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# Beneath 50 m of NW Pacific Water: Coral Reefs on the Benham Bank Seamount off the Philippine Sea


## ABSTRACT

*The benthic habitats on the Philippine (Benham) Rise were unknown until the joint University of the Philippines Marine Science Institute (UPMSI)/University of the Philippines Los Baños (UPLB)/Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR) cruise of May 2014 when extensive coral reefs were discovered on the summit of the Benham Bank Seamount. Short observational surveys of five stations at depths up to 55 m revealed that the reefs were pristine and with excellent cover mostly by tiered, thick, rigid and foliose plate-forming Porites (Synaraea) rus. The voucher specimen collections indicated that there are at least 11 reef-building and two solitary coral species in the reef communities. The fish visual census and random hook-and-line fishing surveys recorded 62 species, 16 of which were reef health indicators and the rest were commercially exploited species. These short surveys yielded the first records of mesophotic coral reef biodiversity on the Benham Bank, albeit incomplete, and point to the inevitable requisite of further exploring these pristine reefs and their associated benthic habitats, since this Philippine natural heritage serves as an important area for fisheries.*



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## INTRODUCTION

Seamounts are topographic rises of the ocean floor that are ubiquitous but unevenly distributed among the ocean basins (*Wessel et al. 2010*) and the large isolated ones, i.e., with summits extending ≥1 km from the seafloor, are mostly located in the Pacific basin (*Kitchingman et al. 2007, Kim and Wessel 2011, Yesson et al. 2011*). Seamounts differ in characteristics—their bathymetry, topography, substrates, and interactions with variable background flow conditions result in a nutrient-enriched water column and enhanced larval retention (*Haney et*

*al. 1995, Richer de Forges et al. 2000, Koslow et al. 2001, Genin and Dower 2007, Pitcher and Bulman 2007, Lavelle and Mohn 2010*), as well as curbed local sedimentation (*Boehlert and Genin 1987*). These conditions have concomitant influence on standing stocks and local distributions of benthic and pelagic organisms, for example, seamount-aggregating fish and commercial pelagic stocks (e.g., tuna species) (*Uchida and Tagami 1984, Holland and Grubbs 2007, Morato and Clark 2007, Pitcher et al. 2010*), pelagic sharks (*Litvinov 2007*), marine mammals (*Kaschner 2007*), benthic algae (*Littler et al. 1986*), and megafauna dominated by suspension and/or filter-feeders, e.g., corals and sponges (*Rogers et al. 2007, Samadi et al. 2007, McClain et al. 2009*). The diversity of seamount assemblages may also be relatively high at depths where the summit interacts with the euphotic zone (*Pitcher and Bulman 2007, Yesson et al. 2011*), where light-dependent benthic organisms such as corals and macroalgae would recruit and establish. Seamounts are also areas where seabirds aggregate (*Haney et al. 1995*).

Deep sea environments of the Philippines have been part of historic great expeditions, which revealed the high diversity of the deep sea and resolved the old perception that it was devoid of life. The collections of these missions were deposited in various museums and thereafter described, e.g., Philippine mollusks from the Expedition of HMS Challenger (*Watson 1879, 1881, 1882*), various fish resources from the fisheries steamer Albatross (*Smith and Williams 1999*), and trawl fauna of the Philippine Trench by the Galathea (*Bruun 1951*). The same paradigm was supported by new species discovered by more recent deep sea research projects, e.g., PANGLAO 2005 (*Richer de Forges and Ng 2007*), the Inner Space of the Celebes Sea (*NOAA 2007, Osborn et al. 2010*), and the Philippine Biodiversity Expedition (*CAL 2011*), among others. Subsequently, at least two compendia of discoveries by the larger MUSORSTOM-TDSB deep sea exploration program in the tropical Indo-Pacific (1976-2012) also included rare and new species of crustaceans from the Philippine archipelago (*Richer de Forges et al. 2014*).

Discoveries of deep-water habitats are opportunities to document biodiversity and understand its interactions with the changing natural environment. Key populations of shallow-water marine biodiversity hotspots may be compared with counterparts in deep-waters to ascertain habitat connectivity (e.g., *Lesser et al. 2009*) and justify the establishment of, e.g., networks of marine protected areas or large marine parks (e.g., *Johnston and Santillo 2004*). For this study, the aim is to describe the coral reef habitats discovered at summit depths of the Benham Bank Seamount (BBS), a unique underwater geological feature in the Philippine (Benham) Rise Region off the Philippine Sea. The Bank may be a unique biodiversity feature that allows for new perspectives on the ecological and evolutionary significance of isolated seamounts. While the shallower biogeographic regions have been proposed as the world's center of the center of marine biodiversity (*Carpenter and Springer 2005*), the eastern Philippine Sea occupies a considerable gap in the explanation of the three dominant evolutionary theories, i.e., center of origin, center of accumulation and overlap, and the combined evolutionary ecology on the center of refugia (*Sanciangco et al. 2013*). Understanding the ecological and evolutionary explanations of the phylogeography of the Benham Bank has profound implications in unravelling its resiliency to the climate change challenge, in addition to its implications on the sustainability of the tuna stocks in the larger Philippine (Benham) Rise Region. As this work jumpstarts further assessments and monitoring of the marine biological features of the Bank, essentially building up records of Philippine deep-water biodiversity, the results may be linked to the productivity of the Benham Rise Region, where fishing activities are known to occur. Finally, this study consolidates the management and scientific responsibility of the Philippines in this globally significant area.

## MATERIALS AND METHODS

### Study Area

The Philippine Rise (then referred to as the Benham Rise) is one of several oceanic bathymetric highs that currently impinge the Philippine archipelago (*Yumul et al. 2008*). It is a submarine ridge of the West Philippine Basin (*Tetreault and Buiter 2014*) and is a prominent seafloor structure that is at least 49 Ma (*Deschamps and Lallemand 2002*). The Benham Bank Seamount (BBS), located at approximately 15°47'36.10"N and 124°17'47.65"E (**Figure 1**), rises from about 3,000 m of seafloor to its summit, which makes the area the shallowest part of the Philippine Rise. The BBS is also among the large seamounts in the Pacific basin (*Yesson et al. 2011*). From earlier cruises, surface waters around the BBS, often transported vigorously northward at ~2 knots, were found to mix with either the subtropical western North Pacific water or the warmer North Equatorial Current NEC) water when its bifurcation latitude was located south (*Gordon et al. 2014*). These strongly moving waters eventually feed into the waters of the nascent Kuroshio Current. *Cabrera et al.* (*2015*)

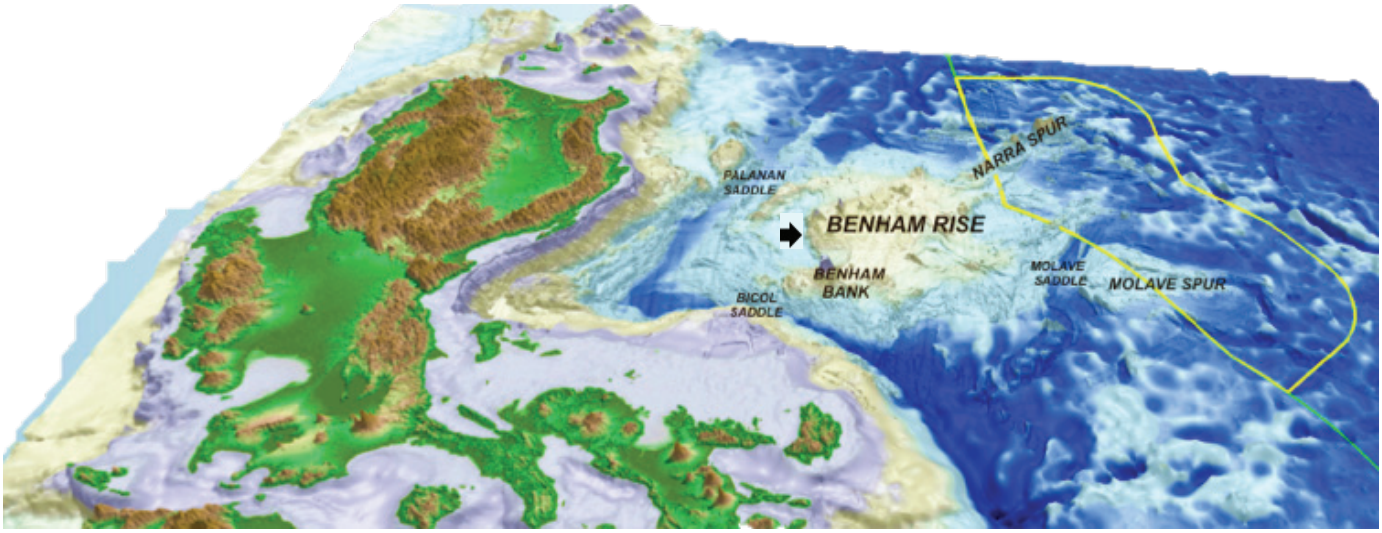


Figure 1. Location of the seamount (➧) on the Benham Bank, where coral reefs at mesophotic depths up to 55 m were discovered and surveyed on 6-14 May 2014 during the UPMSI/UPLB/DA-BFAR Joint Cruise. The area enclosed by the yellow polygon constitutes the extended continental shelf (ECS) of the Philippines, granted in April 2012 by the UN Commission on the Limits of the Continental Shelf (CLCS) (Source of base map: NAMRIA; http://www.namria.gov.ph/projects.aspx).

subsequently found that chlorophyll *a* of surface waters were also influenced by the NEC's bifurcation latitude, so the typical oligotrophic waters of the Benham Bank area may also occasionally exhibit high chlorophyll *a*, i.e., when the NEC bifurcates at a southern latitude.

**The UPMSI/UPLB/DA-BFAR Joint Cruise (Cruise DY27 Leg 1), 3-18 May 2014**

The Joint Cruise to the Benham Bank, carried out aboard the research vessel M/V DA-BFAR (**Figure 2**) by the University of the Philippines-Marine Science Institute (UPMSI), UP Los Baños, through the School of Environmental Science and Management (UPLB-SESAM), and the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR), departed Pier 3 of the Manila North Harbor on 3 May 2014 and arrived at the Benham Bank on the morning of 6 May. From 6 to 16 May, diving activities were performed on the summit and then oceanographic samplings were conducted in the vicinity of the Bank (*Benham Rise Potential Productivity Project 2014*). The cruise departed the Bank on 16 May for the Port of Legazpi in Albay, arrived on 17 May to disembark and load equipment and samples in a hired truck; participants alighted the M/V DA-BFAR on 18 May.

Figure 2. The marine vessel M/V DA-BFAR (DYCA) was the research platform used during the UPMSI/UPLB/DA-BFAR Joint Cruise, 6-14 May 2014. The small rubber boats moved divers from the starboard to behind the stern for diving and underwater activities (Photo courtesy of the Physical Oceanography Lab, UPMSI).

**Coral Reef Assessment**

**Verifying Depth and Bottom Type**. After the M/V DA-BFAR anchored, underwater cameras (SplashCam point of view camera and GoPro Hero cameras) and a dive computer were lowered with a weighted line to film the bottom and confirm the depth reading at anchor point. The short footages were reviewed after the cameras were retrieved and then dives were thoroughly planned when depth was dive-permitting and footages revealed a coral reef bottom.

**Diving**. Divers used SCUBA for their bounce dives and rapid underwater activities on the summit of the Benham Bank. The divers were moved behind the ship's stern for the dives. Each diver was tethered to a weighted line

during descents to the bottom. The two most experienced divers in the team served as tenders and deployed reserve air tanks with regulators at three decompression depths and then stayed tethered at the shallow decompression depths. At the bottom, the divers worked within a radius of ~10 m from the weighted line. The tenders sounded off the signal when bottom time was reached (5-7 min), hence, prompted divers to approach and then fasten their carabiners to the weighted line prior to starting their ascent.

Whenever possible, three pairs of divers were deployed sequentially to maximize the collection of data from each station, allowing each pair to perform only one specific task while at the bottom depth. Divers also alternated assignments as deep divers and tenders between dives. Safety procedures were followed in deploying divers at the summit depths. The dives were scheduled on mornings every other day from 6 to 14 May 2014.

**Observational Surveys and Collections of Specimens**. At the five dive stations, divers performed video- and photographic documentation of the reef and associated benthos. A rapid fish visual census (FVC) for 5 to 7 min was done in Stations 1 and 2, in which reef fish species were enumerated and fish total lengths (TL) were estimated. In Stations 3, 4, and 5, two 5 x 10-m observation areas were delimited for the rapid FVCs, where fish species were also enumerated, fish individuals were counted, and TLs were estimated, so that fish biomass can be calculated. The divers also collected voucher specimens manually, i.e., pieces of corals, conspicuous invertebrates (sponges, soft corals), macroalgae, and samples of loose sediments.

**Onboard Activities**. All the samples collected were photo-documented, i.e., the large ones were photographed using digital SLRs while the smaller associated organisms were photographed under M/V DA-BFAR's Nikon stereoscopic zoom microscope mounted with a diascopic stand, a digital camera, and a stand-alone monitor control unit. Thereafter, the coral specimens were sun-dried, macroalgal samples were pressed onto clean white paper and inserted into old newspapers, and the macroinvertebrates (e.g., sponges and soft corals) were fixed in 70% ethanol in seawater. Subsamples for microbial analyses were obtained from sediment samples prior to preservation with 10% formalin in seawater.

Opportunistic fishing by hook-and-line was carried out by the crew of the M/V DA-BFAR in four stations (Stations 2 to 5) to complement data from the FVCs. These were done when the ship was still anchored and divers were not underwater. The fishes caught were identified, measured, and photographed; some fish individuals were frozen until preservation and archiving at the UPMSI. Species lists from both rapid fish visual censuses and hook-and- line fishing events were merged into one database and each species was classified as either indicator or target species and as demersal or pelagic species.

## RESULTS AND DISCUSSION

The underwater activities were carried out at verified depths from 51.3 (Station 2) to 55.1 m (Station 1) and with confirmed coral reef bottoms in five stations located on the eastern ridge of the Benham Bank summit (**Table 1**).

### Coral Reef Benthos

The coral reefs on the Benham Bank Seamount were found to be in pristine condition and with excellent benthic cover, i.e., 75 to 100% hard corals on the bottom (**Figure 3**). The foliose plate-forming species, identified as *Porites* (*Synarea*) *rus* (**Figure 4**), was found in all the stations, particularly dominated the coral reef bottom of Stations 1 and 2, and, at the same time, entirely covered the substratum. *Porites* (*Synarea*) *rus* formed circular tiers and gave an undulating appearance at bottom depth; these were made up of heavy coralline framework, indicating possible slow growth rates. The reefscapes included other coral lifeforms, e.g., encrusting *Galaxea*, encrusting and massive *Porites*, massive *Platygyra*, branching *Pocillopor*a, fungiids, and the blue coral *Heliopora coerulea*. There were also occasional tufts of the green algae *Halimeda* (**Figure 5**) observed, including arborescent sponges and soft corals (Families Alcyoniidae, Neptheidae, and Xeniidae). The divers also noted sediments that became exposed as a result of the ship's anchor being dragged at the bottom.

In Stations 3, 4, and 5, the reefs were more heterogeneous (**Figure 6**) as other coral growth forms (e.g., massive *Porites* and *Astreopora*, submassive

Table 1. Survey date, location, and depth of the five coral reef stations on the Benham Bank Seamount, 6-14 May 2014.

| Date of survey (2014) | Station | Location | Depth (m) |
|---|---|---|---|
| 6 May | 1 | 15°48.106'N, 124°18.160'E | 55.1 |
| 8 May | 2 | 15°48.060'N, 124°18.225'E | 51.3 |
| 10 May | 3 | 15°49.230'N, 124°18.210'E | 54.8 |
| 12 May | 4 | 15°49.214'N, 124°18.187'E | 54.4 |
| 14 May | 5 | 15°48.134'N, 124°18.258'E | 53.8 |

*Alveopora* and *Cyphastrea*, branching *Acropora* and *Pocillopora*) were observed as well as other conspicuous lifeforms, i.e., soft corals (Neptheidae, *Xenia* sp., *Sinularia* sp., and *Sarcophyton* sp.), arborescent sponges, and *Halimeda*. Coralline sand and calcified remains of *Halimeda* constituted the loose surface sediments, observed as large areas in between the coral communities of Stations 3 and 4.

Based on examination and identification of collected specimens, the following reef-building species occurred on the Bank- *Fungia scutaria, Cycloseris cyclolites, Alveopora verrilliana, Cyphastrea calcidicum, Cyphastrea. microphthalma, Galaxea astreata, G. fascicularis, Pocillopora verrucosa, Acropora valida, Porites lutea, Porites.murrayensis, Pavona minuta,* and the octocoral *Heliopora coerulea,* as previously noted (**Figure 7, a** to **m**).

The thriving reefs were under clear waters that allowed sunlight to reach their depths. Zooxanthellate corals require sunlight in order for their symbiont algae to carry out photosynthesis and, in turn, support coral growth and survival. From a previous cruise in Lamon Bay, light intensities down to 300 m were measured (as PAR, photosynthetically active radiation) using a sensor attached to the CTD (*Cabrera et al. 2015*). The profile indicated that light received at the Bank summit was only 12% of surface irradiance (~200 µE $m^{-2}$ $s^{-1}$), which is quite low relative to light intensities received by shallower reefs. Under such low light environment, only particular taxa of certain growth forms have successfully adapted and proliferated, thus, the diversity of coral species and coral growth forms become limited. At ~125 m, light disappears and signals the depth at which the aphotic zone in the Benham Bank begins (*Cabrera et al. 2015*).

Figure 3. Foliose and plate-forming corals dominated the reef bottoms of the Benham Bank Seamount (photo grabbed from a video clip courtesy of L.A.B. Meñez, 6 May 2014).

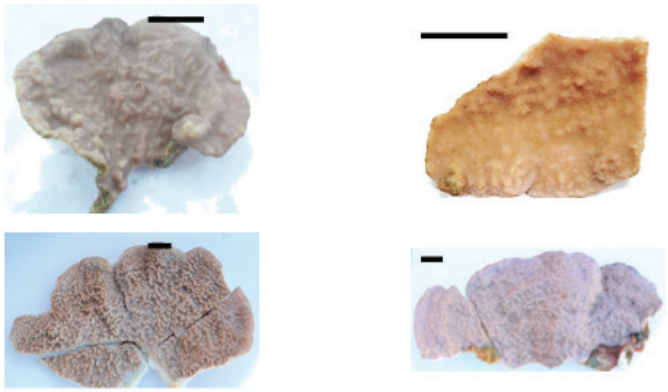

Figure 4. Fresh voucher specimens of *Porites* (*Synarea*) *rus*, the dominant foliose plate-forming scleractinian coral in the five stations surveyed on the summit of the Benham Bank Seamount, 6-14 May 2014 (scale bar: 2 cm) (photos courtesy of G.S. Jacinto and D.O. De Jesus).

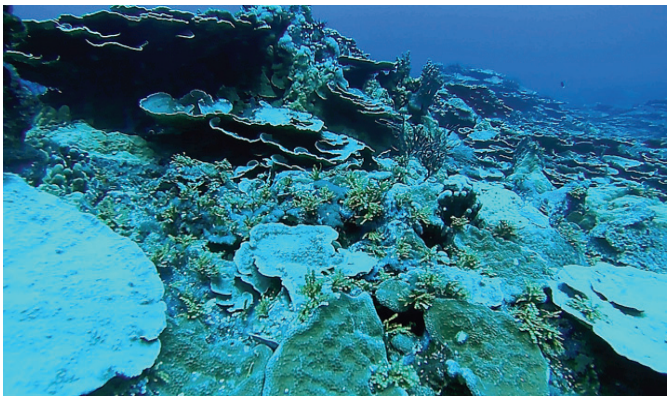

Figure 5. Tufts of the green algae Halimeda sp. with hard corals on the Benham Bank Seamount. *Halimeda* is a major contributor of loose surface sediments on the Bank (photo grabbed from a video clip courtesy of L.A.B. Meñez, 6 May 2014).

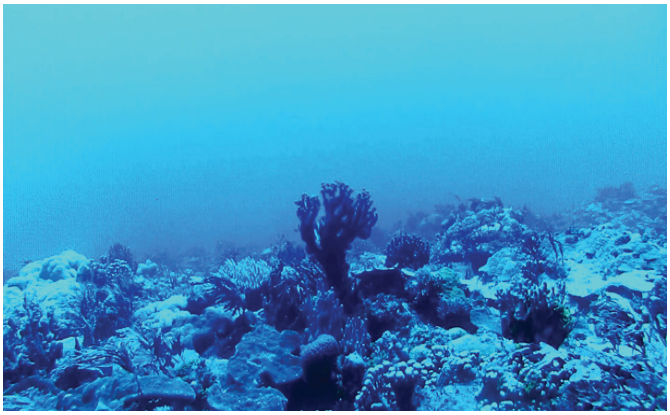

Figure 6. Mix of coral growth forms in Station 4, Benham Bank Seamount (photo grabbed from a video clip courtesy of A.T. Yñiguez, 12 May 2014).


Figure 7. Solitary corals (a, b) and reef-building species (c to m) on the Benham Bank that occurred together with *Porites* (*Synarea*) *rus*, based on the voucher specimens collected on 6-14 May 2014 (scale bar: 2 cm) (photos courtesy of G.S. Jacinto and H.M.E. Nacorda).

**Reef-Associated and Pelagic Fishes**

The combined data from underwater FVCs and opportunistic hook and line fishing listed a total of 61 bony fishes and two cartilaginous fish, *Triaenodon obesus* and *Atelomycterus marmoratus*, associated with the coral reefs of the Benham Bank Seamount. Among the reef fishes, the most speciose families were the Chaetodontidae (butterflyfishes, 10 species), Serranidae (groupers, 9 species), and Acanthuridae (surgeonfishes, 8 species) (**Table 2**). Five Families (16 species) were known indicators of coral reef health- Chaetodontidae, Pomacanthidae (angelfishes, 2 species), Pomacentridae (damselfishes, 2 species), Ptereleotrididae (dart gobies, 1 species), and Zanclidae (Moorish idol, 1 species) (**Table 2**). Thirteen families (47 species) were commercially important or food fish (**Table 2**). The schooling tunas (*Gymnosarda unicolor*, made up of 5 to 15 individuals) were the largest among the target pelagic species observed, with an estimated total length (TL) of ~150 cm. The solitary rainbow runner (*Elegatis bipinnulata*, Family Carangidae) observed was also large, sized ~70 cm TL. Only one individual was observed to be relatively large among the demersal (coral reef-attached) species, i.e., the footballer cod *Plectropomus laevis* (Family Serranidae) at 80 cm TL (**Table 2**). The estimated pooled

Table 2. Species, estimated sizes (in cm), and counts of demersal (site-attached) and pelagic fishes recorded during five days of fish visual census (FVC) and four days of hook-and-line fishing (*) on the summit of the Benham Bank Seamount, 6-14 May 2014.

| Family (Common Name)/ Species | Size (cm) | Classification | Station | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| Chaetodontidae (butterflyfishes) | | | | | | | |
| *Chaetodon guentheri* | 8 | Demersal; indicator | - | 1 | - | - | - |
| *Chaetodon kleinii* | 8 | Demersal; indicator | - | 1 | - | - | - |
| *Chaetodon mertensii* | 8 | Demersal; indicator | - | 1 | - | - | - |
| *Chaetodon punctatofasciatus* | 10 | Demersal; indicator | - | - | - | 1 | - |
| *Chaetodon reticulatus* | 12 | Demersal; indicator | - | 1 | - | - | - |
| *Chaetodon unimaculatus* | 8 | Demersal; indicator | - | 1 | - | - | - |
| *Forcipiger longirostris* | 10 | Demersal; indicator | - | 1 | - | - | - |
| *Hemitaurichthys polylepis* | 12-14 | Demersal; indicator | - | 1 | - | 1 | 1 |
| *Heniochus monoceros*[a] | 16-25 | Demersal; indicator | - | - | - | 1 | - |
| *Heniochus singularius* | 16-18 | Demersal; indicator | 1 | - | 1 | 1 | - |
| Pomacanthidae (angelfishes) | | | | | | | |
| *Centropyge heraldi* | 8 | Demersal; indicator | - | 1 | - | - | - |
| *Pomacanthus imperator* | 25 | Demersal; indicator | - | - | - | 1 | - |
| Pomacentridae (damselfishes) | | | | | | | |
| *Chromis margaritifer* | 5-6 | Demersal; indicator | 1 | 1 | - | 1 | 1 |
| *Dascyllus reticulatus* | 6 | Demersal; indicator | - | - | - | 1 | - |
| Ptereleotrididae (dart gobies) | | | | | | | |
| *Nemateleotris magnifica* | 7 | Demersal; indicator | - | - | 1 | - | - |
| Zanclidae (Moorish idols) | | | | | | | |
| *Zanclus cornutus* | 12-14 | Demersal; indicator | - | 1 | 1 | - | - |
| Acanthuridae (surgeonfishes) | | | | | | | |
| *Acanthurus nigricans* | 10-12 | Demersal; target | - | 1 | - | - | 1 |
| *Acanthurus nigrofuscus* | 10-12 | Demersal; target | - | - | 1 | 1 | - |
| *Acanthurus pyroferus* | 12-14 | Demersal; target | - | | 1 | - | 1 |
| *Acanthurus thompsoni* | 12-15 | Demersal; target | - | 1 | 1 | 1 | 1 |
| *Naso brachycentron* | 40 | Pelagic; target | - | - | - | - | 1 |
| *Naso lopezi* | 30-50 | Pelagic; target | 1 | 1 | - | - | - |
| *Naso unicornis* | 40 | Pelagic; target | - | - | - | - | 1 |
| *Naso vlamingii*[a] | 30-50 | Pelagic; target | - | 3 | 14 | 2 | 6 |
| Balistidae (triggerfishes) | | | | | | | |
| *Balistapus undulatus** | 23 | Demersal; target | - | - | 1 | - | - |
| *Balistoides conspicillium* | 15 | Demersal; target | - | - | 1 | - | - |
| *Melichthys vidua** | 22 | Demersal; target | - | - | 1 | - | - |
| *Sufflamen bursa** | 16 | Demersal; target | - | - | 1 | - | - |
| *Sufflamen chrysoptera* | 10 | Demersal; target | - | 1 | - | - | - |
| Caesionidae (fusiliers) | | | | | | | |
| *Pterocaesio tile* | 14 | Pelagic, target | - | 1 | - | - | - |
| Carangidae (trevallies) | | | | | | | |
| *Caranx sp.** | 43 | Pelagic, target | - | - | - | - | 1 |
| *Elegatis bipinnulata* | 70 | Pelagic, target | - | 1 | - | - | - |
| Holocentridae (squirrelfishes) | | | | | | | |
| *Myripristis murdjan* | 16-18 | Demersal; target | - | 1 | - | - | 1 |
| *Sargocentron caudimaculatum** | 17-19 | Demersal; target | - | 2 | - | - | 1 |
| *Sargocentron spiniferum** | 32-35 | Demersal; target | - | 3 | - | - | 1 |
| *Sargocentron tiere** | 27 | Demersal; target | - | - | - | - | 1 |
| Labridae (wrasses) | | | | | | | |
| *Bodianus mesothorax* | 14 | Demersal; target | - | - | - | - | 1 |
| *Cheilinus unifasciatus* | 12-16 | Demersal; target | - | 1 | 1 | 1 | 1 |

Table 2. Species, estimated sizes (in cm), and counts of demersal (site-attached) and pelagic fishes recorded during five days of fish visual census (FVC) and four days of hook-and-line fishing (*) on the summit of the Benham Bank Seamount, 6-14 May 2014. (cont.)

| Family (Common Name)/ Species | Size (cm) | Classification | Station | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| *Halichoeres chrysus* | 12 | Demersal; target | - | 1 | - | - | - |
| *Labroides bicolour* | 6 | Demersal; target | - | 1 | - | - | - |
| *Oxycheilinus diagramma** | 17-28 | Demersal; target | - | 1 | 8 | 5 | 8 |
| *Thalassoma lutescens* | 12-18 | Demersal; target | - | 1 | - | - | 1 |
| Lethrinidae (emperors) | | | | | | | |
| *Gnathodentex aureolineatus** | 18-23 | Demersal; target | - | - | 6 | - | 1 |
| *Monotaxis grandoculis* | 15 | Demersal; target | - | - | 1 | - | - |
| Lutjanidae (snappers) | | | | | | | |
| *Aphareus furca* | 18 | Demersal; target | - | - | - | 1 | - |
| *Lutjanus bohar** | 24 | Demersal; target | - | - | 1 | - | - |
| *Macolor macularis*[a] | 25-36 | Demersal; target | - | 1 | - | 1 | 1 |
| Mullidae (goatfishes) | | | | | | | |
| *Parupeneus multifasciatusa* | 18-20 | Demersal; target | - | - | - | - | 1 |
| Scaridae (parrotfishes) | | | | | | | |
| *Scarus forsteni* | 16-18 | Demersal; target | - | 1 | - | 1 | 1 |
| Serranidae (groupers) | | | | | | | |
| *Cephalopholis spiloparaea** | 17-21 | Demersal; target | - | 4 | 4 | 2 | 3 |
| *Cephalopholis urodeta*[a] | 15-18 | Demersal; target | - | 1 | 1 | 1 | 1 |
| *Epinephelus fasciatus** | 20-30 | Demersal; target | - | 2 | - | 12 | - |
| *Gracila albomarginata* | 20 | Demersal; target | - | 1 | - | - | - |
| *Plectropomus areolatus* | 72 | Demersal; target | - | - | - | 1 | - |
| *Plectropomus laevis*[a] | 80 | Demersal; target | 1 | - | - | - | - |
| *Pseudanthias tuka* | 7 | Demersal; target | - | 1 | - | - | - |
| *Variola albimarginata** | 25-38 | Demersal; target | - | - | - | 2 | 1 |
| *Variola louti** | 24-42 | Demersal; target | - | - | - | 2 | 1 |
| Synodontidae (lizardfishes) | | | | | | | |
| *Synodus variegatus** | 16 | Demersal; target | - | - | - | - | 1 |
| Carcharhinidae (requiem sharks) | | | | | | | |
| *Triaenodon obesus* | 150 | Pelagic, target | - | - | 1 | - | - |
| Scyliorhinidae (cat sharks) | | | | | | | |
| *Atelomycterus marmoratus** | 70 | Pelagic, target | - | 1 | - | - | - |
| Scombridae (tunas) | | | | | | | |
| *Gymnosarda unicolor* | 150 | Pelagic, target | 1 | 1 | - | - | 1 |
| Rhincodontidae (whale sharks) | | | | | | | |
| *Rhincodon typus*[b] | 400 | Pelagic, target | - | 1 | - | - | - |
| | | Number of species recorded: | 5 | 35 | 19 | 21 | 27 |
| | | Cumulative number of species recorded: | 5 | 40 | 59 | 80 | 107 |
| | | Number of unique species: | 5 | 32 | 11 | 8 | 7 |
| | | Cumulative number of unique species: | 5 | 37 | 48 | 56 | 63 |

[a] Species was recorded during both FVC and hook and line fishing

[b] Species was recorded during the verification of bottom type and not during FVC or through hook-and-line

fish biomass, based on data of Stations 3 to 5, ranged from 17 to 102 mt km$^{-2}$ (mean at 60 mt km$^{-2}$), which is almost threefold lower when compared to the mean biomass of coral reef-associated fishes in 10-m deep waters of the protected Tubbataha Reefs National Park off the Sulu Sea for the same year (~150 mt km$^{-2}$; *Dejucos et al. 2015*). This difference in fish biomass may be verified when the communities are sampled through comparable methods, or sufficiently using underwater technologies for deep water environments, with other representative reef areas also covered during sampling.

There were 23 species (13 families) of fish from hook- and-line fishing, which frequently caught the surgeonfish *Naso vlamingii* and wrasse *Oxycheilinus diagramma*.Only six fish species were common in the

species lists from the fishing events and FVCs, i.e., *Heniochus monoceros* (Chaetodontidae), *N. vlamingii* (Acanthuridae), *Macolor macularis* (Lutjanidae), *Parupeneus multifasciatus* (Mullidae), *Cephalopholis urodeta*, and *Plectropomus laevis* (both Serranidae) (**Table 2**).

Overall, the important observations for the reefs on summit depths of the Benham Bank Seamount with respect to reef fishes were: that the diversity of butterflyfishes (Chaetodontidae) was high, which is consistent with the high species diversity of butterflyfishes per unit area of reef observed in surveys conducted along the Pacific Seaboard between 2001 and 2003 (*DOST 2004*); that despite the depth, the majority of the reef fish species observed were commercially important food fish, represented by large species of snappers, emperors, groupers, trevallies, and surgeonfishes; and that majority of the fishes observed were mostly adults or large-sized individuals.

## CONCLUSION AND RECOMMENDATION

The first observations of the newly discovered mesophotic reefs on the offshore underwater seamount of the Benham Bank are presented here. The rapid observational surveys revealed the pristine state of the reefscapes, composed of mostly the foliose plate-forming *Porites* (*Synaraea*) *rus* and at least 11 reef-building and two solitary coral species that covered the bottom, together with 63 reef-associated fish species, conspicuous soft corals, arborescent sponges, and the small-sized *Halimeda*. The apparent diversity observed (corals, fish, macroalgae, and other invertebrates), however, seemed lower than those in the nearshore and shallower finging reefs (cf. *Carpenter and Springer 2005, Sanciangco et al. 2013*). Further investigations on the reefs' biodiversity need to be performed to understand its functioning and dynamics as an offshore habitat, and to ascertain its connectivity with nearshore reefs (e.g., *Van Oppen et al. 2011, Kahng et al. 2014, Thurber et al. 2014, Abesamis et al. 2017*). The Bank's summit depth at 50 m is currently used for anchorage during a limited window (April to June each year) and may be vulnerable to further fishing pressure (cf. *Koslow et al. 2000, Morato et al. 2006, Clark et al. 2010, Pitcher et al. 2010, Koslow and Couture 2013*). Its fisheries potential must also be examined (*White et al. 2007, Taranto et al. 2012*) if fishers were to be weaned from nearshore fishing or if the Bank (or part thereof) would be endorsed as a no-take marine reserve and contribute to food security.

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