Effects of Commercial Fishery Trawling on Intertidal Benthic Communities in the Minas Basin

Final Report

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SUMMARY

As part of a programme to evaluate the potential impact of fishing activities on benthic systems, a 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 meiofauna and macrofauna numbers, is relatively minor.

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I. INTRODUCTION

The potential impact of groundfish trawling on benthic habitats and communities is currently a major concern among both fisherman and scientists. Some believe that this practice, which is widely employed by fisherman 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 work is being 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 a two month period from mid-October to mid-December 1990, the Acadia Centre for Estuarine Research carried out a preliminary field study to determine the impact of flounder dragging on the benthic habitat and community within the intertidal area of the Minas Basin. The objectives of the study were to evaluate the extent of physical and biological disturbance to benthic systems caused by flounder dragging activities, and to document the subsequent changes over time paying particular attention to the recovery potential of the benthic community. The results of this preliminary study suggested that the impact, as measured by changes in sediment chlorophyll *a* and benthic macrofauna numbers, was relatively minor. This study, however, was carried out during late fall when biological activity is decreasing and thus may not have been indicative of the potential impact of draggers operating during the spring and early summer when biological activity is much greater, and when most dragger activity occurs. To address this concern a similar study was carried out during the spring and summer of 1991.

II. ACKNOWLEDGEMENTS

This study was sponsored by the Habitat Ecology Division of the Bedford Institute of Oceanography and was funded through a DFO/NSERC subvention grant. Dr. D. C. Gordon of BIO acted as liaison officer and, along with numerous other members of the Bedford Institute, aided in site selection, experimental design and aerial photography. Patricia Burt identified the macrofauna species and Kuflom Kuflu assisted in the field.

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 late spring and 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 areas selected for study are located within the intertidal zone along the western shoreline of the Basin. Studies were carried out at two sites; Houston Beach, located just North of Delhaven, and Porter Point to the south of Kingsport (Figure 1). At both sites the intertidal area is about 1.5 km wide and remains exposed for two to four hours. The two sites differ from each other in both physical and biological characteristics. The substrate at Houston Beach consists of relatively coarse sands overlain by a silty layer varying in thickness from one to several cm, and the biological community is dominated by three species of polycheates (*Clymenella torquata, Spiophanes bombyx* and *Nephytes caeca*). The Porter Point site has a siltier substrate which is relatively uniform to a depth of 10 cm, and the biological community is much less diverse consisting largely of the one polycheate species (*Heteromastis filiformis*).

IV. METHODS

A. Dragger Transects: The study was initiated in late May, 1991 by performing a series of drags parallel to the shoreline at previously marked locations in the mid-intertidal zone. The drags were carried out by a local fisherman using a 40 foot trawler towing a 60 foot flounder trawl. At Houston Beach the trawl was equipped with 400 pound Westpick wooden doors. At Porter Point # 2 1/2 metal Bison doors were used. The speed (ca 2 knots) and operating procedure were typical of those normally employed during fishing. On 16 June an additional drag was made at Houston Beach nearer to the low tide mark and running diagonally toward the shore. This drag was made by a 43 foot trawler towing an 80 foot flounder trawl fitted with # 6 metal Bison doors.

Immediately after exposure each track was examined and found to be relatively uniform in terms of the degree of physical disturbance and a sampling station was established along a representative section of the track.

B. Physical Disturbance: At each sampling station a metering channel was used to determine the initial disturbance and rate of recovery of the sediment surface caused by the door tracks. The metering channel consisted of a 150 cm long aluminium bar marked at 5 cm intervals. When making measurements the bar was set atop two reference stakes permanently set into the substrate. The distance from the bar to the substrate was measured at 5 cm intervals along the bar and these measures were used to produce profiles of the door track over time. The metering bar was removed between sampling times as previous studies showed that the bar itself created excessive turbulence and erosion of sediments in its immediate surrounding area.

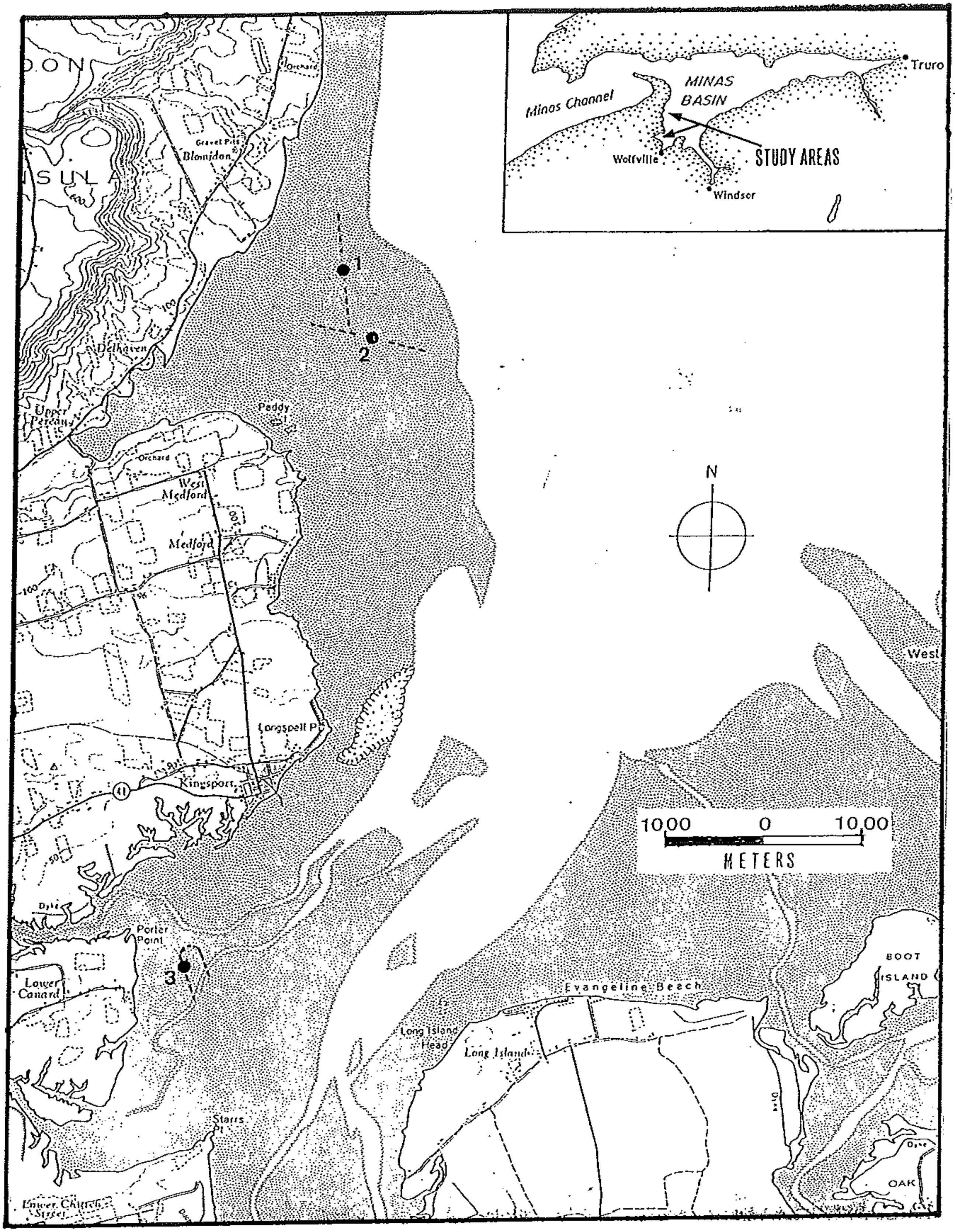

Figure 1. Overview of study site showing location, dragger transects and sampling sites.

Additional records of physical disturbance and recovery were made by photography throughout the study, both from the ground and the air.

C. Biological Samples: Biological sampling consisted of taking core samples for sediment chlorophyll *a* (a measure of benthic diatom abundance), benthic meiofauna (mainly nematodes) and benthic macrofauna. Samples were taken from an area within the door track and from a control area located outside of the area disturbed by the trawl. Care was taken to avoid taking samples from areas that had been disturbed by previous sampling.

The coring device used for obtaining sediment chlorophyll samples consisted of a 1.2 cm diameter syringe modified to sample the upper 5 mm of sediment. At each sampling time six samples were taken from within the track and six from the control area. Samples were stored frozen in scintillation vials prior to analysis. Chlorophyll was extracted from the sediment sample by adding 10 ml of 90 % acetone to the vial, hand shaking vigorously, and allowing extraction to proceed for 24 hr in the dark under refrigeration. Samples appearing excessively turbid were transferred to a 15 ml centrifuge tube and centrifuged for 15 min at 2400 rpm. The acetone extract was then transferred to a 1 cm pathlength cuvette and measurements of absorbance made at wavelengths of 664 nm for chlorophyll and 750 nm for turbidity. The sediment weight of each sample was determined by oven drying at 70 C for 24 hr.

Nematode samples were collected using a 2.6 cm dia syringe modified to sample the top 2 cm of sediment. Samples were transferred to vials and preserved in 10 % formalin. Triplicate samples were taken from both within the door track and from the control area. Prior to enumeration, the nematodes were stained with rose bengal by transferring each sample to a beaker containing 75 ml of filtered sea water containing the dye. The number of nematodes in each sample was determined by subsampling the mixture while it was slowly stirred, transferring the subsample to a petri dish and counting the nematodes using a binocular microscope. The size of the subsample varied from .5 to 2 ml depending on the amount of turbidity caused by sediments in the subsample and the number of nematodes present. Subsampling continued until further subsampling produced little change in the mean number of nematodes per sample. In most cases five subsamples proved adequate.

Triplicate samples for benthic macrofauna were collected from the door and control areas using a 10 cm dia metal core that was inserted into the sediment to a depth of 10 cm. Samples were gently sieved in the field through a 850 um mesh screen, preserved in 70 % alcohol, and later sorted and enumerated by species.

D. Sampling Schedule: The frequency of sampling at each site varied depending on the rate of physical recovery of the drag track, and on the difference in biological parameters between the door track and control. At the site of the first Houston Beach drag samples were collected at approximately weekly intervals for a period of two months. The second Houston Beach drag was sampled at weekly intervals for the first month, and then twice afterwards at 58 and 109 days. The Porter Point site was sampled most intensely. Weekly samples were collected for about two months after the drag was made and then again at 104 and 126 days.

V. RESULTS

A. Physical Disturbance:

1. Initial: The extent of the initial physical disturbance caused by the trawls varied greatly between sites. The least disturbance was caused by the first trawl at Houston Beach. Both the door track and roller marks were visible, and the sediments appeared to have been compressed to a depth of .5 to 2 cm, but there was little evidence of actual scraping or gouging of the sediment surface. The second Houston Beach trawl created more disturbance, probably because of the larger size of the trawl. The door left a track about 60 cm wide varying in depth to a maximum of about 2 cm (Figure 2a).

The greatest amount of physical disturbance occurred at the Porter Point site. Roller tracks were visible, but the rollers did not appear to scrape the sediments. Most of the disturbance was caused by the doors which created a furrow about 30 cm wide and 5 cm deep and deposited the sediment along the inside of the track as a mound about 5 cm high (Figure 2b).

2. Recovery: Due to the minimal physical impact of the first Houston Beach trawl, it was not possible (with the method used) to quantitatively monitor the recovery of sediments in the door track. However, observations were made and photographs taken of the track on each visit to the site. Despite the minimal disturbance of the sediment, the track remained clearly visible until early July, more than two months after it was made. From then onward the track became gradually less distinct and by early October it could no longer be seen.

At the site of the second Houston Beach drag, and at the Porter Point site, the greater physical disturbance created by the trawl allowed the recovery of the substrate to be monitored quantitatively. At Houston Beach recovery was rapid. After 16 days the track was less than 1 cm deep and after 58 days it was not visible. At Porter Point the furrow filled in more slowly. After 49 days it was half filled and after 126 days it had completely filled, but was still visible. The mound of sediment deposited alongside the track slowly eroded and was no longer visible after 49 days. Figures 3 and 4 illustrate the time course of recovery.

B. Biology

1. Nature of Biological Community: Sediment biology within the study area was dominated by benthic diatoms, nematodes and polycheates. Some crustaceans and bivalves were found but none were particularly abundant. Benthic diatom abundance, as measured by sediment chlorophyll *a*, was about twice as great at the Porter Point site than at the Houston Beach sites. This was also true of nematodes. At Houston Beach the most dominant polycheate was *Clymenella torquata*, a tubiculous polycheate forming long straight tubes of sand and mucus. Also abundant were *Spiophanes bombyx* and *Nephytes caeca*. *S. bombyx* is a tube-building polycheate and *N. caeca* is a predaceous burrowing polycheate. All of these species occur subtidally to depths greater than 100 m. These three polycheates constituted about 95 percent of the total number of macrofauna during each sampling. Macrofauna at the Porter Point site was dominated by one polycheate, *Heteromastis filiformis*, a burrowing polycheate very abundant in soft muds and found subtidally to depths of 60 m.

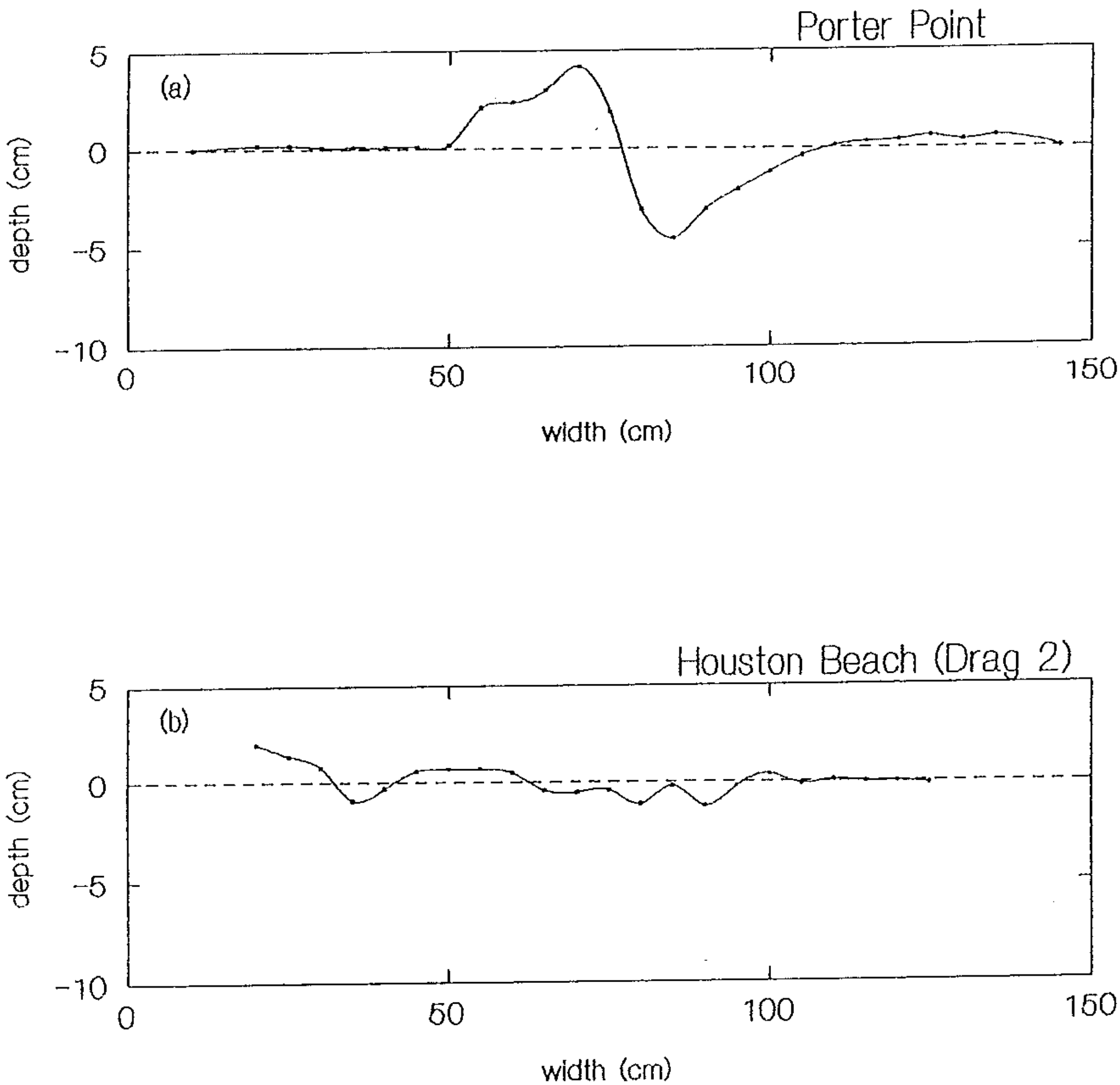

Figure 2. Profile of door tracks one day after the drag was made.

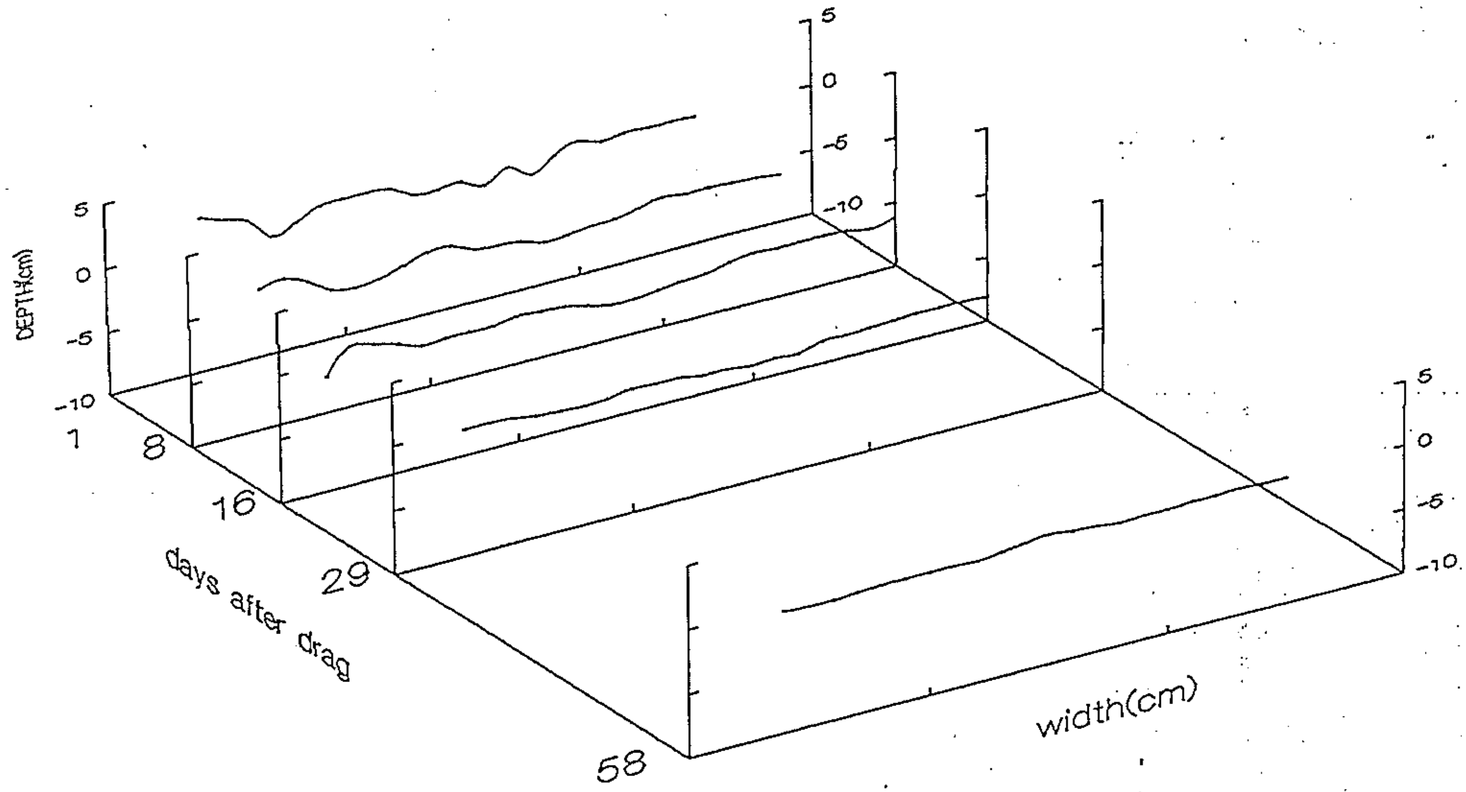

Figure 3. Time series of door track profiles at Houston Beach (Drag 2)

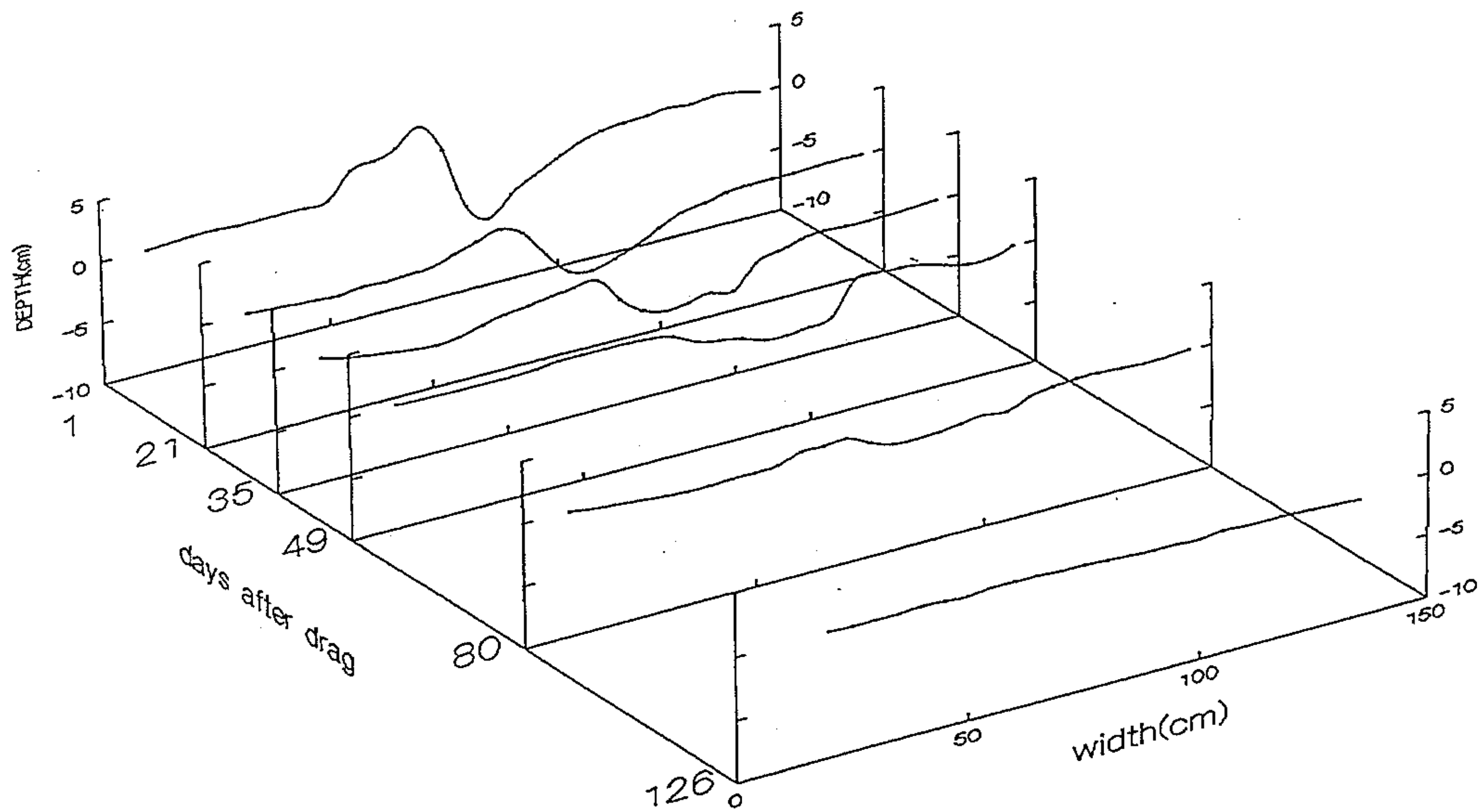

Figure 4. Time series of door track profiles at Porter Point.

2. Impact and Recovery: Figure 5 shows time series of chlorophyll *a* concentrations for each site. At the two Houston Beach sites the door stations had slightly lower chlorophyll *a* levels than the controls for the first 3-4 weeks after the drag was made. After that time there was little difference between the two. The Porter Point site showed a similar response but with a much greater depression of chlorophyll *a* at the door station. After about three months, however, chlorophyll *a* levels in the door track were about twice that of the control and benthic diatom blooms could easily be seen along the length of the track.

There was no obvious impact on the polycheate community at either of the two Houston Beach drags. Immediately after the drags were made polycheate numbers were slightly lower within the drag track, but the differences were not statistically significant ($p>0.05$), and afterwards the door track and control showed no consistent difference in either polycheate numbers (Figure 6a and b) or species composition (Figure 7).

At the Porter Point station polycheate numbers were very low when the drag was made and did not increase substantially until about 30 days afterward. Initially the rate of increase was slightly greater at the control (Figure 6c), but after about seven weeks there was little difference in polycheate numbers at the control and within the door track.

Nematodes exhibited a more obvious response to the drags than either the benthic diatoms or polycheates (Figure 8). At all sites nematode numbers were considerably depressed immediately after the drag was made and took 4-6 weeks to recover to the levels observed at the control stations. This was particularly obvious at the Porter Point site.

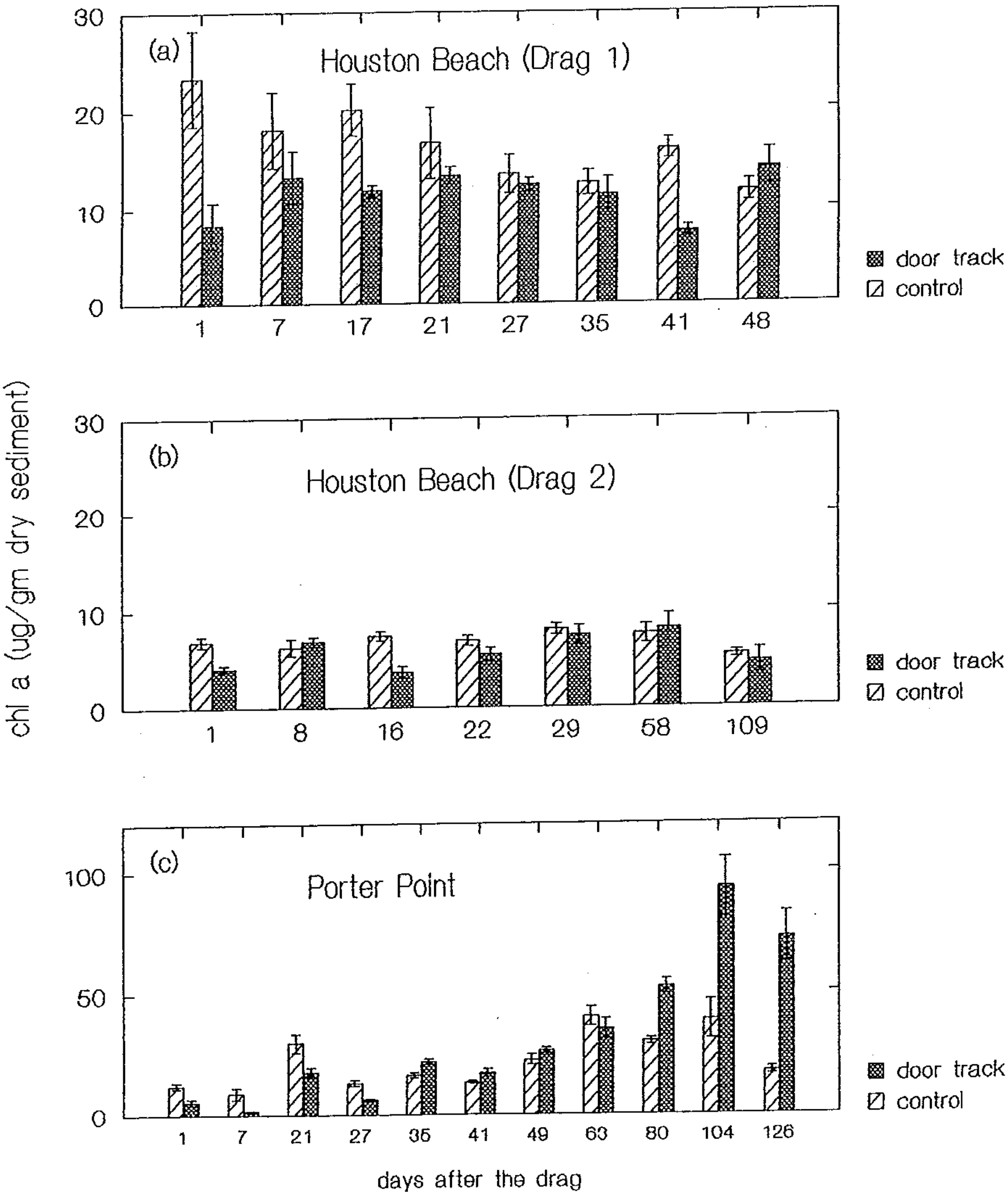

Figure 5. Time series of sediment chlorophyll a at each site (error bars are one standard error of the mean).

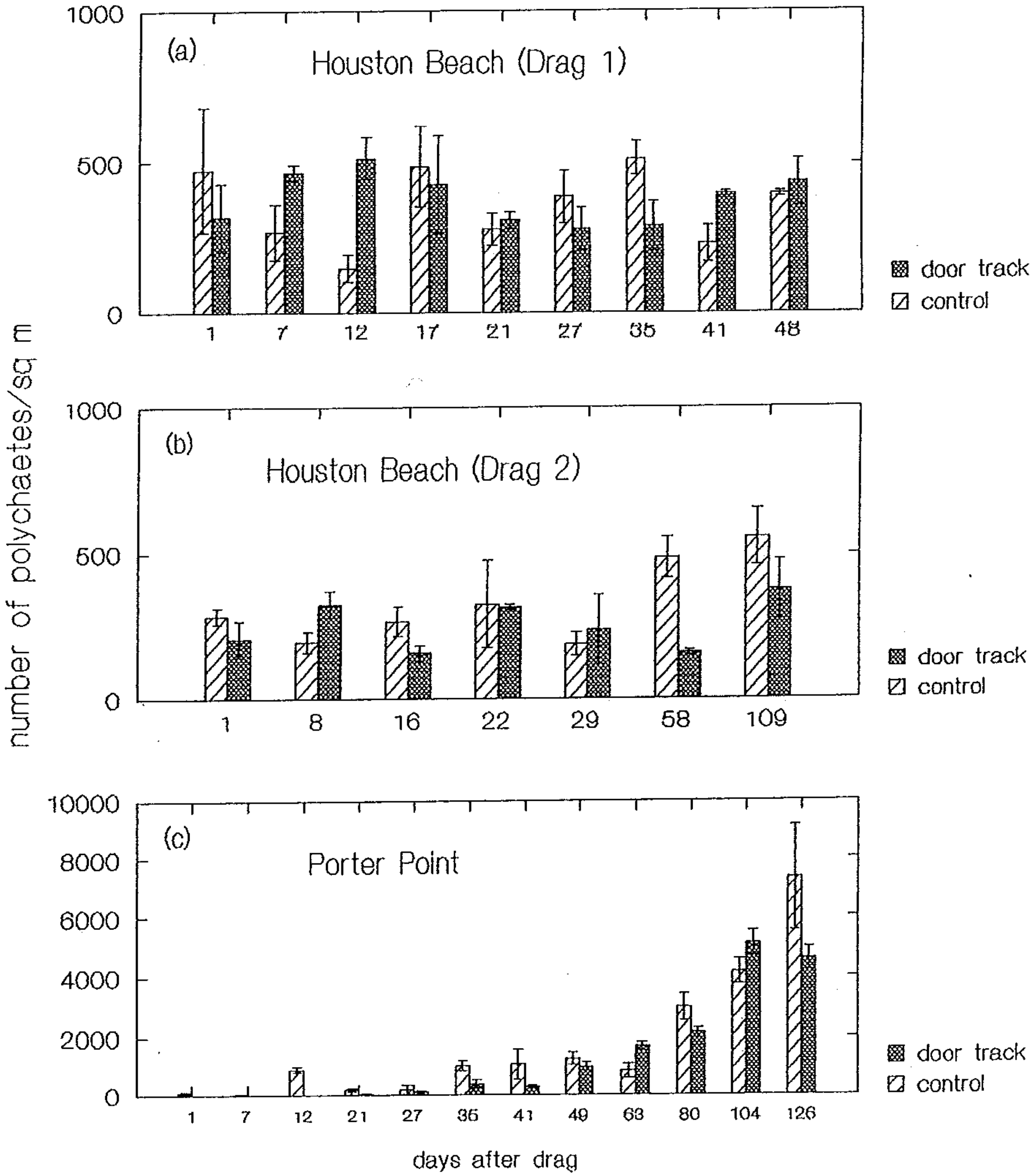

Figure 6. Time series of polycheate numbers at each site (error bars are one standard error of the mean).

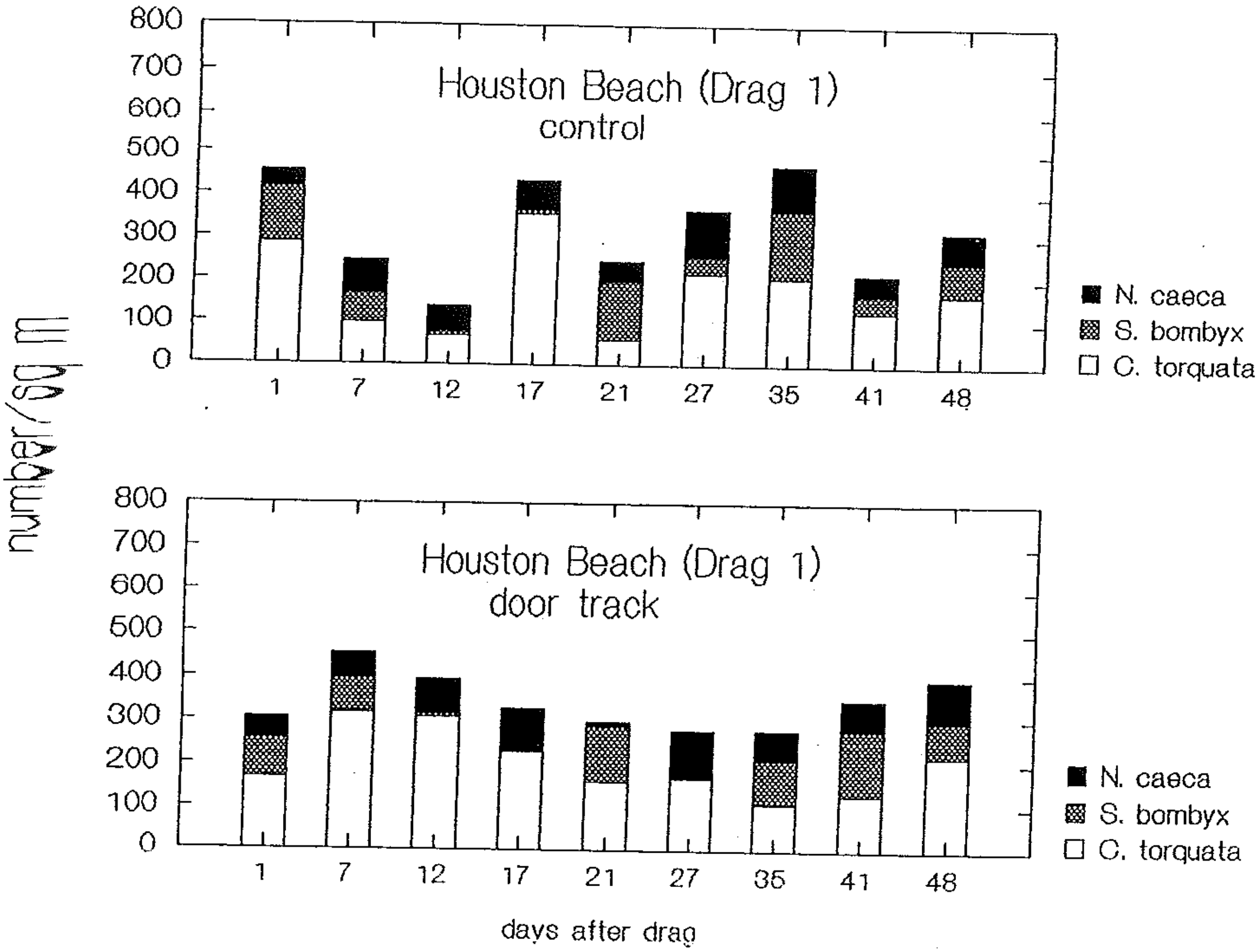

Figure 7. Time series of the species composition of the polycheate community at the Houston Beach sites.

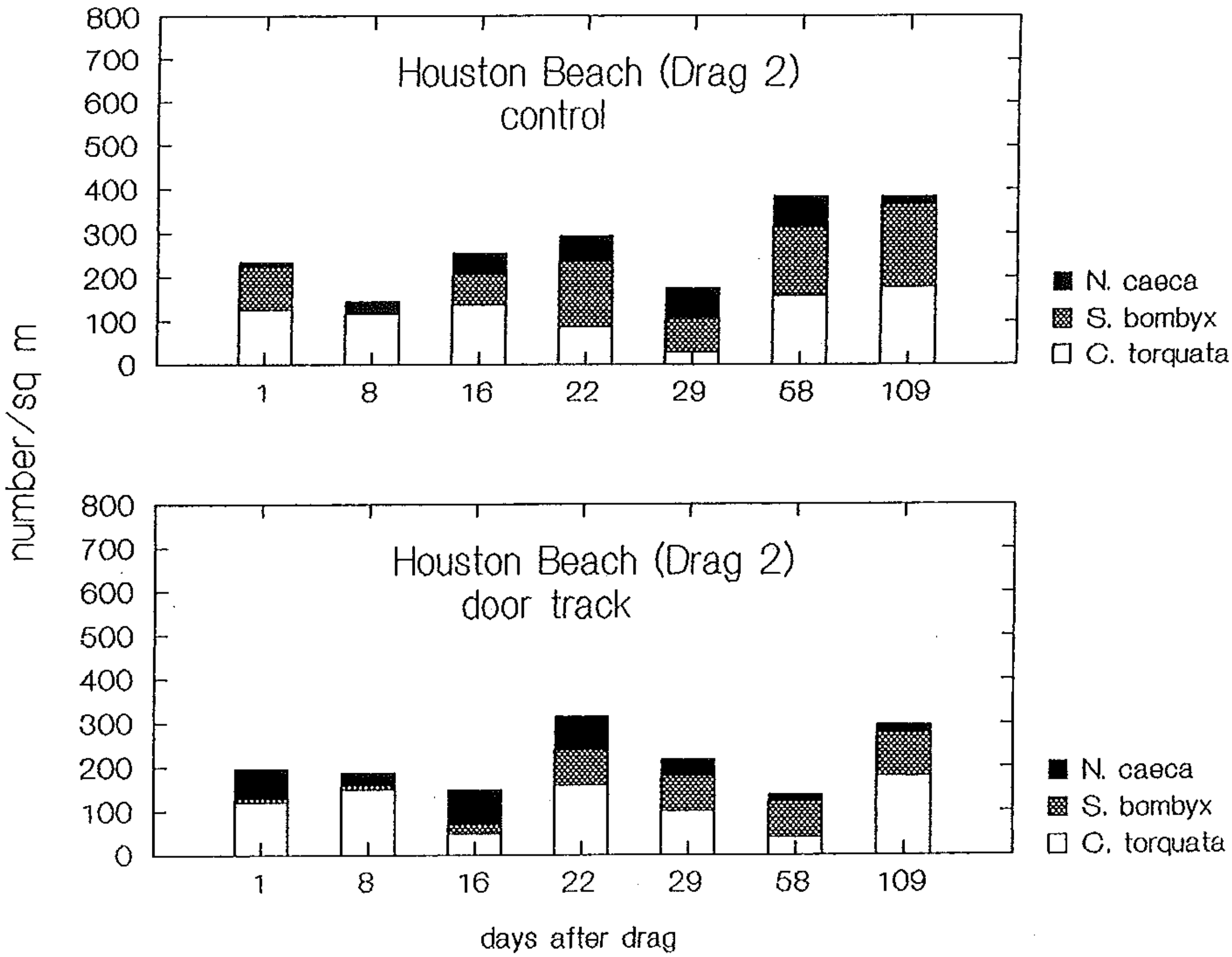

Figure 7. Continued.

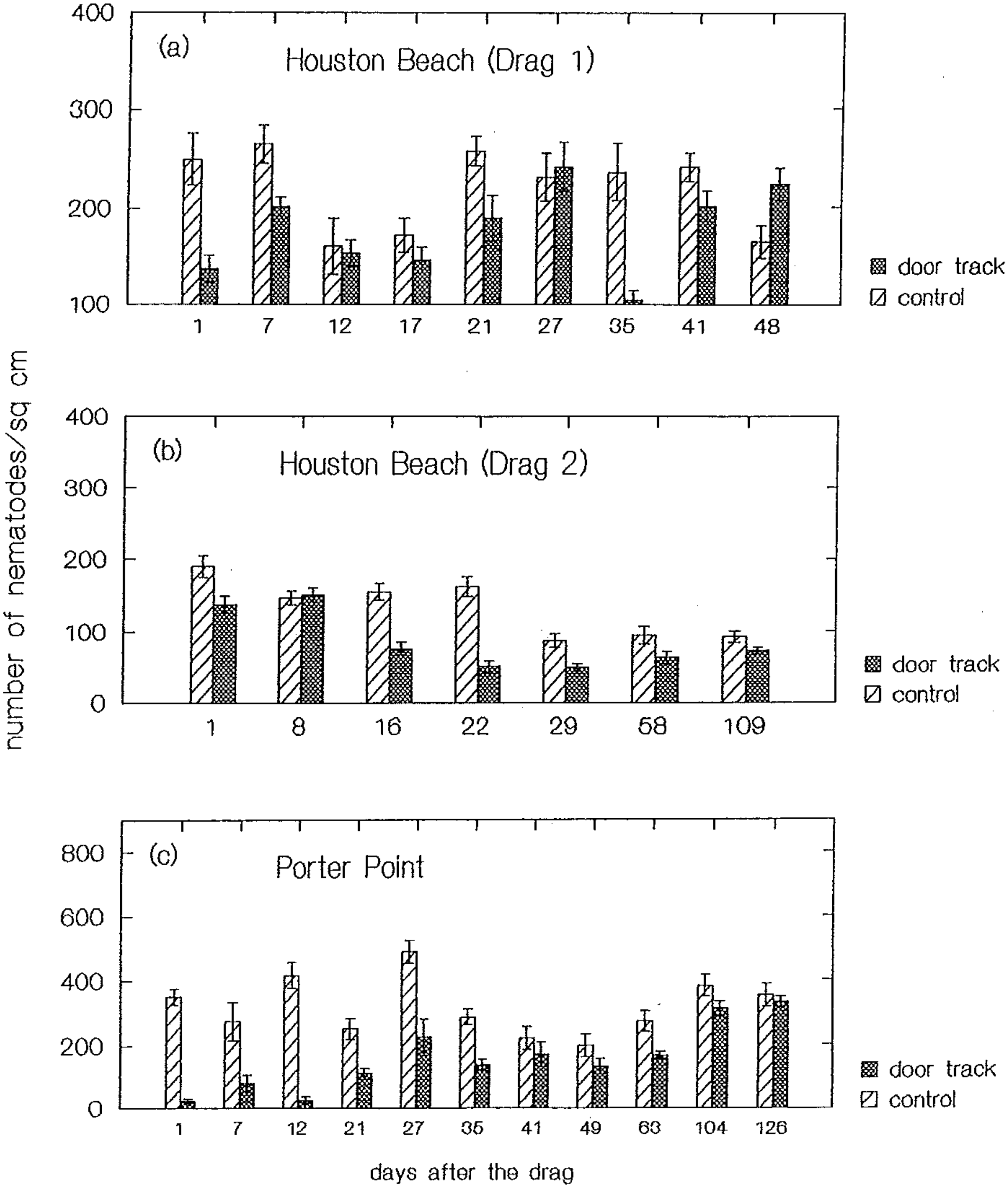

Figure 8. Time series of nematode numbers at each site (error bars are one standard error of the mean).

VI. DISCUSSION

The results of this study suggest that, although some impact was evident, the activity of flounder draggers on the intertidal benthic community is not particularly great. Most of the impact appeared to be relatively minor and did not persist over a long time period.

At the Houston Beach sites there was no obvious difference between the control and door track in terms of chlorophyll *a* levels or macrofauna numbers, either immediately after the disturbance was made, or later as the community developed. There were also no obvious differences, other than the amount of physical disturbance created, resulting from differences in the time the drags were made or in the type of trawl used.

At the Porter Point site, perhaps because of the softer substrate and greater physical disturbance created by the trawl, an initial impact was more obvious. Chlorophyll *a* levels in the door track were initially depressed relative to the control and this persisted for about one month. After that time, however, chlorophyll *a* levels increased at a much faster rate within the door track and eventually became twice as great as at the control, perhaps as a result of increased nutrient availability resulting from disturbance of the sediments. Polycheates, however, showed no difference within the door track and at the control in terms of both abundance and rate of increase in numbers.

Considering all sites combined, the most consistent impact of the drags was a depression in the number of nematodes within the door track relative to the control. This was obvious at all sites but greatest at the Porter Point site where it persisted for almost two months.

The different results observed for polycheates and nematodes may be due to the relatively small size and limited mobility of the latter, making them more susceptible to dislocation as well as slower at recolonization. At the Houston Beach sites, which appeared to have an already well established polycheate community at the time the drags were carried out, most of the polycheates were larger burrowing forms that may be able to sense the oncoming of the trawl and move down into the sediments to avoid being damaged, and in the process, redistributed by the trawl.

It seems reasonable to assume that the results of this study, although carried out in the intertidal, are applicable to what would occur subtidally. With respect to differences between the intertidal and subtidal benthic communities, although benthic diatoms do not occur to any great extent in the deeper subtidal systems, the species of polycheates present at the intertidal sites examined in this study are also common subtidally in the Minas Basin. One major difference between the intertidal and subtidal may be the rate at which the two systems recover physically. Because of the higher wave energy and resulting greater turbulence in the intertidal, sediments would tend to be eroded and redeposited to a much greater extent than subtidally, resulting in a much faster physical recovery of the substrate. There was little evidence from this study, however, to suggest that the persistence of the physical disturbance is important in determining the impact of the trawl on the biological community.