Status of Coral Communities and Reef-Associated Fish and Invertebrates in Batangas and Northern Palawan

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ABSTRACT

The present study shows the status of certain reefs of Batangas and northern Palawan using data gathered with volunteers, community members, local governments, and civil society groups utilizing Reef Check® methods. Both provinces have mean densities of less than 1 per 100 m^2 for most of the fish and invertebrate indicators—signifying that they are overfished. Batangas is an urbanized province with an average hard coral cover of 40% (n = 22 sites from three towns and one city). Northern Palawan reef assemblages were generally distant from centers of population and have a higher average hard coral cover of 53% (n = 29 sites from five towns). According to Gomez et al.'s (1981) categories based on live coral cover, the reefs of northern Palawan are in "good" health, while those in Batangas are said to be "fair." Conversely, in terms of the Coral Reef Health Index (CRHI), the coral reef assemblages of Batangas are in "good" health (CRHI = 10), while those in northern Palawan are in "poor" health (CRHI = 8)—despite the latter's higher coral cover. The difference between the overall health of the provinces' coral reef assemblages seems to be attributable to the biases of the indices used. Overfishing, overexploitation, siltation, and destructive fishing methods remain to be the most prevalent anthropogenic disturbances acting on the reefs for both provinces.

Keywords: coral reef status, indicator species, fish density, invertebrate density, benthic composition, human impacts

INTRODUCTION

The Philippines is a biodiversity hotspot due to its high levels of biodiversity and the high risk to this diversity (Roberts et al., 2002; Carpenter & Springer, 2005; Carpenter et al., 2008; Sanciangco et al., 2013; DENR-BMB, 2014). The country's 26,000 km^2 of reef area is the second largest in Southeast Asia and the third largest globally (Burke et al., 2002; Burke et al., 2011) and is home to at least 571 species of corals and 1,770 reef fishes (DENR-BMB, 2014; Huang et al., 2014). About 500 species of mollusks and crustaceans can be found in the country (Sanciangco et al., 2013).

Half of the country's population relies on food and livelihood (e.g., fishery and tourism) that coral reefs provide (Aliño, 2001; Alcala & Russ, 2002; Burke et al., 2011; Maulil et al., 2014a, 2014b). However, with a population growth rate of 1.9%, and 41 million people now living within 30 km of the coastal areas, there is a high and increasing demand for coastal and reef resources (Ericta, 2010; Burke et al., 2011; Maulil et al., 2014b). Coastal development, overfishing, and destructive fishing remain as the major sources of human impacts to reefs (Gomez et al., 1994; Alcala & Russ, 2002; Burke et al., 2002).

According to Licuanan and Gomez (2000a), only 4.3% of the Philippine's coral reefs remain in "excellent" condition, that is, having a hard and soft coral cover of more than 75%. Furthermore, the average hard coral cover for the country was 32.3% (Licuanan & Gomez, 2000a). Burke et al. (2011) estimate that 95% of the reefs in Southeast Asia are in danger of loss due to anthropogenic disturbances. The country's average hard coral cover is higher compared to the regional average of Indo-Pacific reefs (which measures 22.1%; Bruno & Selig, 2007). However, the coral cover for the entire region has been declining at an annual rate of 1% for the past two decades (Bruno & Selig, 2007).

The reef fish communities in the country are also in decline, with some areas at risk of fishery collapse (Maulil et al., 2012; Maulil, Cleland, & Aliño, 2013; Maulil et al., 2014a). According to Maulil et al. (2014a), 68% of the coastal fisheries in the country are overfished and more than half of fishing communities must cease unsustainable fishing if complete fishery collapse is to be averted. Reef fish diversity, abundance, and biomass have been reduced due to overfishing since the 1970s (Aliño, 2001; Alcala & Russ, 2002; Maulil et al., 2014b). About 5% of the reefs were considered to be "poor" in terms of fish diversity, having <26 species per 1000 m^2 (Licuanan & Gomez, 2000b). Hilomen and others (in Licuanan & Gomez, 2000b) reported that 45% of the reefs in the Philippines had "moderate" in reef fish abundance, with 677–2267 individuals per 1000m^2. However, 75% of the country's reefs were categorized as either having "very low" (<5.0 t/km^2) or "low" (5.1–20.0 t/km^2) reef fish biomass. The conservation status of reef associated invertebrates in the country is poorly known. This is alarming because Alcala and Russ (2002) report that some invertebrates such as the *Nautilus pompilius, Placuna placenta, Cypraea* sp., and *Conus* sp. have disappeared in certain parts of the Philippines, where each was found historically. Similarly, giant clams (Family Tridacnidae) have been reported to be overfished since the 1980s, even in areas of the country considered to be their "strongholds" (Villanoy et al., 1988). At present, it is estimated that most parts of the country have <10^{-6} individuals of giant clams per square meter, while other parts have had local extinctions (Lizano & Santos, 2014).

Given these facts, reef conservation, along with its associated communities, should be of paramount importance. Pending the completion of ongoing initiatives, the Philippines does not have "a real comprehensive picture" of the current condition of its reefs (Licuanan & Aliño, 2014). The present study presents the current state of the coral reef communities in two sections of the country: the provinces of Batangas and Palawan. Batangas is a highly industrialized province with a total population of over 2.3 million. It belongs to a subregion of four provinces that is the second largest contributor to the country's gross domestic product. Palawan, on the other hand, is primarily an agricultural province with a population of almost one million individuals. Furthermore, the gross domestic product of the four province subregion that includes Palawan is among the five regions with the least contribution to the national economy (NSO, 2010; NSCB, 2011). These two contrasting provinces are probably a good example of the common pattern that coral reef health is inversely proportional to its adjacent human population density (Hodgson, 1999; Adjeroud et al., 2002; Mumby et al., 2006; Cleary et al., 2008; Adjeroud et al., 2009; Sandin et al., 2008; Osborne et al., 2010; Burke et al., 2011; Kavousi et al., 2011). The present study therefore sought to assess the current condition of selected sites in Batangas and northern Palawan using Gomez et al.'s (1981) categories based on live coral cover and Hodgson's (1999) Coral Reef Health Index (CRHI). More specifically, this study determined (1) the density of indicator species, (2) the substrate composition, (3) the degree of human impacts, and (4) compared the same (nos. 1–3) between provinces and the Reef Check® standards.

MATERIALS AND METHODS

Site Selection

Site selection in the Reef Check® protocol requires that surveys be conducted at the "best" reef in each area. This was not adopted by the present study. The process of site selection involved three levels. Initial site selection was done using the geotagged, stitched still images produced by the Teardrop technology (Judilla et al., 2012). This allowed the authors to rapidly determine the boundaries of coral reefs or coral communities over large areas (i.e., available coastline per town/city). The second level involved only one person (WYL) to examine the images and identify potential sites (i.e., nonpatchy reefs/coral communities). The final site selection was done by the team leaders (authors) in situ to ensure selected sites had at least a 100-m stretch of homogenous reef/coral community with a relatively constant depth contour (i.e., no gullies/fissures >1 m).

Twenty-two (22) sites were surveyed for the province of Batangas, and twenty-nine (29) sites were surveyed for northern Palawan. Three towns and one city in Batangas were included in the study: Nasugbu (6), Lian (4), Mabini (3), and Batangas City (9). As for Palawan, more sites were surveyed, focusing on the towns of Culion (6), Coron (2), Linapacan (7), El Nido (8), and Taytay (6; see Fig. 1). All the northern Palawan sites included in the study, as well as those in Mabini, were selected from an extensive list of sites imaged with the Teardrop technology. Sites in Batangas City (9) and Nasugbu (6) were chosen by other investigators who were not involved in the present study. These sites were selected after manta tows and following the protocols of English et al. (1997), which prescribe choosing representative sites in reefs. Generally for all sites, transect lines were deployed at shallow depths (2–6 m) parallel to shore, maintaining a constant depth contour, and over a homogenous reef or coral community. Data collection was done from 2012 to 2013.

Fish and Invertebrate Survey

The densities of eight fish, and invertebrate indicator species were measured along a 100-m transect line, which was divided into four 20-m

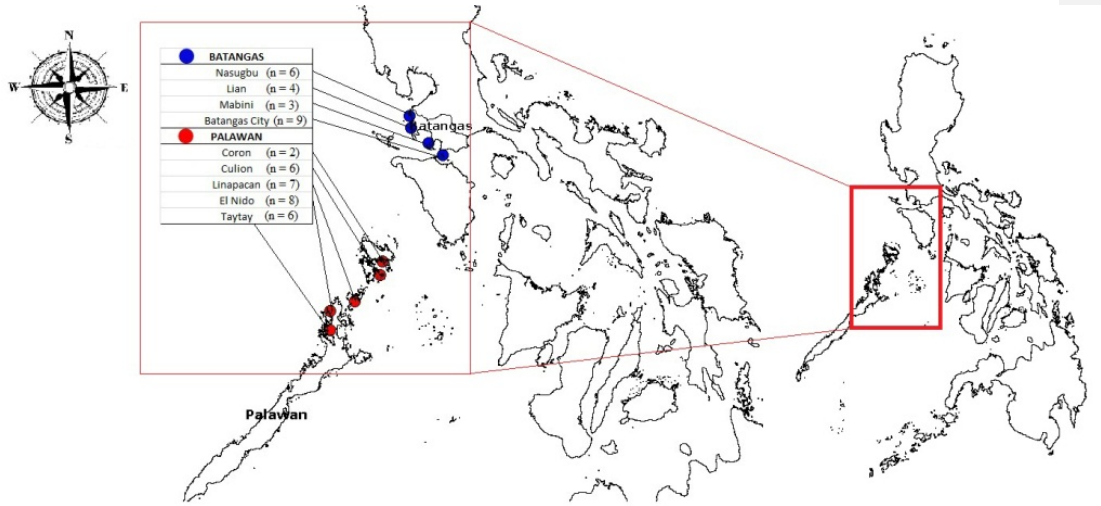

Figure 1. Map of study locations.

× 5-m belt transects that were 5 m apart. The indicator organisms for the fish survey were the butterflyfish (all species of Chaetodontidae), grunts/sweetlips (Haemulidae), snappers (Lutjanidae), bumphead parrotfish (*Bolbometopon muraticum*), humphead wrasse (*Cheilinus undulatus*), barramundi cod (*Cromileptes altivelis*), other parrotfish (Scaridae of at least 20-cm length), and the grouper/coral trout (Serranidae of at least 30-cm length). The invertebrate indicator species on the other hand include the banded coral shrimp (*Stenopus hispidus*), long-spined sea urchin (*Diadema* spp. and *Echinothrix diadema*), pencil urchin (*Heterocentrotus mammillatus*), lobster (Decapoda), crown-of-thorns seastar (*Acanthaster planci*), triton (*Charonia tritonis*), giant clam (*Tridacna* spp.), and the edible sea cucumbers (*Holothuria edulis*, *Thelenota ananas*, and *Stichopus chloronotus*).

Substrate Survey

The benthos was surveyed using the point intercept methodology (see Hodgson et al., 2006, and the Indo-Pacific data sheets available at www.reefcheck.org). With the same 100-m transect line, 20-m segments that were 5 m apart were sampled every 0.5 m. Thus, each 20-m segment had 40 point samples or a total of 160 points in the entire 100-m transect line. The substrate was identified using ten categories: hard coral, soft coral, recently killed coral, nutrient indicator algae, sponge, rock, rubble, sand, silt, and other organisms.

Human Impacts

Semi-qualitative data on 13 different human impacts (e.g., blast fishing, poison fishing, tourist diving/snorkeling, sewage pollution, commercial fishing, etc.) were gathered using the Reef Check Site Description Form (see the Indo-Pacific data sheets available at www.reefcheck.org). This form was accomplished with the input of key individuals such as MPA managers and Bantay Dagat, local fishermen, local government unit (LGU) officials, and team scientists. The degree of each anthropogenic activity was estimated and assigned a level, that is, "none," "low," "medium," or "high." For the data analysis, the extents of human impacts were assigned values of 0, 1, 2, and 3, respectively, to rank the anthropogenic disturbances acting on each site. The values were then summed up for each province.

Reef Condition

The state of each reef surveyed was assessed using Gomez et al.'s (1981) categories based on live coral cover. The four categories and corresponding ranges of live coral cover (LCC) are as follows: "poor" (0%–25% LCC), "fair" (25%–50% LCC), "good" (50%–75% LCC), and "excellent" (75%–100% LCC). Live coral cover was measured by simply adding the hard coral and soft coral covers per site.

The present study also utilized a modified form of Hodgson's (1999) CRHI. To compute the CRHI, densities of the butterflyfish, sweetlips, grouper, lobster, and long-spined sea urchin, as well as the percent coral cover, are used as variables. These variables are assigned to categories whether they fall under the "upper," "middle," or "lower" third class compared to the Reef Check's global standards (Hodgson & Liebeler, 2002; see Table 1). Each category is assigned values of 3, 2, or 1, respectively. A value of 0 is given to a variable that measured 0 for density or cover. Note that the scoring for the long-spined sea urchin is in reverse, as high densities of this organism could result to overgrazing. Therefore the perfect CRHI a site can obtain is 16 (3 + 3 + 3 + 3 + 1 + 3). A CRHI of 9 is considered to be the "midpoint." Thus, CRHI scores above or below 9 are considered to be in "good" or "poor" health, respectively. A summary of the densities and percent cover gathered from the Reef Check's second global assessments (Hodgson & Liebeler, 2002) is shown in Table 1.

Table 1. Coral Reef Health Index Scores Based From the Upper, Middle, and Lower Third Classes of the Baseline Data From the 2002 Reef Check Global Assessment

Variables	**Class**		
	***Lower Third/* Low**	***Middle Third/* Moderate**	***Upper Third/* High**
	Value		
	(1)	***(2)***	***(3)***
Butterflyfish	≤1 per 100 m^2	2–12 per 100 m^2	≥13 per 100 m^2
Sweetlips	≤1 per 100 m^2	2–68 per 100 m^2	≥69 per 100 m^2
Grouper	≤1 per 100 m^2	2–24 per 100 m^2	≥25 per 100 m^2
Lobster	≤1 per 100 m^2	2–4 per 100 m^2	≥5 per 100 m^2
Long-spined sea urchin	≥36 per 100 m^2	11–35 per 100 m^2	≤10 per 100 m^2
Hard coral cover	≤21%	22%–84%	≥85%

Note: The authors took the liberty of rounding off the global averages to whole numbers, as well as supplying the ranges for the middle third class. Moreover, for this paper, the terms high, moderate, and low will be used to represent Reef Check's "upper third," "middle third," and "lower third" classes, respectively.

Statistical Analysis

Selected reefs in Batangas and northern Palawan were compared in terms of the presence and density of indicator species, benthic composition, and extent of human impacts. The sites per province served as replicates, while the segments per transect stood for subsamples. Utilizing the software JMP Pro version 11.1.1, the two-sample *t*-test was used to compare means between provinces and the Reef Check standards.

RESULTS AND DISCUSSION

Most of the fish indicators for both provinces had average densities of <1 per 100 m^2 (see Table 2 and Fig. 2). Furthermore, significant differences were found between the average densities of both provinces and the Reef Check standards for majority (5 out of8) of the indicators (see Appendix). Significant differences were found in the mean densities of the butterflyfish, sweetlips, snapper, parrotfish, and grouper indicators. To be precise, Batangas had a mean density for butterflyfish of 14 per 100 m^2 (SE = ±4.2), which was significantly higher than Palawan's (4 per 100 m^2, SE = ±0.33, $p = 0.011$), as well as the Reef Check standard (10 per 100 m^2, SE = ±0.30, $p < 0.001$). However, compared to Batangas, Palawan had significantly higher densities for the sweetlips, snapper, and parrotfish indicators with average densities of 0.1 per 100 m^2 (SE = ±0.33, $p = 0.019$), 7 per 100 m^2 (SE = ±1.78, $p = 0.007$), and 0.02 per 100 m^2 (SEM = ±0.88, $p = 0.002$), respectively. Moreover, Palawan's average density for snapper was also significantly higher than the Reef Check standards of 2 per 100 m^2 (SEM = ±0.16, $p < 0.0001$). But both Batangas and Palawan have been found to have significantly smaller mean densities of sweetlips compared to the Reef Check standard of 1 per 100 m^2 (SEM = ±0.07, both $p = 0.001$). Similarly, both provinces have significantly lower average densities of parrotfish and grouper compared to the Reef Check standard of 2 per 100 m^2 (SEM = = ±0.09, both $p < 0.001$) and 0.3 per 100 m^2 (SEM = = ±0.02, both $p < 0.001$), respectively. No bumphead parrotfish (*Bolbometopon muraticum*) and other parrotfish (Scaridae, >20cm in length) were recorded for the sites in Batangas. The humphead wrasse (*Cheilinus undulatus*) was never encountered in any of the surveys in both provinces.

The long-spined sea urchin was the most ubiquitous invertebrate indicator observed in both provinces (see Fig. 3). It had mean densities of 11 per 100 m2 (SE = ±1.5) and 47 per 100 m2 (SE = ±5.5), for Batangas and Palawan, respectively. Palawan's average density for the long-spined sea urchin was significantly higher than Batangas' (p < 0.001), and the Reef Check standard (17 per 100 m2, SE = ±1.75, p < 0.0001). Batangas and Palawan had average densities of sea cucumber measuring 0.1 per 100 m2 (SE = ±0.03) and 0.03 per 100 m2 (SE = ±0.01), respectively; both were found to be significantly smaller than the Reef Check standard of 1 per 100 m2 (SE = ±0.04, p < 0.001). Batangas' mean density for lobster of 0.1 / 100 m2 (SE = ±0.06) was not significantly different from Palawan's (0.03 per 100 m2, SE = ±0.02, p = 0.074) but was significantly greater than the Reef Check standard (0.1 per 100 m2, SE = ±0.01, p = 0.002). Furthermore, Palawan's average density of giant clam (2 per 100 m2, SE = ±0.37) was significantly greater than Batangas' (0.4 per 100 m2, SE = ±0.10, p = 0.001), but both provincial means were not significantly different from the Reef Check standard (4 per 100 m2, SE = ±0.57, p = 0.086 and p = 0.257, respectively).

The benthos of the sites for both provinces was mostly made up of hard coral (Fig. 4). However, there was a significant difference ($p = 0.001$) between the provinces' hard-coral-cover values. The sites surveyed in Batangas ($n = 22$) had an average hard coral cover of 40% (SE = ±0.02), while those in Palawan ($n = 29$) had 53% (SE = ±0.02). Furthermore, both provincial averages were found to be significantly higher than the Reef Check standard of 32% (both with $p < 0.001$). The second dominant substrate type in Batangas and Palawan was rock (or dead coral) with average measurements of 30% (SE = ±0.01) and 24% (SE = ±0.01), respectively. Batangas' mean rock cover was found to be significantly higher than Palawan's ($p = 0.042$), as well

Table 2. Average Measurements of Reef Check Indicators and Substrate Categories With Standard Error of the Means (SEMs)

	Batangas	**SEM**	**Palawan**	**SEM**	Reef Check	SEM
Fish Indicators (n per 100 m²)						
Butterflyfish	14	4.23	4	0.33	10	0.30
Haemulidae	0.02	0.02	0.1	0.05	1	0.07
Snapper	0.1	0.03	7	1.78	2	0.16
Barramundi cod	0.04	0.02	0.1	0.04	0.03	0.01
Humphead wrasse	0	0	0	0	0.1	0.05
Bumphead parrot	0	0	0.03	0.01	0.3	0.05
Parrotfish	0	0	0.02	0.01	2	0.09
Grouper	0.02	0.02	0.03	0.01	0.3	0.02
Invertebrate Indicators (n per 100 m²)						
Banded coral shrimp	0.1	0.02	0.1	0.03	0.1	0.01
Diadema	11	1.54	47	5.49	17	1.75
Pencil urchin	0.1	0.04	0	0	0.4	0.09
Sea cucumber	0.1	0.03	0.03	0.01	1	0.04
Crown-of-thorns	0.3	0.14	0.04	0.02	0.2	0.03
Triton	0.03	0.03	0.01	0.01	0.03	0.01
Lobster	0.1	0.06	0.03	0.02	0.1	0.01
Giant clam	0.4	0.10	2	0.37	4	0.57
Benthic Composition						
Hard coral (HC)	40%	1.67	53%	2.10	32%	—
Soft coral (SC)	5%	0.79	1%	0.12	6%	—
Recently killed coral (RKC)	1	0.18	0.3%	0.10	6%	—
Nutrient indicator algae (NIA)	6%	1.36	6%	0.77	4%	—
Sponge (SP)	2%	0.40	3%	0.47	2%	—
Rock (RC)	30%	1.39	24%	1.39	26%	—
Rubble (RB)	5%	0.74	6%	0.64	10%	—
Sand (SD)	6%	0.71	3%	0.49	8%	—
Silt (SI)	2%	0.36	0.3%	0.08	1%	—
Others (OT)	3%	0.70	3%	0.43	3%	—

Note. SEMs of Reef Check standards for substrate categories were not available from literature.

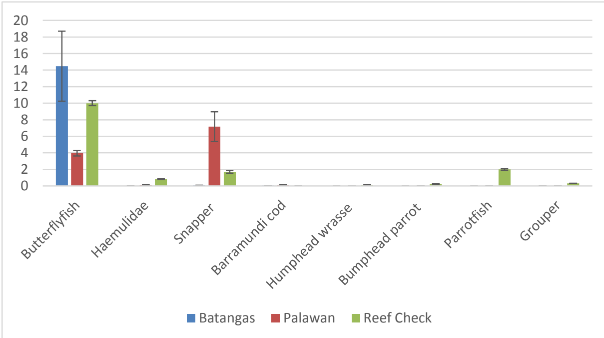

Figure 2. Bar graph showing average densities of Reef Check fish indicators. Error bars are SEMs.

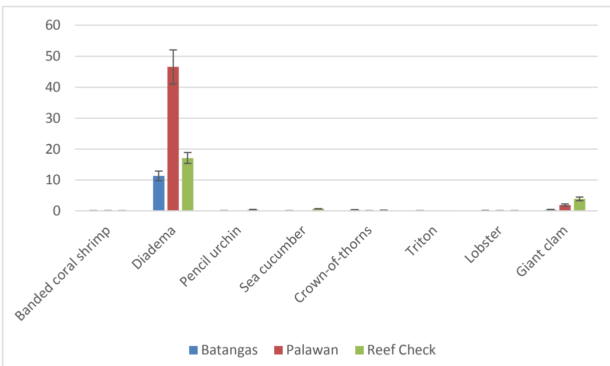

Figure 3. Bar graph showing mean densities of Reef Check invertebrate indicators. Error bars are SEMs

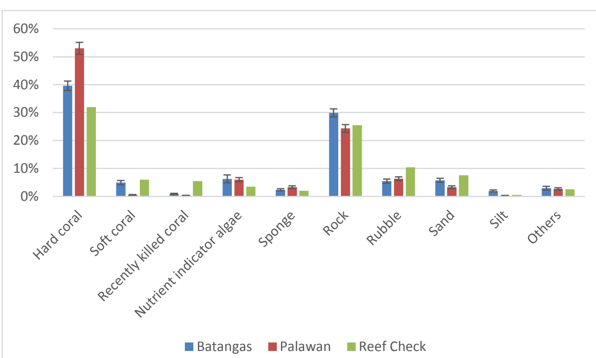

Figure 4. Average covers (%) of Reef Check substrate categories. The Reef Check standards have no SE bars because they were not provided in the literature.

as the Reef Check standard (26%, both with $p < 0.001$). Palawan's average recently killed coral cover (RKC) of 0.32% (SE = ±0.10) was significantly lower ($p = 0.001$) than Batangas' 1% (SE = ±0.18), and the Reef Check standard (6%, $p < 0.001$). But both Batangas and Palawan had significantly higher mean nutrient indicator algae (NIA; 6%, SE = ±1.36, and 6%, SE = ±0.77, respectively) cover compared to the Reef Check standard of 4% ($p = 0.044$ and $p = 0.002$, respectively). Lastly, Batangas' average silt (SI) cover of 2% (SE = ±0.36) was found to be significantly higher than both the Reef Check standard (1%, $p = 0.004$) and Palawan's (0.3%, SE = ±0.08, $p < 0.001$).

The top three human impacts perceived to be affecting Batangas sites were tourist diving/snorkeling, presence of yachts, and siltation (see Fig. 5), whereas for Palawan sites, the human impacts perceived to affect its reefs most were artisanal/recreational fishing, tourist diving/snorkeling, harvest of invertebrates for food, and sewage pollution. Destructive fishing practices were also observed in the duration of data collection. For example, some 10–20 instances of dynamite fishing, which were probably 3–5 km from the study locations, were detected—majority of which were in Palawan. Likewise, cyanide fishing was reported by certified Reef Check EcoDivers in Culion at sites not included in the present study.

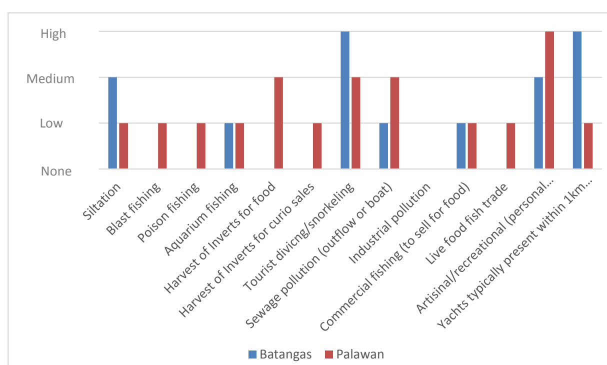

Figure 5. Perceived extent of human impacts acting on the reefs of Batangas and Palawan.

According to Gomez et al.'s (1981) categories, Batangas' mean hard coral cover of 40% falls under the "fair" category (i.e., 25%–50% live coral cover), along with majority (55%) of the sites in the province (see Table 2). On the other hand, Palawan's average hard coral cover of 53% qualifies for the "good" category (50%–75% live coral cover), as well as almost half (48%) of the province's sites.

Table 3. Number and Proportion of Sites per Reef Condition Index for Batangas and Palawan

Reef Condition Index (RCI)	Live Coral Cover (HC + SC)			
	Batangas (*N* = 22)		**Palawan (*N* = 29)**	
	n	%	***n***	%
Excellent (75%–100%)	0	0.0	4	14
Good (50%–75%)	8	36	14	48
Fair (25%–50%)	12	55	7	24
Poor (0%–25%)	2	9	4	14

Computing for the Coral Reef Health Index of each province shows that Batangas is one point above the midpoint score of 9, while Palawan is one point below (see Table 3). This suggests that the coral reefs surveyed in Batangas are in "good" health, whereas those in Palawan are "poor" in health. The two-point lead of Batangas over Palawan can be attributed to the butterflyfish and long-spined sea urchin variables. In the earlier discussion for fish indicators, omitting one site in Batangas City, which contributes to the huge variance for the mean density of butterflyfish, brings down the provincial average to the "moderate" level, garnering only two points instead of three. This correction would then give Batangas a CRHI of 9 and be considered as "moderately" healthy, which is still one point above Palawan.

Table 4. Coral Reef Health Indices of Both Provinces

Variables	**Batangas**	**Palawan**
Butterflyfish	3	2
Sweetlips	1	1
Grouper	1	1
Lobster	1	1
Long-spined sea urchin	2	1
Hard coral cover	2	2
Total	10	8

The densities of fish indicators recorded in this study are very similar to the global assessments of Reef Check (Hodgson, 1999; Hodgson & Liebler, 2002). Since most of Reef Check's indicators species are the commercially important organisms, it can be inferred that the reefs of Batangas and northern Palawan are overfished. Target species such as those belonging to Family Haemulidae (sweetlips), Lutjanidae (snappers), and Serranidae (groupers) have been found to be absent or diminished in almost all of the study locations, similar to the findings of earlier studies (Hodgson & Liebeler, 2002; Alcala & Russ, 2002). This is especially true for the bumphead parrotfish (*Bolbometopon muraticum,* Family Scaridae) and barramundi cod (*Cromileptes altivelis*, Family Serranidae). Worse still, the humphead wrasse (*Cheilinus undulatus,* Family Labridae) was never encountered in all the surveys for both provinces.

In terms of the invertebrate indicators, most have been overfished as well. The most dominant indicator species surveyed was the long-spined sea urchin (mostly belonging to genus *Diadema*). The unhealthy densities of long-spined sea urchins, particularly for the province of Palawan, could reflect a prey release response due to overharvesting of predatory target fishes (McClanahan et al., 1996; McClanahan et al., 2005; Mumby et al., 2006). Additionally, sites with high densities of long-spined sea urchins could enhance grazing and bioerosion, which could negatively affect coral recruitment and reef structural integrity, respectively (Sammarco, 1982; Connell, 1997; Hodgson & Liebeler, 2002; Obura & Grimsditch, 2009). Conversely, at healthy densities, long-spined sea urchins are effective grazers, which facilitate in coral recruitment and colonization (Edmunds & Carpenter, 2001; Carpenter, 2005).

Because of the medium to high levels of recreational activities, anchoring, and low to medium levels of siltation/sedimentation in Batangas, it can be inferred that the corals in the province are experiencing relatively higher rates of coral mortality compared to Palawan. This is substantiated by the lower coral cover and higher proportions of recently killed corals as well as dead corals compared to either Palawan or the Reef Check standards. But since half of the study locations in Batangas were either dive sites (with some form of legal protection) or near dive resorts, its coral reefs have a more diverse assemblage of fishes that are spared from extraction (Anticamara, Zeller, & Vincent, 2010). For example, the presence of predatory fishes belonging to Family Acanthuridae and Balistidae could explain the healthy densities of long-spined sea urchins in Batangas (personal observation). In contrast, the stations surveyed in Palawan are said to be predominantly experiencing extraction of commercially important fishes and invertebrates, medium levels of disturbance from recreational activities, and sewage. However, the sites surveyed in Palawan still had more of Reef Check's fish and invertebrate indicators present (e.g., sweetlips, snapper, barramundi cod, bumphead parrotfish, giant clams), as well as having significantly higher mean densities for majority of the indicators. This could suggest that Palawan reefs are experiencing less overfishing relative to Batangas. This is not reflected in the CRHI because the indicator species where Palawan had significantly higher average densities are not incorporated in the computation of the CRHI (e.g., snapper, barramundi cod, bumphead parrotfish, giant clams). This highlights the limitation of the CRHI, which was designed to compare coral reef condition across global regions. In other words, if the CRHI was recalibrated for the Indo-Pacific region only, then we could probably see a better distinction of the extent of overfishing between the reefs surveyed in Batangas and Palawan. Lastly, the RCI of Palawan indicates that the province has a good or healthy benthic composition. This can be substantiated by the significantly higher mean coral cover and significantly lower averages of recently killed coral, dead coral, and silt compared to Batangas.

It is apparent that in terms of overall coral reef health, there is a discrepancy between the Reef Condition Index (RCI) and the Coral Reef Health Index (CRHI). According to the RCI, the reefs surveyed in Batangas are in "fair" condition, but in terms of the CRHI, the province is said to be healthy. Conversely, the RCI reflects that the sites surveyed in Palawan are in "good" condition but according to the CRHI, Palawan reefs are unhealthy. These inconsistencies can be explained by the bias of each conservation index. For example, the RCI primarily looks at the proportion of live coral cover and therefore is focused on the benthic composition. Thus, the RCI could indirectly reflect the condition of the coral community. On the other hand, the CRHI is focused on the densities of fish and invertebrate indicators (which would account for around 80% of the overall CRHI score), which indirectly reflects the extent of overfishing. Integrating therefore both conservation values, we can evaluate the overall health of the reefs in each province in terms of a) the condition of the coral community and b) the extent of overfishing.

CONCLUSION

To conclude, most of the fish and invertebrate indicators in this study had densities that strongly suggest that target species are overexploited or overharvested in both provinces. Furthermore, despite Batangas having a higher CRHI than Palawan, the authors are still inclined to believe that the sites surveyed in Batangas are experiencing more overfishing. Furthermore, comparing the RCI of both provinces, it appears that the coral reefs surveyed in Palawan have healthier benthic compositions than those in Batangas. Thus, overall the coral reefs of Palawan are in better condition than those in Batangas. However, the coral reefs of both provinces are still at risk from further degradation if human impacts such as overfishing, recreational activities, anchoring of boats, and siltation/ sedimentation are not mitigated. The same is true if destructive fishing methods such as blast and cyanide fishing are not stopped completely.

ACKNOWLEDGEMENTS

We thank the following individuals and organizations who made this research possible: Dr. Ma. Luisa D. Enriquez (DLSU) and her Research Program Workshop on Coral Diseases, the staff of the DLSU Br. Alfred Shields FSC Ocean Research Center and its Marine Station for the technical and logistical support, the Reef Check Conservation Program Inc. for leading the surveys, Dr. Maricor Soriano and her laboratory (U.P. National Institute of Physics) for providing an innovative means of reef reconnaissance, and the Malampaya Foundation Inc. for funding most of the field work.

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APPENDIX

Table 5. Summary of ***p***-Values From All the Two-Sample ***t***-Tests Comparing Batangas and Palawan, as Well as Both Provinces Versus the Reef Check Standards

	Batangas Versus Palawan	**Batangas Versus Reef Check**	**Palawan Versus Reef Check**
Fish Indicators			
Butterflyfish	0.011	<0.001	<0.001
Haemulidae	0.019	0.001	0.001
Snapper	0.007	0.003	<0.001
Barramundi cod	—	0.159	0.106
Humphead wrasse	0.159	0.412	0.442
Bumphead parrot	0.159	0.118	0.095
Parrotfish	0.002	<0.001	<0.001
Grouper	0.088	<0.001	<0.001
Invertebrate Indicators			
Banded coral shrimp	0.783	0.320	0.326
Diadema	0.000	0.351	<0.0001
Pencil urchin	0.052	0.332	0.165
Sea cucumber	0.530	<0.001	<0.001
Crown-of-thorns	0.102	0.535	0.042
Triton	0.417	0.905	0.472
Lobster	0.074	0.002	0.520
Giant clam	0.001	0.086	0.257
Benthic Composition			
Hard coral (HC)	0.001	<0.001	<0.001
Soft coral (SC)	<0.001	0.178	<0.001
Recently killed coral (RKC)	0.000	<0.001	<0.001
Nutrient indicator algae (NIA)	0.592	0.044	0.002
Sponge (SP)	0.369	0.422	0.007
Rock (RC)	0.042	0.002	0.420
Rubble (RB)	0.476	<0.001	<0.001
Sand (SD)	0.010	0.015	<0.001
Silt (SI)	<0.001	0.000	0.004
Others (OT)	0.771	0.564	0.726