A SHORT-TERM STUDY TO EVALUATE THE POTENTIAL IMPACT OF FLOUNDER DRAGGERS ON THE INTERTIDAL BENTHIC HABITAT AND COMMUNITY IN THE MINAS BASIN, BAY OF FUNDY, NOVA SCOTIA

Final Report

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SUMMARY

As part of a programme to evaluate the potential impact of fishing activities on benthic systems, a short-term field study was conducted to document the changes that occur in benthic habitats and communities resulting from the activities of commercial flounder draggers. The study was carried out within the intertidal zone of the Minas Basin, Bay of Fundy to take advantage of the ability to sample and make observations within the intertidal during the long exposure times that characterize this macrotidal system. The results suggest that the impact, as measured by changes in chlorophyll a and benthic macrofauna biomass, is relatively minor. This may, however, be partly a reflection of the time the study was performed (late fall), and it is recommended that a similar study be carried out during the spring and summer when biological activity and the potential for impacts within the intertidal is greater.

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I. INTRODUCTION

The potential impact of groundfish trawling on benthic habitats and communities is currently a major concern among both fishermen and scientists. Some believe that this practice, which is widely employed by fishermen in Atlantic Canada, may be responsible for recent declines in groundfish stocks. In response to this concern the Department of Fisheries and Oceans has initiated a programme to evaluate this impact. The majority of this work will of necessity be conducted in continental shelf subtidal environments since this is where most fishing activity occurs. Impact evaluation within subtidal environments requires considerable effort and expense since observations and sampling must be made below low water using remote techniques. Within the Minas Basin of the Bay of Fundy, however, the large tidal amplitude (>12 m) results in a wide intertidal zone that remains exposed for long periods during each tidal cycle. Much of this intertidal area contains benthic communities similar to those found subtidally. This situation presents a unique opportunity to evaluate the potential habitat destruction, together with the potential for recovery, of benthic systems without the observational and sampling constraints encountered when working in subtidal environments.

During the two month period from mid-October to mid-December 1990, the Acadia Centre for Estuarine Research of Acadia University carried out a field study to determine the impact of flounder dragging on the benthic habitat and community within the intertidal area of the Minas Basin. The primary objectives of the study were:

(1) to evaluate the extent of physical and biological disturbance to benthic systems caused by flounder dragging activities; and

(2) to study and document the physical and biological changes that occurred during a two-month period following the disturbance, with particular attention being paid to the recovery potential of the benthic community.

II. ACKNOWLEDGEMENTS

This study was sponsored by the Habitat Ecology Division of the Bedford Institute of Oceanography and was funded through a Department of Supply and Services contract to the Acadia Centre for Estuarine Research. Dr. D.C. Gordon of BIO acted as scientific authority and, along with numerous other members of the Bedford Institute, aided in site selection, experimental design and aerial photography. Ms. K. Mawhinney of the Biology Department of Acadia University performed all sample collection and processing.

III. STUDY AREA

The Minas Basin is located within the upper reaches of the Bay of Fundy (Figure 1). It is a macrotidal system characterized by current velocities often exceeding 1 m s^{-1} and a tidal amplitude ranging between 11 and 14 m. The intertidal zone often extends to distances of several km from the high tide mark and in some areas may remain exposed for periods of up to six hours. Substrates within the intertidal are typically sandy forming numerous sand bars and sand flats. Mud flats are characteristic of the more protected areas. The Minas Basin presently supports about six flounder draggers that operate out of a government wharf located at Delhaven, and in the early summer of each year as many as 15 additional flounder draggers come into the Basin from other areas, often remaining for periods of up to two months.

The area selected for the field study was located within the intertidal zone along the western shoreline of the Basin. At this site the intertidal zone is about 1.5 km wide and remains exposed for periods of two to four hours. The substrate is characterized by relatively coarse sands overlain by a silty layer varying in thickness from one to several cm.

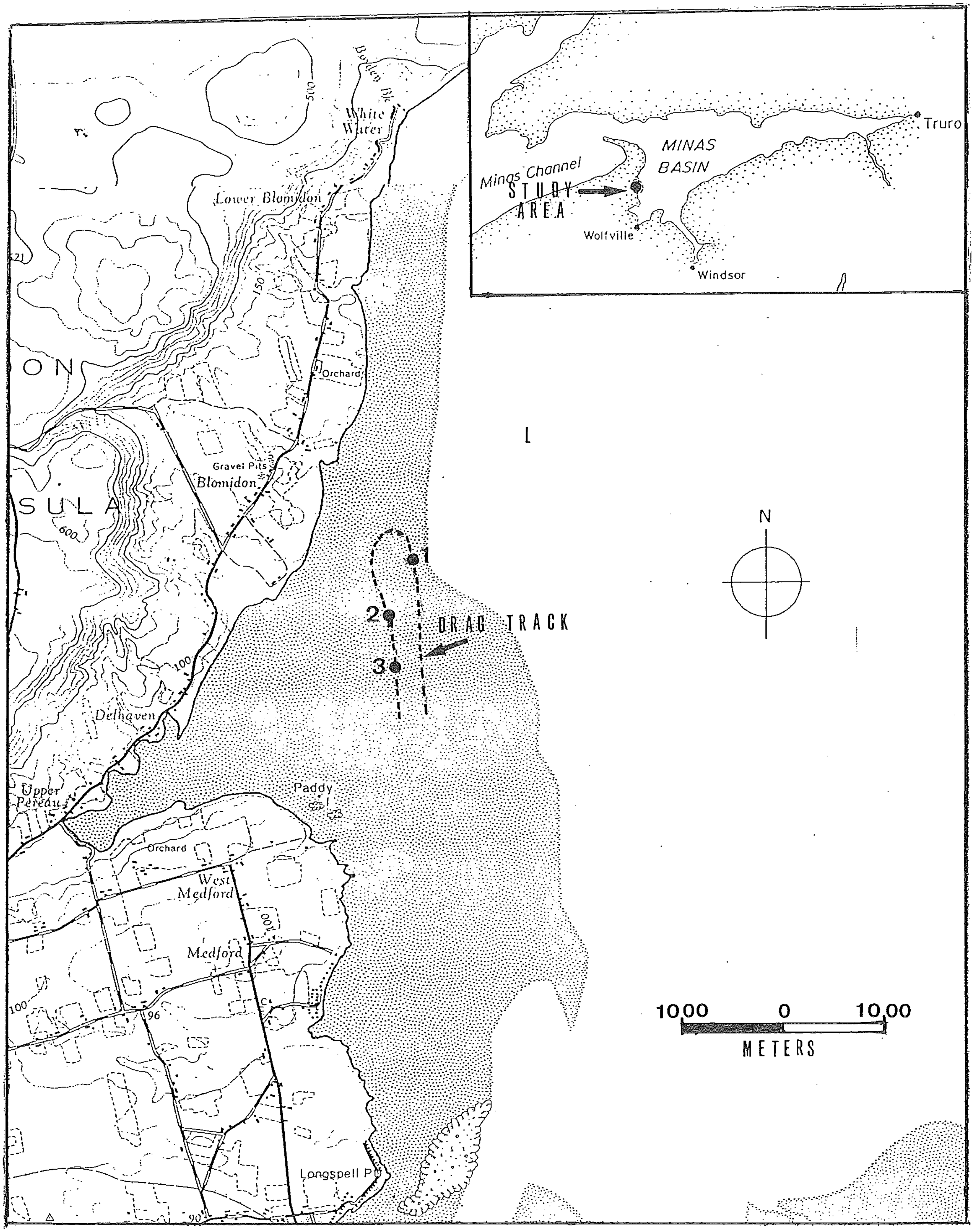


Figure 1. Overview of study site showing location, dragger transects and sampling sites

IV. METHODS

A. Dragger Transects: The study was initiated by performing a series of drags at high tide along previously marked areas of the mid-intertidal zone. The drags were carried out by a local fisherman using a 40-foot trawler towing a 60-foot flounder trawl equipped with 400-pound wooden doors. Two drags were made, each of which was about 3 km in length running parallel to the shoreline. The speed and general procedure used was typical of that normally employed during fishing operations.

B. Physical Disturbance: Immediately after exposure, the drag tracks were examined and found to be relatively uniform in terms of the degree of physical disturbance to the substrate. Measurements of the total amount of area disturbed by various portions of the trawl were made and a metering channel was installed at three representative sampling sites. The metering channel consisted of a 150-cm aluminum bar marked at 5 cm intervals and was mounted above and perpendicular to the area affected by the doors of the trawl. It served to provide both a reference for measuring physical disturbance to the sediment and to mark the location of the sampling sites. Additional records of physical disturbance and recovery were made by photography throughout the study, both from ground and air.

C. Sediment Samples: Sediment samples for grain size analysis were collected from three stations at each sampling site: one located within the disturbance created by the door of the trawl; one located within the disturbance created by the rollers of the drag's net; and one, to serve as a control, within an area outside of any disturbance. Sediment samples were collected by making surface scrapes with a small metal spatula and were stored in sealed vials. These were deposited with the Bedford Institute of Oceanography for analyses.

D. Biological Samples: Samples for biological analysis consisted of small cores for sediment chlorophyll *a* analysis, a measure of benthic diatom abundance, and larger cores for benthic macrofauna. Triplicate samples were taken at the same sites and stations as described for sediment samples.

The coring device used for obtaining chlorophyll *a* samples consisted of a 1.2 cm diameter syringe modified to sample the upper five mm of sediment. Samples were stored frozen in scintillation vials prior to analysis. Chlorophyll was extracted from the sediment sample by adding 10 ml of 90 percent acetone to the vial, hand shaking vigorously, and allowing extraction to proceed for 24 hr in the dark under refrigeration. The sample was then transferred to a 15 ml centrifuge tube and centrifuged for 15 min at 2400 rpm. The resulting supernatant was used to determine chlorophyll *a* spectrophotometrically using a 1 cm pathlength cuvette. Measurements of absorbance were made at wavelengths of 664 nm for chlorophyll and 750 nm for turbidity. Phaeophytin was also determined by making the same measurements after acidification of the sample with 0.1 ml of 1N HCL. The sediment weight of each sample was determined by oven drying at 70 C for 24. Chlorophyll *a* and phaeophytin concentrations were normalized for sediment weight.

Samples for benthic macrofauna were collected using a 10 cm diameter metal core that was inserted into the sediment to a depth of 5 - 10 cm. Samples were gently sieved in the field through a 0.85 mm mesh screen, preserved in 70 percent alcohol, and later sorted, counted and oven dried at 70 C for 24 hr to obtain species composition, numbers and dry weight estimates.

All samples were taken within close proximity to each other to avoid large-scale differences in sediment characteristics and biology, and in a systematic manner that avoided sampling within areas disturbed by previous sampling.

E. Sampling Times: Sampling times varied throughout the study. During the first two weeks samples were collected every three days and this was extended to four, five and six day intervals over the remaining three biweekly periods of the study. In some cases the sampling schedule was altered by a day or two to avoid sample collection during tidal exposures that occurred during dark. In a few instances Site 1, which was located closest to the low tide mark, did not become exposed at low water due to a combination of high onshore winds and neap tides and was not sampled.

V. RESULTS

A. Physical Disturbance:

1. Initial: Figure 2 illustrates the general morphology of the drag track in terms of the physical disturbance readily observable immediately after the track was made. The width of the track, as well as the amount and kind of disturbance, was very consistent over its entire length. The overall width of the track averaged about 23 m. The greatest degree of disturbance occurred within the door tracks which ranged between 0.75 and 0.85 m in width. Figure 3 illustrates the depth of penetration into the sediment by the door at each site immediately after the drag was made. The greatest penetration, up to 5 cm, occurred on the outer edge of the door, most of the disturbed sediment being pushed up towards the inner edge of the drag. Within the area of the drag track covered by the rollers of the net, the sediments appeared to have been slightly compressed but there was little evidence of actual scraping or sediment movement. There was also little evidence of any sediment disturbance within the bridle area between doors and net, or to the sediment surface between rollers. Calculation of the total proportion of surface area disturbed indicated that of the total area covered by the drag track about 7 percent is disturbed by the doors and 5 percent by the rollers.

2. Recovery: Documentation of the physical recovery of the sediment surface was limited to general observations and photography. Use of the metering bar to record the rate at which the door tracks filled in proved unsuccessful as the bar itself created conditions leading to excessive turbulence and erosion in its immediate surrounding area (Figure 4).

Physical recovery during the two-month sampling period was surprisingly low, despite numerous periods of strong winds and wave activity that significantly changed the nature of surface sediments. During late October, seven days after the tracks were made, strong winds resulted in water movements that removed the upper silty layer of sediments and created bedforms in the exposed sandy sediments (Figure 5). Although this made the roller marks less obvious, they could still be seen over most areas of the track, and they remained visible throughout the study. The door tracks also remained clearly visible throughout the study and were easily discernable on aerial photos made in early December (Figure 6). They did, however, begin to fill in early in the study and by the end had lost much of their definition.

B. Biology:

1. Nature of Biological Community: Sediment biology within the study area was dominated by benthic diatoms and polycheates. Some crustaceans and bivalves were found but none were particularly abundant. There was very little indication of any significant difference in pigment composition and numbers or species composition of macrofauna among the three sampling sites. The most dominant organism was *Clymenella torquata*, a tubiculous polycheate forming long straight tubes of sand and mucus. Also abundant were *Glycera dibranchiata* and *Phyllodoce mucosa*. *G. dibranchiata* is the common 'blood worm', a deep burrowing carnivorous polycheate. *P. mucosa* is also a carniverous polycheate. These three polycheates constituted about 95 percent of the total number of organisms during each sampling. Table 1 lists the invertebrate species collected in order of abundance.

2. Impact and Recovery: Figures 7 to 9 present time series of chlorophyll *a* and phaeophytin concentrations for each station at each site. The most consistent trend over the course of the study was a gradual decrease in chlorophyll *a* concentration with time. This was evident at most sites and stations including the controls. Phaeophytin concentrations showed the same general trend but a bit less consistently, particularly in the control areas which all showed a peak about mid-way through the study. At most sites the greatest decrease in chlorophyll *a* appeared to coincide with the storm event occurring during the first week of the

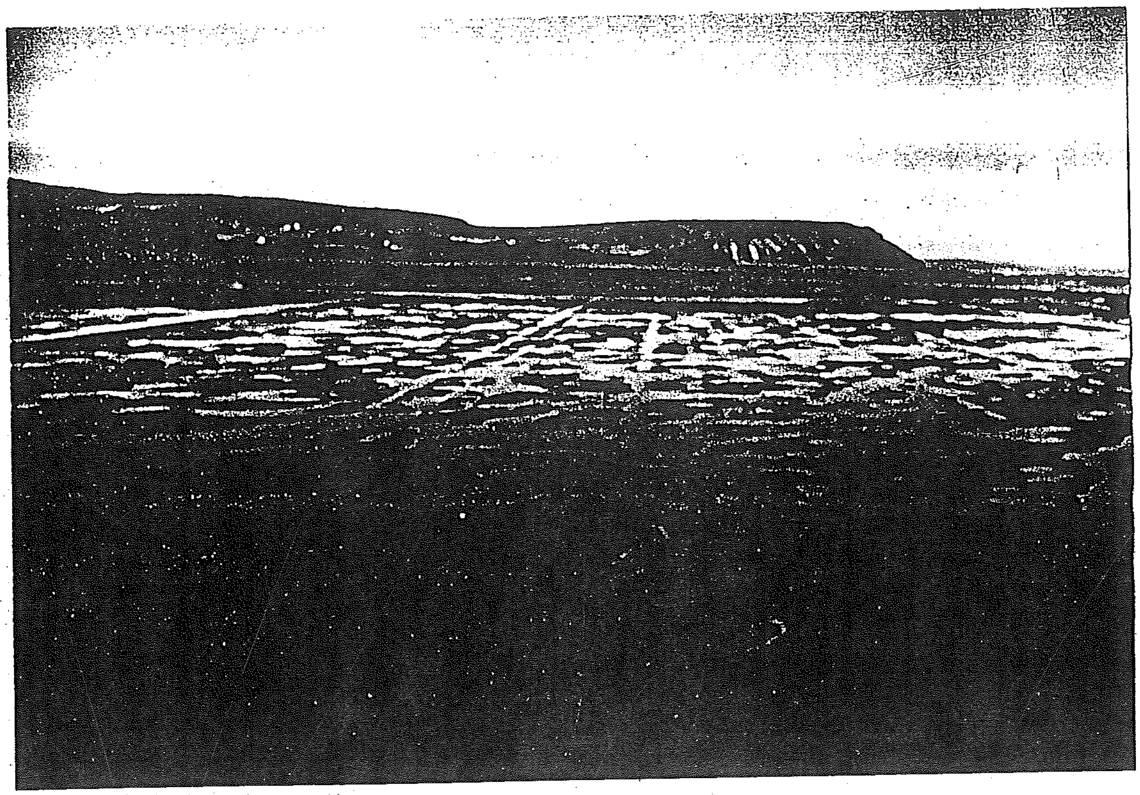


Figure 2. Photograph taken immediately after exposure of the drag track

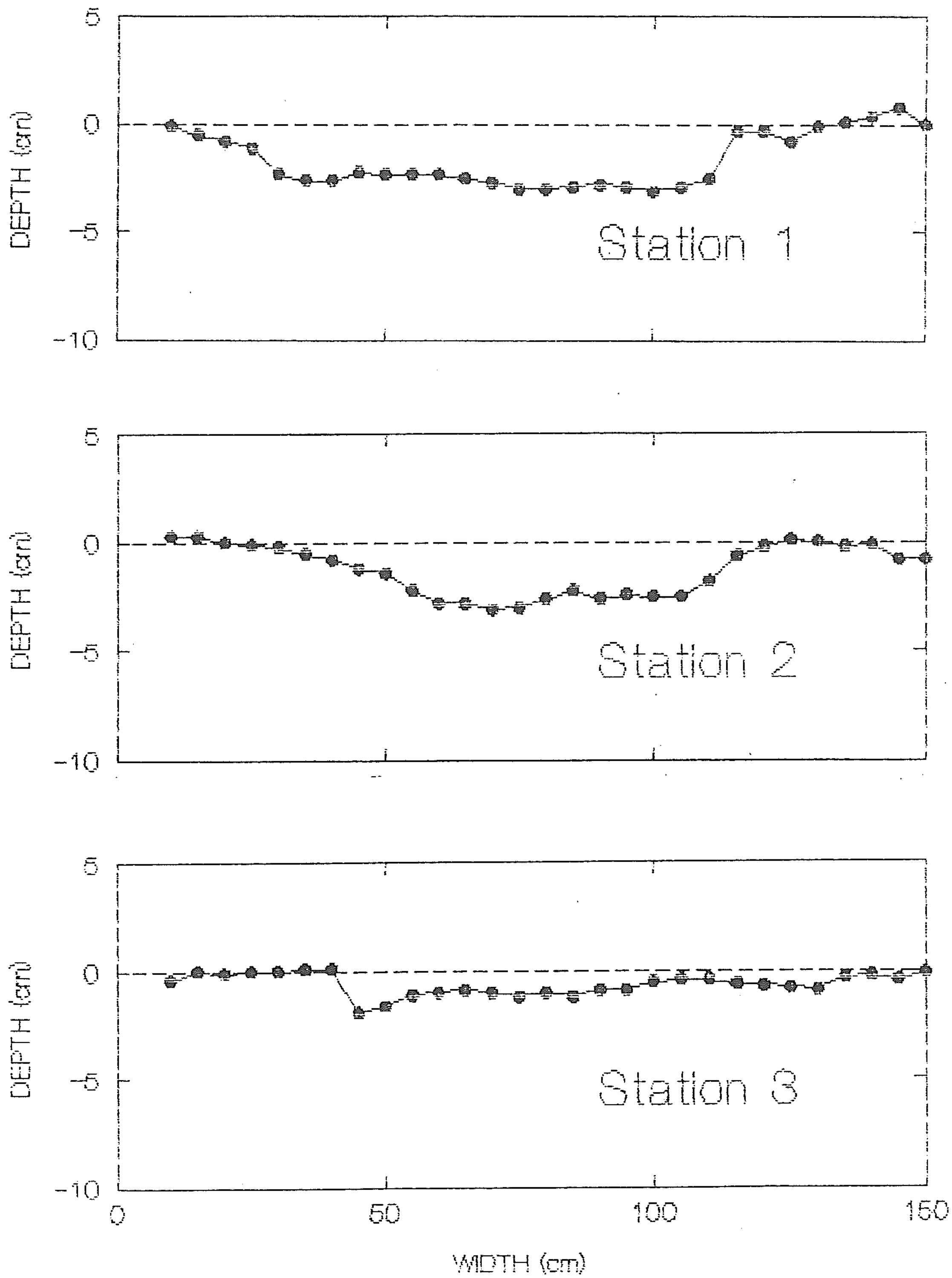


Figure 3. Depth profiles showing degree of penetration into the sediment by the doors of the drag

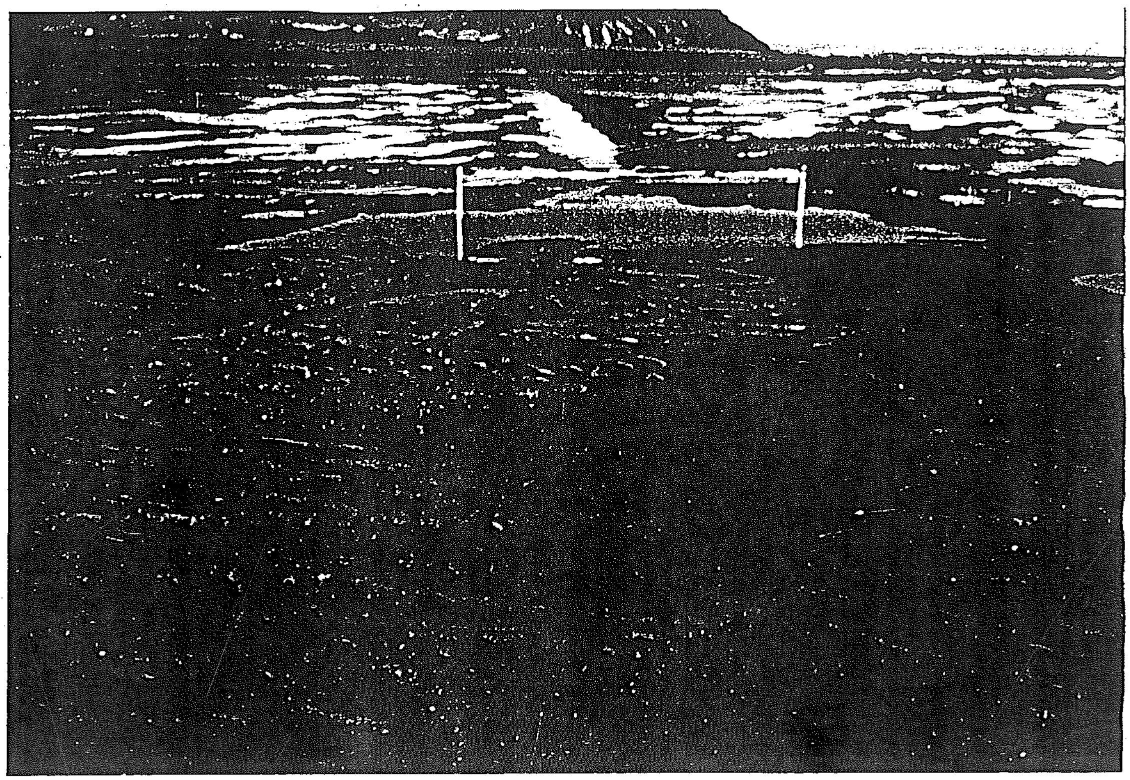


Figure 4. Metering bar at Site 1 showing local erosion created by the bar

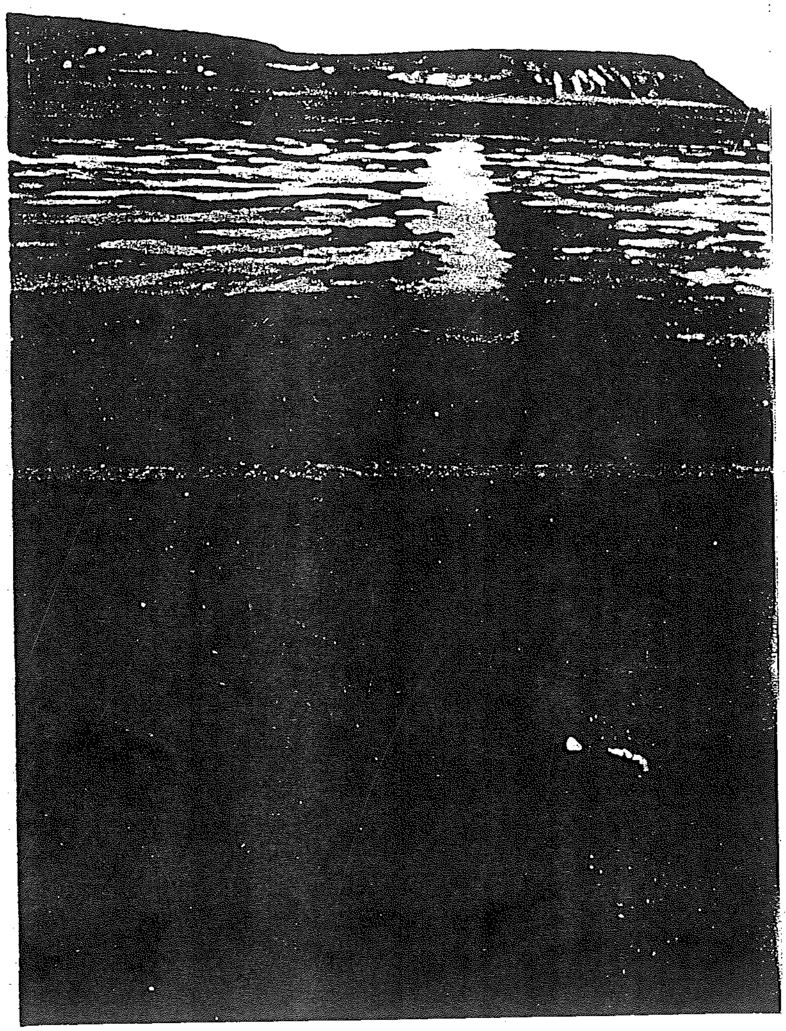
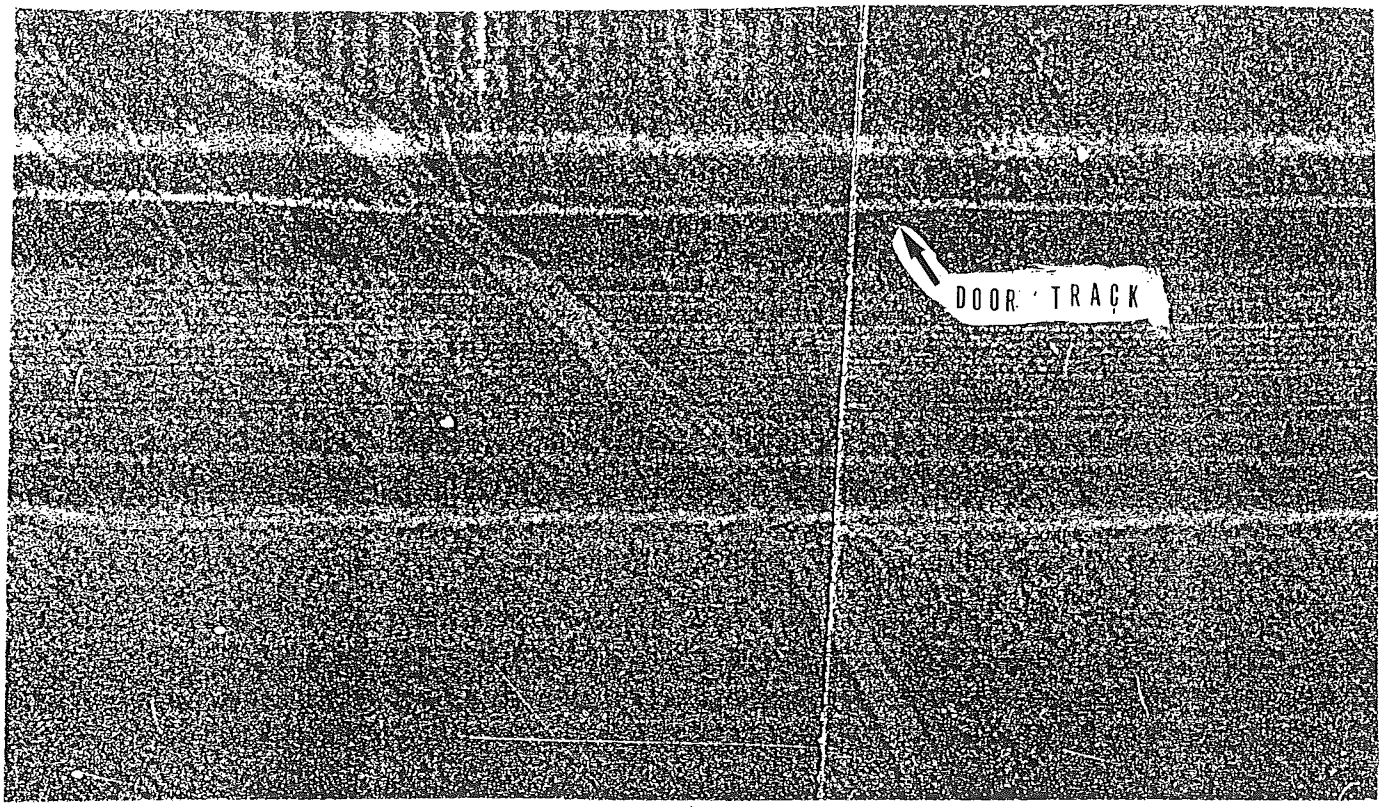


Figure 5. Photograph of drag track after Day 7 when storm events removed the silty surface layer and created bedforms in the underlying sand



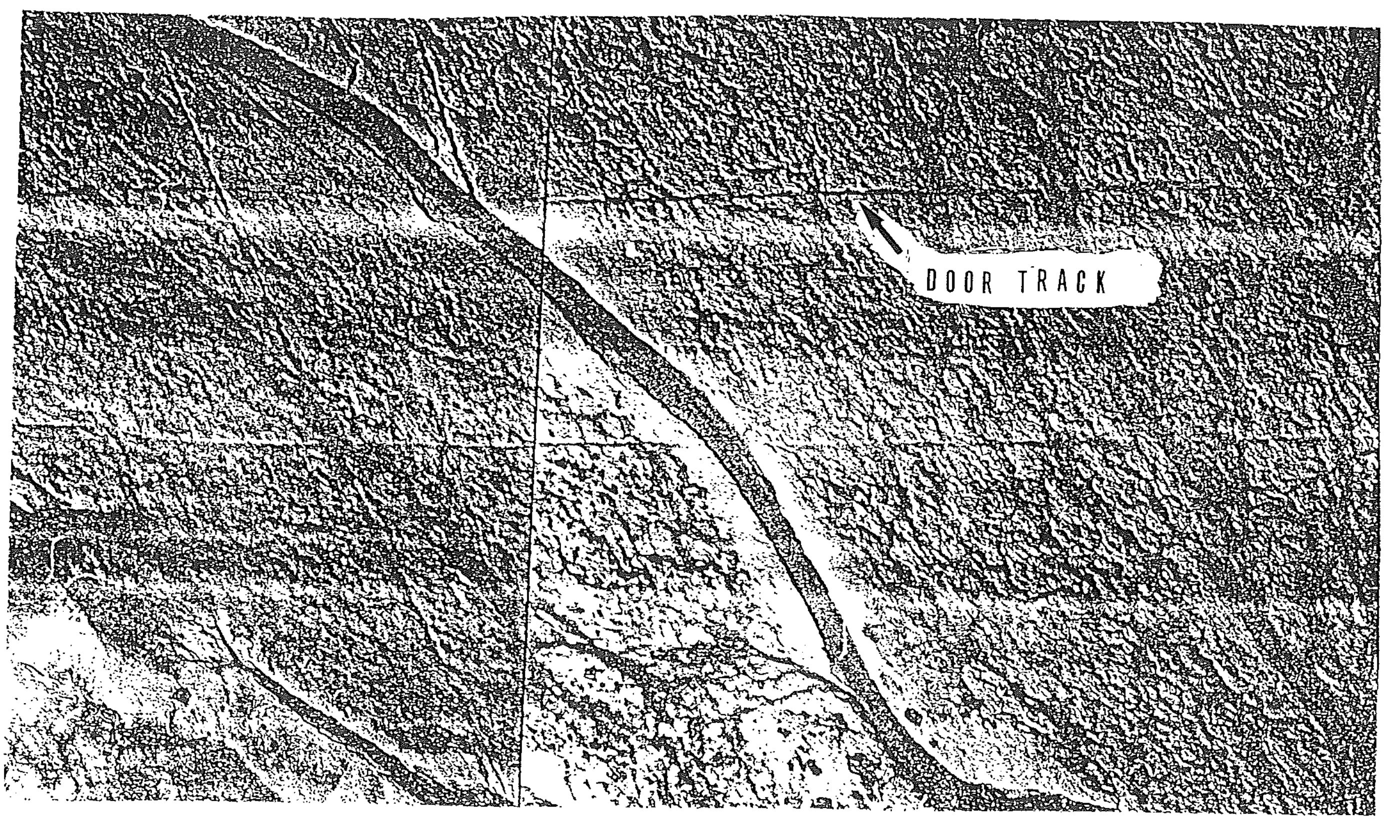


Figure 6. Aerial photographs showing drag tracks the day after being made (upper) and on December 7 (lower), 46 days later

Table 1. Invertebrate macrofuna present at study site.

Clymenella torquata
Glycera dibranchiata
Phyllodace mucosa
Crangon septemspinosa
Nereis diversicola
Odostomia bisuturalis
Chiridotea coeca
Idotea phosphorea
Crenella glandula
Glycera robusta
Ophioglycera gigantia
Cancer borialis
Corophium volutator
Nassarius trivittatus
Cancer irroratus
Cerebratulus lacteus

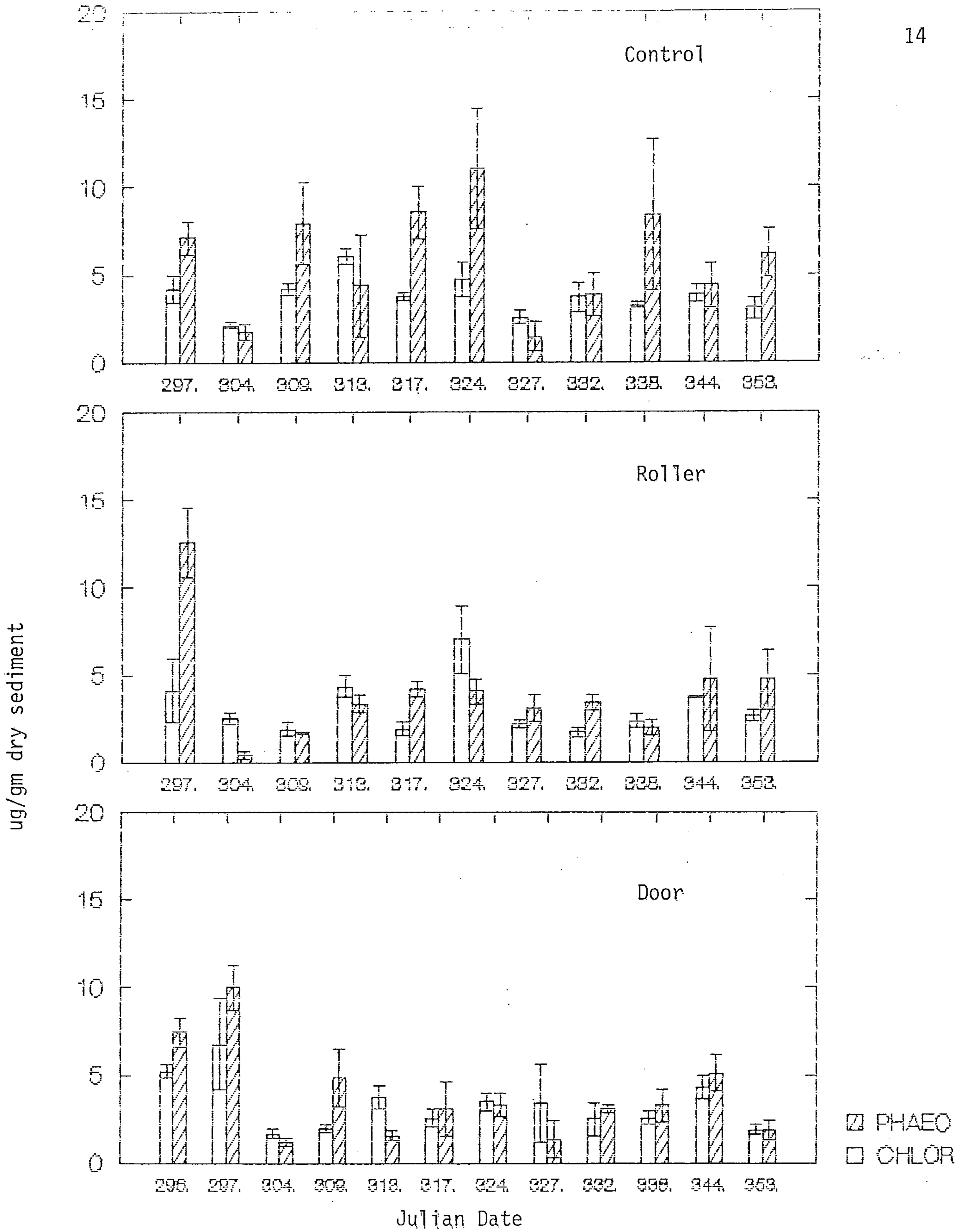


Figure 7. Time series of chlorophyll a and phaeophytin at Site 1 (error bars are 1 SE of mean)

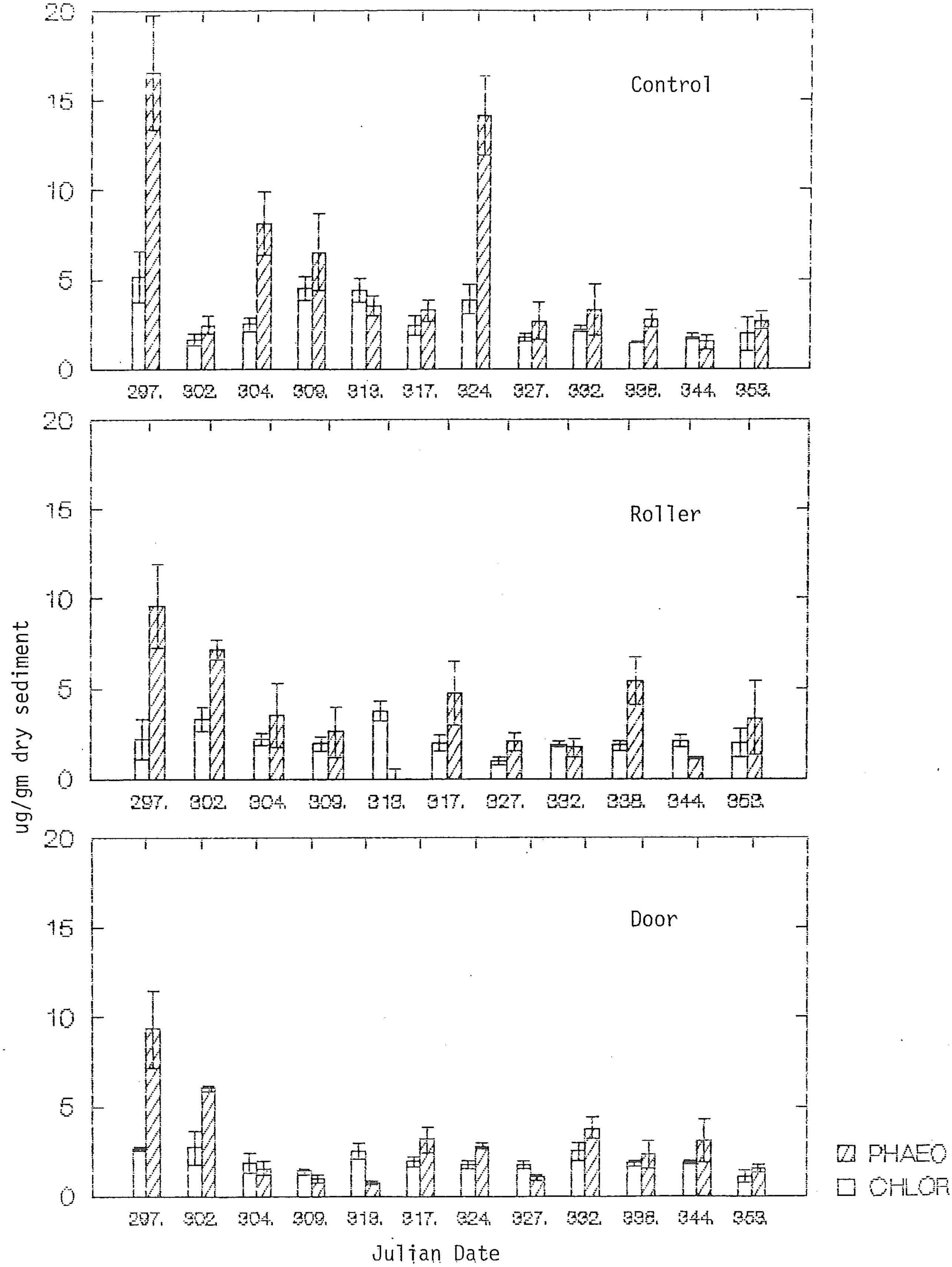


Figure 8. Time series of chlorophyll a and phaeophytin at Site 2
(error bars are 1 SE of mean)

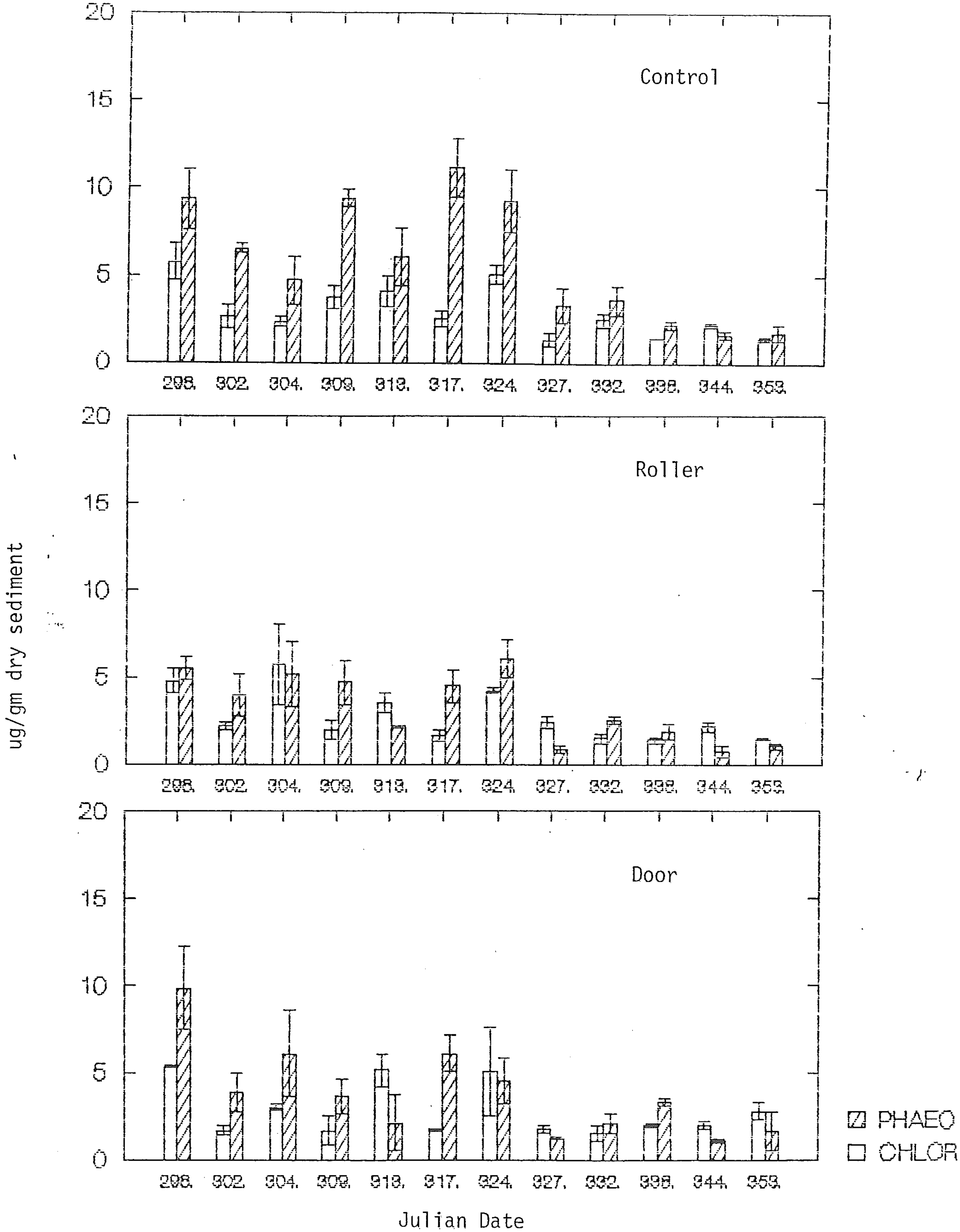


Figure 9. Time series of chlorophyll a and phaeophytin at Site 3 (error bars are 1 SE of mean).

study. As noted previously, this resulted in the removal of the upper surface layer of sediments and formation of bedforms and probably caused chlorophyll to become either buried or exported from the intertidal. An ANOVA of chlorophyll *a* for all sites showed significant differences between sites which prohibited the pooling of all data. Table 2 presents the results of an ANCOVA on individual sites with date as the covariate. Although all stations (control, roller and door) show significant changes with time, only at Site 2 was there a significant difference between stations. At this site the door and roller areas contained less chlorophyll *a* than the control.

Surprisingly, there were no consistent differences in the numbers or species composition of macrofauna, either between or among sites and stations, with time. Figures 10 to 15 present time series of the numbers and biomass of the three most common polycheates. An ANOVA on all data for the total number of the three major polycheates showed significant differences between sites. An ANCOVA on individual sites (date as covariate), however, showed no significant differences between stations at individual sites. There were, however, significant differences with time at stations 1 and 3 (Table 3).

Table 2. Results of ANCOVA on chlorophyll *a*.

SOURCE	SS	DF	MS	F-ratio	p
SITE 1:					
STATION	7.596	2	3.798	1.135	0.325
DAY	12.321	1	12.321	3.683	0.048
ERROR	327.858	98	3.345		
SITE 2:					
STATION	13.014	2	6.507	5.187	0.007
DAY	19.185	1	19.185	15.292	0.000
ERROR	126.714	101	1.255		
SITE 3:					
STATION	1.105	2	0.553	0.203	0.816
DAY	52.794	1	52.794	19.407	0.000
ERROR	282.923	104	2.720		

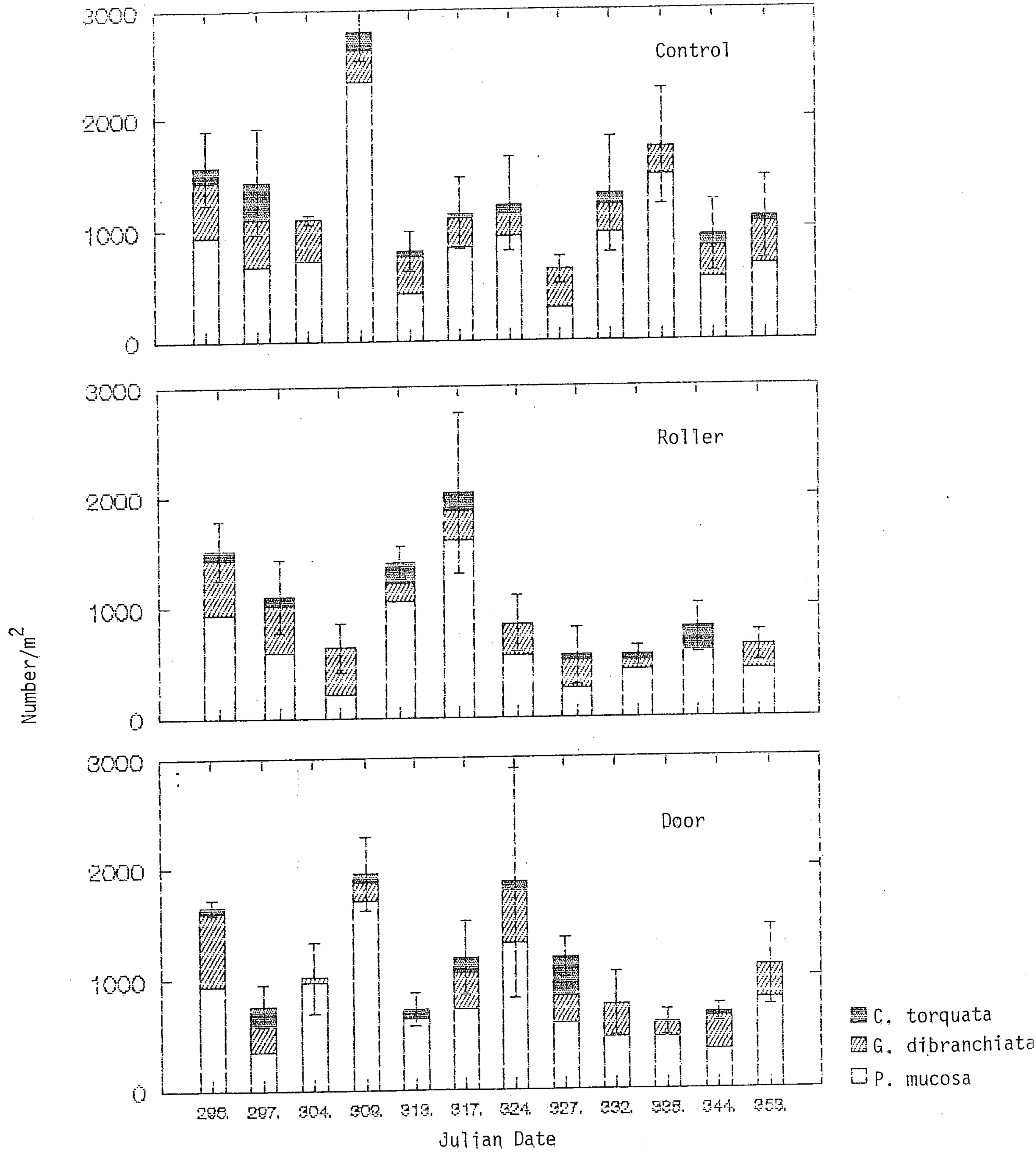


Figure 10. Time series of numbers of the three dominant polycheates - Site 1 (error bars are 1 SE of mean)

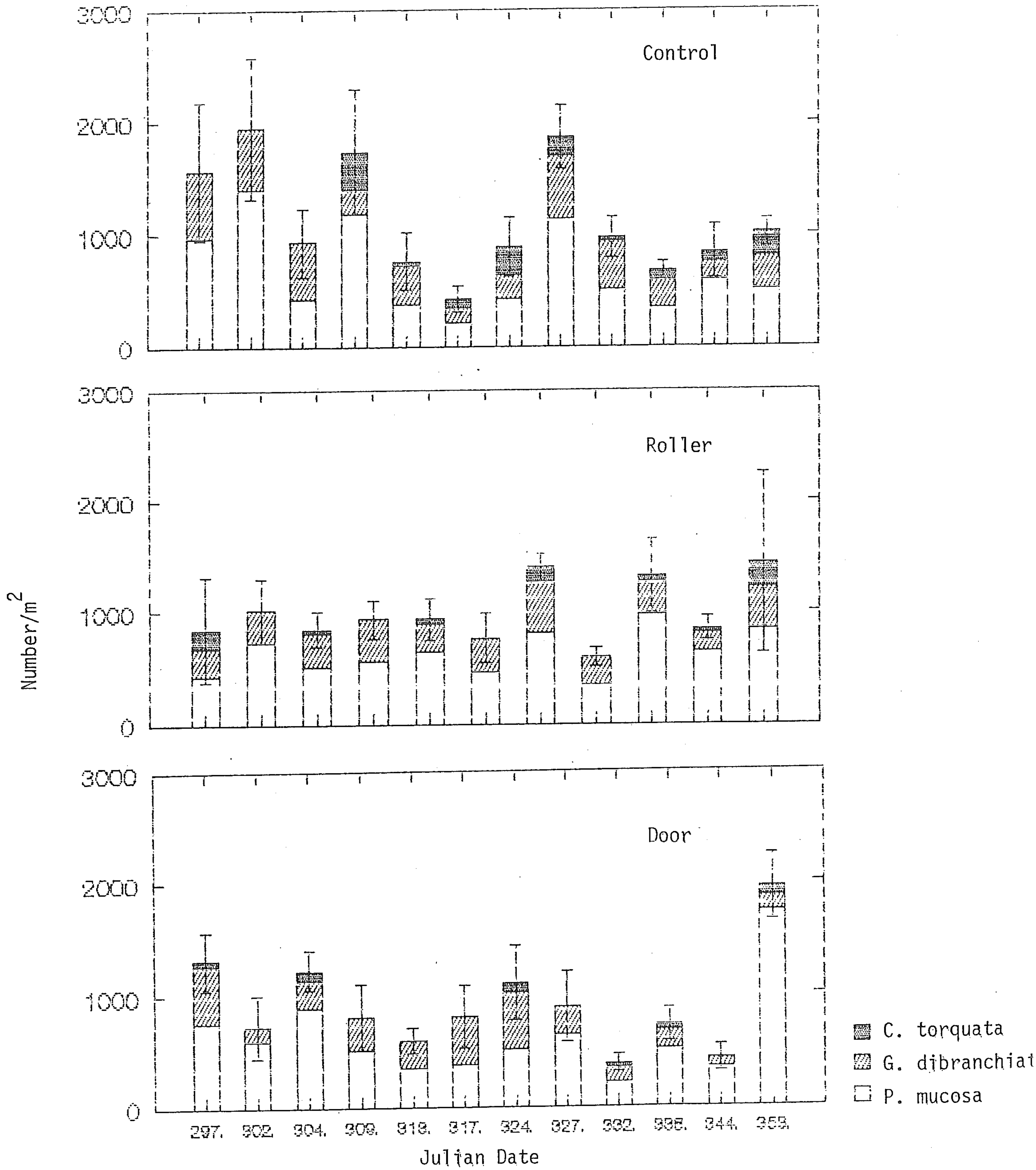


Figure 11. Time series of numbers of the three dominant polycheates - Site 2 (error bars are 1 SE of mean)

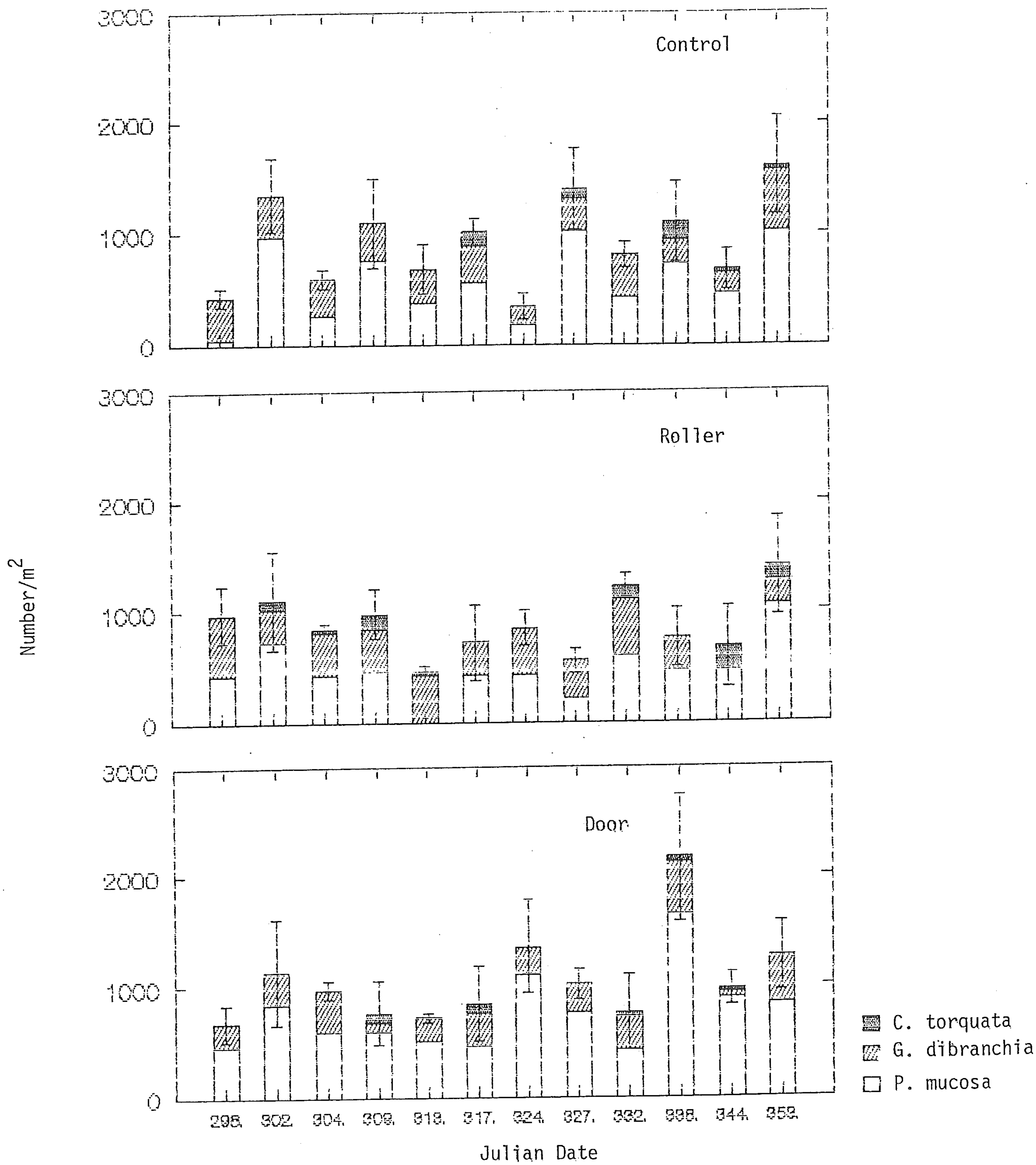


Figure 12. Time series of numbers of the three dominant polycheates - Site 3 (error bars are 1 SE of mean)

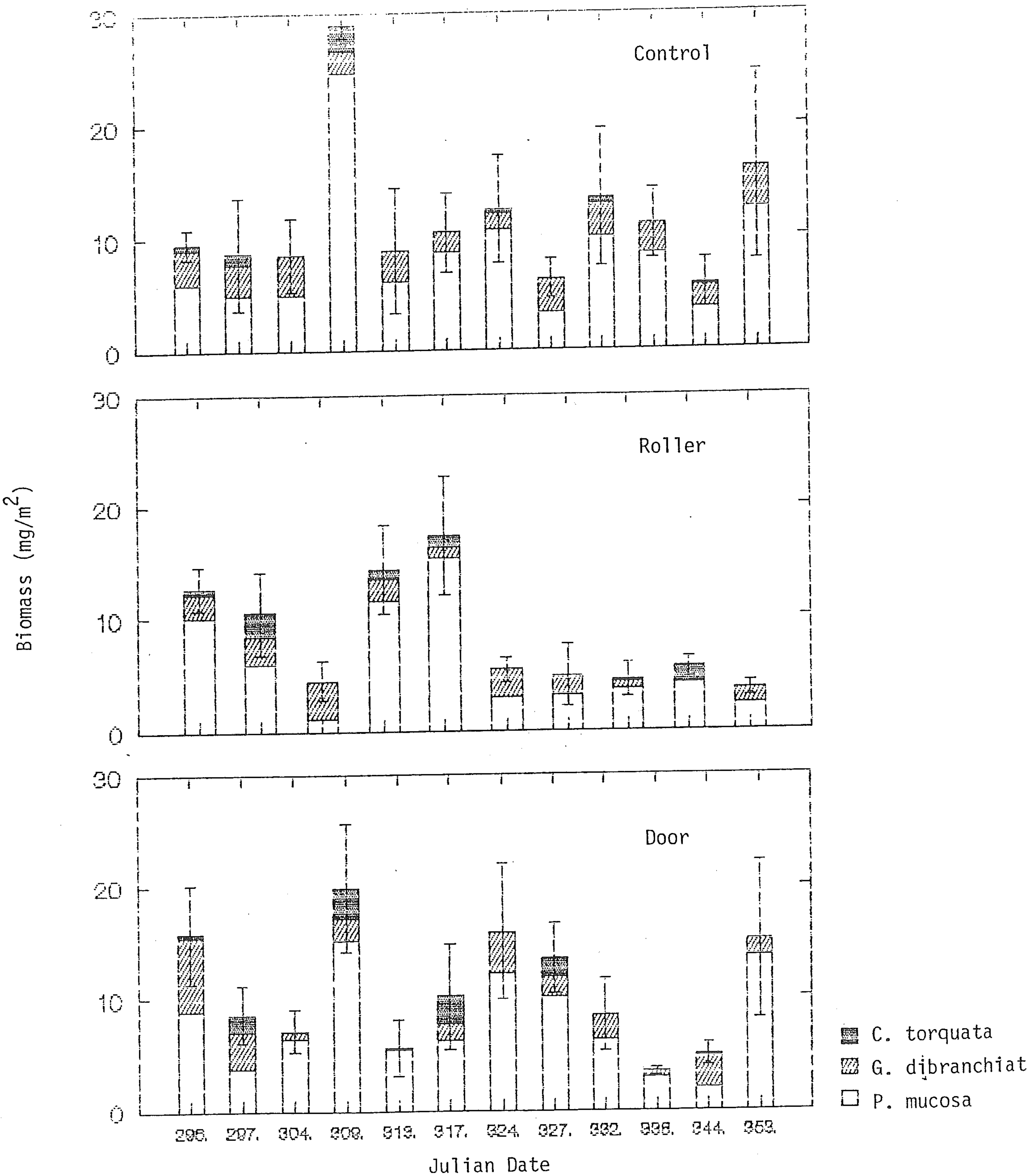


Figure 13. Time series of biomass of the three dominant polycheates - Site 1 (error bars are 1 SE of mean)

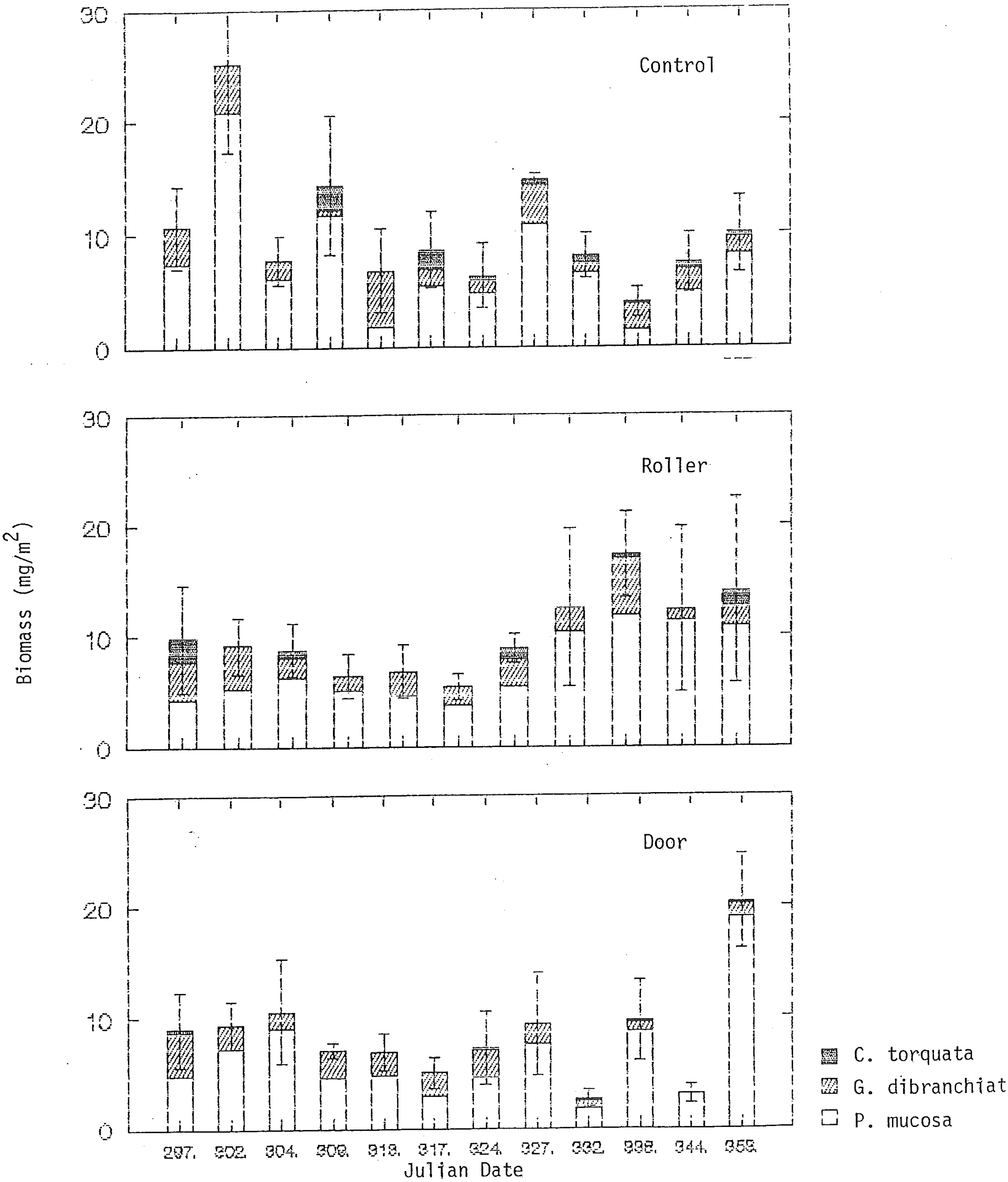


Figure 14. Time series of biomass of the three dominant polycheates - Site 2 (error bars are 1 SE of mean)

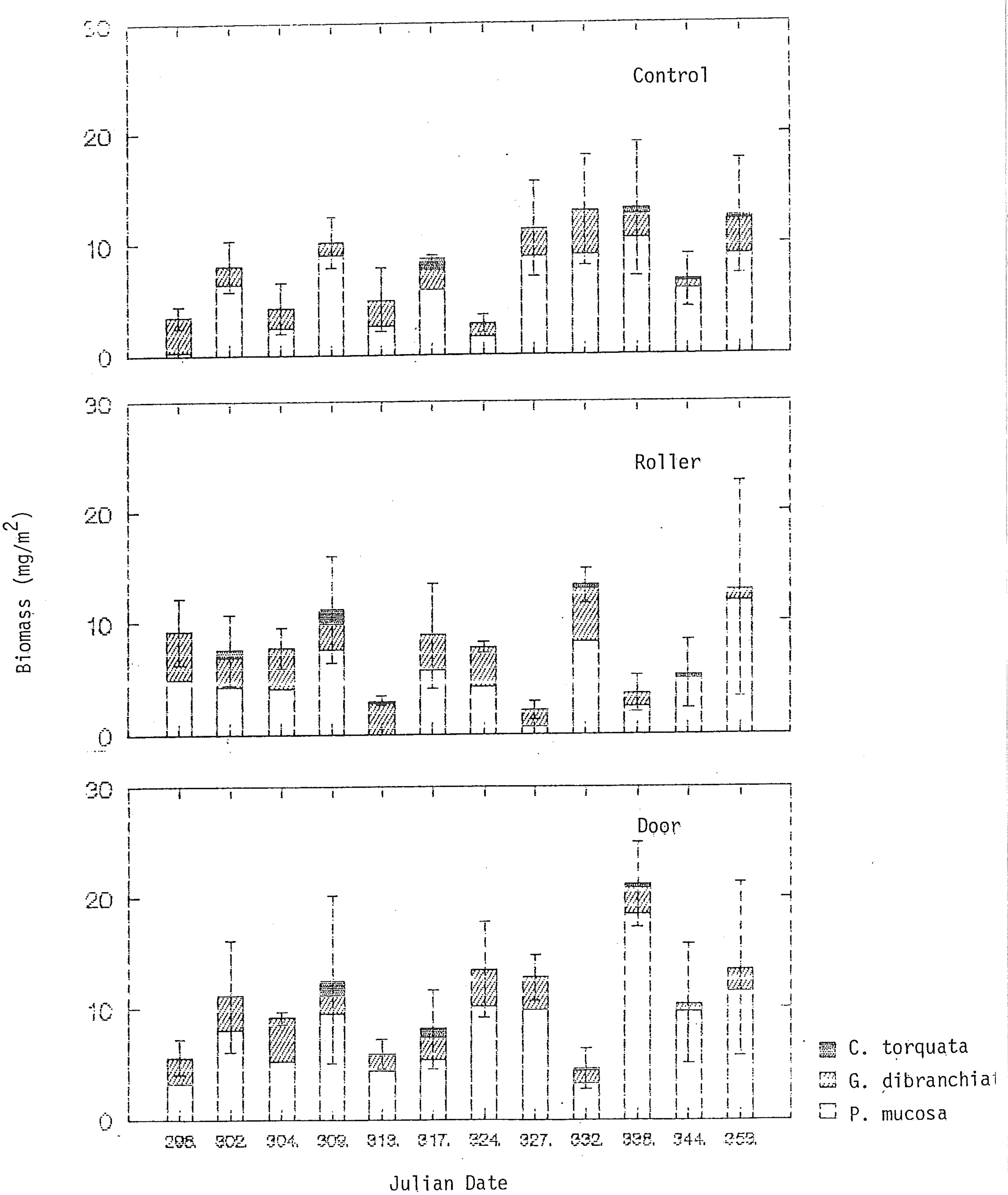


Figure 15. Time series of biomass of the three dominant polycheates - Site 3 (error bars are 1 SE of mean)

Table 3. Results of ANCOVA on total number of the three dominant polycheates.

SOURCE	SS	DF	MS	F-ratio	p
SITE 1:					
STATION	69.114	2	34.557	1.122	0.330
DAY	190.966	1	190.966	6.202	0.014
ERROR	3017.678	98	30.793		
SITE 2:					
STATION	27.907	2	13.953	0.551	0.578
DAY	4.375	1	4.375	0.173	0.679
ERROR	2558.256	101	25.329		
SITE 3:					
STATION	34.463	2	17.231	0.932	0.397
DAY	75.831	1	75.831	4.104	0.045
ERROR	1921.808	104	18.479		

VI. DISCUSSION

The results of this study clearly suggest that the physical disturbance caused by flounder draggers has relatively little impact on the benthic community. The reason for this is probably related to both the type of benthic community present in the study area as well as to the time the study was performed. The most abundant organism inhabiting the sediments is *C. torquata* which burrows to depths of 10 - 15 cm. Although the upper portions of its tubes may be removed by the doors of the dragger, it may be able to detect the oncoming of the drag and avoid being physically damaged by moving deeper into its tube. Most of the other macrofauna present were free living and, although some may become damaged by the drag (although there was little evidence of this during sample processing), most are probably simply redistributed for a short period of time. The lack of any significant change in chlorophyll *a* levels is probably more a result of the time the study was undertaken. Sediment chlorophyll within the Minas Basin typically peaks during late July and then declines as a result of decreasing daylength. Phaeophytin concentrations, however, probably increase and it is likely that during the study period the active chlorophyll was largely masked by phaeophytin making small changes in chlorophyll *a* difficult to detect.

It is recommended that a study similar to the one described here be carried out during the spring and summer of the year. During this time biological processes in the sediments are more active and any significant impacts would be easier to detect. This is also the time when dragger activity is greatest and is therefore a more relevant time to carry out a study of this sort.