Assessing the Marine Biodiversity of Manila Bay:
Status and Strategies for Resources Management

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Based on the results of deep-sea surveys conducted by the M.V. DA-BFAR, waters approaching the Manila Bay area abound with deep-sea shrimp resource, and that traps had been found to be the most suitable gear to harvest the resource. However, there is a need to develop management measures in order that the resource would not be depleted in the long-term.

Being located within the Coral Triangle (**Fig. 1**), the Philippines is teeming with biodiversity and thus, has been considered as one of the 18 mega-biodiversity countries containing 2/3 of the Earth's biodiversity and inhabited by about 70-80% of the world's aquatic plant and animal species. National records have also indicated that the country's waters abound with various aquatic species, *i.e.* 468 scleractinian corals, 1755 reef-associated fishes, 648 species of mollusks, 19 species of sea grass, and 820 species of algae (Fishbase, 2008; BFAR-NFRDI-PAWB, 2005). Carpenter and Springer (2005) also declared that the concentration of species per unit area in Philippine waters is higher than that of Indonesia including the group of Indonesian islands known as Wallacea. In addition, the country has been declared as the center of 46 marine shore fish diversity in the world (DENR-PAWB, 2009).

As defined by the United Nations (1992), biodiversity is the variability among living organisms from all sources, including, *inter alia*, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part such as: diversity within species, between species,

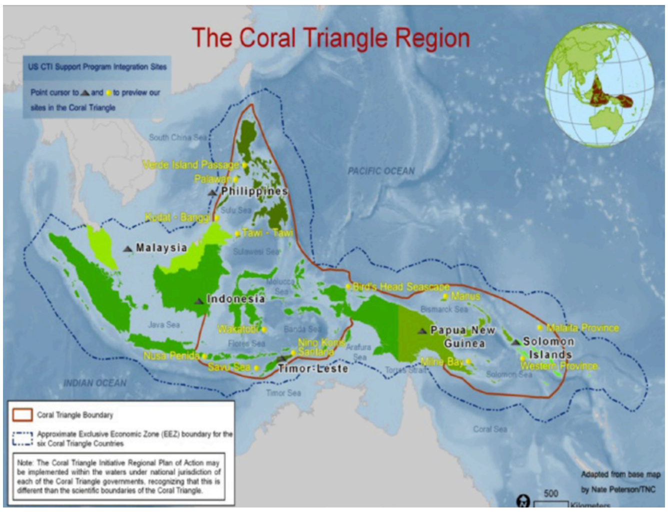


Fig. 1. The Coral Triangle Region with the Philippines at its apex

and of ecosystems (New World Encyclopedia, 2008; Wikipedia, 2011). Unfortunately, reports have indicated that the Philippine biodiversity is under threat. Reports from the Biodiversity Indicators for National Use (BINU) in 2005 indicated declining trend in the state of most coral and marine ecosystems of the Philippines. Nevertheless, reports have also identified the lack of comprehensive data and information to better understand the state of the resources and habitat, as the most glaring gap in the effective conservation and management of coastal and marine biodiversity (DENR-PAWB, undated). Likewise, DENR-PAWB (2009) cited that the Philippines had been included in the list of the world's hot spots, a top global priority area due to the large numbers of endangered and threatened endemic species.

Assessment Survey

In support of the goal of the Convention on Biological Diversity to limit biodiversity loss and the need to improve information systems about the Philippine marine biodiversity, particularly deep-sea biodiversity, a deep-sea fisheries survey was conducted by the Philippine Bureau of Fisheries and Aquatic Resources (BFAR) in western Philippine Sea using the M.V. DA-BFAR. Conducted in May 2011, the survey brought out the potential resources of the target area (**Fig. 2**) for fisheries based on abundance and came up with information on the distribution of deep-sea shrimps (Family Padalidae), a prospective resource found abundant in the area (Nepomuceno *et al.*, 2013). Focusing on the index of marine biodiversity, the study made use of traps and trawls as sampling gears considering that these are the most common implements used for deep-sea fishing although their target catch and impacts could be different. It is the goal of the survey that marine diversity loss can be minimized if marine resource users including the fisheries sector have adequate understanding and awareness of the current status of fisheries and thus, would resort to adopting sustainable fishing operations.

The survey was conducted along the continental shelf and slope of southwestern Luzon in western Philippine Sea, covering the waters of Batangas, Bataan, and the approaches to Manila Bay. Ten stations were used to deploy traps at minimum depths of 61-71 m and maximum depths of 802-844 m. In addition, six (6) beam trawl fishing

Fig. 2. Map of the Philippines showing the survey area along the continental shelf and slope of western Philippine Sea

operations were conducted in Bataan waters with minimum sampling depths of 100-104 m and maximum of 609-904 m.

Fishing Gear Used

Traps

Traps are among the most popular passive gears used in many localities in the country to catch selective species of fish and crustaceans. In this survey, traps were used to catch deep-sea scavengers particularly the species of deep-sea shrimps belonging to the Family Padalidae. The traps are cylindrical in shape and measured 65 cm in length and 30 cm in diameter. Flatbars are used as frames and polyethylene screen as covering material. Three trap designs were used in the survey, *i.e.* fully covered where the inner side of the trap is fully covered with fine-mesh black plastic screen; partially covered where the opening at both sides were not covered, and uncovered where the frame was covered only with polyethylene screen (**Fig. 3**). About 30-45 traps were deployed for every fishing operation and immersed for a period of 12-19 hours. Chopped *Sardinella* spp. was used as bait.

Fig. 3. Three types of traps used in the survey: fully-covered, partially covered and uncovered

Beam Trawl

Beam trawl is an active fishing gear which is operated by towing and used to assess demersal or benthic organisms. The trawl used is a 4.2 m wide bottom trawl which was kept open by a 4.15 m wooden beam. The height of the beam over the bottom is 0.35 m while the iron runners used to stabilize the net measure 0.5 m in height and 0.45 m in length (**Fig. 4**). Dragging time for every fishing operation lasted for 30-60 minutes.

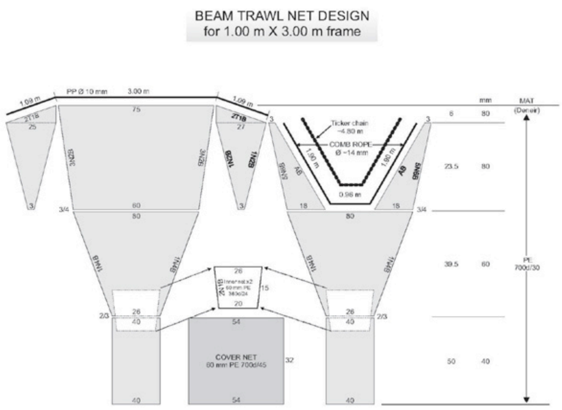


Fig. 4. Beam Trawl used in the survey

Results and Discussion

Sorting and Identification of Samples

The samples were temporarily grouped into mollusks, fishes, crustaceans, and other invertebrates at the main deck of the vessel, after which these were brought the laboratory onboard the vessel for identification, based on morphological features of the organisms described by various authors. However, there were samples that could not be identified by species-level therefore, most of the samples were identified by family-level only, while some were identified to the most possible taxonomic level such as Phylum, Infraorder, and Class.

The survey was able to collect a total of 4043 samples (**Fig. 5**) comprising mostly crustaceans (about 70%), mollusks (about 9%), fishes (more than 7%), and other invertebrates (about 14%). Moreover, the crustaceans have been classified into 39 taxa, mollusks into 32 taxa, fishes into 32 taxa, and other invertebrates into 9 taxa.

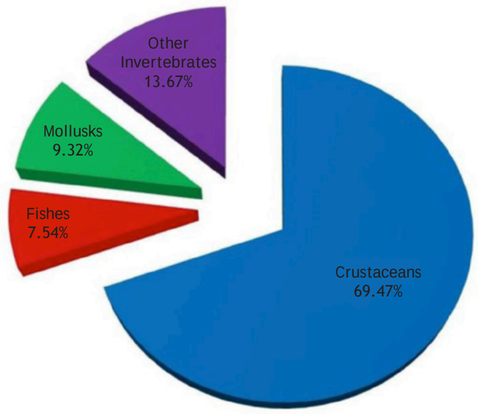


Fig. 5. Samples collected during the survey comprise mostly crustaceans followed by other invertebrates

Analysis of Data

In measuring the biodiversity, Simpson's Index (D) was used in view of its characteristics of giving meaningful ecological interpretations, and the Index being cited by various authors (Bertram, 2010; *wsc.malaysia.org*, 2007; Khan, undated) for its efficiency especially in estimating without bias, the probability of any two individuals drawn randomly from an infinitely large ecosystem, to belong to different species or some category other than species. The Simpson's Index (D) was computed using the formula:

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where: ***n*** = total number of organisms of a particular category used
N = total number of organisms of all category used

Moreover, other modifications of D were also employed in the analysis, *i.e.* Simpson's Index of Diversity (I-D) and Simpson's Reciprocal Index (I/D), especially in determining the richness and evenness of the samples. While richness is the total amount of different taxa in the samples, evenness is the value of I/D divided by the richness value (r) of the samples.

The samples taken from the beam trawl and trap fishing operations were separately treated considering the disparity of the two gears in terms of catchability. However, a comparison by sampling stations for every gear was undertaken. The most abundant organisms in every sampling station were derived from the computed value of Simpson's Reciprocal Index. Using the abovementioned formula, the biodiversity from different trap stations was computed as shown in **Fig. 6**.

As shown in **Fig. 7**, the black dots represent the depth range covered by each trap fishing operation and the corresponding computed biodiversity index. Generally, the largest dot indicates the highest biodiversity index (BI) and the smallest dot the lowest, except for the Simpson's Index (D) shown in **Fig. 6(1)**, that indicated otherwise. Highest BI and evenness (E) was constantly observed in Trap Station (567) at depths of 280-297 m along Bagac in Bataan, while the lowest BI was recorded in Trap Station (558) at depths of 627-651 m also along the waters of Bataan. While highest richness was noted at Trap Station 562 it also exhibited the lowest evenness of the samples (**Fig. 8**).

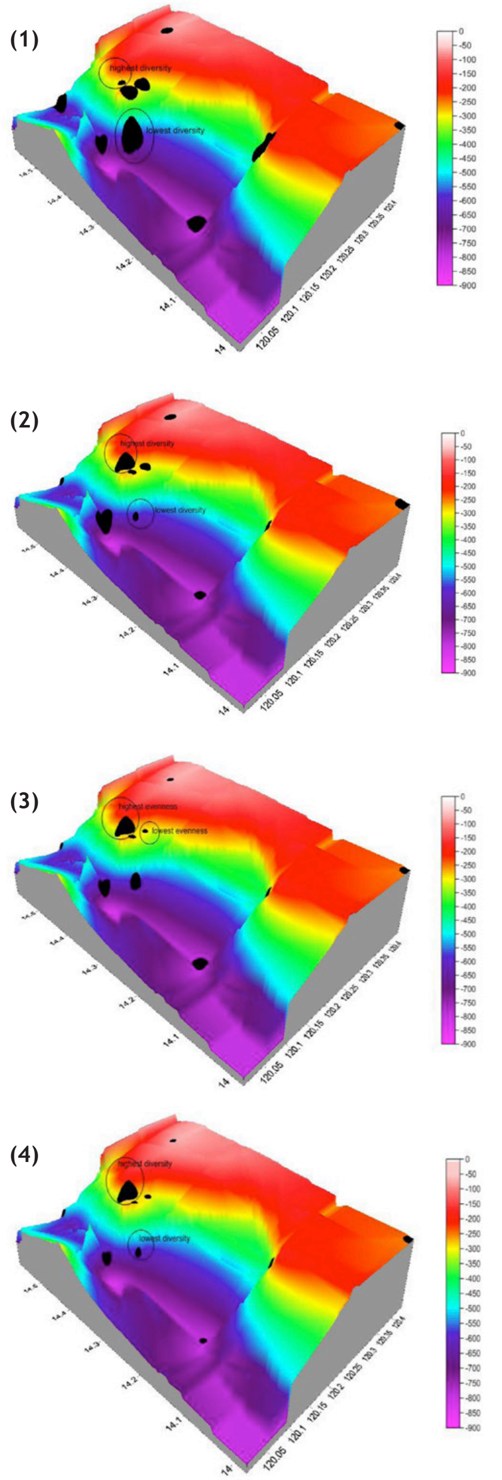


Fig. 6. Biodiversity of the different trap stations: **(1)** – Simpson's Index (D); **(2)** - Simpson's Index of Diversity (I-D); **(3)** – Evenness; and **(4)** - Simpson's Reciprocal Index (I/D)

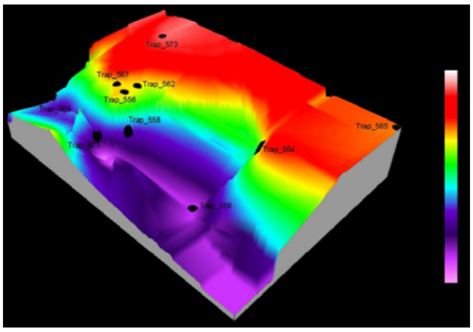


Fig. 7. Trap sampling stations

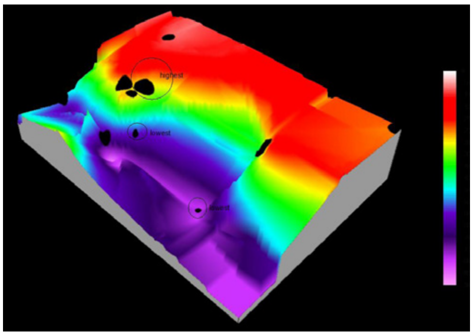


Fig. 8. Richness of samples from different trap stations

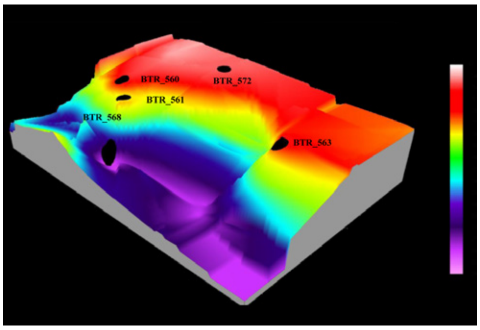


Fig. 9. Beam trawl sampling stations

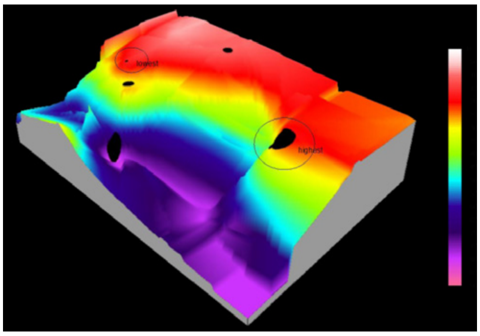


Fig. 10. Richness of samples from different beam trawl stations

The different beam trawl sampling stations are shown in **Fig. 9**, and the richness of the samples generated from the different beam trawl stations in **Fig. 10**, while the biodiversity indices of the different beam trawl stations are shown in **Fig. 11**.

On the overall, the biodiversity indices (BIs) in the beam trawl stations were high, with the highest observed in BTR 561 at depths of 200-295 m while the lowest was in BTR

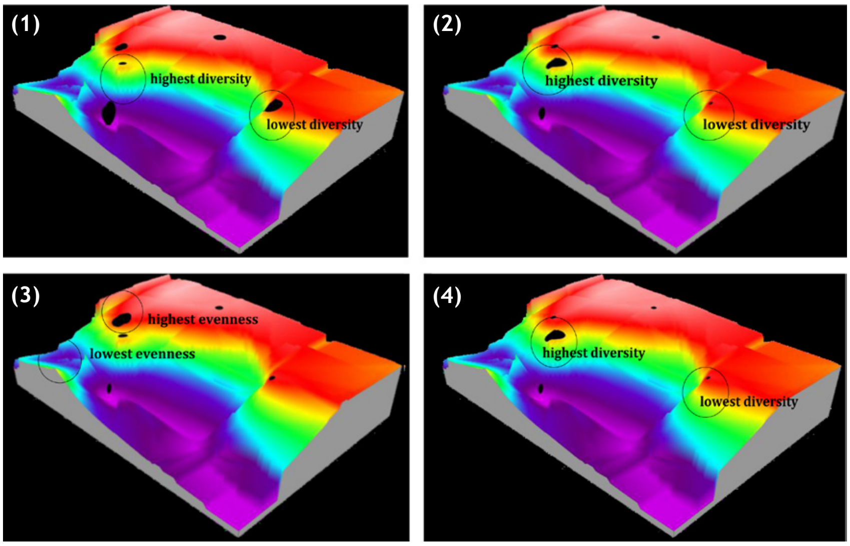


Fig. 11. Biodiversity indices from different beam trawl stations: **(1)** – Simpson's Index (D); **(2)** - Simpson's Index of Diversity (I-D); **(3)** – Evenness; and **(4)** - Simpson's Reciprocal Index (I/D)

563 at depths of 180-190 m. There were approximately 15 dominant taxa from the samples in BTR 561 and at least seven (7) at BTR 563. In terms of richness (r), the highest r was found in BTR 563 (46 taxa) and lowest at BTR 560 (15 taxa). The low evenness of the samples from BTR 563 could have contributed to its lower BI compared to other beam trawl stations while the high evenness of the samples from BTR 560 (in spite of its low richness) could have led to its increased BI.

Grouped-catch of Fishing Gears

A total of 1220 samples have been collected from the trap stations and 1383 samples from the beam trawl stations. Majority of the samples from the trap stations were crustaceans while those from beam trawl stations comprise other invertebrates (**Fig. 12**).

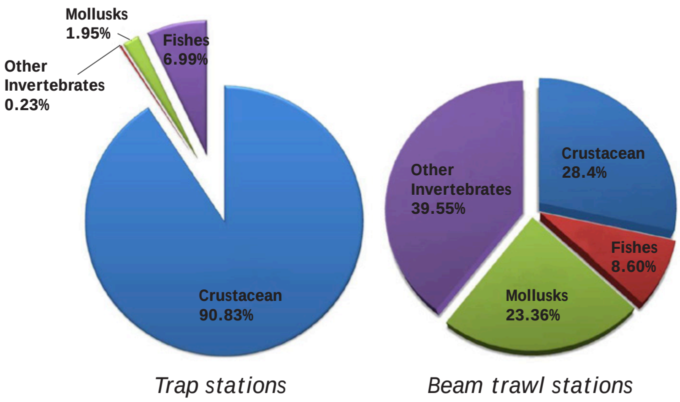
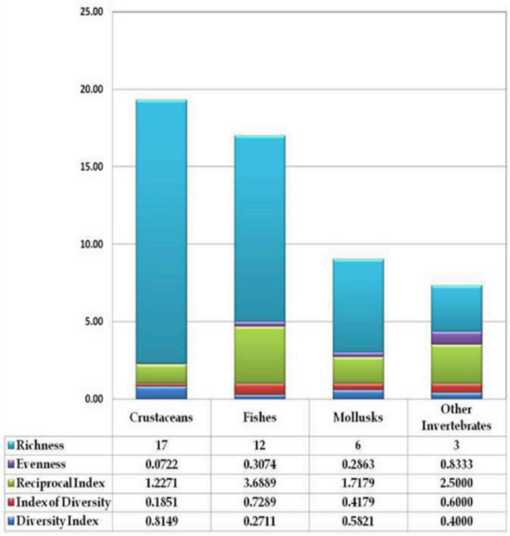
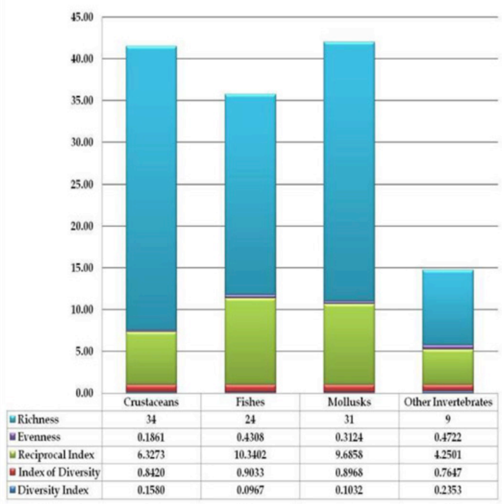


Fig. 12. Percentages of grouped-catch: *left* – from trap stations, and *right* – from beam trawl stations

The comparative analysis of the BI of the grouped-catch, showed higher diversity of fishes from the catch of both gears compared to other groups of species. This implies the least diversity of crustaceans from the catch of traps and other invertebrates from the total catch of beam trawl despite of the bulk catch (**Fig. 13**). The low BI of the 2 groups could be due to the dominance of Family Pandalidae among the crustaceans sampled from traps and of 4 classes of invertebrates (*Anthozoa*, *Asteroidea*, *Echinoidea* and *Ophiuroidea*) on the catch from beam trawls. The fish families that dominate the catch of traps were: *Apogonidae*, *Chlopsidae*, *Myxinidae* and *Scyliorhinidae* while deep-water fish families such as *Macrouridae*, *Ogcocephalidae*, *Ophidiidae*, *Chaunacidae*, *Myctophidae*, *Lophiidae*, *Halosauridae*, *Congridae*, *Scorpaenidae* and *Tetrarogidae* dominate the catch from beam trawl.



Traps

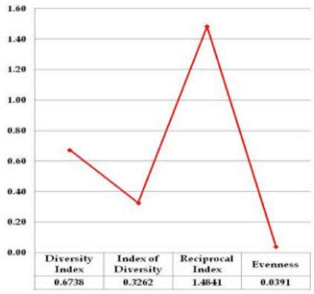


Beam trawl

Fig. 13. The ***r*** and BI of the grouped-catch by traps and beam trawl

Total Catch of Fishing Gears

As shown in **Fig. 13**, the computed BI of the total catch by the traps was moderately low with very low evenness, strongly suggesting the dominance of 1 family (Pandalidae) in the total samples, while on the contrary, the BI of the beam trawl proved high with low evenness. At least 18 taxa dominated the catch by beam trawl including *Anthozoa*, *Aristeidae*, *Asteroidea*, *Echinoidea*, *Holothuroidea*, *Ophiuroidea*, *Polychaeta*, *Conidae*, *Fasciolariidae*, *Galatheidae*, *Gastrochaenidae*, *Macrouridae*, *Ogcocephalidae*, *Pandalidae*, *Ranellidae*, *Thallasidae*, *Trochidae* and *Turridae*. The BIs of the total catch by traps and beam trawl are indicated in **Fig. 14**.



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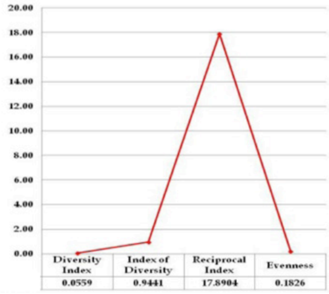

Beam trawl

Fig. 14. BIs of total catch by traps and beam trawl

Potential Fishing Grounds for Deep-sea Shrimps

The areas that were found to have been dominated by *Pandalidae* could be gleaned from **Fig. 15**, where the potential deep-water shrimp fishing areas are identified by circles. The fishing areas were identified based on absolute dominance in the catch by the beam trawl. Nevertheless, the deep-water shrimps were only present in stations with depths > 200 m although deep-water shrimps exhibited greater abundance in stations with average depths of 300-700 m.

Conclusion and Recommendations

Based on the abovementioned discussions, the catchability of the gears mainly influenced the diversity of the samples. Likewise, the zonation (depth deployment) and possible avoidance of some marine organisms of the gear might have also affected the type and abundance of the catch. Nevertheless, area along 14.4385-14.4475° E Latitude and 120.1803-120.1858° N Longitude (southwest of Bagac in Bataan) was monitored with highest biodiversity index among the stations. The most potential resource in the sampling area was Pandalidae as represented by its dominance from the total catch of the two sampling gears. However, the selective characteristics of traps make it an ideal fishing implement for deep-sea shrimps compared to beam trawl as observed from the beam trawl stations which had low abundance of Pandalidae and diversity of less valuable catch. Therefore, the area along Bataan waters and approaches to Manila Bay at depths (300-700m) had been found to be good fishing grounds for deep-sea shrimps.

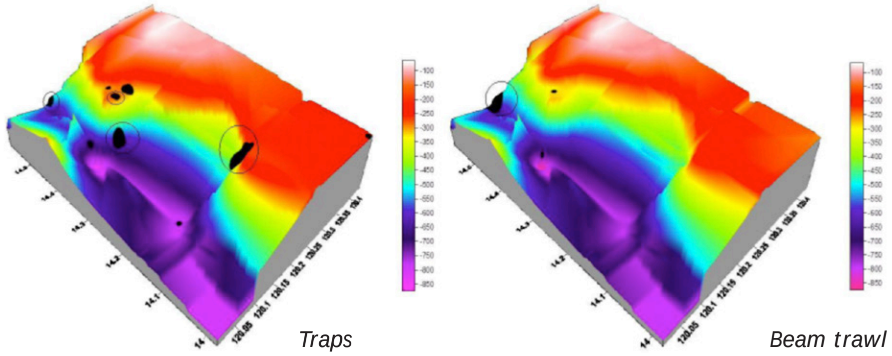

Fig. 15. Fishing areas known to have abundant deep-water shrimp resources

In this regard, traps are strongly suggested to be used in deep-water shrimps fishing because of the tool's efficiency and less ecological impact. Nonetheless, other trap models could be developed to study the efficiency of different gear designs. Furthermore, another study on the sampling area could be conducted to substantiate the results of this study.

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