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Effects of Cage Aquaculture to the Physico-Chemical Status of Mariculture Park in Tubalan Cove

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Abstract: ***This study was conducted at Tubalan Cove, Tubalan, Malita, Davao Occidental in order to determine the amount of dissolved oxygen (DO), biological oxygen demand (BOD), phosphates, nitrates, pH, salinity, temperature, and transparency and compare them to standard levels. Awareness determination on cove preservation and catch volume in fishing and gleaning "before" and "after" establishment of cage aquaculture also included. Results revealed that turbidity is significantly higher in Alibungog than Tubalan and Udalo. Temperature, salinity, pH, and DO vary insignificantly among three sampling stations. Water parameters that are on critical level are COD, phosphates, and Amm-cal N while parameters still within standard levels are pH, DO, nitrate, nitrite, salinity, and hydrogen sulfide. Nokos (squid) was the frequently caught fish. Average of 4 hours daily and 4 days weekly spent in fishing; gill net was the common fishing gear. Tuway was frequently caught in gleaning, 3 hours daily and 2 days weekly was spent in gleaning, tagad was the common gleaning tool. Morecatch rated by respondents on fishing and gleaning "before" the establishment of cage aquacutlure,while slightlymore catch "after" the establishment of cage aquaculture. Moderatelyaware is the awareness level on dynamite fishing, poison fishing, and illegal fine mesh net, and aware only on water quality monitoring. Tubalan Cove seawater started to deteriorate particularly on COD, phosphates, and ammonia. It is recommended to conduct regular water qualitymonitoring to be spearheaded either by Malita LGU (Local Government Unit), BFAR (Bureau of Fisheries and Aquatic Resources), or SPAMAST (Southern Philippines Agribusiness and Marine and Aquatic School of Technology) Research Center to prevent further deterioration of seawater in the Mariculture Park of Tubalan Cove.***

Keywords: water parameters; standard levels; water quality; deterioration; catch volume

1. Introduction

Marine fishpen and fishcage are flourishing in the coves of Davao Occidental particularly in Malalag and Tubalan bays. The trend is increasing perhaps due to the profitability of these aquaculture but uncertain as to when this may continue to flourish or may stop due to pollution in marine waters.

Unlike in the aquaculture of Laguna de Bay, no fish kill yet occurring in the bays of Davao del Sur and Occidental since it an open water. Unlike to Taal Lake which is an isolated body of water with limited carrying capacity thus more prone to fish kills. Though coves are interconnected to open oceans, it has to be well regulated through scientific research so that significant findings can be a good tool for policy makers in the barangay or municipal level.

Furthermore, through policy legislations it can prevent further deterioration of the marine ecosystem in the area. Significant indicators like dissolved oxygen (D.O.), biological oxygen demand (B.O.D.), Chemical Oxygen Demand (COD), hydrogen sulfide, nitrate-N, nitrite-N, nitrogen-ammonia cal, phosphates, salinity, temperature, and transparency are essential parameters to determine the balance of aquatic ecosystem. The side bit of this study is to determine also whether the positive impact of this aquaculture practices is more than its negative impact particularly in the fish catch outside the cage structures before and after the proliferation of these cage aquaculture.

Thus this study was proposed in order to find out what is the extent of the organic matter build up in the seafloor and water column of the Tubalan Cove

1.1. Objectives of the Study

This research was conducted to assess the impact of widespread commercial feeding to cage aquaculture in Tubalan Cove Mariculture Park. In particular the study aimed to answer the following questions:

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 normal standard.
2) To determine volume of fish catch and shell gleaning activity as affected by commercial feed inputs in the mariculture park.
3) To determine awareness level of coastal folks in the preservation effort of Tubalan Cove.

2. Review of Related Literature

Any material discharged into the sea can change the marine ecosystem, be it natural (flashflood) or man made (commercial feeds, industrial wastes, etc.). Such changes may either be big or small, temporary or permanent, widely or locally spread. If the change can make damage to the marine ecosystem, it constitutes pollution [1]. Pollution of various types can cause fish kills in numerous cage aquacultures [2].

Floating cages of farmed fish release large amounts of dissolved nutrients into the marine environment [3]. The dissolved nutrients accumulate around the farm, especially at places with limited water circulation [2]. Benthic decomposition of organic matter accelerates oxygen consumption [4]. Subsequently, the sediment becomes anoxic and unaerobic decay processes generate hydrogen sulfide and methane [5].

Normal standard reading of different water parameters: unpolluted, natural water should have a BOD of 5mg/li or less. Healthy streams have a D.O value of 8mg/li or ppm. In general DO of less than 3 ppm is stressful to most aquatic organisms [6]. Total phosphate levels of non-polluted waters are usually less than 0.1mg/L or ppm. The range to be expected in fresh water is from 0.04 to 0.2 ppm for phosphorus, depending on the type of water, and from 1 to 4 ppm for nitrogen. The range relates to different waters. Rivers are mostly on the high end, while deep lakes are mostly measuring lower values (if the nutrient content is more or less natural). The values in salt water can be lower: 0.1 for phosphorus falls in the same range, but nitrogen can be as low as 0.04. This makes it harder to measure the nitrogen content in the sea than in freshwater.

The chemical oxygen demand (COD) test procedure is based on the chemical decomposition of organic and inorganic contaminants, dissolved or suspended in water. The result of a chemical oxygen demand test indicates the amount of water-dissolved oxygen (expressed as parts per million or milligrams per liter of water) consumed by the contaminants, during two hours of decomposition from a solution of boiling potassium dichromate. The higher the chemical oxygen demand, the higher the amount of pollution in the test sample.

Recommended water quality parameters for shrimp farming are the following: temperature: 26-33°C, salinity: 10-25 ppt, dissolved oxygen: >3.0 ppm, pH: 7.5-8.5, total ammonia nitrogen: <1.0 ppm, total nitrate nitrogen: <5.0 ppm, nitrite nitrogen: <0.01 ppm, sulphide: <0.03 ppm, biological oxygen demand (BOD), <10 ppm, and Chemical Oxygen Demand (COD):<70 ppm [7].

2.1 Conceptual/Theoretical Framework of the Study

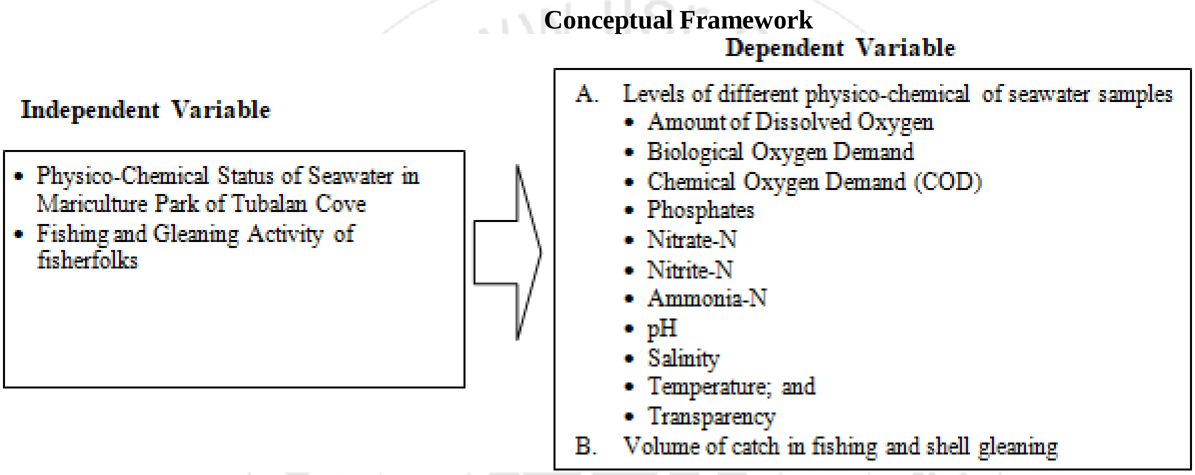

Figure 1: Conceptual framework showing the input and output variables.

3. Materials and Methods

Research Locale

BFAR XI (2011) conducted the verification trial in the culture of milkfish culture in Tubalan Cove with a total stock of 20,000 at 5,000 pieces per 6mX6mX5m cage. From that of 2011 verification trial, the number of pens and cages in the cove were tripled. Tubalan Cove is one of the Mariculture Parks for fish pen and fishcage aquaculture aside from Malalag Bay, Kaputian Strait at IGACOS and Panabo, and other bays in Pantukan, Compostela Province, and Pujada Bay in Mati, Davao Oriental [8]. Thus Tubalan Cove needs assessment from time to time regarding physico-chemical parameters in order to preserve its aquatic environment.

Formulation of Questionnaire and Focus Group Discussion

Cage operators and care takers were the focus group to fill-up or answer the formulated questionnaire. The questionnaire was discussed first to the focus group for their comments to further improve its content particularly on volume of catch in both fishing and gleaning of the coastal folks. It comprises demographic profile of respondents, fishing activities, gleaning activities, and awareness level in the preservation of the mariculture park.

Collection of Water Samples

Sites of water sampling were sourced from surrounding vicinity (about 5 m distance) of actual locations of fish cages. Using empty bottle of mineral water, water samples were collected from top layer of seawater (about 6 inches depth) as usual practice in pond aquaculture water sampling. About 200 ml per site was collected and a total of 60 sites were sampled. The total ml collected was about 12,000 ml or equivalent to about 3 gallons and comprise as composite sample representing one condition for the entire surrounding water of cage aquaculture. Water sample preservation for laboratory analysis at UIC Science Resource Center, Davao City was done by placing the composite samples inside a plastic cooler with ten pieces of ice water inside. It was tightly sealed prior to transport. Three to four hours travel time were maintained so that the samples be received by the laboratory in-charge before 11 am to ensure stability of the physico-chemical parameters of water samples. Highly unstable parameters such as pH, temperature, transparency, salinity and dissolved oxygen were measured on site and simultaneous with the three sampling stations for three consecutive weeks [9]. Three sampling stations were determined namely Udalo, Tubalan, and Alibungog. At Udalo where most of the fish cages were installed was the focus of water analysis for pH, salinity, DO, BOD, COD, phosphate, nitrate, Amm-cal N, Nitrite, and hydrogen sulfide for four quarters to have a good data collection.

Analysis of Different Physico-Chemical Parameters

All the collected samples were analyzed in the accredited laboratory in Davao City particularly the UIC-Science Resource Center. Three types of sampling adopted for collecting water samples [10]. *Grab or Catch sampling,* the sample is collected at a particular time and place that represents the composition of the source at that particular 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 different points simultaneously.

Parameters such as pH, DO, temperature, and transparency were measured on site for three consecutive weeks. The preservation procedure includes keeping the samples in the dark (inside plastic cooler with cover), lowering the temperature to retard reactions. Care was given emphasis in the travel time and preservation of samples [11].

Launching of Survey Questionnaire

Coastal folks that reside along shorelines of the three sampling stations were personally interviewed by enumerators. Only matured ones ranging from 20 to 58 years old were interviewed as active fish catchers and shell gleaners. Personal interview were done simultaneously among the three sampling stations.

Research Design

This study is a descriptive research and utilized both the results of laboratory analysis of identified parameters and the utilization of survey/interview questionnaire that includes volume of catch in both fishing and gleaning of coastal folks in the study area.

Volume of Catch Determination Before and After Establishments of Cage Aquaculture

It is important to note that the "after" values would mean the present fish and gleaning catch during the conduct of the study. While "before" values represents the volume of catch in both fishing and gleaning prior to the proliferation of cage aquaculture in the cove.

Statistical Treatment

Descriptive statistics was employed by determining the recent pysico-chemical parameters of seawater in Tubalan Cove Mariculture Part and compare it with the international standard in aquaculture water quality. This is to evaluate whether it is still on safe or already in critical level the surrounding seawaters of cage aquaculture. ANOVA was used in comparing different levels of water parameters among the three sampling stations [12].

4. Results and Discussion

On-sight sampling of Unstable Parameters

Turbidity

Unstable parameters like turbidity, temperature, salinity, pH, and DO were sampled on sites for the three sampling stations, namely: Udalo,Tubalan, and Alibungog. Table 1 below shows the raw data of turbidity sampled for three consecutive weeks. All the readings were within tolerable limits for aquaculture.

Ability of water to transmit the light that restricts light penetration and limit photosynthesis is termed as turbidity and is the resultant effect of several factors such as suspended clay particles, dispersion of plankton organisms, particulate organic matters and also the pigments caused by the decomposition of organic matter.

Boyd and Lichtkoppler[13] suggested that the clay turbidity in water to 30 cm or less may prevent development of plankton blooms, 30 to 60 cm and as below 30 cm - generally adequate for good fish production and there is an increase in the frequency of dissolved oxygen problems when values above 60 cm, as light penetrates to greater depths encourage underwater macrophyte growth, and so there is less plankton to serve as food for fish. According to Bhatnagar*et al.* [14] turbidity range from 30-80 cm is good for fish health; 15-40 cm is good for intensive culture system and < 12 cm causes stress. According to Santhosh and Singh [15] the transparency between 30 and 40 cm indicates optimum productivity of a pond for good fish culture.

Table 1 (a): Turbidity (in ft) raw data in weekly interval

Sampling Station	Turbidity (ft)		
	Week 1	Week 2	Week 3
Udalo	10	9	11
Tubalan	12	11	12
Alibungog	13	14	15

Although there were variations in turbidity readings from week 1 to week 3 among three sampling stations but statistically it revealed no significant difference (Table 1b). The *P-value* of 0.729 is beyond 0.05 level of significance.

Table 1 (b): Turbidity analysis in weekly interval

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Week 1	3.00	35.00	11.67	2.33	0.729^{ns}
Week 2	3.00	34.00	11.33	6.33	
Week 3	3.00	38.00	12.67	4.33	

By comparing means of turbidity among the three sampling stations, it showed a significant difference that favors for Alibungog. Alibungog was under LGU management headed by the mayor of the municipality of Malita that it is intended for tourism purposes and no fish cage nor fish pen was allowed to be established in the area.

Table 1(c): Turbidity analysis in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Udalo	3	30	10	1	0.0042*
Tubalan	3	35	11.67	0.33	
Alibungog	3	42	14	1	

Temperature

It is defined as the degree of hotness or coldness in the body of a living organism either in water or on land [16]. As fish is a cold blooded animal, its body temperature changes according to that of environment affecting its metabolism and physiology and ultimately affecting the production.

Higher temperature increases the rate of bio-chemical activity of the micro biota, plant respiratory rate, and so increase in oxygen demand. It further cause decreased solubility of oxygen and also increased level of ammonia in water. However, during under extended ice cover, the gases like hydrogen sulphide, carbon dioxide, methane, and some others can build up to dangerously high levels affecting fish health. Table 2a below shows the raw data of temperature sampled for three consecutive weeks. All the readings were within tolerable limits for aquaculture.

Table 2 (a): Temperature raw data in 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

Although there were variations in temperature readings from week 1 to week 3 among three sampling stations but statistically it revealed no significant difference (Table 2b). The *P-value* of 0.331 is beyond 0.05 level of significance.

Table 2 (b): Temperature analysis in weekly interval

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Week 1	3.00	85.00	28.33	0.33	0.331^{ns}
Week 2	3.00	83.00	27.67	0.33	
Week 3	3.00	83.00	27.67	0.33	

By comparing means of temperature among the three sampling stations, it showed no significant difference with a *P-value* of 0.098 (Table 2c). It would mean there was similarity in temperature reading among stations.

Table 2 (c): Temperature analysis in different sampling stations

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Udalo	3.00	84.00	28.00	0.00	0.098^{ns}
Tubalan	3.00	85.00	28.33	0.33	
Alibungog	3.00	82.00	27.33	0.33	

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 organism's population [17].

Fish are sensitive to the salt concentration of their waters and have evolved a system that maintains a constant salt ionic balance in its bloodstream through the movement of salts and water across their gill membranes. According to Meck[18] fresh and saltwater fish species generally show poor tolerance to large changes in water salinity. Often salinity limits vary species to species level. Garg and Bhatnagar[19] have given desirable range 2 ppt for common carp; however, Bhatnagar*et al*. [20] gave different ideal levels of salinity as 10-20 ppt for *P. monodon*; 10-25 ppt for euryhaline species and 25-28 ppt for *P. indicus*. Barman *et al*. [21] gave a level of 10 ppt suitable for *Mugilcephalus*and Garg*et al*. [22] suggested 25 ppt for *Chanoschanos* (Forsskal).

Table 3a shows the raw data for salinity in a weekly sampling for the three sampling stations. All the values were within tolerable limits for *Chanoschanos* cultured in an open sea or in amariculture park.

Table 3 (a): Salinity raw data in 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 three sampling stations but statistically it revealed no significant difference (Table 3b). The *P-value* of 0.341 is beyond 0.05 level of significance.

Table 3 (b): Salinity analysis in weekly interval

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Week 1	3.00	110.00	36.67	14.33	0.341^{ns}
Week 2	3.00	118.00	39.33	4.33	
Week 3	3.00	108.00	36.00	3.00	

By comparing means of salinity from among the three sampling stations, it showed no significant difference with a *P-value* of 0.503 (Table 3c). It would mean there was similarity in salinity reading among stations.

Table 3 (c): Salinity analysis in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Udalo	3.00	110.00	36.67	2.33	0.503^{ns}
Tubalan	3.00	109.00	36.33	10.33	
Alibungog	3.00	117.00	39.00	12.00	

pH

pH is measured mathematically by, the negative logarithm of hydrogen ions concentration. The pH of natural waters is greatly influenced by the concentration of carbon dioxide which is an acidic gas [23]. Fish have an average blood pH of 7.4, a little deviation from this value, generally between 7.0 to 8.5 is more optimum and conducive to fish life. pH between 7 to 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 certain at a pH of less than 4.0 or greater than 11.0 [24]. The suitable pH range for fish culture is between 6.7 and 9.5 and ideal pH level is between 7.5 and 8.5 and above and below this is stressful to the fishes. Ideally, an aquaculture pond should have a pH between 6.5 and 9 [25]. Bhatnagar*et al*. [9] 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 acceptable limits; 9.0 -10.5 is sublethal for fish culture.

Table 4a shows the raw data for pH in a weekly sampling for the three sampling stations. All the values were within tolerable limits for *Chanoschanos* cultured in an open sea or in a mariculture park

Table 4 (a): pH raw data in weekly interval

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

Although there were variations in pH readings from week 1 to week 3 among three sampling stations but statistically it revealed no significant difference (Table 4b). The *P-value* of 0.661 is beyond 0.05 level of significance.

Table 4 (b): pH analysis in weekly interval

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Week 1	3.00	24.90	8.30	0.07	0.661^{ns}
Week 2	3.00	25.60	8.53	0.01	
Week 3	3.00	24.20	8.07	1.02	

By comparing means of pH from among the three sampling stations, it showed no significant difference with a *P-value* of 0.473 (Table 4c). It would mean there was similarity in pH reading among stations.

Table 4 (c): pH analysis in different stations

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Udalo	3.00	25.10	8.37	0.12	0.473^{ns}
Tubalan	3.00	25.70	8.57	0.00	
Alibungog	3.00	23.90	7.97	0.86	

DO (Dissolved Oxygen)

Dissolved oxygen affects the growth, survival, distribution, behaviour and physiology of shrimps and other aquatic organisms [7]. The principal source of oxygen in water is atmospheric air and photosynthetic planktons. Obtaining sufficient oxygen is a greater problem for aquatic organisms than terrestrial ones, due to low solubility of oxygen in water and solubility decreases with factors like- increase in temperature; increase in salinity; low atmospheric pressure, high humidity, high concentration of submerged plants, plankton blooms. Oxygen depletion in water leads to poor feeding of fish, starvation, reduced growth and more fish mortality, either directly or indirectly [26].

According to Banerjea[10] DO between 3.0-5.0 ppm in ponds is unproductive and for average or good production it 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 [27] so for oxygen, the approximate saturation level at 50° F is 11.5 mg L-1, at 70° F., 9 mg L-1, and at 90° F., 7.5 mg L-1. Tropical fishes have more tolerance to low DO than temperate fishes. According to the two authors [9] and [14] DO level >5ppm is essential to support good fish production. Bhatnagar*et al.* [14] also suggested that 1-3 ppm has sublethal effect on growth and feed utilization; 0.3-0.8 ppm is lethal to fishes and >14 ppm is lethal to fish fry, and gas bubble disease may occur. DO less than 1- Death of Fish, Less than 5 -Fish survive but grow slowly and will be sluggish, 5 and above-desirable. According to Santhosh and Singh [15] Catfishes and other air breathing fishes can survive in low oxygen concentration of 4 mg L-1. Ekubo and Abowei[24] recommended that fish can die if exposed to less than 0.3 mg L-1 of DO for a long period of time, minimum concentration of 1.0 mg L-1 DO is essential to sustain fish for long period and 5.0 mg L-1 are 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 *Chanoschanos* cultured in an open sea or in a mariculture park.

Table 5(a): DO raw data in weekly interval

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

Although there were variations in DO readings from week 1 to week 3 from among three sampling stations but statistically it revealed no significant difference (Table 5b). The *P-value* of 0.320 is beyond 0.05 level of significance.

Table 5(b): DO analysis in weekly interval

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Week 1	3.00	21.40	7.13	0.65	0.320^{ns}
Week 2	3.00	17.70	5.90	3.51	
Week 3	3.00	22.70	7.57	0.70	

By comparing means of DO from among the three sampling stations, it showed no significant difference with a *P-value* of 0.116 (Table 5c). It would mean there was similarity in DO reading among stations.

Table 5 (c): DO analysis in different sampling stations

Groups	*Count*	*Sum*	*Average*	*Variance*	*P-value*
Udalo	3.00	17.40	5.80	1.48	0.116
Tubalan	3.00	20.40	6.80	1.99	
Alibungog	3.00	24.00	8.00	0.00	

Results of Laboratory Analysis of Composite Water Samples

Table 6a shows the quarterly lab analysis of composite water samples of Tubalan Cove. There were ten parameters analyzed and seven out ten samples are still within the safe level. This will be shown in the succeeding table. 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 t0 1.0 with a mean of 0.99. COD reading ranges from 119 to 713 with a mean of 423. Phosphate has uniform reading of 0.22 all 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. Hydrogen sulfide reading has uniform of 0.02 for the four quarters.

Table 6 (a): Composite Water Sample Analysis from UIC-Science Resource Center

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

Comparison of Water Sample Analysis with the International Standard

Table 6b shows the mean reading of different water parameters from Tubalan Cove and its equivalent reading for International Standard. There seven parameters that are within the International Standard and three parameters that are beyond the standard (colored blue in the table).

Seven parameters that are still on its safe levels are: pH, DO, BOD, Nitrate, Nitrite, salinity, and hydrogen sulfide. The three parameters that are beyond the standard are: COD, phosphate, and Ammonium-cal Nitrogen.

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

Clerk [28] reported that BOD range of 2 to 4 mg L-1 does not show pollution while levels beyond 5 mg L-1 are indicative of serious pollution. According to Bhatnagar*et al.* [9] 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 [15] recommended optimum BOD level for aquaculture should be less than 10 mg L-1 but the water with BOD less than 10-15 mg L-1 can be considered for fish culture. Bhatnagar and Singh [14] suggested the BOD <1.6mg L-1 level is suitable for pond fish culture and according to Ekubo and Abowei[24] aquatic system with BOD levels between 1.0 and 2.0 mg L-1 - considered clean; 3.0 mg L-1 fairly clean; 5.0 mg L-1 doubtful and 10.0 mg L-1 definitely bad and polluted.

Table 6 (b): Comparison of water sample analysis with the International Standard

Parameters	Mean	International Standard
pH	7.725	optimum is 7.5 to 8.5
Dissolved Oxygen (D.O) mg/l	7.4	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	optimum is 0.05 to 0.07 ppm; 1 ppm is good for plankton production
Nitrate mg/l	0.3975	optimum less than 5 ppm
Amm-cal Nitrogen mg/l	1.5825	optimum less than 1 ppm
Nitrite mg/l	0.00325	optimum less than 0.01 ppm
Salinity mg/l	40704	optimum 35 to 45 parts per thousand
Hydrogen Sulfide mg/l	0.02	optimun 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 planktons, sewage etc. The unionized form of ammonia (NH3) is extremely toxic while the ionized form (NH4+) is not and both the forms are grouped together 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, kidney failure. Fish suffering from ammonia poisoning generally appear sluggish or often at the surface gasping for air.

The toxic levels for un-ionized ammonia for short-term exposure usually lie between 0.6 and 2.0 mg L-1 for pond fish, and sublethal effects may occur at 0.1 to 0.3 mg L-1 (EIFAC, 1973; Robinette, 1976). Maximum limit of ammonia concentration for aquatic organisms is 0.1 mg L-1 (Meade, 1985: Santhosh and Singh, 2007). According to Swann [29] and OATA [30] the levels below 0.02 ppm were considered safe. Stone and Thomforde[31] stated the desirable range as Total NH3-N: 0-2 mg L-1 and Un-ionized NH3-N: 0 mg L-1 and 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.* [9] suggested 0.01-0.5 ppm is desirable for shrimp; >0.4 ppm is lethal to many fishes & prawn species; 0.05-0.4 ppm has sublethal effect and <0.05 ppm is safe for many tropical fish species and prawns. Bhatnagar and Singh [14] recommended the level of ammonia (<0.2 mg L-1) suitable for pond fishery.

Nitrite is an intermediate product of the aerobic nitrification bacterial process, produced by the autotrophic *Nitrosomonas*bacteria combining oxygen and ammonia. Nitrite can be termed as an invisible killer of fish because it oxidizes haemoglobin to methemoglobin in the blood, turning the blood and gills brown and hindering respiration also damage for nervous system, liver, spleen and kidneys of the fish.

The ideal and normal measurement of nitrite is zero in any aquatic system. Stone and Thomforde[31] suggested that the desirable range 0-1 mg L-1 NO2 and acceptable range less than 4 mg L-1 NO2. According to Bhatnagar*et al*. [9] 0.02-1.0 ppm is lethal to many fish species, >1.0 ppm is lethal for many warm water fishes and <0.02 ppm is acceptable. Santhosh and Singh [15] recommended nitrite concentration in water should not exceed 0.5 mg L-1. OATA [30] recommended that it should not exceed 0.2 mg L-1 in freshwater and 0.125 mg L-1 in seawater.

Nitrate is harmless and is produced by the autotrophic *Nitrobacter*bacteria combining oxygen and nitrite (fig.4). Nitrate levels are normally stabilized in the 50-100 ppm range. Meck[18] recommended that its concentrations from 0 to 200 ppm are acceptable in a fish pond and is generally low toxic for some species whereas especially the marine species are sensitive to its presence. According to Stone and Thomforde[31] nitrate is relatively nontoxic to fish and not cause any health hazard except at exceedingly high levels (above 90 mg L-1). Santhosh and Singh [15] described the favourable range of 0.1 mg L-1 to 4.0 mg L-1 in fish culture water. However, OATA [30] recommends that nitrate levels in marine systems never exceed 100 mg L-1.

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

Soil phosphorus (unit- mg of P2O5 per 100gm of soil) level below 3 might be considered indicative of poor production, between 3 and 6 of average production and ponds having available phosphorus above 6 are productive [10]. According to Stone and Thomforde[31] the phosphate level of 0.06 mg L-1 is desirable for fish culture. Bhatnagar*et al*. [9] suggested 0.05-0.07 ppm is optimum and productive; 1.0 ppm is good for plankton / shrimp production.

Demographic Profile of Respondents

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

Table 7 (a): 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 are matambaka, barilis, carabalias, nokos, and others. Out of five choices nokos is frequently caught.

In terms of hours spent in fishing in a day, the respondents spent 4 hours with a mean score of 4.35 or rounded to 4. When asked on days spent per week in fishing, the mean score is 3.84 or rounded to 4 that categorized to 4 days in a week going to fishing. On types of fishing gears they commonly used, the mean score is 1.73 and rounded to 2 that categorizes for gill net. In comparison of fish catch “before” establishment of cage aquaculture, their mean score is 2.41 and rounded to 2 that categorizes to *more*. When asked on fish catch after the establishment of cage aquaculture, their mean score is 1.89 and rounded to 2 that still categorizes as *more* but lesser extent as compared to *before* cage aquaculture establishments. This implies that Tubalan Cove has still more fish catch according to responses of respondents. The proliferation of cage aquaculture in the cove is still on its sustainable state as to the conduct of this study.

So far no breaking news about mass mortality or fish kills of all sorts in the cove up to the write up of this research. However, there were minimal mortality of cultured bangus per cage but this seems to be in isolated cases that are occurring inside the culture cage only.

Table 7(b): Fishing Activity of respondents

Frequently Caught Fish (1=matambaka, 2=barilis, 3= carabalias,4=nokos, 5=others	Hours Spent Fishing in a day (1=2hr, 2=3hr,3=4hr, 4=5hr, 5=5hr above)	Days spent fishing per week (1=1day, 2=2 days3=3 days, 4= 4days, 5= days above)	Type of Fishing Gears Used (1=hook & line, 2=gill net, 3= scope net)	Comparison of Catch "before" Establishment of Cage Aqaculture (1=less catch, 2=more catch, 3=the same catch)	Comparison of Catch "after" Establishment of Cage Aqaculture (1=less catch, 2=more catch, 3=the same catch)
3.72	4.35	3.84	1.73	2.41	1.89
nokos	4 hrs in a day	4 days in a wk	gill nets	more	more

Gleaning Activity of Respondents

Table 7c shows the mean scores of respondents in their gleaning activity. The five choices on types of shells frequently caught are sina, litub, tuway, wasaywasay, and others. Out of five choices tuway is frequently caught.

In terms of hours spent in gleaning in a day, the respondents spent 3 hours with a mean score of 2.67 or rounded to 3. When asked on days spent per week in gleaning, the mean score is 2.11 or rounded to 2 that categorizes to 2 days in a week going to gleaning. On types of gleaning gears they commonly used, the mean score is 1.61 and rounded to 2 that categorizes for tagad. In comparison of shell catch “before” establishment of cage aquaculture, their mean score is 2.40 and rounded to 2 that categorizes to *more* catch.

When asked on shell catch after the establishments of cage aquaculture, their mean score is 1.61 and rounded to 2 that still categorizes as *more* catch but with lesser extent as compared to *before* cage aquaculture establishments. This implies that Tubalan Cove has still more shell catch according to responses of respondents.

Table 7 (c): Gleaning activity of respondents

Frequently Caught Shell (1=sina, 2=litub, 3= tuway, 4=wasaywasay,5= others	Hours Spent gleaning in a day (1=1hr, 2=2hr,3=3hr, 4=4hr, 5=5hr above)	Days spent gleaning in a week (1=1day, 2=2 days3=3 days, 4= 4days, 5= days above)	Type of gleaning Gears Used (1=guna, 2=tagad, 3= barehands)	Comparison of Gleaning Catch "before" Establishment of Cage Aqaculture (1=less catch, 2=more catch, 3=the same catch)	Comparison of Gleaning Catch "after" Establishment of Cage Aqaculture (1=less catch, 2=more catch, 3=the same catch)
2.83	2.67	2.11	1.61	2.4	1.61
tuway	3hrs in a day	2 days in a wk	tagad	more	more

Respondent's Awareness Level to Preserve Tubalan Cove

Table 7d shows the mean scores of respondents in their awareness level. The rating scale is from 1 stands for low awareness and 5 for high awareness. In dynamite fishing, the mean score of respondents is 3.5 and rounded to 4 that categorizes as *moderately aware*. In poison fishing, the mean score is 3.97 and rounded to 4 that categorizes *moderately aware*. In fine mesh net fishing, the mean score is 3.82 and rounded to 4 that categorizes *moderately aware*. In water quality monitoring, the mean score is only 3.32 and rounded to 3 that categorizes *aware* only.

So far, the awareness level of respondents in the preservation of Tubalan Cove is higher which is equivalent to 80% ($^4/_5$) for dynamite, poison, and fine mesh net fishing. But for water quality monitoring, it has only 60% ($^3/_5$).

This is a challenge for BFAR, Malita LGU and SPAMAST Research Center to find ways in monitoring regularly the water quality of Tubalan Cove in order to prevent reaching the critical limit for life support system capacity of the cove. Regular info- disseminations be conducted on the bad effects of so much establishments of cage aquaculture in the area through science based findings.

Table 7d. Respondent's awareness level to preserve 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
3.5	3.97	3.82	3.32
Moderately aware	Moderately aware	Moderately aware	Aware

5. Summary and Conclusion

The following conclusions were derived as study findings:
1) Turbidity is significantly higher (more clear water) in Alibungog than in Tubalan and Udalo.
2) Temperature, salinity, pH, and DO varies insignificantly among the three sampling stations.
3) Water parameters that are beyond the international standards are COD, phosphates, and Amm-cal Nitrogen while parameters within the standard levels are pH, DO, nitrate, nitrite, salinity, and hydrogen sulfide.
4) Mean age of respondents is 39 years old that ranges from 20 t0 56 y.o., majority are married (85%), and majority are high school level.
5) Nokos (squid) are frequently caught fish, 4 hours in a day spent in fishing, 4 days a week spent in fishing, gill nets type of fishing gears mostly used, *more catch* before the establishment of cage culture, and slightly *more catch* after the establishment of cage aquaculture.
6) Tuway frequently caught in gleaning, 3 hours in a day spent in gleaning, 2 days spent in a week gleaning, tagad common type of gleaning gears, *more catch* on gleaning before the establishment of cage aquacutlure, slight *more catch* in gleaning after the establishment of cage aquaculture.
7) Respondent's awareness level on dynamite fishing is *moderately aware*, poison fishing is also *moderately aware*, fine mesh net fishing also *moderately aware*, and water quality monitoring is *aware* only.

6. Implication and Recommendations:

The following recommendations were suggested as implications of the findings:
1) Close monitoring of water quality particularly those parameters that are beyond international standards be budgeted in close coordination with Malita LGU, BFAR, SPAMAST Research Center to have an advance prevention of possible occurrence of fish kill in TubalanMariculture Park.
2) Formulation of policies for sustainable cage aquaculture production particularly on planning stage that includes zoning, carrying capacity, and siting.
3) Monitoring on the management aspects that includes licensing of fish cage operators, environment monitoring, production regulation, and ensuring sustainability as to social and economic impacts of cage culture in a mariculture park.

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