3. RESULTS

Unmanipulated plots

There were no significant differences in species composition between the two clearing times. *Cladophora prolifera* and *Polysiphonia sphaerocarpa* were the most conspicuous species in unmanipulated plots, 73% ± 3.74 (mean ± SE) and 52.2% ± 8.94 respectively for the dry season (Figure 6) and 72% ± 5.15 and 39% ± 18.80, respectively for the rainy season (Figure 7). In the dry season, *Dictyerpa* stage of *Padina* was relatively abundant in the first 6 months of this study, but its abundance was lower after that; it became less abundant during the raining season. The ephemeral alga, *Ulva paradoxa*, was less abundant in unmanipulated plots. The highest percent cover was only 16% in the dry season and only 8% in the rainy season. These findings are different to that found in surveys at Samui Island which is in the Gulf of Thailand and not in the Andaman Sea (Mayakun and Prathep, 2005). Seasonal changes in algal abundance were greater for both *C. prolifera* and *P. sphaerocarpa* compared to *Dictyerpa* stage of *Padina* (Figure 6 and 7).

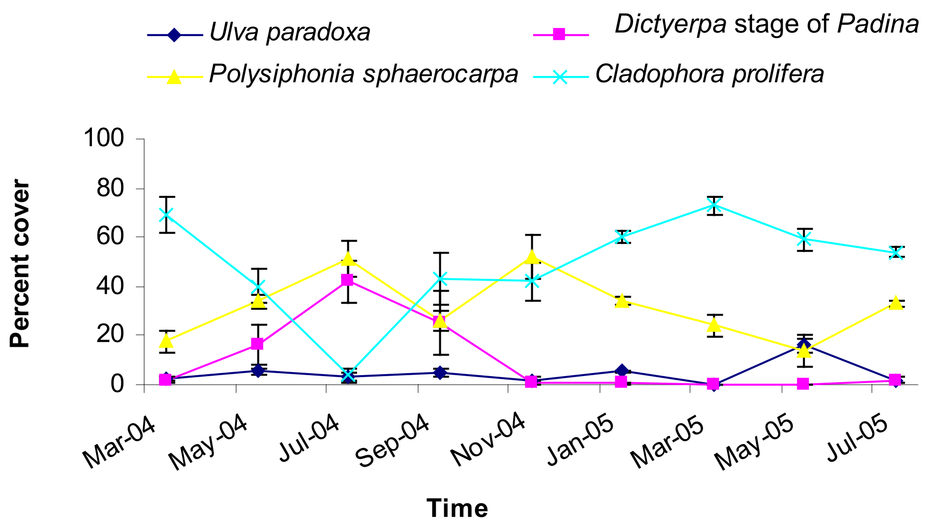

Figure 6. The percent cover of algal species in unmanipulated plots without cage over 18 months. Data shown are from plots cleared in the dry season (January 2004). Data are the mean ± SE of 5 replicates.

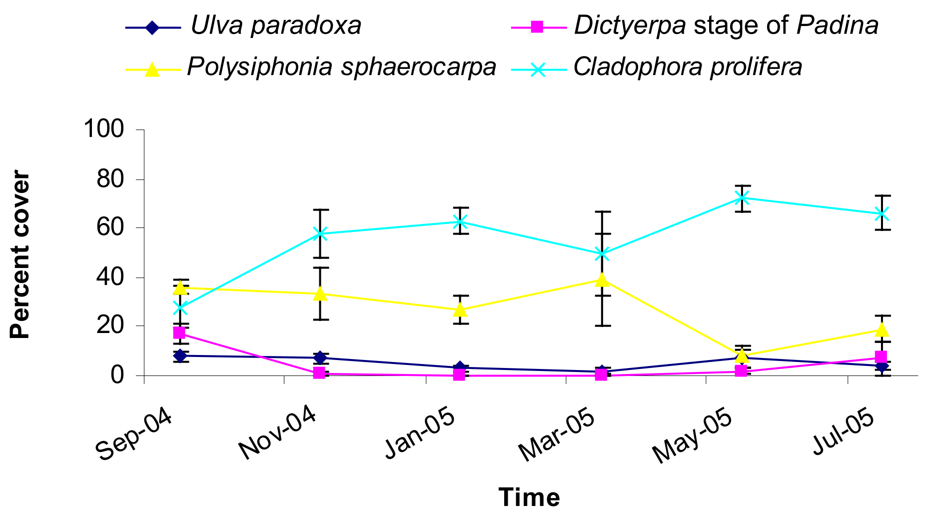

Figure 7. The percent cover of algal species in unmanipulated plots without cage over 12 months. Data shown are from plots cleared in the rainy season (July 2004). Data are the mean ± SE of 5 replicates.

Effects of clearing season

There were temporal patterns of species diversity in both the dry and rainy season. The results showed that the highest species diversity was found in the manipulated plots in the dry season, H' = 2.43; and the minimum diversity was found in the rainy season, H' = 1.37. Species diversity of the algal community in plots cleared in the dry season increased more rapidly than those cleared in the rainy season (Figure 8). They increased quickly until September 2004 and they were higher in July 2005 in manipulated plots. In the rainy season cleared plots, species diversity of control plots decreased initially until March 2005. Diversity increased slowly in manipulated plots and highest species diversity was reached in July 2005. The result showed that the same four dominant species occupied cleared sites in areas cleared during both the rainy and dry seasons.

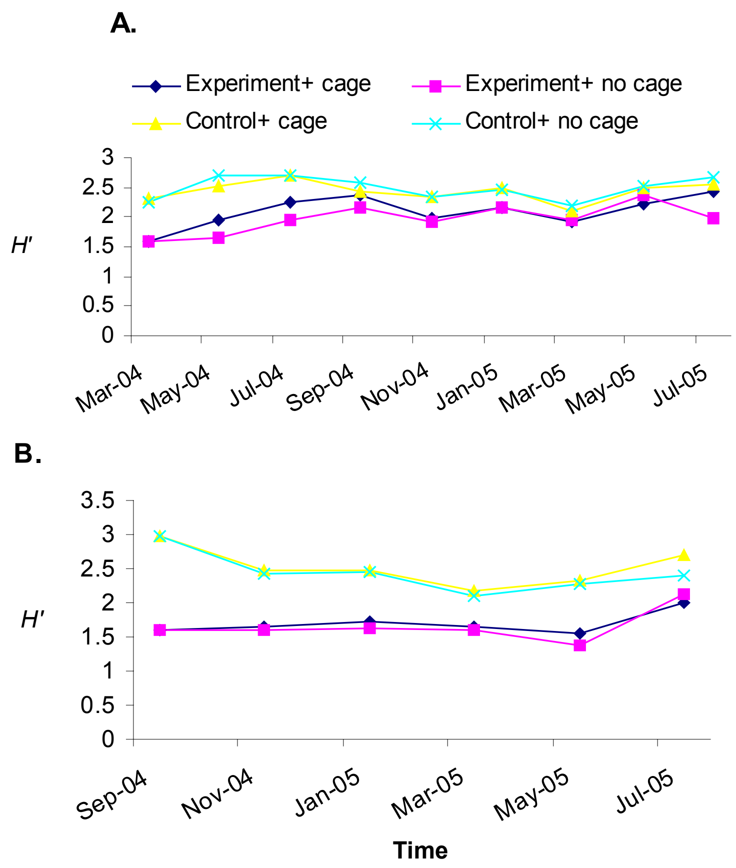

Figure 8. Temporal patterns of species diversity of A) Dry and B) Rainy season

In total, 10 algal species occurred in the manipulated plots (Table 1). Species composition of colonists was not different between the plots that were cleared at the two different times (January and July 2004). However, algal abundance was different depending on the clearing time (Table 2 and 3). Two months after clearing, there was a high initial cover of ephemeral algal species, *U. paradoxa*, in both clearing times (Figure 9).

Open up space **Two months after clearing**

Figure 9. *Ulva paradoxa* was a dominant species in a manipulated plot and it colonized rapidly in this plot.

Ulva has often been found to colonize and grow rapidly during the early stages of succession. When patches were cleared during the dry season (i.e. January 2004), *U. paradoxa* was the first dominant species in the plots, comprising 86% of the ground cover in May 2004. After 4 months elapsed, *U. paradoxa* declined until March 2005 and was displaced by a filamentous rhodophyte, *P. sphaerocarpa*. *P. sphaerocarpa* had a high percentage cover with 23% in July 2005 and *Dictyerpa* stage of *Padina* had a low cover in these cleared plots (Figure 10). However, *C. prolifera* was not found in plots cleared during the dry season. When the areas were cleared in the rainy season, the percent cover of *U. paradoxa* was 99% in September 2004 (Figure 11) and was found to colonize more rapidly in the rainy season than during the dry season. *Dictyerpa* stage of *Padina* and *P. sphaerocarpa* had a very low cover in the plots that were cleared in the rainy season while *C. prolifera* also was not found in these plots when compared with plots that were cleared in the dry season.

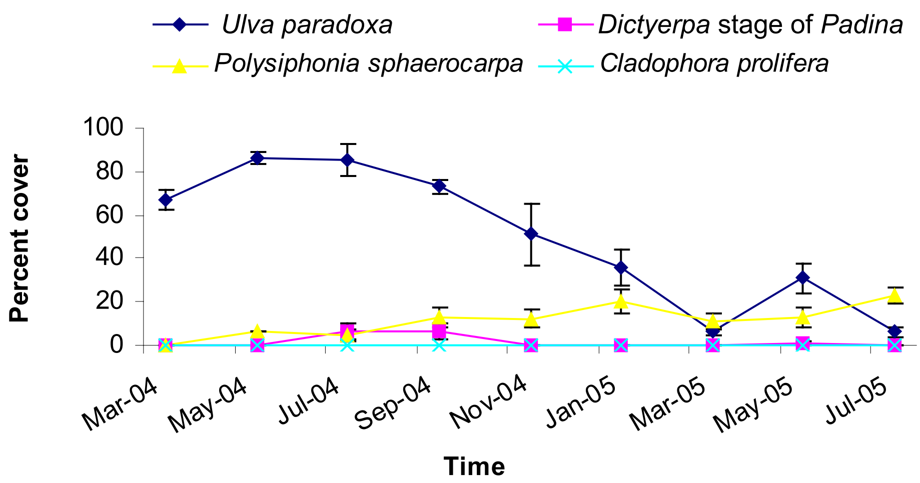

Figure 10. The cover of abundant algae in manipulated plots without cages over 18 months. Data shown are from plots cleared in the dry season (January 2004). Data are the mean ± SE of 5 replicates.

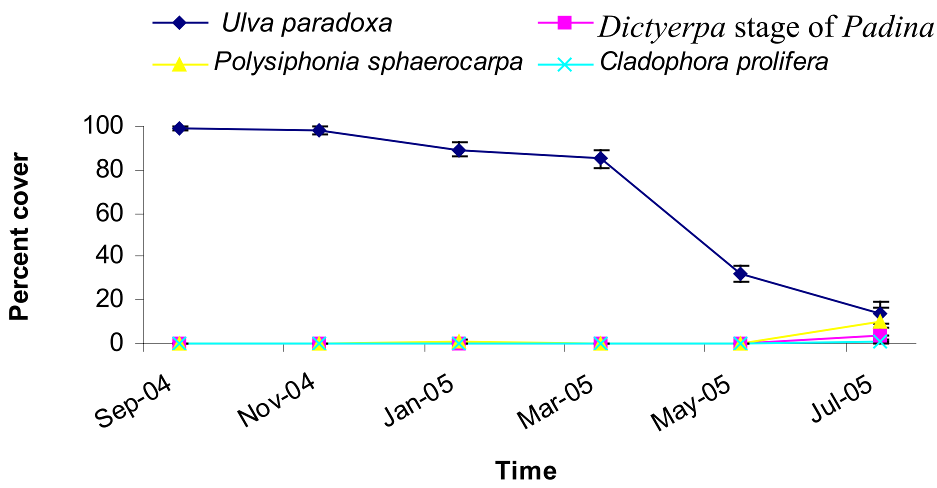

Figure 11. The cover of abundant algae in manipulated plots without cages over 12 months. Data shown are from plots cleared in the rainy season (July 2004). Data are the mean ± SE of 5 replicates.

Table 1. List of algal species and their abundance in the each experiment between dry and rainy seasons. Ch: Chlorophyta; Ph: Phaeophyta; Rh: Rhodophyta. C: common occurrence more than 10% in percentage cover at least 1 sample; R: rare occurrence less than 10%; -: no occurrence.

Functional groups / Species	Phylum	Abundance							
		Experimental plots				Unmanipulated plots			
		Dry		Rainy		Dry		Rainy	
		Cage	No Cage	Cage	No Cage	Cage	No Cage	Cage	No Cage
Filamentous algae									
Centroceras clavulatum (C. Agardh) Montague	Rh	-	-	-	-	-	-	R	R
Ceramium mazatlanense Dawson	Rh	C	C	R	-	C	C	C	C
Cladophora prolifera (Roth) Kütz	Ch	-	-	-	R	C	C	C	C
Polysiphonia sphaerocarpa Børgesen	Rh	C	C	C	C	C	C	C	C
Foliose algae									
Dictyosphaeria cavernosa (Forsskal)	Ch	R	-	-	-	R	-	R	R
Ulva paradoxa C. Agardh	Ch	C	C	C	C	C	C	C	C
Corticated macrophytes									
Dictyerpa stage of *Padina*	Ph	C	C	C	C	C	C	C	C
Leathery macrophytes									
Valonia aegagropila C. Agardh	Ch	-	-	-	-	R	R	C	C
Laurencia sp.	Rh	R	-	-	-	R	-	C	-
Gelidium sp.	Rh	-	R	-	-	-	-	-	-
Calcareous algae									
Acetabularia sp. *	Ch	-	-	R	-	-	-	-	-
* (15 thallus)									

Table 2. Effects of herbivory and season of clearing on recolonization of total algae from each season.

	Dry				Rainy			
Source of variation	**df**	**MS**	***F***	**P**	**df**	**MS**	***F***	**P**
Month	5	0.101	6.814	0.000	5	0.421	5.238	0.000
Caged	1	4.259E-04	0.029	0.866	1	2.027E-03	0.025	0.874
Season *Caged	5	3.485E-03	0.235	0.946	5	1.603E-02	0.199	0.962
Error	108	1.484E-02			108	8.033E-02		

Season of clearing affected the relative abundance patterns of *Dictyerpa* stage of *Padina* and *P. sphaerocarpa* (season effect: *p*= 0.013 and *p*= 0.000, respectively; Table 3, Figure 12 and 13). However, differences in percent cover of *C. prolifera* and *U. paradoxa* between dry and rainy clearing were not significantly different (*p*= 0.606 and *p*= 0.922, respectively). Thus, there were seasonal changes in the dominant species between seasons.

Table 3. Effects of herbivore and season of clearing on recolonization of 4 dominant algae, *Cladophora prolifera*, *Ulva paradoxa*, *Dictyerpa* stage of *Padina* and *Polysiphonia sphaerocarpa*.

	Cladophora prolifera				***Ulva paradoxa***				***Dictyerpa* stage of *Padina***				***Polysiphonia sphaerocarpa***			
Source of variation	**df**	**MS**	***F***	**P**	**df**	**MS**	***F***	**P**	**df**	**MS**	***F***	**P**	**df**	**MS**	***F***	**P**
Between subjects																
Season	1	8.453E-03	0.267	0.606	1	1.179E-03	0.010	0.922	1	1.060	6.312	0.013	1	8.973	35.338	0.000
Cage	1	8.453E-03	0.267	0.606	1	2.059E-02	0.167	0.684	1	0.408	2.433	0.122	1	4.80	1.889	0.172
Season *Cage	1	5.476E-02	1.733	0.191	1	7.781E-02	0.631	0.429	1	6.408 E-02	0.382	0.538	1	0.262	1.033	0.312
Error	116	3.161E-02			116	0.123			116	0.168			116	0.254		

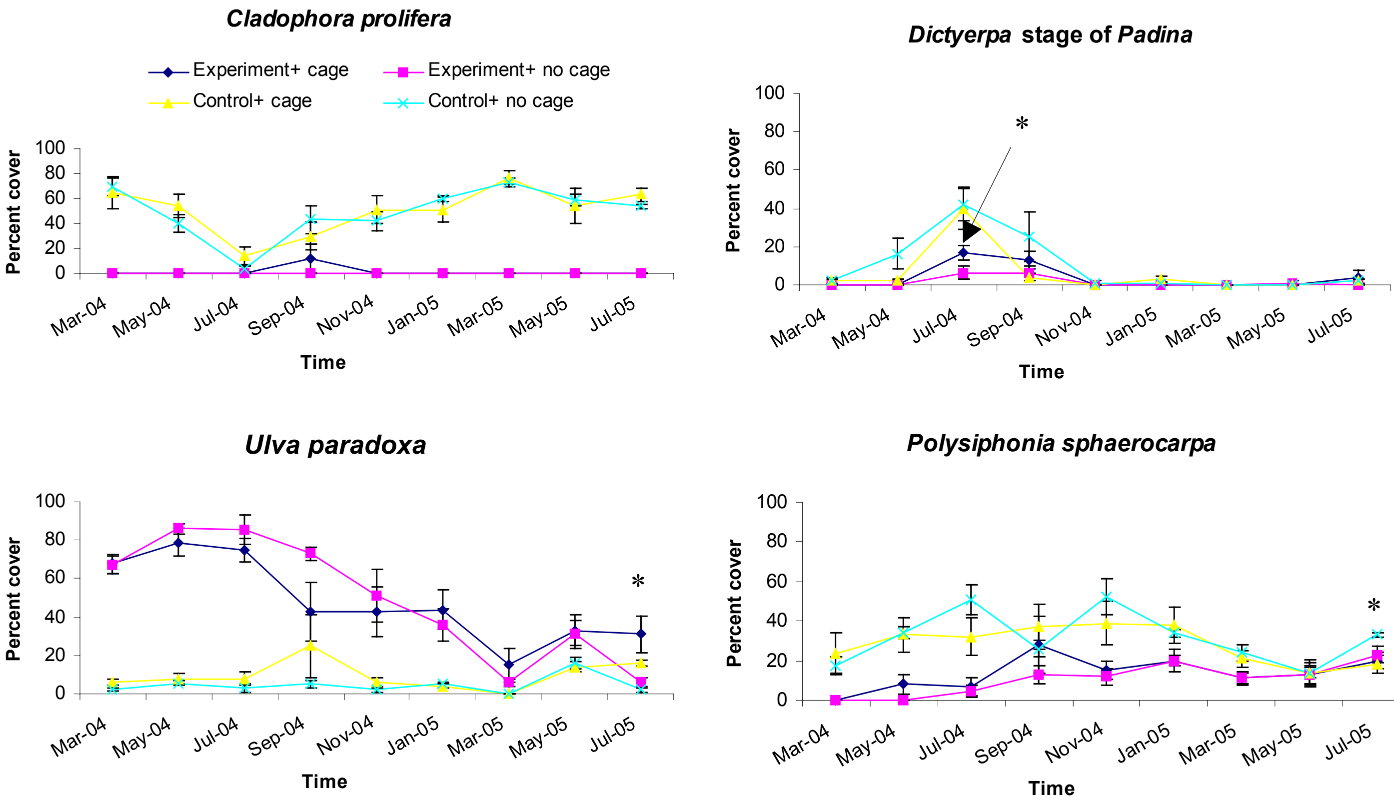

Figure 12. Seasonal changes of alga percent cover, *Cladophora prolifera*, *Ulva paradoxa*, *Dictyerpa* stage of *Padina* and *Polysiphonia sphaerocarpa* in 20×20 cm of clearing. Data shown are from dry season (January 2004) plots. Data are the mean ± SE of 5 replicates for each experiment. Comparisons between cages were made using independent *t*-test: * $0.05 \geq p > 0.01$; ** $0.01 \geq p > 0.001$; *** $p < 0.001$.

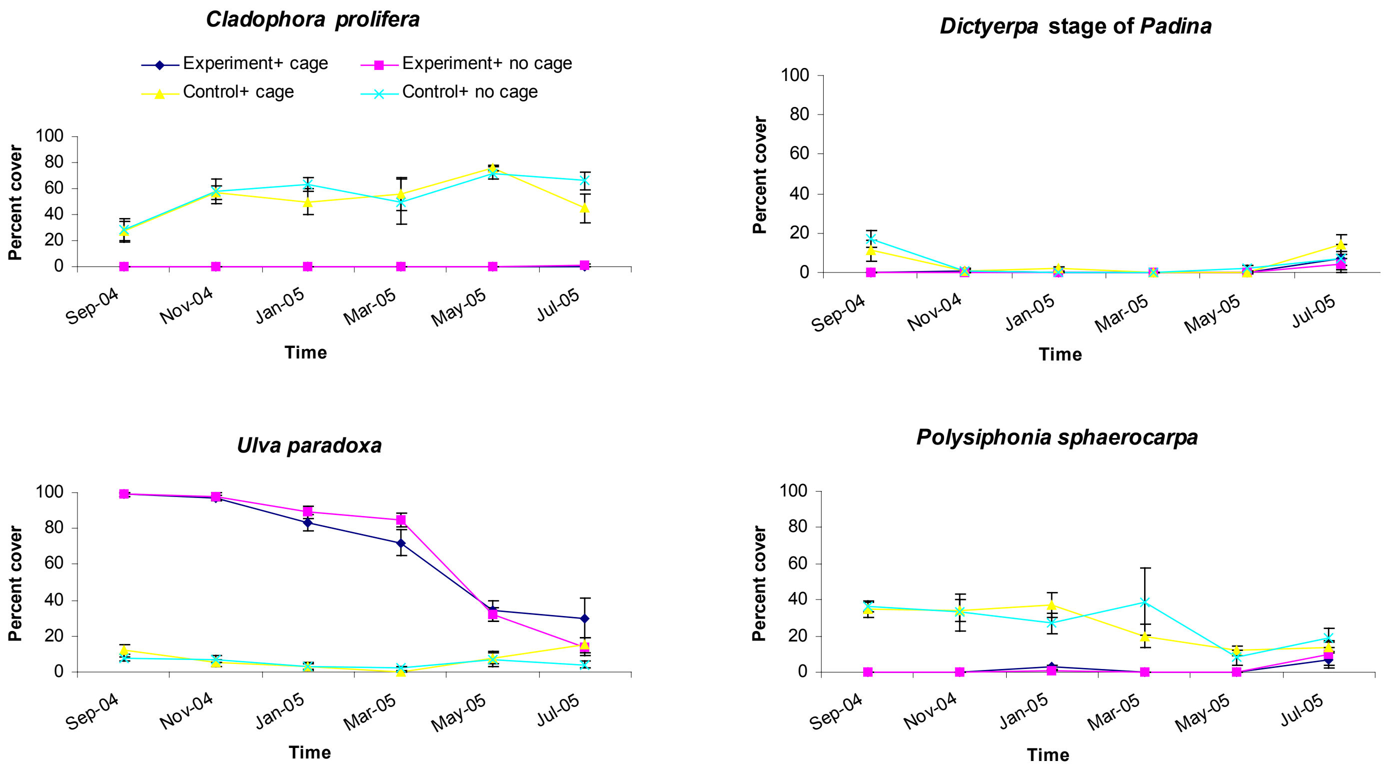

Figure 13. Seasonal changes of algal percent cover, *Cladophora prolifera*, *Ulva paradoxa*, *Dictyerpa* stage of *Padina* and *Polysiphonia sphaerocarpa* in 20×20 cm of clearing. Data shown are from rainy season (July 2004) plots. Data are the mean ± SE of 5 replicates for each experiment. Comparisons between cages were made using independent *t*-test: * 0.05≥ p >0.01; ** 0.01≥p >0.001; *** p <0.001.

The effect of clearing time on total algal cover and two dominant species in manipulated plots without caging is shown in Figure 14. Plots cleared in the rainy season had a greater percent cover of total algae and *U. paradoxa* than in plots cleared in the dry season within 2 and 4 months after clearing (Independent *t*-tests, p = 0.001, p = 0.035 and p = 0.001 and p = 0.012 respectively). Eight and 10 months after clearing, there was a significant difference in *P. sphaerocarpa* cover between the two clearing times (Independent *t*-tests, p = 0.006, p = 0.005, respectively).

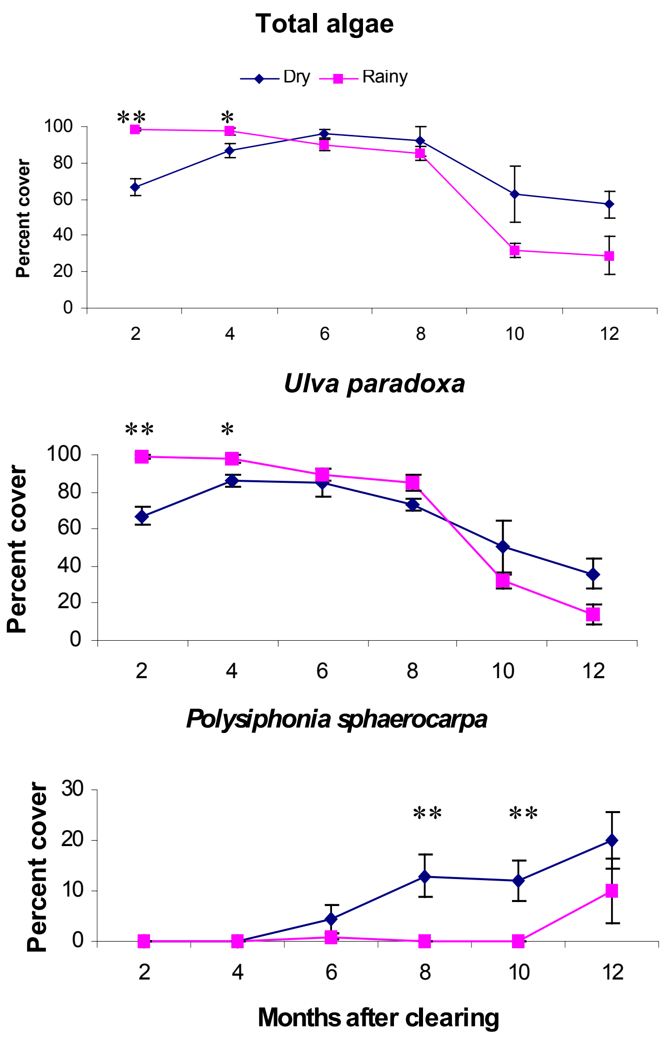

Figure 14. Effects of clearing time on total algae and two dominant species, *Ulva paradoxa* and *Polysiphonia sphaerocarpa*, in manipulated plots without cage. Comparisons between clearing time were made using independent *t*-test: * 0.05≥ p >0.01; ** 0.01≥p >0.001; *** p <0.001.

Herbivory effects

Cage controls were conducted on both experimental and unmanipulated plots to determine the effect of herbivory on algal abundance and succession patterns.

Abundance of 4 dominant algal species was not significantly different between the caged and uncaged plots (Table 3; Figure 12 and 13). Both in the absence of fish grazing within cages and inside damselfish territories without cages, plots were first dominated by green alga, *Ulva paradoxa*, followed by *Polysiphonia sphaerocarpa*. *Ulva paradoxa*, however, persisted longer in the caged plots than in the uncaged plots and the late successional algae, *Dictyerpa* stage of *Padina* and *P. sphaerocarpa*, were rare until the end of the study. However, there was significant difference when compared in the manipulated plots with cages between two clearing season. The results indicated that there was significantly greater in total algal cover 2, 6 and 8 months after clearing (Independent *t*-tests, p = 0.01, p = 0.037, p = 0.024 respectively; Figure 15), 2 and 4 months after clearing of *U. paradoxa* cover (Independent *t*-test, p=0.001, p=0.045). In contrast, *P. sphaerocarpa* was significantly different in 8, 10 and 12 months after clearing (Independent *t*-test, p=0.000, p=0.000 and 0.034 respectively; Figure 15). When algal percent cover between inside and outside cages was compared, the algal cover inside cages was lower than outside cages. This result was found in experimental plots set up at both clearing times especially in percent cover of *U. paradoxa*. Species diversity of the algal community was no different and showed a similar pattern between the caged and non-caged plots (Figure 8).

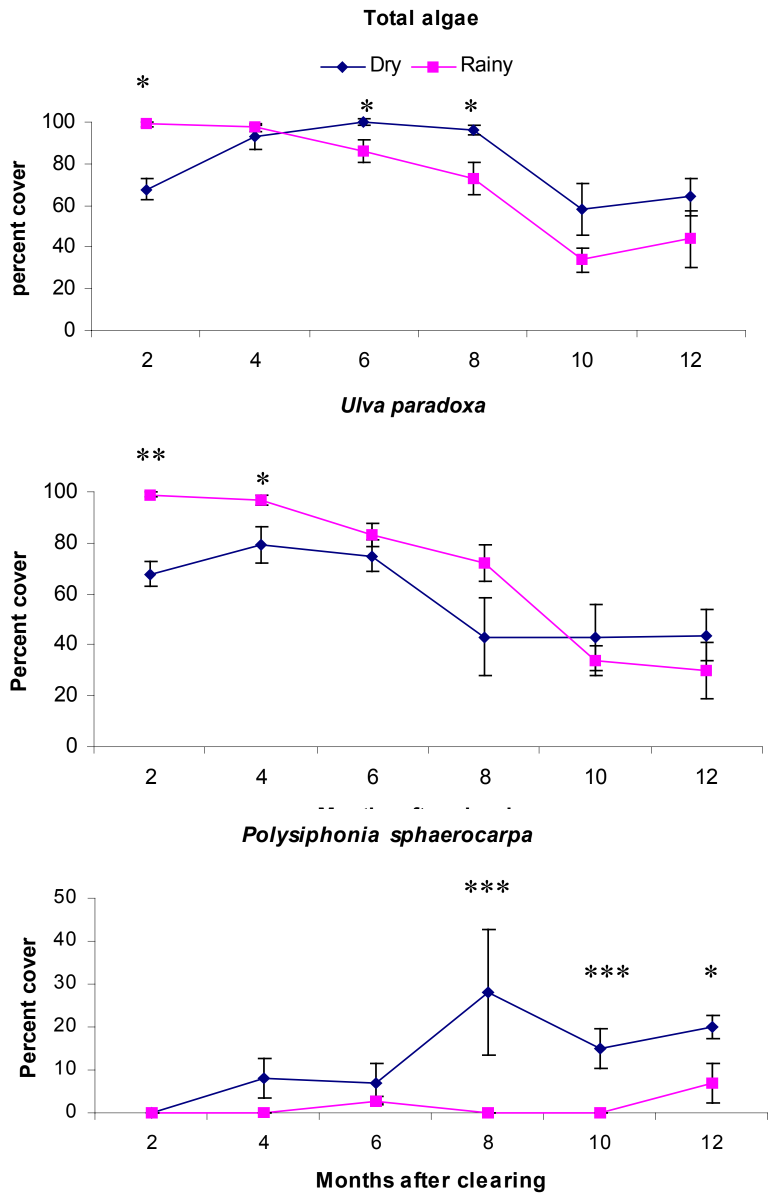

Figure 15. Effects of clearing time on total algae and two dominant species, *Ulva paradoxa* and *Polysiphonia sphaerocarpa* in manipulated plots with cages. Comparisons between clearing time were made using independent *t*-test: * $0.05 \geq p > 0.01$; ** $0.01 \geq p > 0.001$; *** $p < 0.001$.

Effect of sediment

This study investigated the amount and grain size of sediment at three shore levels: upper, middle and lower levels. The sediment varied from silt to very coarse sand. Total amount of sediment trapped varied between 121-2,340 g/m^2. The amount present differed with shore levels (Table 4; Figure 16) but there were no significant difference between dry seasons and rainy seasons. The results showed that a greater amount of sediment was found especially on the mid shore level and higher on this shore, while there was less sediment on the lower shore. The sediment fraction which usually was found in mid and lower intertidal zone was 250-500 µm (Medium sand), whilst the sediment in the lower zone was fine sand (the fraction was125-250 µ m). There was no relationship between amounts of sediment on algal abundance of *Ulva paradoxa* and *Cladophora prolifera*.

Table 4. Effects of different shore levels and two seasons on sediment.

Source of variation	**df**	**MS**	***F***	**P**
Between subjects				
Season	1	7.158E-03	0.311	0.587
Shore level	2	0.240	10.428	0.002
Season *Shore level	2	2.317E-02	1.007	0.394
Error	12	2.301E-02		

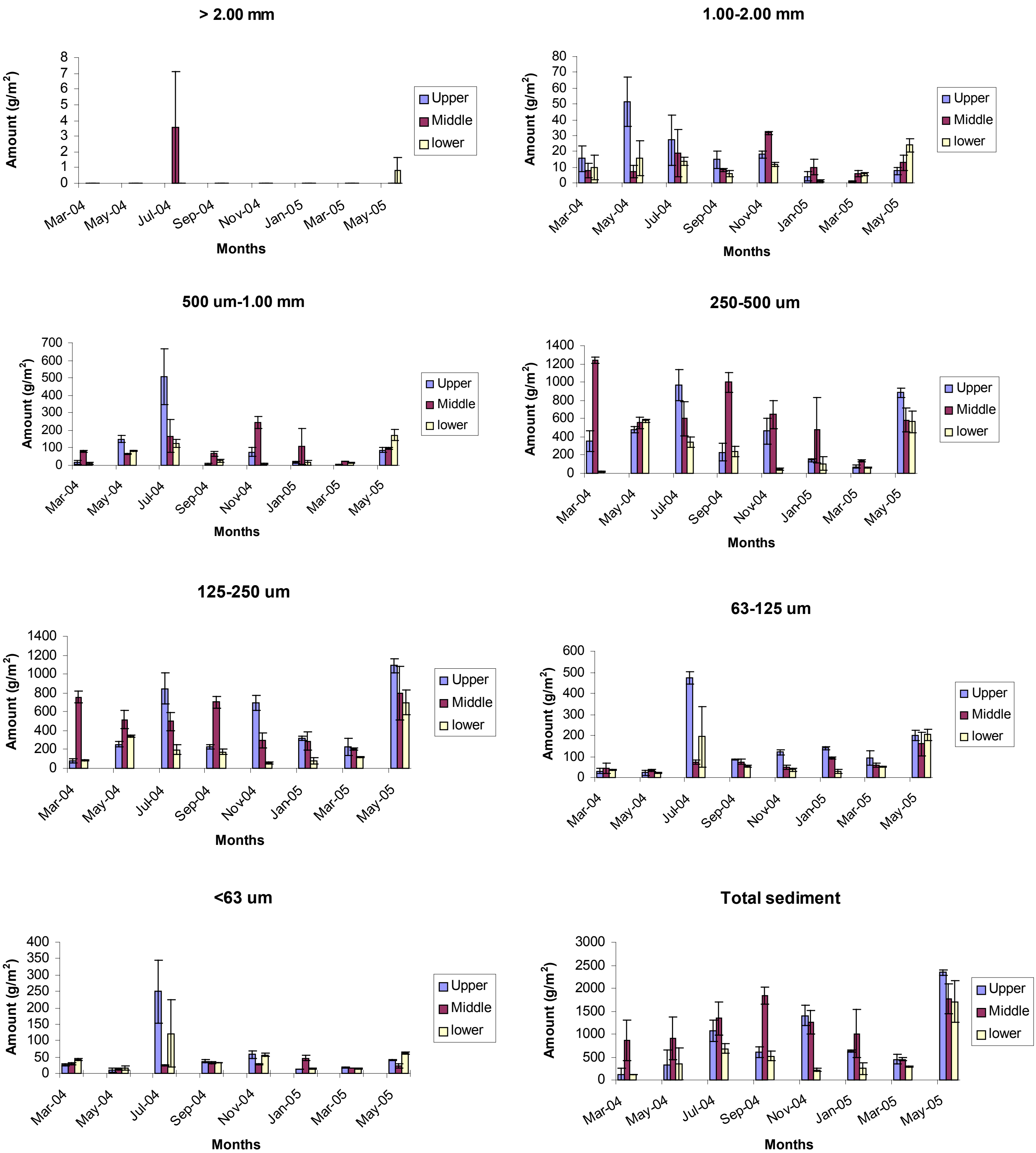

Figure 16. Total amount of sediment were trapped during the experiment.