# Assessment of the sea cucumber resource and fishery in the Bolinao-Anda reef system

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**ABSTRACT**

Fishery-independent and -dependent surveys were conducted to assess the status of the sea cucumber resource and fishery in Bolinao and Anda, Pangasinan. Thirty-five species of sea cucmbers were recorded in 25 sampling stations within seagrass beds, coral reefs and mixed habitats. Combined with previous studies in the area, there about 49 species of sea cucumbers in the Bolinao-Anda reef system. The estimated total population density of all aspidochirote sea cucumber species is 63 ind. has$^{-1}$. The artisanal multi-species fishery is at present primarily based on *Holothuria scabra*, *Stichopus horrens* and *Bohadschia marmorata* although there are indications that other high-value species were fished to local extinction. Taken together, the small sizes (<15 cm body length) of the majority of aspidochirote sea cucumbers, their low population densities, and the continuous decrease in catches are clear signs of an overexploited fishery that will likely collapse without management intervention. Adaptive management strategies for Bolinao and Anda are recommended based on the findings of this survey.

*Keywords:* biodiversity; holothurians; resource assessment; resource management; sea cucumbers; *trepang*

## INTRODUCTION

Sea cucumbers are among the most important and highly priced marine invertebrate resources in the Philippines. Its fishery served as a significant source of livelihood for many of the coastal communities in the archipelago (Domantay, 1934; Trinidad-Roa, 1987; Nievales, 2007; Choo, 2008), and forms the basis of a multi-million dollar export industry of *trepang* or dried sea cucumbers (Gamboa et al., 2004). The insatiable market demand and unsustainable fishery practices have led to a rapid decline in high-value sea cucumber resources throughout the Philippines and in many parts of the world (Lawrence et al., 2004; Battaglene & Bell, 2006). Although the Philippines is the second largest exporter of tropical sea cucumbers in the world, there has been no specific effort to effectively regulate and manage the fishery on a national scale (Casilagan & Juinio-Meñez, 2007). The scarcity of useful fishery baseline information in most regions is often cited as an obstacle in the formulation of a management plan (Gamboa et al., 2004).

This paper aims to address information gaps in the municipalities of Bolinao and Anda, both in Pangasinan, Luzon Island, Philippines. Transect surveys were done to identify the sea cucumber species present in the area, their relative abundance, densities and size structure, and distribution in major marine habitats. Interviews with sea cucumber collectors, processors and traders were undertaken to document local fishery methods and knowledge/perceptions, and characterize socio-

economic aspect of the fishery. This paper presents the results of the baseline surveys conducted in October 2007 to February 2009 and recommends adaptive management strategies for the sea cucumber fishery in Bolinao and Anda.

## MATERIALS AND METHODS

### Site selection and survey method

Sampling stations were selected from three broad habitat types, particularly seagrass, coralline and mixed habitats using a satellite map of the Bolinao and Anda reef system superimposed with remote sensing data. Manta tows were undertaken to ground-truth preselected sites. GPS coordinates of sampling stations are plotted in mapping software. A total of 25 sampling stations covering 37,500-$m^2$ were surveyed in the Bolinao-Anda reef: 25,500 $m^2$ in Bolinao (19,500 $m^2$ in fishing grounds and 6,000 $m^2$ inside protected areas) and 12,000 $m^2$ in Anda (Figure 1).

Three replicate 500 $m^2$ (100 m x 5 m) belt transects per sampling station were laid perpendicular to the shore and surveyed by pairs of observers for sea cucumbers during daytime and within 1-20 m depth range. Identification to genus and species level was done through examination of external morphology, microscopic dermal ossicles from tissue samples and using identification keys (e.g. Domantay, 1960; Tan Tiu, 1981; Reyes-Leonardo et al., 1985; Cannon & Silver, 1986; Conand, 1998; Schoppe, 2000; Desurmont, 2003; and Kerr et al., 2006). Aspidochirotes or those species belonging to families Holothuriidae and Stichopodidae were measured in its relaxed state either *in situ* or in the boat. As sea cucumbers contract when disturbed, many specimens were placed in 90L bins with seawater in the boat for a few minutes to let it regain its "relaxed" length and width. Total body length (from mouth to anus) and maximum width were measured to the nearest cm by tracing a tape measure in its body contour. Specimens were then taken out of the water for a few

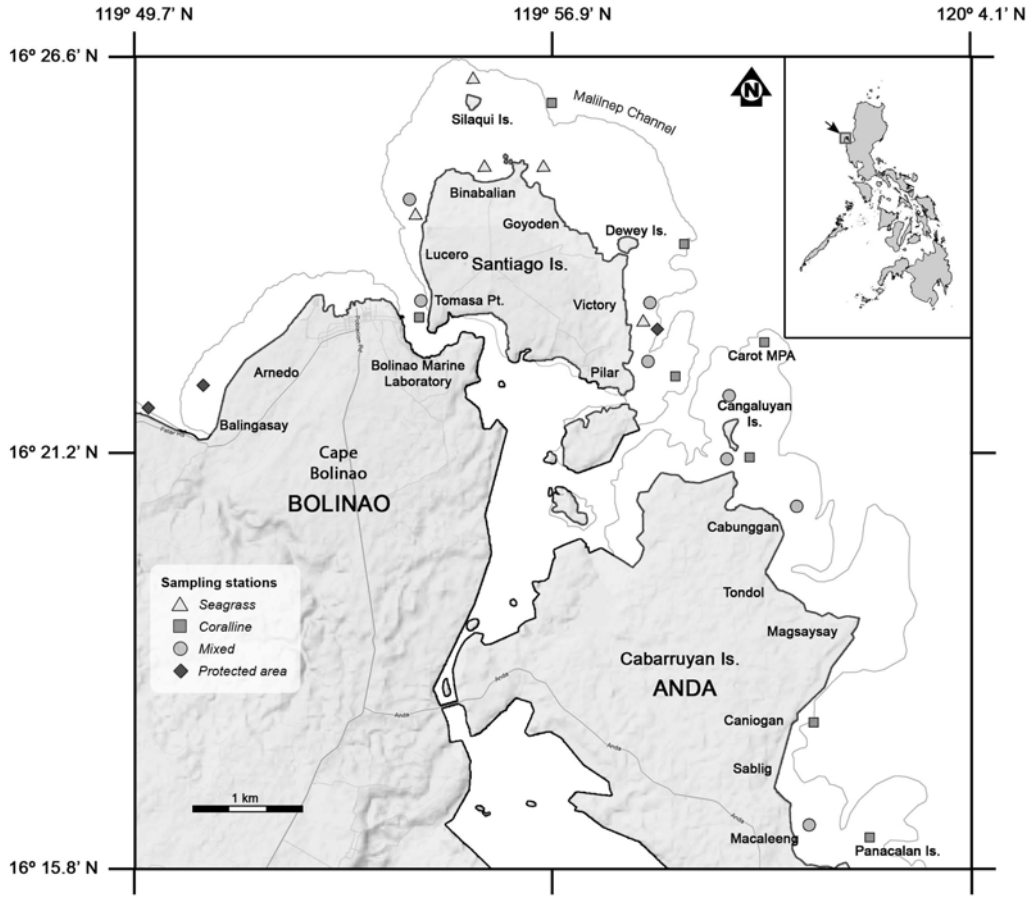


**Figure 1. Location map of sampling stations in the Bolinao-Anda reef system**

minutes (to let it expel some water from its gut) and weighed to the nearest gram using a digital scale for individuals below 100 g and to the nearest 10 g using a weighing scale more than 100 g.

Meetings with stakeholders were held in coordination with the local government to identify stakeholders based on their involvement in the fishery (i.e. traders, processors and fishers). Key informants near traditional sea cucumber fishery areas (e.g. *Barangays* Dewey, Victory and Pilar) were interviewed using stratified survey questionnaires and unstructured discussions on site. Focus group discussions (FGD) were undertaken with a group of young sea cucumber collectors, old fishermen, and the middlemen traders of Bolinao and Anda. One-year price records dated June 2006–June 2007 from the sales receipts of a major sea cucumber trader in Anda were analyzed. Wholesale and retail buyers in Binondo (Manila's Chinatown) were also surveyed to gather and confirm information on product grading, pricing and insights on trepang trade.

### Data handling and analysis

The following formulae were used in the calculation of population parameters:

Population density per species (*D*):

$$D = n_i / A$$

where:
$n_i$ = total number of individuals per species
$A$ = total area covered in hectares

Relative abundance per species (*% Ab*):

$$\% Ab = D / \Sigma D$$

The Shannon index of general diversity was calculated using the formula:

$$H = -S\, n_i/N \log n_i/N$$

where:
$n_i$ = importance value for each species (i.e number of individuals)
$N$ = total of importance values

## RESULTS AND DISCUSSION

### Species richness, distribution, abundance and density

A total of 35 sea cucumber species were found in the Bolinao-Anda reef system during the surveys, adding 15 new records to the taxonomic study done in Bolinao, which reported 28 species (Reyes-Leonardo et al., 1985). The species inventory based on the surveys conducted and available literature shown in Table 1 indicates that there are at least 49 species in Bolinao-Anda reef system. Table 1 also shows the common names, local names and commercial values of the sea cucumbers listed. Note that *Thelenota ananas*, *T. anax*, and *Stichopus chloronotus* were only found as dried products and four species under the Order Dendrochirotida are still being identified with the help of taxonomists.

There are over 170 sea cucumber species in the Philippines (Clark & Rowe, 1971; Tan Tiu, 1981; Reyes-Leonardo, 1984; Reyes-Leonardo et al., 1985; Lane et al., 2000; Kerr et al., 2006). Of these, over 137 species are present in the South China Sea biogeographic region including those that are found in Bolinao-Anda reef system (Reyes-Leonardo et al., 1985; Lane et al., 2000; this study). Compared to the neighboring reef, the Hundred Islands in Alaminos, has around 30 species (Domantay, 1960; Juinio-Meñez et al., unpublished) and share at least 15 species in common with the present study. Taxonomic works for sea cucumbers in Calatagan, Batangas (Pacific side) reported 28 species (Reyes-Leonardo, 1984), while in Mactan and the other islands off Cebu (Visayan Sea) reported 27 species (Tan Tiu, 1981).

In terms of species diversity, the Shannon index for pooled sampling stations indicated high species diversity across habitats (1.98-2.50), as well as in the overall index for Bolinao and Anda, with 2.67 and 2.38, respectively (Table 2). Most of the sea cucumber surveys in the Philippines, however, report only number of species and vary greatly in the total area surveyed whenever indicated.

The number of species of all aspidochirotid sea cucumbers (Order Aspidochirotida) varied per station

from 1-12 species with an average of 5 species. The most species-rich station was Brgy. Victory seagrass station (12 species), closely followed by Brgy. Pilar coralline station (11 species) and Panacalan Island mixed habitat station (11 species). From pooled stations per habitat, the most species-rich habitats were coralline stations, closely followed by seagrass stations (Table 2). The MPA sampling stations were not any better compared to open-access coralline stations in terms of the number of species and individual sea cucumbers. In order to clearly establish patterns of species richness and elucidate occurences of species in the different habitat types there is a need to employ quantitative methods of selecting and categorizing sampling stations in future surveys.

**Table 1.Sea cucumber species inventory for Bolinao and Anda, Pangasinan with local names and trade value.**

| | SCIENTIFIC NAME | COMMON NAMES [a] | LOCAL NAMES | VALUE [b] |
|---|---|---|---|---|
| **Order ASPIDOCHIROTIDA** | | | | |
| 1 | *Actinopyga echinites* | Deepwater Redfish | Khaki | M |
| 2 | *Actinopyga lecanora* [+] | Stonefish | Buli-buli | M |
| 3 | *Actinopyga miliaris* [+] | Blackfish | Khaki | M |
| 4 | *Bohadschia argus* | Leopardfish | Matang-itik, Leopard | L |
| 5 | *Bohadschia koellikeri* [+] | Mottled SC | Lawayan | NC |
| 6 | *Bohadschia marmorata* | Brownspotted Sandfish | Bi-ker, Lawayan | L |
| 7 | *Bohadschia similis* [+] | Brownspotted Sandfish | Bi-ker, Lawayan | L |
| 8 | *Bohadschia vitiensis* | Brown Sandfish | Lawayan-taba | L |
| 9 | *Bohadschia sp. "*spots*"* | Eye-spot SC | Matang-itik | L |
| 10 | *Holothuria (Acanthotrapeza) coluber* | Snakefish | Balat-aso, Patola rig | VL |
| 11 | *Holothuria (Cystipus) inhabilis* | - | - | NC |
| 12 | *Holothuria (Halodeima) atra* | Lollyfish | Black Beauty | L-VL |
| 13 | *Holothuria (Halodeima) edulis* | Pinkfish | Red Beauty, Hotdog | VL |
| 14 | *Holothuria (Halodeima) pulla* [+] | - | - | NC |
| 15 | *Holothuria (Lessonothuria) pardalis* | - | - | NC |
| 16 | *Holothuria (Lessonothuria) verrucosa* | - | - | NC |
| 17 | *Holothuria (Mertensiothuria) leucospilota* | Whitethreadsfish | Brown Beauty, Balat Uwak | VL |
| 18 | *Holothuria (Metriatyla) albiventer* | Marten's SC | Rotong, Batunan | NC |
| 19 | *Holothuria (Metriatyla) scabra* | Sandfish | Putian, Bokloden, Kurtido | H-M |
| 20 | *Holothuria (Microthele) nobilis* | Black Teatfish | Susuan, Kiskisan | H-M |
| 21 | *Holothuria (Microthele) fuscogilva* | White Teatfish | Susuan, Kiskisan | H-M |
| 22 | *Holothuria (Platyperona) difficilis* | - | - | NC |
| 23 | *Holothuria (Selenkothuria) erinacea* [+] | - | - | NC |
| 24 | *Holothuria (Stauropora) fuscocinerea* | Variegated SC | Labuyo, Puyos | VL |
| 25 | *Holothuria (Stauropora) pervicax* | Stubborn SC | Sunlot, Sunlutan | VL |
| 26 | *Holothuria (Thymiosycia) arenicola* | Borrowing SC | Rotong | NC |
| 27 | *Holothuria (Thymiosycia) hilla* | Tigertail SC | Rotong, Batuli | VL |
| 28 | *Holothuria (Thymiosycia) aff. hilla* | Epi's SC | Rotong | NC |
| 29 | *Holothuria (Thymiosycia) impatiens* | Impatient SC | Sunlot | NC |
| 30 | *Pearsonothuria graeffei* | Flowerfish | Flower | VL |
| 31 | *Stichopus chloronotus** | Greenfish | Kwatro Kantos | H |
| 32 | *Stichopus hermanni* | Curryfish | Gadul, Hanginan | H-M |
| 33 | *Stichopus horrens* | Dragonfish, Warty SC | Gadul, Hanginan, Daremusak | H-M |
| 34 | *Stichopus variegatus* [+] | Variegated SC | Gadul, Hanginan | H-M |
| 35 | *Stichopus sp.* | - | Gadul, Rotong | H-M |
| 36 | *Thelenota ananas** | Prickly Redfish | Pinya-pinya | M |
| 37 | *Thelenota anax ** | Amberfish | Legs | M |
| **Order DENDROCHIROTIDA** | | | | |
| 38 | *Actinocucumis typicus* [+] | - | - | NC |
| 39 | *Cladolabes schmeltzii* [+] | - | - | NC |
| 40-43 | 4 unidentified dendrichirotid species | - | - | NC |
| **Order APODIDA** | | | | |
| 44 | *Opheodesoma glabra* [+] | Medusan SC | Rokosan | |
| 45 | *Opheodesoma grisea* | Medusan SC | Rokosan | NC |
| 46 | *Pendekaplectana nigra* [+] | Medusan SC | Rokosan | NC |
| 47 | *Polyplectana kefersteini* | Medusan SC | Rokosan | NC |
| 48 | *Synapta maculata* | Medusan SC | Rokosan | NC |
| 49 | *Synaptula media* | Sponge SC | - | NC |

+ Reported in Reyes-Leonardo et al. (1985) but not found during the survey; * Found as processed samples only; [a] SC=sea cucumber; [b] H(high)=P1,000-4000/kg, M(medium)=P500-1,000/kg, L(low)=P100-500/kg, VL(very low)=<P100/kg or rejected; NC=Non-commercial

**Table 2. Presence, frequency of observation, species richness and species diversity of sea cucumbers in Bolinao and Anda sampling stations (excluding individuals and species found outside the transects)**

| | SPECIES NAME* | BOLINAO | | | ANDA | | PRESENCE IN SAMPLING STATIONS (%) |
|---|---|---|---|---|---|---|---|
| | | SEAGRASS (5 stations) | CORAL REEF (6 stations) | MACROALGAE (4 stations) | SEAGRASS (4 stations) | MACROALGAE (4 stations) | |
| 1 | *Actinopyga echinites* | ++ | | | ++ | ++ | 25 |
| 2 | *Bohadschia argus* | + | | | | | 4 |
| 3 | *B. marmorata* | + | + | | + | ++ | 21 |
| 4 | *B. vitiensis* | | | | + | + | 8 |
| 5 | *Bohadschia sp.* "spots" | | + | | | | 4 |
| 6 | *Holothuria (Acanthotrapeza) coluber* | | | + | | + | 8 |
| 7 | *H. (Cystipus) inhabilis* | + | | | | | 4 |
| 8 | *H. (Halodeima) atra* | ++ | | | | + | 8 |
| 9 | *H. (Halodeima) edulis* | | | | | + | 4 |
| 10 | *H. (Lessonothuria) verrucosa* | + | + | | | | 8 |
| 11 | *H. (Mertensiothuria) leucospilota* | ++ | ++ | + | | +++ | 33 |
| 12 | *H. (Metriatyla) albiventer* | ++ | | ++ | +++ | + | 33 |
| 13 | *H. (Metriatyla) scabra* | + | ++ | + | +++ | | 29 |
| 14 | *H. (Microthele) fuscogilva* | | + | | | | 4 |
| 15 | *H. (Stauropora) fuscocinerea* | +++ | + | + | ++ | + | 33 |
| 16 | *H. (Stauropora) pervicax* | + | | + | | + | 13 |
| 17 | *H. (Thymiosycia) arenicola* | ++ | + | + | | + | 21 |
| 18 | *H. (Thymiosycia) hilla* | + | | ++ | | | 13 |
| 19 | *H. (Thymiosycia) aff. hilla* | + | | | | | 4 |
| 20 | *H. (Thymiosycia) impatiens* | + | +++ | +++ | +++ | ++ | 50 |
| 21 | *Pearsonothuria graeffei* | | ++ | | | | 8 |
| 22 | *Stichopus hermanni* | | | | + | | 4 |
| 23 | *S. horrens* | + | +++ | | + | + | 25 |
| 24 | Dendrochirotid sp. 1 | | + | | | | 4 |
| 25 | Dendrochirotid sp. 2 | | ++ | | | | 8 |
| 26 | Dendrochirotid sp. 3 | | + | | | | 4 |
| 27 | Dendrochirotid sp. 4 | | ++ | | | | 8 |
| 28 | *Opheodesoma grisea* | +++++ | ++ | | + | + | 38 |
| 29 | *Polyplectana kefersteini* | ++++ | | | + | + | 25 |
| 30 | *Synapta maculata* | +++++ | ++++ | ++++ | +++ | +++ | 79 |
| 31 | *Synaptula media* | | + | | | + | 8 |
| | **Species Richness** | **19** | **17** | **10** | **12** | **17** | |
| | **Species Diversity** | **2.50** | **2.01** | **2.13** | **1.98** | **2.19** | |
| | **(Shannon Index) of Aspidochirotes** | **2.67** | | | **2.38** | | |

* Of the 35 species found in Bolinao-Anda reef system, 3 species (*Stichopus chloronotus*, *Thelenota ananas* and *T. anax*) were found only as processed samples.

The most frequently observed species were *Synapta maculata*, *Holothuria impatiens*, *Opheodesoma grisea*, *H. leucospilota* and *H. albiventer* (Table 2). *Holothuria scabra*, *H. fuscocinerea* and *H. impatiens* were present in all the habitats surveyed. Other species were observed to have narrow distributions with respect to habitat type, specifically *Pearsonothuria graeffei* in coralline sites, *Bohadschia argus*, *H. inhabilis*, and *H. aff. hilla* in seagrass sites, and *H. coluber* in macroalgae-dominated sites. *Holothuria fuscogilva*, which was earlier thought to be depleted to local extinction, was observed only once in a coralline site in Brgy. Balingasay MPA. *Synaptula media* and 4 species of dendrochirotid sea cucumbers (Order

**Table 3. Actual counts of aspidochirote sea cucumbers (Order Aspidochirotida), estimates of density and relative abundances in Bolinao-Anda transect surveys.**

| RANK | SPECIES | NUMBER OF IND. | | | DENSITY (IND. HAS$^{-1}$) | | | RELATIVE ABUNDANCE (%) |
|---|---|---|---|---|---|---|---|---|
| | | BOLINAO | ANDA | POOLED | BOLINAO | ANDA | POOLED | |
| 1 | *Holothuria impatiens* | 18 | 17 | 35 | 7.1 | 14.2 | 9.3 | 14.9% |
| 2 | *H. albiventer* | 10 | 22 | 32 | 3.9 | 18.3 | 8.5 | 13.6% |
| 3 | *Stichopus horrens* | 9 | 17 | 26 | 3.5 | 14.2 | 6.9 | 11.1% |
| 4 | *H. scabra* | 10 | 13 | 23 | 3.9 | 10.8 | 6.1 | 9.8% |
| 5 | *H. fuscocinerea* | 11 | 6 | 17 | 4.3 | 5.0 | 4.5 | 7.2% |
| 6 | *H. hilla* | 14 | 1 | 15 | 5.5 | 0.8 | 4.0 | 6.4% |
| 7 | *Pearsonothuria graeffei* | 15 | 0 | 15 | 5.9 | 0.0 | 4.0 | 6.4% |
| 8 | *H. leucospilota* | 9 | 4 | 13 | 3.5 | 3.3 | 3.5 | 5.5% |
| 9 | *A. echinites* | 4 | 6 | 10 | 1.6 | 5.0 | 2.7 | 4.3% |
| 10 | *H. arenicola* | 8 | 1 | 9 | 3.1 | 0.8 | 2.4 | 3.8% |
| 11 | *S. hermanni* | 0 | 8 | 8 | 0.0 | 6.7 | 2.1 | 3.4% |
| 12 | *Bohadschia marmorata* | 3 | 3 | 6 | 1.2 | 2.5 | 1.6 | 2.6% |
| 13 | *H. edulis* | 0 | 5 | 5 | 0.0 | 4.2 | 1.3 | 2.1% |
| 14 | *H. coluber* | 2 | 2 | 4 | 0.8 | 1.7 | 1.1 | 1.7% |
| 15 | *H. pervicax* | 3 | 1 | 4 | 1.2 | 0.8 | 1.1 | 1.7% |
| 16 | *H. atra* | 2 | 1 | 3 | 0.8 | 0.8 | 0.8 | 1.3% |
| 17 | *H. rigida* | 2 | 1 | 3 | 0.8 | 0.8 | 0.8 | 1.3% |
| 18 | *B. vitiensis* | 0 | 2 | 2 | 0.0 | 1.7 | 0.5 | 0.9% |
| 19 | *H. verrucosa* | 2 | 0 | 2 | 0.8 | 0.0 | 0.5 | 0.9% |
| 20 | *B. argus* | 1 | 0 | 1 | 0.4 | 0.0 | 0.3 | 0.4% |
| 21 | *Bohadschia sp. "spots"* | 1 | 0 | 1 | 0.4 | 0.0 | 0.3 | 0.4% |
| 23 | *H. fuscogilva* | 1 | 0 | 1 | 0.4 | 0.0 | 0.3 | 0.4% |
| | | **125** | **110** | **235** | **49.4** | **91.7** | **62.9** | **100** |

Dendrochirotida) were found to be aggregating in a small area in Tomasa Point, Bolinao and were rarely found elsewhere during the survey. These species of dendrochirotids tend to aggregate in large numbers, have limited distribution, and small adult sizes.

The number of aspidochirotid sea cucumber individuals per species in a site and even in pooled habitats was generally very low that density estimates per species were pooled for the whole reef (Table 3). Estimates of population densities ranged from 0.3 to 9 ind.ha$^{-1}$ per species and a total of 63 ind.ha$^{-1}$ for all aspidochirotes in the Bolinao-Anda reef. Anda stations have denser populations compared to Bolinao. The densities in fished coralline areas and coralline MPAs were almost identical (46 and 44 individuals has$^{-1}$, respectively). While MPAs were expected to have higher population densities by providing refuge from fishing, the MPAs sampled varied in the level of enforcement (e.g. from not guarded to strictly guarded by stakeholders), and as such, poaching could have negated the potential effect of closed access habitats on sea cucumber populations.

Among aspidochirotid sea cucumbers, *Holothuria impatiens, H. albiventer, S. horrens, H. scabra, H. fuscocinerea* and *H. hilla* have the highest density with a range of 4-9 ind.ha$^{-1}$ (Table 3). Although the minimum population densities for broadcast spawning sea cucumber species to reproduce effectively have not been established, densities less than 100 ind.ha$^{-1}$ is considered low, and less than 30 ind.ha$^{-1}$ may be within a critical level at which populations will fail to repopulate (Purcell et al., 2009). The population densities of sea cucumbers in the Bolinao-Anda reef may be too sparse to achieve a high probability of

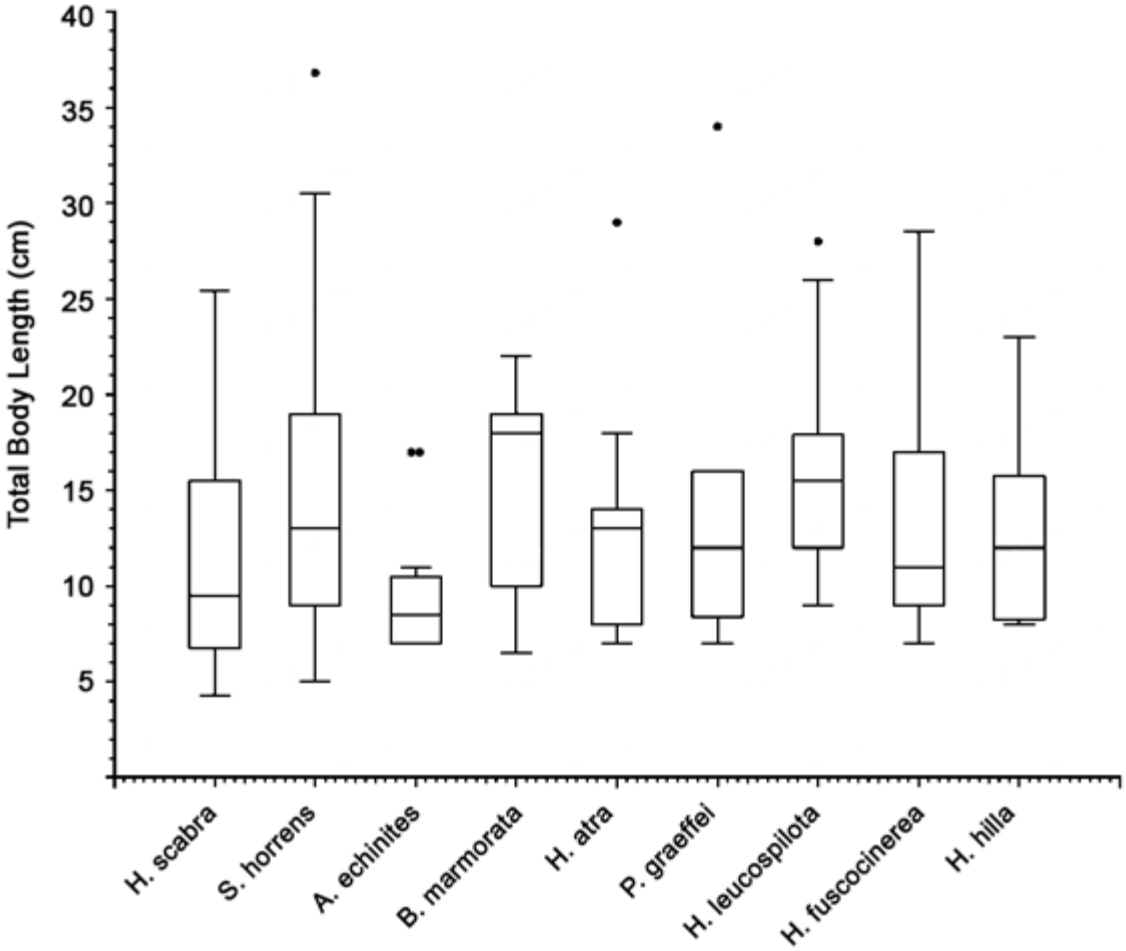


**Figure 2. Lengths of commercial sea cucumbers species in Bolinao and Anda, Pangasinan**

fertilization success during spawning events, thus, affecting contribution the larval supply of sea cucumbers. At present, the vulnerability of the sea cucumber stocks to decline is exacerbated by its unregulated fishery.

## Size structure

The majority of the aspidochirotid sea cucumbers found have mean lengths less than 15 cm (Figure 2). The legal minimum length imposed in Queensland, Australia is 15 cm for all species (Bruckner, 2005). This, however, may not provide enough chance for sea cucumbers to reproduce before being harvested and did not consider studies on species-specific size-at-first-maturity (e.g. Conand, 1993). Based on the species-based size limits in Papua New Guinea for 17 major species (Bruckner, 2005), the majority of the sea cucumbers in Bolinao and Anda are undersized and should not be collected, processed or sold**.** The low abundance of large, sexually mature individuals for the main commercial species *H. scabra, S. horrens, A. echinites,* and *B. marmorata* reflects strong fishing pressure in the area, and indicates that reproductive potential is low relative to the reported population density. Despite the low densities of adult sea cucumbers, the presence of some juvenile *H. scabra* in Cangaluyan station, and numerous *S. horrens* in Tondol station suggest that recruitment persist at least in these areas, although the source of larvae may be outside the area covered in the survey.

## Catch composition, fishing techniques and fishery profile

There are about 41 commercial species in the Philippines (NFRDI, unpublished), and 25 of these are

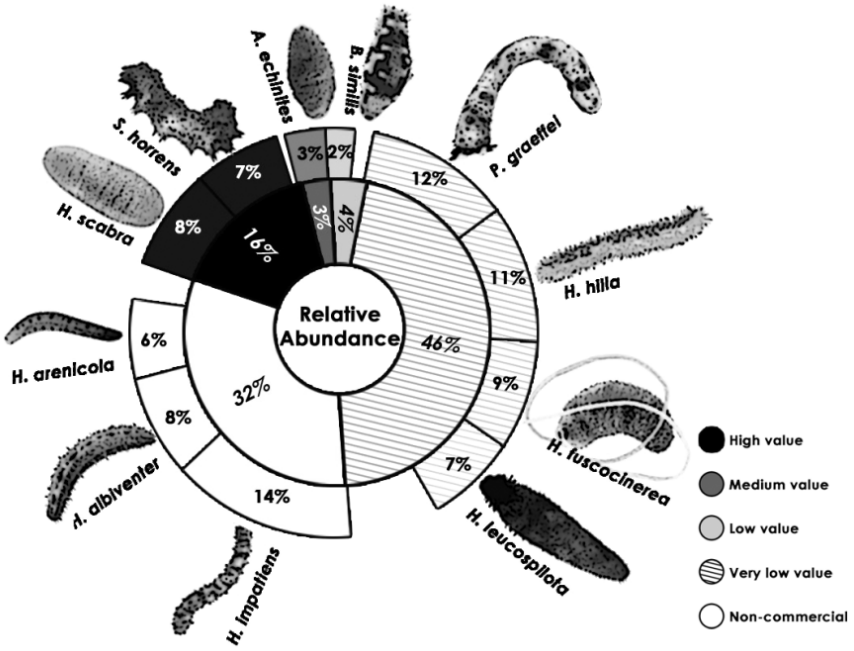


**Figure 3. Relative abundance of sea cucumbers in Bolinao, Pangasinan per species and value category (non-aspidochirote species and species with very low abundance not shown but included in the computation)**

regularly collected for the *trepang* or dried sea cucumber product (Schoppe, 2000). Based on interviews with local processors and traders, 26 species are considered commercial in Bolinao and Anda: 7 of high-value, 5 of medium-value and the rest of minor or no value (Table 1). The combined percentage of "low value species" (*Bohadschia* and *Holothuria* species with thin body wall), "medium value species" (*Actinopyga* and *Thelenota* species), and "high value species" (*Holothuria* species with thick body walls and *Stichopus* species) is only 23% (Figure 3). Most of the sampled commercial species belong to the "very low value" category, which refers to the "worm-like" species previously considered non-commercial.

Fishing high-value sea cucumber species such as *H. scabra* and *S. horrens* is mainly done by free-diving or gleaning. Groups of gleaners typically collect shallow-water sea cucumbers in addition to shellfishes, crabs and seaweeds during low tide in intertidal flats often by wading or by raking the sediments. Free-divers and spearfishers equipped with bamboo rafts (*balsa*), makeshift goggles and wooden fins, dive to depths of around 2-5 m to scan the bottom area, overturn rocks and pick any sea cucumbers in addition to target organisms. Before the widespread depletion of sea cucumber stocks, air compressors allowed fishers to efficiently harvest deeper water species such as *Thelenota ananas*, *T. anax* and *H. whitmaei*. Dedicated nighttime harvests are also done monthly or seasonally for predominantly nocturnal species (e.g. *Stichopus* spp., *Bohadschia* spp., and *Actinpyga lecanora)*.

This multi-species fishery is an important supplemental livelihood for 90% (n=29) of the respondents in Bolinao, of which 57% are young males, 29% are adult males, and 14% are adult females. The young males, mostly primary school leavers, are free-divers whereas the adult males are engaged in more varied fishery activities often using *balsa* or motorized *bangka*. The women augment the income of the family by weaving *buri* (palm leaves) sleeping mats and gleaning.

## Historical trends in the local fishery

Interviews and focused group discussions with fishermen in Bolinao (n=16) and Anda (n=18) who collected sea cucumbers since 30 years ago revealed major changes in the fishery (Figure 4; Paña et al.,

unpublished data). In the early 1970's, there were only around 25 fishing households who regularly gleaned and trawled for sea cucumbers, primarily targeting *B. marmorata*, *H. fuscopunctata*, *H. scabra*, *H. atra*, and *S. horrens*. Chinese traders who visited the area stimulated local interest in the fishery, and also taught some fishers how to process sea cucumbers into *trepang* the traditional way. Fishing efforts soon intensified reaching an average of 100 kg day$^{-1}$ per person during its peak in the 1980's, which coinciding with the "boom" in sea cucumber fishery exports of the Philippines (Trinidad-Roa, 1987). Over 35 families in Brgy. Victory alone regularly harvested high-value sea cucumbers by the boatload, often by means of compressor-diving. The target species now included *A. echinites*, *H. fuscogilva*, *H. nobilis*, *T. ananas* and *T. anax*.

In the 1990's, however, there was a sharp decline in catch to an average of 25 kg day$^{-1}$ per person, and collection was done twice or thrice a week. Based on catch landings in Brgy. Pilar in 2002, the average daily catch per gleaner was 2.55 kg day$^{-1}$, and total catch for all gleaners was only 27 kg day$^{-1}$ (Nievales et al., unpublished data). The average monthly catch for *H. scabra* in the municipality of Anda, peaked at 109 kg in 2002 but sharply declined to around 20 kg in 2004, and has not been able to recover since (Pastor et al., 2007). Five more lower value species were added to the list of targeted species, namely: *H. leucospilota*, *H. coluber*, *H. fuscocinerea* and *A. lecanora*. Longtime fishers also note the remarkable decline in average size of sea cucumbers caught, and their need to cover more area to make the trip worthwhile. Many coastal *barangays* that traditionally collect sea cucumbers like Brgy. Pilar and Brgy. Victory reported that income derived from sea cucumber fishing has become less significant as a means of livelihood.

Overall, the fishery has downgraded from commercial to artisanal level and is characterized by the collection of smaller-sized sea cucumbers in an expanding fishing ground, increasing number species, increasing proportion of low value types, and a diminishing catch per effort. Despite the decline of sea cucumber stocks due to unsustainable fishing practices, the fishery remains largely unmanaged.

## Recent trend in sea cucumber trade

The traditional market flow in Bolinao and Anda is that fishers sell their catch (for as low as Php 40 kg$^{-1}$ for assorted species and size) to local processors-traders who, in turn, sell dried sea cucumbers to a middlemen or the satellite branch of a marine products company in Alaminos City. The price of the product depends on the species, and "grade" according to size and specific product standards for appearance, texture, odor, and hardness based on cursory assessment by traders (Akamine 2001). The market testing done for Bolinao and Anda products revealed that most of the medium-sized *H. scabra* products were assessed as "Class B" and priced at Php1,300 kg$^{-1}$ because of inadequate cleaning and drying ("Class A" is priced at Php 2,900 kg$^{-1}$). Although the Binondo, Manila market offers much higher profit margins for the fishers (Table 4), most of the local stakeholders who sell directly to wholesale buyers in Binondo also lose considerable potential income due to poor product quality. Poorly processed and small-sized *trepangs* are especially prone to downpricing. Alternative direct markets in Binondo include the authentic Chinese restaurants along Ongpin St., Arranque wet market where "rehydrated" trepang is bought anywhere around Php 280-500 kg$^{-1}$, and Chinese grocery stores that sell prime grade trepang for Php 6,000 kg$^{-1}$.

The price of the high-value species typically fluctuates every month but eventually leads to a yearly increase. Based on sales records for *Stichopus* spp, prices increase almost monthly for all size grades, with a peak between February and March coinciding with the Chinese New Year. Small but steady price increases are also apparent for low-value species such as *Holothuria coluber*, *H. edulis*, *H. fuscocinerea*, *H. leucospilota*, and *H. atra*. Strong market pressure on the unregulated fishery is further reflected by the multi-level categorization even for the small-sized products (e.g. sizes "S", "XS" and "XXS" for *H. scabra* and *A. echinites*) and the shift of proportion of the products towards the lower value species that are always sold for less than Php 1,000 kg$^{-1}$ regardless of processing quality and size. In any case, premium prices are paid for large individuals while prices for smaller products declines disproportionately (Battaglene & Bell, 2006).

**Table 4. Price list of common commercial sea cucumbers from wholesale buyers in Alaminos and Binondo.**

| SPECIES | | GRADE | | PRICE PER KG (PHP) | |
|---|---|---|---|---|---|
| Scientific Name | Trade Name | Size grade | Size or No./kg | Alaminos, Pangasinan | Binondo, Manila |
| *Stichopus horrens* | Dudlo, Hanginan, Gadul, Daremusak | L | 3.1 in. | 2,280 | 2,600 |
| | | M | 2.5-3.0 | 2,080 | 2,300 |
| | | S | 3.0-2.5 | 1,750 | 1,700 |
| | | XS | 1.5-2.0 | 1,250 | 1,250 |
| | | XXS | <1.5 | - | 1,250 |
| | | Class B, XXS | <1.5 | - | 700 |
| *Holothuria scabra* | Putian, Kurtido | XXL | 15 pcs. | - | 4,800 |
| | | XL | 16-26 | 2,480 | 4,500 |
| | | L | 26-35 | 1,750 | 3,800 |
| | | M | 36-45 | 1,400 | 2,900 |
| | | S | 46-60 | 950 | 2,300 |
| | | XS | 61-80 | 780 | 2,100 |
| | | XXS | >80 | - | 1,400 |
| | | Class B, L | 26-35 | - | 1,500 |
| | | Class B, M | 36-45 | 950 | 1,300 |
| | | Class B, S | 46-60 | 1000 | 1,200 |
| | | Class B, XS | 61-80 | - | 1,100 |
| | | L | | 730 | 950 |
| | | M | | 700 | 750 |
| | | S | | 500 | 500 |
| *Bohadschia marmorata* | Lawayan | XS | | - | 200 |
| *Holothuria coluber* | Patola Orig | Assorted | | 540 | 600 |
| *Holothuria atra* | Black Beauty | M-L | | - | 400-600 |
| | | S or Assorted | | 180 | 180 |
| *Holothuria leucospilota* | Brown Beauty | Assorted | | 250 - 410 | 250-420 |
| *Pearsonothuria graeffei* | Tres Cantos | S-L | | - | 70-240 |
| | | Assorted | | 170 | - |
| *Holothuria fuscocinerea* | Labuyo, Puyos | L | | - | 180 |
| | | S or Assorted | | 100 - 115 | 130 |

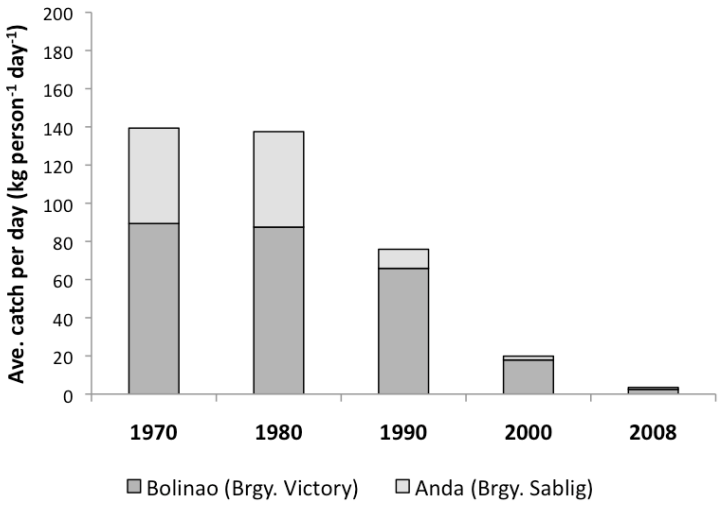


**Figure 4. Trend of catch per unit of effort for commercial sea cucumbers in Bolinao and Anda, Pangasinan from 1970's to present based on 16 respondents from Bolinao and 18 respondents from Anda.**

## CONCLUSIONS AND RECOMMENDATIONS

As in many parts of the Philippines where surveys have been conducted, the sea cucumber resources in the Bolinao-Anda reef system is characterized by high species diversity. Thirty-five species recorded in this study, and when combined with previous species inventories in the area, a total of 49 species can be found in Bolinao-Anda reef system. New species or records are likely to be found in often overlooked or less known taxa such as the dendrochirotids. Species distributions in the habitat types suggest habitat association in several species such as *Pearsonothuria graeffei*, *Holothuria inhabilis* and the dendrochirotids.

On the other hand, population densities of aspidochirotid species including high-value species (e.g. *Holothuria scabra* and *Stichopus horrens)* fall critically below the level for fertilization success during spawning, which could indicate that the area is a poor larval source for sea cucumbers. Size structure of major commercial species indicates strong fishing pressure. Interviews provided corroborating anecdotal accounts of the fishery's decline since the 1980s due to overfishing. Furthermore, potential income is not realized due to poor post-harvest and trade practices. Taken together, these are clear signs of an overexploited fishery that is likely to collapse without proper management intervention.

We, therefore, recommend the following management strategies based on the findings and insights from the surveys undertaken in Bolinao and Anda:

1) Protection and monitoring of critical nursery areas where juveniles of high-value species were found (e.g. Brgy. Tondol and Cangaluyan);
2) Maintenance of the pilot sea cucumber ranching sites established in Bolinao and Anda as reproductive reserves for sea cucumbers and supplemental livelihood for the stakeholders;
3) Explore sea cucumber restocking using wild stocks in the Bolinao Seagrass Demonstration Site to help rebuild a multi-species community of sea cucumbers;
4) Restrict and sanction the gathering or processing of any live sea cucumber below 350 g or 20 cm in length, and the trading of less than 5 cm dried sea cucumber (or over 60 pieces per kilogram);
5) Establish a registry, fishing permit and catch monitoring system in the municipal level in order to gather long-term fishery data, and encourage compliance to regulations;
6) Improve product value of *trepang* through post-harvest support and quality control at the municipal level for fishers and processors;
7) Integration of the recommended strategies for sea cucumber management into municipal fisheries management plan and Municipal Fisheries Ordinance following the adaptive management approach.

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