4. DISCUSSION

4.1 Diversity study

Thirty-seven genera with 52 species were found in this study. These account for 15.6% of the total number of marine algae recorded in Thailand. Twenty-two species of Rhodophyta, 16 species of Chlorophyta, 9 species of the Class Phaeophyceae and 5 species of Cyanobacteria were collected. The highest diversity belonged to the Rhodophyta, characteristically diverse and abundant in the tropics (Taylor, 1960; Trono, 1997; Littler and Littler, 2003). More than 4,000 species of rhodophytes have been described and they are known to have greater diversity in the tropics than in the temperate regions. Although marine red algae occur at all latitudes, there is a marked shift in their diversity and abundance from the equator to colder sea (Lee, 1999).

Thirteen percent higher diversity of macroalgae were found at the site, as compared to the study of Sakuntab (1976), in which only 46 species were reported throughout Phuket province. Only 22 genera were reported from Sirinat Marine National Park, 40% fewer than in this study. In addition, the number of species of macroalgae in this study was two times greater than the report of Prathep (2005). Only two field collections were made in those previous studies as compared to the six field collections in this study. Thus, the number of visits field collection could be important for appraising species diversity. In addition, this suggested that there was temporal variation in diversity of macroalgae at the sites.

Of the total number, 9 species are believed to be new records for the Thai marine flora. There are only few studies published in Thailand such as a series of taxonomical studies on red algae, *Gracilaria* (Lewmanomont, 1994, 1995; Lewmanomont and Chirapart, 2004). *Gracilaria* seems to be the only red algae genus which has been well studied. Some of the new records found in this study such as *Acetabularia*, *Polysiphonia* and *Corallophila* are rather small in size. These, therefore, could be hidden or covered by other algae or substrates when collected the specimens, while *Gelidiopsis* and *Wurdemannia* are conspicuous and easy to collect in the field. *Chondrophycus, Sargassum* and *Hypnea* have been studied by a few scientists both globally and regionally. Also, revisions of these genera are still ongoing e.g. *Chondrophycus* and *Laurencia* (Nam, 1999); *Sargassum* (Yoshida, 1988; Trono, 1992; Tseng and Baoren, 1997) and *Hypnea* (Chiang, 1997; Yamagishi and Masuda, 1997). Therefore, many more new records of macroalgae are likely to be found with increasing of research.

More of algae taxonomists are needed in Thailand, the taxonomy study could provide basic information for further study in biology and ecology of macroalgae. Many macroalgae become more of ecological problems in marine ecosystem. For example, some species such as *Padina* can grow rather fast and occupy very large area, inhibited recruitment and cause death to coral in Surin island (Liddle and Phongsuwan, 2004). However, the taxonomical knowledge and reproductive biology of *Padina* is still little known. *Ulva*, a causing green-tide bloom species in many marine habitats including Patong beach, Phuket. Its taxonomy has been little studied. Just recently, there are revisions of *Enteromorpha* and *Ulva*, they both now belong into a same genus, *Ulva* (Tan *et al.,* 1999).

4.2 Abundance and distribution study

The highest number and percent cover of macroalgae were found at the semi-exposed site, which might be due to better nutrient and gas exchange as well as more efficient removal of waste products (Díez *et al.*, 2003). In contrast, fewer species and less abundance were characteristic of the exposed and sheltered shores. On the sheltered shore, macroalgae could be exposed to stress due to limited circulations of nutrients and gas exchange. While, exposed shores have better circulation due to wave action, but such wave motion also wash and snaps off the larger fronds of *Turbinaria* (Stewart, 2004). The results indicated that fragile algae such as *Boodlea composita* and the filamentous forms, had greater abundance on the sheltered shore. *Boodlea's* leaf-like thallus is more intact on the sheltered shore than on the semi-exposed or the exposed shore where some thalli were easily broken and frayed (Prathep, 2005).

Exposed shores are known to be occupied by fewer marine organisms (Stephenson and Stephenson, 1972). Some algae, however, are well-adapted to the exposed shore such as *Chondrophycus* spp., *Gelidiella acerosa, Gracilaria salicornia,* and *Hypnea spinella.* These algae form clumps of turf, decreasing the area exposed to strong wave motion, and help them to resist desiccation when the tide is out (Hay, 1981). Individual fronds of *Chondrophycus* spp. and *G. salicornia,* for example, aggregate together, decreasing the area exposed to strong wave action. Also, the red crustose algae, another dominant alga on the exposed shore, accumulate calcium carbonate and encrust onto the rock. These algae are tougher and their flat form is less affected by strong wave action. They, therefore, can better withstand the strong forces of the waves (Prathep, 2005).

Statistical analyses indicated that shore elevation does not influence the macroalgal population significantly. The shore elevation at this study is not very steep, thus the exposed hours during the low tide was short, only 4-5 hours differences during the spring tide. Thus, desiccation and temperature might not play crucial role on this shore, this is rather different from the temperate zone where shore zonation is rather well-defined (Littler, 1973; Kapraun, 1974; Kim *et al.*, 1996; Boaventura *et al.*, 2002). Also, biological interactions such as herbivory, competition and predation are known to play important roles on community structure (Lubchenco and Gaines, 1981; Paine, 1984), such studies are still very scarce. The combination of such study could give a better understanding of diversity and abundance of macroalgae community on the shore.

Lyngbya and *Padina* are the most common genera found at all sites in all seasons. They also had greater percentage cover on the shore, 31.66% and 27.77%, respectively, which are 20 times greater than others. *Lyngbya* are known to have secondary metabolites which make them unpalatable for herbivores (Bager, 1987; Nagle and Paul, 1999; Paul *et al.*, 2005). They can form mat and bloom in tropical area. With decreasing desiccation, they can occur from sheltered to exposed and from upper to lower shores. The success of *Lyngbya* occurs in various shore (Whitton and Potts, 2000; Thacker *et al*., 2001; Boaventura *et al.*, 2002; Mayakun and Prathep, 2005). Similar to *Lyngbya, Padina* forms dense patches, with funnel-shaped blade, help to maintain water at low tide out. Also, *Padina* reproduction was observed throughout the year with very high number of spores (Lewmanomont, 1980; Liddle and Phongsuwan, 2004). This allows for high recruitment rates and population success. Such abundance is characteristic of the shores of other sites in Thailand such as at Ko Samui, Surat Thani Province (Mayakun and Prathep, 2005), Talibong, Trang Province (Prathep and Tantiprapas, in press) and Tang Khen Bay, Phuket Province. In addition, *Padina* accumulates calcium carbonate ($CaCO_3$) in the thallus, this could help them to withstand the high wave exposure; and also they are known to produce phenol with unflavored for herbivores (Shaikh *et al.,* 1991; El-Masry *et al.,* 1995).

Community grouping with 45% of the variance in the coverage of the macroalgae investigated in the CCA analysis. The CCA showed that some filamentous algae such as *Ceramium mazatlanense*, *Cladophoropsis sundanensis* and *Enteromorpha flexuosa* were influenced by phosphate (PO_4^{3-}) concentration. The highest phosphate (PO_4^{3-}) and nitrate (NO_3^-) concentrations were 4 mg/l and 8.8 mg/l, respectively, in this study. It seems that the algae use the nutrients efficiently, and there were no nutrient limitation effects in this study. These concentrations were high, and suitable for macroalgae. Fluctuations of salinity, water and air temperature in this study site were low; and the conditions found in this study were suitable for growth and reproduction of macroalgae (Subbaraju *et al.,* 1982). However, further investigations are needed for a better understanding of PO_4^{3-} on those species, wave motion on *Padina australis* and light on *Gracilaria salicornia.*

4.3 Variations in morphology and reproduction of *Acanthophora spicifera* and *Chondrophycus tronoi*

There was variation in height among sites and seasons of *Acanthophora spicifera*. The highest plants were found at the sheltered area in May. Smaller plants were found in July and November concomitant with lesser abundance. The shorter plants might be due to their having been snapped off by strong wave action. There were, however, no reproductive organs observed throughout the year in this study. Fragmentation, therefore, might be an adaptation for asexual reproduction of *A. spicifera* in this area. This also could increase the ability in dispersal and distribution of plants in many areas throughout the world as for example at Galeta Point, Panama (Kilar and McLachlan, 1986b) and Taranto, Southern Italy (Cecere *et al.,* 2000; Cecere and Perrone, 2002). The disappearance of *A. spicifera* in September might have been because of high sedimentation in July and September which covered the plants (Mayakun, 2006). Higher plants were found later in November when sediment was washed away.

Macroalgae are known to adapt to withstand the greater wave motion such as shorter fronds, forming turfs or even encrusting to the substrate (Norton, 1991). Kilar and McLachlan (1986a) found that in the fore-reef, where *Acanthophora spicifera* plants were exposed to intense wave action, the plants had fewer branches compared to the sheltered area. There was, however, no significant correlation between height and degree of wave exposure in *A. spicifera* plants in this study. However, it is noteworthy that the number of primary branches in sheltered area was slightly higher than those in exposed and semi-exposed area during wet season, this suggested that stronger waves during the wet season could also slightly influence branching patterns of *A. spicifera* by snapping the branch off.

Chondrophycus tronoi in sheltered areas were also taller and larger than plants in exposed area, similar to the pattern in *Acanthophora spicifera.* In contrast, however, slightly greater branching of *C. tronoi* was observed on the exposed shore, as suggested in Kilar and McLachlan (1986a). They found that *Laurencia papillosa* (transfer to *Chondrophycus papillos*us at present) on the fore-reef area had shorter fronds, with greater branching, forming a dense patch to protect themselves from wave action and desiccation.

The reproductive stages of *Chondrophycus tronoi* were not found in this study. *C. tronoi* is a perennial plant (Cecere *et al.,* 2000; Cecere and Perrone, 2002), during our study plant could be in juvenile stage, thus no reproductive organs were found in this study. However, the disappearance of sexual reproduction is a common phenomenon of a red alga forming turf; and vegetative propagation seems to be an asexual reproduction for this turf (Guiry and Womersly, 1993). Increasing of young *C. tronoi* turfs also noticed in this study. Further investigation would be useful to understand the phenomenon of the red algae reproduction.

CONCLUSIONS

1. Total of 52 species, 9 species are believed to be new records for Thai marine flora; they are

Acetabularia pusilla (Howe) Collins

Chondrophycus tronoi (Ganzon-Fortes) Nam

Chondrophycus dotyi (Saito) Nam

Polysiphonia sphaerocarpa Børgesen

Gelidiopsis variabilis (J. Agardh) F. Schmitz

Wurdemannia miniata (Sprengel) J. Feldmann & G. Hamel

Hypnea spinella (C. Agardh) Kützing

Sargassum cristaefolium C. Agardh

2. Wave motion influenced diversity, abundance and distribution of macroalgae at Sirinat Marine National park. The greatest diversity was found on the semi-exposed area.

3. *Lyngbya majuscula* and *Padina australis* were the dominant species and common at all sites throughout the study with the greatest percentage cover of 31.66% in semi-exposed area at mid shore level during March 2004 and 27.77% in exposed area at mid shore level during November 2004, respectively.

4. Wave motion affected height and diameter of *Acanthophora spicifera* and *Chondrophycus tronoi*. On the other hand, branching patterns of both species was not influenced by wave motion.

5. There were no sexual reproduction of either *Acanthophora spicifera* and *Chondrophycus tronoi* found in this study.

RECOMMENDATIONS

1. An acute shortage of taxonomists is a worldwide problem and occurs in many fields of study, including taxonomy of macroalgae study, more taxonomists are urgently needed.

2. Further study in relationships between species distributions and environmental factors are needed for better understanding at community level.