

Environmental Condition of Cockle Farm in Bandon Bay, Gulf of Thailand

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Abstract— Bandon Bay (Surat Thani Province) is one of the best coastal areas in southern Thailand and important as natural spawning, nursery and also fisheries such as blood cockles, green mussels, oyster and shrimps. The abundance of the area mainly comes from Tapi river. Minerals and nutrients from the rivers flow through the large estuary resulted the area is fertility and suitable for nursery of cockles. The study was occurred in rainy season (August 2013) and summer (March 2014) in cockle culture area. It was found that the characteristics of sediment in east coast (loamy soil) were quite different from the west coast (sandy soil). Water temperature in both seasons was in the range of 25.1-32.1°C, dissolved oxygen 5.56-12.07 mg/l, transparency 0.1-1.7 m and the depth was not more than 3.0 m. Water salinity was 18.1-24.4 ppt in rainy season and 10.6-28 ppt in summer. Water nutrients in summer were quite high comparing to rainy season. Phytoplankton density in rainy season was much more than in summer by group, but the high diversity distribution of plankton found in summer which was mainly diatom, dinoflagellate, green algae, blue-green algae and others. Dominant species in rainy season and summer were *Surirella* spp. (20.34%) and *Rhizosolenia pungens* (32.62%) respectively.

Keywords— cockle farm, water quality, Bandon Bay

I. INTRODUCTION

COCKLE production from marine aquaculture sites generates considerable amounts of influence including nutrients and environments. Organic matters input to the sediment, whether from natural or artificial sources, lead to a series of changes in chemical and physical parameters [1] which in turn have both direct and indirect effects on the faunal communities in the area [2]. Tapi is the main river that flows through the districts in Surat Thani before flows into the Gulf of Thailand via Bandon Bay [3]. The environmental condition of cockle farm in Bandon Bay has an abundance of the area mainly from Tapi river. Since the flow of nutrients in the water and sediment, these nutrients are distributed in solution form and fallen to the ground as well as sediment accumulation followed by the physical, chemical and biological processes.

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For the previous reasons, Bandon bay is the power source which is important primary production for aquatic animals and transfer to the food chain [4]. However, at the present it was found that the area around of Bandon bay degraded because wastewater discharged to the farming area caused by drainage from industrial factories, pesticides, chemicals used in shrimp farms, including environmental pollution in the coastal urban area. Thus, enrichment of nutrients could change the physical and chemical characteristics of sediment. In addition environmental factors are such as light, temperature, salinity and nutrients had impact on differences in species composition and plankton distribution [5]. Furthermore, the amount of nitrate, nitrite, ammonia and phosphate contents have influence to the primary producers of the food chain [5] that can affected to the growth and survival rate of the cockles. Therefore, the study of characteristics of sediment, water quality, water nutrients and phytoplankton density in aquaculture area mainly cockle farm aimed to know the environmental condition and quality of the sediment. Which are contributed to explain the relationship of cockle production occurred and characters of the environment area in rainy season and summer in the western and eastern side of Bandon Bay and the condition of the place could distribute the primary information of cockle aquaculture.

II. MATERIALS AND METHOD

A. Sampling sites and sample analysis

The study was located in coastal aquaculture area in Bandon Bay, Surat Thani Province, Thailand, during rainy season (August 2013) and summer (March 2014). Specified sampling stations using a Global Positioning System (GPS) was divided into 12 stations, along the east coast (station 1, 2 and 3), the mouth of Tapi river (station 4, 5 and 6), and the west coast (station 7, 8 and 9) of the bay (Figure 1). Physical parameters of water such as salinity, dissolved oxygen, temperature, transparency and conductivity were measured using multivariate devices (YSI Model Pro 2030). Water samples at the surface layer were collected and nutrients in the water were analyzed for nitrite, nitrate, ammonia, orthophosphate and silicate according to [6]. To investigate the distribution and type of plankton in the bay, plankton net pore size 20 μ m was dragged in the vertical direction and phytoplankton collected was preserved with 2% formaldehyde, pH 7 before classification under the microscope. Cell density, species type and distribution with 3 replications for each station were

calculated. All data were examined and analyzed by comparing average in each area and seasons by Analysis of Variance (ANOVA) at 95% confidence level.



Fig. 1 Location of study sites in aquaculture area at Bandon Bay, Surat, Thani Province, Thailand

III. RESULT AND DISCUSSION

A. Environmental condition of Bandon Bay

Coastal areas in Bandon Bay was almost all cultured of cockles, clams, oysters and mussels. Characteristics of sediment in the east coast were shown as loamy soil different from the west coast which consisted of sandy soil and loam mixed with mud belonged to the estuary of Tapi river. The difference composition of the sediment was involved in the proportion of sediment particle size, nutrients and organic waste resulted to the production of shellfish that cultured or buried in sediment.

Physical water quality in the cockle farming on the east coast, west coast and the estuary of the Tapi river were recorded as Table I. The geographical location of U-shaped bay and the effect of two monsoons result the heavy rain all year round (8 months a year) in the area. During rainy season, the salinity of water in the west coast (18.4-24.4 ppt) was higher than in the east (18.1-21.1ppt), whereas, the east coast salinity (27.1-28 ppt) showed the high amount than the west side (10.6-18.4 ppt) in summer. Water salinity around the mouth of Tapi river was quite low (less than 13 ppt) due to the flow from the rivers into the Bay. The average depth of water in cockle field was 2 and 3 meters in rainy season and summer, respectively. Dissolved oxygen of the water in the west side (6.05-12.07 and 6.25-7.30 mg/l) of the bay was higher than the east coast (5.90-6.50 and 6.29-9.54 mg/l) and estuaries (5.56-5.95 and 5.74-8.62 mg/l) both in rainy season and summer. However, the transparency of the water in the cockle farming did not exceed 2 meters.

TABLE I
PHYSICAL PROPERTIES OF WATER IN BOTH SEASON IN COCKLE FARM AT BANDON BAY

Season	Site	Temp. (°C)	Salinity (ppt)	Depth (m)	Dissolved Oxygen (mg/l)	Transparency (m)
Rainy	East	29.4-29.9	18.1-21.1	1.2-1.9	5.90-6.50	0.4-1.3
	West	29.7-32.1	4.5-12.3	0.5-1.6	5.56-5.95	0.5-0.95
Summer	East	28.4-29.5	18.4-24.4	0.4-0.9	6.05-12.07	0.1-0.5
	West	28.7-28.8	27.1-28	0.9-2.3	6.29-9.54	0.4-0.5
Summer	East	27.2-27.5	4.2-9.0	0.7-2.7	5.74-8.62	0.4-0.6
	West	25.1-27.2	10.6-18.4	0.9-2.8	6.25-7.30	0.3-1.7

Comparison physical properties of water layers (surface, middle and bottom) in seasons were done. In rainy season, temperature was in the range of 29.55-29.63°C, salinity 18.01-21.38 ppt and dissolved oxygen 6.11-7.90 mg/l, while in summer, water temperature was in the range of 28.89-29.03 °C, salinity 15.93-19.08 ppt and dissolved oxygen 5.81-6.38 mg/l, respectively (Fig. 2). The data showed that there was no different of water temperature, dissolved oxygen in each depth. The salinity in each depth was quite similar in the same season, but comparison between seasons found that the salinity in rainy season was slightly higher than summer. It was possible that at the time of collecting samples (rainy season), there was relatively little rainfall, comparing to summer that has supported high quantities of drain from communities. This led to change in salinity. Some studies reported the physical character in Bandon Bay. [7] studied the spatial variation and nutrients in the estuary of Tapi river in March and September 2011 and found salinity in the bay with an average of 20.93 ppt, the estuary 5.66 ppt, the community 0.1 ppt (average in March was 12.6 ppt and 12.14 ppt in September). Temperature was in the range of 28.15-29.43oC (the average value of 29.43 °C in March and 28.03 °C in September). Dissolved oxygen was occurred during 4.26-6.53 mg/l. The value of 4.14-7.84 mg/l showed in March and 3.33-7.33 mg/l in September.

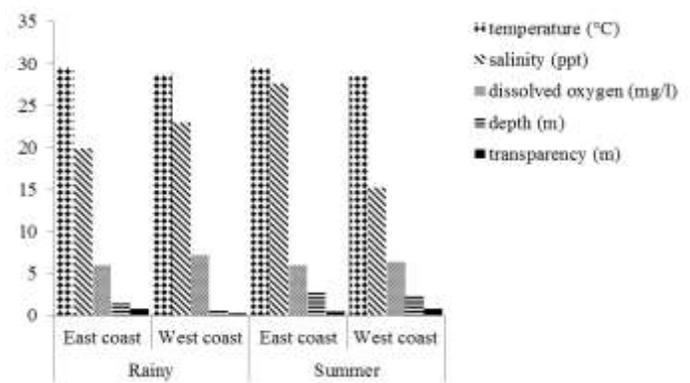


Fig. 2 The average of physical data of coastal area in rainy season (August 2013) and summer (March 2014) in cockle culture area, Bandon Bay

[8] reported that the amount of oxygen dissolved in water and nutrient contents of the estuary of Tapi river was higher than the standard. This may be due to a direct effect of discharge and flow of water from the river to the Bay, while the area of the west side was adjacent to the mangrove forest [9]. In addition, tide and the direction of the flow is the important key to the changes that occur as well.

B. Water nutrients

Water quality analysis of 5 parameters including ammonia, nitrite, nitrate, phosphate and silicate of the samples collected from the east and west coast and Tapi estuary of Bandon Bay were done. The results indicated that all nutrient concentrations in water were shown in the benchmark.

In rainy season, the concentrations of ammonia, nitrite, nitrate, phosphate and silicate were shown in the range of 0.04-0.11, 0.001-0.007, 0.0001-0.0016, 0.0004-0.0027 and 0.005-0.011 mg per liter, respectively. The total suspended solid contents of the three sides were played in the range of 1.29-3.38 mg per liter. Ammonia contents in the west coast and the mouth of the Tapi river were presented higher than in the east (Table II), especially at the stations 9, 10 and 11. Nitrate concentration distinctively expressed at station 9, while nitrite and phosphate content were not significantly different among the three sides.

In summer, the concentration of ammonia, nitrite, nitrate, phosphate and silicate were shown in the range of 0.08-0.21, 0.004-0.020, 0.0001-0.005, 0.0004-0.0027 and 0.001-0.025 mg per liter, respectively. The total suspended solid contents of the three sides were shown in the range of 0.57-1.16 mg per liter. Ammonia contents in the west coast and the mouth of the Tapi river were also higher than in the east, especially at the station 11. Nitrate, nitrite and phosphate content were not significantly different among the three sides.

[7] studied the nutrients in the estuary of Tapi river in March and September 2011 and reported that the average of nitrite, nitrate, ammonia and phosphate were 0.21 ± 0.13 , 2.70 ± 1.88 , 5.65 ± 3.30 micrograms nitrogen atoms/L and 0.20 ± 0.02 micrograms phosphorus atoms/L in March, respectively. And 0.22 ± 0.10 , 2.59 ± 1.30 , 4.38 ± 2.68 micrograms nitrogen atoms/L and 0.27 ± 0.12 mg phosphorus atoms/L in September.

TABLE II
WATER QUALITY IN RAINY SEASON AND SUMMER AT THE EAST AND THE WEST COAST OF BANDON BAY

Season	Site	NH ₃ -N	NO ₂ ⁻ -N	NO ₃ ⁻ -N	PO ₄ ³⁻ -P
Rainy	East	0.0692±0.006	0.0050±0.0000	0.2332±0.000	0.0322±0.0026
	Tapi	0.1155±0.007	0.0055±0.0000	0.7332±0.002	0.0213±0.0036
	West	0.1102±0.005	0.0076±0.0000	0.170±0.001	0.0271±0.0050
Summer	East	0.1269±0.007	0.0062±0.0030	0.0573±0.025	0.0074±0.0007
	Tapi	0.1690±0.040	0.0083±0.0010	0.0364±0.002	0.0072±0.0003
	West	0.2112±0.024	0.0146±0.0010	0.0506±0.011	0.0079±0.0013

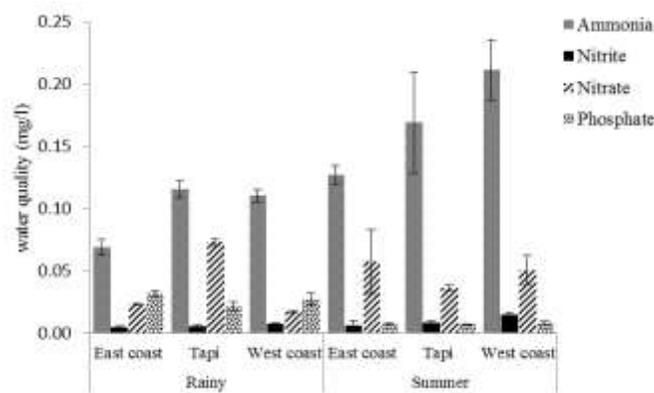


Fig. 3 Water quality in rainy season (August 2013) and summer (March 2014) in cockle culture area, Bandon Bay

Our results corresponded to [10] stated that in summer, the decomposition of organic matter will occur higher than in rainy season, hence the slowly flowed of water. So, it was affected the sedimentation of organic matter. Most organic matter would settle down and embed in the sediment and microbial degradation started resulting to the express of differences between seasons and the amount of suspension had changed by the depth, season and the river flow in the Bay which was important to the exchange process of the nutrients and distribution of organic matter.

C. Density of phytoplankton

Phytoplankton density in rainy season was expressed much more than in summer by group, but the high diversity distribution of plankton found in summer, mainly diatom, dinoflagellates, green algae, blue-green algae and others. Dominant species in rainy season and summer were *Surirella* spp. (20.34%) and *Rhizosolenia punger* (32.62%) respectively. Because in the rainy season, sediment and nutrients from community and agricultural areas was drained into many rivers before flowed into the Bay. The mixing of marine and freshwater resulted in physical and biological changes in a wide range. Estuary was the big source accumulated the nutrients drainage from the coast, thus this area become abundant [2]. Growth of phytoplankton is dependent on several factors such as light, temperature, salinity and nutrients, etc. These factors cause the differences in species composition and the distribution of phytoplankton [3].

Dominant species found in rainy season were *Coscinodiscus* spp., *Surirella* spp., *Pleurosigma* spp., *Nitzschia* spp., *Thalassionema nitzschioides* and *Cyclotella* spp., while the dominant species in summer were *Pleurosigma* spp, *Nitzschia* spp, *Cyclotella* spp, *Coscinodiscus* spp, *Navicula* sp. and *Pseudosolenia calcaravis*, respectively. Our results were compared to [11] who studied the distribution and abundance of phytoplankton in the coastal areas in Surat Thani Province during January and December 1998 and found 64 genera of phytoplankton. The high amount group (total 82.44%) consisted of *Nitzschia* spp., *Pleurosigma* spp., *Chaetoceros* spp. and *Coscinodiscus* spp. In addition, [12] examined water quality and

phytoplankton in Bandon Bay and found 46 genera in 5 divisions of phytoplankton, including *Trichodesmium* (67.40%) *Nitzschia* (15.09%) *Chaetoceros* (5.88%) *Oscillatoria* (5.58%) *Coccosinodiscus* (1.53%) *Pleurosigma* (1.53%) and *Pleurosigma* (1.39%), respectively.

Comparing to the dominant species in the east and west coast during rainy season and summer, it was found that there were different in the species distribution. In the east coast *Protoperidinium* sp., *Ceratium furca*, *Peridinium* spp., *Trachyneis* sp. were dominant in rainy season, while *Noctiluca* sp., *Bacillaria* sp., *Lauderia annulata* and *Ceratium furca* were the major in summer. In the west coast, the main species in rainy season were *Cocconeis* sp., *Navicula* sp., *Thalassionema frauenfeldii* and *Diploneis* sp., while *Rhizosolenia pungeri*, *Ditylum brightwellii*, *Surirella* spp. and *Rhizosolenia formosa* were dominant in summer (Table III).

TABLE III
DOMINANT SPECIES IN THE EAST AND WEST COAST OF BANDON BAY
DURING RAINY SEASON AND SUMMER

Area	Season	
	rainy (August 2013)	summer (March 2014)
East coast	<i>Protoperidinium</i> sp.	<i>Noctiluca</i> sp.
	<i>Ceratium furca</i>	<i>Bacillaria</i> sp.
	<i>Peridinium</i> spp.	<i>Lauderia annulata</i>
	<i>Trachyneis</i> sp.	<i>Ceratium furca</i>
	<i>Cocconeis</i> sp.	<i>Rhizosolenia pungeri</i>
West coast	<i>Navicula</i> sp.	<i>Ditylum brightwellii</i>
	<i>Thalassionema frauenfeldii</i>	<i>Surirella</i> spp.
	<i>Diploneis</i> sp.	<i>Rhizosolenia formosa</i>

It was concluded that physical properties of water in each depth (surface, middle and bottom level) was occurred in the same ways, while the east coast (the communities and estuaries) and the west coast (mangrove area) showed the difference due to the nature of area utilization and the impact of human activities as well. Water quality and the distribution of phytoplankton showed the differences all the year cause of seasonal influences the amount of nutrients, tides and density of plankton.

There were some reports examination water quality and species composition of phytoplankton in Bandon Bay. [8] found 3 divisions of phytoplankton in Bandon Bay; Cyanophyta (Class Cyanophyceae), Chlorophyta (Chlorophyceae and Euglenophyceae), Chromophyta (Bacillariophyceae, Dinophyceae and Dictyochophyceae). [13] studied a variety of types and amounts mainly diatom in the Tung-Kha, Chumphon Province in March, April and May, 2009, and found 26 genera divided into division Chromophyta. The dominant species were different in each month. *Chaetoceros* spp. was mainly found in March and April, but *Rhizosolenia* sp. was shown in May. Types and quantities of plankton in mussel culture, Chumphon Province was shown as 46 genera in three divisions, Cyanophyta (4 genera), Chlorophyta (6 genera) and Chromophyta 36 genera [14].

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