Chapter 1

Introduction

1.1 Background and Rationale

Pattani Province, covering a land area of approximately 2,000 sq. km. in lower Southern Thailand, is situated on the east coast facing the Gulf of Thailand, between latitudes of 6° 56′ N to 60° 32′ 48″ N and longitudes of 101° 45′ E to 101° 1′ 18″ E. The Gulf of Thailand on the North borders Pattani, by Narathiwat on the southeast and by Yala on the south and southwest. Pattani Bay lies between latitudes of 6° 53′ N to 6° 57′ N and longitudes of 101° 14′ E to 101° 21′ E, covering an area of about 74 sq. km. On the north of Pattani bay lies Leam Pho, a 16-km.-long spit stretching parallel to the east west coastline of the peninsular mainland. Its mouth faces the Gulf of Thailand to the west. Inside the Bay is the mouth of Pattani River, Yaring River, Rusamilea, Prince of Songkla University and an industrial area.

Depending on the seasonal variation, the water in Pattani Bay changes to brackishness with the salinity about 4 - 32 ppt on average (Ninchim, 1998). Especially in November to December, a lot of freshwater flows into the Bay, therefore the salinity in the Bay Mouth goes down to 0 ppt (Hatta, 1980). It is also the receptive of freshwater, minerals and deposits from two principle rivers: the Pattani River and the Yaring River. In addition, the northeast and southwest monsoon winds also affect it, which in turn bring in a lot of rain almost throughout the year.

The salinity varies according to seasonal changes, besides variation of space and duration due to disturbance from human activities around the Bay, tide and drought, which all affect the quality of the water. The effects of the sediment formation at the bottom of the Bay have led to the formation of a long strip of delta as wide mud beach. This gradually developed from the riverine pilling up along the coastline and led to the formation of eco-mud beach systems along the shoreline around the Bay. This adds up to a land area of about 37 square kilometers. Within the area of mud beaches, mangrove forests, seawater swamps and waterways these exist a variety of

marine life species of some economic significance. These include bass, live fish in cages, sea catfish, blue crabs, giant tiger prawns (*Penaepsis monoceros*-Peneidae), *Peneus merguiensis* (Peneida), cockles and green mussels, and various species of algae, such as *Glacilaria* (Ninchim, 1998).

The changes and variations of salinity directly affect the natural resources, particularly aquatic animals dwelling in Pattani Bay. According to Yisin (1996), the salinity affects the economic sea animals. This means that six different levels of salinity significantly affect the hatching rate of cuttle fish (*Sepiella inermis*). Yisin found that the eggs were not able to hatch at salinities below 15 ppt. It was also found that the salinity for maximum hatching rate, up to 76%, for the species was 25 ppt. Among the salinities of 20, 30 and 35 ppt, the hatching rates were less than 60%. The eggs hatched under lower than optimum levels of salinity cause an abnormal development of embros. Puttapricha (1998) investigated eleven different levels of salinity affecting the adaptation to seawater and growth of juvenile red tilapia. It was found that juvenile red tilapia had 100% survival among salinities of 0, 5, 10, 15, 20, 21, 23 and 24 ppt. The salinity for minimum survival rate was 25 and 30 ppt, respectively. The salinity is also affected by the depth of water, probably due to human activities around the Bay, especially industrial activity.

Previous work (Viriyanon, 1990) involved investigating the quality of water and environment status in Pattani Bay and analysing chemical, biological and physical parameters including depth, temperature, transparency, total suspended solids, salinity, pH, dissolved oxygen, nitrogen and phosphorus. However there has been little work directly about salinity. It is therefore significant and worthwhile to examine the factors affecting the salinity in Pattani Bay.

1.2 Objectives, Scope and Expected Benefits of Study

Despite extensive study, including a comprehensive data collection exercise over two periods each of 25 hours duration at six locations around Pattani Bay in 1996 (see Khumpai et al, 2000), where water salinity was measured at 30-minute intervals, the factors determining salinity in Pattani Bay remain unclear.

This study has two objectives as follows:

(a) To study the relation between salinity and water elevation in Pattani Bay.
(b) To develop a statistical model for predicting the salinity in Pattani Bay based on location and water elevation.

The research hypothesis:

The salinity in Pattani Bay is determined mainly by the water depth, time and location (latitude and longitude).

The data were collected on 30 July 1999 by two boats starting at Rusamilae jetty, Pattani Province, and sailing to the Bay Mouth and collecting measurements on water depth and salinity at prescribed locations following a designed experiment.

The expected benefits are as follows:

(a) A model for predicting the salinity in Pattani Bay is obtained.

(b) The study design, though limited to measurements taken on a single day within a relatively small area near the mouth of the Bay, provides a feasible method for routine data collection in the future.

(c) Studies such as these add to the body of knowledge about the Pattani Bay environment, and such knowledge will ultimately benefit local industry.

1.3 Conceptual Framework

The conceptual model with plausible directional associations is shown in Figure 1.1. In this model, we assume that the salinity might be determined and by the depth (water elevation), time of observation (because of the tide) and location (latitude and longitude).

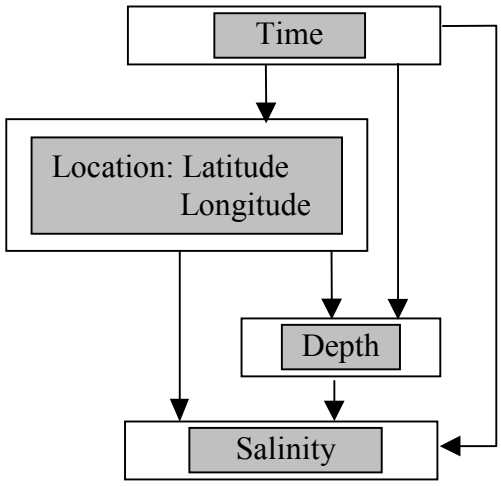

Figure 1.1: Conceptual framework diagram

Since the study involved taking measurements of water salinity from specified locations at different times, the most basic determinant is the time of observation, which then determined the locations at which the measurements were taken.

1.4 Literature Review

There has been some work related to the study of salinity and some water characteristics such as the water depth. For example, Viriyanon et al (1990) studied salinity in Pattani Bay (Phase I) by collecting data at 12 stations: (1) Bang Tawa, (2) Rusamilea, (3) Pattani River mouth, (4) Leam Nok, (5) Tanyong Lulo, (6) Bang pu, (7) Dato, (8) Budi, (9) Lighthouse, (10) Leam Tachi, (11) Bay mouth, and (12) Bay center. They found the salinity value of the water in Pattani Bay ranged from 19.8 ppt to 29.3 ppt with an average of 25.2 ppt. However the salinity was quite high at every station, especially in March with a highest salinity 31.2 ppt and the salinity value was down to 21.0 ppt in September. The depth in the sample stations found to

have a range of 0.52-1.98 meters in average. Viriyanon et al (1998) also investigated the quality of water and environmental status in Pattani Bay (Phase II). Samples of water from the middle depth in Pattani Bay (8 stations), Pattani River (3 stations) and Yaring River (2 stations) were collected every 3-6 months from October 1991 to July 1994, and analysed for chemicals. They found the salinity values of water in Pattani Bay was 25±3 ppt in average. Furthermore, the salinity in the two rivers, measured at high tide, increased in those stations situated in the lower part and toward the end of the Bay. Concerning the depth, it was found that the average values of depth at the stations where water samples were collected from Pattani Bay, Pattani River and Yaring River were 1.36±0.17, 2.70±0.31 and 4.55±0.70 meters, respectively.

Ninchim (1997) studied the relationship between rainfall and salinity in Pattani Bay. Data collected at three stations: (a) the Science Building of Prince of Songkla University, Pattani campus, (b) Yaring River mouth, and (c) Leam Tachi between January 1995 and December 1996. The data on salinity were collected by Pattani Coastal Aquaculture Station at Yaring from 14 locations around the Bay and measured between 7 February 1995-29 August 1996 and at intervals from two to six weeks. It was found that the salinity of the water is affected by location in the Bay, time of the year, and rainfall.

Rungsupa (1998) studied variations of water quality of the Inner Gulf of Thailand during 1990-1994. The variation of water quality parameters i.e. temperature, salinity, dissolved oxygen, pH and transparency of the Inner Gulf of Thailand were investigated. Analysis of variance and multiple regression analysis were employed to test the relationships between the water quality parameters and independent variables i.e. time (year), season (dry and wet), sampling station and depth. They found that the salinity depended on time and sampling station. The salinity in the Inner Gulf of Thailand varied from 22 - 34 ppt. The statistical analysis displayed by the average of salinity in two levels of water depth was not different with respect to season.

In further research, (USGS WRD, 1995: website), examined water quality in SF Bay; Sacramento River, Suisun Bay, San Pablo Bay, Bay Bridge and South Bay, and salinity space and time contours were graphed. Since salinity measures the relative proportion of freshwater and seawater, it reflects the changing importance of river

flow as a source of dissolved materials carried into the Bay-Delta from runoff. It is an important habitat descriptor, a control of chemical reactions, and the salinity distribution is an important mechanism that drives water circulation and transport in the Bay. The salinity of Bay-Delta waters ranged from about 0.1 to about 33 psu (practical salinity units, which are nearly identical to parts per thousand, ppt).

1.5 Definitions of Variables

Depth refers to the water level in Pattani Bay, distance from the surface to the bottom.

Occasion refers to particular time and location (longitude and latitude) in Pattani Bay.

Salinity refers to the quality of solid substances containing salts, especially sodium chloride (NaCl) dissolved in water. It is generally measured in weight units in terms of grams per kilogram of water or parts per thousand (ppt). Salinity results from carbonated salts becoming oxidised, bromide and iodide salts being replaced by chloride, and organic matter becoming oxidized.

Salinity in water may be related to chlorinity, which is the quantity of chlorides, bromides and iodides in one kilogram. A similar term to chlorinity is chlorosity, which is derived from the chlorinity value multiplied by the water density at 20 degrees Celsius. The salinity can be simply calculated by using the following formula (Greenberg et al, 1992)

$$\text{Salinity (ppt)} = 1.80655 \text{ chlorinity (ppt)}$$

Although this formula can be used for estuarine waters and brines, there are limitations. The salinity of water may vary depending on the location and soil type. Freshwater has an equivalent to zero salinity, whereas seawater has average salinity of 35 ppt.