Contributers

- **Marine Ecology Laboratory, Department of Marine Science, Faculty of science, Chulalongkong University, Bangkok 10330.**

    - Associate Professor Nittharatana Paphavasit -**Project co-ordinator and Chief Scientist** (Post-tsunami Impact Assessment and Recovery Capacity in Mangrove Ecosystem in Relation to Biological Productivity and Biodiversity)
    - Assisistant Professor Dr. Ajcharaporn Piumsomboon -**Chief Scientist** (Post-tsunami Environmental Impacts in Mangrove Ecosystem on the Andaman Coastline)
    - Ms. Itchika Sivaipram
    - Mr. Suriyan Saramul
    - Mr. Porntep Punnarak
    - Ms. Nirucha Mongkonsangsuree
    - Ms. Cholthaya Songroop
    - Ms. Sirimard Sukprasert
    - Mr. Bancha Sabuytua
    - Ms. Supichaya Wongchinvit
    - Ms. Thipnapha Suwansanit
    - Mr. Pongvithid Chulaing
    - Ms. Woraya Khwaiphan
    - Mr. Vichaya Gunbua
    - Mr. Ekapol Aumnuch

- **College of Population Studies, Chulalongkong University, Bangkok 10330.**

    - Ms. Siriwan Siriboon -**Chief Scientist** (Post-tsunami Impact Assessment on Socioeconomic and Public Participation: Andaman Coastal Communities)
    - Ms. Busarin Bangkaew
    - Ms. Chanettee Milintangkul

- **Mangrove Research and Development Division, Department of Marine and Coastal Resource**
    - Mr. Viroj Teratanatorn -**Chief Scientist** (Integrated study on Impact Assessment on Mangrove Forests from Tsunami)
    - Mr. Sangob Panichchart
    - Mr. Sombat Karnchanapaiharn
    - Mr. Yuthasilp Suwanwong

Preface

Final report on the "**Post-tsunami Monitoring of Impact Assessment on Mangrove Ecosystem on the Andaman Coastline of Thailand**" is the opportunity given to our multi-disciplinary research team by Thailand Environment Institute to turn the "**Crisis**" of the 2004 tsunami into "**Opportunity**". We were able to apply our knowledge-based researches into the integrated post-tsunami mangrove rehabilitation and management plan for the coastal communities on the Andaman coastline. We tried to answer indepth research questions related to the impacts of tsunami as presented in this final report. It is hoped that our research findings can be integrated into the post-tsunami rehabilitation program in order to enhance the quality of life and livelihood of residents in the affected coastal communities. Most importantly, these research findings can be transformed into working reality in order to conserve and manage our precious mangrove forest.

Acknowledgement

Our research team truly appreciate the opportunity given to us by Thailand Environment Institute and UNOCAL Foundation to conduct the research on Post-tsunami Monitoring of Impact Assessment on Mangrove Ecosystem on the Andaman Coastline of Thailand. Our sincere gratitude goes to Professor Dr. Sanit Aksornkoae, President of Thailand Environment Institute, for having faith in our team's ability.

This research can not be completed without the assistance and kindness from various individuals. We would like to express our heartfelt thanks to them.

To our local authorities in Ban Nam Khem/Phang-nga Province: Mr. Pratom Rasamee and Mr. Suriya Sornserm of the Mangrove Conservation and Development Unit. Mr. Maitree and Mr. Satira Petchkling, the two local authorities. Also to our local authorities in Bang Rong, Phuket Province: Mr. Rorchad Tortip, Mr. Manas Kongnarm and Mr. Chade Kerdsap. We truly appreciated the team effort of our mangrove field officers: Ms. Chalisa Jirapruk, Mr. Pichate Siabay and Mr.Sitthichote Tongkittichote, both of whom are based in Phuket Province.

To the Phuket Marine Biological Center, Department of Marine and Coastal Resources for allowing the facility and equipment for nutrient analyses. Our special thanks go to Mr. Somkiat Khokiattiwong and Mrs. Nipavan Bussarawit for their assistance in this task.

To our team spirits and brotherhood as always, we want to thank our ex-members of the Marine Ecological Laboratory, Department of Marine Science, Chulalongkorn University, who always lent their helping hands: Ms. Wanwiwa Wichitworakhun of Department of Biology, Silpakorn University, Ms. Woraporn Tarangkoon of Department of Marine Science, Srivichai Ratchamangala University and Mr. Bundit Sikhanthakasamit of Southeast Asia START Regional Center.

We want to thank our newly-recruited staff to our laboratory and have taken this opportunity to train them for the task of mangrove and coastal researches ahead: Ms. Nutanun Wangprasert, Mr. Chinnakorn Noothong, Mr. Komgrit Prawatlertudom, Mr. Thanaphol Meepolka, Mr. Joonvijit Wangprasertkul, Mr. Nittikorn Chulaing and Mr. Kongkiat Sakdianuchaicharn.

Content

Content

Research Synopsis

On December 26th 2004 a tsunami disaster strucked the Indian Ocean. Thirteen countries in Asia and Africa shared the same disastrous fates. Six provinces on the Andaman coastline in Thailand were affected. The tsunami caused great loss of lives and property. But mangrove forest proved one of their ecological roles as barriers against wind, waves and erosions, helping to lessen the loss. The important question posed that required indepth research was "Can mangrove help to reduce tsunami damage?". Another research question was the assessment of the disastrous tsunami impact on the mangrove ecosystem, demographic, socio-economic and ecological condition in the affected area.

Having the multi-disciplinary researchers in our team, both in the field of science and social science, we believe that this **"crisis"** can be turned into the **"opportunity"** for us to apply our knowledge-based researches into the integrated post-tsunami mangrove rehabilitation and management plan for the coastal communities along the Andaman coastline. Our integrated research project **"Post-tsunami Monitoring of Impact Assessment on Mangrove Ecosystem on the Andaman Coastline of Thailand"**, aimed to elucidate, on the basis of integrated science and socio-economic data, the ability of mangrove forest structure to withstand the impacts of tsunami. Our scientific team members also investigated the ecological changes that have occurred in the mangrove ecosystem due to tsunami. Our social scientists investigated the impact of tsunami on the socio-economic and demographic condition of the study areas. Ecological consideration will be brought to attention in appropriate theme. The community awareness and participation in mangrove rehabilitation program will be examined in order to find out the mechanism for sustainable management of mangrove resources through local community action.

Comparative post-tsunami impact assessment was carried out in two research sites namely Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province during October-November, 2005. The two mangrove forests prior to tsunami were considered degraded forests. These forests had been under two-rotation-cycle concession for wood cutting from 1976-2000. After the year 2000, the two forests experienced two different paths. *Rhizophora apiculata, R. mucronata, Ceriops tagal* and *Bruguiera cylindrica* were dominant species in the natural regenerated forest in Ban Nam Khem. *Avicennia alba* and *Sonneratia ovata* can also be found. Dense *Rhizophora* forests characterized the intact Bang Rong mangrove forest. *A. marina*, *A. alba* as well as *S. ovata* can be found. The rich intact forest in Bang Rong was due to the mangrove reforestation program launched by the Royal Forest Department together with the Petroleum Authority of Thailand in 1996. Since then, the community has taken an interest in mangroves at heart by managing this precious resource themselves. During the tsunami, the mangrove forest in Ban Nam Khem was directly impacted by tsunami. The Bang Rong mangrove forest only received indirect impacts from high standing waves. Two different mangrove forests, *Rhizophora* and *Avicennia*, receiving different degrees of impact from tsunami, were also compared. Looking at the history of the two villages, tin-mining in 1975 was the pull factor for in-migration to the unknown remote rural area of Ban Nam Khem village in Phang-nga Province. People from everywhere with low socio-economic status moved in for job opportunity. The majority of people in Ban Nam Khem were not the citizen of the village by birth. This resulted in a low level of cooperation among people in the community. In contrast to Bang Rong, Phuket Province, the village has very long history of more than 200 years. The majority of the villagers were born in the community which was highly united through religion. Mangroves have played many significant roles that benefit the community.

His Majesty King Bhumibol Adulyadej of Thailand has laid down the concept of self-sufficiency/self-reliance as the important step towards sustainable development. Taken his

royal initiatives as the guideline for our multi-disciplinary research, the assessment of the existing biological productivity and maintenance processes in the affected areas was carried out. This is one of the most important elements to determine the self-reliance of the ecosystem. It will also demonstrate the resilience and response of the ecosystem to disturbances. Understanding the population structure and way of life in the coastal area is also important. Public awareness and participation in the coastal resources conservation and rehabilitation is another important element of self-reliance apart from biological productivity of the area. From our ecological risks assessment, we predicted that both mangrove forests at Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province should be resilient to disturbances, such as tsunami, due to foodweb complexity and high stabity in these forests. High recovery ability was also predicted.

Our post-tsunami monitoring of impact assessment in the two study sites has confirmed our predictions in ecological risk assessment. Our findings showed the relationship and mechanism of different vegetation to wave impact reduction. The ability of mangrove forest structure to withstand the impacts of tsunami is based on the position of forest, facing directly or indirectly to tsunami, selected dominant mangrove species, and the forest condition namely, forest width, tree density, root system and tree canopy charecteristics. The fringe mangrove forest in Ban Nam Khem was directly exposed to the action of the tidal waves. Degree of impacts differed between the *Avicennia* forest and *Rhizophora* forest. This was also evidenced from the forest in Bang Rong which were left intact and unaffected by the tsunami. *Rhizophora* species have higher ability to withstand tsunami impact than *Avicennia* species. Three damage patterns were observed from Ban Nam Khem area, namely, windthrow, bole damages and death where the tree remained standing.

The assessment on the existing biological productivity and maintenance processes in the two mangrove forests reflected the self-reliance of the forests. The two mangrove forests were resilient to disturbances due to their food web complexity and high stability as already predicted. The coastal and mangrove productivity both in Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province were not affected as the tsunami aftermath. The two mangrove forests continue to provide ecological functions as habitats, nursery ground and feeding grounds to numerous mangrove inhabitants. The return of certain birds and long-tailed macaques in the affected area was a good indication.

The impact of tsunami disaster on demographic and socio-economic was evident. Most villagers in Ban Nam Khem were affected from tsunami both directly, in terms of loss of household members and relatives and also loss of and damaged properties, and indirectly in terms of mental health problem. One-third of households in Ban Nam Khem lost-family members. Among them, approximately 2 members lost their lives in the disaster. The fear of tsunami, the stress and sorrow due to the loss of their beloved ones, the feeling of being insecured about their future and career and also the loss of faith were main factors underlying their mental health problems. Bang Rong did not experience the loss of the same degree as Ban Nam Khem since the village was indirectly impacted from tsunami. No casualty was recorded during the tsunami. Houses and dwellings were not destroyed, only the fishing gears were damaged. Migration was the major factor contributing to the changed population structure and composition in Ban Nam Khem. High percentage was reported to move out from the village permanently and temporarily.

It was evident that tsunami has caused severe impacts on the economic conditions of Ban Nam Khem community. One-third of the respondents and one-fourth of their spouses were unemployed after tsunami. More than half of the people had to change their occupation, particularly fishermen. Many of them had to work as unskilled labourers and needed to move to work away from home. This had a significant impact not only on the changing in the economic structure but also in life styles and relationship with family members. The reduction

in income as tsunami aftermath was 3.5 times when compared to the period prior to tsunami. The severity of economic difficulty also reflected in increasing debts. People in Ban Nam Khem evaluated that they would face the economic strain for a long period of time, not less than 4 years in the future. In Bang Rong, the tsunami disaster affected the economic condition of certain groups namely, small-scaled fishermen, those in aquaculture business and eco-tourism.

Several pre-tsunami mangrove reforestation activities had been carried out in the two study areas. These activities were not successful in Ban Nam Khem due to the lack of public participation. In contrast, the reforestation program was a success in Bang Rong due to the community-based management. It is clear in this study that active participation in mangrove conservation is positively correlated with the degree of the mangrove-dependency by local communities. The findings pointed out that sustainable development of mangroves should not solely be the government responsibility. Local communities should have the responsibility to conserve mangroves as well as the rights to utilize the forest and its products. With different goals and objectives for mangrove restoration, the same basic blue print can not be drawn. There is a need for the design of mangrove rehabilitation scheme which is site-specific to suit the objectives of the coastal communities.

As the mitigation of tsunami impacts, we have proposed the site specific rehabilitation scheme based on our integrated knowledge of the area. Coastal green belt as a natural shield against disaster and shoreline protection was proposed for Ban Nam Khem area. The mangrove rehabilitation program in Ban Nam Khem should be in the form of co-management that required active participation from all stakeholders with joint responsibility among the tripartite parties namely, government, non-governmental organizations and local communities. The co-management should begin with networking building within the community. Mangrove rehabilitation as the enhancement of coastal fishery and mangrove rehabilitation as landscaping for ecotourism were proposed for Bang Rong area. We have highly recommended that the mangrove rehabilitation program should be launched in Bang Rong under the supervision and joint responsibility of the mosque committee. The government organizations, particularly at provincial level, should work hand in hand with the mosque committee as well as other groups responsible for environmental development.

In order to conserve and maintain long-term sustainable yields from this valuable mangrove resources, full cooperation among tripartite parties namely: government sectors (both national and local levels), non-governmental sectors and public participation are ultimately required. The six REs namely REvalue, REstrategy, REprocess, REstructure, REcondition and REsearch were proposed as underlying factors determining sustainable development of mangrove resources. Monitoring and capacity building were also suggested as an integral part of the proposed mangrove rehabilitation program.

Chapter 1

General Background of Project

Nittharatana Paphavasit Viroj Teratanatorn Siriwan Siriboon
Ajcharaporn Piumsomboon Porntep Punnarak and Nirucha Mongkolsangsuree

Introduction

On December 26th 2004 a tsunami disaster strucked in the Indian Ocean. Thirteen countries in Asia and Africa shared the same disastrous fates. Six provinces on the Andaman coastline in Thailand were affected. The tsunami caused great loss of life and property. But the mangrove forest proved one of their ecological roles as barriers against wind, waves and erosions helping to lessen the loss. John Pernetta, the Project Director for the United Nations Environment Program has commented ***"The mangrove are extremely important in forming an effective barrier against any type of wave… It takes the energy out of the wave, so while the forest itself will be trashed, it will protect the infrastructure behind it"*** (http://msnbc.msn.com) Dr. J. Primavera, one of the world authority in mangrove ecology has shared the same view that ***"Tsunami-triggered waves destroy only things that lie in their path including houses and tourist resorts. But a green belt of mangroves and beach forests will mitigate the impact of 15-meter waves. It's nature's protection against nature's fury".***

Of the coastal ecosystem in Thailand, approximately 2,415 rai or 386.4 hectares of mangrove forest were reported to receive impacts from the tsunami. The damaged mangrove area was small when compared to other coastal ecosystem, coral reefs, seagrass beds and sandy beaches, of 4,321 rai or 691.36 hectares and 6,200 rai or 992 hectares respectively. Only 555 rai or 88.88 hectares of mangroves in Ranong Province was reported to be severely damaged. Large areas of mangroves in Phang-nga Province were slightly damaged. Mangrove forest in Phuket Province also received minimal impacts. The important question posed that required indepth research was "Can mangroves help to reduce tsunami damage?" Another research question was the impact assessment of the disastrous tsunami on the mangrove ecosystem, demographic, socio-economic and ecological condition in the affected area. Among planners and academicians, mangrove forest was seen as life-saver during tsunami. They believed that this **"crisis"** could be turned into the **"opportunity"** for them to apply their knowledge-based research into the integrated post-tsunami mangrove rehabilitation and management plan for the coastal communities in the Andaman coastline (Paphavasit *et al.,* 2005)

Attention has been focused on the coastal resource rehabilitation. The rehabilitation of mangrove forest will benefit not only future safety of these communities, but also their long term socio-economic development by enhancing livelihood opportunities and provision of needed resources. Prior to initiating specific mangrove rehabilitation activities, a more comprehensive understanding of the complex ecological-social-economic linkages is necessary to determine suitable approaches as they are not only related to the coastal environment, but also equally important to enhance the quality of life and livelihood for residents in affected coastal communities. The multi-disciplinary researches on ecological risk assessment and post-tsunami monitoring as well as socio-economic conditions of communities are essential.

Assessment of 2004 tsunami impacts on mangrove ecosystem on the Andaman coastline

The Indian Ocean tsunami of December 26th, 2004 had a devastating impact on coastal ecosystem in 13 Asian and African countries. Of the coastal ecosystem, coastlines fringed by mangroves were strikingly less damaged than those where mangroves were absent or had been removed. Assessment on the affected areas indicated that although coastal ecosystem, such as mangrove forest, were damaged by the tsunami, they also played an important role in protecting coastlines. Several field reports indicated that mangroves saved thousands of lives by preventing people from being washed into the sea, and in addition, trapped driftwood preventing property damage and injury to people. Green belts of other trees, coastal dunes and intact coral reefs performed similar functions (Parish, 2005). In Penang, Malaysia, according to P. Balan-an, adviser to the Penang Inshore Fishermen's Welfare Association (PIFWA) which represents 6,000 small-scaled fishermen was quoted ***"We receive reports from fishermen who said they saved themselves by running into the mangrove forest. Some of their boats were also saved as they got struck between the trees. Houses 500 to 800 meters from the shoreline were left intact"***[1]

[1] In this section, several experiences and comments on the impacts of tsunami on mangrove forests shared by many prominent scientists and authorities as quoted from the Tsunami websites mainly Mangrove Action Project-Tsunami Action Alert and River Basin Initiatives. There fore the references were not given. In contrast, scientific findings as appeared in scientific meeting and publication will be properly cited.

The coastline of West Malaysia, mainly along Selangor and Perak was better protected by mangroves compared to Kedah and Penang, both of which suffered severely during the tsunami. However, Koay Jetty in George Town, the capital of Penang, was reported by Balan to suffer minimal damage as its area was lined with intact mangrove forest.

Similar cases were reported in Indonesia, Malaysia, Thailand, India and Sri Lanka that dense mangrove forests can help reduce the devastating impacts of tsunami by absorbing some of the waves' energy. Mangrove is an efficient soil binder and has a dense root and branch structure, which can combat the most violent cyclones and tidal waves. Tidal surges thrown up by tsunami can easily be arrested and slowed down by thick mangrove vegetation as observed by M.S. Swaminathan, Head of the M.S. Swaminathan Research Foundation in Chennai, India. In Banda Aceh, Indonesia, closed to the epicentre of the disastrous earthquakes, 5 villages in Julok, approximately 100 km. to the southeast of Banda Aceh, were saved by the extensive mangrove in the area. On Simeuleu Island which was only about 40 km. from the epicentre, was also saved by the wide belt of mangroves (Parish, 2005)

In India, nearly 11,000 people mostly in Tamil Nadu State were still living in relief camps. They could not return to fishing because their boats were destroyed and few fish were found close to the shore. Many fishermen were scared to go back to the sea. But in Pichavaram, there were 900 hectares of intact mangrove forests. There was no loss of human life or property in these villages, located 100 to 700 m. from the sea. The local residents continue to fish just as they did before as reported by S. Ramamurthy, the forest officer-in-charge. Kathiresan and Rajendran (2005) have conducted a study after the December 26th, 2004 tsunami in 18 villages along the 25 km. coastline at Parangpipetta, Tamil Nadu, India. Two mangrove formations, intact mangrove forest at Pichavaram and mangrove plantations since 1992 along the vellar estuary. They found that there was a significant negative correlation between human death toll and the distance of human inhabitants, the elevation from mean sea level and the area of mangrove and other coastal vegetation. Heavy loss of human lives was recorded in 6 villages in close proximity to the shoreline at the distance between 100-400 m. without any significant vegetation cover. No loss of lives in 3 villages and human death toll was low in 4 villages. All these villages were situated behind mangrove forests, located at a distance ranging 1,000-2,500 m. from the shoreline and also in elevated places. According to Ramamurthy, after the tsunami, authorities in Tamil Nadu State launched a massive reforestation program along the coast. Official asked fishermen families to plant a sapling and dedicate it to the family member who died in the disaster. In the Nagappattinam district where nearly 7,000 people died, Akash Deep Baruch, the Chief. Forest Officer, has special mangrove reforestation program. ***"The plant will have a small tag with the engraved name of the dead person. This way, they will be motivated to grow vegetation and stop encroaching on land along the coast. Also it will help to diversify the livelihood of the fishermen."***

The Department of Marine and Coastal Resources conducted rapid assessment of tsunami impact on Andaman mangrove forests in Thailand. The severe damages were reported in Ranong and Phang-nga Province. Degree of impacts varied. In heavily damaged areas, some trees were uprooted, in particular those close to the sea. Some mangrove area was eroded, in particular those receiving direct impacts from furious waves and in the riverine mangroves. Debris and destroyed properties including houses, vehicles and boats were scattered in the mangrove areas. Environmental impact assessment of the tsunami in Thailand conducted by Aiemsiri *et al.* (2005) in the affected area in 6 provinces on the Andaman coastline shared the same findings as conducted by Wanaprapoti *et al.* (2005). Ban Nam Khem, Phang-nga Province received severe impacts resulting in the loss of property, mainly hotels, resorts, fishermen villages and shrimp ponds within a radius of 1.5 km. from the beach. Certain beaches were totally eroded with 30-50 m. clearance zone. Since tin mining operation had been carried out in Ban Nam Khem, several large deep ponds were found in the area. During the tsunami, the furious waves swept people as well as vehicles into those ponds. Wanaprapoti *et al.* (2005) carried out the study on the dynamics of natural forests after the tsunami. In Phang-nga mangrove area, large trees were broken. *Rhizophora apiculata, Xylocarpus granatum* and *Rhizophora mucronata* were recorded as the dominant species in the study areas. Approximately 7.3 percent of large trees were broken while other less dominant species and shrubs were not affected. Another damage in the mangrove forest as recorded was the uprooting and fallen trees. This was due to the impact of the monstrous waves. In Ban Palai and Ban Pan-wa, Phuket Province, three damages in the mangrove forest were recorded. Approximately 5.6 percent of large trees were broken. The dominant species in this area were *Rhizophora apiculata, Sonneratia alba* and *Avicennia alba*. Approximately 1 percent of trees were inflicted with injured wounds/cut from impacts. Uprooting and fallen trees in the area was approximately 4.4 percent. It was predicted that the mangrove structure was slightly damaged. Recovery rate should be materialize in short time. Mangrove regeneration was not affected. From their survey, some seedings from mangrove forests appeared to have 100 percent survival rate. Pakdikul *et al*. (2005) carried out the impact assessment on the Pra Tong Island Ecosystem. Mangrove forest at Ban Tung Dab was severely impacted. The waves eroded and widened the channels in the mangroves. The channel bank was eroded as *Rhizophora* root system was seen clearly. Sedimentation has increased. In Ban Pak Chok where intact forest appeared, low impacts were observed.

Kiartiprayoon *et al.* (2005) conducted the impact assessment on mangrove ecosystem including the forest structure and local communities in Phang-nga. They concluded the degree of damages on forest structure varied. As shown, most of the impact assessment on mangrove ecosystem were based on the physical alterations. The assessment on the ecological functions, being permanent habitats, feeding and nursery grounds and nutrient transports between mangrove forests and coastal waters, have not been carried out. Moreover, it still has to be confirmed whether mangroves prevent significant damage from the Indian Ocean tsunami. It is important to gather more detailed information on the linkage between mangroves and the damages caused by tsunami.

Objectives of research

Having the multi-disciplinary researchers in our team both in the field of science and social science, we feel that this **"crisis"** could turn into the **"opportunity"** for us to apply our knowledge-based researches into the integrated post-tsunami mangrove rehabilitation and management plan for the coastal communities in the Andaman coastline. We have always taken the royal initiatives on mangrove rehabilitation and management into account. Our research team have drawn the framework transforming these initiatives into a working reality in the post-tsunami mangrove rehabilitation and management as elaborated by Paphavasit *et al*. (2005). Three phases in the post-tsunami mangrove rehabilitation scheme were proposed, namely immediate phase concentrating on the ecological risk assessment impacts. The short-term phase involved the post-tsunami monitoring survey. This was important phase involving the comparison of the field survey and the predicted risk assessment. Site-specific rehabilitation plans would be drawn accordingly to the landscape and the public need. The long-term phase would require 3-4 years to implement the proposed mangrove rehabilitation plan on selected pilot site together with the human resources capacity building and the assessment of the rehabilitation project.

Our integrated research project **"Post-tsunami Monitoring of Impact Assessment on Mangrove Ecosystem on the Andaman Coastline"**, as funded by Thailand Environment Institute and UNOCAL, provided us the opportunity to follow the first two phases of our framework on post-tsunami mangrove rehabilitation and management plan. Our research aimed to elucidate the ability of mangrove forest structure to withstand the impact of tsunami in terms of integrated science and socio-economic data. Our scientific team members also investigated the ecological changes that have occurred in the mangrove ecosystem due to tsunami. Our social scientists investigated the impact of tsunami on the socio-economic and demographic condition of the study areas. Ecological considerations will be brought to attention in appropiate theme. The community awareness and participation on mangrove rehabilitation programs will be examined in order to find out the mechanism for sustainable management of mangrove resources through local community action.

Our research aimed to elucidate:

1. The ability of mangrove forest structure to withstand the impact of tsunami and also to lessen the impact from tsunami in terms of integrated science and socio-economic data.
2. The ecological changes that have occurred in the mangrove ecosystem due to tsunami in terms of environmental changes and biological productivity.
3. The ability of the research sites for natural regeneration/succession and prediction of natural recovery.
4. Impact assessment on socio-economic and population structure in the communities in the research sites.
5. Public participation and awareness in mangrove rehabilitation programs.
6. Proposed mangrove rehabilitation programs suitable to research sites.
7. Key indicators in environmental monitoring program to be developed for coastal communities.

Description of research sites

After the preliminary survey in Phang-nga and Phuket Province, all research teams agreed on two research sites namely, Ban Nam Khem, Phang-nga Province and Ban Bang Rong, Phuket Province as shown in Figure 1.1. Comparative post-tsunami impact assessment can be carried out in two different mangrove forests, *Rhizophora* and *Avicennia*, both of which experienced different degrees of tsunami impact.

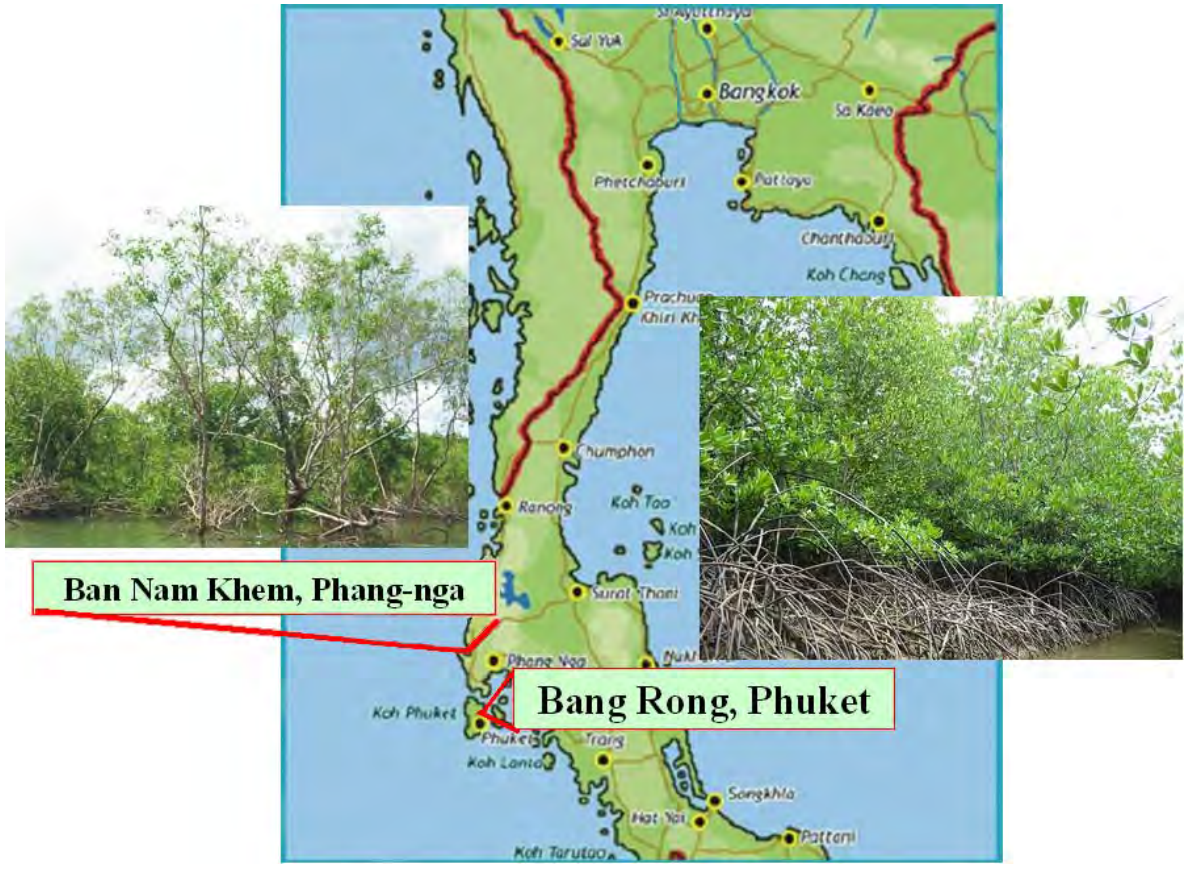


Figure 1.1 Two research sites namely Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province.

Ban Nam Khem is a village in Bang Muang Sub-district, Takuapa District of Phang-nga Province. Prior to tsunami, most people were not in fishing occupation. Looking back at the history of the village, tin-mining in 1975 was the pull factor for in-migration in this unknown remote rural area. People from everywhere with low socio-economic status moved in to search for job opportunity and better living. The majority of people in Ban Nam Khem were not born in the village. This resulted in a low level of cooperation among people in the community. When the tin mine concession was abolished, many villagers moved out of the village. For those who stayed, some became fishermen. Prior to tsunami, the economy of the community climbed up to the peak when tourism and commercial fishery business were introduced. As the tsunami aftermath, the number of fishermen were drastically reduced due to the loss of their boats and fishing gears. They turned to other occupation, mainly labourers. Still, some were jobless. In contrast to Bang Rong, Phuket Province, the village has a very long history for more than 200 years. The village is located in Pak-Klok Sub-district, Tha-Lang District, Phuket Province. The majority of the villagers were born in the community which is highly united through religion. More than 95 percent of the villagers are Muslim. The mangroves have played many significant roles that benefit the community. There have been many activities related directly and indirectly to mangrove conservation and rehabilitation programs.

The two mangrove forests prior to tsunami were considered degraded forests. Both had been under the two-rotation-cycle concession for wood from 1976-2000. After the year 2000, the two forests experienced two different paths. *Rhizophora apiculata*, *R. mucronata*, *Ceriops tagal* and *Bruguiera cylindrical* were dominant species in the natural regenerated forest in Ban Nam Khem. *Avicennia alba* and *Sonneratia ovata* can also be found. Dense *Rhizophora* forests characterized mangrove forest in Bang Rong estuary. *Avicennia marina*, *A. alba* as well as *Sonneratia ovata* can be found. The rich intact forest in Bang Rong was due to the mangrove reforestation program launched by the Royal Forestry Department, together with the Petroleum Authority of Thailand in 1996. Since then, the community has taken an interest in mangroves at heart by managing this precious resource themselves. During the tsunami, the mangrove forest in Ban Nam Khem received direct impacts. The Bang Rong mangrove forest only received indirect impacts from high standing waves.

Research methodology

Field Survey for Forestry, Environmental and Fishery Resources Team

The field survey for scientific teams in the two research sites was conducted from 1 October – 20 November 2005. Detailed research methodology is summarized in Table 1.1.

- Ban Nam Khem, Phang-nga Province

Figure 1.2 showed the 7 stations in Ban Nam Khem area where the environmental team and fishery team carried out their survey on the water quality and plankton samplings. Five stations were located from the upper reach of Khlong Pak Ko to Laem Pom Bay. Two stations were within Khlong Bang Por and Khlong Lat Bang Muang. All stations coincided with the stations set by the fishery team for benthic and fishery monitoring. Circulation as well as suspended solids concentrations were also monitored. Analyses of certain nutrients parameters were carried out at PMBC.

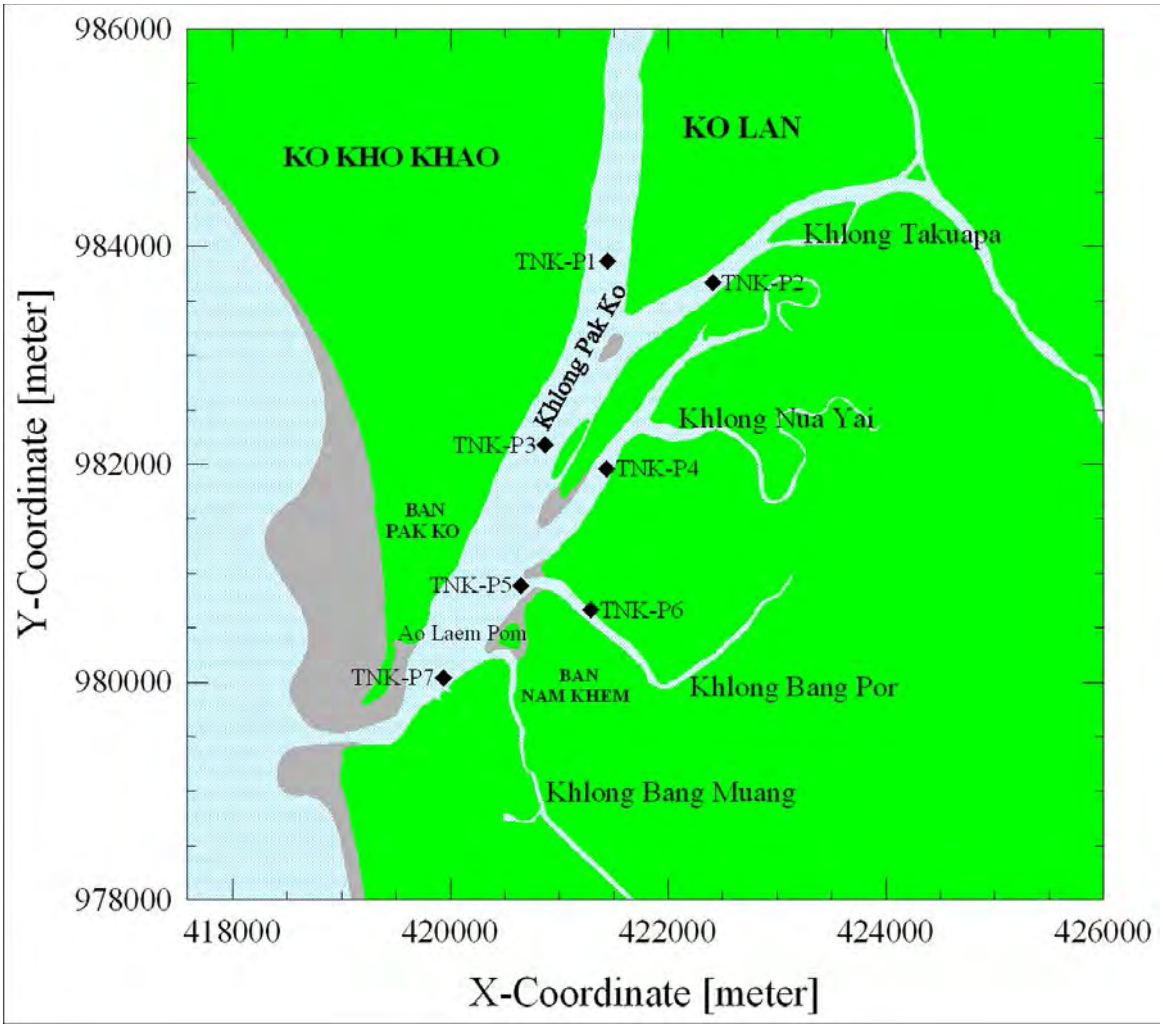


Figure 1.2 Water quality and plankton sampling sites at Ban Nam Khem, Phang-nga Province.

Fishery team carried out the meiofaunal and macrofaunal sampling as well as the fish communities in the *Avicennia* mangrove forest of different tree density as shown in Figure 1.3. The benthic and fish samplings were also carried out in the two *Rhizophora* mangrove forest of different tree density. The new mudflat that had previously been cleared due to tsunami was also monitored. New trees had been planted in this area to replace the old *Avicennia* forest. The sediment was cellected by using corers. Fishes were also monitored from the fisherman catches and fishing piers. The forestry team carried out the study on forest structure according to the benthic samplings.

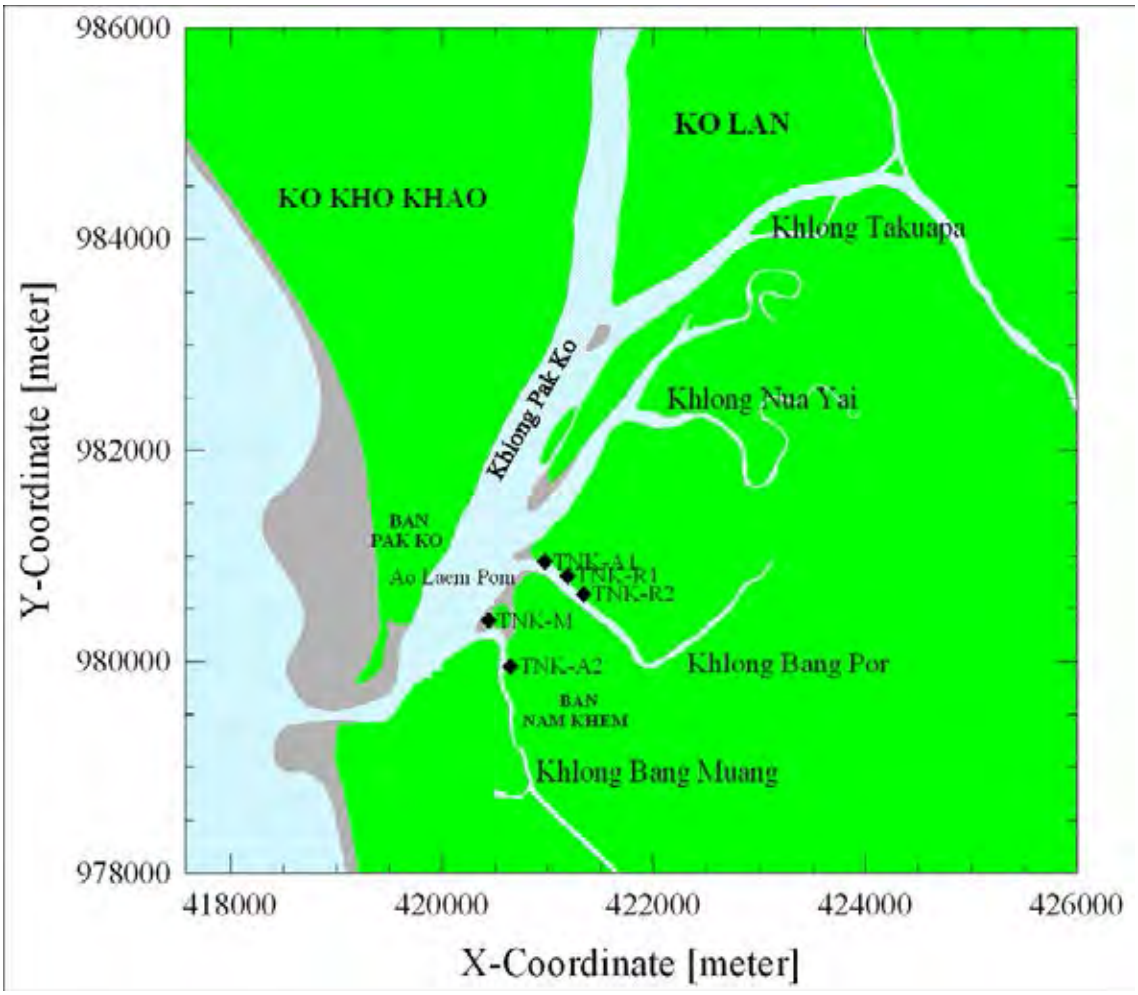


Figure 1.3 Sediment and benthos sampling sites at Ban Nam Khem, Phang-nga Province.

- Bang Rong, Phuket Province

Six stations as shown in Figure 1.4 monitored water quality and plankton with 2 stations in Khlong Bang Rong Estuary near Laem Ao Po and 4 stations within the Khlong Bang Rong to the upper reach above the fish cage culture area. Each station was located in front of the mangrove forest where the fishery team carried out their benthic and fish samplings. Water circulation and suspended solids concentrations were monitored. Analyses of certain nutrient parameters were also carried out at PMBC.

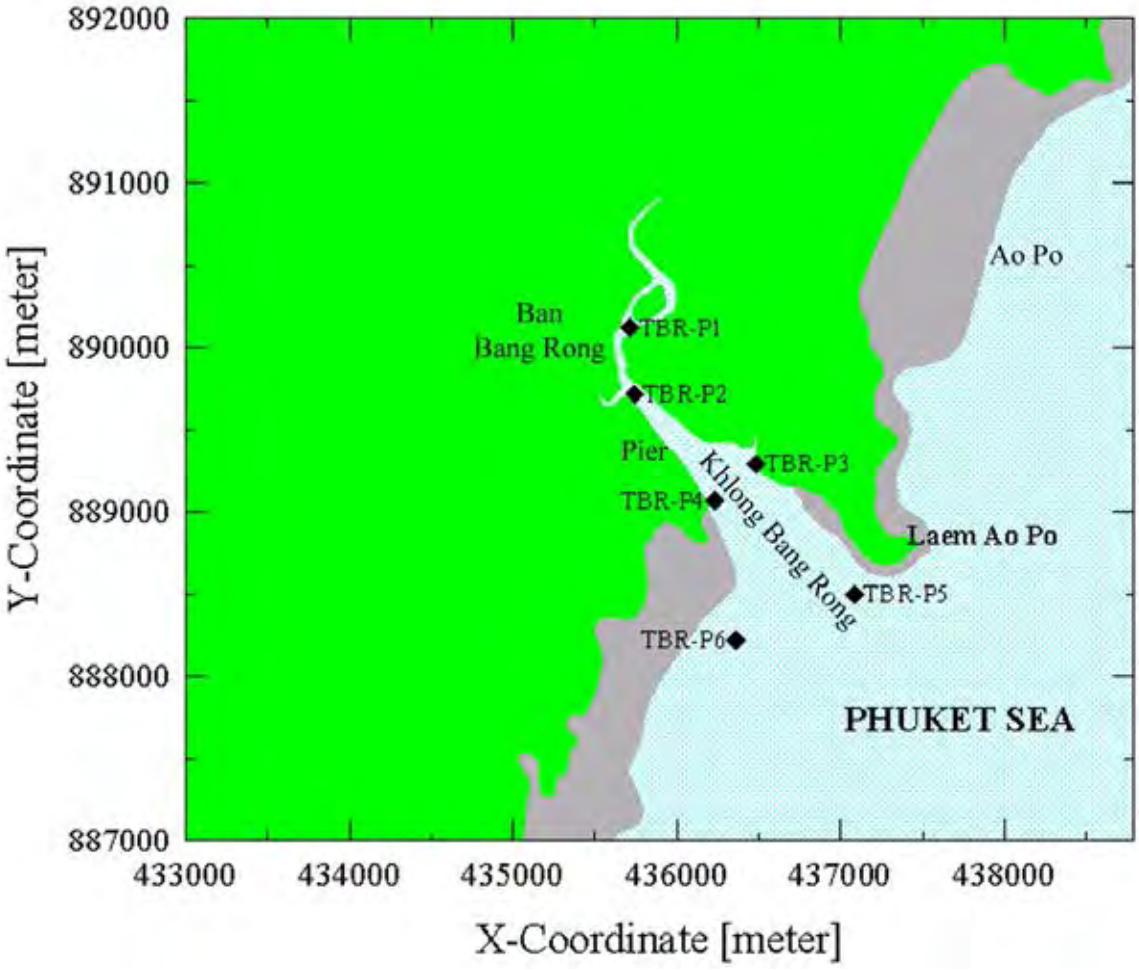


Figure 1.4 Water quality and plankton sampling sites at Bang Rong, Phuket Province.

As shown in Figure 1.5, benthic samplings of both meiofaunal and macrobenthos were carried out in the same protocols as Ban Nam Khem, Phang-nga Province with two *Avicennia* forests and two *Rhizophora* forests. The dense thick *Rhizophora* forest was the community-based forest while the low density forest has been managed by RFD since 1986. Another community-based forest closed to the village was also monitored. This was deteriorated forest with mud lobster mounds. Benthic samplings were also monitored by using grab samplers as in Figure 1.6

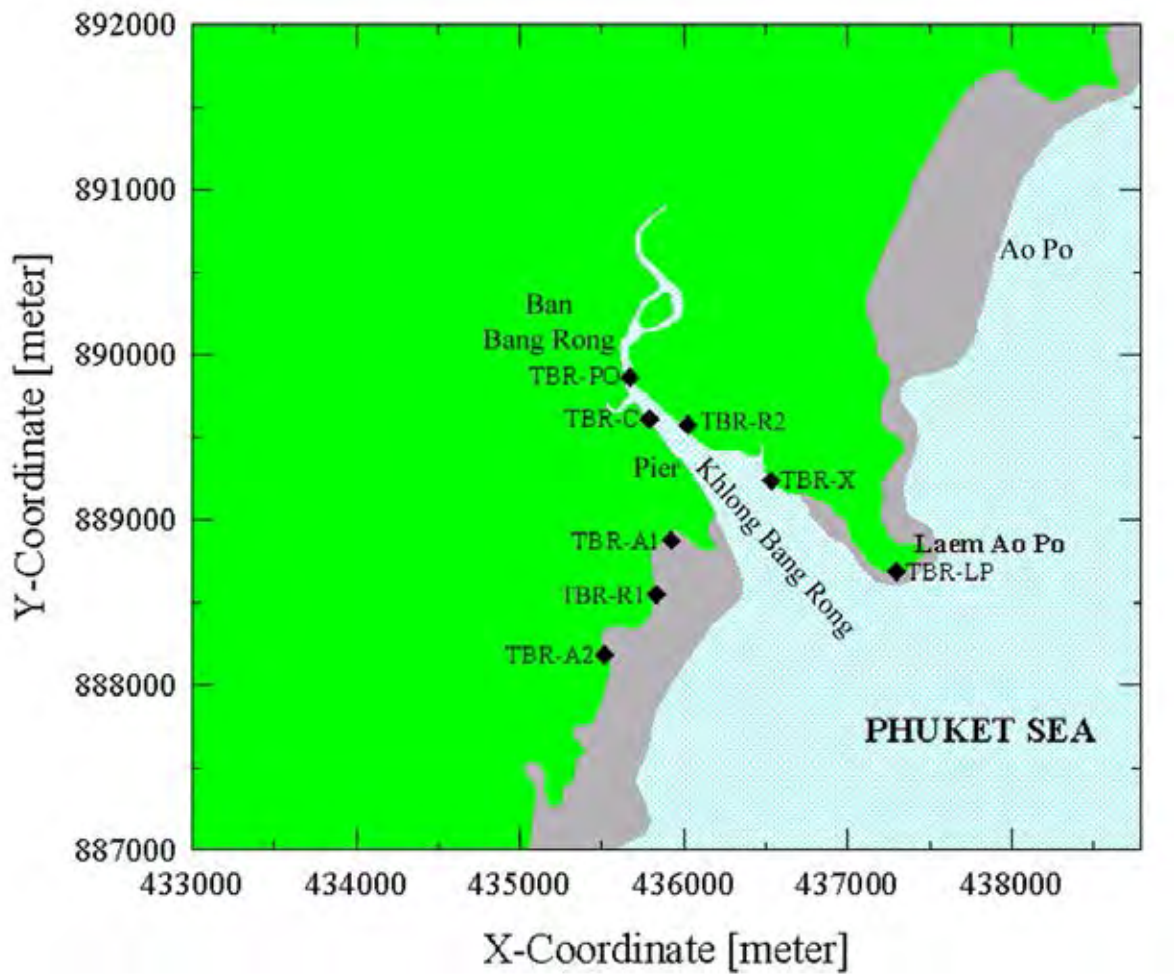


Figure 1.5 Sediments and benthos sampling sites at Bang Rong, Phuket Province.

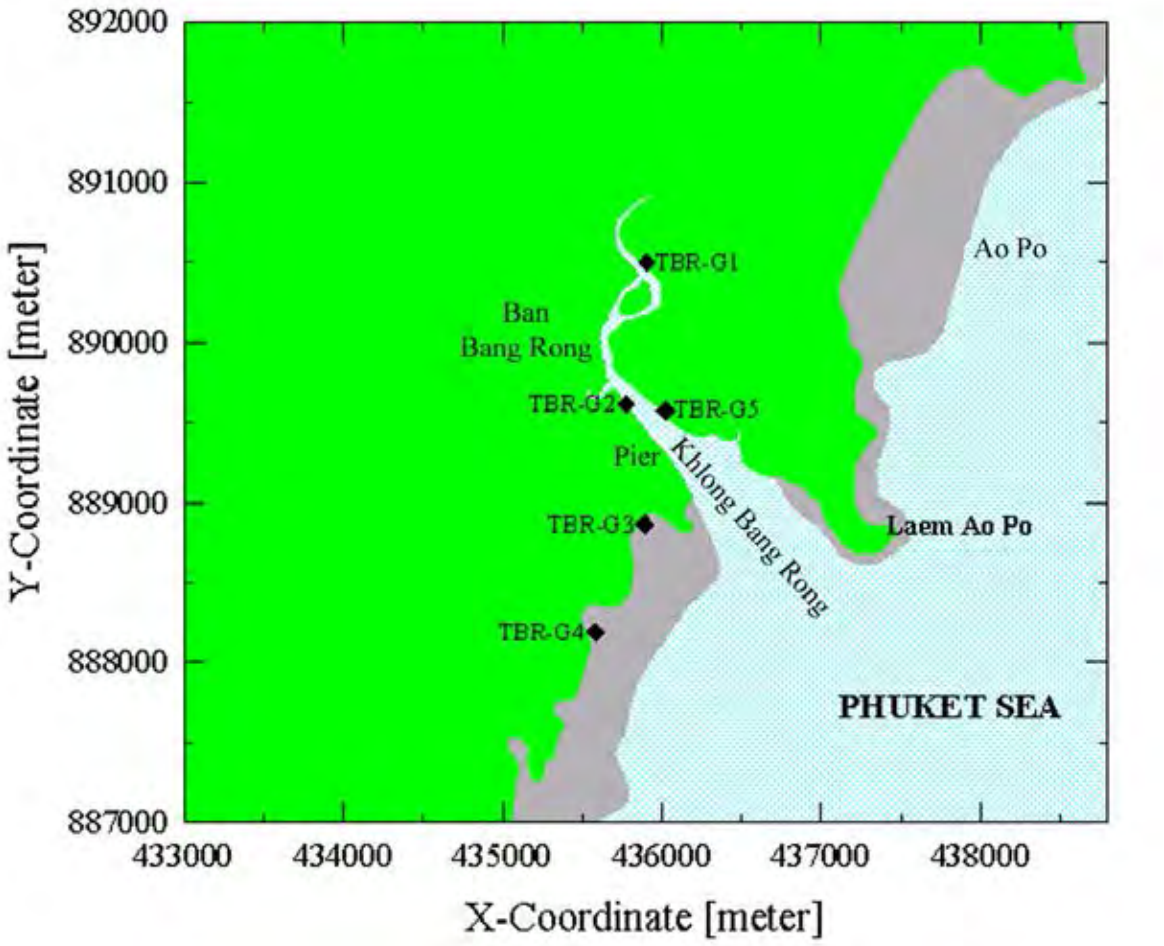


Figure 1.6 Sediments and benthos sampling sites at Bang Rong, Phuket Province.
(Using grab samplers)

Table 1.1 Research methodology on environmental monitoring, forest structure and biological productivity in the post-tsunami monitoring of impact assessment on mangrove ecosystem on the Andaman coastline.

Research Discipline	Research Methodology
1. Environmental Monitoring	• Magnitude and direction of water circulation measured by Valeport current meter model 105 current speed and direction were simultaneously recorded every 15 seconds interval for 1 min. at sub-surface and at near-bottom. Representative current velocity at particular station and depth was calculated by averaging 4 recorded data of current velocities (15 second interval) at each level. • Water quality monitored: depth by depth sounder; temperature and salinity by S-C-T-Meter (YSI model 30); dissolved oxygen concentration by DO meter (YSI model 55); pH by pH checker (HANNA); light attenuation by LI-COR radiation sensor with Submersible quantum sensor-probe reading and water transparency by secchi disc. • Total suspended solid measured from water samples collected at 0.5 m. below surface and 0.5 m. above bottom using 10 liter water sampler. Total suspended solid methodology followed the Standard Operating Procedure for the Sampling and Analysis of Total Suspended Solids in Great Lakes Waters with reference to Grace Analytical Lab, U.S.A. • Physical characteristics in sediment: temperature and salinity in interstitial waters by Sinar Salt Meter (model NS-3P); Redox potential by ORP meter (model TRX-90); pH by pH checker (HANNA)

Table 1.1 (cont.)

Research Discipline	Research Methodology
2. Forest Structure	• Establish transect lines from the seaward margin of the forest at right angles to the edges of the mangrove forest. Belt transect of subsequent 10 m. x 10 m. plots along the transect • Species composition, density and height in each located plot were recorded. • Seedlings (girth less than 4 cm. and height less than 1.30 m.) are identified and the number of individual species counted in the 1 m. x 1 m. subplot. • Saplings (girth less than 4 cm. and height over 1.30 m.) are identified and the number of individual species counted in the 5 m. x 5 m. subplot. • Tree (larger than 4 cm. in girth) - When stem with prop roots (*Rhizophora* species) measure girth 10 cm. above root collar. - The GBH measurement measured at 1.30 m. for stem without proproots. - Identify and record species of each tree and its position in the 10 m. x 10 m. plot. Use the X and Y coordinates set up by the corner of the plot (English *et al.*, 1994) • Importance Value Index calculated from data collected followed Waltel and Steiner in 1936 as quoted by Aksornkoae (1999)
3. Phytoplankton productivity and community structure	• A depth integrated 10-20 liters of water sample collected in duplicate for each station. Then filtered onto a 20 μm. meshed net. Aliquot divided into parts Aliquots preserved in 2% neutral formalin for studying diversity and abundance of microphytoplankton • Another aliquot was filtered in triplicate onto GF/F and Poloycarbonate membrane filtered which were kept frozen for further chlorophyll *a* analysis followed USEPA Method (Arar and Collons, 1992) by Fluorometer (Turner Design Model 10-Au-500) • The filtrate was also frozen for the analyses of major dissolved nutrients NO2-N plus NO_3-N, PO_4-P and SiO_2-Si and also ammonia NH_4-N (Parson *et al, 1984*) • Plankton biomass was measured from water sample collected from 0.5 m. subsurface and at 1-2 m. near bottom. Then filtered onto 200 μm. meshed net. • Biomass measured from aliquots.

Table 1.1 (cont.)

Research Discipline	Research Methodology
4. Zooplankton productivity and community structure	• Zooplankton samples collected by plankton net of 100 and 330 μm. mesh size equipped with flow meter (General Oceanics model 2030R). Duplicate horizontal tow with from 1m near bottom depth to surface. Samples preserved in 4-5% neutralized formalin solution for further identification and enumeration.
5. Benthic communities	• Macrobenthos sampling was taken by quadrat 0.5 m. x 0.5 m. and also by core sampler with dia. of 0.15 m. and 0.5 m. in length with triplicate samples per station. Sieve samples through 0.5 mm. mesh size. Benthos retained on seive collected and preserved in 10% neutralized formalin for further identification and biomass estimation. Grab samples from modified Petersen grab were also collected for benthos and sediment. • Meiofauna sampling was taken by small core sampler of 3 cm. dia. Pushed to the 10 cm. depth in sediment. Sediment from core preserved with 10% neutralized formalin with Red Bengal dye for further identification and enumeration. • Grain size analysis by mechanical sieving through series of sieves according to Wentworth grade classification and median grain size was also calculated. • Organic content in sediment measured by Walkley Black Wet Oxidation Technique (Chemical Agriculture Unit, 1982)

Table 1.1 (cont.)

Research Discipline	Research Methodology
6. Fish Communities	• Fish larvae and juveniles collected by the fry-sweeper, the modified push net. This fry-sweeper comprised of V-shaped bamboo frame with Velon wing net and a pouch of fine mesh net. Operated during low tides by moving back and forth along the shoreline in waist-to-chest deep water. Gill net of 3 mm. mesh size also employed for fish larvae and juveniles collection. Preserved samples in 10% neutralized formalin for further identification and enumeration. • Fish populations collected by using local gill nets of approximately 1 cm. mesh size. Sampling period was approximately 30 min. in each day collection per station. Fishes sorted out and identified according to species. Size distribution of each fish species by length and weight measurement. Fish samples preserved in 10% neutralized formalin for further identification and stomach content analyses.




Post-tsunami impact assessment on socio-economic status and public participation: Andaman coastal communities

Two types of data collection by both quantitative and qualitative methods were utilized to assess the impact of tsunami on the socio-economic status and public participation.

1. *Quantitative Approach*: Data was derived from two different sources, namely primary data and secondary data.

For primary data, the sampling survey was conducted by the College of Population Studies, Chulalongkorn University. The structured interview with questionnaires provided quantitative information on the level and trend of the impact of tsunami on the demographic and socio-economic status of people in the study areas. In addition, the level of community participation the mangrove rehabilitation programs as well as the level of community awareness of the benefit and value of mangrove forest were also detected from the questionnaires. The target population was the community members from the sampled household.

For secondary data, the existing data on socio-economic and demographic conditions of the community reported by the government organization, mainly from the Ministry of Interior, was used to examine the past trend of population and level of socio-economic status of the study areas before and after tsunami disaster.

2. *Qualitative Approach*: Two methods of data collection, namely in-depth interview and focus group discussion, were applied. The qualitative data obtained from the two methods were another alternative method to add up some more detailed information on the process of constructing public participation and awareness of mangrove rehabilitation activities. Moreover, the information on the beliefs, values, attitude and opinion of people together with the information on social control, social organization, socialization process as well as social network towards the community participation and awareness on the activities related to mangrove rehabilitation programs were defined. These data provided necessary information to assess the underlying factors of community participation in the mangrove rehabilitation programs.

Development of the instrument

As mentioned earlier, the quantitative and qualitative methods for data collection were utilized in this research project. The structured interview with questionnaire was used as a tool for collecting the quantitative data. The guideline of interested topics was constructed for obtaining qualitative information on attitude and opinion from key informants or direct stakeholders who were involved in the topics to be studied.

1. Development of the Questionnaires Used in the survey

Two questionnaires were administered in this survey, namely the household schedule and the individual questionnaire for the head of household or his/her spouse

a) The household schedule

The household schedule called for information of each household member on the name, relationship to the household head, sex, age, marital status, educational level, work status, occupation, duration of stay in the community and birthplace. The household schedule was to administere all sampled households and was intended to serve as a screening device to identify the eligible person, the household head and his/her spouse, for the individual interview in the individual questionnaire

The data derived from the household schedule provided information necessary for constructing population pyramid, the diagram for identifying the age structure of the population. The sex ratio, the age distribution, the mean age, the literacy rate and the employment rate were calculated from the data derived from the household schedule. This would be used as an indirect estimation for the socio-economic and demographic status of the people in the community.

b) The individual questionnaire for the head of household or his/her spouse

Several meetings among the working group members from the fields of ecology, social science and forestry were held to discuss the content and wording of the questionnaire. The questions of tsunami impact on socio-economic status and public participation were divided into 6 sections:

1) *Household information.* This section included the information on type of family, employment status of household member and migration experience of all household members after the tsunami disaster. The report on the impact of tsunami on the changing number of the household members, the changing size of land and dwellings as well as the changing relationship to neighbour was also specified in this section.

2) *Demographic profile.* Information was collected on such items as birth date, reported age, sex, marital status, migration experience and the desire to move out of the village. It was compared with demographic profile before tsunami.

3) *Socio-economic status.* In this section, questions were asked about the educational level of the household head and his/her spouse to provide the social status of the respondents. The information on employment status, the type of main occupation and secondary occupation before and after tsunami derived from this section will provide a rough indicator of the impact of tsunami on a changing pattern of occupation. The comparative study on the average monthly income, average amount of debt, source of loan and reasons for being in debt from two reference period of time, before and after tsunami, will provide information of tsunami impact on the economic status of the people in the community.

4) *Direct and indirect impact of tsunami.* The respondents were asked to evaluate the impact of tsunami on economic and social conditions of the community where they lived. The direct and indirect impact of tsunami on the lives of the respondents and their family members were also asked. In addition, the impact of tsunami on physical environment, such as changing soil condition, canals, seashore and mangrove forests, perceived by the respondents were obtained.

5) *Value of and benefit from mangrove forest*. General attitude about the advantages of mangrove forest. The direct and indirect utilization of mangrove forest by the respondents and their family members. The perception of the respondents on the function of the mangrove forest as a barrier against tsunami disaster as well as the attitude of respondents towards the value of mangrove forest after tsunami were some of the questions asked in this section.

6) *Community awareness and participation in mangrove rehabilitation activities.* Questions asked included community participation in any activities related to mangrove rehabilitation and reforestation in two different reference periods, before and after tsunami. The questions on the factors contributing to the strength and weakness of communities on constructing mangrove forest rehabilitation programs together with the factors that were related to the opportunity and threat to the programs were constructed. Importantly, the question on how people learned from tsunami and the lesson from tsunami were included in order to examine whether we could turn "crisis" into "opportunity" for the sustainable management of mangrove resources through local community action.

2. Development of the Guideline Used in the Qualitative Approach

The guideline for in-depth interview and focus group discussion was constructed based on the 4 topics as follow.

1. The attitude towards the impact of tsunami on the socio-economic and demographic conditions of the community.
2. The opinion towards the impact of tsunami on the physical environment, particularly mangrove forest.
3. The perception on the importance and the benefits of mangrove forest.
4. The community participation in and awareness of mangrove rehabilitation activities and the underlying factors contributing to the strength, weakness, opportunity and threat of the community in carrying out mangrove rehabilitation activities.

Sample Selection and Target Population

1. *Quantitative Approach*

Due to budget and time constraints, the sampling technique was applied to draw a sample from the large target population. In this study, the sample unit was the household in the community. The sampling frame was the total number of houses in each community. In Phang-nga Province, the dwelling units in Ban Nam Khem were devastated due to tsunami. The information on the sampling frame can barely be defined. Moreover, we found that many new houses built up in the devastated area were occupied mainly by Burmese employees even though the houses were registered under the name of Thai citizens. Since Thai people still feared tsunami and were hesitated to move in, many new houses were still vacant. These caused a great discrepancy between the total number of houses that the research team visited and the number of houses reported by the Ministry of Interior (Table 1.2 and Table 1.3). However, it is evident that the number of houses reported by the Ministry of Interior may be overestimated. We found in the fieldwork that many community members who lost their houses reported that they intended to move out of Ban Nam Khem permanently to stay in Ban Pru-teao and other areas arranged by government and non-governmental organizations. In this study, we visited 964 houses and used this number as our sampling frame. The sampled houses drawn from the frame were 396 houses or approximately 41 percent of a total houses in the sampling frame.

In Phuket Province, houses remained intact from tsunami. The sampling frame was composed of 539 houses. The sampled household drawn from the total target houses were 176, approximately 33 percent of a total number of houses in Bang Rong.

Table 1.2 Total number of houses and total number of population of Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province in during the year 2003 to 2005

Category	2003	2004	2005
Ban Nam Khem, Phang-nga Province			
Total number of houses	1,533	1,566	1,840
Total number of population	4,218	4,181	3,523
Average number of house members	2.75	2.67	1.9
Male	2,097	2071	1,749
Female	2,121	2,110	1,774
Sex Ratio	103.8	98.2	98.6
Bang Rong, Phuket Province			
Total number of houses	513	539	606
Total number of population	1,818	1,922	1,962
Average number of house members	3.5	3.6	3.2
Male	915	951	964
Female	903	972	998
Sex Ratio	101.3	97.8	96.6

Sources: Registration, Bureau of Registration Administration, Takuapa district, Phang-nga Province and Tha-lang district Phuket Province

Table 1.3 Total number of household visited and interviewed; Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province

Category	Visited	Interviewed
Ban Nam Khem, Phang-nga Province		
Total number of houses	964	395
Total number of household members	-	1,359
Male	-	704
Female	-	655
Sex Ratio	-	107.5
Bang Rong, Phuket Province		
Total number of houses	539	176
Total number of household members	-	752
Male	-	358
Female	-	394
Sex Ratio	-	90.9

In our analysis, the household head or his/her spouse will be posted as the respondents since they are the main decision-makers of the families. The background characteristics of the respondents from the two sampled areas were presented in Table 1.4. In all areas, the proportion of male respondents was higher than female. The average age of all respondents clustered around 44 years. There was no significant differences in the age of the respondents between Ban Nam Khem and Bang Rong. Since tsunami caused great loss of life and property in Ban Nam Khem, the proportion of widowed respondents was about 16 percent which was twice the number reported by the respondents in Bang Rong (only 7 percent).

The majority of the respondents in both areas had primary school education (63 percent). The level of education, however, was found to be higher among the respondents in Bang Rong than in Ban Nam Khem. Approximately 27 percent of the respondents in Bang Rong reported of their education higher than secondary level compared to only 22 percent in Ban Nam Khem. Interestingly, about 5 percent of respondents from Bang Rong graduated from university. This may be due to the fact that Bang Rong is located in the urban area of Phuket Province where people have the higher opportunity to further their education. Moreover, the history of Ban Nam Khem revealed that large proportion of people residing in Ban Nam Khem were migrants with low education. They moved into the village to work as labourers in tin mining and as fishermen. The level of education of spouse of the respondents did not follow the same pattern as the respondents. Ten percent of spouses in Bang Rong had no education, which was twice the number of the spouses in Ban Nam Khem.

Table 1.4 Percent distribution of respondents according to demographic and socio-economic background classified by village

Category	Ban Nam Khem	Bang Rong	Total

	Phang-nga Province	Phuket Province	
Sex of respondents			
Male	55.1	60.2	56.7
Female	44.9	39.8	43.3
Total	100.0 (394)	100.0 (176)	100.0 (570)
Age of respondents			
Less than 25 year	5.6	4.0	5.1
25-39 year	35.0	35.8	35.3
40-59 year	48.2	46.0	47.5
60 year or more	11.2	14.2	12.1
Total	100.0 (394)	100.0 (176)	100.0 (570)
Average Age of respondents	43.5	44.4	43.8
Marital status of respondents			
Married and live together	69.3	80.7	72.8
Married but not living together	2.3	2.3	2.3
Separated, divorced	5.8	3.4	5.1
Widow	16.2	7.4	13.5
Single	6.3	6.3	6.3
Total	100.0 (394)	100.0 (176)	100.0 (570)
Educational level of respondents			
No education	7.1	9.1	7.7
Lower than primary education	4.6	8.0	5.6
Primary education	66.8	55.7	63.3
Secondary education	18.5	20.5	19.1
High school	1.8	2.3	1.9
University	1.3	4.5	2.3
Total	100.0 (394)	100.0 (176)	100.0 (570)
Educational level of spouse			
No education	5.1	10.2	6.7
Lower than primary education	3.3	5.1	3.9
Primary education	54.6	55.7	54.9
Secondary education	24.1	15.3	21.4
High school	2.5	3.4	2.8
University	0.3	2.8	1.1
Total	100.0 (394)	100.0 (176)	100.0 (570)

2. *Qualitative approach*

Two sampling techniques, dimensional sampling and snowball sampling, were used for selecting key informants. The dimensional sampling was used for selecting key informants from 5 dimensional groups, namely governmental group, non-governmental group, local administration group, local community leader group and community member group as shown in Figure 1.7

The snowball sampling was applied as a referral system by asking the key informants from each dimensional group to introduce additional key informants who could provide more detailed information or dealing directly or indirectly with the topics being interviewed.

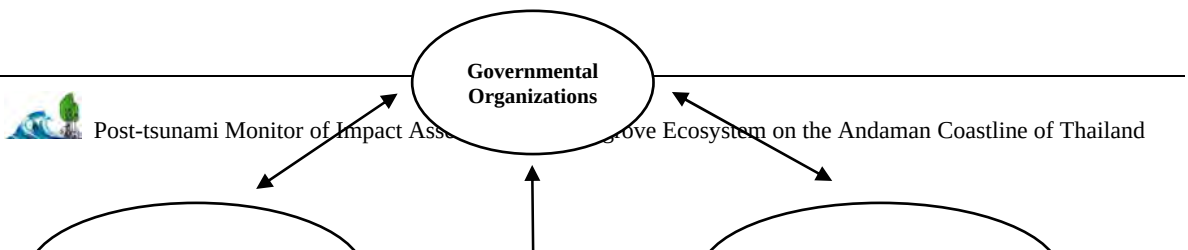


Figure 1.7 Dimensional groups classified for sample selection of the key informants

Training for assistant supervisors and interviewers

For the field survey, three experts and senior researchers of the College of Population Studies, Chulalongkorn University, were responsible for the field survey. Nine interviewers, all graduate students, were recruited and trained for two days. The training covered lectures in fieldwork techniques, interview method, data recording and explanation of the purpose of every single question in the questionnaire. Practical work together with role play was carried out to test the field interview and prepare the interviewer for the actual fieldwork.

Fieldwork

Survey data were collected during 15-23 October 2005 with the sample size of 396 households consisting of 1,359 household members in Ban Nam Khem, Phang-nga Province and 176 households with 752 household members in Bang Rong, Phuket Province.

The in-depth interview and the focus group discussion with community leaders, key informants and direct stakeholders in the two study areas were carried out during 18-24 November 2005. Total number of key informants classified by study areas were shown in Table 1.5

Table 1.5 Total number of key informants interviewed in the two study areas

Type of key informants	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total

1. Governmental organization	2	1	3
2. Local Administration organization	2	1	3
3. Non-governmental organization	1	1	2
4. Community leaders	2	8	10
5. Community members	13	11	24
Total	20	21	41

Chapter 2

Ecological Risks Assessment

Nittharatana Paphavasit Ajcharaporn Piumsomboon Itchika Sivaiphram
Suriyan Saramul Viroj Tiratanatorn Sangob Panichchart Siriwan Siriboon
Busarin Bangkaew Chanette Milintangkul Cholthaya Songroop Thipnapha Suwansanit
Vichaya Gunbua Worraya Khwaiphan Pongvithit Chuliang and Ekaphol Aumnuch

In terms of sustainable development, His Majesty The King Bhumibol Adulyadej of Thailand is the leader. His vision of **self-sufficiency** is an important step towards a balanced development that will sustain both human beings and natural environment (Paphavasit *et al.*, 2000). The concept of self-reliance concentrates on the principles of producing enough to live on while preserving the integrity of the environment which is most essential for sustainable development. The success of forest rehabilitation, according to His Majesty the King, requires full understanding of how different elements, both natural and human, interact. The assessment of the existing biological productivity and the possibility of maintaining ecological processes is one of the most important elements to determine the self-reliance of the ecosystem. This demonstrates the resilience and response of the ecosystem to environmental changes. Understanding the population structure and way of life in the coastal area is also important. Public awareness and participation in the coastal resources conservation and rehabilitation is another important element of self-reliance, apart from the biological productivity of the area. These two major elements play important roles as internal driving forces to sustain the rehabilitation and conservation of coastal resources.

From the integration of knowledge-based researches, the evaluation of ecological risks and impacts can be conducted. Based on the ecological risks, predictions of short-term impacts can be elucidated. This will also demonstrate the resilence from tsunami and recovery capacity of Ban Nam Khem mangrove forest, Phang-nga Province as compared to Bang Rong mangrove forest, Phuket Province.

Pre-tsunami population structure and way of life in coastal communities

Ban Nam Khem is a village in Bang Muang Sub-district, Takuapa District of Phang-nga Province. Before 1975, the community was just an unknown remote rural area. The area was underdeveloped with low quality of infrastructure. The tin mining commenced in the year 1975 and became a pull factor for immigration. Many "Gold Diggers" with very low socio-economic status from all over the country, particularly from the south, moved into the village. They sought for job opportunity and a better living. At the beginning of the "Tin Mining Era", people who migrated to the village were mainly those "Nothing to Lose People". They were labourers, low class people, murderers, prostitutes, out-laws and beggars. Clearly, the majority of people in Ban Nam Khem were not citizen of the village by birth. This resulted in low level of cooperation among people in the community. It was evident that, prior to tsunami, group activity or community activities indicating cooperation among people in the community hardly existed.

When the tin mining concession was abolished, many villagers moved out of the village. Those who stayed became fishermen. At the beginning, the fishery was of small-scale. They were self-sufficient in terms of living. The community economy rose up to the peak when tourism and commercial fishery were introduced. Pre-tsunami disaster, the total number of houses in the village increased to 1,566 with approximately 4,100 villagers. The total number of boats were 420. Of these, 350 were small boats. Heavily populated areas were in 8 zones, Laem Son-Laem Pom, Poh-Noi, Na-Talad, Sai-Thong, Tha-Rua-Chang, Soi Ong-karn, Soi Go-Pud and Soi Supan. After tsunami, there were only 210 houses left, others were completely devastated. In early January of 2005, only 855 households with 3,450 members were registered at the "Community Disaster Center" arranged by Bang Muang Sub-district Administration Organization. The fishermen lost at least 300 boats out of the total 420 boats, or a loss of more than 70 percent.

In contrast to Ban Nam Khem, Bang Rong is a small village of 539 houses with 1,900 people. The village is located in Pak-Klok Sub-district, Thalang District, Phuket Province with a very long history of more than 200 years. The majority of the villagers were born in the community, which was highly united through religion. More than 95 percent of the villagers are Muslim. The village experienced very small impact from tsunami since the mangrove forest acted as a great barrier against the waves. The villagers viewed mangrove forest as a property of the community. The mangroves have played many significant roles that benefit the community. In the past, during war times, mangrove forest helped protecting the villagers from the Burmese invaders. The degree of mangrove-dependency is very high among the villagers. There have been many activities related directly and indirectly to mangrove rehabilitation programs. Many group activities have been set up for mangrove conservation, such as Environmental Conservation Group and Eco-tourism Group.

Family Structure

The socio-economic and demographic statistics presented in Table 2.1 were derived from a total of 1,359 household members from 394 sampled houses of Ban Nam Khem, Phang-nga Province and 752 household members from 176 sampled houses of Bang Rong, Phuket Province. The family structures of the two communities revealed that three-fourth of the sampled households in the two communities were nuclear family. The type of extended family, however, differed. The household members in Ban Nam Khem lived in horizontal extended family, while those in Bang Rong reportedly lived in vertical extended family. This partly reflected a high proportion of migrants in Ban Nam Khem since people of the same generation, particularly those who were in the labor force age, tended to move into the village to find jobs and live together in the same house. The vertical extended family in Bang Rong revealed that the residents lived for a longer time in the community and formed family of many generations. This was supported by the data on birthplace and duration of stay in the communities. Almost 70 percent of the household members in Bang Rong were born and have lived in the community ever since. In contrast, less than half of household members in Ban Nam Khem were reportedly born in the community. When the average duration of stay in the community was classified by age, the pattern was clear that the duration of stay in the community among the older persons (aged 60 years and over) in Bang Rong was twice higher than those who stayed in Ban Nam Khem (52 years compared to 29 years).

Table 2.1 Distribution percentage of household members based on demographic socio-economic status

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Family Type			
Nuclear family	75.6	75.6	75.6
Extended family–Vertical	12.7	17.0	14.0
Extended family–Horizontal	9.6	4.5	8.1
Extended family–both types	2.0	2.8	2.3
Total	100.0 (394)	100.0 (176)	100.0 (570)
Birthplace of household members			
Born in the community	46.0	69.1	54.2
Born elsewhere	54.0	30.9	45.8
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)
Duration of stay in the community			
From birth and never move out	45.2	68.8	53.6
Less than 5 years	8.9	11.2	9.7
5-9 years	3.2	3.6	3.3
10-14 years	5.4	3.6	4.8
15-19 years	5.4	2.7	4.4
20 years or more	31.9	10.0	24.1
Unknown/No answer	0.0	0.3	0.1
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)
Average duration of stay in the community	18.9	22.1	20.0
Average duration of stay in the community by age group			
Less than 15 years	7.2	6.6	7.0
15-59 years	21.9	25.1	23.0
60 year or more	29.3	51.8	36.6
Sex of household members			
Male	51.8	47.6	50.3
Female	48.2	52.4	49.7
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)
Sex Ratio	107.5	90.9	101.2
Age of household members			
0-4 years	6.7	8.6	7.4
5-9 years	8.0	7.6	7.9
10-14 years	9.1	8.2	8.8
15-19 years	8.2	8.2	8.2
20-24 years	8.8	8.5	8.7
25-29 years	9.6	11.4	10.3
30-34 years	7.6	12.0	9.1
35-39 years	8.8	7.7	8.4
40-44 years	7.3	6.3	6.9
45-49 years	8.5	6.1	7.6
50-54 years	5.9	6.1	6.0
55-59 years	4.9	3.2	4.3
60-64 years	2.7	2.4	2.6
65 years and over	4.0	3.5	3.8
Unknown/No answer	0.1	0.1	0.1
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)

Table 2.1 (cont.)

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Average age of household members	30.8	29.2	30.2
Age group of household members			
0-14 years	23.8	24.5	24.0
15-59 years	69.5	69.5	69.5
60 years and over	6.7	5.9	6.4
Unknown/No answer	0.1	0.1	0.1
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)
Marital status of household members aged 13 and over			
Married and live together	59.4	62.4	60.4
Married but not live together	1.9	2.2	2.0
Separated, divorced	3.3	2.7	3.1
Widow	8.4	4.6	7.1
Single	27.0	28.2	27.4
Total	100.0 (1,093)	100.0 (593)	100.0 (1,686)
Educational status of household members			
Not studying	75.3	75.5	75.4
Studying	24.7	24.5	24.6
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)
Highest educational level of household members			
No schooling	15.0	17.8	16.0
Lower than primary education	7.7	8.4	7.9
Primary education	43.6	38.3	41.7
Secondary education	26.6	28.3	27.2
High school	2.9	2.8	2.9
University	3.7	3.9	3.7
Unknown/No answer	0.5	0.5	0.5
Total	100.0 (1,359)	100.0 (752)	100.0 (2,111)
Work status of household members aged 11 and over			
Not working	41.7	31.8	38.2
Working	58.2	68.2	61.7
Unknown/No answer	0.1	0.0	0.1
Total	100.0 (1,137)	100.0 (619)	100.0 (1,756)
Occupation of household members who reported of working at time of interview			
Fishery	19.5	10.4	15.9
Farmer	2.0	14.5	6.8
Employee	30.3	27.0	29.0
Commerce	28.8	20.6	25.6
Business/Service	9.8	16.1	12.3
Technician	5.0	5.0	5.0
Others (government/state enterprise)	4.5	6.4	5.3
Unknown/No answer	0.2	0.0	0.1
Total	100.0 (663)	100.0 (422)	100.0 (1,085)

Sex ratio and age structure

The sex ratio of one male to 100 females revealed a higher proportion of male over female in Ban Nam Khem. The age structure of the population derived from the sampled houses of Ban Nam Khem and Bang Rong as shown in Figure 2.1 also confirmed a higher proportion of male over female in Ban Nam Khem, particularly in labour age. The population pyramids in Figure 2.2 and Figure 2.3 calculated from the registration data collected by the Bureau of Registration Administration, both in Phang-nga and Phuket Provinces, also showed identical patterns of age and sex distribution calculated from survey data. This finding reflected a higher rate of male migration over female in Ban Nam Khem where job opportunity was higher for male. Type of occupation, such as labourer or mechanic, was more suitable to male than female.

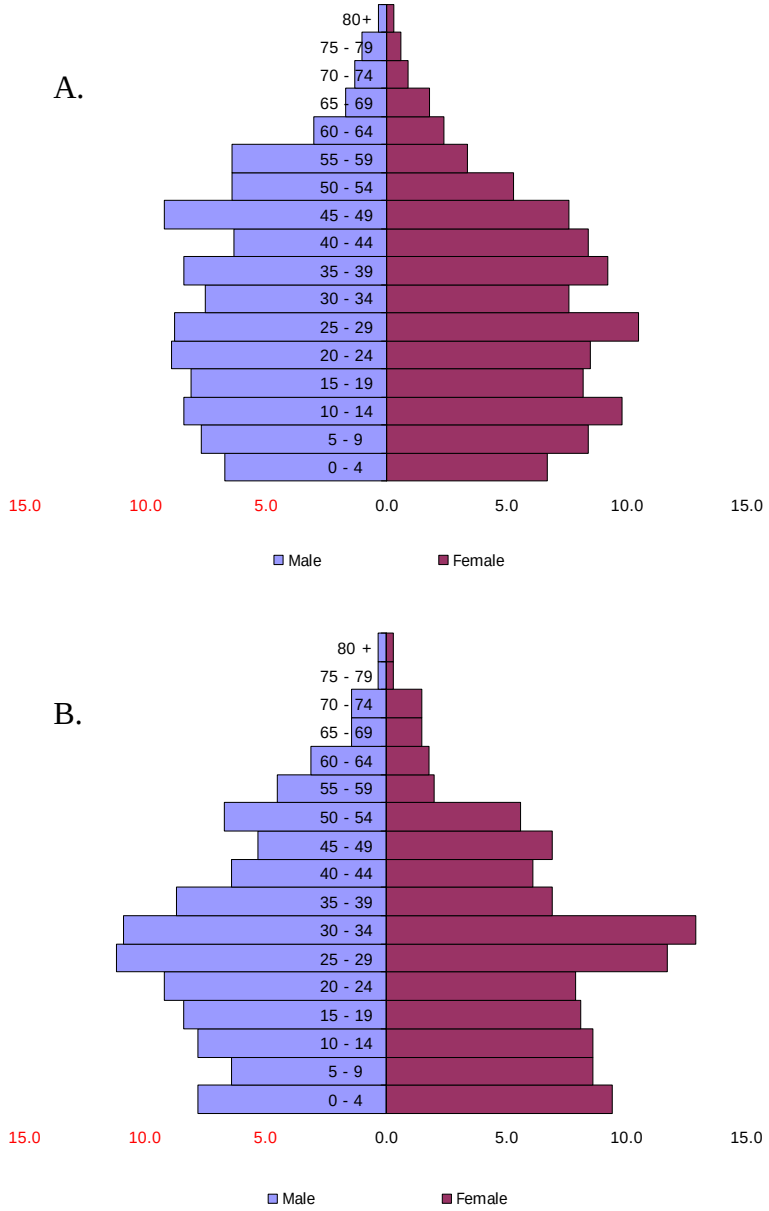


Figure 2.1 A. Population Pyramid derived from all household members in the sampled houses of Ban Nam Khem, Phang-nga Province
B. Population Pyramid derived from all household members in the sampled houses of Bang Rong, Phuket Province

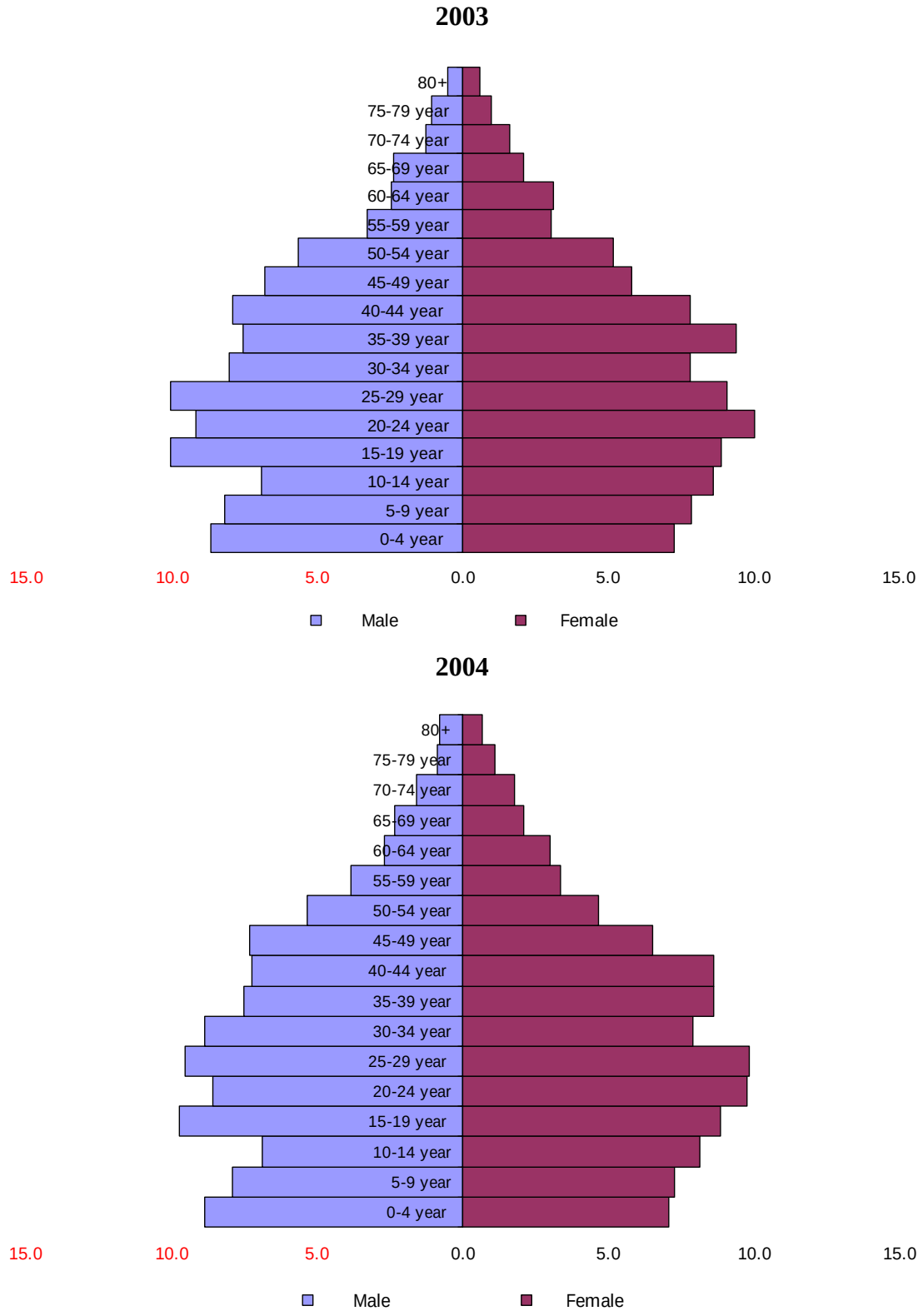


Figure 2.2 Population Pyramid derived from all household members of registered houses in Ban Nam Khem, Phang-nga Province in 2003 -2004

Sources: Registration, The Bureau of Registration Administration, Takuapa District, Phang-nga Province

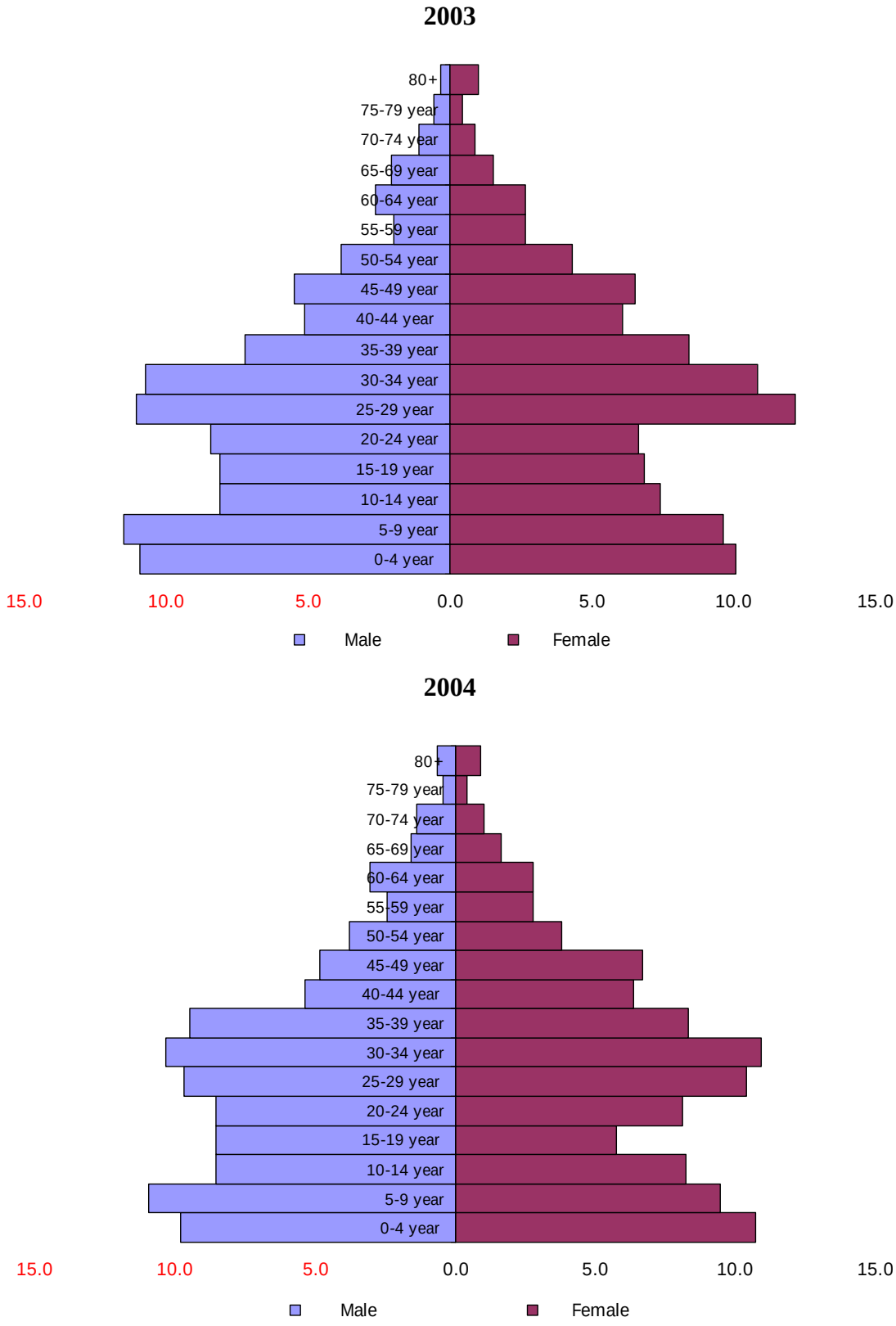


Figure 2.3 Population Pyramid derived from all household members of registered houses in Bang Rong, Phuket Province in 2003-2004

Sources: Registration, The Bureau of Registration Administration, Thalang District, Phuket Province

The high proportion of widowers in Ban Nam Khem reflected the great loss of life due to tsunami. It was twice higher than that found in Bang Rong. The literacy rates and the educational level of household members in the sampled houses of the two communities were similar. The high discrepancy between work status of people in the two communities reflected the impact of tsunami on the economic conditions of the community. About 42 percent of household members in Ban Nam Khem that received direct impact from tsunami were not working compared to only one-third in Bang Rong, the area with small impact from tsunami. The high proportion of people in Ban Nam Khem was working as employee and commercial business that mostly required unskilled labour. As the tsunami aftermath, the number of fishermen was drastically reduced due to the loss of their boats and fishing gears. In Ban Nam Khem, the proportion of fishermen, therefore, was lower than expected.

Pre-tsunami mangrove forest structure

Mangrove forest on the Andaman coastline of Thailand was once considered the most extensive intact in the country. Its deterioration over a period of 35 years (1931-1986) increased tremendously with a reduction rate of 33.56 and 62.32 percent in Phang-nga and Phuket Province, respectively (Platong, 1998). Conversion of mangrove forest for other land use purposes, such as shrimp farming, mining concessions and agriculture, were major factors impacting mangrove ecosystem. Urbanization, industrial expansion and tourism had also contributed to mangrove degradation.

In the past, tin mining, both onshore and offshore, in Phang-nga and Phuket Province, had been one of the major factors affecting mangrove forest. Apart from a decrease of mangrove forest area, increased sedimentation and turbidity in the mangrove area and coastal waters were evidenced. Tin mining affected both plant and animal communities. Natural regeneration was slow in tin mining area.

> *During tin mining period, the villagers faced many hardships. Offshore mining turned the sediment over. Mangroves were destroyed. Water quality was degraded due to turbid waters. Villagers had hard times making sufficient income. They had to fish offshore. Those not in the tin mining business were most affected. We had to cut mangrove woods for living. Despite the concession, wood production was low. The demand for wood and over-exploitation had turned the mangrove forests into desert.*
>
> *In depth Interview in Ban Nam Khem, Phang-nga Province*

More than 29 species of mangroves were recorded in Phang-nga Province with *Rhizophora apiculata*, *R. mucronata*, *Avicennia alba*, *A. officinalis*, *A. marina*, *Sonneratia* spp., *Bruguiera* spp., *Ceriops* spp., *Lumnitzera* spp., *Xylocarpus* spp., *Phoenix* spp. and *Exocoecaria* spp. being dominant in respective order (Aksornkoae, 1993; Havanond, 2000; Teratanatorn, 2004; Pakdikul *et al*., 2005; Wanapropoti *et al*., 2005 and Kiartiprayoon *et al*., 2005).

The mangrove forest in Ban Nam Khem, Phang-nga Province, prior to tsunami, was considered degraded forest. The forest had been under two-rotation-cycle concession for wood from 1976-2000. Since the concession ended in 2001, the forest was in natural regenerating process. Large trees were rare. Small trees of 5-6 meters in height were dominant. *Rhizophora apiculata* was dominant along the river bank. *R. mucronata*, *Ceriops tagal* and *Bruguiera cylindrical* can be found landwards in composition with *R. apiculata*. Seaward mangrove forest at Laem Pom Bay was found on muddy mudflats. Big trees, such as *Avicennia alba* and *Sonneratia ovata*, were found in abundance.

Rhizophora spp., *Avicennia* spp., *Bruguiera gymnorrhiza*, *Ceriops* spp., *Xylocarpus* spp., *Deris trifoliata*, *Heritiera littoralis* and *Finlaysonia maritina* were reported to be dominant in Phuket mangrove forest. (Marine National Parks Division, 1995). In Bang Rong, the mangrove forest is under Bang Rong National Forest. The mangrove forest was also under two-rotation-cycle concession for wood from 1976-2001. Prior to the beginning of the second rotation cycle in 1986, the forest was in deteriorating condition with small trees of mainly *Rhizophora mucronata*, *R. apiculata*, *Ceriops tagal* and *Bruguiera cylindrical*. Mud lobster mounds can be found scattered in the area. *Acanthus ebracteatus* and *Acrostichum speciosum* can be found in association with mud lobster mounds. Royal Forestry Department (RFD), together with the Petroleum Authority of Thailand, launched the mangrove reforestation

program in 1996. Enrichment reforestation was employed by planting in the gaps in the forest and also in the degraded area with 1.5 m. x 1.5 m. spacing. *Rhizophora* spp. was the selected species. In high elevation area, *Ceriops tagal* and *Bruguiera cylindrica* were selected.

The two *Rhizophora* species, *R. mucronata* and *R. apiculata*, were dominant in Bang Rong forest prior to tsunami. Dense *Rhizophora* forest appeared in the area. Several mangrove forests were looked after and managed by the local community themselves. The *Rhizophora* trees were of small and medium sizes, aged between 10-16 years. Natural regeneration was abundant. The forest was productive with high density and extensive root system. At Bang Rong estuary, *Avicennia marina*, *A. alba* as well as *Sonneratia ovata,* can be found. These were mainly big trees.

There have been speculation that if the intact and healthy mangrove forest lined along the coastline instead of the degraded forest, damages on lives and property would be less from the tsunami. Mangrove Action Program, an environmental organization based in Port Angeles, Washington, had viewed that many lives could have been saved if mangroves and reefs had been conserved in a healthy state. Instead, these vital protective buffers that nature provides against wind and wave had been foolishly degraded or removed for unstainable development. Thus, health condition as well as type of mangrove forest will affect the ability of the forest to withstand the impacts of tsunami, which in turn will affect regeneration and recovery ability of the mangrove forest.

Pre-tsunami biological productivity

According to previous study, the coastal productivity in Phang-nga and Phuket Provinces revealed that the biological productivity, particularly in Ban Nam Khem and Bang Rong, were in the range of oligotrophic-mesotrophic environment. The primary production estimated from the chlorophyll *a* content was found to be not exceeding 50 gmC/m^2/yr. The foodweb complexity in the two areas were evidenced due to the diversity of each biological component.

Phytoplankton communities

Previous study indicated that the Andaman coast, with offshore water influence, is in oligotrophic-mesotrophic condition. The concentration of chlorophyll *a* as an indicator of phytoplankton biomass, which is usually in the range of <1 – 5,000 µg/l. Chlorophyll *a* contents at the stations in the west coast of Kho Khao Island, Ban Nam Khem with an average depth of 45 m., was reported to be less than 1,000 µg/l between 1982 to 1983, respectively. These values were comparable to an average primary production of 850 mg C/m^2/d for the Andaman coast from Ranong province to Satun province in 1982 – 1983 and of 578 mg C/m^2/d in 1981 – 1986 (Janekarn and Hylleberg, 1989).

Higher chlorophyll *a* contents and primary production were reported in Phang-nga Bay on the east of Phuket during 1981 – 1982. An average concentration of chlorophyll *a* was about 2.03 µg/l in the dry season while higher concentration of 2.45 µg/l was reported for the wet season. Primary productivity calculated from incubation experiment showed the values of higher than 1,000 mg C/m^2/d for both seasons, with higher production also in the wet season. Besides, phytoplankton assemblage in this area was dominated by diatoms and sometimes a cyanobacterium *Trichodesmium* sp. (Sundstrom *et al*., 1987). In the mangrove creek of Bang Rong, chlorophyll *a* content from phytoplankton was ca. 0.800 µg/l (Suraswadi, 2002).

Studies on phytoplankton diversity and abundance indicated the phytoplankton community structure of more than 78 species in the area. The dominant groups were diatoms, dinoflagellates and cyanobacteria in respective order. Angsupanich (1994) studied on phytoplankton in mangrove forest of Khlong Khao Kao, Phang-nga Bay. During rainy season, 18 genera of diatoms and 4 genera of dinoflagellates were found and a total density of phytoplankton was 1.16 x 10^4 cell/L. The dominant species were *Chaetoceros* sp., *Trichodesmium* sp. and *Merismopedia* sp. In dry season, 32 genera of diatoms, 4 genera of dinoflagellates and 2 genera of cyanobacteria were found. The total density of phytoplankton was 1.65–6.43 x 10^3 cell/L. The Institute of Science and Technology of Thailand (1989) found that the dominant species were *Bacillaria* sp., *Skeletonema* sp. and *Nitzschia* sp. with the average density of phytoplankton at 1,389.11 cell/L.

Zooplankton communities

Zooplankton forms the important linkage between the primary producers and other consumers in the foodweb. Aquatic larvae, such as mollusk larvae, crustacean larvae and fish larvae, are important food sources for other aquatic animals. They also play an important role as indicators of coastal productivity.

Prior to tsunami, zooplankton densities in Ban Nam Khem, Phang-nga Province ranged between 1–6,497 individual/m^3. Dominant groups were copepods, polychaete larvae and foraminiferans. The economic species larvae were crab larvae and crab zoea. Zooplankton densities in Bang Rong, Phuket Province were recorded in the range of 1–8,301 individual/m^3. Dominant groups were copepods, arrow worms and larvacean. The economic species larvae were mollusk larvae, mysids and *Lucifer* spp. Moreover, the common coastal zooplankton, such as hydromedusae, ctenophores, amphipods, cirripedia larvae, ostracods, isopods,

cumaceans and fish larvae could be found. More than 90 families of fish larvae have been recorded from the mangrove forest along the Andaman coastline.

Benthic communities

Mangrove forest provides microhabitats for macrofauna to reside, such as soil surface, litter falls, root systems, tree trunks and tree canopy. Mangrove macrofaunal species composition, biomass and abundance reflect biological productivity of the mangrove forest. These resident mangrove intertidal fauna play significant roles in detritus production and energy flow in the mangrove ecosystem. They serve as a food supply for the aquatic consumers, especially fish and shrimp (UNDP/UNESCO, 1991). Niche partitioning in the mangrove forest, including nutrient richness, roles in marine food chains and habitat heterogeneity leading to various degree of specialization in aquatic animals, are major factors maintaining biodiversity in mangrove forests (Paphavasit, 1995). Most mangrove macrobenthic study in Thailand have been concentrated in 3 areas, namely natural forest, disturbed forest and mangrove plantation or reforestation areas. The natural forest showed the highest diversity and biomass. The three most dominant groups of benthos were crustaceans, mollusks and polychaetes of 40, 30 and 15 in percentage, respectively. Disturbed mangrove forest, such as abandoned-shrimp ponds, tin mining area and denuded forest due to coastal reclamation showed low diversity and biomass. The changes in macrobenthic composition may be used as an indicator of the health state of the mangrove forest.

The macrobenthic communities on the Andaman coastline was usually richer in terms of diversity and abundance. This was due to the intact mangrove forest lining the Andaman coastline. In natural mangrove forest, the diversity and biomass were high. The species composition was similar to those of the Gulf of Thailand. Crustaceans were highly diversed in mangrove forest in Phang-nga Bay. Molluscs and polychaetes were next in respective order (Paphavasit and Setti, 1982). The three most dominant groups of benthos were crustaceans, mollusks and polychaetes of 40, 35 and 15% respectively. Tin mining was one of the major factors impacting the benthic communities on the Andaman coastline. Mollusc gastropods in the Family Potamididae, such as *Cerithidea* spp. and *Cerithium* spp. were common species in the post-mining mangrove plantation. (Piyakarnchana, 1988). These gastropods were often found with thick shell, allowing them to withstand high temperature and desiccation. The species composition was similar to those mangroves in abandoned shrimp farm of 30%

crustaceans, 10% molluscs and 60% polychaetes. In most denuded mangrove forest, polychaetes in the Family Nereidae was found in abundance (To-on, 1999; Sudthongkong, 1996). These polychaetes are opportunistic species and are omnivorous. There have been several studies on the time scale in the successsional process for the rehabilitation of benthic communities. In one such study in Phuket Province, Prasertwong (1984) found that it would take more than 20 years for the recolonization of benthic communities to take place in the post-mining periods.

In Phang-nga and Phuket Province, mud lobster mounds scattered in some areas. These crustaceans were often associated with denuded mangrove forest. However, the mud lobster mounds provided the habitats for several other benthos, such as various grapsid crabs, to live in.

Fish communities

Several studies of the mangrove and its relation to fish community in Thailand provide evidences that Thai mangrove forest have been used by fish as (a) nursery ground; (b) permanent habitats or (c) breeding ground in the case of some coastal species. Rich fish diversity was reported from the Andaman coastline of Ranong, Phang-nga, Phuket, Trang and Satul. Dominant fish species in Ranong mangrove forest system were in the families Clupeidae, Engraulidae, Mugilidae, Atherinidae, Centropomidae, Ambassidae, Carangidae, Leiognathidae, Polynemidae, Blenniidae and Gobiidae (UNDP/UNESCO, 1991; Boonruang *et al*., 1994; Duangdee *et al*., 1997, Wongchinvit, 2002). Gobiidae stand out as the dominant mangrove fish along the Andaman coastline as well as the Gulf of Thailand. Apart from Gobiidae, fishes in the families Engraulidae, Ariidae, Mugilidae, Platycephalidae, Ambassidae, Carangidae, Leiognathidae, Gerreidae, Sciaenidae, Terapontidae, Nemipteridae, Callionymidae, Scatophagidae and Monacanthidae were common in Phang-nga mangrove forest. (Boonruang *et al*., 1994, Janekarn, 1993, Monkolprasit, 1994). In Phuket mangrove forest as summarized by Satapoomin and Poovachiranon (1997), fishes in the families Engraulidae, Clupeidae, Mugilidae, Leiognathidae, Carangidae were common, apart from Gobiidae.

These fishes found in the mangrove forest can be divided into true mangrove species, which are permanent residents in the families of Gobiidae, Clupeidae, Engraulidae, Gerreidae, Leiognathidae, Hemiramphidae, Apogonidae, Sillaginidae and Tetraodontidae. Fishes in the mentioned families come into the forest during their spawning period and occasionally come in to feed in the forest where they become matured: Blenniidae, Atherinidae, Ambassidae, Mullidae, Syngnathidae, Terapontidae, Exocoetidae, Cynolossidae, Monacanthidae, Soleidae and Synodondidae. The mangrove forest on the Andaman coastline serve as breeding and nursing grounds for various fish. More than 90 families of fish larvae and juveniles have been recorded in the area.

Declining fishery production in Thai waters is generally due to overfishing, pollution and coastal habitat degradation. These three major factors seem inseparable. There were several studies in Thailand that well demonstrated the decrease in mangrove area in Ranong, Phang-nga and Phuket Province, which was correlated well in time with the decrease in coastal fishery production (Satapoomin and Poovachiranon, 1997; Paphavasit and Piumsomboon, 1998) Phang-nga Province was recorded with high fishery occupation due to its rich intact mangrove forest. Fishing zone expanded from the rich Phang-nga Bay to the offshore Andaman Sea bordering Burma. Commercial as well as small-scaled fishery was important occupation as shown in Figure 2.2.

Table 2.2 Fishery occupation in Ranong, Phang-nga and Phuket province
(Fisheries statistic, Department of Fishery)

Province	Year	Total	Marine Fishery	%	Aquaculture	%	Fishery & Aquaculture	%	Licensed Fishery
Ranong	1990	1,959	1,944	99.23	12	0.61	3	0.15	2,174
	1995	2,452	2,145	87.48	221	9.01	86	3.51	2,436
	2000	2,430	2,143	88.19	151	6.21	136	5.60	2,420
Phang-nga	1990	3,072	2,701	87.92	180	5.86	191	6.22	2,871
	1995	4,916	3,333	67.80	946	19.24	637	12.96	3,633
	2000	5,584	4,395	78.71	917	16.42	272	4.87	4,806
Phuket	1990	909	881	96.92	23	2.53	5	0.55	988
	1995	1,271	1,064	83.71	177	13.56	30	2.36	972
	2000	1,126	953	84.64	164	14.56	9	0.80	964

Aquaculture, in particular cage cultures, mussels, pearl oysters, oysters and cockle can be found in the area. Shrimp farming, in particular *Penaeus monodon* in Phang-nga Province has been the major cause of mangrove degradation since the year 1992 onwards. As for Phuket Province, fishery is one of the important occupations. Shrimp farming, cage cultures, mud crab farms, mussel and oyster farms as well as pearl oyster cultures are important aquaculture activities in the province. Rapid expansion of shrimp farming area also contributes to the decrease in area and degradation of Phuket mangrove forest, particularly in Muang District and Thalang District. Table 2.3 shows the marine fish landing with the declining trend between the year 1993-2003.

Table 2.3 Quantity of marine fish at major landing places in Ranong, Phang-nga and Phuket in tons (Fishery Statistic, Department of Fishery)

Year	Province	Total	Fish Sub-Total	Food fish	Trash fish	Aquatic resources			
						Shrimp	Lobster	Crab	Squid
1996	Ranong	286,044	138,852	94,911	43,941	5,481	-	563	2,296
	Phang-nga	109,786	54,433	36,713	17,720	-	-	-	920
	Phuket	138,673	67,853	38,879	28,974	1,000	0	177	1,790
1999	Ranong	132,473	64,014	37,801	26,213	2,977	-	226	1,242
	Phang-nga	113,592	56,561	34,707	21,854	-	-	-	470
	Phuket	141,659	69,020	31,543	37,477	931	1	416	2,271
2003	Ranong	121,331	55,346	34,366	20,980	2,859	-	911	6,869
	Phang-nga	165,935	44,665	36,268	83,974	-	-	-	1,028
	Phuket	129,410	63,102	35,828	27,274	1,143	2	352	1,709

Ability of mangrove forest structure to withstand tsunami impacts

According to Parish (2005), mangroves had demonstrated 4 functions in protecting shoreline during tsunami as follows:

1. Reflecting and reducing tidal waves and energy dissipation. Mangroves absorb wave energy.
2. Stopping driftwoods and other materials moved by tsunami and to prevent secondary damage by driftwoods
3. Preventing people from being washed out to sea
4. Reducing erosion of beaches and dunes

In Parish view, front edge mangroves absorb wave energy, although tree can be uplifted but the back forest springs back and survives as the second line of defense. There are situations where mangrove forest provides less protection, such as being close to epicenter, landforms leading to extremely high waves and eroded riverine mangrove forest.

Several factors contributing to the ability of mangrove forest structure to withstand the impacts of the tsunami are as follows:

1. Species of mangrove trees

Several cases showed that *Rhizophora* species are more suitable to mitigate the effects of tsunami than *Avicennia* due to their more endurable aerial stilt roots which than pneumatophore of the latter to long periods of submergence by flood water. (Kathissan and Rajendra, 2005; Saenger, 1982) Tree density should be high. The width of the forest is also important, which should not be less than 40 meters. These mangrove forest serves as a natural shield against monsterous waves.

2. Position of the mangrove forest. Fringe forest facing directly to the sea severe or inside the channel or creeks. The further the distance from the sea, the less impact. High elevation also reduces the risk from tsunami.

3. Density of mangrove species as well as the tree height determines the ability to withstand the tsunami. There has been concern about the mangrove plantation style in that uniform distribution will not lessen the damages from tsunami. However, rows planting which imitates natural forest would reduce the risk from tsunami impact. This is similar to the defense lines in American football team.

4. The complexity and flexibility of aerial root system provides both the sedimentation and wave reduction process.

5. Tree canopy characteristic of each mangrove species is also important. If the canopy height is higher than the wave, this allows the tree to withstand the wave impacts.

Ecological risk assessment on coupling processes between mangrove forest and coastal water

The exchange of water and, thus, nutrients and other properties between nearshore zone and the mangrove forest can occur by either direct tidal exchange or through diffusive processes. Direct exchange of mangrove water and coastal water can also occur under the influence of freshwater inflow (Wolanski *et al.*, 1992) Tsunami has demonstrated the profound impacts on the coupling processes between mangroves and coastal water. This will in turn affect the coastal productivity and changes in seawater intrusion and shorelines.

Table 2.4 shows the assessment of tsunami impact on the mangrove forest on the Andaman coastline. This data is based on the survey by questionaires. The forest officers in the field were our target group to complete our questionaires in the post-tsunami survey of 3-4 months.

Table 2.4 The assessment of tsunami impact on the mangrove forest on the Andaman coastline of Thailand

Impacts on Mangrove Ecosystem	Provinces					
	Ranong	**Phang-nga**	**Phuket**	**Krabi**	**Trang**	**Satun**
1. Physical Alterations						
1.1 Water quality						
- seawater intrusion in mangrove forest	0-1	0-2	0-2	0-1	0	0-1
- channel fill-up	0	0-1	0-2	0-1	0	0-1
- changes in waterways	0	0-3	0-2	0	0	0-1
- increase channel depth due to erosion	0	0-2	0-2	0	0-1	0-1
- increase turbidity	0-1	0-3	0-3	1	0-1	0-1
- changes in seawater coloration	0	0-4	0-1	1	0	0-1
- increase in offensive odours	0-1	0	0-3	0	0	0-1
1.2 Sediment quality						
- increase sedimentation in mangrove area	0	0-4	0-3	0	0	0-1
- soil erosion	0-1	0-3	1-3	1	0-1	0-1
- changes in sediment coloration	0-1	0-2	0-1	1	0	0-1
- increase in offensive odours	0-1	0-1	0-2	0	0	0-1
2. Biological Alterations						
2.1 Mangrove flora						
- loss of mangrove area	0-1	0-3	0	0	0	0
- loss of seedlings area	0	0-2	0	0	0	0
- mangrove regenerations	0	0-2	0-1	0	0	0
- increase damages on mangrove shrubs	0	0-2	0-3	0	0	0
2.2 Mangrove fauna						
- decline in fishery resources	0-1	0-3	1-2	0-1	0	0-1
- increase in fishery resources	0	0-2	0	0	0	0-1
3. Socio-economic Aspects (Fishing communities)						
- decline in catches	0	0-3	0-1	0-1	0-1	0-1
- decline in fishing boats	0	0-4	0-2	0-2	0-1	0-1
- decline in fishing families	0	1-4	0-2	0-2	0	0
- occupational shifts	0-1	0-4	0-2	0-1	0	0-1

Remark: 0 = not affected
1 = 1-25% alterations from normal condition
2 = 26-50% alterations from normal condition
3 = 51-75% alterations from normal condition
4 = 75% alterations from normal condition

The result showes that mangrove forest in Phang-nga experienced the heaviest impacts in terms of physical alterations of water quality and sediment quality as well as biological alteration.

Water circulation

Ban Nam Khem: Due to the geography of Ban Nam Khem, the sea water can penetrate and mix with freshwater in Pak Ko canal at the northern and southern part of Kho Khao Island. According to the water level data at Tap La Mu tide gauge station, the tide rise and fall twice a day in vicinity area including Ban Nam Khem. Therefore, tide can cause water movement at Ban Nam Khem region, especially in Pak Ko canal. At the sea front, wave together with tide plays a major role in changing the coastline, especially Ban Kho Khoa, a sandy beach area (Wichiencharoen *et al.*, 2005). There are no small islands or coral reefs located within the vicinity area of Ban Nam Khem that can reduce the wave energy. Therefore when two waves moving in different direction (northward and southward) meet at the open and funnel-shaped channel (convergence zone) it can cause a severe damage to Ban Nam Khem and Ban Pak Ko.

Bang Rong: On the northeast coast of Phuket Island is Bang Rong mangrove forest. It is classified as a tidal creek of 3 km length. Sources of freshwater come from direct precipitation and run-off from mainland (Suraswadi and Kristensen, 2002). Climatological condition is under the influence of monsoon in a wet season (November to April) and a dry season (May to October). Khokiatwong *et al.* (1991) studied oceanographic variations in Phang-nga Bay and found that the tide at station near Bang Rong mangrove had a spring and a neap tidal range of 2.40 m and 0.88 m respectively. The model results from 2-D depth-averaged model showed that the absence of large-scale residual tidal circulation and wind-driven circulation plays a role for advection and salt transport while tidal oscillation increases mixing and dispersion of salt in Phang-nga Bay (Sojisuporn *et al*., 1994). From above reasons it can be concluded that the water circulation in Bang Rong mangrove forest is caused by semidiurnal tides. The flushing time calculated were 2 and 2.3 days respectively (Suraswadi and Kristensen, 2002).

A buffer zone of mangrove area at Ban Nam Khem is located behind Kho Khao Island. Conifer is the dominant species in the beach forest. Therefore, a storm surge could have a significant damage to Kho Khao Island and at the lower part of Ban Nam Khem, because the coastline directly faces to the ocean. The storm surge is less influential at Bang Rong, because it is situated in sheltered area of Phang-nga Bay. Dense mangrove forest can reduce the water movement energy.

Water quality

Since the Andaman coast in under the influence of the monsoon, the fluctuation in water quality parameters is strongly related to the amount of rain and freshwater runoff. In general, coastal water along the coastline of Phang-nga province is quite clean without serious problems of either eutrophication or bacterial contamination. The studies on the west coast of Kho Khao Island from 1982-1985 indicated that the average concentration of phosphate-phosphorus (PO_4^3-P), nitrate-nitrogen (NO^3-N) and nitrite-nitrogen (NO^2-N) was <0.33 μg-at P/l, <0.53 μg-at N/l and <0.03 μg-at N/l, respectively. Current studies indicated that concentrations of dissolved inorganic nutrients along the coast of Phang-nga were always less than 15.00 μg-at N/l of total nitrogen and 1.00 μg-at P/l of total phosphorus. The majority of dissolved inorganic nitrogen in coastal water of Phang-nga is NO^3-N and there was a point source of high concentration of nitrate-nitrogen from Thaimhuang district, particularly in the wet season (Pollution Control Department, 2004a). This situation was different in Phuket Bay, where major nitrogen species is ammonia-nitrogen (NH_3^+-N). The concentrations of chlorophyll *a* in coastal water of both provinces were not exceeding 5 μg/l. There is, however, a tendency of higher bacterial contamination as indicated by higher densities of coliform bacteria and feacal coliform during the wet season in comparison to the dry season (Pollution Control Department, 2004a and Panutrakul, 1996)

Oceanic water intrusion due to storm surge or tsunami into the coastal zone as well as into the mangrove area will affect physico-chemical characteristics of coastal water. Increase in salinity of water and interstitial water logged among sediment particles is one of the expected results. The problem of increasing salinity will affect not only the diversity but also the morphology and physiology of plants and animals inhabiting in the coastal area and the flooding area. Besides, oceanic water is usually under oligotrophic conditions in comparison to coastal water, mixing of oceanic water to coastal one would result in lowering concentrations of dissolved nutrients and increasing pH of coastal water. Water transparency is another indicator that may be affected by the increase in water column turbidity due to the re-suspension of surface sediment in response to rapid movement of water. The offensive odors may also be detected in the area where seawater with large amount of detritus has been trapped for a long time.

One month after the tsunami, the water quality conditions of Phang-nga and Phuket coasts were generally fair or good according to Marine Water Quality Index (Department of Marine and Coastal Resources, 2005). Only the increase in suspended particles in coastal water was observed in the provinces located south of Phuket (Office of Natural Resources and Environmental Policy and Planing, 2005). The post-tsunami coastal water along Phang-nga and Phuket provinces were reported to be in better condition than the pre-tsunami period (Office of Natural Resources and Environmental Policy and Planning, 2005).

Sediment quality

The major impact of tsunami on sediment properties at Ban Nam Khem was the accumulation of sediment carried onshore by tsunami. This sediment layer of 10 cm. thick which was brown or gray was composed mainly of sand and clay (Division of Environmental Geology, 2005 and Aiemsiri *et al.*, 2005). In Bang Rong, the sediment contained more than 80% dry weight of silt and clay and >4% organic matters (Suraswadi, 2002). The rapid increase in water level may accelerate the sedimentation in the mangrove forest as well as increase turbidity in creek water. However, the impact may not be prominent since there was no significant change in the total suspended solid in the Bang Rong creek in the post-tsunami period.

Ecological risk assessment on maintaining diversity and coastal productivity

As evidenced in the biodiversity in the mangrove forests in Thailand, mangroves represent a unique habitat for a diverse variety of marine and terrestrial organisms. Paphavasit (1995) concluded that niche partitioning and ecophysiological adaptation were the two major factors maintaining biodiversity of mangrove forest in Thailand. Niche partitioning in the mangrove forests included the habitat heterogeneity, nutrient richness and the roles in the marine food webs. Disturbances such as natural disasters, cyclones and tsunami as well as human activities can directly affect the two important factors maintaining the biodiversity of mangrove forest and coastal productivity.

From the integration of knowledge-based researches, the evaluation of ecological risks and impacts can be concluded as shown in table 2.5. This will also demonstrate the resilience and recovery capacity of mangrove forest to disturbances, such as tsunami. From our ecological risk assessment, we predict that both mangrove forests at Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province should be resilient to disturbances, such as tsunami due to food web complexity and high stability in these forests. High recovery ability are also predicted. The detailed analyses of our field data should be able to confirm these predictions.

Table 2.5 Ecological risk assessment in Ban Nam Khem mangrove forest, Phang-nga Province and Bang Rong mangrove forest, Phuket Province.

Ecological Risk Assessment	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province
Mangrove Forest prior to tsunami	These mangrove forests were considered degraded forests. They had been under the two-rotation-cycle concession for wood from 1976 – 2001. Since the concession ended in 2001, the forest was in natural regeneration process. Small trees of 5 – 6 meters in height were dominant. *Rhizophora apiculata* was dominant along the bank. *Rhizophora mucronata*, *Ceriops tagal* and *Bruguiera cylindrical* can be found landwards in composition with *R. apiculata*. Seaward mangrove forest at Laem Pom Bay were found on the muddy mudflats. Big trees such as *Avicennia alba* and *Sonneratia ovata* were found in abundance.	These mangrove forests were also under the two-rotation-cycle concession for wood from 1976 – 2001. Prior to the beginning of the second rotation cycle in 1986, the forest was in deteriorating condition with small trees of mainly *Rhizophora mucronata, R. apiculata*, *Ceriops tegal* and *Bruguiera cylindrical.* Mud lobster mounds could be found scattered in the area. RFD together with the Petroleum Authority of Thailand launched the mangrove reforestation program in 1996. Several mangrove forests have been managed by the communities themselves. Thus the dense *Rhizophora* forests appear in the area. At the Bang Rong estuary, *Avicennia marina, A. alba* as well as *Sonneratia ovata* can be found.

Table 2.5 (cont.)

Ecological Risk Assessment	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province
Ecological risk assessment on maintaining diversity • Habitat loss/heterogeneity	The *Avicennia* mangrove forest along the Laem Pom Bay was totally destroyed by being uprooted from direct wave impact. Total forest clearence zone of mainly *Avecinnia* 10 - 50 meters wide was found along Klong Pak Ko. In area where *Rhizophora* grew in dense forest, the damage would be less.	The mangrove forest in this area was slightly damaged from high water inundation and rapid water ingression. Some *Rhizophora* trees along the Khlong Bang Rong bank were fallen. The big *Avicennia* trees as well as *Sonneratia ovata* in the Bang Rong estuary were broken but the trunks still stand.
• Mangrove regeneration/ loss of seedling area	• No loss in seeding area due to small trees dominance • 25% of the mangrove area estimated to be affected in terms of germination • 25% of the mangrove area estimated to be affected in terms of damages on mangrove shrubs	• 25% of seeding area in Phuket affected • Flowering in *Rhizophora* spp. affected. The normal flowering season starts from December – February • Damages on germination and mangrove shrubs noticeable
Ecological risk assessment on coupling processes between mangroves and coastal productivity • Water quality	• Seawater intrusion in mangrove forest • Channel fill up (1–25% alteration from normal condition) • Changes in waterways (51–75% alteration from normal condition)	• Increased channel depth due to erosion • Slight increase in turbidity • Increase in offensive odours due to mass mortality of small fishes
• Sediment quality	• Increased sedimentation (75% alternation from normal condition) • Soil erosion (more than 50% alternation from normal condition) • Slight changes in sediment coloration • Slight increase in offensive odours	• Increased sedimentation (less than 25% alteration from normal condition) • Soil erosion (less than 25% alteration from normal condition) • Slight changes in sediment coloration

Table 2.5 (cont.)

Ecological Risk Assessment	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province
Ecological risk assessment on coastal productivity/ diversity	• Oligotrophic – mesotrophic environment with the estimated primary productivity from chlorophyll_a content lower than 50 gmC/m^2/yr • Diatoms dominant in phytoplankton communities • Dominant zooplankters are copepods, polychaete larvae, shrimp larvae, crab zoea and foraminiferans • Benthic communities in mangrove forest revealed condition similar to matured forest with crustaceans and mollusks as dominant groups • Rich fish diversity with different feeding niches, niche partitioning in fishes sharing the same trophic levels were evident	• Oligotrophic-mesotrophic environment with the estimated primary productivity from chlorophyll_a content lower than 50 gmC/m^2/yr • Diatoms dominant in phytoplankton communities • Dominant zooplankters are copepods, *Lucifer* sp. arrow worms, mollusk larvae, larvacean and mysids • Benthic communities in mangrove forest revealed condition similar to matured forest with crustaceans and mollusks as dominant groups • Rich fish diversity with different feeding niches, niche partitioning in fishes sharing the same trophic levels were evident
• Food web complexity	• High with fishes, birds snakes as top predators	• High with fishes, birds snakes, monitor lizards and macaques as predators
• Ecosystem stability	• High	• High
Ecological risk on population structure and way of life in coastal communities • Total Household interviewed • Average family members/ household • Sex ratio (%male: %female) • Age structures (%) - lower than 25 yrs. - 25 – 39 yrs - 40 – 50 yrs - 60 yrs or older • Education - lower than secondary level - secondary level - higher than secondary level	 368 4 54.9 : 45.1 7.6 33.2 48.1 11.1 9.8 67.4 22.8	 156 4 62.8 : 37.2 4.5 34.0 48.1 13.5 16.7 56.4 26.9

Table 2.5 (cont.)

Ecological Risk Assessment	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province
• Occupation	32.9	7.7
- Jobless	12.5	19.2
- Fishing	54.6	73.1
- Other than fishing		
• Birthplace	16.3	60.9
- In the village	83.7	39.1
- elsewhere		
• Reason for moving into villages		
- to work	64.8	38.5
- move with family	35.2	61.5
• Participation in community activity	Low	High

Chapter 3

Post-tsunami: Monitoring of Impact Assessment on Mangrove Ecosystem

Nittharatana Paphavasit Viroj Teratanatorn Ajcharaporn Piumsomboon
Sangob Panichchart Itchika Sivaipram Sombat Karnchanapraiharn
Suriyan Salamul Yuthasilp Suwanwong Cholthaya Songroop
Nirucha Mongkolsangsuree Porntep Punnarak Bancha Sabuytua
Sirimard Sukprasert and Supichaya Wongchinvit

Natural disturbances may affect mangrove forest in local scale events such as breakage of branches during storm to whole-scale destruction of the forest by hurricane and tsunami. Gradients in the type and frequency of disturbance were also presented across the geographic range of mangrove forest. The influence of disturbances on structure and function of mangrove forest is poorly investigated. Mangroves could have reduced tsunami damage as Simon Cripps, Head of the Worldwide Fund for Nature's Marine Program based in Grand, Switzerland. ***"It wouldn't have been able to stop it completely, of course, but we've seen areas already…where there were mangroves, there was substantially less damage"***.

It still has to be confirmed whether mangroves have prevented significant damage from the Indian Ocean tsunami. More detailed information on the linkage between mangroves and the damage caused by the tsunami is required. Not only the physical alteration of the mangroves but also its ecological functions should be assessed. The relationship and mechanism of different vegetation to wave reduction is yet to be determined. According to Kathiresan and Rajendran (2005) concluded from their post-tsunami survey that there was a significant negative correlation between human death toll and the distance of human inhabitat, the elevation from mean sea level and the area of mangrove and other coastal vegetation. The mangrove forest functions as sinks for the suspended sediment with annual sedimentation rate ranging between 1 to 8 mm. Density of mangrove species and their complexity and flexibility of aerial root system contributed to the sedimentation and the wave reduction process. Parish (2005) reported on a Coastal Greenbelt Initiative (CGI) being developed by the Global Environment Centre and other partners in order to complement existing activities. This would provide an open-ended framework to bring together key stakeholders to collaborate in supporting the protection and rehabilitation in the coastal area. He also concluded the poor design and management of coastal greenbelt in several countries were affecting their effectiveness. Therefore, he suggested that mangrove species be selected, the complex root system and tree density and spacing be considered in designing the effective coastal greenbelt. Along the coastline of Parangipettai, Tamil Nadu in India, Kathiresan and Rajendra (2005) suggested that *Rhizophora* species growing seawards were more suitable species to mitigate the effect of tsunami than *Avicennia* species that existed generally landwards. This was due to the fact that the aerial stilt roots of the former were more endurable than pneumatophores of the latter to long period of submergence by flood water.

According to selected tree species, Smith and Dukein 1987, as quoted by Smith (1992) found the positive relationship between large-scale disturbance (cyclone) and species richness in the mangrove forest in north eastern Queensland, Australia. Forests that were impacted on average by one cyclone every 5 years, had more species than forests affected by fewer storms. Dominant species were in Rhizophoraceae. In contrast, the Suderbans mangroves in Bangladesh, Rhizophoraceae was a minor component. This area was struck by up to 40 cyclones a year. The Rhizophoraceae was not able to cope in comparison to other groups (*Avicennia, Laguncularia, Excoecaria and Xylocarpus*). In our case, it is necessary to investigate the ability of mangrove forest structure to withstand the impact of tsunami and ecological changes that have occurred in the mangrove ecosystem due to tsunami. The two major mangrove forests, *Avicennia* and *Rhizophora*, were compared in terms of their ability to withstand tsunami impact and the ecological consequences that have taken place.

Mangrove forest structure

Ban Nam Khem, Phang-nga Province

In Ban Nam Khem, Phang-nga Province, seventeen mangrove species were recorded. As shown in Table 3.1 and 3.2, *Rhizophara apiculata* and *Avicennia alba* were widely distributed in the area. Highest tree density was recorded in the dense *Rhizophara* forest (TNK-R2) while the dense *Avicennia* (TNK-A2) recorded the highest diversity. Apart from the three dominant species of *R. apiculata*, *R. alba* and *Ceriops tagal*, *Xylocarpus granatum* and *X. moluccensis*, which favor hard landward substrate, thrived well in the new mudflat. Table 3.3 revealed the tree structure measurement in Ban Nam Khem mangrove forest. The two *Avicennia* forests were investigated, namely, the low density forest (TNK-A1) and the high density/dense forest (TNK-A2). Two *Rhizophara* forest were also investigated of low density forest (TNK-R1) and dense forest (TNK-R2). The forest structure in the tidal mudflat (TNK-M) was also investigated. This was the area severely affected during the tsunami. As the tsunami-aftermath, the rehabilitation program was set up in this area.

Table 3.1 Composition of trees in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 stem/hectare
(++) = 101-1,000 stem/hectare
(+++) = 1,001-10,000 stem/hectare

Scientific name		Station				
		TNK-A1	**TNK-A2**	**TNK-R1**	**TNK-R2**	**TNK-M**
Family Rhizophoraceae						
Rhizophora mucronata	(โกงกางใบใหญ่)	-	-	+	++	-
Rhizophora apiculata	(โกงกางใบเล็ก)	++	-	++	+++	++
Bruguiera cylindrica	(ถั่วขาว)	-	-	-	++	-
Bruguiera gymnorrhiza	(พังกาหัวสุมดอกแดง)	-	-	+	-	-
Ceriops tagal	(โปรงแดง)	-	-	-	++	++
Family Verbenaceae						
Avicennia alba	(แสมขาว)	-	++	+	-	++
Avicennia officinalis	(แสมดำ)	-	+	+	++	-
Avicennia marina	(แสมทะเล)	+	-	-	-	-
Clerodendrum inerme	(สำมะง่า)	-	+	-	-	-
Family Sonneratiaceae						
Sonneratia alba	(ลำพูทะเล)	-	-	+	-	+
Family Meliaceae						
Xylocarpus granatum	(ตะบูนขาว)	-	-	-	-	++
Xylocarpus moluccensis	(ตะบูนดำ)	-	-	-	-	+
Family Ebenaceae						
Excoecaria agallocha	(ตาตุ่มทะเล)	-	++	-	-	-
Family Acanthaceae						
Acanthaus ilicifolius	(เหงือกปลาหมอดอกม่วง)	-	+	-	-	-
Family Sterculiaceae						
Heritiera littoralis	(หงอนไก่ทะเล)	-	+	-	-	-
Family Leguminosae						
Derris trifoliata	(ถอบแถบน้ำ)	-	+	-	-	-
Family Casuarinaceae						
Casuarina equisetifalia	(สนทะเล)	-	+	-	-	-

Table 3.2 Tree Density in the mangrove forest at Ban Nam Khem, Phang-Nga Province during the post-tsunami in October 2005

Scientific name	Density (stem/hectare)														
	TNK-A1			TNK-A2			TNK-R1			TNK-R2			TNK-M		
	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant
Family Rhizophoraceae															
Rhizophora mucronata (โกงกางใบใหญ่)									50			250			
Rhizophora apiculata (โกงกางใบเล็ก)			233			20			50			950	700		1,250	425		782
Bruguiera cylindrica (ถั่วขาว)				280			50					200			
Bruguiera gymnorrhiza (พังกาหัวสุมดอกแดง)									50						
Ceriops tagal (โปรงแดง)							50			200		350	75	25	225
Family Verbenaceae															
Avicennia alba (แสมขาว)						140			50	100	50		25	18	129
Avicennia officinalis (แสมดำ)						20			100			100			
Avicennia marina (แสมทะเล)			100	260	200										
Clerodendrum inerme (สำมะง่า)				220											
Family Sonneratiaceae															
Sonneratia alba (ลำพูทะเล)									50						4
Family Meliaceae															
Xylocarpus granatum (ตะบูนขาว)				60			300			300			75		125

Table 3.2 (cont.)

Scientific name	Density (stem/hectare)														
	TNK-A1			TNK-A2			TNK-R1			TNK-R2			TNK-M		
	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant
Xylocarpus moluccensis (ตะบูนดำ)															50
Family Ebenaceae															
Excoecaria agallocha (ตาตุ่มทะเล)				460	40	360									
Family Acanthaceae															
Acanthaus ilicifolius (เหงือกปลาหมอดอกม่วง)					80						100				
Family Sterculiaceae															
Heritiera littoralis (หงอนไก่ทะเล)				40											
Family Leguminosae															
Derris trifoliata (ถอบแถบน้ำ)					160										
Family Casuarinaceae															
Casuarina equisetifalia (สนทะเล)						20									

Table 3.3 Tree structure in the mangrove forest at Ban Nam Khem, Phang-Nga Province during the post-tsunami in October 2005

***Avicennia* forest**

Scientific name	TNK-A1					TNK-A2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora apiculata	7.78	3.64	4.14	1.66	1.67					
Avicennia alba						5.57	1.39	4.16		0.35
Avicennia officinalis						5.5	0.8	4.7		0.50
Avicennia marina	9.17	3.16	6		5.63					0.27
Excoecaria agallocha						5.25	1.68	3.56		
Casuarina equisetifalia						18	2	16		0.80

***Rhizophora* forest**

Scientific name	TNK-R1					TNK-R2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata	7.5	5	2.5		0.60	6.06	2.24	3.82	0.61	7.55
Rhizophora apiculata	9.39	3.18	6.15	1.34	0.98	6.68	2.52	4.12	1.15	1.09
Bruguiera cylindrica						6.25	3.5	3.85		0.26
Bruguiera gymnorrhiza	9	3.5			1.50					
Ceriops tagal						5.3	1.47	3.83		0.41
Avicennia alba	12	1.5			4.50					
Avicennia officinalis	11	2	12.5		5.43	5.75	2	3.75		4.60
Sonneratia alba	3.5	1.01	2.49		1.00					

Table 3.3 (cont.)

New mudflat forest

Scientific name	TNK-M				
	Average height	**Average height of first branch**	**Canopy height**	**Root collar**	**Root system diameter**
	(m.)	**(m.)**	**(m.)**	**(m.)**	**(m.)**
Rhizophora apiculata	8.765	2.84	5.9	1.54	1.89
Ceriops tagal	6.71	2.13	4.59		0.53
Avicennia alba	7.41	2.1	5.3		4.42
Xylocarpus granatum	6.88	1.13	5.75		0.77
Xylocarpus moluccensis	6.12	2.72	3.41		3.39









1. Forest structure in the low density *Avicennia* forest (TNK-A1)

Figure 3.1 showed the forest structure along the transect line of 250 m. in connection with the exposed shore of Khlong Pak Ko. The maximum tide of 8.11 m. during tsunami was also shown as the possible indication of what the forest had gone through during the tsunami. This may not be exact due to the elevation and the water circulation. But at least, it could give some indication on the forest ability to withstand the tsunami impact. Considering the forest structure and the root system in the area, two dominant mangrove species found in the area were *R. apiculata* and *A. marina* with *R. apiculata*. The tree density was recorded at 233 stem/hectare with the average girth of 6.98 cm. The average tree height was 7.79 m., 3.64 m. in first branch height and 4.14 m. in canopy height was recorded as shown in table 3.3. The root system was measured at 1.66 m. in height and 1.67 m. in width on average. The average root surface area was 944.17 cm^2. No seedling and sapling were recoded in the area.

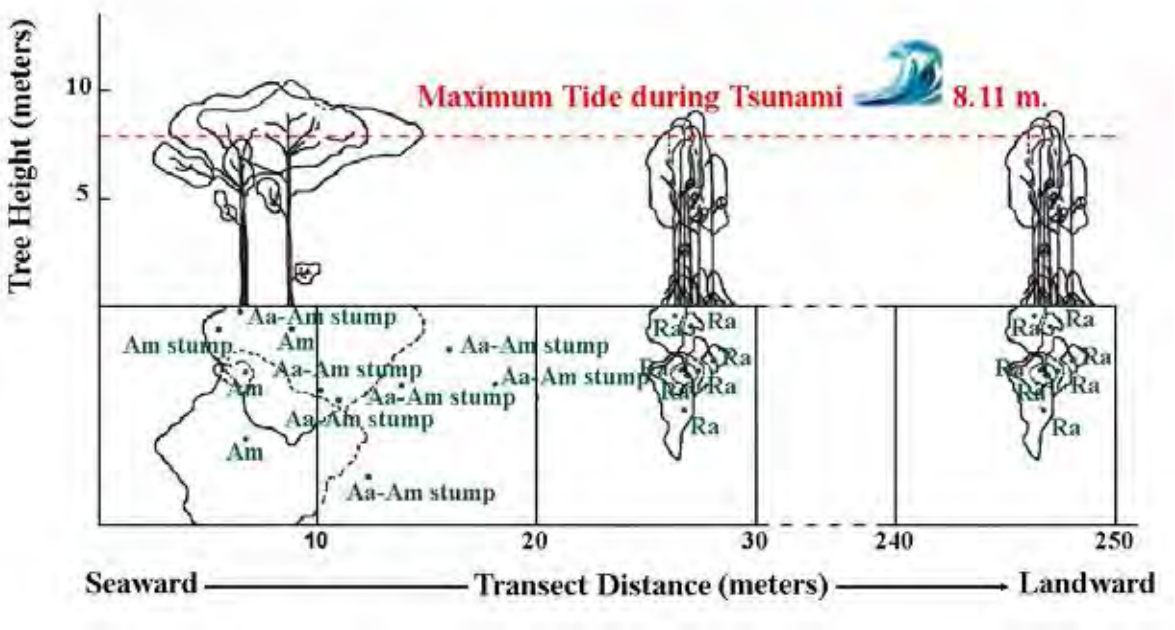


Figure 3.1 Forest structure in the low density *Avicennia* forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October, 2005.

2. Forest structure in the dense *Avicennia* forest (TNK-A2)

This was the high diversity forest in Khong Bang Muang as compared to other investigated areas in Ban Nam Khem. The dominant tree species were *Exceocaria agallocha*, *A. alba*, *A. officinalis* and *Casuarina equisetifolia* as shown in Figure 3.2. *Acanthus ilicifolius*, *Heritiera littoralis*, *Clerodendrum inerme* and *Derris trifoliata* were also found in the area. *E. agallocha* was the dominant species. Average tree density was 360 stem/hectare. The girth measurement was 7.52 cm. on average. The average tree height recorded was 7.35 m., 2.2 m. first branch height and 5.13 m. in canopy height. The average root surface area was 886.86 cm^2. with the root width of 3.57 m. Total number of seedlings and saplings was 1,520 and 260 stem/hectare.

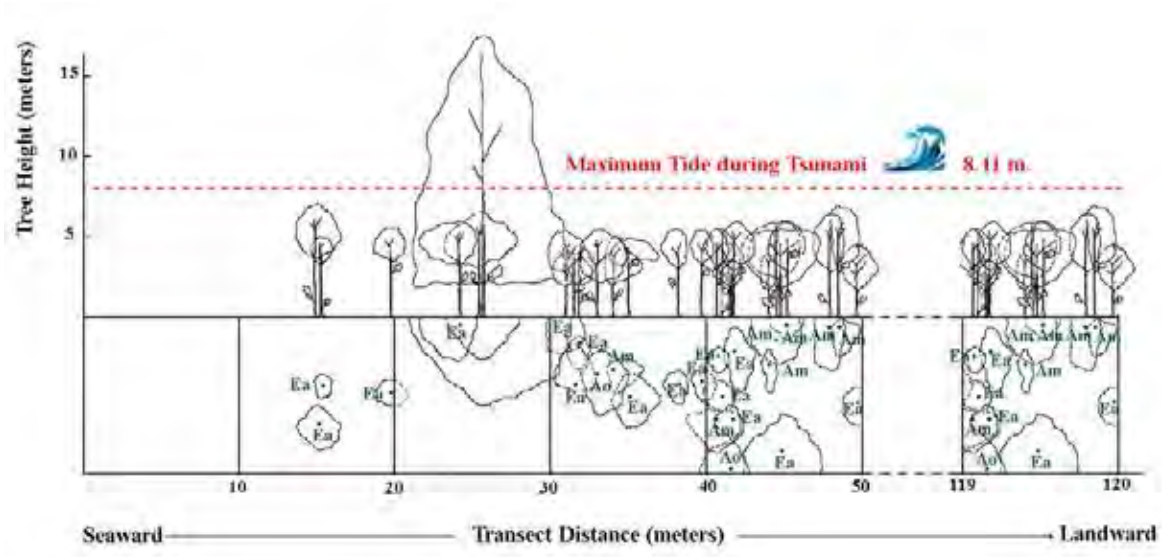


Figure 3.2 Forest structure in the dense *Avicennia* forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October, 2005.

3. Forest structure in the low density *Rhizophora* forest (TNK-R1)

The dominant mangrove species in this forest located in Khlong Bang Po was *R. apiculata* as shown in Figure 3.3. A total of 6 mangrove species was recorded namely *R. apiculata*, *R. mucronata*, *Bruguiera gymnorrhiza*, *A.alba*, *A.officinalis* and *Sonneratia alba*. The tree density recorded in the area was 1,200 stem/hectare with an average girth of 7.38 cm. The average tree height was 9.40 m., 3.18 m. first branch height and 6.22 m. canopy height. The basal root system was 1,387.62 cm^2. The root collar height stood at 1.98 m. and the width 1.80 m. The number of seedlings was 450 stem/hectare while no sapling was found. This transect was 420 meters in length.

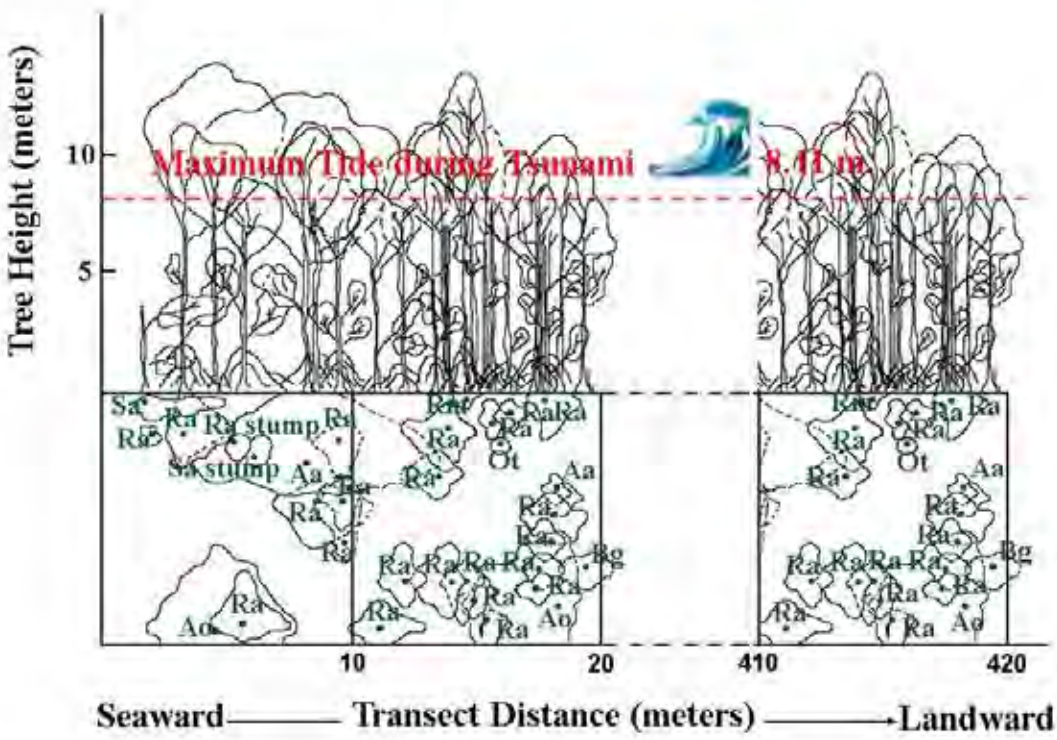


Figure 3.3 Forest structure in the low density *Rhizophora* forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October, 2005.

4. Forest structure in the dense *Rhizophora* forest (TNK-R2)

Five mangrove species were recorded in the forest, which was located in the vicinity of low density *Rhizophora* forest in Khlong Bang Po: *R. apiculata*, *R. mucronata*, *A. officinalis*, *Ceriops tagal* and *B. cylindrical* as shown in Figure 3.4. *R. apiculata* was the dominant species. The tree density was recorded at 1,250 tree/hectare with an average girth of 6.42 cm. The average tree height was 5.75 m., 2.00 m. first branch height and 4.54 m. canopy height. The root collar height stood at 1.16 m. with the width of 4.20 m. The basal root system was 848.59 cm^2. High seedlings were found in the area at 1,300 stem/hectare while the saplings were 50 stem/hectare. The transect was as long as the low density forest of 330 meters.

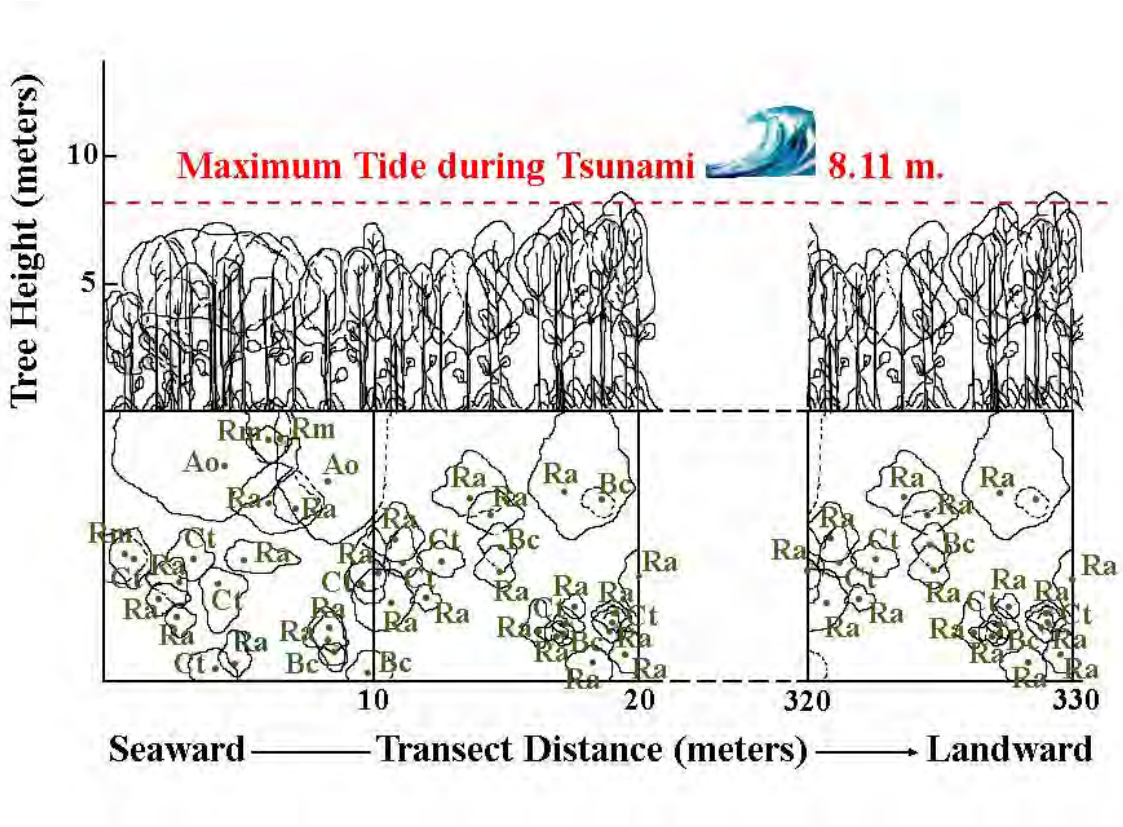


Figure 3.4 Forest structure in the dense *Rhizophora* forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October, 2005.

5. Forest structure in the tidal mudflat (TNK-M)

This forest was the new accreted mudflat area. Rehabilitation program has been initiated here. During the tsunami, the *Avicennia* forest was totally cleared. The transect line was laid at the distance of 510 meters as shown in Figure 3.5. *A. marina*, *A. alba* and *R. apiculata* were the common mangrove species. *A. marina* was the dominant species. The tree density was low at 64 stem/hectare with the girth of 14.06 cm. Those are the big trees left standing in the tsunami aftermath. The average tree height was 7.35 m., 2.22 m first branch height and 5.13 m. canopy height. The width of the root system was 4.25 m. with the basal root area of 3,899.72 cm^2. The seedlings were few at 18 stem/hectares while the saplings were 207 stem/hectare.

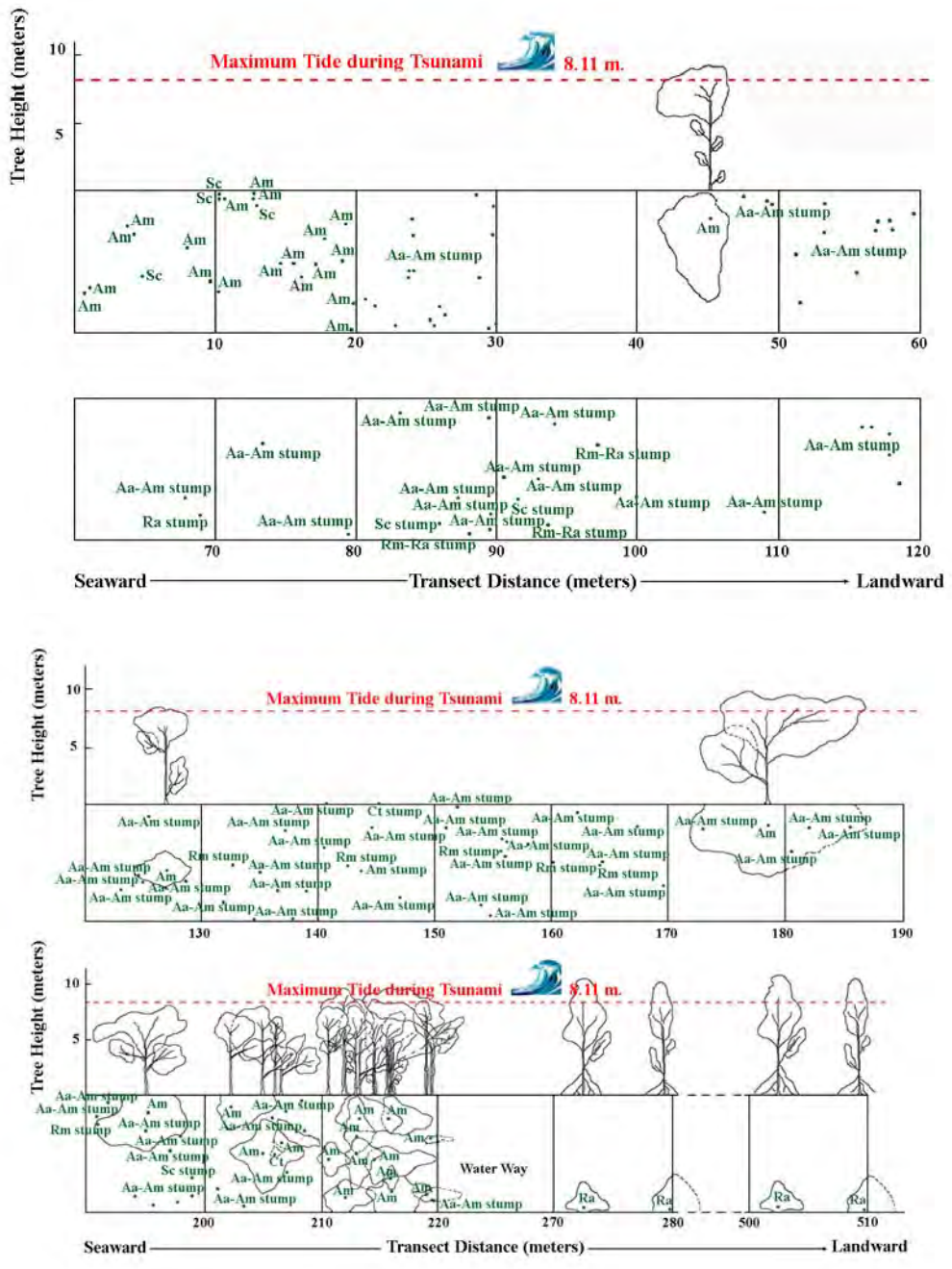


Figure 3.5 Forest structure in the tidal mudflat at Ban Nam Khem, Phang-nga Province during the post-tsunami in October, 2005.

Bang Rong, Phuket Province

Twelve mangrove species were recorded in Bang Rong, Phuket Province as shown in Table 3.4-3.5. The most dominant species were *R. mucronata*, *R. apiculata*, *Ceriops tagal* and *A. alba*. Other species recorded in the area were *B. cylindrica*, *E. agallocha*, *S. alba*, *X. granatum*, *X. moluccensis*, *Lumnitzera racemosa* and *H. littoralis*. Table 3.6 showed the tree structure measurement in Bang Rong, Phuket Province.

Table 3.4 Composition of trees in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 stem/hectare
(++) = 101-1,000 stem/hectare
(+++) = 1,001-10,000 stem/hectare

Scientific name		Station					
		TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Family Rhizophoraceae							
Rhizophora mucronata	(โกงกางใบใหญ่)	+	+	+++	+	-	++
Rhizophora apiculata	(โกงกางใบเล็ก)	-	-	+	+++	+++	++
Bruguiera cylindrica	(ถั่วขาว)	-	-	-	-	+	+
Ceriops tagal	(โปรงแดง)	-	-	-	+	+	++
Family Verbenaceae							
Avicennia alba	(แสมขาว)	++	++	-	-	+	-
Avicennia officinalis	(แสมดำ)	+	-	-	-	-	+
Family Ebenaceae							
Excoecaria agallocha	(ตาตุ่มทะเล)	-	-	-	-	+	-
Family Sonneratiaceae							
Sonneratia alba	(ลำพูทะเล)	+	+	-	-	-	-
Family Meliaceae							
Xylocarpus granatum	(ตะบูนขาว)	-	-	-	+	+	+
Xylocarpus moluccensis	(ตะบูนดำ)	-	-	-	+	+	+
Family Combretaceae							
Lumnitzera racemosa	(ฝาดดอกขาว)	-	-	-	-	+	-
Family Sterculiaceae							
Heritiera littoralis	(หงอนไก่ทะเล)	-	-	-	-	+	-

Table 3.5 Trees Density in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

Scientific name	Density (stem/hectare)																	
	TBR-A1			TBR-A2			TBR-R1			TBR-R2			TBR-C			TBR-PO		
	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant
Family Rhizophoraceae																		
Rhizophora mucronata (โกงกางใบใหญ่)			11	40		80	8		8	1,500	67	1,567				433	269	231
Rhizophora apiculata (โกงกางใบเล็ก)								8	15				67		967	33	233	600
Bruguiera cylindrica (ถั่วขาว)													100			100		
Ceriops tagal (โปรงแดง)													567	131	69	2,267	933	633
Family Verbenaceae																		
Avicennia alba (แสมขาว)		11	178			300		31	25						33	67		
Avicennia officinalis (แสมดำ)			8															33
Family Ebenaceae																		
Excoecaria agallocha (ตาตุ่มทะเล)															33			
Family Sonneratiaceae																		
Sonneratia alba (ลำพูทะเล)			33			60			162									
Family Meliaceae																		
Xylocarpus granatum (ตะบูนขาว)													100	33	33	1,233		33
Xylocarpus moluccensis (ตะบูนดำ)															33	33		67
Family Combretaceae																		
Lumnitzera racemosa (ฝาดดอกขาว)															33			
Family Sterculiaceae																		
Heritiera littoralis (หงอนไก่ทะเล)													33					

Table 3.6 Tree structure in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

***Avicennia* forest**

Scientific name	TBR-A1					TBR-A2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata	5.00	1.10	4.90	1.03	1.22	7.38	1.38	6.03	1.46	
Avicennia alba						11.23	1.73			
Avicennia officinalis	8.00	1.42	6.12		5.24					
Sonneratia alba	9.62	2.00	7.34		5.70	11.00	5.30			

***Rhizophora* forest**

Scientific name	TBR-R1					TBR-R2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata	5.00	1.50	3.50	0.85	1.90	10.31	4.62	5.73	1.55	2.85
Sonneratia alba	7.88	0.59	7.13		4.79					

Table 3.6 (cont.)

Community forest and mangrove forest in the vicinity of cage culture

Scientific name	TBR-C					TBR-PO				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata						9.00	5.00	4.00	1.00	1.00
Rhizophora apiculata	11.21	4.83	6.41	1.40	1.39	10.58	3.89	6.53	1.15	1.18
Ceriops tagal	10.00	1.00	9.00		4.00	8.13	2.98	5.14		47.95
Avicennia alba	8.50	5.50	3.00		3.32					
Avicennia officinalis						11.00	6.50	4.50		5.10
Excoecaria agallocha	7.50	1.60	5.10		7.10					
Xylocarpus granatum	8.00	1.44	6.66		0.23	6.50	3.50	4.00		0.38
Xylocarpus moluccensis	7.00	1.49	5.51		0.20	6.25	3.00	3.75		22.50
Lumnitzera racemosa	5.50	1.00	5.40		2.40					







TO REVIVES THE COAST RESOURCES PROJECT
BY BANBANGRONG COMMUNITY
20.10.2005 16:04


1. Forest structure in the low density *Avicennia* forest (TBR-A1)

Five mangrove species were recorded in the low density *Avicennia* forest along the 130 meters transect as shown in Figure 3.6. *R. apiculata*, *R. mucronata*, *A. marina*, *A. officinalis* and *Sonneratia alba*. The latter was the dominant species. The tree density recorded was 162 stem/hectare with an average girth of 21.96 cm. The average tree height was 9.65 m., 1.33 m. in first branch height and 8.33 m. canopy height. The width of root was 78.94 m. and the basal root area was 9,064.49 cm^2. The low density of seedlings and saplings were recorded at 8 and 38 stem/hectare respectively.

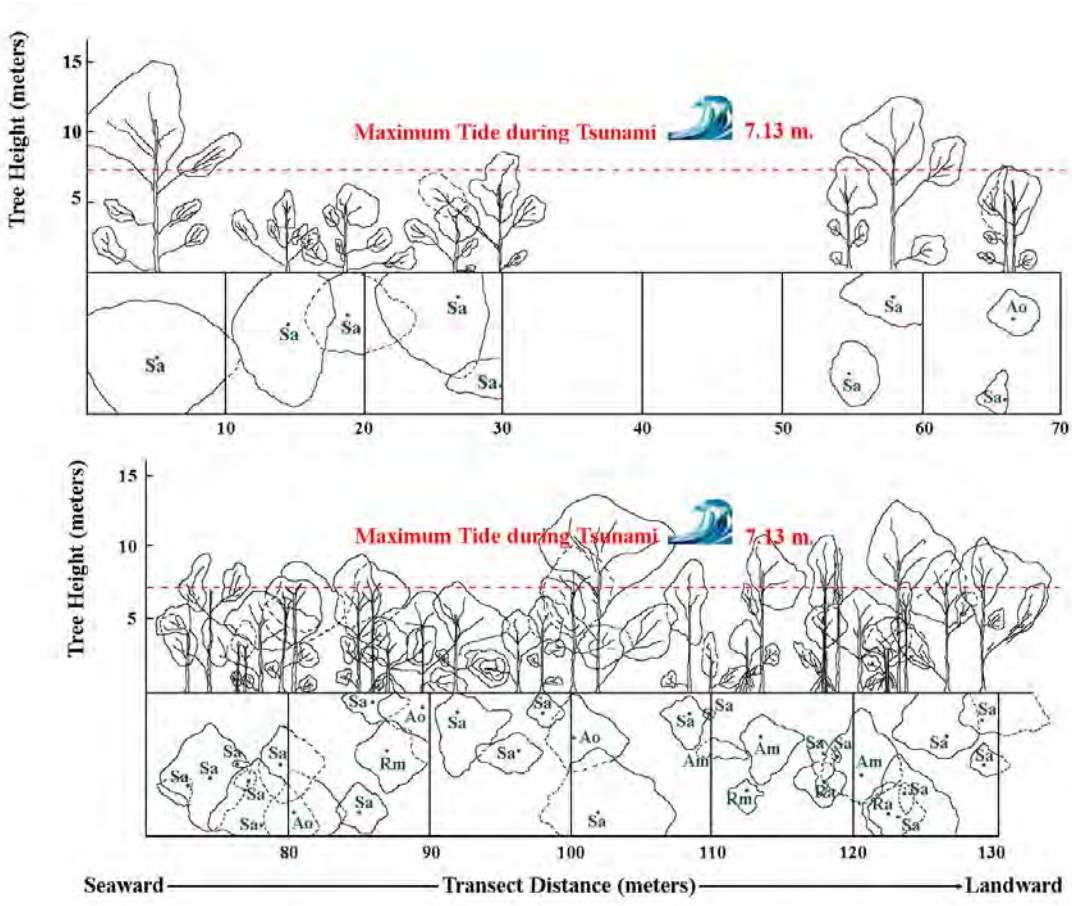


Figure 3.6 Forest structure in the low density *Avicennia* forest at Bang Rong, Phuket Province during the post-tsunami in October, 2005.

2. Forest structure in the dense *Avicennia* forest (TBR-A2)

Most of the seaward area of Bang Rong estuary was lined with dense *Avicennia* forest. *A. alba* was the dominant species in this forest which was 220 meters long as shown in Figure 3.7. Two other dominant species were *R. mucronata* and *S. alba*. The tree density was 300 stem/hectare with an average girth of 25.34 cm. The average tree height was 11.23 m., 1.73 m. first branch height and 9.50 m. canopy height. The width of the root system was 5.38 m. with the basal area of 8,010.29 cm^2. The seedlings were recorded at 40 stem/hectare. No sapling was found.

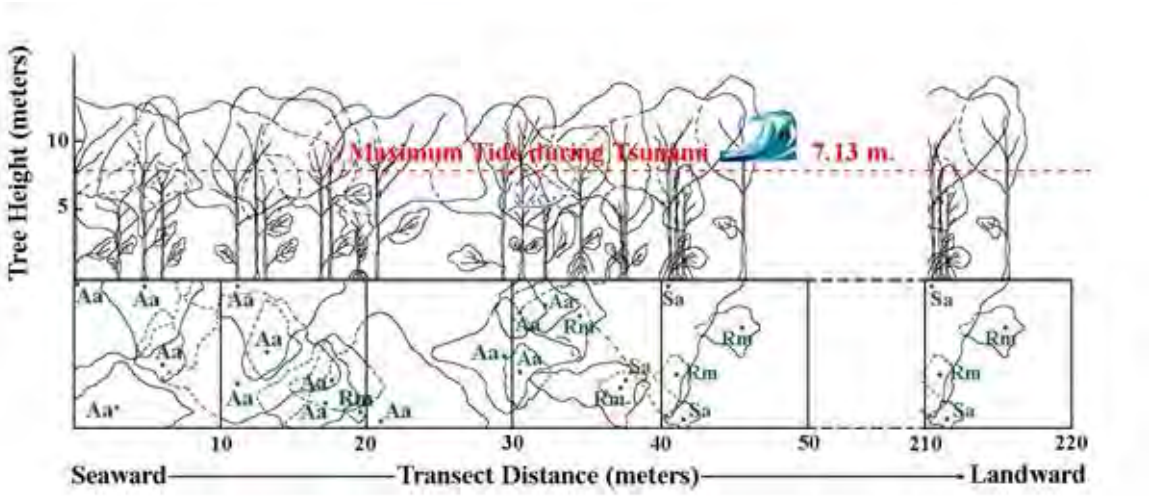


Figure 3.7 Forest structure in the dene *Avicennia* forest at Bang Rong, Phuket Province during the post-tsunami in October, 2005.

3. Forest structure in the low density *Rhizophora* forest (TBR-R1)

Figure 3.8 showed the forest structure in the low density *Rhizophora* forest in this 190 meters transect. The tree density was 1,533 stem/hectare with an average girth of 10.22 cm. This was healthy *Rhizophora* forest. *R. mucronata* was the dominant species. Other common species were *R. apiculata*. The average tree height was 10.31 m., 4.62 m. first branch height and 5.73 m. canopy height. The root system measurement was 1.55 m. root collar height, 2.70 m. root width and the basal root area 4,131.46 cm^2. The seedling density was quite high at 767 stem/hectare. The saplings counted were 33 stem/hectare.

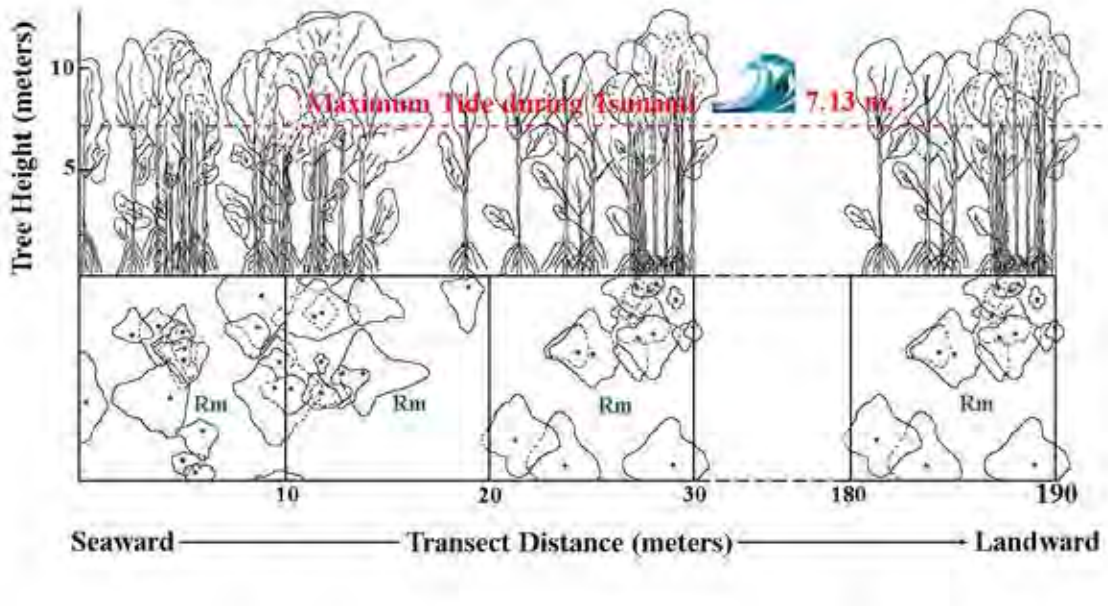


Figure 3.8 Forest structure in the low density *Rhizophora* forest at Bang Rong, Phuket Province during the post-tsunami in October, 2005.

4. Forest structure in the dense *Rhizophora* forest (TBR-R2)

This healthy and extremely dense *Rhizophora* forest was located across from the pier. *R. apiculata* was the dominant species in the 830 meters transect as shown in Figure 3.9. The tree density was 2,350 stem/hectare with an average girth of 11.62 cm. Other mangrove species were *C. tagal, X. granatum* and *X. moluccensis.* The average height of the root collar was measured at 0.99 m., 2.82 m root width and the basal root in this area standing at 1,125 stem/hectare. The saplings were 50 stem/hectare.

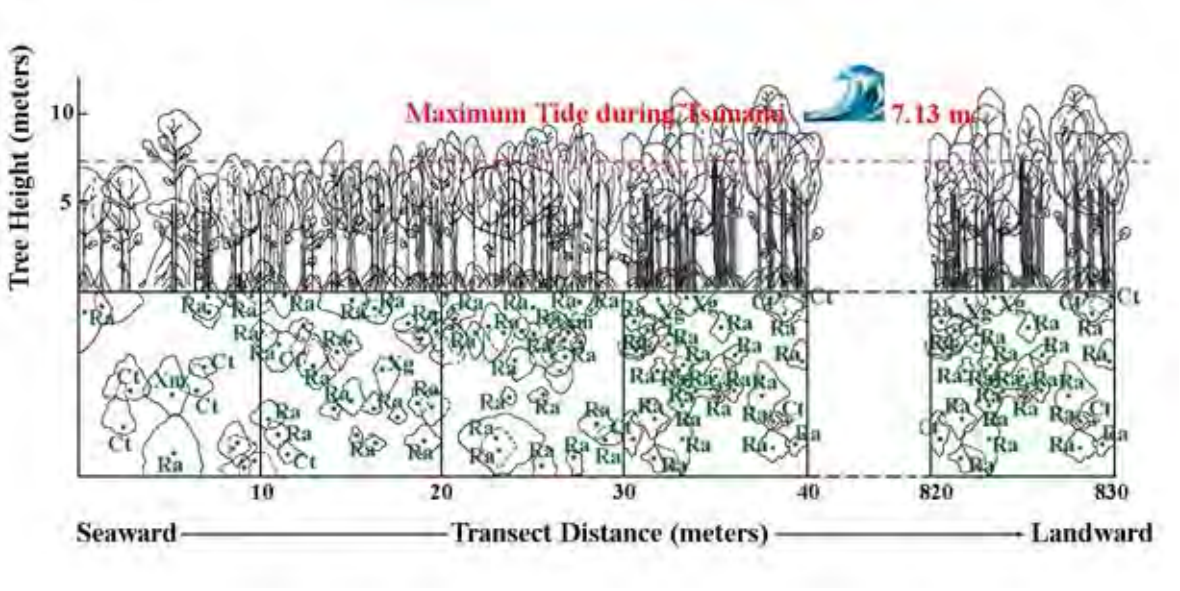


Figure 3.9 Forest structure in the dense *Rhizophora* forest at Bang Rong, Phuket Province during the post-tsunami in October, 2005.

5. Forest structure in the *Rhizophora* forest in the vicinity of cage culture (TBR-PO)

Six mangrove species were recorded in the *Rhizophora* mangrove of 360 meters transect in the vicinity of the cage culture area in Khlong Bang Rong as shown in Figure 3.10 *R. mucronata, R. apiculata, C. Tagal, A. officinalis, X. moluccensis* and *X. granatum* were common. *C. tagal* was the dominant species. The tree density recorded was 1,000 stem/hectare with an average girth of 6.02 cm. The average tree height was measured at 8.13 m., 2.98 m. first branch height and 5.15 m. canopy height. The root system measurement were 8.13 m. in terms of root width and the basal root area of 794.44 cm^2. High density of seedlings and saplings was recorded at 5,500 and 1,600 stem/hectare respectively.

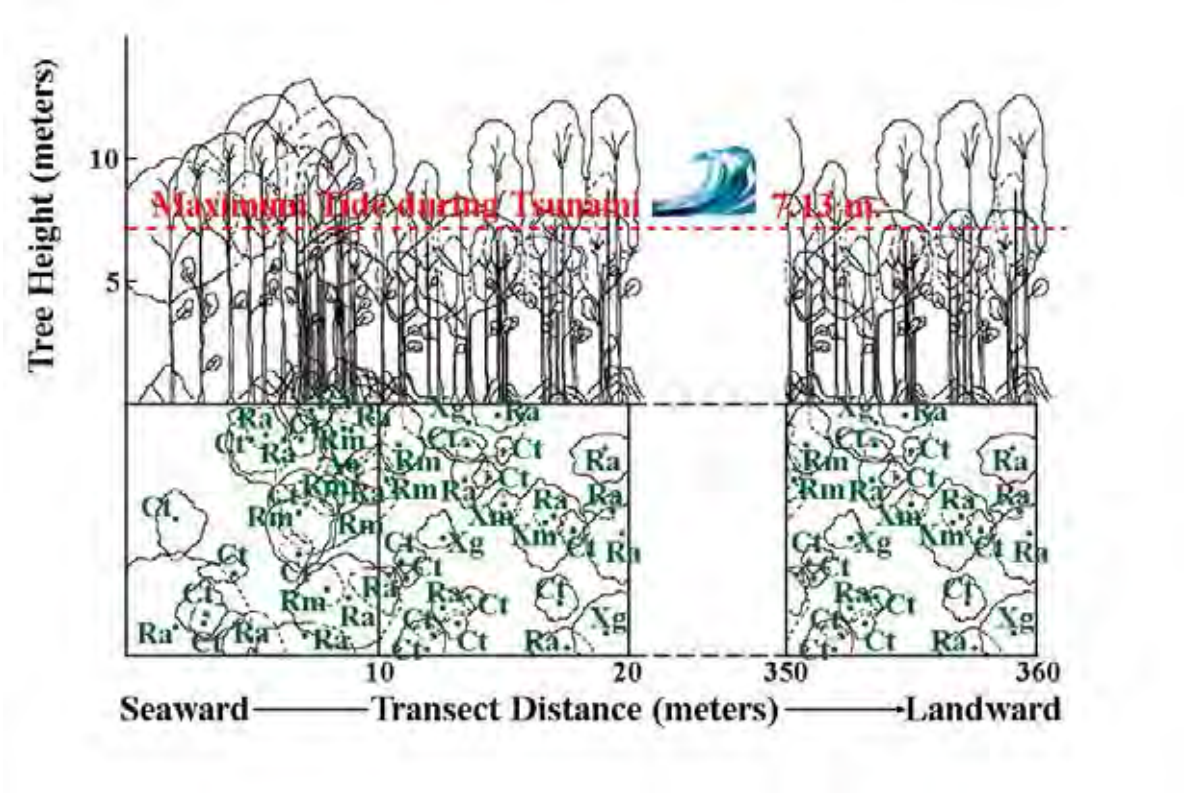


Figure 3.10 Forest structure in the *Rhizophora* forest in the vicinity of cage culture at Bang Rong, Phuket Province during the post-tsunami in October, 2005.

6. Forest structure in the community forest (TBR-C)

Figure 3.11 showed the structure of community-managed forest in front of the village. The total length of transect was 360 meters. Seven mangrove species were recorded, namely, *R. apiculata, E. agallocha, Lumnitzera racemosa, A. officinalis, X. moluccensis, X. granatum* and *C. tagal.* Mud lobster mounds were scattered in the area. *R. apiculata* was the dominant species. The tree density was 1,000 stem/hectare with an average girth of 9.84 cm. The average tree height was measured at 11.21 m., 4.83 m. first branch height and 6.41 m. canopy height. The root system measurement was 1.40 m. in root collar height, 2.77 m. in width and the basal area of 2,375.38 cm^2. The seedling density was 867 stem/hectare while the saplings was 167 stem/hectare.

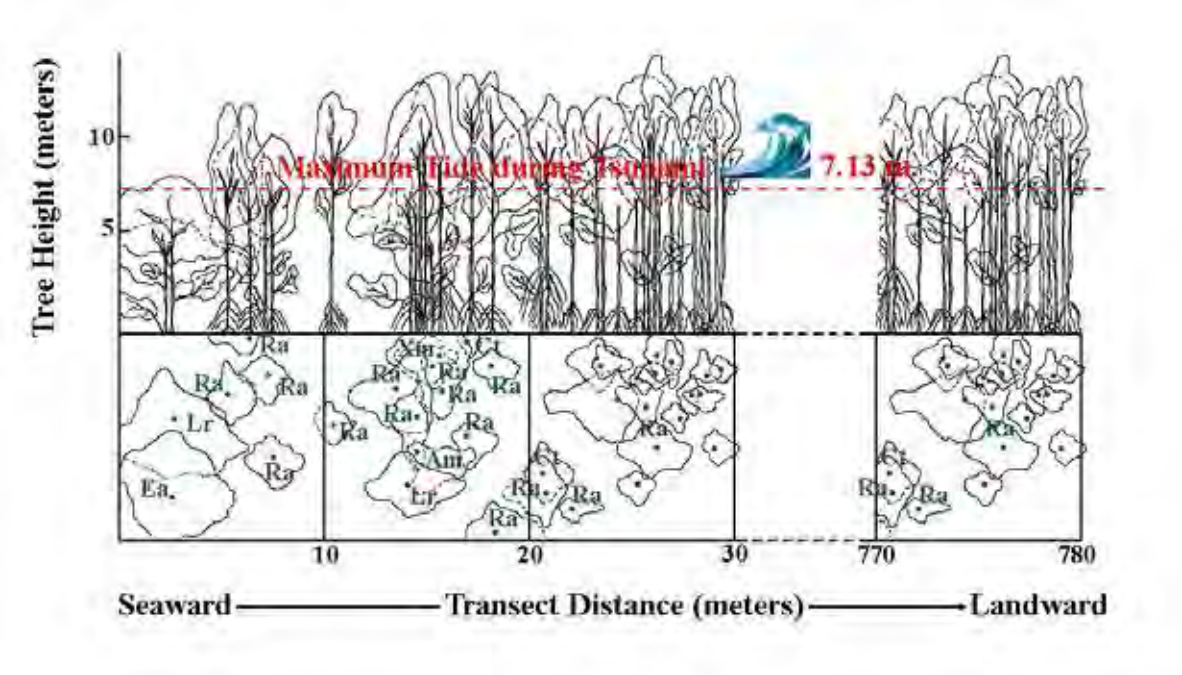


Figure 3.11 Forest structure in a community forest at Bang Rong, Phuket Province during the post-tsunami in October, 2005.

In conclusion, Bang Rong mangrove forest is more productive and healthier than Ban Nam Khem forest. In terms of tree density, Bang Rong mangroves are comparable to the intact forests in Ranong, Phang-nga and Nakhon Si Thammarat province. Ban Nam Khem forest is in the regenerating to degraded mangrove forests in some area. As the tsunami aftermath, the natural regeneration process was proceeding as evidenced from high seedlings and saplings in both areas.

Table 3.2 Tree Density in the mangrove forest at Ban Nam Khem, Phang-Nga Province during the post-tsunami in October 2005

Scientific name	Density (stem/hectare)														
	TNK-A1			TNK-A2			TNK-R1			TNK-R2			TNK-M		
	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant
Family Rhizophoraceae															
Rhizophora mucronata (โกงกางใบใหญ่)									50			250			
Rhizophora apiculata (โกงกางใบเล็ก)			233			20			50			950	700		1,250	425		782
Bruguiera cylindrica (ถั่วขาว)				280			50					200			
Bruguiera gymnorrhiza (พังกาหัวสุมดอกแดง)									50						
Ceriops tagal (โปรงแดง)							50			200		350	75	25	225
Family Verbenaceae															
Avicennia alba (แสมขาว)						140			50	100	50		25	18	129
Avicennia officinalis (แสมดำ)						20			100			100			
Avicennia marina (แสมทะเล)			100	260	200										
Clerodendrum inerme (สำมะง่า)				220											
Family Sonneratiaceae															
Sonneratia alba (ลำพูทะเล)									50						4
Family Meliaceae															
Xylocarpus granatum (ตะบูนขาว)				60			300			300			75		125

Table 3.2 (cont.)

Scientific name	Density (stem/hectare)														
	TNK-A1			TNK-A2			TNK-R1			TNK-R2			TNK-M		
	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant
Xylocarpus moluccensis (ตะบูนดำ)															50
Family Ebenaceae															
Excoecaria agallocha (ตาตุ่มทะเล)				460	40	360									
Family Acanthaceae															
Acanthaus ilicifolius (เหงือกปลาหมอดอกม่วง)					80						100				
Family Sterculiaceae															
Heritiera littoralis (หงอนไก่ทะเล)				40											
Family Leguminosae															
Derris trifoliata (ถอบแถบน้ำ)					160										
Family Casuarinaceae															
Casuarina equisetifalia (สนทะเล)						20									

Table 3.3 Tree structure in the mangrove forest at Ban Nam Khem, Phang-Nga Province during the post-tsunami in October 2005

***Avicennia* forest**

Scientific name	TNK-A1					TNK-A2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora apiculata	7.78	3.64	4.14	1.66	1.67					
Avicennia alba						5.57	1.39	4.16		0.35
Avicennia officinalis						5.5	0.8	4.7		0.50
Avicennia marina	9.17	3.16	6		5.63					0.27
Excoecaria agallocha						5.25	1.68	3.56		
Casuarina equisetifalia						18	2	16		0.80

***Rhizophora* forest**

Scientific name	TNK-R1					TNK-R2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata	7.5	5	2.5		0.60	6.06	2.24	3.82	0.61	7.55
Rhizophora apiculata	9.39	3.18	6.15	1.34	0.98	6.68	2.52	4.12	1.15	1.09
Bruguiera cylindrica						6.25	3.5	3.85		0.26
Bruguiera gymnorrhiza	9	3.5			1.50					
Ceriops tagal						5.3	1.47	3.83		0.41
Avicennia alba	12	1.5			4.50					
Avicennia officinalis	11	2	12.5		5.43	5.75	2	3.75		4.60
Sonneratia alba	3.5	1.01	2.49		1.00					

Table 3.3 (cont.)

New mudflat forest

Scientific name	TNK-M				
	Average height	**Average height of first branch**	**Canopy height**	**Root collar**	**Root system diameter**
	(m.)	**(m.)**	**(m.)**	**(m.)**	**(m.)**
Rhizophora apiculata	8.765	2.84	5.9	1.54	1.89
Ceriops tagal	6.71	2.13	4.59		0.53
Avicennia alba	7.41	2.1	5.3		4.42
Xylocarpus granatum	6.88	1.13	5.75		0.77
Xylocarpus moluccensis	6.12	2.72	3.41		3.39

Table 3.5 Trees Density in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

Scientific name	Density (stem/hectare)																	
	TBR-A1			TBR-A2			TBR-R1			TBR-R2			TBR-C			TBR-PO		
	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant	Seedling	Sapling	Plant
Family Rhizophoraceae																		
Rhizophora mucronata (โกงกางใบใหญ่)			11	40		80	8		8	1,500	67	1,567				433	269	231
Rhizophora apiculata (โกงกางใบเล็ก)								8	15				67		967	33	233	600
Bruguiera cylindrica (ถั่วขาว)													100			100		
Ceriops tagal (โปรงแดง)													567	131	69	2,267	933	633
Family Verbenaceae																		
Avicennia alba (แสมขาว)		11	178			300		31	25						33	67		
Avicennia officinalis (แสมดำ)			8															33
Family Ebenaceae																		
Excoecaria agallocha (ตาตุ่มทะเล)															33			
Family Sonneratiaceae																		
Sonneratia alba (ลำพูทะเล)			33			60			162									
Family Meliaceae																		
Xylocarpus granatum (ตะบูนขาว)													100	33	33	1,233		33
Xylocarpus moluccensis (ตะบูนดำ)															33	33		67
Family Combretaceae																		
Lumnitzera racemosa (ฝาดดอกขาว)															33			
Family Sterculiaceae																		
Heritiera littoralis (หงอนไก่ทะเล)													33					

Table 3.6 Tree structure in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

***Avicennia* forest**

Scientific name	TBR-A1					TBR-A2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata	5.00	1.10	4.90	1.03	1.22	7.38	1.38	6.03	1.46	
Avicennia alba						11.23	1.73			
Avicennia officinalis	8.00	1.42	6.12		5.24					
Sonneratia alba	9.62	2.00	7.34		5.70	11.00	5.30			

***Rhizophora* forest**

Scientific name	TBR-R1					TBR-R2				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata	5.00	1.50	3.50	0.85	1.90	10.31	4.62	5.73	1.55	2.85
Sonneratia alba	7.88	0.59	7.13		4.79					

Table 3.6 (cont.)

Community forest and mangrove forest in the vicinity of cage culture

Scientific name	TBR-C					TBR-PO				
	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)	Average height (m.)	Average height of first branch (m.)	Canopy height (m.)	Root collar (m.)	Root system diameter (m.)
Rhizophora mucronata						9.00	5.00	4.00	1.00	1.00
Rhizophora apiculata	11.21	4.83	6.41	1.40	1.39	10.58	3.89	6.53	1.15	1.18
Ceriops tagal	10.00	1.00	9.00		4.00	8.13	2.98	5.14		47.95
Avicennia alba	8.50	5.50	3.00		3.32					
Avicennia officinalis						11.00	6.50	4.50		5.10
Excoecaria agallocha	7.50	1.60	5.10		7.10					
Xylocarpus granatum	8.00	1.44	6.66		0.23	6.50	3.50	4.00		0.38
Xylocarpus moluccensis	7.00	1.49	5.51		0.20	6.25	3.00	3.75		22.50
Lumnitzera racemosa	5.50	1.00	5.40		2.40					

Degree of damages from tsunami on mangrove structure

The mangrove ecosystem of Ban Nam Khem, Phang-nga Province suffered the direct impacts from tsunami despite the protection of Ko Khao Island. While Bang Rong mangrove was slightly affected from the rapid increase of water level. As pointed out in the ecological risk assessment, the ability of mangrove forest structure to withstand the impacts of tsunami is based on the position of forest (facing directly or indirectly to tsunami wave), selected mangrove species, the width of the forest , the tree density, the root system and the tree canopy characteristics. Our findings at both forest corresponded to Kathiresan and Rajendran (2005) findings that *Rhizophora* species have higher ability to withstand the impacts from tsunami than *Avicennia* species. According to our field survey on forest structure (Figure 3.6-3.11), Bang Rong forest was left intact and unaffected by tsunami. Only the *Rhizophora* forest in the vicinity of cage cultures, fish cages were affected by the rapid increase of tidal waves. During the high tidal flood, the sediment brought by the tidal waves was accumulated in the cages. When the tides rapidly receded, the debris and sediment from land were washed into the cages again. This resulted in fish kills of more than 30 cages.

In contrast to Ban Nam Khem, Phang-nga Province, being the fringe mangrove forest facing the open sea it was directly exposed to the action of the tidal waves. Degree of impacts differed between the two mangrove forests. Total clearance of the *Avicennia* forest within 10-40 meters seaward was observed. No destruction was observed both in the low density and dense *Rhizophora* forest. As revealed from our field survey on forest structure in Ban Nam Khem (Figure 3.1-3.5), the estimated damages in different mangrove species according to the number of stumps standing along the transect are summarized in the Table 3.7.

Table 3.7 Estimation of damages in different mangrove species in Ban Nam Khem mangrove forest, Phang-nga Province

Site	**Estimation damages in percentage**			
	Avicennia	***Rhizophora***	***Sonneratia***	***Ceriops***
Tidal mudflat	82	6.0	83.0	2.7
Low density *Avicennia*	71.8	-	-	-
Dense *Avicennia*	100 (in the 100 m. mangrove fringe)			
Dense *Rhizophora*	-	3.22	100	-

Three damage patterns exist in the study area.

1. Windthrow with uplifted or uprooted trees laying in the area. If the uplifted trees or fallen trees were washed away, deep holes resembled the depth and width of the root structure emerged.

2. Bole damages or broken stem with remaining stumps in the area. These trees were severely fractured due to the twisting forces of the tidal waves. Debris from land, such as fishing boats, house poles and furniture also broke the trees in pieces.

3. Death. The tree remained standing. The root systems of the dead trees were severely impacted from the tidal waves. The roots were probably torned or rocked until they were unable to attach to the soil. The root function was disrupted until the tree gradually died off.

The damage pattern was similar to the wind damage inflicted on mangrove forest by cyclones (Saenger, 1982). Windthrow was the severest form of damage. Mangrove species with weakly developed cable roots system is susceptible to windthrow. It can also be found in the case that the root system is weakened through erosion or bank-slumping. For most species, windthrow results in death.

Bole damage or broken stem susceptibility based on wood structure varied considerably between genera. In *Avicennia,* irregular wood structure with its non-concentric, non-annual growth rings of alternating band of xylem and phloem give for its weight. It is difficult to spilt radially. However, it is easy to do so tangentially. Thus numerous *Avicennia* stumps were observed during the field survey. The twisting forces of tsunami waves caused these bole damage. *Rhizophora,* on the other hand according to Saenger (1982), the wood is extremely strong as in *Henritiera, Brugueira* and *Lumnitera.* Abundant sclerids occur in non-functional phloem tissue, while stone cells and fibres occur throughout the stem.

Mangrove dense root system served two purposes as efficient soil binder and wave reduction. The root system of *Avicennia* spp. developed radial network of vertical pneumatophores which were related to pattern of mud and organic litters accretion. The root system helped to localize trapping and fixing sediment that would otherwise have remained mobile as in the tidal mud flat. *Rhizophora* coped with sediment accumulation by forming extra arches of still roots. The different root system in *Bruguiera* and *Ceriops* as knee-roots, the upward secondary thickening of the roots in *Xylocarpus* and buttress roots in *Henritiera* helped lessen the damages from tsunami.

Wolanski *et al*. (1992) concluded that high vegetation density in the mangrove forest to high friction which retarded the flow resulting in trapping in the mangroves. Muddy bottom together with intertwining roots created the strong bottom friction which, in turn, retarded the flow. Mazda *et al*. (1997) concluded from their study on mangroves as a coastal protection from waves that the wave reduction resulted from the integrated energy loss through the whole width of the vegetated area. The vegetation density and the width of the area important factors for protecting the coast from wave erosion. From their study model, they were able to show that wave reduction due to mangrove vegetation was by mainly drag forces for the water flowing between trees occur throughout the whole water depth and drag forces through the root system and pneumatophores. In a well grown mangrove with high density of vegetation, the effect of wave reduction does not decrease with increasing water depth. In an area with little vegetation, the wave energy loss is caused by bottom friction only. The first case is exemplified by Bang Rong mangrove forest with healthy grown forests and high density of vegetation in particular *Rhizophora.* The average tree height was higher than the maximum tide during tsunami. The dense intact forests provided several defense lines reducing the wave energy. The latter case can be found in the damage occurring in Ban Nam Khem tidal flat. Species of mangrove trees, distances between tree, water depth and wave height and period all contributed to the ability of mangrove forests to lessen the damage from tsunami.

Environmental impacts in mangrove ecosystem

Physical alterations in mangrove ecosystem resulting from tsunami, other than the impact on forest structure, were changes in water and sediment quality. In Ban Nam Khem as evidenced from the reports by our forest officers and from our post-tsunami survey, increase sedimentation and soil erosion occurred in certain area. Soil erosion accounted for more than 50% alteration from normal condition. Soil coloration and texture were changed due to furious waves. Increased channel depth due to erosion and increased turbidity were observed in Bang Rong estuary. However, soil erosion and increased sedimentation were less than 25% alteration. Slight changes in sediment coloration and odours were noticed.

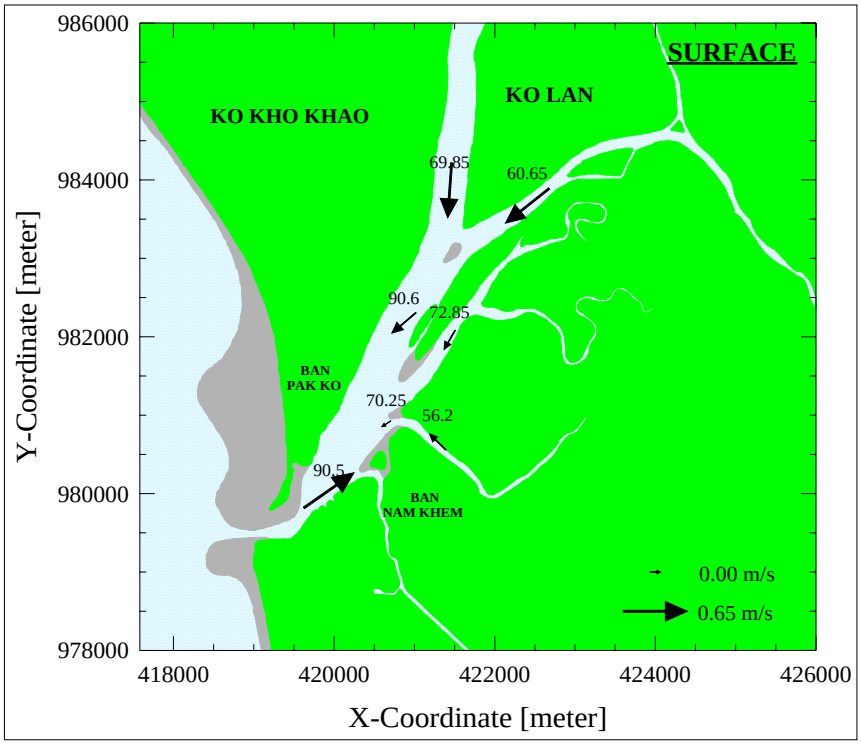
Water Circulation

Current velocities obtained from field measurement at Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province are plotted together with total suspended solid shown in Figure 3.12 and Figure 3.13. At Ban Nam Khem, the current velocities were observed during the ebb tide except at station TNK-P7 where water was rising. It is clearly seen that, during ebb tide, water flows out Pak Ko Cannel at the mouth, while during flood tide it flows in different direction. The maximum current speed was 0.62 m/s at surface and 0.43 m/s at bottom while minimum was nearly zero both surface and bottom. At station TNK-P7, which situated closed to the entrance to the coastal sea, different direction of current velocity occurred where water flowed in at surface while the bottom water flowed in different direction. It can be noted that a current velocity at surface is higher than at bottom.

At Bang Rong, Phuket Province, the current meter was deployed to measure the current velocities during the increasing water level. It was the time that water changed from rising to falling when the measurement took place at the innermost station, TBR-P1. Current velocities at surface and bottom were shown in different direction. As shown in Figure 3.13, it found that the maximum current speed was 0.27 m/s at surface and 0.21 m/s at bottom while the minimum was 0.02 m/s and 0.01 m/s at surface and bottom respectively.

From the above results, it could be concluded that the current velocities at Ban Nam Khem, Phang-nga Province was higher than those at Bang Rong. Due to the fact that the morphological feature of Ban Nam Khem is a channel, water can penetrate through in both directions northern and southern part of Ko Kho Khao Island. Therefore the volume transport at Ban Nam Khem is greater than at Bang Rong. Bang Rong is a small tidal creek, approximately 3 km long, and a volume of about 1.25×10^6 m^3 (Suraswadi and Kristensen, 2002) which is small compared to Ban Nam Khem that has a channel length of about 13 km.

Because both stations are under the influence of tides, the fluctuation of water level induced changes in physical and biological parameters. Moreover, water discharge and precipitation also affect DO and salinity. As observed by our field officers in the area, changes in waterways and channel fill up can be detected in the post-tsunami period in Ban Nam Khem. Seawater instrusion was also observed. In Bang Rong Forest, increased channel depth due to erosion was evidenced.



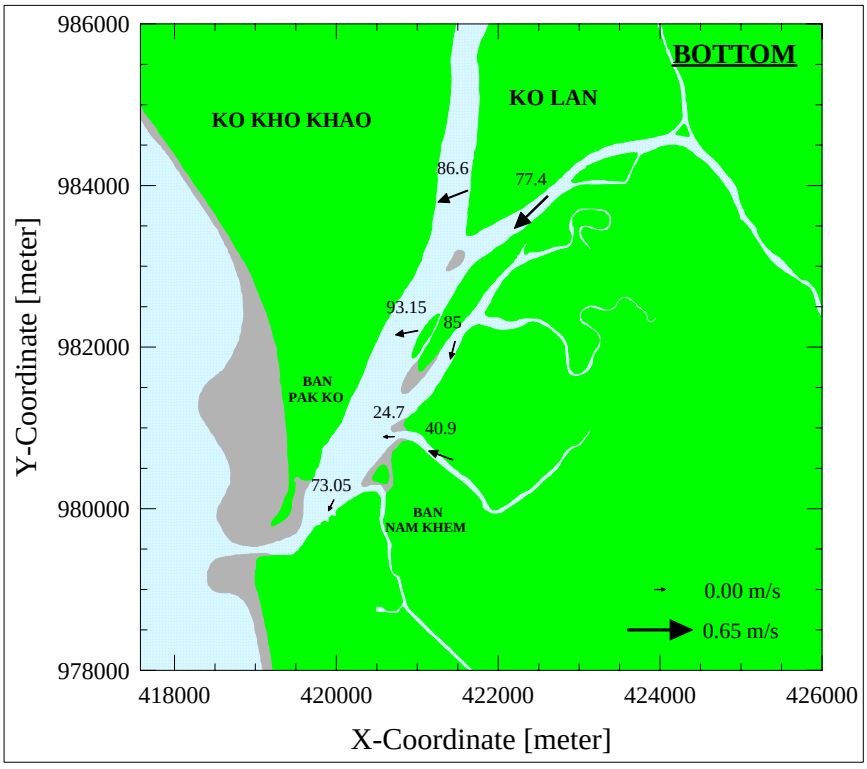
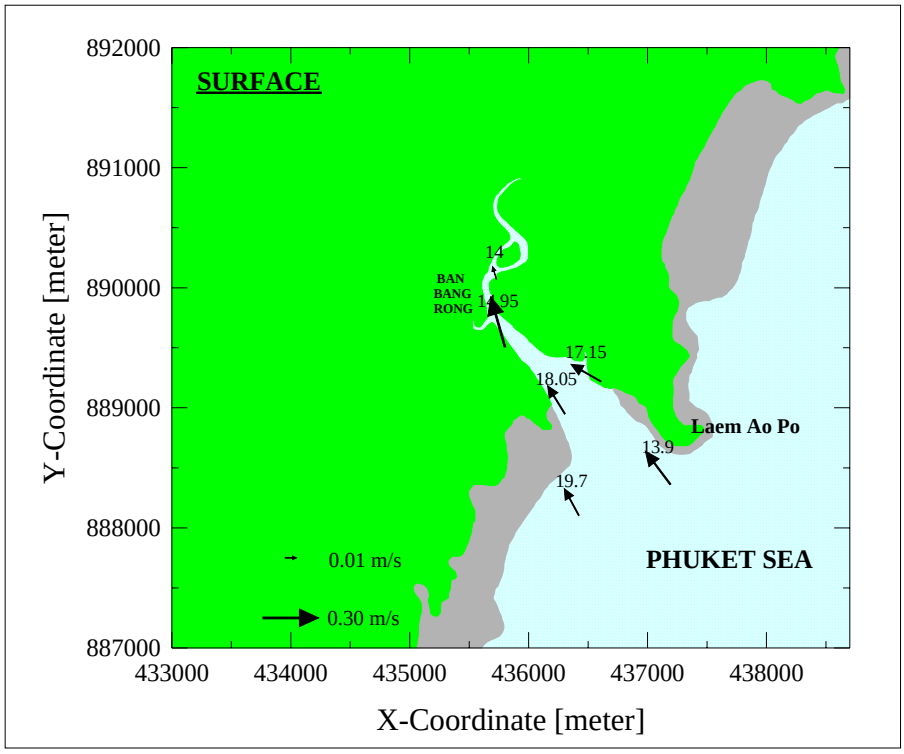


Figure 3.12 Current velocities at Ban Nam Khem, Phang-nga Province: (a) surface, (b) bottom



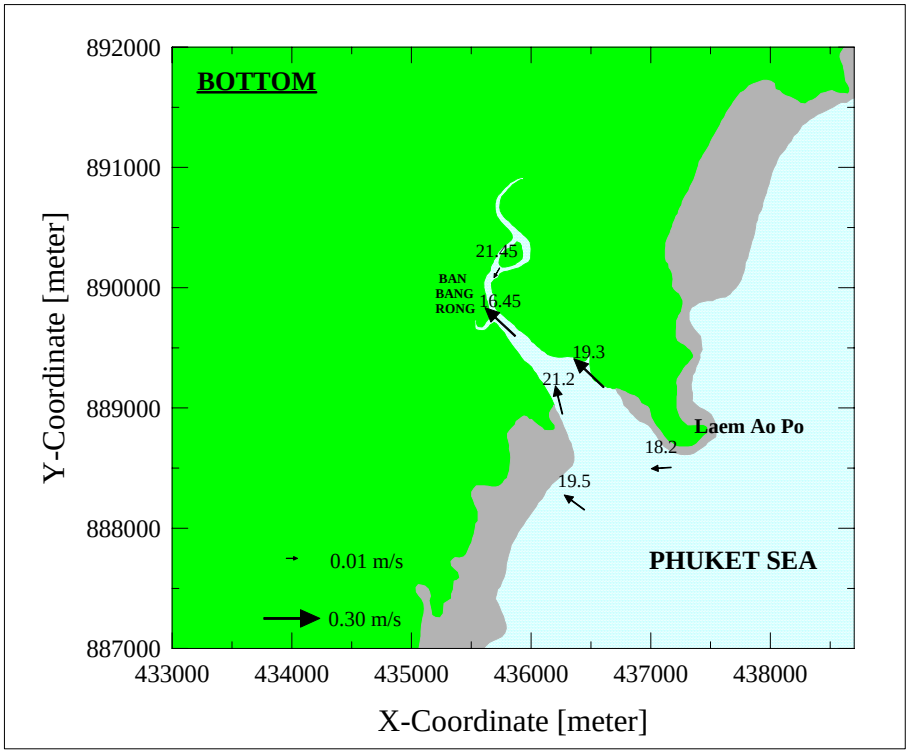


Figure 3.13 Current velocities at Bang Rong, Phuket Province: (a) surface, (b) bottom

Water quality

Water quality parameters were monitored in the coastal areas of Ban Nam Khem, Phang-nga province (419936-422406 N and 98042-983867 E) and Bang Rong, Phuket province. Both areas are under the moonsoonal influence. Rainy season (with an average rainfall >200 mm), due to the southwest monsoon, starts from May to mid October while dry season, governed by northeast monsoon, covers the months of October to February. The inter-monsoon period of March and April is characterized by warmer air temperature and little rainfall (Figure 3.14). At Ban Nam Khem, physico-chemical parameters were obtained in situ from seven stations in October 2005. Khlong Pak Ko, the channel between mainland and Ko Kho Khao, connects to the open sea both at the north end and the south end at Ban Nam Khem. The channel is under the influence of the runoff from Khlong Takuapa as well as several smaller creeks, Khlong Nua Yai and Khlong Bang Po, located on the northeastern side. An average depth of the channel was 4.8 m with the deepest part of 8.0 m at the mouth of Ban Nam Khem and the shallowest place at the mouth of Khlong Takuapa. An average depth in the west side of the channel was 6.7 m, deeper than the east side where an average depth was 4.0 m along the coast.

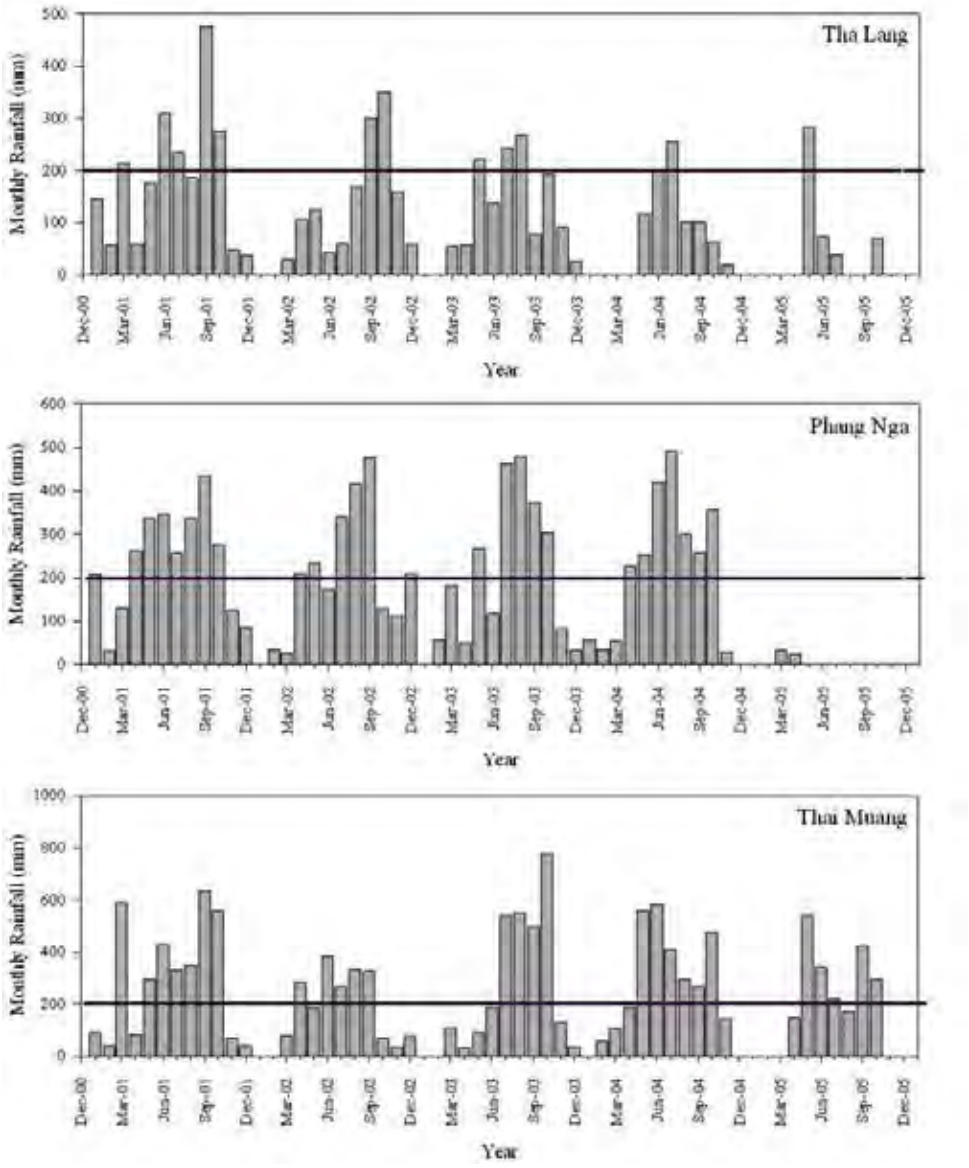


Figure 3.14 Monthly rainfall in the vicinity of Phang-nga province from December 2000-2005. (Source: Meteorological Department)

An average transparency as indicated by secchi depth was 1.2 m with a maximum transparency of 1.6 m at the seaward side in Ban Nam Khem while a minimum one at the mouth of Klong Takuapa (Figure 3.15 a).

An average depth in Khlong Bang Rong was 3.2 m with a maximum depth of 5.8 m was near the pier. The transparency of cf. was 1.0 m except at station TBR-P5 at the mouth of Khlong Bang Rong where due to clearer water than other stations. The transparency was 1.2 m (Figure 3.15 b)

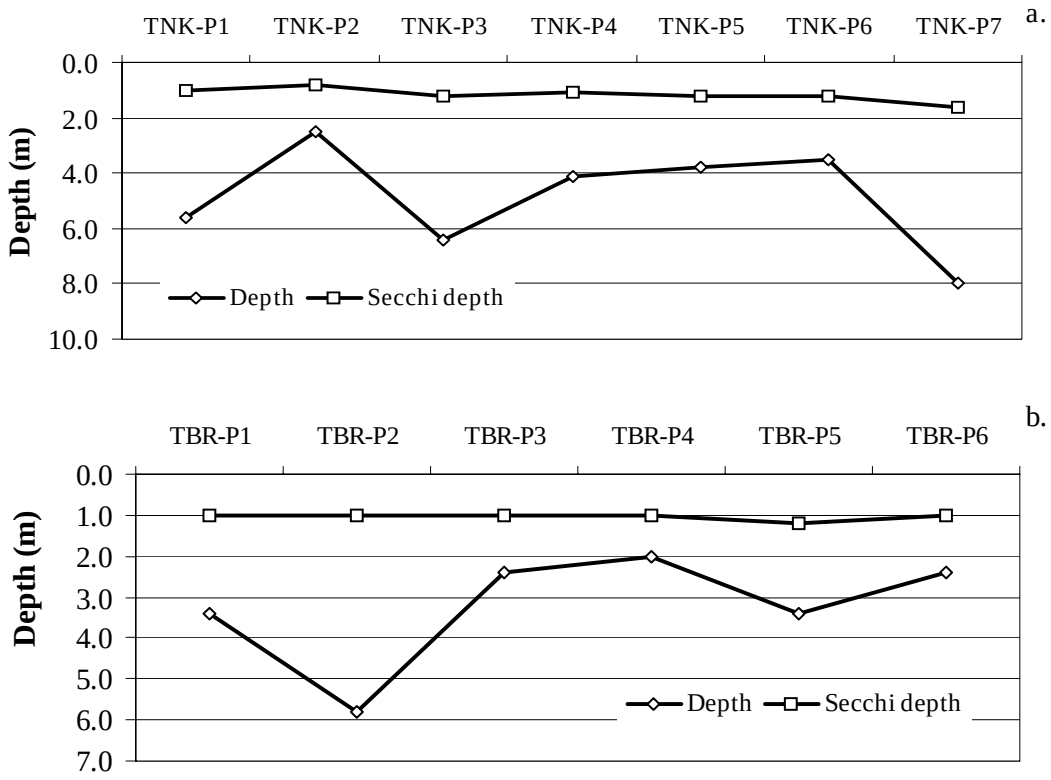


Figure 3.15 Depth and transparency of water in October 2005:
(a) Ban Nam Khem, Phang-nga Province (b) Bang Rong, Phuket Province

Water quality parameters, particularly the salinity of water in Khlong Pak Ko, Ban Nam Khem, 30.02±4.28 psu, indicated the influence of freshwater runoff from Khlong Takuapa in comparison to those of Bang Rong area, 33.07±0.10 psu (Figure 3.16). An average temperature in Ban Nam Khem of 29.46±0.05°C was lower than an average of 30.00±0.00°C in Bang Rong. Dissolved oxygen in both sites were in the ranges of 5.62±0.22 and 5.53±0.27 mg/l in Ban Nam Khem and Bang Rong, respectively (Figure 3.17). pH of water in Bang Nam Khem, 7.44±0.38 was higher than the value in Bang Rong, 7.09±0.52 (Figure 3.18). Water quality in the cage culture vicinity revealed that the value of dissolved oxygen was lowest but the pH value was higher than other stations. The water quality conditions of Phang-nga and Phuket coast in the post-tsunami as monitored by the Department of Marine and Coastal Resources (2005) were generally fair to good as corresponded to our findings.

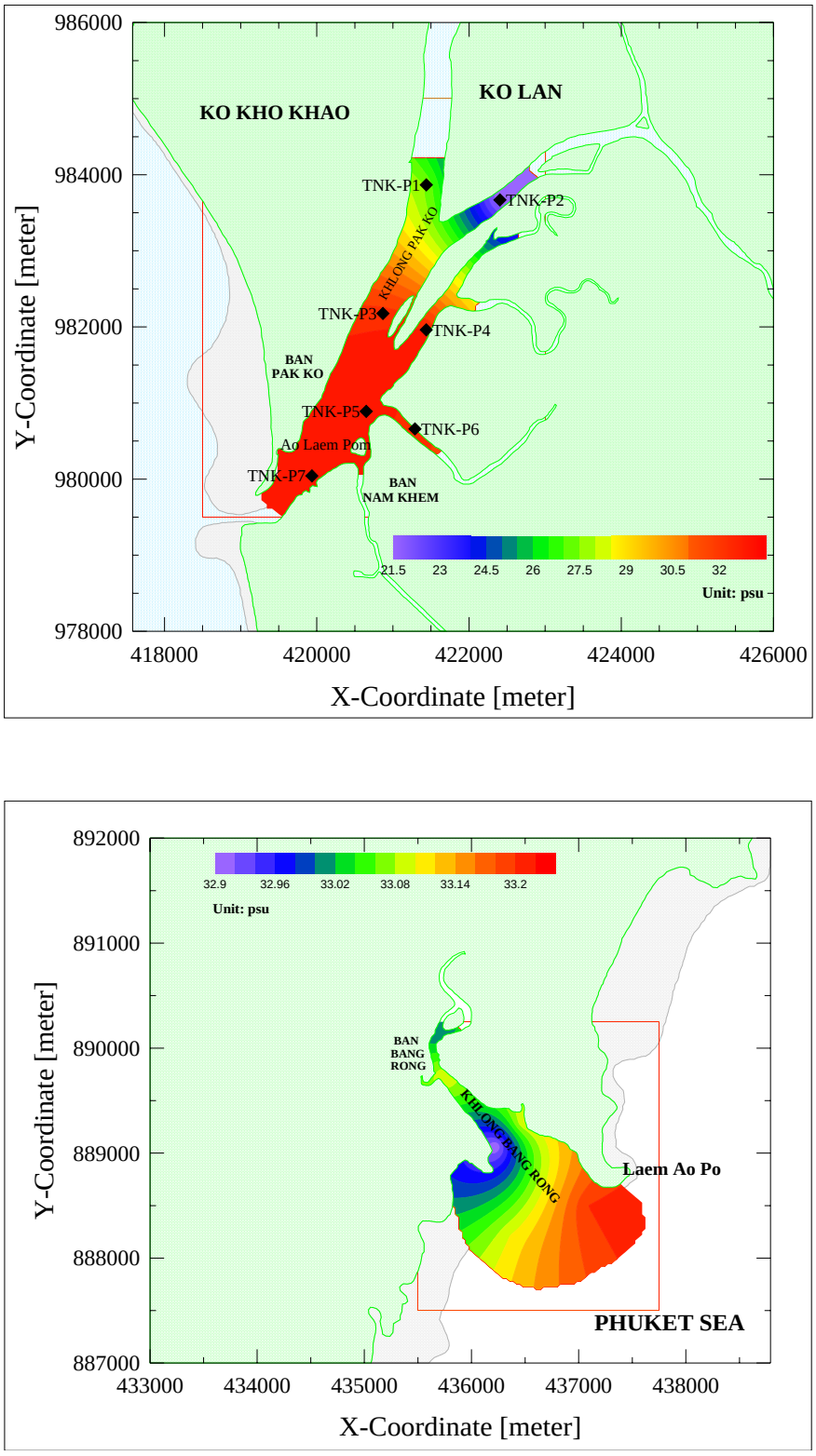
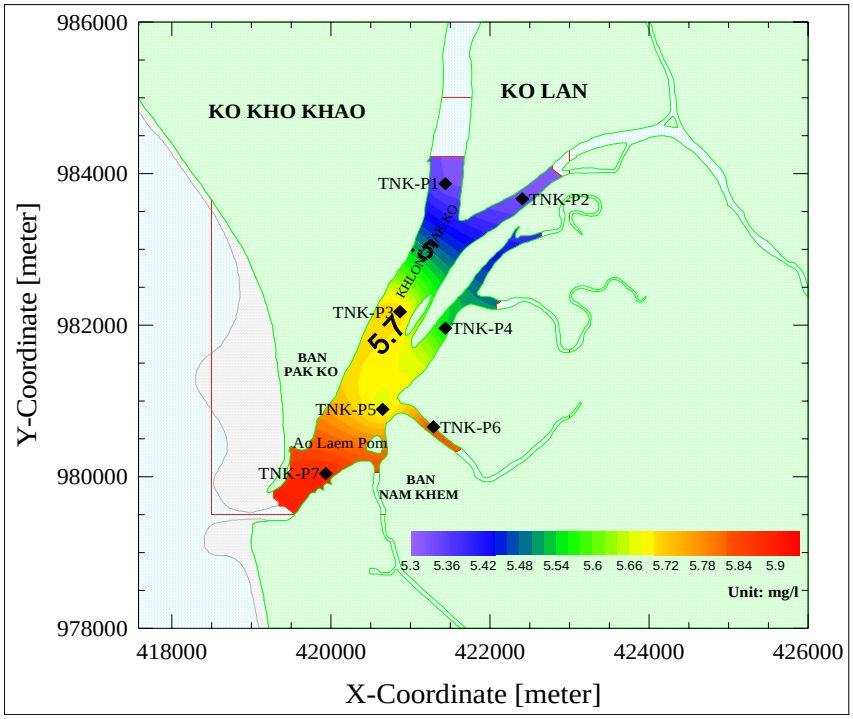


Figure 3.16 Variation in salinity of water in Ban Nam Khem and Bang Rong in October 2005. (a) Ban Nam Khem, Phang-nga Province (b) Bang Rong, Phuket Province



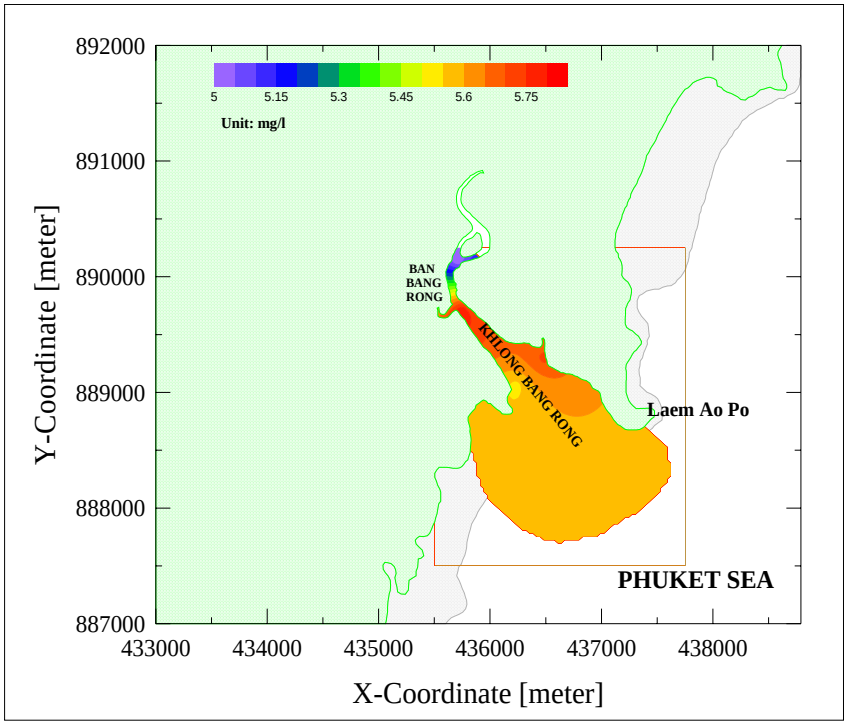
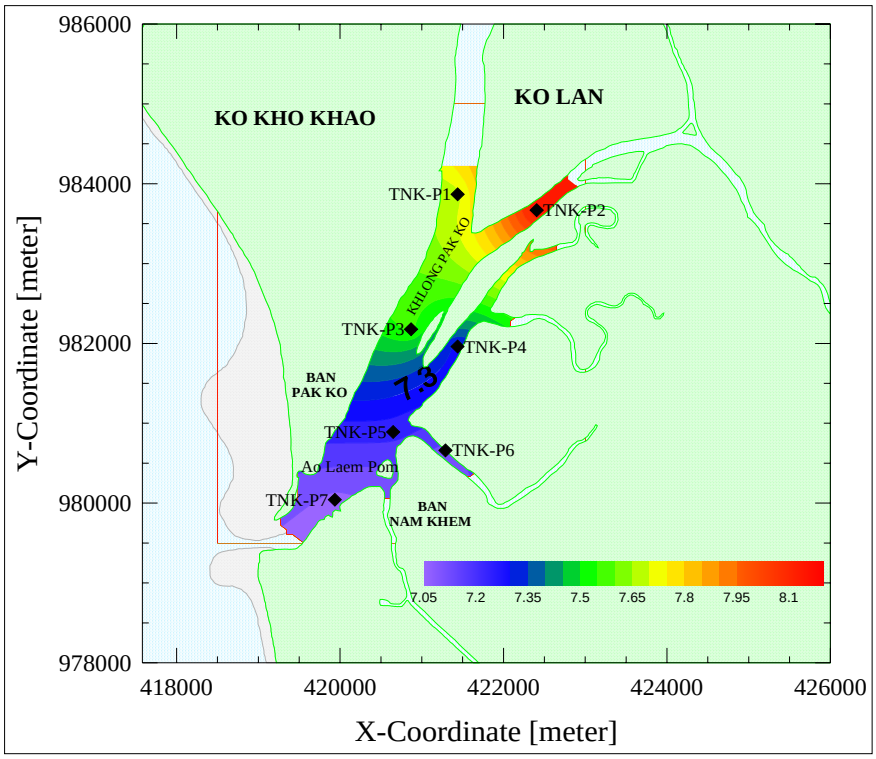


Figure 3.17 Variation in dissolved oxygen of water in Ban Nam Khem and Bang Rong in October 2005. (a) Ban Nam Khem, Phang-nga Province (b) Bang Rong, Phuket Province



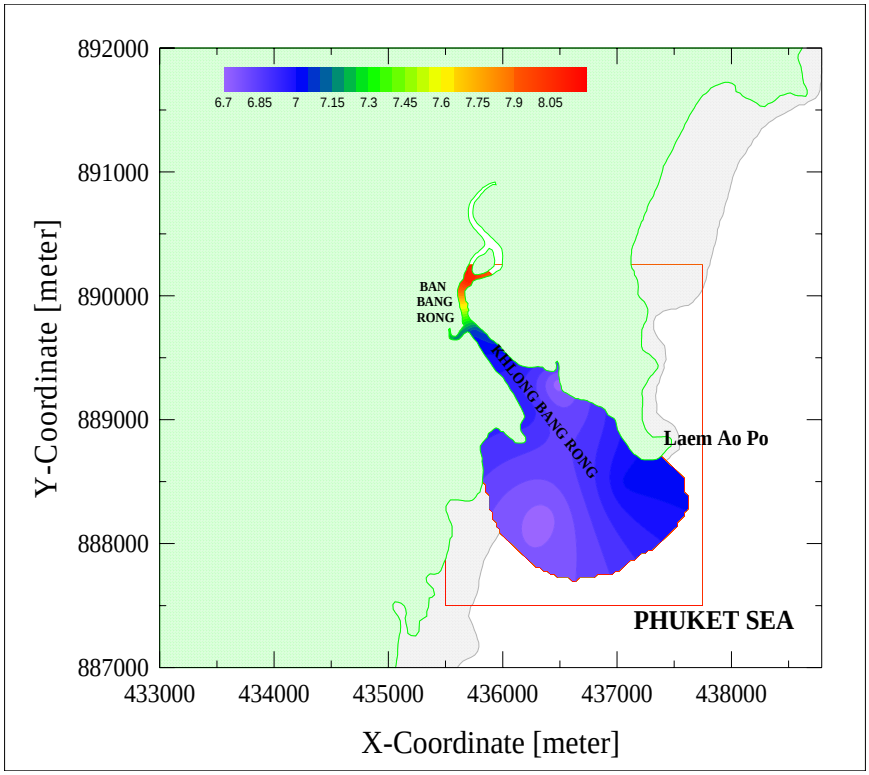


Figure 3.18 Variation in pH of water in Ban Nam Khem and Bang Rong in October 2005.
(a) Ban Nam Khem, Phang-nga Province (b) Bang Rong, Phuket Province

Dissolved inorganic nutrients

Since dissolved inorganic nutrients are necessary for the biosynthesis processes in phytoplankton, concentrations of these nutrients were determined from surface water and water above the bottom sediment in Khlong Pak Ko, Ban Nam Khem and Khlong Bang Rong, Bang Rong. The results showed the oligotrophic nature of both studied sites where the concentrations of nitrate, nitrite, and ammonia-nitrogen as well as phosphate usually fell below the detection limit of analytical methods used. The concentrations of nitrate-nitrogen, the major form of dissolved inorganic nitrogen, ranged from < 0.005 to 1.565 and 1.210 μg-at N/l in Ban Nam Khem and Bang Rong waters, respectively (Table 3.8). Concentrations of nitrite and ammonia-nitrogen were much lower than those of nitrate-nitrogen. Dissolved inorganic phosphorus measured in form of phosphate was also presented in low concentrations from < 0.030-0.186 μg-at P/l in Ban Nam Khem. Phosphate-phosphorus in Khlong Bang Rong was always below the detection limit of 0.030 μg-at P/l (Table 3.8). The molar ratios of dissolved inorganic nitrogen (nitrate + nitrite + ammonium) to phosphate-phosphorus, N:P ratio, were lower than the Redfield ratio of 16N:1P in most of the studied stations. This indicated that nitrogen may play an important role in limiting phytoplankton productivity in these areas. The higher N:P ratios were found only from stations TNK-P1 and TNK-P3 in Ban Nam Khem, Phang-nga Province as well as TBR-P1 in Bang Rong, Phuket Province. Concentrations of silicate were quite low in both studied sites with average concentrations of 15.244±14.753 μg-at/l in Ban Nam Khem. This high value of standard deviation indicated the patchyness of high silicate concentration water mass in Khlong Pak Ko, Ban Nam Khem. The average concentration in Bang Rong was 11.224±3.796 μg-at P/l.

Table 3.8 Concentrations of dissolved inorganic nutrients and chlorophyll *a* in Ban Nam Khem and Bang Rong in October 2005

Nutrients	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province
Nitrate (μg-at/l)	0.49±0.54	0.24±0.47
Nitrite (μg-at/l)	0.04±0.03	<0.01
Ammonium (μg-at/l)	0.14±0.12	<0.10
Phosphate (μg-at/l)	0.06±0.06	<0.03
Silicate (μg-at/l)	15.24±14.75	3.99±3.54

Suspended solid and Sediment quality

Like the current velocities, the suspended solids were analyzed both at surface and bottom. It was found that high suspended solid occurred at Ban Nam Khem with mean of 73.00 mg/l and 68.69 mg/l at surface and bottom respectively. However at Bang Rong, lower concentration of suspended solids were found to be 16.29 mg/l at surface and 19.25 mg/l at bottom. The maximum concentrations at Ban Nam Khem and Bang Rong were 93.15 mg/l and 21.41 mg/l respectively. It should be noted that even the value minimum of 24.70 mg/l concentration at Ban Nam Khem was still greater than the maximum value of Bang Rong.

The results of total suspended solid at both stations showed the suspended solid concentration was different from place to place (Figure 3.19). At Ban Nam Khem, it was about 4 times greater than at Bang Rong. The sources of suspended solid for both sites were different as well: mining activity at Ban Nam Khem and runoff, which appeared during wet season, at Bang Rong.

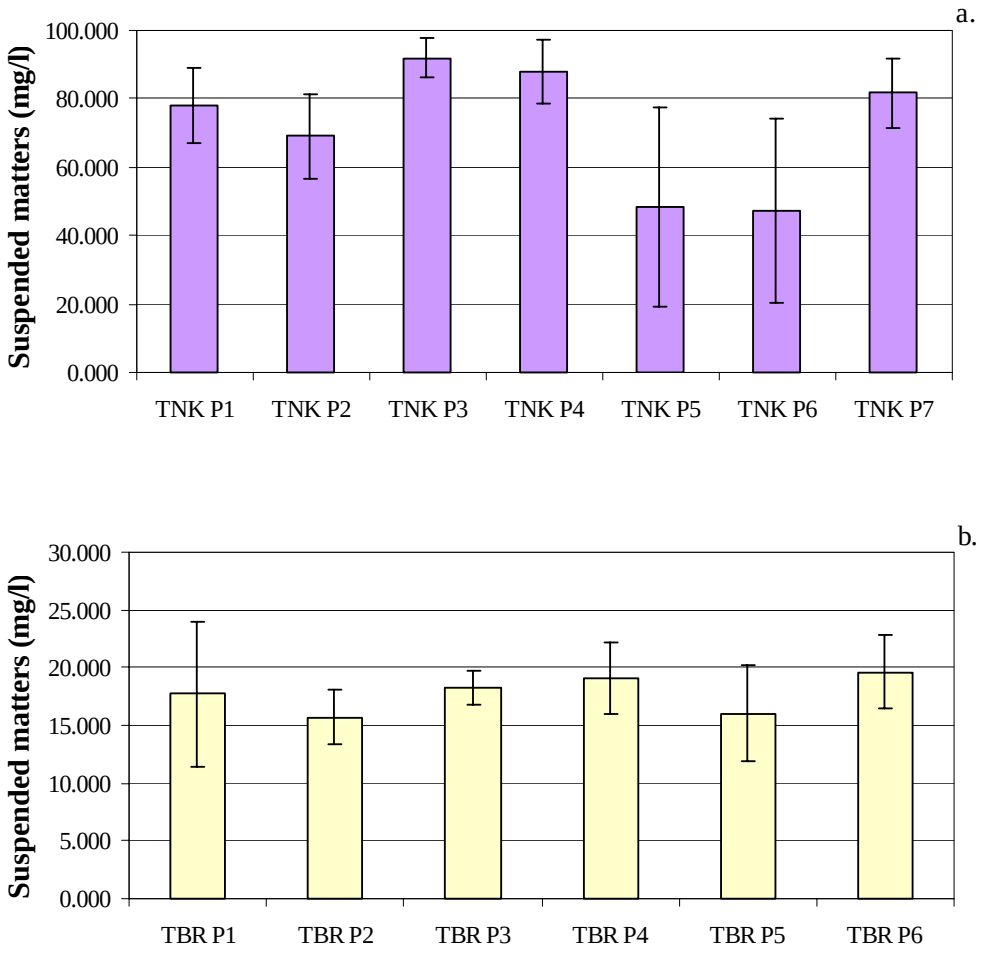


Figure 3.19 Concentrations of suspended solid in Ban Nam Khem and Bang Rong in October 2005. (a) Ban Nam Khem, Phang-nga Province (b) Bang Rong, Phuket Province

From grain size analysis, it was clear that the percentages of small particles (clay, silt and very fine sand; easily in the mobilized phase) at Ban Nam Khem was high compared with the value at Bang Rong. These small particles contributed to more than 50% of total sediment, except at the station TNK-A2 where the fraction of fine sand was dominant (Figure 3.20 a). In fact a smaller in size, the easier a particle can be forced into the suspension. This shows the best agreement with the results from total suspended solids. In Bang Rong, the sediment composition is coarser with the dominant fractions of larger than 0.25 mm. Medium sand (0.25-0.5 mm) and coarse sand (0.5 -1.0 mm) were the important composition in most of the studied area except at stations TBR-A1, TBR-R1, and TBR-G3 where the major composition of sediment was smaller particles (clay, silt, very fine sand) as shown in Figure 3.20 b. The physico-chemical parameters of interstitial water in the sediment were under the influence of seawater from the northern and southern part of Khlong Pak Ko channel as well and from freshwater runoff from Khlong Takuapa on the northeast part of the channel. The temperature of interstitial water was quite high, ranging from 27.3°C to 33.0°C. Salinity, however, reflected the influence of freshwater with the value varying between 5.4 psu to 31.5 psu The Eh value of the sediment was between -85.0 to -318.0 mV and pH ranged from 6.92 to 8.23. These conditions indicated the undergoing decomposition process in the sediment of Ban

Nam Khem mangrove and coastal sediment. The condition was different in Bang Rong where the sediment quality such as Eh and pH values were quite high with the Eh varying from -106 to 80 mV and pH ranging between from 7.21 to 10.12. The salinity of interstitial water, 22.5-29.8 psu, also indicated less influence of freshwater in Khlong Bang Rong.

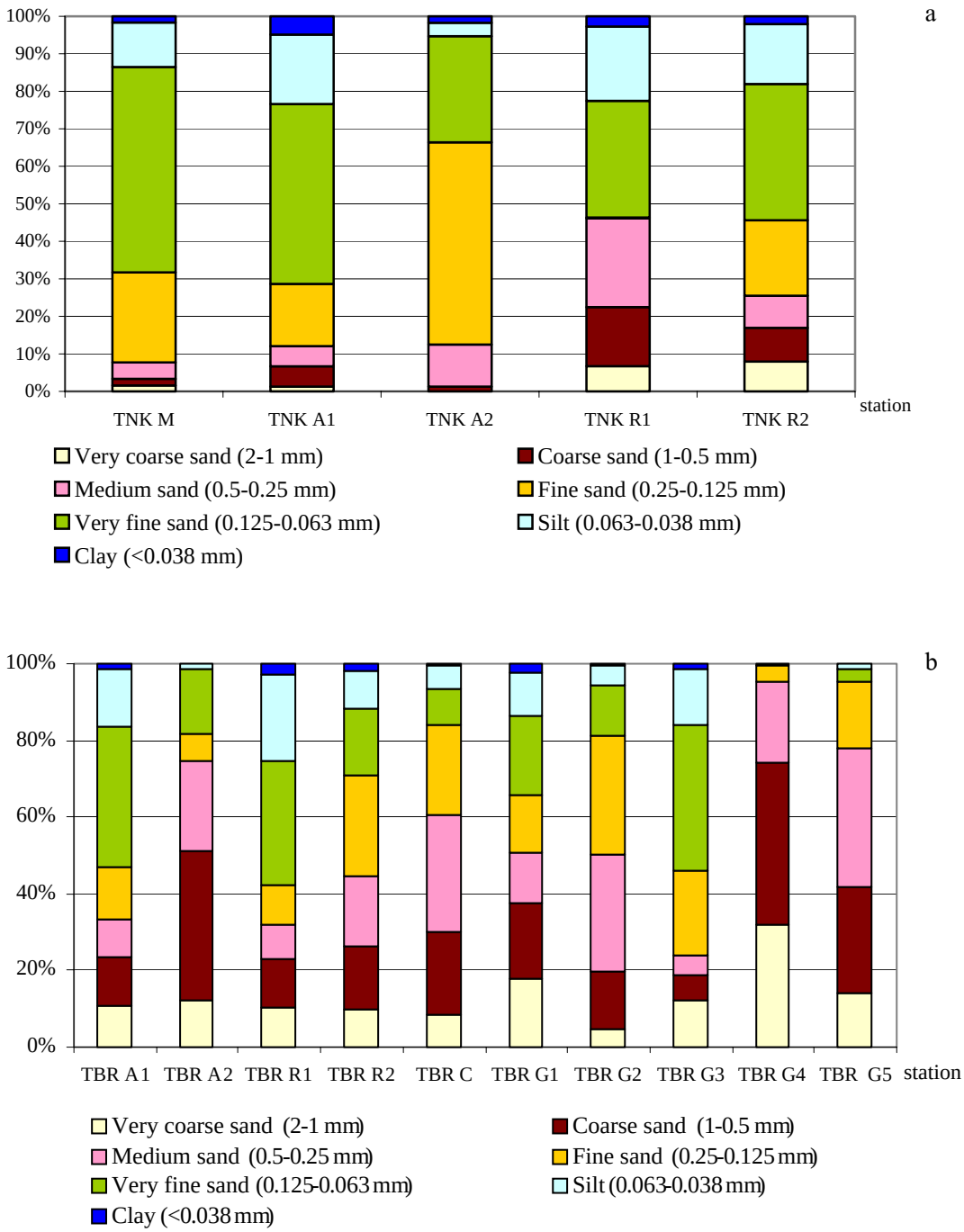


Figure 3.20 Grain size composition in Ban Nam Khem and Bang Rong mangrove forest on an adjacent coast in October 2005: (a) Ban Nam Khem, Phang-nga Province (b) Bang Rong, Phuket Province

Biodiversity and productivity

Our post-tsunami monitoring of the impacts of tsunami on the mangrove ecosystem confirmed our ecological risk assessment that the two mangrove forests were resilent to disturbances. The recovery potential was also high. This was due to the food web complexity and high stability in the two mangrove forests.

Phytoplankton communities

Phytoplankton communities in the vicinity of Ban Nam Khem, Phang-nga province consisted of 100 genera: 5 genera of cyanobacteria, 15 genera of dinoflagellates, 69 genera of diatoms, 7 genera of chlorophytes, 3 genera of Dictyochophyceae and a genus of Euglenoids. The density of phytoplankton in Ban Nam Khem ranged from 1.2 x 10^4 cells/L to 4.1 x 10^4 cells/L (Figure 3.21). A cyanobacteria, *Anabeana* sp., with an average density of 1,001-10,000 cells/L at each station was the most dominant genera. *Thalassionema*, a pennate diatom, was found in the density between 1,001 – 5,000 cells/L. Others, whose density was ranging from 1 to 10,000 cells/L, were the diatom *Bacillaria* and *Pseudo-nitzschia* (Figure 3.21 and Table 3.9).

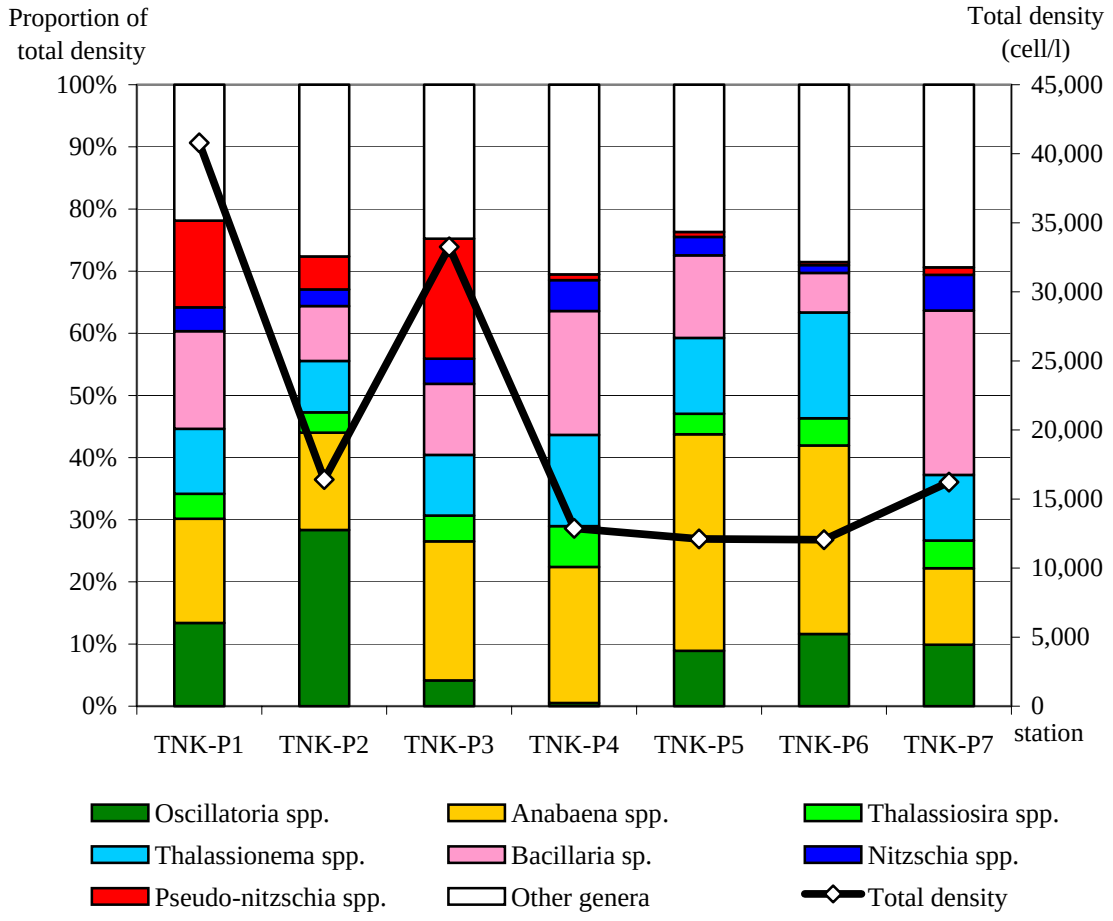


Figure 3.21 Dominant genera of phytoplankton as proportion of total phytoplankton density in Khlong Pak Ko and adjacent Ban Nam Khem mangrove forest in October 2005.

Table 3.9 Composition of phytoplankton in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1 – 1,000 cells/L
(++) = 1,001 – 5,000 cells/L
(+++) = 5,001 – 10,000 cells/L
(++++) = > 10,001 cells/L

Scientific Name	Stations						
	TNK P1	TNK P2	TNK P3	TNK P4	TNK P5	TNK P6	TNK P7
Division Cyanophyta							
Class Cyanophyceae							
Family Chroococcaceae							
Merimospedia sp.	-	-	-	-	-	-	+
Family Oscillatoriaceae							
Lyngbya sp.	+	-	-	-	+	+	+
Oscillatoria spp.	+++	++	+	+	++	++	++
Family Nostocaceae							
Richelia sp.	-	-	+	-	+	+	+
Anabaena sp.	+++	++	+++	++	++	++	++
Division Chromophyta							
Class Dinophyceae							
Family Prorocentraceae							
Prorocentrum spp.	+	+	+	+	+	+	+
Family Dinophysiaceae							
Dinophysis spp.	+	+	+	+	+	+	+
Ornithocerus sp.	-	-	-	-	-	+	-
Phalacroma sp.	-	+	-	-	+	+	+
Family Gymnodiniaceae							
Gymnodinium sp.	+	+	+	+	+	+	-
Family Ceratiaceae							
Ceratium spp.	+	+	+	+	+	+	+
Family Goniodomataceae							
Alexandrium sp.	-	+	-	-	-	-	+
Family Gonyaulacaceae							
Gonyaulax sp.	+	+	-	+	+	+	+
Family Oxytoxaceae							
Corythodinium sp.	+	-	-	-	+	-	+
Oxytoxum sp.	-	-	-	+	-	-	-
Family Pyrophacaceae							
Pyrophacus spp.	-	-	-	+	-	+	-
Family Kolkwitziellaceae							
Diplopsalis sp.	+	+	+	+	+	+	+
Family Peridiniaceae							
Peridinium spp.	+	+	+	+	+	+	+
Family Podolampaceae							
Podolampas sp.	-	-	-	+	+	+	+
Family Protoperidiniaceae							
Protoperidinum spp.	+	+	+	+	+	+	+
Cyst	-	+	+	+	-	+	-

Table 3.9 (cont.)

Scientific Name	Stations						
	TNK P1	TNK P2	TNK P3	TNK P4	TNK P5	TNK P6	TNK P7
Class Dictyochophyceae							
Family Dictyochaceae							
Dictyocha sp.	+	+	+	+	+	+	+
Distephanus sp.	-	-	+	+	+	-	+
Division Bacillariophyta							
Class Coscinodiscophyceae							
Family Thalassiosiraceae							
Thalassiosira spp.	++	+	++	+	+	+	+
Planktoniella sp.	-	-	-	-	+	-	-
Porosira sp.	+	+	+	+	+	+	+
Family Skeletonemataceae							
Detonula spp.	+	+	+	+		+	+
Family Stephanodiscaceae							
Cyclotella spp.	++	+	+	+	+	+	+
Family Lauderiaceae							
Lauderia sp.	-	-	-	+	-	-	-
Family Melosiraceae							
Melosira sp.	+	+	+	+	+	+	+
Family Stephanopyxidaceae							
Stephanopyxis sp.	+	+	+	-	-	-	+
Family Paraliaceae							
Palaria spp.	+	+	+	+	+	+	+
Family Coscinodiscaceae							
Coscinodiscus spp.	+	+	+	+	+	+	+
Family Hemidiscaceae							
Hemidiscus sp.	-	-	-	-	+	-	+
Actinocyclus sp.	+	+	+	+	+	+	+
Azpeitia sp.	+	+	+	+	+	+	+
Family Heliopeltaceae							
Actinoptychus spp.	+	+	+	+	+	+	+
Family Asterolampraceae							
Asterolampra sp.	-	-	-	-	-	-	+
Asterolamphalus sp.	+	+	-	+	+	+	+
Family Triceratiaceae							
Triceratium spp.	+	+	+	+	+	+	+
Odontella spp.	+	+	+	+	+	+	+
Family Biddulphiaceae							
Biddulphia sp.	-	-	+	+	+	-	+
Family Hemiaulaceae							
Hemiaulus spp.	+	+	+	+	+	+	-
Eucampia spp.	+	+	+	+	+	+	+
Ceratualina spp.	+	+	+	+	+	+	+
Family Bellerocheaceae							
Bellerochea sp.	+	+	+	-	-	-	+
Family Anaulaceae							
Eunotogramma sp.	-	-	+	-	-	-	-

Table 3.9 (cont.)

Scientific Name	Stations						
	TNK P1	TNK P2	TNK P3	TNK P4	TNK P5	TNK P6	TNK P7
Family Lithodesmiaceae							
Ditylum sp.	+	+	+	-	-	-	+
Helicotheca sp.	-	-	-	+	+	-	-
Family Corethraceae							
Corethron sp.	+	+	+	-	-	-	-
Family Rhizosoleniaceae							
Rhizosolenia spp	+	+	+	+	+	+	+
Dactyliosolen sp.	+	+	+	+	+	+	+
Family Chaetocerotaceae							
Chaetoceros spp.	+	+	+	+	+	+	+
Bacteriastrum spp.	+	+	+	+	+	+	+
Family Leptocylindraceae							
Leptocylindrus sp.	+	+	+	-	-	+	+
Centric sp.A	-	-	-	-	-	-	+
Class Fragilariophyceae							
Family Fragilariaceae							
Fragilaria sp.	+	+	-	+	-	-	-
Synedra sp.	-	+	-	+	+	-	-
Asterionellopsis sp.	+	+	+	+	+	+	+
Synedropsis sp.	-	-	+	-	-	-	-
Family Licmophoraceae							
Licmophora spp.	+	+	+	+	-	+	+
Family Ardissoneaceae							
Ardissonea sp.	+	+	+	+	+	+	+
Family Thalassionemataceae							
Lioloma sp.	-	-	-	-	+	-	-
Thalassionema spp.	++	++	++	++	++	++	++
Thalassiotrix spp.	+	+	+	+	+	+	+
Class Bacillariophyceae							
Family Lyrellaceae							
Lyrella spp.	+	+	+	+	+	+	+
Family Gomphonemataceae							
Gomphonema sp.	-	+	+	-	-	-	-
Family Achnanthaceae							
Achnanthes sp.	+	+	+	-	-	+	+
Family Cocconeidaceae							
Cocconeis spp.	+	+	+	+	+	+	+
Family Berkeleyaceae							
Climaconeis sp.	-	-	+	+	-	-	-
Family Amphipleuraceae							
Amphipleura sp.	-	+	-	-	-	-	-
Family Scoliotropidaceae							
Scoliotropis sp.	-	-	-	+	-	-	+
Family Pinnulariaceae							
Pinnularia sp.	-	-	-	-	-	-	+
Diatomella sp.	-	-	-	-	-	-	+
Family Diploneidaceae							
Diploneis spp.	+	+	+	+	+	+	+

Table 3.9 (cont.)

Scientific Name	Stations						
	TNK P1	TNK P2	TNK P3	TNK P4	TNK P5	TNK P6	TNK P7
Family Naviculaceae							
Navicula spp.	+	+	+	+	+	+	+
Haslea sp.	+	+	+	+	+	+	+
Family Pleurosigmataceae							
Gyrosigma/Pleurosigma spp.	+	+	+	+	+	+	+
Family Stauroneidaceae							
Stauroneis sp.	+	-	+	+	-	-	-
Family Catenulaceae							
Amphora spp.	+	+	+	+	+	+	+
Family Bacillariaceae							
Bacillaria sp.	+++	++	++	++	++	+	++
Psammodictyon spp.	+	+	+	+	+	+	+
Pseudo-nitzschia spp.	+++	+	+++	+	+	+	+
Nitzschia spp.	++	+	++	+	+	+	+
Cylindrotheca sp.	-	-	+	+	-	-	-
Family Entomoneidaceae							
Entomoneis spp.	+	+	+	+	+	+	+
Family Surirellaceae							
Petrodictyon spp.	+	+	+	+	-	+	+
Surirella spp.	+	+	+	+	+	+	+
Campylodiscus sp.	+	+	+	+	+	-	+
Pennate sp.A	+	-	+	+	+	+	-
Pennate sp.B	-	-	+	-	+	+	+
Auxospore	-	-	-	+	-	-	-
Division Euglenophyta							
Class Euglenophyceae							
Family Euglenaceae							
Euglena sp.	-	-	+	-	-	-	-
Division Chlorophyta							
Class Chlorophyceae							
Family Scenedesmaceae							
Actinastrum sp.	-	+	-	-	-	-	-
Family Hydrodictyceae							
Pediastrum spp.	-	+	-	-	-	-	-
Family Scenedesmaceae							
Scenedesmus spp.	+	+	+	+	-	+	+
Family Desmidiaceae							
Closterium sp.	+	+	-	-	-	-	+
Cosmarium sp.	-	+	+	+	-	-	-
Euastrum sp.	-	-	-	-	-	+	-
Staurastrum sp.	+	+	+	-	+	+	+

The biomass of phytoplankton as indicated by chlorophyll *a* content in Ban Nam Khem was less than 2.000 µg/L except at station TNK-P3. This chlorophyll content is in the normal ranges found along the Andaman coast (Figure 3.22). These low concentrations of chlorophyll *a* as well as the low concentrations of dissolved inorganic nutrients indicated the oligotrophic nature of the studied areas. Nanophytoplankton was the major contributor to chlorophyll *a* biomass in our studied sites with the chlorophyll *a* concentrations of more than 42% of total chlorophyll concentrations in Ban Nam Khem (Figure 3.23).

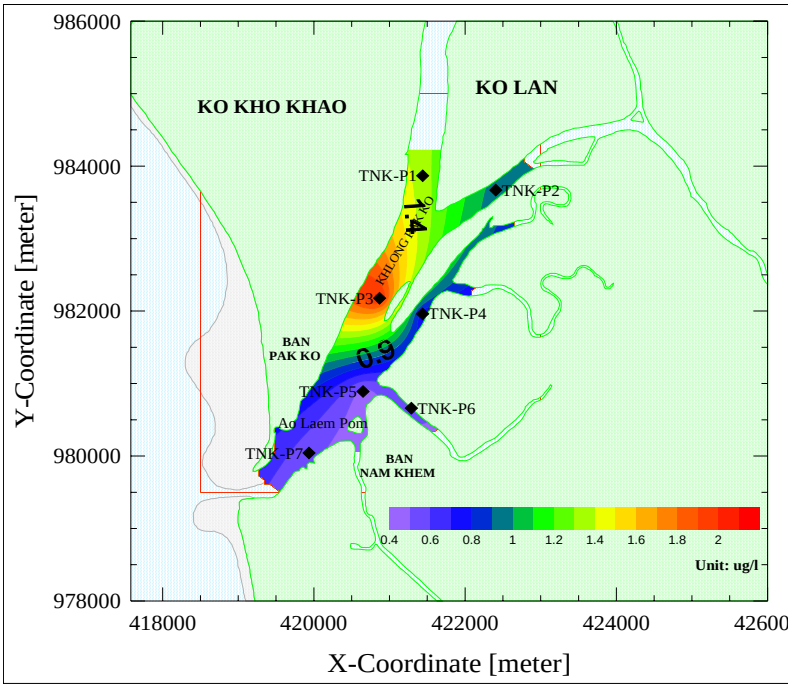


Figure 3.22 Contour of chlorophyll *a* concentrations in Ban Nam Khem, Phang-nga province in October 2005.

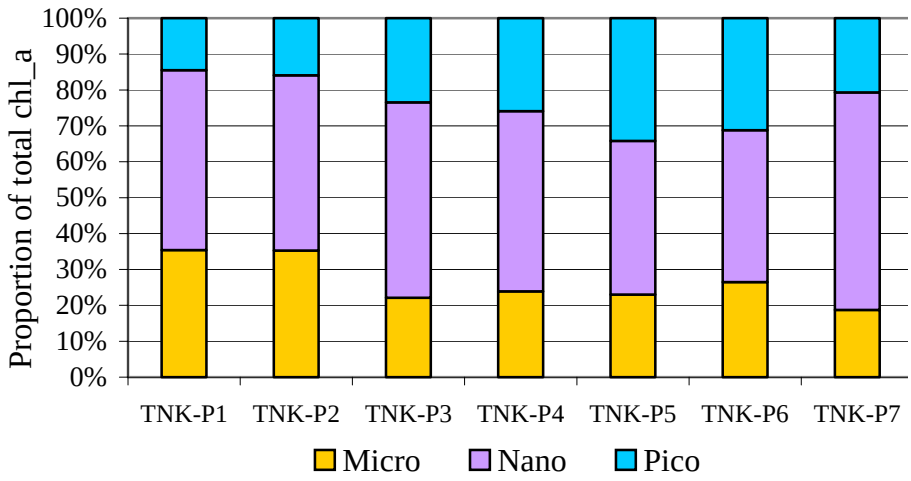


Figure 3.23 Contributions of picoplankton, nanoplankton and microplankton on chlorophyll *a* biomass in Ban Nam Khem, Phang-nga Province in October 2005.

Community of phytoplankton in Ban Nam Khem can be divided into 2 groups: communities of phytoplankton in the lower part of Khlong Pak Ko (Station TNK-P4, TNK-P5, TNK-P6, and TNK-P7) and communities of phytoplankton in the upper part of Khlong Pak Ko (Station TNK-P1, TNK-P2, and TNK-P3). With a density of 30.63%, phytoplankton communities in the lower part of Khlong Pak Ko in Ban Nam Khem/Khlong Pak Ko were dominated by diatoms (60.91% of total density). Cyanobacteria was a sub-dominant group with a density of 33.10% of total phytoplankton density. The upper Khlong Pak Ko communities governed 69.37% of total phytoplankton density with >60% of the populations of Cyanobacteria, Euglenophyte, Chlorophytes and diatom inhabiting in this part of the area. The dominant genera of phytoplankton in Ban Nam Khem/ Khlong Pak Ko area were the diatoms; *Thalassionema*, *Bacillaria*, *Thalassiosira*, *Nitzschia*, *Pseudo-nitzschia*; and the cyanobacteria *Anabaena* and *Oscillatoria*. Characteristic phytoplankton genera of the upper part communities were mainly the dinoflagellates and diatoms while the lower part communites included members of chlorophytes and diatoms (Table 3.10)

Table 3.10 Characteristics of phytoplankton communities in Ban Nam Khem/Khlong Pak Ko area in October 2005.

Characteristics	**Upper part of Khlong Pak Ko**	**Lower part of Khlong Pak Ko**
Dominant genera	*Anabaena* *Pseu-donitzschia* *Oscillatoria*	*Anabaena* *Bacillaria* *Thalassionema*
Characteristic genera	*Phacus* *Actinastrum* *Pediastrum* *Corethron* *Eunotogramma* *Synedropsis* *Gomphonema* *Amphipleura*	*Merismopedia* *Euastrum* *Orinthocerus* *Oxytoxum* *Pyrophacus* *Podolampas* *Planktoniella* *Lauderia* *Hemidiscus* *Asterolampra* *Heliotheca* *Liocoma* *Grammatophora* *Scoliotropis* *Pinnularia* *Diatomella* Auxospore of diatoms
Salinity (psu)	27.03 ± 5.35	32.57 ± 0.22
Dissolved oxygen (mg/L)	5.47 ± 0.22	5.73 ± 0.16
pH	7.80 ± 0.31	7.18 ± 0.09
Silicate-silicon (µg at/L)	25.99 ±19.46	7.19 ± 4.75

Phytoplankton communities along Bang Rong mangrove creek consisted of 80 genera, including 7 genera of cyanobacteria, 11 genera of dinoflagellates, 60 genera of diatoms, and a genera of silicoflagellate and chlorophyte. A cyanobacteria, *Oscillatoria* spp. was the most abundant genera with a density ranging between 1,001- >10,001 cells/L, apart from the *Anabaena*-dominated communities of Ban Nam Khem, Phang-nga province. Pennate diatoms, *Nitzschia* and *Pseudo-nitzschia* were the second and the third dominant genera with the densities between 1-10,000 cells/L and 1-5,000 cells/L, respectively. The centric diatoms *Rhizosolenia*, and *Palaria* sp. were also found in the density range of 1,001-5,000 cell/L in stations TBR-P1 and TBR-P4-P6 (Figure 3.24 and Table 3.11).

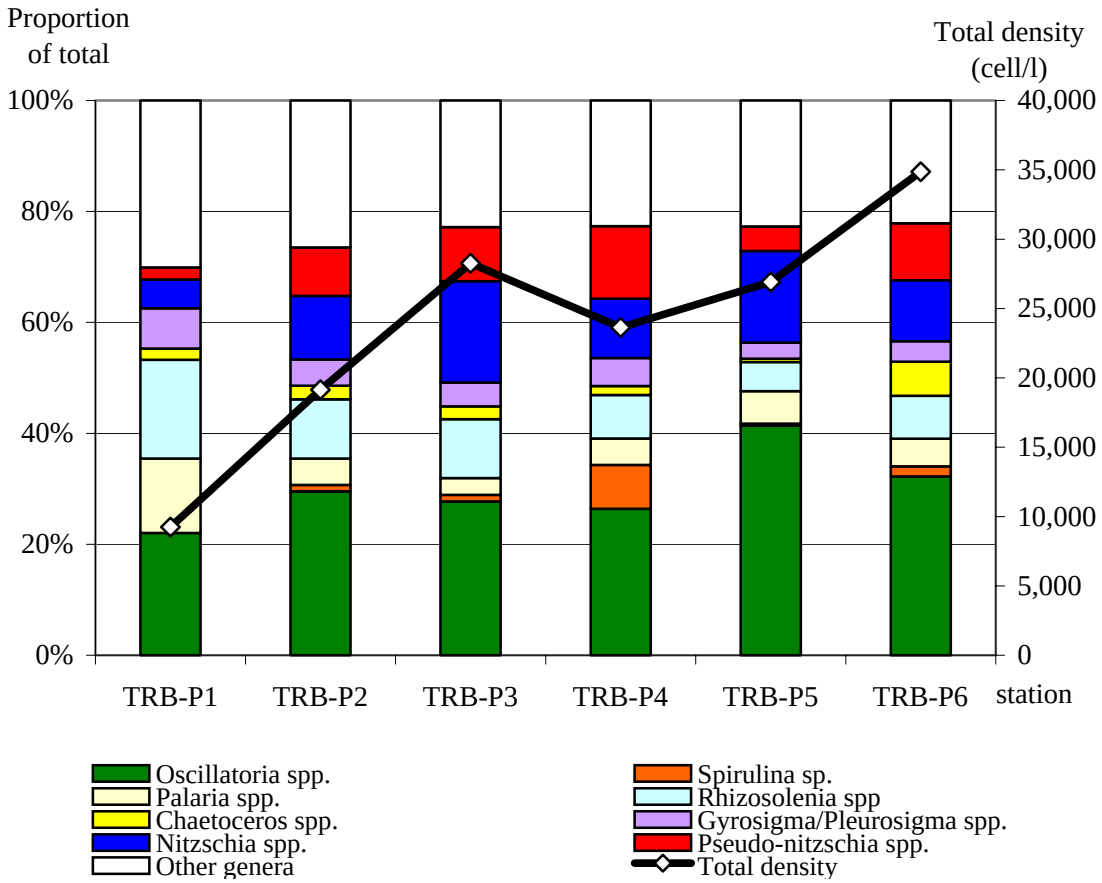


Figure 3.24 Dominant genera of phytoplankton as proportion of total phytoplankton density in Bang Rong mangrove creek in October 2005.

Table 3.11 Composition of Phytoplankton in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005.

(-) = Not found
(+) = 1 – 1,000 cells/L
(++) = 1,001 – 5,000 cells/L
(+++) = 5,001 – 10,000 cells/L
(++++) = > 10,001 cells/L

Scientific Name	Stations					
	TBR P1	TBR P2	TBR P3	TBR P4	TBR P5	TBR P6
Division Cyanophyta						
Class Cyanophyceae						
Family Chroococcaceae						
Merimospedia sp.	-	-	+	-	-	-
Family Oscillatoriaceae						
Lyngbya sp.	-	+	-	+	-	-
Oscillatoria spp.	++	+++	+++	+++	++++	++++
Spirulina sp.	-	+	+	++	+	+
Family Nostocaceae						
Richelia sp.	-	+	+	-	+	+
Anabaenopsis sp.	-	+	+	-	-	-
Anabaena sp.	+	+	+	+	+	+
Division Chromophyta						
Class Dinophyceae						
Family Prorocentraceae						
Prorocentrum spp.	+	+	+	+	+	+
Family Dinophysiaceae						
Dinophysis spp.	-	+	-	-	-	-
Family Gymnodiniaceae						
Gymnodinium sp.	-	-	-	+	+	-
Family Ceratiaceae						
Ceratium spp.	+	+	+	+	+	+
Family Goniodomataceae						
Alexandrium sp.	+	-	-	-	-	-
Family Gonyaulacaceae						
Gonyaulax sp.	-	+	-	+	+	+
Family Pyrophacaceae						
Pyrophacus spp.	+	-	+	+	-	-
Family Kolkwitziellaceae						
Diplopsalis sp.	+	+	+	+	+	+
Family Peridiniaceae						
Peridinium spp.	+	+	+	+	+	+
Family Podolampaceae						
Podolampas sp.	-	-	-	-	+	-
Family Protoperidiniaceae						
Protoperidinum spp.	+	+	+	+	+	+
Class Dictyochophyceae						
Family Dictyochaceae						
Dictyocha sp.	+	+	+	+	+	+

Table 3.11 (cont.)

Scientific Name	Stations					
	TBR P1	TBR P2	TBR P3	TBR P4	TBR P5	TBR P6
Division Bacillariophyta						
Class Coscinodiscophyceae						
Family Thalassiosiraceae						
Thalassiosira spp.	+	+	+	+	+	+
Porosira sp.	+	+	+	+	+	+
Family Skeletonemataceae						
Detonula spp.	+	+	+	+	+	+
Family Stephanodiscaceae						
Cyclotella spp.	+	+	+	+	+	+
Family Melosiraceae						
Melosira sp.	+	+	-	+	+	+
Family Stephanopyxidaceae						
Stephanopyxis sp.	+	+	+	+	+	+
Family Paraliaceae						
Palaria spp.	++	+	+	++	++	++
Family Coscinodiscaceae						
Coscinodiscus spp.	+	+	+	+	+	+
Family Hemidiscaceae						
Hemidiscus sp.	+	-	+	-	-	-
Actinocyclus sp.	+	+	+	+	+	+
Azpeitia sp.	-	+	-	+	+	-
Family Heliopeltaceae						
Actinoptychus spp.	+	+	-	+	+	+
Family Asterolampraceae						
Asterolampra sp.	+	-	+	-	-	-
Asterolamphalus sp.	-	+	-	+	+	+
Family Triceratiaceae						
Triceratium spp.	+	+	+	+	+	+
Odontella spp.	+	+	+	+	+	+
Auliscus sp.	-	-	-	+	-	+
Family Biddulphiaceae						
Biddulphia sp.	-	-	-	-	-	+
Terpsinoe sp.	-	-	-	+	-	-
Family Hemiaulaceae						
Hemiaulus spp.	+	+	+	+	+	+
Eucampia spp.	+	+	+	+	+	+
Ceratualina spp.	+	+	+	+	+	+
Family Bellerocheaceae						
Bellerochea sp.	-	+	+	-	+	+
Family Streptothecaceae						
Streptotheca sp.	-	-	+	-	-	-
Family Lithodesmiaceae						
Ditylum sp.	+	-	+	-	-	-
Helicotheca sp.	-	+	+	+	+	+
Family Corethraceae						
Corethron sp.	-	+	-	+	-	+
Family Rhizosoleniaceae						
Rhizosolenia spp	++	++	++	++	++	++
Dactyliosolen sp.	+	+	+	+	+	+

Table 3.11 (cont.)

Scientific Name	Stations					
	TBR P1	TBR P2	TBR P3	TBR P4	TBR P5	TBR P6
Family Chaetocerotaceae						
Chaetoceros spp.	+	+	+	+	+	++
Bacteriastrum spp.	+	+	+	+	+	+
Family Leptocylindraceae						
Leptocylindrus sp.	-	-	+	-	-	-
Class Fragilariophyceae						
Family Fragilariaceae						
Fragilaria sp.	+	+	+	+	+	+
Asterionellopsis sp.	-	+	+	+	+	+
Family Licmophoraceae						
Licmophora spp.	-	+	+	+	+	+
Family Rhaphoneidaceae						
Pesisnoë sp.	-	+	+	-	-	+
Family Ardissoneaceae						
Ardissonea sp.	-	-	-	+	+	-
Family Thalassionemataceae						
Lioloma sp.	+	-	-	-	+	-
Thalassionema spp.	+	+	+	+	+	+
Thalassiotrix spp.	-	+	+	+	-	+
Class Bacillariophyceae						
Family Lyrellaceae						
Lyrella spp.	+	+	+	+	+	+
Family Achnanthaceae						
Achnanthes sp.	-	+	-	+	-	-
Family Cocconeidaceae						
Cocconeis spp.	+	-	+	+	+	+
Family Scoliotropidaceae						
Scoliotropis sp.	-	-	-	+	-	+
Family Pinnulariaceae						
Diatomella sp.	-	-	+	-	-	-
Family Diploneidaceae						
Diploneis spp.	+	+	+	+	+	+
Family Naviculaceae						
Navicula spp.	+	+	+	+	+	+
Haslea sp.	+	-	+	+	+	+
Family Pleurosigmataceae						
Gyrosigma/Pleurosigma spp.	+	+	++	++	+	++
Family Catenulaceae						
Amphora spp.	+	+	+	+	+	+
Family Bacillariaceae						
Bacillaria sp.	+	+	+	+	+	+
Psammodictyon spp.	+	-	+	+	+	+
Pseudo-nitzschia spp.	+	++	++	++	++	++
Nitzschia spp.	+	++	+++	++	++	++
Family Entomoneidaceae						
Entomoneis spp.	+	+	+	+	+	+
Family Surirellaceae						
Petrodictyon spp.	+	+	+	+	+	+
Surirella spp.	+	+	+	+	+	+
Campylodiscus sp.	+	+	+	+	+	+

Table 3.11 (cont.)

Scientific Name	Stations					
	TBR P1	TBR P2	TBR P3	TBR P4	TBR P5	TBR P6
Pennate sp.A	+	+	+	+	+	+
Pennate sp.B	-	+	-	+	+	+
Auxospore	-	-	-	-	-	+
Division Chlorophyta						
Class Chlorophyceae						
Family Chlorophyceae						
Crucigeniella sp.	+	-	-	-	-	-

Concentrations of chlorophyll *a* in Bang Rong mangrove creek, Phuket province, was as low, <2.000 µg/L, as in Ban Nam Khem, Phang-nga province (Figure 3.25). High percentage of nanophytoplankton contribution to a total chlorophyll *a* was found at the stations around the mouth of Bang Rong mangrove creek (Stations TBR-P5 and TBR-P6) while picophytoplankton was the major contribution of more than 40 % of chlorophyll content in upstream stations located near the municipal pier and fish cages (Figure 3.26).

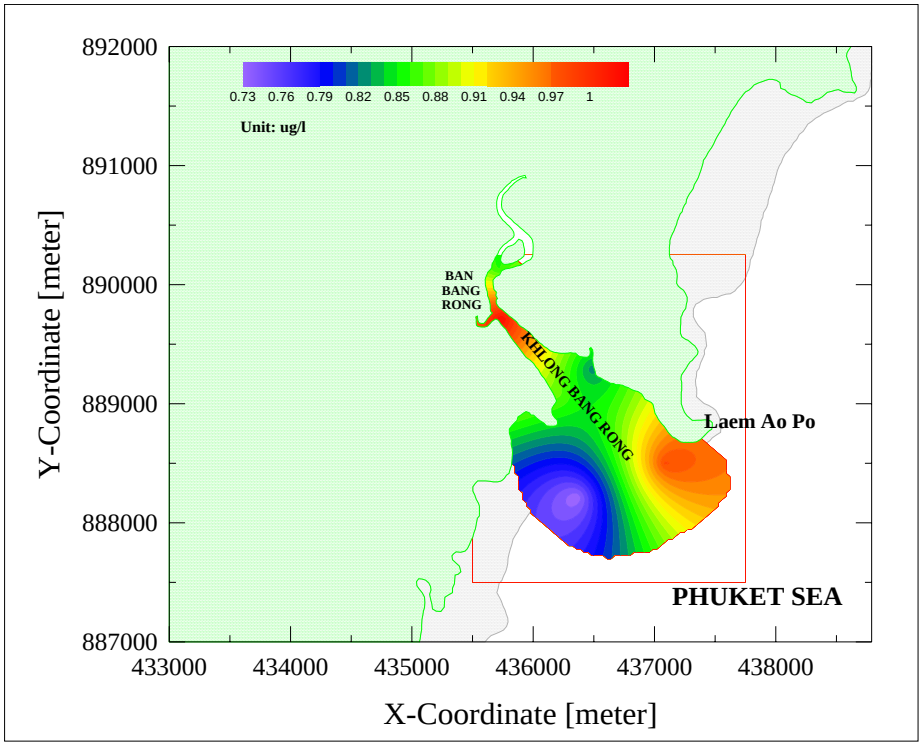


Figure 3.25 Contour of chlorophyll *a* concentrations in Bang Rong, Phuket province in October 2005.

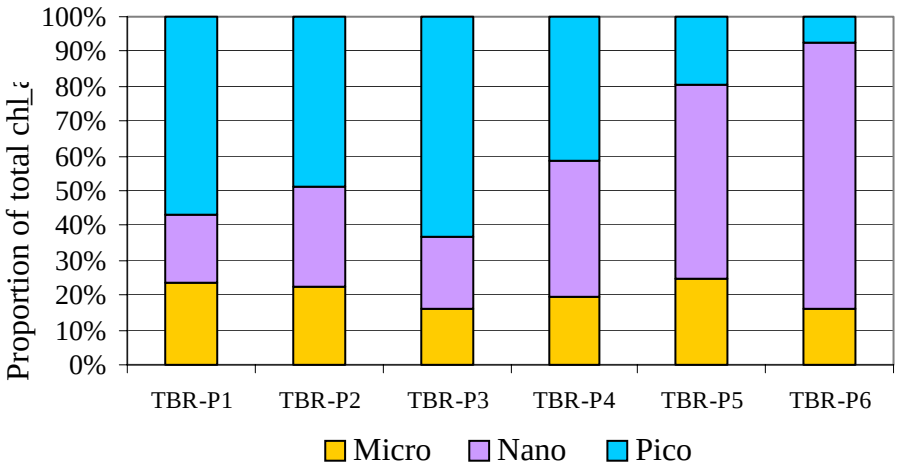
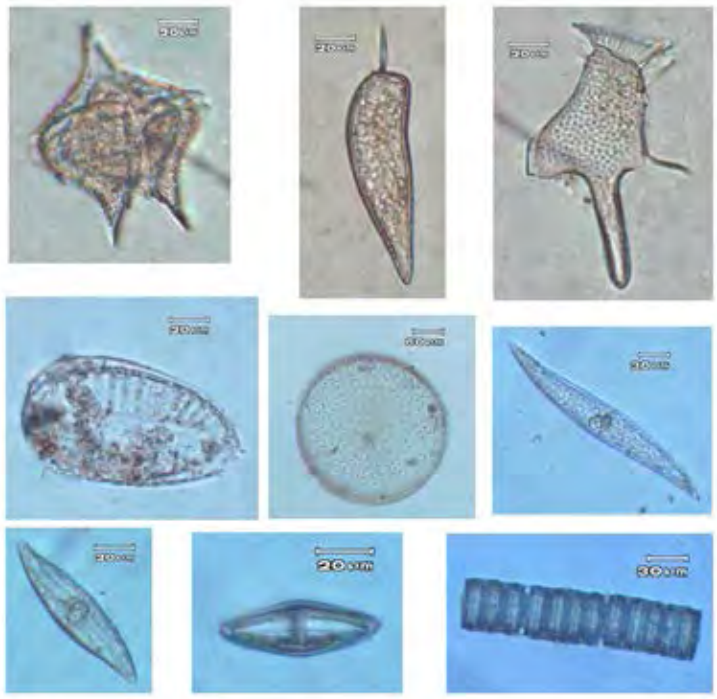


Figure 3.26 Contributions of picoplankton, nanoplankton and microplankton on chlorophyll *a* biomass in Bang Rong, Phuket province in October 2005.

Phytoplankton communities in Bang Rong mangrove creeks in the innermost part at TBR-P1 was different from others. *Oscillatoria* spp., *Rhizosolenia* spp. and *Palaria* spp. dominated the area. *Crucigeniella* sp. and *Alexandrium* sp. a potential PSP producing genus, were characteristic species. The phytoplankton communities in the main mangrove creeks shared the similar characters in terms of phytoplankton composition and environmental conditions. These were dominated by cyanobacteria and diatom population. Human activities on the bank of the creek may induce the physico-chemical parameters to favor the community of dinoflagellates. The characteristic phytoplankton in these stations included the dinoflagellate *Dinophysis* sp., a DSP producing genera. The concentrations of these harmful microphytoplankton should be closely monitored for cage cultures was reintroduced as one of the rehabilitation for fishery in this area. *Oscillatoria* spp. and *Nitzschia* spp. were dominant throughout the area also at the station at the mouth of the creek in station TBR-P5. Phytoplankton composition at this station was different from other being in the seaward side and with seagrass bottom. Structure of phytoplankton communities in Bang Rong mangrove creek was included in Table 3.12.

Table 3.12 Characteristics of phytoplankton communities in Bang Rong mangrove creek in October 2005.

Characteristics	**Inner part (TBR-P1)**	**Main mangrove creeks**	**Outer part (TBR-P5)**
Dominant genera	*Oscillatoria* *Rhizosolenia* *Palaria*	*Oscillatoria* *Nitzschia* *Pseudo-nitzschia*	*Oscillatoria* *Nitzschia*
Characteristic genera	*Crucigeniella* *Alexandrium*	*Merismopedia* *Lyngbya* *Anabaenopsis* *Dinophysis* *Biddulphia* *Auliscus* *Terpsinoe* *Corethron* *Streptotheca* *Leptocylindrus* *Pesisnoe* *Thalassiothrix* *Achnanthes* *Scoliotropis* *Diatomella* Auxospore of diatoms	*Podolampus*
Salinity (psu)	33.00	33.05±0.10	33.20
Dissolved oxygen (mg/L)	5.01	5.65±0.12	5.58
pH	8.11	6.86±0.17	7.02
Silicate-silicon (µg at/L)	10.16	10.63±4.24	7.29



Zooplankton communities

Zooplankton communities in Khlong Pak Ko, a water channel between Ban Nam Khem and Kho Khao Island, were dominated by calanoid copepods (10^5- >10^6 inds/100 m^3), followed by cyclopoid copepods (10^5- >10^6 inds/100 m^3), harpacticoids and copepod nauplii (10^4-10^6 inds/100 m^3), bivalve larvae (10,001-1,000,000 inds/100 m^3), polychaete larvae (1,00-1,000,000 inds/100 m^3), foraminiferans (10^2- >10^5 inds/100 m^3), and arrow worms (10^4-10^5 inds/100 m^3) (Table 3.13). Total density of zooplankton ranged from 1.37 x 10^6 inds/100 m^3 (in a station close to mangrove forest, Station TNK-P4) to 9.87 x 10^6 inds/100 m^3 in the uppermost region of the channel (Station TNK-P1). Total densities of zooplankton in the eastern part of the channel (Station TNK-P2, TNK-P4, TNK-P5 and TNK-P6) were less than 2.0 x 10^6 inds/100 m^3. Microphytoplankton feeders, copepods, foraminiferans and radiolarians were the dominant groups contributin to more than 40% and up to 80% of total zooplankton density (Figure 3.27)

Table 3.13 Zooplankton composition in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-1,000 inds/100 m^3
(++) = 1,001-10,000 inds/100 m^3
(+++) = 10,001-100,000 inds/100 m^3
(++++) = 100,001-1,000,000 inds/100 m^3
(+++++) = >1,000,000 inds/100 m^3

Taxa	Station						
	TNK-P1	**TNK-P2**	**TNK-P3**	**TNK-P4**	**TNK-P5**	**TNK-P6**	**TNK-P7**
Phylum Protozoa							
Class Sarcodina							
Order Foraminifera							
Foraminiferans (ฟอแรมมินิเฟอรา)	++++	+	++++	++++	+++	+++	++++
Order Radiolaria							
Radiolaria (เรดิโอลาเรีย)	-	-	+	+	+	+	+
Class Ciliata							
Order Tintinnida							
Tintinnids (ทินทินนิด)	+	-	-	-	-	-	-
Phylum Cnidaria							
Class Hydrozoa							
Hydromedusae (ไฮโดรเมดูซี)	++	+	++	+	++	+	+
Siphonophores (แมงกะพรุน)	++	++	++	+	+	+	+
Phylum Ctenophora							
Class Tentaculate							
Ctenophores (หวีวุ้น)	++	+	++	+	+	+	+
Phylum Nemertea							
Pilidium larvae (ตัวอ่อนหนอนริบบิ้น)	+	+	+	+	-	-	-
Phylum Nematoda							
Nematodes (หนอนตัวกลม)	+	-	+	-	-	-	+
Phylum Platyhelminthes							
Turbellaria larvae (ตัวอ่อนหนอนตัวแบน)	-	+	+	-	+	+	+
Phylum Phoronida							
Phoronid larvae (ไฟโรนิด)	-	-	-	+	+	+	-
Phylum Annelida							
Class Polychaeta							
Polychaete larvae (ตัวอ่อนไส้เดือนทะเล)	++++	++++	++++	+++	+++	++	+++
Phylum Arthropoda							
Class Crustacea							
Subclass Ostracoda							
Ostracods (ออสตราคอด)	++	+	+	+	+	+	+

Table 3.13 (cont.)

Taxa	Station						
	TNK-P1	**TNK-P2**	**TNK-P3**	**TNK-P4**	**TNK-P5**	**TNK-P6**	**TNK-P7**
Subclass Cirripedia							
Cirripedia larvae (ตัวอ่อนเพรียง)	+++	+	++	+	+	+	+
Subclass Copepoda							
Copepod nauplii (ตัวอ่อนโคพีพอด)	++++	++++	++++	++++	+++	+++	++++
Order Calanoida							
Calanoid copepod (คาลานอยด์โคพีพอด)	+++++	++++	+++++	++++	++++	++++	++++
Order Cyclopoida							
Cyclopoid copepod (ไซโคลพอยด์โคพีพอด)	+++++	++++	+++++	++++	++++	++++	++++
Order Harpcticoida							
Harpacticoid copepod (ฮาร์แพคทีคอยด์โคพีพอด)	++++	++++	++++	++++	++++	++++	++++
Subclass Malacostraca							
Order Mycidacea							
Mysids (เคยตาดำ)	++	-	+	-	-	-	+
Order Cumacea							
Cumaceans (คิวมาเซียน)	+++	+	+	+	-	-	+
Order Isopoda							
Isopods (ไอโซพอด)	+	+	+	+	+	-	+
Order Amphipoda							
Amphipods (แอมฟิพอด)	++	+	+	+	+	-	++
Order Decapoda							
Natantia							
Lucifer sp. (เคยสำลี)	++	+	++	+	++	++	+
Acetes sp. (เคยหยาบ)	++	+	+	+	++	++	+
Shrimp larvae (ลูกกุ้ง)	+++	++	++	++	+++	++	++
Reptantia							
Anomuran larvae (ลูกปูเสฉวน)	-	-	-	-	-	+	-
Zoea of Brachyura (ลูกปูระยะซูเอีย)	+++	+++	+++	++	++	++	++
Megalopa of Brachyura (ลูกปูระยะเมกาโลพา)	+	-	+	+	+	-	+
Alima larvae (ลูกกั้งตั๊กแตน)	-	-	-	+	-	-	-
Phyllosoma larvae (ลูกกุ้งมังกร)	-	-	-	-	+	-	-
Phylum Chaetognatha							
Class Sagittoidea							
Family Sagittidae (หนอนธนู)	+++	+++	+++	+++	+++	+++	+++

Table 3.13 (cont.)

Taxa	Station						
	TNK-P1	**TNK-P2**	**TNK-P3**	**TNK-P4**	**TNK-P5**	**TNK-P6**	**TNK-P7**
Phylum Mollusca							
Class Gastropoda							
Gastropod larvae (ตัวอ่อนหอยฝาเดียว)	++++	++	+++	+++	+++	+++	+++
Heteropods (เฮเธอโรพอด)	+++	+	+++	+++	+++	+++	++
Pteropods (เธอโรพอด)	+++	+	+++	+++	++	+++	++
Class Pelecypoda							
Bivalve larvae (ตัวอ่อนหอยสองฝา)	++++	+++	++++	++++	++++	++++	+++
Phylum Echinodermata							
Class Asteroidea							
Bipinnaria larvae (ตัวอ่อนดาวทะเล)	+	+	+	+	+	+	+
Class Holothuroidea							
Auricularia larvae (ตัวอ่อนปลิงทะเล)	-	-	-	-	-	+	-
Class Ophiuroidea							
Ophiopluteus larvae (ตัวอ่อนดาวเปราะ)	+	+	+	+	+	+	+
Phylum Urochordata							
Class Larvacea							
Larvaceans (ลาร์วาเซียน)	+++	+++	++	+	+	+	+
Class Thaliacea							
Thaliaceans (ทาลิเอเซีย)	-	+	+	+	+	-	-
Phylum Chordata							
Class Pisces							
Fish larvae (ลูกปลา)	++	+	+	+	+	+	+
Fish eggs (ไข่ปลา)	+	+	+	+	+	+	+

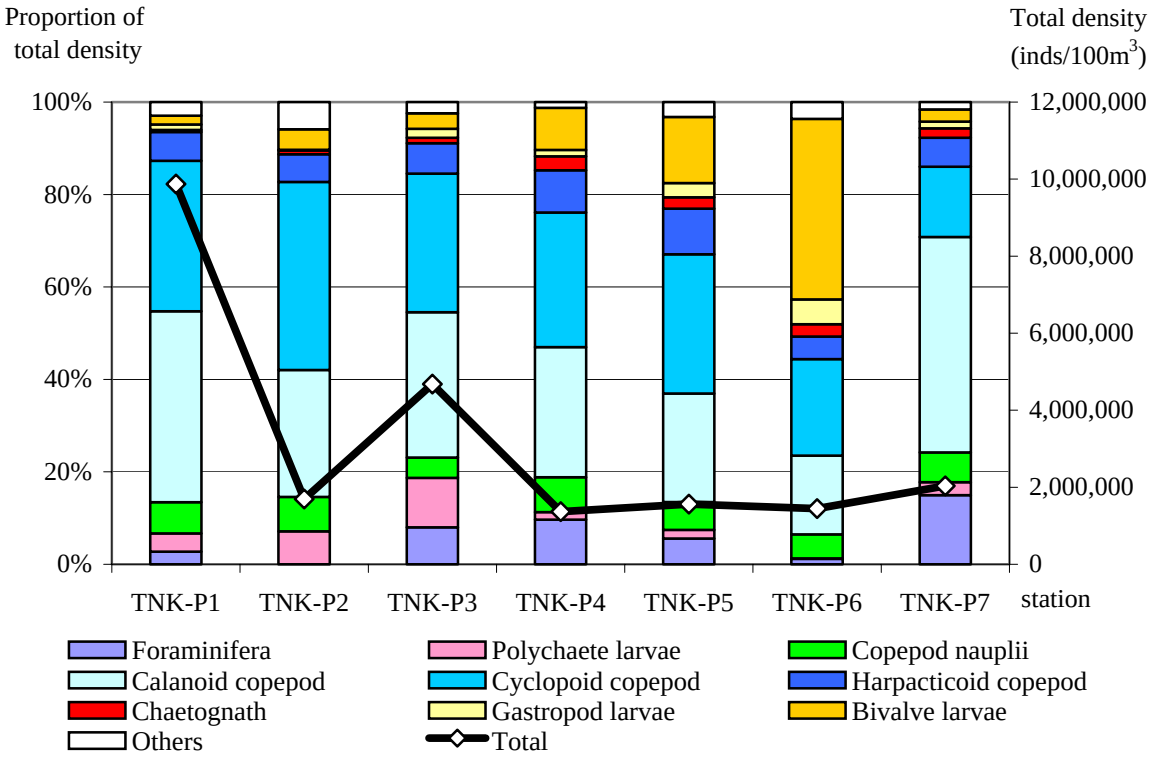


Figure 3.27 Composition and total density of zooplankton in Ban Nam Khem, Phang-nga Province during post-tsunami in October 2005.

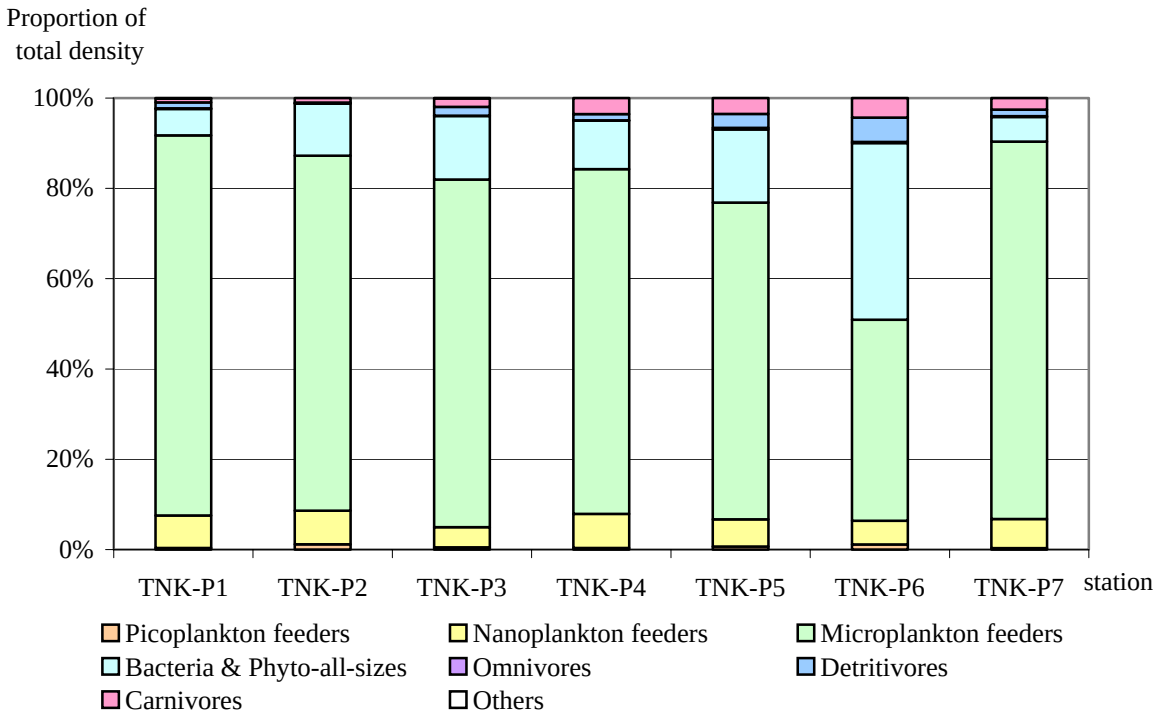


Figure 3.28 Composition of zooplankton based on their nutritional status in Ban Nam Khem, Phang-nga Province during post-tsunami in October 2005.

Zooplankton communities of Ban Nam Khem can be divided into 2 groups. The first group contained zooplankton communities in Pak Ko canel, close to Kho Khao Island. There was a high density of copepods, zoea of brachyurans, chaetognaths, gastropod larvae in comparison to the rest of zooplankton in other stations. The nutritional status of the dominant groups were microphytoplankton feeders (Figure 3.28). The characteristic zooplankton included the protozoan; tintinnid; nematode and mysid shrimps. Another group included zooplankton communities in the stations along the coast of Ban Nam Khem, nearly mangrove creeks with bivalve larvae as the dominant zooplankton. Zooplankton communities were dominated by microphytoplankton feeders and Mucus net feeders (Figure 3.28) particularly in the mangrove creek (Station TNK-P6). Characteristic group in these communities were Phoronid larvae, pagurid larvae, alima larvae, phyllosoma larvae, and auricularia larvae.

Table 3.14 Characteristics of zooplankton communities in Ban Nam Khem, Phang-nga Province during October 2005.

Characteristics	**Pak Ko canel**	**Along the coast of Ban Nam Khem**
Dominant groups	Calanoid copepod Cyclopoid copepod Harpacticoid copepod Copepod nauplii Polychaete larvae	Cyclopoid copepod Calanoid copepod Bivalve larvae Copepod nauplii
Characteristics groups	Tintinnid Nematode Mysid shrimp	Phoronid larvae Pagurid larvae Alima larvae Phyllosoma larvae Auricularia larvae
Salinity (psu)	30.81±2.97	29.74±5.49
Temperature (^{o}C)	29.44±0.17	29.47±0.33
Dissolved oxygen (mg/L)	5.65±0.28	5.59±0.21
pH	7.44±0.31	7.45±0.47

In the mangrove creek of Bang Rong, zooplankton densities were in the range of 1.60 x 10^{6}-2.18 x 10^{7} inds/100 m^{3} (Figure 3.29). The uppermost station (St. TBR-P1) located in the area with many fish cages possessed the highest zooplankton density. Calanoid and cyclopoid copepods were the most abundant zooplankton in this area. Their density ranged at 10^{5}-10^{6} inds/100 m^{3}. Polychaete larvae and bivalve larvae were presented in the density range of 10^{3}->10^{6} inds/100 m^{3} (Table 3.14). Microphytoplankton feeder as well as nanophytoplankton feeder (Figure 3.30).

Table 3.15 Zooplankton composition in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-1,000 inds/100 m^3
(++) = 1,001-10,000 inds/100 m^3
(+++) = 10,001-100,000 inds/100 m^3
(++++) = 100,001-1,000,000 inds/100 m^3
(+++++) = >1,000,000 inds/100 m^3

Taxa	Station					
	TBR-P1	**TBR-P2**	**TBR-P3**	**TBR-P4**	**TBR-P5**	**TBR-P6**
Phylum Protozoa						
Class Sarcodina						
Order Foraminifera						
Foraminiferans (ฟอแรมินิเฟอรา)	+	+	+	+	+	+
Order Radiolaria						
Radiolaria (เรดิโอลาเรีย)	+	+	+	+	+	+
Phylum Cnidaria						
Class Hydrozoa						
Hydromedusae (ไฮโดรเมดูซี)	+++	++	++	++	+	++
Siphonophores (แมงกะพรุน)	+++	++	+++	++	+++	+++
Phylum Ctenophora						
Class Tentaculate						
Ctenophores (หวีวุ้น)	++	+	+	+	-	+
Phylum Nemertea						
Pilidium larvae (ตัวอ่อนหนอนริบบิ้น)	-	-	+	-	-	+
Phylum Nematoda						
Nematodes (หนอนตัวกลม)	+	-	-	+	-	-
Phylum Platyhelminthes						
Turbellaria larvae (ตัวอ่อนหนอนตัวแบน)	+	+	+	+	+	+
Phylum Phoronida						
Phoronid larvae (โฟโรนิด)	-	+	-	-	-	-
Phylum Annelida						
Class Polychaeta						
Polychaete larvae (ตัวอ่อนไส้เดือนทะเล)	+++++	++++	++++	++++	++	++++
Phylum Arthropoda						
Class Crustacea						
Subclass Ostracoda						
Ostracods (ออสตราคอด)	++	++	++	+	+	+
Subclass Cirripedia						
Cirripedia larvae (ตัวอ่อนเพรียง)	+++	++	++	++	+	++

Table 3.15 (cont.)

Taxa	Station					
	TBR-P1	**TBR-P2**	**TBR-P3**	**TBR-P4**	**TBR-P5**	**TBR-P6**
Subclass Copepoda						
Copepod nauplii (ตัวอ่อนโคพีพอด)	+++++	++++	++++	++++	++++	++++
Order Calanoida						
Calanoid copepod (คาลานอยด์โคพีพอด)	+++++	++++	++++	++++	++++	++++
Order Cyclopoida						
Cyclopoid copepod (ไซโคลพอยด์โคพีพอด)	+++++	++++	++++	+++++	++++	++++
Order Harpacticoida						
Harpacticoid copepod (ฮาร์แพคทีคอยด์โคพีพอด)	++++	++++	++++	++++	+++	++++
Subclass Malacostraca						
Order Cumacea						
Cumaceans (คิวมาเซียน)	-	-	-	-	-	+
Order Isopoda						
Isopods (ไอโซพอด)	+	+	+	+	+	+
Order Amphipoda						
Amphipods (แอมฟีพอด)	-	+	+	-	+	+
Order Decapoda						
Natantia						
*Lucifer*sp. (เคยสำลี)	+++++	++++	++++	+++	++	++++
Acetes sp. (เคยหยาบ)	+	+	+	+	-	+
Shrimp larvae (ลูกกุ้ง)	+++	+++	++	++	+	++
Reptantia						
Zoea of Brachyura (ลูกปูระยะซูเอีย)	+++	+++	+++	++	++	+++
Megalopa of Brachyura (ลูกปูระยะเมกาโลพา)	+	+	+	+	+	+
Alima larvae (ลูกกั้งตั๊กแตน)	-	-	-	-	-	+
Phylum Chaetognatha						
Class Sagittoidea						
Family Sagittidae (หนอนธนู)	++++	++++	+++	+++	+++	++++
Phylum Mollusca						
Class Gastropoda						
Gastropod larvae (ตัวอ่อนหอยฝาเดียว)	++++	+++	+++	+++	+++	+++
Heteropods (เฮทเธอโรพอด)	++++	+++	+++	+++	+++	+++
Pteropods (เธอโรพอด)	++++	++	+++	+++	+++	+++
Class Pelecypoda						
Bivalve larvae (ตัวอ่อนหอยสองฝา)	+++++	++++	++++	++++	++++	++++

Table 3.15 (cont.)

Taxa	Station					
	TBR-P1	**TBR-P2**	**TBR-P3**	**TBR-P4**	**TBR-P5**	**TBR-P6**
Phylum Echinodermata						
Class Ophiuroidea						
Ophiopluteus larvae (ตัวอ่อนดาวเปราะ)	++	++	+++	+	++	++
Class Asteroidea						
Bipinnaria larvae (ตัวอ่อนดาวทะเล)	-	-	+	+	+	-
Class Echinoidea						
Echinopluteus larvae (ตัวอ่อนเม่นทะเล)	-	-	++	+	++	++
Phylum Urochordata						
Class Larvacea						
Larvaceans (ลาร์วาเชียน)	+++	++	++	++	++	++
Class Thaliacea						
Thaliaceans (ทาลิเอเชีย)	+++	+++	+++	++	+++	+++
Phylum Chordata						
Class Pisces						
Fish larvae (ลูกปลา)	+++	+++	+++	++	++	++
Fish eggs (ไข่ปลา)	++	+	+	++	++	++

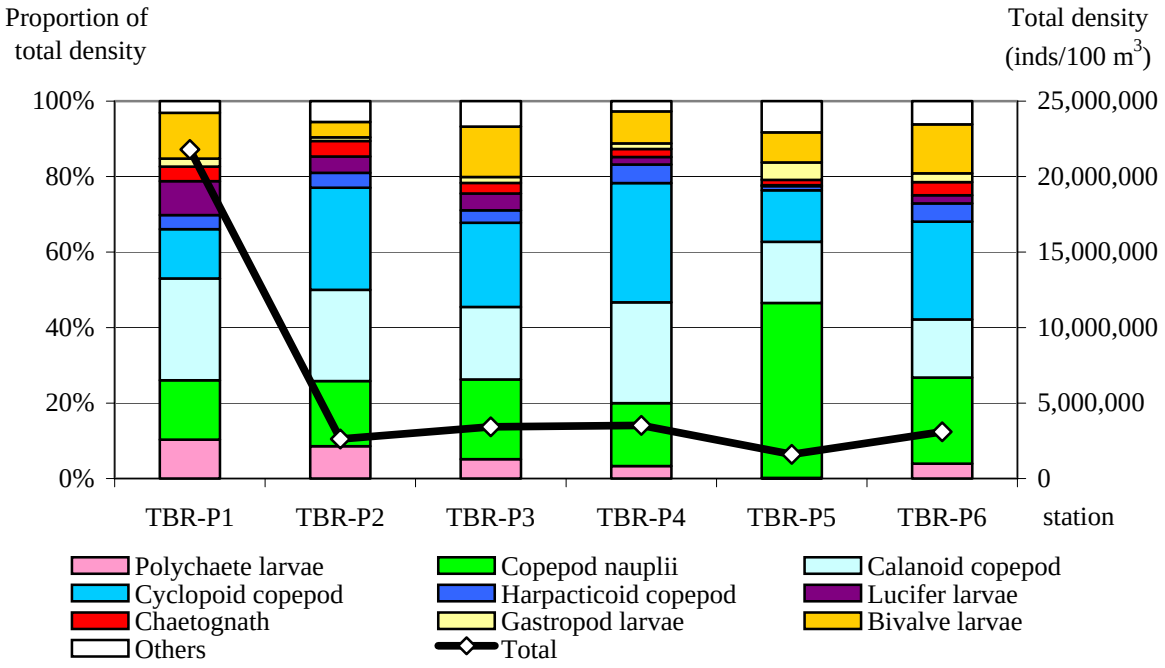


Figure 3.29 Composition and total density of zooplankton in Bang Rong, Phuket province during post-tsunami in October 2005

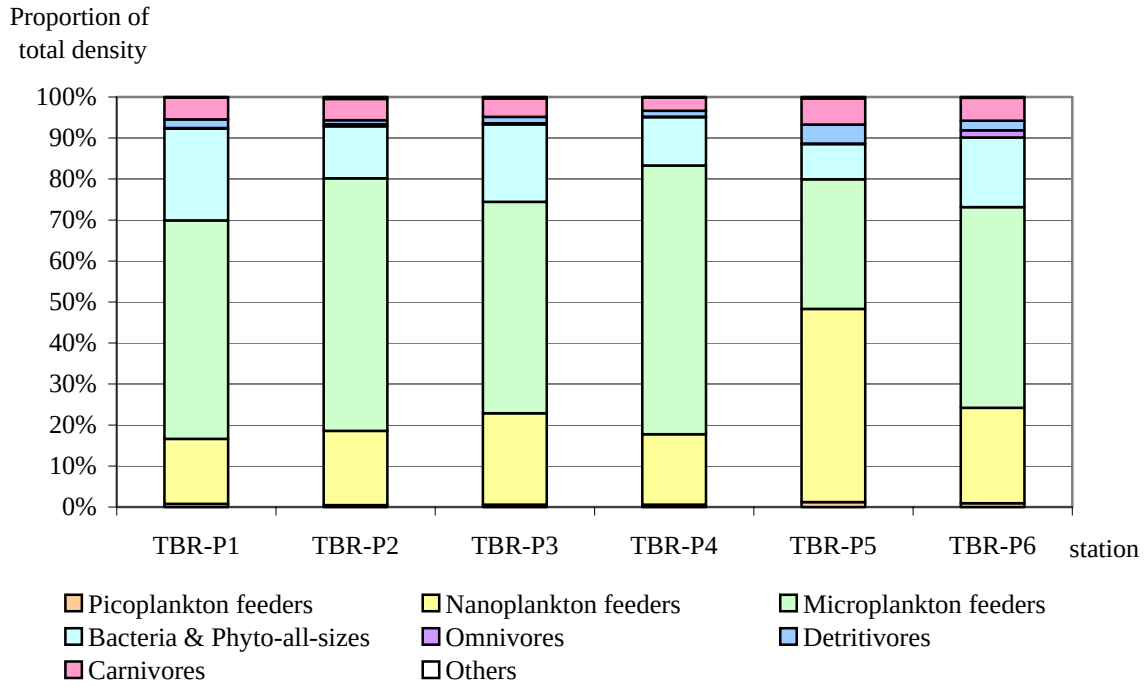


Figure 3.300 Composition of zooplankton based on their nutritional status in Bang Rong, Phuket Province during post-tsunami in October 2005.

Zooplankton communities in Bang Rong mangrove creek also follows the similar pattern to phytoplankton communities. They can be divided in to 3 clusters or groups with the innermost station, TBR-P1 dominated with Calanoid copepod, copepod nauplii, Cyclopoid copepod, bivalve larvae, polychaete larvae and *Lucifer* larvae. The main mangrove creek populations dominated by Cyclopoid copepod, Calanoid copepod, copepod nauplii and bivalve larvae. Pilidium larvae, Phoronid larvae, cumaceans and Alima larvae were the characteristic groups. Copepod nauplii, Calanoid copepod and Cyclopoid copepod were also common in the seaward area at station TBR-P5.

Table 3.16 Characteristics of zooplankton communities in Bang Rong, Phuket Province during October 2005.

Characteristics	**Inner part (TBR-P1)**	**Main mangrove creeks**	**Outer part (TBR-P5)**
Dominant groups	Calanoid copepod Copepod nauplii Cyclopoid copepod Bivalve larvae Polychaete larvae *Lucifer* larvae	Cyclopoid copepod Calanoid copepod Copepod nauplii Bivalve larvae	Copepod nauplii Calanoid copepod Cyclopoid copepod
Characteristics groups	-	Pilidium larvae Phoronid larvae Cumaceans Alima larvae	-
Salinity (psu)	33.00	33.05±0.10	33.20
Temperature (^{o}C)	30.30	30.13±0.10	30.01
Dissolved oxygen (mg/L)	5.01	5.65±0.12	5.58
pH	8.11	6.86±0.17	7.02

Benthic communities

Meiofaunal communities

Meiofaunal composition in the two mangrove forests were different in terms of sediment type, organic content and plant biomass. Table 3.17 and Figure 3.31 showed the 22 meiofaunal taxa groups in Ban Nam Khem, Phang-nga Province. Nematodes and foraminiferans were the two most dominant groups in terms of abundance and distribution. Nematodes were most abundant in the tidal mudflat, the low density *Avicennia* and low density *Rhizophora* forests. These two latter forests were in the vicinity of each other. Foraminiferan was recorded in highest density at the dense *Avicennia* forest. Polychaetes in the families Sabellidae and Capitellidae were common in the low density *Avicennia* and low density *Rhizophora* forest. Small polychaetes were widely distributed in the area. When compared to the meiofaunal diversity in the two *Avicennia* forests, foraminiferans and ostracods were more abundant in the dense *Avicennia* forest. Small polychaetes in low density *Avicennia* forest were found twice as much as companed to the dense *Avicennia* forest. This was also true for the nematode distribution. Foraminiferan were found in high abundance in the dense *Rhizophora* forest. However, the low density *Rhizophora* was found in high abundance of nematodes and small polychaetes. The meiofaunal composition in the tidal mudflat consisted mainly of turbellarians, harpacticoid copepods, oligochaetes and bivalves. The median grain size in all sites at Ban Nam Khem was in the same range consisting of fine sand to very fine sand with clay. The smallest grain size was recorded in the low density *Avicennia*. The low organic content of 0.25 % was recorded in the tidal mudflat. The *Rhizophora* forest possessed high organic content and plant biomass as shown in Figure 3.33 and Figure 3.34.

Table 3.17 Composition of meiofauna in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005.

(-) = Not found
(+) = 1-100 inds/10 cm^2
(++) = 101-1,000 inds/10 cm^2
(+++) = 1,001-10,000 inds/10 cm^2

Taxa	Station				
	TNK-A1	TNK-A2	TNK-R1	TNK-R2	TNK-M
Phylum Protozoa					
Class Sarcodina					
Order Foraminifera					
Single chambered, soft-walled foraminifera	+	+	+	+	+
Foraminiferans (live) (ฟอแรมินิเฟอรา)	++	++	+	++	+
Subphylum Ciliophora	-	+	+	+	+
Class Ciliata					
Order Tintinnida					
Tintinnids (ทินทินนิด)	-	-	-	-	+
Phylum Platyhelminthes					
Turbellaria (หนอนตัวแบน)	+	+	+	+	+
Phylum Nematoda					
Nematodes (หนอนตัวกลม)	++	++	++	++	++
Phylum Kinoryncha					
Kinoryn	+	-	+	-	-
Phylum Sipunculida					
Sipunculids (หนอนถั่ว)	-	-	+	-	-
Phylum Annelida					
Class Polychaeta (ไส้เดือนทะเล)					
Family Sabellidae	+	-	+	+	-
Family Capitellidae	+	-	+	-	-
Family Maldanidae					
Bamboo worms	+	-	+	-	-
Small polychaetes	+	+	+	+	-
Class Oligochaeta					
Oligochaetes	+	+	+	-	+
Phylum Arthropoda					
Class Crustacea					
Subclass Ostracoda					
Ostracods (ออสตราคอด)	+	+	+	+	-
Subclass Copepoda					
Order Harpacticoida					
Harpacticoid copepods (ฮาร์แพคทีคอยด์โคพีพอด)	+	+	+	+	+
Nauplius of harpacticoid copepods	+	+	+	+	-
Superfamily Halacaroidea					
Halacarids	+	-	+	+	-
Class Insecta					
Insect larvae (ตัวอ่อนแมลง)	-	-	-	-	+
Phylum Mollusca					
Class Gastropoda					
Gastropods (หอยฝาเดียว)	+	+	-	-	+
Class Pelecypoda					
Pelecypods (หอยสองฝา)	-	-	-	-	+
unknown eggs	+	+	+	+	-
unknown	+	-	+	-	+

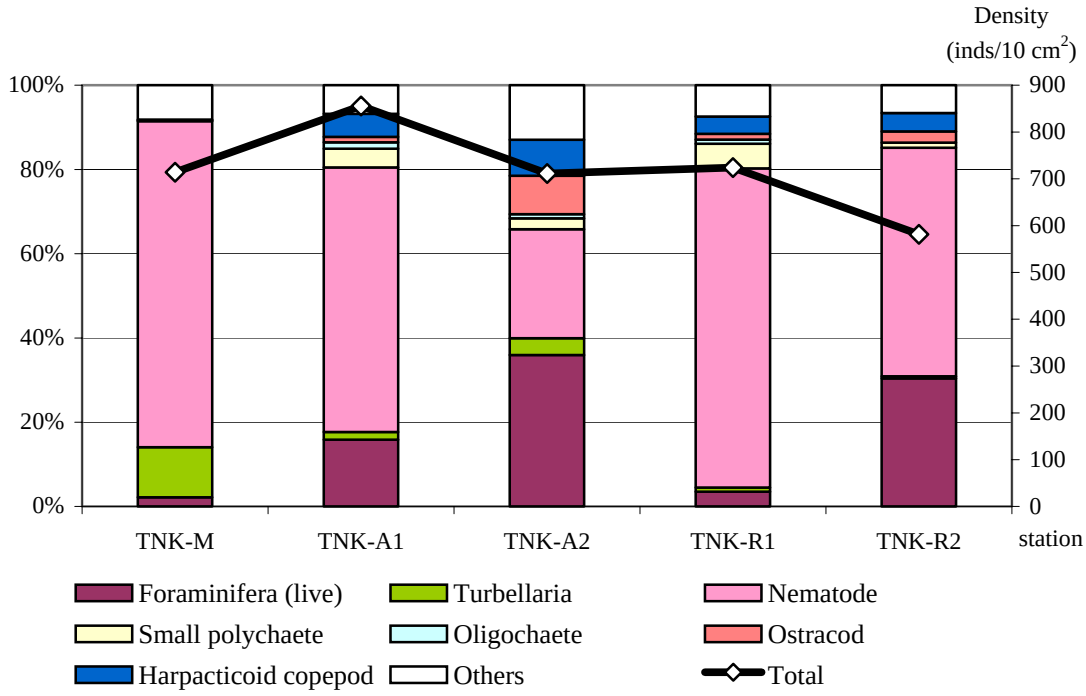


Figure 3.31 Composition and total density of meiofauna in Ban Nam Khem, Phang-nga Province in October 2005

Twenty-six meiofaunal taxa groups were sorted from the Bang Rong mangrove forest samples as shown in Table 3.18 and Figure 3.32. Foraminiferan and nematodes were the two most dominant groups follow by small polychaetes and harpacticoid copepods. Foraminiferans were found in high density in the two *Rhizophora* forest. Polychaete, in the family Sabellidae were more abundant at the low density *Avicennia* forest. Gastropods and ostracods were rare. Most of the Bang Rong sediment were mainly coarse sand. Fine sand can be found in the low density *Avicennia* and *Rhizophora* forests. The common meiofauna as reported from Phuket were nematodes, copepods, copepod nauplii. Foraminifera was not listed. (Nozawa *et al*., 1983; Chullasorn, 2000)

Table 3.18 Composition of meiofauna in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 inds/10 cm^2
(++) = 101-1,000 inds/10 cm^2
(+++) = 1,001-10,000 inds/10 cm^2

Taxa	Station					
	TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Phylum Protozoa						
Class Sarcodina						
Order Foraminifera						
Single chambered, soft-walled foraminifera	+	+	+	+	+	+
Foraminiferans (live) (ฟอแรมินิเฟอรา)	+++	++	+++	++	++	+
Subphylum Ciliphora	-	-	-	-	+	-
Phylum Platyhelminthes						
Turbellaria (หนอนตัวแบน)	+	+	-	+	+	+
Phylum Nematoda						
Nematodes (หนอนตัวกลม)	++	++	++	++	++	++
Phylum Rotifera						
Rotifer (โรติเฟอร์)	-	+	+	-	+	+
Phylum Kinoryncha						
Kinoryn	+	+	+	+	+	+
Phylum Nemertea						
Nemertean (หนอนริบบิ้น)	-	+	-	-	+	-
Phylum Annelida						
Class Polychaeta (ไส้เดือนทะเล)						
Family Sabellidae	+	-	-	-	-	-
Family Capitellidae	-	-	-	-	-	+
Family Maldanidae						
Bamboo worms	-	-	-	-	-	-
Small polychaetes	+	++	+	+	+	+
Class Oligochaeta						
Oligochaetes	+	+	-	+	+	+
Phylum Arthropoda						
Class Crustacea						
Subclass Ostracoda						
Ostracods (ออสตราคอด)	+	+	+	+	+	+
Subclass Copepoda						
Order Calanoida						
Calanoid copepods (คาลานอยด์โคพีพอด)	-	-	-	-	-	+
Order Cyclopoida						
Cyclopoid copepods (ไซโคลพอยด์โคพีพอด)	-	++	-	-	-	-
Order Harpacticoida						
Harpacticoid copepods (ฮาร์แพคทีคอยด์โคพีพอด)	++	+	+	+	+	++
Nauplius of harpacticoid copepods	+	+	+	+	+	+
Superorder Thermosbaenacea						
Thermosbaenacea	-	-	+	-	-	-
Subclass Malacostraca						
Order Amphipoda						
Amphipods (แอมฟิพอด)	+	-	-	-	-	-
Superfamily Halacaroidea						
Halacarids	+	+	-	-	+	-

Table 3.18 (cont.)

Taxa	Station					
	TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Class Insecta						
Insect larvae (ตัวอ่อนแมลง)	-	-	-	-	-	+
Phylum Mollusca						
Class Gastropoda						
Gastropods (หอยฝาเดียว)	+	-	+	+	+	-
Class Pelecypoda						
Pelecypods (หอยสองฝา)	+	+	-	-	-	+
unknown eggs	+	+	+	++	+	+
unknown	-	-	-	-	-	+

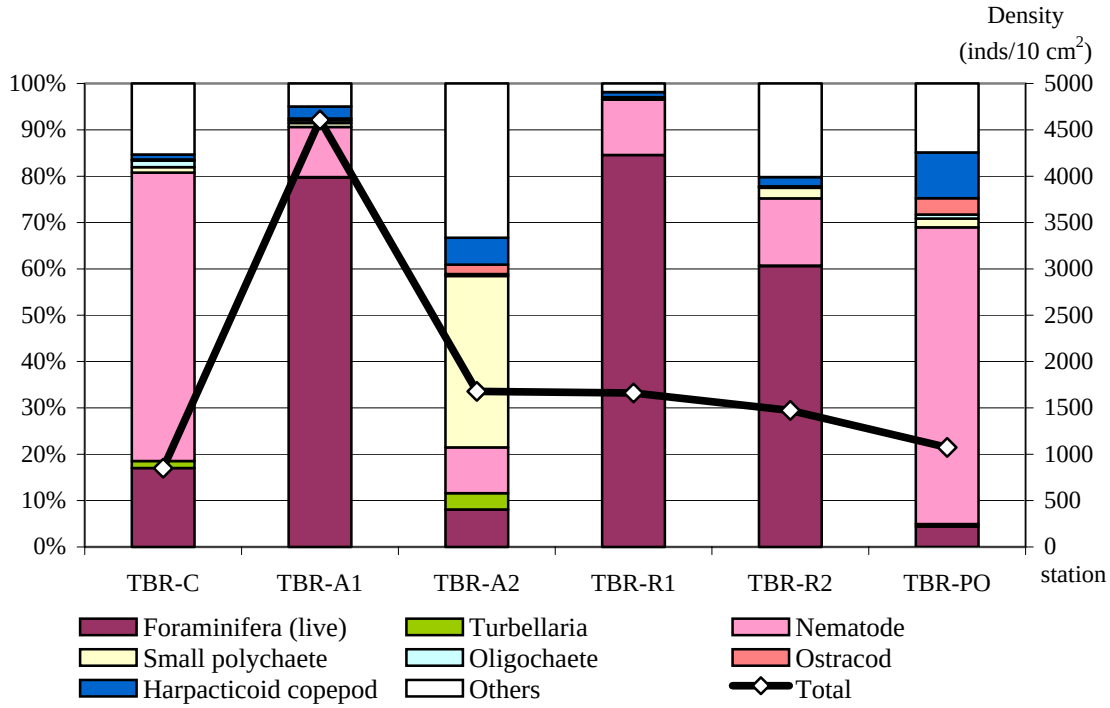


Figure 3.32 Composition and total density of meiofauna in Bang Rong, Phuket Province in October 2005

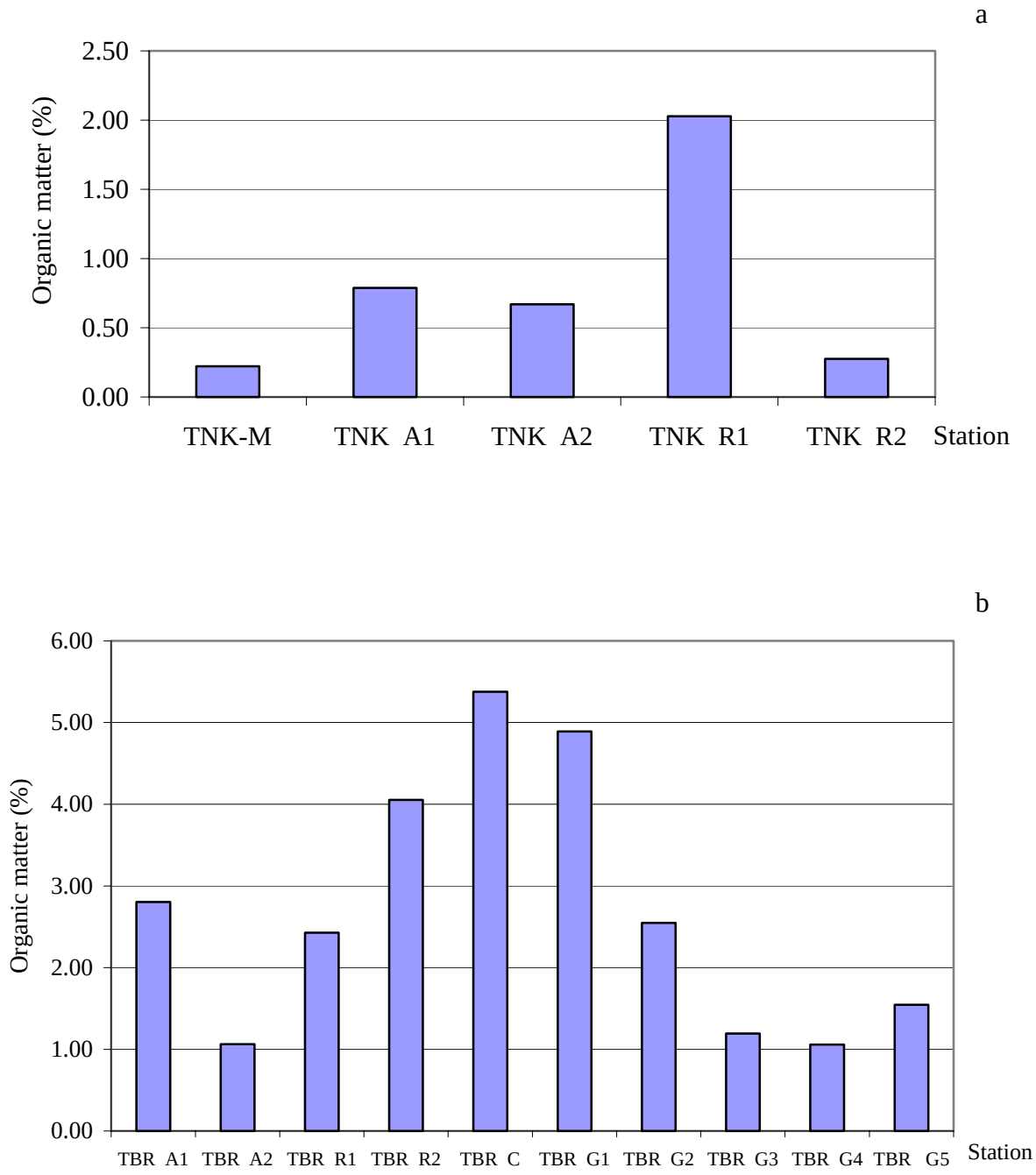


Figure 3.33 Organic matter in the sediment during post-tsunami monitoring in October 2005:
(a) Ban Nam Khem, Phang-nga Province
(b) Bang Rong, Phuket Province

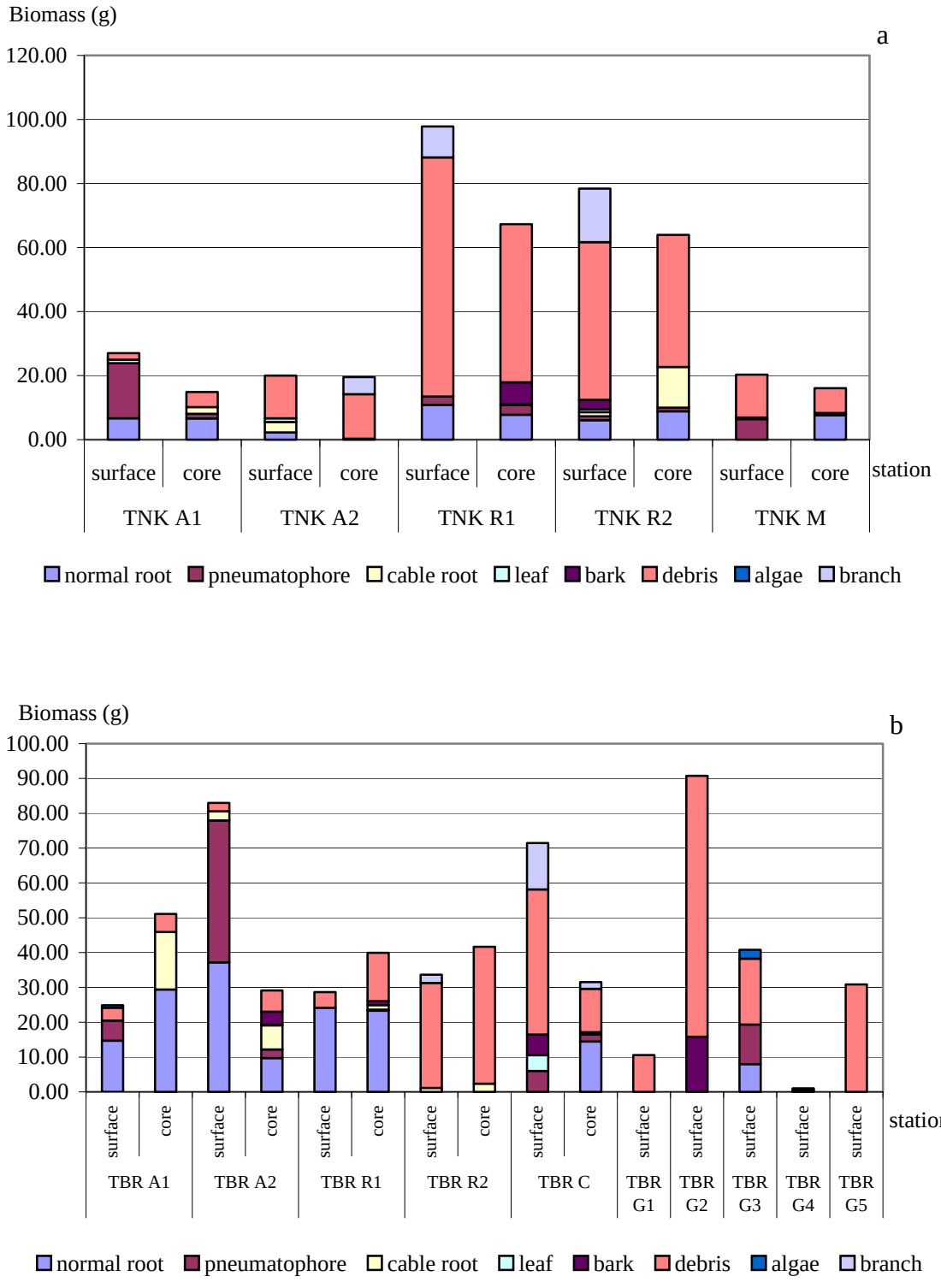


Figure 3.34 Plant biomass in mangrove forest during post-tsunami monitoring in October 2005: (a) Ban Nam Khem, Phang-nga Province
(b) Bang Rong, Phuket Province

Macrofaunal communities

Fifty-eight taxa/species of macrofauna were recorded from Ban Nam Khem mangrove forest as shown in Table 3.19. The composition of macrobenthos in their respective orders of dominance: polychaetes, molluscs and crustaceans indicated that Ban Nam Khem mangrove forest was the disturbed forest with polychaete as the dominant group. In the two *Avicennia* macrobenthic composition, more than 80% of polychaetes were found. Polychaete in the families Capitellidae, Nereidae and Sabellidae were most common. Polychaete in the family Sabellidae was most abundant at the dense *Avicennia* forest. This polychaete showed the positive correlation with grain size and organic matter. Common gastropods, *Cerithidae djadjaviensis* and *Cerithium* sp. were found in the dense *Rhizophora* and the low density *Rhizophora* forests respectively. Opportunistic and deposit feeders amphipods can be found at every station. Several juvenile *Uca* spp. can be found. The fiddler crab, *Uca urvillei*, were found in both dense *Avicennia* and dense *Rhizophora* forests. Large fiddler crab, *Uca vocans* was found in the tidal mudflat. Grapsid crab, *Sarmatium germaini*, was common at the dense *Rhizophora* forest. Grapsid crabs were related to the plant biomass and organic content.

The composition of macrobenthos in their respective orders of dominance: polychaetes, molluscs and crustaceans, indicated that the Bang Rong mangrove forest, too was in the deteriorating condition. However, high diversity of 104 taxa/species was recorded (Table 3.20). High polychaetes diversity and abundance were found in the *Rhizophora* forest. The community forest reflected the more matured forests predominantly by crustaceans and polychaetes. The three dominant families of polychaetes in the Bang Rong forests were Nereidae, Capitellidae and Sabellidae. The bamboo worm in the family Maldanidae was found to be associated with coarse sand in the two *Avicennia* forests.

The gastropods were more abundant in the two *Avicennia* forests. Most deposit feeding gastropods, such as *Cerithidea cingulata* and *C. djadjaiensis*, were common too in these forests. When compared to Ban Nam Khem mangrove forest, the diversity of molluscs in particular small gastropods in Bang Rong was higher. The common grapsid crab, *Metaplex crenulata*, can be found in all sites. The crustacean diversity was also high. Amphipods and isopods were common in the two *Avicennia* forests. Fiddler crabs, *U. perplexa* and *U. bengali* were also recorded.

Table 3.19 Composition of macrofauna in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-10 inds/m^2
(++) = 11-100 inds/m^2
(+++) = 101-1,000 inds/m^2

Taxa	Station				
	TNK A1	**TNK A2**	**TNK R1**	**TNK R2**	**TNK M**
Phylum Protozoa					
Class Sarcodina					
Order Foraminifera					
Foraminiferans (ฟอแรมมินิเฟอรา)	-	-	-	-	+
Phylum Nematoda					
Nematodes (หนอนตัวกลม)	-	+	-	-	-
Phylum Annelida					
Class Polychaeta (ไส้เดือนทะเล)					
Family Arabellidae	-	-	+	-	-
Family Capitellidae	+++	+++	++	++	+
Family Lumbrineridae	+	-	-	-	-
Family Maldanidae	++	-	-	-	-
Family Nereidae	+++	++	++	+	+
Family Pisionidae	-	-	+	-	-
Family Sabellidae	+	++	-	-	-
Phylum Sipuncula					
Sipunculids (หนอนถั่ว)	+	-	+	+	-
Phylum Arthopoda					
Class Crustacea					
Order Isopoda					
Isopods (ไอโซพอด)	-	+	+	+	-
Order Amphipoda					
Amphipods (แอมฟิพอด)	+	-	+	+	+
Order Decapoda					
Suborder Natantia					
Family Alpheusidae					
Alpheus sp. (กุ้งดีดขัน)	+	-	-	-	-
Shrimp larvae	-	-	+	-	-
Suborder Reptantia					
Anomura					
Family Paguridae					
Coenobita cavipes (ปูเสฉวน)	-	-	+	+	-
Clibanarius padavensis (ปูเสฉวน)	-	-	-	-	+
Clibanarius longitarsus (ปูเสฉวน)	-	+	-	-	-
Brachyura					
Family Grapsidae					
Sarmatium germaini (ปูแสม)	-	-	-	+	-
Metaplax sp. (juveniles) (ปูแสม)	-	-	-	-	+
Neoepisesarma versicolor (ปูแสมก้ามม่วง)	+	-	+	-	-
Parasesarma plicatum (ปูแสม)	+	-	-	+	-
Perisesarma eumolpe (ปูแสมก้ามแดง)	-	-	-	-	-

Table 3.19 (cont.)

Taxa	Station				
	TNK A1	**TNK A2**	**TNK R1**	**TNK R2**	**TNK M**
Metopograpsus latifrons (ปูแสม)	-	+	-	+	-
Metopograpsus frontalis (ปูแสม)	-	-	-	+	-
Clistocoeloma merquiensis (ปูแสม)	-	-	+	-	-
Family Ocypodidae					
Ilyoplax punctatus	-	-	-	+	-
Uca urvillei (ปูก้ามดาบ)	-	+	-	+	-
Uca vocans (ปูก้ามดาบ)	-	-	-	-	+
Uca sp. (juveniles) (ปูก้ามดาบ)	-	+	+	+	+
Class Insecta					
Insect (แมลง)	-	-	-	+	-
Insect larvae (ตัวอ่อนแมลง)	-	++	++	+	-
Phylum Mollusca					
Class Gastropoda					
Family Stenothyridae					
Stenothyra sp.	+	-	-	-	-
Family Rissoinae					
Alvania (*mamillata*)	-	-	-	-	+
Family Potamididae (หอยเจดีย์, หอยขี้กา)					
Cerithidea djadjariensis	-	++	+	-	+
Cerithidea obtuse	-	-	-	+	-
Cerithidea quadrata	-	+	-	-	-
Cerithidea sp.	-	-	+	-	-
Family Cerithiidae					
Clypeomorus sp.	+	-	-	-	-
Cerithium (*kobelti*)	+	-	-	-	-
Cerithium coralium	+	-	-	-	-
Cerithium sp.1	++	-	-	-	-
Cerithium sp.2	+	-	-	-	-
Cerithium sp.3	+	-	-	-	-
Family Iravadiidae					
Iravadia sp.	+	-	-	-	-
Iravadia (*reticulata*)	-	-	+	-	-
Family Nassariidae					
Hebra sp.	+	-	-	-	-
Family Mitridae					
Mitra sp.	+	-	-	-	-
Family Carychiidae					
Melampus (*luteus*) sp.1	-	-	-	-	+
Melampus (*luteus*) sp.2	-	-	+	-	-
Family Onchidiidae					
Platevindex sp.				+	
Family Ellobiidae					
Cassidula aurisfelis		+			
Cassidula mustelina		+			
Class Pelecypoda					
Family Unguliniidae					
Cycladichama (*oblonga*)	+	-	+	-	-
Family Lucinidae					
Pillucina sp.	-	-	+	-	-

Table 3.19 (cont.)

Taxa	Station				
	TNK A1	TNK A2	TNK R1	TNK R2	TNK M
Family Erycinidae					
Pseudopythina (*sagamiensis*)	-	-	+	-	+
Family Mactridae					
Mactra (*ortona*)	+	-	-	-	-
Semelangulus sp.	+	-	-	-	-
Family Laternulidae					
Crassostrea commercialis (หอยนางรม)	+	-	-	-	-

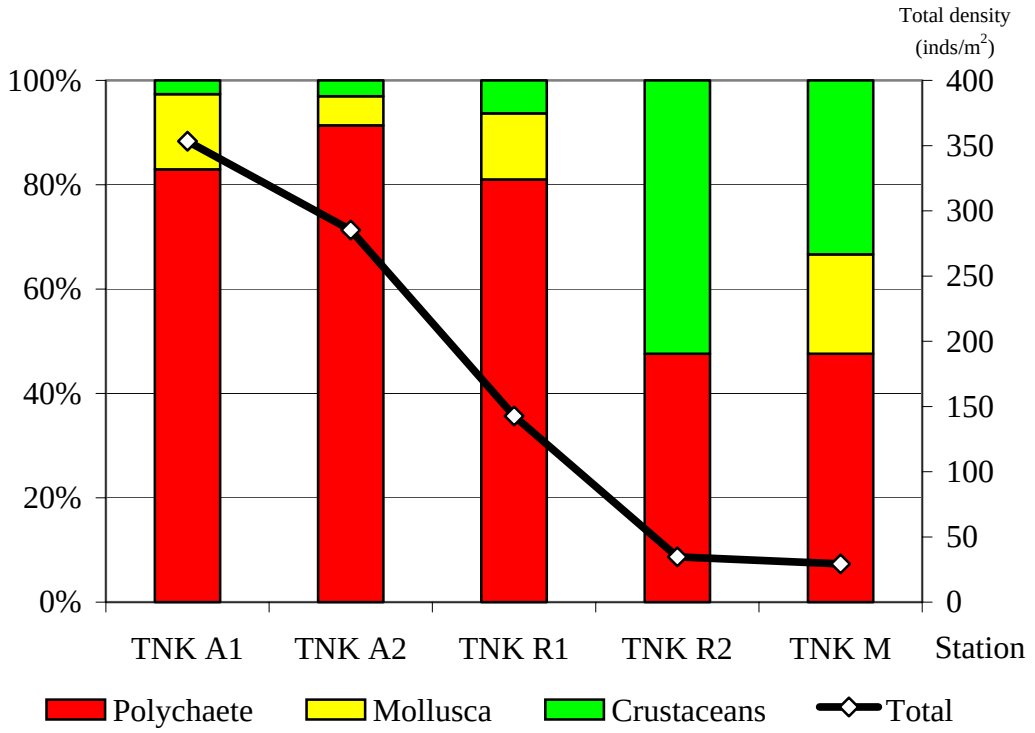
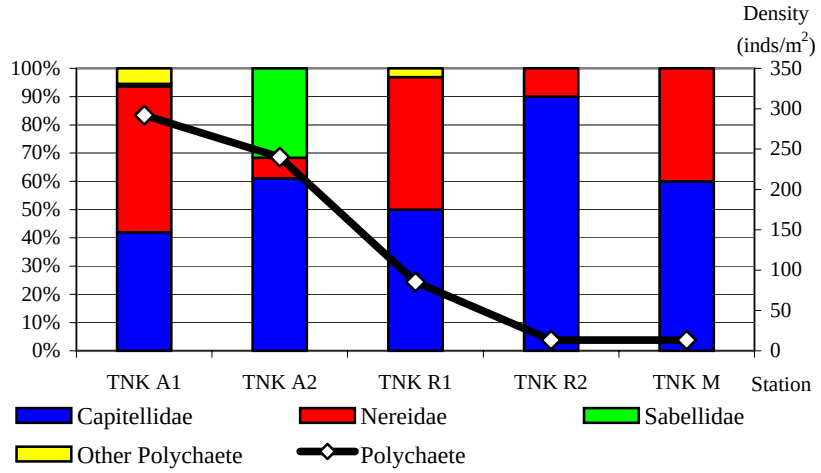
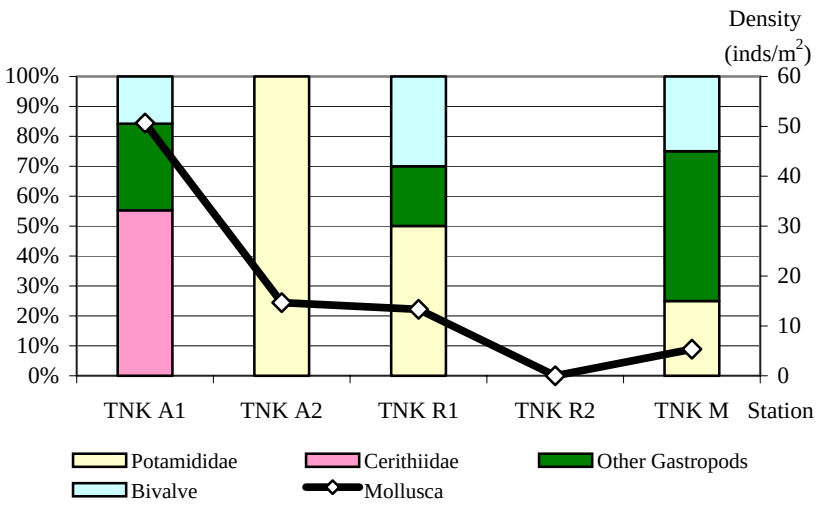


Figure 3.35 Ratio of Polychaete : Mollusca : Crustacean in Ban Nam Khem mangrove forest during the post-tsunami in October 2005.





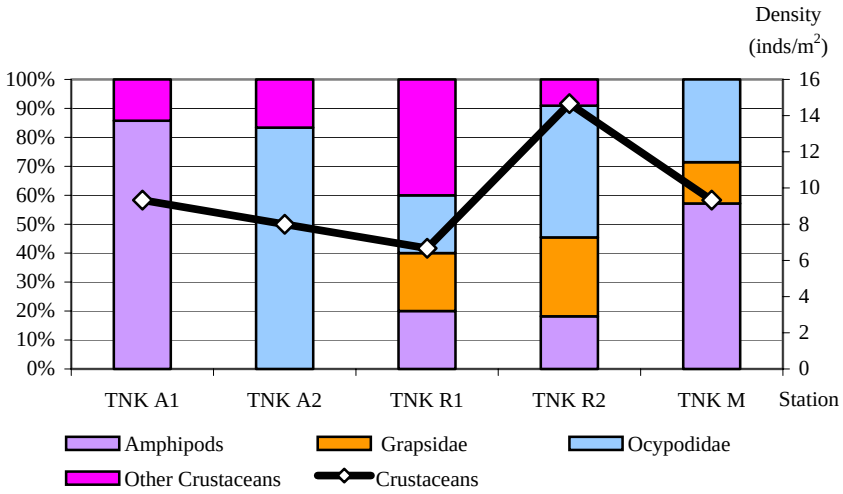


Figure 3.36 Composition and total density of benthos in Ban Nam Khem mangrove forest during post-tsunami in October 2005:
(a) Polychaete
(b) Mollusca
(c) Crustaceans

Table 3.20 Composition of macrofauna in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-10 inds/m^2
(++) = 11-100 inds/m^2
(+++) = 101-1,000 inds/m^2

Taxa	Station					
	TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Phylum Coelenterata						
Sea anemone (ดอกไม้ทะเล)	-	-	-	-	-	+
Phylum Nematoda						
Nematodes (หนอนตัวกลม)	+	+	-	+	+	+
Phylum Annelida						
Class Polychaeta (ไส้เดือนทะเล)						
Family Arabellidae	-	-	-	-	-	++
Family Capitellidae	++	++	++	+++	++	+++
Family Cirratulidae	++	++	-	++	++	++
Family Eunicidae	-	++	+	-	-	-
Family Lumbrineridae	-	+	+	-	++	+++
Family Maldanidae	+	++	-	+	++	++
Family Nereidae	+++	++	++	++	++	++
Family Polynoidae	+	-	-	-	-	-
Family Pisionidae	-	++	+	-	-	-
Family Sabellidae	++	++	++	++	++	+
Family Syllinae	++	-	-	-	-	-
Family Onuphiridae	-	-	-	-	+	-
Trochophore larva	-	+	-	-	-	-
Phylum Sipuncula						
Sipunculids (หนอนถั่ว)	-	-	-	+	+	-
Phylum Arthopoda						
Class Crustacea						
Subclass Cirripedia						
Balanus sp. (เพรียงหิน)	+	-	-	-	-	-
Order Cumacea						
Cumaceans (คิวมาเซียน)	-	-	-	+	-	-
Order Thanidacea						
Thanidaceans (ทาไนดาเซียน)	+	-	-	-	-	-
Order Isopoda						
Isopods (ไอโซพอด)	+	+	-	-	++	-
Order Amphipoda						
Amphipods (แอมฟิพอด)	++	+	-	++	++	-
Order Decapod						
Suborder Natantia						
Family Palaemonidae						
Leptocarpus sp.	-	-	+	-	+	-
Family Alpheidae						
Alpheus audouini (กุ้งดีดขัน)	++	-	-	-	-	-
Shrimp larvae (ตัวอ่อนกุ้ง)	-	-	-	-	+	-
Suborder Reptantia						
Anomura	-	-	-	-	-	-
Family Upogebiidae						
Wolffogebia sp.	+	-	-	+	-	-

Table 3.20 (cont.)

Taxa	Station					
	TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Family Paguridae						
Coenobita cavipes (ปูเสฉวน)	-	-	-	+	+	-
Clibanarius padavensis (ปูเสฉวน)	+	-	-	-	-	-
Clibanarius longitarsus (ปูเสฉวน)	-	+	-	-	-	-
Pagurus sp.	-	++	-	-	-	-
Pagurus sp. (juveniles)	++	+	-	-	-	+
Brachyura						
Family Grapsidae						
Neoepisesarma versicolor (ปูแสมก้ามม่วง)	+	-	+	-	-	-
Parasesarma plicatum (ปูแสม)	+	-	-	+	-	-
Perisesarma eumolpe (ปูแสมก้ามแดง)	+	-	-	+	-	-
Metopograpsus latifrons (ปูแสม)	-	+	-	+	-	-
Metopograpsus frontalis (ปูแสม)	-	-	-	+	-	-
Metaplax cernulata (ปูแสม)	++	-	+	+	+	++
Varuna litterata (ปูแป้น, ปูจาก)	-	+	-	-	-	-
Metaplax sp. (juveniles) (ปูแสม)	++	-	-	+	++	++
Metaplax elegans (ปูแสม)	-	-	+	-	-	-
Metaplax distinctus (ปูแสม)	-	-	+	-	-	-
Nanosesarma pontianacensis (ปูแสม)	+	-	-	-	-	-
juveniles of Grapsid crab	+	-	-	-	-	-
Megalopa larvae of Brachyura	+	-	-	-	-	-
Family Ocypodidae						
Ilyoplax punctatus	-	-	-	+	-	-
Ilyoplax sp.	+	-	-	-	-	-
Ilyoplax (juveniles)	+	-	-	-	-	-
Macrophthalmus sp. (ปูตายาว)	+	-	-	-	+	-
Cleistostoma sp.	-	-	-	-	+	-
Ocypode ceratophthalma	-	+	-	-	-	-
Uca perplexa (ปูก้ามดาบ)	+	-	-	-	-	-
Uca bengali (ปูก้ามดาบ)	-	-	-	-	+	-
Uca sp. (juveniles) (ปูก้ามดาบ)	+	-	+	-	-	+
Family Xanthidae						
Sphaerozius nitidus	+	-	-	-	-	-
Typhlocarcinus nudus (ปูไข่)	+	-	-	-	-	++
Class Insecta						
Insect larvae (ตัวอ่อนแมลง)	++	-	-	+	-	++
Mollusca						
Class Gastropoda						
Family Trochidae						
Umbonium sp. (หอยทับทิม)	-	+	-	-	-	-
Family Cyclostrematidae						
Liotinaria (peronii)	-	-	-	-	++	-

Table 3.20 (cont.)

Taxa	Station					
	TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Family Neritidae						
Ritena undata	-	-	+	-	-	-
Nerita (theliostyla) planospira	-	-	-	+	-	-
Nerita articulata	+	+	-	+	-	-
Clithon sp. (หอยถั่วเขียว)	+	+++	-	-	-	-
Family Littorinidae						
Littorina scabra (หอยขี้นก)	-	+	-	-	-	-
Family Stenothyridae						
Stenothyra sp.	++	-	-	-	-	+
Family Rissoidae						
Alvania (mamillata)	+	-	-	-	-	-
Family Vitrinellidae						
Teinostoma proboscidea	-	-	-	-	-	++
Family Tornidae						
Pygmaeorota (cingulifera)	+	-	-	-	-	-
Family Turritellidae						
Turritellopsis acicuta stimpsoni	++	-	-	-	-	-
Family Iravadiidae						
Fairbankia spp.	++	-	+	-	-	++
Family Potamididae						
Cerithidea cingulata	+++	++	-	-	-	+
Cerithidea djadjariensis	+++	++	-	+	+	-
Telescopium telescopium	-	-	-	-	+	-
Family Cerithiidae						
Conocerithium (repletutum)	-	-	+	-	-	-
Plesiotrochus (acutangulus)	-	+	-	-	-	-
Cerithium coralium	+++	-	-	-	-	-
Family Cerithiopsidae						
Cerithiopsis sp.	+	++	-	-	-	++
Furukawaia sp.	++	-	-	-	-	-
Family Nassariidae						
Hebra sp.	+	-	-	-	-	-
Family Turridae	+	-	-	-	-	-
Family Scaphanderidae	+	-	-	-	-	-
Family Siphonariidae	-	-	-	-	+	-
Class Pelecypoda						
Family Nuculidae						
Nuculana sp.	-	-	-	-	-	+
Family Arcidae						
Striarca (Spinearca) interplicata	++	-	-	-	-	-
Barbatia sp.	-	-	-	-	-	++
Arca avellana	+	-	-	-	+	-
Family Mytilidae						
Musculus (senhousia)	+	-	-	-	-	-
Musculus cupreus	+	-	-	-	-	-
Family Codylocardiidae						
Carditellona (pulchella)	-	-	-	+	-	-
Family Sportellidae						
Anisodonta sp.	-	+	-	-	-	-
Family Ungulinidae						
Cycladichama (oblonga)	-	+++	-	-	-	-

Table 3.20 (cont.)

Taxa	Station					
	TBR-A1	**TBR-A2**	**TBR-R1**	**TBR-R2**	**TBR-C**	**TBR-PO**
Family Thyasiridae						
Thyasira sp.	+	-	-	-	-	-
Family Lucinidae						
Anodontia sp.	-	-	-	-	++	-
juveniles (unidentify)	+	-	-	-	-	-
Family Erycinidae						
Pseudopythina (sagamiensis)	-	-	-	+	-	-
Kellia (porculus)	-	+	-	-	-	-
Family Mactridae						
Mactra (ornata)	-	-	-	-	-	++
Family Tellinidae						
Fabulina (soyoae)	-	-	-	-	-	++
Tellina (minuta)	-	-	-	-	-	+
Tellina radians	-	-	-	-	-	+
Semelangulus sp.(juvenile)	+	-	-	++	-	-
juvenile (unidentify)	++	-	-	+	-	++
Family Solenidae						
Solen sp.	-	-	-	-	++	++
juveniles (unidentify)	+	-	-	-	-	-
Family Psammobiidae						
Gari sp.	-	-	-	-	++	-
Family Laternulidae						
Laternula (limicola)	+	-	-	-	-	-

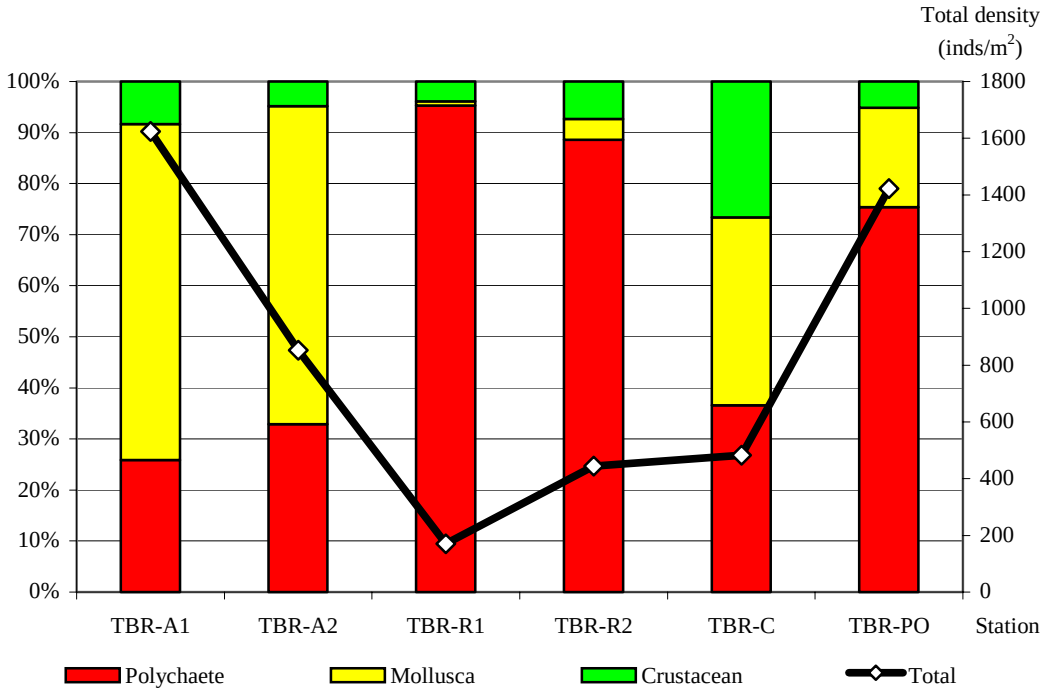


Figure 3.37 Ratio of Polychaete : Mollusca : Crustacean in Bang Rong mangrove forest during the post-tsunami in October 2005.

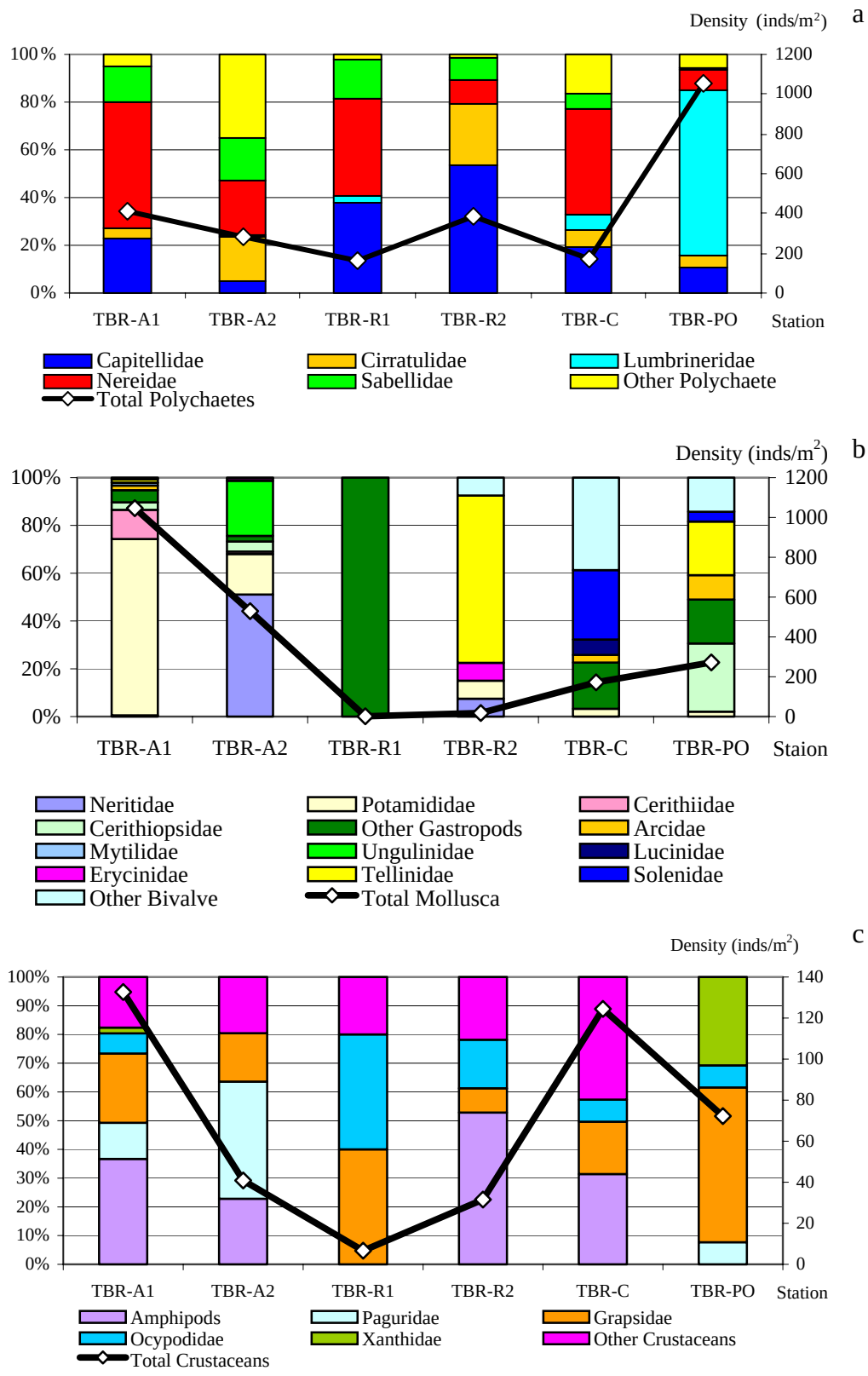


Figure 3.38 Composition and total density of benthos in Ban Nam Khem mangrove forest during post-tsunami in October 2005:
(a) Polychaete
(b) Mollusca
(c) Crustaceans

Fish communities and other vertebrates

Fish communities

Our fish data was not completed. We were not able to get good representative from Ban Nam Khem mangrove forest due to heavy storms at the time. The fishermen were too scared to go out and fish during the heavy rain. We had to resort to the fish landing belonging to the village headman in order to get the data. However, we had a good set of data for fish larvae of the two forests and a good set of data for fish population in Bang Rong. The Ban Nam Khem forest provided the breeding and nursery ground for several of the total 14 families of fish larvae, the family Adrianichthydae, *Oryzias javanicus,* was the most dominant. Family Eleotridae, *Butis butis* and Family Gobiidae, *Acantrogobius* spp. were next in terms of abundance of the total 11 species, mostly coastal fish were recorded. Table 3.21 and Table 3.22 showed the composition of fish larvae and fish population in Ban Nam Khem area.

Table 3.21 Composition of fish larvae in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 inds
(++) = 101-1,000 inds
(+++) = 1,001-10,000 inds

Scientific name	Common name	Station				
		TNK-A1	TNK-A2	TNK-R1	TNK-R2	TNK-M
Order Elopiformes						
Family Elopidae						
Elops machana (ตาเหลือกยาว)	Tenpounder	+	-	-	-	-
Family Megalopidae						
Megalops cyprinoides (ตาเหลือกสั้น)	Indo-Pacific tarpon	+	-	-	-	-
Order Clupeiformes						
Family Engraulidae (กะตัก)	Anchovies	+	-	-	-	-
Order Beloniformes						
Family Adrianichthyidae						
Oryzias javanicus (ชิวข้าวสาร)	Javanese ricefish	+	+	+	-	-
Order Perciformes						
Family Ambassidae						
Ambassis spp. (แป้นแก้ว)	Glass perchlet	+	-	-	-	-
Family Leiognathidae						
Leiognathus spp. (แป้น)	Ponyfish	+	-	-	-	-
Family Lutjanidae						
Lutjanus argentimaculatus (กะพงสีเลือด)	Mangrove red snapper	-	+	-	-	-
Lutjanus russelli (กะพงแดงข้างปาน)	Russell's snapper	+	-	-	-	-
Family Gerreidae						
Gerres oyena (ดอกหมากครีบสั้น)	Common silver-biddy	-	+	-	-	-
Family Mullidae (แพะ)	Goatfishes	+	-	-	-	-
Family Blenniidae						
Omobranchus spp. (กระบี่)	Blenny	+	-	-	-	-
Family Eleotridae						
Butis butis (บู่เกล็ดแข็ง)	Duckbill sleeper	+	+	-	-	-
Family Gobiidae						
Acentrogobius spp. (บู่)		-	+	-	-	++
Glossogobius biocellatus (บู่สองจุด)	Sleepy goby	-	-	+	-	-
Glossogobius spp. (บู่)		-	+	-	-	-
Papillogobius reichei (บู่)	Tropical sand goby	+	-	-	-	-
Periophthalmus argentilineatus (ตีน,กระบี่)	Barred mudskipper	-	-	-	+	+
Stigmatogobius sadanundio (บู่จุด)		-	+	-	-	-
Gobiidae	Goby	+		-	-	-

Table 3.21 (cont.)

Scientific name	Common name	Station				
		TNK-A1	TNK-A2	TNK-R1	TNK-R2	TNK-M
Order Pleuronectiformes						
Family Cynoglossidae						
Cynoglossus spp. (ยอดม่วง)	Tonguesoles	-	-	-	-	+
Order Tetraodontiformes						
Family Tetraodontidae						
Chelonodon nigroviridis (ปักเป้าจุดเขียว)	Spotted green puffer	+	+	-	-	-
Chelonodon patoca (ปักเป้า)	Milkspotted puffer	-	+	-	-	-
Fish larvae (Unidentified)		-	-	-	-	+

Table 3.22 Composition of fish in the mangrove forest at Ban Nam Khem, Phang-nga Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 inds
(++) = 101-1,000 inds
(+++) = 1,001-10,000 inds

Scientific name	Common name	Station	
		TNK-Coastal area	TNK-Klong Bang Muang
Order Elopiformes			
Family Elopidae			
Elops machanna (ตาเหลือกยาว)	Tenpounder	-	+
Order Siluriformes			
Family Ariidae			
Arius sagor (กดทะเล)	Sagor catfish	+	-
Order Mugliformes			
Family Mugilidae			
Chelon tade (กระบอก)	Tade mullet	-	+
Order Perciformes			
Family Sillaginidae			
Sillago sihama (เห็ดโคน)	Silver sillago	+	-
Family Carangidae			
Caranx sexfasciatus (หางแข็ง)	Bigeye trevally	+	+
Family Haemulidae			
Pomadasys kaakan (ครืดคราด)	Javelin grunt	-	+
Family Sciaenidae			
Dendrophysa russelli (จวดหน้าสั้น)	Goatee croaker	+	-
Otolithes ruber (จวดเตียน)	Tiger-toothed croaker	++	-
Pennahia anea (จวดครีบเทา)	Greyfin croaker	+	-
Family Scombridae			
Scomberomorus commerson (สีเสียด)	Narrow-barred Spanish mackerel	+	-
Order Pleuronectiformes			
Family Cynoglossidae			
Cynoglossus puncticeps (ช่างขุน)	Mottled tongue sole	-	-

The intact forest in Bang Rong provided the habitats for fish larvae and juveniles of a total of 19 families. The *Rhizophora* forests with their complex root system supported the highest fish diversity and density. Fish larvae in the family Clupeidae, Ambassidae, Leiognathidae, Nemipteridae and Gobiidae were common. Nineteen families of fish larvae were recorded in the area. Most dominant species were *Leiognathus equulus*, *L. decovus*, *Chelon tade*, *Ambassis nalva*, *Sillago sihama* and *Caranx sexfasciatus*. These were also economically important species. Table 3.23 and Table 3.24 showed the fish larval and fish composition in Bang Rong mangrove forest, Phuket Province, respectively.

According to the fish data, two groups of fish were found in the mangrove area. The permanent residents were fishes in the families Elopidae, Megalopidae, Clupeidae, Mugilidae, Adrianchthyidae, Platycephalidae, Centropomidae, Ambassidae, Leiognathidae, Gerreidae, Eleotridae, Gobiidae, Scatophogidae, Cynoglossidae and Tetraodontidae as shown in Table 3.25. Several fishes were partial residents coming into the forest to feed or utilize the forest as nursery ground. These fishes were in the families of Dasyatidae, Engraulidae, Ariidae, Belonidae, Scorpaenidae, Serranidae, Sillaginidae, Carangidae, Lutjanidae, Haemulidae, Sciaenidae, Teraponidae, Sphyraenidae, Scombridae and Monacanthidae.

Certain dominant fishes were dissected for stomach content analysis. The large proportion of 31.97% were carnivore, 27.55% were omnivore, 18.37% were herbivores and 22.11% detritivores. As the forests developed, the portion of carnivores and detritivores should increase.

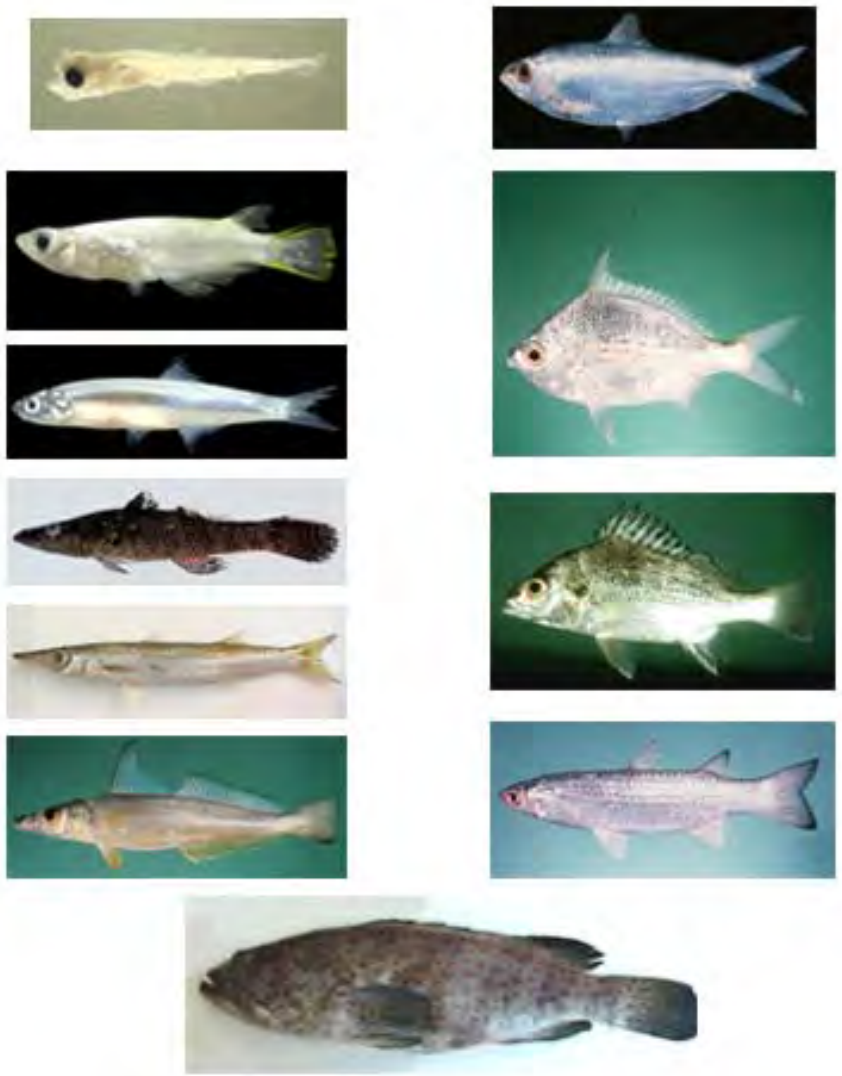


Table 3.23 Composition of fish larvae in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 inds
(++) = 101-1,000 inds
(+++) = 1,001-10,000 inds

Scientific name	Common name	Station				
		TBR-A1	TBR-A2	TBR-R1	TBR-R2	TBR-C
Order Elopiformes						
Family Megalopidae						
Megalops cyprinoides (ตาเหลือกสั้น)	Indo-Pacific tarpon	+	-	-	-	+
Family Engraulidae						
Engraulidae (กะตัก)	Anchovies	-	-	-	+	+
Thryssa spp. (แมว)	Thryssa	-	+	-	+	
Order Clupeiformes						
Family Clupeidae						
Clupeidae (หลังเขียว)	Herrings	++	+	+++	+++	+++
Escualosa thoracata (ชิวแก้ว)	White sardine	-	-	-	-	+
Order Mugliformes						
Family Mugilidae						
Mugilidae (กระบอก)	Mullets	-	+	-	-	-
Order Beloniformes						
Family Adrianichthyidae						
Oryzias javanicus (ชิวข้าวสาร)	Javanese ricefish	-	-	-	+	+
Order Scorpaeniformes						
Family Scorpaenidae						
Vespicula chinoides (ขี้ขุยขาว)	Goblinfish	-	-	-	-	+
Order Perciformes						
Family Ambassidae						
Ambassis spp. (แป้นแก้ว)	Glass perchlet	+	+	-	+	+++
Family Apogonidae						
Apogonidae (อมไข่)	Cardinalfishes	-	-	-	-	+
Family Sillaginidae						
Sillago sihama (เห็ดโคน)	Silver sillago	-	-	+	+	+
Family Leiognathidae						
Leiognathus equulus (แป้นชักษ์)	Common ponyfish	-	-	+	-	-
Leiognathus spp. (แป้น)	Ponyfish	-	-	++	-	+
Secutor spp. (แป้น)	Ponyfish	-	+	+	-	-
Family Lutjanidae						
Lutjanus russelli (กะพงแดงข้างปาน)	Russell's snapper	-	-	-	-	+
Family Nemipteridae						
Nemipteridae (ทราย)	Threadfin breams	+	-	+	+	+
Family Mullidae						
Mullidae (แพะ)	Goatfishes	-	-	-	+	+
Family Blenniidae						
Omobranchus spp. (กระบี่)	Blenny	-	-	+	+	-

Table 3.23 (cont.)

Scientific name	Common name	Station				
		TBR-A1	TBR-A2	TBR-R1	TBR-R2	TBR-C
Family Eleotridae						
Butis butis (บู่เกล็ดแข็ง)	Duckbill sleeper	+	-	-	-	-
Butis koilomatodon (บู่ฟันเลื่อย)	Mud sleeper	-	-	-	-	+
Family Gobiidae						
Gobiidae (บู่)	Goby	+	+	++	++	++
Papillogobius reichei (บู่)	Tropical sand goby	-	-	-	+	+
Paramonacanthus tricuspis (วัว)		-	-	-	-	+
Family Scatophagidae						
Scatophagus argus (ตะกรับ)	Spotted scat	-	-	-	-	+
Order Pleuronectiformes						
Family Cynoglossidae						
Cynoglossus spp. (ยอดม่วง)	Tonguesoles	-	-	-	-	+
Order Tetraodontiformes						
Family Tetraodontidae						
Chelonodon nigroviridis (ปักเป้าจุดเขียว)	Spotted green puffer	+	-	-	-	-
Arothron immaculatus (ปักเป้าหางด่าง)	Immaculate puffer	+	-	-	-	-
Fish larvae (Unidentified)		+++	-	++	++	++
Eggs		++	-	++	++	++

Table 3.24 Composition of fish in the mangrove forest at Bang Rong, Phuket Province during the post-tsunami in October 2005

(-) = Not found
(+) = 1-100 inds
(++) = 101-1,000 inds
(+++) = 1,001-10,000 inds

Scientific name	Common name	Station			
		TBR-A1	TBR-A2	TBR-R1	TBR-R2
Order Rajiformes					
Family Dasyatidae					
Himantura imbricata (กะบาง)	Scaly whipray	+	-	-	-
Order Elopiformes					
Family Elopidae					
Elops machanna (ตาเหลือกขาว)	Tenpounder	+	-	+	-
Order Mugliformes					
Family Mugilidae					
Chelon tade (กระบอก)	Tade mullet	+	++	-	-
Order Beloniformes					
Family Belonidae					
Strongylura strongylura (กระทุงควาย)	Spottail needlefish	-	-	-	+
Order Scorpaeniformes					
Family Platycephalidae					
Platycephalus indicus (หางควาย)	Bartail flathead	+	-	-	-
Order Perciformes					
Family Centropomidae					
Lates calcarifer (กะพงขาว)	Giant seaperch	-	+	-	
Family Ambassidae					
Ambassis interruptus (แป้น)	Sailfin perchlet	-		-	+
Ambassis nalua (ข้าวเม่า)	Scalloped perchlet	-	++	-	+
Family Serranidae					
Epinephelus bleekeri (กะรัง)	Sea basses	-	-	-	+
Epinephelus coioides (กะรังปากแม่น้ำ)	Orangespotted grouper	-	+	-	
Family Sillaginidae					
Sillago sihama (เห็ดโคน)	Silver sillago	+	-	+	+
Family Carangidae					
Caranx sexfasciatus (หางแข็ง)	Bigeye trevally	+	+	-	+

Table 3.24 (cont.)

Scientific name	Common name	Station			
		TBR-A1	TBR-A2	TBR-R1	TBR-R2
Family Leiognathidae					
Gazza dentex (แป้นทะเล)	Ovoid toothpony	-	-	+	+
Leiognathus decorus (แป้นจมูกสั้น)	Decorated ponyfish	-	+	++	+
Leiognathus equulus (แป้นยักษ์)	Common ponyfish	-	+	++	+
Leiognathus smithursii (แป้น)	Ponyfish	-	-	+	-
Leiognathus splendens (แป้นกระสวย)	Splendid ponyfish	+	-	+	-
Family Lutjanidae					
Lutjanus argentimaculatus (กะพงสีเลือด)	Mangrove red snapper	-	-	-	+
Lutjanus russelli (กะพงแดงข้างปาน)	Russell's snapper	-	+	+	-
Family Gerreidae					
Gerres filamentosus (ดอกหมากกระโดง)	Whipfin silverbiddy	-	-	+	+
Gerres oyena (ดอกหมากครีบสั้น)	Common silverbiddy	-	-	-	+
Family Haemulidae					
Pomadasys kaakan (ครืดคราด)	Javelin grunt	-	-	+	+
Family Sciaenidae					
Pennahia anea (จวดครีบเทา)	Greyfin croaker	-	-	+	
Family Teraponidae					
Terapon jarbua (ข้างตะเภาลายโค้ง)	Crescent perch	+	-	-	+
Family Scatophagidae					
Scatophagus argus (ตะกรับ)	Spotted scat	+	+	-	-
Family Sphyraenidae					
Sphyraena baracuda (น้ำดอกไม้)	Great baracuda	-	+	-	-
Order Pleuronectiformes					
Family Cynoglossidae					
Cynoglossus puncticeps (ช่างขุน)	Mottled tongue sole	+	-	+	-

Table 3.25 Fish communities in the Phang-nga and Phuket Mangrove Forest.

Permanent fish resident	**Partial residents (Nursery&Feeding Ground)**
Elopidae: *Elops machnata* **Megalopidae**: *Megalops cyprinoids* **Clupeidae**: *Escualosa thoracata* **Mugilidae**: *Chelon tade* **Adrianichthyidae**: *Oryzias javanicus* **Platycephalidae**: *Platycephalus indicus* **Centropomidae**: *Lates calcarifer* **Ambassidae**: *Ambassis interruptus* *Ambassis nalua* **Leiognathidae**: *Gazza dentex* *Leiognathus decorus* *Leiognathus equulus* *Leiognathus smithursii* *Leiognathus splendens* *Secutor* spp. **Gerreidae**: *Gerres filamentosus* *Gerres oyena* **Eleotridae**: *Butis butis* *Butis koilomatodon* **Gobiidae**: *Papillogobius reichei* **Scatophagidae**: *Scatophagus argus* **Cynoglossidae**: *Cynoglossus puncticeps* **Tetraodontidae**: *Tetraodon nigroviridis* *Arothorn immaculatus*	**Dasyatidae**: *Himantura imbricate* **Engraulidae**: *Thryssa* spp. **Ariidae**: *Arius sagor* **Belonidae**: *Strongylura strongylura* **Scorpaenidae**: *Vespicula trachinoidea* **Serranidae**: *Epinephelus bleekeri* *Epinephelus coioides* **Sillaginidae**: *Sillago sihama* **Carangidae**: *Caranx sexfasciatus* **Lutjanidae**: *Lutjanus argentimaculatus* *Lutjanus russelli* **Haemulidae**: *Pomadasys kaakan* **Sciaenidae**: *Dendrophysa russelli* *Otolithes rubber* *Pennahia anea* **Teraponidae**: *Terapon jarbua* **Sphyraenidae**: *Sphyraena barracuda* **Scombridae**: *Scomberomorus commersoni* **Monacanthidae**: *Paramonacanthus tricuspis*

Orther Vertebrates

Mangrove forests provide the feeding ground for several birds, snakes, monitor lizards and crab-eating macaque. Common birds in the area were Little Egret (*Egretta garzetta*), Great Egret (*Casmerodius albus*), Pacific swallow (*Hirundo tahitica*) and Eurasian Curlew (*Numenlus arquata*). These birds feed on shellfishes and aquatic animal. Brahming Kite, Monitor lizards and snakes shared the same niche of being predators. The crab-eating macaque is a very unique animal. They are omnivorous. They feed on crabs and molluscs. They sometime feed on larvae, fruits, *Rhizophora* propagules and pneumatophores.






Food web complexity

Our post-tsunami study on coastal and mangrove productivity in Ban Nam Khem mangrove forests, Phang-nga Province and in Bang Rong mangrove forest, Phuket Province revealed the biological productivity in these areas were not affected as the tsunami aftermath. These forests and coastal waters were in the range of Oligotrophic-mesotrophic environment. Primary production calculated from the chlorophyll *a* content was not exceeding 50 gmC/m^2/yr. With the exception of Khlong close to Ko Kho Khao in Ban Nam Khem and the pier in Bang Rong, high primary production was recorded in these areas. Phytoplankton biomass as calculated from chlorophyll *a* content was in the normal range prior to tsunami. Nanoplankton was the major primary producer in Ban Nam Khem. Copepods and polychaete larvae were the dominant consumers of nanoplankton while the picoplankton was the dominant primary producer in Bang Rong mangrove forest. This corresponded with the high occurrence of larvacean, the major consumer of these picoplankton. However, in Bang Rong estuary, the major primary producers were nanoplankton and microplankton. Large zooplankton, such as copepods, *Lucifer* and mysids were found. Zooplankton composition in these areas were marine affiliated. Zooplankton composition has not been altered when compared to those pre-tsunami reports.

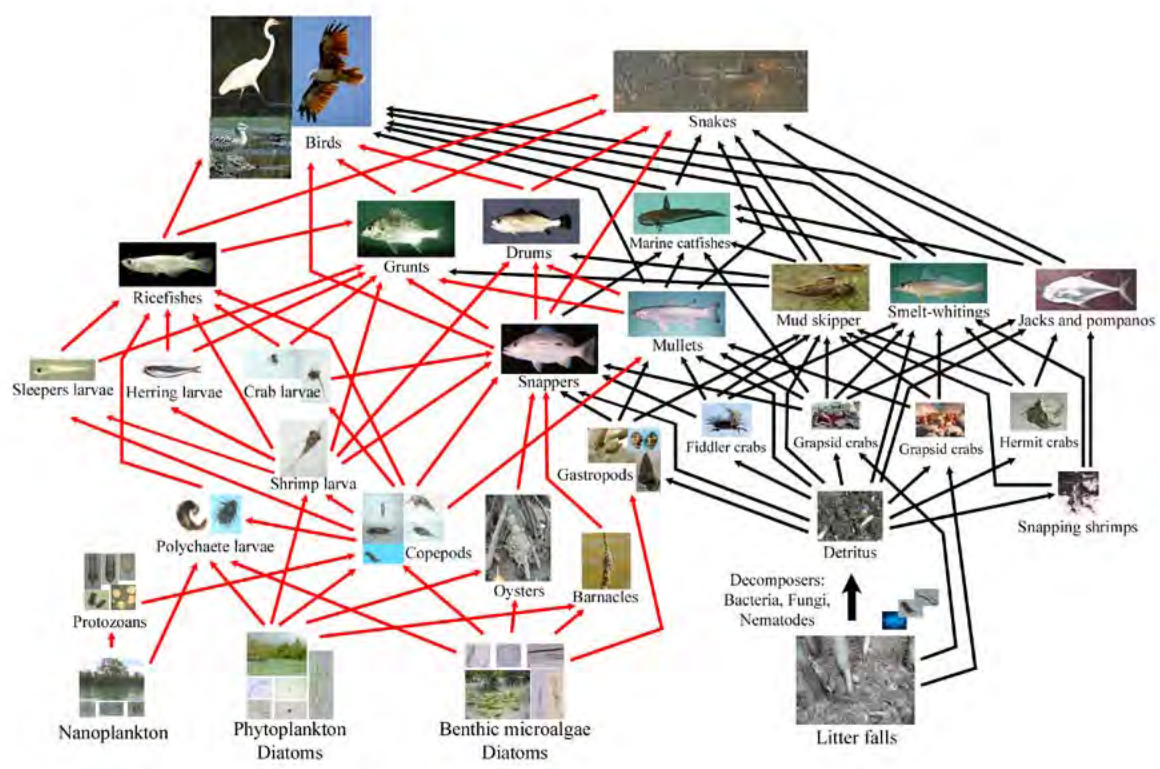


Figure 3.39 Food web complexity in Ban Nam Khem mangrove forest, Phang-nga Province during post-tsunami in October 2005. Grazing food chains indicated by → line while detrital food chains indicated by → line.

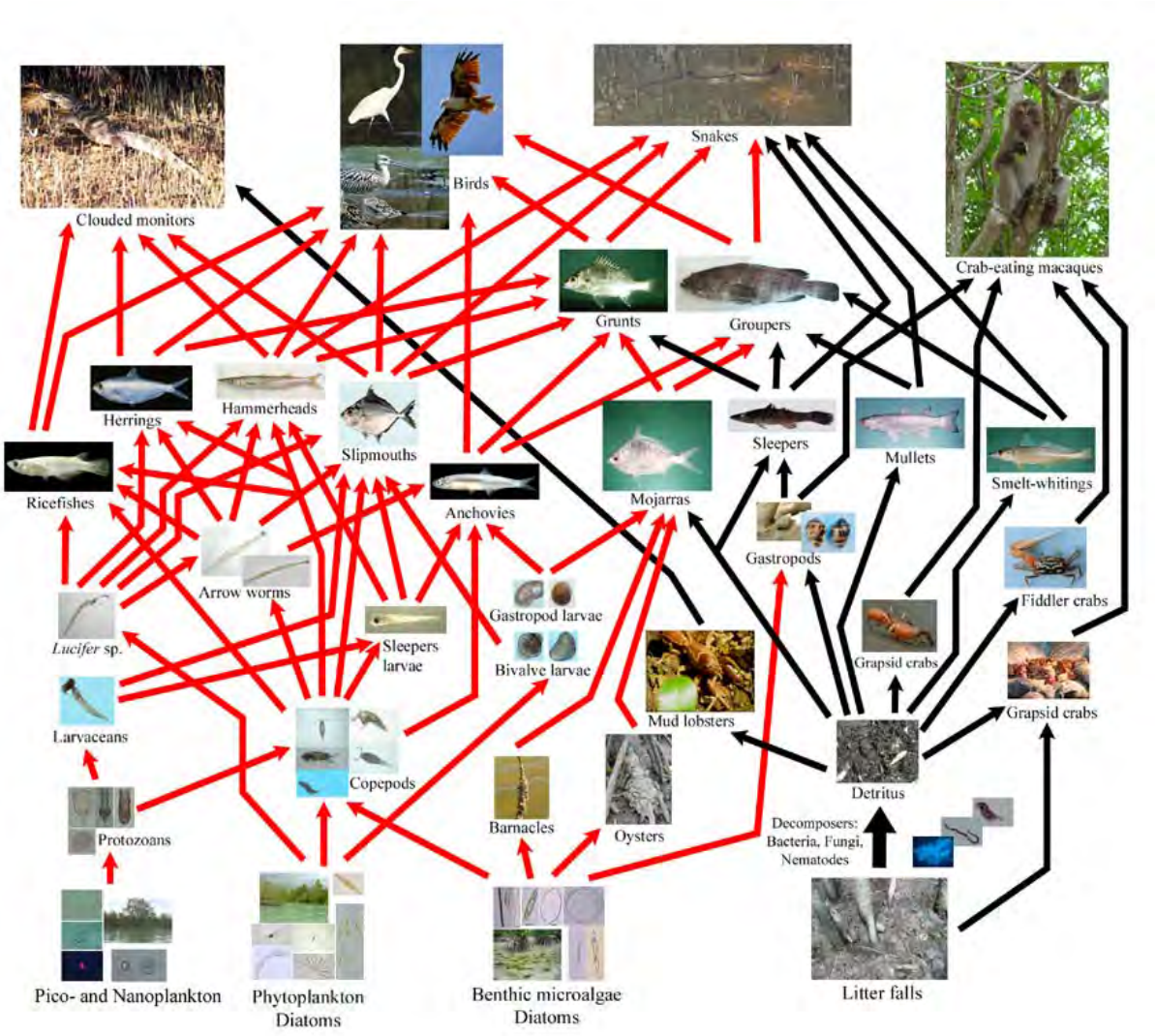


Figure 3.40 Food web complexity in Bang Rong mangrove forest, Phuket Province during post-tsunami in October 2005. Grazing food chains indicated by ⟶ line while detrital food chains indicated by ⟶ line.

Food web complexity in Ban Nam Khem mangrove forest, Phang-nga Province and Bang Rong mangrove forest, Phuket Province reflected the resilience of the ecosystem to environmental changes and disturbances. Major primary producers, such as micro-phytoplankton, nanoplankton and picoplankton, were found. Zooplankton of different trophic levels, herbivores, omnivores and carnivores, were found. Fish diversity in terms of feeding ecology with herbivores, benthic feeders, zooplankton feeders, detritivores and carnivores reflected the niche partitioning in the ecosystem. Thus, we found the diversity of fishes, birds, both local and migratory, as well as reptiles, amphibians and mammals that came into the mangroves to feed, seek shelters and to breed and nurse their offsprings.

Predictions of natural recovery of mangrove ecosystems

Mangrove ecosystem is usually dynamic. Natural changes in soil and water quality may facilitate the replacement of one mangrove species by another as succession proceeds. The seaward margins of the mangrove forest often show evidence of advance as indicated by abundance of seedlings and saplings/young plants and sustained advance by unbroken rising canopy of mangrove that increases in age and size landward (Bird and Barson, 1982). Natural recovery of the study area, in particular in Bang Rong as revealed from our field survey was quited rapid. This corresponds to the findings of Chairatana, 2005; Patanaponpaiboon and Poungparn, 2005; Poungparn and Patanaponpaiboon, 2005) Patanaponpaiboon and Poungparn (2005) reported the apparent impact found in the physical damage of broken and fallen trees. Some mangroves showed damage of root system, such as *A. marina*. Elevation of shoreline was lifted in certain area so that aerial roots became dry. They concluded that coastal vegetations affected by tsunami disaster can be naturally rehabilitated if time is allowed. The rate of recovery can be intervened by human activities.

In Bang Rong, high density of seedlings and saplings was recorded. Also the natural seed production areas were unaffected. These areas were in the vicinity of the selected mangrove forests. Tree density was also high, particularly pioneer species. As revealed from our field data, the hydrology and sediment quality were slightly affected. The tidal inundation in most of selected sites have not changed. Thus, this will not affect the natural regeneration and recovery. In certain area of Ban Nam Khem, in particular the tidal flat, low density of seedling and saplings were recorded.

Recovery capacity in mangrove ecosystem in relation to biological diversity and productivity was evidenced from our field survey. The biodiversity and productivity were comparable to those reported prior to tsunami. The high stability and food web complexity in the two mangrove forests contributed as the driving forces to sustain the coastal ecological processes. The two mangrove forests continue to provide ecological functions as habitats, nursery ground and feeding ground to numerous mangrove inhabitants. The return of certain birds and long-tailed macaques in the affected areas was a good indication.

Chapter 4

Post-tsunami: Monitoring of Impact Assessment on Demographic and Socio-economic Status

Siriwan Siriboon Busarin Bangkaew
Chanette Milintangkul and Nittharatana Paphavasit

The Indian Ocean Tsunami of December 26, 2004 caused economic and ecological disaster in 13 Asian and African countries. The montrous waves killed more than 0.2 million people and left about 2 million people homeless. The tsunami disaster resulted in a loss of 6 billion US $ in 13 countries (Kathiresan and Rajendran, 2005). According to the Office of Natural Resources and Environmental Policy and Planning (2006), the tsunami, which strucked 6 provinces on the Andaman coastline of Thailand, had caused colossal destruction including loss of lives and damage to property, natural resources and the environment. It caused severe damages to the society and economy as well. Casualties count confirmed 5,395 people from more than 37 countries including Thailand while some 8,457 people were injured. Other 2,817 people were still missing. Severe damages occurred to residential building, hotels, shops, schools and government buildings including offices of national parks, roads, ports and piers. Fishing communities were affected due to loss of life, boats as well as fishing gears, fish and shrimp ponds and fish cages. Village water supply systems and sources of freshwater, beach front and public gardens, were severely damaged.

Environmental impact assessment of the tsunami in Thailand as conducted by Aiemsiri *et al.* (2005) in the affected areas in 6 provinces revealed low impact with approximately 19 percent of the total number of villages were being affected. Urban community areas of Phuket had the highest degree of impact. More than 70 percent of the affected areas were claimed to be unused land and coastal areas. Workplaces and premises mainly for tourism business were most affected, accounting for 87.7 percent of loss. Fishery accounted for 12 percent of loss and agricultural areas had only 1.2 percent loss. Fisheries yields decreased but recovered in a short time. Decrease in catch were mainly from the damages of fishing gears and equipments. Public health and safety facilities experienced moderate impacts. In the first month, there were 3,823 cases of patients that needed monitoring and 9,174 cases that needed psychiatric services. Most of the water supply, electricity, telephone, sewage facilities and road, mostly in urban areas, were damaged. These were rehabilitated in a short period of time.

The impact of tsunami disaster on demographic and socioeconomic in the coastal communities was evidenced as our results from Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province revealed. Several studies of mangrove forest communities in Thailand showed that the fishing communities had moderate and reasonable standard of living. They followed closely His Majesty King Bhumibol Adulyadej of Thailand guidance on self-sufficiency. The fishermen had faced major obstacles in pursuing their livelihoods namely the degradation of coastal ecosystem, declining fishery production and conflicts of interest between commercial and small-scaled fishery. It was found that those who received direct benefit from the mangrove forest in particular the fishermen were more determined than others to participate in the rehabilitation programs (Siriboon, 2000). The changes in mangrove productivity would be the major factor sustaining the fishing communities and their livelihood. In turn, the prosperity of the fishing communities would provide a good indicator of coastal productivity. Of the two research sites chosen in this study, the population

structures were quite similar in terms of occupation compositions. Most people were not in fishing occupation. Prior to the tsunami, people at Ban Nam Khem were mainly fishermen. As the tsunami aftermath, the number of fishermen was drastically reduced due to the loss of their boats and fishing gears. These fishermen turned to other occupation mainly being labourers. In contrast to Bang Rong, the community was in the urban vicinity of Phuket. The ratio of fishermen was lower than non-fishing occupations. Most of the fishermen lived on the coast and continued the fishing occupation as a family tradition. Looking at the percentage of indigenous population, more than 50 percent of the Bang Rong residents were born within the village. They were bounded to participate in the community activities or rehabilitation programs. It is predicted that the participation in any community programs at Ban Nam Khem area would be less due to less than 20 percent were indigenous population.

Public perception of the impact of tsunami on demographic and socio-economic status.

Our study was aimed to elucidate impact of tsunami on the life of people in the studied areas. The statistics on Table 4.1 indicated that almost everyone in Ban Nam Khem was affected from tsunami. The socio-economic conditions of the community were affected. It was found that about half of the villagers in Ban Nam Khem experienced both direct and indirect effect from tsunami. While other 48 percent claimed direct impact, which were listed as job loss (58%), loss of housing (51%), damages on dwellings (28%) and damages on property (14%). Twenty eight percent of household reported the loss of household members or relatives. The indirect impact of tsunami on the village livelihood in Ban Nam Khem revealed that three-fourth of the population had mental health problem. The fear of tsunami, the stress and sorrow due to the loss of their loved ones, the feeling of being unsecured about their future and career and also the lack of faiths were the main factors underlying the mental health problems.

The information from qualitative data derived from in-depth interview of the community leaders and key informants reflected a major shake-up of the socio-economic status of Ban Nam Khem due to tsunami.

Sompong: Our village washed to sea. Houses were destroyed and people lost their jobs. Almost 100 % of fishermen lost their boats and fishing gears in the big wave.

Jermsak: Not only fishermen but also people from various occupations, for example labourers and mechanicians, were jobless. They also lost tools that they used for work. They did not have instruments so they could not continue with their jobs.

Wittaya: More than 90 percent of all houses were damaged altogether. Only 200 houses were not struck by the big waves. The most severe impact was on the occupation of the villagers. Ban Nam Khem was known as the fishing village. Almost 90 percent of boats were lost in the waves. Even though 10 percent remained, they were underrepaired. It seemed that the economy of the village was at rock bottom. There was almost no economic activity in Ban Nam Khem.

In-depth Interview in Ban Nam Khem, Phang-nga Province

In contrast, approximately 40 percent of people in Bang Rong claimed no impact from the tsunami. Only 18 percent experienced both direct and indirect effects. One-fourth of the population claimed receiving direct impact. The villagers in aquaculture and eco-tourism business were severely affected. There were about 20 villagers who ran aquaculture business. The cost of damage on fishing cages and gears used in aquaculture was estimated to be around 10 million bahts. The unestimated high loss of income was due to the decline in number of tourists for fear of tsunami. Like Ban Nam Khem, the high proportion of people in Bang Rong had mental health problems. Even though no casualty had been reported during tsunami, Bang Rong villagers had anxieties over the uncertain future and the risk of another tsunami.

Amphon: No one died. However our properties, such as cages and tools for aquaculture, boats and houses along the river bank, were severely damaged. The total cost was estimated to be about 10 million bahts.

Lert: Here, the impact of tsunami on economic condition as related to fishery was relatively small. Only about 10 % of fishery were damaged. People who were involved in eco-tourism and service sectors, in fact, were severely impacted because the number of tourists declined.

In-depth Interview in Bang Rong, Phuket Province

Table 4.1 Percentage of respondents in relation to the perception on the direct and indirect impacts of tsunami on their livelihood.

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Impact of tsunami on the livelihood of respondents and their families			
No impact at all	3.6	37.5	14.0
Receiving direct impact	47.5	25.6	40.7
Receiving indirect impact	1.5	19.3	7.0
Receiving both direct and indirect impacts	47.5	17.6	38.2
Total	100.0 (394)	100.0 (176)	100.0 (570)
Direct Impacts from tsunami			
Lost house/dwelling	50.8	1.3	42.3
House/dwelling damaged	27.5	3.8	23.5
Loss of Household members	28.1	1.3	23.5
Impact on occupation	57.8	87.2	62.8
Lost all property/bankrupt	9.4	0.0	7.7
Property damaged	14.2	12.8	13.9
Mental health problem	2.1	1.3	2.0
Being injured	3.2	1.3	2.9
Indirect Impacts from tsunami			
Lost job	39.5	80.0	49.3
Mental health	66.3	26.2	56.7
Lost everything/having no future	4.4	0.0	3.3
Being injured	0.5	0.0	0.4
Quit school	1.0	0.0	0.7

The respondents in Ban Nam Khem were asked to evaluate the impact of tsunami on community economy. Their views were shown in Table 4.2. It was evident that the impacts were inflicted on their work status and level of income. The decline of income among the villagers (67%), bankruptcy of community members (63%), increased unemployment rates (32%) and changes in type and pattern of occupation of the villagers (16%) were main economic problems of community caused by tsunami.

Sommai: It has been already 1 year that we haven't earn a living. We asked for the support for our boats and other fishing gears but could not get them. Until now, we are unemployed. People in the village are all unemployed. We have only expense. We have no income but we have to pay for electricity and water supply.

Samart: Economic condition of the village became worse. There is almost no income generated. Only some fishermen can fish. Most of the villagers survived by receiving money donated from charity.

Suwit: Now only 7-8 big boats could fish in the deep sea since most of the big boats were damaged. Every off-shore fisherman had debts exceeding one million baht. The fishermen who owned big boats were rated by the government as a middle class who can easily stand on their feet. In fact, they had already spent a large amount of money on investment prior to tsunami. They had debts before facing the disaster. After tsunami, the situation was worsened. Some fishermen had debts totalling 8 to 10 million baht.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Other impacts from tsunami viewed by the respondents in Ban Nam Khem were mainly mental health problems, loss of people in community and the impact on population structure since people had to move out of the village.

Samart: Some people moved out because they had a horrible experience from the disaster. They did not want to stay here any more. They changed their place of living and built up new houses in other sites. They did not want to stay in the same place as before. They abandoned their own houses. Many villagers requested for new permanent houses from the government in the community far away from seashore. They were tensed and depressed. Most stressful people have had direct experiences. They were almost drowned in the big waves during the time. It caused great anxiety to them.

In-depth Interview in Ban Nam Khem, Phang-nga Province

In Bang Rong, as reported by the respondents, the villagers were facing similar economic problems as in Ban Nam Khem. The impact of tsunami caused a high rate of unemployment, change in occupations, aquaculture damages, increased cost of investment and insufficient incomes. Since people in Bang Rong were dependent on the pristine mangrove forests and the wealth of coastal resources, it was found that one-fourth of respondents was worried about the depletion of water resources and water quality caused by tsunami. However, almost 70 percent of respondents in Bang Rong did not see any significant impacts of tsunami, besides economic impact. Mental health impact was stated as one of the main problems in Bang Rong population. This was similar to Ban Nam Khem.

> *Prakorn: Another main impact was mental health. People were stress and they still feared of tsunami. Even though some were retrieved, the bad experience still hung deep on their minds. Some people dared not spend money on investment because of the uncertainty of the situation.*
>
> *In-depth Interview in Bang Rong, Phuket Province*

Table 4.2 Percentage of respondents in relation to the perception on the impacts of tsunami on the economic condition of the community.

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Impact of tsunami on the economy of the community			
No impact at all	2.0	9.7	4.4
Changing occupation	16.6	16.4	16.5
Job lost /bankruptcy	63.0	27.7	52.7
Unemployed	31.9	24.5	29.7
Depletion of water resources	5.7	25.8	11.6
Aquaculture damages	0.5	13.2	4.2
Being in debts	6.2	1.9	5.0
Lower income	66.6	77.4	69.7
Agriculture was damaged	0.5	3.1	1.3
Increase in cost of investment	3.1	8.8	4.8
Impact of tsunami on other aspects			
No impact at all			
Having to move to a new house	22.1	68.2	36.3
Having to move out of the village	4.9	1.8	4.4
Loss of Household members	28.3	0.0	24.0
Mental health problem	30.9	1.8	26.4
Loss of house/property	61.2	60.7	61.2
Environmental damage	5.5	17.9	7.4
Social problem/disorganized	3.6	16.1	5.5
Public utility system	3.6	3.6	3.6
Take advantages from event	2.0	0.0	1.7
Changing faith of religion	1.6	5.4	2.2
	0.7	0.0	0.6

Pre- and post-tsunami demographic condition

The changes in the population structure and composition in the study areas were monitored by household survey questionnaires. The comparative study on the number of household members before and after the tsunami disaster as shown in Table 4.3 indicated the impact of tsunami on the loss of household members due to death and migration. In Ban Nam Khem, Phang-nga Province the average number of household members in each family was reduced from 5 persons prior to tsunami to approximately 3.5 persons in the post-tsunami period. One-third of households suffered the loss of their members in tsunami. Among these households that suffered such loss reported, approximately 2 members died in the disaster. There was 17 percent of the households in Ban Nam Khem whose members moved out permanently to live in a new house in the same village, with the average number of 3 members moved out. The total percentage of households with members leaving Ban Nam Khem permanently was 16 percent. Among these households, it was found that 2 members on the average decided to move out of the village.

Suwit: Ban Nam Khem was like a slum area. It was crowded and people lived together in a dense area. Before the tsunami, there were about 1,556 households with 6,000 people. In fact, we once had about 8,000 people including immigrants. About 2-3 thousands of people died in tsunami.

Somporn: A Large number of population clearly decreased. Thousands of people died and lost in the disaster. Numerous houses were vanished. Even though new houses were built up, number of household members was low.

Chaiwit: Some people in labour age moved out temporarily to work in other villagse nearby. Majority moved out permanently from Ban Nam Khem and were registered as new members of Ban Pru-teaw and Ban Rut. Total number of villagers in Ban Nam Khem declined. Previously, we had more than 1,000 houses with about 4,800 members. Now the number of houses was decreased to less than 1,000 houses.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Since hundreds of houses in Ban Nam Khem were destroyed by the tsunami, only half of the sample households were located in the same areas prior to tsunami. Evidently, about 70 percent of households reported smaller size of their dwellings after tsunami. In addition, almost half of the households in Ban Nam Khem faced the problems of the decrease in the size of their land. The information on the ownership of the land for dwellings revealed the differences between the owners before and after tsunami. Prior to tsunami, the majority of people in Ban Nam Khem stayed in their own land (40 %) or the land that belonged to their parents or parents-in-law (20 %). As has been mentioned, most of the residents of Ban Nam Khem migrated from other areas to search for jobs. Therefore, about 20 percent reported that prior to tsunami, they rented land and dwellings from private sectors. The situation was changed after the tsunami. Almost half of the respondents indicated that they were now living on the land that belonged to government organizations, such as the Ministry of Natural Resource and Environment, school, temple and sub-district administration organization, as well as the land of non-governmental organizations.

The Bang Rong village in Phuket Province did not experience the loss in the same magnitude as Ban Nam Khem, Phang-nga Province. Luckily, the village received indirect impacts only from high standing waves. No severe loss of houses and dwellings and lives were reported. Only the fishing gears and boats were damaged. The population structure and composition in this village was not affected. The total number of household members remained the same of approximately 4 persons in each house. No migration was reported. The proportion and pattern of land and house ownership were not altered.

Table 4.3 Percentage of respondents in relation to the impact of tsunami on household composition

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Pre-tsunami total number of household members			
only one member	4.1	5.7	4.6
2-3 members	23.1	33.5	26.3
4-5 members	37.1	40.3	38.1
more than 5 members	35.8	20.5	31.1
Total	100.0 (394)	100.0 (176)	100.0 (570)
Pre-tsunami average number of household members	5.01	4.26	4.78
Post-tsunami total number of household members			
only one member	9.6	5.1	8.2
2-3 members	46.2	34.1	42.5
4-5 members	34.8	42.0	37.0
more than 5 members	9.4	18.8	12.3
Total	100.0 (394)	100.0 (176)	100.0 (570)
Post-tsunami average number of household members	3.44	4.20	3.67

Table 4.3 (cont.)

Category	Ban Nam Khem Phang-nga province	Bang Rong Phuket Province	Total
Post-tsunami death and migration of household members			
- Percentage of household suffered loss of members in Tsunami	29.2	0.0	20.2
- Average number of household members died in Tsunami	2.0	0.0	2.0
- Percentage of household whose members permanently moving out to live in a new house in this village	17.5	1.7	12.6
- Average number of household members permanently move out to live in a new house in this village	3.1	*	*
- Percentage of household whose members permanently moved out to live in another village	16.0	1.1	11.4
- Average number of household members that permanently moved out to live in another village	2.3	*	*
Post-tsunami place of resident of the respondent			
- In the same place (land area)	51.0	98.3	65.6
- In a new place (land area)	49.0	1.7	34.4
Total	100.0 (394)	100.0 (176)	100.0 (570)
Post-tsunami size of housing			
- Bigger than before	6.3	2.3	5.1
- Same as before	22.6	96.0	45.3
- Smaller than before	70.6	1.7	49.3
- Do not know/No answer	0.6	0.0	0.4
Total	100.0 (394)	100.0 (176)	100.0 (570)

* Not present due to small sample size

Table 4.3 (cont.)

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Post-tsunami size of land			
- Bigger than before	4.1	1.7	3.3
- Same as before	47.7	97.7	63.2
- Smaller than before	47.7	0.6	33.2
- Do not know/No answer	0.5	0.0	0.4
Total	100.0 (394)	100.0 (176)	100.0 (570)
Pre-tsunami land ownership			
- His own/spouse	39.6	N/A	39.6
- Parents	20.1	N/A	20.1
- Rent from private sectors	20.7	N/A	20.7
- Supported by government	1.8	N/A	1.8
- Relatives	8.9	N/A	8.9
- Friend	0.6	N/A	0.6
- Encroached land	4.7	N/A	4.7
- Temple ground	0.6	N/A	0.6
- Land of Subdistrict Administration Organization	3.0	N/A	3.0
Total	100.0 (169)	N/A	100.0 (169)
Post-tsunami land ownership			
- His own/spouse	33.8	53.4	39.8
- Parents	12.9	22.2	15.8
- Rent from private sectors	2.8	6.8	4.0
- Supported by government	23.1	4.5	17.4
- Relatives	3.6	9.1	5.3
- Friend	0.3	0.6	0.4
- Encroached land	3.3	3.4	3.3
- Temple ground	5.1	0.0	3.5
- School ground	11.4	0.0	7.9
- Land of World vision Organization	2.3	0.0	1.6
- Land of Subdistrict Administration Organization	1.0	0.0	0.7
- Do not know/No answer	0.5	0.0	0.4
Total	100.0 (394)	100.0 (176)	100.0 (570)

Since migration was one of the main factors contributing to the changes in population structure and composition, the questions on whether the villagers desired to move out of the village or to stay on were posed. The findings presented in Table 4.4 and 4.5 revealed the drastic change on the desire to migrate among villagers in Ban Nam Khem. Prior to tsunami, less than 5 percent of the residents of Ban Nam Khem claimed they wanted to move out of the village, mainly due to economic reasons: being unemployed (42%), not owning their own land and houses (32%) and having insufficient income (16 %). After tsunami disaster, the desire to migrate out of the village increased tremedously to 27 percent. As expected, the crucial reason was the risk of another tsunami. For those who decided to stay, half of them

reported having good jobs. Others felt that they belonged to here. Almost 40 percent have land ownership in the affected area.

The percentage of the villagers desire who expressed their to migrate out of the village in Bang Rong were similar prior to and post-tsunami period. Among those, who wanted to move out, expressed their fears of risking another tsunami (67%). Some were having certain difficulty due to economic reasons, such as no ownership of land and house (25%) and income decrease (17%). These were two push factors for out-migration.

Table 4.4 Percentage of respondents in relation to the desire and reasons to migrate from the village in pre-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
The desire to move out of the village in pre-tsunami			
No desire	94.9	96.6	95.4
Want to move out	4.8	2.8	4.2
Not stay here prior to tsunami	0.3	0.6	0.4
Total	100.0 (394)	100.0 (176)	100.0 (570)
Reasons for desire to move out of the village in pre-tsunami			
Having poor neighbor	5.3	20.0	8.3
Jobless	42.1	60.0	45.8
No owners of land and house	31.6	20.0	29.2
Insufficient income	15.8	0.0	12.5
New job	5.3	0.0	4.2
Move to be live with family	5.3	0.0	4.2
Reasons for no desire to move out of the village			
Good physical environment	4.3	10.6	6.3
Good infrastructure	1.9	2.9	2.2
Good neighbors	3.5	2.9	3.3
Having job	69.8	37.1	59.6
Land and house ownership	34.2	46.5	38.1
Having sense of belonging	36.9	51.8	41.5
With relatives	0.5	1.2	0.7

Table 4.5 Percentage of respondents in relation to the desire and reasons to migrate from the village in post-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
The desire to move out of the village in post-tsunami			
No desire	72.8	93.2	79.1
Want to move out	27.2	6.8	20.9
Total	100.0 (394)	100.0 (176)	100.0 (570)
Reasons for the desire to move out in post-tsunami			
Risk of another tsunami	88.8	66.7	86.6
Jobless	4.7	0.0	4.2
No land and house ownership	8.4	25.0	10.1
Reduced income	4.7	16.7	5.9
Mental health problem	4.7	0.0	4.2
Reasons for the desire to stay on in post-tsunami			
Good physical environment	1.4	7.9	3.8
Good infrastructure	1.7	4.3	2.7
Good neighbors	1.7	1.8	1.8
Having job	50.5	35.4	45.0
Land and house ownership	38.0	52.4	43.2
Having sense of belonging	49.5	52.4	50.6
With relatives	0.0	0.6	0.2
Low cost of living	0.3	0.0	0.2

Impact of tsunami on socio-economic condition in coastal communities.

In this section, the retrospective observation on the economic status of the respondents prior to tsunami disaster was applied to assess the change in the status in the post-tsunami period. The respondents, in this case, were the breadwinners or spouses of the household heads. They were questioned about work status, type of occupation, income level and the sufficiency of income prior to and after tsunami. Table 4.6 indicated that prior to the tsunami, most respondents of 95 percent in Ban Nam Khem had jobs. Of these, a high proportion of spouses (86%) had job. Only one-fourth of respondents reported being unemployed. The main reasons for the unemployment household heads and their spouses, mainly female, prior to tsunami, were their responsibility for household chores.

It was evident that the tsunami has caused great impact on the economic conditions of Ban Nam Khem community as shown in Table 4.7. The statistic revealed a very high unemployment rate among the breadwinners and their spouses in the post-tsunami. Of all respondents, one-third was unemployed while one-fourth of their spouses was jobless. This reflected that the impacts of tsunami were apparent among the fishermen. The percentage of fishermen and related occupations declined from 38 percent prior to tsunami to 17 percent after the disaster. The same pattern can be seen in the spouses' occupations. The percentage of the spouses being fishermen declined from 33 percent to 18 percent.

Pongpat: We were unemployed for so long. Fishermen just started fishing only in the last 2 months. Before that they could not fish because they didn't have tools, instrument and fishing gears.

Sarayut: Besides those in fishery, people from other occupations were also affected. They were unemployed because they worked in the hotel. Some worked in Pi Pi islands and in Patong, Phuket. After the tsunami, hotels had no income, they had to lay off the employees.

In-depth Interview in Ban Nam Khem, Phang-nga Province

As shown in Table 4.7, more than half of the people in Ban Nam Khem (56%) had to change their occupations due to tsunami, particularly the fishermen. The main reason was due to the lack of instruments. 37% of fishermen were without boats and fishing gears 19% reported that fishing instruments were under repaired. No employment was reported at 33%. The lack of boats and fishing gears was the major problems to the fishermen. Of these fishermen in Ban Nam Khem, 51% were small-scaled fishery. Almost in the same proportion were commercial fishery. Few were in aquaculture business.

Damrong: Assuming that 100 percent of fishermen had operable boats prior to tsunami. I guessed that only 30 percent now were left. Fishermen needed time to repair their boats. Eventhough some may still have their boats, they are without fishing gears. The boats given as donation normally were not fully equipped.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Table 4.6 Percentage of respondents according to work status and type of occupation of respondents and their spouses in the pre-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Pre-tsunami work status of the respondents			
Not working	4.6	6.3	5.1
Working	95.4	93.8	94.9
Total	100.0 (394)	100.0 (176)	100.0 (570)
Pre-tsunami work status of the spouses			
Not working	6.6	17.6	10.0
Working	86.0	75.0	82.6
Single	6.3	6.3	6.3
Do not know	1.0	1.1	1.1
Total	100.0 (394)	100.0 (176)	100.0 (570)
Reasons for not working in respondents in pre-tsunami			
Health problem	5.6	9.1	6.9
No jobs	22.2	0.0	13.8
Studying in school	5.6	0.0	3.4
Doing household chore	66.7	90.9	75.9
Total	100.0 (18)	100.0 (11)	100.0 (29)
Reasons for not working in spouses in pre-tsunami			
Too old to work	6.7	3.0	4.8
Health problem	3.3	6.1	4.8
No jobs	23.3	6.1	14.3
Doing household chore	53.3	78.8	66.7
Do not know	13.3	6.1	9.5
Total	100.0 (30)	100.0 (33)	100.0 (63)

Table 4.6 (cont.)

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Types of occupation of the respondents in pre-tsunami			
Unemployment	4.8	6.3	5.3
Fishery/related to fishery	38.1	25.6	34.2
Agriculture	5.6	15.9	8.8
Employee	13.7	22.2	16.3
Commerce	24.9	17.0	22.5
Business/Service	9.4	9.1	9.3
Government/State enterprise	0.5	2.8	1.2
Technician	3.0	1.1	2.5
Total	100.0 (394)	100.0 (176)	100.0 (570)
Types of occupation of the spouses in pre-tsunami			
Unemployment	7.6	18.2	10.9
Fishery/related to fishery	32.5	11.5	26.0
Agriculture	4.3	18.8	8.8
Employee	17.9	22.4	19.3
Commerce	23.8	13.3	20.6
Business/Service	6.5	11.5	8.1
Government/State enterprise	2.4	1.2	2.1
Technician	3.0	1.8	2.6
Do not know	1.9	1.2	1.7
Total	100.0 (369)	100.0 (165)	100.0 (534)
Types of fishery in respondents and their spouses in pre-tsunami			
Fish cage/Fish pond	6.5	9.3	7.0
Aquaculture	10.0	25.6	13.1
Small-scaled fishery	51.2	62.8	53.5
Commercial off-shore fishery	50.6	7.0	41.8
No answer	1.2	2.3	1.4

Table 4.7 Percent distribution of respondents according to current type of occupation of respondents and their spouses in the post-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Post-tsunami current occupation of the respondents			
Unemployment	32.5	12.5	26.3
Fishery/related to fishery	17.3	22.2	18.8
Agriculture	1.5	16.5	6.1
Employee	19.0	22.2	20.0
Commerce	20.8	16.5	19.5
Business/Service	5.1	6.8	5.6
Government/State enterprise	1.0	1.7	1.2
Technician	2.8	1.7	2.5
Total	100.0 (394)	100.0 (176)	100.0 (570)
Post-tsunami current occupation of the spouses			
Unemployment	23.2	22.9	23.1
Fishery/related to fishery	18.4	7.8	14.9
Agriculture	1.6	14.4	5.8
Employee	22.9	22.9	22.9
Commerce	20.6	17.0	19.4
Business/Service	4.2	8.5	5.6
Government/State enterprise	1.9	2.0	1.9
Technician	2.9	2.0	2.6
Do not know	4.2	2.6	3.7
Total	100.0 (310)	100.0 (153)	100.0 (463)
Occupational shift in the respondents pre- and post-tsunami			
Same occupation			
Different occupation	44.4	79.5	55.3
Total	55.6	20.5	44.7
	100.0 (394)	100.0 (176)	100.0 (570)
Reason for the respondents' occupational shift after tsunami			
No instrument/ no boat	37.0	19.4	34.5
Unemployment	32.4	19.4	30.6
Instruments are under repaired	18.7	8.3	17.3
Less pay in former jobs	5.0	19.4	7.1
Fear for Tsunami	4.1	2.8	3.9
Bankrupt	6.4	5.6	6.3
Too old/not healthy	1.8	13.9	3.5
Too hard	1.8	8.3	2.7
Problem due to transportation	0.0	2.8	0.4
Others	3.7	11.1	4.7
Do not know/No answer	2.7	5.6	3.1

Many fishermen in Ban Nam Khem, Phang-nga Province were forced by situation to change their job. They seemed to have no choice. Since they normally had low education, the new job was limited to unskilled labour. Many fishermen had to work as labourers and needed to move to work away from their home. This had significant impacts not only on the economic structure of the families and community but also on changing life styles and relationships with family members.

> *Sompob: Former fishermen are now unemployed. They had to work as construction labourers. Some are still unemployed. They survived from compensation money provided by the government. They spent that amount of money for living not for investment. They still could not earn more by working. This is the biggest tragedy that I had ever seen.*
>
> *In-depth Interview in Ban Nam Khem, Phang-nga Province*

Our finding corresponded to the impact assessment from tsunami on fishery occupation in the 6 provinces on the Andaman Coastline, summarized by Department of Marine and Coastal Resources as shown in Table 4.8. The fishermen in Phang-nga Province were mostly affected by this disaster.

Table 4.8 Impact assessment from tsunami disaster on the fishery occupation in the 6 provinces on the Andaman Coastline (http://hazard.disaster.go.th/)

Province	**Damages (recorded from field survey)**								**Total Cost (Baht)**
	Aquaculture (No)			**Fishing Boats (No. of boats)**		**Fishing gears**			
	Fish cages	**Fish ponds**	**Hatchery**	**Small**	**Large**	**Stake traps**	**Nets**	**Traps**	
Phang-nga	1,733	7	67	390	473	-	477	517	913,549,111
Krabi	890	2	-	1,034	10	345	643	402	191,696,510
Phuket	529	2	209	968	473	-	649	72	320,504,169
Ranong	1,229	-	-	420	356	56	522	267	170,737,983
Trang	470	-	-	815	1	8	600	483	14,980,000
Satun	1,126	-	1	1	30	274	580	584	119,393,730
Total	5,971	11	277	3,628	1,343	683	3,471	2,322	1,730,861,458

In Bang Rong, Phuket Province, the tsunami disaster affected the economic conditions of following occupations: small-scaled fishery, aquaculture business and eco-tourism. As previously shown, aquaculture (26%) and small-scaled fishery (63%) were the main types of fishery in Bang Rong. In Bang Rong, the work status and types of occupation before and after the tsunami had not been altered. However, the percentage of unemployment increased from 6 percent prior to tsunami to 12 percent after the tsunami. The economic structure of the community also remained unchanged. Fishery, employee, agriculture and commerce were still the major occupation in Bang Rong.

> *Sirichai: Not much affected in terms of economy. Local fishery experienced small impact because mangrove forests protected them. Only a small group of fishermen who ran aquaculture business faced a small-scale impact. Only one boat of local fisherman was damaged.*
>
> *In-depth Interview in Bang Rong, Phuket Province*

When comparing the types of occupation of the respondents in Bang Rong before and after the tsunami, only 20 percent changed their jobs. However, the reasons for occupational shift could not be directly related to tsunami. It was highly attributed to health problems and less earning from former jobs, creating insufficient income.

Data on Table 4.9 revealed the indirect estimation of jobs satisfaction when questioned on the desire to change jobs. Obviously, half of the respondent in Ban Nam Khem were not satisfied with their jobs. As already mentioned, after the tsunami, people in Ban Nam Khem seemed to have no choice in working. When questioned on the desire to change jobs, half of the respondents said yes. Economic reasons were the main factors such as insufficient income (55%) and low payment (18%). Interestingly, 12 percent of respondents reported that they had no skill and other 8 percent wanted to seek for secured jobs. The latter reflected that some people in Ban Nam Khem still did not have permanent jobs. They seemed to work only to survive and did not have much choice. Almost half (47%) chose to work in commerce business because the work was independent in nature and did not require a large amount of investment. One-fifth mentioned that they would seek work in fishery or those related to fishery. These respondents were fishermen prior to tsunami and they would like to resume their occupation.

The situation in Bang Rong, Phuket Province, was different. The villagers were not forced by situation to find jobs due to small-scale impact on the economic condition. People were able to choose their desired job. Therefore, it was found that three-fourths of respondents were satisfied with their jobs and did not want to change their occupation. Among those who seek job change, commerce was their first choice. Similar proportion of respondents in Bang Rong, Phuket Province chose to work as fishermen (17%), agriculturists (14%) and employees (14%).

Table 4.9 Percent distribution of respondents on the desire and reasons to change jobs

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Desire to change job			
No desire	50.0	76.1	58.1
Desire to change change	50.0	23.9	41.9
Total	100.0 (394)	100.0 (176)	100.0 (570)
Reasons to change job			
Insufficient income	54.8	54.8	54.8
No skill	11.2	4.8	10.0
Seek better payment	17.3	14.3	16.7
Seek for secured job	8.1	16.7	9.6
Fear for Tsunami	3.0	0.0	2.5
Seek for independent job	7.1	9.5	7.5
Too old/not healthy	9.1	11.9	9.6
Boring/tedious	1.5	7.1	2.5
Others	2.5	0.0	2.1
No answer	0.5	0.0	0.4
Type of new occupation seek			
Fishery/related to fishery	20.3	16.7	19.7
Agriculture	11.2	14.3	11.7
Employee	8.6	14.3	9.6
Commerce	47.2	38.1	45.6
Business/Service	11.2	9.5	10.9
Others	2.5	7.1	3.3
Do not know	3.0	0.0	2.5

The data on the second occupation of the respondents was interesting since they could provide insightful information on the economic condition of the families and of the communities. From Table 4.10, it was interesting that prior to tsunami, more than 40 percent of people in Ban Nam Khem had second occupation. The proportion fell to only 11 percent after the disaster. The main reasons for having secondary occupation were due to additional income (67%) and insufficient income from the main job (38%).

Among those who had secondary occupation prior to tsunami, we found that 25 percent lost their secondary occupation after the tsunami. The reduction in the proportion of secondary occupation did not imply that people in Ban Nam Khem had sufficient income or were satisfied with their economic conditions in the post-tsunami period. Nevertheless, the lower proportion merely reflected the loss of economic opportunity in the community due to the tsunami. Our study revealed that before the tsunami, the economic condition of Ban Nam Khem was at peak. Job opportunity was open for all. Many occupations required unskilled labours and gave opportunity for those who needed additional income. Therefore, it was found that people still held on to their secondary occupations in Ban Nam Khem.

Table 4.10 Percent distribution of respondents having secondary occupations and reasons for the secondary occupations.

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Having secondary occupation in post-tsunami			
Not having secondary occupation	88.6	71.0	83.2
Having secondary occupation	11.4	29.0	16.8
Total	100.0 (394)	100.0 (176)	100.0 (570)
Type of secondary occupation in post-tsunami			
Fishery/related to fishery	20.0	23.5	21.9
Agriculture	13.3	25.5	19.8
Employee	37.8	27.5	32.3
Commerce	13.3	11.8	12.5
Business/Service	8.9	13.7	11.5
Others	6.7	9.8	8.3
Reasons for having secondary occupation			
Insufficient income	37.8	37.3	37.5
Having skill	6.7	9.8	8.3
Want additional income	66.7	68.6	67.7
No answer	0.0	2.0	1.0
Having secondary occupation in pre-tsunami			
Not having secondary occupation	64.0	68.8	65.4
Having secondary occupation	36.0	31.3	34.6
Total	100.0 (394)	100.0 (176)	100.0 (570)
Type of secondary occupation in pre-tsunami			
Fishery/related to fishery	21.8	27.3	23.4
Agriculture	12.0	20.0	14.2
Employee	33.1	29.1	32.0
Commerce	19.7	10.9	17.3
Business/Service	10.6	12.7	11.2
Others	7.0	7.3	7.1
Comparing type of secondary occupations of the respondents in pre- and post-tsunami			
Same secondary occupation	5.3	23.3	10.9
Different secondary occupation	5.6	2.3	4.6
No secondary occupation prior to tsunami	5.6	3.4	4.9
No secondary occupation prior to tsunami	24.9	6.8	19.3
Never have secondary occupation	58.6	64.2	60.4
Total	100.0 (394)	100.0 (176)	100.0 (570)

Interestingly, employee and fishery were ranked first and second in terms of secondary occupation. Most employees in Ban Nam Khem were hired in construction work, which allowed for unskilled labour. For those who chose fishery, most of them were working as small-scaled fishermen. They earned their living in the canal, near the mangrove forests. The fishery product was used as food and goods. Obviously, near-shore fishery and fishing in mangrove forest were alternative ways for survival. Many respondents reported that during the time that they were unemployed or during the monsoon period when the off-shore fishermen could not fish, they survived by fishing in the mangrove creeks and in mangrove areas.

> *Songpol: In rainy season, almost all villagers in Ban Nam Khem earn their living by fishing in mangrove areas because small fishing boats can not go out in the deep sea. They catch shellfishes from mangroves both for selling and their own consumption.*
>
> *In-depth Interview in Ban Nam Khem, Phang-nga Province*

In Bang Rong, where tsunami caused less direct impact on the economic condition and structure of the community, the proportion of secondary occupation remained unchanged during the time prior to and after tsunami. Employee, fishery and agriculture were still the major secondary occupations found in Bang Rong.

Our study revealed that those in small-scaled fishery, commercial fishery and aquaculture business were the first group of people who were able to be back on their own feets during the crisis. The intact mangrove forests provided them with ample food for consumption and to earn their living. They went out fishing in the mangrove creeks and the mangrove fringes. Most of the fishermen who worked in the commercial fishery could manage on ample subsitence from mangrove forest when they were unemployed. For those in aquaculture business, once the fishing cages and gears were repaired, they can easily operate again. The fertile mangrove forests provided them with the "natural welfare system" to sustain their needs and economy in the time of crisis. The fishermen can easily repaire their damaged fishing gears and houses with the wood from mangrove forest. Kiratiprayoon *et al.* (2005) carried out the impact assessment on the population condition in the vicinity of mangrove forests in Phang-nga area. They also found that the mangrove forests provided the villagers with stable incomes from fishery products, tourism and aquaculture. From their interview, the villagers expressed that the income derived from the mangrove forests remained the same or was slightly affected. The income from fishery products slightly dropped from 4,829 baht per family prior to tsunami to 3,600 baht after the tsunami. The aquaculture income also dropped from 5,892 baht prior to tsunami to 4,000 baht per family after the tsunami.

The 2004 tsunami caused catastrophic damage to beachside properties and particularly a great loss of lives along the Andaman coastline. This destructive natural disaster could turn people's livelihood from rich to rag overnight. The consequences of the disaster caused poverty in these affected not only for this generation but also the next ones. Table 4.11 reflected the great impact of tsunami on the economic status of people in Ban Nam Khem. The average household monthly income dropped from about 22,000 baht prior to tsunami to only 6,200 baht after tsunami. The ratio of loss was 3.5 times. Prior to tsunami, approximately 80 percent of people in Ban Nam Khem had sufficient income. The economic situation turned upside down when the village was struck by tsunami. Only one-third of people was reported with sufficient income.

Table 4.11 Percent distribution of respondents according to the average monthly household income pre- and post-tsunami disaster

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Pre-tsunami monthly household income			
Less than 5,000 Baht	5.8	15.3	8.8
5,000-9,999 Baht	29.2	38.1	31.9
10,000-19,999 Baht	32.7	25.0	30.4
20,000-29,999 Baht	12.2	9.7	11.4
30,000-49,999 Baht	9.4	6.8	8.6
50,000 Baht or more	9.1	4.0	7.5
Do not know/No answer	1.5	1.1	1.4
Total	100.0 (394)	100.0 (176)	100.0 (570)
Pre-tsunami average monthly household income	22,134.0	13,041.4	19,318.9
Pre-tsunami income sufficiency			
Sufficient income	78.7	72.2	76.7
Insufficient income	20.3	27.8	22.6
Total	100.0 (394)	100.0 (176)	100.0 (570)
Post-tsunami monthly household income			
Less than 3,000 Baht	28.7	7.4	22.1
3,000-4,999 Baht	22.8	15.9	20.7
5,000-9,999 Baht	28.4	40.9	32.3
10,000-19,999 Baht	12.9	19.3	14.9
20,000 Baht or more	5.8	15.3	8.8
Do not know/No answer	1.3	1.1	1.2
Total	100.0 (394)	100.0 (176)	100.0 (570)
Post-tsunami average monthly household income	6,209.2	10,901.7	7,659.4
Post-tsunami income sufficiency			
Sufficient income	35.5	56.8	42.1
Insufficient income	64.5	43.2	57.9
Total	100.0 (394)	100.0 (176)	100.0 (570)

The information on debts reflected the severity of financial problems. As indicated in Table 4.12, half of the respondents in Ban Nam Khem were, prior to tsunami in debt, exceeding 200,000 baht on average. Major sources of loan were not formal organizations such as bank or community funds supported by the government. High proportion of the respondents (25%) borrowed money from private money lenders who normally charged for a very high and unreasonable interest rate. Saving Cooperative arranged by community members seemed to be an alternative way of reducing of financial strains. However, the cooperative assisted only its own members, with a mere 16 percent being reported of receiving assistance. People in Ban Nam Khem were in debt prior to tsunami because the majority needed money for investment (73%) and for buying land and houses (16%). Unfortunately, about 17 percent were using the loan for daily living and expenses which indicated considerable financial strains.

Though the proportion of people being in debt in Ban Nam Khem declined from 50 percent prior to tsunami to 35 percent after tsunami, the average amount of debt before and after tsunami was not different. As indicated in Table 4.13, the average amount of debt due to tsunami was about 190,000 baht which was very close to 200,000 baht reported prior to tsunami. This reflected the severity of economic difficulty of people in Ban Nam Khem since the amount of debt caused by tsunami only was almost the same as cumulative debts from all sources prior to tsunami. Moreover, the respondents estimated that they would be in debt caused by tsunami for at least 3.5 years.

The reduction decrease of people being in debt after tsunami in Ban Nam Khem did not imply that the villagers did not face any economic difficulty. In fact, that phenomenon reflected the decline in their creditability. The source of loan data after tsunami confirmed the declining proportion of people borrowing money from formal organizations such as bank, savings cooperative as compared to those relying on informal sources, such as money lenders or friends and relatives since they lost their credits in business. Other source of loan after tsunami was non-governmental organizations such as religious organizations, or charity organizations. These sources, however, could not provide long term assistance. People in Ban Nam Khem expressed their concerns over the economic strain lasting for no less than 4 years or more.

In Bang Rong, the proportion of people reportedly being in debt prior to tsunami was lower than Ban Nam Khem. However, the average amount of debt was higher than that of Ban Nam Khem, about 230,000 bahts compared to 200,000 bahts. The pattern of loaned money spending in the two villages was quite similar. The majority of respondents in Bang Rong also spent money on investment (62%), buying land and house (30%) as well as daily living (13%). The discrepancy of the sources of loan prior to tsunami of the two villages was obvious. The proportion of people in Bang Rong who borrowed money from bank was about twice higher than that in Ban Nam Khem. However, the source of loan from informal sources, such as private money lenders was also detected.

Table 4.12 Percent distribution of respondents according to experience of having debts in the pre-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Pre-tsunami dept status			
No debt	50.0	55.7	51.8
In debt	49.5	43.8	47.7
No answer	0.5	0.6	0.5
Total	100.0 (394)	100.0 (176)	100.0 (570)
Pre-tsunami average amount of debt among the respondents who were in debt	207,884.6	231,002.6	214,429.0
Pre-tsunami source of loan			
Bank	21.4	35.9	25.5
Private money lenders	24.5	20.5	23.4
Savings Cooperative	26.5	20.5	24.8
Village/Community Fund	13.8	9.0	12.4
Relatives/friends	20.4	15.4	19.0
Shop	5.1	3.8	4.7
Government organization	1.0	0.0	0.7
Others	2.6	0.0	1.8
Reasons for debt in pre-tsunami			
Use as an investment	73.0	61.5	69.7
Buy land/house	15.8	29.5	19.7
Children education	9.2	6.4	8.4
Medical treatment	0.5	2.6	1.1
Daily living/expense	16.8	12.8	15.7
Buy automobile/motorcycle	2.0	2.6	2.2
Others	1.0	0.0	0.7
No answer	1.0	0.0	0.7

With respect to the impact of tsunami on economic condition, Bang Rong faced smaller impact than Ban Nam Khem. Obviously, the proportion of people being in debt remain unaltered as shown in Table 4.12-4.13, This was smaller than those found in Ban Nam Khem. However, the sources of loan in Bang Rong before and after tsunami were different. The most popular source of loan prior to tsunami was bank. Almost 40 percent of Bang Rong villagers borrowed money from bank. After tsunami, however, private financial loan was ranked first among sources of loan. Approximately one-third of people in Bang Rong who claimed being in debt, borrowed money from private money lenders since they needed reportedly emergency assistance. Unlike Ban Nam Khem, Bang Rong villagers reported that no financial assistance from non-governmental organizations was provided. They viewed that this was due to smaller tsunami impact on their village as compared to other hard-hit areas.

Table 4.13 Percent distribution of respondents according to experience of having debt in the post-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Post-tsunami debt status			
No debt	65.5	80.1	70.0
In debt	34.5	19.3	29.8
No answer	0.0	0.6	0.2
Total	100.0 (394)	100.0 (176)	100.0 (570)
Post-tsunami average amount of debt among the respondents	186,552.9	124,235.3	174,089.4
Average time expect to pay back all the debts (in years)	3.4	3.6	3.4
Post-tsunami source of loan			
Bank	19.1	25.7	20.5
Private money lenders	13.2	31.4	17.0
Savings Cooperative	16.2	14.3	15.8
Village/Community Fund	0.7	5.7	1.8
Fishery group	2.2	0.0	1.8
Relatives/friends	22.1	22.9	22.2
Shop	3.7	5.7	4.1
NGO	26.5	0.0	21.1
Government organization	1.5	0.0	1.2
Sub-district Administration Organization	2.2	0.0	1.8
Others	3.7	0.0	2.9
No answer	0.0	2.9	0.6
Reasons for debt the post-tsunami			
Use as an investment	74.3	54.3	70.2
Buy land/house	2.9	0.0	2.3
Children education	5.1	11.4	6.4
Medical treatment	1.5	0.0	1.2
Daily living/expense	23.5	14.3	21.6
House repairment	11.8	5.7	10.5
Instruments repairment	10.3	11.4	10.5
Buy automobile/motorcycle	5.1	17.1	7.6
No answer	0.0	5.7	1.2

Public perception of the impact of tsunami on mangrove forest and coastal environment.

News and reports on December 26, 2004 tsunami usually focused on great loss of life and property. Few had been reported on the impact of tsunami on the coastal environment and mangrove forests. During the tsunami, mangrove forests played their roles as solid wall of trees against the furious waves which helped to lessen the impact. Only a few people perceived environmental impacts on mangrove ecosystem from the tsunami diaster. The success of mangrove rehabilitation and monitoring programs is dependent on the awareness and public participation among the villagers as in the case of Samut Songkram Province (Paphavasit *et al*., 2000, Suwannodom *et al*., 2002) and in Nakhon Si Thammarat (Suwannodom *et al*., 2000, Suwannodom *et al*., 2004) Suwannodom *et al.* (2004) in her comparative study on the public participation in the mangrove reforestation program in the coastal communities of Thailand concluded that the public participation was the key to success in any reforestation programs. The degree of mangrove degradation as perceived by the villagers themselves would be the driving forces. Most coastal communities expressed their views the mangrove rehabilitation efforts should be carried out by the government and the local villagers themselves. The task of mangrove rehabilitation is too great for any party concerned alone.

In this analysis, as in Table 4.14 showed that 12 percent of people in Ban Nam Khem ignored and could not perceive the impacts of tsunami on the mangrove forests. Among those that perceived the impacts, less than 60 percent felt that tsunami had an enormous effect on the mangroves. Three-fourth of the respondents could not estimate the magnitude of tsunami impacts on the mangrove forests.

Prab: *Tree growth in mangrove forests was not the same. It was very green before but now several trees were damaged and gone. It's very pity. We need at least 10 years to have green forest like that.*

Daeng: *Before tsunami, there was new deposited mudflat approximately half a kilometer and the area was covered with mangroves. Now the mangrove trees could not be found in that area.*

Wisut: *All died out.*

Focus Group Discussion in Ban Nam Khem, Phang-nga Province

Table 4.14 Percentage of respondents according to the perception on the impact of tsunami on the mangrove forest environment

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Impact of tsunami on the mangrove forest in their community			
No impact at all/no forest	6.1	46.0	18.4
Small impacts	16.0	43.2	24.4
Moderate impacts	15.0	4.5	11.8
Large impacts	56.9	5.7	41.1
Do not know/No answer	6.1	0.6	4.4
Total	100.0 (394)	100.0 (176)	100.0 (570)
Estimation of mangrove area in the community being depleted			
Total (in rai)	530.91	45.52	418.90
Do not know (in percent)	68.4	64.5	67.6
Changing in soil color in post-tsunami			
No change	21.3	35.8	25.8
Having brighter color	6.5	8.0	6.9
Having darker color	84.8	78.8	83.2
Do not know/ No answer	9.0	13.3	10.2
Changes in soil condition/ texture in post-tsunami			
No change observed	11.2	37.5	19.3
More sand	38.9	17.3	33.7
Hard substrate	3.4	7.3	4.3
Bad smell	9.1	7.3	8.7
Muddy substrate	37.4	53.6	41.3
Polluted substrate	14.3	10.0	13.3
Not suitable for planting	4.9	0.9	3.9
Improved soil quality	2.0	2.7	2.2
Do not know/ No answer	7.1	8.2	7.4
Changing in physical condition of canal in post-tsunami			
No change	18.0	29.0	21.4
Shallower	45.8	50.4	47.1
Water was purified	13.9	17.6	15.0
Water was polluted	17.3	24.0	19.2
Having mud	18.3	20.8	19.0
Canal was narrower	4.0	0.0	2.9
Water route was changed	10.8	16.8	12.5
Canal was wider	8.0	8.0	8.0
Do not know/ No answer	8.0	6.4	7.6
Changing in physical condition of sea shore in post-tsunami			
No change	8.9	50.0	21.6
Soil erosion	34.0	46.6	36.5
Lost of land	57.9	20.5	50.6
Lost of tree/forest	8.9	17.0	10.5
Coral was damaged	1.1	0.0	0.9
River bank was steeper	7.5	2.3	6.5
Having more sand	8.1	3.4	7.2
Sea shore was cleaner	2.2	5.7	2.9
Having more garbage/muddy	4.7	17.0	7.2
Do not know/ No answer	5.0	10.2	6.0

Our scientific data from Ban Nam Khem revealed that the *Avicennia* mangrove forests along Laem Pom Bay were totally destroyed by being uprooted by direct wave impact. Total forest clearance zone of mainly *Avicennia* on the newly accreted mudflat 10-50 meters wide were found along Klong Pak Ko. In area where *Rhizophora* grew in dense forest, the damage would be less. The villagers in Ban Nam Khem also confirmed our scientific findings on the changes in water and sediment quality. Increased sedimentation was evidenced in the area. Soil erosion occurred in certain area with more than 50% alteration from normal condition. There were slight changes in sediment colorations and increased offensive odours. According to the interview, only twenty percent of respondents in Ban Nam Khem did not see any change in soil coloration after the tsunami. However, among those that observed the changes, 85 percent perceived darker soil colour. In their views, this may be due to the increasing mud brought by the furious waves. It was also evident that more than 40 percent of the respondents in Ban Nam Khem felt that there was more sand in sediment after the tsunami.

Sanguan: Soil condition changed. The surface sediment on Andaman shore was covered with sand that came with tsunami. Big waves caused the coastal erosion and carried mud and sand with them to smoother the shores.

Choenjit: Soil colour turned black from the beginning.

Wanchai: It used to be mud but now turned to be sand. The mudflat was covered with very fine sand. All trees in the area were dead.

In-depth Interview/and/Focus Group Discussion in Ban Nam Khem, Phang-nga Province

About 82 percent of respondents in Ban Nam Khem indicated the physical alterations of the canal in the village. Half of these people observed that the canal was shallower. Other physical changes as observed by the respondents were increased turbidity and mud content (18%), water pollution (17%) and changes in the water ways and depth (11%). It was interested to note that, some people perceived and welcomed the changes with positive attitude. Of these 14 percent of the respondents mentioned that water in canal was purified and with better quality after tsunami.

Sanguan: The canal was shallower. Tsunami carried sediment and sand from the sea to be deposited here and made the canal shallow.

Surat: The physical environment of canal had changed. The water current changed its route. The trees on the shore, acting as natural wall to prevent the wind and waves were cracked and damaged.

In-depth Interview/and/Focus Group Discussion in Ban Nam Khem, Phang-nga Province

When questioned on the whole impact of tsunami on the shoreline, only 9 percent of Ban Nam Khem villagers had not noticed any alterations. Majority of the population could clearly identify the changes. Of these, 58% reported the loss of land and 34% observed soil erosion. They concluded that these were two major environmental damages resulting from tsunami.

The physical alterations in water and sediment quality in Bang Rong mangrove forests as observed by our scientific team showed the increased channel depth due to erosion, slight increase in turbidity and increase in offensive odours due to mass mortality of fish, including caged fishes. Increased sedimentation, less than 25% alteration from normal condition, was observed. Soil erosion of less than 25% alteration was observed in certain area. Slight changes in sediment coloration and odours were noticed. The mangrove forest in Bang Rong area was slightly damaged from high water inundation and rapid water ingression. Some *Rhizophora* trees along Khlong Bang Rong bank fell down. The big *Avicennia* trees as well as *Sonneratia ovata* in Bang Rong estuary were broken but the trunks remained standing.

Eventhough the villagers in Bang Rong, Phuket Province did not suffer great loss of life and property compared to those in Ban Nam Khem, Phang-nga Province. But approximately 54% of the villagers were highly perceptive of the impacts of tsunami on the mangrove forests. In Ban Nam Khem, the majority of people (65%) could not estimate tsunami depleted areas of mangrove forest. Since the impact of tsunami on physical condition in Bang Rong was minimal as compared to Ban Nam Khem, a high proportion of Bang Rong villagers tended to observe no change in soil coloration (36%), soil condition (38%), physical condition of channel (29%) and physical alterations of shoreline (50%).

Among the villagers who observed post-tsunami changes in physical environment, approximately 80 percent of the respondents in Bang Rong observed darker soil colour. 54 percent observed more mud in soil component. The changes in canal depth, water pollution and the changes in water ways were the main impacts of tsunami. In addition, soil erosion (47%), loss of land (21%), loss of forest areas (17%) and increased mud and garbage were major alterations in Bang Rong.

Tongchai: Soil coloration in the canal changed. The colour was darker than before.

Decha: Soil coloration was darker and not as purified as before. It was not clear. It was more turbid. Big waves carried sand and garbage to the shore. Water was polluted.

Focus Group Discussion in Bang Rong, Phuket Province

Chapter 5

Public Awareness and Participation in Mangrove Forest Rehabilitation Program

Siriwan Siriboon Busarin Bangkaew
Chanette Milintangkul and Nittharatana Paphavasit

For our beloved King and Queen of Thailand, the success of forest rehabilitation requires full understanding of how different elements, both natural and human, interact. Apart from the biological productivity, public awareness and participation in the coastal resources conservation and rehabilitation is another important element of the self-reliance concept as laid down by His Majesty The King Bhumibol Adulyadej. The King has stressed that **"Change must come with in attain sustainability, every part of the society must move along in unison towards the commonc goals. Foster the spirit of unity and pause, only to go forward."**

Her Majesty The Queen Sirikit also laid down the **3-wells principles** for the Royal initiatives project-**Little House in the Big Forest** which are applicable to mangrove rehabilitation and management plan as elaborated by Paphavasit *et al.* (2005). **Well-being** of the people is Her Majesty's prime concern. People should be living in harmony with the forest under the guidance of His Majesty on self-sufficiency. The rights to conserve and utilize the forest land should be provided for the people to produce the **Well-to-do** condition for their families. **Well-knit** principle is to foster the spirit of unity for the locals to conserve and rehabilitate the forest. On the other hand, **well-knit** principle implies how the people and the forest have intertwined in harmony. Taken the royal initiatives into account, our research team

drew a framework for the mangrove rehabilitation research project by transforming these principles into working reality.

Several studies of mangrove forest communities in Thailand provide evidences that fisherman's way of life is a paradigm that follows His Majesty's guidance on self-sufficiency. Fishermen have faced major obstacles in pursuing their livelihood, namely, the degradation of coastal ecosystem, declining fishery production and conflicts of interest between commercial and small-scaled fishery. It can be concluded that small-scaled fishermen were mostly affected by mangrove degradation. It was found that those who gained direct benefit from mangrove forest, in particular fishermen, were more determined than others to participate in the rehabilitation programs (Siriboon, 2000). Suwannodom *et al.* (2004) concluded from her study that fishermen were often well aware of how the changes in mangrove forests would affect their livelihood. Mangrove reforestation/afforestation, therefore, would help to lessen their burden. They believed that if mangrove forest could appear once again along the coast, the quality of life of small-scaled fishermen would be better. The success of future mangrove rehabilitation in tsunami affected area will depend on the public awareness and participation of the coastal communities.

Perception of community members of the value and benefit of mangrove forest.

Mangrove forest as coastal welfare center.

Over the centuries, mangrove ecosystems have provided a variety of goods and services to coastal communities and others. Their ecological functions are numerous. It acts as buffer against winds and waves, stabilizes sediments, and prevents shoreline and riverbank erosion. Mangrove helps to regulate flooding and recycle nutrients. Mangrove forest serves as a coastal welfare center. In economic terms, mangrove is considered as welfare cost. Once the mangrove productivity is sustained, fishermen and their family can easily fish in mangrove and coastal areas for livelihood. Fishing occupation can be passed on from one generation to the next. Mangrove trees provide them with fuelwood, fishing gears and wood to build their home. If the forests were degraded or reduced in area, the coastal communities would lose the opportunity to gain such natural welfare from mangroves. They would have to pay a high sum of money to meet their daily needs. The value and benefit of mangrove forests were assessed by the respondents in Ban Nam Khem and Bang Rong as shown in Table 5.1. Community awareness on the benefit of mangrove in their livelihood as well as its role as coastal barrier were also assessed.

In Ban Nam Khem, mangrove forest contributed benefits listed in priority as a breeding ground for aquatic animal (60%), fishery resources for food (41%) and coastal barriers against winds and waves (35%). Mangrove also provided a source of income (25%), prevented coastal erosion (24%) and maintained good environment quality (14%). When questioned on the ecological function of mangrove forest as a natural wall against tsunami, about 80 percent of the respondents in Ban Nam Khem were confident that mangrove forest could protect them and the infrastructure behind the forest. Most of Ban Nam Khem villages were not located behind the mangrove forest, the damages caused by tsunami were significant. However, approximately 20 percent of the respondents did not believed that mangrove could protect them from tsunami. The information from focus group discussion among small-scaled fishermen as well as the data from in-depth interview revealed that mangrove forest enhances the fishery production and prevents the risks and damages from tsunami.

Choenjid: Mangrove means a lot to Ban Nam Khem. If we plant and conserve them, good consequences will follow. We will have seashell and fish for food. We will not be starving, at least we have something to eat.

Chitjai: I believed that mangrove forest more or less can protect us from tsunami. The speed of big wave was reduced before reaching our village.

Somjai: Ban Nam Khem can be sustained and survive by off-shore fishing in the deep blue sea and near-shore fishing in mangrove forest.

Chaivit: The most important benefit from mangrove is fishery resources. We catch all fishery resources such as fish, crabs, shrimps and shellfish from mangrove forest and coastal areas. These areas are the breeding ground for various animals. The amount of income we have gained from fishery resources in the mangrove forest the figure will be around 500 baht a day. We do not need to spend money on food because we get them from fishery product. We only pay money for rice and ingredients. That's all we need to pay for.

Jermsak: My friend has seen for himself that mangrove forest could actually reduce the damage of exposed shoreline from tsunami and reduce the speed of wave stress. It seemed like the wave stopped in the forest areas. Houses and people behind the forest were saved from severe impacts. Unlike the major part of the village that experienced severe impacts because no forest was there.

Focus Group Discussion and In-depth Interview in Ban Nam Khem, Phang-nga Province

Table 5.1 Percentage of respondents according to the perception on mangrove forests as coastal welfare center

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Mangrove forest as coastal welfare center			
No advantage	0.5	0.0	0.4
Breeding ground	59.7	74.4	64.3
Food sources	40.6	61.9	47.2
Source of income	25.3	37.5	29.0
Barrier against wind/storm	34.4	55.7	41.0
Stabilized soil erosion	24.2	29.5	25.9
Mangrove wood for consumption	12.2	33.0	18.7
Maintenance of good environment	13.8	8.5	12.1
Tourist attraction	2.3	5.7	3.3
Maintenance of good water quality	1.8	3.4	2.3
Habitats for animals	1.8	2.8	2.1
Pier for fishermen	1.0	0.6	0.9
Medicinal herbs from forest	0.0	2.8	0.9
Source of knowledge	0.0	1.7	0.5
Maintenance of fresh air	2.8	0.0	1.9
Environment/ecology conservation	2.6	2.8	2.6
Do not know/No answer	6.1	1.1	4.6
Mangrove forest as natural barriers against tsunami disaster			
No barrier	22.1	1.7	15.8
Slight barrier against tsunami	11.4	6.8	10.0
Moderate barrier against tsunami	20.3	12.5	17.9
Strong barrier against tsunami	43.4	77.8	54.0
Do not know/No answer	2.8	1.1	2.3
Total	100.0 (394)	100.0 (176)	100.0 (570)

The perception of mangrove forest as a welfare center in Ban Nam Khem was not high as compared to Bang Rong village in Phuket Province. Looking back at the history of the mangrove forest in Phang-nga Province, mangrove degradation in this area was due to tin mine concessions. Siriboon and Milintangkul (2004) reported that the concessionaires were usually people outside the mangrove community, indigeneous people. Meanwhile, the community members had no rights to control and no authority to cope with the problems arisen from the mismanagement of mangrove resources. Human factors were major drive inorder to accomplish the rehabilitation program. Good visioned and conscientious leaders, perception of community members on value and benefit of mangrove, and community solidarity and civil society were other controlling factors. The degree of dependency on mangrove was very high in Bang Rong village. High mangrove productivity provides good quality of life for people residing in the area. The villagers perceived that mangrove forest have benefitted their community in several ways. The value and benefit from mangrove were ranked in priority as breeding ground (75%), food source (62%) and coastal barrier (56%). Source of income (38%), source of wood production (33%) and reducing coastal erosion (30%) were next in terms of benefits. They believed that Bang Rong suffered smaller impacts from tsunami due to productive mangrove forest in the area which acted as a natural wall against the sea fury.

Chartchai: I can say that half of the people in Bang Rong get their food from mangrove forest. I don't know about other villages but in Bang Rong we catch fish, shrimps and crabs in mangrove area. Now we have arranged eco-tourism. Many villagers earn their income from this business. Mangrove is a source of income for villagers and a source of knowledge for tourists. Our village has already arranged eco-tourism for more than 10 years.

Sarayuth: People here use wood from mangrove forest. Rhizophora is very useful for us. We use its product for building houses, bridges and making fishing gears. Some people get herb from the forest too. I, myself, do not know how to use herb but some in our village know it very well. Sometimes the roots of Rhizophora are used for making furniture.

Pong: Everybody fully realized that mangrove has protected us from tsunami. Before reaching us, the big waves ran through the roots and the stem of Rhizophora. The speed of the wave, therefore, was reduced. People in Bang Rong discussed that without mangroves, they would share the same fate as people in Pa Thong Beach where there was no natural barrier to protect them from big waves. When the wave came, it ran directly onto their buildings.

In-depth Interview in Bang Rong, Phang-nga Province

Direct and indirect use of mangrove forest.

The degree of the respondents' dependency on mangrove was assessed from their direct and indirect utilization of the forest product. Sathirarhai (1997) estimated the Total Economic Value of mangrove forest as shown in Figure 5.1. In Table 5.2, less than half of the people in Ban Nam Khem reportedly relied on mangrove for their livelihood. Approximately 37 percent utilized mangrove directly, 10 percent indirectly and another 9 percent both directly and indirectly. Direct use of mangrove was fishery resources for food (59%), fishery for income (31%) and wood product (16%), respectively. The information from in-depth interview and focus group discussion confirmed the importance of mangrove forests as food source and source of income for people in Ban Nam Khem, in particular small-scaled fishermen.

Wood comsumption among the villagers was quite low. The respondents may refrain from responding to this question since it is against the law to cut wood from mangrove forests. The data from the qualitative research revealed that people in Ban Nam Khem used mangrove wood, only in small amount. The mangrove wood consumption were used in terms of fuel wood, charcoal, poles for housing and fishing gears. In addition, after the tsunami disaster, many villagers were unemployed. Most of the fishermen lost their boats and fishing gears during the tsunami. Fishing and aquaculture in mangrove area were alternative sources of income.

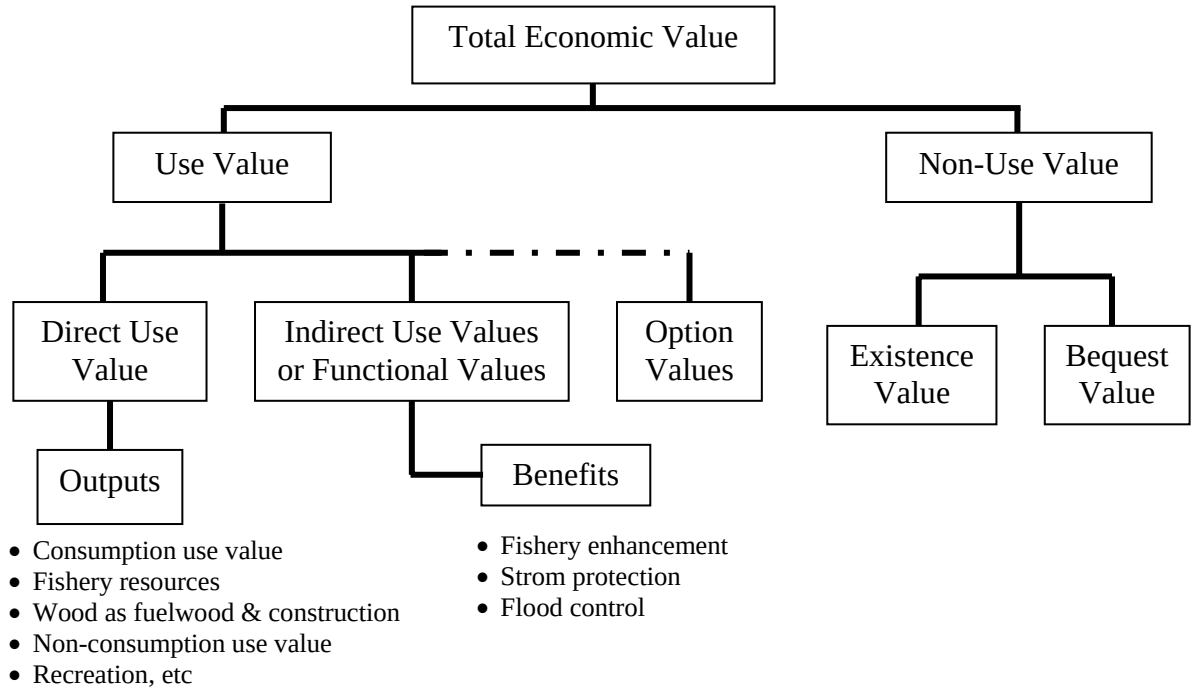


Figure 5.1 Estimation of the Total Economic Value of Mangrove Forests (Modified from Sathirathai, 1997)

Table 5.2 Percentage of respondents according to the direct and indirect use of mangrove forest

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Mangrove forest utilization by the respondents and their families			
No use	43.1	30.7	39.3
Direct use	36.5	47.7	40.0
Indirect use	9.9	9.1	9.6
Both direct and indirect use	9.4	12.5	10.4
Do not know/ No answer	1.0	0.0	0.7
Total	100.0 (394)	100.0 (176)	100.0 (570)
Direct Use of mangrove forest			
Breeding Ground	19.0	8.5	15.3
Food source	59.3	73.6	64.4
Source of income	31.2	27.4	29.8
Barrier against wind/storm	8.5	9.4	8.8
Stabilize soil erosion	3.7	0.9	2.7
Mangrove wood for consumption	15.9	31.1	21.4
Maintenance of good environment	6.9	0.9	4.7
Tourist attraction	2.6	1.9	2.4
Maintenance of good water quality	0.5	1.9	1.0
Maintenance of fresh air	1.1	0.9	1.0
Pier for fishermen	2.1	0.0	1.4
Medicinal herb	0.0	1.9	0.7
Indirect Use of mangrove forest			
Breeding Ground	14.1	13.2	13.8
Food source	18.5	31.6	22.3
Source of income	7.6	7.9	7.7
Barrier against wind/storm	18.5	31.6	22.3
Stabilize soil erosion	12.0	2.6	9.2
Mangrove wood for consumption	13.0	10.5	12.3
Maintenance of good environment	21.7	15.8	20.0
Tourist attraction	5.4	21.1	10.0
Maintenance of good water quality	1.1	2.6	1.5
Maintenance of fresh air	9.8	2.6	7.7
Environment/ecology conservation	2.2	0.0	1.5
Pier for fishermen	1.1	0.0	0.8
Military strategy	0.0	2.6	0.8

Sanguan: We use mangrove tree directly to make charcoal. I think that the whole village gain benefit either directly or indirectly from mangrove forests. Villagers catch shells, crabs and fish from Rhizophora forest. They gain fresh food from mangrove. Mangrove forest is their source of income.

Jermsak: Some villagers earn their living from mangrove forest. They utilize mangrove product in traditional way. The fishing gears are made with local wisdom. They do not use modern tools. Of course, they use wood from forest but in small amount to make house poles or fishing gears. They also use Nypa leaves for making roofs. Fishermen are the major group who use products from mangrove forest. In Ban Nam Khem, about half of the villagers are fishermen. Mangrove forest serve a lot of people.

Chenjit: We gain benefit directly from mangrove forest by working as employee in the reforestation program. We are responsible for planting and thinning the forest. We also get food from the forest. Without mangrove, we will not have shellfish.

Sommai: We catch crabs from mangrove. We also work as fishermen. Our boats are quite small compared to others. We can not fish in the deep sea. We often fish in the coastal area. During the monsoon season, many fishermen can not go out to fish. They catch a quatic animals from mangrove. Without mangrove, we do not know where to find food.

Samart: Fishing in this village is usually small-scaled. Our boats are small. We either row the boats or use small engines to propel the boats. We spend only 20 baht for gasoline. That's our way of life. We are self-sufficient.

Suvit: After the tsunami, we still could not fish offshore. We had to switch to aquaculture along the coast. We started with 20 villagers, now we had about 50 members. Mangrove helped our business as a protective wall from strong wind and waves. We needed not to pay for fish feeding in aquaculture because there were plenty of plankton in mangrove. We are now waiting to harvest aquaculture product. We don't yet reap any income but we can earn our living by catching fish and shellfish in mangrove forest.

Focus Group Discussion and In-depth Interview in Ban Nam Khem, Phang-nga Province

The degree of dependency on mangrove in Bang Rong was very high. Approximately 70 percent of the respondents reportedly utilized mangrove for their livelihood. Of these, 60 percent used mangrove directly. Direct traditional uses were namely fishery resource for food (74%), wood consumption (31%) and fishery for income (27%). Indirect local uses were listed as coastal barrier (32%), eco-tourism (21%) and maintenance of good environmental quality (16%). Our study confirmed that every household in Bang Rong gained benefits from mangrove. Mangrove played a significant role as a main source of fresh food. This can be easily observed that more than 100 houses of Bang Rong had at least one type of fishing gears per house. The indirect use of mangrove was eco-tourism run by the group of leaders of Bang Rong. Household and community income was generated from eco-tourism. Community income in turn was used for social welfare of medical treatment and education for those villagers who need support.

Prakorn: Mangrove is an important breeding ground for aquatic animals. It's a big source of food. Villagers catch shrimps, shells, crabs and fish from the forest.

Lert: We gain indirect benefit from mangrove forest by running eco-tourism. Tourists come for vacation and villagers get income from tourists.

Prakorn: About 10 percent of villagers get direct benefit from mangrove forest by earning their living, particularly fishermen. But the rest or 90 percent gain benefit indirectly because they occasionally use wood products in terms of timber. If they do not use wood from mangroves, they have to buy timber and furniture with a large sum of money. As I know, about 30 houses in our village use wood from mangroves but the amount of timber used is very small. They don't use it very often.

Lert: I think that all villagers used mangrove products but they did not realized it. They did not use them in large quantity in everyday life.

Sarayuth: Almost every house, I can say, at least 100 houses here have fishing gears. Even though some do not work as fishermen, they fish in the mangrove for fresh seafood. They save money for food.

Focus Group Discussion in Bang Rong, Phuket Province

Turning "Crisis" into "Opportunity"

The severity of the tsunami disaster on December 26th 2004 was beyond comprehension. This fact was soberly understood. Nevertheless, the immense loss in human life and property boggled the mind. Reports from multiple scenes of the disaster were terrible nightmares. In fact, the loss of human life and suffering could have been lessened and if the coastal ecosystem were in pristine and productive stages. However, the truth was the degradation of coastal ecosystem, such as mangrove, coral reef and seagrasses, existed. This crisis confirmed that mangrove play significant roles in preventing damages from tsunami. Scientific findings proved that where there was mangrove, there were substantially less damages. Mangroves grow in thickets along the coastlines and their complicated root systems help to bind the shore together, effectively providing a shield against destructive waves. The disastrous experiences from the tsunami have provided the **"Opportunity"** from this **"Crisis"** for the coastal communities to learn from their first hand experiences or account on the importance of mangrove forest as the barrier against winds and waves. It is the opportunity for public to gain the insights and awareness on the importance of mangroves conservation. The coastal communities had actual evidences of how mangroves could lessen the damages from furious waves other than those that were written in texts. Several villagers from Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province, had voiced how mangrove forest saved their lives and their families.

Fortunately, our mangrove forest was thick. It pushed back the waves and bound the shore together preventing erosion. This help our village at the back of the forest not to be destroyed. This help us to pay more attention. The forest has saved us from the blink of death. We have never seen anything like this in our life. We were scared to death.

The mangrove saved us. Without forest, we would all be dead by now. The mangrove forest gave us a new life.

If not for the mangrove forest, I would be dead. The forest help to reduce the furious waves. My three sons survived by clinging on tight to the mangrove tree.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Without Bang Rong mangrove forest, more destruction would have occurred. The forest is like the nature wall. When compared to Ao Por which was 5 kilometers away, the villages there were destroyed because there was no mangrove forest.

The Rhizophora forest helped to reduce the rapid currents and lessen the damages. It also helped us to realize that we should save the mangrove forest in the future because the mangrove saved our lives and property.

It is a warning to us to pay more attention and beware of natural diaster. Before this, we had no knowledge whatsoever about it. Without mangrove forest, all villages would be washed out to the sea. The root system of Rhizophora tree helped bind the sediment together and prevent erosion.

We need to plant more trees in the forest. The mangrove have lessen the damages. We need to conserve these precious forest. We need to think that these mangrove forest belong to us all.

This will teach us a lesson the hard way that the degradation of mangrove forest in order to build beaches and resorts had destroyed the natural disaster prevention system. Our villages were less affected. Thanks to the mangrove that shielded us from the furious waves.

In-depth Interview in Bang Rong, Phuket Province

Planners and academicians believed that this "crisis" could be turned into the "opportunity". It is important to gather more detailed information on the linkage between mangrove and the damages caused by tsunami. People living along the coastline should be aware that mangrove helps to prevent damages from this disaster. It was evidenced from our scientific study and from the first-hand experiences of the villagers, particularly in Bang Rong, that the *Rhizophora* dense forest had saved them from the disaster. The condition of the forest, position of the forest in relation to villagers, plants species, tree density and height, as well as root systems contributed to the magnitude of prevention from tsunami. The coastal communities should be aware that mangrove prevented and lessened damages from tsunami. It is a very good opportunity to convince people about the importance of mangrove and to introduce the integrated post-tsunami mangrove rehabilitation and management plan for the coastal communities in the Andaman coastline. The rehabilitation of mangrove forests not only will ensure future safety of these communities, but also will contribute to their long-term socio-economic development by enhancing livelihood opportunities and supplies of needed resources.

The attitude of the people in Ban Nam Khem towards mangrove changed after the tsunami as shown in Table 5.3. More than half of the respondents viewed that mangrove was more important than before. Most respondents (84%) reported that they had learned from their own experience that mangrove helped to protect coastlines by absorbing the wave energy. Mass media from various sources, such as radio, television and newspapers, also played significant roles in providing these information. Approximately 10 percent of the people in Ban Nam Khem mentioned that they received knowledge and information about the role of mangrove as the natural barrier in lessening the loss and damages from mass media. The villagers have not only become more aware of the mangrove as a natural barrier against the furious waves but also to participate more in the mangrove reforestation program.

Supot: We had informed the villagers several times about the importance of mangrove forest on the well-being of people but they did not pay attention. Until now, they have learned by themselves that mangrove forest is like a natural wall protecting people living behind the forest from tsunami. Now they have started listening to us. They also receive information about mangrove from various sources, such as radio, TV, newspapers and government or non-government officers. Information from all sources confirmed the importance of mangrove. Now they believe us.

Choenjid: I felt that people have paid more attention on mangrove after the tsunami.

Sommai: After tsunami, we organized activity on reforestation and several people joined the meeting. In the past, not many people appeared in the meeting. They ignored it.

Chidjai: Before tsunami, when we held a training program on mangrove, many people from other villages participated. However, people from Ban Nam Khem did not join us. Even the leaders, such as the village head man or Kamnun (representative from sub-district), did not attend the training.

Focus Group Discussion and In-depth Interview in Ban Nam Khem, Phang-nga Province

Besides helping to increase the level of understanding and enhancing positive attitude towards mangrove, tsunami had an unexpected additional function. It was found from the qualitative data that tsunami helped in binding people in Ban Nam Khem together. Even though Ban Nam Khem was more than 40 years old, the community was not united. People who resided in the village were mostly migrants who searched for job opportunity. There was almost no cooperation among people in the community in any social activities even in formal events arranged by community leaders.

Suwit: *Before tsunami, our village was very weak in terms of cooperation. We hardly had meeting. By mandate of Ministry of Interior, every month each village needed to arrange a meeting. You know, we had only about 20 participants out of 1,566 houses. It's very pity. It's very difficult to bring people together because most of the villagers here were not born in the village. They migrated here to work in order to earn money as long as they were satisfied. They did not have any sense of belonging. After tsunami, we tried to turn this crisis into opportunity. We tried to bring people together to induce a sense of sharing. We hope that it works.*

Vitoon: Tsunami gave us a chance to be united. Before the tsunami, we barely had any cooperation of community members in the activity. Now, people joined hands. Many group activities were now active. I am confident that if someone sets up a conservation group now, several villagers will join.

In-depth Interview in Ban Nam Khem, Phang-nga Provincee

Table 5.3 Percentage of respondents according to the attitude toward the value of mangrove forest in the post-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Attitude towards the value of mangrove forest in the pre-tsunami and post-tsunami			
More positive attitude toward mangroves	51.5	74.4	58.6
No change in attitude	39.8	25.0	35.3
Less positive attitude toward mangroves	6.6	0.6	4.7
Do not know/ No answer	2.0	0.0	1.4
Total	100.0 (394)	100.0 (176)	100.0 (570)
Reason for having more positive attitude			
First hand experiences that mangroves as natural shield against tsunami	83.7	96.9	88.9
Learn from mass media that mangrove can protect them from tsunami	10.3	1.5	6.9
Public relation in community	6.9	3.1	5.4
Mangroves as food source during hardship	3.0	1.5	2.4
Reason for having less positive attitude			
Mangroves cannot protect them from tsunami	34.6	0.0	33.3
Not related to mangroves in daily life	11.5	0.0	11.1
No benefit gained from mangroves	57.7	100.0	59.3

Only about 7 percent of respondents in Ban Nam Khem had less positive attitude towards the mangrove after the tsunami. Of these, almost 60 percent viewed that mangrove forest had play minor role and they did not get any benefit from them directly. One-third of these also pointed out that they did not see that mangrove could save people from the tsunami disaster.

In Bang Rong, three-fourths of respondents had expressed more positive attitude towards mangrove after the tsunami. Less than 1 percent of respondents had less positive attitude. As expected, the increase in positive attitude towards mangrove was mostly due to the fact that 97% of respondents had direct experiences with tsunami disaster. They now have seen how community mangrove forests could protect them.

Ampon: In fact, villagers in Bang Rong perceived the value of mangrove because of its major role in their occupation. People realized the value of mangrove more after the tsunami. They had direct experiences. They saw that mangrove had helped reducing the loss. Thousand rais of mangrove were like natural green barrier. Without mangrove, more loss would have occurred.

Prakorn: I can say that people learned more from tsunami. I noticed that after the tsunami many villagers started to pay more attention to mangrove forest. In fact in the previous day, a group of villagers set up a conservation group and arranged activities on reforestation. Some community members, however, used to treat these activities as a joke and some laughed at the ideas. After the tsunami, I didn't see that reaction any more. Villagers learned from their direct experiences that Rhizophora forest was like a buffer zone that could help protect their lives, their houses and their property from tsunami. Those who run aquaculture farm would appreciate more.

In-depth Interview in Bang Rong, Phuket Province

Like in Ban Nam Khem, the community leaders and the key informants in Bang Rong were optimistic about the situation. They planned to turn this crisis into opportunity by introducing intensive program on reforestation and mangrove rehabilitation in the community. There was a sign that people paid more attention to mangrove activities and reforestation program. The story about how mangrove could protect the loss of life and property became an interesting issue and was discussed widely and frequently in public places.

Sarayuth: People became more alert and more aware on mangrove conservation. In those days, when community leaders arranged the reforestation activity, some members were not interested to join in. Some parents even complained and opposed when we took their kids to plant the tree. They said that these made their children dirty. Now, when we took young children to the reforestation program, they too would accompany their children and asked for more information. They wanted to know more on the condition of site, type of tree to be planted, tree density and total area of reforestation. We can see that many villagers started to discuss about mangrove reforestation in public like in the coffee shop.

Lert: Tsunami had alerted us. Governmental and non-governmental organizations as well as activity groups in our community responded to this disaster in positive direction. Even though we had many groups working on mangrove rehabilitation in the past, many activities were undertaken as routine work. In addition, people who were not fishermen ignored the reforestation program since they thought that their ways of life and well-being had nothing to do with the mangrove. Nowadays the situation changed. People realize that mangrove is important.

In-depth Interview in Bang Rong, Phuket Provine

The community leaders and villagers who worked in the mangrove rehabilitation program were optimistic about the situation and would take this opportunity to provide more knowledge and good understanding on the importance of mangrove forest to their community members.

> *Pong:* *We were optimistic. We thought that this disaster provided us a good opportunity. The tsunami has lightened up our mind. We had to think back. It made us realize the value of mangrove. If we didn't have mangrove, we would have been completely destroyed. We would have lost everything. We should grab this opportunity to provide knowledge and good understanding on the importance of mangrove forest to our community.*
>
> *In-depth Interview in Bang Rong, Phuket Province*

When posed whether they wanted to gain more knowledge on mangroves, about 55 percent of all respondents in Ban Nam Khem showed the needs for additional information relevant to mangrove (Table 5.4). The knowledge required was the advantage of mangrove (46%), knowledge related to management (35%), planting technique (26%) as well as trees and animals diversity in the mangrove (13% and 10%), respectively. On the other hand, there were those who did not need any information about mangrove (45%). The main reasons for this were mangroves irrelevance to their daily life (60%), no benefit from the forest (16%), knowledge on mangroves already acquired (14%) and no time to learn more about the forest (11%).

Even though the people in Bang Rong were more actively engaged in mangrove-related activities than people in Ban Nam Khem and had undertaken more activities on mangrove reforestation, the degree of their desire to learn more about mangrove was still very high. Almost two-thirds of the respondents wanted to gain additional knowledge. They requested information in forest management or conservation (49%), advantage of mangrove (39%) and planting technique (33%). Mangrove management was top of the list. This may be due to the fact that mangrove activities in Bang Rong have been carried out for a long time. Many villagers have already gained fundamental information, such as type of mangrove trees, animals in the forest as well as the advantage of mangrove. They were in the process of constructing mangrove rehabilitation program, therefore, they needed knowledge on good management.

Table 5.4 Percentage of respondents according to their wishes to gain more knowledge mangrove forest

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Wish to gain more knowledge on mangrove forest			
No wish	45.2	36.4	42.5
Wish to gain more	54.8	63.6	57.5
Total	100.0 (394)	100.0 (176)	100.0 (570)
Reason for not wanting to gain more knowledge			
Not related to mangroves in daily life	60.1	48.4	57.0
Not benefit gained from mangroves	16.3	10.9	14.9
No time	11.2	23.4	14.5
Enough knowledge gained	14.0	21.9	16.1
Health problem	0.6	4.7	1.7
Additional knowledge on mangrove forest needed			
Advantage of forest	45.8	39.3	43.6
Planting techniques	25.5	33.0	28.0
Forest management/conservation	35.2	49.1	39.9
Type of trees in the forest	13.0	14.3	13.4
Type of animal in the forest	9.3	8.9	9.1
Mangrove Ecosystem	0.0	4.5	1.5

Pre- and post-tsunami community activities on mangrove forest rehabilitation

Several Andaman coastal communities in Thailand are still trying to cope with the aftermath of tsunami that struck the region on December 26, 2004. While most communities needed to pursue livelihoods and regain a minimum quality of life, attention should be focus on the rehabilitation of coastal resources on a sustainable basis. It was suggested that participatory community planning or management approaches should be implemented to introduce better mangrove ecosystem management through a systematic capacity building program at the community level (Suwannodom *et al*., 1998). Prior to working with target communities on specific mangrove rehabilitation activities, a more comprehensive understanding of social mechanism on community participation is necessary.

In this analysis, the statistics in Table 5.5 stated clearly that only half of the villagers in Ban Nam Khem had some activities related to mangrove reforestation program in the pre-tsunami. The reasons for not having any mangrove related activity were mainly due to lack of interest (39%), being too busy with work (31%) and no cooperation among community members, respectively. It is noticeable that previous activities were undertaken on an occasional basis, such as reforestation program in commemoration of the Royal family and the exhibition during the visit of Prime Minister etc. The program on mangrove rehabilitation was still not sustainable and was not operated on a continuous basis.

During the pre-tsunami period, Ban Nam Khem seldom had mangrove reforestation activities. The reforestation activity held only once a year. Even though the activities were conducted for almost a decade and combined other activities, such as releasing of fish larvae and crabs in the mangrove ecosystem, they were not sustainable. The participation was limited only to a certain group of fishermen who had direct benefit from mangrove. Even though the local schools have put lots of effort on coastal environment rehabilitation, the activities were limited only within the school compound. However, the systematic management of mangrove forest was just proposed after tsunami disaster. This conceptual framework is still in an early stage and is yet to be implemented.

Chaivit: Pre-tsunami, we had reforestation activities but only once a year. We planted mangrove to build habitats for shrimps, shellfishes and fish. We released fish and crab larvae on an occasional basis. We had held these activities for about 6-7 years. After the tsunami, the villagers started to work systematically on the rehabilitation program. The program will not be limited only within the village. We hope to extend the program to other neighbouring villages or even to adjacent provinces.

Supot: In the past, we have had reforestation activities but only among a group of small-scale fishermen. Other villagers did not pay attention because they thought that the activities would have nothing to do with their well-beings. After the tsunami, the cooperation among several groups, such as villagers, GO, NGO, private foundations as well as sub-district administration organization, took shape. Many reforestation activities are held more frequently.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Table 5.5 Percentage of respondents according to the perception on community activities on mangrove rehabilitation in the pre-tsunami period

Category	Ban Nam Khem Phang-nga Province	Bang Rong Phuket Province	Total
Pre-tsunami mangrove rehabilitation program in community			
No activity	43.9	4.5	31.8
Some activities	48.5	93.8	62.5
Do not know	7.6	1.7	5.8
Total	100.0 (394)	100.0 (176)	100.0 (570)
The reason for not having mangrove rehabilitation in community			
Not interest	38.7	12.5	37.6
Mangroves already fertiled	7.5	0.0	7.2
Government in charge	2.9	37.5	4.4
No cooperation	26.0	25.0	26.0
No time/too busy working	31.2	25.0	30.9
No news/no information	5.8	12.5	6.1
No leader	9.2	0.0	8.8
No forest	2.9	25.0	3.9
Do not know/No answer	9.8	0.0	9.4
Types of community mangroves related activities			
Reforestation program in the commemoration of the Royal family	92.5	97.0	94.6
Training in mangrove forest	4.3	7.9	6.0
Marine resources conservation	4.8	11.5	8.0
Having mandate for not cutting wood	1.6	2.4	2.0
Forest survey	1.6	2.4	2.0
Forest dating	4.8	9.7	7.1
Government temporary employee	1.1	0.0	0.6
Eco-tourism program	0.0	3.0	1.4
Zoning	0.0	0.6	0.3
Setting conservation group	0.0	1.8	0.9

Kamol: *Fishermen believed that mangrove should be the major objective for coastal resources rehabilitation. If we take very good care of our mangrove, we will always have enough coastal resources. We will not be poor. I have observed that fish lay their eggs, particularly in rainy season, in mangrove area. Even though I am a commercial fisherman and fish off-shore, I do not go fishing in the mangrove, I believe that we should be more concerned about the mangrove rehabilitation program. The fertile mangrove is a nursing and breeding ground for coastal fish. When they grow up, they will move to the deep sea and become off-shore fishery products. This is the reason why we need to have mangrove rehabilitation. Mangrove is like the core of coastal fishery resources.*

Sopon: *Actually our school have many programs related to mangrove reforestation. We had arranged many exhibitions on these mangrove activities. Last two months, during the visit of the Prime Minister, we also had some exhibitions. Now, the government organizations had contacted our school and asked for cooperation. We have arranged the reforestation activities for students.*

Jermsak: *We still do not have a new generation to work on the reforestation activities. It's a good opportunity to recruit new generation. We should start from school because we have already had some environmental conservation groups. They still do not play a major role because they only limit their responsibility within school compound.*

Prawat: *Even though we had reforestation activities prior to tsunami, only few villagers participated. After the tsunami, people knew that mangrove forest could protect their lives and their property. This has increased their awareness because many villagers have paid more attention to mangrove and cooperated more.*

In-depth Interview in Ban Nam Khem, Phang-nga Province

The data in Table 5.6 revealed that, prior to tsunami, a large proportion of respondents (43%) in Ban Nam Khem have never participated in the community reforestation activity. The main reasons were due to too their too busy involvement with daily work (45%), their lack of free time (40%), no news or information (26%), no cooperation among villagers (13%) and their perceived irrelevance of mangrove to their daily life (10%). Even after the tsunami, only 35 percent of respondents joined the reforestation activities held in the community. The ignorance of the villagers on the reforestation program partly reflected the lack of proper information dissemination and the level of community participation.

It is clear in this study that the level of participation in any mangrove rehabilitation activity is highly correlated with the degree of mangrove-dependency (Siriboon, 2005). Villagers whose economic well-being is not dependent on the existence or the pristine of mangrove will not pay attention to mangrove rehabilitation related programs. Despite an attempt to promote environmental management in the community, the activities were arranged occasionally, not on a sustainable basis. Villagers joined the program in the form of cooperation not participation. Community members are still not involved in the whole process starting from formulating/thinking together, working together, analyzing together, as well as evaluating together and planning together. Any activity arranged, therefore, was in the form of occasional participation or just a social function, not actually intended for rehabilitation.

> *Manop: I think that during the last decade we have had significantly improved our environmental management under the concept of participatory management. However, we still have problem in terms of continuity of the participation. At this moment, the participation is merely an occasional event or just to be in trend. There is no procurement. The participation do not last long. I think that this cannot be called participation. It's just cooperation. In my point of view, participation has more meaning than cooperation. Cooperation is temporary but participation means thinking together, working together, analyzing together, evaluating together and planning together. It's more than just getting together.*
>
> *In-depth Interview in Ban Nam Khem, Phang-nga Province*

In contrast to Ban Nam Khem, the efforts to increase mangrove forest was evident in Bang Rong. It is clear in this study that most villagers in Bang Rong (94%) realized that the community had mangrove reforestation activities. Participation was always high. Table 5.6 showed that, prior to tsunami only, one-fifth of the respondents had never joined the activities. There was only 13 percent of respondents reportedly not knowing about community reforestation activities after the tsunami. Of those respondents that participated in the reforestation activities after tsunami, the average frequency of participation was about 2.5 times annually.

Table 5.6 Percentage of respondents in relation to public participation in mangrove rehabilitation activities in the pre- and post-tsunami

Category	Ban Nam-Khem Phang-nga Province	Bang Rong Phuket Province	Total
Pre-tsunami participation in mangrove activity			
Never participate	42.9	22.4	33.4
Sometimes	36.1	32.1	34.3
Frequently	20.9	45.5	32.3
Total	100 (191)	100.0 (165)	100.0 (356)
Reason for not participating			
Life is not depend on forest	10.3	5.7	8.8
Never utilized any forest product	1.3	5.7	2.7
No time/very busy	39.7	48.6	42.5
No news/ no information	25.6	17.1	23.0
Have to earn their living	44.9	37.1	42.5
No cooperation	12.8	11.4	12.4
Reason for participating			
Asked by community leader	9.3	18.1	14.1
Community activities	50.5	55.9	53.4
Advantage for community	33.6	42.5	38.5
Advantage for his/her family	13.1	9.4	11.1
Having fun	7.5	5.5	6.4
Earn money	7.5	1.6	4.3
Having responsibility	0.0	11.0	6.0
Total number of time participating in the post-tsunami			
Still have no activity	31.7	13.1	26.0
Still not participate	32.7	22.2	29.5
Only once	19.8	14.8	18.2
2-3 times	13.9	30.7	19.1
More than 3 times	1.8	18.7	7.1
Do not know/No answer	0.0	0.6	0.2
Total	100.0 (394)	100.0 (176)	100.0 (570)
After tsunami, average time in participating in mangrove rehabilitation program	0.9	2.4	1.5

The qualitative data revealed that the community had carried out activities related to mangrove rehabilitation for a long time. There was also an attempt to build up the network and cooperation not only within the village but also among the adjacent villages and related organizations to join the forest rehabilitation program. The program was focused on educating young children in the village and adjacent areas to ensure the future conservation of mangrove.

Somphol: We had activities for youth. We built up sub-district networks. We knew that mangrove activities can not be carried out solely by only one village. We had a total of 9 villages in Pak Klog sub-district and all the villages worked on mangrove activities together. In our village, we had many group activities run by a group of Imam (religious instructors) and Village Youth Council. These two groups were responsible for gathering children who attended religious class on weekend. We arranged camp for kids every month. We had rotation system. Each month, each village had the responsibility in setting up a camp. We started this activity in the year 2004 and had worked on this program continuously. There were many activities in the camps, such as environmental conservation, garbage collection, mangrove reforestation as well as releasing of young fish, shellfish, shrimps and crabs into the mangrove ecosystem.

Amnad: We have had reforestation activities long time ago since 1998, and have worked on this program continuously. Besides planting trees, we also had activities of releasing of young fish and shellfish. We worked hand in hand with the government organization. The Royal Fishery Department supplied us with fish larvae. The Royal Forestry Department supported us with mangrove seedling. The Office of Provincial Agriculture provided knowledge on aquaculture. We had very good cooperation.

In-depth Interview in Bang Rong, Phuket Province

The qualitative data from community leaders and stakeholders in Bang Rong revealed that the community attempted to construct a system of "social capital". In their point of view, the social capital comprised 5 components: natural resources, human resources, budget, social control and social wisdom. In order to succeed in the mangrove rehabilitation program, the social capital needed to be constructed.

In terms of natural resources conservation, the key informants pointed out that the utilization of natural resources under the sufficiency economy was the key factor for natural resources and mangrove conservation. Releasing fish and crab larvae was also a means to increase the capacity of coastal resources. The community, therefore, carried out many activities on releasing fish larvae and gravid females. The Crab Bank was one example of such activities.

Piput: We set up a group of coastal conservation called "Crab Bank". When the villagers catch gravid female crabs, the Crab Bank give immatured crabs as an exchange. Then the conservation group will let the grabvid female crabs to lay their eggs. We also built up habitats for fish. We constructed artificial reefs from concrete blocks. In addition, we also defined the conservation zone. The villagers agreed to which zone they can not fish.

Amnad: We use timber from the forest. In our village we have forest zoning. We have conservation zone and utilization zone. We will carry out reforestation after cutting the wood. In the utilization zone, we also fish based on sufficiency economy. If young crabs are caught, we free them. We catch only big crabs. We also free gravid female crabs because they can produce more crabs. Sometimes they can produce million young crabs.

In-depth Interview in Bang Rong, Phuket Province

Human resource management is one of crucial factors that contributes to the success of mangrove rehabilitation program. In Bang Rong, community leaders viewed the recruitment of new generation as future human resources would play major role in natural resources and mangrove conservation. The educating process in instilling consciousness in the young generation was held in the community through religious classes and reforestation activities outside classroom. The community leaders believed that the success of this generation would become the role model for the next generation. The continuity of activities conducted in the community will lead to the sustainable development of natural resources and mangrove forest.

Choochat: We are now in the process of educating the new generation on natural conservation. Each year we give 20-30 scholarships to children aged around 7 to 10 years to continue their study both within and outside community. We expect that they will return home and become a part of our social capital in terms of human resource development. They will be resource persons for the next generation.

Prakorn: The important thing is carrying out activities continuously. We have been focusing on young children because we believe in their learning ability. We are concerned that children need to study but we do not want to limit the learning process only in the classroom. They need to learn more about life outside classroom.

Lert: We start from children because they are the future of our village. It is easier to educate children rather than adults who are not easy to change. When we start from one generation, the next generation will be educated accordingly. When they grow up, they will be a model for another generation. This will create continuation process and the development of mangrove will be sustained.

Focus Group Discussion and In-depth Interview Bang Rong, Phuket Province

Since budget was another important factor for mangrove rehabilitation program, the community leaders in Bang Rong set up "eco-tourism group" to generate income. In their opinion, the budget from government organization alone was not sufficient to run mangrove rehabilitation program. The community needed to generate their own income to work on the activities that can actually solve the community problem and fit the need of the villagers. Eco-tourism was the business that the community can earn money from and at the same time proved that the existence of fertile mangrove forest could provide the villagers a better living.

> *Amphon: What we have is natural resources. Now we are thinking of using natural resources in the way which is less harmful to the ecological system. Actually, we have already done something. We have arranged eco-tourism. We also have a restaurant run by the villagers. The income from restaurant will be used as community welfare. You know, we can now stand on our feet. We can run our activities without having any support from government organizations. Mangrove conservation is like a value-added activity. The air quality is good. The abundance of coastal fishery and income from eco-tourism are increasing. We do not need to put in more investment. We do not need to spend money on investment. Just conserve our natural resources, we can earn without having to invest.*
>
> *In-depth Interview in Bang Rong, Phuket Province*

The key informants viewed that social control, as one of the social capital component, has become one major tool for mangrove conservation. The community is not allowed by law to punish people who have encroached upon the mangrove. However, the social control through community mandate and social sanction has helped to conserve and maintain the community mangrove forest many times.

> *Amphol: We can not use law but we can use the community mandate. Those who fish or cut woods in the conservation zone will be sanctioned. They will be blamed by the villagers. No one will communicate with them. They will become "black sheep" in the community. How do we know that people has broken the rule? Of course we know because they use or sell product in the village. They can not escape.*
>
> *Choochat: We have the community rules. We will not allow the villagers to use certain types of fishing gears that can be harmful to larvae, juveniles or gravid females. We control them through religious and social activities. Every Friday, villagers have to go to the mosque. In the mosque, we have public meeting. We discuss about the problems that have occurred in our community including mangrove conservation and utilization. Moreover, we have community welfare system such as funding for medical treatment. We provide 150 baht a day for the villager who has stayed in this village for more than 3 years if they are hospitalized. If they do not behave well, we will not provide any financial and other supports.*
>
> *In-depth Interview in Bang Rong, Phuket Province*

Social wisdom helps to regain the capability of community on mangrove management. The key informants pointed out that sustainable development of mangrove is not solely the government responsibility. Local communities should have the responsibility to conserve mangrove from their own wisdom. The government organization should not take the role in implementation, instead they should act as supervisor or supporting agent.

> *Choochat: Even though we have networks on mangrove conservation, the government organizations act as supporting agents. It is the villagers who play a major role in mangrove rehabilitation program, otherwise the activities will not be sustained. Once the villagers carry out these activities by themselves, they will feel that the forest belongs to them. They will love it and protect it because they feel that "it's mine".*
>
> *In-depth Interview in Bang Rong, Phuket Province*

SWOT analysis of factors affecting community awareness and participation

In this study, SWOT analysis is applied to 4 factors: strength, weakness, opportunity and threat. These 4 factors are expected to have significant impacts on the community's awareness and participation in any activities related to mangrove rehabilitation program. When questioned about the strength of community in organizing the activities related to mangrove rehabilitation, the respondents in Ban Nam Khem, as shown in Table 5.7, identified community unity (56%), utilization of mangrove products (21%) and the potential of community leader (18%) as key factors contributing success in mangrove rehabilitation program. Noticeably, approximately 15 percent of the respondents in Ban Nam Khem could not provide the strength factors of the community related to the achievement of the mangrove rehabilitation program.

Even though the information from survey data pointed out that community unity was the factor that could strengthen the ability of community in mangrove rehabilitation program, the data derived from focus group discussion among stakeholders, who were in charge of arranging the program, showed the contrast. The key informants stated clearly that they were not satisfied with the cooperation of community members. In their point of view, it was the government organization that helped to maintain mangrove forests since the villagers were not interested in the program. The community leaders also did not put up enough efforts on the rehabilitation.

Somjai: It is very difficult for us to set up activities on mangrove reforestation because most villagers have to struggle for a living. We have to work. We don't have much time. The support from government organization is very important.

Chidjai: Royal Forestry Department was the pioneer in mangrove reforestation. Without this organization, we could not carry out mangrove conservation program. Local leaders were not strong enough to organize group activities in our community.

Focus Group Discussion in Ban Nam Khem, Phang-nga Province

The qualitative research showed a high degree of a correlation between mangrove dependency and public participation. A high degree of dependency on mangrove resulted in cooperation and participation in mangrove conservation. It was found that fishermen and villagers who earned their living from mangrove products were willing to join the rehabilitation program and would become an active group on program monitoring.

Manob: The profit from natural resources that villagers receive can be our strength in mangrove rehabilitation. The high degree of mangrove dependency will lead to cooperation in mangrove conservation. Even though villagers now get together only in a small group, in the long run we can transform the occupational group into activity group on mangrove management. I believe that this can be done.

Suvit: We have a group of people living in "Soi Tok Poo". The area where they are now living is part of mangrove forest and they earn their living from mangrove products, particularly catching crabs. People call them "a group of Soi Tok Poo" because "Tok Poo" means catching crabs. They earn their living by catching crabs in mangrove forest. They reap profit from mangrove forest. We have planned to start our mangrove rehabilitation program in that area because people there will give us helping hands. We will have manpower and a group of people to monitor the program. Adjacent to this area is another village where we can extend our program and build up a new network.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Table 5.7 Percentage of respondents according to the attitude towards the community strength in organizing mangrove rehabilitation programs

Community strength	Ban Nam-Khem Phang-nga Province	Bang Rong Phuket Province	Total
No strength factors	3.0	0.6	2.3
Potential of community leader	17.5	20.6	18.5
Community unity	55.8	81.8	63.9
Mangrove dependency	20.9	34.9	25.3
Existing conservation group	7.1	14.9	9.5
Information dissemination	4.5	2.9	3.9
Do not know/No answer	14.9	1.7	10.8

Even though prior to tsunami, the community members of Ban Nam Khem did not put up a lot of efforts in the mangrove activity program, there was a good sign of improvement in community participation after the tsunami disaster. Villagers started setting up a group called "civil group" to set up a program on natural resources rehabilitation. Several study tours related to mangrove reforestation were conducted in order to improve the knowledge and understanding of villagers towards mangrove. Moreover, the Community Bank was set up for economic well-being of the community. The bank will be responsible for monetary business, and other activities related to income generating. Therefore, mangrove rehabilitation program can be included in this scheme.

Jermsak: After tsunami we have a group called "civil group". This group aims to rehabilitate natural resources. Group members have initiated eco-tourism and mangrove rehabilitation program as part of their activities.

Suvit: I think that the education and learning process can help. Now in our community we have arranged the study tour program. We found that the program provides not only knowledge and concept of natural resources development but also the concept of unity. Small groups of villagers start to get together and built up into bigger groups. Now we discuss about tourism and we try to link tourism and coastal management together.

Chaivit: We just set up what we call "Community Bank". The bank is supported by the Krung Thai Bank Headquarter in Bangkok. Community Bank will play a role in conservation activity because we will have a committee who will be responsible for economic matter in the community. Mangrove rehabilitation program will be one of the activities since people have realized the advantages of mangroves in the economic well-being of the community.

In-depth Interview in Ban Nam Khem, Phang-nga Province

The mangrove rehabilitation program in Bang Rong was found to be a big success. The respondents mentioned that the key factors that strengthened the community capability in such program were community unity (82%), mangrove utilization (35%), potential of community leaders (21%) and existing conservation group in the community (15%). The qualitative research helped to confirm the survey results in Table 5.7. In addition, the qualitative data revealed that it was not only the leadership but also the team work and the recognition of community members' roles and responsibilities were the key factors leading to success.

> *Amphon: Our leaders are not self-centered. They are more concerned about the community benefit not individual profit. Their teamwork is good. Bang Rong community is not "a one-man show community". Everybody has roles and responsibilities to work for the community. Each villager is like an actor in the drama who knows and plays his or her role for the well-being of the whole community. We work in team.*
>
> *In-depth Interview in Bang Rong, Phuket Province*

Community unity in Bang Rong was in top priority compared to Ban Nam Khem partly because most of the villagers in Bang Rong were born and have resided in the community for longer period. The villagers have became relatives and closed neighbours. They are bounded with family tie and clan system. The good social relationship and interactions are performed at the early stages starting from family, schools and work places. These phenomena have resulted in to good cooperation in various aspects including mangrove rehabilitation program. Moreover, it is evident that community solidarity is performed through religious activities. It is the mosque committee, who is the leader in organizing community activities and building up the community network. The mosque committee is like a central administration of the community that ties many different activity groups to work together. One of the important tasks of the mosque committee is to provide education to young generation in order to prepare them for future mangrove conservation.

Lert: *We are united. We have good cooperation not only because of the strength from religious unity. We cooperate and get together very well because we are linked together with the family tie and clan system. We feel that we are all relatives. That's really helps when we need to work together or to join hands.*

Pong: *We have many group activities such as Group of Young Lad, Group of Older Brothers Assisting Younger Brothers and Conservation Group etc. The group that plays a major role is the Board of the Mosque. The board is like a central government and has responsibility to build up and take care of several group activities such as housewife group, conservation group, young lad group, fishermen group and eco-tourism group. Even though we have many groups, we can work together because each group is part of the network of the board of the Mosque.*

Pong: *We are getting old. We are like dead wood, so we are now discussing about "changing new leaves". We want to have young blood or new generation to take care of the reforestation and conservation programs for us. We have tried to set up a group of young leaders and we act as supervisors. Religious class that we set up every weekend is the place for recruitment. We educate our young generation and build up community consciousness through religious class. We will keep eyes on ways of life and life style of the selected young leaders. We support them. We give them scholarship to continue their education in the university level from "Sargad" which is the money that villagers donate for community activities. We also set up a program called "Upgrading ourselves, Building for Others". The program aims to have senior students work as supervisors in educating younger generation.*

In-depth Interview in Bang Rong, Phuket Province

When question on the weakness of community mangrove rehabilitation was posed, the respondents in Ban Nam Khem, as shown in Table 5.8, pointed out that lack of cooperation among villagers (44%), shortage of good leaders (25%) and low perception on the value of mangrove (22%) were the main causes of community weakness. There was 13 percent of respondents who could not identify the factors related to community weakness. This probably reflected the ignorance on community participation. Lack of cooperation among villagers was partly due to population diversity. Most of the villagers in Ban Nam Khem are not members by birth. People moved to Ban Nam Khem to seek employment. They do not have a sense of belonging. When community activity was organized, not only the mangrove rehabilitation program, the cooperation was low. The situation was even worse when the topics on the potential of leaders came into consideration since the key informants in the focus group discussion stated clearly that local leaders failed to act and conduct community mangrove activity. They themselves did not have good understanding in mangrove forest.

Supot: *There is lack of cooperation in Ban Nam Khem. Most of the villagers migrated from other areas. People here are diversed in terms of culture, ways of life and occupations. They are not members of the village by birth. It seems like they came from everywhere from the north, northeast, central and south. When they reside here, they just communicate and limit their social activities with those from their own region. We have very low integration. This results in our weakness in terms of cooperation in community activities including mangrove rehabilitation program.*

Somjai: *Most of villagers are not interested in reforestation program because they are in commercial fishery. They fish in the deep sea. They don't have time to join activity on shore.*

Sommai: *Each one has to earn his living. They are too busy working.*

Chidjai: *Villagers in Ban Nam Khem don't have monthly salary. They work day by day. If they don't work, they will not have income.*

Sommai: *Frankly speaking, people here are interested to join reforestation activities but they don't have time. The main problem is we don't have a good leader. Village headman do not support such activity.*

Somjai: *Village headman and officers of local administration organization do not know much about mangrove. Our leaders are not like leaders of other village who has good knowledge about mangrove forest.*

Borwon: *Community leaders are not united.*

Focus Group Discussion and In-depth InterviewBan Nam Khem, Phang-nga Province

Table 5.8 Percentage of respondents according to the attitude towards the community weakness in organizing mangrove rehabilitation program

Community weakness	Ban Nam-Khem Phang-nga Province	Bang Rong Phuket Province	Total
No weakness factors	8.2	26.1	13.7
No leader/ weak leader	24.7	2.3	18.8
No cooperation	43.6	53.8	46.3
Value of mangrove not perceived	21.9	30.0	24.1
Not utilizing mangrove forest	5.6	3.1	4.9
Budget constraint	3.3	6.2	4.1
Not sufficient knowledge/skill	7.5	10.8	8.4
No time/earning	2.8	0.8	2.2
No forest area/no zoning	0.8	0.8	0.8
No news/ no information	3.3	5.4	3.9
Risk of tsunami	1.9	2.3	2.0
Invaded by capitalist	0.8	4.6	1.8
Activities not continuous	0.3	1.5	0.6
Obstructed by government policy	0.0	4.6	1.2
Do not know/ No answer	13.1	8.5	11.8

It is now more than 2 years that tsunami struck southern Thailand, many villagers in Ban Nam Khem are still struggling and trying to cope with basic livelihood issues such as replacement of boats and equipment. Some are still unemployed. This situation has become a weakness factor for the mangrove rehabilitation program since any development programs initiated to secure human security will be meaningless as long as the disaster victims have to live with hunger and under poverty. As long as the villagers still do not realize the benefit from mangroves, they will not join the mangrove rehabilitation program. Even though many organizations provided assistance, they concentrated only on material support. Social consciousness on mangrove rehabilitation has not been built up among villagers. The situation became worse when the external assistance was not evenly distributed among the villagers. This led to conflicts which will in turn affect the future cooperation in community activity.

Pravat: *Many villagers still can not settle down. Some are still unemployed. It seems like we have to start counting from one again. Life has just begun. We need more time. We just escaped from death. Even though we have a place to stay but some are still unemployed.*

Visoot: *Our village do not have mangrove forest. The village is located in front of mangrove belt. In addition, many villagers do not get any direct benefit from the mangrove. So, they do not see any advantage of mangrove.*

Wit: *They are commercial fishermen. They fish in the deep sea. Importantly, we don't have a leader who is responsible for mangrove reforestation.*

Visoot: *We seldom have reforestation activities. We did not have good leaders who were able to manage these activities.*

Daeng: *The reforestation program could be run if the government hired villagers to work in the program because villagers need money.*

Sanguan: *The important factor is money. We have to convince villagers that they can earn their living if the mangrove forest is pristine.*

Manob: *The biggest weakness of our village is lack of unity. We can easily be interfered by external factors. After tsunami, many organizations came in and provided assistance. Each organization had its own objectives. The participation of villagers in many activities conducted by organizations with different objectives sometimes caused conflicts in our community. Another important thing is some organizations focused only on material support. Such assistance could not provide us an opportunity to learn or to work together. The organizations failed to construct social consciousness on mangrove rehabilitation. The situation was even worse when the villagers did not get material support equally, leading to conflicts of interest among villagers.*

Focus Group Discussion and In-depth interview in Ban Nam Khem, Phang-nga

In Bang Rong, one-fourth of the respondents did not foresee the community weakness in mangrove rehabilitation activities. The causes of weakness that the respondents perceived were lack of cooperation (54%), low perception in the value of mangrove (30%) and insufficient knowledge and skill (11%), respectively. The information derived from in-depth interview revealed that low cooperation occurred among new comers. It was evident that new migrants did not provide good cooperation and sometimes created problems in mangrove management by breaking the community mandate. Additional problems were public relation and lack of continuity of support from government organizations. Lack of sense of belonging and self-sufficiency concept were also significant factors resulting in community weakness.

Amnad: Our weakness is outsiders. We found that new community members who moved from other places were self-centered. They were not concerned about community interest. They want to have only individual profit. Sometimes these people persuaded other villagers to join them. That's why now we have focus on building up consciousness on the value of mangroves in our young generation. We trained them at least twice a year under the project "Loving Mother Land". The training were related to the perception on value of natural resources and mangrove forests. We also have religious ceremony related to the training program. We teach young generation that it was a sin to destroy natural resources and environment. We have to serve our Allah by conserving nature.

Prakorn: We still have some limitation on public relation. Sometimes community leaders organized mangrove activities without informing villagers. I understand that sometimes community leaders avoid informing because they felt that some activities are like propaganda. They were afraid that the villagers will misunderstand that the activities were arranged for their own interest or benefit not for community as a whole.

Sarayut: We don't have any problem in terms of management in our community. The main problem is lack of continuity of support from government organizations. The main problem is shortage of mangrove seedlings/tree. If we don't have support from government organization, we can not proceed with our reforestation activities.

Amphon: Our weakness is lack of understanding of fundamental things. In my view, there are 2 fundamental things that need to be taken care of. The first thing is community. If we discard our own community or if we don't think about the well-being of our community as a whole, our community will be weak and we can not run any activities relevant to resource conservation. The second thing is we forget to examine our capability, we don't understand the concept of self-sufficiency. For example, if we could earn only 200 baht a day but we spend more than we could earn, that would lead to more natural exploitation. We will have to overharvest natural products. We will encoach on mangrove for land. We will cause mangrove degradation and depletion.

In-depth interview in Bang Rong, Phuket Province

Even though there are many factors weakening community capacity to organize mangrove rehabilitation activities, the respondents in Ban Nam Khem indicated several factors that could provide a positive opportunity for the rehabilitation program in community. As shown in Table 5.9, almost half of the respondents in the survey identified support from government. One-fifth indicated the community also recieved the support from local administration organization. Other opportunities for activity arrangement were good network in the community (17%), tripartite cooperation governmental organizations (both national and local levels), non-governmental organizations and community (12%) and network outside community (10%), respectively. The qualitative data confirmed that the continuity of support from government and tripartite cooperation were the most important driving forces. The villagers needed support from government in terms of budget support, knowledge or information as well as technical assistance. The role of the government organization, however, should be supervisor, not the leaders. The activities on planning, implementing and monitoring of the rehabilitation program should be carried out through local community leaders or groups.

Pravat: As an officer of sub-district organization, I think that the support and cooperation from government organization will give us a good chance in succeeding mangrove management. Government organizations could help in terms of budget allocation. Local organization like us can provide manpower and knowledge or help in creating awareness among villagers.

Jermsak: Government should support budget or provide knowledge and information for the better understanding towards mangrove. Villagers should run activities based on their own interest and capability. Government organizations should act as supervisors. They don't need to work on or manage everything. The villagers should be the one who carry out the work in the field.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Table 5.9 Percentage of respondents according to the attitude towards the community opportunity in organizing mangrove rehabilitation program

Community opportunity	Ban Nam-Khem Phang-nga Province	Bang Rong Phuket Province	Total
No opportunity factors	2.5	2.8	2.6
Support from government	48.2	63.2	52.8
Support from local organizations	20.8	21.6	21.1
Support from private sectors	2.6	5.8	3.6
Tripartie Cooperation	11.7	18.1	13.7
Budget support	10.2	14.0	11.4
Knowledge/training provided	5.7	6.4	5.9
Community network already existed	17.4	26.3	20.2
Network outside community	9.4	15.2	11.2
Dissemination of good information/PR/Monitoring	4.4	7.0	5.2
Do not know/No answer	14.3	2.9	10.8

The key informants were optimistic that even though tsunami caused a great loss of life and property, the "crisis" could be turned into "opportunity". It was evident that the mangrove belt reduced the impact from tsunami by serving as natural shields against disastrous waves. Moreover, the indirect benefit from tsunami could be seen from the increasing level of cooperation among villagers in Ban Nam Khem in most community activity arranged after tsunami. This could be a good opportunity to integrate ecological consideration into post-tsunami mangrove rehabilitation program in relation to public participation. Government organizations or academic groups should gather and disseminate more detailed information based on ecological researches on the linkage between mangrove and the damage caused by tsunami. The advantages and values of mangrove forest on their ecological functions should also be integrated into public awareness program.

Supot: Actually tsunami provided us a chance to introduce mangrove rehabilitation program into our community because the villagers whose houses were behind the mangrove belt were our good eyewitnesses. The villagers perceived that people who lived behind the forest experienced less damage. In contrast, those who lived near the beach faced greater loss both their relatives, lives and property. I can say that this disaster, despite its damages, could at least give us a good chance to change people attitude and gain better understanding towards mangroves.

Jermsak: Originally, villagers in Ban Nam Khem were not members of the community by birth. Prior to tsunami, the cooperation among people was rare. After tsunami, villagers tended to participate more in community activities. They started to be united. This is a good opportunity to arrange group activities for mangrove rehabilitation. We should encourage villagers to play more roles in the rehabilitation program. Even though the government organizations have the responsibility on national resources management, the activities related to local management should be run by the local community. Government organizations should limit their role as supervisors not lead actors

Mano: We tried to organize our community in a systematic way by setting up a committee on community development. We also have community funds. We are now trying to develop community fund into a firm organization as a community bank. We will use community fund as a tool for reorganizing our community. After the community is united, we will proceed to work on natural resource management.

Sanguan: The ignorance of villagers on mangrove rehabilitation program in the past was partly due to lack of knowledge and understanding. Most of the villagers were concerned only about the economic well-being of their families. Very few of them paid attention to mangrove conservation. The government organization should convince people by linking the advantage of mangrove conservation with the economic well-being of the villagers. If the villagers see how they can earn their living from mangrove forest, for example eco-tourism, they will join the mangrove rehabilitation program. People normally calculate what they will get or how much they can earn from participating in any activity.

In-depth Interview in Ban Nam Khem, Phang-nga Province

It was also evident that a higher proportion of villagers in Ban Nam Khem, compared to Bang Rong, refused to give any responses concerning the opportunity of the community to organize any mangrove rehabilitation activities. The respondents in Bang Rong reported that support from governmental organizations (63%), assistance from local administration organizations (22%), network in community (26%), tripartite cooperation (18%) and building up network outside community (15%) were significant factors that enhanced community capability in setting up mangrove rehabilitation program. They also believed that tripartite cooperation namely government organization, non-governmental organization and local community, together with the network formed both within and outside the community were the major driving forces that provided opportunity for the community to set up mangrove rehabilitation program.

Prakorn: The most important thing is cooperation and support from local administration organization. Pak-kok sub-district administration organization supported us in several aspects. The budget allocation from this organization really helped us in running activities on mangrove conservation. The mosque in our village also worked hand in hand with this organization.

Lert: We got support from other organizations as well, such as Community Development Organization and some NGOs.

Prakorn: Right. We also got support from provincial office of the Ministry of Agriculture, the Ministry of Natural Resources and Environment, Royal Forestry Department. We got a lot of support from many organizations outside community. The opportunity is opened in terms of support from many organizations. It is not the problem of having no support, but it is the lack of continuity that hindered us.

Focus Group Discussion in Bang Rong, Phuket Province

Information from in-depth interview pointed out that social control and community-based management were the underlying factors contributing to the success in mangrove reforestation and rehabilitation. In Bang Rong, social sanction was used as a tool to punish people whose activities were harmful to the existence and pristine condition of mangrove. The involvement of community in mangrove and natural resource management that resulted in the provision of both direct and indirect benefit to community members in the form of income-generating eco-tourism or community welfare was the key factor for the success in implementing the mangrove rehabilitation scheme.

Pong: *In fact, we are not government organization, so we have no legal power to arrest or to fine people who break the rule, but we have community mandate. We use social sanction. The villagers will not pay attention, not talk to and not communicate with the violators. We will not join them in any social events such as marriage ceremony or funeral ceremony. Sometimes we write their names on the board and condemn them publicly. This is how the community make a punishment. The rule violators will know that the community always keep their eyes on them.*

Amphon: *What we have is natural resources. Now we are thinking of using them in a less harmful way to the ecological system. Actually, we've already done something. We have run an eco-tourism. We also have a restaurant run by villagers. The income from restaurant will be used as community welfare. You know, now we can stand on our feet. We can run our activities without having any support from government organizations. Mangrove conservation is like a value-added activity. The air quality is good. The abundance of coastal fishery and income from eco-tourism are increasing. We do not need to put more investment. We do not need to spend money on investment. Just preserve natural resources, we can earn without investment.*

In-depth Interview in Bang Rong, Phuket Province

When questioned about the threat facing the community in running a mangrove rehabilitation program, almost 60 percent of respondents in Ban Nam Khem, as shown in Table 5.10, could not provide any responses. Among those who responded concluded that the threat factors were lack of cooperation (42%), problems caused by outsiders (11%), lack of potential leader (10%) and budget constraint (8%), respectively.

The lack of cooperation among community members was partly due to the inappropriate method of assistance provided by other organizations outside the community. The support the disaster victims received was material supply or money. The ignorance of the organizations on capacity building to raise a social consciousness on the sustainable development process became an important threat for organizing mangrove rehabilitation and management program.

Jermsak: *Public relation is very important. We have public relation on mangrove. It's not the problem of the public relation. The problem is the knowledge and information provided to villagers. Sometimes it is not clear. The villagers can not thoroughly understand it.*

Supot: *At the beginning, the provincial government organization set up the reforestation program and hired some villagers for planting. After tsunami, the number of workers was decreased not because they had other occupation but because they got material supply and monetary support from several organizations. The money gained is a higher sum than the payment from government organization. The assistance from other organizations was like giving fish not teaching how to fish. Now the villagers get acquainted to receiving things. They do not want to do anything, They just stay in their lodgings and wait for help to come by. This is very dangerous for the future development of the community, including the cooperation in mangrove rehabilitation program.*

In-depth Interview in Ban Nam Khem, Phang-nga Province

The conflict and lack of cooperation among local leaders together with their ignorance in mangrove management were major obstructing factors in introducing and implementing mangrove rehabilitation scheme. It was evident from qualitative research that local leaders usually concentrated on material infrastructure development rather than environment or coastal management.

Mana: *We don't have good cooperation. OK. Don't mention about the villagers. That's the biggerscale. Let's start from the leaders. We have 5 leaders, 3 members from sub-district administration organization, one village headman and another sub-district leader. These 5 leaders always have conflicts among them.*

Visoot: *If the leaders have conflicts, how can we expect good cooperation among villagers?*

Suvit: *We don't have enough land for planting trees. We need cooperation among community leaders but we still can not get it. The leader of local administration organization whom we expected to be the cooperating agent is not interested in mangrove rehabilitation program. He is more concerned about infrastructure development, such as electricity, pipe water and road. I have seen that the budget allocation on mangrove rehabilitation was stated only in the policy but no implementation until now.*

In-depth Interview in Ban Nam Khem, Phang-nga Province

The information from qualitative research conducted in Ban Nam Khem also indicated that inadequate land area for reforestation was another main obstructing factor to the success of mangrove rehabilitation program. Local community also mentioned about their lack of rights to manage mangrove in the community since the areas were government property. The key informants voiced out that local community should have the responsibility to conserve mangrove as well as the rights to utilize the forest and their products.

Visoot: *We don't have areas for planting. The mangrove areas are in other village. We are not the members of that village. If we want to run any activity, we don't know whether we can carry out the job in that area or not.*

Chaivit: *Mangrove forest here is government property. It's not the community forest in the sense that we want it to be. We are not allowed to do any management. If the forest is identified as community forest, we will have the rights and responsibility to manage it. As for now, we don't want to do anything because the picture is still not clear. However, we still keep our eyes on the forest because we can earn our living from mangrove products.*

In-depth Interview in Ban Nam Khem, Phang-nga Province

In Bang Rong, almost half (47%) of the respondents in the survey mentioned that the community faced no obstacle in running mangrove rehabilitation program. Those identifying threat factors cited lack of cooperation (55%) and the interference of powerful encoachers (17%). The key informants in the community stated clearly that the outsiders, both new migrants and the tour companies, were the main groups that caused natural resource degradation. They also obstructed mangrove rehabilitation scheme. These people were self-centered and concerned only about monetary profit without any consciousness on natural resources conservation.

Amphon: *Tourism run by business sectors has caused problems to mangrove conservation since they are concerned about monetary benefit only. We tried to protect the natural resource by running eco-tourism. We set up restaurant and managed the pier to guarantee that coastal environment will not be further degraded from the outsiders and the income distribution will go to our villagers.*

Chartchai: *We had new comers in our village but they did not follow the community mandate. They started activities that were harmful to our environment and rehabilitation program. Moreover, they persuaded other members to follow. This really created a big problem in our community. We start to have conflicts of interest.*

In-depth Interview in Bang Rong, Phuket Province

Table 5.10 Percentage of respondents according to the attitude towards the threat of community in organizing mangrove rehabilitation program

Community threat	Ban Nam-Khem Phang-nga Province	Bang Rong Phuket Province	Total
No threat factors	20.6	47.2	28.8
No land	4.5	2.2	3.9
Misused of the forest	6.7	4.3	6.2
Powerful encoachers	10.9	17.2	12.3
Budget constraint	8.3	11.8	9.1
Lack of knowledge and skill	6.1	3.2	5.4
No cooperation	41.5	54.8	44.6
No leader/weak leader	9.6	1.1	7.6
Do not know/No answer	19.5	10.8	17.5

Chapter 6

Proposed Mangrove Forest Rehabilitation Program

Nittharatana Paphavasit Siriwan Siriboon Viroj Teratanatorn
Ajcharaporn Piumsomboon Busarin Bangkaew and Chanette Milintangkul

To realize the importance of mangrove as the best barrier to mitigate tsunami, there has been heightened interest in protecting and rehabilitating the coastal forests. Various affected countries in the region have initiated plans to develop coastal greenbelts to protect their shorelines, such as Malaysia, Thailand and India. However, poor design and management of such schemes is affecting their effectiveness. In our case, mangrove rehabilitation scheme can be divided into four major stages; 1) drawing the goals and objectives of mangrove rehabilitation in each site; 2) outlining the activity and operation plan based on the ecological process in human interactions which play the important roles in mangrove rehabilitation; 3) defining the criteria for the monitoring/assessment of mangrove rehabilitation and 4) management plan. The Department of Marine and Coastal Resources has launched massive mangrove rehabilitation programs in the affected area. In Phang-nga Province alone, the rehabilitation covered 1,952 rai. It is necessary to design the rehabilitation project to suit each site and the objectives of the community. Site specific design of mangrove plantation should be proposed and based on suitable species, existing biological productivity and their maintenance processes as the aftermath of the tsunami disaster. In-depth data on the complex socio-economic and ecological relationship are useful in designing specific rehabilitation program. The coastal rehabilitation will not only ensure the future safety for coastal communities but also contribute to the long term sustainable development.

Proposed mangrove forest rehabilitation program of different objectives

There are two terminologies “rehabilitation” and “restoration” that are often mistakenly used. The concept of “rehabilitation” of a mangrove ecosystem as explained by Field (1999) is the return of degraded mangrove land to a fully functional mangrove ecosystem regardless of the original state of the degraded land. While “restoration” of a mangrove ecosystem is the return of degraded mangrove land to something like its presumed original state. There is time that “rehabilitation” equates to “restoration”. This is the case when the degraded mangrove is being rehabilitated for conservation purpose, therefore, all ecological processes and genetic diversity must be reinstated. The goals and objectives of the rehabilitation program must clearly be defined.

As the mitigation to impacts of tsunami, site specific rehabilitation scheme based on our integrated knowledge of the area is proposed for 3 objectives:

1. Coastal green belt as a natural shield against disaster and shoreline protection
2. Mangrove rehabilitation as an enhancement of coastal fishery
3. Mangrove rehabilitation as landscaping for ecotourism

1. Coastal green belt as a natural shield against disaster and shoreline protection

This rehabilitation scheme was proposed on the basis that rapid re-colonization in plant communities was expected in a short term. The re-colonization will allow the tree to establish root and upright itself. In area such as Ban Nam Khem, Phang-nga Province, the area has received direct impact from tsunami. In area where the average tree height was less than the tidal wave, the tree canopy could not resist the wave impact, resulting in fallen stem and uprooted tree. In the dense *Avicennia* forest, the root system of *Excoecaria*, which penetrated deeper than *Avicennia,* helped save these species as compared with *Avicennia*. Fring mangrove forest facing the open sea had been totally destroyed and cleared approximately 10-50 m. Coastal green belt should be initiated along this coastline. Mangrove species in the Family Rhizophoraceae in particular *R. apiculata* and *R. mucronata* are selected species. Most mangroves have the laterally spreading cable roots with smaller vertically descending anchor roots. The root system is usually shallow less than 2 m. Despite the shallowness of the root system, the ratio of below-to-above ground biomass is higher in mangroves species. This high biomass ratio is an adaptation to the unstable substrate. *Rhizophora spp.* similar to *Ceriops* also have stilt roots generally branched out from the trunk and growing into the substrate. These elaborate twining root system of *Rhizophora* will help to reduce the wave energy by created the strong bottom friction retarding the flow.

The root system is also the effective sediment binder. Mud accretion can be rapid up to 1.5 cm. per year *Rhizophora* in response to cope with sediment accumulation by forming extra arches of the stilt roots (Saenger, 1982; Bird and Barson, 1982). In term of growth, R. apiculata was best selected species on the abandoned shrimp farm.

For planting, the seedling used should be reared in the nursery not less than 1 year but the seedling can be order. The propagule should not be used because they are slow in growth and the root yet to establish, they will be washed out on the next tide. The seedling should be planted in alternate rows or not in rows as irregular planting imitating the natural forest. The spacing should be approximately 1 m. x 1 m. instead of the normal spacing 1.5 m. x 1.5 m. There have been concerns in planting mangrove trees in rows in “plantation style” in the coastal green belts initiative. Having the trees lined in alternate rows was like having the second row as line of defense (Parish, 2005).

As in the tidal mudflat in Ban Nam Khem, the newly accreted sediment is usually soft and unstable. The chance for seedling survival is slim. Prior to planting, the area should care fully been investigated in particular the mud accumulation. If the mud on the surface exceed 1 meter, the area should be avoided. Moreover if the area already with pioneer species such as *Avicennia* and *Sonneratia* indicate that the area is hard enough for planting. The planting should conducted in small patches instead of launching the large plantation.

2. Mangrove rehabilitation as an enhancement of coastal fishery

Reintroducing different species of mangrove was the key to reestablishing the forests as viable ecosystem. As in the case of mangrove rehabilitation as the enhancement of coastal fishery, multispecies are recommended as in the rehabilitation of abandoned shrimp farm. This rehabilitation program is recommended for Bang Rong, Phuket Province. Different mangrove species required different environmental requirement with in turn in different zonation as in Table 6.1.

Table 6.1 Environmental requirement for certain mangrove species (Aksornkoae *et al*., 1996)

Zonation	Tidal inundation	Water Quality		Sediment Quality		Mangrove species
		pH	Salinity (psu)	pH	texture	
Seaward/Riverine	Daily	6.7-7.2	15-30	6.2-6.8	soft mud	*Rhizophora*
Seaward/Riverine	Daily	5.0-7.2	5-30	6.0-7.5	soft mud/ sandy mud	*Avicennia*
Seaward/Riverine	Daily	6.7-7.2	0.5-20	6.0-7.5	sandy mud	*Sonneratia*
Landward fringe	Daily-Occasionally	6.0-7.0	15-30	7.0-8.0	soft-hard mud/ muddy surface	*Bruguiera*
Landward fringe	Daily-Occasionally	6.0-7.0	15-30	7.0-8.0	soft-hard mud/ muddy surface	*Ceriops*
Landward fringe	Daily-Occasionally	6.0-7.0	10-25	7.0-8.0	hard mud	*Xylocarpus/ Excoecaria*

From our study on the assessment of 4-5 year mangrove plantation of multispecies mangrove on abandoned shrimp farm on coastal fishery, the multispecies mangrove plantation on abandoned shrimp farm had enhanced the coastal fishery as in Figure 6.1. The rate of recovery was comparable to those with natural succession without human interference. The rate of recovery was within 5 year (Paphavasit *et al*., 2002, Paphavasit *et al*., 2004, Teeratanatorn, 2002)

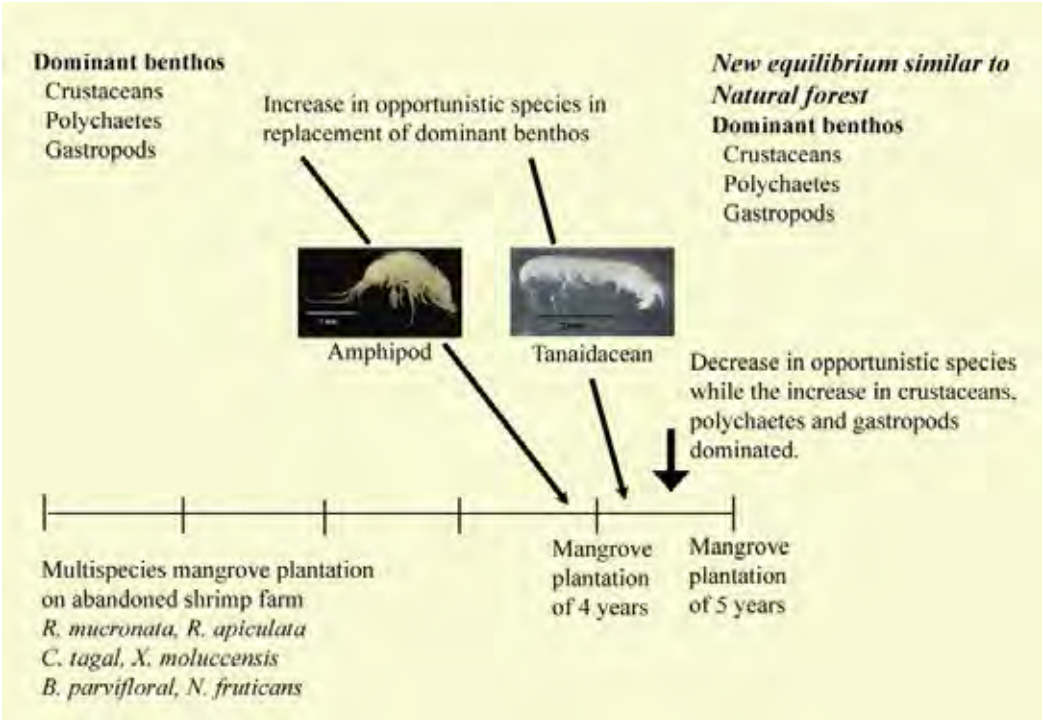


Figure 6.1 Successional pattern in the multispecies mangrove plantation on abandoned shrimp farm in Nakhon Si Thammarat

Multispecies of mangroves can be selected according to zonation of different species based on the sediment characteristic distance from the sea and elevation on shore.

2.1 Mangrove species: *A. marina, A. officinalis, A. alba, R. apiculata and R. mucronata*., should be planted seaward edge, along the shoreline and channel banks as in Figure 6.2

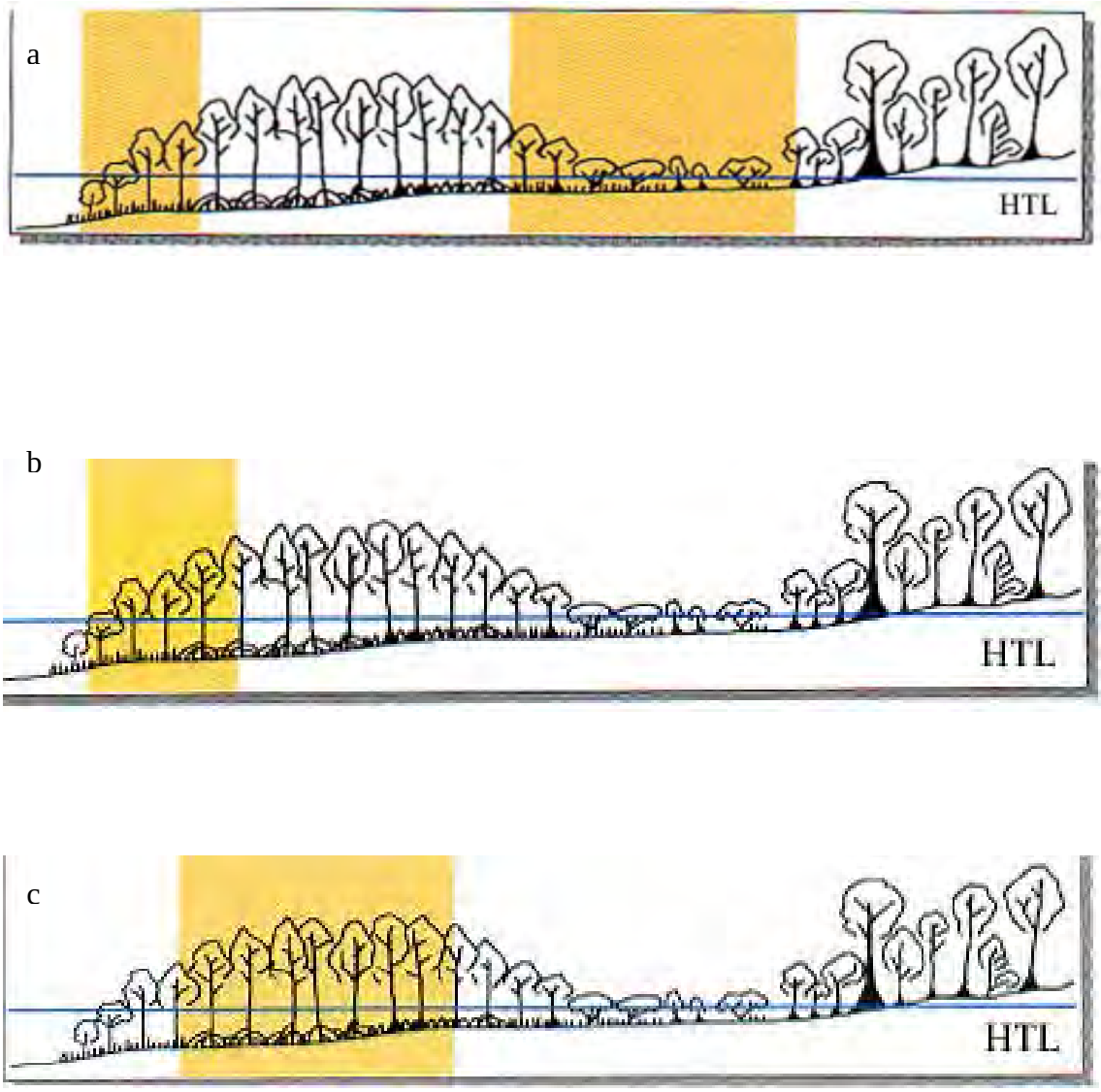


Figure 6.2 Zonation pattern for (a) *Avicennia* spp. (b) *Rhizophora apiculata* and (c) *R. mucronata*

Minagawa and Nakamura (1996) have investigated mangrove vegetation zonation in Thailand and reasons for its formation in Phang-nga Bay. They have classified the mangrove forest in Phang-nga Bay into two patterns based on field research and past survey according to Figure 6.3

Rhizophora mucronata	***Rhizophora apiculata***	**Mixed Forest**	**Back Mangrove**

Sonneratia alba, Avicennia officinalis* or *Avicennia alba	**Mixed Forest**	**Back Mangrove**

Seaward Landward

Figure 6.3 Two main types of zonation patterns in Phang-nga bay
(Minagawa and Nakamuwa, 1996)

In our survey, we also find similar zonation where *Sonneratia* spp. mixed with *Avicennia* spp., *Sonneratia* spp. can also be selected in the rehabilitation plan because they require similar ecological factors as *Avicennia* spp. as shown in Figure 6.4.

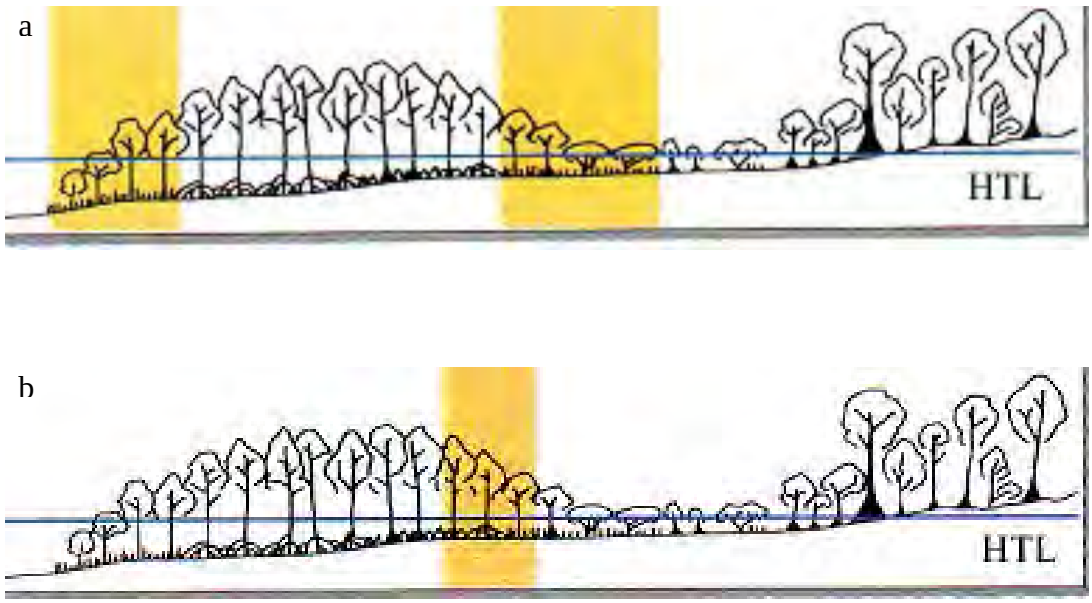


Figure 6.4 Zonation pattern for (a) *Sonneratia alba* and (b) *Sonneratia caseolaris*

2.2 *Bruguiera gymnorrhiza, B. sexangula, B. parviflora, B. cylindrica, Ceriops tagal* and *C. decandra* should be planted in inland zone next to *Rhizophora* zone as shown in Figure 6.5 and 6.6. The mud is harder than the previous zone.

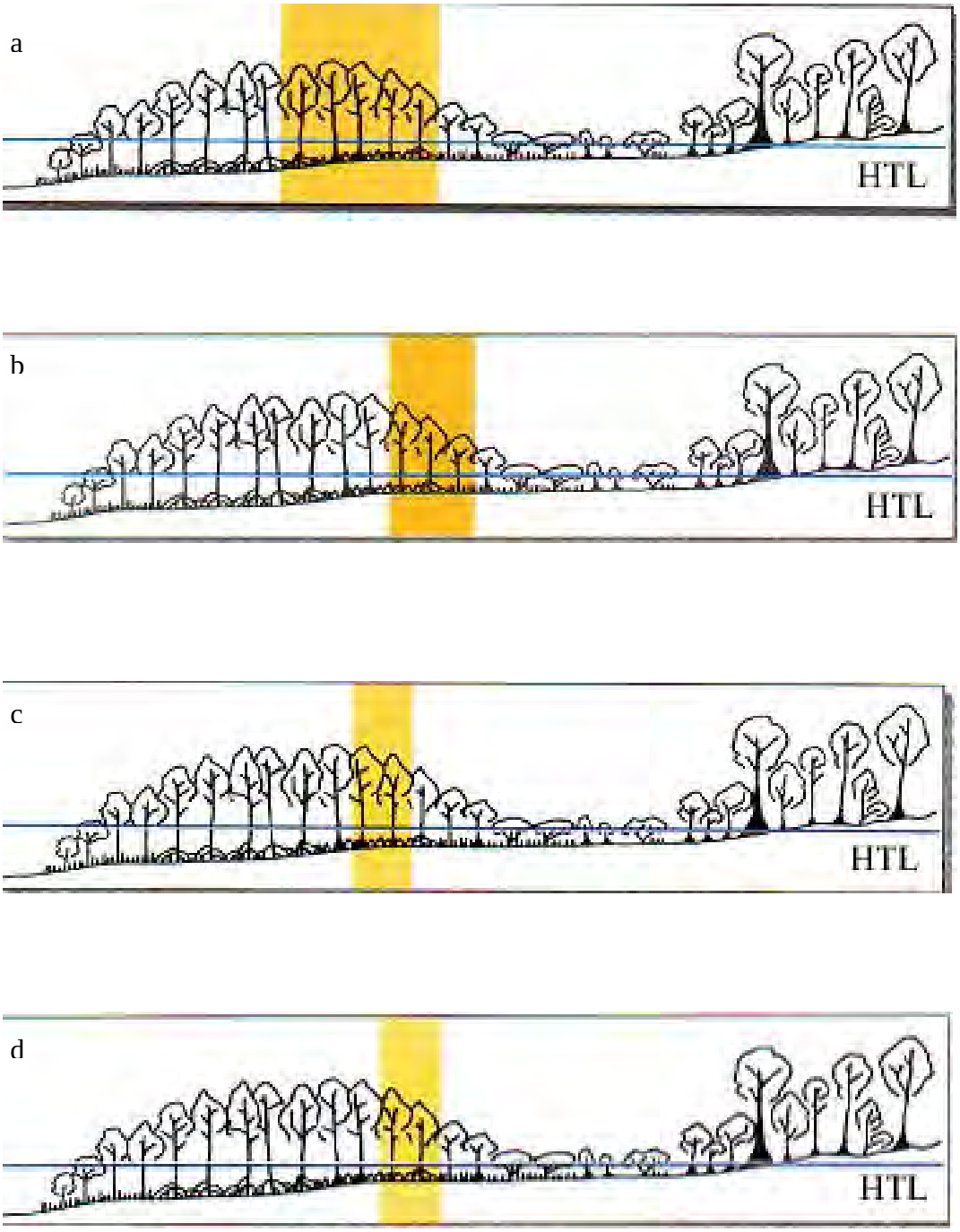


Figure 6.5 Zonation pattern for (a) *Bruguiera gymnorrhiza* (b) *B. sexangula* (c) *B. parviflora* and (d) *B. cylindrica*

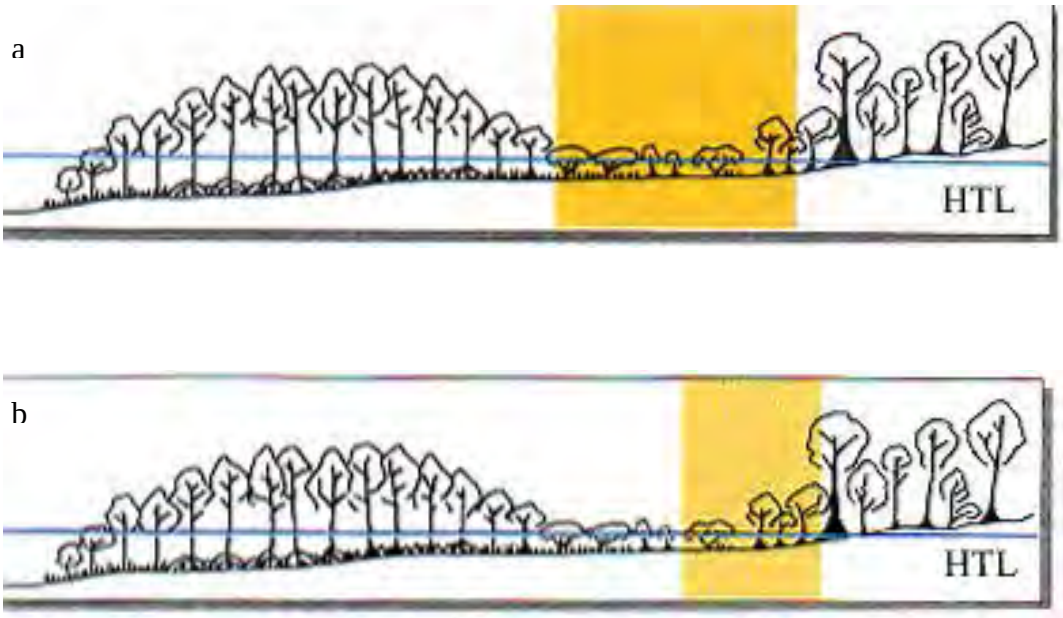


Figure 6.6 Zonation pattern for (a) *Ceriops tagal* and (b) *C. decandra*

2.3 *Xylocarpus moluccensis, X. granatum, Lumnitzera littorea, L. racemosa* usually favor high elevated inland. The sediment is usually hard and within the high tide water *Nypa fruticans* distributed in the brackish area or in the freshwater reach in the channel as in Figure 6.7 and 6.8.

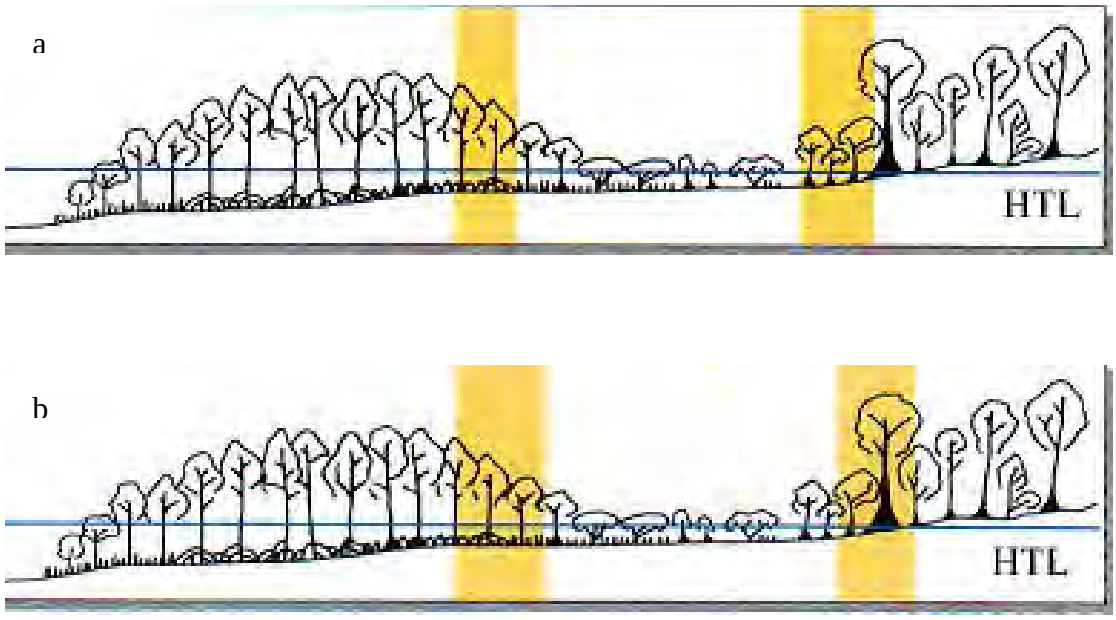


Figure 6.7 Zonation pattern for (a) *Xylocarpus moluccensis* and (b) *X. granatum*

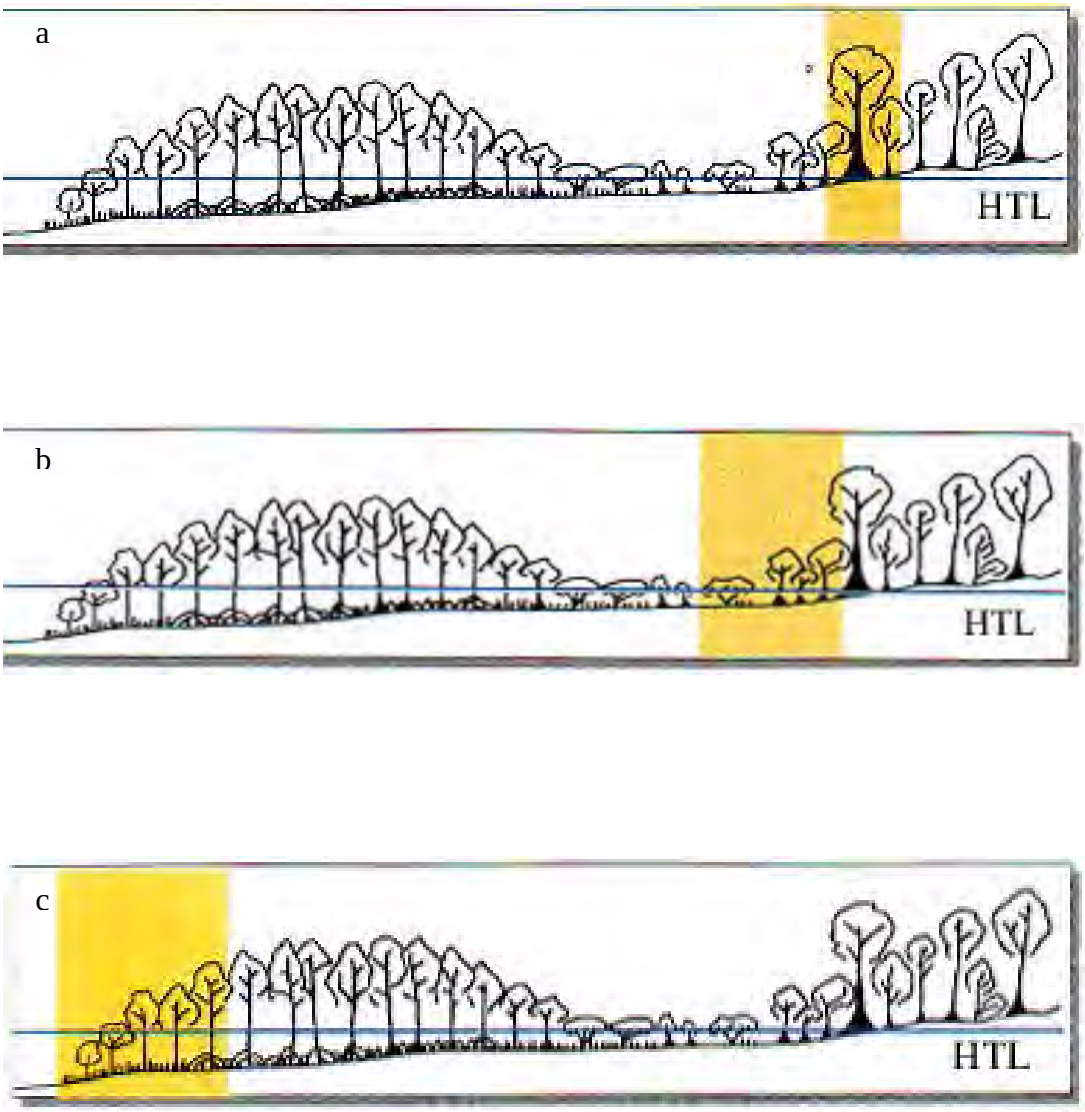


Figure 6.8 Zonation pattern for (a) *Lumnitzera littorea* (b) *L. racemosa* and (c) *Nypa fruticans*

2.4 In Bang Rong community based forest, mud lobster mounds were found scattered in the areas. The sediment was turned over and many areas have been elevated so that occasional high tides were reached. These areas were appropriated for *Excoecaria algallocha, X. moluccensis, Thespecia populnia.* These mangrove species are deciduous species able to withstand drought as in Figure 6.9.

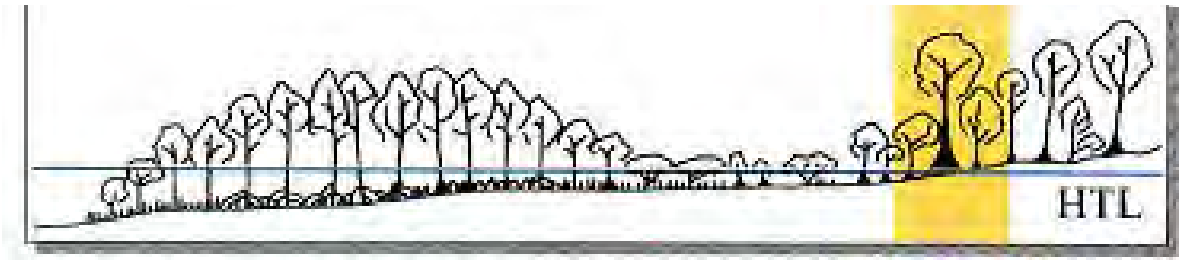


Figure 6.9 Zonation pattern for *Excoecaria algallocha*

The planting technique employed here is the irregular system. Each species is planted in mosaic community according to the appropriate zonation. Enrichment planting can also be used in this case. Planting spaces can be the gaps within the natural forests. Selected species can be those that thrived well in the nearby forest.

3. Mangrove rehabilitation as landscaping for ecotourism

One of the main reason of rehabilitation as stated by Field (1999) is the use of mangroves for the purpose of enhancing the landscape. There are examples of mangroves being planted as part of a resort complex. Most importantly another reason is to produce a sustainable mangrove ecosystem that will enhance a coastline or estuary. Mangrove ecosystem can be managed as multiple use system for the high and sustainable yield of natural products. This rehabilitation is proposed for Bang Rong forests. In this case the rehabilitation can be modified to cover both the landscaping for ecotourism and to enhance coastal fishery. From our in-depth interview in Bang Rong, the villagers have already organized the ecotourism in their village. They want their mangroves as the source of knowledge for visitors. Selected mangrove species of high diversity should be replanted. Species diversity should be considered to select several species for landscaping for aesthetical purposes. Plants of the same genera of different species are also selected to demonstrate genetic diversity, different phenotypic characteristics. There is also the need to select different area in the forest representing topography diversity. Along the channels, trial paths and walkways for visitors, selected species are replanted for landscaping or to enhance certain plant zonation. In our two study area, we proposed that several endemic and rare species should be reintroduced through the rehabilitation programs. These species were *Heritiera littoralis*, *Xylocarpus macrophylla, Excoecaria agallocha* and *Lumnitzera racemosa*.

Specific considerations when the rehabilitation program is implemented in one area, assessment and monitoring on the protocols of the project is necessary in order to adjust to enhance the productivity and to sustain the activities. Identify the causes of site degradation and assessing site selection criteria are the two first important steps based on the ecological data. This is important for outlining the planting techniques and the master plan. Sourcing of seedling and planting whether the natural, field transplant or nursery seedlings and samplings are required. Monitoring/assessment of the success of the rehabilitation program is the next integral step. The most difficult step is to maintaining the resulted mangrove ecosystem. This

need to be carefully plan in term of management and maintenance of the forest productivity. Public participation is the most important element leading to the rehabilitation success and to sustain the forest productivity.

Four main guidelines on criteria measuring the success of a mangrove rehabilitation programme (Field, 1999) and can easily be adapted to the proposed rehabilitation program as follows:

1. Effectiveness of the planting

The main criteria is to look for the closeness to which the new mangrove ecosystem meets the original objectives. If the objective of the mangrove rehabilitation in enhancing coastal fishery, the key indicator is the biological productivity in term of planktons and fishes. Fishes and shellfishes can easily be monitored from fisherman catches or simple statistic kept from fish landing in the market. Fish composition and abundances are enumerated. The successional process taken in any ecosystem would require the long term monitoring of 3 – 5 years.

2. The rate of recruitment of flora and fauna

This is important to measure how quickly the rehabilitated site recovers its integrity. As the rehabilitation program implemented, there is always the question ask whether the rehabilitated forests as productive as the intact forest. These require the monitoring which can be carried out in two level; In-depth multidisciplinary research on the forest productivity and the effects on the villagers and their livelihood should be conducted at interval after 3 – 5 years of the project. Community-initiated monitoring program should be plan after the trainings provided for the tripartite stakeholders in the rehabilitation program. The data resulted from this continuous monitoring carried out by the villagers can be put in use in the management and maintenance of the forest productivity. These data can also be used for the long term management plan. The villagers can be trained to monitor the regeneration ability of the new forest by simply counting the number of seedling and samplings in the permanent plots or at random. They can carefully take notes of the actual flowering and fruiting season in their respective site as in Figure 6.10. This phonological information is important in term of the prediction of regeneration ability of the new forest. It also help to locate the source and timing for the seedling and saplings for the rehabilitation project and the maintenance of the forest.

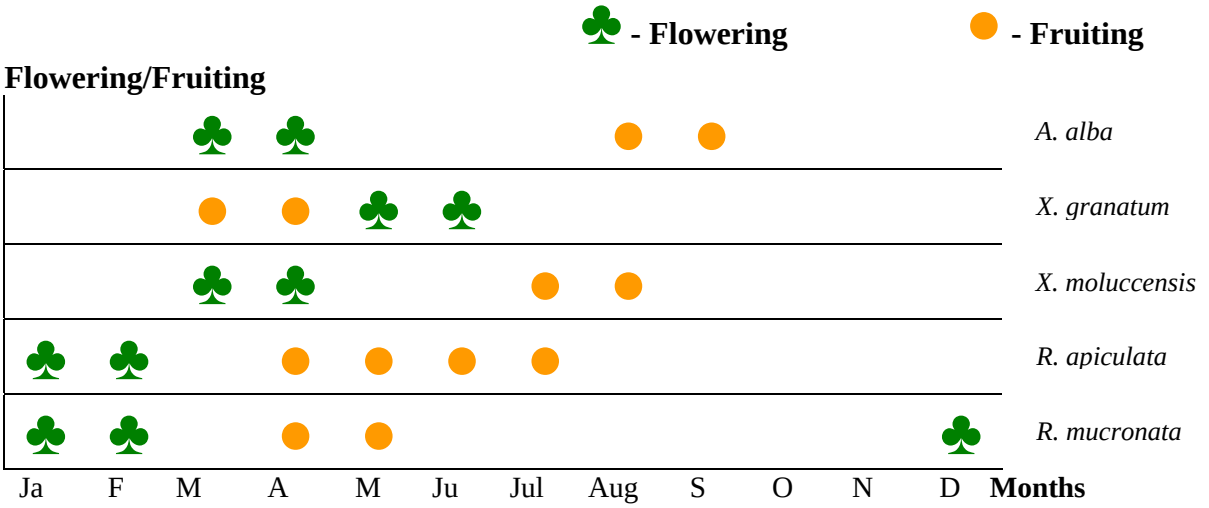


Figure 6.10 Flowering and fruiting season in dominant mangrove species in Phang-nga and Phuket Province

3. The efficiency of rehabilitation program

This can be measured in terms of the amount of labor, resources and material used.

4. The long term sustainability of the new mangrove ecosystem

This is the most crucial step and should be carefully plan according to the specific sites and objectives. We have underline the important of this long term sustainability of the rehabilitated forest and put forward several factors that need to be considered in the section **Factors underlying sustainable development of mangrove resource.**

Factors underlying sustainable development of mangrove resources.

This study aimed to understand the complex ecological-social-economic linkage which was necessary to determine suitable approach for mangrove rehabilitation program. The findings from the study lead to the critical review of factors determining suitable development of mangrove resources. Evidently, it was suggested that sustainable development of mangroves should not solely be the government responsibility. Local communities should have the responsibility to conserve mangroves as well as the rights to utilize the forests and their products. In order to conserve and maintain long-term sustainable yields from these valuable resources, full cooperation among tripartite bodies: government sector (both national and local levels), non-governmental sector and public participation, is ultimately required. The **six REs** namely **REvalue**, **REstrategy**, **REprocess**, **REstructure**, **REcondition** and **REsearch** were proposed as underlying factors determining sustainable development of mangrove resources as followed.

1. REvalue. The current direction of community and national development focuses on material and monetary profit which results in natural resoures exploitation, including overutilization of mangrove forests and overharvesting of mangrove products. The success of mangrove rehabilitation program run by villagers of Bang Rong, Phuket Province, suggested that the revalue of the concept of materialization to self-sufficiency guided by His Majesty King Bhumibol Adulyadej should be introduced. His Majesty's vision on self-sufficiency is the important step toward a balanced development that will sustain both human being and natural environment. The concept of self-reliance concentrates on the principles of producing enough to live on while preserving the integrity of the environment which is the most essential element for sustainable development.

Our findings also suggested that the tsunami has provided a good opportunity to revalue the benefit of mangroves as perceived by the villagers. The disaster helped to demonstrate that the benefit of mangrove was not limited only to direct use and consumption of its output but also to its indirect values that are mainly functional benefits. They are more concerned with ecological functions, such as breeding and nursing grounds, maintaining coastal productivity, natural pollution control as well as shoreline stabilization and protection. These ecological values are usually interrelated and difficult to quantify. Other values, such as values from biodiversity for future utilization as well as the culture and heritage values for conserving mangroves for the next generations, are not only difficult to quantify but to be fully aware or understand by the villagers. The local villagers must be well-informed on these information.

Amnard: The village committee has put a lot of effort on conservation. We try to keep the villagers in the traditional ways of life. We don't need modernization like we found in the city life. We don't want to have hotel in our community even though it seems to be an important part of tourism. This is the reason why we are against the villagers who want to sell land to outsiders. It such villagers are in trouble and need money, we will give them an advice to sell land or to make a mortgage through community saving cooperatives. We try to preserve green areas in our community. We have many activities on reforestation. Even in the residential areas, we advised the villagers to have their own kitchen gardens. They can have green areas and at the same time can save money by harvesting vegetable from garden instead of buying it.

In-depth Interview in Bang Rong, Phuket Province

> *Supot: If we discussed the community development based on the benefit of preserving the natural resources for the sake of the community or the country, we will never succeeded. We will not have full cooperation. The important thing is we need to convince people about the direct and indirect benefit that they will get from conserving the forest. Then it will works. Even though we do not talk much or to pursue, people will join.*
>
> *In-depth Interview in Ban Nam Khem, Phang-nga Province*

2. REstrategy. The strategy on mangrove management both in macro and micro levels need to be redefined. The national development that emphasizes only on the macro economy should be reviewed. The concrete evident from this study stated that mangrove forests act as *a natural social welfare center* for the poor and the victims from tsunami disaster. The mangrove forests and products have been alternative sources of food and income during hardship. It was suggested that the strategy of top-down management or centralization should be reformed and changed to bottom-up management and decentralization.

It was clear from this study that the success of mangrove reforestation program in Bang Rong, Phuket Province, depended upon public participation and awareness. This suggested that resource partitioning or sharing mangrove resources should not solely be the government's responsibility. The comparative study on mangrove management between Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province pointed out that the decision to allow local management efforts should be based on the capability of communities to enforce their local rules or mandates effectively in order to manage the forest sustainability. Moreover, such community rights should not involve full ownership of the forests, but should be in the form of user rights. Governmental organizations should act as supervisors not executors. Management of the forests should be the joint responsibility of the local communities and the government. Plantation scheme and mangrove replanting should be encouraged under the community forest management. Most importantly the rehabilitation scheme should be site-specific according to the ecological changes and natural recovery processes. The objective of the rehabilitation plan should be in accordance with the community and ecological conditions. The Ministry of Natural Resource and Environment should not only expand its efforts in promoting any initiatives but also work closely with coastal communities to enhance the success of mangrove rehabilitation program.

Teeravit: I think that changes in government policy have played a significant role in mangrove conservation. In the past, forest management focused on the concept of preserved forests. Then the villagers viewed that mangrove forests only belonged to the government. Afterward the policy on community participation was introduced, the villagers felt that the forests belonged to local community or their community. So, they keep their eyes on it. As an officer, I can say that this policy really helps us because we have a small number of officers. You know, we have only 2 or 3 officers but our responsibility is taking care of forests in the whole province. We can not work efficiently. Now the villagers become our networks. They look after the forests for us. They also give us information when they see something irregular. Sometimes they call us, sometimes they send letter. It's really works.

Suvit: Now Phang-nga Province has a policy to promote eco-tourism. The province has encouraged us to set up a home-stay program. This policy clearly implies that the local community should conserve natural resources and coastal environment. When the policy is clear, it is easier for the villagers to set up the mangrove rehabilitation program or any activities related to coastal environment conservation.

In-depth Interview in Ban Nam Khem, Phang-nga Province

3. REprocess. The respondents from the survey as well as the key informants of qualitative research voiced out that a successful community forest management regime could not be done solely by each community. The co-management was proposed and required active participation from all stakeholders with joint responsibility among the tripartite bodies: governmental organization, non-governmental organization and local community. Such effective co-management will require active participation of existing coastal community organizations. This will allow the representatives of such organizations to have the rights to express their opinions and make decision regarding to management plan and regulations on the utilization of mangrove resources.

The findings also suggested that the process of co-management should be channeled from individual level, community organizations or groups within community up to the network building outside the community. Community capacity building should be commenced from human resource development. Local wisdom together with village intellectuals needs to be promoted. The awareness of young generation about mangrove conservation and rehabilitation should be promoted. The co-management process should begin within the community and expand to the network outside, particularly other nearby communities.

> *Bancha: We can not work on mangrove reforestation program on our own. We need help. We need cooperation, particularly from our neighboring villages. One village can not keep eyes on or conserve the mangrove forests because the mangroves grow along the coastline of many villages such as Koh Kor Kah, Ban Thung Noi, Ban Bang Si. Every village needs to work on conservation of mangrove forests in their own area. We cannot pass the buck. Every village needs to work on it. If only one or two villages work on reforestation program, the work will not be succeeded because the forest areas are continuum, not divided by administration area.*
>
> *In-depth Interview in Ban Nam Khem, Phang-nga Province*

4. REstructure. Some villagers were not yet satisfied with the community mangrove management since the management was still limited only to cooperation not participation. Many conservation activities organized in the community by villagers or the so called "participation" does not exist. Joining the activities was only temporary or occasional as a social function. Sometimes it was not over on a voluntary basis. Therefore, it was suggested that joining in any mangrove activities should be restructured from cooperation to participation under the concept of civil society. From the key informants' point of views, the civil society will lead to a success of mangrove rehabilitation program since it involves voluntary associations and informal networks, in which individuals and groups can be engaged.

Partitioning should not be the structure of mangrove management. According to the interrelationship of the mangrove forests and the coastal ecosystem, the management scheme should incorporate other coastal ecosystem, such as seagrass beds and coral reef. Moreover, maintaining mangrove productivity and natural succession recovery process need to be integrated into mangrove rehabilitation program in relation to public participation. The integrated study on the complex ecological-social-economic linkage and site-specific design need to be encouraged. These integrated findings would be most beneficial to the future coastal management. The results should be distributed to the villagers in order for them to gain more insights.

Manop: I think that during the last decade we had significantly improved environmental management under the concept of participatory management. However, we still have practical problems in terms of continuity of the participation. At this moment, the participation is only occasional or in a fancy style. There is no procurement. The participation does not last long. I think that this cannot be called participation. It's just cooperation. In my view, participation has more meaning than cooperation. Cooperation is temporary but participation means thinking together, working together, analyzing together, evaluating together and planning together. It's more than just getting together.

In-depth Interview in Ban Nam Khem, Phang-nga Province

Amnard: Cooperation among several groups is the most important factor. In addition, working on mangrove rehabilitation program does not mean that we will focus only on mangroves. In fact, we need to work on the ecological system. If we want to conserve mangrove, we need to conserve seagrass beds and coral reef as well.

In-depth Interview in Bang Rong, Phuket Province

5. REcondition. Even though the co-management of mangroves between governmental organizations and local communities was introduced, the comparative study on the mangrove management between the two areas suggested that there was no specific model or blue print for the co-management of mangrove forests. The model will have to vary according to the unique ecological and socio-economic conditions in each area. Therefore, there is the need to design a site-specific mangrove rehabilitation scheme to suit the objectives of the coastal communities. With different goals and objectives for mangrove restoration, the same basic blue print cannot be drawn as previously carried out.

Moreover, the government must provide technical, educational and financial support for the local community organizations whose fundamental responsibility is to encourage participation in mangrove management. The co-management system is not just passing all the responsibilities from the government to community organizations. It requires the sharing of work and responsibilities between the governmental agencies and local communities. Local communities have the rights to use and manage the forests under their community forest regime. The community rights, however, can be attenuated by the governmental organizations, in particular the Ministry of Natural Resource and Environment or the governmental agencies in provincial level. They should retain the rights to monitor and sanction in order to prevent misuse of the forests.

> *Pong: We want to be a part of the community participation in mangrove management. Actually we look forward to having community forest. Local community should have responsibility to manage community resources. Government officers alone can not succeed in working on any rehabilitation or conservation programs since they will face manpower shortages. If we left this responsibility to the government officer alone, we would not have mangrove forests left. The management run by community will give a chance to villagers to set up community mandate on utilization. Even though the mangrove forests in our community do not belong to us, at present we set up a rule and mangrove zoning. We allow the villagers to use or to cut mangrove tree but with they have limited number and they need to replant 10 trees to substitute 1 tree cut. By this way, people get benefit from mangroves. They are willing to take care of them. This is what we called "Paddy fields have eyes, forests have ears". Have you ever heard of that?*
>
> *In-depth Interview in Bang Rong, Phuket Province*

6. **REsearch**. It was suggested by academic and many organizations that the coastal resources rehabilitation will not only ensure the future safety of coastal communities by reducing damages from natural disaster, but also contribute to the long-term socio-economic development. The coastal rehabilitation program will enhance livelihood opportunities and provision of needed resources. It was evident from this study that the empirical research on the values of mangrove, particularly ecological and economic values of mangrove to community, is needed indeed. It is also important to gather more detailed research-based data on the linkage between mangroves and damage caused by tsunami. The multidisciplinary researches on ecological risk assessment and post-tsunami monitoring as well as socio-economic conditions of communities are essential. These data can be transformed and integrated into public awareness program.

Moreover, the post-tsunami monitoring or time series data was needed to elucidate the long term changes in ecological and socio-economic conditions in mangrove areas. Since the community participation on mangrove management has been proposed, there is also the need to monitor or assess the outcome of such program. It was suggested that the local communities should be responsible for the monitoring program. The community members, particularly direct stakeholders on coastal management, should be trained to do monitoring as well as carry out the pilot survey to identify key indicators in environmental monitoring program. Such capacity building program will reinforce the coastal communities, potential to sustain the mangrove and coastal productivity. This will in turn increase the economic and social well-being through mangrove rehabilitation program.

Amnad: We need research but we can not do it by ourselves. The villagers normally do not have high education. We finished our study only at primary educational level. We need academic support from the university or any educational institutes. We feel that we have something that needs to be improved but we don't know how. The Community Development Organization came and provided additional knowledge on occupation. We still want to learn more on the aspect of management. We have already known some basic or fundamental knowledge about mangroves and ecological conditions. We don't need more during this time. We need to know how community can be involved in the natural resource management. How can we make a plan by ourselves?

In-depth Interview in Bang Rong, Phuket Province

Proposed community-based management of mangrove forest

As has been mentioned, there is no specific model or blue print for the mangrove rehabilitation program that can be used in replication in every community. The mangrove rehabilitation scheme should be site-specific to suit the objectives of the coastal communities. Therefore, we suggested in our study that the mangrove rehabilitation scheme in Ban Nam Khem, Phang-nga Province and Bang Rong, Phuket Province should be constructed differently according to unique conditions and characteristics of each area. We have already outlined site-specific mangrove rehabilitation program in response to environmental condition, forest condition and, most importantly, the specific goals and objectives of the local villagers in implementing the program. We have suggested the mangrove reforestation/ afforestation program for Ban Nam Khem, Phang-nga Province. The mangrove rehabilitation program for the Bang Rong community was aimed to achieve the dual objectives of coastal fishery enhancement and natural resources for ecotourism.

In Ban Nam Khem, Phang-nga Province, the degree of cooperation and participation in the community activity was still very low. The perception of the importance and benefit of mangrove was limited only among certain groups of people, such as fishermen and villagers who earned their living by fishing in mangrove areas. The mangrove rehabilitation program should, therefore, be initiated by the certain groups that have already perceived or gained benefit from mangroves. The massive program that requires participation from a large group of people is not recommended at this early stage since the participation in such a program will only be on occasional basis and will not be sustained. The group that can start the mangrove rehabilitation program is the villagers who live in the area called "Soi Tok Poo" since their well-being directly depend upon the condition of mangroves. They are willing to help. However, the training program for this certain group need to be constructed before the mangrove rehabilitation program is launched. These training programs may assist them in their fishing or increase their production. There is also a need on the manuals for self-learning on the benefit of mangroves, ecological roles of mangrove ecosystem as well as the manuals for self-monitoring on ecological risk and impact assessment.

> *Suvit: We have a group of people living in "Soi Tok Poo". The area where they live is part of the mangrove forest. They earn their living from mangrove products, particularly crabs. People call this group "group of Soi Tok Poo" because "Tok Poo" means catching crabs. They earn their living by catching crabs in the mangrove areas. They gain profit from mangrove forest. We have plan to start our mangrove rehabilitation program in that area because people there will lend us their helping hands. We will have labour and a group of people to monitor the program. Adjacent to this area is another village where we can extend our program and build up a new network.*
>
> *In-depth Interview in Ban Nam Khem, Phang-nga Province*

We also would like to propose that the mangrove rehabilitation program in Ban Nam Khem should be in the form of co-management that requires active participation from all stakeholders and joint responsibility among tripartite bodies: governmental organization, non-governmental organization and local community. The co-management process should begin with network building within the community. Besides groups of small-scale fishermen in "Soi Tok Poo", another group in Ban Nam Khem that can have the potential to handle the mangrove rehabilitation program is the "Community Bank". Even though the "Community

Bank" has only been set up after tsunami, it had clear objectives on monetary support in improving livelihood of villagers including providing budget or "seed money" for improving environmental conditions, such as mangrove conditions for the well-being of the community members.

In addition, our study recommended that the sharing of responsibility among the governmental organization, local administration organization, particularly at the sub-district level, and villagers in Ban Nam Khem should be strongly encouraged. At this fledging stage, the assistances provided by governmental organizations are essential. The governmental agencies, particularly at the sub-district or provincial level, need to provide technical, educational and financial assistances for the local community organizations that have the fundamental responsibility in encouraging public participation in the mangrove management. The community rights, however, can be attenuated by the governmental agencies at provincial level. The agencies should retain the rights to monitor and sanction in order to prevent the misuse of the forests in Ban Nam Khem.

As in the case of Bang Rong, Phuket Province, the socio-economic conditions were somewhat different from that in Ban Nam Khem, Phang-nga Province. The mangrove rehabilitation scheme should not be identical. The massive rehabilitation program can be launched in Bang Rong since the village had already carried out a series of reforestation programs for over a long time. Most villagers perceive the benefit of mangroves and have positive attitude towards mangrove rehabilitation program. The community had high potential in organizing mangrove activities. There are already many existing organizations for mangrove rehabilitation program, such as conservation group and eco-tourism group. The network building both within and outside communities reveals the success in mangrove management.

We highly recommend that the mangrove rehabilitation program should be launched in Bang Rong under the supervision and joint responsibility of the mosque committee. In this village, the mosque committee is the core organization for the community. It has a significant role and acts like a central administration of all activities in the community. The governmental organizations, particularly at provincial level, should work hand in hand with the mosque committee as well as other groups responsible for environmental development, such as conservation group and eco-tourism group. These are often assigned by the mosque committee to be directly responsible for mangrove management.

Monitoring and capacity-building as an integral part of the proposed mangrove forest rehabilitation program

First we need to understand that once the environmental change is induced, be it from tsunami impacts or from human activities, the sequences of environmental changes would follow like Domino Theory. The end product is yet to be determined whether the new equilibrium will be reached or not. This question is opened for further investigation. Each mangrove forest will response differently to the disturbances, depending on their resilience. The ability for natural regeneration or natural recovery is also important in assessing the long term impacts on the forest as well as coastal productivity. Whether we like it or not, we need to be well aware and well prepared to adjust or adapt accordingly. Most importantly we should learn from past experiences as in the case of tsunami in order to mitigate disastrous effects. Is it true that mangrove rehabilitation program provide us the only option to mitigate the impact from such disaster? This is quite a challenge for all researchers involved.

Outlining the activity and operation plan based on the ecological processes in human interactions play important roles in mangrove rehabilitation. Defining the criteria for the monitoring/assessment of mangrove rehabilitation is even more difficult, since the objective and goal of the mangrove rehabilitation program in each area is different. As we know that the coastal green belt initiatives have been actively introduced in many countries, but they may have been intended only to serve as natural shield against winds and waves. It may also serve to increase water quality and fishery production. Monitoring is one of the integral parts of the rehabilitation activity. But in reality, this crucial step has been totally ignored. Criteria for the monitoring should clearly be defined. Key indicators must be specified. As in forestry, there is the need to monitor whether the remaining forest will thrive well. This should be carried out by at least one survey on forest structure, mortality rate and growth in the growth season within the same year of the tsunami. We also need to assess the regeneration ability by enumerating the seedling and saplings. Procedures and key indicators need to be outlined and most practical when implemented in the field. As the forest grows, there is always the question whether the forest is similar to the natural mangrove forest in terms of productivity. Is the forest ready for harvesting?

It has always been the practice that the monitoring/assessing should be carried out by academicians or researchers. There are several limitations to this. Uncontinuous monitoring, mainly a short-termed one, lack of funding, lack of time as well as researcher's limited field of interest or expertise. Thus the monitoring/assessment should be initiated and carried out by the community themselves. This will also involve public participation as well as capacity-building programs for the locals, field officers and young scientists to monitor and assess the progress of the project. This involves the monitoring of planting, growth and survival studies of mangrove species and maintenance protocol. Protocols for seed germination as well as a culture extension of selected species, protocols for seedling cultivation should be included for the maintenance of mangrove forests, which would be the community-base management. Environmental monitoring as well as coastal fishery will also be monitored. Certain indices for the recovery of the mangrove forests will be determined. The researchers will work hands in hands with the locals, field officers and young scientists in On-the-Job Training process. This is the capacity building for the community.

A general manual on the benefit of mangroves, ecological roles of mangrove ecosystem and self-monitoring asides, a manual on management in relation to social capital should be distributed to groups of key persons or direct stakeholders in mangrove management in the village. This is because Bang Rong villagers have participated in the mangrove reforestation program for more than 10 years. The key persons have already learned about the importance of mangroves and their ecological roles. The important information that they need is the management of "social capital" which is composed of 5 components namely, natural resources, human resources, community budget, social control and local wisdom.

The training should be conducted in two levels. The first level should be for general public with the objectives of building awareness and insight into the understanding of the benefit of mangroves, the roles of mangrove eco-system and the means to conduct self-monitoring by grass-root villagers. The second level should be the intensive training course on mangrove resources management. The course should be held among key persons such as village headman, heads of activity groups responsible for mangrove management as well as direct stakeholders in various fields. The training on management of mangrove forests can not be done solely in one or two communities because the mangroves grow naturally along the coastline regardless of administration areas. Therefore, the training on mangrove resources management in the second phase should also be held for the adjacent communities. The network building among communities located nearby should also be constructed in order to provide better knowledge and understanding of mangrove management as well as to expand the cooperation among coastal communities which will result in a success in mangrove rehabilitation program along the Andaman Coastline.

Outcome evaluation should be included in the project to determine the success of the project not only in terms of the enhancement of coastal productivity and fishery, but also the community capacity to sustain the on-going mangrove rehabilitation scheme.

References

Aiemsri, A., P. Suwanich, U. Tontrakulratanpa, P. Dumrongpol, R. Chairatana, W. Niumratana, P. Soontornchainaksang, T. Janejittikul, J. Samana, P. Nuchpongsai and K. Tontakarnapa. 2005. Environmental Impact Assessment of the Tsunami. Prasertphan, W. (Editor).Faculty of Environmental and Resources, Mahidol University. 156 p.

Aksornkoae, S., N. Paphavasit and G. Wattayakorn. 1993. Mangrove of Thailand: Present Status of Conservation, Use and Management. ISME Mangrove Ecosystem Technical Reports Vol.1 : The Economic and Environmental Values of Mangrove Forests and Their Present State of Conservation in the Southeast Asia/Pacific Region, B.F. Clough, Project Coordinator: pp. 83-113.

Aksornkoae, S., S. Havanond and C. Maknual. 1996. Manual for Mangrove Planting ITTO/JAM/Thai NATMANCOM Development and Dissemination of Re-afforestation Technique of Mangrove Forests. Funny Publishing. 93 p.(in Thai)

Angsupanich, S. 1994. Diversity and Abundance of Plankton in a Mangrove Estuary at Khao Kao Canal, Phang-nga Bay. Thai J. of Aqua. Sci. 1(1): 78-91.

Beauchene, M. 2005. Rapid Bioassessment in Wadeable Streams and Rivers by Volunteer Monitors. State of Connecticut Department of Environmental Protection Bureau of Water Management Planning and Standards Division Ambient Monitoring Program Gina Mccarthy, Commissioner. 70 p.

Bird E.C.F. and M.M. Barson. 1982. Stability of Mangrove System In: Mangrove Ecosystems in Australia Structure, Function and Mangement (BF. Clough-Editor): Australian Institute of Marine Science. pp.265-274.

Boonruang, P. 1985. The community structure, abundance and distribution of zooplankton at the east coast of Phuket Island, Southern Thailand, Andaman sea. Phuket Mar. Bio. Cent. Res. Bull. 39: 12.

Boonruang, P., S. Sawangarreruks and S. Poung-in. 1994. The Community Structure of Fish and their Relation to Food Items in the Mangrove Area. Paper Presented at the Department of Fisheries Annual Seminar, September 19-21, 1994 National Institute of Fisheries. (in Thai)

Chullasorn, S. 2000. Diversity of Meiobenthic Fauna in Mangrove Area, Banpaklok, Phuket Province. In: Proceeding of the 11th National Seminar on Mangrove Ecosystem, pp. III-5 (1-10). National Research Council of Thailand. 9-12 July, 2000, Trang Plaza Hotel, Trang, Thailand. (in Thai)

Division of Environmental Geology. 2005. Erosion of the Andaman Coast of Ranong, Phang-nga, Phuket and Krabi Provinces after Tsunami. Department of Mineral Resources. Bangkok, Thailand. 51 p. (in Thai)

Duangdee, K. 1995. Identification and Distribution of Fish Larvae in Seagrass Beds at Jao Mai Natural Park, Trang Province. Master of Science (Marine Science), Major Field Marine Science, Department of Marine Science Kasetsart University. (in Thai)

English, S., C. Wilkinson and V. Baker. 1994. Survey Manual for Tropical Marine Resources. ASEAN-Australia Marine Science Project: Living Coastal Resources. Australian Institute of Marine Science. 368 p.

Faculty of Science. 2005. Regional Symposium on the 2004 Tsunami Event 21-22 November 2005. Faculty of Science, Chulalongkorn University. 34 p.

Field, C.D. 1995. Journey amongst Mangroves. International Society for Mangrove Ecosystems. International Society for Mangrove Ecosystems Okinawa, Japan. 140 p.

Field, C.D. 1996. Rational for Restoration of Mangrove Ecosystem In: Restoration of Mangrove Ecosystem, (C.D. Field Editor) International Society for Mangrove Ecosystems Okinawa, Japan.

Field, C.D. 1999. Mangrove Rehabilitation: Choice and Necessity Hydrobiologia 413 R.S. Dodd (Ed.) Diversity and Function in Mangrove Ecosystem: pp. 47-52.

Fortes, M. 1995. Causes of Failure (and Success?) of Mangrove Restoration in the Philippines. Proceeding of the Ecotone IV. Ecology and Management of Mangrove Restoration and Regeneration in East and Southeast Asia: pp.129-141.

Harada, K., F. Imamura and T. Hiraishi. 2002. Experimental Study on the Effect in Reducing Tsunami by the Coastal Permeable Structures. Final Proceedings of the International Offshore and Polar Engineering Conference USA. pp. 652-658.

Havanond, S. 2000. Effect of Mud Lobster (*Thalassina anomala* Herbst.) Mounds on Mangrove Succession in Thailand. Degree of Doctor of Philosophy in the Field of Bioregulation Studies, Royal Forest Department, Thailand (Tokyo University).

Holmer, M. F.O. Andersen, N. Holmboe, E. Kristensen and N. Thongtham. 2001. Spatial and Temporal variability in Benthic Processes Along a Mangrove-Seagrass Transect near the Bangrong Mangrove Thailand. Wetland Ecological and Management 9: pp.141-158.

Janekarn, V. and P. Boonruang. 1986. Composition and occurrence of fish larvae in mangrove areas along the east coast of Phuket Island, Western Peninsular, Thailand. Phuket Mar. Bio. Cent. Res. Bull. 44: 15.

Janekarn, V. and J. Hylleberg. 1989. Coastal and offshore primary production along the west coast of Thailand (Andaman Sea) with notes on physical-chemical variables. Phuket Mar. Biol. Cent. Res. Bull. 51:20.

Janekarn, V. and T. Kiorboe. 1991. The Distribution of fish larvae in along the Andaman Coast of Thailand. Phuket Mar. Bio. Cent. Res. Bull. 56:41-61.

Kathiresan, K. and N. Rajendran. 2005. Coastal mangrove forests mitigated Tsunami (Short note) Estuarine, Coastal and Shelf Science 65(2005). pp.601-606.

Kiartiprayoon, S., T. Wichayakovitten, R. Khunanak, S. Yommee and K. Nuntapong. 2005. Impact Assessment on Mangrove Forest and Local Communities in Phang-nga Bay. Thammasat University Research and Consultant Institute, Department of Marine and Coastal Resources. 100 p. (in Thai)

Khokiatwong,S., P. Limpsaichol, S. Petpiroon, P. Sojisuporn and B. Kjerfve. 1991. Oceanographic Variations in Phang-nga Bay, Thailand Under Monsoonal Effect. Phuket Mar. Biol. Cent. Res. Bull. 55:43-76.

Luasinsub A. and S. Suwapeepan. 1964. Analysis of Plankton in Andaman Sea, Thailand (1963-1964). Department of Fisheries Technical Report. (in Thai)

Mazda, Y., M. Magi and P. N. Hong. 1997. Mangroves as a coastal protection from waves in the Tonkin delta, Vietnam Mangroves and Salt Marshes.1: pp.127-135.

Minagawa, R. and T. Nakamura. 1996. Zonation of Mangrove Vegetation in Thailand and Reasons for its Formation. Proceedings of the FORTROP' 96: Tropical Forestry in the 21st Century, 25-28 Novenber 1996, Kasetsart University, Bangkok: pp.82-90.

Nozawa, K., N. Yoshikawa, S. Shokita and S. Limsakul. 1983. Mangrove Meiofauna in Thailand. Mangrove Ecology in Thailand. Bulletin of Thai-Japanese Cooperative Research Project on Mangrove Productivity and Development. pp.63-72.

Pakdekul K., A. Sawangpol, M. Srisupanont, P. Suwannich, J. Arunlertaree and R. Rojanakanont. 2005. Effects of the Tsunami on the Pra Tong Island Ecosystem. Bhumejumnong N. (Editor) Faculty of Environmental and Resources, Mahidol University. 166 p.

Panutrakul, S. 1996. Water quality in Phuket Bay. Phuket Mar. Biol. Cent. Res. Bull. 61:57-81.

Paphavasit, N. and N. Setti. 1982. Benthic Communities in the Mangrove Forest in Phang-nga Bay. Proceeding of the Fourth National Seminar on Mangrove Ecosystem, National Research Council of Thailand, Surat Thani Province: pp.198-216.

Paphavasit, N. 1995. Factors Maintaining Biodiversity of Mangrove Forest in Thailand. Proceedings of the ECOTONE IV: Ecology and Management of Mangrove Restoration and Regeneration in East and Southeast Asia: pp.80-86.

Paphavasit, N., C. Sudtongkong and D.J. Macintosh. 1996. Mangrove Macrofauna in Different Mangrove Plantations at Klong Ngao Mangrove Forests, Ranong Province, Southern Thailand. Proceedings of the 21st Century, 25-28 November 1996, Kasetsart University, Bangkok: pp.104-117.

Paphavasit, N., S. Aksornkoae, S. Suwannodom, A. Piumsomboon and S. Siriboon. 2000. Mangrove Reforestation as the Enhancement of Coastal Fshery in the Tha Chin Estuary, Thailand: A Paradigm to Fulfil His Majesty Vision on Sustainable Development. J. of Multidisciplinary Research (13)2 (Serial No.50) pp.34-41.

Paphavasit, N. *et al.* 2002. Ecological Assessment of Mangrove Reforestation/Afforestation in Samut Songkhram Province on Zooplankton and Benthic Communities. National Research Council of Thailland. (in Thai) 214 p.

Paphavasit, N., P. Tongnunui, C. Sudtongkong, A. Piumsomboon, J. Jivalak, K. Patisayna and V. Teeratanatorn. 2004. Effect of multispecies mangrove plantations on abandoned shrimp farms on coastal fishery at Pak Nakhon, Nakhon Si Thammarat Province. In Integrated Management of Mangrove Plantations for Development of Coastal Resources and Environment of Thailand S. Aksornkoae *et al.*-Editor. Thailand Research Fund: pp. 353-369.

Paphavasit, N., A. Piumsomboon., I. Sivaipram S. Saramul and S. Aksornkoae. 2005. Conceptual Model on Capacity Building of Fishing Communities in Post Tsunami Mangrove Rehabilitation. In Symposium on the Importance of Mangrove and Other Coastal Ecosystems in Mitigating Tsunami Disasters 22-26 August 2005 at Pan pacific Hotel, Kuala Lumpur, Malaysia.

Paphavasit, N., A. Piumsomboon., I. Sivaipram and S. Saramul. 2005. Ecological Risk Assessment in Mangrove Ecosystem in Thailand: Tsunami 2004 Aftermath. In Regional Symposium on the 2004 Tsunami Event 21-22 November 2005 Faculty of Science, Chulalongkorn University, Bangkok.

Parish, F. 2005. 26 December Tsunami: Ecosystem Impacts and Coastal Rehabilitation. Global Environment Centre (GEC). (Abstract).In: Symposium on the Importance of Mangrove and Other Coastal Ecosystems in Mitigating Tsunami Disasters 22-26 August 2005 at Pan Pacific Hotel, Kuala Lumpur, Malaysia.

Patanaponpaiboon, P. and S. Poungparn. 2005. Impact of Tsunami on Coastal Vegetations and Mangroves. In Regional Symposium on the 2004 Tsunami Event 21-22 November 2005 Faculty of Science, Chulalongkorn University, Bangkok.

Piyakarnchana, T. 1988. Some Ecological Factors Limiting the Crabs and Gastropods Mollusc Population Living on Abandoned Tin Mines and Mangrove Reforestation Soils. Proceedings on the Symposium on New Perspectives in Research and Management of Mangrove Ecosystems, Colombo, Srilanka: pp.105-120.

Prasertwong, P. 1984. Recolonization of Macrobenthos in the Post-Mining areas. Thesis, Master of Science, Chulalongkorn University.

Platong, J. 1998. Status of Mangrove Forests in Southern Thailand. Wetlands International – Thailand Programme/PSU, Publication No.5. 128 p.

Pollution Control Department. 2004a. Marine Environmental Quality: Phang-nga Province. Ministry of Natural Resources and Environment. Bangkok, Thailand.

Pollution Control Department. 2004b. Marine Environmental Quality: Phuket Province. Ministry of Natural Resources and Environment. Bangkok, Thailand.

Poungparn S. and P. Patanaponpaiboon, 2005. Natural Rehabilitation of Coastal Vegetations After Tsunami. In Regional Symposium on the 2004 Tsunami Event 21-22 November 2005 Faculty of Science, Chulalongkorn University, Bangkok.

Robertson, A.I. and D.M. Alongi (eds.). 1992. Tropical Mangrove Ecosystems. Coastal and Estuarine Studies. American Geophysical Union, Washington, DC. pp. 49-119.

Satapoomin, U. and S. Poovaciranon. 1997. Fish Fauna of Mangrove and Seagrass Beds in the West Coast of Thailand, The Andaman Sea. Phuket Mar. Bio. Cent. Res. Bull. 2:63.

Satapoomin, S. 1999. Zooplankton community in Kapor mangrove canal, Ranong province. Phuket Mar. Bio. Cent. Res. Bull. 62: 33-56.

Saenger, P. 1982. Morphological, Anatomical and Reproductive Adaptation of Australian Mangrove. Australia.

Siriboon, S. 1998. Population, Socio-Economic Characteristics and Mangrove Forest Community's Environment: Data From Survey, in Mahachai Mangrove Forest Communities, Concept for Rehabilitation Development and Conservation. College of Population Studies, Chulalongkorn University, Bangkok. (in Thai)

Siriboon, S. 2000. Community Awareness on the Values and Used of Mangrove Forest: Case Study of Nakhon Si Thammarat Province, Thailand. In ICLARM-APN/PCE Seminar. Hotel Equatorial, Penang, Malaysia. April 10-11, 2000.

Siriboon, S. and N. Paphavasit. 2006. Integrating Ecological Consideration into Post-tsunami Mangrove Rehabilitation Program in Relation to Public Partucipation. Paper Presented at the International Conference on Population and Development in Asia: Critical Issues for a Sustainable Future 20-22 March 2006, Phuket Province, Thailand. 34 p.

Smith T.J.III. 1992. Forest Structure. In: Robertson, A.I. and D.M. Alongi. (eds). Tropical Mangrove Ecosystems. American Geophysical Union, Washington, DC. pp. 101-136.

Sojisuporn, P., B. Kjerfve and S. Khokiattiwong. 1994. Numerical Model of Tidal Circulation in Phang-nga Bay, Thailand. Phuket Mar. Biol. Cent. Res. Bull. 59:65-81.

Sundstrom, B., Janekarn, V., Hylleberg, J. and P. Boonruang. 1987. Annual pelagic primary production with notes on physical and chemical variables at Phuket, The Andaman Sea, Thailand. Phuket Mar. Biol. Cent. Res. Bull. No. 46, 18p.

Sudtongkong, C. 1996. Habitat Selection, Food Preferences and Fishery Biology of Mud Crab *Scylla serrata* (Forskal, 1755) in Klong Ngao Mangrove Forest, Ranong Province. Degree of Master Science, Graduate School, Chulalongkorn University. (in Thai)

Suraswadi, P. 2002. Nutrient dynamics in a mangrove estuarine system in Phuket, Thailand and the environment imparts of coastal aquaculture development. Ph.D. dissertation. Institute of Biology, University of Southern Denmark-Odense. 120 p.

Suraswadi, P. and E. Kristensen. 2002. Hydrodynamics of the Bangrong Mangrove Forest, Phuket Thailand. Phuket Mar. Biol. Cent. Res. Bull. 64:89-99.

Suwannodom, S. and Others. 1999. Interrelationship Between Population and the Mangrove Ecosystem. College of Population Studies, Chulalongkorn University, Bangkok. (in Thai)

Suwannodom, S., S. Siriboon., N. Paphavasit, and P. Thanasukarn. 2000. Inter relationship Between Coastal Communities and the Mangrove Ecosystem Lesson From the Green Carpet Project in Nakhon Si Thammarat. In Annual Report 1999 (Second Year: May 1999-March 2000) on Green Carpet Project in Nakhon Si Thammarat Province, Thailand. pp.94-114.t

Suwannodom, S., S. Siriboon., B. Bangkaew, C. Milintangul, N. Lertprasopsuk and L. Kachanuban. 2004. A Comparative Study on the Desire for Increasing Mangrove Forest Areas of Local People in Coastal Communities. In Aksornkoae, S. *et al.* (editors) Integrated Management of Mangrove Plantations for Development of Coastal Resources and Environment of Thailand. pp. 661-671. (in Thai)

Teeratanatorn, V. 2002. Comparative Study on Growth and Biomass of Mangrove Species Planted on Abandoned Shrimp Ponds in Pak Nakhon Suddistrict, Nakhon Si Thammarat Province. In proceedings of The Symposium on Aquatic Resources and Environment: Integrated Management and Utilization. Lotus Pang Suankaew Hotel, Chiangmai Province. Thailand. December 6-8, 2002. pp. II-94-II-100. (in Thai)

Teeratanatorn, V. 2005. Status of Mangrove Forest in Phang-nga Bay: In Status of Natural Resources and Environment in Phang-nga Bay (A. Nateewatana-Editor) Vol.4 Department of Marine and Coastal Resources and CHARM: 36 p. (in Thai)

To-on, J. 1999. Benthic macrofauna and distribution of fiddler crabs in mangrove forest, Tha Chin Estuary, Samut Sakhon province. Degree of Master Science, Graduate School, Chulalongkorn University. (in Thai)

Thornsirikul, M., S., Wisan, P., Sanghaisuk, W., Phuangcharoen, T., Sukloy and P., Pinyodom. 2005. 1 Year After Tsunami: Restoration of Thailand's Natural Resources and Environment. Office of Natural Resources and Environmental Policy and Planing. Bangkok, Thailand. 128 p.

Thrush, S.F. and R.B. Whitlatch. 2001. Recovery Dynamics in Benthic Communities: Balancing Detail with Simplification. Ecological Studies, 151: 297-316.

UNDP/UNESCO Regional Mangrove Project RAS/86/120. 1991. Final Report to the Integrated Multidisciplinary Survey and Research Programme of the Ranong Mangrove Ecosystem: Fauna and Fisheries Studies: pp.82-154.

Walter, H. and M. Stiener. 1936. Die Okologie der Ost-Afrikanichen Mangroven. Z. Bot. 30:65-193.

Wanapapoti W., V. Niumratana, P. Dumrongpol, N. Aonparn. and S. Kumkate. 2004. Dynamics of Natural Forests after the Tsunami. Chairatana, R. (Editor) Department of Biology, Faculty of Science, Mahidol University. (in Thai)

Wichiwarakhun, W., A. Tongpoo, N. Paphavasit, A. Piumsomboon and K. Wongkamheng. 2001. Changes in the Macrobenthos Compositions in Mangrove Plantation. In Proceedings of The Symposium on Aquatic Resources and Environment: Integrated Management and Utilization. Lotus Pang Suankaew Hotel, Chiangmai Province. Thailand. December 6-8, 2002. pp. I-97. (in Thai)

Wolanski, E., Y. Mazda and P. Ridd. 1992. Mangrove Hydrodynamics Tropical Mangrove Ecosystems A.I. Robertson and D.M. Alongi (Eds) Coastal and Estuarine Studies 41. American Geophysical Union, Washington, DC. pp. 43-62.

Wongchinvit, S. 2002. Identification and Distribution of Fish Larvae in the Mangrove Area at Klong Ngao, Ranong Province. Master of Science (Marine Science), Major Field Marine Science, Department of Marine Science Kasetsart University. (in Thai)

http://www.hazard.disaster.go.th
http://www.msnbc.msn.com
http://www.Riverbasin.org/ev-River Basin Initiative