Potential stock of stony corals in Indonesia

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Abstract. Indonesia is part of the coral triangle region which is known as the world’s highest marine biodiversity, including stony corals. This situation used to benefit local people by trading ornamental corals. The aims of this study are to investigate the potential stock of ornamental corals as well as the reef conditions. The study took place in Kendari, Luwuk, Sumbawa and Belitung where the ornamental coral-collecting activities used to occur. The result indicates there were approximately 110 species of corals found with the majority of coral status are common (harvest limited) and uncommon (harvest with cautions). Based on the juvenile existence, only 66 corals have potential stocks. Euphyllidae (Euphyllia glabrescens and Plerogyra sinousa) had the highest potential stock in Kendari and Luwuk, while Fungiidae (Fungia spp) held the highest potential stock in Belitung and Sumbawa. This difference is likely related to different locality or habitat type. In general, coral reefs in Kendari, Luwuk and Belitung are in good condition, while fair condition occurs in Sumbawa. To conclude, the stock of ornamental corals is still high and the reefs are generally good, suggesting the collecting activities may be allowed with proper quota and continuous monitoring habitat condition to ensure the sustainability.

1. Introduction

Indonesia is part of the coral triangle region, well known as the world’s highest marine biodiversity. There are about 2,500,000 hectares of Indonesia coral reefs with 83 genera and 569 species of hard corals, representing approximately 76% and 69% for genera and species of corals of the world [1]. 70.48% of the reefs have less than 50% coral covers, mainly distributed on the south coast of Java, south coast of East Timor, South Sulawesi, west coast of Sumatera, and the South China Sea. This situation is firmly attributed to its natural condition (especially the reefs facing the Indian Ocean), natural disturbances, and anthropogenic factors [2]. Thus, the authority should not only concern about managing the reefs, but also the people’s activities.

Ornamental corals have been popular as people become more interested in keeping them in aquariums for their house decoration. This causes the collection activities to soar for export, especially and has become an essential economic factor for the locals. Surprisingly, over 90% of coral trading occurred in Indonesia [3]. In this situation, the authority had already set up the quotas for export to...
ensure that there would be no detrimental effect on the species as listed on CITES appendix II. However, smuggling activities still occurred and might deplete the potential stock on the local scale [4]. Furthermore, the harvest could alter the benthic community structures and decrease the coral cover. Since 2018, the activity has ceased as fish quarantine and inspection agency has no longer issued the health certificate for both wild and coral farms to export.

In this study, we provide the information regarding the potential stock of ornamental corals in some locations where people used to harvest the corals actively. Furthermore, this study also investigates the coral reef condition as another consideration of whether the reefs are healthy enough to sustain the ecosystem. Besides, a recommendation will be provided to policymakers to achieve a sustainable environment and society.

2. Materials and methods
2.1. The study area
The study took place at four locations, two locations located in the coral triangle region (Kendari and Luwuk), and the rest are outside (Sumbawa and Belitung) (figure 1). These locations were selected as the harvest activities mainly occurred. Each of these has ten sites to observe; involving local people to guide where they used to collect the corals.

![Figure 1. The locations of the study](image)

2.2. Methods
The study collected the data of the number of occurrences, genera dominance, size of the colony, and coral cover, which then were classified into a 1-4 scaled value for each. Afterward, the total amount could be obtained by adding up all of the benefits and then sorted into five categories; very rare (5-7), rare (8-10), uncommon (11-13), common (14-16), and very common (17-20) [5]. To investigate the potential stock, the abundance of juveniles sized less than 5 cm was calculated – assuming that the juveniles are subject to the harvest – and then extrapolated to the size of reef areas. Identification of corals refers to “Corals of the World” [6].
3. Results and discussion

3.1. Total value-based coral status

The total number of species found from 4 locations in this study is about 110 species belonging to 14 families (appendix A). This number is much fewer than previous studies conducted in the areas [7, 8, 9]. In this case, the method used was different; this study did not use an explorative approach to observe the biodiversity of hard corals in the reefs but focused on the corals along the belt transect, thus making the result much different in terms of the number of species. However, the corals found are nearly similar to what the studies confirmed. Therefore, it indicates that there might be no, at least, genera loss in the locations.

In terms of the total value, the range starts from 6 (very rare) to 20 (very common) (appendix B). There are only one species that are categorized “very rare”, Heliofungia actiniformis, meaning that the coral is strictly prohibited for harvest. Interestingly, this condition only occurs at Belitung’s Station 4. Still, at the other five stations in Belitung, the coral status is uncommon (limited to harvest) to common (yield with caution), and the other four stations were not found. The farmers should recognize this uneven distribution that they could only collect at particular sites only with caution or limited numbers. However, this long polyp mushroom coral has been the main target for collection in Makassar and caused a significant decline in the population, especially the juveniles due to its higher price [10].

In general, the majority of the corals’ total value range from 14 to 17 (common to uncommon) (appendix B). In Luwuk, the range of total value is between 14 and 20 (common to very common) from 54 species found, and this is relatively similar to Kendari, where the range is between 12 and 19 (common to very common) from 72 species seen. In this case, although having the same coral status as Luwuk, Kendari is more diverse, indicating that the environmental condition in Kendari is much suitable for plenty of corals to strive. On the other hand, Sumbawa and Belitung have a nearly similar number of species found, 49 and 52 species respectively, but have a relatively different range of corals’ total value, 9 – 19 (rare to very common) for Sumbawa and 6 – 19 (very rare to very common) for Belitung. Such a result could be attributed to its natural conditions where the biodiversity is declining as the distance gets far from the biodiversity center [11] or to over-harvesting in which the collection activities are faster than the corals’ reproduction and growth [12]. Overall, the results could be assumed that the majority of corals are still abundant in the field, but there is a tendency of a rarity for some corals. Also, although not all corals are preferable for trading - only the unique colors, shapes, and appropriate sizes that farmers commonly collect – the very rare and rare-categorized corals may vanish if the morphological characters meet what the market demands.

3.2. Potential stock of corals

Not all of the corals found in the locations could be harvested, although the corals are categorized common. In this case, to preserve the population, only corals that have juveniles can be collected. Furthermore, juveniles’ corals sized less or equal to 5 cm is the main target for collection as they do not take too much space in aquariums. However, more than 5 cm sized corals may have reached reproductive maturity, which is very important for population sustainability [13], thus not recommended to be harvested. Also, harvesting big-sized corals may damage the reefs as they need to break the colonies to get the proper size.

In terms of the juvenile abundance of coral families, in general, Sumbawa has the highest abundance for Fungiidae by 296 ind/100m², followed Pocilloporidae 178 ind/100 m² and then Poritidae by 86 ind/100 m² (figure 2). Other significant families, such as Euphylliidae, Faviidae, Mussidae, and Trachyphylliidae, possess the highest abundance in Kendari by 145 ind/100 m², 26 ind/100 m², 110 ind/100 m² and 28 ind/100 m² respectively. In terms of total abundance, the most abundant family is Fungiidae and followed by Euphylliidae by 362 ind/100 m² and 341 ind/100 m², respectively. In contrast,
Acroporidae, Agariciidae, Dendrophylliidae, and Stylasteridae have a total abundance of fewer than ten ind/100 m². This result might be attributed to the mode of development - Fungiidae, Pocilloporidae, and Poritidae are generally categorized brooder corals where the planula larvae commonly settle within hours after release and close to the parent corals, making them more abundant on particular sites than broadcast spawning corals which have wider dispersal [14, 15, 16, 17].

Figure 2. The abundance of hard coral families in four different location

![Figure 2](image_url)

Figure 3. a) *Heliofungia actiniformis* in Belitung, b) mushroom corals, *Fungia* spp, in Sumbawa

In terms of harvest, in total, there are about 66 out of 110 corals that are allowed to collect from all locations with each location has its own number (figure 4, 5, 6, 7). In Kendari, the highest potential stock of hard corals belongs to *Euphyllia glabrescens* by 85611 ind/145.99 ha. In Luwuk, *Plerogyra sinousa* possesses the highest potential stock by 154003 ind/468.39 ha. Both in Belitung and Sumbawa, *Fungia* spp holds the highest potential stock by 444114 ind/1110.01 ha and 1535505 ind/330.39 ha respectively. *E. glabrescens* and *P. sinousa*, belonging to Family Euphylliidae, are the main target for trading due to its beautiful fleshy polyps [18]. Although such corals have wide distribution and were distributed in all locations, the study found that they are commonly abundant in unexposed reefs with high water transparency. The majority of observed reefs in Kendari and Luwuk are sheltered to semi-exposed with low turbidity and far from human anthropogenic impact. Previous studies indicate the
same result that Euphylliidae was poor both in abundance and diversity in the places where environment stress is high [19, 20]. On the other hand, *Fungia* appears to be the most abundant in Sumbawa and Belitung where the reefs have generally declining slopes with sandy bottom. This result difference could be attributed to different locality or habitat type. In general, the potential stock hard corals are still high, but not all corals have the same number to be harvested.

**Figure 4.** Potential stock of stony corals in Kendari

**Figure 5.** Potential stock of stony corals in Luwuk
Figure 6. Potential stock of stony corals in Belitung

Figure 7. Potential stock of stony corals in Sumbawa
3.3 Coral reef condition

The result indicates that there is a significant difference in the live coral cover among the locations (p-value = 0.00) (figure 9). Three sites are categorized as good condition (Luwuk, Kendari, and Belitung), while fair conditions occurred in Sumbawa by having the lowest percent cover. Nevertheless, Sumbawa possesses the highest potential stocks among the locations, showing that the reefs have more juveniles than adults. This result of coral cover is much better than previous studies conducted in the same places [7, 8, 9, 21], indicating that the collection activities might have minimal impact on the reefs.

4. Conclusion

In general, the potential stock of ornamental corals is still high, and the majority of reefs are in good condition. Thus, collection activities may be allowed under clear regulations that consider the environment and economic sustainability. It is strongly suggested to develop the mariculture that can replace the wild harvest in the future.
5. References

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### Appendix A. Abundance of < 5 cm juvenile corals found in the observation locations

| No | Family     | Coral Type               | Kendari | Luwuk | Belitung | Sumbawa |
|----|------------|--------------------------|---------|-------|----------|---------|
| 1  | Mussidae   | Acanthastrea bowerbanki  | 4       | 2     | 0        | 0       |
| 2  | Mussidae   | Acanthastrea echinata    | 0       | 0     | 0        | 0       |
| 3  | Mussidae   | Acanthastrea rotundiflora| 0       | 0     | 0        | 0       |
| 4  | Mussidae   | Acanthastrea spp         | 0       | 0     | 1        | 0       |
| 5  | Acroporidae| Acropora elegans         | 1       | 0     | 0        | 0       |
| 6  | Acroporidae| Acropora carduus         | 0       | 0     | 0        | 0       |
| 7  | Acroporidae| Acropora formosa         | 0       | 0     | 0        | 0       |
| 8  | Acroporidae| Acropora granulosa       | 0       | 0     | 0        | 0       |
| 9  | Acroporidae| Acropora loriipes        | 0       | 0     | 0        | 0       |
| 10 | Acroporidae| Acropora brueggemannii   | 0       | 0     | 0        | 0       |
| 11 | Acroporidae| Acropora caroliniana     | 0       | 0     | 0        | 0       |
| 12 | Acroporidae| Acropora spp             | 0       | 0     | 0        | 0       |
| 13 | Poritidae  | Alveopora alingi         | 0       | 0     | 0        | 0       |
| 14 | Poritidae  | Alveopora catalai        | 0       | 7     | 0        | 0       |
| 15 | Poritidae  | Alveopora tizardi        | 0       | 1     | 0        | 0       |
| 16 | Acroporidae| Anacropora pillai        | 0       | 0     | 0        | 0       |
| 17 | Acroporidae| Astreopora myriophthalma | 0       | 0     | 0        | 0       |
| 18 | Mussidae   | Astralommussa rowleyensis| 12      | 1     | 0        | 1       |
| 19 | Faviidae   | Barabattoia amicorum     | 0       | 0     | 0        | 0       |
| 20 | Mussidae   | Blastomussa welsi        | 2       | 0     | 2        | 0       |
| 21 | Faviidae   | Caulastrea curvata       | 15      | 3     | 0        | 0       |
| 22 | Faviidae   | Caulastrea furcata       | 0       | 0     | 2        | 0       |
| 23 | Euphyllidae| Catalaphyllia jardinei   | 2       | 0     | 0        | 38      |
| 24 | Fungiidae  | Ctenactis echinata       | 0       | 0     | 0        | 0       |
| 25 | Mussidae   | Cynarina lacrymalis      | 66      | 18    | 2        | 2       |
| 26 | Fungiidae  | Cycloseris costulata     | 1       | 0     | 0        | 0       |
| 27 | Fungiidae  | Cycloseris fragilis      | 2       | 0     | 0        | 75      |
| 28 | Faviidae   | Cyphastrea microphthalma | 0       | 0     | 0        | 0       |
| 29 | Faviidae   | Cyphastrea decadia       | 0       | 0     | 0        | 0       |
| 30 | Faviidae   | Diploastraea heliopora   | 0       | 0     | 6        | 0       |
| 31 | Euphyllidae| Euphyllia ancora         | 11      | 15    | 3        | 5       |
| 32 | Euphyllidae| Euphyllia cristata       | 29      | 10    | 4        | 8       |
| 33 | Euphyllidae| Euphyllia paradivisa     | 8       | 0     | 0        | 0       |
| 34 | Euphyllidae| Euphyllia divisa         | 11      | 19    | 0        | 0       |
| 35 | Euphyllidae| Euphyllia globrescens    | 19      | 8     | 2        | 3       |
| 36 | Euphyllidae| Euphyllia paraancora     | 18      | 4     | 0        | 0       |
| 37 | Euphyllidae| Euphyllia yaeyamaensis   | 10      | 12    | 0        | 2       |
| 38 | Euphyllidae| Euphyllia sp.            | 0       | 2     | 0        | 0       |
| 39 | Pectinidae | Echinophyllia echinata   | 0       | 0     | 0        | 0       |
| 40 | Pectinidae | Echinophyllia sp.        | 0       | 0     | 2        | 1       |
| 41 | Pectinidae | Echinophyllia aspera     | 0       | 0     | 0        | 0       |
|   | Family    | Genus          | Count 1 | Count 2 | Count 3 |
|---|-----------|----------------|---------|---------|---------|
| 42| Faviidae  | *Echinopora lamellosa* | 0       | 0       | 0       |
| 43| Faviidae  | *Echinopora spp*     | 0       | 0       | 0       |
| 44| Faviidae  | *Favia speciosa*     | 0       | 0       | 0       |
| 45| Faviidae  | *Favia matthai*      | 0       | 0       | 0       |
| 46| Faviidae  | *Favia spp*          | 5       | 0       | 2       |
| 47| Faviidae  | *Favites spp*        | 6       | 1       | 0       |
| 48| Fungiidae | *Fungia*             | 21      | 0       | 40      |
| 49| Oculinidae| *Galaxea astraea*    | 4       | 0       | 6       |
| 50| Oculinidae| *Galaxea fascicularis* | 4     | 0       | 4       |
| 51| Oculinidae| *Galaxea paucisepta* | 0       | 1       | 0       |
| 52| Oculinidae| *Galaxea longisepta* | 0       | 9       | 0       |
| 53| Oculinidae| *Galaxea archelia*   | 0       | 0       | 0       |
| 54| Oculinidae| *Galaxea spp*        | 0       | 6       | 1       |
| 55| Poritidae | *Goniastrea aspera*  | 0       | 1       | 0       |
| 56| Poritidae | *Goniopora columna*  | 3       | 1       | 5       |
| 57| Poritidae | *Goniopora lobata*   | 0       | 1       | 0       |
| 58| Poritidae | *Goniopora spp*      | 1       | 0       | 3       |
| 59| Poritidae | *Goniopora stokesi*  | 13      | 0       | 0       |
| 60| Fungiidae | *Heliofungia actiniformis* | 0     | 1       | 0       |
| 61| Fungiidae | *Herpolitha limax*   | 0       | 0       | 1       |
| 62| Merulinidae| *Hydnophora pilosa*  | 1       | 0       | 0       |
| 63| Merulinidae| *Hydnophora rigida*  | 0       | 0       | 2       |
| 64| Faviidae  | *Leptastrea purpurea* | 0       | 0       | 0       |
| 65| Faviidae  | *Leptoria phrygia*   | 0       | 0       | 0       |
| 66| Agariciidae| *Leptoseris exlanulata* | 0     | 0       | 0       |
| 67| Agariciidae| *Leptoseris scabra*  | 1       | 0       | 0       |
| 68| Mussidae  | *Lobophyllia robusta* | 0       | 0       | 0       |
| 69| Mussidae  | *Lobophyllia dentatus* | 0     | 0       | 0       |
| 70| Mussidae  | *Lobophyllia hemprichii* | 1     | 0       | 0       |
| 71| Mussidae  | *Lobophyllia corymbosa* | 1    | 0       | 0       |
| 72| Mussidae  | *Lobophyllia spp*    | 0       | 1       | 28      |
| 73| Merulinidae| *Merulina ampiata*   | 0       | 0       | 21      |
| 74| Faviidae  | *Montastrea multipunctata* | 0   | 0       | 2       |
| 75| Faviidae  | *Montastrea sp.*     | 0       | 0       | 0       |
| 76| Acroporidae| *Montipora sp.*     | 0       | 0       | 4       |
| 77| Euphyllida| *Nemenzophyllia turbida* | 3    | 0       | 0       |
| 78| Pectinidae| *Mycedium elephantotus* | 0   | 2       | 0       |
| 79| Pectinidae| *Mycedium robokaki*  | 0       | 4       | 0       |
| 80| Faviidae  | *Oulophyllia sp.*    | 0       | 0       | 0       |
| 81| Pectinidae| *Oxypora glabra*     | 0       | 0       | 0       |
| 82| Pectinidae| *Oxypora lacera*     | 0       | 0       | 0       |
| 83| Pectinidae| *Oxypora spp*        | 0       | 0       | 0       |
| 84| Agariciidae| *Pavona sp.*        | 0       | 0       | 0       |
| No. | Family          | Genus      | Species          | Juveniles 5 cm | Harvested 5 cm | Total | Ref. |
|-----|----------------|------------|------------------|----------------|----------------|-------|-----|
| 85  | Pocilloporidae | *Palauastrea* | *ramosa*         | 0              | 0              | 0     |     |
| 86  | Agariciidae    | *Pachyseris* | *speciosa*       | 0              | 0              | 0     |     |
| 87  | Pectinidae     | *Pectinia*  | *alicornis*      | 8              | 1              | 4     | 6   |
| 88  | Pectinidae     | *Pectinia*  | *paenia*         | 0              | 0              | 7     | 0   |
| 89  | Pectinidae     | *Pectinia*  | *elongata*       | 0              | 0              | 0     |     |
| 90  | Pectinidae     | *Pectinia*  | *lactuca*        | 0              | 1              | 0     | 0   |
| 91  | Euphyllidae    | *Physogyra* | *lichtensteinii* | 0              | 2              | 9     | 0   |
| 92  | Euphyllidae    | *Plerogyra* | *simplex*        | 2              | 7              | 4     | 0   |
| 93  | Euphyllidae    | *Plerogyra* | *sinuosa*        | 32             | 21             | 10    | 9   |
| 94  | Faviidae       | *Platygyra* | *lamellina*      | 0              | 0              | 0     |     |
| 95  | Pocilloporidae | *Pocillopora* | *damicornis*     | 0              | 0              | 0     |     |
| 96  | Fungiidae      | *Podabacea* | sp.              | 0              | 0              | 0     |     |
| 97  | Fungiidae      | *Polyphylia* | *talpina*        | 0              | 0              | 0     |     |
| 98  | Poritidae      | *Porites*   | *lutea*          | 0              | 0              | 0     |     |
| 99  | Poritidae      | *Porites*   | sp.              | 0              | 0              | 3     | 0   |
| 100 | Fungiidae      | *Sandalolitha* | sp.             | 0              | 0              | 0     |     |
| 101 | Mussidae       | *Scolymia*  | *vitiensis*      | 16             | 1              | 5     | 0   |
| 102 | Pocilloporidae | *Seriatopora* | *caliendrum*    | 0              | 0              | 0     |     |
| 103 | Stylastreidae  | *Stylaster* | sp.              | 0              | 0              | 0     | 2   |
| 104 | Mussidae       | *Symphyllia* |                 | 8              | 0              | 4     | 0   |
| 105 | Pocilloporidae | *Stylophora* | *pistillata*     | 0              | 0              | 0     | 178 |
| 106 | Trachyphyllidae| *Trachyphyllia* | *geoffroyi*     | 28             | 6              | 0     | 0   |
| 107 | Dendrophyllidae| *Tubastrea*  | *micrantha*      | 0              | 1              | 0     | 0   |
| 108 | Dendrophyllidae| *Turbinaria* | *frondens*       | 0              | 0              | 2     | 0   |
| 109 | Dendrophyllidae| *Turbinaria* | *reniformis*     | 1              | 0              | 0     | 0   |
| 110 | Dendrophyllidae| *Tubastrea*  | *faulkneri*      | 3              | 0              | 0     | 0   |

0 = not found or no ≤ 5 cm-sized juveniles (not allowed to harvest)
### Appendix B. Total value of corals found at each site (very rare (5-7), rare (8-10), uncommon (11-13), common (14-16) and very common (17-20))

**Kendari**

| No | Species                          | KDR1 | KDR2 | KDR3 | KDR4 | KDR5 | KDR6 | KDR7 | KDR8 | KDR9 | KDR10 |
|----|----------------------------------|------|------|------|------|------|------|------|------|------|-------|
| 1  | Acanthastrea bowerbanki          | 15   |      |      |      |      |      |      |      |      | 17    |
| 2  | Acropora elegans                 | 16   | 18   |      |      |      |      |      |      |      |       |
| 3  | Acropora carduus                 |      |      | 19   |      |      |      |      |      |      |       |
| 4  | Acropora formosa                 |      |      |      | 17   |      |      |      |      |      |       |
| 5  | Acropora granulosa               |      |      |      |      | 16   |      |      |      |      |       |
| 6  | Acropora loripes                 |      |      |      |      |      | 18   |      |      |      |       |
| 7  | Alveopora alingi                 |      |      |      |      |      |      |      |      |      | 16    |
| 8  | Anacropora pillai                |      |      |      |      |      |      |      |      |      | 14    |
| 9  | Astreopora myriophthalma         |      |      |      |      |      |      |      |      |      | 16    |
| 10 | Australomussa rowleyensis        | 15   | 17   | 15   | 16   | 16   | 14   | 15   | 16   |      |       |
| 11 | Barabattoa amicorum              |      |      |      |      |      |      |      |      |      | 13    |
| 12 | Blastomussa wellsi               |      |      |      |      |      |      |      |      |      | 16    |
| 13 | Caulastrea curvata               |      |      |      | 15   | 16   | 17   |      |      |      |       |
| 14 | Caulastrea furcata               |      |      |      |      |      |      |      |      |      | 15    |
| 15 | Catalaphyllia jardinei           | 13   | 19   |      |      |      |      |      |      |      | 15    |
| 16 | Ctenactis echinata               |      |      |      |      |      |      |      |      |      | 16    |
| 17 | Cynarina lacrymalis              | 15   | 17   |      | 16   | 16   | 14   | 14   | 17   |      |       |
| 18 | Cycloseris costulata             |      |      |      |      |      |      |      |      |      | 12    |
| 19 | Cycloseris fragilis              |      |      |      |      |      |      |      |      |      | 15    |
| 20 | Cyphastrea microphthalmal        |      |      |      |      |      |      |      |      |      | 14    |
| 21 | Euphyllia ancora                 | 15   | 17   | 15   | 16   | 16   | 15   | 15   | 17   | 18   |       |
| 22 | Euphyllia cristata               |      |      |      | 16   | 16   | 15   | 15   | 16   |      |       |
| 23 | Euphyllia paradivisa             |      |      |      | 16   | 15   | 16   | 16   |      |      |       |
| 24 | Euphyllia divisa                 | 15   | 16   | 16   | 16   | 15   | 15   | 16   | 17   |      |       |
| 25 | Euphyllia glabrescens            | 15   | 16   | 15   | 15   | 15   | 16   |      |      |      |       |
| 26 | Euphyllia paraancora             | 15   | 17   |      | 16   | 15   | 15   | 16   |      |      |       |
| 27 | Euphyllia yaeyamaensis           | 18   | 16   | 16   | 15   | 16   | 17   |      |      |      |       |
| 28 | Echinophyllia echinata           |      |      |      |      |      |      |      |      |      | 17    |
| 29 | Favia speciosa                   |      |      |      |      |      |      |      |      |      | 15    |
| 30 | Favia spp.                       | 15   | 16   | 15   | 16   | 15   | 16   | 16   | 16   | 17   |       |
| 31 | Favites spp.                     | 15   | 17   | 14   | 16   | 16   | 15   | 16   | 17   |      |       |
| 32 | Fangia spp.                      | 15   | 15   | 16   | 16   | 14   | 16   | 17   |      |      |       |
| 33 | Galaxea astreata                 | 13   | 17   | 13   |      | 15   | 17   | 16   |      |      |       |
| 34 | Galaxea fascicularis             | 15   | 13   | 15   | 15   | 15   | 15   | 18   |      |      |       |
| 35 | Galaxea puncisepta               |      |      |      |      |      |      |      |      |      | 16    |
| 36 | Galaxea spp.                     |      |      |      |      |      |      |      |      |      | 17    |
| 37 | Goniopora columna                |      |      |      |      |      |      |      | 17   | 16   | 16   |
| 38 | Goniopora lobata                 |      |      |      |      |      |      |      |      |      | 17    |
| No | Species                      | LWK1 | LWK2 | LWK3 | LWK4 | LWK5 | LWK6 | LWK7 | LWK8 | LWK9 | LWK10 |
|----|------------------------------|------|------|------|------|------|------|------|------|------|-------|
| 39 | Goniopora spp.               |      |      |      |      |      |      |      |      |      |       |
| 40 | Goniopora stokesi            | 18   | 16   | 16   | 16   | 17   |      |      |      |      |       |
| 41 | Heliofungia actiniformis     | 17   | 16   | 16   | 15   |      |      |      |      |      |       |
| 42 | Hydnophora pilosa            | 19   | 15   |      |      |      |      |      |      |      |       |
| 43 | Hydnophora rigida            | 17   |      |      |      |      |      |      |      |      |       |
| 44 | Leptastrea purpurea          | 12   |      |      |      |      |      |      |      |      |       |
| 45 | Leptoseris exanulata         | 15   |      |      |      |      |      |      |      |      |       |
| 46 | Leptoseris scabra            | 14   |      |      |      |      |      |      |      |      |       |
| 47 | Lobophyllia robusta          | 18   |      |      |      |      |      |      |      |      |       |
| 48 | Lobophyllia dentatus         |      |      |      |      |      |      |      |      |      | 17    |
| 49 | Lobophyllia hemprichii       | 17   | 17   |      |      |      |      |      |      |      | 15    |
| 50 | Lobophyllia corymbosa        |      | 14   |      |      |      |      |      |      |      | 18    |
| 51 | Montastrea multifunctata     |      |      |      |      |      |      |      |      |      | 15    |
| 52 | Nemenzophyllia turbida       | 16   | 16   | 16   |      |      |      |      |      |      | 17    |
| 53 | Oxypora lacera               | 14   |      |      |      |      |      |      |      |      |       |
| 54 | Oxypora spp.                 |      | 18   |      |      |      |      |      |      |      |       |
| 55 | Palauastrea ramosa           | 19   |      |      |      |      |      |      |      |      |       |
| 56 | Pachyseris speciosa          | 16   |      |      |      |      |      |      |      |      |       |
| 57 | Pectinia alcicornis           | 15   | 17   | 14   | 16   | 16   | 16   | 15   |      |      | 17    |
| 58 | Pectinia paenonea            | 14   |      |      |      |      |      |      |      |      |       |
| 59 | Pectinia elongata            | 18   | 17   |      |      |      |      |      |      |      |       |
| 60 | Physogyra lichensteini       |      |      |      |      |      |      |      |      |      | 17    |
| 61 | Plerogyra simplex            | 15   | 16   | 16   | 16   | 15   | 17   | 16   |      |      |       |
| 62 | Plerogyra simusosa           | 15   | 17   | 16   | 16   | 16   | 15   | 15   | 16   | 17   |       |
| 63 | Platygyra lamellina          | 16   |      |      |      |      |      |      |      |      |       |
| 64 | Pocillopora damicornis       |      |      |      |      |      |      |      |      |      | 15    |
| 65 | Polyphyllia tajlina          | 16   |      |      |      |      |      |      |      |      |       |
| 66 | Porites lutea                | 15   |      |      |      |      |      |      |      |      |       |
| 67 | Scollymia vitiensis          | 15   | 16   | 16   | 16   | 16   | 13   | 15   | 13   | 16   |       |
| 68 | Sympyilla spp.               | 16   | 15   | 16   | 15   |      |      |      |      |      | 16    |
| 69 | Trachyphyllia geoffroyi      | 14   | 16   |      |      |      |      |      |      |      | 17    |
| 70 | Turbinaria frondens          | 17   | 18   | 15   | 16   | 16   | 17   |      |      |      |       |
| 71 | Turbinaria reniformis        | 12   |      |      |      |      |      |      |      |      | 15    |
| 72 | Tubastrea falkneri           |      |      |      |      |      |      |      |      |      | 16    |

**Luwuk**

| No | Species                        | LWK1 | LWK2 | LWK3 | LWK4 | LWK5 | LWK6 | LWK7 | LWK8 | LWK9 | LWK10 |
|----|--------------------------------|------|------|------|------|------|------|------|------|------|-------|
| 1  | Acanthastrea bowerbanki        |      |      |      |      |      |      |      |      |      |       |
| 2  | Acanthastrea echinata          |      |      |      |      |      |      |      |      |      | 18    |
| 3  | Acanthastrea rotundoflora      | 16   |      |      |      |      |      |      |      |      | 17    |
| 4  | Alveopora catalai              | 17   | 16   | 17   |      |      |      |      |      |      | 17    |
|   | Species                        |   |   |   |   |
|---|-------------------------------|---|---|---|---|
|5  | Alveopora tizardi             |   |   |   |17|
|6  | Australomussa rowleyensis    |16 |16 |17 |17 |
|7  | Caulastrea curvata            |   |   |   |17 |
|8  | Cynarina laccymalis           |   |   |17 |17 |
|9  | Cyphastrea decadua            |   |   |   |16 |
|10 | Euphyllia ancora              |17 |17 |17 |18 |
|11 | Euphyllia cristata            |17 |17 |17 |17 |
|12 | Euphyllia paradivisa          |   |   |   |17 |
|13 | Euphyllia divisa              |17 |17 |17 |17 |
|14 | Euphyllia glabrescens         |17 |17 |17 |17 |
|15 | Euphyllia paraeocrina         |16 |17 |17 |17 |
|16 | Euphyllia yaeyamaensis        |17 |18 |17 |17 |
|17 | Euphyllia sp.                 |   |   |   |17 |
|18 | Echinophyllia aspera          |   |   |   |17 |
|19 | Echinopora lamellosa          |18 |19 |   |   |
|20 | Echinopora spp                |   |   |   |18 |
|21 | Favia sp.                     |18 |17 |17 |17 |
|22 | Favites sp.                   |17 |17 |17 |17 |
|23 | Fungia sp.                    |   |   |   |17 |
|24 | Galaxea fascicularis          |   |   |   |17 |
|25 | Galaxea paucisecta            |18 |17 |18 |17 |
|26 | Galaxea longisepa             |   |   |17 |17 |
|27 | Galaxea spp                   |17 |17 |18 |17 |
|28 | Goniastrea aspera             |   |   |   |17 |
|29 | Goniopora columna             |16 |18 |19 |18 |
|30 | Goniopora lobata              |18 |18 |19 |19 |
|31 | Goniopora spp                 |   |   |   |18 |
|32 | Heliophyllia actiniformis     |17 |17 |17 |17 |
|33 | Lobophyllia hemprichii        |20 |19 |18 |18 |
|34 | Lobophyllia corymbosa         |20 |19 |19 |19 |
|35 | Lobophyllia spp               |19 |17 |   |18 |
|36 | Mycedium elephantotus         |19 |18 |18 |17 |
|37 | Mycedium robokaki             |17 |19 |18 |17 |
|38 | Oxypora glabra                |17 |18 |19 |19 |
|39 | Oxypora lacerka               |18 |18 |   |   |
|40 | Oxypora spp                   |20 |18 |18 |18 |
|41 | Pectinia alcicornis            |16 |18 |18 |17 |
|42 | Pectinia lactuca               |   |   |17 |   |
|43 | Physogyra lichtensteini       |17 |17 |17 |19 |
|44 | Plerogyra simplex             |18 |18 |18 |17 |
|45 | Plerogyra sinuosa             |17 |17 |17 |17 |
|46 | Scolymia vitiensis            |16 |   |   |16 |
|47 | Seriatopora caliendrum        |15 |   |   |   |
| No | Species                              | BLT1 | BLT2 | BLT3 | BLT4 | BLT5 | BLT6 | BLT7 | BLT8 | BLT9 | BLT10 |
|----|-------------------------------------|------|------|------|------|------|------|------|------|------|-------|
| 48 | Stylaster sp.                       |      |      |      |      |      |      |      |      |      | 17    |
| 49 | Symphyllia spp                      | 14   | 17   | 18   | 18   | 18   | 18   | 17   |      |      |       |
| 50 | Stylophora pistillata               |      |      |      |      |      |      |      |      |      |       |
| 51 | Trachyphyllia geoffroyi             |      |      |      |      |      |      |      |      |      | 17    |
| 52 | Tabastrea micrantha                 |      |      |      |      |      |      |      |      |      | 16    |
| 53 | Turbinaria frondens                 | 18   | 18   |      |      |      |      |      |      |      | 18    |
| 54 | Turbinaria reniformis               |      |      |      |      |      |      |      |      |      | 18    |

**Belitung**

| No | Species                          | BLT1 | BLT2 | BLT3 | BLT4 | BLT5 | BLT6 | BLT7 | BLT8 | BLT9 | BLT10 |
|----|----------------------------------|------|------|------|------|------|------|------|------|------|-------|
| 1  | Acanthastrea spp                 |      |      | 15   | 16   | 15   | 17   |      |      |      |       |
| 2  | Acropora formosa                 |      |      |      |      |      |      |      |      |      | 19    |
| 3  | Acropora brueggemanni            | 19   | 19   | 19   |      |      |      |      |      |      | 19    |
| 4  | Acropora spp                     | 19   | 18   | 19   | 19   |      |      |      |      |      |       |
| 5  | Australomussa rowleyensis        |      |      |      |      |      |      |      |      |      | 14    |
| 6  | Blastomussa wellsi               |      |      |      |      |      |      |      |      |      | 11    |
| 7  | Caulastrea curvata               |      |      |      |      |      |      |      |      |      | 11    |
| 8  | Caulastrea furcata               |      |      | 18   | 19   | 17   | 18   | 11   |      |      |       |
| 9  | Ctenactis echinata               |      |      |      |      |      |      |      |      |      | 18    |
| 10 | Cynarina lacrymalis              |      |      |      |      |      |      |      |      |      | 11    |
| 11 | Diploastrea heliopora            |      |      | 18   | 19   | 18   | 18   | 16   | 19   | 18   | 18    |
| 12 | Euphyllia ancora                 | 17   | 14   | 15   | 19   | 15   | 15   | 18   | 16   | 16   | 14    |
| 13 | Euphyllia cristata               |      |      |      |      |      |      |      |      |      | 10    |
| 14 | Euphyllia glabrescens            |      |      | 16   | 15   | 15   |      | 11   | 12   |      |       |
| 15 | Euphyllia paraancora             |      |      |      |      |      |      |      |      |      | 16    |
| 16 | Euphyllia yaeyamaensis           |      |      |      |      |      |      |      |      |      | 19    |
| 17 | Echinophyllia sp.                | 12   | 16   | 14   | 19   |      |      | 17   | 16   |      |       |
| 18 | Favia spp                        | 13   | 14   | 18   | 15   | 15   | 17   | 16   | 18   | 15   |       |
| 19 | Favites spp                      | 17   | 18   | 17   | 17   | 18   | 15   | 15   | 17   | 16   | 16    |
| 20 | Fungia spp                       | 14   | 15   | 15   | 15   | 15   | 15   | 16   | 15   |      |       |
| 21 | Galaxea astreata                 |      |      |      |      |      |      |      |      |      | 15    |
| 22 | Galaxea fascicularis             |      |      |      |      |      |      |      |      |      | 16    |
| 23 | Galaxea archelia                 |      |      |      |      |      |      |      |      |      | 14    |
| 24 | Galaxea spp                      | 17   | 16   | 19   | 17   | 18   | 17   |      |      |      |       |
| 25 | Goniastrea aspera                |      |      |      |      |      |      |      |      |      | 12    |
| 26 | Goniopora lobata                 |      |      |      |      |      |      |      |      |      | 19    |
| 27 | Goniopora spp                    | 19   | 18   | 19   | 17   | 15   | 15   | 16   | 16   | 14   | 18    |
| 28 | Goniopora stokesi                |      |      |      |      |      |      |      |      |      |       |
| 29 | Heliofungia actiniformis         | 12   | 11   | 6    | 12   | 16   | 14   |      |      |      |       |
| 30 | Herpolitha limax                 | 13   | 17   | 16   | 14   | 16   | 17   | 14   | 18   | 16   |       |
| 31 | Hydnophora pilosa                |      |      |      |      |      |      |      |      | 18    | 17    |
| 32 | Leptoria phrygia                 | 13   | 18   |      |      |      |      |      |      |      |       |
| No | Species                  | SBW1 | SBW2 | SBW3 | SBW4 | SBW5 | SBW6 | SBW7 | SBW8 | SBW9 | SBW10 |
|----|--------------------------|------|------|------|------|------|------|------|------|------|-------|
| 1  | Acanthastrea spp         |      |      |      |      |      |      |      |      |      | 13    |
| 2  | Acropora loriipes        |      |      |      |      |      |      |      |      |      | 11    |
| 3  | Acropora caroliniana     |      |      |      |      |      |      |      |      |      | 16    |
| 4  | Acropora spp             | 15   |      |      |      |      |      |      |      |      | 16    |
| 5  | Australomussa rowleyensis| 15   |      |      |      |      |      |      |      |      | 11    |
| 6  | Catalaphyllia jardinei   |      |      |      |      |      |      |      |      |      | 14    |
| 7  | Ctenactis echinata       | 15   |      |      |      |      |      |      |      |      | 15    |
| 8  | Cynarina lacrymalis      |      |      |      |      |      |      |      |      |      | 13    |
| 9  | Cycloseris fragilis      |      |      |      |      |      |      |      |      |      | 15    |
| 10 | Diploastrea heliopora    |      |      |      |      |      |      |      |      |      | 16    |
| 11 | Euphyllia ancora         | 16   | 15   | 14   | 15   | 17   | 15   | 15   | 15   | 12   |       |
| 12 | Euphyllia cristata       | 9    | 9    | 15   |      |      |      |      |      |      | 13    |
| 13 | Euphyllia glabrescens    | 13   |      | 16   | 14   |      |      |      |      |      |       |
| 14 | Euphyllia paraancora     | 10   |      |      |      |      |      |      |      |      |       |
| 15 | Euphyllia yaeyamaensis   | 17   |      | 15   | 12   | 15   |      |      |      |      |       |
| 16 | Echinophyllia sp.        | 16   | 16   | 15   | 19   |      |      |      |      |      | 18    |
| 17 | Echinopora lamellosa     |      |      |      |      |      |      |      |      |      | 17    |
| 18 | Echinopora spp           |      |      |      |      |      |      |      |      |      | 18    |
| 19 | Favia matthai            |      |      |      |      |      |      |      |      |      | 10    |
|   | Species                      | 15 | 12 | 14 | 13 | 16 | 15 | 14 | 15 | 15 | 15 | 15 |
|---|------------------------------|----|----|----|----|----|----|----|----|----|----|----|
| 20| Favia spp                    |    |    |    |    |    |    |    |    |    |    |    |
| 21| Favites spp                  |    |    |    |    |    |    |    |    |    |    |    |
| 22| Fungia spp                   |    |    |    |    |    |    |    |    |    |    |    |
| 23| Galaxea fascicularis         |    |    |    |    |    |    |    |    |    |    |    |
| 24| Galaxea archeaica            |    |    |    |    |    |    |    |    |    |    |    |
| 25| Galaxea spp                  |    |    |    |    |    |    |    |    |    |    |    |
| 26| Goniatrea aspera             |    |    |    |    |    |    |    |    |    |    |    |
| 27| Goniopora spp                |    |    |    |    |    |    |    |    |    |    |    |
| 28| Heliofungia actiniformis     |    |    |    |    |    |    |    |    |    |    |    |
| 29| Herpolitha limax             |    |    |    |    |    |    |    |    |    |    |    |
| 30| Hydnophora pilosa            |    |    |    |    |    |    |    |    |    |    |    |
| 31| Leptoria phrygia             |    |    |    |    |    |    |    |    |    |    |    |
| 32| Lobophyllia corymbosa        |    |    |    |    |    |    |    |    |    |    |    |
| 33| Lobophyllia spp              |    |    |    |    |    |    |    |    |    |    |    |
| 34| Montastrea sp.               |    |    |    |    |    |    |    |    |    |    |    |
| 35| Mycedium elephantotus        |    |    |    |    |    |    |    |    |    |    |    |
| 36| Oxypora spp                  |    |    |    |    |    |    |    |    |    |    |    |
| 37| Pectinia alcicornis           |    |    |    |    |    |    |    |    |    |    |    |
| 38| Pectinia lactuca             |    |    |    |    |    |    |    |    |    |    |    |
| 39| Physogyra lichtenstein       |    |    |    |    |    |    |    |    |    |    |    |
| 40| Plerogyra simplex            |    |    |    |    |    |    |    |    |    |    |    |
| 41| Plerogyra simosa             |    |    |    |    |    |    |    |    |    |    |    |
| 42| Podabacea crustacea          |    |    |    |    |    |    |    |    |    |    |    |
| 43| Polyphyllia talpina          |    |    |    |    |    |    |    |    |    |    |    |
| 44| Sandalolitha sp.             |    |    |    |    |    |    |    |    |    |    |    |
| 45| Scolymia vitiensis           |    |    |    |    |    |    |    |    |    |    |    |
| 46| Symphyllia sp.               |    |    |    |    |    |    |    |    |    |    |    |
| 47| Trachyphyllia geoffroyi      |    |    |    |    |    |    |    |    |    |    |    |
| 48| Tubastrea micrantha          |    |    |    |    |    |    |    |    |    |    |    |
| 49| Turbinaria reniformis        |    |    |    |    |    |    |    |    |    |    |    |