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EFFECT OF TURBULENCE AND DIFFERENT TYPES OF FERTILIZERS ON PHYTOPLANKTON AND OYSTER LARVAE (Ostrea edulis) IN MESOCOSMS.

by

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ABSTRACT

Different types of inorganic fertilizers were added to five cubic metres plastic bags. Different turbulent regimes were established in the bags. The effects of these manipulations on nutrient salts, chlorophyll a, phytoplankton composition and growth and survival of newly liberated oyster larvae were monitored.

INTRODUCTION

Production of juvenile oyster (Ostrea edulis) has been carried out successfully in ponds for a long time (Gaarder and Bjerkan 1934). However, the regularity of the pond production method has been unacceptable and juvenile oyster are frequently a limited resource in Norway. Large-scale production of juveniles of many flatfish species has been carried out in plastic bags (Berg et al. 1985 and Berg and Øiestad 1986). This system has been adapted for oyster larvae-production.

A pilot-scale bag study was carried out in 1985 (unpublished). The oyster bags were given different nutrient and turbulent regimes. That type of manipulations in the bags in 1985 resulted in different phytoplankton communities in different treated bags. Turbulence and supply of silicate maintained a diatom community, while flagellates were dominating in the untreated bags. Turbulence in combination with diatom dominance seemed to improve the water quality by stabilizing pH and oxygen levels and therefore ought to be chosen as a production system if the diatom dominated community also contained feasible food items for the oyster larvae. The purpose of the 1986 experiment was to give an answer to this question. The study was carried out in Svartatjoenn, a landlocked pond at Austevoll Marine Aquaculture Station which is a part of the Institute of Marine Research in Bergen.

MATERIALS AND METHODS

Four cylindrical semi-transparent plastic bags with conical bottoms were filled with 200 µm filtered seawater of about 30 ppt 20 - 22 June. The water depth was 2.8 m and the volume was about 5 m . Three to six brood oysters with internal larvae were placed in each of the four bags with the following experimental design (Table 1):

Table 1. Experimental design. (N is nitrate, P is phosphate and Si is silicate)

Bag number	Number of brood oysters	Fertilizer	Turbulence
1	6	N,P,Si	Yes
2	5	Not added	Yes
3	5	Not added	No
4	3	N,P	No

Turbulence in bag 1 and 2 was maintained by a compressor continously giving approximately one litre air per min. Bag 1 and 4 were fertilized twice a week with amounts resulting theoretical concentrations of 10 µM nitrate, 2 µM phosphate and 10 µM silicate. Samples for nutrient and chlorophyll a analyses, temperature and oxygen measurements, together with phytoplankton and larval samples were collected twice a week and prior to the fertilizations. The quantitative phytoplankton samples were not analysed within the deadline of this report. When the pelagic oyster larvae had a size of 200 µm, 11 strips of PVC-plates (170 x 15 cm) were immersed and a disc (Ø = 80 cm) containing a thin horisontal layer of 200 to 500 µm sand were placed in each bag serving as settling substrate. The experiment was ended 25 July when no pelagic oyster larvae were observed in the bags.

RESULTS AND DISCUSSION

Due to fertilization the bags 1 and 4 were richer in chlorophyll a than bags 2 and 3 during the entire study (Fig. 1). Bag 1 showed declining values until 15 July and than the chlorophyll a concentration increased to more than 10 µg per litre. In bags 2 and 3 chlorophyll a was almost exhausted between 4 July and 15 July.

Phosphate was probably never limiting the primary production in any of the bags (Fig. 2). On the other hand nitrate seemed to be the limiting nutrient in all bags during the first half of the study, even in the fertilized bags which had nitrate values exceeding 1 µM only at the end of the study (Fig. 3). Despite of the silicate fertilization in bag 1 the silicate concentration was below 1 µ M from start to end of the experiment (Fig. 4). The turbulence in bag 1 kept the non-motile diatoms suspended in the water masses. Also in bag 2 the phytoplankton were kept in suspension by air-bubbling, but as no silicate was supplied to support the diatom community, it starved and vanished.

Bag 1 was dominated by diatoms, mainly Nitzschia and Chaetoceros species, during the entire study. Bag 2 had a high diversity, also including diatoms, while bags 3 and 4 were flagellate-dominated with mainly chlorophyceans in bag 4.

The oxygen saturation in bags 1 and 2 maintained a stable level at about 100 % while bags 3 and 4 showed declining saturation from 4 July throughout the study with minimum value of 105 % at 1 m depth in bag 3 (Fig. 5). The fertilization seemed to be critical for the pH-variation with parallel development in bags 1 and 4 (Fig. 6). In bag 4, without turbulence, the pH level increased to possible lethal levels (pH > 9) at the end of the experiment (Gaarder and Spärck 1932).

Brood oysters were put in the bags 23 June and the first pelagic larvae were observed in the samples twelve days later (Fig 7). Oyster larvae were most abundant in bag 1 with 504 per litre or a standing crop of 2.7 mill. In the other bags the numbers were from 0.8 mill to 1.8 mill. Already the first week after the larvae were liberated a rapid decrease in abundance was observed in bags 1 and 4. At the time of settling (16 July) the abundancies were less than 100 per litre in 1 and 4, and less than half of the abundancies in bags 2 and 3. The number of larvae in bag 3 did not decrease significantly in number until after settling.

At the time of observed settling the average size of the larvae was significantly larger for bags 2 and 3 than for bags 1 and 4 (Fig. 8). The larvae in the non-manipulated bag 3 had a stable and rapid growth compared to the manipulated bags. This fact was also reflected in the survival beyond metamorphosis (Table 2):

Table 2. Settled juvenile oyster and survival in the different bags.

Bag number	Settled larvae	% settled (of highest number)	% settled (of number prior to settling)
1	0	0	0
2	19400	1.1	1.9
3	129300	7.9	11.4
4	100	0.0	0.0

The decreasing larval size in bag 2 at the end of the pelagic stage was due to the disappearence of the larger size-fractions (Fig. 9) and probably reflected the settling of larvae. The fraction larger than 300 µm in bag 3 on 18 July had also declined compared to the previous sampling date. A similar development could be seen in bag 4, but was not observed in bag 1, the later having no larvae reaching a size of 300 µm which has been reported critical for settling (Walne 1956, Loosanof and Davis 1963).

Several experiments have demonstrated the selection of diatoms in turbulent and nutrient-(including silicate) supplied mesocosms (Dunstan and Tenore 1973, Eppley et al. 1978, Grice et al. 1980, Harrison and Davis 1979, Harrison and Turpin 1982). The preliminary qualitative phytoplankton records in the oyster bags seem to verify this theories, but the quantitative phytoplankton analysis will give more information about the effect of the manipulations on the phytoplankton composition.

Despite the larger chlorophyll a concentrations in the fertilized bags the larvae experienced a reduced survival rate and grew far less than the larvae in the unfertilized bags, although it was almost exhausted with chlorophyll a. Bag 3 without any manipulation seemed to be the best system for growth and survival of pelagic oyster larvae. It is not clear whether the reduced growth and survival in the manipulated bags were caused by starvation (bad-quality food particles), by mechanical disturbance due to the bubbling or by some poisoning effect of the supplied fertilizers.

The experiment has shown that the plastic bag system is suitable for rearing of oyster larvae through the pelagic stage, resulting in more than 7 % easy collectable settled larvae. The experiment is beeing repeated by the time of the writing of this report.

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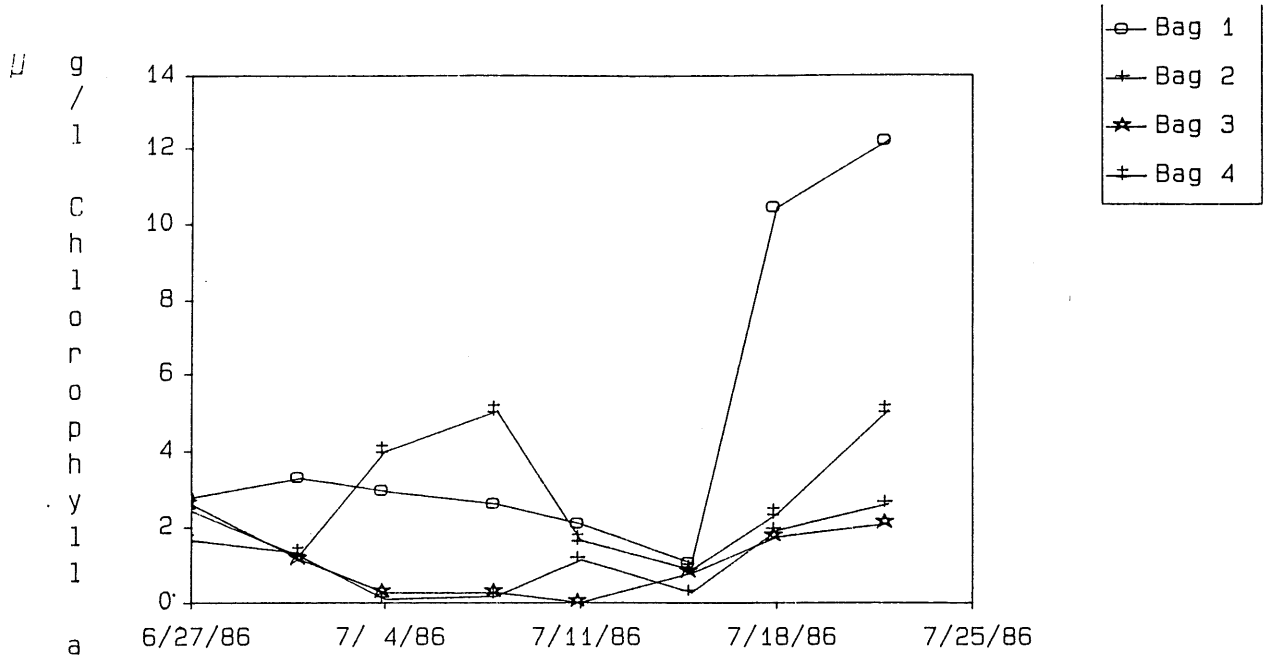

FIGURE 1. The chlorophyll a variation at 1 m depth in the four experimental bags.

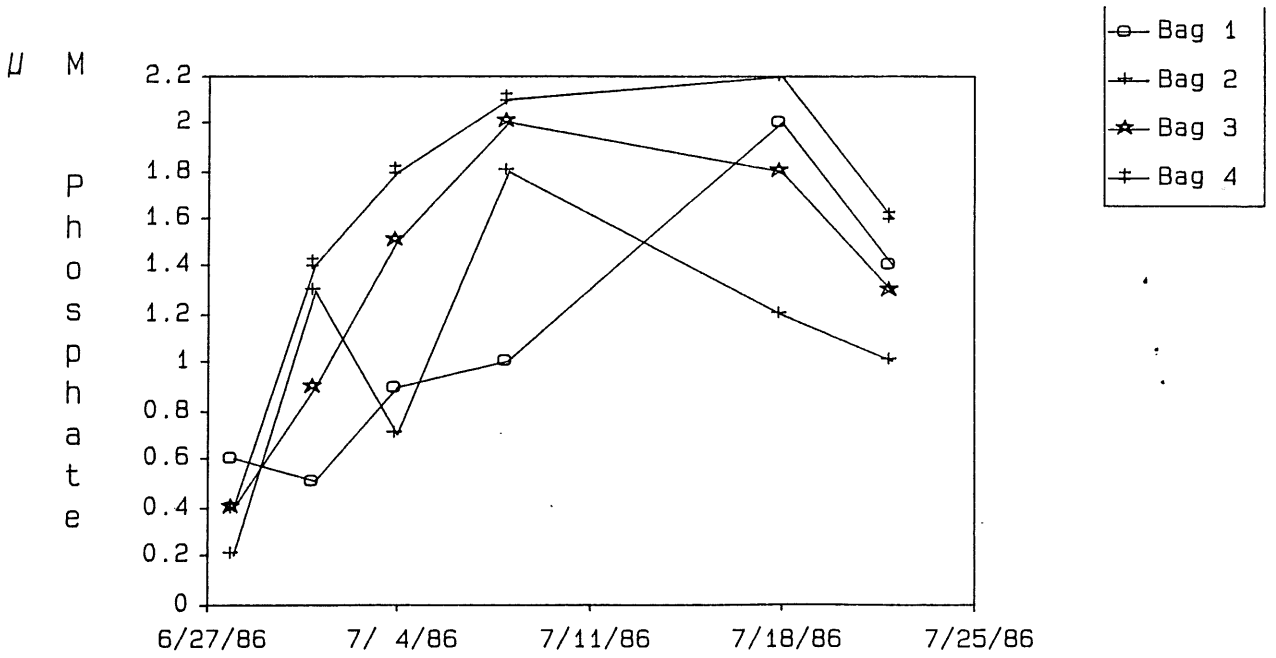

FIGURE 2. The phosphate variation at 1 m depth in the four experimental bags.

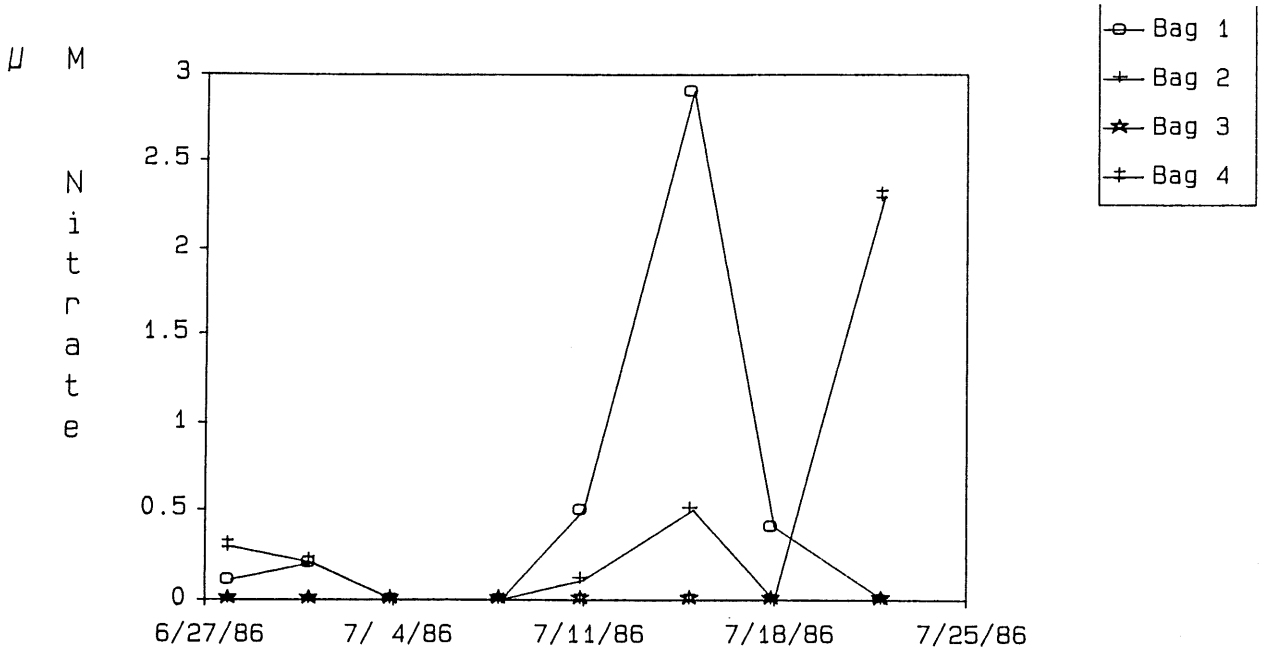

FIGURE 3. The nitrate variation at 1 m depth in the four experimental bags.

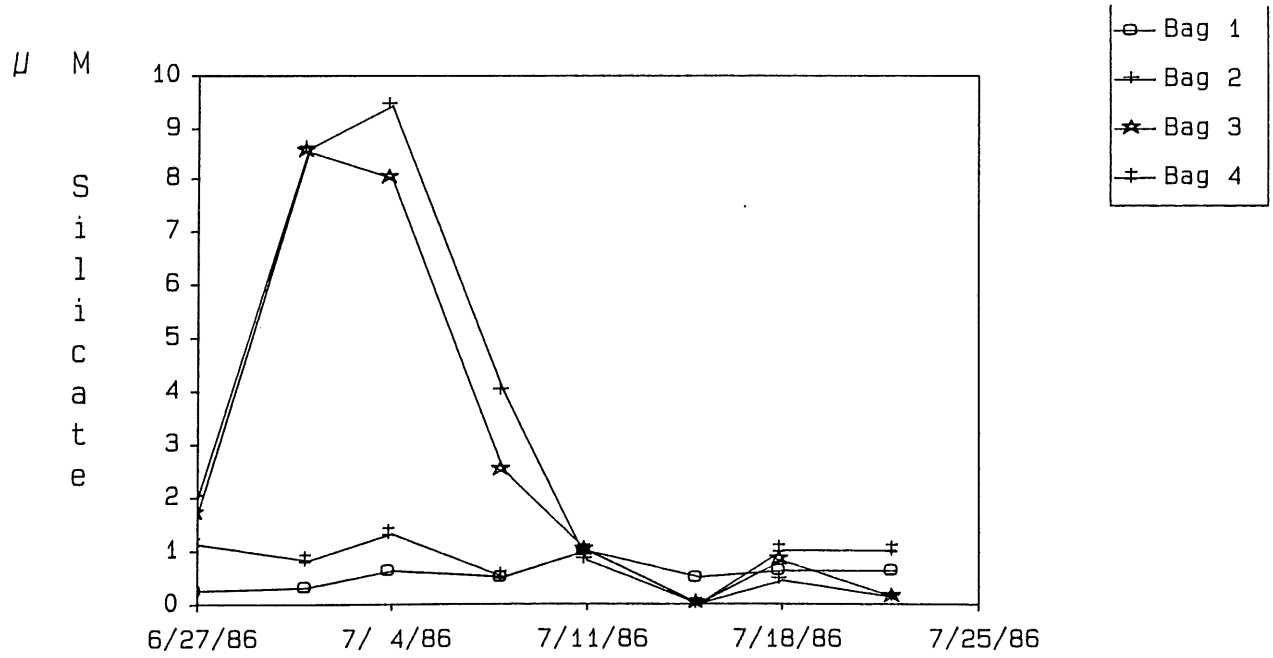

FIGURE 4. The silicate variation at 1 m depth in the four experimental bags.

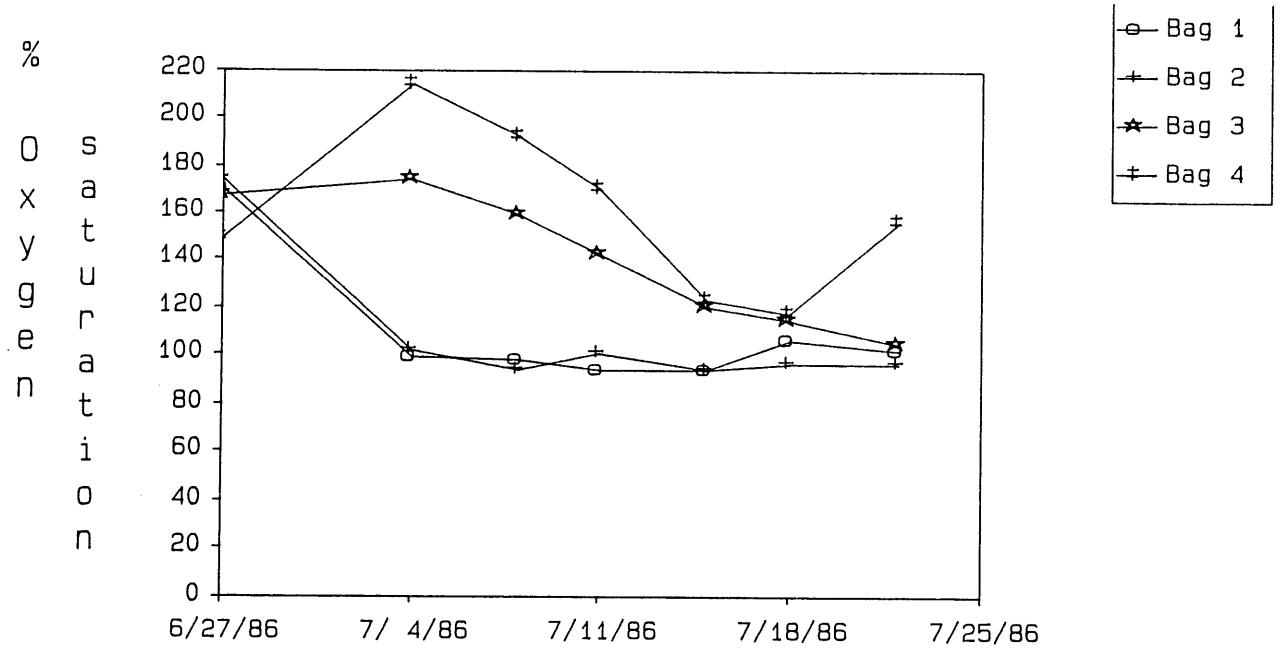

FIGURE 5. The oxygen saturation at 1 m depth in the four experimental bags.

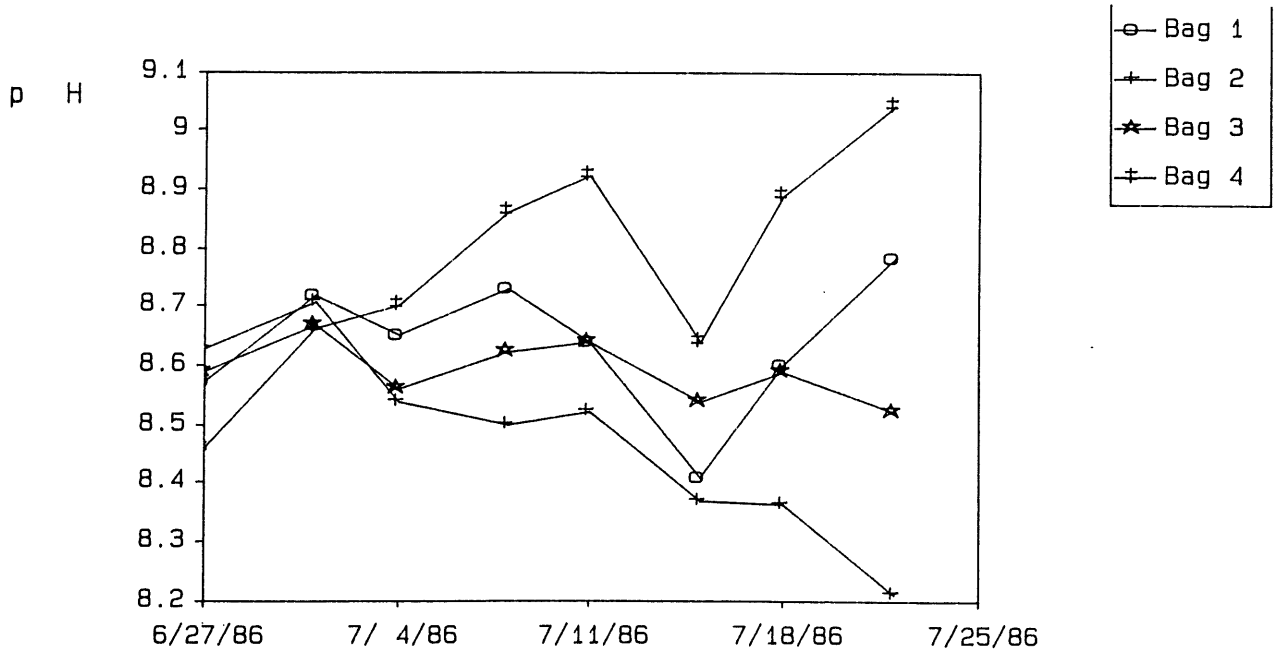

FIGURE 6. The pH variation at 1 m depth in the four experimental bags.

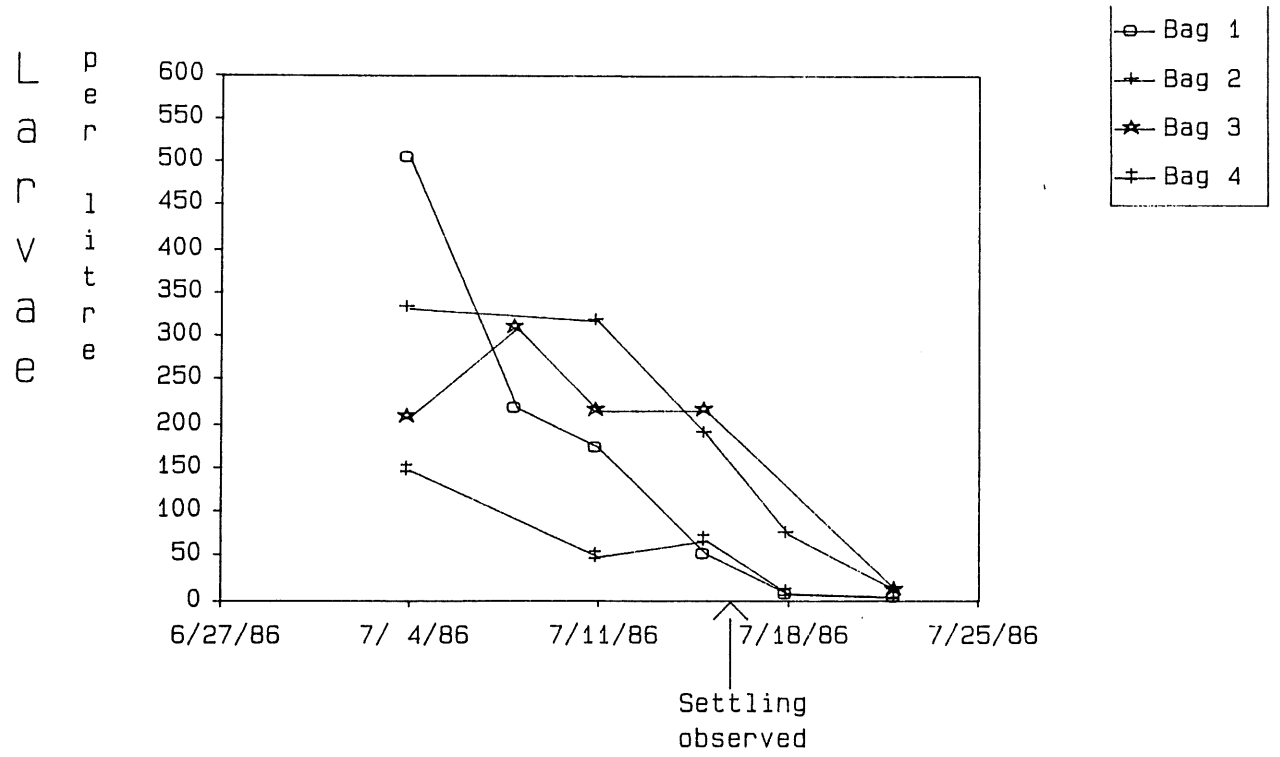

FIGURE 7. Oyster larvae abundancies in the four experimental bags (4 litre tube-samples).

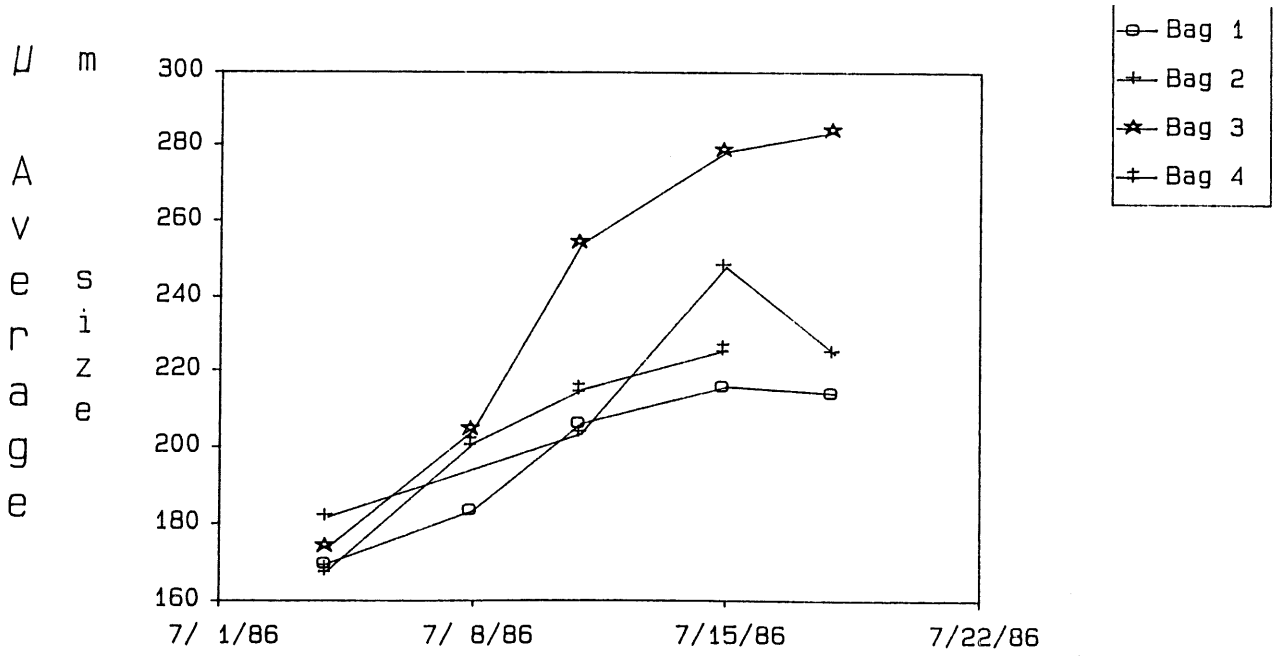

FIGURE 8. The average size of pelagic oyster larvae in the four experimental bags.

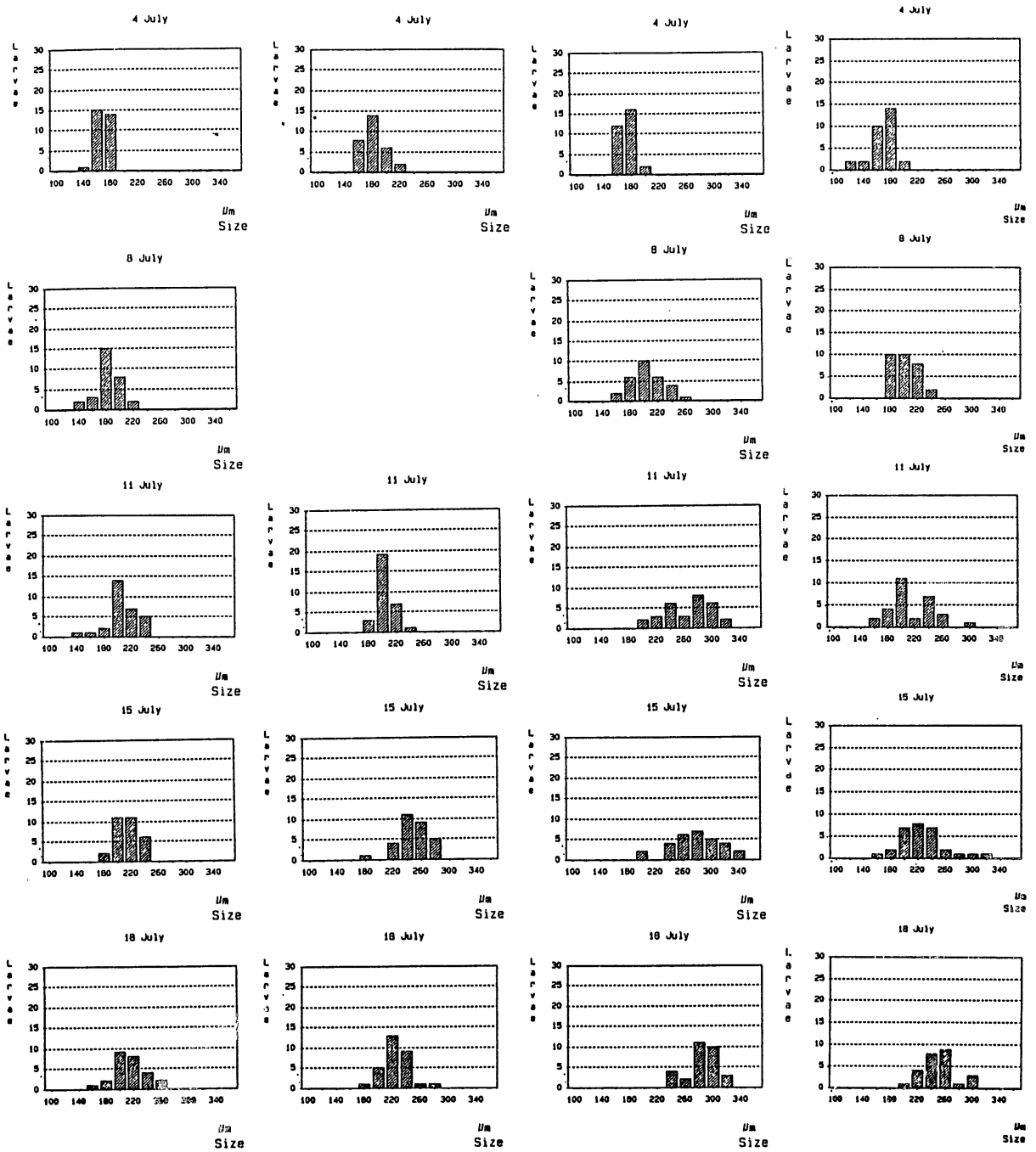

FIGURE 9. The size distributions of oyster larvae in the four experimental bags.