# Puerto Rico DRNA Coral Reef Monitoring Project Report 2002

## Task 1: Monitoring of Natural Reserve Baseline Sites

**Prepared by:**

**Michael Nemeth**
**Marine Resources Division**
**Department of Natural and Environmental Resources**
**San Juan, Puerto Rico**

**December 2002**

## Introduction

In August 2000, the Marine Resources Division of the Puerto Rico Department of Natural and Environmental Resources (DNER), under the auspices of the National Coral Reef Initiative, began a coral reef monitoring project in Puerto Rico and the offshore Islands. The objectives of this project are three-fold. First, to establish a baseline regarding the condition of coral reef communities at selected reef sites by sampling key biotic parameters. Second, to look for changes in coral reef community condition by monitoring these sites yearly on a long-term basis. Third, to attempt to assign causality to observed changes by determining the factors that may negatively affect coral reef community condition.

Coral reef community condition was evaluated using well-established ecological parameters that relate to the persistence and health of the community (Rogers, et al. 1994). These parameters include the relative abundance and diversity of sessile-benthic components such as corals, octocorals, algae and sponges. The intent is to determine if and where coral reef degradation is occurring. Coral reef degradation can be defined as a decrease in the relative abundance of scleractinian corals (coral cover) with an increase in one of the other benthic components, most commonly turf algae. Scleractinian corals are selected because they have been identified as being principally responsible in the building of reefs and hence are a keystone group in the community. Information on species richness and diversity also provides a way to determine coral reef condition since these parameters vary with the level of disturbance (Hernandez-Delgado 2000). Also, the reef fish and motile invertebrate components of the community were sampled to monitor their condition as part of the coral reef community. Information on these components is valuable in order to examine interspecific interactions that may influence the abundance of corals, such as the amount of herbivory from parrotfish. Knowing the abundances of commercially important fish and lobster is useful for stock assessment efforts used to manage commercial and recreational reef based fisheries.

This report provides preliminary result of the project to the end of 2002. The information is divided into the sessile benthic component (corals, algae, etc.) and the reef fish component. For the benthic component the data is presented in terms of percent cover of the different benthic categories and rugosity. These parameters are compared among the study sites and with the baseline data collected 1-2 years earlier. The reef fish data in presented in terms of density and species richness for fish.

## Methods

<u>Study Sites:</u>

The monitoring design for this project includes 3 reef sites at each of the locations with 5 replicate transects at each reef site. Monitoring was carried out at the reef sites established by the baseline characterizations conducted in 1999 and 2000 (Garcia-Sais et al. 2001a, 2001b). However, in Jobos, Fajardo, and Boqueron sampling was done at 2 of the reef sites because of difficulty in finding the third sites. Sampling for both the sessile-benthic component and fish/invertebrate component was done utilizing 10 m transects that have been marked permanently with steel stakes. The reef sites include fringing and bank reefs with depth ranging from 8 to 18 meters. Descriptions of the reef sites are included in the baseline characterizations (Garcia-Sais et al. 2001a, 2001b).

Table 1. Study site location.

| Location | Reef Site | Depth (m) | Type | Coordinates |
|---|---|---|---|---|
| Fajardo | | | | |
| | Palominos | 11 | Bank | 18°21.333' 65°34.267' |
| | Diablo | 11 | Bank | 18°21.602' 65°31.942' |
| Jobos | | | | |
| | Caribe | 10 | Fringing | 17°55.094' 66°12.595' |
| | Barca | 10 | Fringing | 17°54.635' 66°13.564' |
| Caja Muertos | | | | |
| | West | 8 | Fringing | 17°53.701' 66°31.703' |
| | Windward | 9 | Hardground | 17°53.341' 66°29.810' |
| | Berbería | 8 | Bank | 17°55.191' 66°21.190' |
| Guanica | | | | |
| | Coral | 8 | Bank | 17°56.173' 66°53.303' |
| | Ballena | 10 | Bank | 17°56.380' 66°51.633' |
| | Ventana | 17 | Shelf Edge | 17°56.500' 66°48.400' |
| Mayagüez | | | | |
| | Tourmaline | 11 | Bank | 18°09.794' 67°16.418' |
| | Coronas | 10 | Bank | 18°05.836' 67°17.225' |
| | Media Luna | 11 | Bank | 18°06.079' 67°18.731' |
| Desecheo | | | | |
| | North | 11 | Fringing | 18°23.416' 67°29.229' |
| | Botes | 17 | Fringing | 18°22.895' 67°29.316' |
| | Canoas | 18 | Fringing | 18°22.699' 67°29.026' |
| Boqueron | | | | |
| | El Palo | 3.0 | Fringing | 18°00.034' 67°12.670' |
| | Resuellos | 8.2 | Bank | 17°59.470' 67°13.987' |

Sessile-benthic Reef Community Monitoring:

The baseline characterizations and the monitoring activities were accomplished using the chain transect method. This is a continuous line-intercept method that uses a light chain to follow the contour of the reef and provides information on the relative abundance of the benthic categories.  At each of the reef stations, transects were established over the reef using a 10 meter long fiberglass tape measure tensioned between two stakes.  A short linked chain was loosely draped over the reef and the linear distance (number of chain links) of the different benthic categories occurring beneath the chain was recorded.  Chain links were 1.42 cm long.  Steel nails were hammered into available hard substrate approximately 0.5-1.0 meters apart to provide fixed reference points along the linear transect.

Individual measurements of benthic categories, as recorded from the number of chain links were sorted, added and divided by the total distance (in chain links) on each transect to calculate cumulative percentages of cover by each category.  The vertical relief of the reef, or rugosity, was calculated by subtracting 10 meters from the total length (links) recorded with the chain at the 10-meter marker of the reference tape.

Underwater videos of each transect were taken using a digital video at Guanica, Mayaguez and Boqueron.  Videos were taken using a Cannon GL1 camera in a Quest Sports housing.  The filming was done by moving the camera in a vertical position 50 cm from the bottom next to a line tensioned between the two transect stakes.  Both sides of the transect line were recorded.  The videos were taken to provide a permanent record of the transects and to evaluate the point-count video method against the chain-transect method.  The results from this analysis are not yet available therefore the video data is not presented here.

Reef Fish and Motile Invertebrate Monitoring:

Reef fish and motile invertebrates (lobsters, crabs, echinoids, molluscs) were surveyed using the belt-transect technique. Transects are the same as those used for the reef benthic community surveys and measure 10 meters long by 3 meters wide (surface area = 30 m2). To minimize the effect of human disturbance on these organisms, invertebrate and fish monitoring was performed prior to the sessile-benthic reef community monitoring.  A diver swam slowly over the transect for 10 minutes first locating the more motile species that are likely to leave the area and then carefully looking among the reef structure for small and more cryptic species. Identification and enumeration was done for fishes and motile invertebrates present within 1.5 meters along each side of the linear transects.  A total of five (5) belt-transects were surveyed at each reef station (total area = 150 $m^2$).  Abundance data on fishes is reported as number of individuals for each species per 30 $m^2$ (belt-transect area) and as the total number of species. The results from the sampling of mobile macro-invertebrates are not provided in this reports as the data need to be entered into the database and analyzed.

## Results

Table 1 depicts the study sites sampled to date.  A total of 18 reef sites have been sampled for the benthic, reef fish and motile invertebrates.  The most abundant benthic component at most of the reef sites was turf algae, ranging from a high of 83.6% to a low of 12.9% (Table 1).  Mean coral cover ranged from a high of 59.7% to a low of 2.0% and mean rugosity from a high of 7.5 to a low of 2.8.  The reef sites with the highest abundance of live coral include Tourmaline, Botes, Canoas, and Diablo.  The sites with the lowest amount of live coral are El Palo, Berberia, Barca , and Caribe.  Medialuna and Windward also have low cover but these are colonized hardbottom habitats and should not be included with the other true biogenic coral reefs.  The mean values for the other benthic components are presented in Table 2 and Figures 1-7.

The comparisons between the data from the baseline characterizations and the first monitoring event are provided in Figures 8-25. These figures show a comparison of the mean cover for the sessile benthic categories of coral, gorgonians, turf algae, other algae combined, and sponges. The different algal categories except turf are combined to allow a better comparison between the two sampling events. The mean in coral cover increased at some sites over the sampling periods and it decreased in others. Further statistical tests must be done to determine the significance of these differences. An analysis of the data on coral diversity and species richness will also help in determining whether change has occurred at some of the sites.

The mean density (individuals/30m$^2$) of reef fish ranged from a high of 93.2 at Botes reef to a low of 12.6 at the Windward hardground (Figure 27). There is high variability among transects within a site in these data. Some of this variability is due to the presence of schools of fish in some of the transects. The density of reef fish seems to be positively correlated to both rugosity and coral cover, but a stronger relationship was found with the latter (Figures 28, 29).

The mean species richness of reef fish at each of the study sites ranged from a high of 16.8 to a low of 7.0 (Figure 26). These values are probably underestimates because there are some species of reef fish that are not sampled for using the methods in this study. This includes the many cryptic species.

**Discussion**

In general the sites farthest from shore (Desecheo, Tourmaline, Diablo) have the highest coral cover and may be considered to be the healthiest of the reefs. The reef sites with the lowest coral cover were generally those closest to sources that degrade water quality such as river discharges or developed coastlines. More work is needed to determine how this information can be used to classify the condition or health of the reefs in this report.

The comparison of the baseline data to the monitoring data from 2001 or 2002 reveals some apparent trends. At Caribe Reef in Jobos there was a decrease in coral cover and an increase in the cover of both turf algae and macro algae. Further analysis and sampling should be accomplished to determine if this trend is real and if it increases in magnitude over time. At some sites such as Berberia there are changes in the cover of turf and other algae, but these may be due to differences in the way algae was classified between baseline and monitoring events. Some effort needs to be made to determine if these changes are real or if the method needs to be standardized.

The relationship between rugosity and coral cover may provide information regarding changes in reef condition. A general trend is apparent of increasing rugosity with increasing coral cover. This is reasonable relationship since high coral cover means high coral growth and corals are responsible for building most of the reef structure. This is represented in Figure 30, where rugosity and percent live coral cover are shown in the same graph for all of the study sites. Some sites, such as El Palo in Boqueron, have high rugosity but low coral cover. There is a possibility that the deviation from the overall rugosity-coral cover trend signals degradation has taken place. A reef with high coral cover and high rugosity could loose coral cover faster that erosion processes can destroy the reef structure and lower rugosity. Other factors likely influence the relationship between coral cover and rugosity. But this analysis serves in flagging El Palo as a site to search for more evidence that degradation has taken place.

There is a need to further evaluate how the information from this monitoring project can be utilized to make management decisions for the conservation of Puerto Rico's coral reefs. The monitoring information serves to document changes in the condition of the reefs. If reef condition worsens, it remains to be seen whether the current monitoring design and site location will yield conclusions regarding the source of the stressors. It is possible that including more spatial replicates in certain zones will help in identifying these sources. It is evident that the current limited coverage of near-shore reefs results in leaving out much information about reefs that have already have experienced degradation. However, before adding more sampling effort to the project, the capacity of the existing personnel resources must be evaluated. It may be favorable to increase sampling in certain areas if the sampling frequency is reduced overall.

The reef fish abundance data from this project as well as from the baseline characterizations exhibits high variability. In order to reduce this variability it may be necessary to increase the number of replicates currently in the monitoring design. The spatial layout of the sampling transects could be improved by allowing grater spacing between transects. Currently, the 5 transects at a reef site are all within 2-3 meters from the adjacent transect. This design could lead to high variability since all of the sampling effort is done on one small part of the reef and some reef fish species are highly mobile. This shortcoming may be improved by increasing the number of samples and locating them randomly throughout the reef. Also, more information could be collected if the protocol included recording the length of fishery important species as is done in other monitoring programs. Since fishing has been shown to reduce the mean size of target species, length data can be combined with abundance data and used to determine the effectiveness of management measures. The reef fish component has the potential to provide valuable information considering the current emphasis on new fishing regulations and the creation of marine reserves. However, the project will require additional personnel to accomplish additional sampling. A similar situation may be occurring with the motile invertebrate sampling (for lobster and urchins).

The information provided by the reef fish and motile invertebrate component should be useful for supporting management measures. It serves as fishery-independent information on abundance that may be used for complementing stock assessments for fisheries management. Also, this component may aid in determining the effectiveness of current and planned Marine Reserves (No-Take Zones) as is being done in Culebra and throughout the world. For these reasons the reef fish and motile invertebrate component should be further developed. It may be necessary to separate this component logistically from the benthic component if the needs of the location of the sampling sites are not complementary.

Overall, there is a need to evaluate and focus the objectives of the monitoring project in order to evaluate the spatial layout of the current sampling effort. Such an evaluation must incorporate what is presently known about stressors to coral reef. The Coral Reef Task Force has determined that a stress-based approach should be used in developing conservation objectives. The information provided in this report

## Literature Cited

Garcia Sais, J.; R. L. Castro and J. Sabater Clavel. 2001a. Coral Reef Communities from Natural Reserves in Puerto Rico: A qualitative baseline assessment for prospective monitoring programs. Volume I. Report submitted to Department of Natural and Environmental Resources, Puerto Rico.

Garcia Sais, J.; R. L. Castro, J. Sabater Clavel, and M. Carlo. 2001b. Coral Reef Communities from Natural Reserves in Puerto Rico: A qualitative baseline assessment for prospective monitoring programs. Volume II. Report submitted to Department of Natural and Environmental Resources, Puerto Rico.

Hernández-Delgado E. and A. Sabat. 2000. Ecological status of essential fish habitat through an anthropogenic environmental stress gradient in Puerto Rican coral reefs. Proc. Gulf Caribb. Fish. Inst. 51:457-470.

Rogers, C.S., G. Garrison, R. Grober, Z.M. Hillis, and M.A. Framke. 1994. Coral reef monitoring manual for the caribbean and western atlantic. U.S. National Park Service, Virgin Islands National Park.

| Reef Sites → Benthic Categories | Caribe | Barca | Coral | Ballena | Ventana | Tourmaline | Coronas | Media Luna | West | Windward | Berberia | Norte | Botes | Canoas | Palominos | Diablo | El Palo | Resuellos |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CORAL** | 14.9 | 18.7 | 19.4 | 29.2 | 23.4 | 59.7 | 30.4 | 8.8 | 24.9 | 2.0 | 17.6 | 23.1 | 45.3 | 52.5 | 26.0 | 36.8 | 12.8 | 21.5 |
| **GORGONIAN** | 3.2 | 2.3 | 4.0 | 13.4 | 6.1 | 2.5 | 8.7 | 4.0 | 2.1 | 0.1 | 6.3 | 0.1 | 0.0 | 0.0 | 2.7 | 3.7 | 10.5 | 31.8 |
| **TURF ALGAE** | 54.9 | 34.9 | 55.1 | 42.5 | 50.3 | 22.6 | 40.2 | 78.0 | 59.7 | 83.6 | 31.5 | 29.8 | 29.1 | 12.9 | 57.7 | 41.1 | 52.2 | 33.6 |
| **FLESHY ALGAE** | 6.7 | 25.3 | 0.0 | 0.0 | 1.0 | 0.0 | 0.8 | 0.1 | 0.2 | 3.4 | 17.1 | 37.3 | 15.0 | 24.6 | 4.8 | 1.5 | 0.6 | 0.0 |
| **ENCR. ALGAE** | 1.0 | 1.5 | 0.9 | 2.1 | 6.4 | 1.8 | 0.2 | 0.3 | 0.1 | 1.2 | 1.4 | 2.8 | 2.2 | 3.0 | 0.5 | 3.0 | 0.4 | 0.3 |
| **CALC. ALGAE** | 8.8 | 5.1 | 1.8 | 0.5 | 2.6 | 2.8 | 12.7 | 0.0 | 0.2 | 1.5 | 20.6 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 4.0 | 0.0 |
| **SPONGE** | 6.9 | 4.2 | 1.4 | 4.7 | 7.2 | 1.9 | 1.4 | 7.8 | 2.3 | 7.2 | 1.8 | 4.5 | 3.2 | 3.3 | 0.4 | 1.6 | 2.8 | 4.2 |
| **ANEMONE** | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 |
| **ZOANTHID** | 0.7 | 0.0 | 1.1 | 3.7 | 0.0 | 0.7 | 0.1 | 0.1 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.2 | 0.3 | 0.0 | 0.0 |
| **TUNICATE** | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.0 | 0.4 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **SAND** | 0.1 | 2.8 | 3.8 | 1.7 | 0.9 | 0.2 | 1.4 | 0.7 | 1.2 | 0.5 | 0.0 | 2.2 | 0.7 | 1.1 | 1.2 | 7.5 | 0.9 | 0.3 |
| **GRAVEL/ RUB.** | 0.5 | 0.0 | 4.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 |
| **DEAD CORAL** | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 3.6 | 0.4 | 0.0 | 2.3 | 0.2 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| **OVERHANG** | 2.2 | 5.2 | 7.6 | 2.2 | 1.9 | 3.9 | 3.2 | 0.0 | 7.0 | 0.0 | 3.0 | 0.2 | 4.1 | 2.3 | 5.9 | 4.5 | 15.4 | 8.3 |

**Table 2.** Mean percent coverage by benthic category for the 18 reef sites (n=5 transects per site).

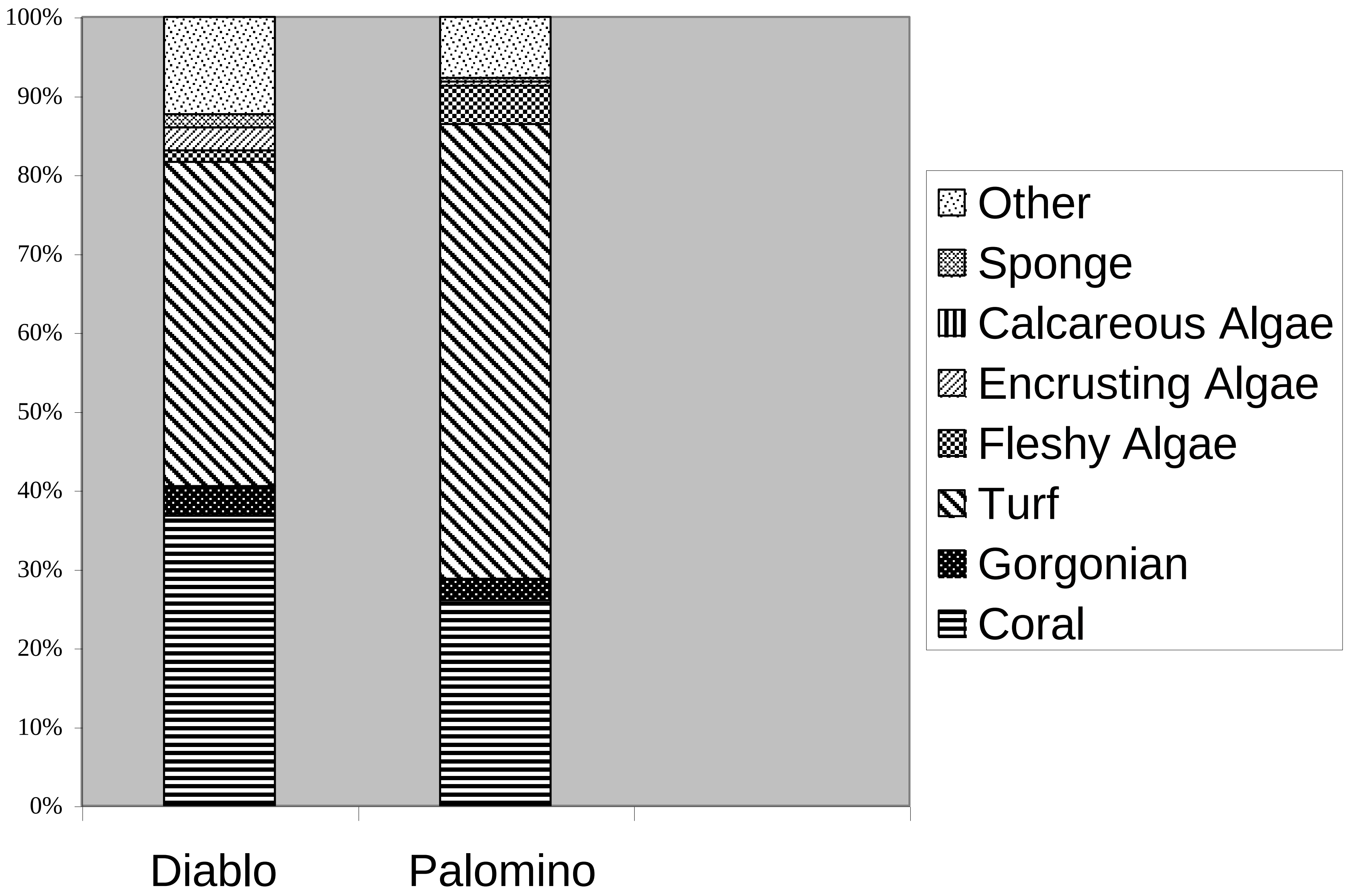


Figure 1. Percent Coverage of Benthic Categories at Fajardo Reef Sites.

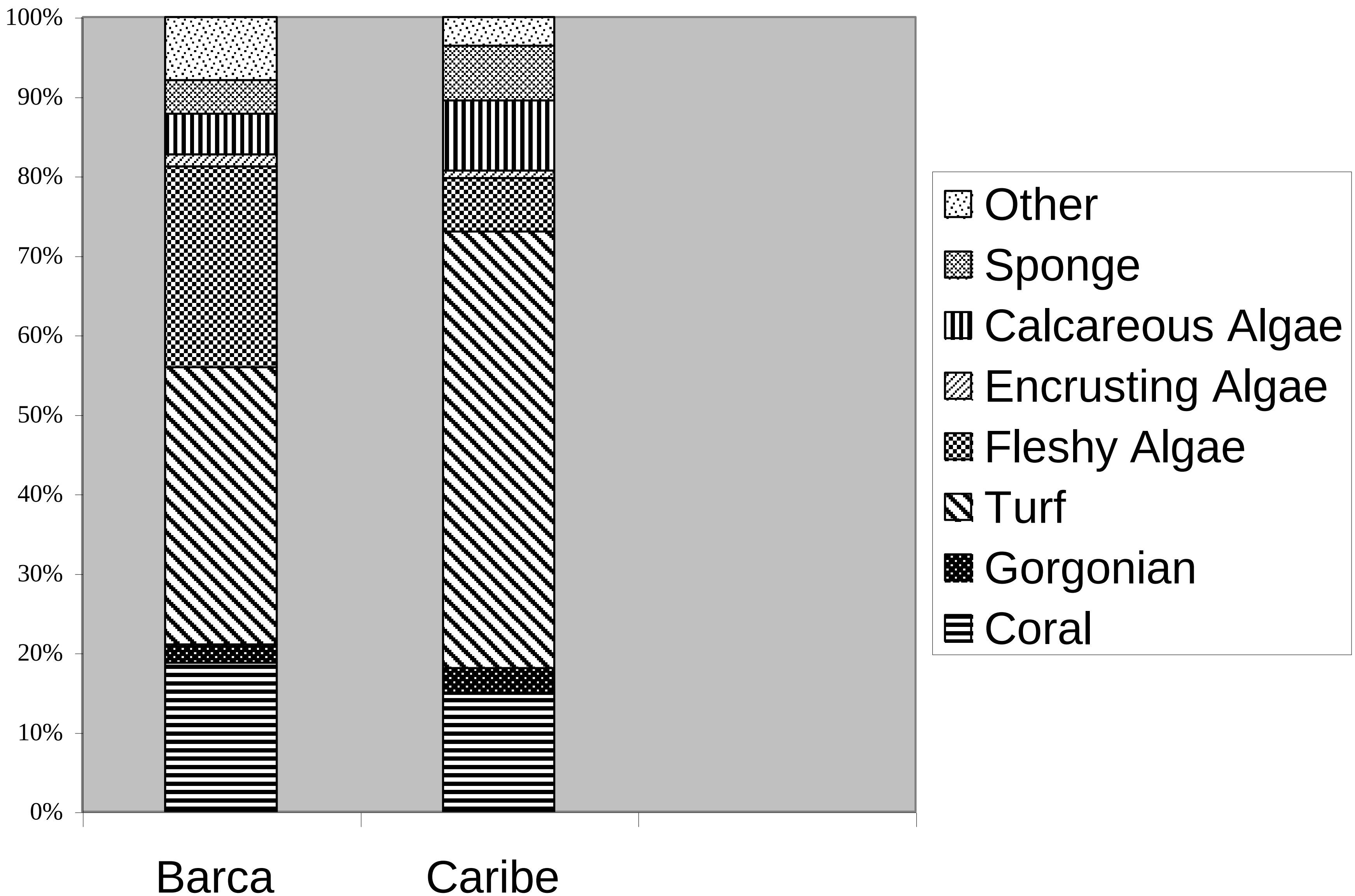


Figure 2. Percent Coverage of Benthic Categories at Jobos Reef Sites.

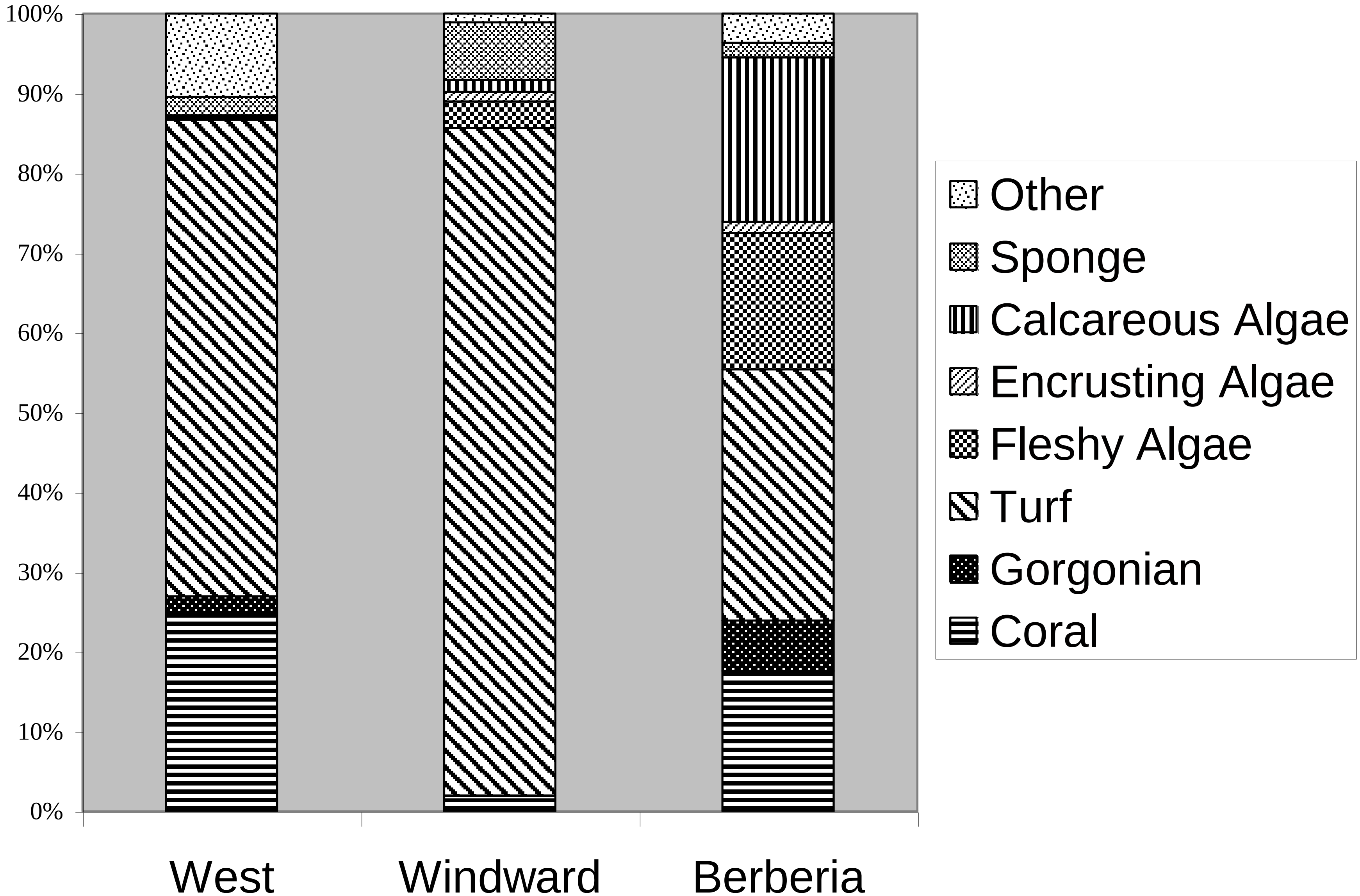


Figure 3. Percent Coverage of Benthic Categories at Caja de Muertos Reef Sites.

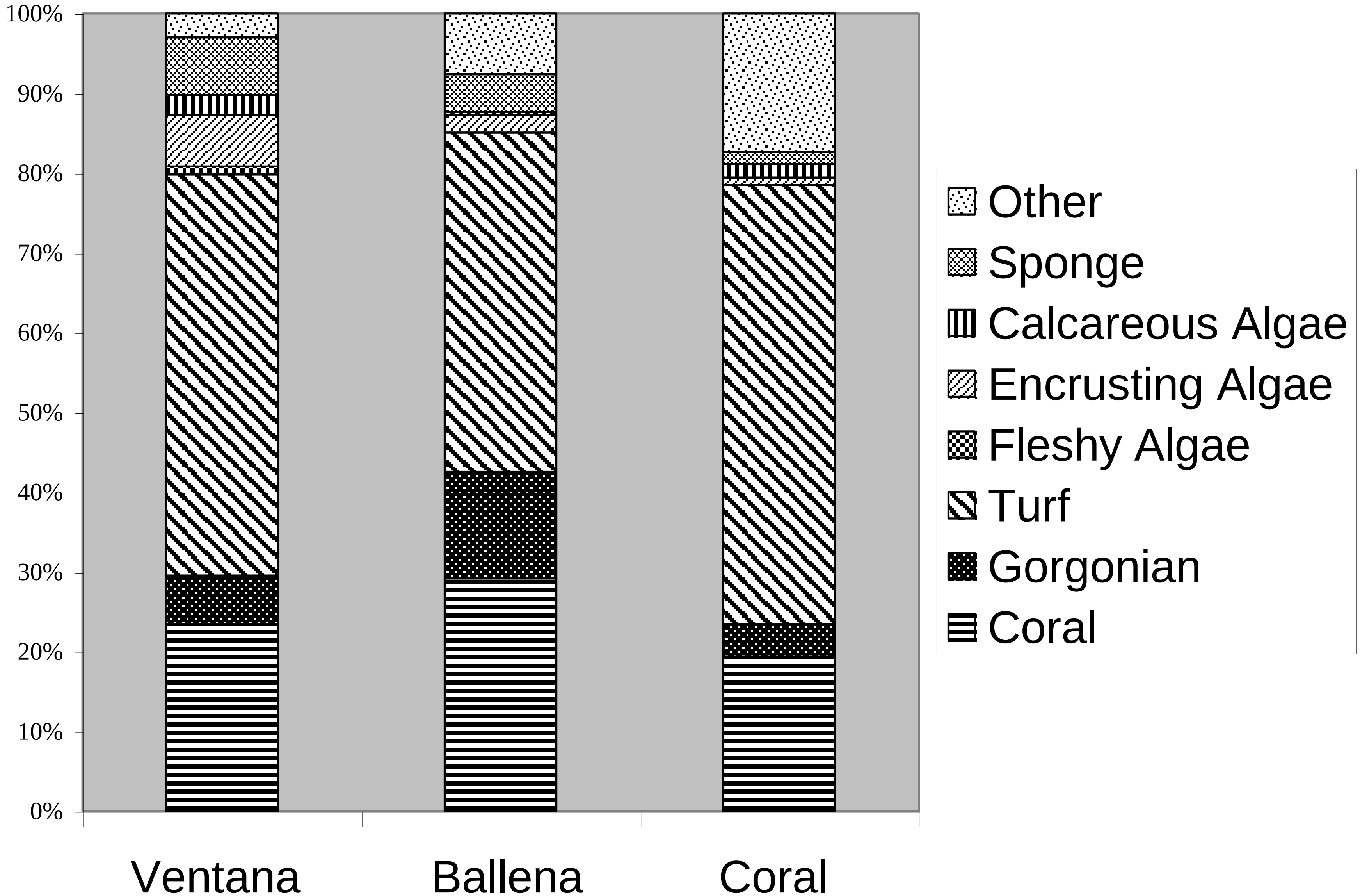


Figure 4. Percent Coverage of Benthic Categories at Guanica Reef Sites.

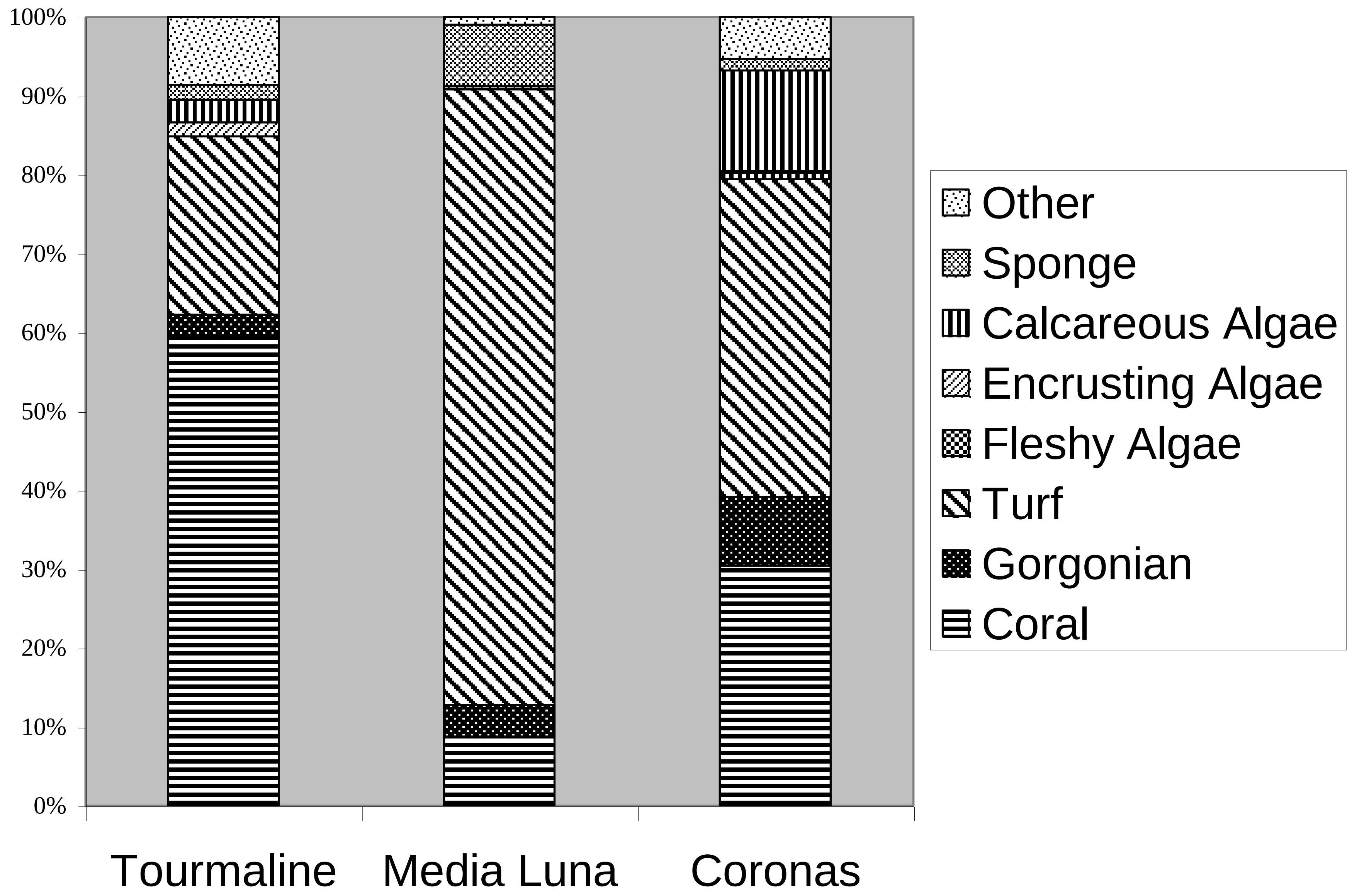


Figure 5. Percent Coverage of Benthic Categories at Mayaguez Reef Sites.

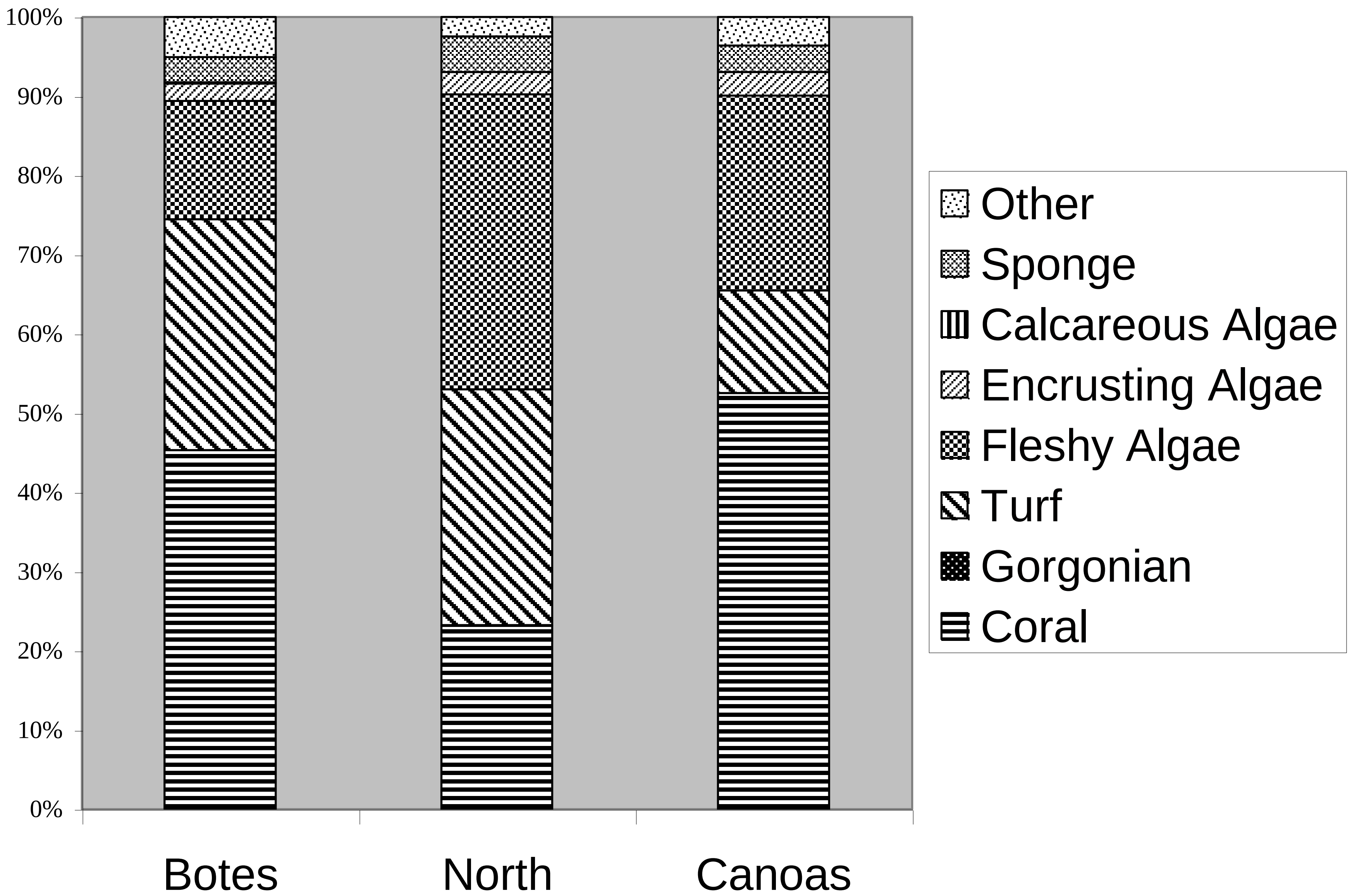


Figure 6.  Percent Coverage of Benthic Categories at Desecheo Reef Sites.

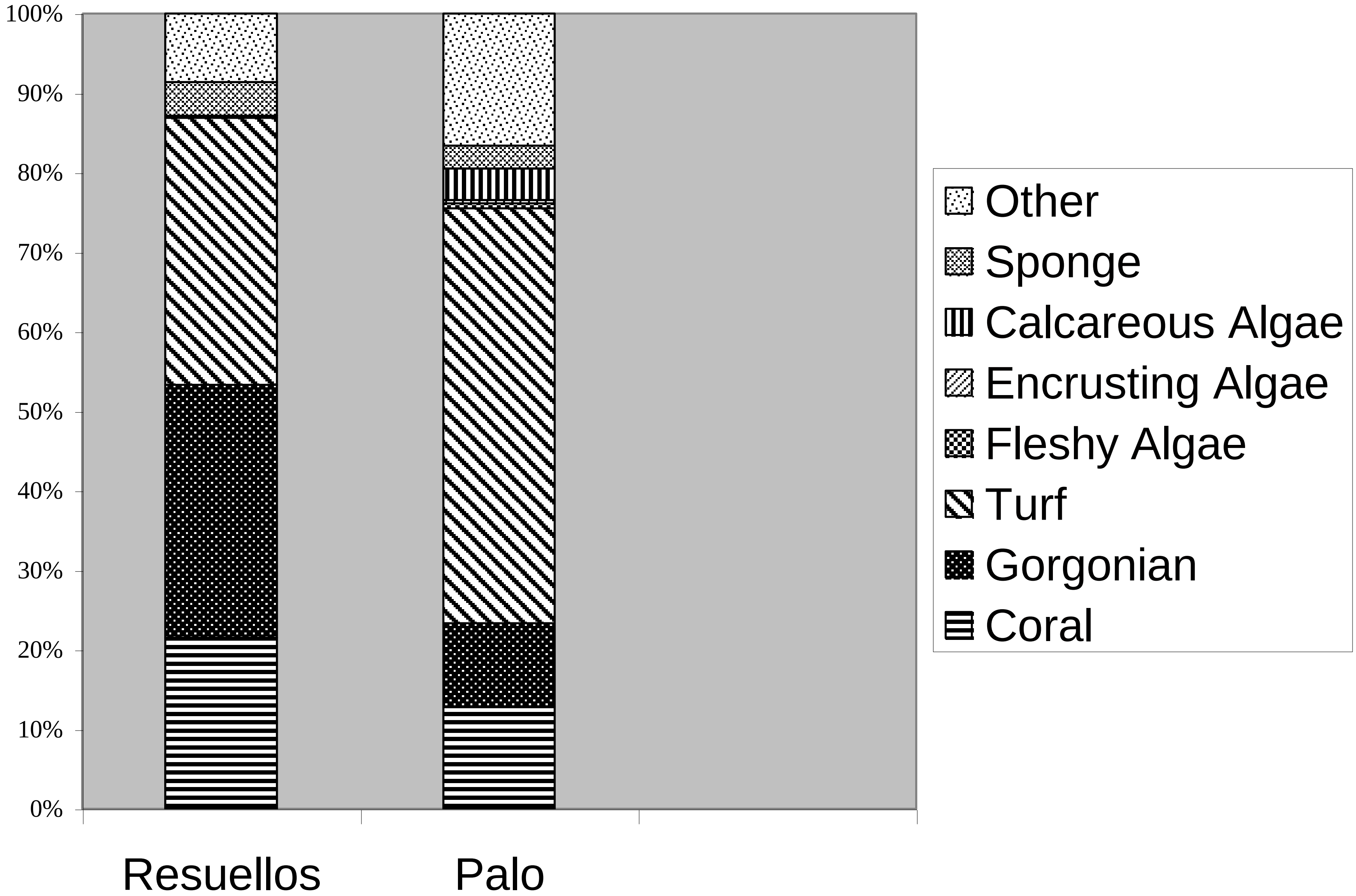


Figure 7. Percent Coverage of Benthic Categories at Boqueron Reef Sites.

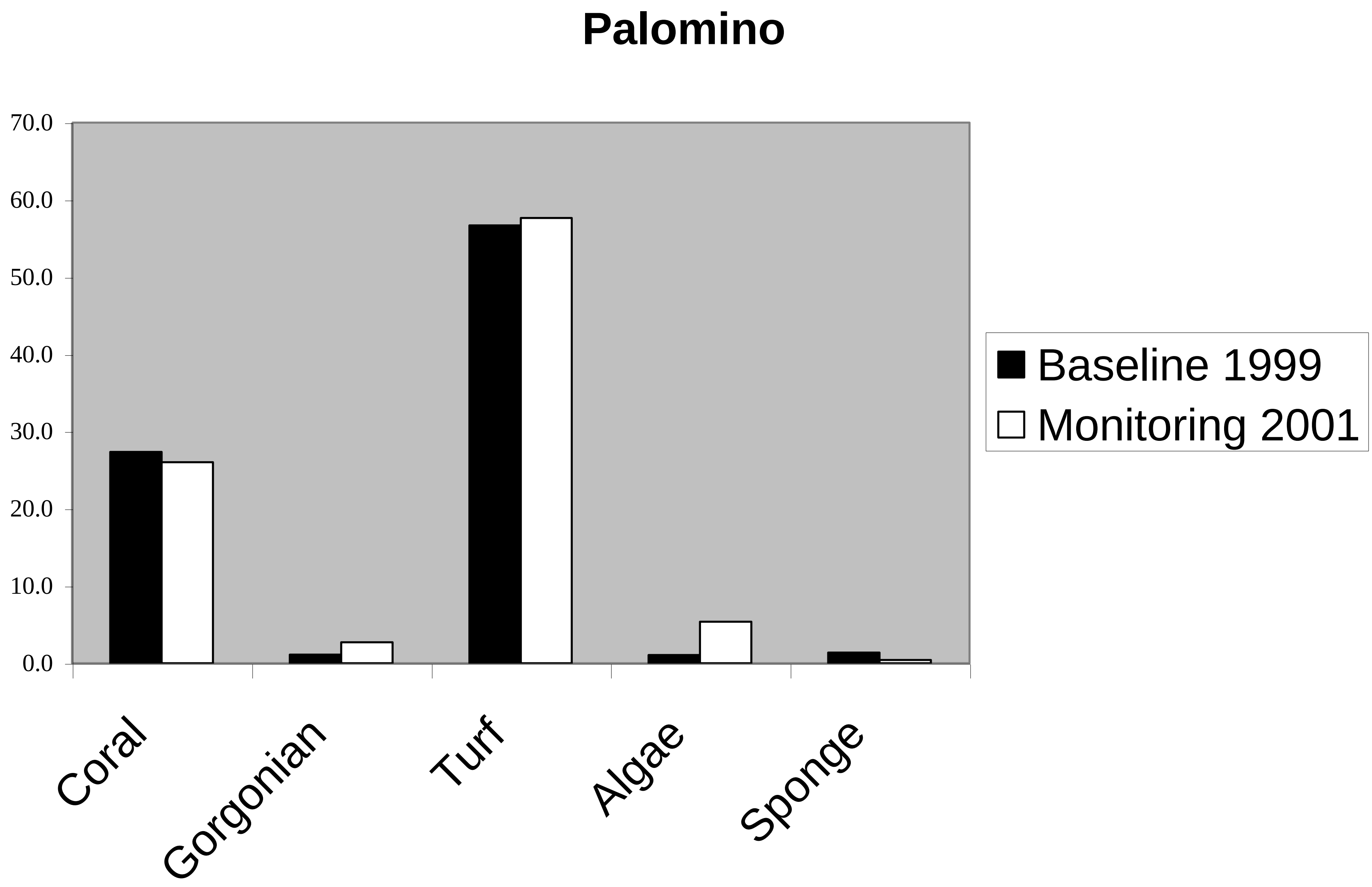


Figure 8. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Palominos.

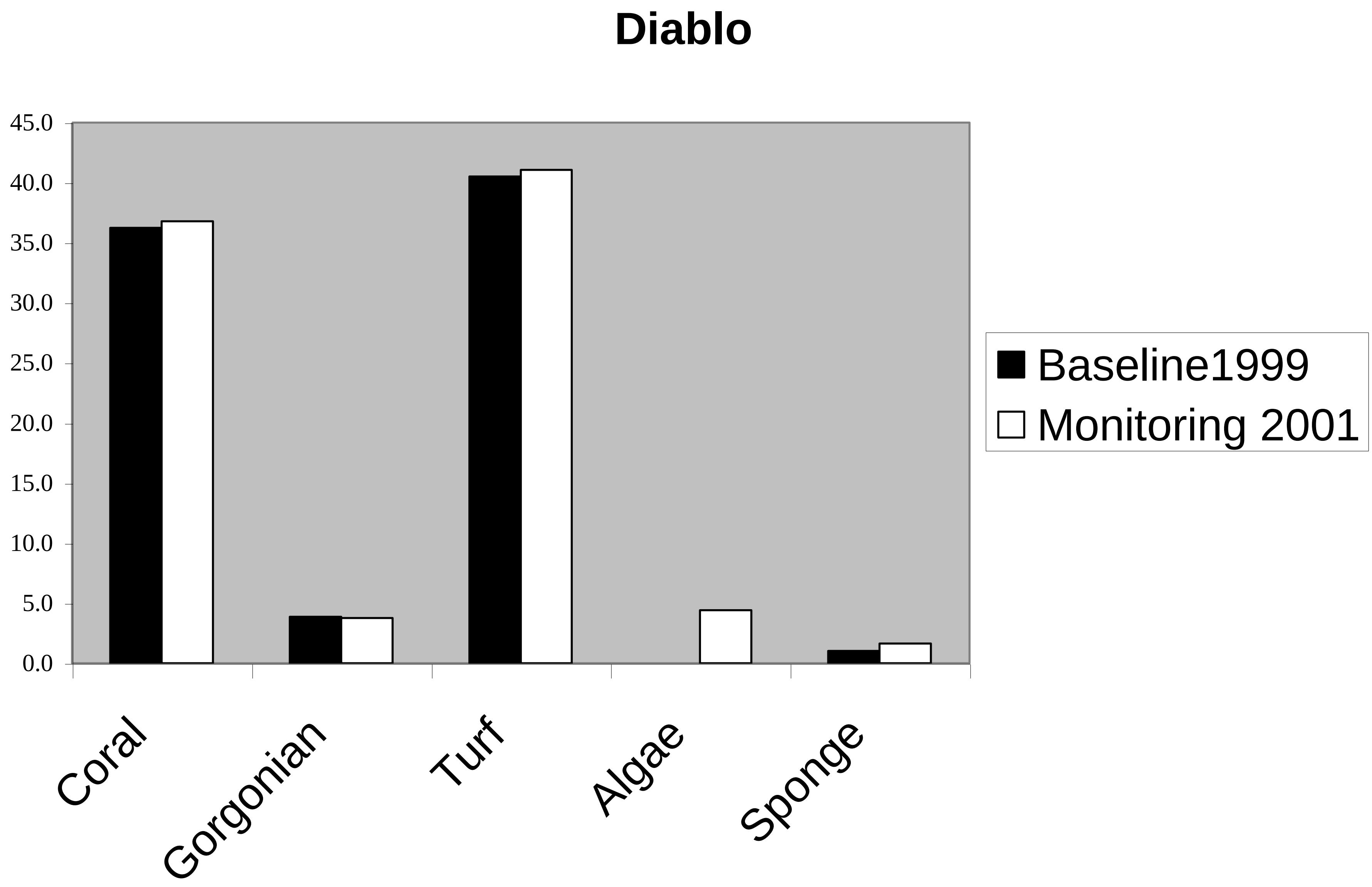


Figure 9. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Diablo.

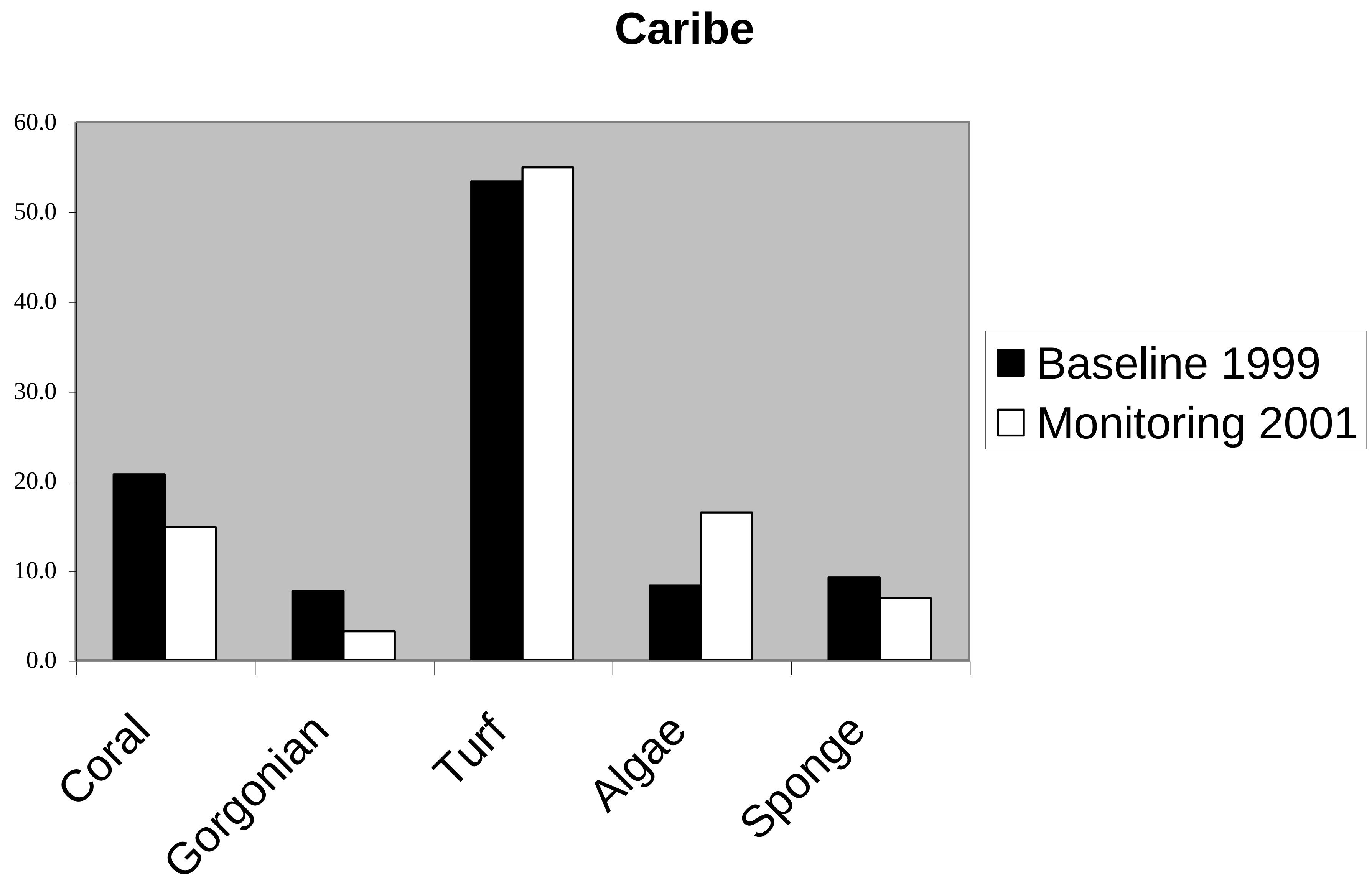


Figure 10. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Caribe.

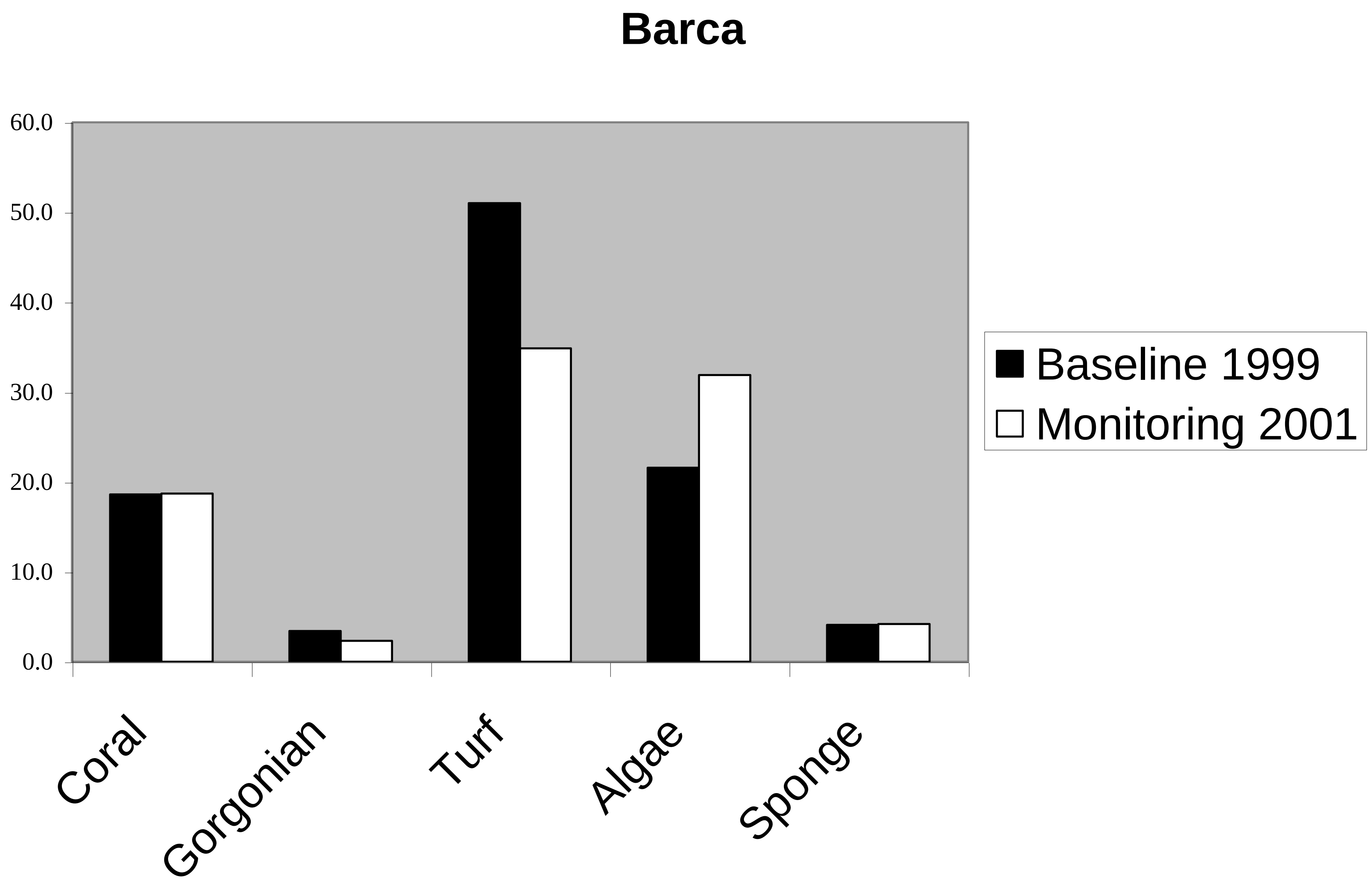


Figure 11. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Barca.

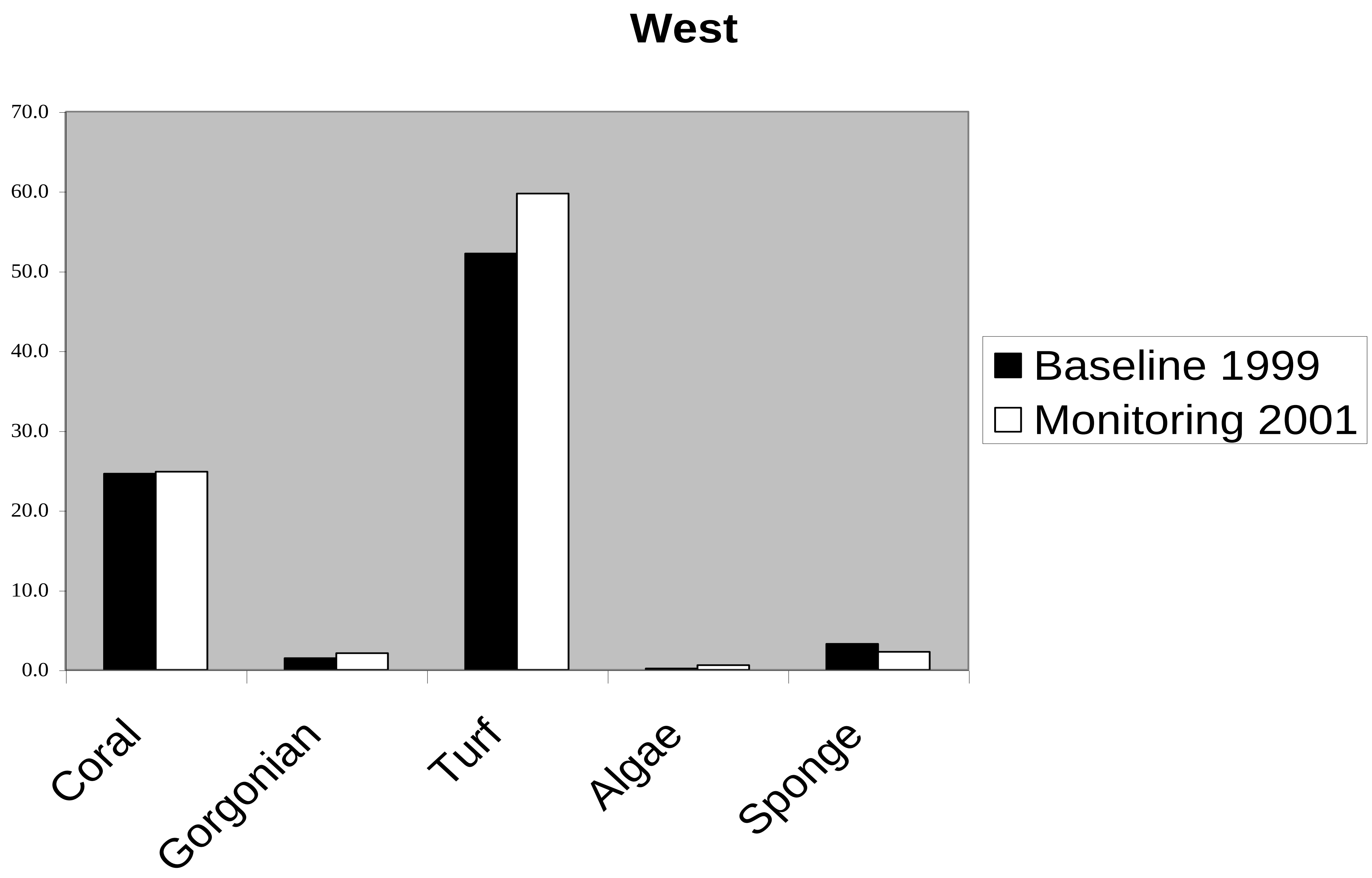


Figure 12. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at West Reef.

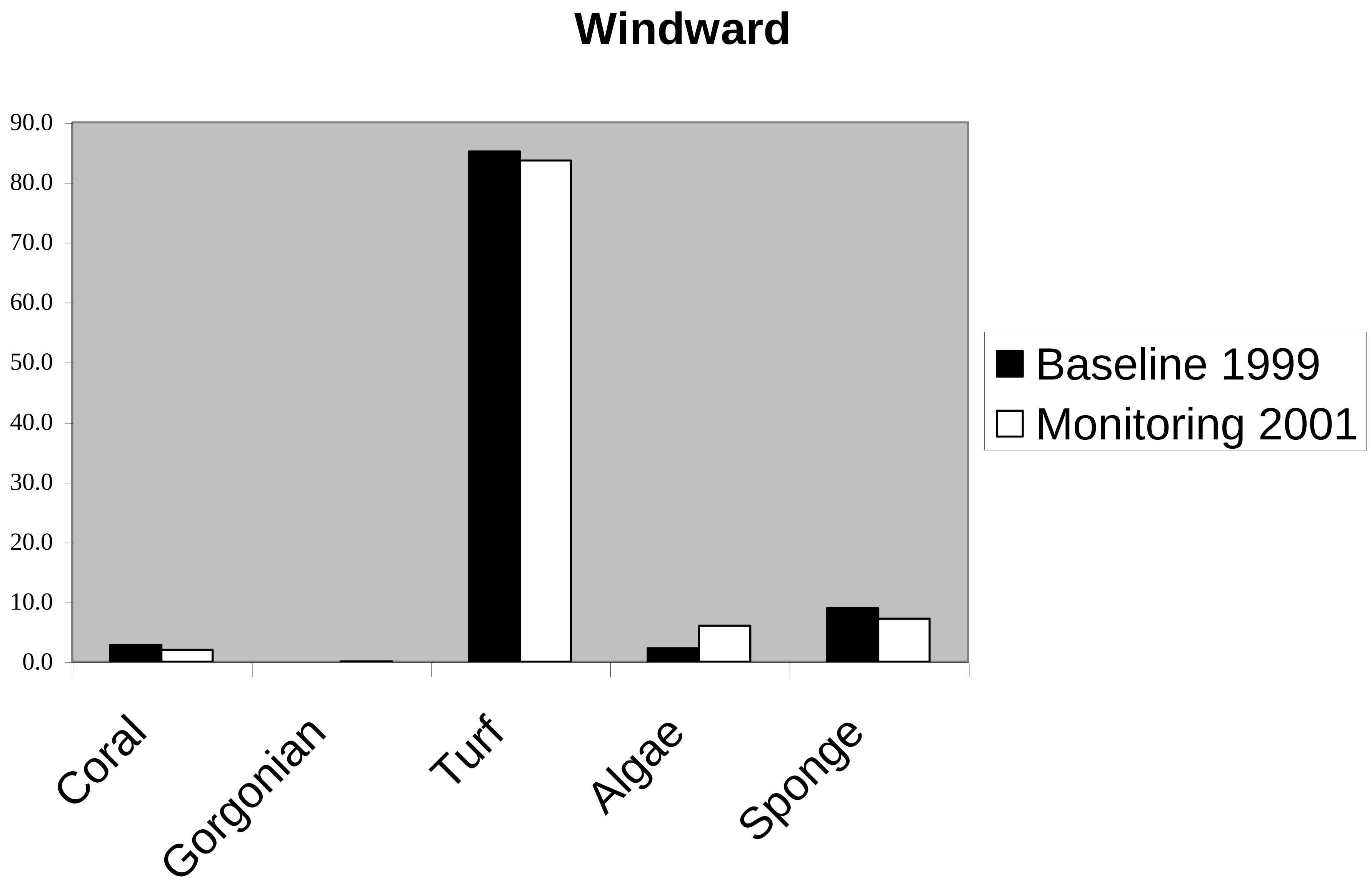


Figure 13.  Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Windward.

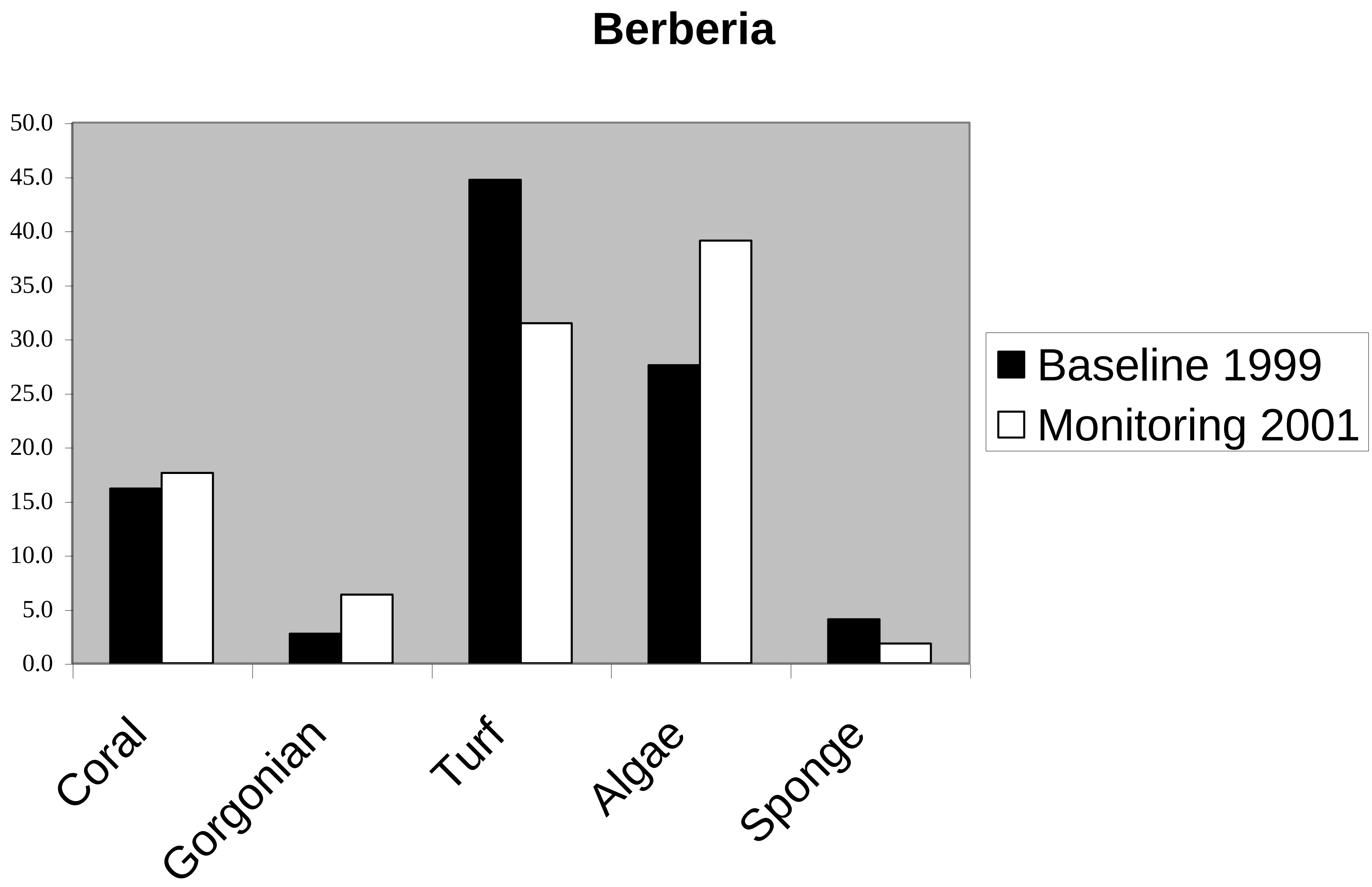


Figure 14.  Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Berberia.

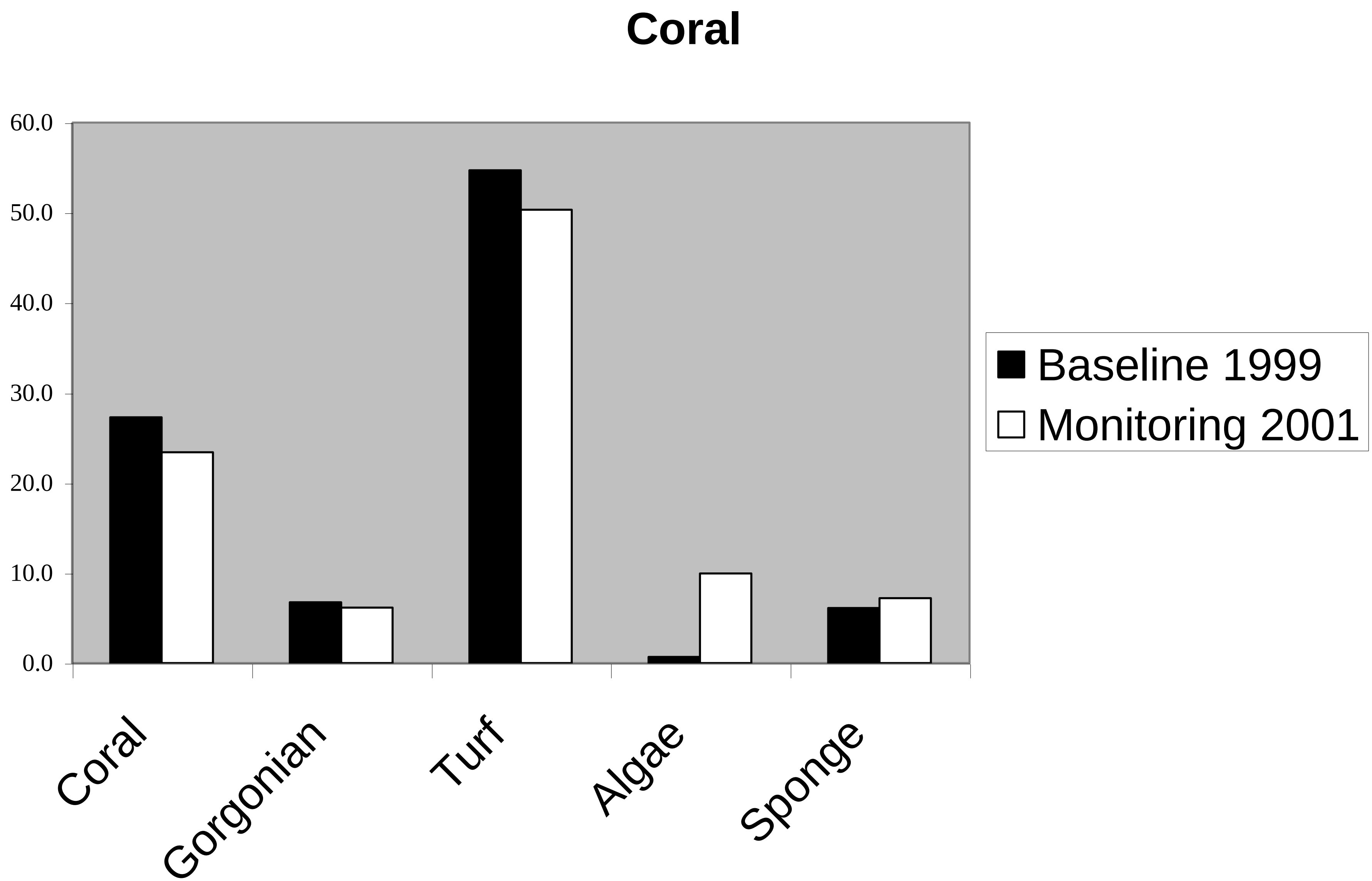


Figure 15. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Coral.

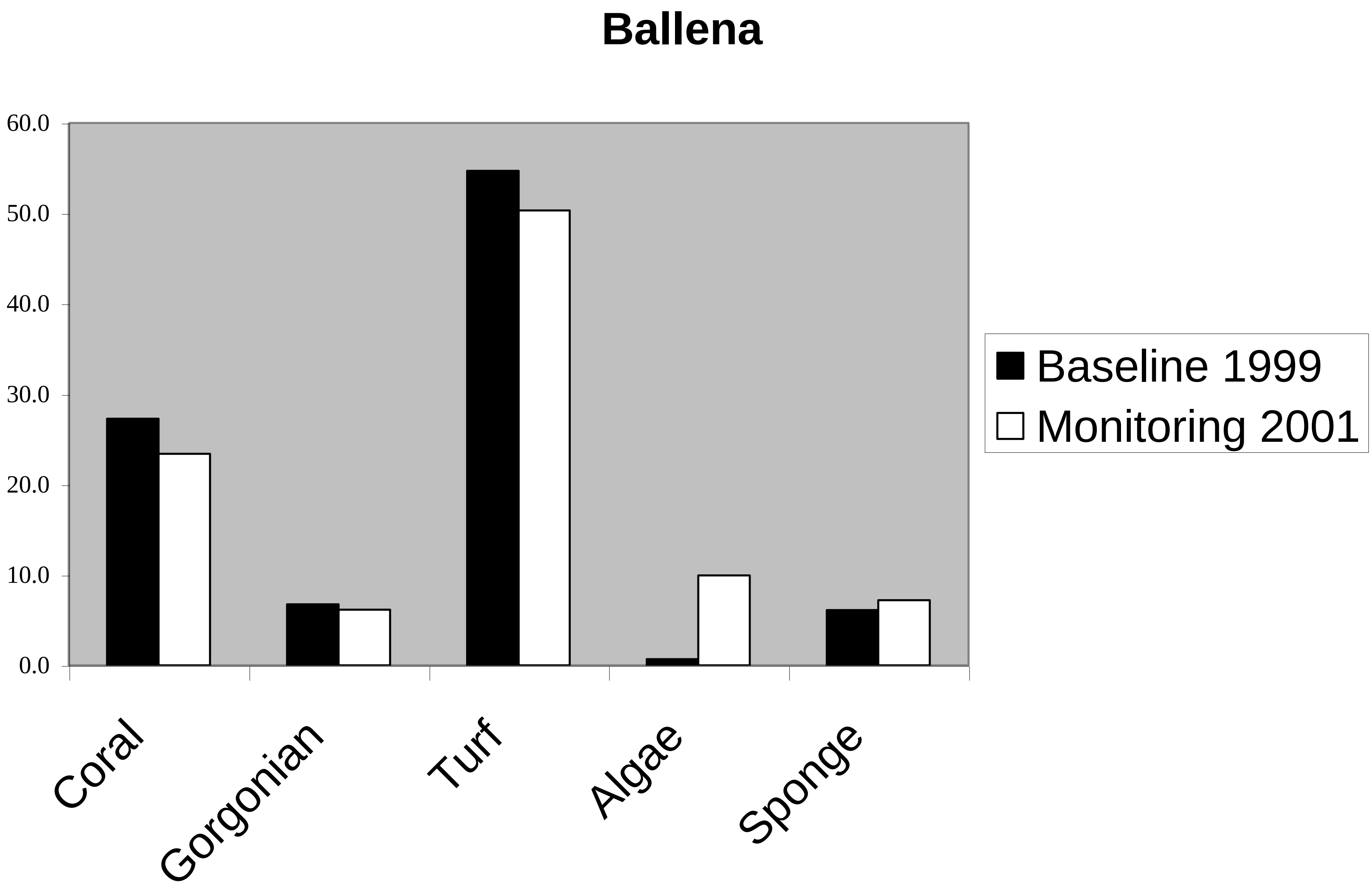


Figure 16. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Ballena.

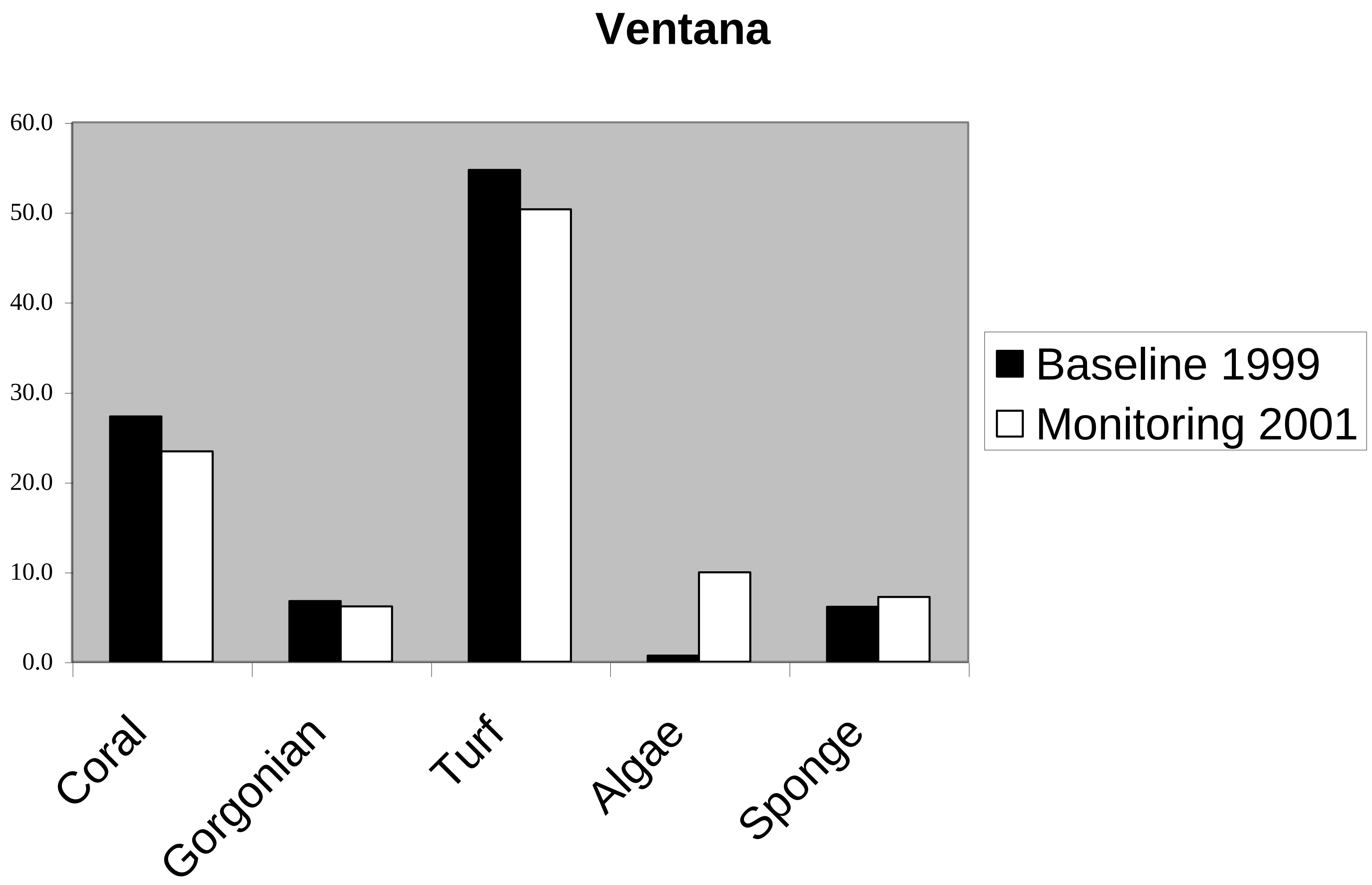


Figure 17. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Ventana.

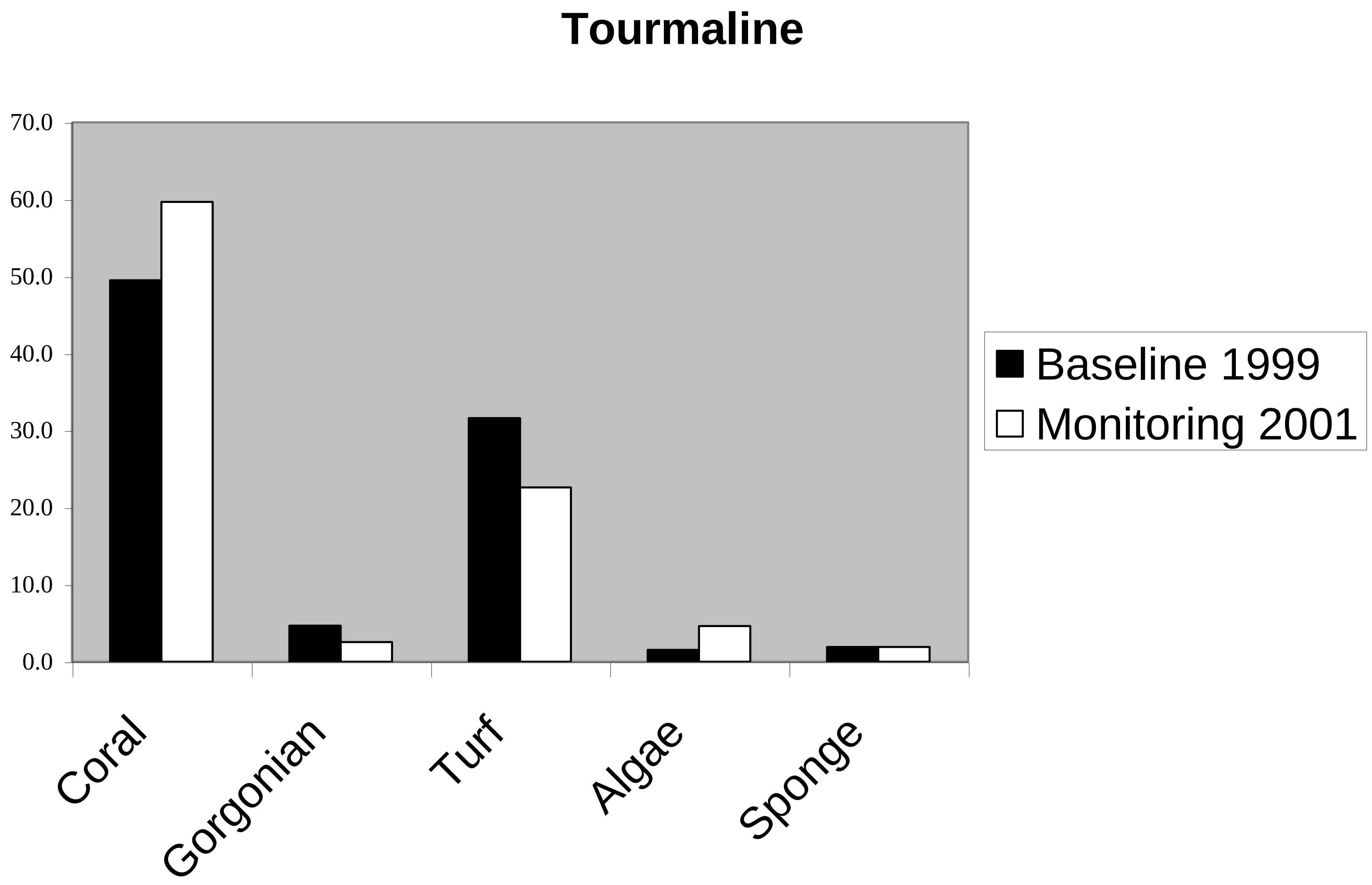


Figure 18. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Tourmaline.

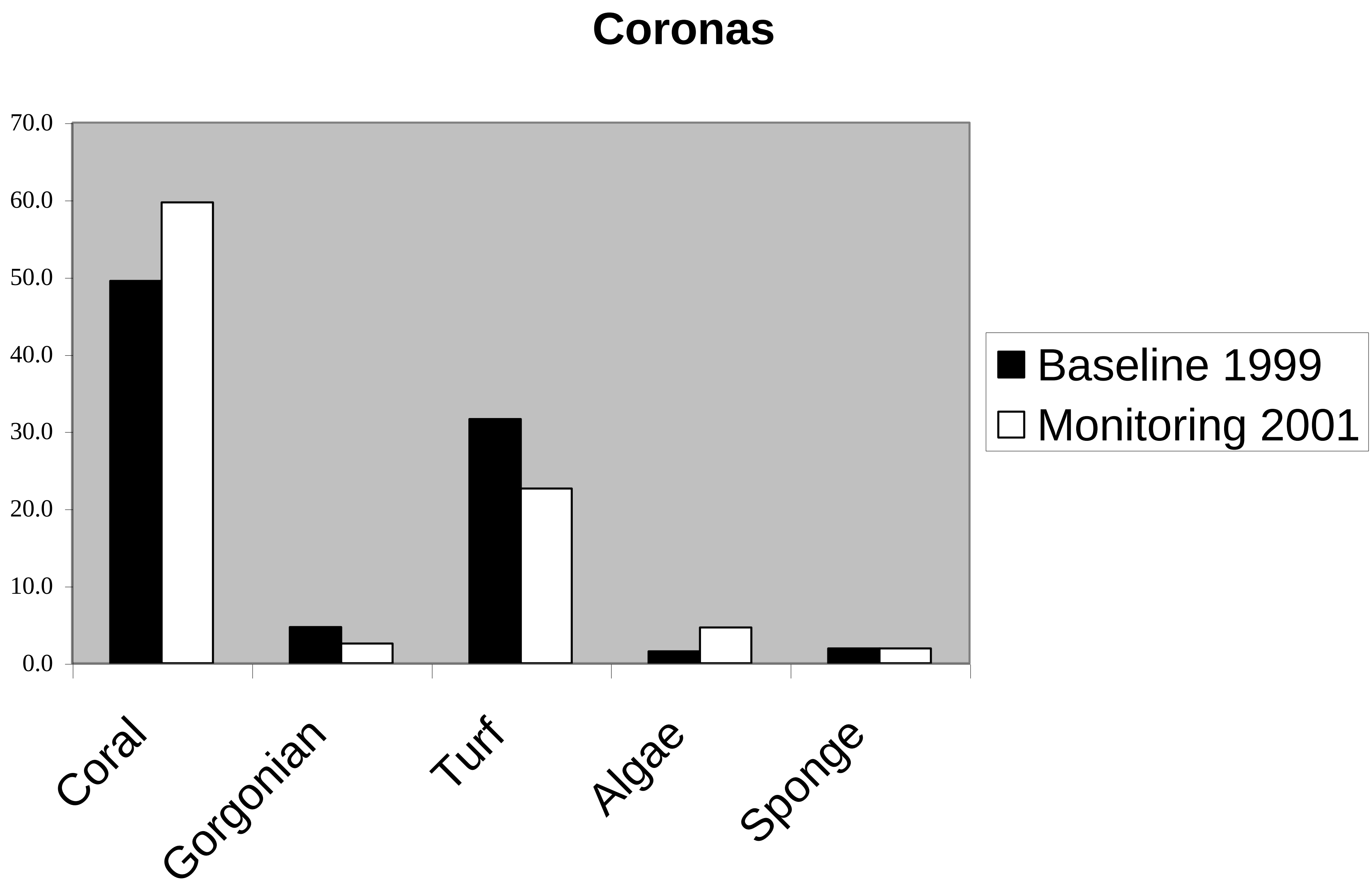


Figure 19. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Coronas.

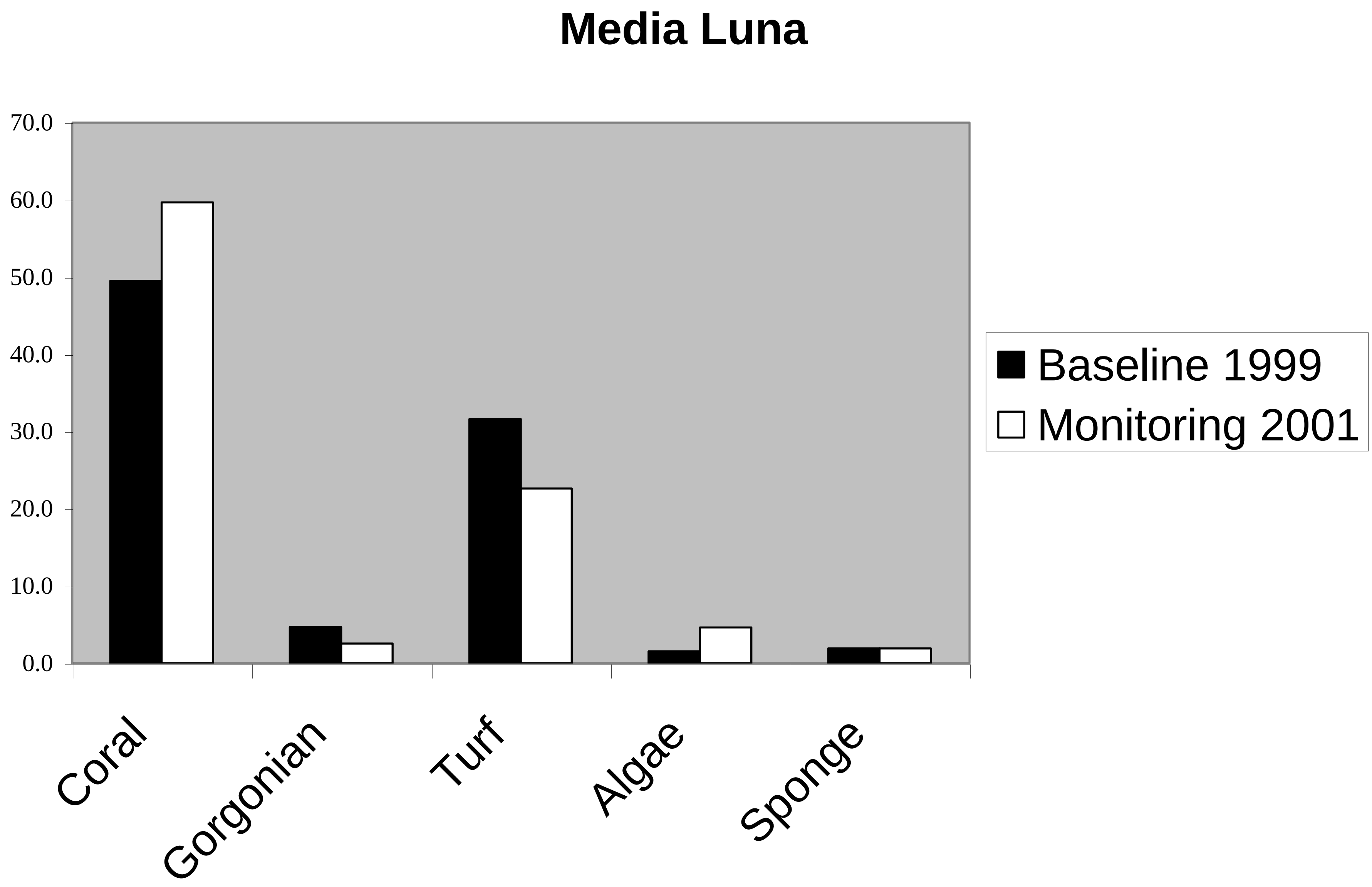


Figure 20.  Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Medialuna.

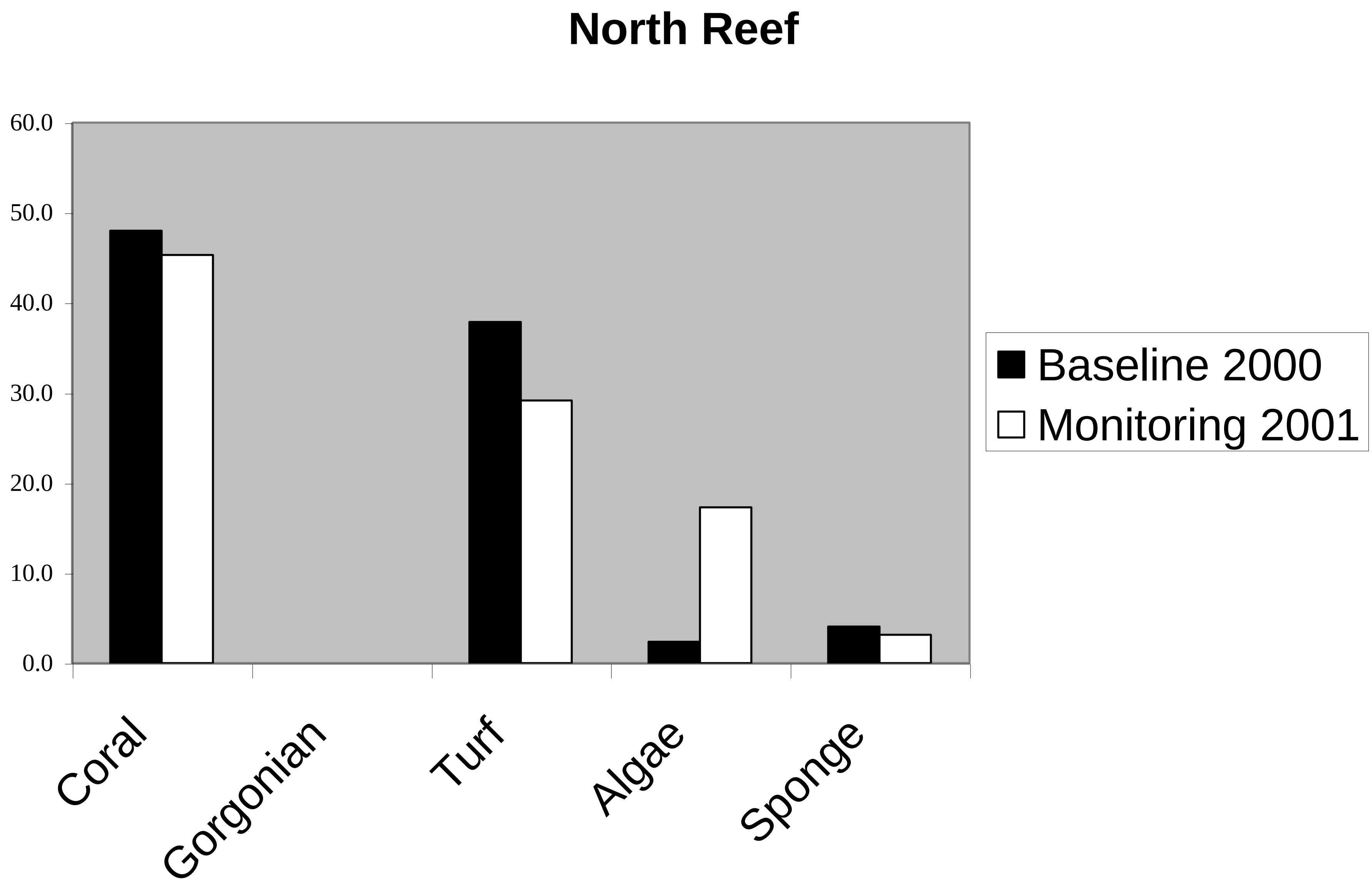


Figure 21. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at North.

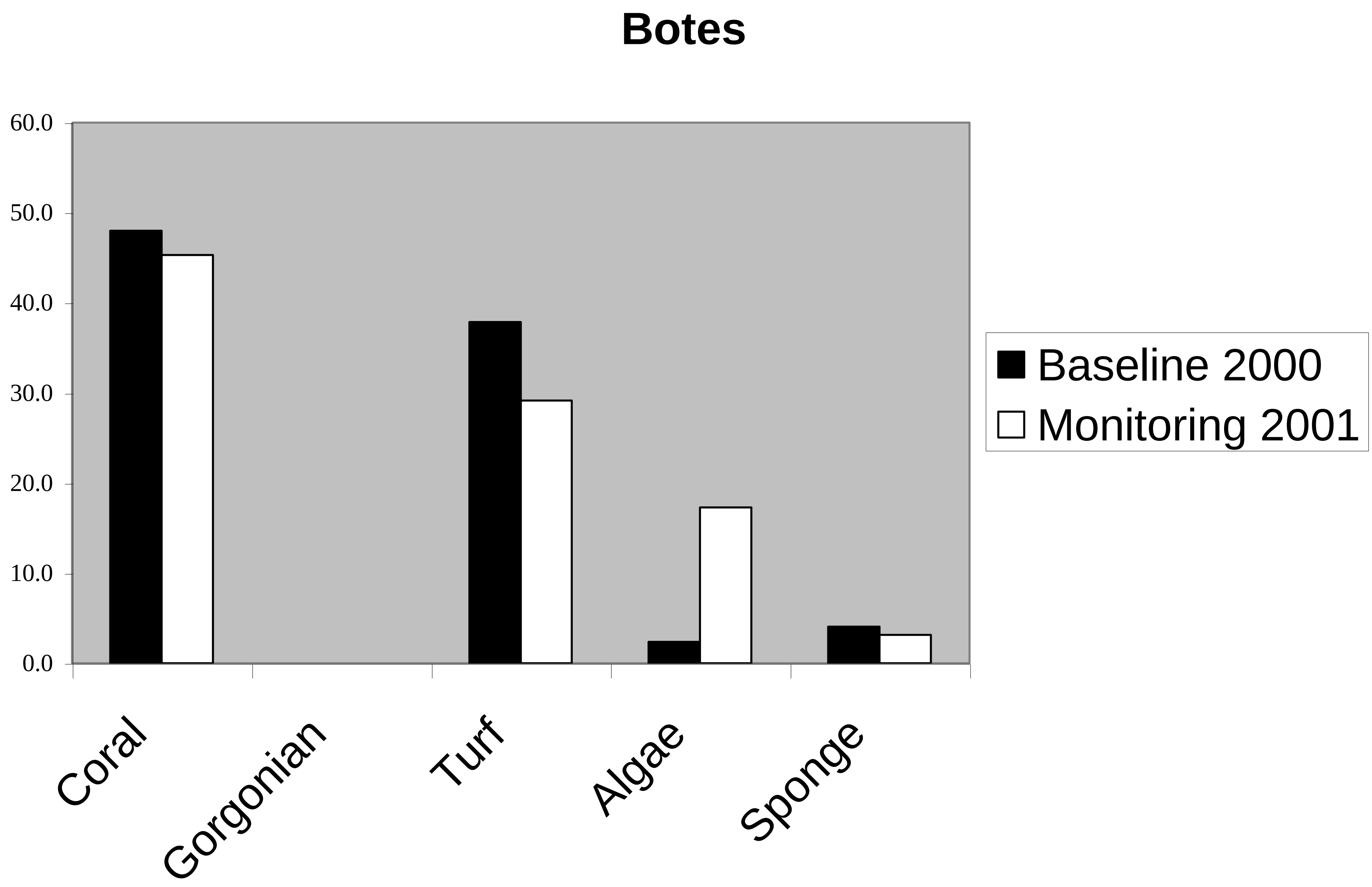


Figure 22. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Botes.

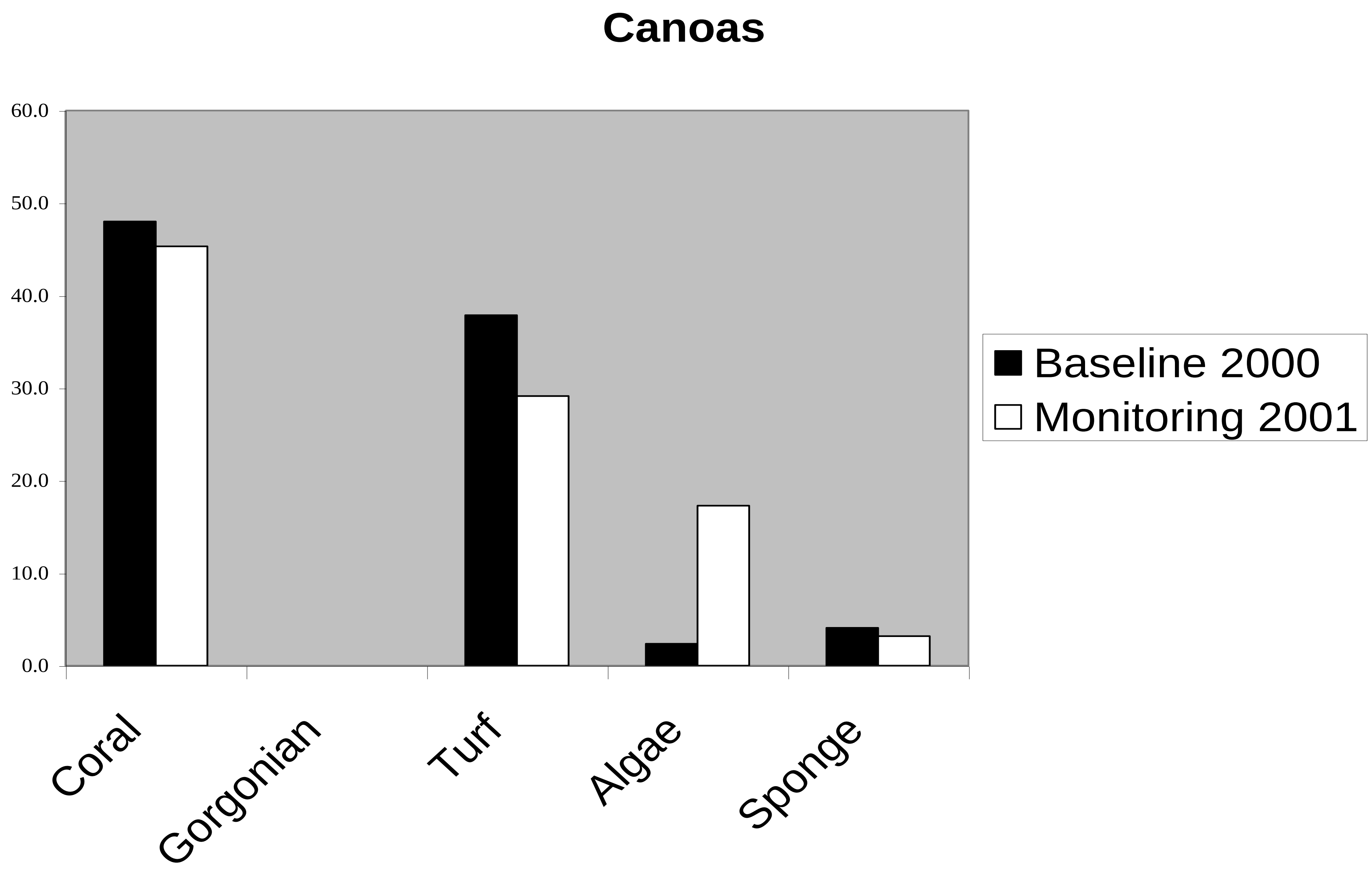


Figure 23. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Canoas.

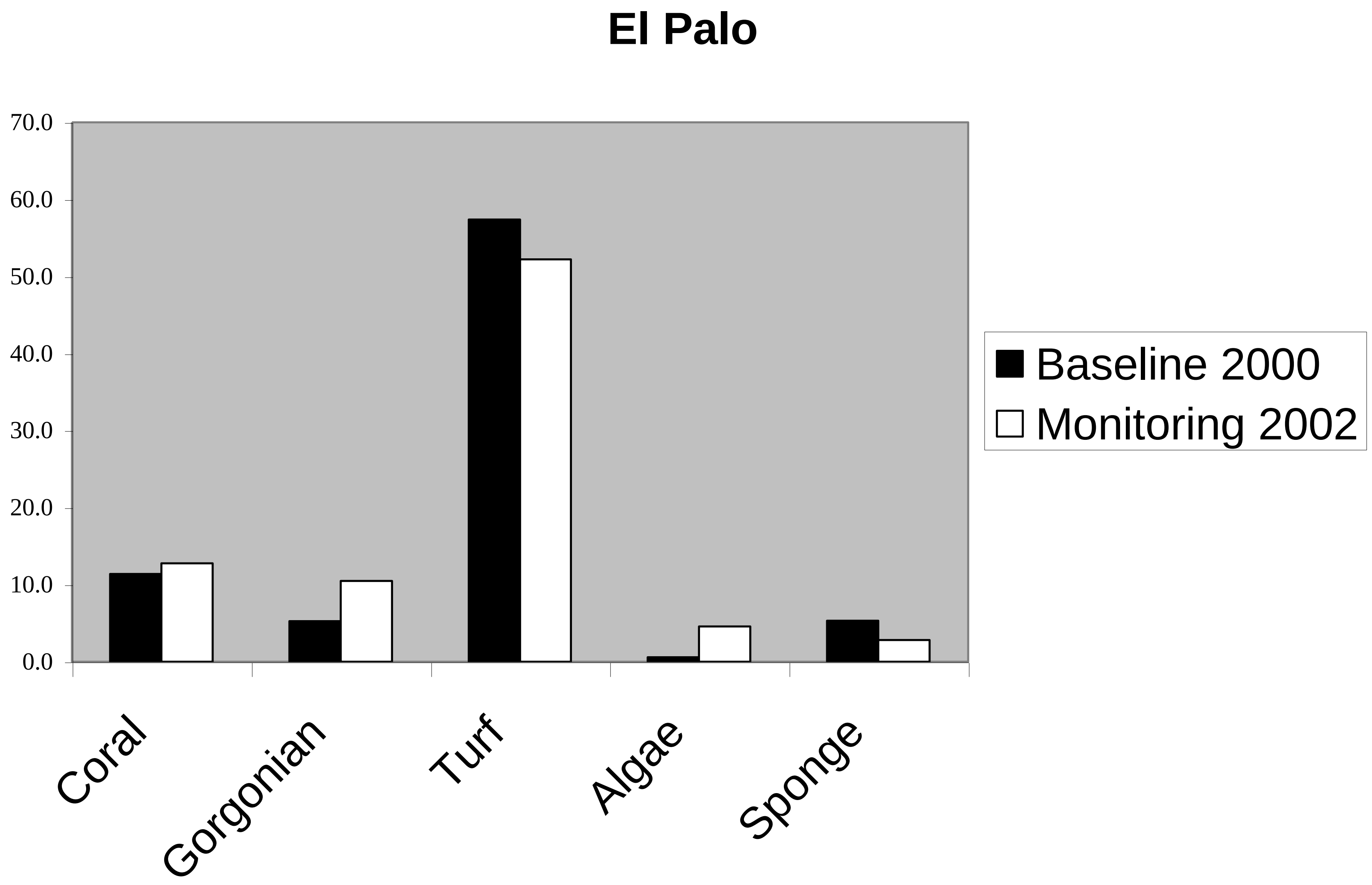


Figure 24. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at El Palo.

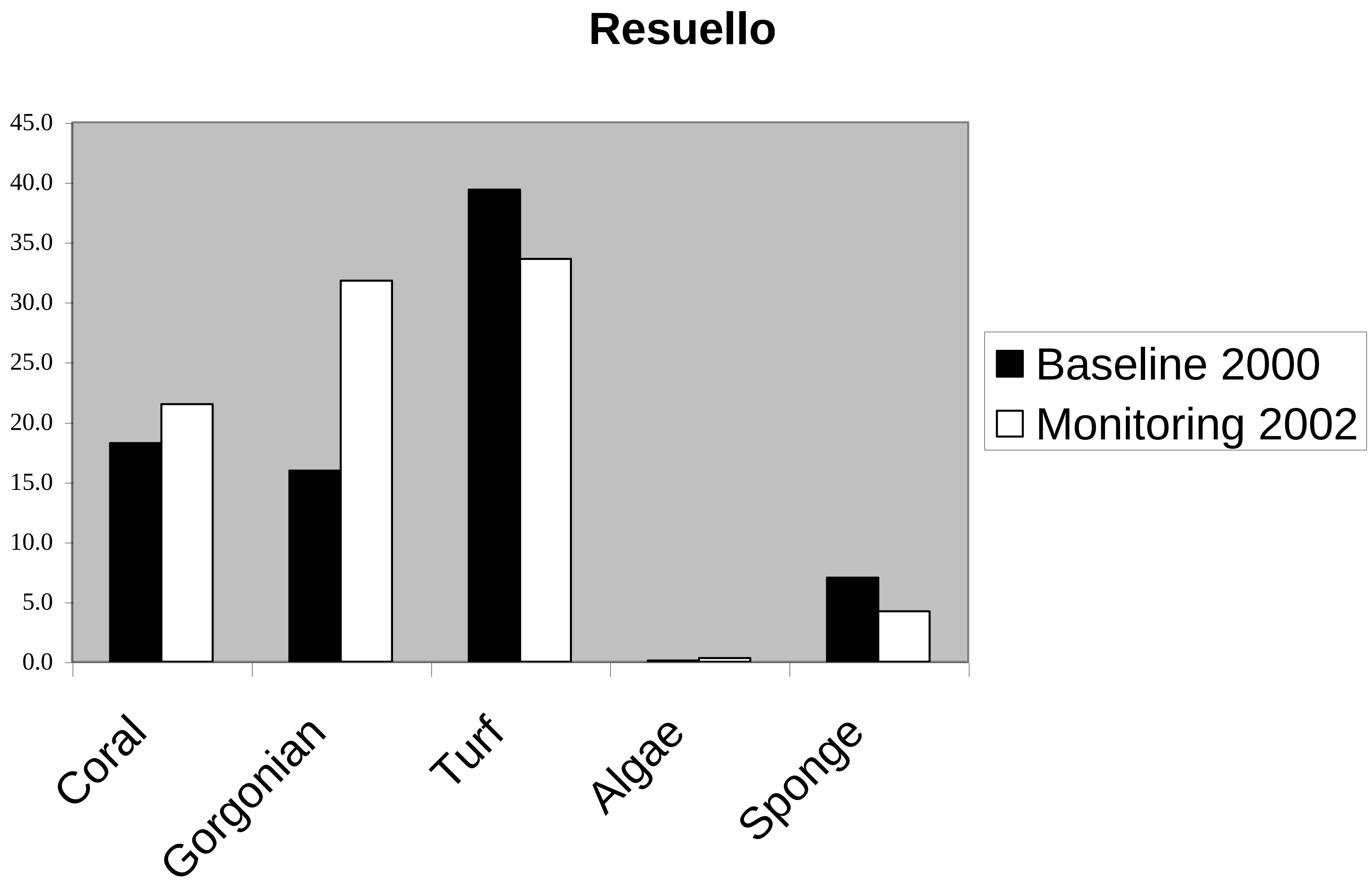


Figure 25. Comparison of Percent Coverage of Benthic Categories Between Baseline and Monitoring at Resuellos.

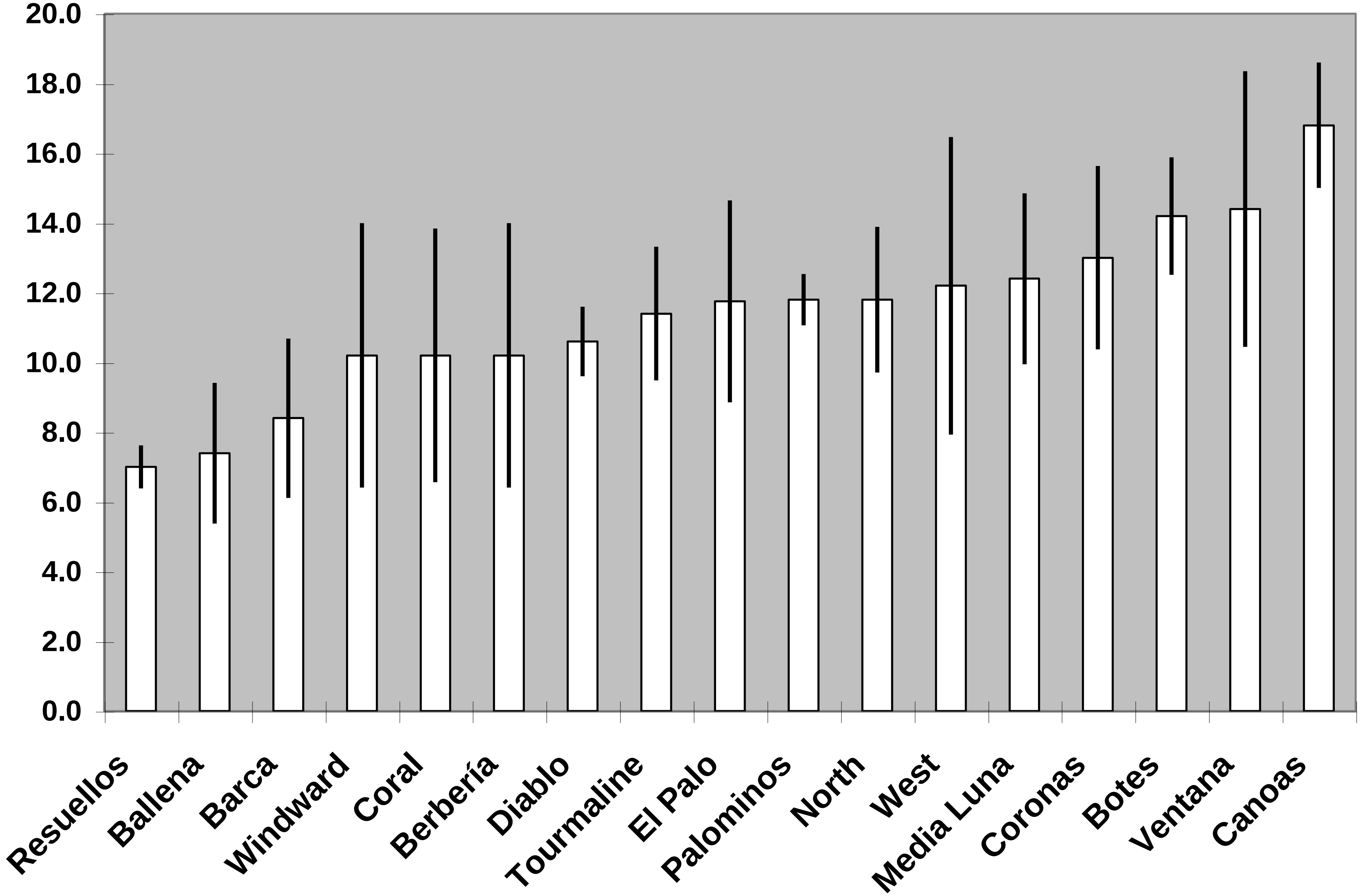


Figure 26. Mean Species Richness of Reef fish at all Study Sites with 95% Confidence intervals.

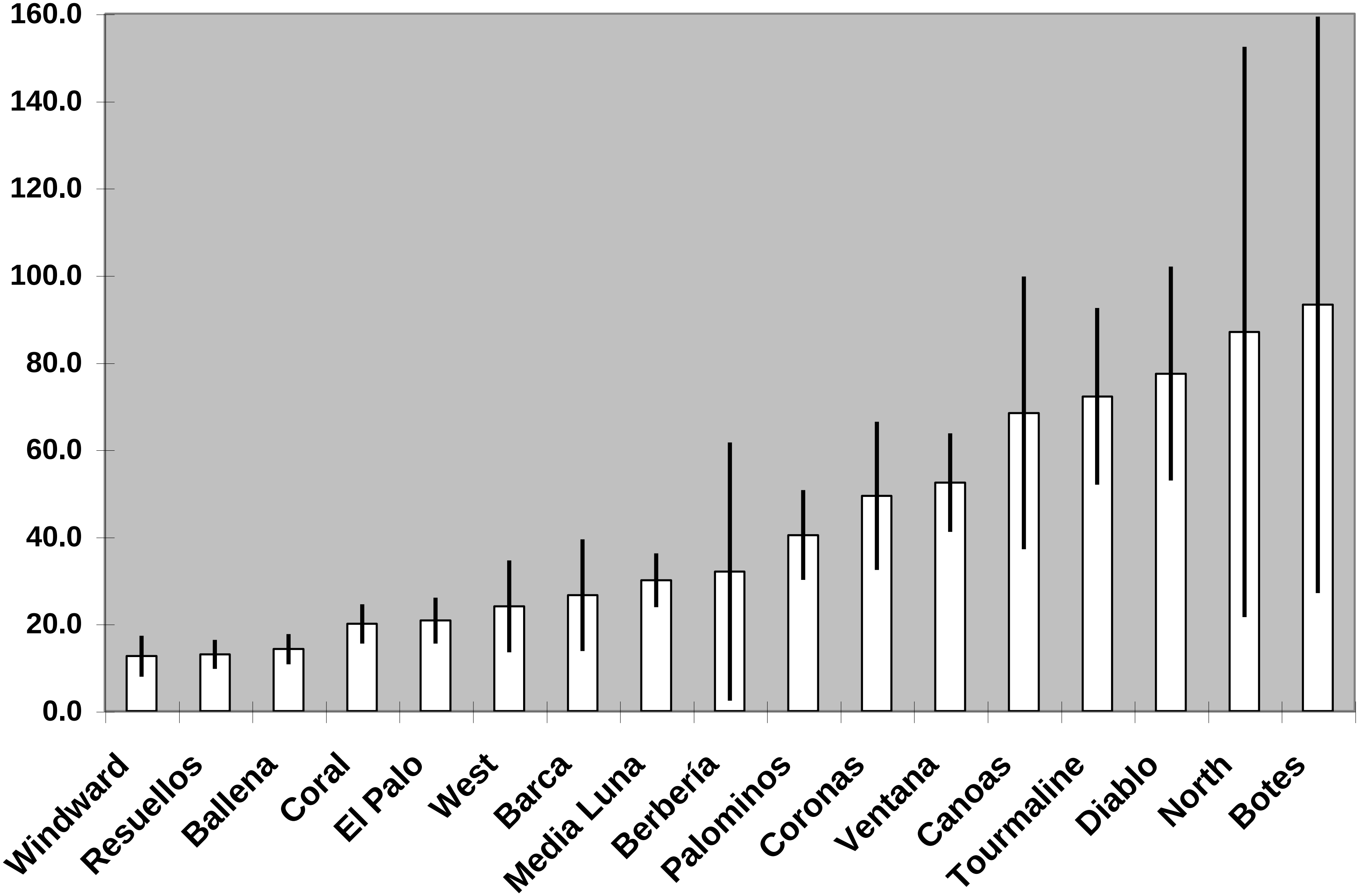


Figure 27. Mean Density of Reef fish (indv./30m$^2$) at all Study Sites with 95% Confidence Interval.

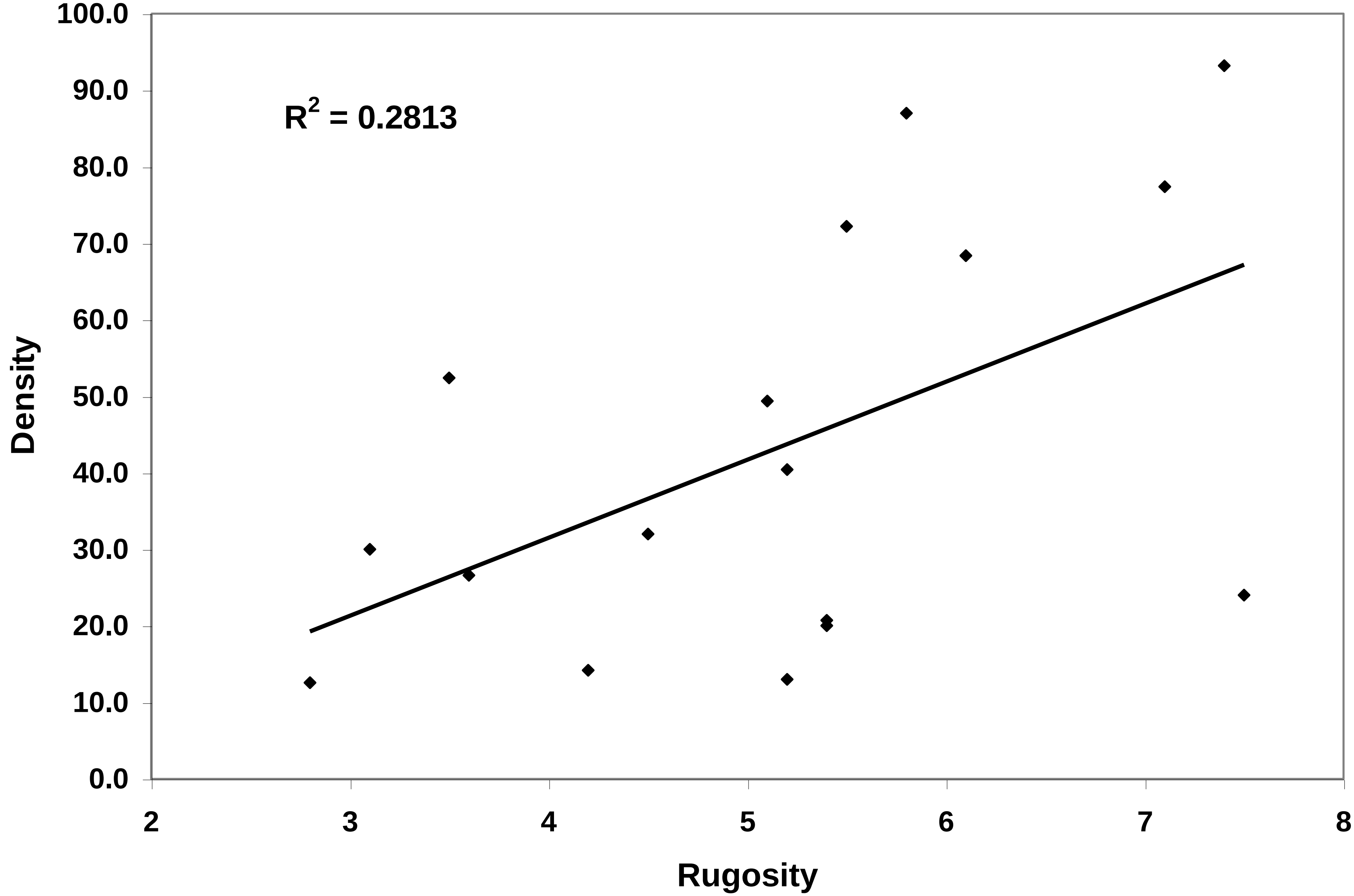


Figure 28. The Relationship Between Reef fish Density and Rugosity.

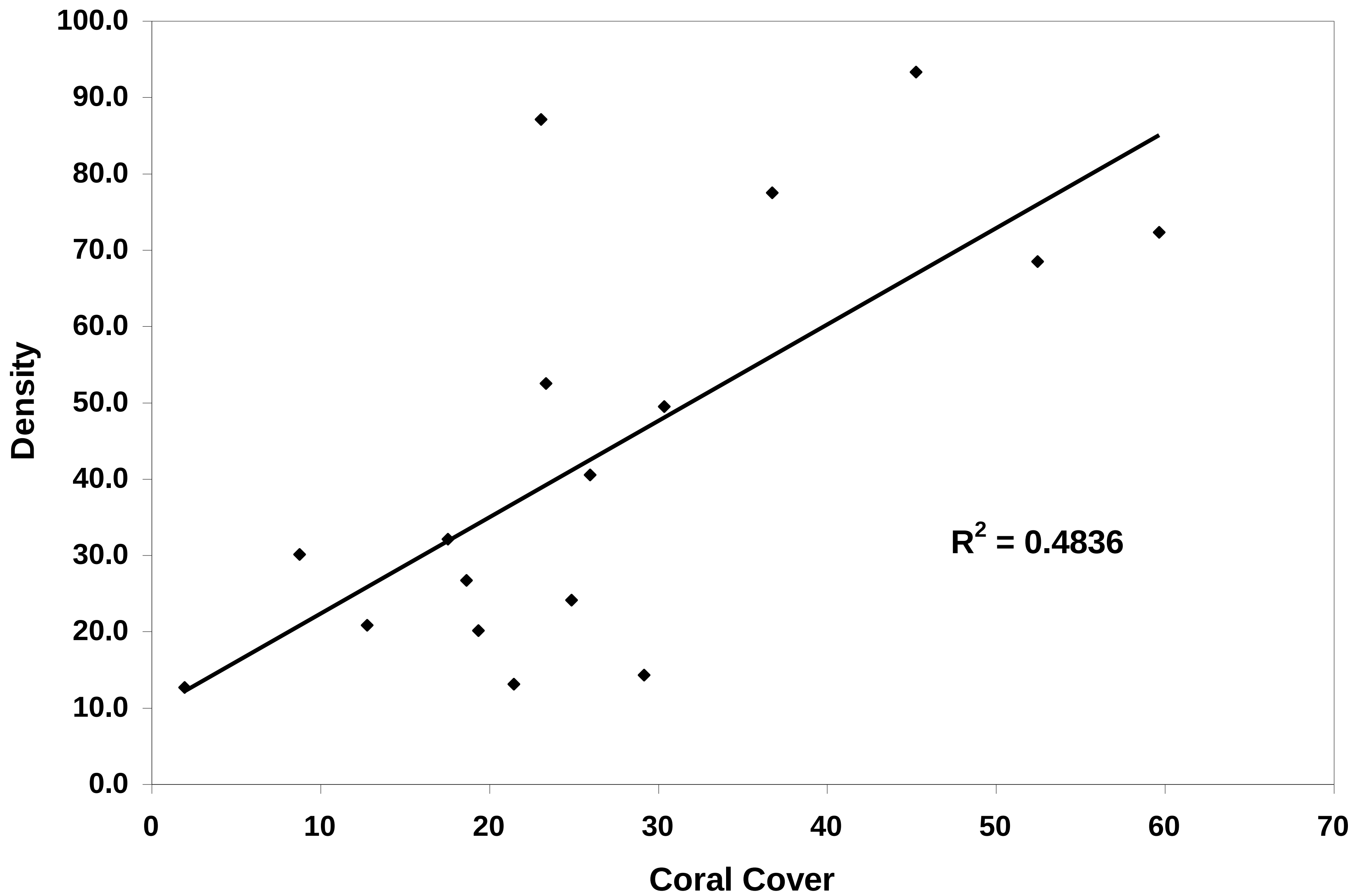


Figure 29.  The Relationship Between Coral Cover and Reef fish Density.

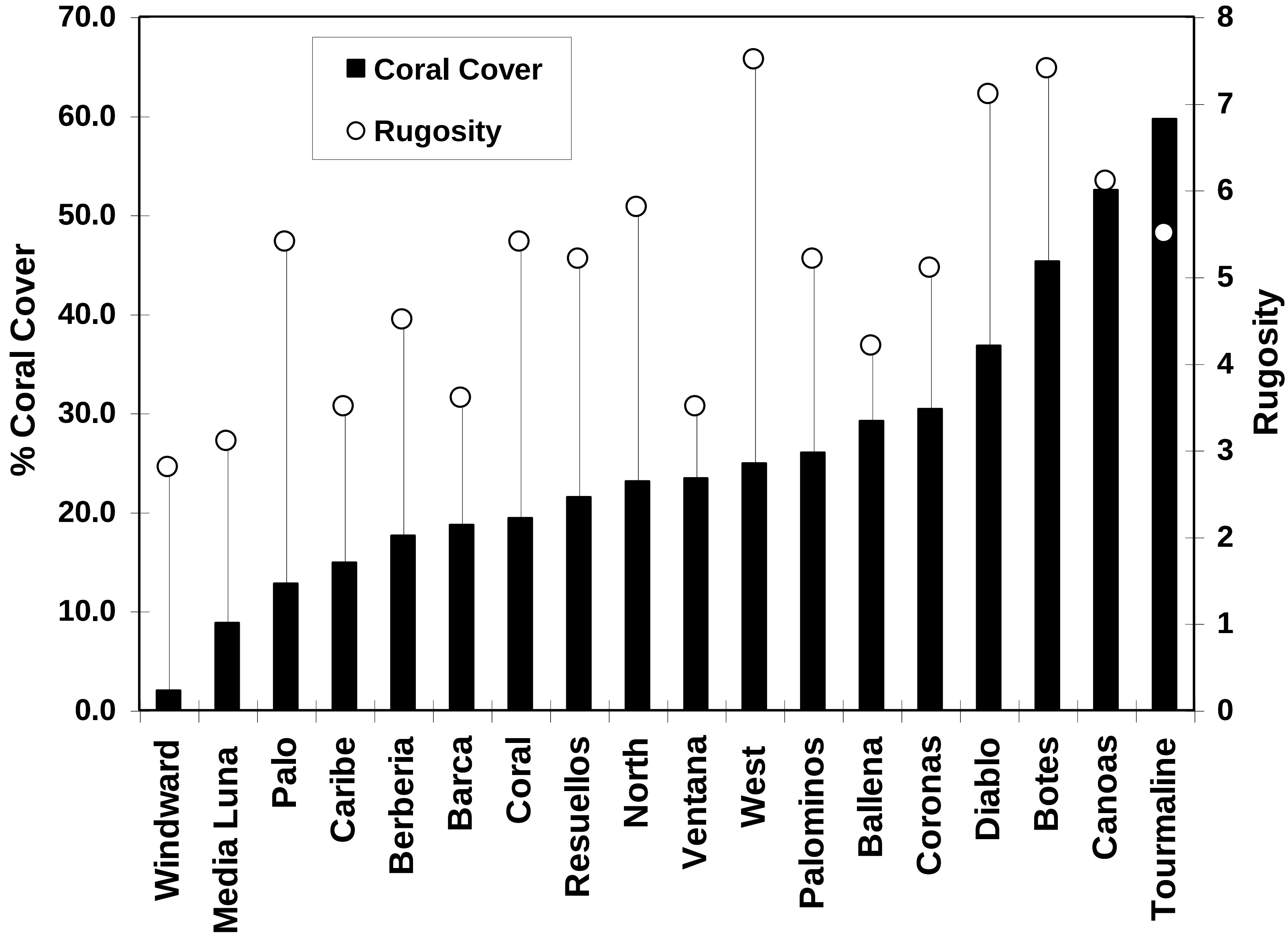


Figure 30. The relationship between Rugosity and Coral Cover at all Sites.