RESULTS

Shallow Transects

Overall coral cover decreased slightly in both the control site and the impact site between the 1992 survey and this survey, and as a result the time x location interaction was not significant. This was due to a decrease in cover of the more fragile acroporid species. The cover of the more massive growth form poritid and faviid corals did not change significantly over this time (figure 3, table 3). The time x location interaction was significant for faviids: cover decreased slightly at the impact site, probably due to shading by over-growing acroporids, and increased at the control site.

Table 3. Analysis results for the 1992-1997 coral cover data. Separate analyses were made for each depth strata as they were looking at different potential impacts. See table 2 for analysis details. Note: NS = not significant; * = 0.1>p>0.01; ** = 0.01>p>0.001; *** = p<0.001.

	Shallow transects			Deep transects		
	Location	Time	TxL	Location	Time	TxL
Total hard corals	**	*	NS	*	NS	***
Pocilloporidae	NS	NS	NS	*	*	NS
Acroporidae	NS	*	NS	**	**	**
Poritidae	**	NS	NS	**	*	NS
Faviidae	NS	NS	*	*	NS	NS
Total soft corals	NS	NS	NS	NS	NS	NS
Coral height	NS	*	NS	*	NS	*
Colony damage	NS	***	NS	NS	***	*

Five of these transects had been part of the 1987-88 monitoring program and had been surveyed five times over the past 10 years (figure 3). Over this time period hard coral cover had remained relatively stable on the control transects, but had increased by a mean of about 30% on the impact transects, giving a significant time x location interaction in this case (table 4). This change was primarily due to a 40% increase in the cover of fast growing acroporid corals, as well as an increase in faviid corals up till 1992. Poritid coral cover remained stable on both the control and impact transects.

Table 4. Analysis results for the 1987-1997 coral cover data. Separate analyses were made for each depth strata as they were looking at different potential impacts. See table 2 for analysis details. Note: NS = not significant; * = 0.1>p>0.01; ** = 0.01>p>0.001; *** = p<0.001.

	Shallow transects			Deep transects		
	Location	Time	TxL	Location	Time	TxL
Total hard corals	*	NS	*	NS	NS	**
Pocilloporidae	NS	NS	*	**	NS	NS
Acroporidae	NS	NS	NS	*	*	**
Poritidae	NS	NS	NS	*	*	NS
Faviidae	**	*	NS	NS	NS	NS
Total soft corals	NS	NS	NS	NS	NS	NS
Coral height	NS	NS	NS	NS	***	***

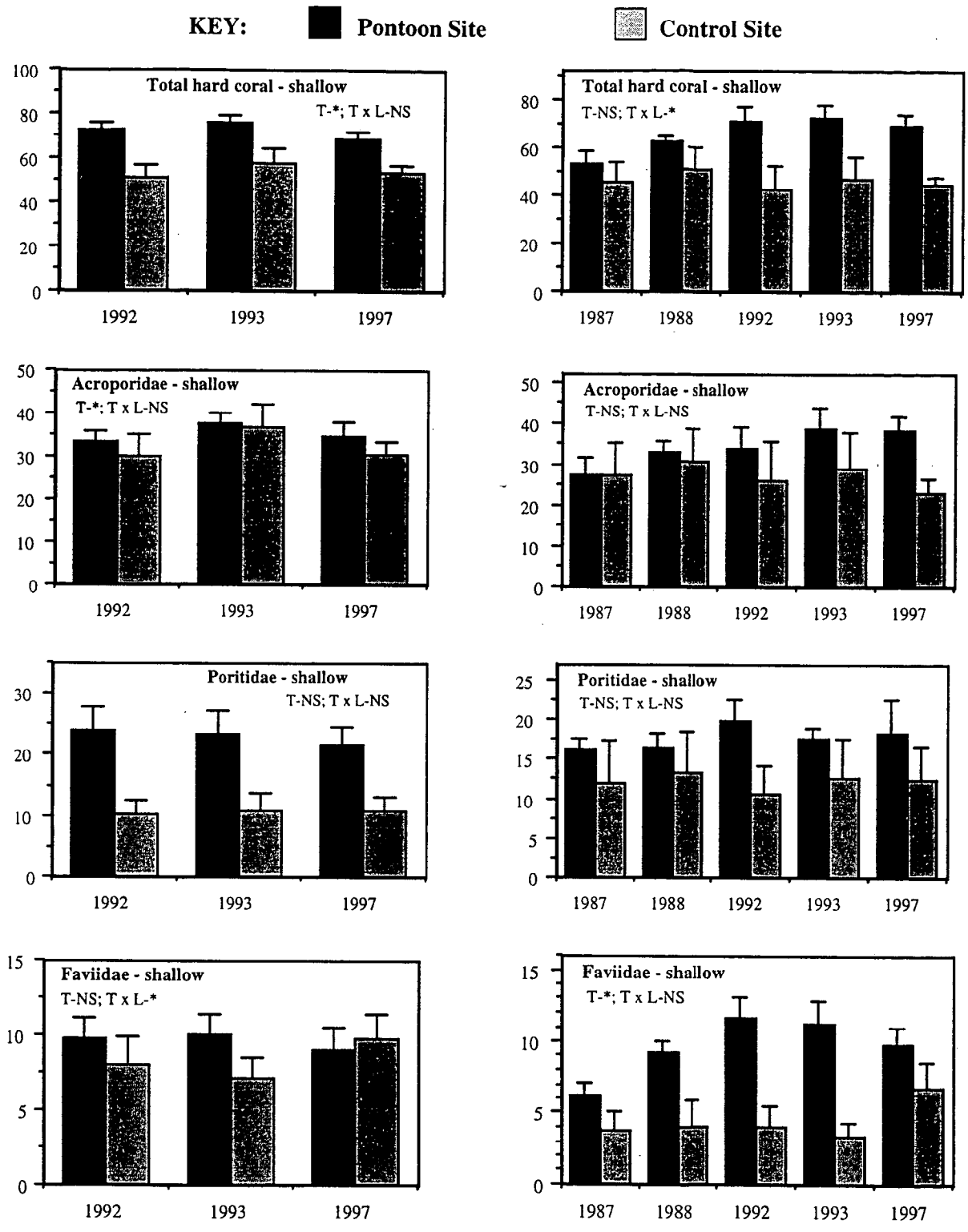

Figure 3. Cover changes of encrusting organisms in shallow monitoring sites. Left graphs show results from 10 transects per site over five years; right graphs from five transects per site for 10 years. Error bars are standard errors. Significance of tests for time and time x location are shown. NS = not significant; * = 0.05>p>0.01; ** = 0.01>p>0.001; *** = 0.001>p

Although mean colony height increased slightly at the pontoon site between 1993 and 1997, and decreased significantly on the shallow control site, the time x location interaction was not significant (figure 5). The percentage of coral colonies that showed evidence of recent damage was almost an order of magnitude greater in 1997 compared with levels recorded in the 1992-93 monitoring program (figure 6). There were nominally more damaged colonies in the control site than in the impact site during the 1997 survey but the time x location interaction was not significant (table 3).

Deep Transects

In the four years between the 1993 survey and this survey there had been a slight decrease in the total cover of hard corals on the deep impact transects (figure 4). Over the same period there had been an increase in coral cover on the controls, and as a result the time x location interaction was significant (table 3). Acroporid cover had increased significantly on the controls and remained stable on the impact transects, whereas poritid cover recorded a decrease on the impact transects and remained stable on the controls. There were no significant changes in faviid abundance.

The five long-term deep control transects showed a 50% increase in hard coral cover over the 10 years since they were first surveyed (figure 4). This compares with an overall 30% decrease in cover on the impact transects that were beneath the pontoon over the same period, and the time x location interaction was highly significant. The change on the controls was due to a five times increase in acroporid cover, there was a 15% decrease in poritid, and a 25% decrease in faviid cover. The coral decrease on the impact transects was primarily due to a drop in poritid cover.

There was a slight decrease in mean coral colony height between 1993 and 1997, both in the deep control and impact sites (figure 5). As in the shallow transects, there was an almost order of magnitude difference in the level of damaged coral colonies measured in 1997 compared with 1993. There were more damaged corals in the control site than in the impact site (figure 6) and the time x location interaction was significant.

Drag Scar Damage

The pontoon created a drag scar for a distance of approximately 240 m across the reef flat and an average of 13 m wide. Coral cover was greatest near the outer edge of the reef flat, where the pontoon first hit, with overall mean cover of around 40% in the undamaged community (figure 7). Acroporids made up over 80% of this cover, and half of this was staghorn growth form species. Although almost all the coral colonies in this section of the drag scar were badly damaged, living corals still covered over 20% of the scraped substratum and the surviving corals looked healthy at the time of this survey. Staghorn acroporids had been reduced to fragments but many were alive and starting to regrow.

Corals were less abundant in the second section of the scar (reef flat 1 in figure 7), where there was more sand lying on the substratum, and corals in the undisturbed control covered about 25% of the surface. Coral cover in this section was also dominated by acroporids which accounted for about 90% of the total cover. Damage along the drag scar was similar to that in the outer section, with all coral colonies broken up but about half of the coral cover still alive (figure 7).

The section of the drag scar furthest up on the reef flat (reef flat 2 in the figure 7) had damaged a benthic community that lived on a predominantly sand substratum. Coral cover in the undamaged control was less than 15%, about 75% of which was acroporids. Coral damage was proportionally greatest in this section of the scar, with 100% of coral colonies damaged, and coral cover reduced to less than a third of that in the controls (figure 7).

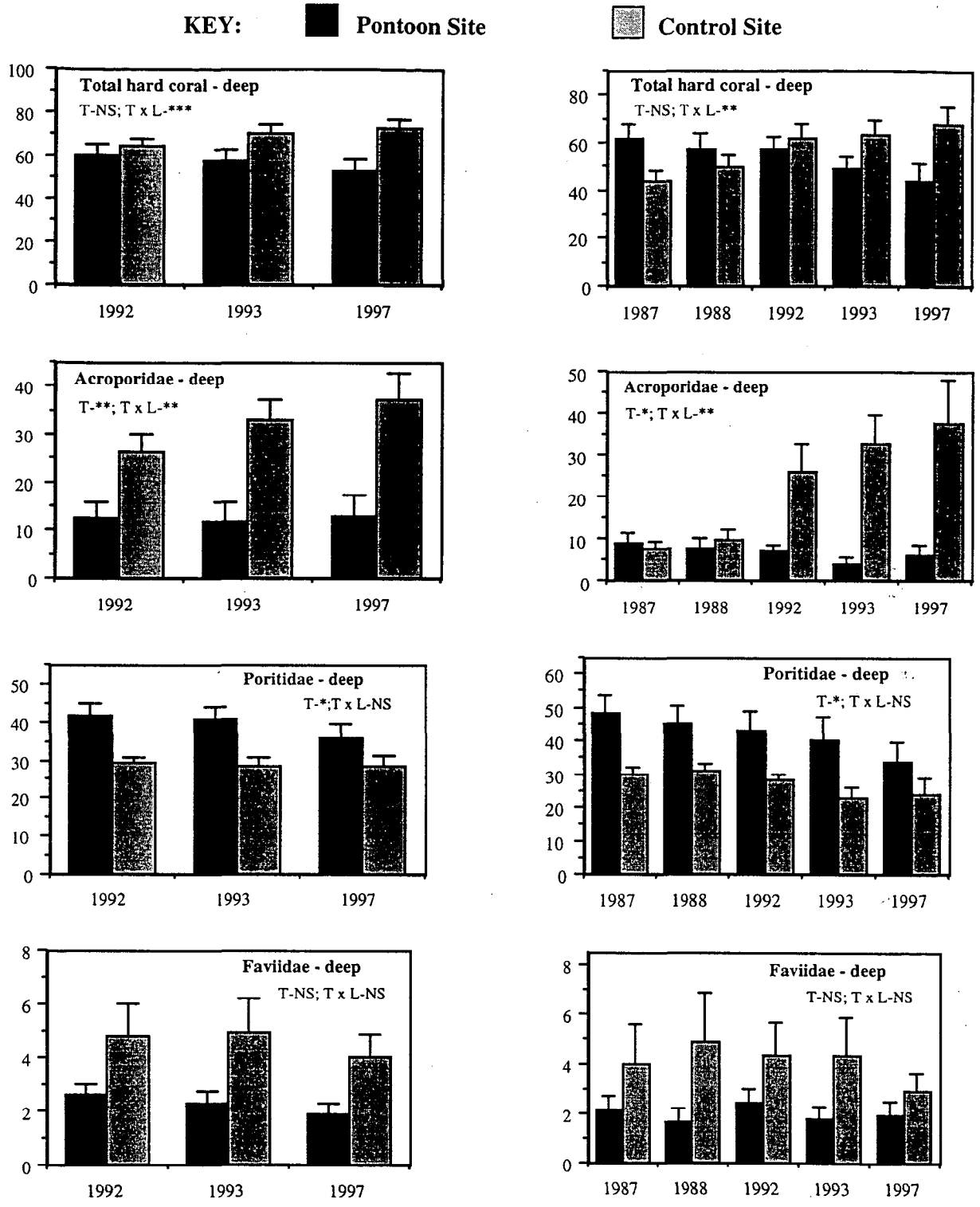

Figure 4. Cover changes of encrusting organisms in deep monitoring sites. Left graphs show results from 10 transects per site over five years; right graphs fromfive5 transects per site for 10 years. Error bars are standard errors. Significance of tests for time and time x location are shown. NS = not significant; * = 0.05>p>0.01; ** = 0.01>p>0.001; *** = 0.001>p

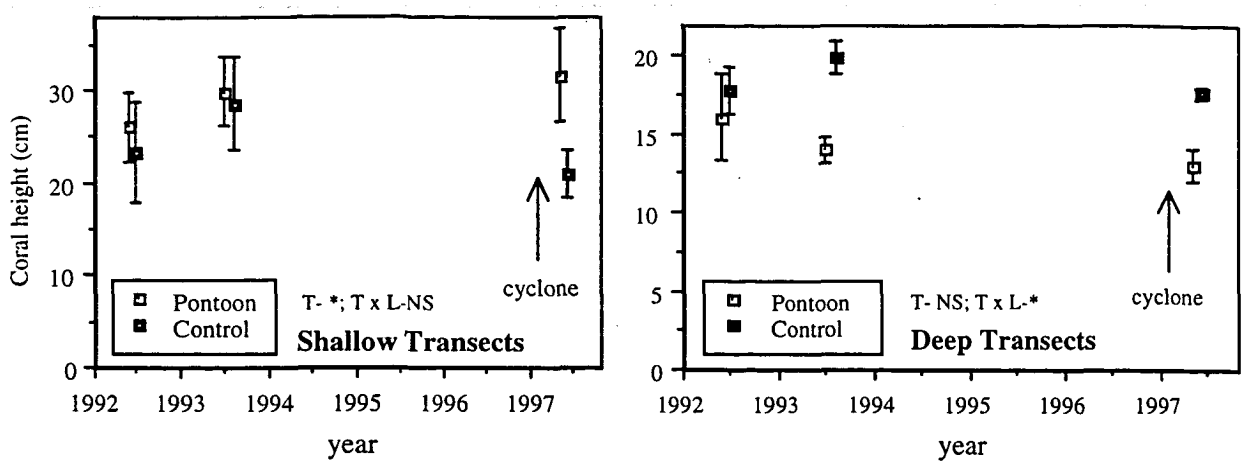

Figure 5. Patterns of coral height change at the pontoon and control locations. Graphs show mean coral colony height per location from twenty measurements along each of the ten 20 x 1 m transects at each location. The approximate time of the impact from cyclone Justin is indicated. Error bars are standard errors. Significance of tests for time and the time x location interaction are shown. NS = not significant; * = 0.05>p>0.01; ** = 0.01>p>0.001; *** = 0.001>p

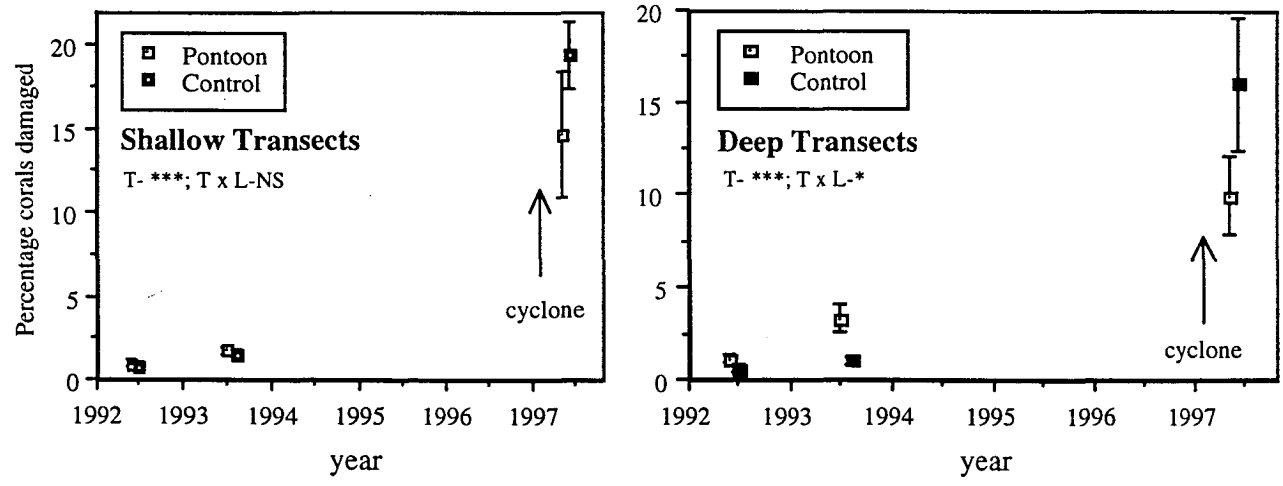

Figure 6. Patterns of coral damage at the pontoon and control locations. Graphs show mean percentage of coral colonies damaged in ten 20 x 1 m transects at each location. The approximate time of the impact from cyclone Justin is indicated. Error bars are standard errors. Significance of tests for time and the time x location interaction are shown. NS = not significant; * = 0.05>p>0.01; ** = 0.01>p>0.001; *** = 0.001>p

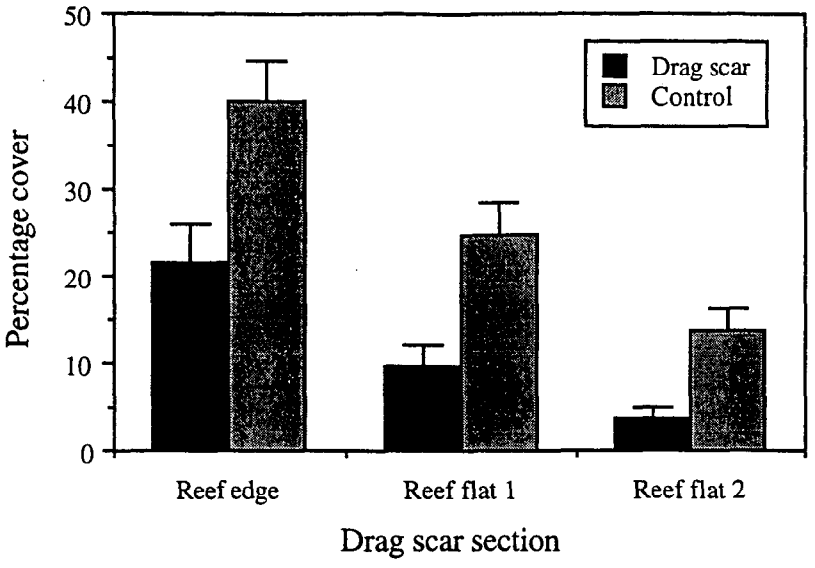

Figure 7. Comparison of coral cover in the drag scar and adjacent reef flat benthic community. Graph shows mean percentage cover of hard coral from six 20 m line intersect transects within three sections of the drag scar, and six transects in the nearby undisturbed community (control). Error bars are standard errors.

Millepora fire corals and *Heliopora* blue corals were relatively common near the reef edge in the undisturbed community, with about 8% cover, most of which was destroyed by the dragging pontoon. Only 0.4% cover of these two groups remained alive in the reef edge drag scar section. Soft corals were also most abundant near the reef flat edge where they covered about 13% of the undamaged substratum. This was reduced by about 75% in the drag scar. Sponges were relatively common in the sandy reef flat community where the pontoon came to rest (reef flat 2), covering about 6% of the substratum, or about half that of hard corals in this section. Sponge cover was reduced to about 1.4% in this section of the drag scar, a 75% reduction. A mean of around 20% of all three drag scar sections was covered with a fine brown algal turf growing on the newly damaged coral substratum. Scarid and acanthurid fishes were grazing intensively on this turf, which was not present in the undisturbed community.