., Bangka |
| *Danafungia horrida* (Dana, 1846) | Gaspar St. |
| *Fungia fungites* (Linnaeus, 1758) | Bangka |
| *Herpolitha limax* (Esper, 1797) | Gaspar St. |
| *Lithophyllon concinna* (Verrill, 1864) | Gaspar St. |
| *Lithophyllon repanda* (Dana, 1846) | Gaspar St. |
| *Lithophyllon undulatum* Rehberg, 1892 | Gaspar St., Bangka |
| *Pleuractis paumotensis* (Stutchbury, 1833) | Bangka |
| *Podabacia crustacea* (Pallas, 1766) | Gaspar St. |
| **Lobophylliidae Dai and Horng, 2009 (12)** | |

| Taxa | Distribution |
|---|---|
| *Acanthastrea echinata* (Dana, 1846) | Bangka |
| *Echinophyllia aspera* (Ellis and Solander, 1786) | Bangka |
| *Echinophyllia glabra* (Nemenzo, 1959) | Gaspar St. |
| *Homophyllia bowerbanki* (Milne Edwards and Haime, 1857) | Gaspar St. |
| *Lobophyllia corymbosa* (Forskål, 1775) | Bangka |
| *Lobophyllia costata* (Dana, 1846)* | Belitung |
| *Lobophyllia hataii* Yabe, Sugiyama and Eguchi, 1936 | Gaspar St., Bangka |
| *Lobophyllia hemprichii* (Ehrenberg, 1834) | Gaspar St., Bangka |
| *Lobophyllia radians* (Milne Edwards and Haime, 1849) | Gaspar St., Bangka, Belitung |
| *Lobophyllia recta* (Dana, 1846) | Gaspar St. |
| *Lobophyllia valenciennesii* (Milne Edwards and Haime, 1849) | Bangka |
| *Oxypora lacera* (Verrill, 1864) | Gaspar St. |
| **Merulinidae Verrill, 1865 (39)** | |
| *Astrea curta* Dana, 1846 | Gaspar St., Bangka |
| *Caulastraea curvata* Wijsman-Best, 1972 | Bangka |
| *Coelastrea palauensis* (Yabe and Sugiyama, 1936)* | Belitung |
| *Cyphastrea chalcidicum* (Forskål, 1775) | Bangka |
| *Cyphastrea serailia* (Forskål, 1775) | Bangka |
| *Dipsastraea danai* (Milne Edwards and Haime, 1857) | Bangka |
| *Dipsastraea favus* (Forskål, 1775) | Gaspar St., Bangka |
| *Dipsastraea maritima* (Nemenzo, 1971) | Gaspar St. |
| *Dipsastraea matthaii* (Vaughan, 1918) | Bangka |
| *Dipsastraea maxima* (Veron, Pichon and Wijsman-Best, 1977) | Gaspar St. |
| *Dipsastraea pallida* (Dana, 1846) | Bangka |
| *Dipsastraea speciosa* (Dana, 1846) | Gaspar St., Bangka |
| *Echinopora horrida* Dana, 1846 | Gaspar St. |
| *Echinopora lamellosa* (Esper, 1795) | Gaspar St., Bangka |
| *Echinopora mammiformis* (Nemenzo, 1959) | Gaspar St. |
| *Favites abdita* (Ellisa and Solander, 1786) | Bangka |
| *Favites flexuosa* (Dana, 1846) | Bangka |
| *Favites halicora* (Ehrenberg, 1834) | Gaspar St., Bangka, Belitung |
| *Favites pentagona* (Esper, 1795) | Bangka |
| *Favites rotundata* Veron, Pichon and Wijsman-Best, 1977 | Gaspar St. |
| *Goniastrea edwardsi* Chevalier, 1971 | Bangka |
| *Goniastrea minuta* Veron, 2000 | Bangka |
| *Goniastrea pectinata* (Ehrenberg, 1834) | Gaspar St. |
| *Goniastrea retiformis* (Lamarck, 1816) | Gaspar St., Bangka |
| *Hydnophora exesa* (Pallas, 1766) | Gaspar St. |
| *Hydnophora microconos* (Lamarck, 1816) | Bangka |
| *Hydnophora pilosa* Veron, 1985 | Gaspar St. |
| *Hydnophora rigida* (Dana, 1846) | Gaspar St., Bangka |
| *Leptoria phrygia* (Ellis and Solander, 1786) | Gaspar St., Bangka |
| *Merulina ampliata* (Ellis and Solander, 1786) | Gaspar St., Bangka |
| *Merulina scabricula* Dana, 1846 | Gaspar St., Bangka |
| *Mycedium elephantotus* (Pallas, 1766) | Gaspar St., Bangka |
| *Oulophyllia bennettae* (Veron, Pichon and Wijsman-Best, 1977) | Bangka |
| *Pectinia alcicornis* (Saville Kent, 1871) | Gaspar St., Bangka |
| *Pectinia lactuca* (Pallas, 1766) | Gaspar St., Bangka |
| *Pectinia paeonia* (Dana, 1846) | Gaspar St., Bangka |
| *Platygyra acuta* Veron, 2000* | Belitung |
| *Platygyra daedalea* (Ellis and Solander, 1786) | Gaspar St., Bangka |

| Taxa | Distribution |
|---|---|
| *Platygyra lamellina* (Ehrenberg, 1834) | Gaspar St., Bangka |
| **Oulastreidae Vaughan, 1919 (1)** | |
| *Oulastrea crispata* (Lamarck, 1816) | Bangka |
| **Plesiastreidae Dai and Horng, 2009 (1)** | |
| *Plesiastrea versipora* (Lamarck, 1816) | Bangka |
| **Pocilloporidae Gray, 1840 (3)** | |
| *Pocillopora damicornis* (Linnaeus, 1758) | Bangka |
| *Pocillopora grandis* Dana, 1846* | Belitung |
| *Seriatopora hystrix* Dana, 1846 | Gaspar St. |
| **Poritidae Gray, 1840 (18)** | |
| *Goniopora columna* Dana, 1846 | Gaspar St., Bangka |
| *Goniopora djiboutiensis* Vaughan, 1907 | Gaspar St. |
| *Goniopora eclipsensis* Veron and Pichon, 1982* | Belitung |
| *Goniopora lobata* Milne Edwards, 1860 | Bangka |
| *Goniopora pedunculata* Quoy and Gaimard, 1833 | Gaspar St., Bangka |
| *Goniopora stokesi* Milne Edwards and Haime, 1851 | Gaspar St. |
| *Porites annae* Crossland, 1952 | Gaspar St. |
| *Porites attenuata* Nemenzon, 1955* | Belitung |
| *Porites australiensis* Vaughan, 1918 | Bangka |
| *Porites cylindrica* Dana, 1846 | Gaspar St., Bangka |
| *Porites eridani* Umbgrove, 1940* | Belitung |
| *Porites harrisoni* Veron, 2000* | Belitung |
| *Porites lichen* (Dana, 1846) | Gaspar St. |
| *Porites lobata* Dana, 1846 | Gaspar St., Bangka |
| *Porites lutea* Milne Edwards and Haime, 1851 | Gaspar St., Bangka, Belitung |
| *Porites nigrescens* Dana, 1846 | Gaspar St., Bangka |
| *Porites rus* (Forskål, 1775) | Gaspar St., Bangka |
| *Porites solida* (Forskål, 1775) | Bangka |
| **Psammocoridae Chevalier and Beauvais, 1987 (1)** | |
| *Psammocora contigua* (Esper, 1794) | Gaspar St., Bangka |
| **Scleractinia incertae sedis (6)** | Gaspar St. |
| *Leptastrea pruinosa* Crossland, 1952 | Bangka |
| *Leptastrea purpurea* (Dana, 1846) | Gaspar St., Bangka |
| *Leptastrea transversa* Klunzinger, 1879 | Gaspar St., Bangka |
| *Pachyseris rugosa* (Lamarck, 1801) | Gaspar St., Bangka |
| *Pachyseris speciosa* (Dana, 1846) | Gaspar St., Bangka |
| *Physogyra lichtensteini* (Milne Edwards and Haime, 1851) | Gaspar St. |
| **Total = 142 species** | |

Note: * indicate new species reports. Coral reef (scleractinia) distribution recorded from Gaspar Strait (Siringoringo *et al.*, 2006); Bangka Island (Siringoringo and Hadi, 2013, 2015); and Belitung Island (current survey).

## Coral Reef Condition

The coral reef ecosystem in the eastern part of Belitung Island was found in poor to excellent condition. The excellent coral covers (>76%) were found in Pekandis Island. While coral covers in Keran Island were categorized in good condition (>55%). Poor condition (about <22%) only found in the Gosong Semut. The coral mortality index also indicated high in the Gosong Semut reef formation (Table 2). The fair coral cover also was reported in Bangka Island (Siringoringo and Hadi, 2013, 2015). Generally, the coral reef condition in Bangka Belitung Islands is in fair to good condition (Table 3).

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Table 2. Condition of coral reef on the eastern part of Belitung Island, Bangka Belitung Islands

| Sampling Sites | Live coral cover (%) | Dead coral cover (%) | CMI | Coral condition |
|---|---|---|---|---|
| Pekandis Island | 76.27 | 11.64 | 0.13 | Excellent |
| Keran Island | 55.17 | 3.42 | 0.06 | Good |
| Gosong Semut | 21.56 | 35.70 | 0.62 | Poor |
| Average | 50.99 | 16.92 | 0.27 | Good |
| SD | 27.59 | 16.78 | 0.31 | - |

Note: CMI (coral mortality index); a ratio of dead coral cover to the sum of dead and hard coral cover. Coral condition based on the live coral cover.

Table 3. Condition of coral reef in Bangka Belitung Islands, Indonesia

| Study Locations | Coral reef condition* | Reference |
|---|---|---|
| Gaspar Strait | Good (67 %) | (Siringoringo *et al.*, 2006) |
| Gaspar Strait | Fair (33 %) | (Putra *et al.*, 2018) |
| Bangka Island | Fair (47 %) | (Siringoringo and Hadi, 2013) |
| West Bangka Island | Fair (36 %) | (Siringoringo and Hadi, 2015) |
| East Belitung Island | Good (50 %) | (Johan *et al.*, 2015) |
| East Belitung Island | Good (50 %) | Current survey |

Note: * average value

## DISCUSSION

A total of 142 hard corals (Scleractinian) were reported from Bangka Belitung Islands. The appearance of corals dominantly is recorded from family Merulinidae, Acroporidae, and Poritidae. The most common species recorded in this area (i.e., appear in all study locations) such as *Acropora robusta*, *Acropora tenuis*, *Pavona decussata*, *Lobophyllia radians*, *Favites halicora*, and *Porites lutea* (Table 1). Globally, some uncommon corals species (Veron *et al.*, 2016) are reported such as *Tubastraea faulkneri, Galaxea longisepta, Lithophyllon undulatum, Favia danai, Goniastrea minuta, Pectinia alcicornis, Oulastrea crispate, Goniopora eclipsensis, Porites eridani*, and *Porites harrisoni.*

Meanwhile, we found 35 species of Scleractinians from the eastern part of Belitung Island. Twenty-two species are considered as new reports from this region (see Table 1). However, considering only one depth zone were surveyed, we expect more species will be found with further surveying. This is because the depth is affecting the coral cover and life form (Fahlevy *et al.*, 2017). Previous studies were also recorded various corals as unspecified species, e.g., *Acropora, Montipora, Porites, Favia, Favites*, and *Platygyra* (Siringoringo *et al.*, 2006; Siringoringo and Hadi, 2013, 2015).

We also consider the line intercept transect that we used possibly was not a precise method for a study like this. We compared our results with other previous studies that used different ways. Survey of corals diversity on Gaspar Strait, Bangka Island, and the western part of Bangka Island by various methods, i.e., line transect, belt transect, roving, were recorded 98, 89, 71 corals species, respectively (Siringoringo *et al.*, 2006; Siringoringo and Hadi, 2013, 2015). Other numerous surveys with more applied methods also found more species (Richards and Rosser, 2012; Waheed and Hoeksema, 2014; Richards, 2015). A similar study on Scleractinian corals with the addition of museum collections examination also recorded more corals species (Richards *et al.*, 2014). Some cryptic and small colony of Scleractinian corals were possibly oversight if only one method was

applied. Additional methods (e.g., belt transect, roving) and more replications are recommended to use to find more species. Additional data from museum collection or any literature review will be required for updating the species list in a particular area (Huang *et al.*, 2009, 2015).

The coral reef around Bangka Belitung Islands considers being disturbed by human activities (Putra *et al.*, 2018). Corals and mangrove forest ecosystems were reported to be degraded and declined in terms of species numbers and their area coverage (Sari and Rosalina, 2016; Putra *et al.*, 2018). The hard coral in this region also infected by various coral diseases, e.g., black band disease, white syndrome, skeleton eroding band, and yellow band disease (Johan *et al.*, 2015). Offshore mining activity increased community wealth, but on the other side, the activity changes environmental stability (Nurtjahya *et al.*, 2017). After the mining activity is done, the location will experience heavy organic water pollution (Liliani *et al.*, 2019).

Bangka Belitung Islands are well known as destination priorities for marine tourism activity in Indonesia (Valeriani and Wardhani, 2015). Coastal development with an environmentally friendly approach needed. Restoration of the degraded area after the post-mining activity is mandatory for other purposes of the area, i.e., tourism, aquaculture, and open space (Pirwanda and Pirngadie, 2015). Effective reef restoration and protection must include all stakeholders and an adaptive management approach (Ban *et al.*, 2011).

## CONCLUSIONS

Coral reef diversity in Bangka Belitung Islands is varied between sites. The study indicates the condition of the coral reef ecosystem in the eastern part of Belitung Island is relatively good. However, other location (Bangka Island, Gaspar Strait) still experiences a fair condition. One hundred forty-two species of Scleractinian corals were recorded. Additional fieldwork methods and other data sources, e.g., museum collection, the literature review, are necessary for biodiversity surveys.

## ACKNOWLEDGEMENTS

The authors would like to thank the Balai Lingkungan Hidup Daerah (BLHD) of East Belitung Regency for logistics support during fieldwork. Two anonymous reviewers are thanked for improving an earlier version of this manuscript.

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