WASTEWATER CHARGE FOR MARINE SHRIMP FARMING: A CASE STUDY OF KUNG KRABAEN BAY ROYAL DEVELOPMENT STUDY CENTER PROJECT, KLONGKHUD SUB-DISTRICT, THAMAI DISTRICT, CHANTHABURI PROVINCE

SUDALAK BUALA

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(TECHNOLOGY OF ENVIRONMENTAL MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2010

Thesis
entitled

WASTEWATER CHARGE FOR MARINE SHRIMP FARMING: A CASE STUDY OF KUNG KRABAEN BAY ROYAL DEVELOPMENT STUDY CENTER PROJECT, KLONGKHUD SUB-DISTRICT, THAMAI DISTRICT, CHANTHABURI PROVINCE

……..……..……
Miss Sudalak Buala
Candidate

……..……..……
Asst. Prof. Patompong Saguanwong, M.B.A.
Major advisor

……..……..……
Assoc. Prof. Suvaluck Satumanatpan, Ph.D.
Co-advisor

……..……..……
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

……..……..……
Asst. Prof. Benjaphorn Prapagdee, Ph.D.
Program Director
Master of Science Program in
Technology of Environmental Management
Faculty of Environment and Resource Studies
Mahidol University

Thesis
entitled

WASTEWATER CHARGE FOR MARINE SHRIMP FARMING: A CASE STUDY OF KUNG KRABAEN BAY ROYAL DEVELOPMENT STUDY CENTER PROJECT, KLONGKHUD SUB-DISTRICT, THAMAI DISTRICT, CHANTHABURI PROVINCE

was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
(Technology of Environmental Management)
on
May 2, 2010

……
Miss Sudalak Buala
Candidate

……
Assoc. Prof. Kungwan Juntarashote, Ph.D.
Chair

……
Assoc. Prof. Suvaluck Satumanatpan, Ph.D.
Member

……
Asst. Prof. Patompong Saguanwong, M.B.A.
Member

……
Prof. Banchong Mahaisavariya,
M.D., Dip Thai Board of Orthopedics
Dean
Faculty of Graduate Studies
Mahidol University

……
Asst. Prof. Sittipong Dilokwanich, Ph.D.
Dean
Faculty of Environment and Resource Studies
Mahidol University

ACKNOWLEDGEMENTS

This research has been accomplished with the help and support from many of the people around me. As a researcher, I would like to express my gratitude to Asst. Prof. Patompong Saguanwong for his guidance, help and motivation to complete my research. Thank you to Assoc. Prof. Suvaluck Satumanatpan and Assoc. Prof. Kungwan Juntarashote for much helps with the research design, research methodology and many helpful comments.

I would like to thank all staff at Kung Krabaen Bay Royal Development Study Center Project, Klongkhud Sub-District, Thamai District, Chanthaburi Province for sharing his data and support to detailed suggestions.

I would like to thank uncle Pong and family that made it possible for her full stay with much joy and happy moments. Thank you to all of my friends for helping me collect data in the field.

I would like to thank the thesis grant from Technology of Environmental Management program (non-regular program), Faculty of Environment and Resource Studies, Mahidol University.

Finally, this thesis would not have been possible without the confidence, endurance and support of my family. My family has always been a source of inspiration and encouragement. I wish to thank my parents, whose affection, understanding and patience, teachings and support have brought me this far.

Sudalak Buala

WASTEWATER CHARGE FOR MARINE SHRIMP FARMING : A CASE STUDY OF KUNG KRABAEN BAY ROYAL DEVELOPMENT STUDY CENTER PROJECT, KLONGKHUD SUB-DISTRICT, THAMAI DISTRICT, CHANTHABURI PROVINCE

SUDALAK BUALA 5036341 ENTM/M

M.Sc. (TECHNOLOGY OF ENVIRONMENTAL MANAGEMENT)

THESIS ADVISORY COMMITTEE : PATOMPONG SAGUANWONG, M.B.A.(ECONOMICS) , SUVALUCK SATUMANATPAN, Ph.D. (ECOLOGY OF COASTAL MARINE SCIENCE)

ABSTRACT

The area of Kung Krabaen Bay Royal Development Study Center Project, Klongkhud Sub- District, Thamai District, Chantaburi Province, contains a great number of coastal marine farms. This research was conducted with the objectives to study operating and maintainence costs for the wastewater collection and treatment system, the willingness of shrimp farmers to pay for wastewater treatment charges, the appropriate rate for wastewater treatment charges, and measures and mechanisms for implementing the wastewater treatment charge system efficiently.

Employing both quantitative and qualitative approaches, this research studied rates of wastewater treatment charge by conducting interviews and using questionnaires with officers of the Center and marine shrimp farmers in the area of responsibility for the center of 200 samples in all. The study found that the cost for operating and maintaining the wastewater collection and treatment system of the saltwater irrigation system in fiscal year 2008 was 2,672,479 baht. Therefore, in order to have farmers pay for wastewater treatment charge according to the Polluters Pay Principle at an amount for which the project can be sustained, farmers should be charged fees of 609 baht/person/cycle, a water charge of 692 baht/rai/cycle, and a wastewater treatment charge of 131 baht/rai/cycle. A study of farmers' willingness to pay found that they were willing to pay at a rate between 500-1,200 baht/rai/cycle. Thus it is possible to charge for wastewater treatment at the calculated rate.

KEY WORDS: WASTEWATER CHARGE / MARINE SHRIMP FARMING

123 Pages

การศึกษาอัตราค่าบำบัดน้ำทิ้งจากการเพาะเลี้ยงกุ้งทะเล กรณีศึกษาโครงการศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบน อันเนื่องมาจากพระราชดำริ ตำบลคลองขุด อำเภอท่าใหม่ จังหวัดจันทบุรี

WASTEWATER CHARGE FOR MARINE SHRIMP FARMING : A CASE STUDY OF KUNG KRABAEN BAY ROYAL DEVELOPMENT STUDY CENTER PROJECT, KLONGKHUD SUB-DISTRICT, THAMAI DISTRICT, CHANTHABURI PROVINCE

สุดาลักษณ์ บัวล่า 5036341 ENTM/M

วท.ม. (เทคโนโลยีการบริหารสิ่งแวดล้อม)

คณะกรรมการที่ปรึกษาวิทยานิพนธ์ : ปฐมพงศ์ สงวนวงศ์ M.B.A. (Economics), สุวลักษณ์ สาธุมนัสพันธุ์ Ph.D. (Ecology of Coastal Marine Science)

บทคัดย่อ

ศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบน อันเนื่องมาจากพระราชดำริ ตำบลคลองขุด อำเภอท่าใหม่ จังหวัดจันทบุรี เป็นพื้นที่ที่มีการเพาะเลี้ยงสัตว์น้ำชายฝั่งเป็นจำนวนมาก งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาศึกษาต้นทุนที่ใช้ในการดำเนินการ และบำรุงรักษาระบบรวบรวมและบำบัดน้ำเสีย ศึกษาความเต็มใจที่จะจ่าย กำหนดอัตราค่าบริการบำบัดน้ำเสีย ที่เหมาะสมสำหรับกิจกรรมการเพาะเลี้ยงกุ้งทะเล และหาแนวทาง มาตรการและกลไกต่างๆ ในการสร้างแรงจูงใจให้สามารถนำค่าบริการบำบัดน้ำเสียมาประยุกต์ใช้ได้อย่างมีประสิทธิภาพ

การวิจัยเชิง ปริมาณและเชิงคุณภาพ ในครั้งนี้เป็นการศึกษา อัตราค่าบริการบำบัดน้ำเสีย โดยใช้แบบ สัมภาษณ์ แบบสอบถามจากเจ้าหน้าที่ และกลุ่มเกษตรกรเพาะเลี้ยงกุ้งทะเล ในโครงการศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบน ตำบลคลองขุด อำเภอท่าใหม่ จังหวัดจันทบุรี จำนวน 200 ราย พบว่า ระบบชลประทานน้ำเค็ม มีต้นทุนในการ ดำเนินการ และบำรุงรักษาระบบรวบรวมและบำบัดน้ำเสีย ในปีงบประมาณ 2551 จำนวน 2,672,479 บาท เพื่อให้เกษตรกร ในโครงการเข้ามามีส่วนร่วมในการรับผิดชอบตามหลักการผู้ก่อมลพิษเป็นผู้จ่ายในขณะที่ โครงการฯ เลี้ยงตัวได้ โครงการฯ จะต้องจัดเก็บค่าธรรมเนียม 609 บาทต่อรายต่อรอบ ค่าน้ำ 692 บาทต่อไร่ต่อรอบ และค่าบำบัดน้ำ เสีย 131 บาทต่อไร่ต่อรอบ และจากการศึกษาความเต็มใจที่จะจ่าย ค่าบริการบำบัดน้ำเสีย พบว่า เกษตรกรมีความยินดีที่จะจ่าย ในอัตรา 500- 1,200 บาท ต่อ ไร่ ต่อ รอบ ดังนั้น นับว่ามีความเป็นไปได้ที่จะดำเนินการจัดเก็บค่าบริการบำบัดน้ำเสียตามอัตราดังกล่าว

123 หน้า

CHAPTER I
INTRODUCTION

1.1 Background

The upper part of the east coast along the Gulf of Thailand is considered to be an important source of environmental and economical natural resources of Thailand. As a result of rapid economical and social growth, land use of the coastal area has changed accordingly. Examples of such growth include expansion of industries, urbanization of cities, and area development for tourism and fisheries. Coastal marine culturing has also been developed to give more commercial yield. Therefore Thailand has become the world's number one exporter of shrimp for many years. The upper part of the Gulf of Thailand and the east coast of Thailand have been extensively utilized for coastal marine culturing, Shrimp farm promotion and development in the east coast of Thailand by Kung Krabaen Bay Royal Development Study Center Project who created seawater irrigation system for shrimp farming as a response to suggestion from His Majesty the King to study and develop land utilization of the east coast of Thailand. According to this project, Kung Krabaen Bay Royal Development Study Center has been permissed to use the deteriorated area around Kung Krabaen Bay for about 1,650 rai, which has been divided into three main zones: 1) 728 rai of the area is divided into 104 plots for shrimp farming by 113 families of farmers; 2) 610 rai is for mangrove forest conservation; and 3) 312 rai for demonstration ponds, rehabilitation of mangrove forest, and facilities. With a great number of shrimp farms, Kung Krabaen Bay is considered an important source of coastal marine animal culturing of Thailand (Kung Krabaen Bay Royal Development Study Center Project, 2008).

According to studying shrimp farming in the area of Kung Krabaen Bay Development Study Center, it was found that the culturing requires disposal of wastewater, flushing mud to expel sediments, using lime to adjust acidity and basicity of water, and medicine to prevent diseases. These waste materials are increasingly discharged to Kung Krabaen Bay, causing degradation of water quality

by having low level of dissolved oxygen, high BOD (Biochemical Oxygen Demand), and high concentration of accumulated nutrients from disposed water such as nitrogen, phosphorus, etc. Due to the enclosing characteristic of Kung Krabaen Bay, waste materials are unlikely to flow out to the ocean, and that can lead to eutrophication within the gulf, especially during low tide period. The polluted water can cause trouble to shrimp farming in Kung Krabaen Bay as clean water may become scarce. Despite coming from the irrigation system, waste water from shrimp farms may still be polluted since some farmers do not separate inflow and outflow gates. The accumulation of waste from artificial food pellets and excrements of the shrimps may cause some other problems in the gulf such as deterioration of the area, expansion of poisonous plankton which is harmful to shrimps, and so on. In addition, ecosystem of Kung Krabaen Bay may be changed as resulted from wastes disposed into the water, particularly from accumulation of organic sediments (Pollution Control Department, 2004).

Development of shrimp farms is an important activity that affect natural ecosystem directly because waste materials from food, chemical, medicine, vitamin supplements, etc are disposed directly into the surrounding environment. Therefore, marine shrimp farming is an important source of pollution that requires control or restriction on waste treatment. Without proper pollution management, the environment's quality will be deteriorated and lead to reduction of biodiversity. Hence, the governmental sector provides budget for construction of the overall wastewater collection and treatment system of Kung Krabaen Bay Development Study Center. The operation and maintenance of the system require some expense in order to administer and manage the system efficiently and sustainably.

The Environmental Quality Management Plan for the year 2007-2011 was composed and issued in order to be used by all sectors as a guideline for management of natural resources and environment for efficient and coordinated environmental management in the coming 5 years. It is also aimed to be in compliance with the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) and the 10th National Economic and Social Development Plan (2007-2011), which emphasizes on creating sustainable happy social based on balance of 3 dimensions of development namely socioeconomic, natural resources and environment, and participation of people. An important part of the Plan states about PPP (Polluters

Pay Principle), requires polluters (farmers) to pay for pollution disposal and treatment. This economical strategy is a new alternative plan for protecting the environment from fundamental cause, and inducing behavioral changes of all sectors to take part in environmental conservation by reducing activities that cause pollution to be within the capacity of the environment (Office of Natural Resources and Environment Policy and Planning, 2006).

From that principle, the researcher is interested in studying charging rates of treatment of drainwater from shrimp farms by using a wastewater treatment charge system that can inspire farmers to reduce the amount of drainwater. It is also expected that the wastewater treatment charge system can control water pollution caused by marine shrimp farming and help to save government's budget in maintaining the wastewater treatment system. The study also aims to provide some ideas for the government in developing wastewater treatment charge system and setting up laws, regulations, criteria, and specifications concerning marine shrimp farming activities that could help in management to reduce water pollution caused by marine animal culturing. The findings and results from this study should be applicable to drainwater management of other similar water pollution sources, and lead to long-term and systematic management of wastewater from marine animal farming in the whole country.

1.2 Objectives

1.2.1 To study the costs needed for operating and maintaining the wastewater collection and treatment system that treats drainwater from marine shrimp farming activities.

1.2.2 To study willingness of shrimp farmers to pay for wastewater treatment charge.

1.2.3 To determine appropriate charging rates for the wastewater treatment charge system of wastewater treatment for shrimp farming.

1.2.4. To study for solutions and strategies to create motivation or inspiration in farmers that help enable implementation and application of the wastewater treatment charge system to efficiently manage and control water pollution caused by activities of shrimp farming.

1.3 Scope of Study

This research will study costs for operating and maintaining the wastewater collection and treatment system in order to calculate for rates of wastewater treatment charge. In addition, the research also studied willingness to pay of farmers so that we can determine the appropriate rates of wastewater treatment charge required for shrimp farming activities. Finally, the research tried to derive solutions and strategies that can inspire or motivate farmers to participate in the implementation of the wastewater treatment charge system. Population and samples for this research were farmers who grow shrimps in the responsible area of Kung Krabaen Bay Development Study Center, Tambol Khlong Khud, Thamai District, Chantaburi Province, totalling 200 farmers.

1.4 Conceptual framework

This research employed the conceptual framework of wastewater treatment charge systems to study charging rates for efficient management in controlling drainage of wastewater from shrimp farming activities. The framework can be diagrammed as the following.

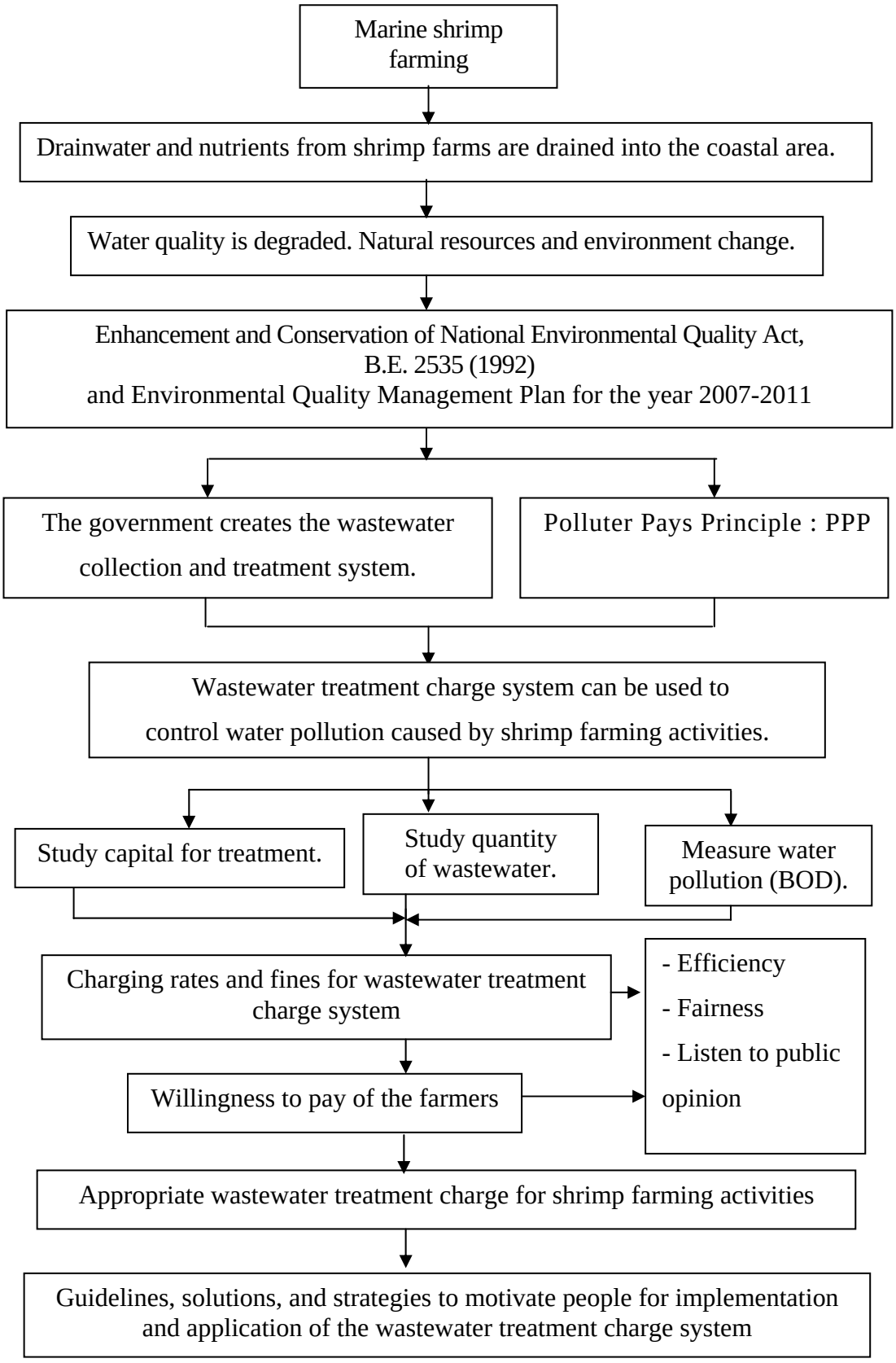

Figure 1-1 Conceptual Framework

According to the afore-mentioned framework for studying about charging rates for treatment of wastewater from marine shrimp farming activities by using wastewater treatment charge system, the research realizes that marine shrimp farming can cause wastes in the form of drainwater and nutrients used in the shrimp ponds which are drained to the coastal area. These activities of shrimp farms can cause deterioration of water quality, and result in changing of natural resources and environment. Without proper management wastewater disposal management, organisms may have difficulties in their living due to imbalance of the ecosystem. The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) and the Environmental Quality Management Plan for the year 2007-2011 are major laws used to protect natural resources and environment of the country, and are used as guidelines for environmental management by defining policies to control and manage all forms of wastes. Regarding wastewater management, the Act and the Plan require the government to create, operate, and maintain the system to collect and treat wastewater. In addition, the important principle in the laws is to require polluters to send their wastewater for treatment and pay for the treatment fee by following the Polluter Pays Principle: PPP. Therefore, the research decided to use the wastewater treatment charge system as an economical tool for administrating and managing wastewater according to the PPP. The research studied cost of treatment, amount of drainwater, dirtiness of wastewater (BOD), and other data concerning shrimp farming activities to bring all the data for determining charging rates and fines in the wastewater treatment charge system. Additionally, in order to specify appropriate and fair charge rates by considering opinions of the people, the research studied willingness to pay of farmers for their agreement and acceptance of the wastewater treatment charge system for shrimp farming activities. Finally, solutions, policies, and strategies that motivated marine shrimp farmers were studied to implement the wastewater treatment charge system with efficient water pollution management.

1.5 Expected Results

1. To know about costs for operating and maintaining the wastewater collection and treatment system that treats wastewater from shrimp farming activities.
2. To know about willingness to pay for wastewater treatment charge of farmers.
3. To know the most appropriate charging rates and fines for the wastewater treatment charge system that can be used with shrimp farming activities.
4. The government can implement the wastewater treatment charge system from this study for environmental management concerning shrimp farming activities.

1.6 Definitions of terms

Economical tool means important mechanism which reflects environmental costs and can lead to behavioral changes of producers and consumers in their production and consumption according to the "Polluter Pays Principle" or PPP.

Willingness to pay means the willingness of consumers to pay with their money or their property in order to exchange with goods or services from others that can serve their desire (Narong, 2002).

Coastal marine animal culturing pond means an area which is made to be capable of storing water in order to grow up seawater animals or brackish-water animals in area outside the saltwater prevention zone of the Royal Irrigation Department or within the inner coastal zone of the Land Development Department (Pollution Control Department, 2003b)

Water animals mean water animals according to the laws about fisheries (Pollution Control Department, 2003a).

Wastewater means water that has been altered from its original natural property, water that has been used and drained, water that has been used from household, from industries, etc. Wastewater may have different colors, odors, and tastes from its natural properties, which are results of human activities. Wastewater can affect health and utilization of human beings on natural resources and the environment (Samit, 2004).

Drainwater means water that has been treated with a water treatment system, and meets the quality standards as specified in the announcement of the Ministry of Natural Resources and Environment entitled “Specifications of standards to control drainage of water from coastal marine animal culturing ponds” (Pollution Control Department, 2003a).

CHAPTER II

LITERATURE REVIEW

Studying on charging rates for treatment of wastewater from shrimp farming around the area of the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province, the researcher has reviewed other relevant writings and researches about the following topics:

1. General characteristics of the study area
2. Marine shrimp farming
3. Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), Environmental Quality Management Plan for the year 2007-2011, and relevant laws
4. Types of economical tools and utilization of economical tools for management of natural resources and environment in Thailand
5. Application of economics on environmental management
6. Relevant researches

2.1 General characteristics of the study area

2.1.1 History of Kung Krabaen Bay Development Study Center

Kung Krabaen Bay Royal Development Study Center Project was originated from instruction of His Majesty the King when he went to the opening ceremony of the Somdet Phrachao Taksin Maharaja Monument in Chantaburi Province on 25 December 1981. He gave instruction to Governor of Chantaburi Province to find appropriate area to make a project for developing fisheries and agriculture in coastal area of Chantaburi Province. In addition, the King advised various organizations to study problems and find solutions to develop the coastal area in order to provide

people the knowledge to utilize natural resources efficiently with proper conservation. Therefore, Kung Krabaen Bay Royal Development Study Center Project was set up to be an education center to conduct researches for developing and managing of coastal natural resources, fisheries, forestry, agriculture, livestock, and industries so that people can come to learn new knowledge in the center and apply the knowledge on their own lands successfully.

2.1.2 General information

2.1.2.1 Location and boundary

The Project Kung Krabaen Bay Royal Development Study Center Project is located on coastal area of eastern Thailand (north eastern of the Gulf of Thailand), covering Tambol Khlongkhud of Thamai District and Tambol Sanamchai and Tambol Krajae of Nayai-arm District, Chantaburi Province. The area is located 30 km away from Muang District of Chantaburi Province, and 230 km away from the south eastern direction from Bangkok. Its boundary is adjacent to the following places.

North	Adjacent to Kao Yai and Kao Noi mountains, Tambol Sanamchai, Nayai-arm District, Chantaburi Province
South	Adjacent to the Gulf of Thailand, Kao Chaolao and Kao Bortoei mountains, Tambol Khlongkhud, Thamai District, Chantaburi Province.
East	Adjacent to Kao Yai Mountain and Khlong Rampan River, Tambol Khlongrampan, Kao Moodood and Kao Amphawa mountains, Tambol Khlongkhud, Thamai District, Chantaburi Province
West	Adjacent to the Gulf of Thailand at Kao Kungkraben Mountain, Laem Hinkan Peninsula, Tambol Khlongkhud, Thamai District, Chantaburi Province

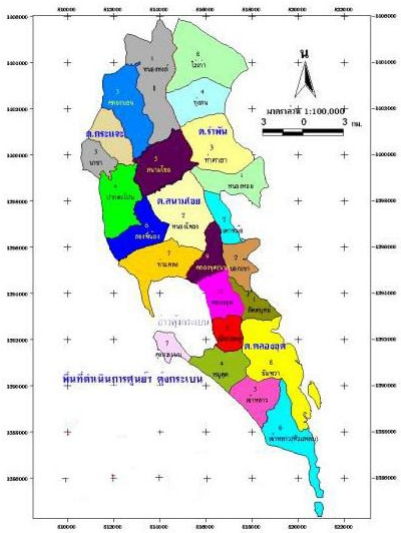

Figure 2-1 Location and area of Kung Krabaen Bay Royal Development Study Center Project

2.1.2.2 Topography of the area

The area's topography is a small watershed, having a narrow shape in the east side with a mountain ridge lying along the north-south direction. The highest hilltop is at Kao Moodood Mountain, which has an elevation of 213 meters above sea level. It is a conservation area (Kung Krabaen Bay Non-hunting Area). On the west side some small mountains lye parallel to the northern coast starting from the opening of the gulf. The middle part of the gulf has an area around 4,000 rai, and its shape is like a kidney. The gulf is almost closed completely by accumulation of sand sediments. There is only one opening for seawater, which is about 650 meters wide. The width of the whole gulf is about 2.6 km, and its deepest water level is 8 meters. There are 7 short canals flowing down to the gulf. Area around the gulf is quite flat, abundance with mangrove forest growing along the curve of the gulf's coast for about 30-200 meters. Next to the mangrove forest are layers of area for shrimp farming of farmers in the Project, rice farms up to mountains, and the mountainous area with rubber tree plantation or fruit plantation respectively.

2.1.2.3 Climate

The climate around the Kungkraben Gulf is tropical. Due to being adjacent to the open sea, the area is affected by the south western monsoon, and features 3 seasons namely 1) rainy season starting from May to October (about 6 months), 2) winter season starting from November to February (about 3 months) with January being the warmest month, and 3) hot season starting from February to May. The weather is very hot during late April to early May.

2.1.2.4 Land use

The Project of Kung Krabaen Bay Royal Development Study Center Project, Chantaburi Province has a total area of 41,280 rai or 66.05 sq.km. covering 16 villages: 8 of them are in Tambol Khlongkhud, Thamai District; 7 of them are in Tambol Sanamchai, Nayai-arm District; and 1 of them is in Tambol Krajae, Nayai-arm District. Land use in the area can be classified into agriculture, fruit plantation, forest, marine animal culturing, as shown in Table 2-1

Table 2-1 Land use in the area of the Project of Kung Krabaen Bay Royal Development Study Center Project, for the year 2005 (Sombat, 2005)

Land use	Area (rai)	Percentage
Rice field	5,097	12.34
Para rubber tree plantation	5,002	12.11
Fruit plantation, trees	12,898	31.20
Forest	11,370	27.53
Mangrove forest	610	1.45
Newly planted mangrove forest	690	1.67
Deteriorated mangrove forest	311	0.75
Shrubs	553	1.33
Grassland	235	0.54
Shrimp farms	3,768	9.11
Accommodation area	299	0.71
Ponds and water reservoirs	119	0.48
Unused area	328	0.78
Total	**41,280**	**100.00**

From studying general characteristics of the study area, we found that the area of the Project of Kung Krabaen Bay Royal Development Study Center Project has a total area of about 41,280 rai. Land use in the area has much variety due to the fertility of the land and the rich environmental resources. The area is utilized for marine shrimp farms, rice farms, para rubber plantation, fruit plantation, and mangrove forest. The most outstanding utilization is shrimp farms which have many shrimp ponds distributing along the gulf's coast. Due to engulfing characteristic of the gulf and only one access to the ocean, sediments and all wastes from shrimp farming activities can easily accumulated within the gulf. During the period of low tide and less water in the gulf, the water can be highly concentrated with wastes.

2.2 Marine shrimp farming

Marine shrimp farming in Thailand has been continuously and rapidly developed and extended along the coastal area throughout the country. The researcher is interested in studying about shrimp farming in order to have some useful information for the research. Regarding shrimp farming, these following topics have been studied.

2.2.1 Formats of shrimp farming

There are many formats of shrimp farming, each has different method of culturing shrimps. The Pollution Control Department has studied for appropriate wastewater treatment system for marine animal culturing in 2002. They classified formats of shrimp farming in Thailand into 3 types namely:

2.2.1.1 Traditional or natural (Extensive) shrimp farming

This is traditional approach to culture shrimps. A shrimp pond for this type have an area about 50-100 rai. There are ditches around the pond with a width of about 10-15 meters and a depth of 1.0-1.2 meters. The middle part of the pond, sometimes called "takad", is left unchanged. Farmers let water flow into the pond when there is much water in the surrounding environment. The water naturally has offspring of many kinds of sea shrimps, and they are kept inside the pond. This natural practice of shrimp farming do not provide supplement to shrimps.

Farmers will open the gate and let water flow out from the pond every month to catch shrimps. This approach gives a relatively low yield, about 50-100 kg/rai/year.

2.2.1.2 Semi-developed (Semi-intensive) shrimp farming

The semi-developed shrimp farming technique has some development from traditional or natural approach. Size of the pond is getting smaller to be about 5-10 rai per pond. In addition to natural offspring of shrimps, farmers will add cultured offspring into the pond with a low density of around 5-10 shrimps/sq.m. Food supplements are occasionally given for the shrimps. The shrimp yield is around between 100-200 kg/rai/year.

2.2.1.3 Developed (Intensive) shrimp farming

Developed shrimp farming was initiated in Thailand around the year 1985 and has been widely developed since then. Size of shrimp ponds for this technique is about 3-6.5 rai, with a depth of about 1.2-1.5 meters. This technique puts only cultured offspring in the pond for about 30-50 shrimps/sq.m. Paddle wheel aerators are used in the pond to add more oxygen for shrimps. Shrimps are fed with artificial shrimp feeds throughout the culturing process. Medicine and chemical are used to maintain water quality and prevent diseases.

At the beginning, shrimp farming for the 3 types widely were open system. The farmers exchanged much water regularly to eliminate waste and adjust water condition. Therefore, water quality had much influence on shrimp farming. Later when there were problems about water pollution and epidemics farmers began to use closed or semi-closed system. The closed system does not exchange water with water outside the system. However, farmers may add water from reserved ponds to substitute water that has been evaporated. The closed system may circulate water into water treatment system. Semi-closed system may exchange water about 10% of water in the pond in last month of the culturing period.

Developed shrimp farming has two periods of water disposal, one is during culturing and the other is catching shrimps period. For the open system, farmers would exchange water during culturing by exchanging only small amount at first and increase the amount more and more in following months. The amount of drained water can be varied depending on areas or preference.

Literature review on this topic was for understanding formats of shrimp farming. It is found from the review that there are 3 types of marine shrimp farming namely traditional or natural shrimp farming, semi-developed shrimp farming, and developed shrimp farming. From the literature review, we can conclude that the format of shrimp farming in the area around the Project of Kung Krabaen Bay Royal Development Study Center Project is developed shrimp farming.

2.2.2 Drained water from shrimp farming, wastewater treatment, and effects to the environment

The researcher has reviewed the manual of the Pollution Control Department in 2005 on how to treat wastewater and to manage coastal marine animal culturing, which was created to be used by farmers or entrepreneurs as guidelines for wastewater treatment and reducing water pollution that may cause problem to shrimp farming in a long term. The following topics have been examined.

2.2.2.1 Wastewater from shrimp farming

Although shrimp farming is an important economical activity, but if there is no proper management on wastewater and sediments, shrimp farming can cause problems to the environment and also to the shrimp farms. This is because wastes from remained food, supplements, and excrements from shrimp farms are drained into surrounding water that may accumulate and cause water to be polluted, leading to epidemics to shrimps extensively.

Waste from shrimp farming composed of food remains and excrements from shrimps which are released to the environment during water exchange when growing or catching shrimps. Drained water normally has high concentration of organic material. The levels of ammonia and nitrite are higher than in natural water sources, while level of dissolved oxygen is lower than normal. Meanwhile, the amount of plankton in water may be too high. Antibiotics and chemicals may be contaminated in the water causing acidity or basicity of the water being inappropriate for growth of marine animals. Drained water can affect the environment and organisms in water directly and indirectly. Direct effects from drainage of wastewater include low water quality, slow growth of marine animals, infertility, and high morbidity of some marine animals.

2.2.2.2 Wastewater treatment system

The purpose of wastewater treatment system is to reduce quantity of sediments and some poisonous substances that are dissolved in drained water so that the water meet required standards before draining into public water sorces or the sea.

The selected treatment system is to allow sediments to deposit naturally in short period in order to eliminate suspended organic and inorganic sediments, reduce amount of sediments, food nutrients, and some other polluted materials in the drained water to some extent. After that, aerators are used to eliminate remaining organic and polluted materials in the drained water. The movement of water mass and the flow of heavy sediment from bottom of the pond during water drainage and drawing to the treatment ponds cause interaction and merging of heavy and light sediments, resulting in deposition of suspended sediments simultaneously. Therefore, efficiency of deposition is enhanced, as most organic and nutrients are eliminated in the form of ammonia and hydrogen sulphide. Some parts of sediments will be dispersed to the air during water drainage and air filling. Some parts are used or oxidized by microorganism to inpoisonous substance. The oxidization turns ammonia into nitrite and then into nitrate, which will then be eliminated from water mass in the form of gas from nitrate reduction process in soil layer without oxygen.

This system of water treatment can be applied in shrimp farms of all sizes. The system is composed of two main treatment units: sediment deposition pond and air filling pond. Each pond has volumn at least equal to the volumn of one shrimp pond so that it can hold all drained water from a whole pond when catching shrimp. The whole process of wastewater treatment to have water that meets standards of drained water requires a short period of about 8-11 days. During this period, 12 hours are needed for letting the sediments to deposit and 7-10 days are for air filling.

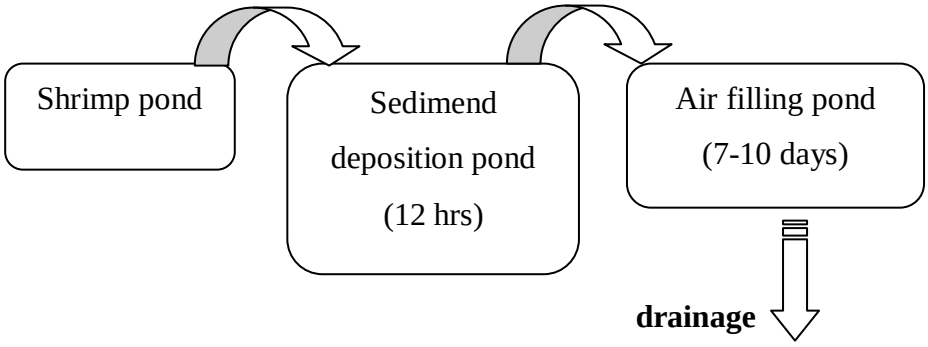

Figure 2-2 Wastewater treatment system

2.2.2.3 Effects of shrimp farming on the environment

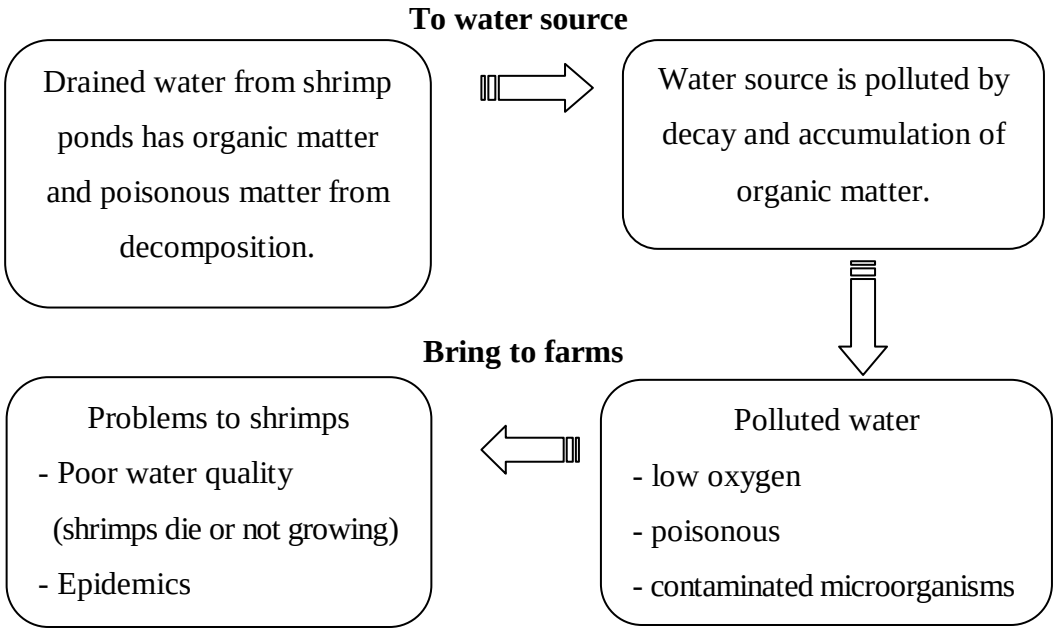

Figure 2-3 Effects of shrimp farming on the environment

The report on situation of marine environmental quality in Chantaburi Province revealed that, in 2004, marine shrimp farming in the Project of Kung Krabaen Bay Royal Development Study Center Project comprised 104 farmers, with 471 shrimp ponds. Shrimp culturing requires draining wastewater, flushing mud to drive sediment and draw waste materials, using lime to adjust acidity and basicity, and using medicine to prevent diseases. Waste materials from these activities are released to Kung Krabaen Bay more and more from the expansion of farming area.

Wastewater from shrimp farming was found to have low dissolved oxygen, high BOD, and high concentration of remaining nutrients. Therefore, these problems arise in surrounding area of Kung Krabaen Bay: 1) shortage of water with sufficient quality for shrimp farming; 2) there is contamination in the water used for shrimp farming because farmers do not separate inflow and outflow gates, even though the water is from saltwater irrigation system; 3) accumulation of wastes from shrimp farms such as remaining food cause deteriorated environment, low quality of water for shrimp farm, and reduced amount of marine animals; 4) there is rapid expansion of plankton which is poisonous to shrimps; and 5) the ecosystem of Kung Krabaen Bay has changed due to wastewater drainage and accumulation of organic matter. (Pollution Control Department, 2004)

The literature review in the topic of "Drained water from shrimp farming, wastewater treatment, and effects to the environment" provides useful knowledge for the research. The researcher has learned and understood that wastes from shrimp farms cause problem to the environment during the drainage process, that the standard wastewater treatment system comsist of 2 main treatment units namely sediment deposition pond and air filling pond, and that drained water from shrimp farms has low dissolved oxygen, high BOD, and high dissolved nutrients. The knowledge allowed the researcher to use BOD as a parameter to signify dirtiness of wastewater from shrimp farms in the area.

2.3 Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), Environmental Quality Management Plan for the year 2007-2011, and relevant laws

2.3.1 The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992)

The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) is the main law that is used a guideline for environmental management of Thailand. Details of Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) covers several topics about environmental pollution

such as EIA and environmental planning and management. The Act has given authority to the National Environment Committee to determine standards on environmental quality, to examine EIA, and to monitor enforcement of the standards. In addition, Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) also states about the Polluter Pays Principle (PPP) and punishment of violation. The PPP on water pollution as stated on the Act can be summarized as the following.

The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) specifies that the owners of pollution sources, the polluters, have to be responsible for treatment of the pollution or wastes. If the polluters' farms are located in the area without wastewater treatment system provided from the government, the polluters have to set up their own wastewater treatment system. If a treatment system is provided by the government, the polluters have to send their wastewater to be treated by the system and pay for the treatment service charge, unless they have their own system. The treated wastewater has to meet the quality standards. The polluters who do not send their wastewater for treatment, who illegally drain their wastewater, do not pay the wastewater treatment service charge have to pay at a rate of 4 times the normal rate. The polluters who have their own wastewater treatment system but illegally use the government's treatment system have to pay a daily fee for 4 times the regular cost of operating their own system, and also have to pay a damage cost to the government. If the polluters drain their wastewater into the environment they will have to pay a daily fee for 4 times the operation cost of treatment system. For implementation of the principle, the local officers have authority to collect service charges and fee, and request for damage cost. This collected money is not required to be sent to the Treasury Office, but required to deduct some part to the Fund as specified by the Fund Committee. The remaining can be used for payment of the operation and maintenance cost of the wastewater treatment system of that local administration.

The Pollution Control Department, Ministry of Natural Resources and Environment (MNRE), used their power as specified in the Section 55 of Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) to issue the MNRE's announcement entitled "Specifications of standards to control drainage of water from coastal marine animal culturing ponds". The announcement sets standards in controlling drainage of wastewater from ponds larger than 10 rai as the following.

Table 2-2 Wastewater drainage standards from marine animal culturing ponds

Standards to control wastewater drainage from marine animal culturing ponds			
Water quality index	**Unit**	**Standards**	**Testing methods**
1. Acidity and basicity (pH)	-	6.5-9.0	Use pH Meter to measure acidity and basicity with Electrometric method
2. Biochemical Oxygen Demand (BOD)	mg/l	≤ 20	Use Azide Modification at 20 Celsius for 5 days
3. Suspended Solids (SS)	mg/l	≤ 70	Use Synthetic Seawater
4. Ammonia (NH_3-N)	mg-N/l	≤ 1.1	Use Glass Fiber Filter Disc, which has filter size of 1.2 micron
5. Total Phosphorus	mg-P/l	≤ 0.4	Use Modified Idophenol Blue method Use Ascorbic Acid method
6. H_2S	mg/l	≤ 0.01	Use Methylene Blue method
7. Total Nitrogen (summation of Total Dissolved Nitrogen and Total Particlate Nitrogen)	mg-N/l	≤ 4.0	Measure Total Dissolved Nitrogen and Total Particlate Nitrogen and combine them. Measurement methods are: (a) Total Dissolved Nitrogen: use persulfate digestion (b) Total Particlate Nitrogen: measure suspension with filter size of 0.7 micron, then analyze with Nitrogen Analyzer

Remark : 1. Collect samples of wastewater to check for compliance with standards of wastewater using Grab Sampling approach at the point of draining wastewater from shrimp ponds out to the surrounding environment.

2. Methods for checking standards of wastewater from shrimp farming follow the specifications in the wastewater analysis manual of Environmental Engineering Association of Thailand, or according to Standard Methods for the Examination of Water and Wastewater (APHA, AWwA and WEF), Practical Handbook of Seawater Analysis (Stickland and Parsons), Methods of Seawater Analysis (Koroleff), Determination of Ammonia in Estuary (Sasaki and Sawada) Methods of Seawater Analysis (Grasshoff K.) and/or the wastewater analysis manual that Environmental Engineering Association and WEF have collaboratively created.

Source: Announcement of the Ministry of Natural Resources and Environment, 2004

Later the Pollution Control Department of MNRE has used authority from Section 69 of Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) to issue the announcement of MNRE entitled "Requirement that coastal marine animal ponds creating pollution must control disposal of wastewater into public water source or into the environment". This Announcement define that coastal marine animal ponds larger than 10 rai are pollution sources that need to be controlled for their disposal of wastewater into public water source or the environment. It also prohibits the owners of the ponds from disposing wastewater into public water source or to the environment, except only if they have already treated the wastewater until it is in compliance with standards about disposed wastewater as specified in the announcement entitled "Specifications of standards to control drainage of water from coastal marine animal culturing ponds". (Announcement of the Ministry of Natural Resources and Environment, 2005)

2.3.2 Announcement of the Ministry of Agriculture and Cooperatives entitled "Requirement that shrimp businesses must register and obtain permission from the authority"

The Ministry of Agriculture and Cooperatives used its authority from Section 25 of the Fisheries Act, B.E. 2490 (1947) to specify that people having shrimp businesses with an area at least 50 rai have to register and request for permission from officers in charge, and specify that shrimp businesses with area less than 50 rai must register with the officers. In addition, the persons who request for registration or permission as a shrimp farming entrepreneur are required to prepare wastewater treatment system that is sufficient for treating water from their ponds while catching shrimps, and the area of the treatment system must be not less than 10 percent of the whole farming area. Farmers who do not have a wastewater treatment system are allowed to use the system of neaboring farmers, or they may group together to set up a common wastewater treatment system, which has to be at least 10% of the total size of all shared shrimp farms. The farmers or entrepreneurs who have been registered or granted permission must follow the regulations about wastewater and mud disposal namely: 1) the water disposed from shrimp ponds must have BOD no greater than 20 mg/l, suspended solid no greater than 70 mg/l, pH being between 6.0-9.0,

and ammonia-nitrogen no greater than 1.1 mg/l; 2) mud from shrimp farms must not be released into natural water source or public places; and 3) saltwater must be controlled to make sure that it will not flow to public freshwater source or other agricultural area. If any entrepreneurs violate these regulations, the officers can revoke their registration or permission. (Announcement of the Ministry of Agriculture and Cooperative, 1998)

2.3.3 Environmental Quality Management Plan for the year 2007-2011

This is a plan to administer and manage natural resources and environment, aimed to be used as guildline for all sectors regarding environmental management for efficient administration and management in the next 5 years. This plan is also set to be in compliance with the outline of the 10th National Economic and Social Development Plan (2007-2011), which concentrates on creating a sustainable happy social based on 3 dimensions of balancing development namely economic, social, and environment, in addition to participation from people. Some important contents in the Environmental Quality Management Plan for the year 2007-2011 have stated about managerial principles, strategies, driving tools, and guidelines for managing environmental resources including management of fishery, marine, and coastal resources, (Office of Natural Resources and Environment Policy and Planning, 2006) as the following.

2.3.3.1 Principles

1) Polluters Pay Principle (PPP) is a principle about responsibility which requires that **polluters must not leave their burden to eliminate pollution from their activities on the social and the environment**. However, being a good principle, this principle cannot be implemented efficiently due to the problem of law enforcement that takes much time to specify polluters, which make it too late to prevent distribution of pollution. Therefore, during the coverage of the Environmental Quality Management Plan, in addition to **enhancing efficiency of law enforcement**, especially in demanding the owners of pollutant sources to set up wastewater treatment system, the government should try to **enhance implementation of**

economic tools to assist in environmetal management, such as proposing to collect environmental tax, pollution management fee, etc.

2) Public–Private Partnership Principle is a principle to create **mutual responsibility** among the governmental sector and the private sector in taking care of expenses and in receiving benefits from environmental management. This principle should be used together with the Polluters Pay Principle to **encourage the private sector to have more investment and play a majorrole in environmental management**. This strategy can be more effective by using modern technologies in enhancing capability of pollution control and management.

3) Precautionary Principle. This is an **offensive managerial principle that emphasizes on preventing advance effects**. It is widely used internationally, and complies with the Agenda 21, which is the World's master plan on sustainable environmental management. This principle is based on the fact that natural resources and environment can be destroyed easily, but being very difficult to recover or requires a great amount of time and budget. Sometimes it is even impossible to recover the previous condition of an ecosystem. Therefore, the main idea of this principle is to **create and enhance immunity for protecting natural resources and environment, especially in areas with vulnerable ecosystem**. Whenever there is a doubt or suspicion whether an activity would be harmful to the natural resources and environment, despite having unclear scientific prove, there must be preparation to prevent possible problems. This is particularly applicable for effects on natural resources and environment of mega projects and other development activities involving dangerous chemical or metal. These major activities are required to have Strategic Environmental Assessment (SEA) during the policy planning stage. It is also required to have tools and preventive mechanism such as to outline development plans in area prone to environmental problems, to announce an area as the environmental protection area, to require that usage of raw material harmful to the environment must conduct a Life Cycle Analysis (LCA), to prepare Code of Conduct for operational standards, and so on.

4) Public Disclosure Principle. This is a principle that **uses social process to support participation process**, which is an important factor for managing of natural resources and environment. This principle encourages people or private sector or stakeholders to take part in monitoring the effects on natural resources and environment resulted from both governmental and private projects. Knowledge and updated information should be given to people and private companies in order to **create social pressure** for persons who cause deterioration in natural resources and environment. There should also be implementation of social strategies to be motivation by **honoring and granting awards** to organizations that are responsible to the environment and the social. For example, there should be a requirement to have reports on Environmental and Social Responsibilities in the annual report of organizations registered in the stock market.

5) Beneficiaries Pay Principle. This is a new principle that should be studied and analyzed in order to apply with management of natural resources and environment in the future. As natural resources are limited and may not meet the increasing demand of people, **there should be implementation of economical tool to support equality and justice for losing people in order to reduce social conflicts on utilization of natural resources**, and create win-win development. Examples of implementation of this principle include giving compensation or sharing benefits with people or the community who are affected from government's projects such as garbage treatment facilities, wastewater treatment facilities being close to the communify, transferring water over watershed areas, distributing water to only some groups during water scarcity, and so on.

In conclusion, the afore-mentioned 5 principles aim to creat balance in administrating and managing natural resources and environment by linking all dimensions collaboratively. These dimensions include the dimension of right and equity in access and utilization, the dimension of efficiency and worthiness in utilization, and the dimension of ecosystem and environmental quality protection. The relationship can be illustrated by Figure 2-4

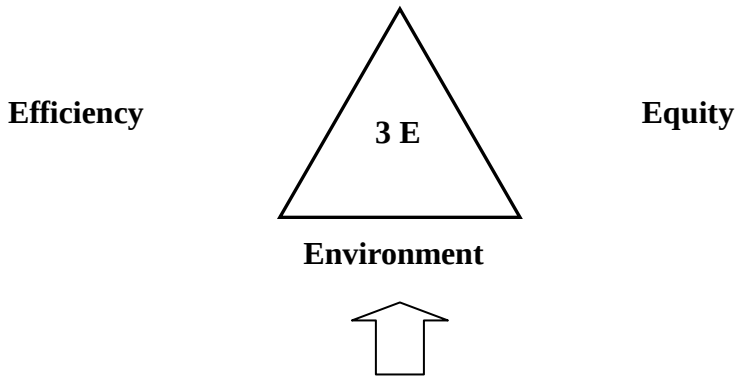

Figure 2-4 Dimension of Administration and Management

To follow the Environmental Quality Management Plan for the year 2007-2011, importance is given to participation of people by considering benefits of the whole people and by using Environmental Communication among all sectors of the social in order to achieve **coordinated natural resources conservation and maintain the quality of good environment** for sustainable development of the social.

2.3.3.2 Solutions for management of natural resources and environment, regarding fishery, marine, and coastal resources

Thailand is considered a world leader in fishery and export of fishery products. However, this success needs to compromise with depletion and deterioration of natural resources. Therefore, the Environmental Quality Management Plan pays attention to rehabilitation of marine and coastal resources in order to bring back natural balance, disaster warning system in order to reduce damage to lives and properties caused by natural disaster, and fishery management. There are rules regarding fishery methods, fishery tools, and fishery zones that have been set up by participation of all sectors, especially local fishermen and commercial fishermen. The plan also requires protecting environmental quality of the sea and coastal areas by preventing pollution from cities and industries and chemical from agriculture, since these pollutants may affect habitats of marine animals and bioaccumurate toxin in the animals, which may lead to sanction in international trade.

Source: Office of Natural Resources and Environment Policy and Planning, 2006

2.4 Types of economical tools and utilization of economical tools for management of natural resources and environment in Thailand

2.4.1 Types of economical tools

There are many types of economical tools, and they are differently suitable for management of natural resources and environment. In 2004, Office of Natural Resources and Environment Policy and Planning has categorized economical tools that can be used to create inspiration and perception toward conservation of natural resources into 7 types (Office of Natural Resources and Environment Policy and Planning, 2004) namely:

2.4.1.1 Rights of utilization

To determine the rights in utilization of natural resources and environment is a strategy to create motivation and inspiration on people having rights to utilize natural resources to take part in conservation of natural resources. Some types of natural resources that people can utilize them easily, such as forest resources and fishery resources, are resources that everyone can access and utilize easily. Therefore, people who utilize these resources are lack of inspiration to use the resource sustainably, since they do not have a feeling of being the owner of that natural resource. Hence, to define rights of utilization is like defining rights of being the owner to that natural resource, and that will lead to inspiration to utilize the resources conservatively for maximum benefits in a long-term.

2.4.1.2 Markets of rights in utilization of natural resources

Markets of buyers and sellers of rights in utilizing natural resources can be a tool to promote efficiency in using the utilization rights. This approach has an objective to control utilization of resources or the level of releasing pollutants to be at an acceptable level. This approach is based on the principle that each entrepreneur may be different from others regarding capability in managing natural resources and environment. Some entrepreneurs who are able to manage their natural resource utilization and pollutants to be lower than the amount they are granted can sell their remaining rights to other entrepreneurs who may have utilized natural resources over the limit of their rights. For example, in case of draining wastewater to a river, the government may, at the beginning, specify the overall quota

of all plants and individual quotas of each plant. Some plants drain wastewater over their limits or want to drain more than the limits, while some others may drain less wastewater than the limit. The plants that are over limits may buy remaining limits of other plants. Such this buying and selling makes rights of utilization become valuable in the market, without a need for intervention by the government who only need to control the overall quota. Therefore, this tool is like an award for entrepreneurs who have efficient management on natural resources and environment, and a punishment for those who have poor management. However, Thailand has not practically applied this tool. The tool is found to be already used in some countries such as the markets of Ozone-Depleting Substances Permit Trading or ODS Permit Trading in the European Union, the markets of Pilot Emission Reducing Trading (PERT) that aims to reduce releasing of pollutants in Canada, for example.

2.4.1.3 Taxation tools

This is a solution to make persons utilize natural resources or entrepreneurs realize the social cost that occurs from utilization of natural resources or releasing pollutants. This cost is combined into the cost of producing goods in the form of tax, examples of taxation tools including excise tax, royalty tax, etc. In addition, the government may use different tax rates for products that have different levels of causing pollution to the environment. For example, the excise tax of leadless gasoline may be lower than the tax of gasoline with lead, which is a solution to motivate drivers to use leadless gasoline more.

2.4.1.4 Fees and Charges

Fees for environmental management are the costs collected from entrepreneurs who do activities that cause problems to the environment. The rates of fee can be varied according to quantity and types of pollutants. For example, there are fees for wastewater treatment, for garbage removal, for eliminating hazardous material, etc. The specified fees can create motivation in polluters to consider the cost for treatment of the pollution. The polluters will try to reduce the amount of their pollutants so that they pay less amount of fee. Meanwhile, the government or the local administration can use income from these fees for investment on managing natural resources and environment.

In order to use fees as a tool to prevent entrepreneurs from violating regulations of the government regarding pollution treatment, the fee should be set to be higher than the cost of operating waste treatment system. This can make entrepreneurs be more willing to treat their wastewater rather than draining it to the environment and paying for the fee.

2.4.1.5 Financial tool

This tool is in the form of setting up a fund for natural reseources and environment conservation. Income of the fund may come from the government's budget, donated money, assisting money from overseas, pollution tax, etc. Money of the fund can be used for natural resources conservation via many forms, for example, money to support education about natural resources management, low interest loan for investment on business that is beneficial for natural resource conservation. Another example of financial tools is formation of the fund to support energy conservation according to Energy Conservation Promotion Act, B.E. 2535 (1992), which has objectives to be a circulating budget and to assist or support energy conservation activities.

2.4.1.6 Responsibility guarantee

Responsibility guarantee is a promise that the entrepreneur will be responsible for any damage happened to natural resources and environment or expenses for the Clean-up-Costs to return the environment to its normal condition after being affected from activities of the entrepreneur. This is a tool to motivate entrepreneurs to try to protect the environment or reduce pollution by themselves. For this solution, entrepreneurs have to deposit some money as an earnest to guarantee their environmental-friendly activities. If there is any incident of environmental damage, the entrepreneur who causes the damage must lose the earnest. The amount of earnest have to reflect the cost needed to clean up that possible damage. Therefore, in a long-term, if the entrepreneurs find that new technology will enable them to pay less for the earnest, they would change their production to use the new, safe, clean, and environmental-friendly technology. However, this solution normally applies to only major environmental damage such as oil spill, leakage of hazardous material, and so on.

2.4.1.7 Earnest-return money system

The earnest-return money system is a solution to motivate consumers to avoid behaviors that are harmful or may negatively affect natural resource and environment. For this solution, consumers are required to pay earnest money when buying some products such as car battery, plastic bottles, and glasses in order to ensure that the buyer will return it for reuse or for proper disposal. If consumers do not return the product, that money will be kept by the seller. Thus this payment is like paying for "disposal tax" for consumers who do not cooperate with the waste management solution.

2.4.2 Utilization of economical tools to manage natural resources and environment in Thailand

2.4.2.1 For natural resource management

Application of economical tools for managing natural resources is limited. Only some types of economical tools are utilized, such as fees for using groundwater resources, concession cost for swiftlet nest, royalty cost for forest resources, mineral, petroleum, and so on. Implementation and application of economical tools for natural resource management has supporting laws and authorized organizations in charge. Utilization of economical tools for managing natural resources in Thailand can be summarized in Table 2-3.

Table 2-3 Utilization of economical tools for natural resource management in Thailand

Natural Resources	Economical tools	Laws	Organizations in charge
Swiftlet nest	Concession cost for swiftlet nest	Swiftlet Nest Duty Act, B.E. 2540 (1997)	- Local administrations - Department of National Park, Wildlife, and Plant Conservation
Mineral	Royalty for minerals	Mineral Royalty Rates Act, B.E. 2509 (1966)	Department of Primary Industries and Mines
	Fees for inventory	Minerals Act, B.E. 2510 (1967)	
Petroleum	Royalty for petroleum	Petroleum Act, B.E.2514 (1971)	Department of Mineral Fuels
Groundwater	Fees for utilization	Groundwater Act, B.E.2520 (1977)	Department of Groundwater Resource
Forest	Royalty for forest	Forest Act, B.E. 2484 (1941)	Royal Forest Department
	Permits for taking forest properties in reserved forest areas	National Reserved Forest Act, B.E. 2507 (1964)	
Fishery	Permits for doing fishery in territorial waters of Thailand	Fisheries Act, B.E. 2490 (1947)	Fisheries Department
Historic National Park and Thailand Museum	Entrance fee	Act on Ancient Monuments, Antiques, Objects of Art and National Museums, B.E. 2504 (1961) as amended by Act (No.2), B.E.2535 (1992)	Fine Arts Department
Land and Marine National Parks	Fees for entering and using National Park areas for overnight stay	National Park Act, B.E. 2504 (1961)	Department of National Park, Widelife, and Plant Conservation

2.4.2.2 For environmental management

Utilization and application of economical tools for environmental management in Thailand can be categorized by types of problems into 3 types namely: 1) industrial pollutions, which include air pollution, hazardous material, hazardous waste, and water pollution; 2) community pollutions, which include water pollution, garbage, signboards, and cleaness; and 3) energy conservation in workplace, plants, households, and small electricity producers who use recycled energy. Pollutions from different sources will be managed by different economical tools. An environmental problem may be handled by using many economical tools simultaneously. Laws and authorized organization in charge of using economical tools for environmental management can be summarized in Table 2-4.

Table 2-4 Utilization of economical tools for environmental management in Thailand

Environmental Problems	Economical tools	Laws	Organizations in charge
1) Industrial pollution			
Air pollution	Reduction of import tax for machines that help protect the environment, such as air filters in cars		Customs Department
	Loan from Environmental Fund for workplace/plants for improving the environment in the plant	The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992)	Office of Environmental Fund
	Using different pricing system by applying different taxes between oils with lead and oils without lead	Excise Tariff Act, B.E. 2527 (1984)	Excise Department

Table 2-4. Utilization of economical tools for environmental management in Thailand (cont.)

Environmental Problems	Economical tools	Laws	Organizations in charge
Hazardous material	Different excise taxes between new batteries and old batteries (10% for new batteries and 5% for recycled batteries)	Excise Tariff Act, B.E. 2527 (1984)	Excise Department
	Different pricing system for buying new battery with returned battery (New battery price will be 50 baht off for returning an old battery while purchasing.)	Excise Tariff Act, B.E. 2527 (1984)	Excise Department
Garbage	Cost for garbage treatment	Public Health Act, B.E.2535 (1992)	Local Aministrations
Hazardous waste	Transportation cost, testing cost for industrial waste, and disposal cost	Factory Act, B.E. 2535 (1992)	Department of Industrial Works
Water pollution	Tax reduction for import of wastewater treatment machines	Investment Promotion Act, B.E 2520 (1977)	Customs Department
Water pollution (continue)	Granting preferences for investment promotion and exclude income taxes for industrial plants situated in assigned areas	Investment Promotion Act, B.E 2520 (1977)	The Board of Investment of Thailand
	Wastewater treatment cost	Factory Act, B.E. 2535 (1992)	Department of Industrial Works

Table 2-4. Utilization of economical tools for environmental management in Thailand (cont.)

Environmental Problems	Economical tools	Laws	Organizations in charge
	Loan from Environmental Fund for workplace/plants for improving the environment in the plant	The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992)	Office of Environmental Fund
2) Community pollution			
Water pollution	Wastewater treatment cost	The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992)	- Local Administrations - Pollution Control Department - Wastewater Management Authority
Garbage	Garbage collecting cost	Public Health Act, B.E.2535	Local Administrations
	Earnest-return money for glass containers		Private companies
Signboards and cleanness	Board tax	Board Tax Act, B.E.2510	Local Administrations
3) Energy conservation			
Energy in workplace/plants for controlled buildings and controlled plants	Energy Conservation Promotion Fund	Energy Conservation Promotion Act, B.E. 2535 (1992)	Department of Alternative Energy Development and Efficiency
Household energy	Energy Conservation Promotion Fund	Energy Conservation Promotion Act, B.E. 2535	Office of Energy Policy and Planning
Small electricity producers using recycled energy	Energy Conservation Promotion Fund	Energy Conservation Promotion Act, B.E. 2535	Office of Energy Policy and Planning

Source: Office of Natural Resources and Environment Policy and Planning, 2005a

2.4.3 Utilization of economic tools for management of natural resources and environment in other countries

2.4.3.1 Management of natural resources

New Zealand employed a quota system for catching fish called Individual Transferable Quota (ITQ). The system has been used for managing fishery area since 1986 with a piloted area, and become widely used in many other areas. The government will define and allocate maximum amount of fish that each fisherman can catch. Fishermen may sale or exchange their quotas during the month. The total amount of fish caught by all fishermen cannot exceed the total amount given to all quotas (Connor, 2000).

2.4.3.2 Management of environment

The United States of America has strategies to protect water in the ocean from being contaminated with oil spills that could affect quality of water in the ocean and coastal areas. They have two strategies for this purpose. 1) Marine Protection, Research, and Sanctuaries Act (MPRSA) is used to protect the ocean environment by prohibiting disposal of garbage or foreign materials that may affect health of human beings or fish or the ecosystem into the ocean. 2) Oil Pollution Act of 1990 (OPA) is a law to control amount of oil spills from ships in the ocean that may be caused by leakage or accidents of ship's turnover. Oil spills can cause extensive damage to the ocean environment. Thus the US government defines that the entrepreneur or persons who cause oil spills must pay for all costs of damage to the oceanic environment. These costs include cleaning and getting rid of oil spills on the sea surface as well as conpensation to people affected by damages of the oil spills (Callan and Thomas, 2000)

2.5 Economics concerning environmental management

2.5.1 Polluter Pay Principle (PPP)

Department of Industrial Works studied application of economical principles for pollution management in plants (Phrase 3) in 2006. It has mentioned about Polluter Pay Principle (PPP) that it is unfair that the government has to pay for treatment of pollution that caused by industries or agricultures since this will increase its budget and social cost, and the problem is not solved at the origin point. Without paying for

pollution treatment, the polluters will not perceive in taking care of the environment, and will just think that they can use the environment or natural resources freely. Thereafter, Polluter Pay Principle (PPP) was originated with a principle that the polluters have to pay for expenses of controlling and preventing pollution so that the environment remains in good condition. Another implication is that the investment of the government should reflect expenses for controlling goods or services that cause pollution from manufacturing or consuming those goods or services. Such that expenses should not be supported by the government since it may cause trade distortion and international investment problems.

The Polluter Pay Principle can be implemented by using various mediums such as regulations, prohibition, or fees. These economical tools can be used separately or mutually. Selected tools must be in agreement with efficient policy. Tool selection is authorized by the government (either federal or local). Factors that should be considered when selecting efficient tools include amount of data or information, operation and administration cost, and so on. The tool of rules and regulations is normally used for solving problems about health and disturbances. It is said to be the most appropriate tool for solving problems in large organization. The tool of fee charges should be based on a policy that people understand and accept widely. The policy should clearly explain about objectives in implementing this tool. Implementation of the policy will be efficient in solving or reducing problems as long as the payers feel that their payment is worthy in maintaining good condition of the environment. Another benefit in using this policy is that it will help solving problems or improving conditions of the environment for continuous and sustainable improvement.

2.5.2 Willingness to Pay Principle

For preventing and solving the problem of water quality deterioration, the most efficient solution is to solve at the origin of the cause. That means to reduce amount of wastes or pollutants that will be drain into water sources. The objective is to have wastewater from all sources treated to meet quality standards before it can be drained into public water sources. Using a common or shared wastewater treatment system is accepted to be capable to solve problems of wastwater drainage.

Currently the government pays attendtion to wastewater treatment and support solutions to the problems by providing budgets to set up wastewater treatment system and conduct several projects to manage water quality in many sources of origin. However, all stakeholders including regular people should realize the importance of problems and should be responsible in trying to make the solutions be effective in practice. A way to express responsibility and participation of people is the willingness to pay for services or wastewater treatment fees in order to support expenses of operating and maintaining the wastewater treatment system.

The Willingness to Pay principle is an economical principle which was originated to assess Consumer Surplus, which is the difference between willingness to pay of the consumer on that product or service and the true price of that product or service that the consumer really have to pay (Samit, 2004).

By reviewing about knowledge on the Willingness to Pay principle, the researcher aims to understand this principle so that it can be basic knowledge in assessing willingness to pay for wastewater treatment of farmers in the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province. This will enable the researcher to understand the attitude of the farmers and the true payment rate of wastewater treatment that they are willing to pay.

2.5.3 Costs and expenses in pollution treatment

Details on costs for pollution treatment, principles for calculation, criteria for calculating charges and fines for pollution treatment, and types of costs for operation pollution treatment system (Pollution Control Department, 2005) are as the following.

2.5.3.1 Principle for cost calculation

1) Fixed cost and Variable cost Fixed cost refers to the cost that does not depend on quantity of production such as design cost, machinery cost, land cost, etc. Variable cost refers to the cost that is varied according to quantity of production such as material cost, labor cost, etc. These costs are considered as economical costs.

2) Direct cost and indirect cost Some costs such as material cost, labor cost, etc. are costs that the business can specify their relevancy with each product and each unit of products. Therefore, these costs are called Direct Cost. Meanwhile, some other costs such as fuel costs (for heat energy), electricity cost, office cost, depreciation cost of the plant and the office, etc. are costs that can not be defined whether they belong to which product or which unit. Therefore, we call this latter type of costs as Indirect Cost or Overhead Cost. Direct cost and indirect cost are considered as accounting cost.

3) Opportunity Cost and Depreciation Cost Opportunity Cost, or also known as Alternative Cost, refer to the cost of resources that lose their best opportunity because the business does not select the best approach, such as opportunity cost of investment in the wastewater treatment system, etc. Meanwhile, Depreciation Cost refers to the cost of using machines or tools in the plants or constructions that have been acquired or built in the past. This cost is considered as accounting cost.

2.5.3.2 Types of costs for operation of wastewater treatment system

1) Fixed cost. Fixed cost is the cost that is not varied with quantity of pollution or wastewater, but depends only on size of the construction, type of machines, and personnel for operating the treatment system. Important fixed costs for wastewater treatment system are depreciation cost of construction and machines, employment cost for personnel who take care of wastewater treatment operation, etc.

2) Variable cost. Variable cost varies by quantity of pollution that takes place such as the amount of wastewater that come to the wastewater treatment system, the amount of polluted air that needs to be treated, etc. Thus we can see that this type of cost depend on quantity of pollution, types of pollution management, and efficiency of the treatment system. Important variable costs are electricity cost, chemical cost, equipment cost, administration cost, and other costs for operating the system (such as sample collection and water analysis, tap water cost, fuel cost, security cost, etc.) In addition, this cost also includes tax cost for hiring external organization for setting up the pollution treatment system.

Addition of all fixed costs and variable costs will yield the total cost needed for pollution treatment.

By reviewing the knowledge on this topic, the researcher understands about cost calculation for pollution treatment. There are three principles for calculating the total cost namely: 1) Fixed cost and Variable cost; 2) Direct cost and Indirect cost; and 3) Opportunity cost and Depreciation cost. The researcher also knows that each type of costs cover which expenses. For example, machinery cost and land cost are considered as Fixed cost, electricity cost and chemical cost are considered as Variable cost, and so on. The total cost needed for pollution treatment is derived from combining all costs from both types of costs. The researcher can use this knowledge as background for designing the research in the part that involves cost of wastewater treatment.

2.5.4 Determining rates for wastewater treatment service charges

2.5.4.1 Service charges and fees

For administration of wastewater treatment system, in addition to wastewater service charges, the governmental organization providing wastewater treatment system have to consider other costs that the users should be responsible as well. Calculation of service charges and fees can be categorized in details as the following. (Pollution Control Department, 2007) are as the following.

1) Wastewater treatment service charge

Wastewater treatment service charge is collected from users of the treatment systems who drain their wastewater into the system or users being within the service area. Normally the charges are collected monthly. Fundamentally, the collected charges should cover all expenses for operating and maintaining the treatment system.

2) Wastewater drainage service charge

Wastewater drainage service charge is collected from users who live in buildings that are required by laws to control wastewater drainage that need to be treated to meet the specified standards. This charge is calculated based on costs that happen during wastewater drainage and collection. A local administration, which is

Pattaya City of Chonburi Province, has already charged wastewater drainage charge, which is charged at the half price of wastewater treatment charge.

3) Fees/Permit charge for connecting pipes of drained wastewater

The Fees/Permit charge for connecting pipes of drained wastewater will be charged from users of all types when there are improvements, adjustment, or connection of pipes. This will be useful for completion of database of users who use the system. There are currently many local administrations that collect this fee/charge. For example, a local administration that charges users of the system once a year is Tambol Saensuk Municipality, Chonburi Province. They calculate this type of charges by multiplying wastewater quantity of the year with 0.65 baht. Another case is a local administration that charge for this fee only one time, which is Pa-tong Municipality, Phuket Province. This latter administration specifies the permit charge for connecting wastewater pipes from general household to be 100 baht/household.

All charges and fees concerning wastewater treatment are considered as tools to control wastewater problems and also as a source of income for operating and maintaining wastewater treatment system. The governmental organization that provides the treatment service may waive some kinds of charges, depending on support from local administration or the government, as to reduce burden of the people. However, they should at least charge for some cost so that people get involved with environmental protection and realize their status of being one of polluters.

2.5.4.2 Determination of rates for wastewater treatment service charge

1) Assessment for appropriate service charges

Rates of service charges can be determined by considering the cost of all expenses for operating and maintaining the wastewater treatment system. There are 6 types of costs that should be considered when determining rates of service charges as the following.

Costs	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Land cost	✓					
Construction cost	✓	✓				
Operation cost	✓	✓	✓	✓	✓	✓
Maintenance cost	✓	✓	✓	✓	✓	
Cost for spare parts of machinery	✓	✓	✓	✓		
Administration cost	✓	✓	✓			
Returned money to the Fund *	✓	✓	✓	✓	✓	✓

Remark: * For local administrations that use budget from the government and money from the Environmental Fund as income for the administrations

Since most of the people are not familiar with wastewater treatment service charge, the government has set a policy to collect this charge little by little. Therefore, at the primary stage, wastewater treatment charges should be collected using the Case 5: that is to charge only operation cost and maintenance cost.

2) Operation cost and maintenance cost for wastewater collection and treatment system

To study about occurred costs from wastewater treatment, consideration should be given to data of relevant costs needed for controlling efficiency of wastewater treatment system. The assessment can be based on yearly minimum expenses for controlling and managing the system with efficiency. Compositions for assessment include:

(1) Employment cost. This can be assessed from number of personnel, their present salaries, and future expansion of employment. (The assessment is based on the minimum number of personnel needed for maintaining efficiency of the system.)

(2) Electricity cost for operating the treatment system and the water pumps (from the electricity bill of the Provincial Electricity Authority)

(3) Maintenance cost (equals 25% of the electricity cost)

(4) Cost of chemicals needed for wastewater treatment system and used in the laboratory for analysis

(5) Cost for sampling analysis, in case needed to send samples to beanalyzed by other organizations

(6) Cost for sediment disposal, both that is done inside the location of the system and that requires transportation to other outside places

(7) Other costs such as expenses for communication, office materials, trainings for personnel, seminar, taking care of guests, tap water, gasoline, security equipments, etc.

2.5.4.3 Factors for determining rates of wastewater treatment charge

Factors that should be considered when determining rates of wastewater treatment charge are 1) The charge must add income to the management system to the level that enables the system to exist by itself or rely on itself as much as possible. 2) The charge must be able to motivate polluters to treat their pollution willingly, rather than pushing the burden to the government and pay for the treatment cost. 3) The charge should not be complicated, and easy to understand and calculate, so that polluters can make decision to use the best approach for treatment. 4) The charge should help adding capability of the treatment system. This will also motivate polluters to try to reduce the level of their pollution by improving their technology and management that will result in less pollution from production process. The central system then will be able to treat wastewater easier and can handle larger volume of wastewater. (Parichart Hawharn ,2000)

2.5.4.4 Methods for collecting wastewater treatment charges

There are various approaches in collecting wastewater treatment charges (Pollution Control Department, 1995), as the following.

1) Collect at a fixed rate, such as 50-100 baht/house/month. This method is suitable for small communities that all houses produce similar amounts of wastewater. The calculation can be based on average data of the whole population. For example, if the polulation produce wastewater averagely 520 litre/house/day, and the wastewater treatment cost per unit is 5 baht per cubic meter, then each household will have to pay for the charge of 78 baht/house/month.

2) Collect according to the land price. The charge can be added to the land tax, without considering that the house will use the treatment system or not, because it is considered that the common treatment system cause increment in the land price. This method is not appropriate for area that has many different land uses.

3) Collect charges according to amount of used water. This method does not take into account some houses that have no tap water but may cause wastewater.

4) Collect charges at a fixed rate according to quantity of wastewater, without considering the level of pollution in the wastewater. The formula for calculation with this method is P = a+bQ.

5) Collect charges at a fixed rate according to both quantity of wastewater and level of dirtiness of the wastewater. For this method, regular houses may be waived for dirtiness charge. This method seems to be more just for users than other methods. The formula for calculation is P = aQ+bC,

P = rate of service charge; a , b = constants; Q = quantity of wastewater ; C = dirtiness (BOD) of wastewater

There are four approache to collect wastewater service charges (Pracha, 2004) namely:

1) Include the charges with electricity or tap water bills

2) Charge separately, for wastewater treatment charge only

3) Charge from service. The wastewater charges may be included with taxes, such as local support tax, household tax, land tax, property tax, etc.

4) Collect via banking services, such as Counter Service

The review on knowledge about determination of rates of wastewater treatment charges has an objective to understand about solutions and methods for determining wastewater treatment charges, factors for determining the charges, and methods of collecting wastewater charges. From the review, the researcher can conclude that determination of wastewater treatment service charges should consider the coverage of operation cost and maintenance cost. Since most people are not familiar with wastewater treatment payment, the government has a policy to start charging little by little. The charges for operation cost and maintenance cost include salaries of employees, electricity cost, repair cost, chemical cost, sample analysis cost, sediment disposal cost, other expenses in the office, etc. The method for collecting charges by

considering quantity and dirtiness of wastewater gives more justice and equality to users more than other methods. This method uses BOD as the parameter for dirtiness in calculation. Knowledge from the review is useful for the research in the part that requires determination of service charges for wastewater treatment.

2.6 Relevant researches

The Department of Industrial Works (2006) studied about application of economical principle for management of pollution from plants (Phrase 3) in 2006. The study results summarize appropriate economical tools for managing or reducing pollution from industrial plants in Thailand as the following.

1. Emission charge (EC). This charge is collected from plants that produce pollution to areas outside the plants without considering effects that may happen to the environment and health of people. The industrial plants have to pay the pollution emission charge to the Department of Industrial Works. The amount of payment is based on the amount of pollution that they produce.

The collected money is saved in the Industrial Pollution Management Fund so that it can be used to support activities to reduce pollution from plants and promote sustainability of safe and sound environment.

2. Pollution Management Fee (PMF). This is an economical tool with an objective to assist and encourage industrial plants that produce high-BOD wastewater to use pollution-reduction strategies for their manufacturing process. The strategies include improvement/adjustment of technologies or machines, improvement/change of raw materials, improvement/adjustment of products, improvement of working practice or management, recycle or reuse, and so on. During the period of improvement plans, the plants will be waived for the pollution emission charge, so that they have sufficient budget for the improvement to reduce pollution. After the improvement has completed, the plants will be charged for emission charge again, but with reduced payment. However, if a plant cannot reduce the amount of emitted pollution within the specified period and target, that plant will have to pay for pollution emission of the previous year plus the interest of the total charge.

The Pollution Control Department (2002b) had a project to study and develop economical strategies for controlling pollution from agricultural activities (freshwater fish culturing) in 2002. The study was conducted in Suphanburi Province,

which is an important source of freshwater fish culturing in Thailand. It can be concluded from the study that appropriate economical tools that can be applied for managing pollution from freshwater fish culturing is to subsidize them or to give low-interest loans to them so that they can develop their farms to meet the specified standards.

The Pollution Control Department (2002a) studied and developed economical strategies for controlling pollution from agricultural activity (pig farming) in 2002. The study was conducted in sampled farms in 2 provinces. The first province was Nakhonpathom Province, which is the largest and most important site of pig farming in Thailand. The study covered two districts of the province namely Muang District and Kampaengsaen District. The second province was Nakhonratchasima Province, which is the most popular pig farming site in the North Eastern of Thailand. The study covered Nongboonmark District, Chokchai District, Muang District, Nonthai District, Kornburi District, Khamtalesor District, and Pakchong District. The study concluded that the economical tools that can be properly used for managing pollution from pig farming were:

1) Green flags. Green flags are used to be a symbol to express the farmers' concern about the environment. It is the strategy to promote awareness in environmental problems to the farmers and motivate them to care for the environment. The Green flags are used to emphasize only environmental management. They can be used in all types of pig farms, including the farms that are not ready to be registered as standard farms. In order to be granted the Green flags, farmers need to make a request to Provincial Cattle Office or District Cattle Office of the area. The farmers also have to follow the regulations required for receiving Green flags and develop the farm's environment to meet assessment criteria of the committee. Farmers who have received Green flags will have benefits in getting subsidy from the government. Therefore, the farmers are motivated to develop and improve the quality of their farms, resulting in overall development of environmental management in the whole region.

2) Pig farming permit fee and Permit extension fee. These fees are charged with different amounts according to the farm size. The calculation is based on cost for wastewater treatment, which has 2 cases of consideration: 1) in case that the fee covers overall damage, the charge is 93.58 baht per pig; 2) in case that the fee covers some part of the damage, the charge is 17.81 baht per pig. (The assessment is based on quality of farm

environment that is released to the outside environment. Farms that have treated wastes to meet specified standards are considered having paid for investment on waste treatment.)

3) Cattle Development and Environmental Management Fund. Source of this fund is from the Permit fee and Permit extension fee, as well as support from the government.

The Office of Natural Resources and Environment Policy and Planning (2002) made a manual for local administration about solutions to use economical tools for environmental management in 2002. According to the manual, economical tools that can be used for environmental management are (1) yearly permit for shrimp farming, calculated based on opportunity to make profits in the business, and (2) fines, in case of violating regulations, calculated based on the level of damage. Rates of fines are as the following.

- Rate of fines for not following the procedures to dispose mud from shrimp farms is 2,900 baht/ton

- Rate of fines for draining salty wastewater to the soil is 1,000 baht/rai (area of the pond that drains wastewater)

- Rate of fines for not submitting the report of waste disposal after catching shrimp, which must be composed by the third person who is not involved with the farm, is 4,000 baht/rai for each time that the report is absence (based on area of the whole culturing area).

- Rate of fines for pollution emission that exceed the specified BOD standard for every 1 mg is 200 baht/rai/crop.

The Office of Natural Resources and Environment Policy and Planning (1998) studied appropriation of service charges by local administrations that have wastewater treatment system and garbage treatment system in 1998. The study was conducted about water pollution in 7 areas namely 1) Kampangpet Municipality, Kampaengpet Province, 2) Varinchamrap Municipality, Ubonratchathani Province, 3) Tak Municipality, Tak Province, 4) Nan Municipality, Nan Province, 5) Chumsaeng Municipality, Nakhonsawan Province, 6) Maesod Municipality, Tak Province, and 7) Pra-intaracha Municipality, Phra Nakhon Si Ayutthaya Province. Study results can be summarized as the following.

1) Only people who benefit from wastewater treatment system should be required to be responsible for wastewater treatment charges as specified in the Section 75 of Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), since wastewater treatment systems cannot cover some areas.

2) Criteria for calculating wastewater treatment charges should be based on the amount of used water and dirtiness in drained water.

3) Private sector should not be allowed to take over the wastewater treatment system, since there is uncertainty that the private sector may charge unfairly.

4) For justice and equality in collecting wastewater treatment service charges, users causing wastewater should be categorized so that similar users that cause similar pollution are categorized in the same group. Water users were classified into 14 types namely 1) houses 2) condominiums/apartments/dormitories, 3) offices of government, state enterprise, and private companies, 4) schools/universities, 5) hospitals, 6) hotels, 7) department stores, 8) restaurants, 9) freshfood markets, 10) entertainment service facilities, 11) gas stations, 12) industrial plants, 13) religious places, and 14) other types of shops.

5) Fixed-rate charging is suitable for users who dispose wastewater without much variation in quantity and dirtiness in each month. Charging based on quantity of used water is suitable for offices of government, state enterprise, and private company, religious places, and other types of shops.

The Office of Natural Resources and Environment Policy and Planning (2004, 2005) studied strategies to increase and to manage green areas in community areas for sustainability in 2004, and studied about solutions for cooperation between the governmental and private sectors in using economical strategies to increase and to manage green areas in community areas in 2005. They used the total sampling areas of 1,136 places, comprising 22 large urban communities namely Bangkok, Pattaya, and other municipalities, 103 medium-sized communities of some district municipalities, and 1,009 small-sized communities of some Tambol municipalities.

In case of green area in urban communities, there are only specifications in Land Distribution and Distributed House Law that require to have a portion of green area. The Building Control Act requires to have spaced area (without having to be

green area) at a proportion of 30 percent. In case that there are laws that have already specified to have green area and spaced area, the appropriate economical tool is addition of other laws about buildings that can motivate land owners to use spaced areas as green areas. This tool should not be used in the area where there is already implementation of Land Distribution and Distributed House Law. However, additional laws may be implemented so that the owners of buildings or projects are inspired to have more green area than the amount specified by lows in order to create better environment.

Regarding effects on involved stakeholders at the social level, the whole community can both gain and lose. The community may have some environmental gains from the increased green areas, but may also have some economical losses from using the area as green area. However, if the solution is accepted from the community, we can say that the social is more satisfied with environmental value rather than economical value. The green areas in urban community are beneficial mainly to local communities. Meanwhile, air pollution also affects the community in that area as well. Thus compensation to afffeced people is a burden of all stakeholders in the community, which is in compliant with the principle of "polluters pay", and "gainers take the burden".

Stakeholders in adding green areas by using economical tools are land owners and people who take the burden. Levels of gains and losses depend on land use structure and tax structure as they are at present and as they may be modified. The land owners have absolute rights on their lands. Thus, in principle, the land owners will try to utilize their areas for maximum benefits. Therefore, motivation to induce land owners to turn their areas to be green areas must be large enough to compensate their opportunity losses.

Worasan Kumyart (1999) studied about attitude of people toward wastewater treatment in the municipal area of Tambol Saensuk, Chonburi Province, and found that people are generally satisfied with the role of the municipality on creating the wastewater treatment system to protect the environment. People were also found to be satisfied with administration of the Municipal Committee of the municipality, and most of them accepted the principle that people causing more wastewater should pay for treatment charges more than people causing less wastewater.

However, some of them had different opinions regarding monthly wastewater treatment charges that middle-class people have to pay to the municipality.

Chayuti Promthep (2003) has studied about opinion of people on wastewater treatment charge in Bangkok. His study also covered background of the construction and operation of Bangkok's wastewater treatment system, opinions of people toward wastewater treatment, and factors affecting acceptance of people in paying for the wastewater treatment charge to Bangkok Metropolitan Administration. The study results found that, as being the center of civilization and economy, Bangkok has become populated and has more water pollution simultaneously. In order to solve the pollution problem, Bangkok has created and operated wastewater treatment system project, and requires that people who cause wastewater have to be responsible in paying for the treatment cost. The study divided samples into two groups namely 1) Owners of residential buildings and semi-commercial residential buildings, and 2) Owners of buildings that are not categorized as the first group, which most of them were restaurant/food shops. Collected opinions from both groups revealed that most people thought that appropriate wastewater treatment charges should be calculated base on the amount of water used. They preferred to pay for the charge together with tap water bills, and were pleased to pay for the charge at a rate of no more than 40 baht/house/month. Factors that affected their willingness to pay for wastewater treatment charges were charging rate of wastewater treatment, format of collecting the charges, type of buildings, family income, and education of the payers.

Samit Thaicharoen (2004) studied factors affecting willingness to pay for wastewater treatment charge of people in the Chiang Mai Municipality. The study was conducted on 405 samples of house owners and 264 samples of workplace owners, totaling 669 samples. It was found that factors affecting willingness to pay for wastewater treatment of people were personal factors, factor of water usage, fundamental knowledge about water pollution, attitude toward wastewater, and information about wastewater. The study also found that most samples were willing to pay for wastewater treatment charge, accounted for 59.2 percents. Regarding the rate of charges, they were willing to pay for wastewater treatment at a rate of 2.26 baht per cubic meter, or 26-50 baht per house per month.

Barry and Martha (2002) in the Netherlands have employed and applied the pollution emission charge system since 1970. The system was enforced with polluters who, either directly or indirectly, dispose wastes, pollutants, or hazardous matter into surface water or into water storage that is used for treating and improving water quality. The charging rates are determined by the government, and might be calculated from quantity and/or concentration of pollution. The parameters used for controlling and collecting charges are BOD, sediments, heavy metals, and hazardous substance. These parameters present high-risk factors that are often found in the country. Rates of charges were made to be suitable for capability of industrial plants. There are two types of charging rates: one is fixed rates and the other is actual rate (cost). Small-sized plants pay at a fixed rate, while large plants who dispose more wastewater have to pay at a rate calculated from amount of disposed pollution that can be measured. The more pollution disposed, the higher charge that plant has to pay. The main objectives for implementing this economical tool are to motivate people to reduce their pollution disposal and to be a source of income for the government to use for wastewater treatment. After having been using the regulation of pollution disposal cost for 20 years, the Netherlands now have many more wastewater treatment systems, and their industrial plants treat wastewater to avoid releasing pollution to the environment. This solution results in better quality of the country's overall water system.

Bellegem et al. (1997) reveal that the Green Investment Funds of Netherlands has set up a fund that general people can deposit money into that fund. Depositors will receive economical returns in the form of interest money. In addition, they do not have to pay tax for their deposited money. The fund will use the deposited money to loan to farmers for their farming investment. The fund has an objective to give loans only to farmers who conduct organic farming, which is free of chemicals. The fund charges a lower interest rate than regular banks or markets. Thus farmers feel that the loan from the fund is worthy, since they receive loans with a low interest rate. Results from the foundation of this fund in Natherlands not only benefit economics but also the environment and natural resourse. Their environment becomes better and recovers from deterioration due to chemical used in agriculture. The growing number of organic farming of farmers benefits conservation of the ecosystem and biodiversity.

Soil quality has been improved from organic matters, and become free from chemical contamination.

It can be concluded that, from reviewing all the above literatures, the researcher is enabled to understand general characteristics of the study area regarding land use in the Project's area, which comprises several types of land use, with shrimp farming being the most apparent land use around Kung Krabaen Bay as a result of being supported from the saltwater irrigation project. However, since shrimp farming produces several kinds of wastes, which are drained to the sea, together with the engulfing characteristic of the Gulf that water current flows in only one direction, the wastes and organic matters are easy to become accumulated. The reviews also provide knowledge about Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), the Environmental Quality Management Plan of 2007-2011, and relevant laws that refer to the Polluters Pay Principle. The researcher also knows about methodology for calculating costs of wastewater treatment and methods for determining rates of wastewater treatment charge. The reviews informed that, at this beginning stage, charging rates should be determined just to cover only the operation cost and the maintenance cost, and collecting charges at a fixed rate by considering quantity of used water and dirtiness of wastewater is fairer and better than other methods. For the charge calculation, BOD can be used as a parameter of dirtiness. From studying other relevant researches, the researcher learns about economical tools and solutions that are appropriate for managing or reducing pollution. Those studies also inform that most people express attitudes and opinions in favor of the Polluters Pay Principle, and they agree to the principle that people who cause more pollution should pay more. The researcher also knows that factors affecting willingness to pay for wastewater treatment of people were rate of wastewater treatment charges, format of collecting the charges, type of buildings, family income, and education of the payers for the treatment system. Henceforth, the researcher can use knowledge from the literature reviews to efficiently support the study on rates of wastewater treatment charges for marine shrimp farming in areas around the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province.

CHAPTER III
RESEARCH METHODOLOGY

The research on rates of wastewater treatment charges for marine shrimp farming around the area of the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province is a quantitative and qualitative study. The research emphasizes on studying operation cost and maintenance cost of wastewater collection and treatment system for marine shrimp farming activities, quantity of wastewater and drained water from marine shrimp farms that can be used for determining rates of the wastewater treatment charge system that is most appropriate for marine shrimp farming activities, as well as solutions, strategies, and mechanism to motivate farmers so that the wastewater treatment charge system can be applied to marine shrimp farming activities efficiently. Secondary data were collected using questionnaires, while primary data were studied by having in-depth interviews with farmers. Data analysis for this study was based on the framework of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) and the Polluters Pay Principle (PPP).

By conducting the research using both quantitative and qualitative methodology, this study has obtained data about operation cost and maintenance cost of the Project's wastewater collection and treatment system, and quantity of wastewater and drained water from marine shrimp farms, which are highly useful in providing answers to the research. Procedures for the study were set up as the following.

1. Define population and select samples.
2. Prepare tools for the research.
3. Test to validate the questionnaires.
4. Collect data.
5. Analyze data statistically.

3.1 Population and samples

Population and samples This research was conducted with the population of people who are associated with the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Klongkhud, Thamai District, Chantaburi Province. There were 200 samples in total, which were 198 shrimp farmers who have farms around the area of the Project, and 2 officers of the Project.

3.2 Research tools

For this research, the researcher has created questionnaires to conduct in-depth interviews with the samples. From reviewing literatures and relevant researches, the obtained knowledge was used to create two sets of in-dept interviewing questionnaires with the following details.

3.2.1 In-depth interviewing questionnaire for the Project's officers

This questionnaire was used to conduct in-depth interview with the Project's officers who work on wastewater collection and treatment system. The questionnaire asked about operation cost and maintenance cost of the wastewater collection and treatment system to get some useful information for determining appropriate rates of wastewater treatment charges. Details in the questionnaire are explained below.

The in-depth interviewing questionnaire for the Project's officers comprises 4 parts namely:

Part 1. Questions about general information of the Project

Part 2. Questions about the Project's wastewater collection and treatment system, operational process of the wastewater treatment system, quantity of wastewater that come to the wastewater collection and treatment system, service area of the wastewater collection and treatment system, and number of users of the wastewater collection and treatment system

Part 3. Questions about costs and expenses for operationing and maintaining the wastewater collection and treatment system, including sources of budgets used for contructing, operating, and maintaining the wastewater collection and treatment system

Part 4. Questions about problems or obstructions concerning the wastewater collection and treatment system

3.2.2 In-depth interviewing questionnaires for shrimp farmers

This questionnaire was used with shrimp farmers in the study area. Details in the questionnaire are explained below.

The in-depth interviewing questionnaire for the shrimp farmers comprises 4 parts namely:

Part 1. Questions about general information of shrimp farmers

Part 2. Questions about their water-use behaviors and quantity of their wastewater

Part 3. Questions about costs and expenses involving marine shrimp farming and profits from marine shrimp farming that farmers receive for each crop of shrimps

Part 4. Questions about ability and willingness to pay for wastewater treatment service charge, together with problems, obstructions, and suggestions regarding wastewater treatment charges.

3.3 Testing and validating the questionnaires

Prior to using the in-depth interviewing questionnaires with the samples, the researcher had used the questionnaires to conduct a pre-test study with a group of shrimp farmers. The questionnaires were modified for completion and readiness before being used with the real samples for data collection.

3.4 Data collection

This research collected data by using the in-depth interviewing questionnaires to ask for useful information from the samples of shrimp farmers in areas around Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province. In addition to interviewing, some more information was collected by observation, and wastewater samples were also collected for analysis to check their quality in the laboratory. All the collected data and information from the questionnaires, interviews, observations, and wastewater quality analyses were reviewed to ensure the accuracy and completion.

3.4.1. Collection of Secondary Data

The secondary data used in this research were collected from technical journals, documents, and researches from some relevant governmental and private organizations in order to obtain efficient and reliable information. Details about collection of the secondary data are given below.

1) Reviewing secondary data about general characteristics of the study area, formats of marine shrimp farming activities, effects from the activities, management and treatment of wastewater from the activities

2) Reviewing secondary data about the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), the Environmental Quality Management Plan for the year 2007-2011, types of economical tools, utilization of economical tools for managing natural resources and environment in Thailand, and economics concerning environmental management

3) Reviewing secondary data about details of solutions, regulations, and laws concerning management and control of pollution from marine shrimp farming activities

4) Reviewing relevant literatures and researches

3.4.2 Collection of Primary Data The primary data for this research were collected from field work by using the in-depth interviewing questionnaires to conduct interviews with an officer of the Project and the samples of all 3 groups of shrimp farmers in the Project's area. Contents on the interviews emphasize on wastewater

from marine shrimp farming activities, quantity of wastewater/drained water of the farmers, operation cost and maintenance cost of the wastewater collection and treatment system, and willingness to pay for wastewater treatment charge of farmers. Data from the interviews were collected for analysis in order to be used for calculating rates of wastewater treatment charges.

3.5 Data analysis

3.5.1 Data analysis with Descriptive Method

Descriptive method was used for analyzing general information regarding the Project's wastewater collection and treatment system, operational process of the wastewater treatment system, service area for wastewater treatment, number of users of the wastewater collection and treatment system, sources of budgets for constructing, operating and maintaining the wastewater collection and treatment system, as well as problems and obstructions concerning the wastewater collection and treatment system. Results were concluded descriptively.

3.5.2 Data analysis with Qualitative Method

Qualitative method was used for analyzing data regarding quality of wastewater that were obtained from analyzing samples collected from shrimp farms and also data obtained from archived data of the Project's database (data older than one year). The collected samples of wastewater from shrimp farms were analyzed in the laboratory for BOD measurement. Results were summarized based on qualitative information of the data.

3.5.3 Data analysis with Quantitative Method

Quantitative method was used to analyze collected data from in-depth interviews regarding quantity of wastewater and drained water from marine shrimp farming activities. Quantitative data used for the analysis are listed below.

1) Quantity of wastewater/drained water from shrimp farms and quantity of wastewater/drained water entering the wastewater collection and treatment system

2) Costs and expenses for operating and maintaining the Project's wastewater collection and treatment system, together with profits from marine shrimp farming that the farmers receive from each crop of shrimps

3) Conclusive results about willingness to pay for wastewater treatment charge of farmers that show the amount of money that farmers are willing to pay for the charge

4) Calculated wastewater treatment service charge that is appropriate for shrimp farming activities

CHAPTER IV
RESULTS AND DISCUSSION

The research on rates of wastewater treatment charges for marine shrimp farms around the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Klongkhud, Thamai District, Chantaburi Province can divide the study results into 3 main parts as the following.

Part 1 of the study results contains results concerning the Project namely general characteristics of the Project, general information of the Project's wastewater collection and treatment system, costs and expenses for operating and maintaining the wastewater collection and treatment system, as well as problems and obstructions regarding the wastewater collection and treatment system.

Part 2 of the study results is about marine shrimp farmers, namely general characteristics of the farmers, water-use behaviors, quantity of their wastewater, costs and expenses for marine shrimp farming, ability and willingness to pay for wastewater treatment charges, as well as their problems, obstructions, and suggestions regarding wastewater treatment charges.

This part is for obtaining information about operation cost and maintenance cost of wastewater collection and treatment system as well as estimates of wastewater quantity produced from marine shrimp farming activities.

Part 3 of the study results is about capability and willingness to pay for wastewater treatment charge as well as appropriate rate of wastewater treatment charge for shrimp farming activities.

4.1 Part 1. Study results about the Project

For the 2008 fiscal year, the total number of marine amimal farmers inside and outside the responsible area of the Project was 229 individuals, and number of culturing ponds was 495 ponds locating in a total area of 1,041.48 rai. Inside the

responsible area of the Project, there were 112 farmers, with a total number of 257 ponds (as shown in Figure 4-2) locating in a total area of 559.68 rai. Outside the Project's area, there were 117 farmers, with a total number of 238 ponds (Figure 4-3) locating in a total area of 481.8 rai.

The Farmers Group has a total number of 198 members. Among the Group's members, 112 farmers inside the Project's area, owning farms in a total area of 559.68 rai, had land title documents. Number of the Group's members outside the Project's area was 86 farmers, doing farms in a total area of 479.60. All members of the Group take part in paying for water usage service charges.

During the 2008 fiscal year, the Farmers Group collected money from its members at a rate of 1,200 baht/rai/crop, giving a total sum of 1,572,040 baht. The Group used the income from water pump service charge for its administration and management of the saltwater irrigation project and for maintenance cost of equipments.

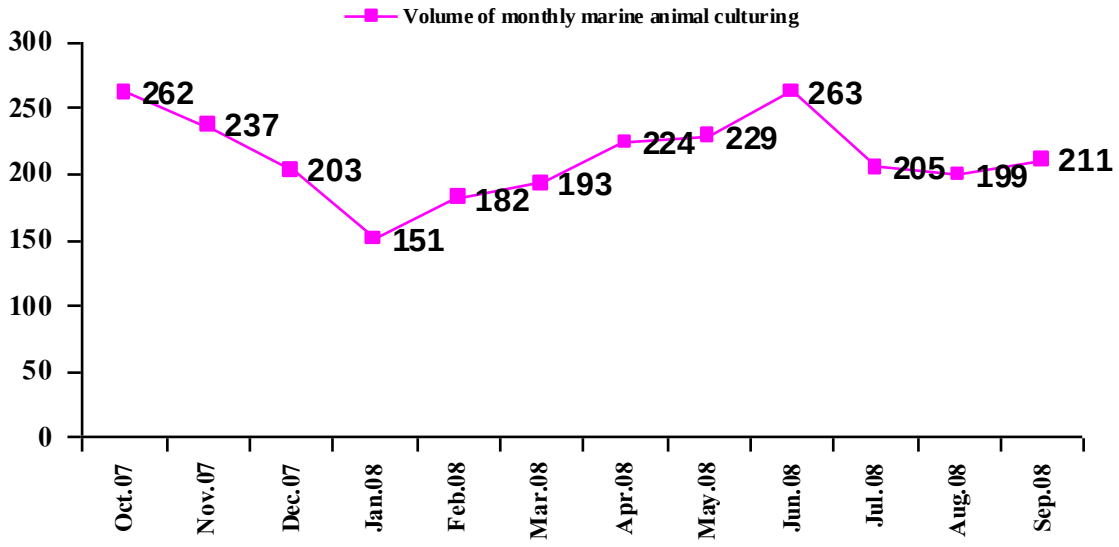

Figure 4-1 Graph of monthly marine animal culturing of 495 ponds inside and outside the Project's area

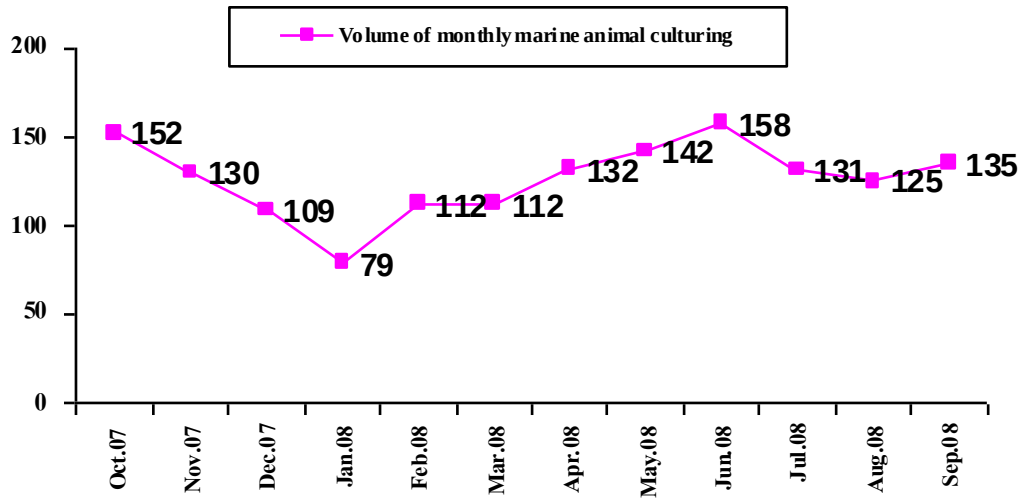

Figure 4-2 Graph of monthly marine animal culturing of 257 ponds inside the Project's area

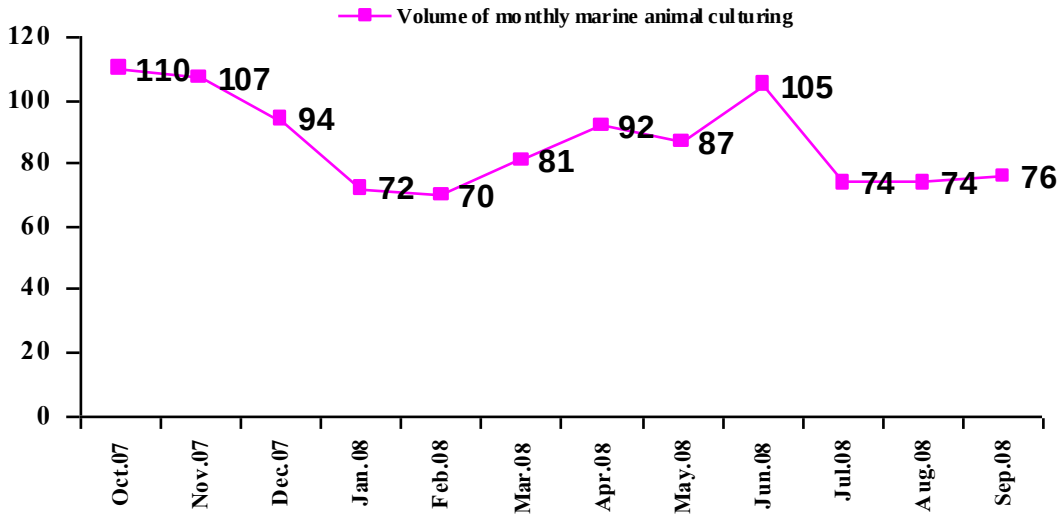

Figure 4-3 Graph of monthly marine animal culturing of 238 ponds outside the Project's area

4.1.2 Pattern of the saltwater irrigation system

The system of saltwater irrigation for shrimp farming in Kung Krabaen Bay has a pattern that is suitable for shrimp farming activities that can collect water from shrimp farms, treat wastewater for better quality, and drain the treated water into Kung Krabaen Bay. Details on construction of the system are as the following.

1) Seawater irrigation system

Pipes for receiving seawater The system uses High Density Polyethylene Pipes (HDPE) pipes, each with 1.00 meter in diameter, arranging in 6 rows, bringing saltwater 350 meters away from the coast into the building of the water pump machines.

The building of water pump machines This building is built with reinforced concrete.It has a function to pump seawater from the ocean. It can store seawater in its underground storage, with 11.50 meter depth from the ground surface. It is capable to handle about 4,650.00 cubic meter of seawater. It has eight 200-horsepower pump machines. Each machine can drain water about 1.25 cubic meter per second through two 1-meter-diameter HDPE pipes into the 3,000-cubic-meter water storage pond.

Figure 4-4 The building of water pump machines of the seawater irrigation system for marine shrimp farming in Kung Krabaen Bay

Irrigation canals Irrigation canals that bring water into shrimp farms around Kung Krabane Bay are made of concrete. They have a total length of 8,820 meters, carrying water from the storage pond to shrimp farms by using the force of earth gravity. The main canal (M line), measuring 12 meters in width and 6,620 meters in length, brings water to farmers in the upper part (north) of the Project. The middle canal (IR line), measuring 8 meters in width and 1,620 meters in length, brings water to all

farmers in the central part of the Project. The sub canals (IR – IR line), measuring 5 meters in width and 580 meters in length, holds water and drains water to farmers in the lower part (south) of the Project. There are also minor canals that are maintained by farmers in order to carry water from big canals into their own farms.

Figure 4-5 Irrigation canals that carry saltwater from the irrigation system for shrimp farms around the Kung Krabaen Bay

Wastewater treatment system

The Project's wastewater treatment system uses natural techniques for treating the wastewater so that the water drained to the environment will be safe for organisms in the water source. Process of the treatment system can be explained below.

1. Wastewater from shrimp farms is stored in farmers' mud-holding ponds, where sediments deposit. Later the remaining clear wastewater will flow into "treatment canal" of the Project.

2. The system fills air into the "treatment canal" by using 24 sets of 5-horsepower aerators arranging along the canals, this is physical treatment approach. Biological treatment approach is also used to enhance efficiency and ensure that the water will be treated to meet required standards before it will be drained through "sediment canal" and reach the Kung Krabaen Bay eventually.

3. The "sediment canal" plays a role in treating drained water that has already been filled air by aerators. This canal stores water so that sediments gradually deposit. The treatment system also has biological treatment by using shellfish, seagrass, and seaweed, which are grown along the canal. These techniques are natural approaches that can treat water so that its quality is suitable for living organisms before draining through mangrove forest into the Kung Krabaen Bay.

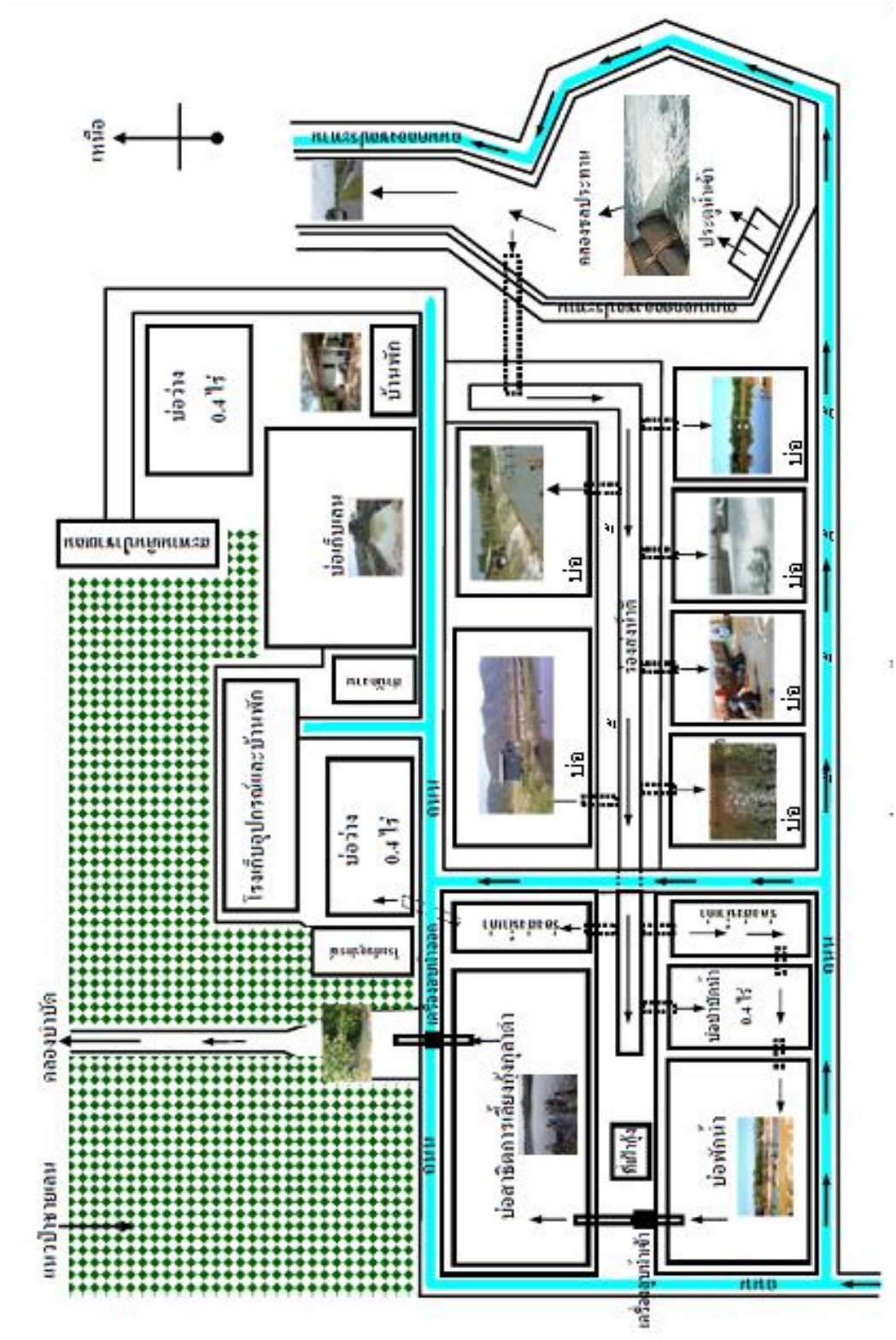

Figure 4-6 Seawater irrigation system and wastewater treatment system of the Project.

4.1.3 Water quality in the Project's area

Water quality in area around the Kung Krabaen Bay Royal Development Study Center Project was studied by randomly collecting water samples from 5 areas namely near the wastewater drainage canal (Points No. 14-19), near the coast (Points No. 1 – 8), 500 meters away from the coast (Points No. 9 – 11 and No. 20 - 23), 1000 meters away from the coast (Point No. 13), and near the bay's mouth (Point No. 12), as shown in Figure 11, from October 2007 – September 2008. The study results were as the following.

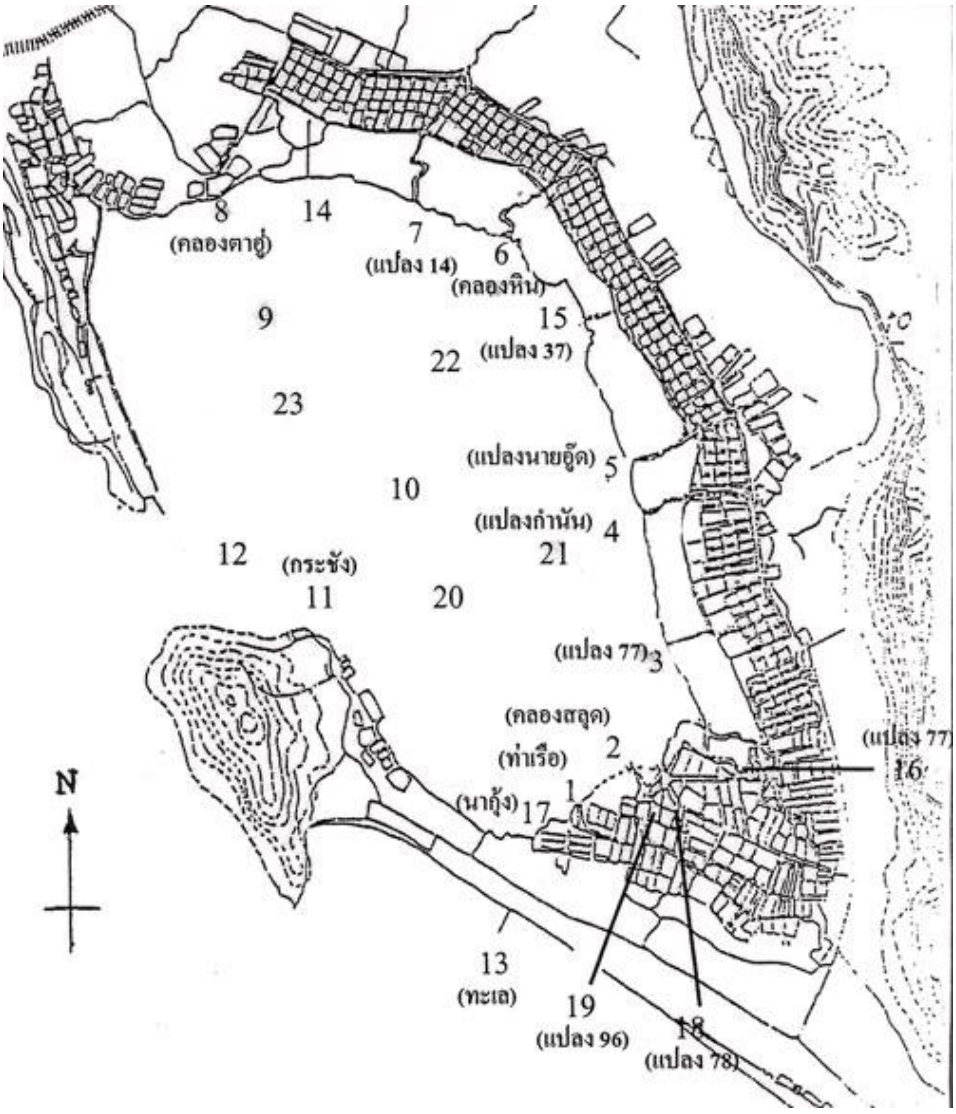

Figure 4-7 Locations of points where water samples were collected around Kung Krabane Bay

1) In the area near wastewater drainage canal, it was found that water **salinity** averaged 30.33 ppt, with a peak in March 2008 (36 ppt), and the minimum value in August and September of 2008 (24 ppt). Average **temperature** was 28.58 degree celcius, with the maximum of 32 degree celcius in April and May 2008, and minimum of 23 degree celcius in August 2008. For **pH** value, the average was 8.2, maximum was 8.4 in June, July, and August 2008, and minimum was 7.9 in February. Regarding **sediment**, the average was 15.97 mg/l, maximum was 31.56 mg/l in May 2008, and minimum was 7.18 mg/l in January. Regarding **Biochemical Oxygen Demand** (BOD), the average was 1.58 mg/l, maximum was 2.7 mg/l in November 2007, and minimum was 0.7 mg/l in January 2008. For **ammonia**, the average was 0.14 mg/l, maximum was 0.3837 mg/l in September 2008, and minimum was 0.005 mg/l in August 2008. For **total nitrogen**, the average was 0.65 mg/l, maximum was 1.24 mg/l in September 2008, and minimum was 0.21 mg/l in January 2008. Regarding **total phosphorus**, the average was 0.06 mg/l, maximum was 0.1262 in October 2007, and minimum was 0.03 mg/l in December 2007 (Details are shown in Table 4-1)

Table 4-1 Water quality in wastewater drainage canal, from October 2007 to September 2008

Month/Year	Salinity (ppt)	Temp. (^{0}C)	pH	Sediment (mg/l)	BOD (mg/l)	Ammonia (mg/l)	Total N (mg/l)	Total P (mg/l)
Oct 2007	26	28	8.1	18.06	1.5	0.1532	0.67	0.1262
Nov 2007	35	28	8.0	14.73	2.7	0.2792	0.85	0.0769
Dec 2007	33	28	8.1	8.92	1.1	0.0676	0.26	0.0300
Jan 2008	35	28	8.2	7.18	0.7	0.0347	0.21	0.0320
Feb 2008	35	26	7.9	9.60	1.1	0.2262	0.59	0.0380
Mar 2008	36	26	8.2	7.66	1.1	0.2067	0.29	0.0358
Apr 2008	34	32	8.2	14.34	1.2	0.1389	0.56	0.0564
May 2008	29	32	8.2	31.56	1.6	0.1732	0.91	0.0686
Jun 2008	27	31	8.4	14.42	1.5	0.0079	0.62	0.0304
Jul 2008	26	31	8.4	13.74	1.8	0.0176	0.70	0.056
Aug 2008	24	23	8.4	22.85	2.1	0.0050	0.94	0.0616
Sept 2008	24	30	8.3	28.60	2.5	0.3837	1.24	0.0723
Total	364	343	98.4	191.66	18.9	1.6939	7.84	0.6842
Maximum	36	32	8.4	31.56	2.7	0.3837	1.24	0.1262
Minimum	24	23	7.9	7.18	0.7	0.0050	0.21	0.0300
Average	30.3	28.6	8.2	15.97	1.6	0.1412	0.65	0.0570
Standard	-	-	6.5-9.0	Less than 70	Less than 20	Less than 1.1	Less than 4.0	Less than 0.4

2) For water samples from area near the coast, water **salinity** averaged at 30.7 ppt, with a maximum of 36 ppt in November 2007 and March 2008, and a minimum of 23 ppt in September 2008. Regarding **temperature**, the average was 29.2 degree celcius, maximum was 32 degree celcius in April, May, and August 2008, and minimum was 26 degree celcius in March 2008. Regarding **pH**, the average was 8.2, maximum was 8.4 in August 2008, and minimum was 8.0 in February 2008. Regarding **sediment**, the average was 14.06 mg/l, maximum was 23.4 mg/l in August 2008, and minimum was 7.15 mg/l in January 2008. Regarding **BOD**, the average was 1.3 mg/l, maximum was 2.0 mg/l in November 2007, and minimum was 0.3 mg/l in August 2008. Regarding **ammonia**, the average was 0.0674 mg/l, maximum was 0.1701 mg/l in February 2008, and minimum was 0.0045 mg/l in July 2008. Regarding **total nitrogen**, the average was 0.48 mg/l, maximum was 1.02 mg/l in May 2008, and minimum was 0.18 in January 2008. Regarding **total phosphorus**, the average was 0.0428 mg/l, maximum was 0.1075 mg/l in October 2007, and minimum was 0.0048 mg/l in September 2008 (Details are shown in Table 4-2).

Table 4-2 Water quality in area near the coast from October 2007 to September 2008

Month/Year	Salinity (ppt)	Temp. (^{0}C)	pH	Sediment (mg/l)	BOD (mg/l)	Ammonia (mg/l)	Total N (mg/l)	Total P (mg/l)
Oct 2007	27	29	8.1	20.63	1.4	0.1061	0.6	0.1075
Nov 2007	36	28	8.2	13.19	1.8	0.0924	0.55	0.0669
Dec 2007	33	29	8.2	10.15	0.9	0.0424	0.20	0.0257
Jan 2008	35	28	8.2	7.15	0.3	0.0181	0.18	0.0239
Feb 2008	35	26	8.0	11.60	0.9	0.1701	0.38	0.0285
Mar 2008	36	26	8.2	7.35	1.8	0.0345	0.34	0.0410
Apr 2008	33	32	8.3	15.46	1.0	0.0610	0.51	0.0598
May 2008	29	32	8.2	21.63	1.2	0.1219	1.02	0.0739
Jun 2008	27	31	8.3	9.44	0.9	0.0073	0.40	0.0262
Jul 2008	29	30	8.3	9.97	1.3	0.0045	0.32	0.0137
Aug 2008	25	32	8.4	23.40	2.0	0.0126	0.49	0.0419
Sept 2008	23	27	8.2	18.70	1.8	0.1383	0.76	0.0048
Total	368	350	98.6	168.67	15.3	0.8092	5.75	0.5138
Maximum	36	32	8.4	23.4	2	0.1701	1.02	0.1075
Minimum	23	26	8.0	7.15	0.3	0.0045	0.18	0.0048
Average	30.7	29.2	8.2	14.06	1.3	0.0674	0.48	0.0428
Standard	-	-	6.5-9.0	Less than 70	Less than 20	Less than 1.1	Less than 4.0	Less than 0.4

3) For water samples from area 500 meters away from the coast, water **salinity** averaged at 31.8 ppt, with a maximum of 35 ppt in November 2007 and a minimum of 27 ppt in June 2008. Regarding **temperature**, the average was 29.2 degree celcius, maximum was 30 degree celcius in May, June, July, August, and September 2008, and minimum was 26 degree celcius in March 2008. Regarding **pH**, the average was 8.3, maximum was 8.4 in November 2007, and minimum was 8.2 in February, March, April, and May 2008. Regarding **sediment**, the average was 10.55 mg/l, maximum was 21.38 mg/l in August 2008, and minimum was 3.40 mg/l in March 2008. Regarding **BOD**, the average was 0.7 mg/l, maximum was 1.2 mg/l in September 2008, and minimum was 0.3 mg/l in January 2008. Regarding **ammonia**, the average was 0.0583 mg/l, maximum was 0.1772 mg/l in March 2008, and minimum was 0.0000 mg/l in July and August 2008. Regarding **total nitrogen**, the average was 0.20 mg/l, maximum was 0.39 mg/l in April 2008, and minimum was 0.05 mg/l in November 2007. Regarding **total phosphorus**, the average was 0.0237 mg/l, maximum was 0.0419 mg/l in May 2008, and minimum was 0.0075 mg/l in June 2008 (Details are shown in Table 4-3).

Table 4-3 Water quality in area 500 meters from the coast, Oct 2007 - Sept 2008

Month/Year	Salinity (ppt)	Temp. (^{0}C)	pH	Sediment (mg/l)	BOD (mg/l)	Ammonia (mg/l)	Total N (mg/l)	Total P (mg/l)
Oct 2007	30	30	8.3	11.30	0.5	0.0490	0.09	0.0297
Nov 2007	35	29	8.4	7.67	0.8	0.0241	0.05	0.0269
Dec 2007	33	29	8.3	8.00	0.6	0.0462	0.11	0.0216
Jan 2008	34	29	8.3	5.17	0.3	0.0202	0.12	0.0246
Feb 2008	35	27	8.2	12.38	0.7	0.1283	0.16	0.0205
Mar 2008	35	26	8.2	3.40	0.6	0.1772	0.17	0.0249
Apr 2008	34	30	8.2	6.17	0.7	0.1283	0.39	0.0277
May 2008	30	30	8.2	20.39	0.9	0.0400	0.32	0.0419
Jun 2008	27	30	8.3	8.00	0.4	0.0012	0.16	0.0075
Jul 2008	31	30	8.3	9.04	0.9	0.0000	0.19	0.0124
Aug 2008	29	30	8.3	21.38	0.8	0.0000	0.29	0.0272
Sept 2008	28	30	8.3	13.71	1.2	0.0854	0.30	0.0190
Total	381	350	99.3	126.61	8.4	0.6999	2.35	0.2839
Maximum	35	30	8.4	21.38	1.2	0.1772	0.39	0.0419
Minimum	27	26	8.2	3.4	0.3	0.0000	0.05	0.0075
Average	31.8	29.2	8.3	10.55	0.7	0.0583	0.20	0.0237
Standard	-	-	6.5-9.0	Less than 70	Less than 20	Less than 1.1	Less than 4.0	Less than 0.4

4) For water samples from area 1,000 meters away from the coast, water **salinity** averaged at 32 ppt, with a maximum of 35 ppt in November 2007, February 2008, and March 2008, and a minimum of 27 ppt in June 2008. Regarding **temperature**, the average was 29.2 degree celcius, maximum was 31 degree celcius in April 2008, and minimum was 26 degree celcius in February and March 2008. Regarding **pH**, the average was 8.3, maximum was 8.4 in November 2007, and minimum was 8.2 in February and July 2008. Regarding **sediment**, the average was 11.03 mg/l, maximum was 23.61 mg/l in May 2008, and minimum was 4.87 mg/l in June 2008. Regarding **BOD**, the average was 0.6 mg/l, maximum was 1.1 mg/l in July 2008, and minimum was 0.2 mg/l in January 2008. Regarding **ammonia**, the average was 0.0500 mg/l, maximum was 0.1768 mg/l in March 2008, and minimum was 0.0000 mg/l in July and August 2008. Regarding **total nitrogen**, the average was 0.13 mg/l, maximum was 0.23 mg/l in August 2008, and minimum was 0.05 mg/l in October 2008. Regarding **total phosphorus**, the average was 0.0237 mg/l, maximum was 0.0584 mg/l in October 2007, and minimum was 0.0049 mg/l in July 2008 (Details are shown in Table 4-4).

Table 4-4 Water quality in area 1,000 meters from the coast, Oct 2007 - Sept 2008

Month/Year	Salinity (ppt)	Temp. (^{0}C)	pH	Sediment (mg/l)	BOD (mg/l)	Ammonia (mg/l)	Total N (mg/l)	Total P (mg/l)
Oct 2007	31	30	8.3	5.87	0.4	0.0149	0.05	0.0584
Nov 2007	35	30	8.4	7.00	0.8	0.0290	0.06	0.0250
Dec 2007	33	30	8.3	11.80	0.7	0.0119	0.1	0.0207
Jan 2008	34	29	8.3	8.47	0.2	0.0339	0.09	0.0251
Feb 2008	35	26	8.2	18.41	0.3	0.0763	0.13	0.0253
Mar 2008	35	26	8.3	7.20	0.5	0.1768	0.12	0.0181
Apr 2008	34	31	8.3	5.80	0.5	0.0988	0.15	0.0175
May 2008	30	30	8.3	23.61	0.5	0.0348	0.17	0.0292
Jun 2008	27	30	8.3	4.87	0.5	0.0006	0.17	0.0088
Jul 2008	32	29	8.2	7.73	1.1	0.0000	0.12	0.0049
Aug 2008	30	30	8.3	19.73	0.3	0.0000	0.23	0.0260
Sept 2008	28	29	8.3	11.86	1.0	0.1224	0.21	0.0248
Total	384	350	99.5	132.35	6.8	0.5994	1.6	0.2838
Maximum	35	31	8.4	23.61	1.1	0.1768	0.23	0.0584
Minimum	27	26	8.2	4.87	0.2	0.0000	0.05	0.0049
Average	32	29.2	8.3	11.03	0.6	0.0500	0.13	0.0237
Standard	-	-	6.5-9.0	Less than 70	Less than 20	Less than 1.1	Less than 4.0	Less than 0.4

5) For water samples from area near the bay's exit, water **salinity** averaged at 31.9 ppt, with a maximum of 35 ppt in November 2007 and January, February, and March 2008, and a minimum of 27 ppt in June 2008. Regarding **temperature**, the average was 29.3 degree celcius, maximum was 31 degree celcius in April 2008, and minimum was 26 degree celcius in February and March 2008. Regarding **pH**, the average was 8.3, maximum was 8.4 in November 2007, and minimum was 8.0 in July 2008. Regarding **sediment**, the average was 10.37 mg/l, maximum was 22.16 mg/l in August 2008, and minimum was 3.10 mg/l in June 2008. Regarding **BOD**, the average was 0.5 mg/l, maximum was 0.9 mg/l in December 2007, and minimum was 0.2 mg/l in January, March, and August 2008. Regarding **ammonia**, the average was 0.0302 mg/l, maximum was 0.1509 mg/l in February 2008, and minimum was 0.0000 mg/l in November 2007, May, June, July, and September 2008. Regarding **total nitrogen**, the average was 0.17 mg/l, maximum was 0.51 mg/l in April 2008, and minimum was 0.06 in October 2008. Regarding **total phosphorus**, the average was 0.0246 mg/l, maximum was 0.0509 mg/l in February 2008, and minimum was 0.0087 mg/l in March 2008 (Details are shown in Table 4-5).

Table 4-5 Water quality in area near the bay's exit, from October 2007 to September 2008

Month/Year	Salinity (ppt)	Temp. (^{0}C)	pH	Sediment (mg/l)	BOD (mg/l)	Ammonia (mg/l)	Total N (mg/l)	Total P (mg/l)
Oct 2007	33	30	8.3	7.30	0.5	0.0148	0.06	0.0174
Nov 2007	35	30	8.4	5.80	0.3	0.0000	0.07	0.0115
Dec 2007	32	29	8.3	11.80	0.9	0.0238	0.15	0.0117
Jan 2008	35	29	8.3	5.60	0.2	0.0119	0.26	0.0324
Feb 2008	35	26	8.2	21.80	0.3	0.1509	0.14	0.0509
Mar 2008	35	26	8.3	5.00	0.2	0.0086	0.10	0.0087
Apr 2008	33	31	8.3	6.10	0.8	0.1230	0.51	0.0299
May 2008	30	30	8.3	20.17	0.7	0.0000	0.14	0.0365
Jun 2008	27	30	8.3	3.10	0.5	0.0000	0.16	0.0148
Jul 2008	30	30	8.0	8.30	0.8	0.0000	0.11	0.0292
Aug 2008	30	30	8.3	22.16	0.2	0.0297	0.15	0.0262
Sept 2008	28	30	8.3	7.30	0.8	0.0000	0.17	0.0258
Total	383	351	99.3	124.43	6.2	0.3627	2.02	0.295
Maximum	35	31	8.4	22.16	0.9	0.1509	0.51	0.0509
Minimum	27	26	8.0	3.10	0.2	0.0000	0.06	0.0087
Average	31.9	29.3	8.3	10.37	0.5	0.0302	0.17	0.0246
Standard	-	-	6.5-9.0	Less than 70	Less than 20	Less than 1.1	Less than 4.0	Less than 0.4

Study results about hours of water pumping, volume of pumped water, and volume of drained water from marine animal farming using irrigation system of the Project, both inside and outside the Project's area, during October 2007 to September 2008, showed that total number of working hours of the pump machines was 4,355 hours, total volume of annual pumped water was 19,564,725 cubic meters, total volume of drained water was 13,695,308 cubic meters, and volume of drained water per rai was 13,178 cubic meters. Details are shown in Table 4-6.

Table 4-6 Hours of water pumping, volume of pumped water, and volume of drained water

Date	Number of hours of water pumping (hours)	Volume of pumped water (cubic meter)	Volume of drained water (cubic meter)	Volume of drained water per rai (cubic meter)
Oct 2007	503	2,265,750	1,586,025	1,526
Nov 2007	399	1,797,750	1,258,425	1,211
Dec 2007	227	1,249,125	874,388	841
Jan 2008	432	1,946,625	1,362,638	1,311
Feb 2008	341	1,244,250	870,975	838
Mar 2008	381	1717,125	1,201,988	1,157
Apr 2008	367	1,653,000	1,157,100	1,113
May 2008	335	1,512,750	1,058,925	1,019
Jun 2008	327	1,476,750	1,033,725	995
Jul 2008	321	1,448,250	1,013,775	975
Aug 2008	386	1,739,475	1,217,633	1,172
Sept 2008	336	1,513,875	1,059,713	1,020
Total	**4,355**	**19,564,725**	**13,695,308**	**13,178**

Costs for operating and maintaining the wastewater treatment system

The study results about costs for operating and maintaining the Project's wastewater treatment system, comprising wages of employees, electricity for operating the system and water pump machines, and repair costs, inside and outside the Project's area during October 2007 to September 2008, found that the total yearly cost for operating and maintaining the wastewater treatment system was 2,672,477baht.

This amount can be classified into 1) wages for employees for 330,130 baht, 2) electricity for water pump machines for 1,821,755 baht, 3) electricity for treatment system for 344,435 baht, and 4) maintenance and reparing for 176,159 baht. Details are shown in Table 4-7.

Table 4-7 Costs for operating and maintaining the wastewater treatment system

Date	Wages for employees (baht)	Electricity		Maintenance cost (baht)
		For pumping water (baht)	For water treatment (baht)	
Oct 2007	27,290	171,998	21,783	7,260
Nov 2007	27,290	169,395	37,050	6,845
Dec 2007	27,290	146,435	29,992	14,120
Jan 2008	27,290	148,881	29,748	13,817
Feb 2008	27,290	161,716	17,539	4,530
Mar 2008	27,290	164,349	27,283	16,745
Apr 2008	27,290	176,077	19,058	10,280
May 2008	27,820	141,053	24,781	23,510
Jun 2008	27,820	118,335	38,537	8,182
Jul 2008	27,820	135,462	32,697	22,490
Aug 2008	27,820	141,379	32,581	12,560
Sept 2008	27,820	146,673	33,386	35,820
Total	**330,130**	**1,821,755**	**344,435**	**176,159**
Grand total	**2,672,477 baht**			

Administration of the Project

The center has been working to make all farmers using water from the saltwater irrigation system to become members, in order to be beneficial for the administration of the irrigation project for shrimp farming in Kung Krabaen Bay in the future. The center has registered the group of farmers with the Chantaburi Province administration under the name of "Group of Marine Animal Farmers in Kung Krabaen Bay Using Saltwater Irrigation System". The Group currently has members from inside the Project's area and nearby area, accounting for 198 members in total.

From 1982 to 1984, the first two years that the Project of Fishery Development Center in Kung Krabaen Bay was taken care by the Fisheries Department, who had supported the Project in several aspects and collected data in all aspects such as facility cost, maintenance cost, yield of shrimps, income of farmers, etc. These data are used for analyzing operation of the Project, and can also be criteria for the Group of Marine Animal Farmers in Kung Krabaen Bay Using Saltwater Irrigation System to use for collecting water service charges from its members.

One year later, in 1985, the Group of Marine Animal Farmers in Kung Krabaen Bay Using Saltwater Irrigation System had to take over the responsibility for administering the saltwater irrigation project for shrimp farming from the Project of Fishery Development Center in Kung Krabaen Bay after 2 years had passed. However, the Center still gave technical support and advice to this group of farmers so that they achieve the objective to maintain sustainability of marine shrimp farming.

4.2 Part 2. Study results about shrimp farmers

1. General characteristics of shrimp farmers

1.1 Education level

Table 4-8 Number and percentage of farmers classified by education levels

Education level	Number	Percentage
Primary education	145	72.5
Secondary education	41	20.5
Diploma	6	3
Bachelor’s degree	8	4
Total	**200**	**100.00**

From Table 4-8, it was found that most farmers had primary education, accounted for 72.5%, followed by secondary education, Bachelor’s degree, and diploma, accounted for 20.5%, 4%, and 3% respectively.

1.2 Main occupation

Table 4-9 Number and percentages of farmers classified by occupations

Occupation	Number	Percentage
Government/state	12	6
enterprise	7	3.5
Trader	181	90.5
Farmer		
Total	**200**	**100.00**

From Table 4-9, it was found that most farmers were farmers, accounted for 90.5%, followed by those who worked as governmental or state enterprise employees, accounted for 6%, and the least proportion of them were traders, accouted for 3.5%.

1.3 Domicile (Place of origin)

Table 4-10 Number and percentage of farmers classified by their domicile

Domicile	Number	Percentage
Native people	190	95
Moved from other	10	5
provinces		
Total	**200**	**100.00**

From Table 4-10, it was found that most farmers were native people of Chantaburi Province, accounted for 95%, while the other 5% of them came from other provinces.

2. Data about farming, water-use behaviors, and quantity of wastewater

Section 2.1. Data about farming

2.1. Types of marine animal farming

Table 4-11 Number and percentage of farmers classified by types of farmed marine animals

Types of farmed animals	Number	Percentage
White shrimps	159	79.5
Tiger shrimps	24	12
Fish	17	8.5
Total	**200**	**100.00**

From Table 4-11, it was found that most farmers grow white shrimps, accounted for 79.5%, followed by tiger shrimps and fish, accounted for 12% and 8.5% respectively.

2.2 Shrimp farming standards

Table 4-12 Number and percentage of farmers classified by shrimp farming standard

Shrimp farming standard	Number	Percentage
Having no standards	72	36
Having standard at GAP Level	117	58.5
Having GAP and CoC standards	11	5.5
Total	**200**	**100.00**

From Table 4-12, it was found that most farmers had only GAP standard, accounted for 58.5%. Farmers whose farms did not have any standards at all accounted for 36%. Farmers that had GAP and CoC standards accounted for 5.5%.

2.3 Methods of marine animal farming

Table 4-13 Number and percentage of farmers classified by methods of farming

Method of farming	Number	Percentage
Exchange water by using water from external water sources	200	100.00
Total	**200**	**100.00**

From Table 4-13, it was found that all farmers, 100%, did their farming by exchanging water with water from external water sources.

2.4 Size of farming ponds

Table 4-14 Number and percentage of farmers classified by sizes of farming ponds

Pond size	Number	Percentage
1-2 rai	47	23.5
2.1-3 rai	118	59
More than 3.1 rai	35	17.5
Total	**200**	**100.00**

From Table 4-14, it was found that most farmers had ponds at a size of 2.1-3 rai, accounted for 59%, followed by those who had ponds at a size of 1-2 rai and a size of 3.1 rai, accounted for 23.5% and 17.5% respectively. The average pond size was 2.44 rai.

2.5 Number, size, and usage of water suspended ponds

Table 4-15 Number and percentage of farmers classified by number, size, and usage of water suspended ponds

Number of water suspended ponds	**Number**	**Percentage**
No water suspended ponds	118	59
1-2 water suspended ponds	76	38
3-4 water suspended ponds	6	3
Total	**200**	**100.00**
Size of water suspended ponds	**Number**	**Percentage**
1-2 rai	182	91
3-4 rai	18	9
Total	**200**	**100.00**
Usage of water suspended ponds	**Number**	**Percentage**
No shrimp culturing in water suspended ponds	200	100
Total	**200**	**100.00**

From Table 4-15, it was found that most farmers did not have water suspended ponds, accounted for 59%, followed by those who had 1-2 water suspended ponds and 3-4 water suspended ponds, accounted for 38% and 3% respectively. Regarding size of water suspended ponds, most ponds' size was 1-2 rai, accounted for 91%, followed by the size of 3-4 rai, accounted for 9%. All farmers, 100%, do not culture shrimps in the water suspended ponds.

2.6 Duration of one farming crop

Table 4-16 Number and percentage of farmers classified by duration of one farming crop

Duration of one farming crop	Number	Percentage
3 months/1 crop	190	95
4 months/1 crop	10	5
Total	**200**	**100.00**

From Table 4-16, it was found that most farmers spent time for about 3 months per one crop of shrimps, accounted for 95%, while those who spent time for about 4 months per one crop accounted for only 5%.

2.7 Type and quantity of feed

Table 4-17 Number and percentage of farmers classified by type and quantity of feed

Type of feed	Number	Percentage
Pellet food	187	93.5
Fresh food	13	6.5
Total	**200**	**100.00**
Quantity of feed	**Number**	**Percentage**
Less than 100 kg/day	94	47
101-300 kg/day	106	53
Total	**200**	**100.00**

From Table 4-17, it was found that most farmers used pellet food to feed their shrimps, accounted for 93.5%, while those who used fresh food accounted for only 6.5%. Regarding quantity of feed, most farmers fed about 101-300 kg/day, accounted for 53%, while the other 47% fed less than 100 kg/day.

2.8 Density of shrimps

Table 4-18 Number and percentage of farmers classified by density of shrimps

Density of shrimps	Number	Percentage
Less than 300,000 shrimps/rai	8	4
300,001-500,000 shrimps/rai	25	12.5
500,001-1,000,000 shrimps/rai	145	72.5
Morethan 1,000,001 shrimps/rai	22	11
Total	**200**	**100.00**

From Table 4-18, it was found that most farmers grow shrimps with a density of 500,001-1,000,000 shrimps/rai, accounted for 72.5%, followed by density of 300,001-500,000 shrimps/rai, more than 1,000,001 shrimps/rai, and less than 300,000 shrimps/rai, accounted for 12.5%, 11%, and 4% respectively.

Section 2.2 Data about water usage, quantity of wastewater, and management of water and mud.

2.9 Source of water used for farming.

Table 4-19 Number and percentage of farmers classified by water sources for farming.

Water source used for farming	Number	Percentage
Use water from the saltwater irrigation system	200	100.00
Total	**200**	**100.00**

From Table 4-19, it was found that all farmers, 100%, used water from the saltwater irrigation system.

2.10 Format of bringing in water

Table 4-20 Number and percentage of farmers classified by methods of bringing water into farms

Method of brining in water	Number	Percentage
Through water pipes	196	98
Use water pumping machines	4	2
Total	**200**	**100.00**
Average volume of pumped water	**271 cubic meter/day**	

From Table 4-20, it was found that most farmers brought water into their farms by letting water flow through pipes, accounted for 98%, while farmers who used pumping machines to bring in water accounted for only 2%. Average volume of pumped water was found to be 271 cubic meter per day.

2.11 Method of water change

Table 4-21 Number and percentage of farmers classified by methods of water change

Format of water exchange	Number	Percentage
Change water during culturing and after catching shrimps	200	100.00
Total	**200**	**100.00**
Source that support drained water		
Treatment canal of the Project	200	100.00
Average volume of drained water	**162 cubic meter/day**	

From Table 4-21, it was found that all farmers, 100%, changed water during culturing shrimps and after catching shrimps. All of them used the Project's treatment canal as the receptor that support water drained from shrimp farms. Average volume of drained water was found to be 162 cubic meter per day.

2.12 Treatment of drained water

Table 4-22 Number and percentage of farmers classified by treatment of drained water.

Treatment of drained water	**Number**	**Percentage**
No treatment before draining	118	59
Use suspended ponds	82	41
Total	**200**	**100.00**
Source that support drained water	**Number**	**Percentage**
Treatment canal of the Project	200	100.00

From Table 4-22, it was found that most farmers do not treat their drainded water to improve water quality prior to drainage, accounted for 59%, while those who treated drained water by using suspended ponds accounted for 41%. Source that support 100 percent of all drained water was found to be the Project's treatment canal.

2.13 Mud management during culturing and after catching shrimps

Table 4-23 Number and percentage of farmers classified by mud management during culturing and after catching shrimps.

Mud management during culturing and after catching	**Number**	**Percentage**
Drain mud away from the pond	187	93.5
Do not drain mud from the pond	13	6.5
Total	**200**	**100.00**

From Table 4-23, it was found that most farmers drained mud away from the pond, accounted for 93.5%, while those who did not drain mud away accounted for 6.5%.

Section 3 Data about costs and income of farmers

3.1 Source of fund.

Table 4-24 Number and percentage of farmers classified by source of fund

Source of fund	Number	Percentage
Saving	178	89
Loan	22	11
Total	**200**	**100.00**
Average investment cost	**412,863 baht/pond**	

From Table 4-24, it was found that most farmers used their own saving to invest in shrimp farming, accounted for 89%, while the other 11% of them had to borrow from non-bank loaners. The average investment cost was found to be 412,863 baht per pond.

3.2 Number of crops per year.

Table 4-25 Number and percentage of farmers classified by number of shrimp crops per year.

Number of crops	Number	Percentage
1 crop per year	10	5
2 crops per year	32	16
3 crops per year	158	79
Total	**200**	**100.00**

From Table 4-25, it was found that most farmers cultured shrimps for 3 crops per year, accounted for 79%, followed by 2 crops per year and 1 crop per year, accounted for 16% and 5% respectively.

3.3 Yield from each crop.

Table 4-26 Number and percentage of farmers classified by yield from each crop.

Yield per each crop	Number	Percentage
Less than 500 kg	4	2
501-1,000 kg	13	6.5
1,001-1,500 kg	28	14
1,500-2,000 kg	46	23
2,001-3,000 kg	85	42.5
3,001-5,000 kg	24	12
More than 5,000 kg	2	1
Total	**200**	**100.00**

From Table 4-26, it was found that most farmers had a yield of shrimps from each crop for 2,001-3,000 kg, accounted for 42.5%, followed by yields of 1,500-2,000 kg/crop, 1,001-1,500 kg/crop, 3,001-5,000 kg/crop, 501-1,000 kg/crop, less than 500 kg/crop, and more than 5,000 kg/crop, accounted for 23%, 14%, 12%, 6.5%, 2%, and 1% respectively.

3.4 Average income from each crop of shrimp farming.

Table 4-27 Number and percentage of farmers classified by average income from each crop

Average income per each crop	Number	Percentage
Less than 50,000 baht/rai	4	2
50,000-100,000 baht/ rai	27	13.5
100,001-150,000 baht/ rai	34	17
More than 150,000 baht/ rai	135	67.5
Total	**200**	**100.00**

From Table 4-27, it was found that most farmers had average income from each crop of shrimp over 150,000 baht/rai, accounted for 67%, followed by average income of 100,001-150,000 baht/rai, 50,000-100,000 baht/rai, and less than 50,000 baht/rai, accounted for 17%, 13.5%, and 2% respectively.

Section 4 Data about ability to pay, willingness to pay, and farmers'attitude

4.1 Awareness about standards of wastewater from coastal marine animal culturing.

Table 4-28 Number and percentage of farmers classified by farmers' awareness about standards of wastewater from coastal marine animal culturing.

Awareness about standards of wastewater from coastal marine animal culturing	**Number**	**Percentage**
Aware	192	96
Not aware	8	4
Total	**200**	**100.00**

From Table 4-28, it was found that most farmers knew about standards regarding wastewater from marine amimal culturing, accounted for 96%, while the other 4% of them did not know about this.

4.2 Opinion about being charged for wastewater treatment

Table 4-29 Number and percentage of farmers classified by farmers' opinions about being charged for wastewater treatment.

Opinion about being charged for wastewater treatment	**Number**	**Percentage**
Agree	114	57
Not agree	86	43
Total	**200**	**100.00**

From Table 4-29, it was found that most farmers, 57% of them, expressed their agreement if the government will set up a policy to charge for wastewater treatment cost from farmers in order to have budget for improving water quality around the shrimp farming areas, while the other 43% did not agree.

4.3 Willingness to pay for wastewater treatment charges.

Table 4-30 Number and percentage of farmers classified by willing ness to pay for wastewater treatment charges.

Willingness to pay (baht/crop)	**Number**	**Percentage**
Less than 500 baht/crop	6	3
501-1,000 baht/crop	31	15.5
1,001-1,500 baht/crop	163	81.5
1,501-2,000 baht/crop	0	0
More than 2,001 baht/crop	0	0
Total	**200**	**100.00**
Maximum amount of willingness to pay (Max)	1,200 baht/crop	
Minimum amount of willingness to pay (Min)	500 baht/crop	
Average amount of willingness to pay	1,075 baht/crop	

From Table 4-30, it was found that most farmers were willing to pay for wastewater treatment charges for an amount of 1,001-1,500 baht/crop, accounted for 81.5%, followed by amounts of 501-1,000 baht/crop and less than 500 baht/crop, accounted for 15.5% and 3% respectively. Meanwhile, the maximum amount that farmers were willing to pay was 1,200 baht/crop, the minimum amount was 500 baht/crop, and the average amount was 1,075 baht/crop.

4.4 Methods for collecting wastewater treatment charges.

Table 4-31 Number and percentage of farmers classified by methods for collecting wastewater treatment charges.

Method for collecting wastewater treatment charges	**Number**	**Percentage**
Charge according to the amount of water used	135	67.5
Collect Pollution Emission Fee	3	1.5
Collect fines for causing pollution	4	2
Charge with Permit for marine animal culture	0	0
No idea	58	29
Total	**200**	**100.00**

From Table 4-31, it was found that most farmers agree with the method to collect wastewater treatment charges by considering the amount of water that they used, accounted for 67.5%, followed by those who had no idea, those who prefered to use fines for causing pollution, and those who preferred to use Pollution Emission Fee, accounted for 29%, 2%, and 1.5% respectively.

4.5 Formats of collecting wastewater treatment charges

Table 4-32 Number and percentage of farmers classified by formats of collecting wastewater treatment charges.

Format of collecting wastewater treatment charges	Number	Percentage
Collect together with the water usage bill	142	71
Collect separately	0	0
No idea	58	29
Total	**200**	**100.00**

From Table 4-32, it was found that most farmers agree with the format of collecting wastewater treatment charges by collecting together with water usage bill of the Project, accounted for 71%, while the other 29% had no idea about format of collecting wastewater treatment charges.

4.3 Part 3 study results about rate of wastewater treatment charges

In order to determine water charges and wastewater treatment charges, fixed costs and variable costs should be considered separately. For this study, fixed cost (wages of employees) should be divided by number of farmers, while variable costs (electricity cost and maintenance cost) should be divided by quantities of clean water and wastewater.

Table 4-33 Distribution of maintenance costs (baht)

	Fixed cost	Variable cost		
	Employees' wages	Electricity cost		Maintenance cost
		Clean water	Wastewater	
Amount	330,130	1,821,755	344,435	176,159
Proportion		0.84	0.16	
Allocation of maintenance cost		148,149	28,010	-176,159

Table 4-34 Fixed cost and variable cost of the Project (baht)

	Fixed cost	**Variable cost**	
		Clean water	**Wastewater**
Total	330,130	1,969,904	372,445

Fixed cost should be averaged by number of farmers, while variable cost should be averaged by quantity of water.

Table 4-35 Calculation for water charges and wastewater treatment charges

	Fixed cost	**Variable cost**	
		Clean water	**Wastewater**
Cost (baht)	330,130	1,969,904	372,445
Number of units	198 members	19,564,725 cubic meter	13,695,308 cubicmeter
Rate per unit	1,667 baht/member	0.10 baht/cubic meter	0.03 baht/cubic meter
Quantity per rai per year		18,826 cubic meter	13,178 cubic meter
Rates	1,667 baht/member	1,895.50 baht/rai/year	358.38 baht/rai/year
Average number of crops per year	2.74	2.74	2.74
Rate for each unit per crop	609baht/member/crop	692 baht/rai/crop	131 baht/rai/crop

Therefore, in order to enable the Project to be self sustained, the charges should consist of 609 baht/member/crop for a fee, 692 baht/rai/crop for water charge, and 131 baht/rai/crop for wastewater treatment charge.

In this case, from considering the willingness to pay of farmers for wastewater treatment charge, the study results showed that the maximum willingness to pay was no more than 1,200 baht/rai/crop, and the minimum amount was 500 baht/rai/crop (Table 4-35). Therefore, it is possible to charge for wastewater treatment service at the computed rate.

4.4 Part 4 Discussion of study results

From studying about rate of wastewater treatment charges for marine shrimp farming of the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province, results from the study can be discussed as the following.

1. As found from the study that the operation cost and maintenance cost of the Project's wastewater collection and treatment system for treating wastewater from marine shrimp farming activities had a total sum of 2,672,477 baht/year. The revenue was, however, only 1,572,040 baht.

According to the results, the Project's wastewater treatment charges should consist of 609 baht/member/crop for a fee, 692 baht/rai/crop for water charge, and 131 baht/rai/crop for wastewater treatment charge, so that it can have sufficient budget to operate and maintain wastewater treatment to support farmers in the area without having to ask for additional budget from the government. This is in agreement with the Polluters Pay Principle (PPP), as stated in the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992) and the Environmental Quality Management Plan for the year 2007-2011 that polluters must not push the burden of their pollution treatment to the society and the environment. In addition, the laws stated that polluters have duty to pay for wastewater treatment charges at a specified rate.

2. The study about willingness to pay of farmers found that shrimp farmers were willing to pay for wastewater treatment charges at the maximum rate of 1,200 baht/rai/crop, the minimum rate of 500 baht/rai/crop, and the average rate of 1,075 baht/rai/crop. This might be resulted from success of the Project in making people understand and realize about standards of wastewater from shrimp farming activities. Farmers now seem to realize their responsibility for wastewater treatment and have good attitude toward wastewater management. Therefore, it is highly possible to collect an additional charge for 131 baht/rai/crop as wastewater treatment charge.

3. The study found that, regarding method of collecting wastewater treatment charges, farmers favored collecting charges according the amount of used water. Regarding format of collecting wastewater treatment charges, they favored collecting charges together with water usage bill. These findings correspond to the study of Chayuti Promthep (2003), who also found that most people think the appropriate wastewater

charges should be based on quantity of used water, and the treatment charge should be billed together with tap water bill.

4. From the study results of water quality with water samples collected from wastewater drainage canal of the Project from October 2007 to September 2008, together with water samples from shrimp farms before drainage, and analyzing the samples in the laboratory comparing with standard values, it was found that all the water samples complied with standards of water quality for marine animal farming. This is in agreement with the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535 (1992), the announcement of Ministry of Natural Resources and Environment entitled "Specifying that coastal marine animal ponds are sources of water pollution that need to be controlled for water drained to the environment", and the announcement of Ministry of Natural Resources and Environment entitled "Specifications of standards to control drainage of water from coastal marine animal culturing ponds".

Therefore, it is probably unnecessary to have the integrated wastewater treatment system, since the drained water, prior to being treated, already complies with standards. However, since the Project aims to treat drained water before releasing to Kung Krabaen Bay so that it has least effect to the environment and the ecosystem, a wastewater treatment system is still needed. However, it is reasonable that the Project should not charge farmers for wastewater treatment at this moment, since the water quality from their farms is still within limits of standard values.

Thus, regarding necessities of collecting wastewater treatment charges, there should be more analysis on wastewater quality before a clearer advice can be given to the Project.

Therefore, using economic tools to maintain water quality may be applicable to only some areas. A suggested solution in this study is to charge based on the total treatment cost, without considering levels of pollution or dirtiness of drained water since there was no marked differences among shrimp ponds.

Solutions, strategies, and mechanism

From the afore-mentioned results, the researcher knows that some farmers feel that it is unnecessary to pay for wastewater treatment charge, and they do not know well about effects of draining wastewater into Kung Krabaen Bay. Therefore, in order to implement the wastewater treatment charge system efficiently, there should be some solutions, strategies, and mechanism to motivate farmers and make the system become practical. There should also be process to create participation of all partners to take care of quality of the environment seriously. The cooperation between governmental organizations and farmers in the area is very important. In order to create acceptance and cooperation in solving wastewater problem by using the Polluters Pay Principle, the researcher would like to suggest the following solutions, strategies, and mechanism.

Solutions

1. Currently, the Kung Krabaen Bay Royal Development Study Center is the organization that manages the Project and takes a good care of farmers of the Project. The implementation of the Charge System at this time may be too early, since it requires some understanding. Therefore, at this primary stage, it is recommended to promote knowledge and understanding to farmers, such as via trainings on wastewater management, so that they realize the importance of controlling quantity and quality of their wastewater.

2. There should be campaigns to provide knowledge to farmers in order to create conservative mind and motivate their participation in managing wastewater and controlling amount and quality of drained water before releasing to the environment, such as arranging trainings on wastewater management.

3. There should be more activities to create participation of farmers so that they have a feeling of unity. This will make them feel like being in the same group or same organization that have learned about the environment, ways of living, and problems of natural resources and environment in the area together. Eventually this will create a network of cooperation for exchanging information in several aspects. Farmers will also share the feeling of being responsible for environmental problems together. Currently the Project has already set up groups of farmers for 8 groups.

If more action is taken to enhance relationship among the groups, they will have fewer conflicts, and the network of farmers will become stronger.

Strategies

1.Develop and enhance capacity in controlling and monitoring the enforcement of environmental laws regarding environmental pollution.

2. Issue regulations about water pollution control and wastewater management service of the Kung Krabaen Bay Royal Development Study Center Project. The current law enforcement is not serious and efficient enough, so farmers are lack of perception and motivation to control the quantity and quality of their wastewater before draining to the environment.

3. Update database of farmers, monitor and check their wastewater drainage, and check the quality of drained water regularly.

4. Encourage marine animal farmers to apply more environmental-friendly approaches into their farming activities.

5. Promote motivation to farmers by, for example, granting them a certicificate that certifies good quality of their drained water or giving them some awards in order to encourage them to manage and reduce pollution.

Mechanism

1. Set up a working committee or special section to work on water pollution control, wastewater treatment, and wastewater treatment charges in order to link all stakeholders. Set up a coordination center to facilitate cooperation and contacts between the Project and farmers. In addition, there should be sufficient and efficient laboratories for checking water quality of drained water.

2. Issue the regulation of the Kung Krabaen Bay Royal Development Study Center Project with the title of "Water pollution control, wastewater treatment service, and wastewater treatment charges, B.E. ……."

3. Create document or leaflet to enhance knowledge and understanding to farmers that will lead to their acceptance and cooperation in collecting wastewater treatment charge. This may include conducting a referendum, collecting public opinion together with economical and environmental requirements of people.

4. Compose an administration plan for the charges system by bringing strategies or principles into practice. This will be guideline to achieve the goals.

Develop readiness and capability of the Project's personnel for the charges system. Create a database system to store updated data of farmers under responsible of the Project.

5. Monitor and check quantity of wastewater drainage of farmers in order to be used for calculating and collecting wastewater treatment charges.

6. Calculate wastewater treatment charge.

7. Collect wastewater treatment charge.

8. Issue wastewater treatment receipt to farmers who have paid for wastewater treatment charges.

9. Monitor and take some action with farmers who do not pay for wastewater treatment charges.

It is believed that if the afore-mentioned solutions, strategies, and mechanism are applied and implemented, the charges system will be widely accepted by farmers. The principles will efficiently become practical. Moreover, the implementation will be in agreement with the current situation of the environment, and will be a process that can lead to protection and prevention of water pollution caused by coastal marine animal culturing for sustainable natural resources

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

The research titling "Charging rates of wastewater treatment for marine shrimp farming in the area of the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province" has objectives to study costs needed to operate and maintain the collection and treatment system of wastewater from marine shrimp farming activities in order to determine an appropriate rate of wastewater treatment charge for shrimp farming. The research also aims to study for solutions, strategies, and mechanism to create motivation to be able to efficiently implement the wastewater treatment charge system which is a system to control water pollution caused by marine shrimp farming activities.

This research conducted study with farmers of the Project. Questionnaires were used to collect information from 200 samples consisting of 198 farmers who do shrimp farms in the Project's area and 2 personnel of the Project who take care of demonstration ponds. The collected data from questionnaires were analyzed using a statistical application software, SPSS. Statistics that were used in analyzing the data were percentage, mean, maximum, and minimum. Results from the analysis can be summarized as the following.

5.1 Conclusion

Part 1. Study results about the Project

It was found from the study that Kung Krabaen Bay Royal Development Study Center Project was founded from instruction of His Majesty the King to be a center for education and researches in order to find solutions for developing and managing environmental coastal resources, to develop fisheries, forestry, agriculture, and livestocks, and to create occupations for local farmers, especially shrimp farming. At present, there are altogether 229 farmers inside and outside the Project's area. Their shrimp ponds have a total area of 1,041.48 rai. The farmers have set up a cooperative

with a total of 198 members. For the 2008 fiscal year, the members paid for the seawater service charge for 1,200 baht/rai/crop, giving the total sum of 1,572,040 baht. This income is used for administration cost and maintenance cost of the saltwater irrigation project.

Marine shrimp farming needs to drain used water away, flush away sediments, and suck wastes from various activities and dispose them to Kung Krabaen Bay, causing deterioration of water quality. To solve the problem, the Center has set up the Project's wastewater treatment system, which uses natural capabilities to treat water quality to meet standards before draining into the gulf. In 2008, the total operation and maintenance cost of the waste treatment system was 2,672,477 baht. Analysis of data from measuring water quality from samples of water collected from 5 areas (i.e. near the wastewater drainage canal, near the coast, 500 meters away from the coast, 1000 meters away from the coast, and near the bay's exit) found that values of water quality differ over time of year. That might be resulted from different stages of shrimp culturing and different seasons. At the early stage, in hot season, value of dirtiness of water was quite high. After entering rainy season, the dirtiness had reduced. Variation of water quality can be seen in details in Table 40. Conclusively, water quality from all samples of drained water complied with standard values for marine animal farming in coastal areas as stated in the announcement of Ministry of Natural Resources and Environment entitled "Specifications of standards to control drainage of water from coastal marine animal culturing ponds".

Table 5-1. Variation of water quality from areas around Kung Krabaen Bay

Parameter	Wastewater canal	The coast	500 meters from coast	1,000 meters from coast	Bay's exit
Salinity (ppt)	24-36	23-36	27-35	27-35	27-35
Temperature (^{0}C)	23-32	26-32	26-30	26-31	26-31
pH	8.2-8.4	8.0-8.4	8.2-8.4	8.2-8.4	8.0-8.4
Sediment (mg/l)	7.18-31.56	7.15-23.4	3.4-21.38	4.87-23.61	3.1-22.16
BOD (mg/l)	0.7-2.7	0.3-2.0	0.3-1.2	0.2-1.1	0.2-0.9
Ammonia (mg/l)	0.005-0.3837	0.0045-0.1701	0.0000-0.1772	0.0000-0.1768	0.0000-0.1509
Total Nitrogen (mg/l)	0.21-1.24	0.18-1.02	0.05-0.39	0.05-0.23	0.06-0.51
Total Phosphorus (mg/l)	0.03-0.1262	0.0048-0.1075	0.0075-0.0419	0.0049-0.0584	0.0087-0.0509

Part 2. Study results about marine shrimp farmers

It was found from the study that most farmers had an education level of primary education, accounted for 72.5% of the total. Their major occupation was farmer, accounted for 90.5%. Most of them were found to be native people of the area, accounted for 95%. Most of the farmers grew white shrimps for 79.5%. There were 58.5% of farmers whose farms complied with GAP standards. One hundred percent of them operated shrimp farms by exchanging water with outside source. Most of the culturing ponds, 59% of them, had an area of approximately 2.1-3 rai each. Proportion of shrimp farms that did not have suspended pond to treat water before drainage was also 59%. Most of them required about 3 months/crop, and used about 101-300 kg of food pellets per day to feed shrimps. The shrimp farmers averagely released about 500,001-1,000,000 shrimps/rai. All of them used water from the saltwater irrigation system by allowing water to flow through pipes that drew water about 271 cubic meter/day on average. The farmers exchange water during culturing and after harvesting shrimps by draining water through wastewater canal of the Project averagely 162 cubic meter/day.

Most farmers used their own budget for investment in the shrimp farms. Normally they spent about 412,863 baht/pond averagely. The average yield for each crop was approximately 2,001-3,000 kg, which gave them an income of over 150,000 baht/rai from each crop.

Most farmers knew about the policy regarding standards of wastewater from marine animal culturing and expressed their agreement if the government determined to charge the farmers for wastewater treatment and used the money for improving water quality around the area. Most of them were willing to pay for wastewater treatment charges for approximately 1,001-1,500 baht/crop. They were pleased to pay the maximum of 1,200 baht/crop, the minimum of 500 baht/crop, and the average of 1,075 baht/crop for wastewater treatment.

Regarding method to collect charges and payment form, the farmers gave opinion that they prefer to be charged for wastewater treatment by including the charge together with saltwater service charge.

Part 3. Study results about rates of wastewater treatment charges

From studying about costs needed for operation and maintenance of the wastewater treatment system, it was found that the operation and maintenance cost for the treatment system in the year 2008 was 2,672,477 baht. Therefore, in order to have sufficient income for the Project, there should a service charge of 609 baht/farmer/crop (cycle of shrimp farming), a water charge of 692 baht/rai/crop, and a wastewater treatment charge of 131 baht/rai/crop.

However, since the Farmers Group has already charged for water usage from its member at a rate of 1,200 baht/rai/crop, it should be possible to collect for wastewater treatment charge at a rate of 131 baht/rai/crop, particularly when comparing with data of willingness to pay of farmers with the maximum rate of 1,200 baht/rai/crop, the minimum of 500 baht/rai/crop, and the average of 1,075 baht/rai/crop.

Nevertheless, in this case study, it is probably unnecessary to charge for wastewater treatment service if further analysis of water quality show that the drained water from shrimp farms meet standards as specified in the announcement of Ministry of Natural Resources and Environment entitled “Specifications of standards to control drainage of water from coastal marine animal culturing ponds”.

5.2 Suggestions

1. The study results reveal that all farmers in the Project use water from the saltwater irrigation system and drain water from their shrimp farms into the wastewater treatment canal of the Project. Most of them, 59 percents, do not have water suspended ponds to store water before draining to the treatment canal. Therefore, in order to reduce dirtiness of drained water and solve problems of water pollution efficiently and sustainably, it is suggested that there should be policy that require all farmers to have water suspended ponds for storing their wastewater prior to draining into treatment canal of the Project.

2. The study found that some farmers do not understand and not willing to pay for wastewater treatment charge. This might be because of this is a new approach and require more time to let farmers understand. Therefore, the Project should promote understanding and knowledge to farmers to convince them to cooperate in managing

wastewater and controlling amount and quality of wastewater drained to the environment. This can be achieved by, for example, trainings about wastewater management, knowledge of wastewater treatment charge, and so on. By taking action to make this approach become tangible, there will be cooperation in solving problems that is in agreement with the Polluters Pay Principle.

3. From studying rates of wastewater treatment charge for marine shrimp farming in the Project of Kung Krabaen Bay Royal Development Study Center Project, Tambol Khlongkhud, Thamai District, Chantaburi Province, the researcher would like to suggest for further study on other wastewater treatment projects that have already charged for wastewater treatment in order to scrutinize their problems and their outcomes regarding water quality and the environment. The information will be useful to be applied to wastewater treatment charge system of this area in the future.

4. The government should accelerate implementation of economical strategies to wastewater management. There should also be laws improvement and enforcement that correspond with the current situation. In addition, more research on appropriate approaches to reduce pollution from marine animal farming will help maintaining balance of natural resources and environment for highest efficiency and efficacy.

REFERENCES

กรมควบคุมมลพิษ.(2538). คู่มือเล่มที่ 3 แนวทางควบคุมปัญหาน้ำเสียสำหรับองค์กรบริหารส่วนท้องถิ่น.กรุงเทพฯ

กรมควบคุมมลพิษ. (2545ก). โครงการการพัฒนามาตรการทางเศรษฐศาสตร์เพื่อใช้ควบคุมมลพิษจากกิจกรรมการเกษตร (กิจกรรมการเลี้ยงสุกร) .กรุงเทพฯ

กรมควบคุมมลพิษ. (2545ข). โครงการการพัฒนามาตรการทางเศรษฐศาสตร์เพื่อใช้ควบคุมมลพิษจากกิจกรรมการเกษตร (กิจกรรมการเพาะเลี้ยงปลาน้ำจืด) .กรุงเทพฯ

กรมควบคุมมลพิษ. (2545ค). โครงการพัฒนาระบบบำบัดน้ำเสียที่เหมาะสมในการเพาะเลี้ยงสัตว์น้ำชายฝั่งและการควบคุมน้ำทิ้ง .กรุงเทพฯ

กรมควบคุมมลพิษ. (2547). รายงานสถานการณ์คุณภาพสิ่งแวดล้อมทางทะเล จังหวัดจันทบุรี . กรุงเทพฯ

กรมควบคุมมลพิษ. (2548ก). คู่มือการบำบัดน้ำทิ้งและการจัดการการเลี้ยงสัตว์น้ำชายฝั่ง .กรุงเทพฯ

กรมควบคุมมลพิษ.(2548ข). คู่มือการจัดทำเกณฑ์การคำนวณค่าปรับในการบำบัดมลพิษ (รายงานฉบับสมบูรณ์) .กรุงเทพฯ

กรมควบคุมมลพิษ. (2550). คู่มือการกำหนดอัตราค่าบริการบำบัดน้ำเสีย. กรุงเทพฯ

กรมโรงงานอุตสาหกรรม. (2549). การประยุกต์ใช้หลักการทางเศรษฐศาสตร์ในการจัดการมลพิษโรงงาน (ระยะที่ 2) .กรุงเทพฯ

กรมโรงงานอุตสาหกรรม. (2549). การประยุกต์ใช้หลักการทางเศรษฐศาสตร์ในการจัดการมลพิษโรงงาน (ระยะที่ 3).กรุงเทพฯ

กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม. (2547). ประกาศกระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม เรื่อง กำหนดมาตรฐานควบคุมการระบายน้ำทิ้งจากบ่อเพาะเลี้ยงสัตว์น้ำชายฝั่ง.กรุงเทพฯ

กระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม.(2548). ประกาศกระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม เรื่อง กำหนดให้บ่อเพาะเลี้ยงสัตว์น้ำชายฝั่งเป็นแหล่งกำเนิดมลพิษที่จะต้องถูกควบคุมการปล่อยน้ำเสียลงสู่แหล่งน้ำสาธารณะหรือออกสู่สิ่งแวดล้อม. กรุงเทพฯ

กระทรวงเกษตรและสหกรณ์. (2543). ประกาศกระทรวงเกษตรและสหกรณ์ เรื่อง ให้ผู้มีอาชีพประกอบกิจการเลี้ยงกุ้งทะเลมาจดทะเบียน และขออนุญาตต่อพนักงานเจ้าหน้าที่. กรุงเทพฯ

ชยุติ พร้อมเทพ. (2546). การศึกษาความคิดเห็นของประชาชนที่มีต่อการจัดเก็บค่าบำบัดน้ำเสียของกรุงเทพมหานคร. ภาคนิพนธ์รัฐประศาสนศาสตรมหาบัณฑิต สาขาวิชาการบริหารทั่วไป. ชลบุรีบัณฑิตวิทยาลัย มหาวิทยาลัยบูรพา.

ณรงค์ ธนาวิภาส. (2545). เศรษฐศาสตร์เบื้องต้น.สถาบันเทคโนโลยีราชมงคลและกรมอาชีวศึกษา. กรุงเทพฯ

ดิเรก ปัทมสิริวัฒน์. (2548). “เก็บภาษีสิ่งแวดล้อม กระจายอำนาจให้ท้องถิ่น” [ออนไลน์]. เข้าถึงได้จาก: http://www.nidambe11.net (วันที่ค้นข้อมูล 11 มกราคม 2551).

ประชา แก้วปรางค์ .(2547) . รูปแบบที่เหมาะสมในการจัดเก็บค่าบริการบำบัดน้ำเสียในเขตกรุงเทพมหานคร. ภาคนิพนธ์สังคมศาสตรมหาบัณฑิต สาขาสิ่งแวดล้อม. บัณฑิตวิทยาลัย มหาวิทยาลัยมหิดล.

ปาริชาติ ห้าวหาญ. (2543). ความเป็นไปได้ในการจัดเก็บค่าธรรมเนียมบำบัดน้ำเสีย: กรณีศึกษาโครงการบำบัดน้ำเสียเทศบาลเมืองภูเก็ต. ภาคนิพนธ์วิทยาศาสตรมหาบัณฑิต สาขาการจัดการทรัพยากร. บัณฑิตวิทยาลัย มหาวิทยาลัยเกษตรศาสตร์.

พระราชบัญญัติส่งเสริมและรักษาคุณภาพสิ่งแวดล้อมแห่งชาติ พ.ศ. 2535.

วรสัณฑ์ คุ้มญาติ. (2542). ทัศนคติของประชาชนที่มีต่อการบำบัดน้ำเสียในเขตเทศบาลตำบลแสนสุข จังหวัดชลบุรี. ภาคนิพนธ์รัฐประศาสนศาสตรมหาบัณฑิต สาขาวิชานโยบายสาธารณะ. ชลบุรี.บัณฑิตวิทยาลัย มหาวิทยาลัยบูรพา.

ศูนย์การศึกษาการพัฒนาอ่าวคุ้งกระเบน อันเนื่องมาจากพระราชดำริ. ระบบชลประทานเพื่อการเลี้ยงกุ้งทะเล. [ออนไลน์]. เข้าถึงได้จาก: http://www.fisheries.go.th (วันที่ค้นข้อมูล 24 ธันวาคม 2551).

สมชาย ศรีอาวุธ. (2544). การบริหารจัดการระบบบำบัดน้ำเสียรวมของเทศบาลตำบลแสนสุข จ. ชลบุรี ภาคนิพนธ์รัฐประศาสนศาสตรมหาบัณฑิต สาขาวิชาการบริหารทั่วไป.ชลบุรี: บัณฑิตวิทยาลัย มหาวิทยาลัยบูรพา.

สมบัติ ธรรมโชติ. (2548). ปัจจัยที่มีความสัมพันธ์กับความคิดเห็นของการพัฒนาคุณภาพชีวิตที่มีต่อราษฎรภายใต้โครงการศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบนอันเนื่องมาจากพระราชดำริ จังหวัดจันทบุรี.กรุงเทพฯ

สมิต ไทยเจริญ.(2547). ปัจจัยที่มีผลต่อความเต็มใจจ่ายค่าบริการบำบัดน้ำเสียของประชาชน ภาคนิพนธ์วิทยาศาสตร์และเทคโนโลยี. มหาวิทยาลัยราชภัฏเชียงใหม่. เชียงใหม่

สำนักงานคณะกรรมการพัฒนาเศรษฐกิจและสังคมแห่งชาติ. (2549). แผนพัฒนาสังคมและเศรษฐกิจแห่งชาติฉบับที่สิบ พ.ศ. 2550-2554 .กรุงเทพฯ

สถาบันวิจัยเพื่อการพัฒนาประเทศไทย. (2547). เอกสารประกอบการสัมมนาวิชาการ "เหลียวหลังแลหน้า: ยี่สิบปีเศรษฐกิจสังคมไทยการจัดการสิ่งแวดล้อม: เครื่องมือทาง เศรษฐศาสตร์" กรุงเทพฯ

สำนักงานนโยบายทรัพยากรธรรมชาติและสิ่งแวดล้อม. (2541). ความเหมาะสมของค่าบริการและองค์กรบริหารของท้องถิ่นที่จัดให้มีระบบบำบัดน้ำเสียและระบบกำจัดมูลฝอย.กรุงเทพฯ

สำนักงานนโยบายและแผนทรัพยากรธรรมชาติและสิ่งแวดล้อม. (2545). คู่มือองค์กรปกครองส่วนท้องถิ่น แนวทางการใช้เครื่องมือเศรษฐศาสตร์เพื่อการจัดการสิ่งแวดล้อม.กรุงเทพฯ

สำนักงานนโยบายและแผนทรัพยากรธรรมชาติและสิ่งแวดล้อม. (2547). มาตรการในการเพิ่มและการจัดการพื้นที่สีเขียวในเขตชุมชนอย่างยั่งยืน. กรุงเทพฯ

สำนักนโยบายและแผนทรัพยากรธรรมชาติและสิ่งแวดล้อม. (2548 ก). แนวทางการประสานความร่วมมือระหว่างภาครัฐและภาคเอกชนในการใช้มาตรการทางด้านเศรษฐศาสตร์เพื่อการเพิ่มและจัดการพื้นที่สีเขียวในเขตชุมชน กรุงเทพฯ

สำนักงานนโยบายและแผนทรัพยากรธรรมชาติและสิ่งแวดล้อม. (2548ข). รายงานสถานการณ์คุณภาพสิ่งแวดล้อม 2547. กรุงเทพ : อัมรินทร์พริ้นติ้งแอนด์พับลิชชิ่ง จำกัด (มหาชน).

สำนักงานนโยบายและแผนทรัพยากรธรรมชาติและสิ่งแวดล้อม.(2549). แผนจัดการคุณภาพสิ่งแวดล้อม พ.ศ. 2550-2554. กรุงเทพฯ

Barry C. Field and Martha K. Field. (2002). Environmental Economic an introduction.3d ed.

Lease, K. (2002). .Asian Countries Jump on the EPR Bandwagon.. No. 41. To Act on Fact. Institute for Local Self-Reliance. Washington D.C. Retrieved from http://www.ilsr.org/recycling/ftao_41_Asia.pdf (Feb 2004)

Connor R. (2000). Initialallocation of Individual Transferable Quota In New Zealand Fisheries

Bellegem T. Van and Group. 1997. GREEN INVESTMENT FUNDS: ORGANIC FARMING. Dutch Case Study for the OECD Expert Group on Economic Aspects of Biodiversity. Netherlands.

Scott J. Callan and Janet M. Thomas. 2000. Environmental Economics & Management: Theory, Policy, and Applications, 3d ed.

APPENDICES

APPENDIX A

แบบสอบถามเกษตรกรเพาะเลี้ยงกุ้งทะเล
เรื่อง การศึกษาอัตราค่าบำบัดน้ำทิ้งจากการเพาะเลี้ยงกุ้งทะเล
กรณีศึกษาโครงการศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบนอันเนื่องมาจากพระราชดำริ

ตอนที่ 1 ข้อมูลทั่วไปของเกษตรกรผู้เพาะเลี้ยงกุ้งทะเล

1. ระดับการศึกษา ☐ ประถมศึกษา ☐ มัธยมศึกษา ☐ อนุปริญญา
☐ ปริญญาตรี ☐ สูงกว่าปริญญาตรี
2. อาชีพหลัก ☐ รับราชการ/รัฐวิสาหกิจ ☐ ค้าขาย ☐ รับจ้าง
☐ เกษตรกร
( ) ปลูกพืช (ระบุ)…….... ( ) เลี้ยงสัตว์(ระบุ)……..
☐ ประมง ☐ อื่นๆ (ระบุอาชีพ)……
3. ภูมิลำเนา ☐ เป็นคนในพื้นที่ ☐ ย้ายมาจากจังหวัดอื่น

ตอนที่ 2 ข้อมูลเกี่ยวกับการเพาะเลี้ยง พฤติกรรมการใช้น้ำและปริมาณน้ำเสีย

ตอนที่ 2.1. ข้อมูลการเพาะเลี้ยง

1. ประเภทการเพาะเลี้ยง
☐ กุ้งกุลาดำ ☐ กุ้งขาว ☐ อื่นๆ ระบุ……..
2. มาตรฐานการเลี้ยงกุ้ง
☐ ไม่มี
☐ มี ระดับอาหารปลอดภัย ( ) ระดับ GAP ( ) ระดับ CoC ( ) อื่นๆ ระบุ……
3. รูปแบบการเลี้ยงกุ้ง
☐ ระบบปิดแบบเติมน้ำเข้าเพียงอย่างเดียว
☐ ระบบเปลี่ยนถ่ายน้ำโดยการหมุนเวียนน้ำภายในพื้นที่บ่อเพาะเลี้ยงเท่านั้น
☐ ระบบเปลี่ยนถ่ายน้ำโดยการใช้น้ำจากแหล่งน้ำภายนอก
☐ อื่นๆ ระบุ……

4. ขนาดบ่อเพาะเลี้ยง

☐ ขนาดบ่อ……ไร่ ลึก……เมตร จำนวน ……บ่อ

☐ ขนาดบ่อ……ไร่ ลึก……เมตร จำนวน ……บ่อ

☐ ขนาดบ่อ……ไร่ ลึก……เมตร จำนวน ……บ่อ

รวม……ไร่ จำนวน ……บ่อ

5. จำนวน ขนาด และการใช้บ่อพักน้ำ

☐ ไม่มีบ่อพักน้ำ

☐ มี ขนาด……ไร่ ลึก……เมตร จำนวน ……บ่อ

( ) เลี้ยงกุ้งในบ่อพัก ( ) ไม่เลี้ยงกุ้งในบ่อพัก

6. ระยะเวลาในการเลี้ยง 1 รอบ

☐ 1 เดือน/1 รอบ ☐ 2 เดือน/1 รอบ

☐ 3 เดือน/1 รอบ ☐ 4 เดือน/1 รอบ

☐ อื่นๆ ระบุ……

7. ชนิดและปริมาณอาหารที่ใช้เลี้ยง

ชนิดอาหารที่ใช้เลี้ยง

☐ อาหารเม็ด ☐ อาหารสด

ปริมาณอาหารที่ใช้เลี้ยง

☐ ปริมาณน้อยกว่า 100 กก./วัน ☐ ปริมาณน้อยกว่า 301-500 กก./วัน

☐ ปริมาณน้อยกว่า 101-300 กก./วัน ☐ อื่นๆ ……

8. อัตราการปล่อย

☐ ไม่เกิน 300,000 ตัว/ไร่ ☐ 300,001-500,000 ตัว/ไร่

☐ 500,001-1,000,000 ตัว/ไร่ ☐ มากกว่า 1,000,001 ตัว/ไร่

☐ อื่นๆ ระบุ……

ตอนที่ 2.2 ข้อมูลการใช้น้ำ ปริมาณน้ำเสีย และการจัดการน้ำและเลน

1. แหล่งน้ำที่ใช้ในการเพาะเลี้ยง

☐ ชลประทานน้ำเค็ม ☐ น้ำบาดาล ☐ น้ำทะเล ☐ อื่นๆ (ระบุ)……..

2. รูปแบบการนำน้ำมาใช้

☐ เปิดน้ำผ่านตามท่อ ☐ สูบน้ำเข้า ☐ อื่นๆ ระบุ……

ความถี่……คิดเป็น ……....ชั่วโมง ปริมาตรโดยประมาณ……/วัน

3. รูปแบบการเปลี่ยนถ่ายน้ำ

☐ ไม่มีการเปลี่ยนถ่ายน้ำระหว่างเลี้ยงและหลังจับกุ้ง

☐ มีการเปลี่ยนถ่ายน้ำระหว่างการเลี้ยงกุ้งและหลังจับกุ้ง

☐ แหล่งรองรับน้ำทิ้ง

( ) ถ่ายน้ำออกสู่แหล่งน้ำธรรมชาติ ปริมาณน้ำ .....ลูกบาศก์เมตร/วัน

( ) ถ่ายน้ำเข้าสู่คลองบำบัดน้ำทิ้งของโครงการ ปริมาณน้ำ .....ลูกบาศก์เมตร/วัน

4. การบำบัดคุณภาพน้ำทิ้งก่อนปล่อยออกสู่สิ่งแวดล้อม

☐ ไม่มีการบำบัดคุณภาพน้ำทิ้ง

☐ มีการบำบัดคุณภาพน้ำทิ้ง

( ) ใช้บ่อบำบัดน้ำทิ้งของโครงการ

( ) มีบ่อพักน้ำทิ้ง

☐ แหล่งรองรับน้ำทิ้ง

( ) ถ่ายน้ำออกสู่แหล่งน้ำธรรมชาติ

( ) ถ่ายน้ำเข้าสู่คลองบำบัดน้ำทิ้งของโครงการ

5. การจัดการเลนระหว่างเลี้ยงและหลังการจับกุ้ง

☐ ไม่ระบายเลนกลางบ่อ

☐ ระบายเลนกลางบ่อ

ตอนที่ 3 ข้อมูลเกี่ยวกับต้นทุนค่าใช้จ่ายและรายได้ของเกษตรกร

1. มูลค่าการลงทุน .....บาท/บ่อ

☐ ทุนส่วนตัว.....บาท/บ่อ

☐ เงินกู้นอกระบบ.....บาท/บ่อ

2. จำนวนรอบในการเลี้ยง

☐1 รอบต่อปี ☐ 2 รอบต่อปี ☐ 3 รอบต่อปี ☐ มากกว่า 3 รอบต่อปี

3. ผลผลิตต่อรอบการเลี้ยง

☐ น้อยกว่า 500 กก. ☐ 501-1,000 กก. ☐ 1,001-1,500 กก.

☐ 1,500-2,000 กก. ☐ 2,001-3,000 กก. ☐ 3,001-5,000 กก.

☐ มากกว่า 5,000 กก. ☐ อื่นๆ (ระบุ) .....

4. รายได้เฉลี่ยจากการเลี้ยงต่อรอบการเลี้ยง

☐ ต่ำกว่า 50,000 บาท/ไร่ จำนวน.....ไร่

☐ 50,000-100,000 บาท/ไร่ จำนวน.....ไร่

☐ 100,001-150,000 บาท/ไร่ จำนวน.....ไร่

☐ มากกว่า 150,000 บาท/ไร่ จำนวน.....ไร่

ตอนที่ 4 ข้อมูลเกี่ยวกับความสามารถ ความเต็มใจในการจ่ายและทัศนคติ

1. การทราบเรื่องมาตรฐานน้ำทิ้งจากการเพาะเลี้ยงสัตว์น้ำชายฝั่งหรือไม่ ☐ ทราบ ☐ ไม่ทราบ
2. ท่านเห็นด้วยหรือไม่หากภาครัฐจะมีการกำหนดมาตรการในการเรียกเก็บเงินค่าบำบัดน้ำเสีย เพื่อนำไปใช้ในการปรับปรุงคุณภาพน้ำบริเวณบ่อเพาะเลี้ยงกุ้งทะเลของท่าน
   ☐ เห็นด้วย ☐ ไม่เห็นด้วย
3. ความยินดีเสียค่าบริการบำบัดน้ำเสีย
   ☐ ไม่เกิน 500 บาท/รอบการเลี้ยง ☐ 501-1,000 บาท/รอบการเลี้ยง
   ☐ 1,001-1,500 บาท/รอบการเลี้ยง ☐ 1501-2,000 บาท/รอบการเลี้ยง
   ☐ มากกว่า 2,001 บาท/รอบการเลี้ยง
   ยินดีเสียค่าบริการบำบัดน้ำเสียในอัตรา .....บาท/รอบการเลี้ยง
4. วิธีการเก็บค่าบริการบำบัดน้ำเสีย
   ☐ การเก็บค่าบริการบำบัดน้ำเสียตามปริมาณการใช้น้ำ
   ☐ การเก็บค่าธรรมเนียมการปล่อยมลพิษ
   ☐ การเก็บค่าปรับมลพิษ
   ☐ การเก็บค่าใบอนุญาตในการประกอบอาชีพ
   ☐ ไม่ทราบ
5. รูปแบบการเก็บค่าบริการบำบัดน้ำเสีย
   ☐ เก็บรวมกับค่าบริการใช้น้ำของโครงการฯ
   ☐ เก็บแยกต่างหาก
   ☐ ไม่ทราบ
6. ข้อเสนอแนะเพิ่มเติม

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

APPENDIX B

แบบสัมภาษณ์เชิงลึกเจ้าหน้าที่โครงการฯ
เรื่อง การศึกษาอัตราค่าบำบัดน้ำทิ้งจากการเพาะเลี้ยงกุ้งทะเล
กรณีศึกษาโครงการศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบนอันเนื่องมาจากพระราชดำริ

ตอนที่ 1 ข้อมูลทั่วไป

1. สภาพโดยทั่วไปของพื้นที่โครงการศูนย์ศึกษาการพัฒนาอ่าวคุ้งกระเบนอันเนื่องมาจากพระราชดำริ พร้อมแผนที่หรือผังแสดงอาณาเขตของโครงการฯ ในปัจจุบัน……

2. พื้นที่ของโครงการฯ รวม ……ไร่
   พื้นที่เลี้ยงกุ้งทะเล จำนวน ……...……ไร่
   พื้นที่ใช้สอยอื่นๆ ประกอบด้วย ……
   ……..

3. การใช้ประโยชน์ที่ดินในบริเวณพื้นที่ของโครงการฯ ในปัจจุบัน……..

4. ประชากรและครัวเรือนในพื้นที่ของโครงการฯ
   ปัจจุบัน …… (ว/ด/ป./) ประชากร……..คน ……ครัวเรือน
   (ขอข้อมูลย้อนหลังประมาณ 10 ปี เพิ่มเติม)
   จำนวนเกษตรกรในพื้นที่ของโครงการฯ……ราย
   ……..
   ……..
   ……..
   ……..
   ……..
   ……..

5. การบริหารจัดการของโครงการฯ ในปัจจุบัน
   ……..
   ……..
   ……..

ตอนที่ 2 ข้อมูลเกี่ยวกับระบบรวบรวมและบำบัดน้ำเสีย

1. ผังระบบรวบรวมและบำบัดน้ำเสียของโครงการฯ

2. ประเภทของระบบบำบัดน้ำเสีย

☐ SP (Stabilization Pond) ระบบบำบัดน้ำเสียแบบบ่อปรับเสถียร

☐ CW (Constructed Wetland) ระบบบำบัดน้ำเสียแบบบึงประดิษฐ์

☐ AS (Activated Sludge) ระบบบำบัดน้ำเสียแบบตะกอนเร่ง

☐ AL (Aerated Lagoon) ระบบบำบัดน้ำเสียแบบบ่อเติมอากาศ

☐ RBC (Rotating Biological Contactor) ระบบบำบัดน้ำเสียแบบแผ่นจานหมุนชีวภาพ

☐ TF (Trickling Filter) ระบบบำบัดน้ำเสียแบบถังโปรยกรอง

☐ อื่นๆ .....

<u>หลักการและวิธีการทำงานของระบบบำบัดน้ำเสีย</u>

.....

.....

.....

.....

.....

.....

.....

.....

3. พื้นที่และจำนวนผู้ใช้บริการระบบบำบัดน้ำเสีย.....

4. ข้อมูลคุณภาพน้ำทิ้งของโครงการฯ (ข้อมูลย้อนหลังอย่างน้อย 1 ปี).....

.....

5. ชั่วโมงการสูบน้ำ ปริมาตรน้ำที่สูบ และ ปริมาตรน้ำทิ้งของการเพาะเลี้ยงสัตว์น้ำด้วยระบบชลประทานน้ำเค็มอ่าวคุ้งกระเบนฯ

.....

.....

.....

.....

.....

.....

.....

.....

ตอนที่ 3 ต้นทุนและค่าใช้จ่ายในการดำเนินการและบำรุงรักษาระบบรวบรวมและบำบัดน้ำเสีย

1. ค่าใช้จ่ายในการเดินระบบและบำรุงรักษาระบบบำบัดน้ำทิ้งของโครงการฯ

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

ตอนที่ 4 ปัญหา อุปสรรค และอื่นๆ.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

APPENDIX C

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนตุลาคม 2550

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลด์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	26	28	5.6	8.1	116	18.06	0.0380	0.0340	0.1532
ชายฝั่ง	27	29	5.9	8.1	115	20.63	0.2942	0.0203	0.1061
500 ม. จากชายฝั่ง	30	30	5.9	8.3	111	11.30	0.0024	0.0112	0.0490
1,000ม. จากชายฝั่ง	31	30	5.8	8.3	112	5.87	0.0029	0.0104	0.0149
ปากอ่าว	33	30	5.4	8.3	114	7.30	0.0000	0.0095	0.0148
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.67	0.0199	0.1262	0.9524	1.5	74.946	8.64	4.27	6.85
ชายฝั่ง	0.6	0.0554	0.1075	0.6970	1.4	68.160	12.39	3.67	5.30
500 ม. จากชายฝั่ง	0.09	0.0029	0.0297	0.4089	0.5	55.664	3.01	2.08	2.14
1,000ม. จากชายฝั่ง	0.05	0.0032	0.0584	0.3981	0.4	55.664	1.81	1.45	1.18
ปากอ่าว	0.06	0.0061	0.0174	0.3886	0.5	129.504	1.99	2.31	1.83

คุณภาพน้ำอ่าวกุ้งกระเบน เดือนพฤศจิกายน 2550

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลด์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	35	28	5.1	8.0	138	14.73	0.0860	0.0341	0.2792
ชายฝั่ง	36	28	6.1	8.2	132	13.19	0.0557	0.0241	0.0924
500 ม. จากชายฝั่ง	35	29	7.0	8.4	118	7.67	0.0023	0.0078	0.0241
1,000ม. จากชายฝั่ง	35	30	6.8	8.4	119	7.00	0.0027	0.0112	0.0290
ปากอ่าว	35	30	6.6	8.4	120	5.80	0.0000	0.0093	0.0000
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.85	0.0167	0.0769	0.6841	2.7	120.416	10.64	6.72	5.87
ชายฝั่ง	0.55	0.0123	0.0669	0.5170	1.8	94.998	10.40	6.43	4.84
500 ม. จากชายฝั่ง	0.05	0.0008	0.0269	0.2101	0.8	111.328	2.44	2.56	7.83
1,000ม. จากชายฝั่ง	0.06	0.0034	0.0250	0.1993	0.8	170.400	1.82	3.25	4.59
ปากอ่าว	0.07	0.0000	0.0115	0.1824	0.3	129.504	1.90	3.56	1.78

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนธันวาคม 2550

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	33	28	6.4	8.1	121	8.92	0.0055	0.0100	0.0676
ชายฝั่ง	33	29	6.9	8.2	119	10.15	0.0054	0.0050	0.0424
500 ม. จากชายฝั่ง	33	29	7.0	8.3	119	8.00	0.0026	0.0006	0.0462
1,000ม. จากชายฝั่ง	33	30	7.1	8.3	119	11.80	0.0028	0.0012	0.0119
ปากอ่าว	32	29	7.2	8.3	118	11.80	0.0063	0.0045	0.0238
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.26	0.0076	0.0300	0.2726	1.1	165.293	3.10	4.09	3.83
ชายฝั่ง	0.20	0.0018	0.0257	0.1813	0.9	111.870	3.62	3.39	2.91
500 ม. จากชายฝั่ง	0.11	0.0000	0.0216	0.0941	0.6	155.493	2.58	4.76	2.53
1,000ม. จากชายฝั่ง	0.1	0.0002	0.0207	0.098	0.7	141.120	2.35	4.27	3.14
ปากอ่าว	0.15	0.0055	0.0117	0.0887	0.9	74.480	2.48	5.63	2.07

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนมกราคม 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	35	28	6.2	8.2	116	7.18	0.0070	0.0059	0.0347
ชายฝั่ง	35	28	6.6	8.2	119	7.15	0.0044	0.0061	0.0181
500 ม. จากชายฝั่ง	34	29	6.8	8.3	116	5.17	0.0036	0.0038	0.0202
1,000ม. จากชายฝั่ง	34	29	6.9	8.3	115	8.47	0.0017	0.0092	0.0339
ปากอ่าว	35	29	7.0	8.3	120	5.60	0.0000	0.0028	0.0119
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.21	0.0021	0.0320	0.2885	0.7	74.480	2.00	3.05	118
ชายฝั่ง	0.18	0.0000	0.0239	0.2398	0.3	102.410	1.95	2.49	133
500 ม. จากชายฝั่ง	0.12	0.0009	0.0246	0.1962	0.3	70.560	1.32	2.14	153
1,000ม. จากชายฝั่ง	0.09	0.0000	0.0251	0.1743	0.2	145.04	1.21	2.00	167
ปากอ่าว	0.26	0.0026	0.0324	0.1897	0.2	94.080	1.49	2.29	210

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนกุมภาพันธ์ 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	35	26	5.4	7.9	120	9.60	0.0272	0.0298	0.2262
ชายฝั่ง	35	26	5.9	8.0	116	11.60	0.0154	0.0159	0.1701
500 ม. จากชายฝั่ง	35	27	6.5	8.2	116	12.38	0.0059	0.0116	0.1283
1,000ม. จากชายฝั่ง	35	26	6.9	8.2	117	18.41	0.0036	0.0099	0.0763
ปากอ่าว	35	26	6.8	8.2	110	21.80	0.0079	0.0069	0.1509
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.59	0.0200	0.0380	0.5370	1.1	179.013	2.67	4.47	103
ชายฝั่ง	0.38	0.0065	0.0285	0.4062	0.9	153.860	3.27	3.89	106
500 ม. จากชายฝั่ง	0.16	0.0050	0.0205	0.3043	0.7	167.253	2.66	2.82	110
1,000ม. จากชายฝั่ง	0.13	0.0004	0.0253	0.2865	0.3	169.869	4.72	2.53	83
ปากอ่าว	0.14	0.0000	0.0509	0.2944	0.3	82.320	2.11	2.87	80

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนมีนาคม 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	36	26	6.0	8.2	121	7.66	0.0097	0.0109	0.2067
ชายฝั่ง	36	26	6.3	8.2	132	7.35	0.0226	0.0087	0.0345
500 ม. จากชายฝั่ง	35	26	6.7	8.2	121	3.40	0.0067	0.0058	0.1772
1,000ม. จากชายฝั่ง	35	26	6.9	8.3	119	7.20	0.0040	0.0054	0.1768
ปากอ่าว	35	26	7.2	8.3	144	5.00	0.0044	0.0057	0.0086
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.29	0.0118	0.0358	0.2907	1.1	196.653	1.79	2.93	95
ชายฝั่ง	0.34	0.0097	0.0410	0.2429	1.8	163.170	3.53	3.62	98
500 ม. จากชายฝั่ง	0.17	0.0056	0.0249	0.1700	0.6	179.400	1.02	2.34	117
1,000ม. จากชายฝั่ง	0.12	0.0035	0.0181	0.1584	0.5	154.187	0.76	2.27	183
ปากอ่าว	0.10	0.0001	0.0087	0.1298	0.2	109.760	0.73	2.10	200

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนเมษายน 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	34	32	4.9	8.2	129	14.34	0.0070	0.0142	0.1389
ชายฝั่ง	33	32	5.3	8.3	125	15.46	0.0039	0.0103	0.0610
500 ม. จากชายฝั่ง	34	30	6	8.2	125.3	6.17	0.0005	0.0067	0.1283
1,000ม. จากชายฝั่ง	34	31	6.1	8.3	118.7	5.80	0.0000	0.0059	0.0988
ปากอ่าว	33	31	6.2	8.3	120	6.10	0.0000	0.0058	0.1230
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.56	0.0058	0.0564	0.3126	1.2	240.427	4.28	5.79	-
ชายฝั่ง	0.51	0.0041	0.0598	1.0644	1.0	164.150	2.77	4.94	-
500 ม. จากชายฝั่ง	0.39	0.0000	0.0277	0.5919	0.7	210.347	1.66	4.50	-
1,000ม. จากชายฝั่ง	0.15	0.0000	0.0175	0.3074	0.5	172.48	0.79	2.81	-
ปากอ่าว	0.51	0.0000	0.0299	0.3061	0.8	86.240	0.81	2.09	-

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนพฤษภาคม 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	29	32	5.2	8.2	115	31.56	0.0728	0.0362	0.1732
ชายฝั่ง	29	32	5.7	8.2	114	21.63	0.0967	0.0463	0.1219
500 ม. จากชายฝั่ง	30	30	6	8.2	112	20.39	0.0237	0.0244	0.0400
1,000ม. จากชายฝั่ง	30	30	6.2	8.3	113	23.61	0.0058	0.0155	0.0348
ปากอ่าว	30	30	6.4	8.3	112	20.17	0.0105	0.0111	0.0000
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.91	0.0278	0.0686	0.9307	1.6	159.413	10.64	6.13	11.19
ชายฝั่ง	1.02	0.0234	0.0739	0.7980	1.2	122.010	12.89	5.82	9.22
500 ม. จากชายฝั่ง	0.32	0.0147	0.0419	0.4822	0.9	197.307	5.41	3.16	10.62
1,000ม. จากชายฝั่ง	0.17	0.0127	0.0292	0.3670	0.5	171.173	3.41	2.45	9.12
ปากอ่าว	0.14	0.0176	0.0365	0.3705	0.7	39.200	4.40	3.06	8.37

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนมิถุนายน 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	27	31	6.8	8.4	88	14.42	0.0033	0.0045	0.0079
ชายฝั่ง	27	31	6.4	8.3	103	9.44	0.0001	0.0040	0.0073
500 ม. จากชายฝั่ง	27	30	6.6	8.3	99	8.00	0.0001	0.0057	0.0012
1,000ม. จากชายฝั่ง	27	30	6.8	8.3	98	4.87	0.0000	0.0045	0.0006
ปากอ่าว	27	30	6.8	8.3	102	3.10	0.0000	0.0117	0.0000
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.62	0.0265	0.0304	0.7810	1.5	190.773	5.87	5.83	6.70
ชายฝั่ง	0.40	0.0259	0.0262	0.7168	0.9	134.750	3.40	4.03	5.46
500 ม. จากชายฝั่ง	0.16	0.0237	0.0075	0.6959	0.4	243.040	1.18	2.71	2.73
1,000ม. จากชายฝั่ง	0.17	0.0183	0.0088	0.6216	0.5	235.200	1.29	2.29	2.20
ปากอ่าว	0.16	0.0232	0.0148	0.6260	0.5	231.280	0.61	2.18	0.90

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนกรกฎาคม 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลด์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	26	31	7.0	8.4	103	13.74	0.0580	0.0121	0.0176
ชายฝั่ง	29	30	7.2	8.3	104	9.97	0.0086	0.0072	0.0045
500 ม. จากชายฝั่ง	31	30	6.8	8.3	110	9.04	0.0026	0.0086	0.0000
1,000ม. จากชายฝั่ง	32	29	6.9	8.2	107	7.73	0.0000	0.0058	0.0000
ปากอ่าว	30	30	6.8	8.0	106	8.30	0.0067	0.0138	0.0000
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.70	0.0216	0.056	0.7175	1.8	51.613	7.02	4.76	5.87
ชายฝั่ง	0.32	0.0137	0.0493	0.5173	1.3	51.450	4.60	3.15	4.56
500 ม. จากชายฝั่ง	0.19	0.0124	0.0124	0.5179	0.9	112.373	2.03	2.57	3.31
1,000 ม. จากชายฝั่ง	0.12	0.0049	0.0049	0.2232	1.1	116.293	1.74	2.43	1.86
ปากอ่าว	0.11	0.0185	0.0292	0.4382	0.8	137.200	1.11	2.08	1.19

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนสิงหาคม 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลต์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	24	23	6.6	8.4	108	22.85	0.1114	0.0359	0.0050
ชายฝั่ง	25	32	6.9	8.4	103	23.40	0.0313	0.0140	0.0126
500 ม. จากชายฝั่ง	29	30	6.7	8.3	109	21.38	0.0034	0.0086	0.0000
1,000ม. จากชายฝั่ง	30	30	6.3	8.3	114	19.73	0.0014	0.0085	0.0000
ปากอ่าว	30	30	6.6	8.3	102	22.16	0.0063	0.0071	0.0297
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	0.94	0.018	0.0616	0.9080	2.1	92.773	4.67	8.23	11.77
ชายฝั่ง	0.49	0.0021	0.0419	0.6309	2.0	122.100	2.97	6.11	11.48
500 ม. จากชายฝั่ง	0.29	0.0006	0.0272	0.4247	0.8	108.440	2.07	4.89	5.57
1,000ม. จากชายฝั่ง	0.23	0.0000	0.0260	0.4238	0.3	169.867	1.02	2.99	8.04
ปากอ่าว	0.15	0.0090	0.0262	0.4233	0.2	94.080	1.56	3.17	5.54

คุณภาพน้ำอ่าวคุ้งกระเบน เดือนกันยายน 2551

จุดเก็บ	ความเค็ม	อุณหภูมิ	ดีโอ	พีเอช	อัลคาไลด์	ตะกอน	ไนไตรท์	ไนเตรท	แอมโมเนีย
คลองบำบัดน้ำทิ้ง	24	30	7.6	8.3	122	28.60	0.0635	0.0196	0.3837
ชายฝั่ง	23	27	7.3	8.2	116	18.70	0.0333	0.0147	0.1383
500 ม. จากชายฝั่ง	28	30	7.4	8.3	119	13.71	0.0030	0.0077	0.0854
1,000ม. จากชายฝั่ง	28	29	7.4	8.3	124	11.86	0.0005	0.0029	0.1224
ปากอ่าว	28	30	7.4	8.3	104	7.30	0.0000	0.0023	0.0000
จุดเก็บ	ไนโตรเจนรวม	ฟอสเฟต	ฟอสฟอรัสรวม	ซิลิเกต	บีโอดี	ซีโอดี	คลอโรฟิลล์เอ	ทีโอซี	ความขุ่น
คลองบำบัดน้ำทิ้ง	1.24	0.0109	0.0723	1.1036	2.5	84.933	12.02	7.29	12.02
ชายฝั่ง	0.76	0.0048	0.0482	0.786	1.8	82.810	9.02	5.64	9.02
500 ม. จากชายฝั่ง	0.30	0.0000	0.0190	0.2660	1.2	183.573	5.94	3.46	5.94
1,000ม. จากชายฝั่ง	0.21	0.0000	0.0248	0.2495	1.0	133.280	4.76	3.14	4.76
ปากอ่าว	0.17	0.0070	0.0258	0.1552	0.8	66.640	3.07	2.83	3.07

APPENDIX D

การสุ่มเก็บตัวอย่างน้ำและตรวจวัดคุณภาพน้ำทิ้งจากบ่อเพาะเลี้ยงกุ้งทะเลของโครงการฯบริเวณปลายท่อที่ระบายน้ำออกสู่สิ่งแวดล้อม จากกลุ่มเกษตรกรทั้ง 3 กลุ่ม จำนวน 26 ตัวอย่าง ประกอบด้วย 1) กลุ่มเกษตรกรที่ประกอบอาชีพเพาะเลี้ยงกุ้งทะเล ที่ไม่มีระบบรวบรวมและบำบัดน้ำเสียเป็นของตนเองแต่ส่งไปบำบัดที่ระบบรวบรวมและบำบัดน้ำเสียรวมของโครงการฯ จำนวน 20 ตัวอย่าง 2) กลุ่มเกษตรกรที่ประกอบอาชีพเพาะเลี้ยงกุ้งทะเลที่มีระบบรวบรวมและบำบัดน้ำเสียเป็นของตนเอง จำนวน 3 ตัวอย่าง 3) กลุ่มเกษตรกรที่ประกอบอาชีพเพาะเลี้ยงกุ้งทะเลที่ไม่มีระบบรวบรวมและบำบัดน้ำเสียเป็นของตนเอง และไม่ส่งไปบำบัดที่ระบบรวบรวมและบำบัดน้ำเสียรวม จำนวน 3 ตัวอย่าง ซึ่งมีรายละเอียดดังนี้

1) กลุ่มเกษตรกรที่ประกอบอาชีพเลี้ยงกุ้งทะเล ที่ไม่มีระบบรวบรวมและบำบัดน้ำเสียเป็นของตนเองแต่ส่งไปบำบัดที่ระบบรวบรวมและบำบัดน้ำเสียรวมของโครงการฯ จำนวน 20 ตัวอย่างในเดือนพฤษภาคม พ.ศ. 2551 พบว่า คุณภาพของน้ำทิ้งมีค่าอยู่ในเกณฑ์มาตรฐานคุณภาพน้ำเพื่อการเพาะเลี้ยงสัตว์น้ำชายฝั่งทั้งหมด โดยค่าบีโอดีของน้ำมีค่าเฉลี่ยเท่ากับ 14.5 ml/l ค่าบีโอดีสูงสุด มีค่าเท่ากับ 19.8 ml/l ส่วนค่าบีโอดีต่ำสุด มีค่าเท่ากับ 9.15 ml/l รายละเอียดแสดงดังตาราง

แปลง	ปริมาณบีโอดี (mg/l)	แปลง	ปริมาณบีโอดี (mg/l)
2	15.2	49	10.7
9	18.8	58	16.2
13	19.8	65	12.3
14	13.8	76	15.8
23	12.2	80	14.0
26	10.2	91	9.15
28	12.6	96	13.2
32	19.5	101	10.7
36	19.8	103	19.7
44	15.3	104	10.8

หมายเหตุ : ค่ามาตรฐานบีโอดี (Biochemical Oxygen Demand, BOD) ไม่เกิน 20 มก./ล. ตามประกาศกระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม เรื่อง กำหนดมาตรฐานควบคุมการระบายน้ำทิ้งจากบ่อเพาะเลี้ยงสัตว์น้ำชายฝั่ง

2) กลุ่มเกษตรกรที่ประกอบอาชีพเลี้ยงกุ้งทะเลที่มีระบบรวบรวมและบำบัดน้ำเสียเป็นของตนเอง จำนวน 3 ตัวอย่าง ในเดือนกรกฎาคม พ.ศ. 2551 พบว่า คุณภาพของน้ำทิ้งมีค่าอยู่ในเกณฑ์มาตรฐานคุณภาพน้ำเพื่อการเพาะเลี้ยงสัตว์น้ำชายฝั่งทั้งหมด คือ แปลงที่ 7 มีค่าบีโอดีเท่ากับ 19.8 ml/l แปลงที่ 29 มีค่าบีโอดีของน้ำเท่ากับ 8.4 ml/l และแปลงที่ 55 มีค่าบีโอดีเท่ากับ 13.8 ml/l โดยค่าบีโอดีของน้ำมีค่าเฉลี่ยเท่ากับ 14 ค่าบีโอดีสูงสุด มีค่าเท่ากับ 19.8 ml/l ส่วนค่าบีโอดีต่ำสุด มีค่าเท่ากับ 8.4 ml/l

แปลง	**ปริมาณบีโอดี (mg/l)**
7	19.8
29	8.4
55	13.8

หมายเหตุ : ค่ามาตรฐานบีโอดี (Biochemical Oxygen Demand, BOD) ไม่เกิน 20 มก./ล. ตามประกาศกระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม เรื่อง กำหนดมาตรฐานควบคุมการระบายน้ำทิ้งจากบ่อเพาะเลี้ยงสัตว์น้ำชายฝั่ง

3) กลุ่มเกษตรกรที่ประกอบอาชีพเลี้ยงกุ้งทะเลที่ไม่มีระบบรวบรวมและบำบัดน้ำเสียเป็นของตนเอง และไม่ส่งไปบำบัดที่ระบบรวบรวมและบำบัดน้ำเสียรวม จำนวน 3 ตัวอย่าง ในเดือนกรกฎาคม พ.ศ. 2551 พบว่า คุณภาพของน้ำทิ้งมีค่าอยู่ในเกณฑ์มาตรฐานคุณภาพน้ำเพื่อการเพาะเลี้ยงสัตว์น้ำชายฝั่ง คือ แปลงที่ 14 มีค่าบีโอดีของน้ำเท่ากับ 13.5 ml/l และแปลงที่ 79 มีค่าบีโอดีของน้ำเท่ากับ 12.6 ml/l ส่วนเกินมาตรฐาน คือ แปลงที่ 42 ที่มีค่าบีโอดีเท่ากับ 21.5 ml/l ตามลำดับ โดยค่าบีโอดีของน้ำมีค่าเฉลี่ยเท่ากับ 15.9 ml/l ค่าบีโอดีสูงสุด มีค่าเท่ากับ 21.5 ml/l ส่วนค่าบีโอดีต่ำสุด มีค่าเท่ากับ 12.6 ml/l

แปลง	**ปริมาณบีโอดี (mg/l)**
14	13.5
42	21.5
79	12.6

หมายเหตุ : ค่ามาตรฐานบีโอดี (Biochemical Oxygen Demand, BOD) ไม่เกิน 20 มก./ล. ตามประกาศกระทรวงทรัพยากรธรรมชาติและสิ่งแวดล้อม เรื่อง กำหนดมาตรฐานควบคุมการระบายน้ำทิ้งจากบ่อเพาะเลี้ยงสัตว์น้ำชายฝั่ง

BIOGRAPHY

NAME	Miss Sudalak Buala
DATE OF BIRTH	December 9, 1983
PLACE OF BIRTH	Ratchaburi, Thailand
INSTITUTIONS ATTENDED	Bachelor of Science, Environmental Science, Suan Dusit Rajabhat University, 2002-2006 Bachelor of Arts, Mass Communication, Ramkhamhaeng University, 2002-2006 Master of Science, Technology of Environmental Management, Mahidol University,2007-2010
HOME ADDRESS	69 M.6,Tambon Ban Rai, Amphoe Dumnernsaduak, Ratchaburi Province, 70130 E-mail: su_friendclub@hotmail.com