WATER PROPERTIES AT FISH CAGE CULTURE IN SULAMAN BAY, TUARAN

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ABSTRACT

Sulaman Bay is one of the aquaculture sites in Sabah that located at the west coast of Sabah, facing to the South China Sea. Most of the fish farming activities are operating in small scales and located along the channel from Sulaman Bay to the South China Sea. The study was conducted to evaluate the current physiochemical properties of the water such as temperature, salinity, pH, dissolved oxygen, as well as the water current in the cage area. In addition, this study was investigated the environmental changes through the cage area during the extreme weather condition and also the relation between the water properties and the surrounding environment of the cage culture. The sampling spot was located at Pusat Pengumpulan dan Pemasaran Ikan Hidup Persatuan Nelayan Kawasan Tuaran at Kampung Sekudung, Sulaman. Two samplings were conducted where the first sampling was on 20 – 21 March 2012, while the second sampling was on 10 -11 April 2012. Field measurement were carried out within 24 hours with 1 hour interval for three different depths; 0.5 m below the water surface, middle depth of the water and 0.5 above the water column. Daily data of water physiochemical (October 2010 – January 2011) was obtained from FELCRA. Data of rainfall was obtained from Meteorological Department while tide tables from IPMB Office also obtained to analyse their effect towards the water parameters. Water parameters measurement shows that the temperatures in different layers were almost similar and range from 28°C - 31°C. Water mixing was occurred at different layers of water. The mean of water pH was above 8.5 and affected by temperature and tidal changes. The concentration of dissolved oxygen at the bottom was high during night and morning. Daily water parameters measurement shows that the mean of the parameters was were fluctuated every month. The total mean of temperature was 32.39±0.86°C. Water salinity mean was 26.85±1.88 PSU, while for dissolved oxygen was 83.53±9.57%. Based on interview, the extreme weathers such as flood were rarely occurred but will bring destruction to the cages structures, disease to fish and rubbish into the cages area.

ABSTRAK

Teluk Sulaman merupakan salah sebauah kawasan akuakultur yang terletak di pantai barat Sabah yang menghadap ke arah Laut China Selatan. Kebanyakan aktiviti penternakan ikan sangkar yang dijalankan adalah berskala kecil dan terletak di sepanjang saliran dari Teluk Sulaman ke Laut China Selatan. Peningkatan populasi penduduk dan cara penggunaan tanah berhampiran kawasan penangkapan serta keadaan cuaca yang ekstrem menyebabkan peubahan kepada parameter air di teluk ini. Kajian dijalankan bagi menilai keadaan semasa fisiokimia air seperti suhu, kemasinan, pH, oksigen terlarut dan juga arus air. Kajian juga bertujuan untuk menyiasat peubahan persekitaran kawasan sangkar semasa cuaca ekstrem serta hubungan antara kualiti air dan persekitaran sekeliling pengkulturan ikan sangkar. Kajian dijalankan di Pusat Pengumpulan dan Pemasaran Ikan Hidup Persatuan Nelayan Kawasan Tuaran di Kampung Sekudung. Kajian dijalanakan sebanyak dua kali iaitu pada 20 -21 Mac 2012 dan 10 – 11 April 2012. Satu titik kajian dipilih di dalam kawasan sangkar bagi membuat pengukuran setiap selang satu jam dalam masa 24 jam pada tiga kedalaman yang berbeza; 0.5 dibawah permukaan air, tengah dan 0.5 diatas dasar air. Data harian fisiokimia air (OKtober 2010 – Januari 2011) diperolehi dari FELCRA. Data taburan hujan diperolehi dari Jabatan Meteorologikal manakala jadual pasang surut air pula dari Pejabat IPMB untuk menganalisa pengaruh terhadap parameter air. Penilaian parameter air menunjukkan suhu air pada kedalaman berbeza mempunyai julat suhu yang hampir sama iaitu 28°C - 31°C. Percampuran air berlaku pada setiap kedalaman. Purata pH air melebihi 8.5 dan dipengaruhi oleh suhu dan pasang surut air. Kepekatan oksigen terlarut di bahagian dasar adalah tinggi semasa malam dan siang. Penilaian parameter harian air menunjukkan purata bagi setiap parameter adalah beubah-ubah pada setiap bulan. Purata bagi suhu air adalah 32.39±0.86°C. Purata bagi keasinan air pula ialah 26.85±1.88 PSU manakala untuk oksigen terlarut ialah 83.53±9.57%. Berdasarkan temuduga, cuaca ekstrem seperti banjir jarang berlaku tetapi boleh mengakibatkan kerosakan pada structur sangkar, membawa penyakit kepada ikan dan juga sampah ke dalam kawasan sangkar.

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%	Percentage
±	Standard deviation
°C	Degree Celsius
°	Degree

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cm/s or cms^{-1}	Centimetre per second
mg/L or mgL^{-1}	Milligram per litre
m/s or ms^{-1}	Meter per second
PSU	Practical Salinity Unit
ppm	Part per million
m	Meter
mm	Milimeter
am	Ante meridiem
pm	Post meridiem

CHAPTER 1

INTRODUCTION

1.1 Introduction of Aquaculture

Due to the increasing population of human beings, aquaculture also known as aqua-farming is becoming an important source of fish supplement for human consumption. Stickney (2005) stated aquaculture is a rearing of organisms under controlled or semi-controlled conditions. It produces high-density of aquatic organisms in controlled environment. Three decades previously have witnessed impressive changes for fish in both domestic and international markets. Fish, shrimps, oyster and seaweed are the aquatic organisms that commonly cultured and have high demand on market. People need these as their protein sources. Hence, aquaculture activities contribute to be the solution for the shortage of protein sources from the aquatic. Aquaculture too can help the growing problem of overfishing that happen due to the increasing of population.

Sulaman Bay is one of the aquaculture sites in Sabah that located at the west coast of Sabah, facing to the South China Sea. There are four types of aquaculture practices which are cage culture of marine fish, mollusks culture, fish culture in ponds and integrated aquaculture. The farming activities at this area can be divided into three categories which are commercial farm, semi-commercial farms and small scale net cages (Rossita et al., 2011). Most of the farming activities are located at the channel from the Sulaman Bay to the South China Sea.

The study was conducted at the estuary of Sulaman Bay where the sampling spot was at Pusat Pengumpulan dan Pemasaran Ikan Hidup Persatuan Nelayan Kawasan Tuaran in Kampung Sekudung, Tuaran. This cages culture was donated by Lembaga Kemajuan Ikan Malaysia (LKIM). There are about 35 cages and currently the cage culture is not operating due to the need of maintenance and was expecting to start operate in April 2012.

Surface wind is the most important weather element at the sea. Weather generates the surface waves and currents in the surface layer of the water which cause turbulence mixing and affect the thermal structure. The turbulence and the water current can affect the fish, however, it is varies to the different species and with time and space. According to Barnabé (1994), currents play essential role in the turnover of water by bring in nutrients into the aquaculture farms.

Tides are periodic with short term changes in the height of the ocean surface at certain location due to the gravitational force between the moon and sun (Garrison, 2010). Tidal currents plays important role to supply sediment to estuary beaches and adjacent open-coast beaches. The shape of the basin was affecting the pattern and height of tides. Some coastlines might experience for semidiurnal tides while others with the diurnal tides.

Water quality is very significance to the environment in the cage culture (Andrew, 2000). A good water quality can avoid the aquaculture animals to be subjected to stressful environments. However, water quality is different for each species and need to be identified to know the best water quality that suitable for the animals that being cultured. A high quality of water resources is among the most needed for aquaculture. Hence, a specific location should be found for the species to perform best and in order to produce high quality of product to fulfil the consumer expect and demand.

The quality of water is always change and affected by both physicals and biological characteristics. The most important water quality parameters for aquaculture that monitored regularly are the dissolved oxygen, water temperature, pH levels, salinity, turbidity, light, ammonia, nitrites and nitrates. However, the study will only cover some of the physiochemical part of the water parameters which are the temperature, salinity, pH value, dissolved oxygen and also the water current.

1.2 Important of the Study

The studies are conducted in one cage area in Sulaman Bay, Tuaran. The aquaculture activities conducted adjacent to this study area can be categorized into three: commercial farm that owned by private companies, semi-commercial farms owned by government agencies and small-scale net cages operated by the locals (Rossita et al., 2011).

The water quality in this area was affected by daily human activities and weather condition and also the changes of tidal phases. Hence, it is very important to know the status of the water properties and determine the problem that might rise in the future related to the water quality. The result obtain from the study can be used as basic information for aquaculture activities in Sulaman Bay, Tuaran.

1.3 Objectives

1. To identify the changes of water current in aquaculture area during the high and low tide.
2. To determine the physiochemical parameters of the water such as temperature, salinity, pH, and dissolved oxygen in the cage culture area.
3. To relate the water properties with the surrounding environment of fish cage culture.

CHAPTER 2

LITERATURE REVIEW

2.1 Cage Culture

The earlier cages probably came from Southeast Asia during the end of 18^{th} century that constructed from woods or bamboos by fishermen to accumulate their fish for market. (Masser, 2008). It was widely used in The Great Lakes of Kampuchea (Cambodia) to hold their commercial valuable fish in bamboo cages to be sold alive (Pillay, 1990). The holding cages are likely more to the modified fish traps or baskets that have been used worldwide for generations. Floating bamboo cages was used since the early of 1920s in Mungdung Lake, Jambi, Indonesia (Reksalegora, 1979; Beveridge, 2004).

The Modern cage culture began in the 1950s with the involvement of synthetic materials for cage constructions (Parker, 2002). The location of cage might be critical for the proper circulation in the cage because the adequate of water circulation is important to ensure the fish health, bring oxygen into the cage and remove metabolic wastes from the cage.

There are four basic types of cage culture which are fixed, floating, submersible and submerged (Beveridge, 2004). Fixed cages are commonly used in tropical countries such as Philippines that consist of a net bag that supported by posts driven into the bottom of water. They are moderately inexpensive and simple to build but it was restricted to the sheltered shallow area with suitable substrates condition (Olivares, 2003).

Cage culture can be classified due to the feed inputs as extensive, semi-extensive and intensive (Beveridge, 2004). In extensive culture, according to Carballo et al., (2008), economic and labour inputs are usually low. Natural food productions are very important due to the low productivity systems. Fertilizer was used to increase fertility and fish production. Fish are relying on the available foods such as plankton, detritus and organisms that carried in the water flow (Beveridge, 2004).

Low protein which less than 10% feedstuffs, is used in the semi-external culture, where mostly came from the locally available plants or agriculture by-products to increase the intake of natural food (Beveridge, 2004). According to Calballo et al., (2008), fertilizer and supplementary feeding are used to increase the moderate level of inputs and fish production. There are higher fish yields but the labour and feed costs are also higher.

For intensive culture, high level of inputs and stocking are involved (Calballo et al., 2008). Fish are depends almost totally on the high protein that more than 20% food that externally supplied (Beveridge, 2004). Food supply is completely under human control, and few ecological factors influence the biomass of fish that can be supported by the pond, tank or cage (Midlen & Redding, 1998).

2.2 Status of Aquaculture

Since the end of World War II, the fish demand around the world as a food sources for human consumption and reduction to fishmeal has grown at a steady pace. 1960s was the year where aquaculture grew rapidly that the yields increased with an average of 6% per annum (Lawson, 1984; Beveridge, 2004).

Aquaculture is among the options to increase the global fisheries production in the 21st century. According to FAO (2010), excluding plants, global aquaculture production was increased from 32.4 million tonnes in 2000 to 52.4 million tonnes in 2008. Contribution of aquaculture in food fish consumption also increased from 33.8% to 45.7% during the period and was estimated to exceed 50% of global food fish consumption by 2012.

Based on Table 2.1, it shows that the aquaculture's production was increased steadily since 2004 to 2009. During 2009, 39% of the total world fisheries are came from aquaculture industry compared to 2004 with production of 31%.

Table 2.1 World production and utilization of fisheries and aquaculture (modified from FAO, 2010).

	2004	**2005**	**2006**	**2007**	**2008**	**2009**
			(Million tons)			
PRODUCTION						
INLAND						
Capture	8.6	9.4	9.8	10.0	10.2	10.1
Aquaculture	25.2	26.8	28.7	30.7	32.9	35.0
Total Inland	33.8	36.5	38.5	40.6	43.1	45.1
MARINE						
Capture	83.8	82.7	80.0	79.9	79.5	79.9
Aquaculture	16.7	17.5	18.6	19.2	19.7	20.1
Total Marine	100.5	100.1	98.6	99.2	99.2	100.0
TOTAL CAPTURE	92.4	92.1	89.7	89.9	89.7	90.9
TOTAL AQUACULTURE	41.9	44.3	47.4	49.9	52.5	55.1
TOTAL WORLD FISHERIES	134.3	136.4	137.1	139.8	142.3	145.1

UTILIZATION						
Human Consumption	104.4	107.3	110.7	112.7	115.1	117.8
Non-food Uses	29.8	29.1	26.3	27.1	27.2	27.3
Population (billions)	6.4	6.5	6.6	6.7	6.8	6.8
Per Capita Food Supply (kg)	16.2	16.5	16.9	16.9	17.1	17.2

2.3 Aquaculture in Malaysia

Culture of marine fishes in floating cages has rapidly developed since its introduction in 1970s (Ismail, 1995). Floating cages are the most common system used in Malaysia for farming of grouper, snapper and other marine finfish (Sih et al., 2004).

In Malaysia, fish was relatively cheap source of protein and readily available. However, according to Lokman (1992), Malaysia is still importing fish from outside the country especially from Thailand and Indonesia which worth between 30 to 40% of the total local needs while, most of the high quality of catches from Malaysian water were exported to Singapore due to the high prices.

Due to the impact of financial crisis in 1997, Malaysia formulated the Third National Agricultural Policy (NAP3) to maintain the agricultural food production. Aquaculture is allocated with RM82 million during the speech by the Malaysian Prime Minister, YAB Dato' Seri Mohd. Najib bin Tun Abdul Razak, to introduce the supply bill for Budget 2010 Malaysia. This shows that aquaculture play major role to increase national economic through this sector.

The main commodity produced from aquaculture food production are marine shrimp with 180 000 metric tons, marine fish with 122 000 metric tons, freshwater fish with 230 000 metric tons, cockle with 130 000 metric tons and seaweed with 125 000 metric tons (Fariduddin, 2008).

Malaysian aquaculture is basically consists of freshwater and brackish water production. Brackish water aquaculture give the major production with 136, 000 tonnes that valued at USD 236 million (FAO, 2005; Kusuadi, 2005). Marine finfish, black tiger shrimp and shelled mollusks are the main species cultured in the country.

2.3.1 Cage Culture in Sulaman Bay, Tuaran

According to Rossita et al. (2011), marine fish farming activities in Sulaman Bay area can be divided into three categories: commercial farms, which is owned by privates companies; semi-commercial farms, that is belong to government agencies; small-scale net cages, that operated by the locals. The net cages made up from wooden frame and attached to high density polyethylene (HDPE) drums to support the structures. Most of the culture systems are in small size (2.0 m X 2.0 m X 2.0 m) to (5.4 m X 5.4 m X 3.5 m), and there are about 16-150 units of cages per farm in the commercial farms and 2-6 units in small-scale farms.

Most of the stocking materials took from wild, local hatcheries in Sabah or Peninsular Malaysia such groupers and seabass, while the stocking materials are supplied from Indonesia, Philippines, China and Taiwan. Only Felcra Agro-Industry Sdn. Bhd. that has a hatchery with successful experience in producing tiger grouper and seabass seeds (Rossita et al., 2011).

2.4 Important of Water Quality

Water quality refers to the quality of water that enables successful propagation of the cultured organisms. Water quality for aquaculture are varies depends on the species being cultured. A good water quality of cages will generate more and healthier fish compared to poor cages. The nature of cage culture creates a need for special consideration to particular water quality (Andrew, 2000).

According to Beveridge (2004), there are three categories for site selection criteria that must be addressed: the physiochemical conditions which are the temperature, salinity, oxygen, currents, pollution, algal blooms and exchange; the factors that need to be considered for establishing the cage system that are the weather, shelter, depth and substrate; and the concern for the establishment of a farm and profitability which are legal aspects, access, land-based facilities, security, economic and social considerations.

Site selection for cage culture should not only free from contaminated toxic pollutants but also meet the temperature, salinity, pH and oxygen requirements for species that farmed (Beveridge, 2004). Table 2.2 summarized the specific standard of water quality for cage aquaculture.

Table 2.2 Water Quality Standard of Cage Aquaculture (Modified from Estim, 2010).

Water Parameters	**WQSA**
Temperature (°C)	27.0 – 31.0 (UNDP/FAO, 1989) 28.0 – 30.0 (Rosly, 1990)
Salinity (ppt)	15.0 – 30.0 (UNDP/FAO, 1989) 25.0 – 32.0 (Rosly, 1990)
pH	7.0 – 8.5 (UNDP/FAO, 1989) 7.5 – 8.5 (Rosly, 1990)
Dissolved Oxygen (mgL^{-1})	>3.0 (UNDP/FAO, 1989)

2.4.1 Water Current (cms^{-1})

Water current is the movements of large scale water through the ocean. It helps to bring nutrients and plankton to the cages. Surface water current is occurred due to the tidal currents. Tidal currents are associated with the rise and fall of the tide. Besides that, the pattern of tidal currents was greatly influenced by the local topography, runoff from the land and prevailing winds.

Cages are best placed in unpolluted waters with good water circulation but protected from strong waves and currents (Tucker, 1998). To decrease the chance for pollution, parasites and other pathogens from the bottom to affect the fish, the water should be at 4-5 m below the cages during the tide (Beveridge, 2004).

The appropriate water velocity is range from 10 - 20 cms^{-1}, which is enough to wash away the fish waste and unconsumed food without causing the fish to swim against the current. Current plays critical role in aquaculture to transfer in planktonic nutrients into the farms (Barnabé, 1994). Beveridge (2004) support that good water exchange throughout the cages is required for both replenishment of oxygen and the removal of waste metabolites.

Maximum current speeds was occur during the middle of the rise (flood) and fall (ebb), and minimum current speeds with slack water during the high and low tides respectively (Beveridge, 2004). Concentration of oxygen in the cage can drop to stressful level when the water exchange is minimal eventhough they are adequate outside the cage. During morning, oxygen level frequently can drop to below 2ppm (Andrew, 2000).

2.4.2 Temperature (°C)

Feeding, reproduction, immunity, and metabolism of aquatic animals are affected by temperature (Parker, 2002). Temperature changes can cause fatal to the aquatic animals if it change drastically. However, different species of fish required different optimum temperature range for growth. The most suitable water temperature for warmwater fish is range between 25 - 30°C. Generally, warmwater fish grow faster than coldwater fish.

According to Michael (2007), when the temperature is below the optimum, feed consumption and conversion will be declined until the temperature reached at which growth ceases and feed consumption is limited to a maintenance ration, while Tucker (1998) stated that the incubation time for eggs will be extended and increase the opportunity for disease to present.

Feed consumption will be increased and the feed conversion is declined when temperature is higher than the optimum (Michael, 2007), while the yolk in fish eggs depleted rapidly and the larvae will hatch prematurely (Tucker, 1998). Larvae will result to have deficient energy reserves and feeding ability.

The differences in temperature between surface and bottom of the water help to produce vertical movement of nutrients and oxygen throughout the water column (Parker, 2002). The solubility of oxygen and the percentage of unionized ammonia in the water also influence by temperature.

2.4.3 Salinity (PSU)

Marine water is saline, which the salinity was expressed in parts per thousands (S‰ or ppt), to represent the mass (g) of solid water that contained in sea water when iodide and bromide ions are replaced by the equivalent chloride, carbonates are converted to oxides and all organic matter oxidized (Barnabé, 1994).

Some species have wide salinity tolerance limits and it is known that some of freshwater fish can slightly grow faster in saline water and some of brackish water fish grow faster in freshwater (Pillay, 1990).

The variation of temperature in sea water was complicated by salinity. The salinity of the seawater is varies in the range of 32‰ to 42‰, and in the open waters are determined by evaporation and precipitation (Beveridge, 2004). The salinity of water surface is different from bottom salinity by several parts per thousand (ppt) and have a strong salinity gradient or halocline at the middle.

There are low salinity for areas with high rainfall, while high salinity for areas with high evaporation (Lawson, 1995). The salinity at estuary also influence by strong winds by opposing or adding to the flow of river or tides (Boyd & Tucker, 1998).

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