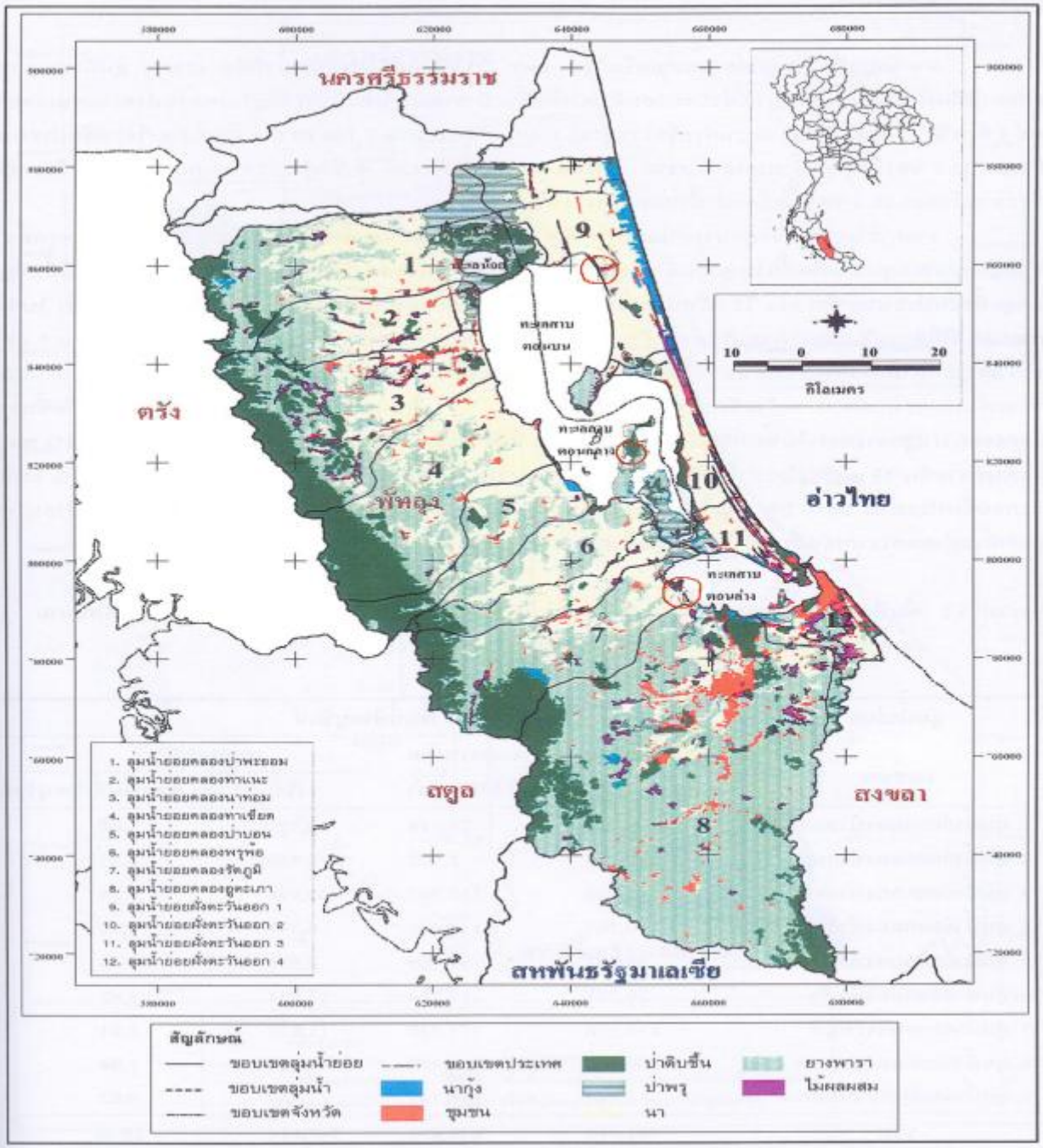
MANGROVES
Experience from Songkla Lake Thailand

Dr. Noparat Bamroongrugsa

Marine and Coastal Resource Institute
Prince of Songkla University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กิโลเมตร
1. ลุ่มน้ำย่อยคลองป่าพะยอม
2. ลุ่มน้ำย่อยคลองท่าแนะ
3. ลุ่มน้ำย่อยคลองนาท่อม
4. ลุ่มน้ำย่อยคลองท่าเชียด
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Mangroves at Songkla Lake

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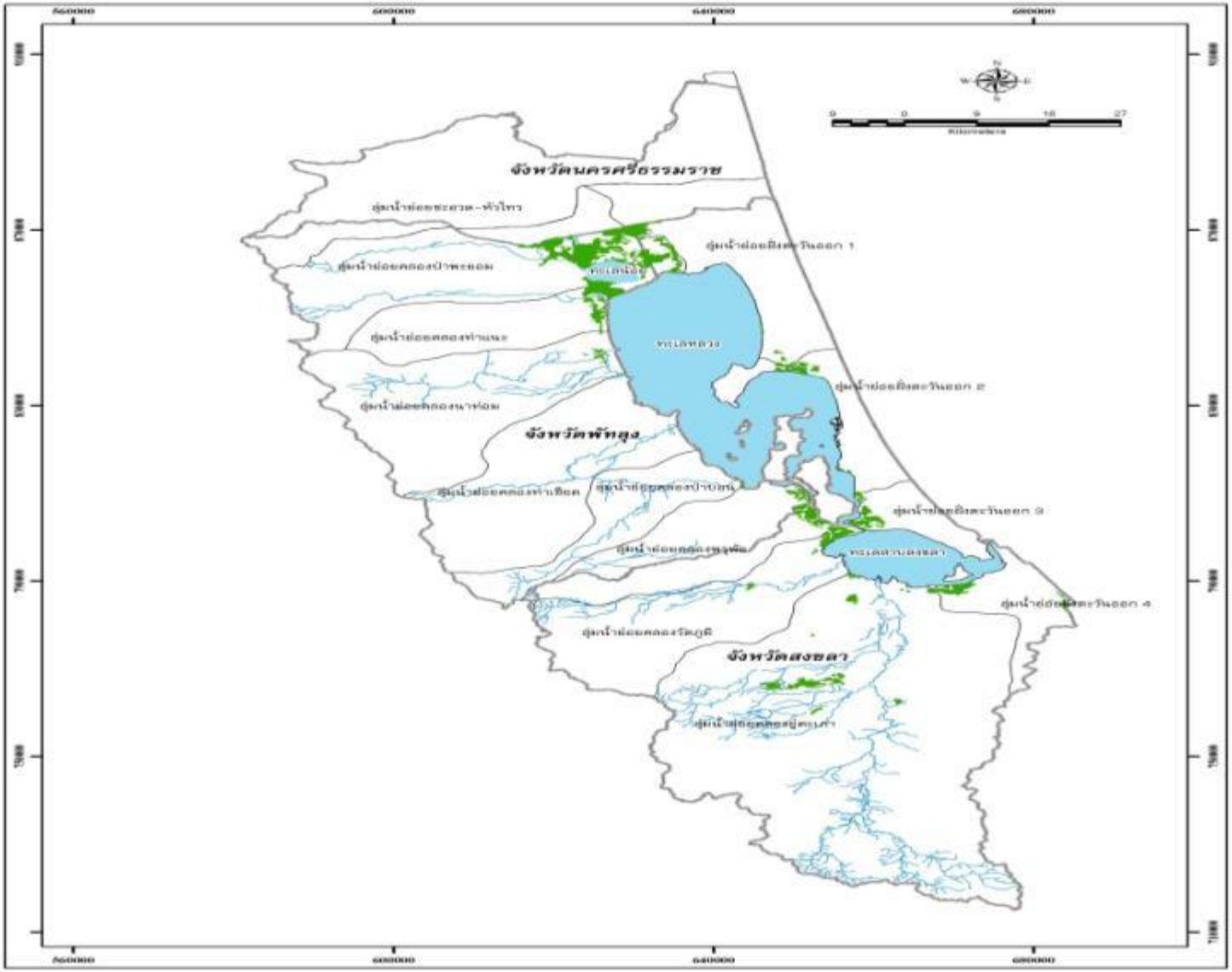
- The lake is actually a sea level coastal lagoon, varying from fresh to salty water in various locations and seasons. It is natural resource of the great value which supports a population of about , , around the basin. As a result of the decrease of mangrove forest which supports fishery as well as rapid population growth, the available fishery resources have been reduced markedly in the last few decades. Thus, mangrove restoration around the lake is needed immediately to solve the problems. Experimentation has been carried out to explore the most suitable technique as well as to extend the growing area of the *Sonneratia caseolaris*, the most suitable mangrove species for the lakeshore.

Mangroves and Peat Forest



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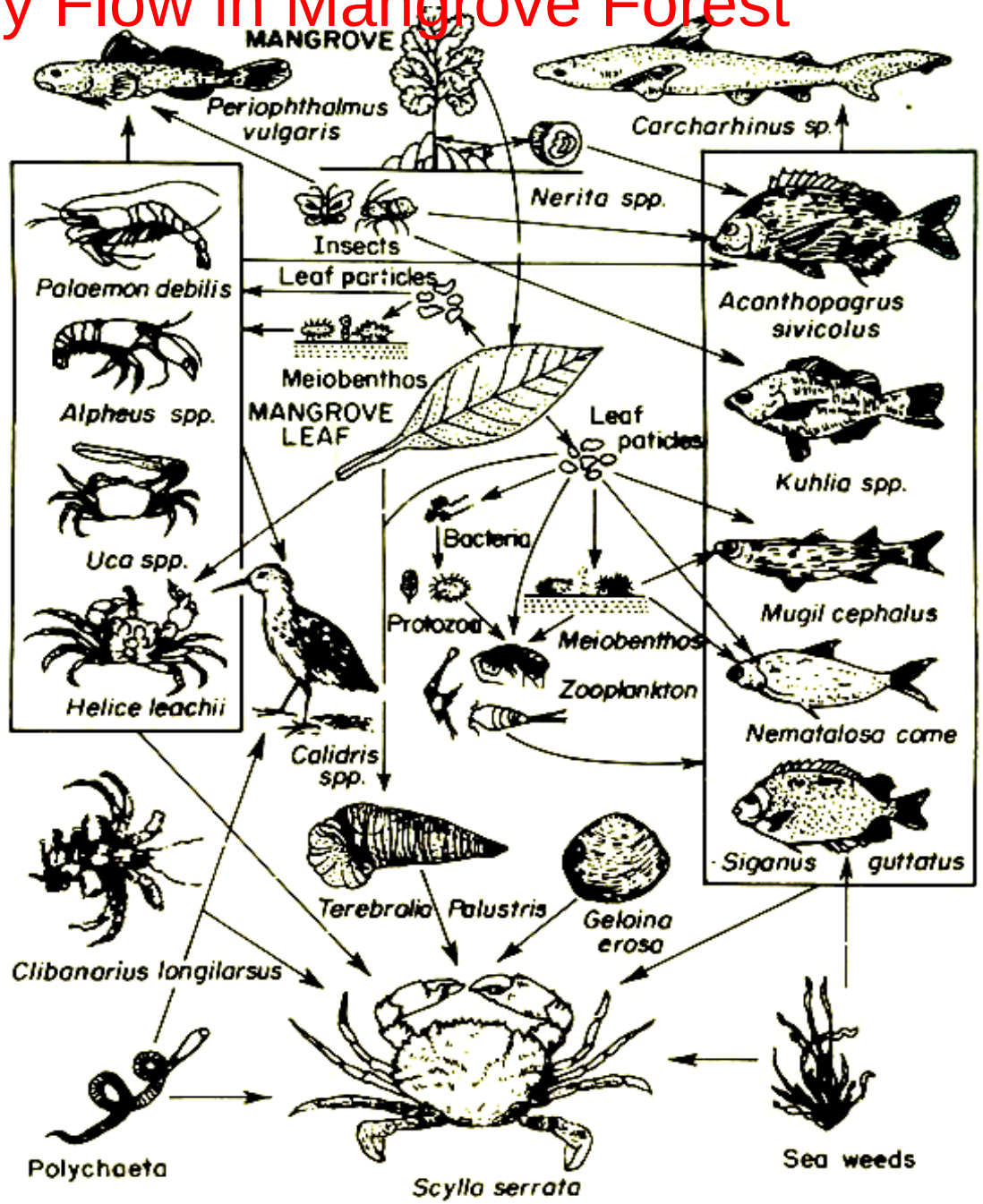
Food Chain and Energy Flow in Mangrove Forest



- As a transition zone between terrestrial and aquatic ecosystems, mangrove areas form an important nursery and breeding area for juvenile fish. They also protect the lake shore from erosion wave action. Mangroves are also a valuable source of firewood and charcoal, and provide poles for fishing stakes. It is a very important habitat as a breeding and feeding ground for prawns and shrimps, mullet, sea-bass and all other important commercial brackish water species. Less than 1 percent of the total mangrove area of Thailand is found in the Songkla Lake Basin but most of this has been severely degraded or converted to agricultural or other uses.

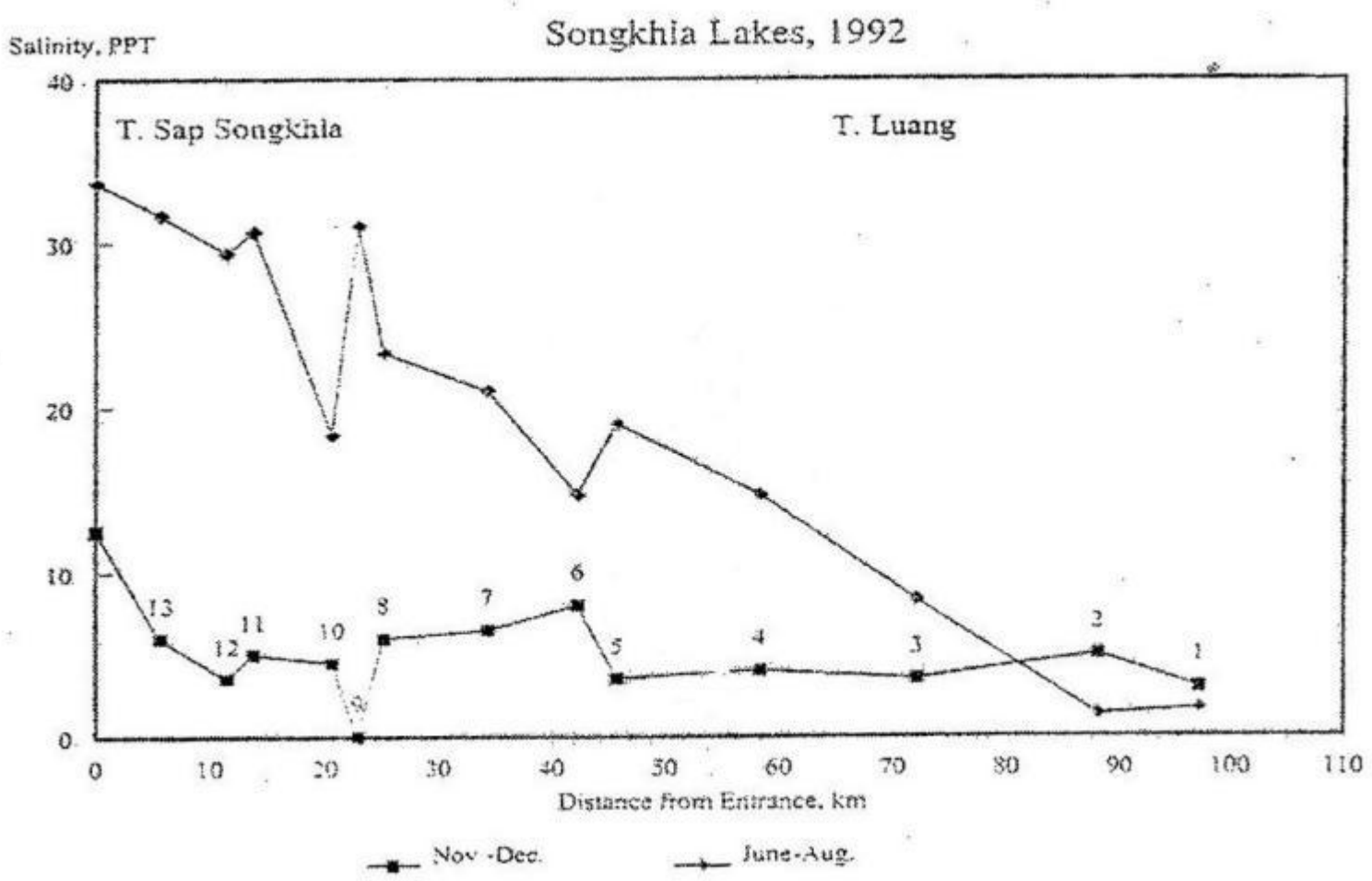
Mangrove destruction by aquaculture

Paddy field Destruction by Shrimp Culture

- The whole area of Songkhla Lake is divided according to salinity distribution, in which seasonal difference of pattern can be clearly recognized. The pattern indicates an existence of a transitive phase after mixing of salt-and fresh water for considerable dimensions. In dry years, however the salinity of the lake system may vary from 1 – 5 ppt at the northernmost part (about 150 km from the lake mouth which opening to the sea) to over 20 ppt at the southernmost part.

- Seasonal variation of water salinity depends upon seawater from the open sea and run-off from the upper lake area and rivers around the lake. There is turbidity increase caused by the transportation of sediment from canals and rivers and by the wind action to bottom agitation in shallower parts.

Variation of water salinity with distances from the sea (Lake Entrance)



- Such dramatic fluctuations in salinity must result in death of some flora and benthos and displacement of nekton, but the long periods of low salinity in the wet season would allow recolonization of those species

- Generally, mangroves grow in waterlogged soils that are commonly anaerobic. Redox potential of mangrove sediments vary considerably, depending on the frequency and duration of tidal inundation, drainage, sediment organic matter content, and the availability of electron acceptors such as nitrate, Fe3+ and Mn4+ (Clough, 1992)

- This factor(flooding) will determine not only how often, but also to what depth, mangrove species are inundated (Macnae, 1968). According to Macnae (1996), salinity is also one of the factor that influences the establishment and zonation of mangroves. Variations of salinity occur in relation to the level of the substrate and the frequency of inundation by seawater, as well as the patterns of inflow of freshwater from lands. Drainage is another factor in the survival of mangroves since some species require well drained soils whereas others can flourish in poorly drained, waterlogged soils. This factor is related to properties of soil, slope of surface and presence of local creeks (Macnae, 1968).

- Because Songkhla Lake system undergoes an annual cycle of salinity corresponding to the wet and dry seasons, the seasons also cause variations in water depth and durations of flooding. It has been observed that under such variations in hydrologic conditions of the lake, mangrove species such as *Sonneratia caseolaris, Rhizophora apiculata, Excoecaria agallocha* dominate shoreline of the lake but at very uneven distribution.

- Mangrove communities are typically zoned, with the zonation depending on a variety of interacting factors namely; physical, chemical and biological which determine whether a species will survive in a given environment. The interplay and balance of these factors determine whether one or several species become established. Some factors that appear to determine the survival of individual species such as frequency of flooding which is dependent on the tidal pattern and on the height of the shore above mean sea level.

Mangroves need fresh water for physiological activities

Sonneratia caseolaris in permanent flood stunts growth

- Experiments on effect of flooding on growth and survival rates of *Rhizophora opiculata* and *Avicennia marina* showed that flooding at 10 cm and 20 cm above the soil surface, both species had normal growth with 100% survival (Eksirinimitr al. al., 2002). As for *Sonneratia caseolaris* (L.), it is generally a pioneer species in accreted mudflat near river mouths with fresh or slighly brackish water. It also withstands flooding conditions as reported by Chapman (1976) that it grew in areas where flooded 1 – 2 times daily and 20 days at the minimum per month. Because *Sonneratia* develops better aerial roots (pneumatophores), thus it is able to adapt itself to waterlogging conditions better than other mangroves. In additions, Bamroongrugsa (2001) reported that *Sonneratia* seedling grown in Songkla lake, southern Thailand in February 2001 showed 75% survival when grown in permament flooding for one year.

- Mangroves are shallow rooted, the roots being concentrated mainly in the top 50 – 100 cm of the soil and seldom penetrating to depths beyond 2 m. Water and nutrients are absorbed by a dense mat of fibrous roots that usually originate from underground cable roots or smaller secondary roots in close proximity to the aerial “breathing” roots. Thus, mangrove must have adaptation if under stresses, especially aerial roots of them. Many studies show that they have morphological, physiological and metabolic adaptations (Jintana et.al., 1992).

- Research and development on mangrove to improve environmental degradation of Songkhla Lake had been carried out at three locations of the lake .
- Because seasonal variation of water salinity in the lake depends upon seawater from the open sea and run-off from the upper lake area and rivers around the lake.
- Therefore the criterion to select the location to plant mangrove depended on the distance away from the lake mouth which was narrow and opening to the sea.

Taller seedlings of *S. caseolaris* planted in SK lake

- The salinity regimes for each experiment site were also selected as salty, brackish and nearly fresh for most parts of the year. The total of 8.8 hectares from all sites were planted with selected mangrove species suitable to each site; ie. *Sonneratia caseolaris* , *Rhizophora mucronata*, *Lumnizera racemosa* and *Bruguira gymnorrhiza* to the number of 5,500 plants.
- The results from this research can be applicable to mangrove restoration and development programs of the lake with long coastal area or other areas with fluctuations in salinity to select the suitable mangrove species and suitable of planting sites.

Fresh or brackish water is ideal for *S. caseolaris* during early growth

Experiment plots on seedling maintenance before planting

- The results showed the steady growth of *Sonneratia* at the area near the lake mouth but less growth than those at the Northern part where the salinity was lower . Growing *Sonneratia* in the moist soil produced higher number of branches than growing in water. In addition, *Sonneratia* seedlings in the moist soil gave higher growth rates than growing them in water but their leaves appeared to be attacked by butterfly worms.

- Long flooding also killed a number of plants in this area. It was observed that *Sonneratia* seedlings grown in low salty water almost doubled the growth rates as compared to those grown in higher saline water of above 20 ppt. *Lumnizera racemosa* and *Rhizophor mucronata* appeared to grow well with high survival rates when grown in soil of the lake shore line . Growth of *Bruguiera gymnorrhiza* was found to be less as compared to other species while the survival rates were similar. However, severe flooding killed most of *Rhizophor mucronata* and shorter trees of *Sonneratia caseolaris* .

Salinity higher than 20 ppt killed newly planted *S.caseolaris* (left) but sudden fresh water regime promoted growth (right)

Since salt tolerant mechanism slowly develops, most of mangrove seedlings need fresh water for early growth

Where and what to grow? Look at indicator plants.

Land preparation for mangrove planting

Mangrove planting activity in Songkla Lake

S. caseolaris at 5 years after planting

Mangrove seedlings may suffer from butterfly worms or fungus but after the season recovery can be observed.

Experiment II
Growth Rates Comparison within Low and High Saline Water.

Since water conditions of the lake vary with season, fresh or low saline conditions for - months and salty or high saline conditions for - months are normal for lake water. Thus, the experiment has been conducted during such period of time using plants in the previous plot to investigate *Sonneratia* seedling

The experiment was carried out to investigate seedling growth of *Sonneratia caseolaris* planted in Songkhla Lake with varying in water depths. To avoid submergence in water during floodling at the rainy season, the root balled-seedlings of slightly more than 1 meter tall were selected for planting. Since the water salinity of the lake varies with the seasons, planting operation was made when the lake water was fresh. In order to observe the effect of water depths, the planting rows were arranged seaward and perpendicularly to the shoreline with varying in water depth from 0-60 cm. It was observed that the intrusion of sea water into the planting site during the dry season stunted seedling growth and caused broken branches and stem tips. This disadvantage was remedied when the lake water changed to fresh or brackish. The results showed that seedling grown in deeper water levels produced greater root (pneumatophore) development ie. root length, root number as well as the distance from the main stem. As a result it was possible that such better root characters in deep water brought about greater numbers in plant height, branch number, stem diameter as well as the survival rates. The results from this experiment will provide an efficial tool for mangrove restoration programme in the Songkhla Lake.

Fencing Experiment

Recovery of *S. caseolaris* can be observed after flooding

- It has been observed that re-establishment of *Sonneratia caseolaris* after transplanting was affected by water salinity. High salinity usually damages transplanted seedlings during re-establishment. Therefore, an experiment has been conducted to explore the most suitable water salinity for re-establishment of seedlings. Six treatments for applying seedlings with water salinity of , , , , and ppt were provided. In additions, another experiment (with treatments) of *Sonneratia* seedling growth in water with varying salinity levels have also been conducted.

Salinity Test

Higher salinity than 45 ppt is harmful to *Rhizophora* seedlings

Community participated in planting mangroves

Fresh or brackish water is better for seedling growth

Salinity Test for *Sapium indicum*

Adequate moisture is needed

Adequate moisture but not permanent flood is needed for *Rhizophora sp*

Replanting for dead plants may be needed

Planting *S. caseolaris* on the ridge in the lake

New leaves develop after long flooding

Mangrove planting activities in Songkla Lake

Growth of *S. caseolaris* in moist soil on the ridge of lake dredging.

- Data showed steady growth of Sonneratia at the area near the lake mouth but less growth than the Northern part where the salinity was lower . Growing *Sonneratia* in the moist soil also produced high number of branches. But their leaves appeared to be attacked by butterfly worms. Long flooding also killed a number of plants in this area.

1 year after planting on the ridge

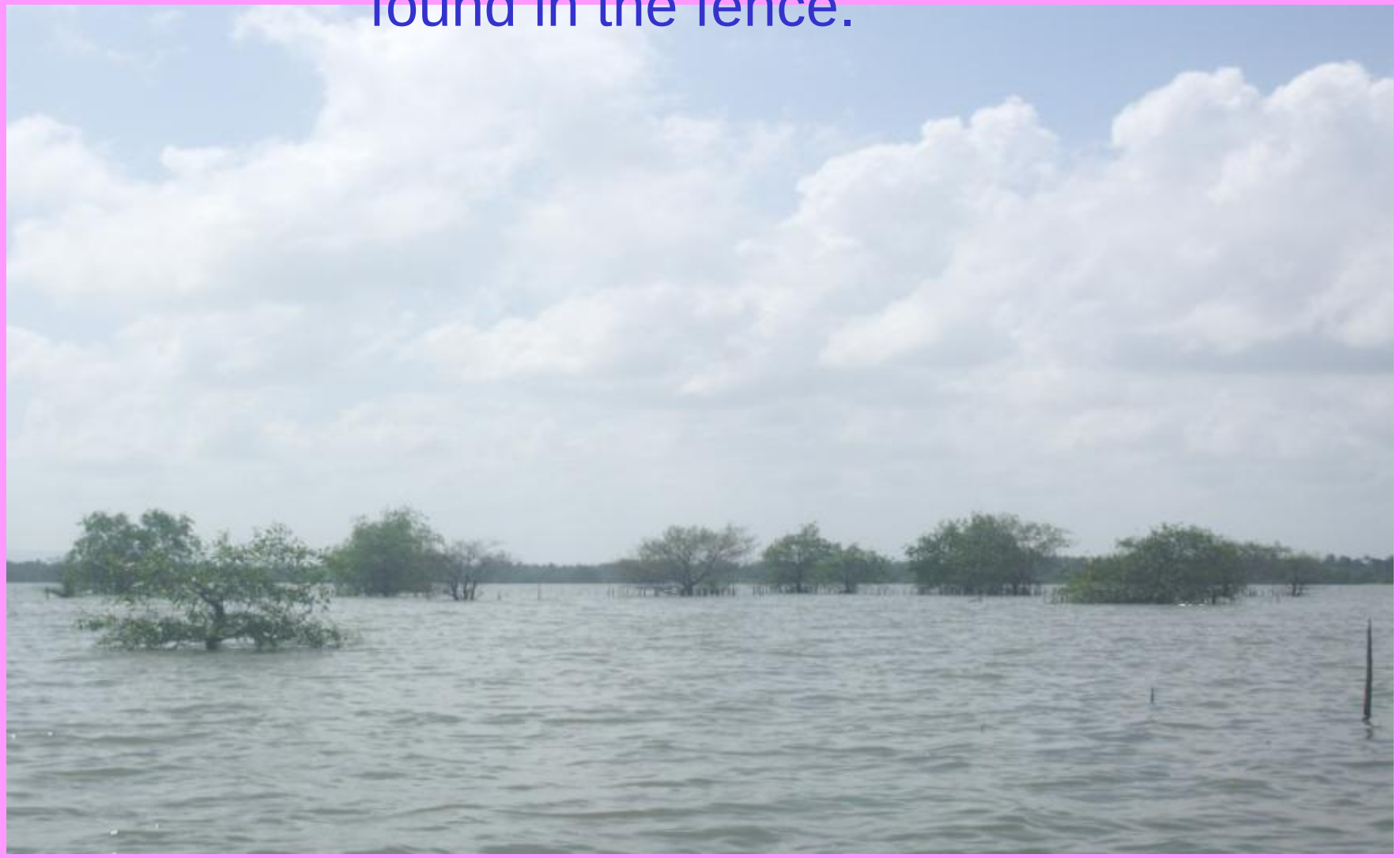
6 years after planting on the ridge

Lumnitzera racemosa planted on upper zones while *S. caseolaris* planted in water zones

Fencing Experiment at 3 years after planting (grows slowly in permanent flood).

S. caseolaris grown near the shoreline at 5 years after planting

Due to banacle attack, about 30 survival rate is found in the fence.



Growing Sonneratia caseolaris in the middle part of the lake before flooding

Sonneratia caseolaris growing at the northern part of the lake (Ranode) before flooding

- Death of *Sonneratia* and *Rhizophora* sp.seedlings at Kuan-niang was observed to be mainly from serious flooding and banacle attack. It was observed that death of some *Sonneratia* was generally due to its shorter stem and under water for longer than 20 days for some plants. The tall trees with greater stem diameter always regenerated new leaves or branches after flooding.

Sonneratia caseolaris grown in permanently flooded water with well developed pneumatophores

- Because the degree of water salinity of the lake vary with season and distance from the lake mount, thus the experiments have been conducted to investigate the effect of salinity regimes influencing 3 locations away from the lake mount. The pattern of salinity regimes, however are salty, brackish and nearly fresh away from the sea. It has been observed from this study that re-establishment of *Sonneratia caseolaris* after transplanting was affected by salinity regimes. At Ranode district where the salinity was very low or near fresh water all the year round, for example, height of the plants at 5 months is similar to those grown after 12 months at the lake mount indicating that fresh water stimulated growth of *S. caseolaris*. At Kuan-niang district where the salinity is relatively higher than the other two sites and the high salinity exists longer than the brackish water, plants grown in the moist soil had greater growth than those in water. The reason for this could be due to the availability of oxygen on the land for roots respiration was higher than in the water.

- As for *Rhizophora mucronata*, most of them died after flooding and without recovery. It is interesting to note that *Sonneratia* with their height at 210 cm., 50% of them was killed by flood at Ranode but most of them survived at Kuan-niang. The result for this might be due to the shorter time and shallower level of flood water at Kuan-niang as compared to Ranode on the Northern part.

Sonneratia caseolaris is grown along the shore for fishing ground

Community participation on mangrove planting

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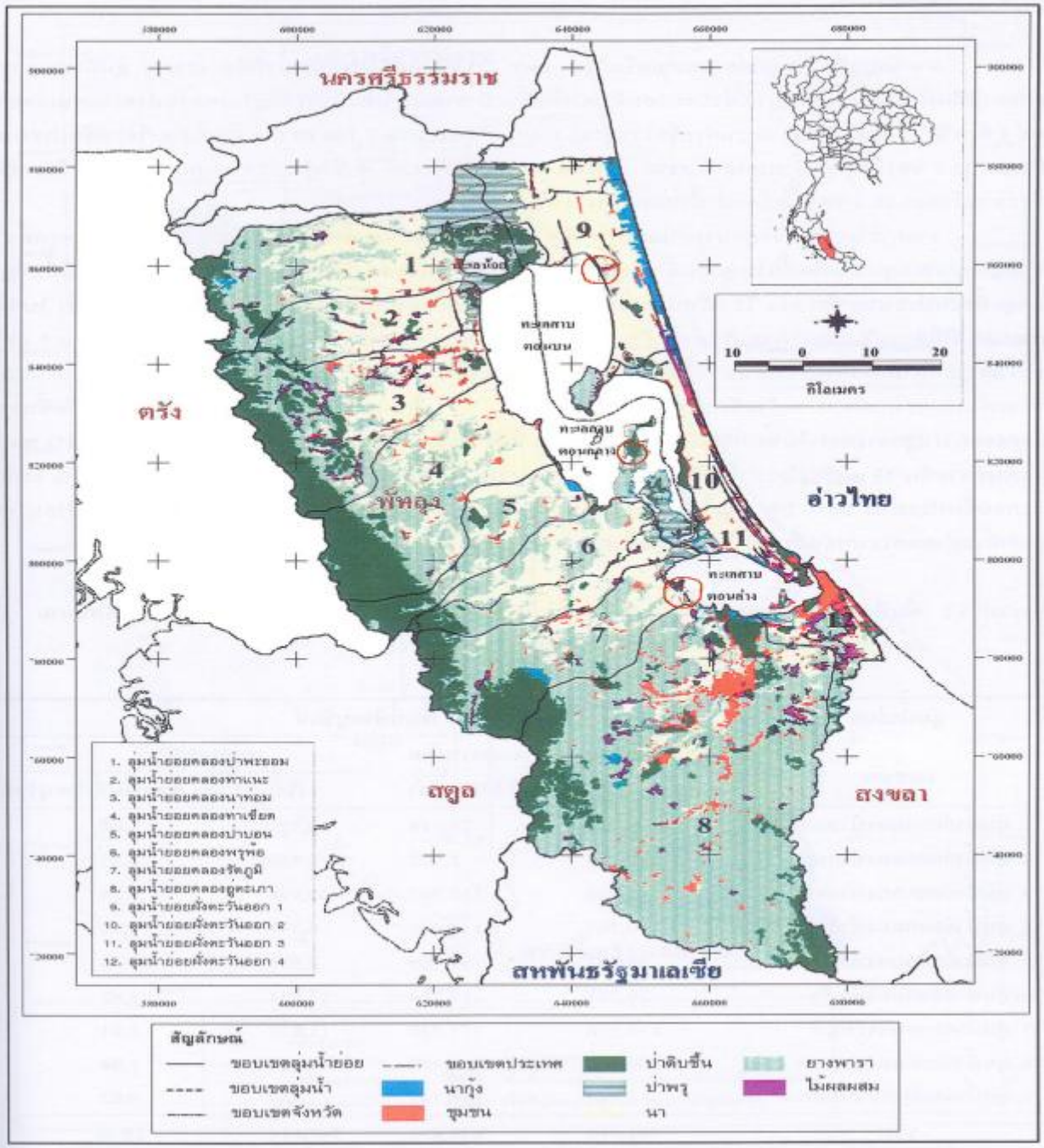
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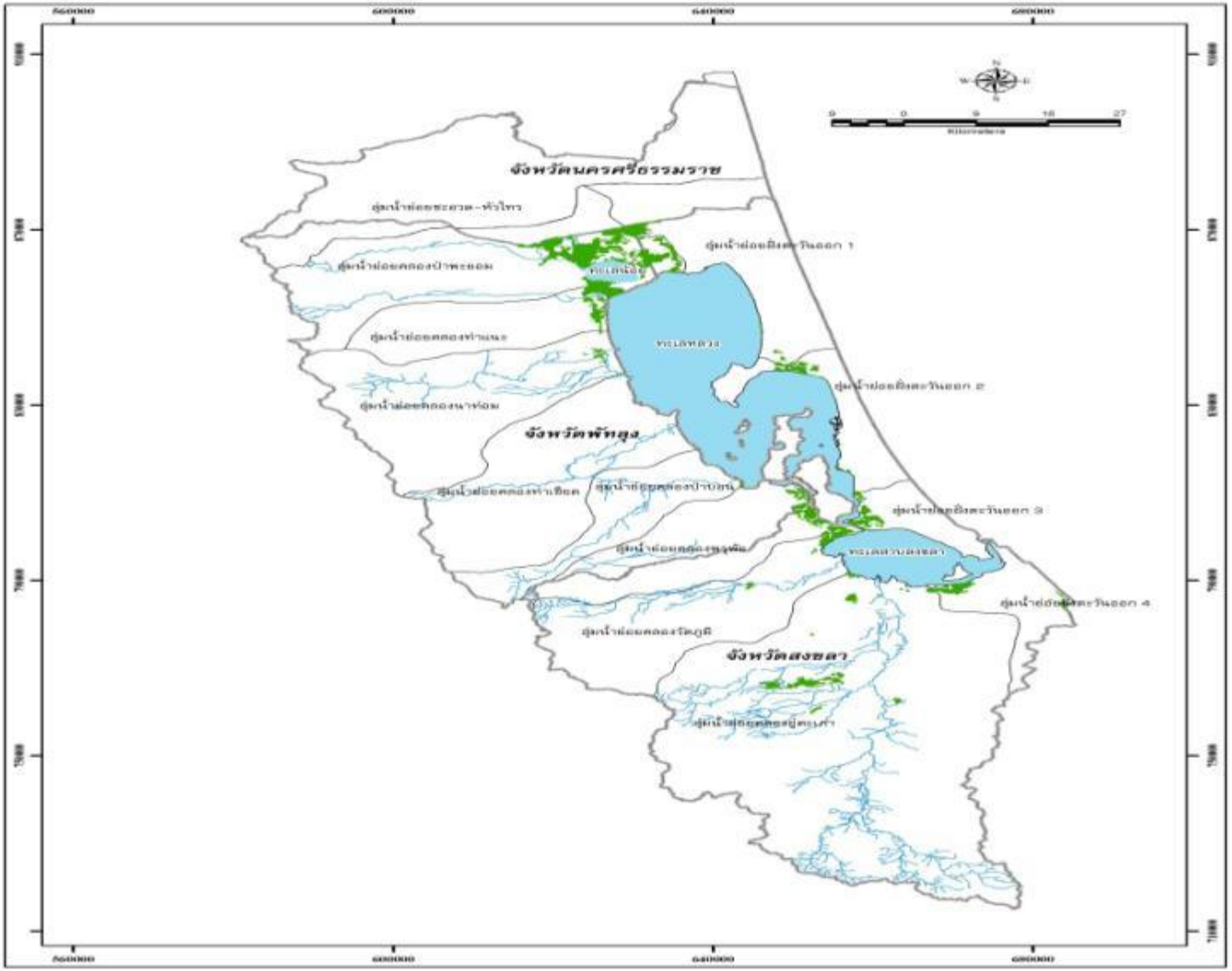

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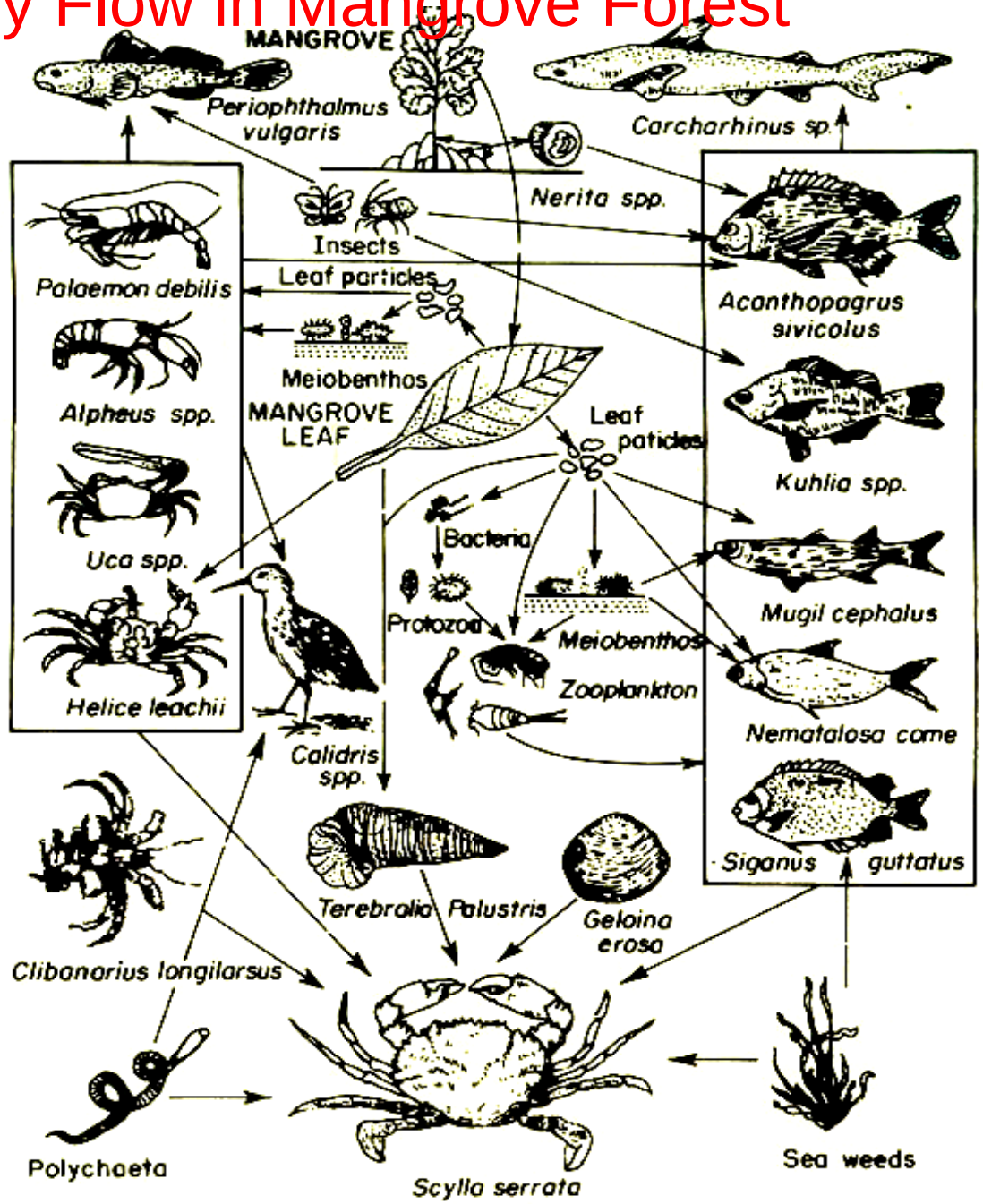

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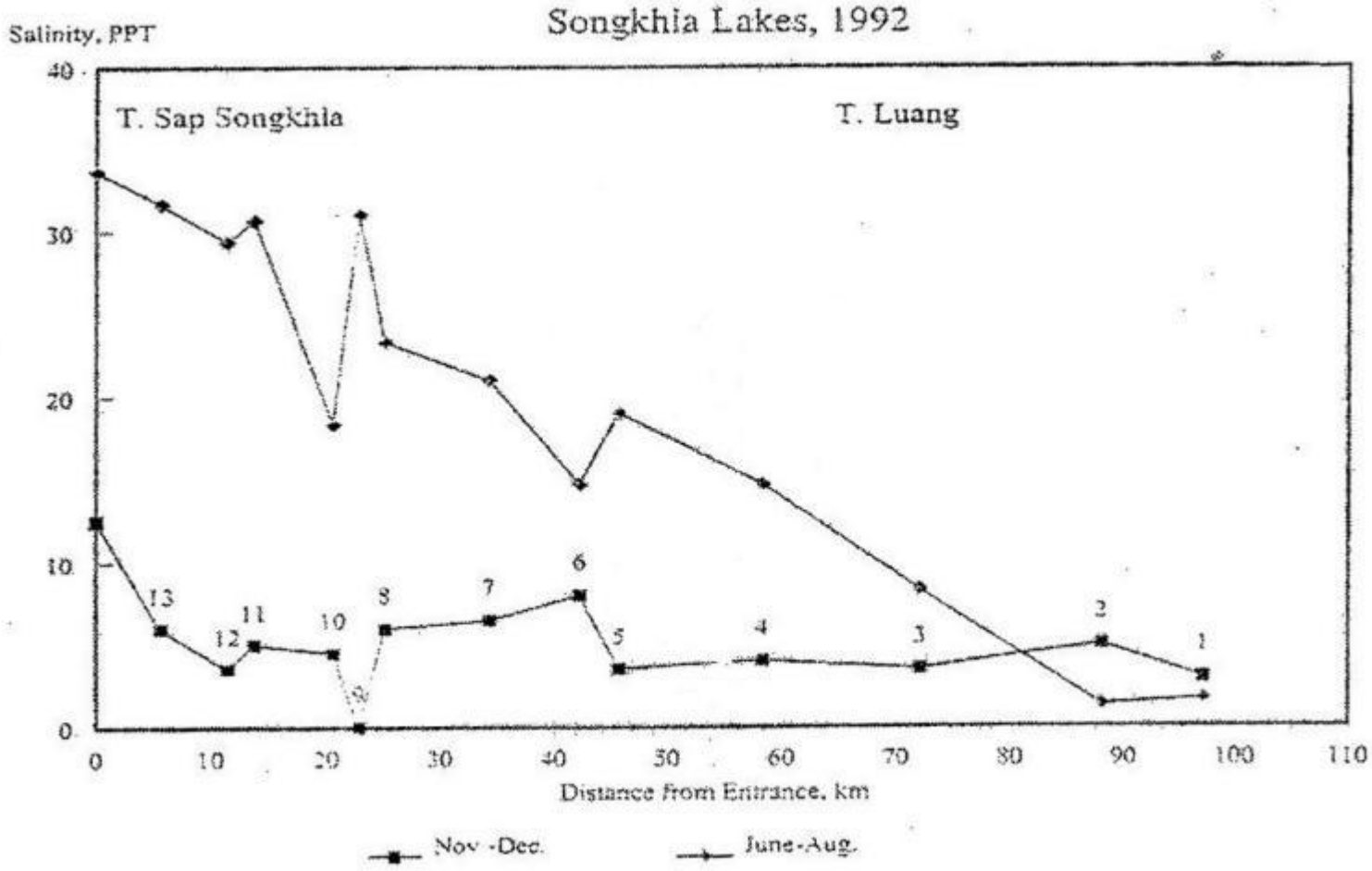

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- Mangroves are shallow rooted, the roots being concentrated mainly in the top 50 – 100 cm of the soil and seldom penetrating to depths beyond 2 m. Water and nutrients are absorbed by a dense mat of fibrous roots that usually originate from underground cable roots or smaller secondary roots in close proximity to the aerial “breathing” roots. Thus, mangrove must have adaptation if under stresses, especially aerial roots of them. Many studies show that they have morphological, physiological and metabolic adaptations (Jintana et.al., 1992).

- Research and development on mangrove to improve environmental degradation of Songkhla Lake had been carried out at three locations of the lake .
- Because seasonal variation of water salinity in the lake depends upon seawater from the open sea and run-off from the upper lake area and rivers around the lake.
- Therefore the criterion to select the location to plant mangrove depended on the distance away from the lake mouth which was narrow and opening to the sea.

Taller seedlings of *S. caseolaris* planted in SK lake

- The salinity regimes for each experiment site were also selected as salty, brackish and nearly fresh for most parts of the year. The total of 8.8 hectares from all sites were planted with selected mangrove species suitable to each site; ie. *Sonneratia caseolaris* , *Rhizophora mucronata*, *Lumnizera racemosa* and *Bruguira gymnorrhiza* to the number of 5,500 plants.
- The results from this research can be applicable to mangrove restoration and development programs of the lake with long coastal area or other areas with fluctuations in salinity to select the suitable mangrove species and suitable of planting sites.

Fresh or brackish water is ideal for *S. caseolaris* during early growth

Experiment plots on seedling maintenance before planting

- The results showed the steady growth of *Sonneratia* at the area near the lake mouth but less growth than those at the Northern part where the salinity was lower . Growing *Sonneratia* in the moist soil produced higher number of branches than growing in water. In addition, *Sonneratia* seedlings in the moist soil gave higher growth rates than growing them in water but their leaves appeared to be attacked by butterfly worms.

- Long flooding also killed a number of plants in this area. It was observed that *Sonneratia* seedlings grown in low salty water almost doubled the growth rates as compared to those grown in higher saline water of above 20 ppt. *Lumnizera racemosa* and *Rhizophor mucronata* appeared to grow well with high survival rates when grown in soil of the lake shore line . Growth of *Bruguiera gymnorrhiza* was found to be less as compared to other species while the survival rates were similar. However, severe flooding killed most of *Rhizophor mucronata* and shorter trees of *Sonneratia caseolaris* .

Salinity higher than 20 ppt killed newly planted *S.caseolaris* (left) but sudden fresh water regime promoted growth (right)

Since salt tolerant mechanism slowly develops, most of mangrove seedlings need fresh water for early growth

Where and what to grow? Look at indicator plants.

Land preparation for mangrove planting

Mangrove planting activity in Songkla Lake

S. caseolaris at 5 years after planting

Mangrove seedlings may suffer from butterfly worms or fungus but after the season recovery can be observed.

Experiment II
Growth Rates Comparison within Low and High Saline Water.

Since water conditions of the lake vary with season, fresh or low saline conditions for - months and salty or high saline conditions for - months are normal for lake water. Thus, the experiment has been conducted during such period of time using plants in the previous plot to investigate *Sonneratia* seedling

The experiment was carried out to investigate seedling growth of *Sonneratia caseolaris* planted in Songkhla Lake with varying in water depths. To avoid submergence in water during floodling at the rainy season, the root balled-seedlings of slightly more than 1 meter tall were selected for planting. Since the water salinity of the lake varies with the seasons, planting operation was made when the lake water was fresh. In order to observe the effect of water depths, the planting rows were arranged seaward and perpendicularly to the shoreline with varying in water depth from 0-60 cm. It was observed that the intrusion of sea water into the planting site during the dry season stunted seedling growth and caused broken branches and stem tips. This disadvantage was remedied when the lake water changed to fresh or brackish. The results showed that seedling grown in deeper water levels produced greater root (pneumatophore) development ie. root length, root number as well as the distance from the main stem. As a result it was possible that such better root characters in deep water brought about greater numbers in plant height, branch number, stem diameter as well as the survival rates. The results from this experiment will provide an efficial tool for mangrove restoration programme in the Songkhla Lake.

Fencing Experiment

Recovery of *S. caseolaris* can be observed after flooding

- It has been observed that re-establishment of *Sonneratia caseolaris* after transplanting was affected by water salinity. High salinity usually damages transplanted seedlings during re-establishment. Therefore, an experiment has been conducted to explore the most suitable water salinity for re-establishment of seedlings. Six treatments for applying seedlings with water salinity of , , , , and ppt were provided. In additions, another experiment (with treatments) of *Sonneratia* seedling growth in water with varying salinity levels have also been conducted.

Salinity Test

Higher salinity than 45 ppt is harmful to *Rhizophora* seedlings

Community participated in planting mangroves

Fresh or brackish water is better for seedling growth

Salinity Test for *Sapium indicum*

Adequate moisture is needed

Adequate moisture but not permanent flood is needed for *Rhizophora sp*

Replanting for dead plants may be needed

Planting *S. caseolaris* on the ridge in the lake

New leaves develop after long flooding

Mangrove planting activities in Songkla Lake

Growth of *S. caseolaris* in moist soil on the ridge of lake dredging.

- Data showed steady growth of Sonneratia at the area near the lake mouth but less growth than the Northern part where the salinity was lower . Growing *Sonneratia* in the moist soil also produced high number of branches. But their leaves appeared to be attacked by butterfly worms. Long flooding also killed a number of plants in this area.

1 year after planting on the ridge

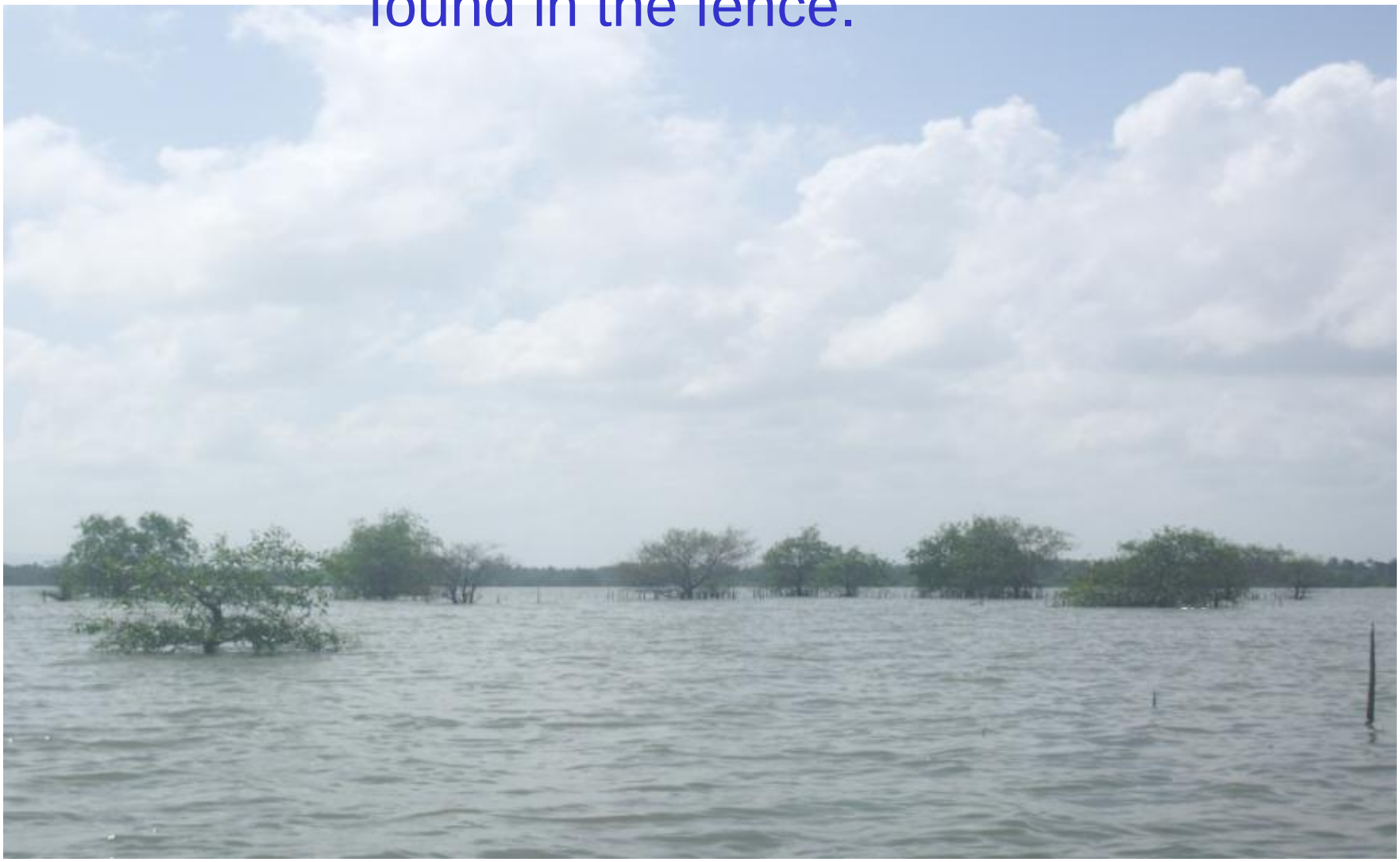
6 years after planting on the ridge

Lumnitzera racemosa planted on upper zones while *S. caseolaris* planted in water zones

Fencing Experiment at 3 years after planting (grows slowly in permanent flood).

S. caseolaris grown near the shoreline at 5 years after planting

Due to banacle attack, about 30 survival rate is found in the fence.



Growing Sonneratia caseolaris in the middle part of the lake before flooding

Sonneratia caseolaris growing at the northern part of the lake (Ranode) before flooding

- Death of *Sonneratia* and *Rhizophora* sp.seedlings at Kuan-niang was observed to be mainly from serious flooding and banacle attack. It was observed that death of some *Sonneratia* was generally due to its shorter stem and under water for longer than 20 days for some plants. The tall trees with greater stem diameter always regenerated new leaves or branches after flooding.

Sonneratia caseolaris grown in permanently flooded water with well developed pneumatophores

- Because the degree of water salinity of the lake vary with season and distance from the lake mount, thus the experiments have been conducted to investigate the effect of salinity regimes influencing 3 locations away from the lake mount. The pattern of salinity regimes, however are salty, brackish and nearly fresh away from the sea. It has been observed from this study that re-establishment of *Sonneratia caseolaris* after transplanting was affected by salinity regimes. At Ranode district where the salinity was very low or near fresh water all the year round, for example, height of the plants at 5 months is similar to those grown after 12 months at the lake mount indicating that fresh water stimulated growth of *S. caseolaris*. At Kuan-niang district where the salinity is relatively higher than the other two sites and the high salinity exists longer than the brackish water, plants grown in the moist soil had greater growth than those in water. The reason for this could be due to the availability of oxygen on the land for roots respiration was higher than in the water.

- As for *Rhizophora mucronata*, most of them died after flooding and without recovery. It is interesting to note that *Sonneratia* with their height at 210 cm., 50% of them was killed by flood at Ranode but most of them survived at Kuan-niang. The result for this might be due to the shorter time and shallower level of flood water at Kuan-niang as compared to Ranode on the Northern part.

Sonneratia caseolaris is grown along the shore for fishing ground

Community participation on mangrove planting

Thank you