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Herring Report #20

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Annual Report

Kelp Regeneration Study for the Bristol Bay Roe-on-kelp Fishery

Data Summary

Michael S. Stekoll

School of Fisheries and Science
University of Alaska, Juneau

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Introduction

This report is a summary of the major data gathered as part of the UAJ Bristol Bay kelp regeneration project. The data has been accumualted over the past three field seasons from intertidal experimental plots situated near Metervik Bay. This summary will address those objectives as originally proposed and as amended by mutual agreement. Detailed descriptions of the experimental set-ups and other background information will be provided in the final report for this project. The intent of this report is to provide data summaries for use in addressing management problems to the Alaska Board of Fisheries.

Data Summary

1. Growth and mortality rates of *Fucus* plants in Bristol Bay.

Tagging studies using both Bar-lok® cable ties and glued tags gave a description of the growth and mortality rates of *Fucus* plants under average or normal conditions. In general the time of maximum growth of the plants occurred in the late spring and in the early summer. During the months of May to June the average growth was about a 20% increase in length per month. The smaller size classes showed greater growth rates at all times in terms of percentage increases, but this was particularly striking in the months of May and June. At that time the small plants (one to five centimeters in length) grew at a rate of 50 to 70% per month. All size classes showed decreased growth as the summer progressed with little or no growth occurring during the winter months (Figure 1). The optimal growing time of the *Fucus* plants coincided closely with the time that the herring spawned in Bristol Bay.

In terms of numbers of plants per unit area or density, there appeared to be a maximum carrying capacity of the intertidal of about 300 to 400 plants which were larger than five centimeters in length in a square meter. These numbers showed a drastic decline during the winter months and began to rebuild in the spring (Figure 2, high density plots).

Consistent with this data, the individual mortality rates were higher in the winter than during the summer growing season. Winter mortalities were approximately 4% per month, compared to 1-2% in the summer. The mid-size plants of 5-15 cm in length showed the highest winter mortality rates. However, the highest mortalities were recorded for the very small plants during the spring. This class of plants of less than 5 cm had about 8% mortalities per month during this time.

The overall picture of an undisturbed Fucus bed in Bristol Bay is one of a population showing rapid growth and turnover. Because the growth and mortality rates are not always in balance, biomass as estimated by the "volume" technique varies as much as two-fold over the year. The size-frequency distribution shows that in undisturbed areas the population consists of a few large plants which make up most of the biomass and many smaller plants comprising the understory.

2. Thinning studies/recolonization.

If a Fucus bed is subjected to a thinning or a harvest, the pattern of growth and mortalities is alterd somewhat. In our experiments all controlled thinnings and other clearings were done during the same time of year as a commercial harvst. Our data is relevant for a harvest but may not be applicable for plants harvested at other times of the year.

Several types of thinning experiments were deployed, including a study on density dependent growth. In addition an unplanned commercial harvest occurred on the experimental plots in May, 1983. The thinnings were done by removing plants which were longer than 5 cm. This sort of thinning appears to be a fair simulation of what happens during an actual harvest. For the plants in the larger size classes (>15 cm) there appeared to be little connection between the density of plants and the growth rates of the individuals. The data for the smaller size classes was not consistent, but, in general the rate of growth was slightly faster for small plants in thinned areas compared to denser areas. Mortalities were unaffected by varying densities.

More interesting was what happened to the total numbers of plants, greater than 5 centimeters, per unit area after a thinning (Figure 2). In these experiments a thinning or clearing allowed for a rapid regrowth of small plants with the density increasing dramatically during the first growing season. Areas that were more thoroughly cleared (e.g. bleaching) showed more rapid regrowth in terms of numbers of plants than other, less severely impacted areas. In most cases the density had returned to pre-harvest levels after one year. The size-frequency distributions had not returned to the same levels, and the estimated biomasses were still low.

In the next season the previously thinned areas overshot the carrying capacity of the environment. Consequently, the ensuing winter caused a severe crash in numbers. By the end of two years, i.e the third spring, all the thinned areas and the controls had virtually the same numbers of plants and the same size-frequency distributions. That is, the thinned areas had recovered to control levels in that time interval. These results were not true for severely impacted sites that had all the plants removed or had been scraped and bleached (Figure 3). In these areas after two years the cleared plots still had many more plants than the carrying capacity. For example, in plots that were bleached, after two years, the number of plants averaged over 1600 per square meter, compared to 300 for the unharvested, control areas.

In summary, a thinning of the Fucus caused a rapid regrowth of the understory germlings such that there was an overshoot in numbers of plants followed by a crash to carrying capacity levels. For areas that were not severely cleared, two growing seasons were required for regrowth of the beds.

3. Herbivory studies.

When an area is harvested, there is the potential that the numbers of plants will be reduced low enough to allow herbivores to prevent the plants from recolonizing. In order to assess grazing pressure on Fucus germlings a series of clearings were made with cages to exclude littorine snails. The results of this study indicate that, although the snails were a significant factor in delaying the recolonization of cleared areas, there were still enough plants available for such areas to be recolonized in the presence of grazing pressure. These studies were testing the ability of Fucus to recolonize bare patches. Since the harvest rarely creates such patches, we see no reason at this time to include herbivory factors in a management strategy for the roe-on-kelp fishery.

4. Dispersal range of eggs/timing of reproduction.

For the Fucus population to recolonize an area it is imperative that there be sufficient numbers of mature plants nearby the cleared area to provide the necessary zygotes. The Fucus in Bristol Bay is monoecious and, thus, both eggs and sperm are produced on the same plant. Preliminary data from our experiments indicate that the fertilized eggs are deposited quite near a mature plant. Comparatively few eggs actually disperse as far away as two meters. However, calculations indicate that at distances of from two to six meters from a fertile plant there will still be on the order of 2000 eggs per square meter deposited every few days. If we assume a survival rate of only one percent to maturity, there would still be sufficient numbers of plants to recolonize the area. Examination of harvested areas indicated that there was more than one fertile plant remaining every two meters. It should be pointed out that Fucus plants which are covered with herring roe are not able to release gametes.

Although a vigorous systematic effort to record timing of fecundity of Fucus was not done, there were enough casual observations made that we can conclude that a peak of fecundity occurs near the time of the herring spawning activity. There were many fertile plants both before the spawns and subsequent to them. In fact, fertile plants were observed to be present in each month of the spring-summer seasons, that is, from April to September. It would appear that the timing of the harvest does not sigificantly affect the fertility and reseeding effort of the Fucus plants. However, it may be worthwhile to verify this point with further studies.

6. Biomass estimation.

A method has been developed in the course of this investigation that allows for an estimate of the biomass of the Fucus plants without destruction of the plants. This method was reported in detail in an appendix to the Annual Report of September, 1982. The method involves the measurement of the depth of the algal cover at selected points under a grid. This method needs to be calibrated by sampling several plots for wet weights. This calibration must be performed for each different site to be biomassed. The surface irregularites and morphological form of the plants will affect the calibration significantly. This biomass estimation technique is not a useful tool for one-time sampling of a large area. It is, however, a very convenient and reliable method by which to monitor individual plots over time without disturbing the plants.

7. Roe survival studies.

In May of 1983 three study sites were selected for assessing the survival of the herring roe on various substrates. Two sites were in the intertidal with Fucus as the substrate. The third site was an eel grass bed behind the intertidal island in Metervik Bay. Attempts to locate a subtidal spawn on Laminaria within Metervik Bay were not successful during that season. Although the data from these experiments are not in final form, the preliminary results indicate that Fucus is a more important substrate for the herring eggs than is eel grass in terms of the survival of the eggs per unit area. It was not possible to monitor the survival of roe on bare rock surfaces, which would appear to be the only other substrate of significance.

8. Effect of a harvest.

In May of 1983 a harvest occurred on many of the experimental plots. While this event precluded following the thinned plots for another growing season to verify the results accumulated to date, it did afford the opportunity to measure the effect of a bona-fide commercial harvest. In this case the harvest occurred during a neap tide. Consequently, much of the harvest was done by raking the submerged plants. Examination of the area after the harvest showed large numbers of unharvested, but severely damaged plants, that is, plants which had been scraped to the midrib.

Before this harvest we estimated that the average biomass was around 2.8 to 3.2 kilograms per square meter in the previously undisturbed plots. After the harvest the estimated biomass was less than 800 grams per square meter (Figure 4). The percentage cover dropped from 90% to about 40% (Figure 5). However, the average number of plants dropped from 308 to 288, or about a 6.5% decrease. In a harvest on a previously undisturbed area very few plants are taken, and yet the total biomass is reduced by a factor of three or more. In areas that had been severely cleared two years previously as part of the experimental plots, a similar decrease was seen in plant biomass and percentage cover, but in this case it required a harvest of 96 of plants per square meter or about five times the number taken from previously unharvested areas.

The main points from this study are that the 'kelpers' will remove about the same biomass from an area whether the plants are large or small. If possible, there is a preference for taking larger plants. An examination of the size-frequency distributions of the areas before and after the harvest show that in all cases the larger plants have been removed (Figure 6). In addition to the plants harvested, many plants were damaged. These damaged plants probably did not recover to a significant extent. We suggest that these plants died within the next two to three months, which would explain the drop in density in two of the three thinning experiments between the last two sampling periods (Figure 2).

Even though the harvesters removed over 70% of the biomass, they left more than enough plants to recolonize the area, if it is left undisturbed for two or three growing seasons. In fact, it is likely that the kelp harvest would be self-limiting in that the harvesters will, if not restricted, pick in areas that tend to have larger plants. It would seem that unless the number of pickers increased sharply, there is little reason to worry that the roe-on-kelp harvest will impact the *Fucus* population dramatically.

Conclusions

The results of these studies provide a pretty clear picture of the effects of a harvest and of the sequence of events subsequent to a harvest. *Fucus* is a fast growing, proliferous plant, a weed in the true sense. It has shown remarkable abilities to survive in harsh climates and to recover quickly following a disturbance.

The current harvest guidelines of 10% of the estimated biomass per year is certainly a conservative management strategy. However, the fluctuating nature of the *Fucus* population itself makes it necessary to obtain biomass estimates each year. It would cost the Department of Fish and Game more money than the harvest is worth to monitor the biomass of *Fucus* in Bristol Bay in a manner which would generate reasonable error estimates. Aerial color infrared (CIR) photography is a good means to map the intertidal *Fucus* beds, but will provide no information on the biomass. Our studies show that areas can have similar percent cover by the plants and differ significantly in wet weights. Further, for CIR to be effective, would require good lighting conditions and low tides at the time of year just prior to the spawning of the herring, conditions that are not easily met in this area.

Although an unmanaged harvest may be self-limiting, a more logical approach to this fishery would be to close harvested areas for a time long enough for the areas to recover. A conservative estimate based on our data would indicate that for sustained yield purposes, this would mean a closure for two to three growing seasons. The 'K' areas could also be made smaller in order to correspond more closely with spawning areas. In this way the managers of the fishery could make available more beds each year.

A possible way to monitor these 'K' areas would be to collect size-frequency data from selected plots each year. Statistical tests can then be used to determine when a harvested area has recovered. In addition the catch itself can be sampled for size-frequency distribution to determine whether the plants are typical of those that would come from a mature *Fucus* bed in that area.

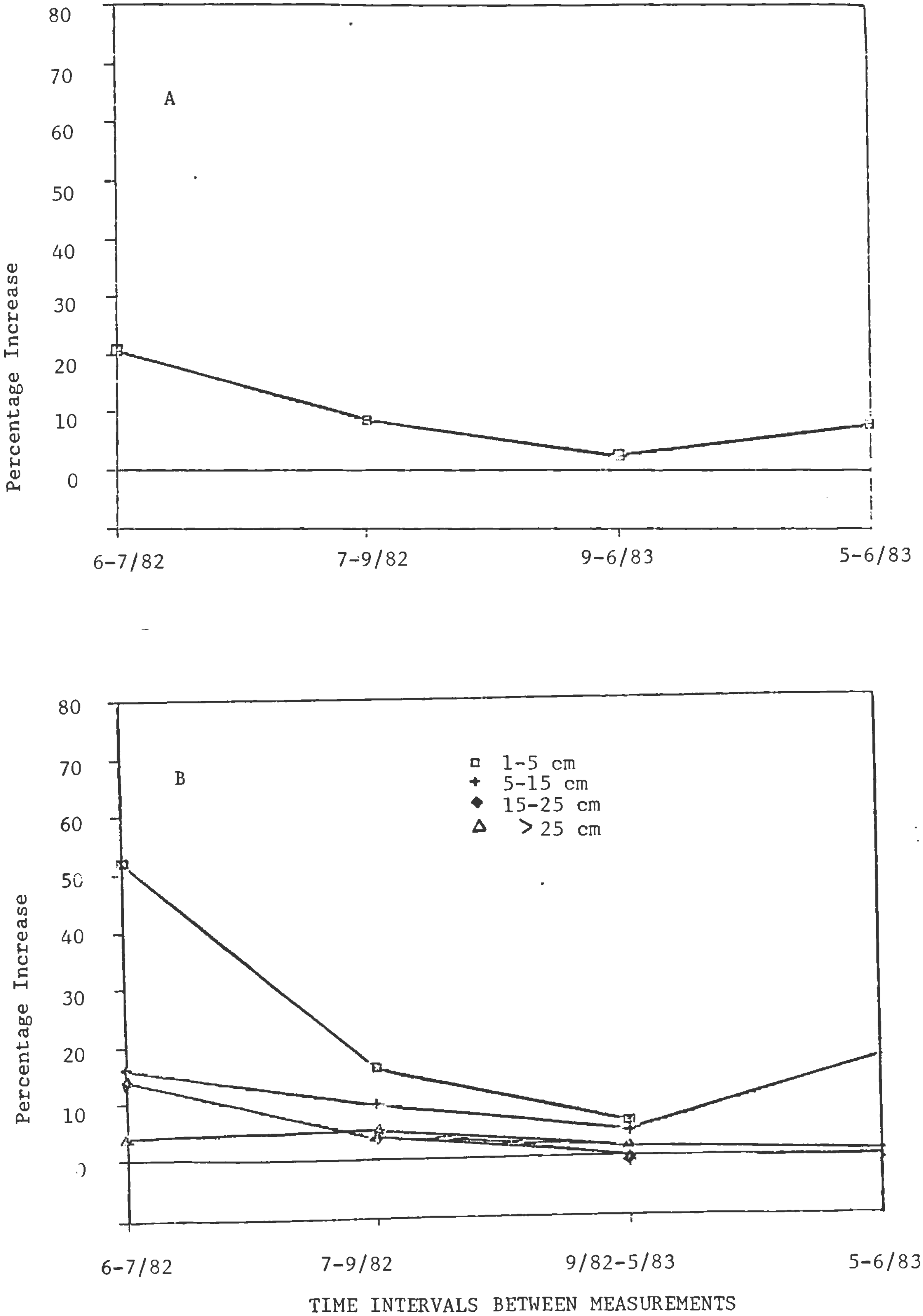


Figure 1. A) The average increase in length per month for all size classes of Fucus for all treatments combined.

B) Average increase in length per month for four size classes of Fucus.

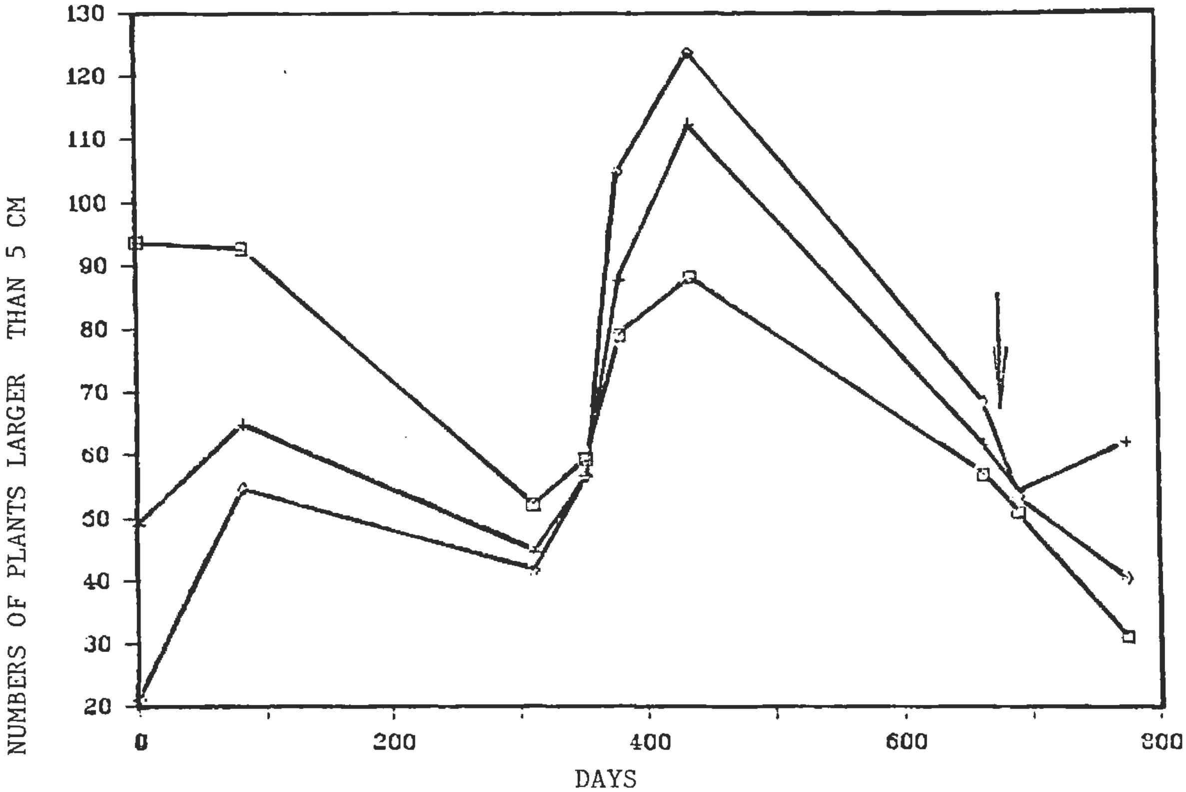


Figure 2. Density Plots. Average number of <u>Fucus</u> plants (longer than 5 cm) per plot. Day 0 is in June, 1981. Days 100 to 300 represent the winter of 1981-1982. The harvest in May, 1983 occurred at the arrow.

□ - High density (control)
\+ - Medium density
◇ - Low density

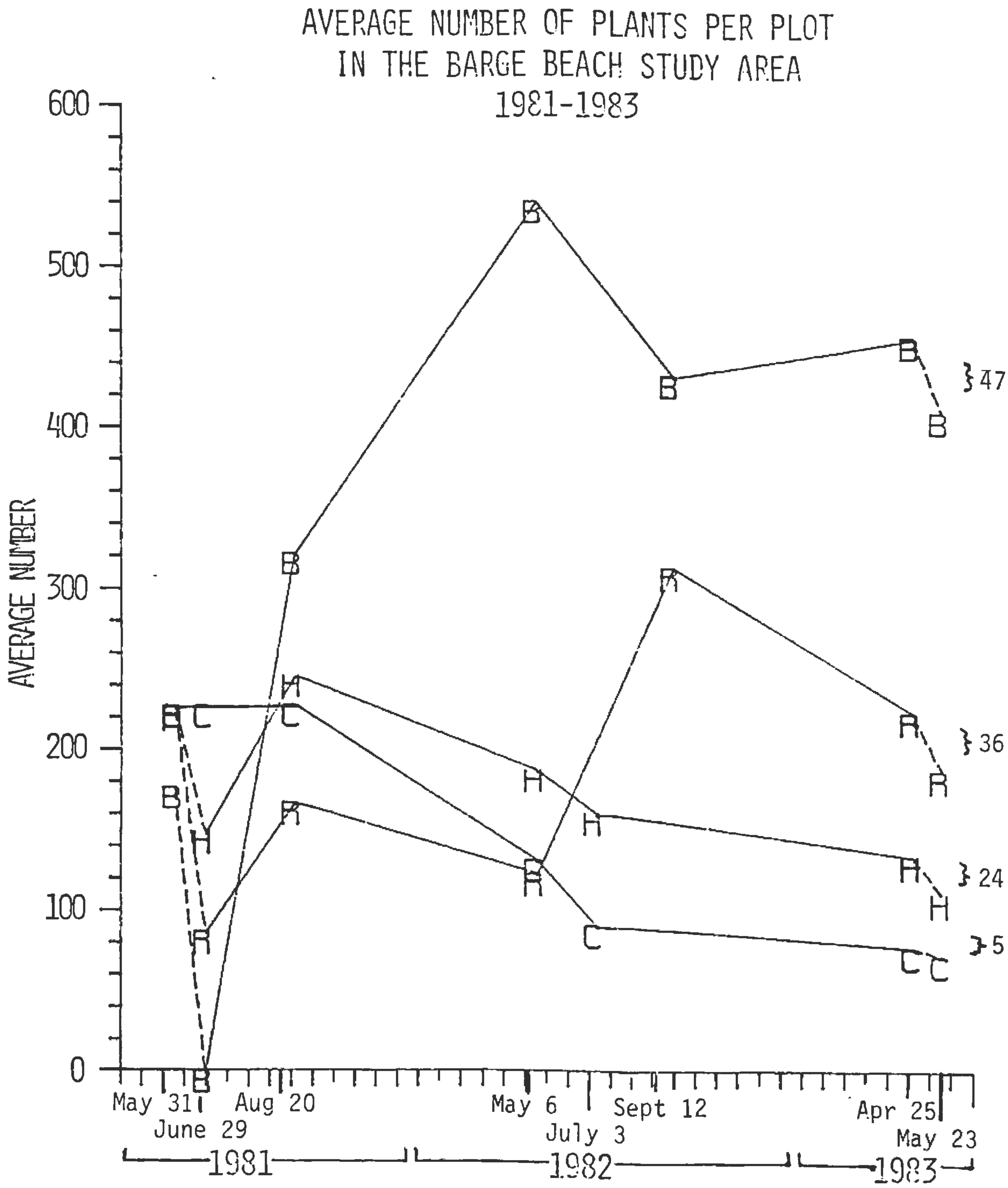


Figure 3. Average number of plants per plot in the Barge Beach experimental study area. C=control plots, H=harvest plots, R=removal plots, and B=bleach plots. Dashed lines represent reduction in plant numbers induced by experimentation in 1981, and by a commercial harvest in 1983. Brackets with associated numbers on right side of graph show average numbers of plants removed by harvesters for each group.

AVERAGE WEIGHT OF FUCUS IN EXPERIMENTAL STUDY
PLOTS AS ESTIMATED USING A
VOLUMETRIC TECHNIQUE
1981-1983

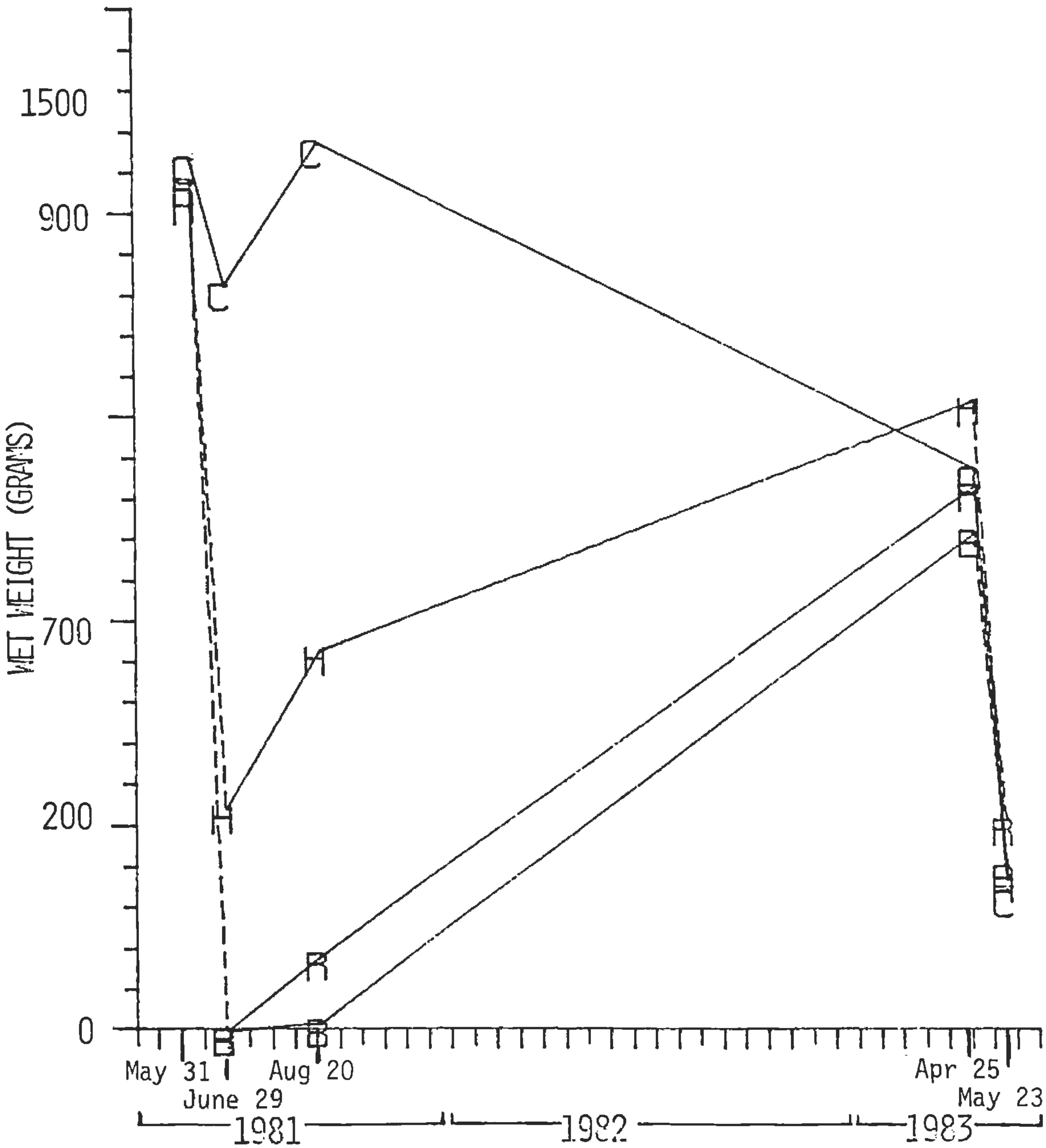


Figure 4. Average wet weight of plant material per plot in the Barge Beach experimental study area. C=control, H=harvest, R=removal, and B=bleach. Dashed lines represent reduction in weight as a result of experimentation in 1981, and by a commercial harvest in 1983.

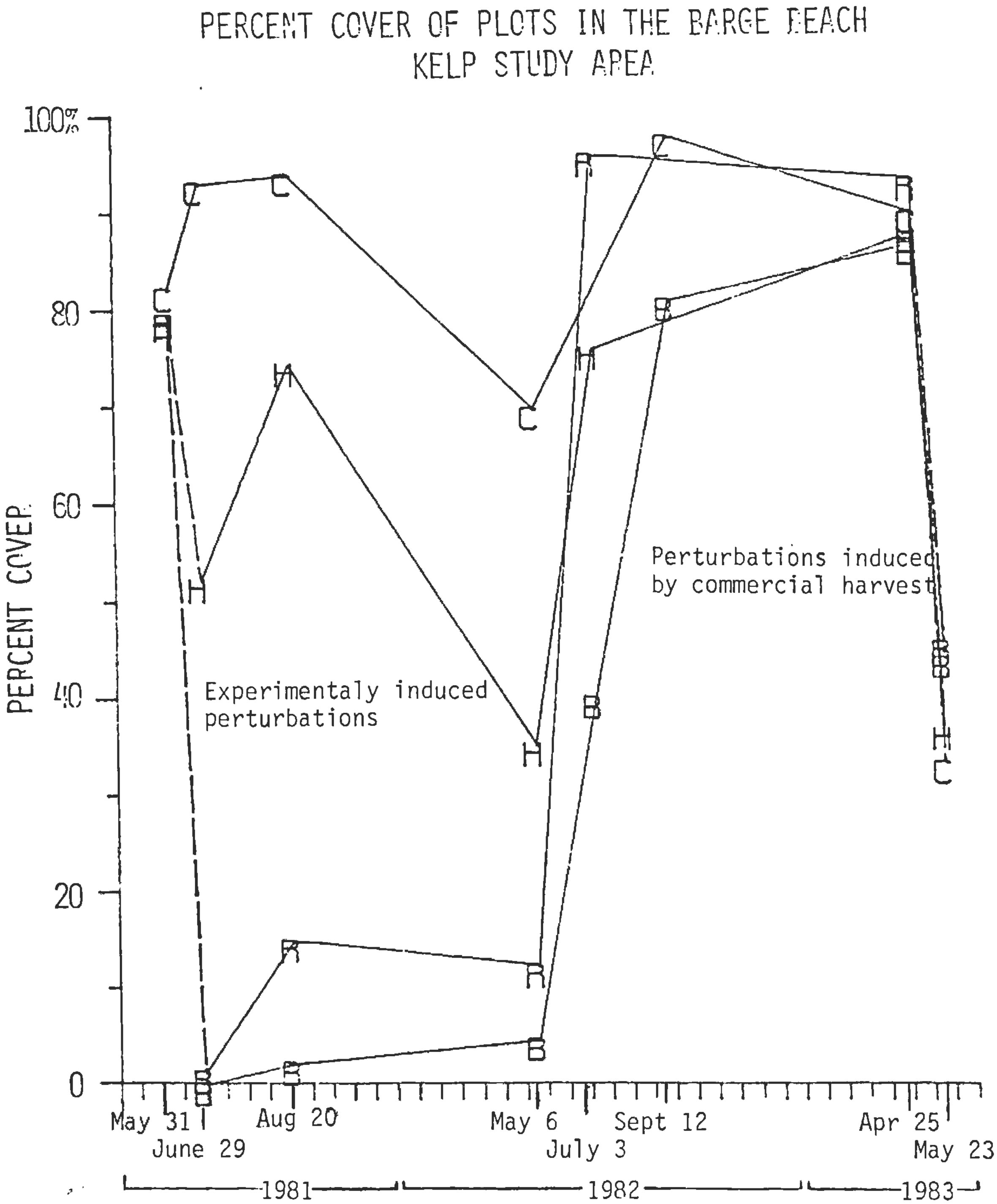


Figure 5. Percent cover of Fucus in the Barge Beach experimental study area. C=control plots, H=harvest plots, R=removal plots, and B=bleach plots. Dashed lines represent the reduction in cover induced by experimentation in 1981, and by commercial roe-on-kelp harvesters in 1983. Vertical bars show standard deviations about the means.

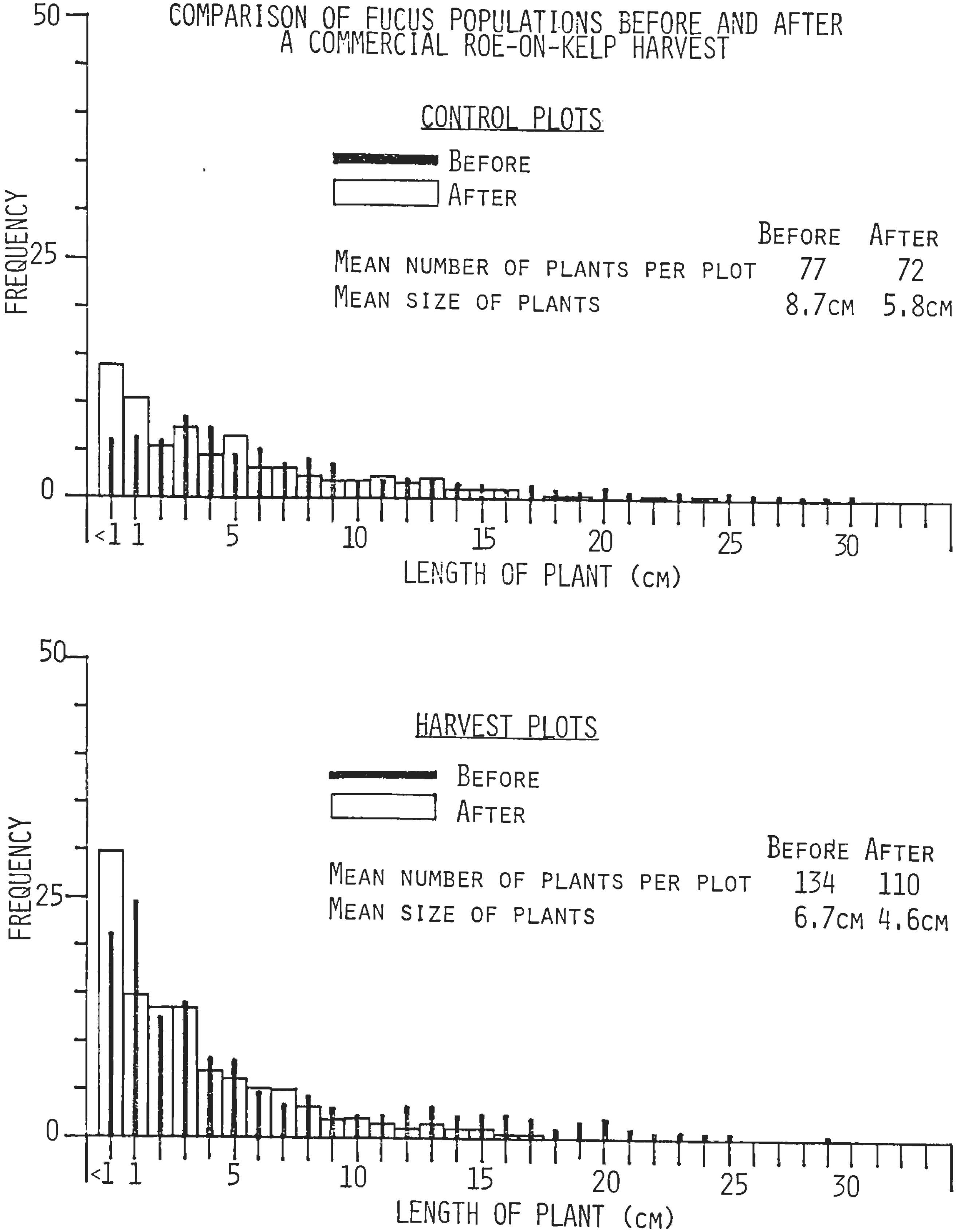
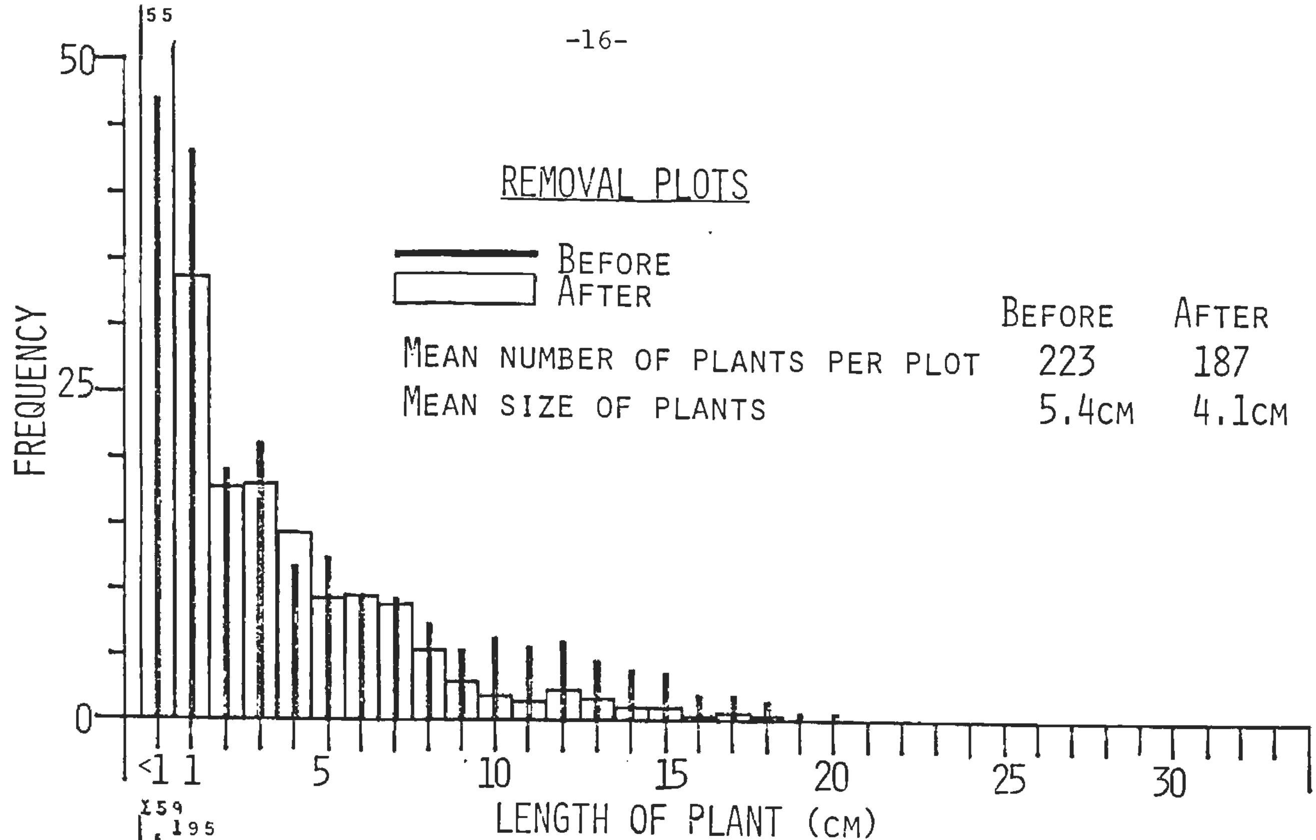
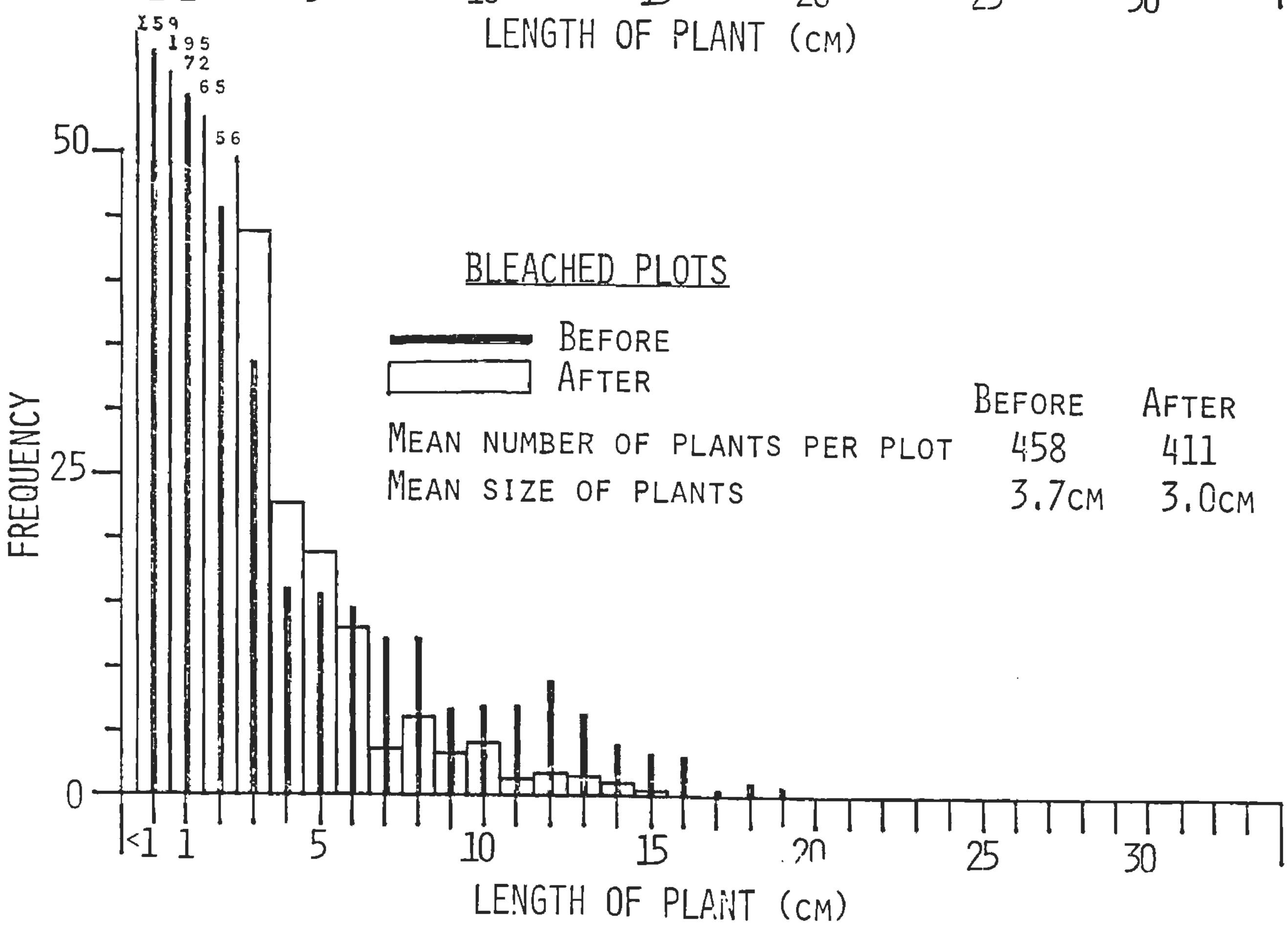


Figure 6. Plant length frequencies before and after the kelp harvest of May 6, 1983 on the Barge Beach Kelp Study Site. 28 1/4 meter square plots at the 1.0 meter tidal level were subjected to one of four treatments in June of 1981. The four treatments, (Control, Harvest, Removal and Bleach), had 7 replicates each. Averages of the four treatment groups as they appeared in April, (before), and May (after) are shown. (continued next page).





(continued from last page.) Small (but not significant) decreases in plant numbers and sizes occured in all groups as a result of the harvest. The greatest effect was in the loss of the larger plants.