COMMUNITY STRUCTURE OF ECHINODERMS IN SIPAWAY ISLAND, SAN CARLOS CITY, NEGROS OCCIDENTAL

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APPROVAL SHEET

This research paper hereto entitled;

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Abstract

The Philippines has been blessed with great coastal scenery making fishing a major occupation among rural folk. Echinoderms play a major role in this fishing community, scavenging decaying matter on the floor and being prey for the fish themselves. Sipaway Island is an island abundant with echinoderms. This study would aim to give basic information of the echinoderms in the island to its inhabitants. Although studies similar to this one have been made in the past, no such study was conducted in the said site.

The study aims to specifically identify the following, Species Composition, Population Abundance, Population Density, Relative Frequency Species Diversity and Distribution patterns. Systematic sampling was used with three sites. There were eleven different species of echinoderm species found. Site 3 was the most populated among the three sites due to the presence of sea grasses which are suitable habitat for echinoderms. (Schoppe 2000) *Protoreaster nodosus* was the most abundant among all the echinoderm species in the three sites while Site 1 was the most diverse among the three sites.

The waters of Sipaway Island have been affected with human activity making some of the echinoderm species scarce like the *Mespilia globulus* which are probably being harvested for food. The researchers recommend that further research be done on the island focusing on the many threats to the echinoderms and its habitats.

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CHAPTER I
INTRODUCTION

A. Background Study

Philippines have been blessed with great coastal scenery. It has many miles of shorelines, making fishing as the major occupation among its rural folks. It has one of the most productive marine ecosystems in the world. Its tropical waters are enriched by currents coming from Japan, South China Sea, Indian Ocean, and the Celebes Sea. Thus the country's waters abound with a rich flora and fauna.

Seas are so abundant in its resources from different kinds of sea creatures to tiny organisms. Sea cucumbers and sea urchins are some of the well-known echinoderms that thrive in our country.

The approximately 7,000 species of extant echinoderms fall into five well-defined clades: Crinoidea, sea lilies and feather stars; Ophiuroidea, basket stars and brittle stars; Asteroidea, starfishes; Echinoidea, sea urchins, sand dollars and sea biscuits; and, Holothuroidea, sea cucumbers. Echinoderms are among the most distinctive of all animal phyla.

All echinoderms are marine; none can live in fresh water or on land. They are found at all oceans and depths. In coral reefs, they can be observed on the platform as well as on the edges and the slopes. They are also found within seagrass beds and around mangroves swamps.

In sandy and muddy areas, either shallow or deep, sand dollars are frequently found. They are either buried in the sand or seen grazing on the sandy substrate. The other main group of echinoderms found in this kind of habitat are some species of sea cucumber.

Sea cucumber fishery used to be an important source of income for many fishers in some Indo-Pacific countries such as Philippines, Indonesia, Fiji, Papua New Guinea, Tonga, Maldives and others. There are about 100 species of sea cucumbers in the Philippines but only few are commercially valuable (Trinidad Roa, 1987).

Echinoderms are often identified with their radial symmetry, an internal skeleton, with a water vascular system and suction-cuplike structures called tube feet. Echinoderms are also maescropic, except for their larvae; they range from a few

millimeters to a few decimeters in size, although the stalks of some crinoids could reach a length of over a meter. With a few exceptions, echinoderms are all benthic (bottom-dwellers); most Paleozoic echinoderms were sessile, while most living echinoderms can creep from place to place. Few can swim or float.

The echinoderms play an important role in the marine community. Echinoderms are efficient scavengers of decaying matter on the seafloor, and they prey upon a variety of small organisms, thereby helping to regulate their numbers. Echinoderms are usually intricate parts of their ecosystems. Many asteroids are keystone species. Sea urchins, if not controlled by predators, may overgraze their habitat. Asteroids have several commensals, including polychaetes that feed on leftovers from the sea star's prey items. (Barnes, 1987; Brusca and Brusca, 2003)

When present in large numbers, sea urchins can devastate seagrass beds in the tropics, adversely affecting the organisms dwelling within. In the Philippines, sea urchins are collected as commercial puposes.

In Sipaway Island located in San Carlos, Negros Occidental, echinoderms are abundant. Crown of Thorns, echinoderm that dwells in the island, is known to be potential to wipe out large areas of corals. They are predators of corals. These starfishes are destructive to sanctuaries and corals if left alone (Animal Diversiy 2001).

This study focuses on the Correlation Study and Relative Abundance of Echinoderms in Sipaway Island, San Carlos City, Negros Occidental. This study will also give more relative information about echinoderms.

Although studies similar to this one have been made in the past, no such study was conducted in Sipaway Island, San Carlos City, Negros Occidental. Likewise, with the present condition of our deteriorating marine life conditions our country would mean that our people should be given such awareness on these matters.

B. Statement of the Problem

What is the Community Structure of Echinoderms in Sipaway Island, San Carlos City, Negros Occidental?

C.1. General Objectives

1. To determine the Correlation Study and Relative Abundance of Echinoderms in Sipaway Island, San Carlos City, Negros Occidental.

C.2. Specific Objectives

1. To measure the physico-chemical factors of the water in Sipaway Island that may affect the growth and population of echinoderms:
    a) Temperature
    b) Dissolved Oxygen
    c) Salinity
    d) pH
2. To compute for the:
    a) Species Composition
    b) Population Density
    c) Relative Abundance
    d) Relative Frequency
    e) Species Diversity
    f) Distribution Pattern

D. Significance of the Study

This study will give basic information on echinoderms in the area to the inhabitants of Sipaway Island, San Carlos City, Negros Occidental. This study will determine the population of echinoderms in the island such as Crown of Thorns, which are known as predators to corals. When the population of Crown of Thorns is determined, the inhabitants of the island will be warned to the consequences waiting because of these starfishes. This study will help the inhabitants of the island to care and preserve the echinoderms in the area and also for the corals and avoid extinction of these species of echinoderms and other marine species as well. This study will also serve as future reference for other researchers.

E. Scope and Delimitation

We will determine the Community Structure of echinoderms in Sipaway Island, San Carlos City, Negros Occidental only. Factors such as Population Density, Relative abundance, Species Composition, Relative Frequency, Species Diversity and Distribution Pattern will be computed. Temperature, Dissolved Oxygen and Water Salinity will be measured.

F. Definition of Terms

Clade - A group of organisms consisting of a single common ancestor and all the descendants of that ancestor.

Dissolved Oxygen - In aquatic environments, oxygen saturation is a relative measure of the amount of oxygen (O2) dissolved in the water.

Echinoderm - Any of numerous radially symmetrical marine invertebrates of the phylum Echinodermata, which includes the starfishes, sea urchins, and sea cucumbers, having an internal calcareous skeleton and often covered with spines.

pH levels - pH is a measure of the acidity of a solution in terms of activity of hydrogen.

Salinity - Salinity is the saltiness or dissolved salt content of a body of water.

Temperature – It is a physical property of a system that underlies the common notions of hot and cold; something that is hotter has the greater temperature.

Commensal - An organism participating in a symbiotic relationship in which one species derives some benefit while the other is unaffected.

Species Composition – the species found in a particular area

Relative Abundance – a comparison of the number in one category to another (eg. number of one species to another, male to female, young to old, etc.). Typically expressed as a percentage or proportion.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter consists of five topics namely (1) Echinoderms (2) Sipaway Island (3) Parameters (4) Population Profile (5) Previous Studies

A. Echinoderms

A marine invertebrate (phylum Echinodermata) characterized by a hard spiny covering, a calcite skeleton, and five-rayed radial body symmetry. About 6,000 existing species are grouped in six classes: feather stars and sea lilies (Crinoidea), starfishes (Asteroidea), brittle stars and basket stars (Ophiuroidea), sea urchins (Echinoidea), sea daisies (Concentricycloidea), and sea cucumbers (Holothurioidea). Echinoderms are found in all the oceans, from the inter-tidal zone to the deepest oceanic trenches. Most species have numerous tube feet that are modified for locomotion, respiration, tunneling, sensory perception, feeding, and grasping. Movement of water through a water vascular system composed of five major canals and smaller branches controls extension and retraction of the tube feet. Most echinoderms feed on microscopic detritus or suspended matter, but some eat plants. (Britannica 2001)

Has a radiating arrangement of parts and a body wall stiffened by calcareous pieces that may protrude as spines and including the starfishes, sea urchins, sea cucumbers, etc. (Infoplease 2000)

A.1 Echinoderm Physiology

Echinoderms evolved from animals with bilateral symmetry; later forms were lopsided. Echinoderms' larvae are ciliated free-swimming organisms that organize in a bilaterally symmetric fashion that makes them look like embryonic chordates. Later the left side of the body grows at the expense of the right side, which is eventually absorbed. The left side then grows in a pentaradially symmetric fashion, in which the body is arranged in five parts around a central axis.

All echinoderms exhibit fivefold radial symmetry in portions of their body at some stage of life, even if they have secondary bilateral symmetry. They also have a mesodermal endoskeleton made of tiny calcified plates and spines, that forms a rigid

support contained within tissues of the organism; some groups have modified spines called pedicellariae that keep the animal free of debris.

Echinoderms possess a hydraulic water vascular system, a network of fluid-filled canals that function in locomotion, feeding, and gas exchange. They also possess an open and reduced circulatory system, and have a complete digestive tube (tubular gut).

They have a simple radial nervous system that consists of a modified nerve net (interconnected neurons with no central organs); nerve rings with radiating nerves around the mouth extending into each arm; the branches of these nerves coordinate the movements of the animal. Echinoderms have no brain, although some do have ganglia.

The sexes are usually separate. Sexual reproduction typically consists of releasing eggs and sperm into the water, with fertilization taking place externally.(Wikipedia 2003)

Many echinoderms have remarkable powers of regeneration: a starfish cut radially into a number of parts will, over the course of several months, regenerate into as many separate, viable starfish. A section as small as a single arm (with the commensurate central-body mass and neural tissue) will, in ideal circumstances, successfully regenerate in this way.(Brittanica 2001)

A.2 Echinoderms Classification

Asteroidea. They exhibit a superficially radial symmetry. Starfish typically have five or more "arms" which radiate from an indistinct disk (pentaradial symmetry). In fact, their evolutionary ancestors are believed to have had bilateral symmetry, and sea stars do exhibit some superficial remnant of this body structure.

Sea stars do not have movable skeletons, but instead possess a hydraulic water vascular system. The water vascular system has many projections called tube feet, located on the ventral face of the sea star's arms, which function in locomotion and aid with feeding.(Wikipedia 2003)

Sea stars, or asteroids, develop through several larval stages. The larva uses its ciliated arms to sweep food into its mouth as it glides through the water column. The arms can also be used to supplement the larva's cilia-drive locomotion. Each arm has a glandular tip, with which the larva attaches itself to the substratum as it settles. The

animal is then able to metamorphose into the familiar five-armed adult form.(Washington Edu 2000)

Concentricycloidea. These species have disk-shaped flattened body and are less than 1 cm in diameter. They have a water-vascular system and are dotted with tube feet around the edge of the disk. They do not have arms, but five ambulacral areas. A gut is either reduced or absent, depending on the species. An oral opening is present, but it is unclear how these organisms derive their nutrition.

Sea daisies typically have two circumoral canals and a single peripheral ring of tube feet (i.e., podia). Concentricyloids (commonly known as sea daisies) were supported as members of the asteroid lineage, although its exact relationship to other asteroids is likely to remain a contentious issue. (Wikipedia 2003)

Crinoids. Also known as "sea lilies" or "feather-stars", are marine animals that are the examples of the class Crinoidea of the echinoderms (phylum Echinodermata). They live both in shallow water and in depths as great as 6000 meters. Crinoids are characterized by a mouth on the top surface that is surrounded by feeding arms. They have a U-shaped gut, and their anus is located next to the mouth. Although the basic echinoderm pattern of five-fold symmetry can be recognized, most crinoids have many more than five arms. Crinoids usually have a stem used to attach themselves to a substrate, but many live attached only as juveniles and become free-swimming as adults. There are only a few hundred known modern forms, but crinoids were much more numerous both in species and numbers in the past. Some thick limestone beds dating to the mid- to late-Paleozoic are entirely made up of disarticulated crinoid fragments. (Wikipedia 2003)

Echinoidea. Sea urchins are examples of the class Echinoidea found in oceans all over the world. (The name urchin is an Old English name for the round spiny hedgehogs sea urchins resemble). Their shell, which biologists call the test, is globular in shape and covered with spines. The size of an adult test is typically from 3 to 10 cm.

Typical sea urchins have spines 1-2 cm (approximately ½ to 1 in.) in length a millimeter or two thick, and not terribly sharp. *Diadema antillarum*, familiar in the Caribbean, has thin spines that can be 10-20 cm long (4-8 in.). Common colors include black and dull shades of green, olive, brown, purple, and red. (Wikipedia 2003)

Holothuroidea. Examples of this class are sea cucumbers, with an elongated body and leathery skin, which are found on the sea floor worldwide. They are so named because of their cucumber-like shape. Like all echinoderms, sea cucumbers have an endoskeleton just below the skin.

Sea cucumbers are generally scavengers, feeding on debris in the benthic layer. Their diet consists of plankton and other organic matter found in the sea. One way they might get a supply of food is to position themselves in a current where they can catch food that flow by with their tentacles when they open. Another way is to sift through the bottom sediments using their tentacles. They can be found in great numbers beneath fish farms. They have the peculiar adaptation of expelling first sticky threads, perhaps to incapacitate predators, and then their internal organs when startled by a potential predator. These organs can then be regrown. (Wikipedia 2003)

Ophiuroidea. They crawl across the sea-floor using their flexible arms as "legs" for locomotion. The ophiuroids generally have five long slender, whip-like arms which may reach up to 60 centimeters (2 feet) in length on the largest specimens.

Ophiuroidea contains two large phylogenetic trees, Ophiurida (brittle stars) and Euryalida (basket stars). Many of the ophiuroids are rarely encountered in the relatively shallow depths normally visited by humans, but they are a diverse group.There are some 1,500 species of brittle stars living today, and they are largely found in deep waters more than 500 metres (1,650 feet) down. (Wikipedia 2003)

The brittle stars, or ophioroids, have a distinctive larval form known as the ophiopluteus. Like all echinoderm larvae, the ophiopluteus uses ciliated bands to feed on particles suspended in the water column. Brittle star larvae are thought to spend several weeks in the plankton before settling as juveniles. (Washington Edu 2000)

A. 3 Uses of Echinoderms

The roe (egg mass) of some sea urchins are relished as a Japanese delicacy and sea urchins are commercially harvested for this reason in various parts of the world. Sea urchins have been extensively studied to better understand egg fertilization and embryo development for other applications. This is because their eggs are large and easy to study.

Sand dollar eggs have been extensively studied to better understand cell division and thus some diseases such as cancer, which is associated with uncontrolled cell growth.

Some large sea cucumbers are considered delicacies and harvested for food. Others may be collected for the live aquarium trade. Scientists are also studying the toxins of sea cucumbers for possible medical and other applications.
(Wild Singapore 2004)

Research on echinoderms has contributed to the overall knowledge of animal fertilization and development. Many echinoderms are easy to culture and maintain in a lab setting, and produce a large amount of eggs. (Animal Diversity 2001)

A. 4 Roles of Echinoderms in the Ecosystem

Echinoderms are efficient scavengers of decaying matter on the seafloor, and they prey upon a variety of small organisms, thereby helping to regulate their numbers. Some Asteroids, such as Acanthaster planci, have increased in population and damage coral reefs as a result of their grazing. Many asteroids are top predators and keystone species. Members of this class are food for crabs, sea stars, fish, birds, otters, and other mammals. Probably the single most important contribution of these animals to scientific knowledge is their embryological development. Researchers investigate the development of deuterostomes using sea urchin eggs, due the clear radial cleavage during a zygote's development.

Crown of thorns starfishes are voracious predators of corals and can wipe out large areas of coral, thus potentially upsetting the basis of one of the world's most diverse ecosystems. It is possible that economically important reef fish preys upon crown-of-thorns starfish eggs and larvae. If left alone, they may destroy sanctuaries and coral habitats. (Animal Diversity 2001)

B. Sipaway Island

Sipaway Island in San Carlos City is otherwise known in the official maps as *"Refugio Island"*. Sipaway Island is essentially a white-sand beach coral island situated some 3.5 kilometers off the eastern coast of San Carlos City. Sipaway is about seven kilometers in length and 1.5 kilometers wide, at the maximum. (San Carlos Gov 2001)

C. Parameters

Dissolved oxygen. Dissolved Oxygen analysis measures the amount of gaseous oxygen (O2) dissolved in an aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis.

Total dissolved gas concentrations in water should not exceed 110 percent. Concentrations above this level can be harmful to aquatic life. Fish in waters containing excessive dissolved gases may suffer from "gas bubble disease"; however, this is a very rare occurrence. The bubbles or emboli block the flow of blood through blood vessels causing death. External bubbles (emphysema) can also occur and be seen on fins, on skin and on other tissue. Aquatic invertebrates are also affected by gas bubble disease but at levels higher than those lethal to fish.

Adequate dissolved oxygen is necessary for good water quality. Oxygen is a necessary element to all forms of life. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills.

pH. pH is a measure of the acidic or basic (alkaline) nature of a solution. The concentration of the hydrogen ion [H+] activity in a solution determines the pH. Mathematically this is expressed as: $pH = - \log [H+]$

The pH value is the negative power to which 10 must be raised to equal the hydrogen ion concentration. The most significant environmental impact of pH involves synergistic effects. Synergy involves the combination of two or more substances, which produce effects greater than their sum.

This process is important in surface waters. Runoff from agricultural, domestic, and industrial areas may contain iron, aluminum, ammonia, mercury or other elements. The pH of the water will determine the toxic effects, if any, of these substances. For example, 4 mg/l of iron would not present a toxic effect at a pH of 4.8. However, as little as 0.9 mg/l of iron at a pH of 5.5 can cause fish to die.

Temperature. Human activities should not change water temperatures beyond natural seasonal fluctuations. To do so could disrupt aquatic ecosystems. Good temperatures are dependent on the type of stream you are monitoring. Lowland streams, known as "warm water" streams, are different from mountain or spring fed streams that are normally cool.

In warm water stream temperatures should not exceed 89 degrees (Fahrenheit). Cold-water streams should not exceed 68 degrees (Fahrenheit). Often summer head can cause fish kills in ponds because high temperatures reduce available oxygen in the water. (KY Water Watch 2001)

D. Population Profile

Population abundance. From an ecological viewpoint, simple species richness indices have limited value. More meaningful measures of diversity take into account the relative abundance of the species concerned. In general, the more equally abundant the species in the area or ecosystem under consideration the more diverse it is considered to be. Furthermore, weight an also be given to the relative abundance of species in various categories for example in different size classes, at different tropic levels, in different taxonomic groups, or different growth forms (Audesirk, 1993).

Species diversity. Biological diversity measures for particular areas, habitats or ecosystem were often attributed to species diversity. Species diversity was related to the number of potential ecological niches. An already complex community offered a greater number of potential ecological niches than a simple community, and for that reason, it

may become even more complex if organisms potentially capable of filling those niches evolve or migrate into the community. Species diversity is inversely related to geographical isolation of habitat. Island communities tend to be less diverse than continental communities with environment conditions. Species diversity is inversely related to the environmental stress of habitat. Only those species capable of toleration extreme environmental conditions could live in an environmentally-stressed community. Thus the species diversity of a polluted stream is low compared to that of a nearby pristine stream. Similarly, the species diversity of high-latitude communities exposed to harsh climates is less than that of lower latitude communities with milder climates. The effect of environmental stress to species diversity was not always clear-cut (Solomon et al., 1993). Species diversity is a measure that combines into a single figure made up of the number of species and the number of individuals of each species. High species diversity has been used in the past as an indicator of stable environments and communities, but there were many exceptions to this dogma.

Population density. It is a measurement of population per unit area or unit volume. It is frequently applied to living organisms, humans and animals alike. It is also a common biological measurement and is often used by conservationists and sociobiologists as a more appropriate measure than population size. (Britannica 2001)

Species composition. It is a commonly determined attribute in rangeland inventory and monitoring. It is also regarded as an important indicator of ecological and management processes at the site. (Britannica 2001)

E. Previous Studies

According to Coland, S. variegates (commonly known as curryfish sea cucumber) is a common species in the Indo-Pacific coral reefs, characteristic of inner lagoon holothurians community, where its mean density is around 50 individuals/ha. Size distribution appears unimodal at a single quadrat, but modes differ between quadrats, suggesting migration towards deeper waters during life.

In the West Indies, echinoderms living in coral habitats were more densely populated than in dead coral or rubble habitats, while diversity indices showed that the

rubble had higher species diversity than living or dead coral habitats. The mean size of individuals was greater in the rubble habitat than in the living and dead coral reefs. (Lewis)

CHAPTER III
METHODOLOGY

I. Materials

A. Dissolved Oxygen (D.O.) kit

B. Refractometer

C. Thermometer

D. Thirty-six pegs

E. Measuring Tape

F. Pencil

G. Paper

H. Glass Containers

I. Gloves

J. pH probe

II. Description of Study Area

Sipaway Island is located in San Carlos City, Negros Occidental. It has two barangays and a land area of 391.9 hectares. Travel time to the site is 10-25 minutes. There are resorts n the island. Protected reefs are found in the island. The island has bird sanctuaries also. Construction of eco-tourism spots in the island is proposed.

The study will be conducted in Brgy. Ermita, the south west part of the island. There will be three transects with a distance of 20 meters from each other.

III. Sampling Procedure

A. Systematic Sampling

Three transect lines were placed on the site. Each transect line measured forty meters and had a minimum distance of 20 meters from each other. Transect lines were randomly assigned and nine 10x10 meter quadrats, three quadrats per transect, with a distance if five meters from each other were placed.

B. Gathering of Species

Echinoderm organisms were counted and representative samples were collected by hand in each quadrat. The data that were obtained were recorded according to the specimen's morphological characteristics. Duplicate samples were not collected because they will be used for identification purposes only. Pictures were taken. Appendicular and transversal pictures of the specimen were taken. The species found were tentatively identified. Specimen were placed in different containers. Sampling was done on the 3rd week of September. Sampling was done from 9 in the morning to 2 in the afternoon.

IV. Identification of Species

Specimen were pre-identified according to their morphological characteristics. Taxonomic key entitled "Echinoderms of the Philippines" was used to identify the specimen.

V. Water Analysis

Water samples were collected in the site and water sampling was done immediately.

A. Temperature

A thermometer was immersed five inches below water surface and the water temperature was read after two minutes. Three replications were done during every sampling.

B. Dissolved Oxygen

A Dissolved Oxygen (D.O.) kit was used to measure the dissolved oxygen level. Steps in the D.O. kit manual were followed accordingly.

C. Salinity

A sample of seawater was placed on a prism of a refractometer. By looking on the eyepiece of the refractometer, which contains a salinity scale, the salinity was measured. The refractometer was washed with distilled water before and after every use. Salinity was measured per sampling.

D. pH

The pH probe was dipped by about an inch and a half below the water surface. Triplicate measurements were done per transect. The probe was washed with distilled water before and after every use.

VI. Data Analysis

A. Species Composition

The species composition was determined by identifying the echinoderms found in every transect. Each echinoderm was counted and documented.

B. Population Density

The density was determined by dividing the total number of representative specimen or individuals counted by the total area with the total unit area. The total unit area is the sum of the areas of all quadrats in each transect.

$$\text{Population Density} = \frac{\text{Total number of species A}}{\text{Total unit area of sampling site}}$$

C. Relative Abundance

The relative abundance of every specimen was determined by dividing the number of specimen per transect by the total number of organisms along the transect.

$$\text{Relative Abundance} = \frac{\text{No. of Species A}}{\text{Total no. of organisms}} \times 100$$

D. Relative Frequency

$$\text{Frequency} = \frac{\text{No. of plots where species occur}}{\text{Total no. of plots}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency of species A}}{\text{Frequency of all species}} \times 100$$

E. Species Diversity

The species diversity was calculated with the use of the Shannon index of General Diversity(H). The following formulas were used:

$H = -\sum(ni/N)\log(ni/N)$ or $-\sum P_I \log P_I$ where ni is the importance value and P_I is the most important probability for each species ($P_I = ni/N$)

P_I= importance probability

N= importance value (total)

ni= importance value (each)

F. Distribution Pattern

The distribution patterns of each site were obtained by comparing the sampling variance (s^2) with the sampling mean(x).

If $s^2 = x$: random distribution

If $s^2 > x$: clumped distribution

If $s^2 < x$: uniform distribution

CHAPTER IV

RESULTS

This study aimed to identify echinoderms along the coasts of Sipaway Island, San Carlos City, Negros Occidental. Random sampling was used to gather the data on the three different study sites.

Eleven species were tabulated. They are *Protoreaster nodosus*, *Archaster typicus*, *Linckia laevigata*, *Oreaster reticulatus*, *Echinothrix calamaris*, *Diadema antillarum*, *Trepneutes gratilla*, *Mespilia globulus*, *Culcita novaguineae*, *Synaptula maculata*, *Eupta lappa*.

From the data gathered, we were able to record and compute number of individuals, population abundance, population density, relative frequency and distribution pattern.

Table 1 presents the No. of Individuals, Population Abundance (%), Population Density (per m^2), Relative frequency, Distribution Pattern of the echinoderms recorded at Site 1 in the Coasts of Sipaway Island, San Carlos City, Negros Occidental.

	No. of Individuals	Population Abundance	Population Density	Relative frequency	Distribution Pattern
Protoreaster nodosus	53	0.42	0.53	0.2	Uniform
Archaster typicus	2	0.016	0.02	0.13	Uniform
Linckia laevigata	4	0.032	0.04	0.2	Uniform
Trepneutes gratilla	60	0.48	0.6	0.2	Clumped
Mespilia globulus	1	0.008	0.01	0.067	Uniform
Culcita novaguineae	4	0.032	0.04	0.13	Clumped
Synaptula maculata	3	0.023	0.03	0.067	Uniform

The number of individuals ranged from 1 to 60 individuals with *Mespilia globulus* having the least and *Trepneutes gratilla* having the most.

For the population abundance, values ranged from 0.008 % to 0.48 % with *Mespilia globulus* having the least and *Trepneutes gratilla* having the highest value. *Protoreaster nodosus* has 0.42 %, *Culcita novaguineae* and *Linckia laevigata* both have 0.032 % while *Synaptula maculata* has 0.023 % and *Archaster typicus* has 0.016 %.

Population densities ranged from 0.01 per m2 to 0.6 per m² with *Mespilia globulus* having the smallest vale with *Trepneutes gratilla* having the biggest. Other values were 0.02, 0.03, 0.04, and 0.53 per m² for *Archaster typicus*, *Synaptula maculata*, *Linckia laevigata*, *Culcita novaguineae* and *Protoreaster nodosus* respectively.

All the species found in Site 1 had uniform distribution except for *Trepneutes gratilla* and *Culcita novaguineae* which had clumped distribution.

Table 2 presents the No. of Individuals, Population Abundance(%), Population Density (per m²), Relative frequency, Distribution Pattern of the echinoderms recorded at Site 2 in the Coasts of Sipaway Island, San Carlos City, Negros Occidental.

	No. of Individuals	Population Abundance	Population Density	Relative Frequency	Distribution Pattern
Protoreaster nodosus	119	0.8	1.19	0.27	Clumped
Archaster typicus	18	0.12	0.18	0.09	Uniform
Oreaster reticulatus	1	0.0063	0.01	0.09	Uniform
Diadema antillarum	3	0.0203	0.03	0.18	Uniform
Trepneutes gratilla	2	0.0135	0.02	0.09	Uniform
Synaptula maculata	2	0.0135	0.02	0.09	Uniform

For the No. of Individuals, *Oreaster reticulatus* had the least with only one individual while *Protoreaster nodosus* had 119 individuals. *Trepneutes gratilla* and *Eupta lappa* both have 2 individuals each while *Diadema antillarum* have 3 individuals. *Archaster typicus* has 18 individuals.

Protoreaster nodosus has the biggest population abundance for site 2 with 0.8 % while *Oreaster reticulatus* had the least with 0.00063 %. SeaUchin2 and *Synaptula maculata* both have 0.0135 % and *Diadema antillarum* having 0.0302 % each. *Archaster typicus* has 0.12 %.

Population Density values range from *Protoreaster nodosus* with 1.19 being the largest and *Oreaster reticulatus* with 0.01 being the least. *Diadema antillarum* and *Synaptula maculata* both have 0.02 per m² and *Diadema antillarum* with 0.03 per m²both. *Archaster typicus* has 0.18.

Relative frequencies ranged from 0.27 % to 0.9 %. *Protoreaster nodosus* has 0.27 % while *Archaster typicus*, *Oreaster reticulatus*, *Trepneutes gratilla* and *Synaptula maculata* have 0.9 % each and *Diadema antillarum* having 0.18 %.

Protoreaster nodosus have clumped distribution patterns while the other discovered at the Site 2 were uniformly distributed.

Table 3 presents the No. of Individuals, Population Abundance(%), Population Density (per m2), Relative frequency, Distribution Pattern of the echinoderms recorded at Site 3 in the Coasts of Sipaway Island, San Carlos City, Negros Occidental.

	No. of Individuals	Population Abundance	Population Density	Relative Frequency	Distribution Pattern
Protoreaster nodosus	2	0.1	0.02	0.09	Uniform
Archaster typicus	4	0.026	0.04	0.09	Uniform
Echinothrix calamaris	5	0.03	0.05	0.09	Uniform
Diadema antillarum	111	0.74	1.11	0.3	Random
Trepneutes gratilla	1	0.006	0.01	0.09	Uniform
Synaptula maculata	25	0.17	0.25	0.2	Uniform
Eupta lappa	1	0.006	0.1	0.09	Uniform

Echinothrix calamaris had the most number of individuals with 111 whilst *Trepneutes gratilla* and *Eupta lappa* having the least with 1 individual each. *Protoreaster nodosus* has 2, *Archaster typicus* has 4, *Echinothrix calamaris* has 5 and *Synaptula maculata* has 25 individuals each.

Population Abundance values ranged from 0.17 % to 0.74 %. *Protoreaster nodosus* has 0.1 % while *Diadema antillarum* has 0.74 %. *Trepneutes gratilla* and *Eupta lappa* both have 0.06 % while *Archaster typicus*, *Echinothrix calamaris* and *Synaptula maculata* have 0.026 %, 0.03 % and 0.17 % respectively.

For Population Density, values ranged from 0.01 to 1.11 per m^2. *Diadema antillarum* having the biggest 1.11 followed by *Synaptula maculata* with 0.25, *Eupta lappa* with 0.1, *Echinothrix calamaris* with 0.05, *Archaster typicus* with 0.04, *Protoreaster nodosus* 0.02 and *Trepneutes gratilla* 0.01 per m^2.

Relative frequencies of *Protoreaster nodosus*, *Archaster typicus*, *Echinothrix calamaris*, *Trepneutes gratilla* and *Eupta lappa* are all 0.9 %. *Echinothrix calamaris* has 0.3 % and *Synaptula maculata* has 0.2 %.

All of the species found in Site 3 have uniform distribution patterns except for *Echinothrix calamaris* which has a random distribution pattern.

Species Diversity

The Species diversity for sites 1 to 3 were all measured using Shannon's diversity index. The species diversity obtained for site 1 was 0.4919 decits. The species diversity obtained for site 2 was 0.3214 decits. The species diversity obtained from site 3 was 0.3719 decits.

Water Quality Assessment

Table 4 presents the data acquired for the Water Quality Assessment of the three sites of Sipaway Island, San Carlos City.

	Temperature	Salinity	pH	Dissolved Oxygen
Site 1	30 Celsius	33 ppt	8.2	6.2 ppm
Site 2	31 Celsius	32 ppt	8.2	6.0 ppm
Site 3	31 Celsius	32 ppt	8.1	5.9 ppm

DISCUSSION

A. Sampling

There were eleven different echinoderm species found along the coast of Sipaway Island, San Carlos City, Negros Occidental.

Site 3 was the most populated among the three sites due to the presence of sea grasses which are suitable habitats for echinoderms (Schoppe 2000). Site 1 was the least populated.

Protoreaster nodosus was the most abundant among all the echinoderm species in the three sites while *Oreaster reticulates, Mespilia globules and Eupta lappa* were the least abundant species found in the three sites.

Site 1 was the most diverse among the three sites while Site 2 was the least diverse.

The distribution patterns of different echinoderm species in different sites were mostly uniform. Some species also showed random and clumped distribution.

Diadema antillarum showed the highest value for the relative frequency of each echinoderm species in the three sites while *Synaptula maculate* had the least.

B. Water Quality

The Dissolved Oxygen readings ranged from 5.9 to 6.2 parts per million (ppm) and the temperature readings ranged from 30 ℃ to 31 ℃. In general, the cooler the water the more oxygen it can dissolve (Weiss, 1970). Sites two and three have the highest temperature readings compared to Site one, therefore, the dissolved oxygen in Site one was the highest among the three sites. The salinity of normal ocean water is about 35 parts per thousand (ppt), total dissolved solids (Gore, 2000). All the water readings were suitable for echinoderms.

CHAPTER V

A. Summary

A.1. Summary of Objectives

To determine the Correlation Study and Relative Abundance of Echinoderms in Sipaway Island, San Carlos City, Negros Occidental.

Specifically, this study aimed:

To measure the Physical and Chemical factors found in the waters of Sipaway Island that may affect the growth of echinoderms.

a) Temperature

b) Dissolved Oxygen

c) Salinity

d) pH

To compute for the:

a) Species Composition

b) Population Density

c) Relative Abundance

d) Relative Frequency

e) Species Diversity

f) Distribution Pattern

A.2. Summary of Results

Site three was the most populated sampling site. All sites had equal number of echinoderm organisms. The species *Protoreaster nodosus* was most abundant in all three sampling sites. It also had the highest mean density, relative frequency and average relative abundance. The species diversity were 0.4919 decits for site one, 0.3214 decits for site two and 0.3719 decits for site three, showing that the site one contained the most number of echinoderm species. Majority of the distribution pattern of the echinoderms

were uniform, but clumped and random distribution were also common among some echinoderms.

The water analysis produced average readings. The salinity for the sampling sites were 33 parts per thousand for site one, 30 parts per thousand for site two, and 32 parts per thousand for site three, the average reading of oceans and seas. The research was conducted from 9:00 am-2:00 pm and the temperature readings ranged from 30.0°C to 31.0°C and the dissolved oxygen reading ranged from 5.9 to 6.2 parts per million. The pH readings ranged from 8.1 to 8.2.

B. Conclusion

Protoreaster nodosus was the most dominant species compared to the other echinoderm species found in three sampling sites. Site 1 was the most diverse among the three sampling sites, making it the site suitable for echinoderm living.

Therefore, we conclude, that the shores of Sipaway Island, San Carlos City, Negros Occidental were affected by human activities and pollution which caused depletion in echinoderm population. *Trepneutes gratilla* were being harvested by townsmen as a source of food which causes the scarcity of these species.

C. Recommendations

The researchers recommend that further echinoderm research be conducted in the other parts of Sipaway Island. The researches were only able to conduct their study in some areas of the island, therefore more studies are needed in order to determine the diversity and abundance of echinoderms in the other parts of the island. They also recommend that diving equipment will be used in future studies so that echinoderms in the deeper parts of the island will be studied. Seasonal studies are recommended to monitor the effects of variations of temperature and other factors will affect the population and breeding of echinoderms. Also, studies regarding the behavioral

adaptation of echinoderms should be conducted in order to determine why some echinoderms thrive better than the others.

Further researches should also focus on the many threats on the diversity of the echinoderms species and make conservation and breeding of the species as primary objectives of the study.

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APPENDIX

Table 1 Water Parameters

	Temperature	Salinity	pH	Dissolved Oxygen
Site 1	30 Celsius	33 ppt	8.2	6.2 ppm
Site 2	31 Celsius	32 ppt	8.2	6.0 ppm
Site 3	31 Celsius	32 ppt	8.1	5.9 ppm

Table 2 Number of Individuals

	Site 1	Site 2	Site 3
Starfish1	53	119	2
Starfish2	2	18	4
Starfish3	4	0	0
Starfish4	0	1	0
Starfish5	0	0	5
SeaUrchin1	0	3	111
SeaUrchin2	60	2	1
SeaUrchin3	1	0	0
BasketStar1	4	0	0
SeaCucumber1	3	2	25
SeaCucumber2	0	0	1
SeaCucumber3	0	3	0

Table 3 Population Abundance

	Site 1 (%)	Site 2 (%)	Site 3 (%)
Starfish1	42	80	10
Starfish2	1.6	12	2.6

Starfish3	3.2	0	0
Starfish4	0	0.63	0
Starfish5	0	0	3
SeaUrchin1	0	2.03	74
SeaUrchin2	48	1.35	0.6
SeaUrchin3	0.8	0	0
BasketStar1	3.2	0	0
SeaCucumber1	2.3	1.35	17
SeaCucumber2	0	0	0.6
SeaCucumber3	0	2.03	0

Table 4 Population Density

	Site 1 (per m^2)	Site 2 (per m^2)	Site 3 (per m^2)
Starfish1	0.53	1.19	0.02
Starfish2	0.02	1.18	0.04
Starfish3	0.04	0	0
Starfish4	0	0.01	0
Starfish5	0	0	0.05
SeaUrchin1	0	0.03	1.11
SeaUrchin2	0.6	0.02	0.01
SeaUrchin3	0.01	0	0
BasketStar1	0.04	0	0
SeaCucumber1	0.03	0.02	0.25
SeaCucumber2	0	0	0.1
SeaCucumber3	0	0.03	0

Table 5 Relative frequency

	Site 1	Site 2	Site 3
Starfish1	0.2	0.27	0.09
Starfish2	0.13	0.09	0.09

Starfish3	0.2	0	0
Starfish4	0	0.09	0
Starfish5	0	0	0.09
SeaUrchin1	0	0.18	0.3
SeaUrchin2	0.2	0.09	0.09
SeaUrchin3	0.067	0	0
BasketStar1	0.13	0	0
SeaCucumber1	0.067	0.09	0.2
SeaCucumber2	0	0	0.09
SeaCucumber3	0	0.18	0

Table 6 Distribution Pattern

	Site 1	Site 2	Site 3
Starfish1	Uniform	Clumped	Uniform
Starfish2	Uniform	Uniform	Uniform
Starfish3	Uniform	-	-
Starfish4	-	Uniform	-
Starfish5	-	-	Uniform
SeaUrchin1	-	Uniform	Random
SeaUrchin2	Clumped	Uniform	Uniform
SeaUrchin3	Uniform	-	-
BasketStar1	Clumped	-	-
SeaCucumber1	Uniform	Uniform	Uniform
SeaCucumber2	-	-	Uniform
SeaCucumber3	-	Clumped	-

Table 7 Species Diversity

	Species Diversity (decits)
Site 1	0.4919
Site 2	0.3214

Site 3	0.3719