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Biodiversity Mapping of MPAs in Papaya, Nasugbu

Duration:
August 17, 2020- July 16, 2021
Approved Extension:
August 1, 2022-December 31, 2022
Approved budget:
PhP 200,000.00

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Duration:
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Summary of Accomplishment

Objectives	Target Accomplishments	Actual Accomplishments
To conduct surveys of coral reefs in MPAs in Barangay Papaya, Nasugbu.	40 Transect Line Surveys covering 3 MPAs (Santelmo, Etayo and Pico de Loro) in Papaya, Nasugbu	25 Transect Line Surveys covering 3 MPAs (Santelmo, Etayo and Pico de Loro) in Papaya, Nasugbu
To obtain biodiversity data in these sites and obtain specific geocoordinates.	Biodiversity data and corresponding geocoordinates	100% biodiversity data and geocoordinates for Santelmo, Etayo, and Pico de Loro MPAs
To process the biodiversity data and specific geocoordinates using GIS mapping.	Processed biodiversity data that can be displayed in GIS format	100% of Santelmo, Etayo, and Pico de Loro images stitched
To store and manage information in a computer repository	Portal/website that will make the biodiversity data accessible to the public.	1 database and 1 website created for continuous coral reef assessment of MPAs in the VIP

Abstract

Nasugbu, Batangas is situated at the heart of the Asia-Pacific region and is providentially located at the entry of the Verde Island Passage (VIP), a region with very high biodiversity. This study aimed to obtain baseline information on substrate cover and biodiversity of three Marine Protected Areas (MPAs) in Papaya, Nasugbu and store the information in a database and publicly-accessible website. Santelmo had the highest coral cover at 50.28% (Category A), followed by Pico de Loro at 18.65% (Category D) and Etayo at 13.41% (Category D). Among the three MPAs, Etayo had the highest macroalgae cover at 17.86%, while the other two MPAs had low macroalgae cover. Etayo and Pico de Loro, which had larger areas, had plenty of rock substrate at 53.13% and 51.09%, respectively. Rock substrate at Santelmo was 26.56%. Pico de Loro had the highest sand/rubble at 25.57%, followed by Santelmo at 19.68%, and Etayo at 14.04%. In terms of biodiversity, Santelmo had the highest biodiversity with 22 hard coral genera (Category B), succeeded Etayo which had 18 genera (Category D), and Pico de Loro which had 7 genera (Category D). The dominant coral genera were as follows: Pico de Loro (*Porites* sp. - 11.62%, *Millepora* - 1.66%, *Acropora* - 0.71%); Santelmo (*Porites rus* - 18%, *Porites* sp. - 18%, *Porites cylindrica* - 5%); Etayo (*Porites* sp. - 4.57%, *Millepora* - 1.01%, *Galaxea* - 0.99%). The stitched images, substrate cover data, biodiversity data and geocoordinates for each MPA were uploaded into a database that was connected to a front-end website accessible to public users. Information about the location and parameters relevant to the state of the coral reef are visible in the website.

Key Words: Coral Reef Assessment, GIS, Biodiversity Mapping, Coastal Resource Management, MPA

Introduction

Nasugbu, Batangas is situated at the heart of the Asia-Pacific region and is providentially located at the entry of the Verde Island Passage (VIP). The coast of Nasugbu is lined with thirteen majestic coves located along Brgy. Papaya, Nasugbu, Batangas. These coves are as follows: Pico de Loro, Santelmo, Etayo, Balibago, Subli, Arkaya, Papaya, Neela, Durado, Patungan, Bucanita, Limbones, and Baybay. Three of these coves (Pico de Loro, Santelmo, and Etayo) were recently declared as Marine Protected Areas (MPAs) by the local government towards the attainment of sustainable development of the coast.

To properly and effectively implement conservation and protection efforts in MPAs of Nasugbu, baseline information on coral communities present in the area is crucially needed. Interviews with fishermen from Nasugbu revealed the presence of several representative from different phylum levels (Valdez *et al*., 2015). This indicates a potential for high biodiversity in the MPAs of Nasugbu. This could be determined by mapping the coral reef areas using Geospatial Image System (GIS) and Geo-tagging technologies. As an example, the Global Reef Expedition was able to obtain habitat and bathymetry maps of 65,000 sq. km. of the Earth's reefs (Purkis *et al.,* 2019). The biodiversity data obtained in this project will be digitally stored in an online database for public access. Monitoring can then be conducted to record the changes in the coral communities. The output of this study will be an accurate assessment of the marine resources in Papaya, Nasugbu, and this information can be relayed to public officials for appropriate policies and action plans.

Review of Literature

The establishment of MPAs aims to preserve coral reefs with high biodiversity indices. Conservation areas are typically large areas that are well connected, and they are selected to include as many elements of biodiversity as possible (Ferrier, 2002). One index to measure biodiversity is species richness, which is a count of the number of species in a given area. In a scientific context, biodiversity is the sum of genetic diversity among living organisms, their abundance, and their distribution patterns. This can be influenced by geodiversity, which is the sum of abiotic factors (*e.g.* geomorphology, hydrology) in the area (Barthlott *et al.* 1999).

Geospatial Imaging Systems (GIS) provides tools that assist in visualizing, exploring, and modeling species distribution data. These tools may be used to aid work in relation to the establishment of MPAs, by helping managers prioritize candidate locations for new MPAs (Foody 2008). GIS can also be used for MPA management by providing and analyzing spatial data sets for conservation and management tasks (Best *et al.* 2007). Technological advancements and information sharing have led to web-based GIS tools to explore biodiversity. A case example is the Global Biodiversity Information Facility Mapping and Analysis Portal Application (GBIF-MAPA), which currently has 420 million records and over one million species names (Flemons *et al*. 2007, Pimm *et al*. 2015). It can list occurrences of species by region, and provides summary data on species richness. It can also serve as a predictive modeling tool to assess the most likely locations where new biodiversity can be discovered (Flemons et al. 2007). Another example is the biodiversity mapping project conducted by Doxa *et al.* 2016, which focused on coralligenous assemblages in the

coasts of Cote d'Azur and Corsica, France. In this study, 111 stations spanning horizontally (north, south, east, west) and vertically (depth) were mapped for biodiversity. Photographs from the stations were analyzed using CPCe 4.1 and a biodiversity map (Figure 1) was produced. The authors noted that additional information such as phylogenetic diversity would be required in order for conservationists to visualize the spatial variations of community composition (Mouquet *et al*. 2012).
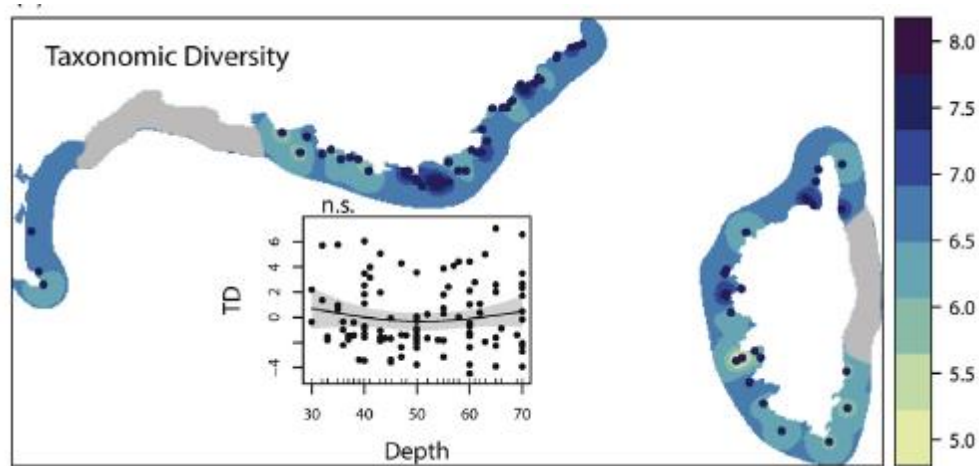

Figure 1. Spatial distribution map showing localized areas with higher biodiversity (blue). Stations are marked by blue dots. Taken from Doxa *et al*. 2016.

Three technologies have advanced greatly in the last decade, and they are expected to make a huge impact in the field of biodiversity mapping: genetic barcoding, remote sensing, and drone technology (Pimm *et al*. 2015). Genetic barcoding aims to produce a unique DNA sequence for every species. Production cost is becoming cheaper, and identifying species will soon cost $1 per sample. However, some taxonomists are wary with the concept of abandoning morphological traits and assigning a species to just a number. Remote sensing is an efficient and non-invasive method for monitoring a specific area, but is not widely used in biodiversity mapping. The resolution from satellite imagery is currently not sufficient to visualize or count individual organisms as species. However, remote sensing can be used in monitoring MPAs and conservation efforts. For instance, real time assessments of broad geographic range can be done to estimate coral or algae cover in response to anthropogenic pressures and MPA establishment. Drones with attached cameras or multispectral sensors give the advantage of taking photos and videos in hard-to-reach areas. They can also make data gathering much faster and efficient. A potential drawback in the depreciation of the hardware.

Objectives of the Project:

1) To conduct surveys of coral reefs in MPAs in Barangay Papaya, Nasugbu.
2) To obtain biodiversity data in these sites and obtain specific geocoordinates.
3) To process the biodiversity data and specific geocoordinates using GIS mapping.
4) To store and manage this information in a computer repository.

Methodology

Biodiversity Data Collection

The three study sites were the following MPAs in Nasugbu (Figure 2):

Site A: Pico de Loro (52.62 ha.)
Site B: Santelmo (13.93 ha.)
Site C: Etayo (40.49 ha.)
(Source: MENRO 2018 data)

Figure 2. A map (inset) showing the MPAs (red boxes) in Papaya, Nasugbu for biodiversity mapping.

In each site, five 50-m transects were laid parallel to the shore following the contour of the upper reef slope at depths ranging between 5 and 10 m. Benthic cover was determined using the line intercept transect method (English *et al*. 1997) on 50-m transects at each site. The benthic categories were aggregated into five major benthic groupings (hard coral, rock, macroalgae, sand/rubble, other living organisms) and cover was expressed as percent cover.

Fifty (50) 1 x 1 m benthic photos were obtained for each transect, for a total of 250 photos per site. Photos were processed using CPCe 4.1 (Kohler & Gill 2006) to obtain values for benthic cover, generic diversity, and dominant coral genera. Ten (10) random points were assigned for scoring in each photo for a total of 500 points per transect and 2500 points per site. For benthic cover, points were scored as hard coral, macroalgae, rock, sand/rubble, sponge, or 'other living organism'. If a point was scored as hard coral, it was further identified to the genus level, whenever possible. Average percent cover values were computed for each benthic type by dividing the number of points for each benthic type by 500 points and averaging the component values across the five transects per site. For each site, generic richness was used as a proxy for biodiversity, and the three coral genera with the highest percent abundance were identified as the dominant genera in that site. Percent abundance of dominant coral genera was computed by dividing the number of points for each coral genera by 500 points and averaging the values across the five transects per site.

GIS Mapping

Biodiversity mapping was done through image stitching of captured images using map stitching software (*e.g.* MapKnitter, Opendrone, Adobe Photoshop or Image Composite Editor). Images were sorted, culling out the best 80-100 best screenshots in every video transect that shows diverse geographic area. Next, the map was built/stitched using the sorted images. This required naming the map image, identifying the location by using the coordinates, and exporting the base image to 'Geo-TIFF' format, the standard image format for GIS applications (Adel *et al*. 2015, Rathnayake *et al*. 2018). Map Stitching needs manual re-alignment procedures of images like warping, distorting, skewing and rotating to create a consistent representation of stitched images. Following this, geo-tagging techniques such as geo-referencing and setting the correct CRS were applied to each video transect using GIS software. The metadata such as timestamp, longitude and latitude on each videotransect were very crucial in locating and monitoring each specific geo-spatial feature and the corresponding organisms. The said parameters concatenated the geo-reference to the base map of the MPAs, ultimately saving all these metadata to a geo-database.

Portal/Website

Information dissemination and presentation thru online platform take plays after all collected data were organized and structured in such a way it can be easily understood by the local community. To present each important details, a Content Management System (CMS) was used to design and develop a web portal/website but still required a custom development procedure to ensure that all specific requirements were met like photo gallery of sites, data entry, sitemap positioning, front-end to back-end configuration. The website also had a web map feature to present Marine Protected Areas on a web format. A web framework called Laravel was also utilized to create the website. It is designed to simplify the development process and make it more efficient by providing a range of tools and features that allow developers to build complex web applications quickly. It provides a range of built-in features such as routing, middleware, authentication, database migrations, and unit testing. In terms of

data storage, MySQL database was used to easily replicate the initially created geo-package from the map stitching process. Lastly is hosting the website to the internet, this ensured that all information is made accessible to the target audiences.

Results and Discussion

Biodiversity Data Collection

Hard coral cover and diversity can be classified into categories, as presented in Table 1, to interpret substrate cover and biodiversity. Table 2 summarizes the major substrate cover of the three MPAs. Santelmo had the highest coral cover at 50.28% (Category A), followed by Pico de Loro at 18.65% (Category D) and Etayo at 13.41% (Category D). Macroalgae cover is an indicator of reef health since corals compete for space with macroalgae. Bare rock that is occupied by macroalgae cannot be colonized by corals. Bleached or dead corals are often colonized by macroalgae. Among the three MPAs, Etayo had the highest macroalgae cover at 17.86, while the other two MPAs had low macroalgae cover. Bare rock is an indicator of available space that can be colonized by corals. Etayo and Pico de Loro, which had larger areas, had plenty of rock substrate at 53.13% and 51.09%, respectively. Santelmo had a smaller area and had very high coral cover, and this can explain the relatively low percentage of rock substrate at 26.56%. Sand/rubble cannot be colonized by corals and is an indication of non-reef forming substrate. Pico de Loro had the highest sand/rubble at 25.57%, followed by Santelmo at 19.68%, and Etayo at 14.04%.

Table 1. Assessment Scales for Hard Coral Cover and Diversity. Taken from Licuanan 2020.

Hard coral cover (HCC)		Hard Coral Diversity	
HCC Category A	>44%	Diversity Category A	>26 TAUs
HCC Category B	>33% – 44%	Diversity Category B	>22 – 26 TAUs
HCC Category C	>22% – 33%	Diversity Category C	>18 – 22 TAUs
HCC Category D	0 – 22%	Diversity Category D	0 – 18 TAUs

Table 2. Summary of baseline substrate cover measurements in three MPAs of Papaya, Nasugbu

Substrate	MPAs		
	Pico de Loro, (11-2022) (% values)	Santelmo, (04-2022) (% values)	Etayo, (04-2022) (% values)
Coral	18.65 (D)	50.28 (A)	13.41 (D)
Macroalgae	3.82	2.32	17.86
Rock	51.09	26.56	53.13
Sand/Rubble	25.57	19.68	14.04

Table 3 summarizes the generic richness/biodiversity and dominant hard coral genera in the three MPAs. Santelmo, which had the highest coral cover, also had the highest biodiversity with 22 hard coral genera (Category B). This was succeeded Etayo which had 18 genera (Category D) and Pico de Loro which had 7 genera (Category D). Massive Porites sp. was found to be dominant in all three MPAs, while other species of Porites (P. rus and P. cylindrica) were dominant in Santelmo. Porites are hardy corals that are resilient to typhoons and coral bleaching, compared to other genera like Acropora (Coward et al. 2020, D'Olivio et al. 2019, Levas et al. 2013). Millepora or fire coral was the second most dominant coral in two MPAs, Pico de Loro and Etayo. Lastly, the third most dominant corals in Pico de Loro and Etayo were Acropora and Galaxea, respectively.

| | MPAs | | |
	Pico de Loro	Santelmo	Etayo
Number of coral genera	7 (D)	22 (B)	18 (D)
Dominant coral genera	*Porites* sp. (11.62%) *Millepora* (1.66%) *Acropora* (0.71%)	*Porites rus* (18%) *Porites* sp. (18%) *Porites cylindrica* (5%)	*Porites* sp. (4.57%) *Millepora* (1.01%) *Galaxea* (0.99%)

GIS Mapping

Images from transect surveys conducted in Pico de Loro, Santelmo, and Etayo were stitched to show the substrate cover and hard coral biodiversity in each transect. A representative set of stitched images from one transect is shown in Figure 3. These images were be uploaded into the database and made visible to public users that access the website.
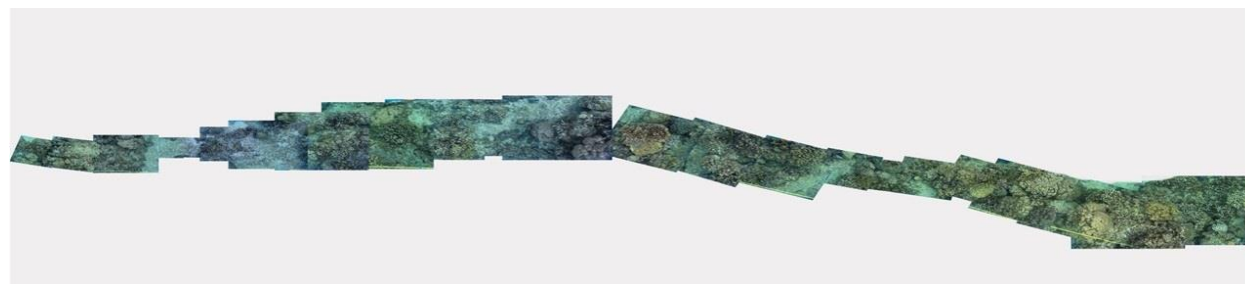

Figure 3. Stitched images from Transect 1 of Santelmo MPA.

Portal/Website

A database was created for encoding substrate cover data, biodiversity data and geocoordinates for each MPA (Figure 4). This is accessible only to VIP CORALS staff. The database was connected to a front-end website that is accessible to public users (Figure 5). Information about the location and parameters relevant to the state of the coral reef are visible in the website.
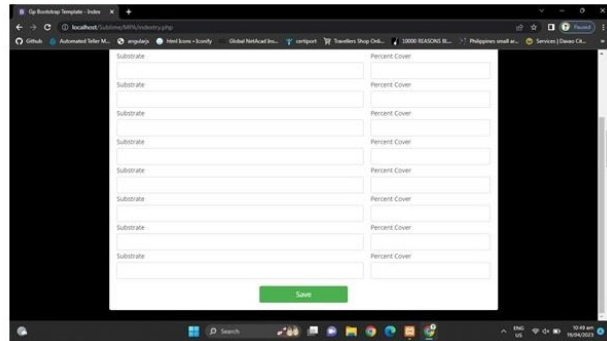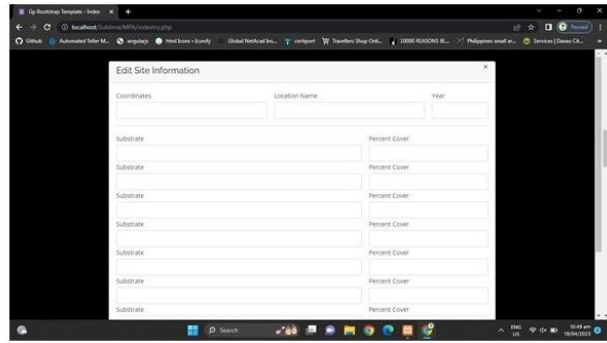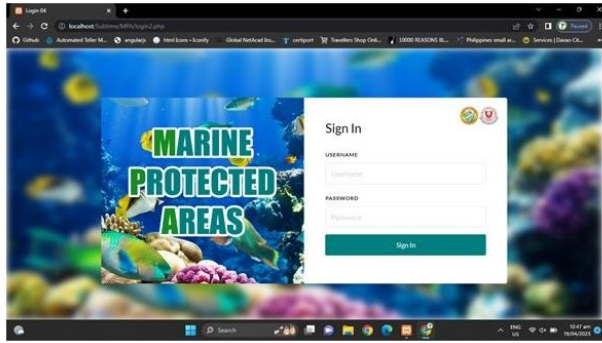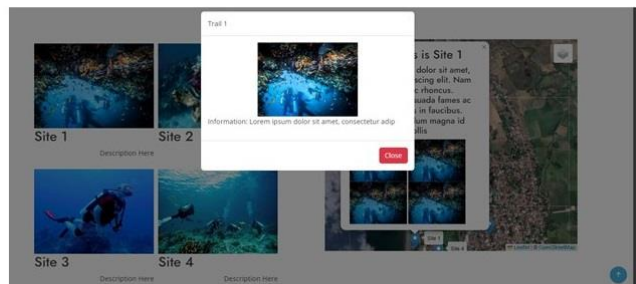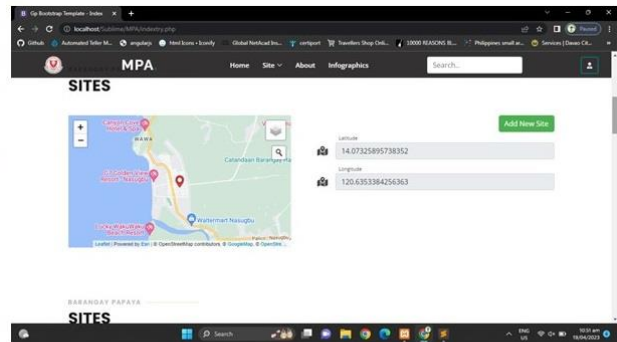
Figure 4. The database is accessible only to VIP CORALS. Left: The login screen requires a username and password. Right: Information about the site name, coordinates, date of data collection, substrate cover, and dominant coral genera are encoded into the database.
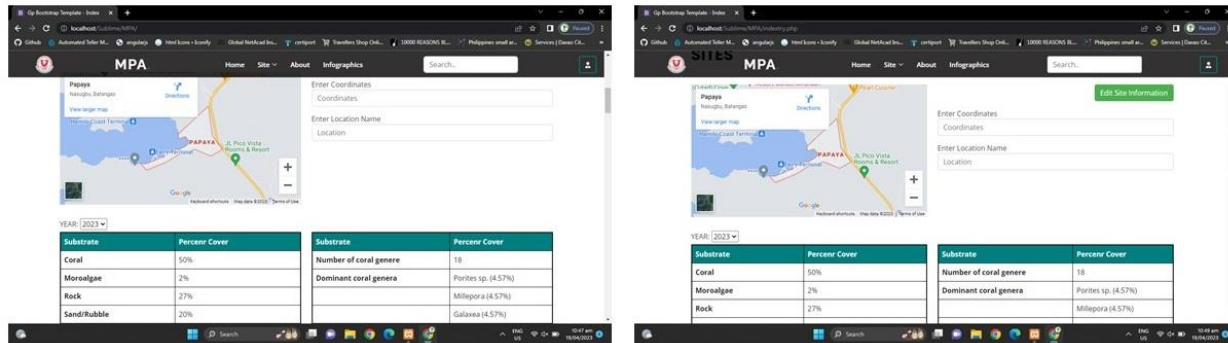
Figure 5. The publicly accessible website allows users to view information about the MPA sites, such as substrate cover, number of coral genera, and dominant coral genera for a specific date

Conclusions

Santelmo had the highest coral cover at 50.28% (Category A), followed by Pico de Loro at 18.65% (Category D) and Etayo at 13.41% (Category D). Among the three MPAs, Etayo had the highest macroalgae cover at 17.86, while the other two MPAs had low macroalgae cover. Etayo and Pico de Loro, which had larger areas, had plenty of rock substrate at 53.13% and 51.09%, respectively. Rock substrate at Santelmo was 26.56%. Pico de Loro had the highest sand/rubble at 25.57%, followed by Santelmo at 19.68%, and Etayo at 14.04%.

In terms of biodiversity, Santelmo had the highest biodiversity with 22 hard coral genera (Category B), succeeded Etayo which had 18 genera (Category D), and Pico de Loro which had 7 genera (Category D). The dominant coral genera for each MPA were identified.

Representative sets of stitched images were made for each MPA. The images, substrate cover data, biodiversity data and geocoordinates for each MPA were uploaded into a database. The database was connected to a front-end website that is accessible to public users. Information about the location and parameters relevant to the state of the coral reef are visible in the website.

Recommendations

Continuous monitoring of the MPAs in Nasugbu should be conducted to detect any upward or downward changes in substrate cover (e.g. coral cover, macroalgae cover) and biodiversity (e.g. decreasing number of species, changes in dominant hard corals). Bi-annual coral reef assessments during the Habagat and Amihan seasons are ideal.

Other MPAs of Nasugbu should be assessed (e.g. Twin Island MPA) to obtain baseline data on substrate cover and biodiversity.

The online website may be hosted by an external provider.

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