CHAPTER 3

LANDUSE FOR SHRIMP FARMING

A. General Background

1. Shrimp Farming in Chanthaburi Province

Chanthaburi Province located on the eastern coastline of Thailand. Its coastline covered approximately 876 km^2. This province consisted of 4 districts or Amphoe, namely, Amphoe Muang, Amphoe Thamai, Amphoe Laem-Singha and Amphoe Khlung. Kung Krabaen Bay located on the coastal area of Amphoe Tamai with the bay area approximately 10 km^2.

Chanthaburi is well-known as an important agricultural province in the eastern coast of Thailand. Agriculture is the major profession in this area from the past until now. Department of Land Development (1981) has divided Chanthaburi Province according to 3 major land-use: agriculture, forests and others. Mangrove forests flourished on this coastline of 80.2 km.

In 1975, most of the coastal land was used for agriculture while most forests were pristined. The Department of Land Development later allocated coastal land into 3 zones, namely preservation zone (zone A), conservation zone and development zone. Agriculture was the major human activity mainly for plantation, i.e. rice field, orchard trees and rubber trees. The population growth was slow for urbanization. Mangrove forests, however, were reclaimed for agriculture and aquaculture due to population growth (Table 3.1). Rice farming was the major occupation which was approximately 95.3 km^2 or 43.2% of total rice field of the province. This was followed by rubber and orchard plantations.

Table 3.1 Land-use in Thamai District in 1975 (Dept. of Land Development, 1981)

Activities	Area (km^2)	% Activity of Province
1. Agriculture		
1.1 Orchard plantation	23.31	90.63
1.2 Orchard trees and Houses	24.35	67.12
1.3 Rubber trees	105.10	97.53
1.4 Rice field	95.35	43.24
1.5 Shrimp culture	8.27	24.51
2. Forest		
2.1 Land forest	32.45	91.28
2.2 Natural mangrove	51.78	22.47
2.3 Deteriorated mangrove	7.10	19.89
3. Others		
3.1 Urbanization	8.20	40.94
3.2 Bared land	21.89	69.21

2. Geomorphology of Kung Krabaen Bay

Geomorphology of Kung Krabaen Bay was mainly comprised of the coastal plain, undulating landform and mountainous chain. The geomorphologic structure was affected by tectonic action to form synclinal structure in the northern part of this area. The present undulating landform of Kung Krabaen Bay area was caused by the weathering process. There were 2 parallel mountainous chains lies along the east and the west from Permian and Permian-Carboniferous Age, respectively. Sedimentation in Kung Krabaen Bay was aged Quaternary Period consisting of sandy beach on the coastline and mud in the mangrove area (Chanthburi Provincial Royal Forestry Office, 1995).

The Chanthaburi Provincial Royal Forestry Office reviewed in 1995 that Kung Krabaen Bay was characterized by flat land on coastal area of about 1.00 m above the mean sea level. Eight types of the geomorphic structure of this area were formed, namely, the beach ridges, the former tidal flats, the active tidal flats, the old lagoon and the low terrace.

a. Beach ridges and Sand Bars: This beach fringed parallelly along coastline from north to south with the newly originated ridge closed to the sea and old ridge inland. The origin of this beach sediment was transported from the bay by wave and wind actions. Soil type series were Ban Thon (Bh), Mai Kao (Mik) and Rayong (Ry) which consisted of sand and shell fragments.

b. Former tidal flats: The fine particle aggregated at the inner part of mangrove area was from estuarine sediment forming tidal flats. These tidal flats consisted of mixed mud and sand of soil type series, e.g. Samutprakarn (Sm), Panthong (Ptg) and Wangpiang (Wp).

c. Active tidal flats: The active tidal flats found connected between the former tidal flats and the old lagoon. This was the tidal flush zone where sediment was mostly mud and muddy sand of soil type series, e.g. Tachin (Tc), Takua-tung (Tkt) and unidentified soil type (Ui).

d. Old lagoon: This area was the wetland area with the accumulation of peat from plant debris of high organic mud. Soil type series was Narathiwas (Nw). This was characterized by 50 –100 cm depth of mud and shell fragments.

e. Low terrace: The lower flat plain area was formed by eroded soil and sand aggregation consisting of soil type series, e.g. Bangnara (Ba), Chonburi (Cb), Chiangrai (Cr), Kantang (Kat), Kleang (Kl) and Kokkian (Ko) and Namkrajai (Ni).

f. Erosion surface: The area of eroded former hills and flat mountains was characterized by humic soil and sand. This sediment was formed from base rocks consisting of soil type series, e.g. Kohong (Kh), Klongteng (Klt), Klongtom (Km), Langsuan (Lan), Nongkla (Nok), Pakchan (Pac) and Pato (Pto).

g. Middle terrace: This area characterized by humic soil and sand consisting of soil type series, e.g. Klongcak (Kc), Chumporn (Cp) and Thachin (Tc),

h. Hills and mountains: The area consisted of carbonate base rocks lied parallel the eastern and the western sides of Kung Krabaen Bay. Soil type characterized by sandy loam and clay loam of Chumporn series.

Major soil types around Kung Krabaen Bay were Tha Chin Series (Tc) of 0-1% slope, deep clay, poor water absorbent, high organic soil, mainly used for rice fields and other agricultural plants. Another common soil type was Chonburi Series (Cb) of 0-2% slope, deep, soil and sand type, moderate water absorb, arid soil, ordinary used for growing rice and other agricultural plants.

Topography of Kung Krabaen Bay was intertidal flat dominated by muddy sand on which slightly slope from coastline to the mouth of the bay as shown in Figure 3.1. Deep mud dominated on the northern and southern of the bay while the inner parts of the bay was fine sand as shown in Figure 3.2. The volume of water exchange between the bay and the outside sea during tide and low tide was about 86% (Sasaki and Inoue, 1985). The direction of tidal currents during flood and ebb tide were shown in Figure 3.3. In the spring tide, the direction of tide current moved northwards while the ebb tide current moved southwards.

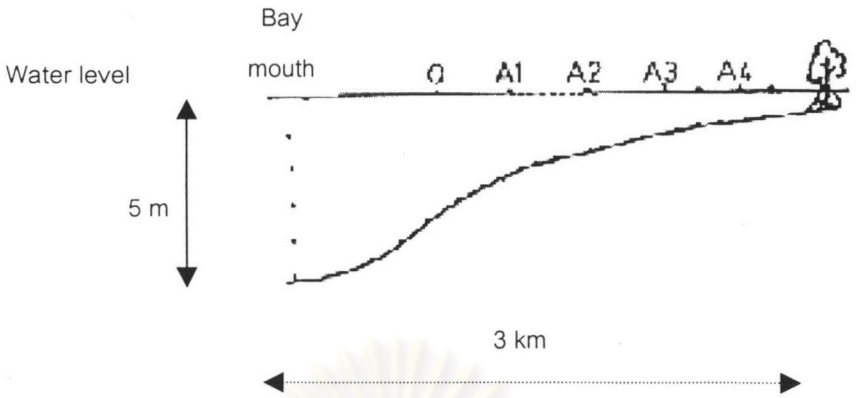

Figure 3.1 Shore profile of Kung Krabaen Bay drawn from the east to the west at the Bay's mouth. (Modified from Nozawa, *et al.*, 1985)

Figure 3.2 Sediment type of Kung Krabaen Bay. Mud dominating on the northern and southern while the rest dominating of fine sand. (Modified from Sangrungruang, 1997)

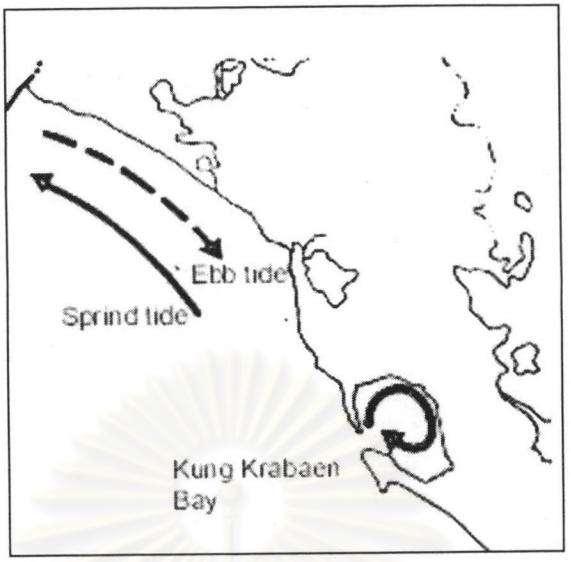

Figure 3.3 Direction of tidal current in the coastal sea. Spring tide current moving northwards and ebb tide current moving southwards. (From Department of Land Development, 1981)

3. Landuse in Kung Krabaen Bay

TESCO Report in 1994 reported that landuse around Kung Krabaen Bay was classified to 6 major area, namely, (1) mangrove forests, (2) shrimp farming, (3) rice fields, (4) terrestrial forests, (5) village and other plantation, and (6) barren lands as shown in Figure 3.4.

Shrimp farming was claimed as the major source of organic material loaded comparing to others activities around Kung Krabaen Bay. The Kung Krabaen Bay Royal Development Study Center reported the trend of shrimp farming increasing recently due to the incentive turn-over rate for shrimp farming was short period than other agricultural. It was evident that many of rice farmers changed rice field to shrimp ponds because of the incentive shrimp price and to avoid the saline water in growing rice problem. Boonsong (1997) interviewed shrimp farmers in this area and found that shrimp farming was still interested in the major profession for the present farmers and also new engaged of other agricultural farmers due to the presently introduced of the seawater irrigation system.

It was considerably that there would be only two organic pointed sources, firstly from the shrimp farming and secondly the domestic loading. According to Pollution Control Department (1997), the average BOD loading from shrimp farms in the Tachin River was approximately 35.04 g/rai/day while the domestic loading estimated 0.5 g/person/day. The relative calculation of BOD loading was carried out for comparison between the shrimp farming and domestic waste in Kung Krabaen Bay area. In 1997, the total shrimp farm area was about 1881.5 rai while the local residents totaled 2,090 persons (modified from Provincial Royal Forestry Office, 1995). The BOD from shrimp farming contributed 65,927.76 g/day and from the domestic waste 1,045 g/day giving 63:1 ratio. It is evidence the shrimp farming activity was the major source of organic enrichment. It was clearly concluded that shrimp farming was the major source of organic loading into the Kung Krabaen Bay.

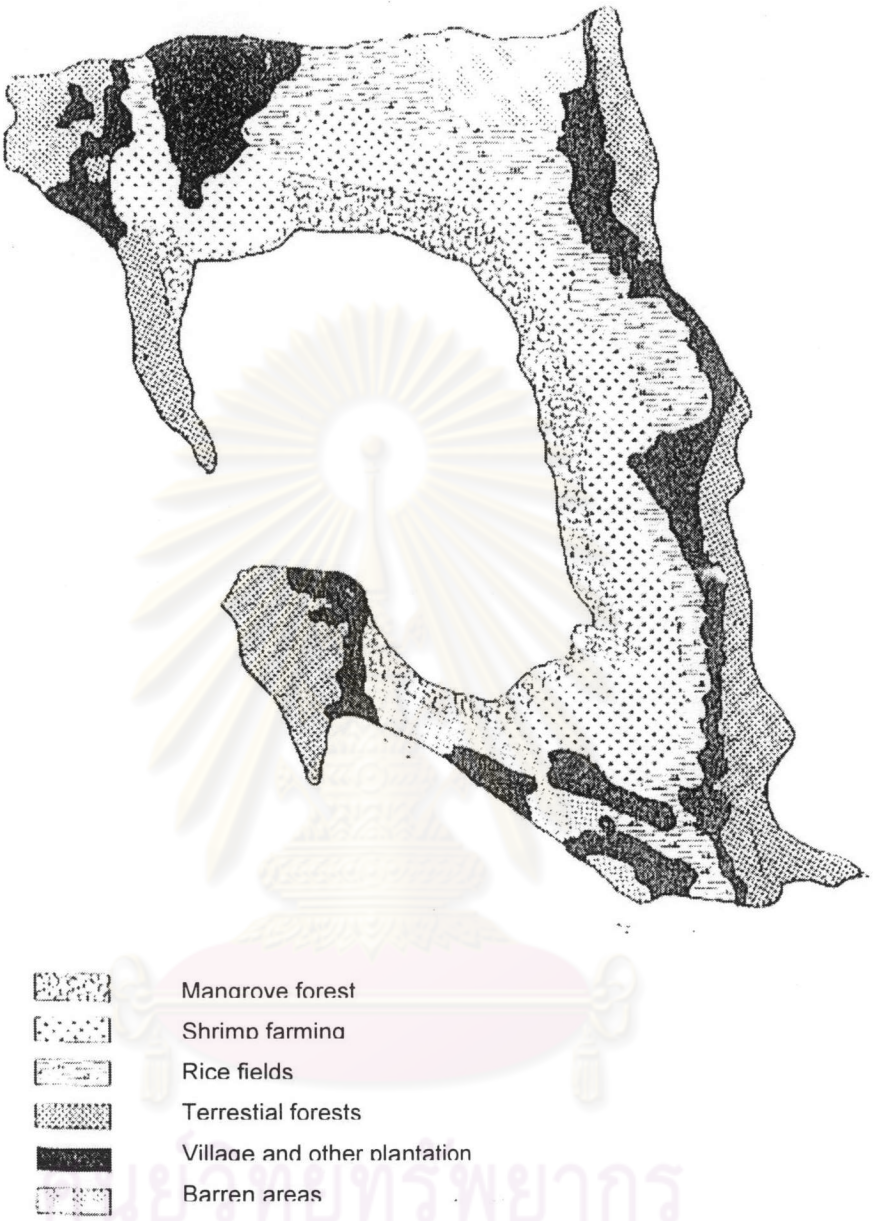

Figure 3.4 Landuse area in Kung Krabaen Bay, Chanthuri Province (TESCO Report, 1994)

B. Expansion of Shrimp Farm Area Around Kung Krabaen Bay

Evolution of land-use structure in the area was modified mainly by shrimp farming. It can be divided into three periods as follows: the period before 1981 before the establishment of KKBRDSC project, the period from 1981 to 1998 before the seawater irrigation system and the period after the seawater irrigation system operation.

1. Changes in shrimp farm area before 1981

Shrimp culture was first introduced to the area more than 3 decades ago. Chanthaburi Fisheries Station's Annual Report (1975) has reviewed the early stage of shrimp farming development. In the past, the coastal area of this province was surrounded by natural mangrove forests. These mangrove with various small creeks had formed the water-way network which transferred natural nutrients and coastal resources supporting this coastal area. The traditional shrimp farming was popular during those period. The shrimp culture was operated by the villagers or local fishermen. They constructed shrimp ponds in the mangrove by raising the dykes between mangrove trees in order to prepare shallow ponds. Supporting canals were dug in order to bring in seawater from creeks to ponds. Only some trees and shrubs were cut but without clear cutting. The traditional shrimp farm imitated natural wetland in mangrove area.

The traditional shrimp ponds usually were 40-50 cm below the water level of the supply canal so that during spring tide the shrimp farmers could open the pond gate to allow seawater flow into the ponds. The farmers could trap the natural shrimp seeds coming in with water during flood tide. Seawater level in shrimp ponds during neap tide was higher than supply canal. The farmers would release water to supply canal and at the same time they put bamboo mat against the entrance gate to protect shrimp from escapes.

There were two culture periods in a year, June to August and October to February. This type of culture would be productive depending on seawater level and natural shrimp seeds. Three main economic important shrimp species were found namely *Penaeus monodon, P. merguiensis and Metapenaeus* spp. However, the yield per crop was rather low about 18.69 to 33.84 kg/rai. However the market price was high comparing to other agricultural products. More farmers had turned to shrimp farming due to high incentives.

The initiative of the King's Project, the Kung Krabaen Bay Royal Development Study Center Project in collaboration of CIDA (Canada) was founded in 1981. This Project aim to run coastal aquaculture mainly black tiger shrimp, *Penaeus monodon*, in environmentally sounded in particular the mangrove forest surrounding the bay. By the King initiative, the project was launched in order to introduce the sustainable intensive shrimp farming while conserving the natural mangrove forest as the alternative to raise the living standard of local villagers. The shrimp ponds were completely constructed and operated in 1988.

Shrimp farming in Kung Krabaen Bay consisted of small traditional farms in the early 1980's. In the late 1981 when Kung Krabaen Bay Royal Development Study Center (KKBRDSC) was established, 104 intensive shrimp farms were added, each farm consisting of three 2-rai ponds. In addition to the development of KKBRDSC farms, other numerous private ponds have been constructed in and around the project site.

In early 1981 there had been little record of landuse for shrimp farms in this area. Due to the report by the Department of Land Development (1981) on the land-use for shrimp farming in Chanthaburi Province as studied by the Science and Technology Research Institute of Thailand, the interpretation from the aerial photographs of shrimp farm area particular to Thamai District contributed to only 15 rai. This was probably underestimated because the shrimp ponds during that period were constructed inside the mangrove forest without clear cutting out. The extensive shrimp culture became popular then.

2. Landuse of shrimp farming in 1981- 1997 before the seawater irrigation system

In 1990, the interpretation of aerial photographs was carried out showing 293 shrimp farms of various sizes and shapes within the CIDA-KKBRDSCP study area. The addition of 390 farms adjacent to the project site in the area of Ban Amphawa and Ban Sattabut. The majority of farms in the KKBRDSC development area were less than 2-rai in area on the average approximately 2800 m^2. Total grow-out pond area within the study boundaries has been estimated from the aerial photographs to be 1449.38 rai (231.9 ha). This consisted of 477.25 rai (76.36 ha) of Kung Krabaen Bay Project ponds and 972.13 rai (155.54 ha) of ponds outside of the Project site. In the same year, the Chanthaburi Provincial Office and the Department of Fisheries have estimated the area of shrimp ponds and their annual potential production in Chanthaburi Province by District (Table 3.2).

Table 3.2 Estimation of shrimp farms area and annual shrimp production in Chanthaburi Province by District in October, 1990. (Chanthaburi Provincial Office and Department of Fisheries)

District	Area (rai)	Farms	Technology	Potential Annual Production (mt)[1/]
Muang [2/]	4,564	555	Intensive (100%)	3,194
Thamai [3/]	14,528	371	Intensive (100%)	20,408
Laem Singha	23,751	725	Intensive (80%)	26,601
			Semi-intensive(20%)	1,950
Khlung	78,119	620	Semi-intensive (50%)	15,624
			Extensive (50%)	7,812
Total	121,012	2,271		75,589

[1/] Yields are based on the following assumptions:

Intensive culture- 700 kg/rai/crop
Semi-intensive culture 200 kg/rai/crop
Extensive culture 100 kg/rai/crop

Assumed a minimun of 2 crops per year in all districts except Muang where due to protected rainy season. It is generally only possible to produce 1 crop per year

[2/] 1 crop per year only

[3/] District where Kung Krabaen Bay is located.

Source: Figures provided by the Chathaburi Provincial Office and the Department of Fisheries.

Satapornvanit (1993) reported that total area of 1066.4 rai around Kung Krabaen Bay was occupied by shrimp farms, of this 503.9 rai belonging to private while 562.4 rai under the KKBRDSC. Leeruksakiat (1995) reported the intensive shrimp farms around Kung Krabaen Bay in 1995 totaled 348 farms and approximately 892.3 rai. Most of shrimp farm employed the intensive shrimp culture technology with induced artificial feed, pesticide, fertilizer, antibiotic, as well as shrimp seeds. This type of culture caused serious problems to coastal environment due to the effluent directly released from shrimp ponds into natural water. Stockwell (1991) noted that the intensive shrimp culture practices at KKBRDSC project site contributed to serious water quality problems in the area. Lacking of good seawater quality to use in shrimp ponds caused negative impacts on crop yields. There were a number of reports from project farmers of complete crop failures during this period.

The intensive shrimp culture is the advanced technique for culturing shrimp. As the shrimp farmers developed landscape for farm area by clear cutting all trees and roots before digging ponds and making dykes. Water supply is supported by canal system separating from drainage canal. Large amount of exogenous organic substance was introduced into the culture ponds during the grow-out phase, e.g. artificial and natural food, antibiotic substance, shrimp seeds and fertilizers. These sources of organic and inorganic material can cause impacts on coastal environment by degrading the adjacent water quality.

3. Landuse for shrimp farming in 1999-2001 after the operation of seawater irrigation system

There was no record of shrimp farm area during the year 1998 to 1999. This study used LANDSAT5 TM data (path 130 Row 53, January 1999) for classifying the shrimp farms around the bay. Bands 4, 3, 2 RGB of the data were composed and provided a false color image of visual interpretation. The estimated shrimp farm area was 1082.55 rai, about 827.98 rai for the farms directly under the project and 255.57 rai for the private farms. This figures had been confirmed by field survey for the unclassified sites.

In 2001, the KKBRDSC had recorded the area of operated shrimp farms about 992.20 rai. Of this, 555.95 rai was under the project and 436.25 rai belonging to private shrimp farms. The area had decreased 272.03 rai or 25% for the farms under the project and 494 rai or 59.7% for the private farms from the year 2000.

During this recent year, as the technology for shrimp culture was further developed. Number of seeds released to each pond had been reduced to suitable level to prevent the risk of disease outbreak. Many shrimp farmers kept low salinity less than 10 psu in their ponds in order to keep healthy shrimps away from diseases. This farm management had been used widely in the area. The shrimp farmers started their first crops at the period of rainy season from March to July and the second crop from September to December. The culture period lasted approximate 140 days per crop and nearly 1 month for pond preparation before starting the next crop.

C. Relationship of Landuse for Shrimp Farming and Nutrient Loading

Landuse around the Kung Krabaen Bay and its neighboring areas had changed from year 1981 to the present. Before 1981, the extensive culture was the major mode of shrimp culture. The shrimp culture in many part of coastal area in Thailand as well as Chanthaburi Province, were conducted by clear cutting mangrove forests for making pond boudaries and pond dikes. This type of shrimp culture was popular with less environmental impacts except for mangrove reclamation. Shrimp seeds and water for shrimp culture were collected and controlled by tidal ranges. No additional feeds or antibiotic substances. After the year 1981, the shrimp culture became more popular due to high profits compared to other agricultural professionals. Many farmers developed their land-scape which they once used to grow rice or other crops. The extensive shrimp culture was then developed to semi-intensive shrimp culture and to intensive shrimp culture in the present time.

Table 3.3 summarized the changes in landuse for shrimp farming around the Kung Krabaen Bay during 1981 – 2001. The rate of shrimp farms expansion increased greatly in 1987 approximate 1770%. This has been diminished to 283.7% and 53.9% in 1989 and 1991 respectively. The trend shifted upward again in 1996, at 112.7%.

Table 3.3 Changes in shrimp farm area from 1981-2001 in the Kung Krabaen Bay, Chanthaburi Province.

Unit : rai

	(1) Before 1981	(2) 1987	(3) 1989	(4) 1991	(5) 1996	(6) 1999	(7) 2001
-Private ponds	<15	<280.5	507.68	648.75	1061.75	997	436.25
-Under the Project's	-	-	510.9 7	775.50	819.75	827.98	555.95
Total	<15	<280.5	1018.65	1424.25	1881.5	1824.98	992.2
Difference	-	265.5	753.15	405.85	457.25	-56.52	-832.78

Sources:
(1) Department of Land Development (1981)
(2) Stockwell (1990)
(3) Tookwinas, et al (1996)
(4), (5), (7) Personal communication with the KKBRDSC's staff
(6) This study

The changes in landuse reflected the shrimp farm activity around the Kung Krabaen Bay. The reduction in shrimp farm area might have arisen from the country economic problem eventhough the seawater irrigation was already installed and operated. The changes in shrimp farm area might be related to the nutrient loading in the bay. To assess the change in nutrients loading to was possible to relate these nutrient loading to the number of shrimp ponds operated during the sampling periods of the water quality surveys by the KKBRSDC's staffs (KKBRSDC,1997, 1998, 1999 and 2000) as showed in Table 3. 4.

There were positive correlation between Dissolved inorganic nitrogen and number of shrimp farms during dry and wet season in all 2 sites, namely the drainage canal and the central part of the bay. In the coastal area, the positive correlation was found during the wet season. However the correlation was negative for the dry season. The dissolved organic nitrogen concentrations showed strong correlation to the shrimp farm areas than the other nutrient concentrations in particular the drainage area.

Table 3.4 The relationship between the changes in shrimp farm area and the average nutrient loadings from drainage canals and central part of the Kung Krabaen Bay , Chanthaburi Province during dry and wet season in 1997 - 2000.

Sampling site	Season	Number of shrimp farms	DIN		DON		DIP		DOP	
			mol/l	Correlation	mol/l	Correlation	mol/l	Correlation	mol/l	Correlation
Drainage canals	Dry season	404	0.0063	0.71897	0.184	-0.16349	0.00035	0.182919	0.00127	-0.12087
		309	0.0024		0.1147		0.00005		0.00078	
		351	0.0043		0.1048		0.00002		0.00057	
		504	0.0054		0.0881		0.00007		0.00056	
	Wet season	471	0.0104	0.878625	0.2577	-0.32491	0.00027	-0.69775	0.00111	0.281858
		323	n.a.		n.a.		n.a.		n.a.	
		559	0.0029		0.0659		0.0005		0.00003	
		1006	0.0246		0.1321		0.00012		0.00101	
Central part of the Kung Krabaen Bay	Dry season	404	0.0038	0.510915	0.1804	0.165631	0.00029	0.260522	0.00105	0.075895
		309	0.0005		0.1070		0.00001		0.000481	
		351	0.0003		0.0930		0.00009		0.00036	
		504	0.0019		0.0785		0.00008		0.00043	
	Wet season	471	0.0071	0.502157	0.1995	-0.47729	0.00025	0.039999	0.0011	-0.00046
		323	0.0010		0.1390		0.00003		0.00039	
		559	0.0010		0.0669		0.00000		0.00036	
		1006	0.0063		0.0919		0.00010		0.00059	
Coastal sea	Dry season	404	0.0021	-0.22012	0.1834	-0.17401	0.00025	0.474191	0.00051	-0.60234
		309	0.0064		0.1135		0.00002		0.00039	
		351	0.0002		0.0955		0.000003		0.00044	
		504	0.0033		0.0817		0.00011		0.00024	
	Wet season	471	0.0029	0.34943	0.1663	-0.47917	0.00014	0.123779	0.00092	-0.29538
		323	0.0005		0.1368		0.000003		0.00036	
		559	0.0013		0.0704		0.00004		0.0003	
		1006	0.0020		0.0973		0.00006		0.00033	

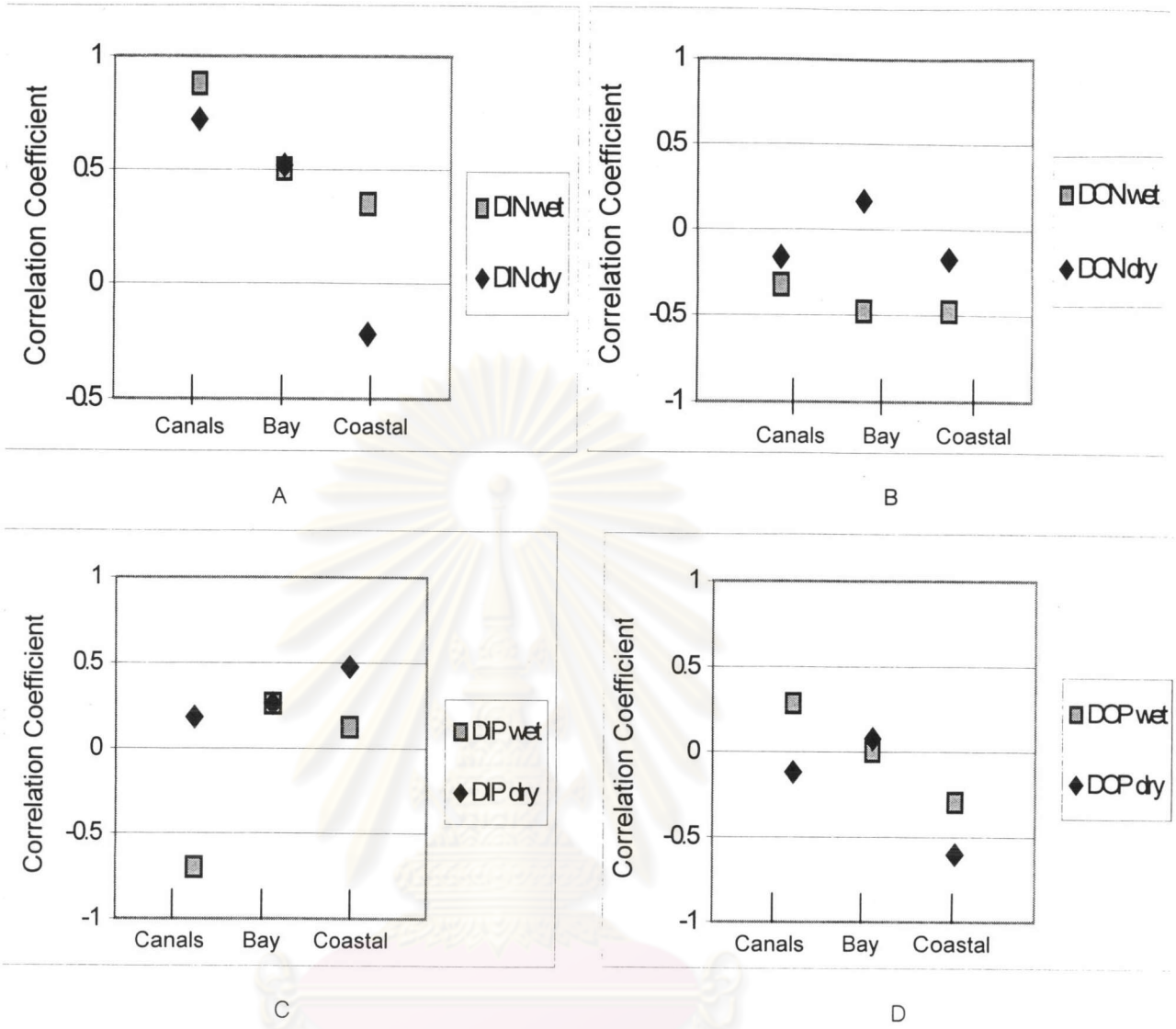

Figure 3.5 Correlation coefficient plots of DIN, DON, DIP and DOP during dry and wet seasons of Kung Krabaen Bay, Chanthaburi Province. A, DIN; B, DON; C, DIP and D, DOP.

D. Landuse for Urbanization

The Kung Krabaen Bay Royal Development Study Center's territory covered 3 Tambols or sub-districts, namely Sanamchai, Klongkud and Naza, with area approximate 48,000 rai and totaled 6,089 residents. Tambol Klongkud consisting of 5 villages located around Kung Krabaen Bay of approximate area 6,672 rai with the residents about 1,398 persons or 22.95% of total residents under the KKBRDSC's project (the Office of Royal Cooperation of Special Project, 1998).

The Provincial Royal Forestry Office (1995) reported that the major professions in this area were shrimp farming and capture fisheries. Of these about one-fourth of the residents engaged in shrimp farming mainly. About 70% of shrimp farmers were local residents while the rest came from other places (Boonsong, 1997). Rice growing as well as orchard and rubber plantation were still popular because of some farmers were employed as labors in shrimp farming. They kept the land as agricultural alternatives when they left from shrimp farms. Rice fields became crisis due to the saline water extruded into farm area, then some farmers turned from rice field to shrimp ponds. Shrimp farming became more popular in this area due to incentive shrimp price and facilities supported by the government, for example the seawater irrigation system and the shrimp clinic run by the center.

Kung Krabaen Bay's natural environment was also fascinated the domestic tourisms by its beautiful environment and seaside and several tourist spots. The Provincial Royal Forestry Office (1995) reported that about 71.4% of tourists interviewed were the KKBRDSC's staffs relatives and friends while the rest were students and privacy companies. The purposes of these tourists were swimming, eco-tourism, sailing, fishing and camping. No specific record on the number of tourists came to Kung Krabaen Bay probably because of the sparsely private bungalows and hotels were located along the seaside far from Kung Krabaen Bay. In addition that many tourists were reported as one-day trip around Kung Krabaen Bay for enjoying the bay scenario and mangrove forests. Because there were not bungalows or hotels on the Kung Krabaen Bay area, except the center's dormitory, then it was fortunate for the bay environment in avoiding from the environmental disturbance.

E. Discussion and Conclusion

In the early stage of landuse development, the shrimp culture type in Chanthaburi Province and particular in Kung Krabaen Bay was extensive and semi-intensive culture. The environmental impacts from these culture types were less influence comparing to the intensive one. Phillips (1995) reviewed that the extensive shrimp culture system was characterized by low stock densities, little or no fertilization or supplement feeding. This extensive farms did not generate significant amounts of wastes while the semi-intensive shrimp culture system received more fertilizers and supplement feeds. These two systems were considered to be less effects the water quality. The intensive shrimp culture system was introduced to Kung Krabaen Bay in the previous years and created more nutrients, more organic matter and more of other wastes that affected the water quality more severely. The result revealed that nitrogen and phosphorus quantities were much higher in the intensive shrimp ponds than the semi-intensive shrimp ponds (Table 3.5).

The expansion of shrimp farming areas around the Kung Krabaen Bay shows fluctuation of landuse due to some impacted factors. Disease outbreak in shrimp culture was experienced with the failure of some shrimp living around the bay (KKBRDSC, 2000). Many shrimp farmers have to give up their shrimp farming activities. The country economic crisis starting in 1997 was one of factors that affected the demand and supply which reduced the exported shrimp production. However, tt can be forecasted that landuse for shrimp farming would tend to increase in the future because of high incentives comparing to other agricultural activities and the seawater irrigation system would be installed to the area. The Provincial Royal Forestry Office (1995) reported that 87% villagers around Kung Krabaen Bay had their own land. Many of them operated shrimp farms by turning rice field to shrimp farming and 1-3 person of each house-holds engaged to shrimp farming as labors. The interviewing showed that the shrimp farmers

Table 3.5 Nutrient budgets for 10-hectare shrimp ponds in term of the amounts of nitrogen and phosphorus in the feed input, shrimp output, and wasted loads (wastes expressed in two quantities). (Phillips, 1995)

Culture System	Nitrogen				Phosphorus			
	Feed (t/yr)	Shrimp (t/yr)	Waste (t/yr)	Waste (kg/t shrimp harvested)	Feed (t/yr)	Shrimp (t/yr)	Waste (t/yr)	Waste (kg/t shrimp harvested)
Semi-intensive ponds Potential harvest 3 t/ha-crop, 9 t/ha-yr: FCR 1.4	2.98	2.66	0.29	9.7	0.45	0.18	0.27	9.0
Intensive ponds Potential harvest 9 t/ha-crop, 27 t/ha-yr: FCR 1.4	38.3	23.99	14.34	53.1	5.83	1.59	4.24	15.7

were still satisfied to continue this profession even though many of them were experience with the disease outbreak and low water quality crisis in the past years. Because those shrimp farmers could do the other agricultural alternatives in their own land, i.e. growing rice, water melon or raring farm animals. In addition, many shrimp farmers were waiting for the seawater irrigation system in order that they could continue their shrimp farming activities.

The landuse for urbanization growth around Kung Krabaen Bay was slightly slow due to the limiting of land. Many of people disagreed to sale the land which still kept for their sons (Provincial Royal Forestry Office, 1995). Of these number 70% of shrimp farmers belonged their own farms (Boonsong, 1997). There was no indication that number of tourists would increase due to the limiting tourist spots around the bay and many tourists preferred one-day trip. In addition, there was no convenient bungalows or hotels besides the center's dormitory. It is considered that landuse for shrimp farming can be increased by turning of rice field while landuse for other activities are limited.

The results of this study shows relationship between nutrient loading and variation of shrimp ponds operated at the same period. The increasing of dissolved inorganic nitrogen (DIN) in the drainage canals and the bay is clearly related to the increasing of shrimp ponds operated in both wet and dry seasons. Small correlation appears with the dissolved organic nitrogen (DON), dissolve inorganic phosphorus (DIP) and dissolved organic phosphorus (DOP). This result is agreed with Boonsong (1997) that high amount of nitrogen loaded into the bay. For this amount of nitrogen loading, Songsangjinda, *et al.* (2000) revealed that the effluent from shrimp farms contained high concentrations but less mass of nitrogen comparing to the inflow water.

It is evident that main factors controlling the change of landuse for shrimp farming was disease outbreak by virus and bacteria for Kung Krabaen Bay area. The weakness of farm management and waste controlled also are concerned as other problems of failure in shrimp activity. The low quality of seawater for shrimp farming in this area was reported by Boonsong (1997) and by the KKBRSDC of annually manipulating water quality monitoring program before the seawater irrigation plan that could cause the disease problem more than the farm management. High organic loading from shrimp farming in this area had been distributed and suggested (Boonsong, 1997; Tookwinas, *et al.*, 1997; Songsangjinda, *et al.*, 2000). Boonsong (1997) suggested mangrove forests could purify this high organic waste water by increasing mangrove areas or growing more trees. It was found by Songsangjinda, *et al.* (2000) that mangrove of this area was less significant in absorption of nitrogen from shrimp farm, about 8%of total ammonia nitrogen loaded from shrimp farm, whereas the main about 78.9% of this nitrogen remained in water column of the bay and transformed to the particulate organic nitrogen. Of this nitrogen amount in the bay, 33.8% of nitrogen was regenerated and 21.8% settled down in bottom sediment.

The disease outbreak has lead a big problem to the shrimp farmers. Many shrimp farmers have to give up their shrimp farming activities. The government has supported to improve the water quality by constructing the seawater irrigation system to the area. This system has already installed and operated in the mid of 2000 by pumping seawater outside the Bay through the supporting canals system to ponds directly. The seawater irrigation system can not be approved yet in solving the major problems in shrimp culture management in this area. The increasing trend of landuse for shrimp farming is possible due to the present study is conducted in the declining period of shrimp farms. Many shrimp farms are awaiting the seawater irrigation system. They expected that this water system can approach to solve the problems.