CHAPTER I

INTRODUCTION

The coastal zone of Thailand with 2,614 km coastline has the important ecosystems characterized by extensive coral reefs, dense mangrove forests and seagrass beds (Paw et al., 1985). Endowed with warm tropical climate and high rainfall, waters are further enriched with nutrients from land which enable them to support wide diversity of coastal lives. Those coastal ecosystems form the important nursery grounds and provide a primary source of food for many marine organisms.

In this situation one of these three major ecosystems, coral reef, is known as the complex and beautiful marine ecosystem affected by many human activities. Those actions are not effectively controlled by the government because there are many obstructions. One important factor which cause the problems is the management plan to handle the reefs is not suitable for the rapidly increasing human activities. The management problems are as follows (Thamrongnavasawat and Sudara, 1991, Sudara et al., 1991):

- The data base survey needs long term period, many researchers and a lot of fund. These requirements make the short term management plans to collect the data only in small areas. The long term management plan needs a lot of time to acquire the data in large areas.
- The previous field survey gets only the data in that area. It can not cope with the present real location. Actually the survey map is made based on the previous map which was produced a long time ago and the technique in locating the point in the reef is not exactly correct.
- The supported data cannot clearly explain the overall reef activities unless they are identified by the scientists. However, the conclusion may be hardly understood by the management administrators. The technique to combine and present the data requires the high technology equipments which need to be developed to be suitable for the marine ecosystem.
- The reef study in Thailand emphasizes only the biological data, some important data, especially geomorphological, zonation and

classification are required. However, the method to study in these situations needs a spatial data for identifying overall reefs which have the same formation and effects.

The aims of this thesis are to develop the remote sensing technique to solve the problem in survey and management in the reef area, and using the results to explain the geomorphological, zonation and classification in the reefs.

1.1 Objective

From the reviewed problems in the reefs study and management in Thailand, the remote sensing become an essential tool for solving the problems. However, there are the problems which described as follow:

- The studies in Thailand have just begun, the previous works were run in the small areas with the standard techniques, they need the study in the developed technique in the large study sites.
- The transferred technique is limited with the different reef characteristics. The research in this must find out how to propose each step in the remote sensing study to suit the reefs in Thailand and also the reefs in some ASEAN countries which have the same characteristic as Thailand Reefs.
- The result from previous studies in Thailand regulated only the result explanation and management plan. The result using remote sensing products as a tool to study the reef has never been done. It needs the project to support this idea.
- Although the remote sensing for management plan was done, the useful data base was not produced. It needs the result to confirm the important of the remote sensing to the reef management plan.
- Although the Geographic Information System (GIS) is used in many natural study and management, it has never been used in coastal area study and management in Thailand. It needs the prototype GIS to support the idea of using GIS in this field.

The objectives of this project are to solve the problem in remote sensing studies of coral reefs in Thailand. It is possible that the results and recommendations may be used for other countries which have the reef remote sensing status similar to Thailand, for example ASEAN countries. Five objectives are pointed out as follows:

1. Developing digital image processing techniques and products for the reefs in Samui Islands.

2. Evolving the new ground truthing method to use in the small and shallow reefs, including the technique for ground positioning method.

3. Using the remotely sensed results to study the reef morphological, zonation and classification in Samui Islands.

4. Producing the management data base from remotely sensed methods. The processes are not only to make the product but also to develop the produced techniques.

5. Producing the prototype of GIS using in reef study. It recommends that the result will be the first prototype of GIS in coastal zone survey and management in Thailand.

The first two aims were developed using the technique in remote sensing studies on the reef which concluded the idea from the previous researches and run through those ideas. The other objectives are recommended as the first step for remote sensing in the reefs in Thailand. Some products, such as multi-resolution TM and SPOT map, are the new techniques which have never been used in remote sensing studies on the reefs before.

1.2 Project Frame Work

To process the results follow the objective, this project will run as follow:

- The developing of the techniques: The project will used the satellite remotely sensed data from Landsat and SPOT. The data preparation will run after the basis remotely sensed techniques, then the operations will be separated in two processes; 1) image analysis 2) image classification. The image analysis techniques compose of image enhancement, band ratio and principle component analysis. The results will used to clarify the remote sensing process in the reef area. While the image classification results will be used to explain the coral reef component distribution and to group the reefs patterns in this area.

- The ground truthin and ground positioning techniques: The techqiues will be developed and tested. These techniques develop to use with the image processing program that built for colleration the ground data with the remotely sensed data. This program calls "mTRAN".

- The data from remote sensing will be analysed to study the coral reef component distribution. It recommends that the remotely sensed results not directly be used for explaining the coral reef component distribution. But the results are used as the guide to explain. The ground survey will be done to point out the results.

- The results from remote sensing will be produced to use for the reef management plan in this area. Thses products are used to help the study. The hard products are 1) multi-resolution map 2) reef thematic and sediment density zone 3) reef area measurement. The multi-resolution map is processed by combined the SPOT XS data and Landsat TM data. The reef thematic and sediment density zone image is done by the classification process, also the reef area measurement.

- The prototype GIS results are 1) reef and depth map 2) perspective three dimensions image. The reef and depth map use the depth data from the topographic map comnined with remotely sensed results. The perspective three dimensions image is interpreted by the program in microBRIAN.

1.3 Remote Sensing of Coastal Wetlands

The remote sensing studied on coastal wetlands started with the study using aerial photography and appropriate ground measurements to quantify biomass and productivity in a large wetland area (Stroud and Cooper 1968). When the Landsat satellite series was launched in 1972, multispectral scanner (MSS) data became available. The advent of digital spectral data in specific wavebands sparked a new in remote sensing. Aerial photography was no longer the only source of synoptic information. Spectral reflectance of wetland canopies measured from the ground using spetroradiometers (Carter and Anderson, 1972) provided a powerful data source for coastal wetlands studying.

1.3.1 Remote Sensing of Reefs Mapping

The principle types of remote sensing studied on physiographic

zonation that occur on the reef was done by Maxwell (1968). It used aerial photography to generate and classify the image mapping of the major reef zones. Some of the earliest work on mapping coral reefs using satellite data was done by Smith et al (1975), the Landsat (ERTS-1) data was used with the aerial photography as the ground truthing. Smith (1975) undertook a preliminary evaluation of three common methods of processing and imaging Landsat data for the purpose of mapping reef zonation. The methods were level slicing of single band data, colour-compositing of three bands of MSS data and categorical analysis of four bands of data.

The second push in coral reef remote sensing started to survey and manage the Great Barrier Reef (Kenchington, Van and Claasen, 1988). The research has concentrated on information value for both mapping and surveying (Jupp et al., 1982) of data which have been collected from wavelengths selected for their suitability to a range of each resources targets. Followed by Kuchler (1985) presenting the using of Landsat MSS mapped the reefs at Great Barrier Reef. Most projects emphasized on Landsat MSS (Jupp et al., 1985) and Nimbus-7 CZCS sensor data (Claasen et al., 1984, Hallock, 1988). Base-map overlays, color-codes thematic maps (component map) and statistical data are the main worthwhile product which was given from remote sensing.

After the high resolution data, Landsat TM and SPOT, were supplied, more works were done to map the individual reefs in stead of mapping in a wide reef region (Bainbridge and Reichelt, 1988). The works considered on extraction of a biotic component to be isolated within the image signal. This indicates that with further work it may be possible to extract substrate types. The work in progress uses depth analysis to push out water may allow substrate types to be mapped (Bainbridge, 1991).

1.3.2 Remote Mapping of Reefs Within the ASEAN Region

ASEAN nationals are participating extensively in the technology transfer process that is required to make digital remote sensing science into a useable form (Sudara and Kuchler, 1988). Soegiarto (1988) pointed out three main works in this regions, there were coastal features and processes, assessment of coastal erosion in selected area, and monitoring of sediment dispersal and transport. However, the works on the coral reefs mapping were very

little compared with other coastal zones such as mangrove ecosystem.

The coral mapping started in 1978 in the Philippines (Bina et al., 1978; Bina and Ombac, 1979). However, the studies followed work were very rare. There were a few works in each country but it did not run in large projects and represented only that country. The work of remote sensing on the reef just started to study when there was the meeting of the ASEAN Experts Group on Remote Sensing in 1988 (Soegiarto, 1988) and the workshops on microBRIAN system which run under ASEAN-Australia Economic Cooperation Program-Marine Science Project: Living Coastal Resources in 1991.

Recently the remote sensing studies on coral reefs in ASEAN country is in the process. It recommends that a few works on reef ecosystem will be presented in the Second Regional Meeting of ASEAN-Australia Economic Cooperation Program-Marine Science Project: Living Coastal Resources which will be held at Singapore in 1992.

1.3.3 Remote Sensing in Thailand

Satellite remote sensing in Thailand was set up under the Thailand National Remote Sensing Program (TNRSP) in 1971. National Remote Sensing Coordinating Committee was established with cabinet decision to participate in the United States NASA Landsat investigation programs with the launched of ERTS-1 (Landsat-1) in 1972 and also the follow-on program, Landsat-2, Landsat-3.

Thailand's national remote sensing program under the auspices of the National Research Council of Thailand (NRCT) originally was responsible for coordinating with NASA to provide the data users with Landsat imagery, to train personnel of various government agencies and also to provide support to researchers with funds with an aim to increase the man-power in the field of remote sensing. With the establishment of the Ministry of Science, Technology and Energy in 1979, the coordinating unit of the TNRSP became a new division within NRCT called Remote Sensing Division. The Landsat data were applied in various fields, such as in land-use mapping, forest change detection, agricultural and environmental management. Satellite imagery were increasingly used in the national development process that finally the Cabinet approved the proposal by NRCT to establish the Landsat Ground Receiving Station in Thailand, as an operational unit under the Remote Sensing Division.

Thailand's Landsat Station (TLS) was commissioned in 1981. The coverage area of the station extends to many countries in Southeast Asia including the surrounding areas. In 1986 NRCT received the grant from Canadian International Development Agency (CIDA) to upgrade the existing facilities to receive and process the high resolution data from Thematic Mapper of Landsat-5 and HRV of SPOT-1. The upgrade facilities started to receive TM and SPOT data from December 1987. TRSC also cooperated with Japan's NASDA to construct a new ground station for MOS-1 which started to receive MOS-1 data from 1988. With the new facilities, TRSC became the regional ground receiving station in Southeast Asia. A plan to upgrade the existing facilities to receive and process ERS-1 data of ESA is being worked out (Vibulsresth and Srisaengthong, 1990).

1.3.4 Remote Sensing of Coastal Ecosystems in Thailand

Among those three main coastal ecosystems, coral reef, mangrove and seagrass, the study in Thailand emphasizes only on mangrove ecosystem. The National Research Council in cooperation with the Royal Forest Department have made some studies on mangrove since 1975 (Vibulsresth, Boonbutra and Ratanasermpong, 1987), the study series based on the mangrove zonation and declination were published (Remote Sensing and Mangrove Project, 1987).

The remote sensing studies on seagrass in Thailand started in 1989 by microBRIAN Remote Sensing Unit, Chulalongkorn University (Thamrongnavasawat, 1990; Sudara et al., 1990). However those studies emphasized on the seagrass communities in the coral reef area. The isolated seagrass study just started in 1991 and the study will feature in the seasonal changing of the seagrass bed.

The study of coral reef using remote sensing in Thailand was planned in 1988 (Sudara and Kuchler, 1988). After Chulalongkorn University received the microBRIAN system from ASEAN-Australia Economic Cooperation Program-Marine Science Project: Coastal Living Resources in 1988, the microBRIAN Remote Sensing was set up. The primary work on coral reef was published in 1990 (Thamrongnavasawat, 1990) which highlighted the reefs in the Gulf of Thailand. The preliminary program for coral reef study started in 1990 with the cooperation of Science and Technology Development Board (Sudara et al., 1990). The first remote sensing studies on the reefs in Andaman Sea was published in 1991 (Thamrongnavasawat and Sudara,

1991). The remote sensing study on the reef may expand to other research groups after the first Thailand microBRIAN workshop in June 1991 (Sudara, Thamrongnavasawat and Tangjaitrong, 1991).

The previous works of the remote sensing studies on coral reefs in Thailand can generate three aims, testing the remotely sensed technique in microBRIAN system to study the small and turbid reef (Thamrongnavasawat, 1990), to find the objective in remote sensing studies on the small reef (Sudara et al., 1990) and using the remotely sensed product to study and management the reefs (Sudara and Thamrongnavasawat, 1991; Thamrongnavasawat, 1991).

Recently it can be said that the remote sensing studies on the reef in Thailand is in the second phase which try to feature the study in the specified objective. There are two works in process. The first one is the remote sensing study on coral reef and sediment factor in Samet Islands within the cooperation of microBRIAN Remote Sensing Unit and Coral Reef Ecosystem Study Team (CREST), Burapa University. The remote sensing studied on the crown-of-thorn starfish affecting the reefs at Adang-Rawi Islands within the cooperation with microBRIAN Remote Sensing Unit and Prince of Songkla University.

1.4 Ground Truthing in the Reef

The ground truthing technique is a main function in the remote sensing studies on reef ecosystem. Different from other ground truthing studies, the reef study must find out how to predict the substrate under water with the biological zonation. The photography technique which is broad used in other studies may not help to survey the reef unless it exposes during the low tide.

The ground truthing in the reef study started with the first remote sensing studies on the reef. Smith (1975) ground truthed imagery from aerial photography though he stated that such interpretation did not replace field work. The field work ground truthing done by Bina et al. (1978) they used a number of methods to ground truth Landsat MSS data. The methods are snorkel observation, line transect, manta board tow and bounce dives.

In 1982 Jupp and Mayo suggested that the key to the ultimate usefulness of Landsat spectral data is the existence of a

relationship between the spectral makeup of the signal recorded by the satellite and the land cover of the target. Mayo et al. (1985) worked on pixel sized sample units selected from the classified image. Sites were located on the reef using 1:50,000 photo maps. A circle 80 meters in diameter was sampled for macroalgae, hard, soft and dead corals. However, Kuchler et al. (1986) reported that this method was not feasible for general surveys and more suited to specific research questions such as ascertaining the reflectance properties of particular reef units. The method employed by Kuchler et al. (1986) involved a modification of the manta tow technique run in a zig-zag pattern cover of dominant organisms on the reef floor and structures arising from it, were recorded.

The first step in the elucidation of the relationship between reef substrate and satellite signa data was presented by Bainbridge and Reichelt (1988). They used the manta tow and line transect techniques to certify the data from Landsat MSS and SPOT XS. The results suggest that SPOT XS data give the higher correlation to the ground data because its higher resolution. The line transect has more quantitative measurements than manta tow which is the visual estimate of the benthic coverage.

The previous reef ground truthing methods were made in the wide reef area with had the separated unique reef type, so the data may not be suited for the small reefs in Thailand. Sudara et al. (1990) checked the manta tow technique which was described by Kuchler et al. (1986) and found that this technique not suited for the small and shallow reefs because it can not run in the zig-zag direction. Thamrongnavasawat and Sudara (1991) suggested that the line transect method has quantitative result but it is hard to run in the field work because it needs a lot of researchers who have the experience to do the life form method. The results also demonstrate that it is difficult to explain the data in the small mixing reef. Most remote sensing studies the reefs in Thailand indicate that it needs the special technique to ground truth the shallow and small reef (Thamrongnavasawat, 1990; Sudara et al., 1990; Thamrongnavasawat and Sudara, 1991).

From those reviewed above, the ground truthing technique of the reef just developed to suit each research. There is no main method that can be run follow. However, the previous suggestions can be gave the idea for developing the ground truthing method which

is suitable for the small reef such as Thailand. Three major ideas are 1) developing the ground truthing technique for overall reef survey 2) developing the ground truthing technique to relate the ground data with the remotely sensed data 3) developing the technique for ground positioning technique and they can be used together.