RESULTS

Permanent Transects

There had been no significant differences in total coral cover among the three locations during any of the 1985–1988 surveys. However, at the time of the first new survey in 1994 there were significant differences among the locations (figure 2, separate analysis of 1994 data), although these differences were over-ridden by the significant site effect in the repeated measures analyses. Total coral cover had not changed in location 1, adjacent to the old road, but had increased significantly in both the other locations. This was primarily due to increases in the cover of *Acropora* spp. in location 3, and *Montipora* spp. in both locations 2 and 3. There were no changes in coral cover over the three surveys between 1994 and 1996, but a significant increase (mean of 6.5%) between 1996 and 1997 (figure 2, table 2). This was due mainly to a 32% increase in *Acropora* spp. cover in location 2 (figure 2), and gave a significant time effect for both total coral cover and *Acropora* spp. (table 2) and a significant time x location interaction for total hard coral. The other major groups of hard corals showed little change over the course of these studies (figure 2). There had been an increase in the cover of faviids in location 3 between 1988 and 1994 caused by an increase in the cover of explanate *Echinopora* species. This lead to a significant time effect and a significant time x location interaction in the eight-year analyses (table 3). Following this there was a slight but significant fall in faviid cover over the time of the new project (table 2). Significant location differences in the cover of pocilloporids (location 1 high, figure 2) were maintained through all surveys.

Table 2. Repeated measures analysis of variance of permanent transect data: 1994–1997
NS = not significant; * 0.05>p>0.01; ** = 0.01>p>0.001; *** = p<0.001

Family/Group	Location	Site (L)	Time	L * T	S * T
Total coral	NS	***	***	*	**
Pocilloporidae	NS	***	NS	NS	NS
Acropora spp.	NS	***	***	NS	NS
Montipora spp.	NS	***	NS	NS	NS
Poritidae	NS	***	NS	NS	NS
Faviidae	*	NS	*	NS	**
Turbinaria spp.	NS	***	NS	NS	NS
Deep water corals	NS	***	NS	NS	NS
Soft corals	NS	***	NS	NS	NS
Sargassum spp.	NS	NS	**	NS	NS
Algal turf	NS	***	***	***	***

Table 3. Repeated measures analysis of variance of permanent transect data: 1985–1997
NS = not significant; * 0.05>p>0.01; ** = 0.01>p>0.001; *** = p<0.001

Family/Group	Location	Site (L)	Time	L * T	S * T
Total Coral	NS	***	***	***	***
Pocilloporidae	*	**	***	NS	NS
Acropora spp.	NS	***	***	**	NS
Montipora spp.	NS	***	***	NS	**
Poritidae	NS	***	NS	NS	NS
Faviidae	NS	NS	*	**	NS
Turbinaria spp.	NS	***	NS	NS	NS
Deep Water Corals	NS	***	**	***	NS
Soft Corals	NS	***	NS	NS	NS
Sargassum spp.	NS	NS	*	**	NS

Cover of the large brown algae *Sargassum* spp. was relatively low in the depth stratum where the permanent transects were located (1–3% cover), and appeared to be somewhat variable from year to year (figure 2). Although there were no significant location or site differences (table 2, 3), overall cover was significantly higher in 1987, 1988 and 1997 compared with the other five surveys. There was no evidence that the cover of *Sargassum* had increased consistently over the time of these two projects. We recorded the cover of algal turf during this new project and although there were no location differences there was a significant increase in cover over the three years covered by these surveys (table 2). Grand mean cover apparently increased from 7.5% to over 18% during this time, although most of this increase was evident in location 1, giving a significant time x location interaction (figure 3).

Species composition of the benthic communities on these fringing reefs had been similar at most sites during the previous project (table 5, figure 4) with explanate and whorl forming *Montipora* spp. dominating with a grand mean cover of almost 25%. A number of species of corymbose plate and staghorn *Acropora* spp. were also important with a grand mean cover of 12.5%. These two groups between them accounted for 75–85% of all hard coral cover at most sites (figure 4). Other groups each accounted for less than 2% cover with the exception of the deep-water corals, a grouping of over 20 species that covered a mean of 7.4%. These community patterns were very similar in 1997, except that the cover of *Montipora* spp. (30%) and *Acropora* spp. (19%) had increased in all location 2 and 3 sites, as had the cover of deep-water corals (figure 4, table 5).

The only exception to this general pattern of species composition was site 5 in location 2 just north of the Emmagen Creek mouth. This site had lower total coral cover than at any of the other permanent sites (table 5). At this site *Montipora* and *Acropora* spp. each accounted for less than 2% cover while *Turbinaria* spp. were dominant with a combined cover of over 11% (figure 5). The deep-water corals were also important (>11%), as were soft corals with a cover twice that of any other site (30%). This site was particularly silty and it is possible that the different composition of the coral community reflects the proximity of Emmagen Creek.

Within the locations, site 1 was anomalous at location 1 in that the cover of hard coral decreased significantly over the 12 years covered by these two studies (table 5). Site 5 was very different in community composition from all other sites as has already been mentioned, but also had much lower overall coral cover than the other three sites in location 2 (table 5). As a result of these few anomalous sites there were significant site differences in most species groups (table 2, 3). Coral cover increases at some of the sites over the 12 years covered by these two projects have been quite spectacular, with site 8 in particular recording a 95% increase in hard coral cover.

Soft corals were not abundant at most sites with mean cover ranging from 5–10%. The dominant species was an encrusting soft coral at all sites except site 5 when the tufty low *Efflatenaria* sp. covered over 25% of the substratum; a far higher soft coral cover than at any of the other sites. These patterns remained consistent over the course of the study (table 5).

Run-off Sites

The run-off sites, surveyed using random transects in a patchy environment, show more variation in benthic community structure than the permanent transects (figure 6). There were consistent significant differences in hard coral cover among the sites (table 4), with very low coral cover at site 13, high coral cover at site 17 (over 60% in 1996), and similar, intermediate levels at the other three sites. There were also significant, but inverse, differences in *Sargassum* cover among these sites. Two sites were *Sargassum* dominated, two had moderate *Sargassum* cover, while the high coral cover site had very low *Sargassum* cover. Turf algae covered a significantly greater area at sites 13–15 than in the other two sites (figure 7).

Table 4. Analysis of variance results for run-off sites transect data . NS = not significant; * 0.05>p>0.01; ** = 0.01>p>0.001; *** = p<0.001

Family/Group	Site	Time	S x T
Total Coral	***	*	**
Pocilloporidae	*	NS	NS
Acropora spp.	***	NS	NS
Montipora spp.	***	NS	*
Poritidae	***	**	NS
Faviidae	***	NS	NS
Turbinaria spp.	***	***	***
Deep Water Corals	**	**	***
Soft Corals	*	*	NS
Sargassum spp.	***	***	***
Turf algae	**	**	NS

Table 5. Species composition of the coral community at each site at the beginning and end of these projects. Coral cover shown as mean percentage cover from five 20 metre permanent transects. Standard deviations and standard errors are shown in appendix 2.

Sample date	1985	1997	1985	1997	1985	1997	1985	1997	1985	1997
LOCATION 1	**Site 1**		**Site 2**		**Site 3**		**Site 4**		**Grand Mean**	
Total Hard Coral	40.4	29.6	53.4	60.1	62.6	63.2	56.0	59.4	**53.1**	**53.1**
Pocilloporidae	2.8	2.7	1.2	1.6	3.2	4.8	4.2	1.9	**2.9**	**2.8**
Acropora spp.	3.8	3.8	21.1	24.9	13.2	10.5	25.4	30.7	**15.9**	**17.5**
Montipora spp.	25.4	19.2	19.3	23.9	37.4	38.4	24.0	24.9	**26.5**	**26.6**
Poritidae	0.8	0.2	2.3	2.2	0.1	0.8	0.1	0.2	**0.8**	**0.9**
Faviidae	4.6	1.7	0.9	1.9	2.1	2.8	0.5	0.2	**2.0**	**1.6**
Turbinaria spp.	0.1	0.1	0.4	0.8	0.1	-	-	0.2	**0.1**	**0.3**
Deep Water Corals	2.0	0.9	6.7	5.5	7.7	8.6	1.6	1.4	**4.5**	**4.1**
Total Soft Corals	14.9	10.6	6.1	5.5	4.4	2.5	1.9	3.9	**6.8**	**5.6**
Total Sponges	-	0.2	-	-	0.1	-	0.4	-	**0.1**	**0.1**
LOCATION 2	**Site 5**		**Site 6**		**Site 7**		**Site 8**		**Grand Mean**	
Total Hard Coral	33.2	40.2	53.2	67.7	58.6	82.9	39.4	76.8	**46.1**	**66.9**
Pocilloporidae	2.0	1.6	0.4	1.0	1.8	1.2	2.5	1.5	**1.7**	**1.3**
Acropora spp.	2.0	5.3	9.5	15.7	19.3	29.8	11.2	24.8	**10.5**	**18.9**
Montipora spp.	1.5	4.5	19.2	23.3	30.8	46.1	21.8	45.8	**18.3**	**29.9**
Poritidae	1.3	2.8	2.3	1.5	0.1	0.4	0.3	0.6	**1.0**	**1.3**
Faviidae	1.9	3.1	3.7	3.1	1.3	0.5	0.2	0.4	**1.8**	**1.8**
Turbinaria spp.	11.3	9.1	-	0.9	4.0	1.1	0.2	0.1	**3.9**	**2.8**
Deep Water Corals	11.4	14.2	18.6	24.9	1.8	4.1	2.7	3.5	**8.6**	**11.7**
Total Soft Corals	29.8	24.9	3.5	0.8	3.1	1.9	0.1	2.9	**9.1**	**7.6**
Total Sponges	3.7	2.2	-	-	1.1	0.3	1.6	0.4	**1.6**	**0.7**
LOCATION 3	**Site 9**		**Site 10**		**Site 11**		**Site 12**		**Grand Mean**	
Total Hard Coral	54.2	64.6	51.9	76.3	47.3	65.7	59.1	77.3	**53.1**	**71.0**
Pocilloporidae	2.0	2.14	1.4	0.9	1.8	2.1	1.0	0.9	**1.5**	**1.5**
Acropora spp.	14.3	22.2	9.9	19.2	12.7	20.2	7.5	17.8	**11.1**	**19.8**
Montipora spp.	27.7	30.2	23.8	31.9	17.1	25.7	45.0	50.0	**28.4**	**34.5**
Poritidae	0.6	-	1.4	2.1	1.1	1.0	0.2	0.3	**0.8**	**0.9**
Faviidae	4.3	6.4	1.8	3.8	4.8	3.5	2.0	3.5	**3.2**	**4.3**
Turbinaria spp.	0.9	-	1.3	2.4	0.2	0.4	0.2	-	**0.7**	**0.7**
Deep Water Corals	8.2	9.0	12.7	19.2	10.6	14.0	4.6	8.2	**9.0**	**12.6**
Total Soft Corals	11.7	10.3	8.9	2.9	7.5	3.0	11.6	7.9	**9.9**	**6.0**
Total Sponges	-	0.5	-	-	0.2	0.3	0.1	-	**0.1**	**0.2**

There had been a slight but significant increase in total hard coral cover at these run-off sites over the last few surveys (table 4). This was driven mainly by an increase in the cover of *Turbinaria* spp. at site 17, although there had also been an increase in poritid coral cover over the last few surveys at several of the sites (figure 6). Soft coral cover was very low at these run-off sites (figure 6). As was the case in the permanent transect sites, the cover of *Sargassum* spp. appeared to fluctuate, with the years 1987, 1988 and 1996 being higher than average and 1985, 1994 and 1995 being lower than average (figure 6). Turf algae cover also fluctuated significantly, being higher in 1995 than in 1994 or 1996 (cover of turf algae was only recorded during these three surveys — figure 7).

Coral community composition at the run-off sites was different from that in the permanent transect sites, with higher representation of poritids, faviids and *Turbinaria* spp. and much lower cover of *Acropora* spp (figure 8). This composition changed between 1985 and 1996, mainly due to an increase in *Turbinaria* spp. cover and a corresponding decrease in *Montipora* cover at site 17 (figure 9).

Site 17, on the south side of Cowie Point was directly off the mouth of Melissa Creek and was completely inundated with sediment-laden water when observed from the air in February 1985. This site had a rich coral community with similar cover to the 12 main sites, but was unusual (as was site 5) in that there was a very high cover of *Turbinaria* spp. (over 35% in 1996) and massive *Porites* (6%). As in the case of site 5, it is possible that normal high silt levels at this site due to the proximity of Melissa Creek are responsible for the unusual species composition of the coral community.

There were no significant decreases in the cover of any species or species group at any of the direct run-off sites during the course of these projects (figure 6).

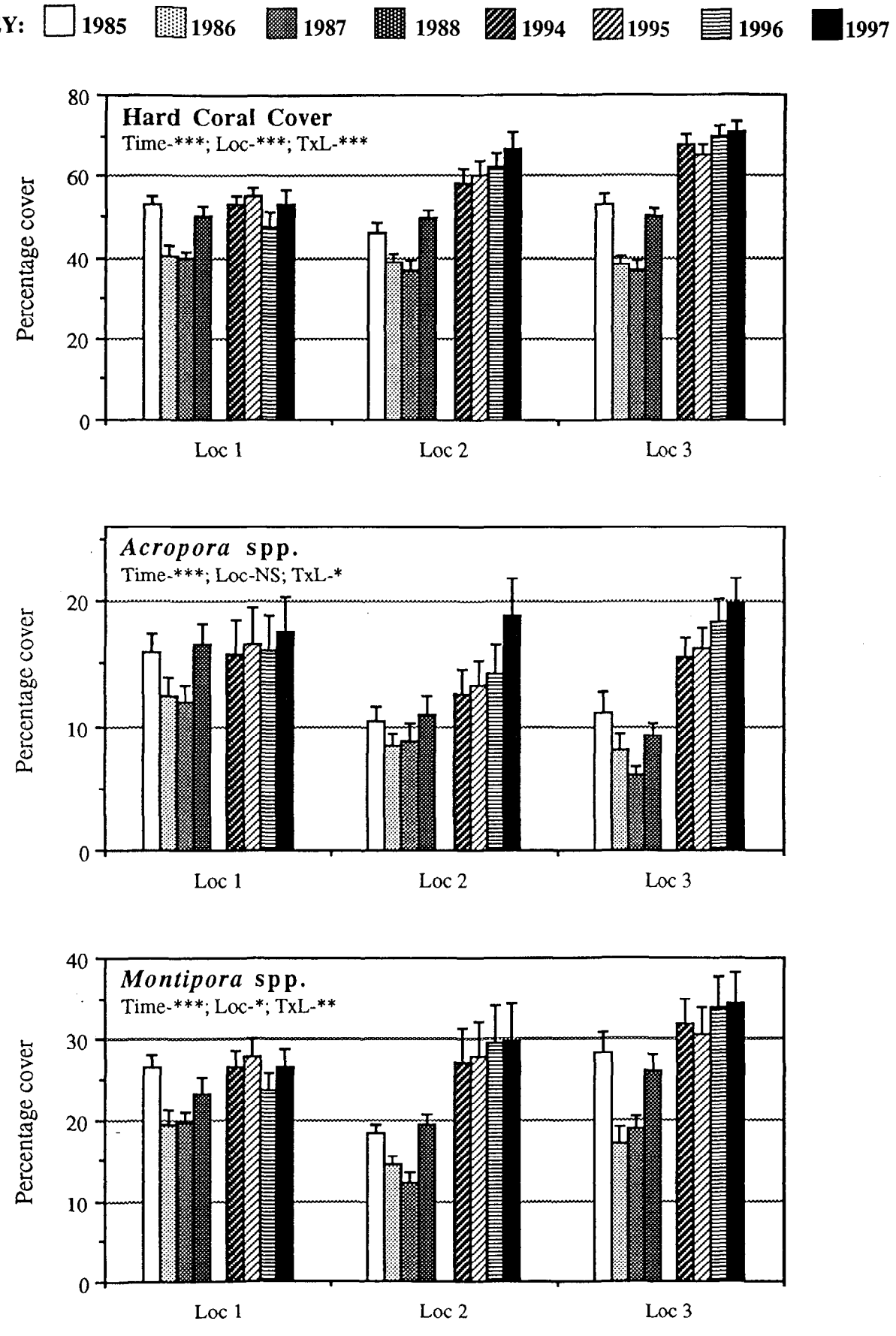


Figure 2. Benthic community changes at the major sites 1985–1997. Graphs show mean percentage cover on the vertical axis for all sites in each location. Error bars are standard errors. No surveys were made between 1989 and 1993. Significance of tests for time, location and the TxL interaction are shown.

Figure 2 cont.

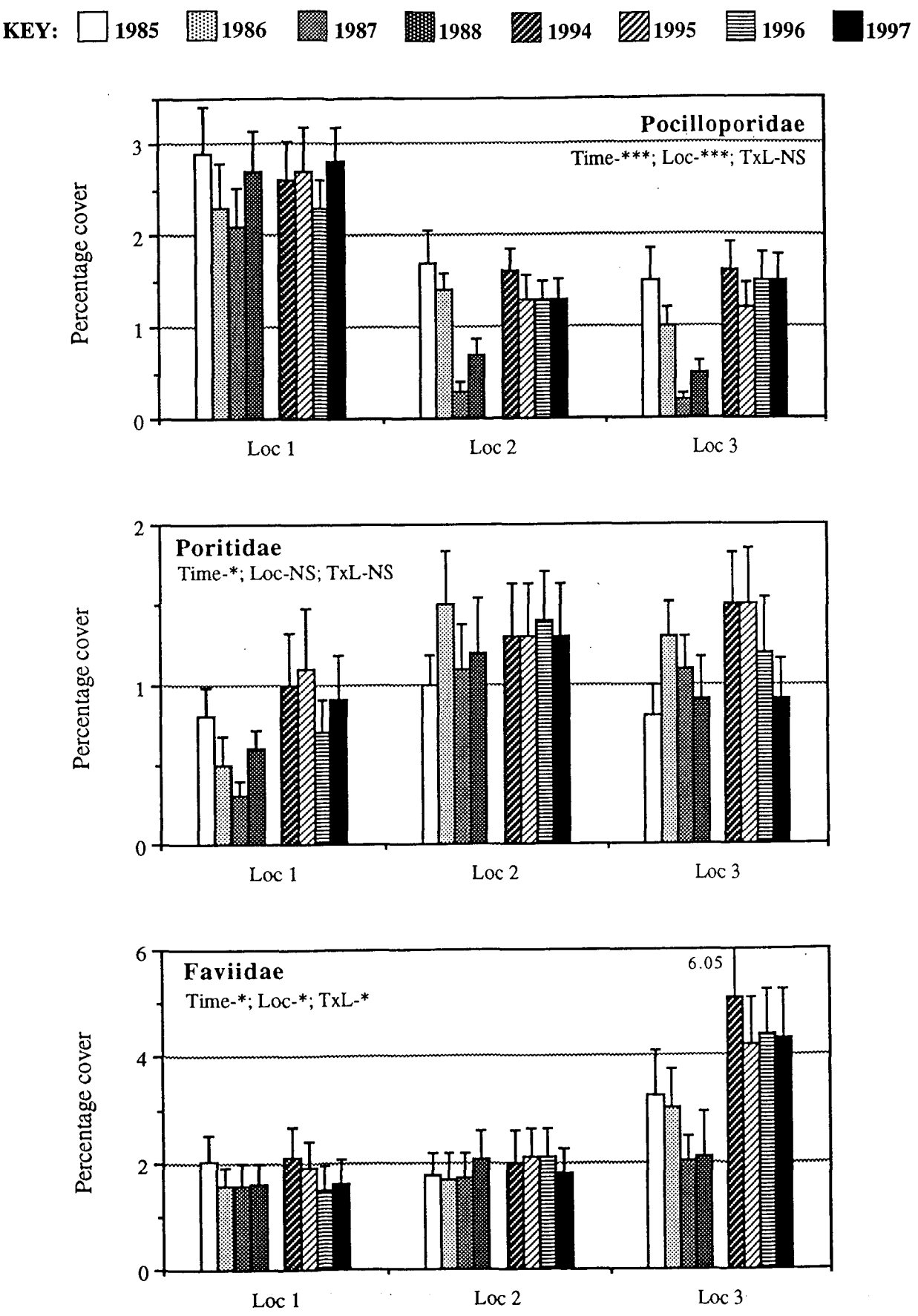
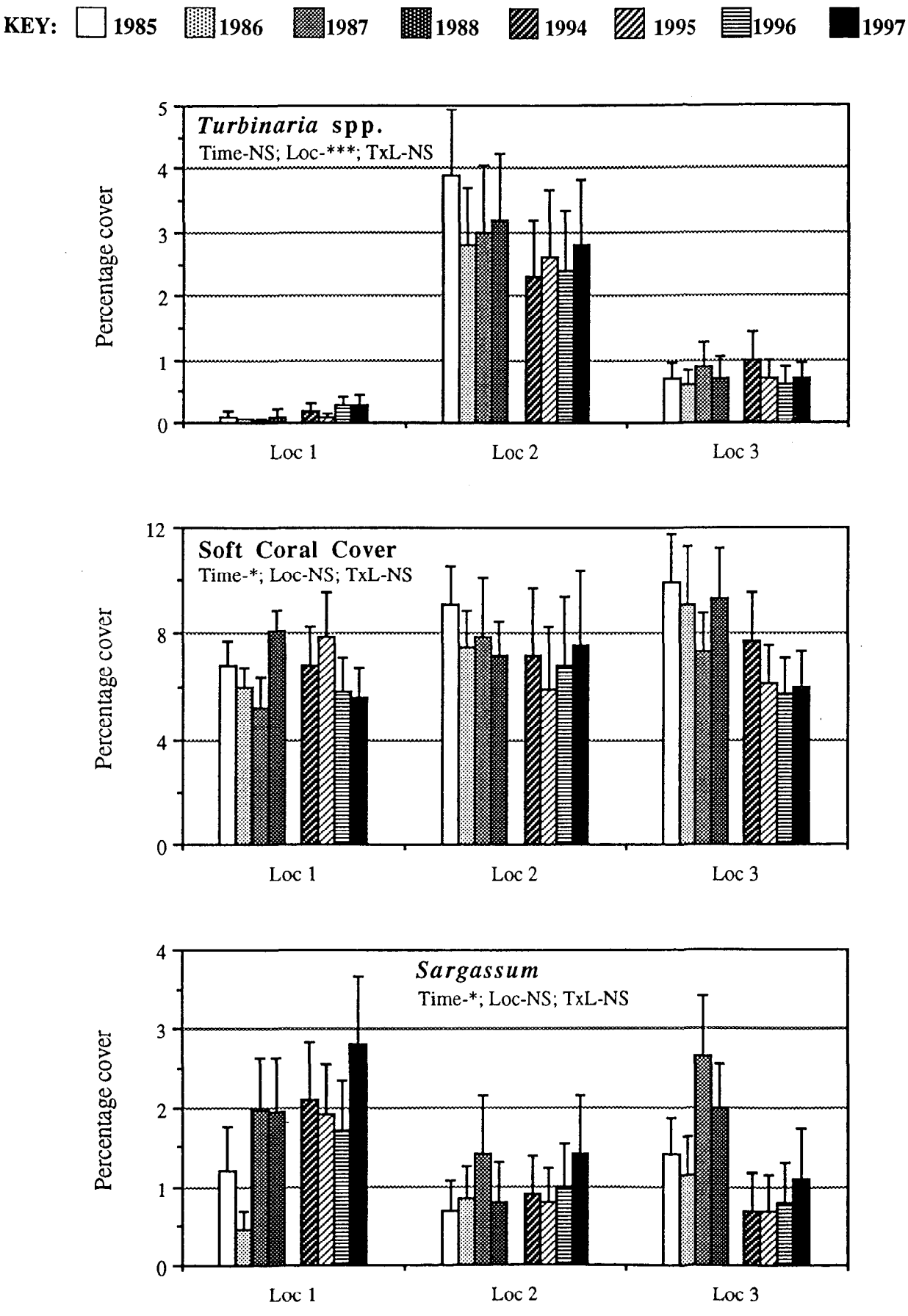


Figure 2 cont.



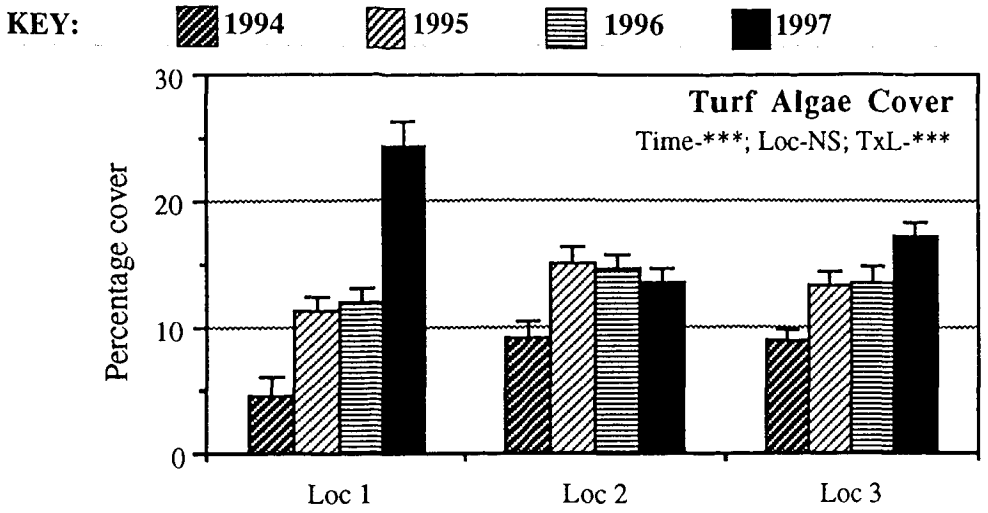


Figure 3. Changes in turf algae cover in the major sites. Mean percentage cover from the four sites of five permanent transects at each location is shown for the years 1994–1997.

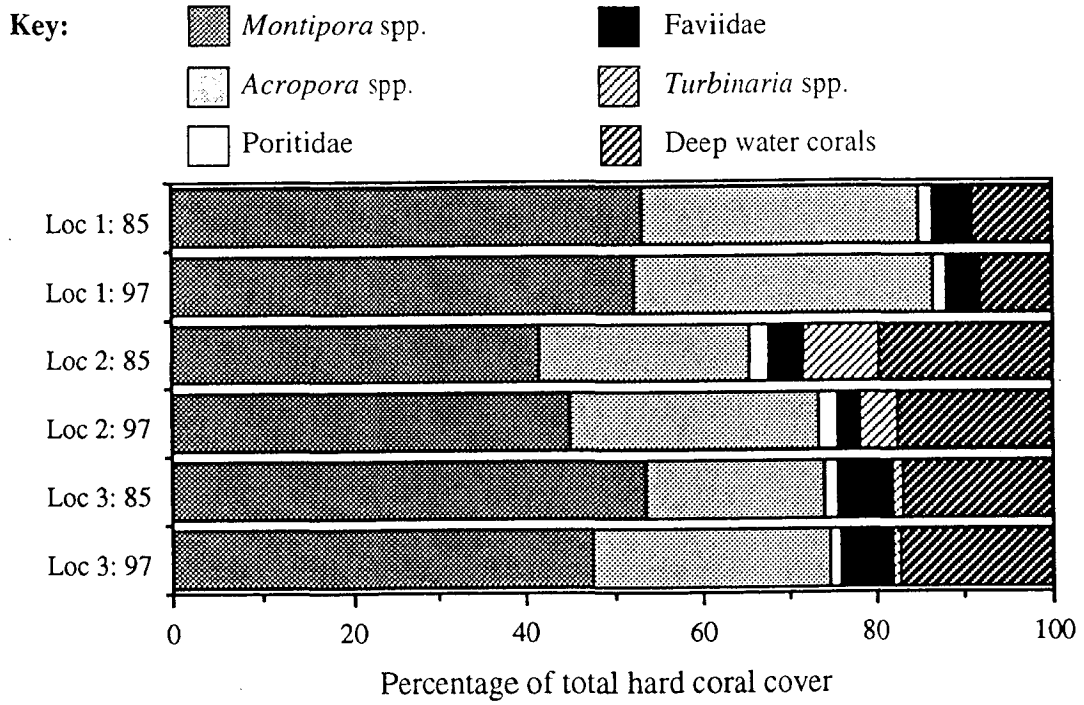


Figure 4. Coral community composition: 1985 and 1997. Percentage mean community representation of the major coral groups is shown from the four sites of permanent transects at each location at the start of the project in 1985 and during the last survey in 1997.

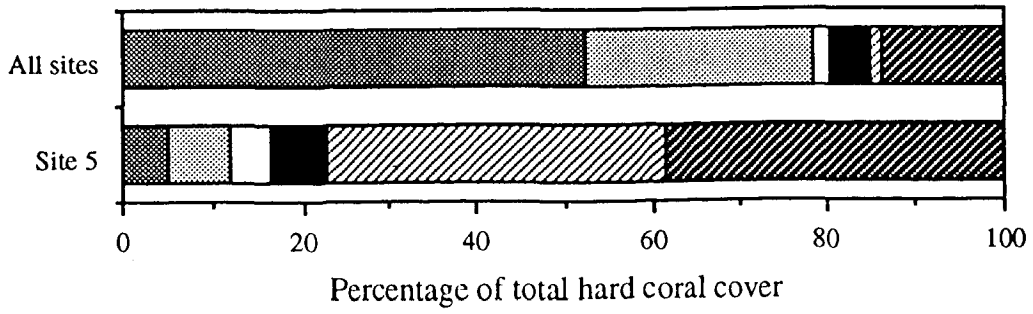


Figure 5. Comparison of coral community composition between site 5 and all other sites. Percentage mean community representation of the major coral groups is shown for site 5 along with the grand mean for all other sites from the 1985 survey. See figure 4 for key.

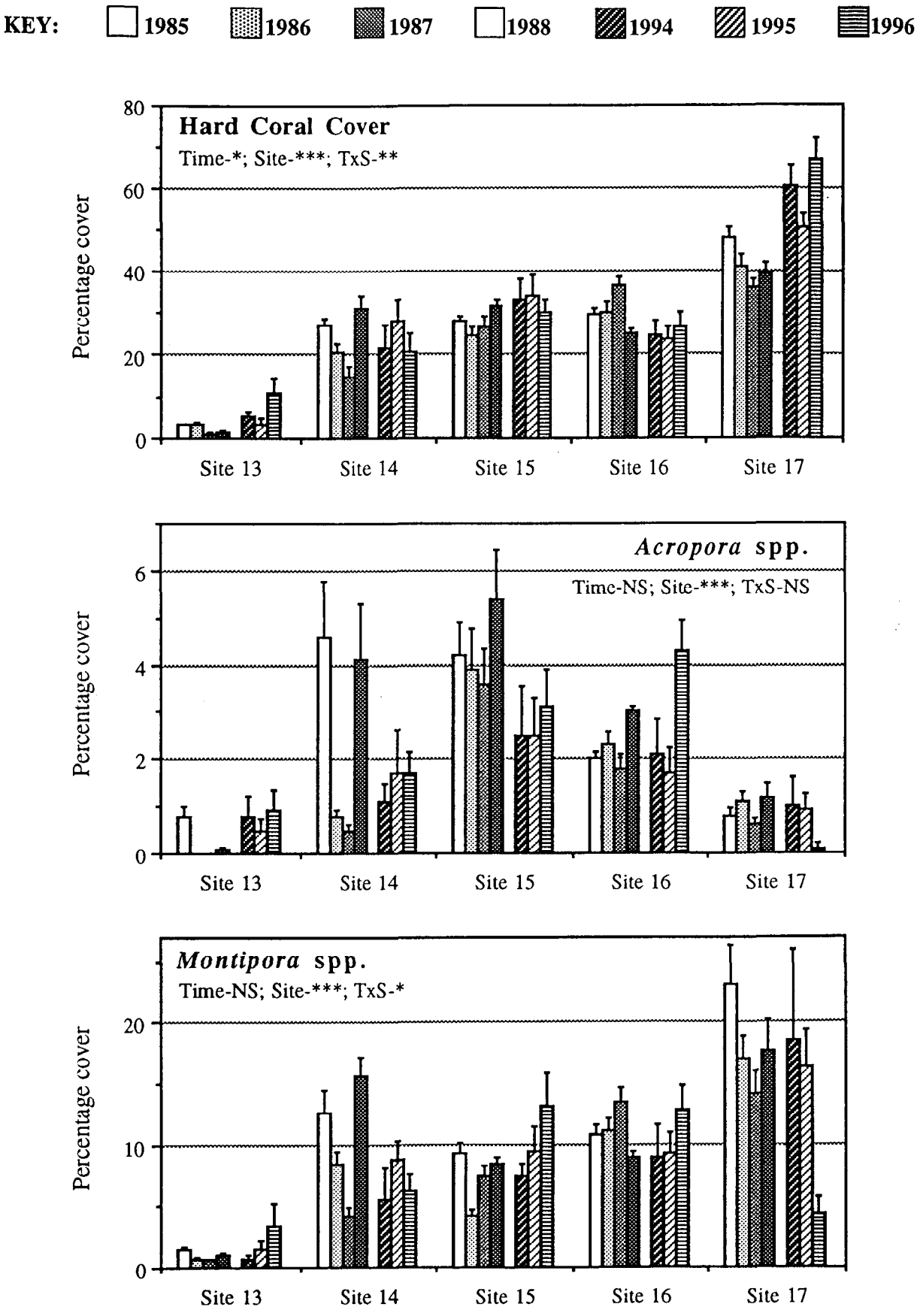


Figure 6. Benthic community changes at the run-off sites 1985–1996. Graphs show mean percentage cover on the vertical axis for all sites in each location. Error bars are standard errors. No surveys were made between 1989 and 1993. Significance of tests for time, site and the TxS interaction are shown.

Figure 6 cont.

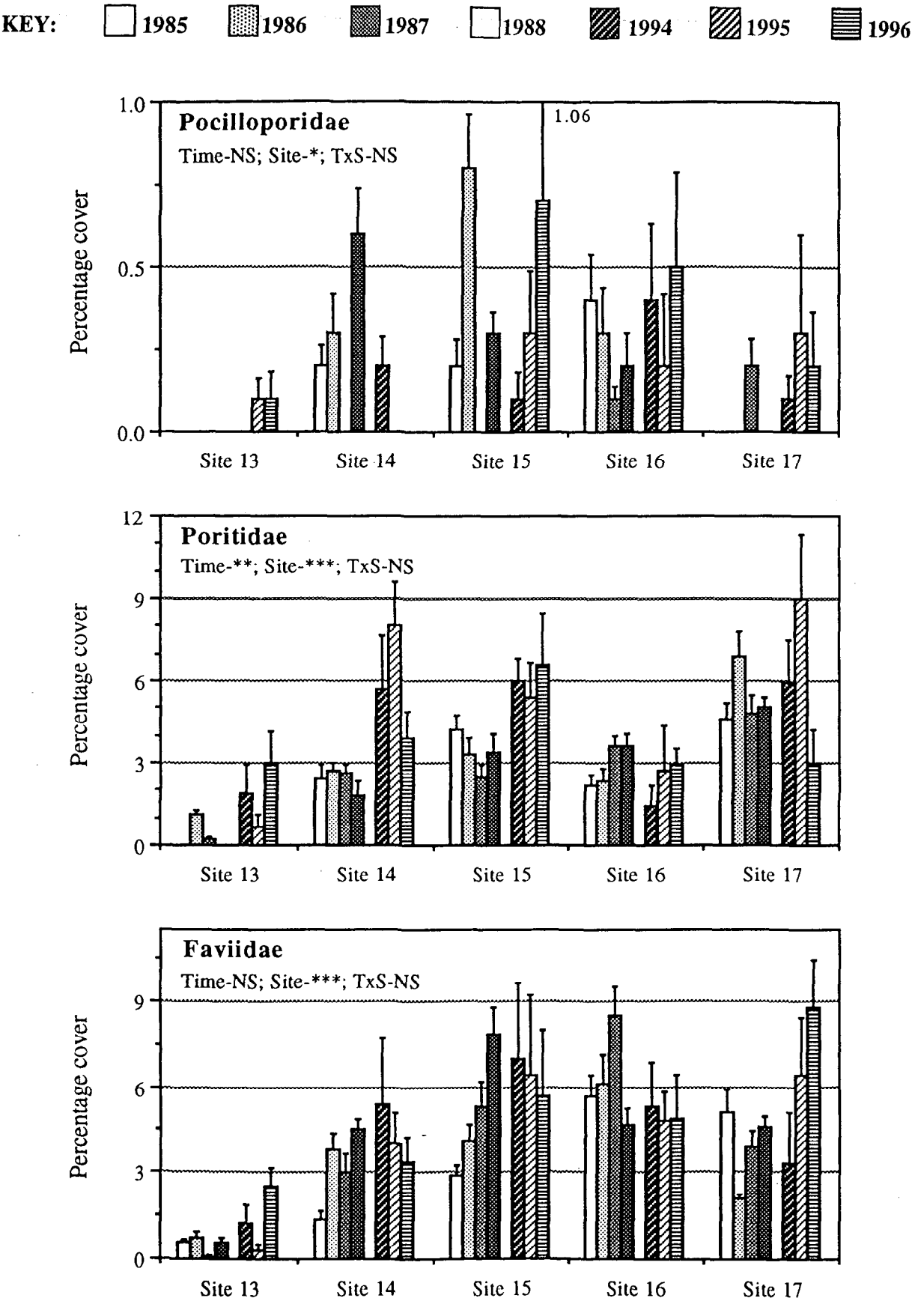
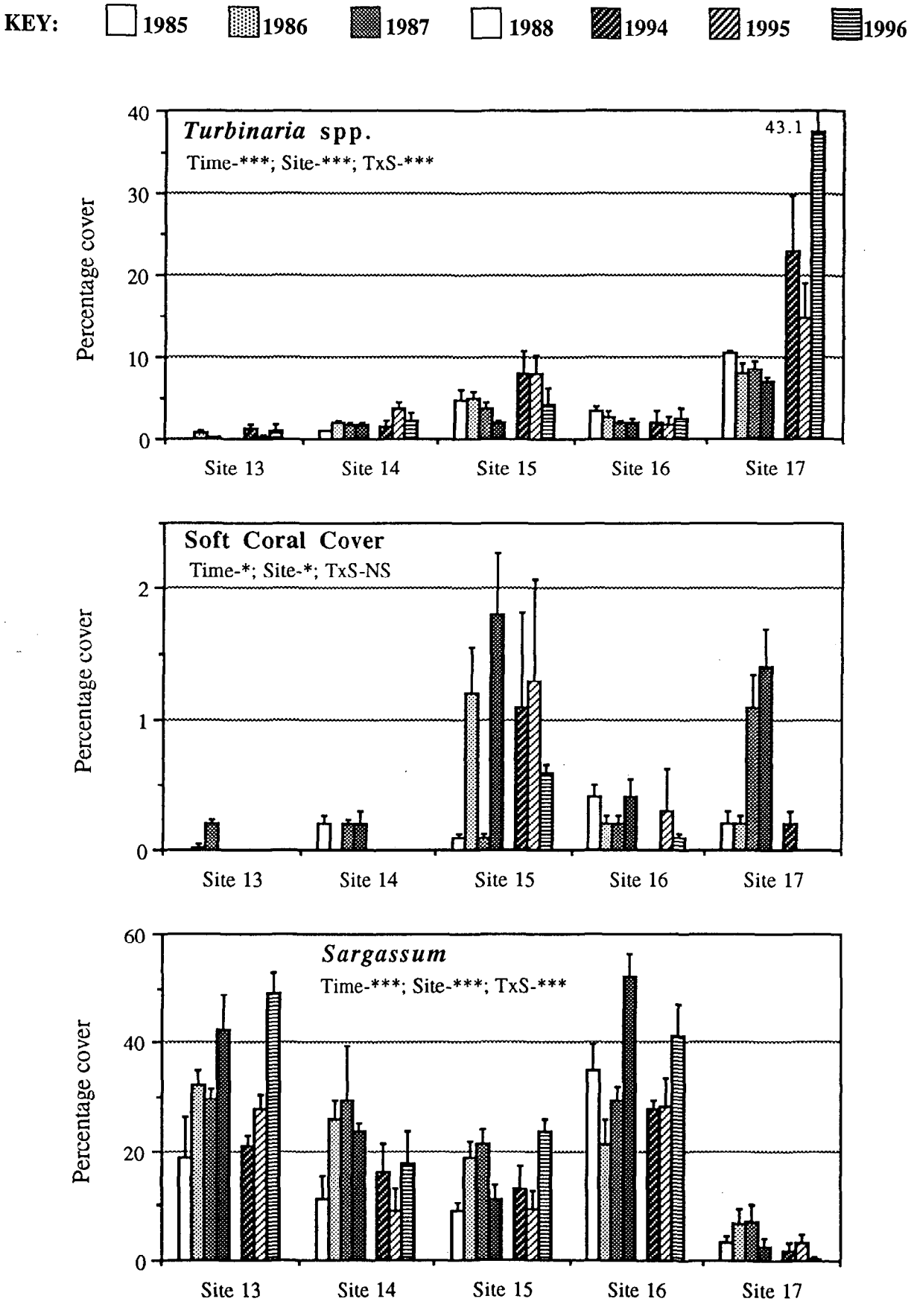


Figure 6 cont.



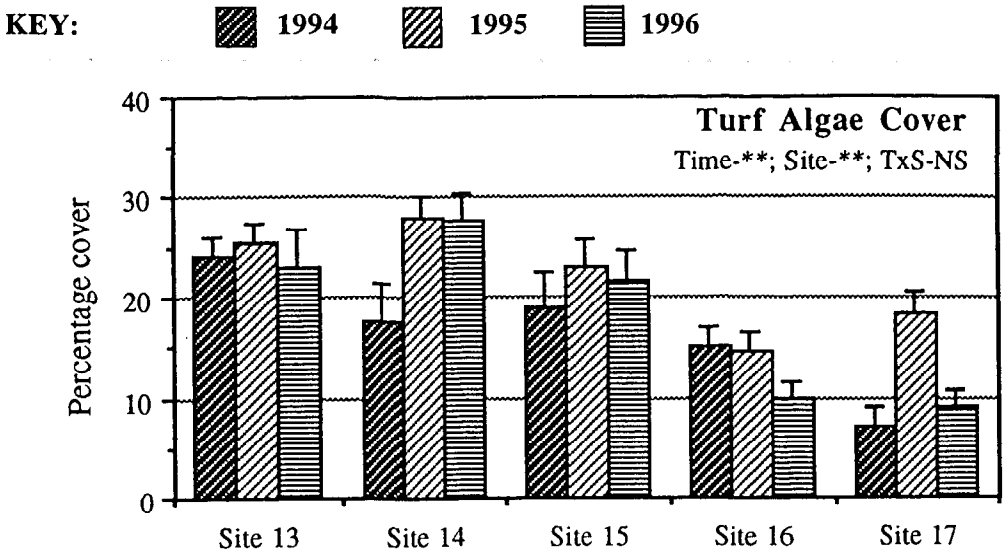


Figure 7. Changes in turf algae cover at the run-off sites. Mean percentage cover from the five sites of five random transects is shown for the years 1994–1996.

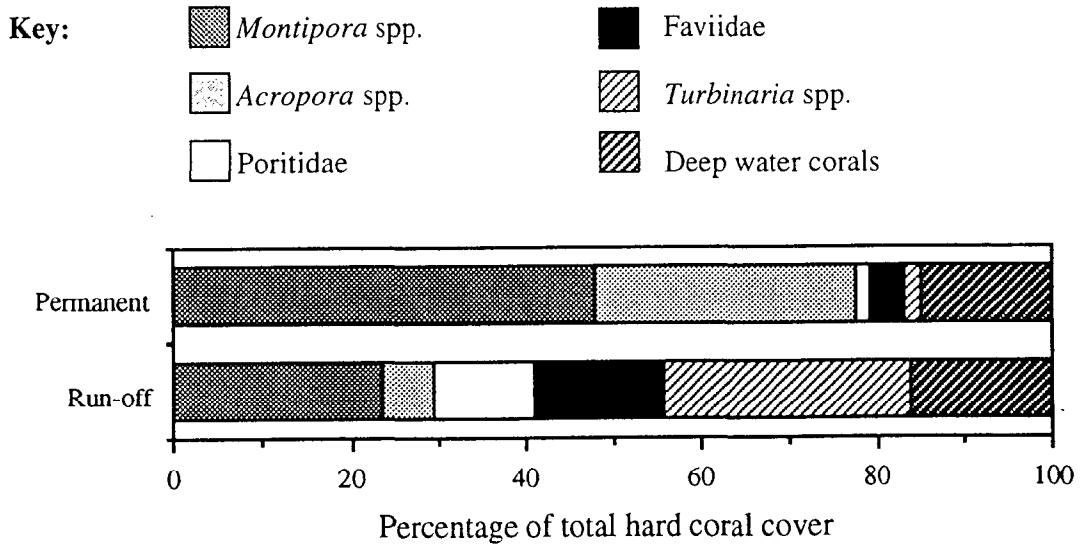


Figure 8. Comparison of coral community composition between the permanent transect sites and the run-off sites. Percentage mean community representation of the major coral groups is shown for all permanent transect sites and all run-off sites from the 1996 survey.

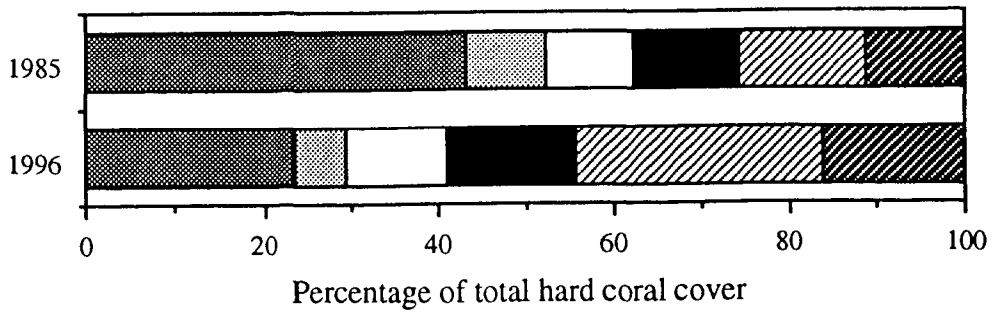


Figure 9. Comparison of coral community composition for the run-off sites: 1985 and 1996. Percentage mean community representation of the major coral groups is shown for all run-off sites from the 1985 and the 1996 survey. See figure 8 for key.