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*Original Article*

# Impacts of shoreline erosion on coastal ecosystems in Songkhla Province

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**Abstract**

Songkhla Province is located on the eastern coast of the southern Thai Peninsula, bordering the Gulf of Thailand for approximately 107 km. Most of the basin's foreshores have been extensively developed for housing, tourism and shrimp farming. The beaches are under deteriorating impacts, often causing sediment transport which leads to an unnaturally high erosion rate. This natural phenomenon is considered to be a critical problem in the coastal areas affected by the hazard of coastal infrastructure and reduced beach esthetics for recreation. In this study, shoreline changes were compared between 1975 and 2006 using aerial photographs and Landsat imageries using Geographic Information System (GIS). The results revealed that 18.5 $km^2$ of the coastal areas were altered during the period. Of this, 17.3 $km^2$ suffered erosion and 1.2 $km^2$ were subjected to accretion. The most significant changes occurred between 1975-2006. Shoreline erosion was found at Ban Paktrae, Ranot District, with an average erosion rate of 5.3 m/year, while accretion occurred at Laem Samila, Muang Songkhla District with an average accretion rate of 2.04 m/year. The occurrences of shoreline erosion have contributed to the degradation of coastal soil and water quality, destruction of beach and mangrove forests, loss of human settlements and livelihood.

These processes have led to deterioration of the quality of life of the residents. Prevention and mitigation measures to lessen economic and social impacts due to shoreline erosion are discussed.

**Keywords:** shoreline erosion, accretion, GIS, prevention and mitigation measures, Songkhla Province

## 1. Introduction

Thailand has extensive shorelines on both the Gulf of Thailand and the Andaman Sea, altogether approximately 2,600 kilometers. Southern Thailand has only 14% of the land area of the country but 70% of the nation's shorelines. These shorelines have varied characteristics of coastal morphology and have been continually changing during the past. The main shoreline changes that occur are erosion and accretion as influenced by geological processes. The shoreline changes result from natural perturbations and human activities.

The shoreline changes in Thailand have occurred on both the Gulf of Thailand and Andaman Sea coasts. Shoreline erosion receives more attention than accretion because it causes damage that affects residences, population and human life. Sinsakul *et al.* (2002) reported severe erosion along the 181 km coastal areas of Songkhla Province with a magnitude of more than 5 m/year in places. Moderate erosion with a magnitude of 1-5 m/year has been found along approximately 33 km of the southern Gulf of Thailand coastline. The northern part of the southern Gulf of Thailand coastline has had greater changes, due to more intense human activity compared to other areas. Shoreline erosion affects coastal ecosystems where people live and hence causes economic losses to the people living in these areas.

The shoreline along Pakrawa sub-District in Ranot District to Kao Taew sub-District, Songkhla Province, has a shoreline of approximately 107 km, along which are located important historical sites, temples, local communities, fisheries, aquaculture farms, transportation links and tourist

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attractions, which bring income to the community and economy of Thailand. However, nowadays the shoreline is confronted with erosion problems that affect the economic and social structure of the coastal communities (Department of Mineral Resources, 2005). The occurrence of shoreline erosion is a major problem that causes land loss, property damage and sometimes hazard to human life.

This paper presents an overview of the shoreline erosion in Songkhla Province, the evidence, impacts and remediation measures.

## 2. Materials and Methods

### 2.1 Shoreline changes

Shoreline changes in the Songkhla Province (Figure 1) from 1975 to 2006 were assessed by comparing aerial photographs and Landsat 5-TM imageries in digital format (because funds were limited and a series of aerial photographs was not available). Aerial photographs were examined for geometric correction and image enhancement using the ERDAS 8.7 software. The shoreline profile based on aerial photographs and satellite imageries was studied using ArcView 3.3a. The digitized shorelines of the two reference years were overlaid and shoreline change maps were produced using ArcView. The software was also used for the calculation of the rates of erosion and accretion. To observe the actual state of the shoreline, field surveys were carried out in April 2006 and May 2007.

### 2.2 Impacts of shoreline changes on soil and water quality

To assess the impacts of shoreline erosion on soil and water quality, samples were collected and analyzed. Three

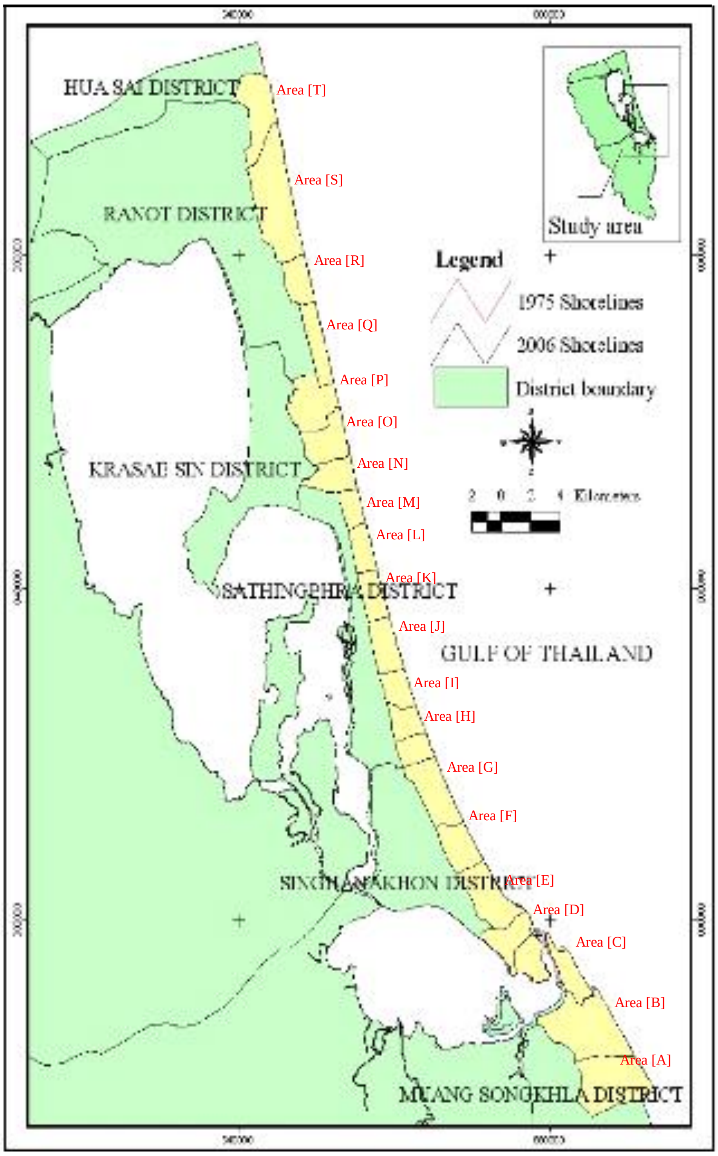


Figure 1. Study area

replicated samples of disturbed soils at two depths, from 0-15 and 15-30 cm, were taken from 12 sampling sites selected based on the land use maps and preliminary field surveys. Water samples were compared. A site approach was conducted to quantify differences between urban and beach areas. After collection, the soil samples were air-dried and crushed in a mortar with a pestle to pass though 2 mm sieve mesh and stored in plastic bottles. The two parameters used to determine soil quality were pH and electrical conductivity (EC). Soil pH and EC were measured using a microprocessor (SARTORIUS model pp-20) and microprocessor conductivity meter (ORION model 160), respectively. At each sampling location, water samples were taken from the center of water flow. The samples were transferred into 1.0 L polyethylene bottles and measurements of dissolved oxygen (DO), pH and EC were performed. After sampling, DO was immediately determined using a Dissolved Oxygen Meter (YSI 550A model), pH with a meter microprocessor and EC with a microprocessor conductivity meter (Laorngsiriwong, 2007).

### 2.3 Impacts of shoreline erosion on coastal livelihood

A semi-structured questionnaire was designed for questioning local people who lived within 1 km of the seashore in the study area. The sampling sites for this questionnaire survey were limited to sub-Districts within convenient access of the main road along the coast. Questionnaires were randomly distributed and collected through house-to-house visits. A preset of the questionnaire was trialed before the actual survey in order to check the appropriateness of the contents and effectiveness of the questionnaire. All statistical data analysis was performed using SPSS version 13.0 software.

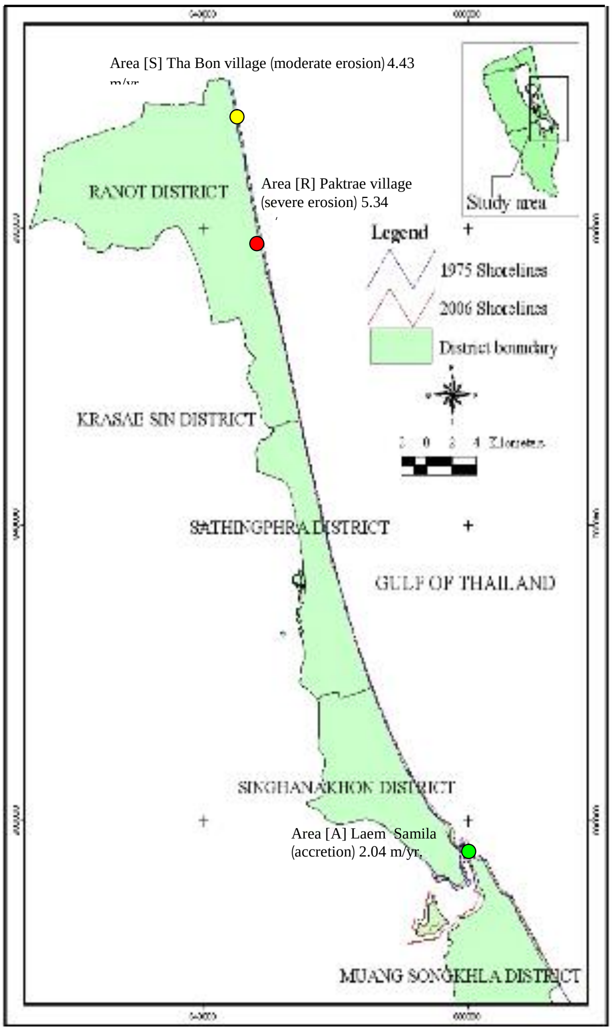


Figure 2. Shoreline status in Songkhla Province during 1975-2006

## 3. Results and Discussion

### 3.1 Shoreline changes

Areas of erosion and accretion were found all along the shoreline of the study area (Figure 2). In most cases, erosions were more apparent than accretions. Erosion occurred along the shoreline. Son-On Cape to Samila Beach, Muang Songkhla District, Songkhla Province showed accretion for approximately 2.37 km along the coastline (1.17 km$^2$) with an accretion rate of 2.04 m/year (Table 1 and Figure 3). A jetty and waves caused sand movement in the north and south of the study area, although this was not actually detrimental

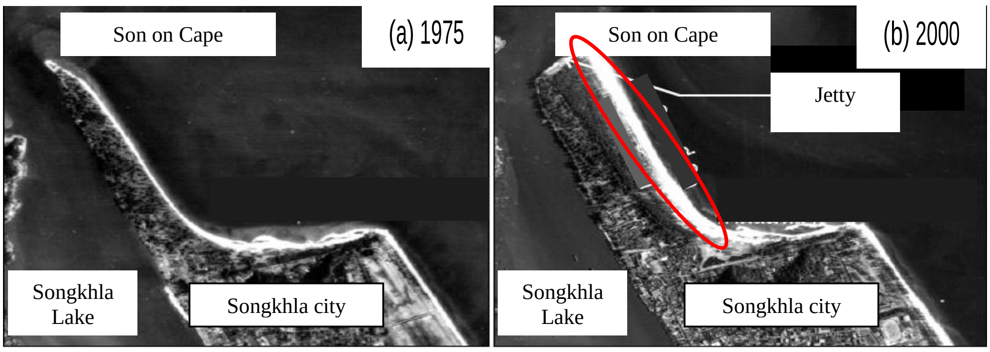


Figure 3. Samila beach (area [C]) in 1975 (a) and Samila beach (area [C]) in 2000 after jetty construction (b)

Table 1. Distribution of eroded and accreted sites areas in the study area between 1975 to 2006

| location of Area (sub-District) | | area changed ($km^2$) | | estimated maximum distance of erosion or accretion (km) | scale of shoreline change (m/year) | |
|---|---|---|---|---|---|---|
| | | eroded area | accreted area | | erosion rate | severity of erosion* |
| area [A] | Bo Yang | - | 1.17 | 2.37 | 2.04 | accreted |
| area [B] | Khao Rub Chang | 0.9 | - | 3.95 | 2.22 | moderate |
| area [C] | Koa Taew | 1.3 | - | 5.04 | 2.47 | moderate |
| area [D] | Hua Khao | 0.24 | - | 1.38 | 0.25 | moderate |
| area [E] | Ching Kho | 1.2 | - | 4.5 | 0.34 | moderate |
| area [F] | Wat Khanun | 0.14 | - | 0.7 | 0.53 | moderate |
| area [G] | Muang Ngam | 1.32 | - | 3.05 | 0.78 | moderate |
| area [H] | Wat Jan | 1.5 | - | 3.24 | 0.45 | moderate |
| area [I] | Bo Daeng | 0.34 | - | 2.75 | 0.47 | moderate |
| area [J] | Bo Dan | 0.65 | - | 2.57 | 0.58 | moderate |
| area [K] | Chathing Phra | 1.12 | - | 3.59 | 0.78 | moderate |
| area [L] | Kradangnga | 0.87 | - | 2.34 | 1.23 | moderate |
| area [M] | Sanam Chai | 0.70 | - | 2.10 | 1.04 | moderate |
| area [N] | Di Luang | 1.24 | - | 2.86 | 1.35 | moderate |
| area [O] | Chumpon | 0.15 | - | 1.87 | 1.26 | moderate |
| area [P] | Wat Son | 1.76 | - | 6.54 | 1.05 | moderate |
| area [Q] | Rawa | 1.86 | - | 4.52 | 1.57 | moderate |
| area [R] | Pak Trae | 2.24 | - | 10.57 | 5.34 | severe |
| area [S] | Tha Bon | 0.76 | - | 3.88 | 4.43 | moderate |
| area [T] | Khlong Daen | 1.04 | - | 3.56 | 3.53 | moderate |
| Total | | 17.29 | 1.17 | 52.85 | - | - |

* Source : Sinsakul (2004)

as it created a new beach which was aesthetically pleasing and thus had become a new tourist attraction. According to Pornpinetpong (2006), when there are coastal structures along the shore area such as breakwaters, groins or jetties, sediments since are transported from the north to the south, With deposition occurring along Laem Samila. Although the erosion occurred on a moderate scale, shoreline changes can be seen in the area where hotels are situated. Erosion of a shoreline can occur along the length of shoreline. Some shoreline erosion occurred at Hua Khao sub-District, Chingkho sub-Districts, Watkanun sub-Districts, Muang Ngam sub-District and Wat Jan sub-District of Singhanakhon District and Bo daeng sub-District, Bordan sub-District and Chathingphra sub-District of Sathing Phra District (Figure 4) at erosion rates of about 0.25-0.78 m/year. Shoreline erosion occurred at a moderate rate (1-4 m/year) in Kradangnga sub-District, Sanamchai sub-District, Di Luang sub-District, Chumpon sub-District, Wat Son sub-Districts and Rawa sub-District of Sathing Phra District (Table 1). The lower erosion rate of 1.25-1.57 m/year was caused by waves, seasonal waves and shrimp aquaculture with sea water supplied through a PVC pipe jutting into the sea resulting in erosion in the area along the length of pipe on the land. Shoreline erosion occurred at a severe rate (5 m/year) and caused damage at Paktrea beach in Ranot District (Figure 4) where the erosion rate was 5.54 m/year along approximately 10.57 km, most probably affected by a jetty located in the north of this area. Damage in areas around the local road was also seen, which affected local transportation. The shoreline at Tha Bon and Khlong Daen sub-Districts of Ranot District had also see erosion at moderate rates of 4.43 and 3.53 m/year, respectively (Table 1). It seems likely that this area will come under a higher erosion rate in the future, as it is influenced by strong waves and the construction of a jetty. Shoreline erosion varies seasonally. During October-February, shoreline erosion is caused by the north-east monsoon in the Gulf of Thailand, while most of the shoreline is stable from May-September without the influence of the monsoon).

### 3.2 Impacts of shoreline erosion on soil and water quality

#### 3.2.1 Soil quality

**- EC**

The chemical properties of the soil samples analyzed are presented in Tables 2 and 3. The EC values of resident soil samples at 0-15 cm depth were in the range of 6.03-20.03 mS $cm^{-1}$ and at soil depth of 15-30 cm in the range of 6.97-28.00 mS $cm^{-1}$. The results indicated that EC values increased with depth of soil in the coastal area, with EC at 0-15 cm depth in the range 14.39-35.77 mS $cm^{-1}$ and at 15-30 cm depth in the range 11.57-38.6 mS $cm^{-1}$. The EC values tended to increase with the depth of the soil. EC values of > 2 mS $cm^{-1}$ affect plant growth due to saltiness, although certain adapted plants can grow in EC values of higher than 16 mS $cm^{-1}$ (Department of Soil Science, 2005; Onthong, 2006; Densrisereekul, 2003). These figures suggest that the supply of sea water to shrimp farms should be reduced. The consequence is the accumulation of salt, which can dissolve and result in salt accumulation in the soil, causing an increase in soil salinity. This can affect many plants, but particularly rice, which is affected by alkaline soil and develops white tip of leaf and dryness, and rice growth is halted and clump destruction is observed if the EC value of the soil is greater than 4 mS $cm^{-1}$ ,these effects can reduce rice production by 10-15 % and up to 50% if the EC greater than 10 mS $cm-^{1}$ (Department of Rice, 2007).

**- pH**

The data show that the pH in the urban soils at 0-15 cm soil depth was in the range of 6.3-8.9, and at 15-30 cm soil depth the range was 6.06-8.29. The results show that the alkalinity was lower in deeper soil and could be classified as slightly acid to moderately alkaline. The coastal soil at 0-15 cm depth was in the range 7.34-9.30 and at depths of 15-30 cm the range was 7.91-9.26 (Table 3). The soil pH at the two

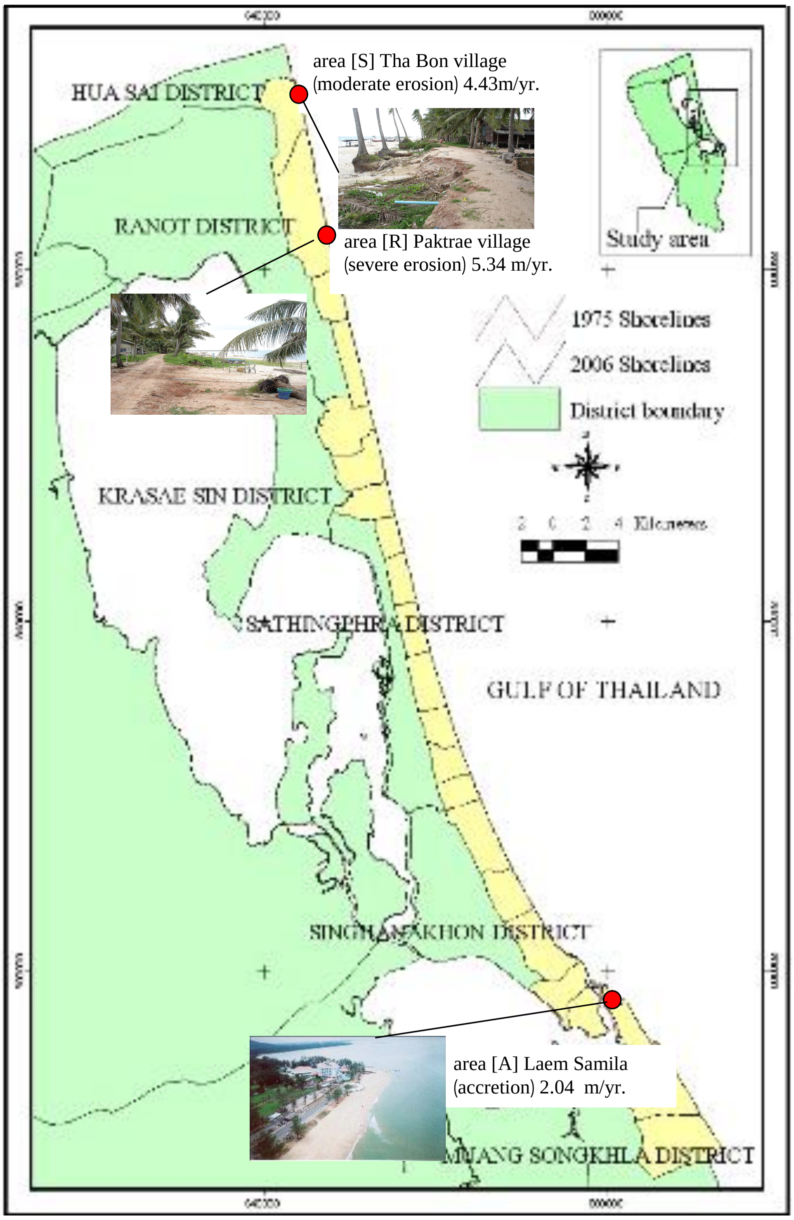


Figure 4. Shoreline changes in Songkhla Province

Table 2. Soil conductivity (mS $cm^{-1}$) in the study area.

| Location of soil sample (village, sub-District) | soil conductivity (mS $cm^{-1}$)(mean ± S.D.) | | | |
|---|---|---|---|---|
| | Urban (soil depth) | | beach (soil depth) | |
| | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| area [C] Khao Taew , Koa Taew | 13.40±0.20 | 16.37±0.06 | 23.48±0.02 | 11.57±0.12 |
| area [B] Hat Kao Seng, Khao Rub Chang | 12.40±0.10 | 15.73±0.12 | 18.38±0.02 | 18.23±0.12 |
| area [A] Laem Samila, Bo Yang | 13.13±0.12 | 16.73±0.12 | 22.77±0.03 | 32.89±0.02 |
| area [D] Deep sea water ferry port, Hua Khao | 12.87±0.12 | 16.43±0.06 | 35.77±0.03 | 31.20±0.03 |
| area [E] Hat Sai Kaeo, Ching Kho | 10.33±0.15 | 17.83±0.12 | 14.39±0.02 | 12.24±0.04 |
| area [G] Ban Moungngam, Muang Ngam | 6.03±0.21 | 6.97±0.06 | 27.00±0.02 | 31.48±0.03 |
| area [J] Ban Watyai, Bo Dan | 8.47±0.12 | 9.37±0.12 | 30.67±0.03 | 26.31±0.03 |
| area [N] Ban Di luang, Di Luang | 20.03±0.40 | 21.00±0.00 | 21.77±0.03 | 38.60±0.03 |
| area [O] Ban Chumpon Chaitale, Chumpon | 13.47±0.25 | 14.47±0.06 | 23.07±0.03 | 34.24±0.05 |
| area [Q] Ban Rawa, Rawa | 8.27±0.12 | 12.37±0.06 | 30.17±0.03 | 27.22±0.05 |
| area [R] Ban Pak Trae, Tha Bon | 16.17±0.40 | 28.00±0.00 | 21.08±0.03 | 17.01±0.01 |
| area [S] Tha Bon, Khlong Daen | 17.8±0.20 | 19.83±0.06 | 34.97±0.03 | 33.39±0.01 |

Table 3. Soil pH in study area

| Location of soil sample (village, sub-District) | pH (mean ± S.D.) | | | |
|---|---|---|---|---|
| | Urban (soil depth) | | beach (soil depth) | |
| | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| area [C] Khao Taew , Koa Taew | 7.81±0.03 | 7.49±0.04 | 7.34±0.04 | 8.52±0.05 |
| area [B] Hat Kao Seng, Khao Rub Chang | 7.79±0.04 | 7.41±0.04 | 8.57±0.03 | 8.17±0.05 |
| area [A] Laem Samila, Bo Yang | 7.72±0.06 | 7.38±0.03 | 7.62±0.05 | 7.97±0.06 |
| area [D] Deep sea water ferry port, Hua Khao | 7.89±0.04 | 7.42±0.03 | 8.60±0.04 | 9.25±0.02 |
| area [E] Hat Sai Kaeo, Ching Kho | 7.84±0.04 | 7.91±0.05 | 8.31±0.04 | 8.37±0.04 |
| area [G] Ban Moungngam, Muang Ngam | 7.72±0.05 | 7.53±0.03 | 7.84±0.03 | 7.98±0.03 |
| area [J] Ban Watyai, Bo Dan | 8.34±0.06 | 7.24±0.04 | 9.26±0.04 | 8.90±0.05 |
| area [N] Ban Di luang, Di Luang | 7.73±0.05 | 7.60±0.02 | 9.27±0.04 | 8.91±0.04 |
| area [O] Ban Chumpon Chaitale, Chumpon | 8.00±0.02 | 7.61±0.04 | 9.18±0.05 | 8.80±0.04 |
| area [Q] Ban Rawa, Rawa | 7.90±0.05 | 7.58±0.02 | 9.24±0.04 | 9.19±0.02 |
| area [R] Ban Pak Trae, Tha Bon | 8.53±0.05 | 8.26±0.03 | 8.09±0.04 | 8.40±0.03 |
| area [S] Tha Bon, Khlong Daen | 8.27±0.03 | 8.26±0.02 | 9.02±0.04 | 9.21±0.04 |

depths was not different. This is explained on the basis that the subsoil at these depths are all under the influence of the salt from sea water (Department of Soil Science, 2005)**.**

### 3.2.2 Water quality

**- DO**

Dissolved oxygen (DO) values in the fresh water samples were in the range of 6.03-7.39 mg $L^{-1}$ and in the sea water samples in the range of 5.63-6.79 mg $L^{-1}$. The results show that the DO of fresh water was higher than that of sea water (Table 4). When compared to fresh water in a shrimp pond, it was found that the DO in the shrimp ponds was ever higher, while the maximum DO levels for shrimp ponds is approximately 5.0 mg $L^{-1}$ (Ackefors, 1994). When dissolved oxygen falls below 5 mg $L^{-1}$, sensitive species of fish and invertebrates can be negatively impacted. At dissolved oxygen levels below 2.5 mg $L^{-1}$ most fish are negatively impacted (Frodge *et al.*, 1990).

The solubility of oxygen depends on several factors such as the stocking density of the shrimp in a ponds, the quantity of phytoplankton used as feed, and photosynthesis; using a paddle wheel for aeration helps circulate the water in the pond and bring up precipitated organic substances to the upper layer of water. According to the National Institute of Coastal Aquaculture (2005) sea water quality in Songkhla Province in January 2005 had an oxygen level in the water in the range of 4.9-8.4 mg $L^{-1}$. The results showed that the DO of fresh water can be used for agriculture and aquaculture when compared with DO standard.

Table 4. Dissolved oxygen in the study area.

| Location of water sample (village, sub-District) | dissolved oxygen (mg $L^{-1}$) (mean±S.D.) | |
|---|---|---|
| | fresh water | sea water |
| area [C] Khao Taew , Koa Taew | 6.92±0.03 | 6.36±0.08 |
| area [B] Hat Kao Seng, Khao Rub Chang | 6.66±0.07 | 5.63±0.04 |
| area [A] Laem Samila, Bo Yang | 6.89±0.33 | 6.27±0.09 |
| area [D] Deep sea water ferry port, Hua Khao | 6.60±0.09 | 6.79±0.07 |
| area [E] Hat Sai Kaeo, Ching Kho | 6.03±0.03 | 6.13±0.08 |
| area [G] Ban Moungngam, Muang Ngam | 7.33±0.07 | 6.28±0.05 |
| area [J] Ban Watyai, Bo Dan | 6.71±0.01 | 5.78±0.15 |
| area [N] Ban Di luang, Di Luang | 6.37±0.01 | 5.80±0.01 |
| area [O] Ban Chumpon Chaitale, Chumpon | 5.32±0.03 | 6.29±0.03 |
| area [Q] Ban Rawa, Rawa | 7.15±0.06 | 6.22±0.06 |
| area [R] Ban Pak, Trae, Tha Bon | 5.45±0.10 | 6.42±0.03 |
| area [S] Tha Bon, Khlong Daen | 7.39±0.06 | 6.23±0.03 |
| area [S] Tha Bon, Khlong Daen (shrimp pond) | 7.33±0.23 | 6.23±0.03 |

Table 5. Water conductivity (mS $cm^{-1}$) in the study area.

| Location of water sample (village, sub-District) | water conductivity (1:5) (mS $cm^{-1}$) (mean±S.D.) | |
|---|---|---|
| | fresh water | sea water |
| area [C] Khao Taew , Koa Taew | 0.16±0.02 | 34.00±0.00 |
| area [B] Hat Kao Seng, Khao Rub Chang | 0.22±0.02 | 33.00±0.00 |
| area [A] Laem Samila, Bo Yang | 1.02±1.02 | 34.00±0.00 |
| area [D] Deep sea water ferry port, Hua Khao | 2.60±0.03 | 33.00±0.00 |
| area [E] Hat Sai Kaeo, Ching Kho | 14.98±0.27 | 36.00±0.00 |
| area [G] Ban Moungngam, Muang Ngam | 0.28±0.03 | 34.03±0.00 |
| area [J] Ban Watyai, Bo Dan | 0.34±0.02 | 35.13±0.26 |
| area [N] Ban Di luang, Di Luang | 0.40±0.02 | 34.23±0.23 |
| area [O] Ban Chumpon Chaitale, Chumpon | 0.62±0.03 | 34.97±0.06 |
| area [Q] Ban Rawa, Rawa | 0.36±0.02 | 35.90±0.17 |
| area [R] Ban Pak, Trae, Tha Bon | 19.45±0.10 | 34.93±0.12 |
| area [S] Tha Bon, Khlong Daen | 10.61± 0.04 | 34.50±0.00 |
| area [S] Tha Bon, Khlong Daen (shrimp pond) | 27.40±0.10 | 34.50±0.00 |

**-EC**

The EC values in the fresh water samples were in the range of 0.16-27.4 mS $cm^{-1}$ and in the sea water from 33.0-38.4 mS $cm^{-1}$ range (Table 5). Generally, water quality suitable for irrigation purposes should not exceed 2.25 mS $cm^{-1}$ in EC and higher EC can lead to higher salinity of water that result in alkaline soil. (Pescod, 1973). When comparing the EC values of fresh water with the standards of water for irrigation, it was found that different sources of fresh water may have different qualities, e.g., water sources in Ban Paktrae and Ban Thaken were not suitable for irrigation purposes. This is because fresh water from the source aforementioned is mixed with the sea water and drained into the estuary, which is then pumped into the shrimp ponds.

**-pH**

According to water quality standards for agriculture established by the Pollution Control Department (2006), suitable pH levels for agriculture range from 5-9 while the maximum pH levels for irrigation range from 6.5-8.5. This study examined 3 sources of water: fresh water, shrimp pond water and sea water. The data show that the fresh water had pH levels of 7.12-8.79 and sea water 8.1-8.3 (Table 6). The sea water samples were more alkaline than water from the other sources because they were affected by mineral salt from the sea water. Water within the standards can be used for agriculture and aquaculture purposes.

Table 6. Water pH in the study area.

| Location of water sample (village, sub-District) | pH (1:5) (mean±S.D.) | |
|---|---|---|
| | fresh water | sea water |
| area [C] Khao Taew, Koa Taew | 7.45±0.03 | 8.16±0.02 |
| area [B] Hat Kao Seng, Khao Rub Chang | 7.57±0.02 | 8.16±0.03 |
| area [A] Laem Samila, Bo Yang | 8.55±0.05 | 8.17±0.03 |
| area [D] Deep sea water ferry port, Hua Khao | 8.76±0.03 | 8.14±0.04 |
| area [E] Hat Sai Kaeo, Ching Kho | 7.42±0.02 | 8.13±0.04 |
| area [G] Ban Moungngam, Muang Ngam | 8.76±0.02 | 8.20±0.03 |
| area [J] Ban Watyai, Bo Dan | 7.69±0.03 | 8.19±0.04 |
| area [N] Ban Di luang, Di Luang | 7.14±0.02 | 8.19±0.04 |
| area [O] Ban Chumpon Chaitale, Chumpon | 7.52±0.03 | 8.26±0.03 |
| area [Q] Ban Rawa, Rawa | 7.46±0.02 | 8.29±0.05 |
| area [R] Ban Pak, Trae, Tha Bon | 7.90±0.02 | 8.30±0.05 |
| area [S] Tha Bon, Khlong Daen | 7.42±0.02 | 8.19±0.05 |
| area [S] Tha Bon, Khlong Daen (shrimp pond) | 8.72±0.03 | 8.19±0.05 |

### 3.4 Impacts of shoreline erosion on biological resources

This research was conducted with the intent of using beach and mangrove forests as an index to determine changes caused by shoreline erosion. The decline in areas of beach forests and mangroves resulted in losses of coastal habitat. 1975 Aerial photographs and 2006 Landsat 5-TM satellite imageries were studied to compare the beach forest and mangrove areas. The data show that beach forest had decreased from 289 to 184 rai or 34.58% of total beach forest area and mangrove forest had decreased from 21.50 to 8.79 rai or 59.30% of total mangrove forest area.

### 3.5 Impacts of shoreline erosion on coastal livelihoods

The effect of shoreline erosion on the economy and social status was studied through interviews with 298 local people from the study area. The data show that the majority of people were fishermen (34.9%), general laborers 28.19%, sea food factory laborers 12.05%, business persons 10.53% merchants 6.71%, government servants 5.70% and unemployed 2.02 %. The monthly incomes were in the range of 5,000-10,000 baht/family for 40.54% of all people sampled. Shoreline erosion had had an effect on people who lived near the shore and the aquaculture farmers who had lost shrimp farm areas. Other local people who lived on the fishery faced the problem of loss of good harbors, thus having to spend longer times on their vessels at the fishing areas**.** The slope gradient of the near shore zone had also increased; therefore, there was less profit from the fishing. For the farmers, their average income was about 1,000-2,000 baht/family/month, which was not sufficient for their livelihood. Therefore, to get more income, they had to look for other jobs. 62.22% of them worked as factory workers whilst 24.44% and 13.34% were merchants and casual labors, respectively. 38.09% of the people expressed a belief that shrimp farming was the major cause of shoreline erosion particularly because of the PVC pipes that pumped the sea water into the ponds. Shoreline erosion can also cause aesthetic deterioration of the shore areas and a decrease in tourism and tourist services. Shoreline erosion also had an effect on people who lived along the beach, and 83.1% of them felt insecure about their future. The people (86.58%) recognized the problem of shore erosion thus must be solved by constructing a seawall (77.86%) a breakwater 8.05%, replanting the beaches with pine trees or mangrove forests (7.05%) giving knowledge about shoreline erosion and protection (5.03% because local people do not have enough time and resources to learn themselves), and relocation of local people into safer areas (2.01%**)** However, people expected the government to solve the shoreline erosion problem.

## 4. Recommendations

Based on the findings in this study as well as suggestions and comments from local people during the questionnaire survey, the following recommendations are made with the aim of preventing the environment becoming more affected by shoreline erosion in the study area and mitigation measures:

(a) Countermeasures for the shoreline erosion problem:

Coastal engineering structures should be conscientiously planned, designed with full consideration of local coastal geomorphology and understanding of potential negative consequences before plans are made and implemented.

(b) Management of shoreline erosion:

Shoreline erosion is a complex problem involving various factors. Each case of shoreline erosion should be considered in view of natural factors of the coastal environment. In order to remedy any adverse situation, baseline knowledge of coastal geological processes and their causes, their rank of importance and their interactions should be established. The Thai government should adopt measures to prevent shoreline erosion in the future.

(c) The causes of the shoreline changes as well as their relationship with adjacent shorelines have yet to be clearly identified. Other considerations, e.g the coastal geomorphology and oceanographic data, discrepancy in aerial photo interpretation and other factors should be incorporated in further studies.

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