EFFECTS OF CAGE AQUACULTURE ON THE PHYSICO-CHEMICAL STATUS OF MARICULTURE PARK IN TUBALAN COVE

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ABSTRACT

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This study was conducted in Tubalan Cove to determine the levels of dissolved oxygen (DO), biochemical oxygen demand (BOD), phosphates, nitrates, pH, salinity, temperature, and transparency; to assess the volume of fish and shellfish caught; and to evaluate the awareness level of coastal residents regarding the preservation efforts in Tubalan Cove. Turbidity was significantly higher in Alibungog than in Tubalan and Udalo. Temperature, salinity, pH, and dissolved oxygen (DO) vary insignificantly among the three sampling stations. Water parameters with high levels included COD, phosphates, and Ammonium-Nitrogen (N), while parameters with normal levels were pH, dissolved oxygen (DO), nitrate, nitrite, salinity, and hydrogen sulfide. The mean age of the respondents was 39 years, and the majority had a high school education or less. The most frequently caught fish was Nokos (squid). A typical day involved 4 hours of fishing, 4 days a week. The gill net was a common type of fishing gear. Tuway shells were frequently caught during gleaning, which involved spending 3 hours a day, 2 days a week, gleaning. Tagad was a common type of gleaning gear. Moreover, the participants revealed that they caught more fish and shells before the

establishment of cage aquaculture in the area. Respondents were moderately aware of dynamite and poison fishing, as well as the use of fine mesh nets, but were less aware of water quality monitoring. Tubalan Cove is still at a safe level. However, close monitoring, particularly of those parameters with high levels, is to be led by the Malita LGU, BFAR, and the SPAMAST Research Center to prevent the possible occurrence of a fish kill.

INTRODUCTION

Marine fish pens and fish cages are flourishing in the coves of Davao Occidental, particularly in Malalag and Tubalan bays. The trend is increasing, perhaps due to the profitability of this aquaculture. However, it remains uncertain whether this will continue to flourish or come to a halt due to pollution in marine waters. Unlike in the aquaculture of Laguna de Bay, no fish kill has yet occurred in the bays of Davao del Sur and Occidental, as they are open water. Unlike Taal Lake, which is an isolated body of water with limited carrying capacity, it is more prone to fish kills. Although coves are interconnected with open oceans, they must be well-regulated through scientific research so that significant findings can serve as a valuable tool for policymakers at the barangay or municipal level.

Furthermore, through policy legislations, it can prevent further deterioration of the marine ecosystem in the area. Significant indicators, such as dissolved oxygen (DO), biological oxygen demand (BOD), Chemical Oxygen Demand (COD), hydrogen sulfide, nitrate-N, nitrite-N, nitrogen ammonia, phosphates, salinity, temperature, and transparency, are essential parameters for determining the balance of an aquatic ecosystem.

This study also determined the effect of fish cage aquaculture practices on the current fish catch in the area. Thus, this study was proposed to determine the extent of organic matter buildup in the seafloor and water column of Tubalan Cove.

Objectives of the Study

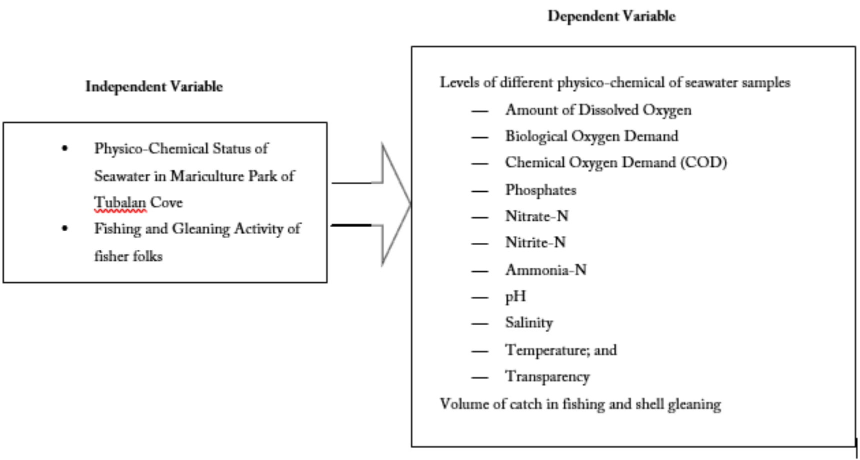
This research was conducted to assess the effect of widespread commercial feeding on cage aquaculture in Tubalan Cove Mari-culture Park. In particular, the study aimed:

1. To determine the amount of DO (Dissolved Oxygen), BOD (Biological Oxygen Demand), phosphates, nitrates, pH, salinity, temperature, and transparency in the study site and compare them to the standard.
2. To determine the volume of fish, catch, and shell gleaning activity as affected by commercial feed inputs in the mariculture park.
3. To determine the awareness level of coastal folks in the preservation effort of Tubalan Cove.

Conceptual Framework

Figure 1

Conceptual framework showing the input and output variables.



METHOD

Research Locale

This study was conducted in Tubalan Cove. Tubalan Cove is situated in Davao Occidental, Southern Philippines. It is geographically located at 60°29'49" North, 125°33'53" East.

Figure 2

Locale of the Study

Research Design

This study employed a descriptive research approach, utilizing both the results of laboratory analysis of identified parameters and a survey/interview questionnaire that included the volume of catch in both fishing and gleaning among coastal residents in the study area.

Formulation of Questionnaire and Focus Group Discussion

Cage operators and caretakers were the focus group that filled out or answered the formulated questionnaire. The questionnaire was first discussed with the focus group to gather their comments and further improve its content, particularly regarding the volume of catch in both fishing and gleaning among the coastal folks. It comprises a demographic profile of respondents, details on fishing and gleaning activities, and an assessment of awareness levels regarding the preservation of the mariculture park.

Collection of Water Samples

Sites of water sampling were sourced from the surrounding vicinity (about 5 m distance) of the actual locations of fish cages. Approximately 200 mL of fluid was collected per site, and a total of 60 sites were sampled. Water sample preservation for laboratory analysis at the UIC Science Resource Center in Davao City was performed by placing the composite samples inside a plastic cooler filled with ice water. It was tightly sealed before transport.

Volatile parameters, including pH, temperature, transparency, salinity, and dissolved oxygen, were measured on-site and simultaneously at the three sampling stations over a period of three consecutive weeks. Three sampling stations were determined, namely Udalo, Tubalan, and Alibungog. At Udalo, where most of the fish cages were installed, the focus of the water analysis was on pH, salinity, DO, BOD, COD, phosphate, nitrate, ammonium-nitrogen, Nitrite, and hydrogen sulfide, conducted over four quarters to facilitate good data collection.

Analysis of Physico-Chemical Parameters

All the collected samples were analyzed in the accredited laboratory at the UIC-Science Resource Center in Davao City, following standard methods.

Three types of sampling methods were employed to collect water samples. Grab or Catch sampling, the sample is collected at a particular time and place that represents the composition of the source in that specific point and time; Composite sampling, a mixture of grab samples is collected at the same sampling point at different time intervals (applicable for quarterly sampling since this study is good for one year); and Integrated sampling, a mixture of grab samples collected at various points simultaneously.

Parameters such as pH, dissolved oxygen (DO), temperature, and transparency were measured on-site for three consecutive weeks. The preservation procedure involves keeping the samples in the dark (inside a plastic cooler with a cover) and lowering the temperature to retard reactions. Emphasis was given to care during travel time and the preservation of samples.

Launching of Survey Questionnaire

Enumerators personally interviewed coastal residents who reside along the shorelines of the three sampling stations. Only mature individuals, aged 20 to 58 years, were interviewed as active fish catchers and shell gleaners. Personal interviews were conducted simultaneously at the three sampling stations.

Volume of Catch Determination before and After the Establishment of Cage Aquaculture

It is essential to note that the "after" values refer to the present fish and gleaning catch during the study's conduct. While "before" values represent the volume of catch in both fishing and gleaning before the proliferation of cage aquaculture in the cove.

Statistical Treatment

Descriptive statistics were employed to determine the recent physicochemical parameters of seawater in Tubalan Cove Marine Culture Part and compare them with the international standard in aquaculture water quality. This study aims to assess whether the surrounding seawaters of cage aquaculture remain safe or have already reached a critical level. ANOVA was used to compare different levels of water parameters among the three sampling stations.

RESULTS AND DISCUSSION

Physico-chemical parameters

Turbidity

Unstable parameters, such as turbidity, temperature, salinity, pH, and dissolved oxygen (DO), were sampled at the three sampling stations: Udalo, Tubalan, and Alibungog. Table 1a below presents the data on turbidity sampled over three consecutive weeks. All the readings were within tolerable limits for aquaculture.

The ability of water to transmit light, which restricts light penetration and limits photosynthesis, is termed turbidity and is the result of several factors, including suspended clay particles, the dispersion of plankton organisms, particulate organic matter, and pigments caused by the decomposition of organic matter.

Boyd and Lichtkoppler (1979) suggested that clay turbidity in water to 30 cm or less may prevent the development of plankton blooms, while 30 to 60 cm is generally adequate for good fish production, and below 30 cm is generally suitable for good fish production. There is an increase in the frequency of dissolved oxygen problems when values exceed 60 cm, as light penetrates to greater depths, encouraging underwater macrophyte growth. Thus, there is less plankton to serve as food for fish. According to Bhatnagar et al. (2004), a turbidity range of 30-80 cm is suitable for fish health; 15-40 cm is ideal for intensive culture systems, and < 12 cm causes stress. According to Santhosh and Singh (2007), the transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture.

Table 1a. *Turbidity (in cm) data in a weekly interval*

Sampling Station	Turbidity (cm) ns		
	Week 1	Week 2	Week 3
Udalo	304.80	274.32	335.28
Tubalan	365.76	335.28	365.76
Alibungog	396.24	426.72	457.20

Although there were variations in turbidity readings from week 1 to week 3 among the three sampling stations, the statistical analysis revealed no significant difference.

By comparing the means of turbidity among the three sampling stations, a significant difference was found in favor of Alibungog. Alibungog was under LGU management, headed by the mayor of the municipality of Malita, which was intended for tourism purposes. No fish cage or fish pen was allowed to be established in the area.

Temperature

It is defined as the degree of hotness or coldness in the body of a living organism, either in water or on land (Lucinda & Martin, 1999). As fish are cold-blooded animals, their body temperature changes according to the environment, affecting their metabolism and physiology, and ultimately impacting production. Higher temperatures increase the rate of biochemical activity in the microbiota and the respiratory rate of plants, thereby increasing oxygen demand. It also causes a decrease in the solubility of oxygen and an increase in the levels of ammonia in water. However, during an extended ice cover, gases such as hydrogen sulfide, carbon dioxide, methane, and others can build up to dangerously high levels, affecting fish health. Table 2a below presents the temperature data sampled over three consecutive weeks. All the readings were within tolerable limits for aquaculture.

Table 2a. *Summary of temperature data in a weekly interval*

Sampling Station	Temperature (^{0}Celcius)		
	Week 1	Week 2	Week 3
Udalo	28	28	28
Tubalan	29	28	28
Alibungog	28	27	27

Salinity

It is defined as the total concentration of electrically charged ions (cations – Ca++, Mg++, K+, Na+; anions – CO3-, HCO3-, SO4-, Cl-, and other components such as NO3-, NH4+, and PO4-). Salinity is a major driving factor that affects the density and growth of aquatic organisms' populations (Jamabo, 2008).

Fish are sensitive to the salt concentration of their waters and have evolved a system that maintains a constant salt ionic balance in their bloodstream through the movement of salts and water across their gill membranes. According to Meck (1996), freshwater and saltwater fish species generally show poor tolerance to significant changes in water salinity. Often, salinity limits vary among species. Garg and Bhatnagar (1996) have provided a desirable range of 2 ppt for common carp; however, Bhatnagar et al. (2004) reported different ideal levels of salinity, specifically 10-20 ppt for P. monodon, 10-25 ppt for euryhaline species, and 2528 ppt for P. indicus. Barman et al. (2005) gave a level of 10 ppt suitable for Mugil cephalus, and Garg et al. (2003) suggested 25 ppt for Chanos chanos (Forsskal).

Table 3a presents the raw data for salinity collected through weekly sampling at the three sampling stations. All the values were within tolerable limits for Chanos chanos cultured in either an open sea or a marine culture park.

Table 3a. *Salinity raw data in a weekly interval*

Sampling Station	Salinity (ppt)		
	Week 1	Week 2	Week 3
Udalo	35	37	38
Tubalan	34	40	35
Alibungog	41	41	35

Although there were variations in salinity readings from week 1 to week 3 among the three sampling stations, the statistical analysis revealed no significant difference. The P-value of 0.341 is greater than the 0.05 level of significance.

pH

The pH of natural waters is significantly influenced by the concentration of carbon dioxide, a highly acidic gas (Boyd, 1979). Fish have an average blood pH of 7.4, with a slight deviation from this value, generally ranging between 7.0 and 8.5, which is more optimal and conducive to fish life. A pH between 7 and 8.5 is ideal for biological productivity. Fishes can become stressed in water with a pH ranging from 4.0 to 6.5 and 9.0 to 11.0, and death is almost inevitable at a pH of less than 4.0 or greater than 11.0 (Ekubo & Abowei, 2011). According to Santhosh and Singh (2007), the suitable pH range for fish culture is between 6.7 and 9.5, with an ideal pH level between 7.5 and 8.5. Levels above and below this range are stressful to the fish. Ideally, an aquaculture pond should have a pH between 6.5 and 9 (Wurts & Durborow, 1992; Bhatnagar et al., 2004). Bhatnagar et al. (2004) also recommended that <4 or >10.5 is lethal to fish/shellfish culture; 7.5-8.5 is highly congenial for P. monodon; 7.0-9.0 is an acceptable limit; 9.0 -10.5 is sublethal for fish culture.

Table 4a presents the raw data for pH from weekly sampling at the three sampling stations. All the values were within tolerable limits for Chanos chanos cultured in an open sea or a mariculture park.

Table 4a. *The prevailing pH level in the three sampling sites*

Sampling Station	pH		
	Week 1	Week 2	Week 3
Udalo	8.0	8.4	8.7
Tubalan	8.5	8.6	8.6
Alibungog	8.4	8.6	6.9

DO (Dissolved Oxygen)

Dissolved oxygen affects the growth, survival, distribution, behavior, and physiology of shrimps and other aquatic organisms (Solis, 1988). The principal source of oxygen in water is atmospheric air and photosynthetic plankton. Obtaining sufficient oxygen is a greater problem for aquatic organisms than for terrestrial ones, due to the low solubility of oxygen in water, which decreases with factors such as increased temperature, increased salinity, low atmospheric pressure, high humidity, high concentrations of submerged plants, and plankton blooms. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth, and more fish mortality, either directly or indirectly (Bhatnagar & Garg, 2000).

According to Banerjea (1967), DO levels between 3.0 and 5.0 ppm in ponds are considered unproductive, while for average or good production, levels should be above 5.0 ppm. It may be incidentally mentioned that very high concentration of DO leading to a state of super saturation sometimes becomes lethal to fish fry during the rearing of spawn in nursery ponds (Alikunhi et al., 1952) so for oxygen, the approximate saturation level at 50° F is 11.5 mg L-1, at 70° F., 9 mg L-1, and 90° F., 7.5 mg L-1. Tropical fishes have more tolerance to low DO than temperate fishes. According to Bhatnagar and Singh (2010) and Bhatnagar et al. (2004), a dissolved oxygen (DO) level of greater than 5 ppm is essential to support good fish production. Bhatnagar et al. (2004) also suggested that concentrations of 1-3 ppm have a sublethal effect on growth and feed utilization. Concentrations of 0.3-0.8 ppm are lethal to fish, and those greater than 14 ppm are lethal to fish fry, potentially leading to gas bubble disease. DO less than 1- Death of Fish, fewer than 5 Fish survive but grow slowly and will be sluggish, five and above- Desirable. According to Santhosh and Singh (2007), Catfishes and other air-breathing fishes can survive in a low oxygen concentration of 4 mg/L. Ekubo and Abowei (2011) recommended that fish can die if exposed to less than 0.3 mg L-1 of dissolved oxygen (DO) for an extended period. A minimum concentration of 1.0 mg L-1 DO is essential to sustain fish for an extended period, and 5.0 mg L-1 is adequate in fishponds.

Table 5a shows the raw data for DO in a weekly sampling for the three sampling stations. All the values were within tolerable limits for Chanos chanos cultured in an open sea or a mariculture park.

Table 5a. *Dissolved oxygen reading in different sampling stations*

Sampling Station	DO (ppm)		
	Week 1	Week 2	Week 3
Udalo	6.4	4.4	6.6
Tubalan	7.0	5.3	8.1
Alibungog	8.0	8.0	8.0

Results of Laboratory Analysis of Composite Water Samples

Table 6a presents the quarterly laboratory analysis of composite water samples from Tubalan Cove. There were ten parameters analyzed, and seven out of ten samples are still within the safe level. This will be illustrated in the table that follows. pH reading ranges from 7.5 to 8.2 with a mean of 7.73. DO reading ranges from 6.9 to 8.6 with a mean of 7.4. BOD ranges from 0.99 to 1.0 with a mean of 0.99. COD reading ranges from 119 to 713 with a mean of 423. Phosphate has a uniform reading of 0.22 throughout the four quarters.

Nitrate reading ranges from 0.2 to 0.89 with a mean of 0.3975. Ammonium-cal N reading ranges from 0.22 to 3.55 with a mean of 1.5825. Nitrite reading ranges from 0.002 to 0.007 with a mean of 0.00325. Salinity reading ranges from 39.8 ppt to 41.9 ppt with a mean of 40.7 ppt. The hydrogen sulfide reading has a uniformity of 0.02 for the four quarters.

Table 6a. *The prevailing physico-chemical parameters in three sampling sites of Mari-culture Park, Tubalan, Davao Occidental*

Parameters	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Mean
	9/27/2017	1/4/2017	6/30/2017	3/21/2018	
pH	7.5	7.5	8.2	7.7	7.73
Dissolved Oxygen (D.O) mg/l	7.1	6.9	8.6	7.0	7.40
Biological Oxygen Demand (BOD) mg/l	0.99	0.99	0.99	1	0.9925
Chemical Oxygen Demand (COD) mg/l	713	610	250	119	423
Phosphate mg/l	0.22	0.22	0.22	0.22	0.22
Nitrate mg/l	0.3	0.2	0.2	0.89	0.3975
Amm-cal Nitrogen mg/l	0.22	0.24	3.55	2.32	1.5825
Nitrite mg/l	0.002	0.002	0.002	0.007	0.00325
Salinity mg/l	40,256	41,984	40,768	39,808	40704
Hydrogen Sulfide mg/l	0.02	0.02	0.02	0.02	0.02

Table 6b presents the mean readings of various water parameters from Tubalan Cove, along with their corresponding readings for the International Standard. Seven parameters fall within the International Standard, and three parameters exceed the standard.

Seven parameters that are still within safe levels are: pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), Nitrate, Nitrite, salinity, and hydrogen sulfide. The three parameters that exceed the standard are: COD, phosphate, and Ammonium-Nitrogen.

COD (Chemical Oxygen Demand) is the standard method for indirectly measuring the amount of pollution (that cannot be oxidized biologically) in a water sample. BOD is the measurement of total dissolved oxygen consumed by microorganisms for the biodegradation of organic matter, such as food particles or sewage. The excess entry of cattle and domestic sewage from non-point sources, as well as the similarly increasing phosphate levels in the village ponds, may be attributed to the high organic load in these ponds, thus causing a higher level of BOD.

Clerk (1986) reported that a BOD range of 2 to 4 mg/L does not indicate pollution, while levels exceeding 5 mg/L are indicative of severe pollution. According to Bhatnagar et al. (2004), the BOD level between 3.0-6.0 ppm is optimum for normal activities of fishes; 6.0-12.0 ppm is sublethal to fishes, and >12.0 ppm can usually cause fish kill due to suffocation. Santhosh and

Singh (2007) recommended that the optimum BOD level for aquaculture should be less than 10 mg L-1; however, water with a BOD of less than 10-15 mg L-1 can be considered suitable for fish culture. Bhatnagar and Singh (2010) suggested the BOD <1.6mg L-1 level is suitable for pond fish culture and according to Ekubo and Abowei (2011) aquatic system with BOD levels between 1.0 and 2.0 mg L-1 -considered clean; 3.0 mg L-1 relatively clean; 5.0 mg L-1 doubtful and 10.0 mg L-1 foul and polluted.

Table 6b. *Comparison of water sample analysis*

Parameters	Mean	International Standard
pH	7.725	The optimum is 7.5 to 8.5
Dissolved Oxygen (D.O) mg/l	7.4	The optimum is above 3.5 ppm
Biological Oxygen Demand (BOD) mg/l	0.9925	optimum less than 10 ppm
Chemical Oxygen Demand (COD) mg/l	423	optimum less than 70 ppm
Phosphate mg/l	0.22	The optimum is 0.05 to 0.07 ppm; 1 ppm is suitable for plankton production.
Nitrate mg/l	0.3975	optimum less than five ppm
Amm-cal Nitrogen mg/l	1.5825	optimum less than one ppm
Nitrite mg/l	0.00325	optimum less than 0.01 ppm
Salinity mg/l	40704	optimum 35 to 45 parts per thousand
Hydrogen Sulphide mg/l	0.02	optimum less than 0.03 ppm

Ammonia is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter (Fig. 4), such as wasted food, faeces, dead plankton, sewage, etc. The unionized form of ammonia (NH3) is highly toxic, while the ionized form (NH4+) is not, and both forms are grouped as "total ammonia".

Ammonia in the range >0.1 mg L-11tends to cause gill damage, destroy mucous producing membranes, "sub-lethal" effects like reduced growth, poor feed conversion, and reduced disease resistance at concentrations that are lower than lethal concentrations, osmoregulatory imbalance, and kidney failure. Fish suffering from ammonia poisoning generally appear sluggish or are often found at the surface, gasping for air.

The toxic levels for un-ionized ammonia in short-term exposure typically range from 0.6 to 2.0 mg/L for pond fish, and sublethal effects may occur at concentrations as low as 0.1 to 0.3 mg/L (EIFAC, 1973; Robinette, 1976). The maximum limit of ammonia concentration for aquatic organisms is 0.1 mg L-1 (Meade, 1985; Santhosh and Singh (2007). According to Swann (1997) and OATA (2008), the levels below 0.02 ppm was considered safe. Stone and Thomforde (2004) stated the desirable range as Total NH3-N: 0-2 mg L-1 and Un-ionized NH3-N: 0 mg L-1, and the acceptable range as Total NH3-N: less than 4 mg L-1 and Un-ionized NH3-N: less than 0.4 mg L-1. Bhatnagar et al. (2004) suggested that 0.01-0.5 ppm is desirable for shrimp; >0.4 ppm is lethal to many fish and prawn species; 0.05-0.4 ppm has a sublethal effect, and <0.05 ppm is safe for many tropical fish species and prawns. Bhatnagar and Singh (2010) recommended the level of ammonia (<0.2 mg L-1) suitable for pond fishery.

Nitrite is an intermediate product of the aerobic nitrification process, produced by the autotrophic bacterium Nitrosomonas, which combines oxygen and ammonia. Nitrite can be termed an invisible killer of fish because it oxidizes hemoglobin to methemoglobin in the blood, causing the blood and gills to turn brown and hindering respiration, while also damaging the nervous system, liver, spleen, and kidneys of the fish.

The ideal and standard measurement of nitrite is zero in any aquatic system. Stone and Thomforde (2004) suggested that the desirable range is 0-1 mg L-1 NO2 and the acceptable range is less than 4 mg L-1 NO2. According to Bhatnagar et al. (2004), 0.02-1.0 ppm is lethal to many fish species, >1.0 ppm is lethal for many warm-water fish, and <0.02 ppm is acceptable. Santhosh and Singh (2007) recommended that the nitrite concentration in water should not exceed 0.5 mg L-1. OATA (2008) recommended that it should not exceed 0.2 mg/L in freshwater and 0.125 mg/L in seawater.

Nitrate is harmless and is produced by the autotrophic Nitrobacter bacteria, which combine oxygen and nitrite (Fig. 4). Nitrate levels are usually stabilized in the 50-100 ppm range. Meck (1996) recommended that concentrations of 0 to 200 ppm are acceptable in a fish pond and are generally low-toxic for some species, whereas marine species are susceptible to its presence. According to Stone and Thomforde (2004), nitrate is relatively nontoxic to fish and poses no health hazard except at exceedingly high levels (above 90 mg/L). Santhosh and Singh (2007) described the favorable range of 0.1 mg L-1 to 4.0 mg L-1 in fish culture water. However, OATA (2008) recommends that nitrate levels in marine systems never exceed 100 mg L-1.

Almost all the phosphorus (P) present in water is in the form of phosphate (PO4), and surface water, it is primarily bound to living or dead particulate matter. In the soil, it is found as insoluble Ca3(P04)2 and adsorbed phosphates on colloids, except under highly acidic conditions. It is an essential plant nutrient, as it is often in limited supply, and stimulates plant (algae) growth. Its role in increasing aquatic productivity is well recognized.

Soil phosphorus levels (unit: mg of P2O5 per 100 g of soil) below three may be considered indicative of poor production, between 3 and 6, average production, and ponds with available phosphorus above six are productive (Banerjea, 1967). According to Stone and Thomforde (2004), a phosphate level of 0.06 mg/L is desirable for fish culture. Bhatnagar et al. (2004) suggested that the optimum and productive range is 0.05 -0.07 ppm, while 1.0 ppm is suitable for plankton and shrimp production.

Demographic Profile of Respondents

A total of 41 respondents were interviewed in the study sites. Table 7a shows the mean age of respondents during the interview activity. Most were married, with 85.36% or a mean score of 1.15, which is close to 1, categorized as married marital status. The educational attainment of respondents was high, primarily in schools, with a mean score of 1.51, which is rounded to 2, indicating a high school educational attainment.

Table 7a. *Demographic profile of respondents*

Age	Marital Status (1=married, 2=single)	Educ. Attainment (1=Elem, 2= High School, 3=Col. Level,
39.39	1.15	1.51
20-58 y.o.	85.36% Mrd	majority HS

Fishing Activity of Respondents

Table 7b shows the mean scores of respondents in their fishing activity. The five choices on types of fish frequently caught were Matambaka, Barilis, Carabalias, Nokos, and others. Out of five choices, Nokos was frequently caught.

In terms of hours spent fishing in a day, the respondents reported spending 4 hours, with a mean score of 4.35, rounded to 4. When asked about the number of days spent fishing per week, the mean score is 3.84, rounded to 4, which corresponds to spending 4 days per week fishing. Regarding the types of fishing gear commonly used, the mean score is 1.73, rounded to 2, which categorizes it as a gill net. In comparison to fish catch "before" the establishment of cage aquaculture, their mean score is 2.41, rounded to 2, which categorizes it as more. When asked about fish catch after the establishment of cage aquaculture, their mean score is 1.89, rounded to 2, which still categorizes as more, but to a lesser extent, compared to before the establishment of cage aquaculture. This implies that Tubalan Cove still catches more fish, according to the respondents' responses. The proliferation of cage aquaculture in the cove is still in a sustainable state, as far as this study is concerned. However, there was minimal mortality of cultured Bangus per cage; however, this appears to be occurring in isolated cases confined to the culture cage itself.

Table 7b. *Fishing activity of respondents*

Frequently Caught Fish	Hours Spent Fishing in a Day	Days spent fishing per week	Type of Fishing Gears Used	Comparison of Catch "before" Establishment of Cage Aquaculture	Comparison of Catch "after" Establishment of Cage Aquaculture
1=Matambak a, 2=Barilis, 3=Carabalias, 4=Nokos, 5=others	1=2hours, 2=3hours, 3=4hours, 4=5hours, 5=5hours & above)	1=1day, 2=2days, 3=3days, 4=4days, 5=days & above)	1=hook & line, 2=gill net, 3= scope net)	1=less catch, 2=more catch, 3=the same catch	1=less catch, 2=more catch, 3=the same catch)
3.72	4.35	3.84	1.73	2.41	1.89
Nokos	4 hours per day	4 days in a week	Gill nets	more	more

Gleaning Activity of Respondents

Table 7c shows the mean scores of respondents in their gleaning activity. The five types of shells most frequently caught were Sina, Litub, Tuway, Wasaywasay, and others. Out of five choices, Tuway was frequently caught.

In terms of hours spent gleaning in a day, the respondents reported spending 3 hours, with a mean score of 2.67, rounded to 3. When asked about the number of days spent per week in gleaning, the mean score is 2.11, rounded to 2, which categorizes it as 2 days per week spent gleaning. Regarding the types of gleaning gears commonly used, the mean score is 1.61, rounded to 2, which categorizes it as tagad. In comparison to the shell catch "before" the establishment of cage aquaculture, their mean score is 2.40, rounded to 2, which categorizes it as more catch. When asked about shell catch after the establishment of cage aquaculture, their mean score is 1.61, rounded to 2, which still indicates a catch, but to a lesser extent than before the establishment of cage aquaculture. This implies that Tubalan Cove still catches more shells, according to the respondents' responses.

Table 7c. *Gleaning Activity of Respondents*

Frequently Caught Shell	Hours Spent gleaning in a day	Days spent gleaning in a week	Type of gleaning Gears Used	Comparison of Gleaning Catch "before" Establishment of Cage Aquaculture	Comparison of Gleaning Catch "after" Establishment of Cage Aquaculture
1=Sina, 2=Litub, 3=Tuway, 4=Wasaywasay, 5=others	1=1hr, 2=2hours, 3=3hours, 4=4hours, 5=5hours & above	1=1day, 2=2days, 3=3days, 4=4days, 5=days & above	1=guna, 2=tagad, 3=barehands	1=less catch, 2=more catch, 3=the same catch	1=less catch, 2=more catch, 3=the same catch
2.83	2.67	2.11	1.61	2.40	1.61
Tuway	3 hours a day	2 days a week	tagad	more	more

Respondent's Awareness Level to Preserve Tubalan Cove

Table 7d presents the mean scores of respondents in terms of their awareness level. The rating scale ranges from 1 (low awareness) to 5 (high awareness). In dynamite fishing, the mean score of respondents is 3.5, which is rounded to 4, indicating a moderate level of awareness. In poison fishing, the mean score is 3.97, rounded to 4, which categorizes the participants as moderately aware. In fine mesh net fishing, the mean score is 3.82, rounded to 4, which categorizes the participants as moderately aware. In water quality monitoring, the mean score is 3.32, rounded to 3, which categorizes awareness as only.

So far, the awareness level of respondents regarding the preservation of Tubalan Cove is higher, equivalent to 80% (4/5) for dynamite, poison, and fine mesh net fishing. However, for water quality monitoring, it has only 60% (3/5).

This is a challenge for BFAR, Malita LGU, and SPAMAST Research Center to regularly monitor the water quality of Tubalan Cove and prevent it from reaching the critical limit for the life support system capacity of the cove. Regular information dissemination can be conducted on the harmful effects of numerous cage aquaculture establishments in the area, based on science-based findings.

Table 7d. *Respondents' awareness level of preserving Tubalan Cove*

Dynamite Fishing 1=unaware, 2=poorly aware, 3=aware, 4=moderately aware, 5= much aware	Poison Fishing 1=unaware, 2=poorly aware, 3=aware, 4=moderately aware, 5= much aware	Fine Mesh Net Fishing 1=unaware, 2=poorly aware, 3=aware, 4=moderately aware, 5= much aware	Water Quality Monitoring 1=unaware, 2=poorly aware, 3=aware, 4=moderately aware, 5= much aware
3.50	3.97	3.82	3.32
Moderately aware	Moderately aware	Moderately aware	Aware

CONCLUSIONS

The following conclusions were derived from the study findings:

1. Temperature, salinity, pH, and DO vary insignificantly in the three sampling stations.
2. Nokos (squid) are frequently caught fish. Four hours a day are spent fishing, and four days a week are spent fishing. Gill nets are the primary type of fishing gear used, and more catch is made before the establishment of cage culture, with a slightly higher catch after the establishment of cage aquaculture. In contrast, Tuway was frequently caught gleaning, spending three hours a day and two days a week doing so. The most common type of gleaning gear was the tagad, which resulted in a slight increase in catch after the establishment of cage aquaculture.
3. Respondent's awareness level on dynamite fishing is moderately aware, poison fishing is also moderately aware, fine mesh net fishing is also moderately aware, and water quality monitoring is aware only.

RECOMMENDATIONS

The following recommendations were suggested as implications of the findings:

1. Close monitoring of water quality, particularly those parameters that exceed international standards, should be budgeted in close coordination with the Malita LGU, BFAR, and SPAMAST Research Center to prevent possible occurrences of fish kill in the Tubalan Mari-culture Park.
2. Formulation of policies for responsible governance in sustainable cage aquaculture production, particularly during the planning stage, which includes zoning, carrying capacity assessments, and site selection.
3. Monitoring of management aspects, which include licensing of

fish cage operators, environmental monitoring, production regulation, and ensuring sustainability of the social and economic impacts of cage culture in a mariculture park.

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