J. mar. biol. Ass. U.K. (1986), 66, 497–503
Printed in Great Britain

GROWTH OF JUVENILE *HALIOTIS TUBERCULATA* (MOLLUSCA: GASTROPODA) IN THEIR NATURAL ENVIRONMENT

JACQUES CLAVIER AND OLIVIER RICHARD

Laboratoire maritime du Muséum national d'histoire naturelle, 17 avenue George V, 35801 Dinard, France

(Figs. 1–6)

A study was made of the growth of the first five generations of a natural population of ormers (*Haliotis tuberculata* L.), during one year, at a subtidal site in the Rance basin (northern Brittany) which was arranged to permit random sampling.

Ormers having a mean length of 3 mm were found from November, about three months after egg-laying. These juveniles were exclusively observed under little slabs of rock where they were preferentially located on encrusting algae of a similar pink colour.

By the end of the first year, the mean shell length is 10 mm. Subsequently the rate of linear growth increases until they are 2·5 years old, and then decreases. The rate of growth of the ormer shows a winter reduction and, on average, approximately 70 % of the annual increase takes place between May and November.

INTRODUCTION

The ormer (*Haliotis tuberculata* L.) occurs in some abundance off the north coast of Brittany and the Channel Islands. On the French coast, exploitation of this species is not legally authorised except in the intertidal zone and the sublittoral stocks have for some years aroused the interest of local fishermen. Studies have therefore been initiated to investigate the exploitation potential of this new resource, and different aspects of the biology and ecology of the ormer have been examined so as to make use of models of population dynamics. Thus, a study of growth merits particular attention.

This parameter has already been the object of precise studies in the Channel Islands (Forster, 1967; Hayashi, 1980*a*) and on the French coast (Cochard, 1982), and its main trends are known. These studies, using marking techniques or the reading of growth rings, provide only relative ages, the growth of young generations remaining ill-defined. We have undertaken to complete the data by a study of a natural population of juveniles, so as to assign an age to each generation of the ormer.

MATERIALS AND METHODS

Our work was based in the region of Saint-Malo (northern Brittany) (Fig. 1). The growth of young ormers was studied in the Rance basin, where environmental conditions, together with the high density of the species there, facilitate work in the natural environment.

A rocky bottom located 3 m below the lowest water levels in the Rance basin, was arranged to facilitate random sampling of the ormer population. A submarine grid, comprising 64 numbered

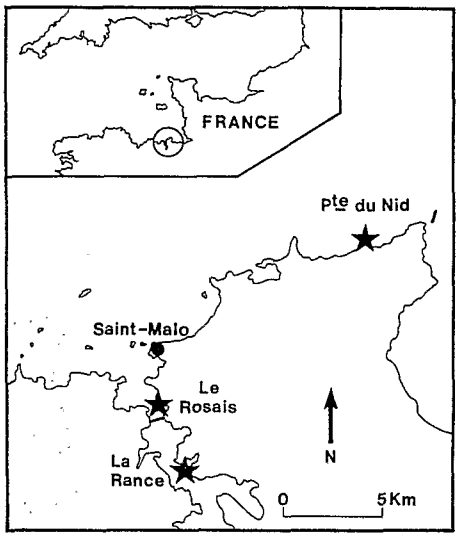

Fig. 1. Location of study areas.

units each of 5 m² area was placed on the shallower part of the site. The ormer population displays a bathymetric stratification of size (Clavier, 1983). The grid was arranged to cover preferentially the habitat of the young individuals.

On each sampling excursion, 12 units of 5 m², chosen at random beforehand, were examined by diving. The maximum length of the ormers present was measured to the nearest 0·5 mm, with vernier calipers, and the size was immediately noted. Each stone lifted was replaced in its original position. The interval between two samplings was never less than two months so as to avoid overdisturbance of the environment, inducing the displacement of individuals outside the experimental grid (Clavier & Richard, 1984). In January high water turbidity prevented the application of the sampling plan in its entirety and only four units were visited.

To supplement the results obtained from the Rance basin, we took two samples in open sea, one in the intertidal zone on very young individuals and the other at a sublittoral area for ormers less than 70 mm long.

The sizes obtained were grouped into frequency distributions. These were transformed into normal curves according to the method proposed by Harding (1949) and clarified by Cassie (1954). We have also calculated a rate of increase for each cohort. It corresponds to the percentage of annual growth achieved at a given time. The shell length being L_t at a time t, L_i at the beginning and L_{i+1} at the end of the year, the rate of increase G will be:

$$G = \frac{L_t - L_i}{L_{i+1} - L_i} \times 100.$$

RESULTS

The size frequency distributions of the ormers on the experimental site are shown in Fig. 2. Four to five cohorts can be distinguished by interpretation of these distributions; the means and standard deviations of normal curves adjusted to the data are shown in Fig. 3.

The first cohort detected by this method has a mean length of 10 mm in August. The youngest specimens unsatisfactorily sampled using SCUBA equipment (Clavier & Richard, 1984) could not be taken into account due to their low

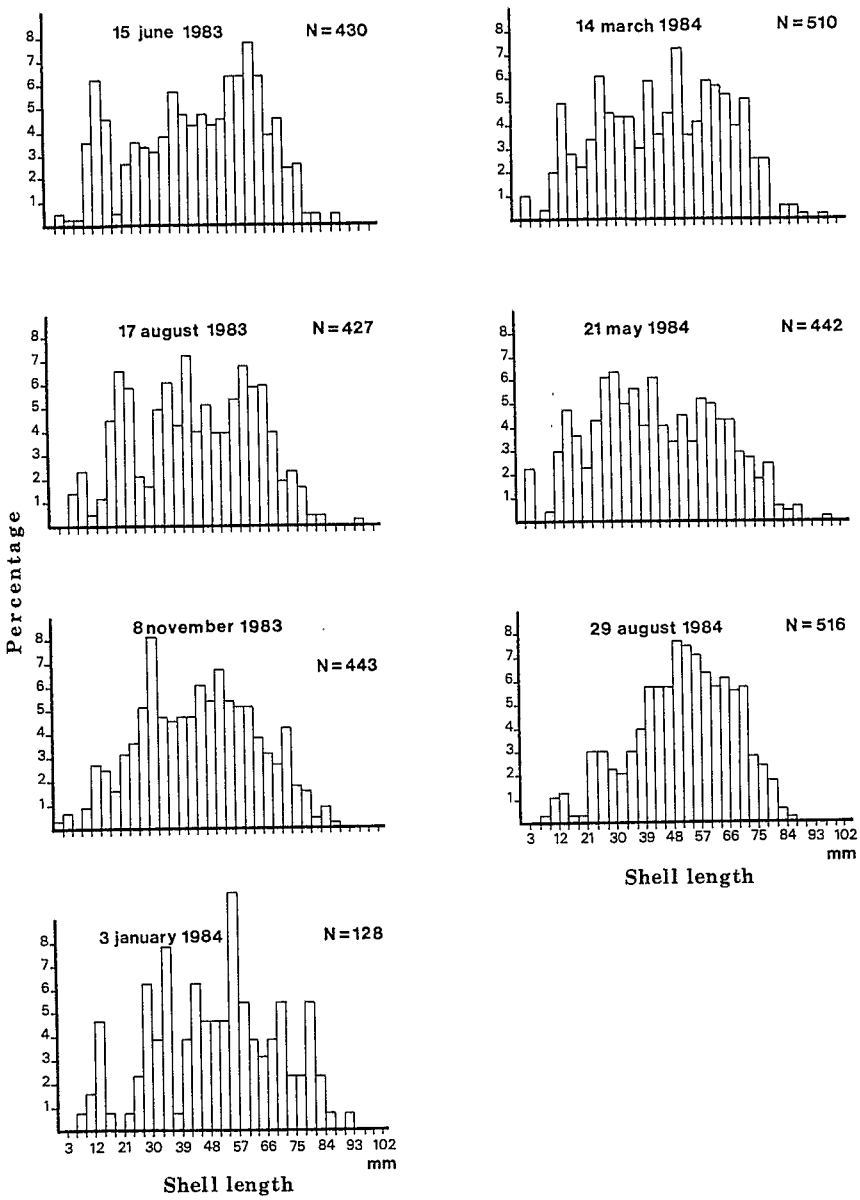

Fig. 2. Size frequency distribution of ormers measured from the Rance basin.

numbers; we have however, calculated their mean lengths (Table 1). We have added to the data from the samples taken in the Rance, the results obtained in March, at the beach of Rosais (Fig. 1), in the intertidal zone. The mean length calculated (Table 1) confirms the order of magnitude of the preceding results.

In the Rance basin the smallest ormers were found in November; their length was 2 mm. Juveniles belonging to the first cohort were found exclusively under the small slabs (from 3 to 20 cm maximum size), they were preferentially located

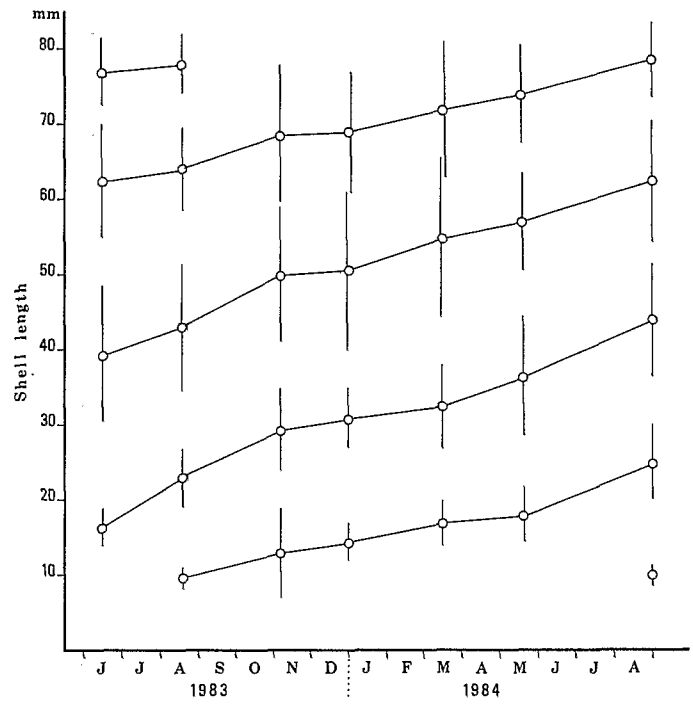

Fig. 3. Range of means and standard deviations of normal curves adjusted to size frequency for each cohort.

Table 1. *Characteristics of individuals of the first cohort, found in the Rance basin and at the beach of Rosais*

N is the number of individuals, $\bar{x}$ is the mean and S.D. the standard deviation of the lengths.

Sampling station	Date	n	$\bar{x}$ (mm)	S.D.
Rance basin	15 June 1983	4	7	3·1
	17 Aug. 1983	22	9	2·2
	8 Nov. 1983	4	3	0·8
	14 Mar. 1984	4	4	0·8
	21 May 1984	10	5·4	0·8
	29 Aug. 1984	16	11	2·2
Le Rosais	3 Mar. 1983	17	3·5	1·3

on the pink encrusting algae, thus confirming the affinity of young *Haliotis* for this type of substrate (Saito, 1981; Morse & Morse, 1984). This mimicry makes it difficult to spot them on this particular substrate.

The development of the length of each cohort (Fig. 3) shows a seasonal fluctuation in the growth of the ormer. We present in Fig. 4, the mean growth rates for the combination of individual cohorts. These rates are low from November to May, during the winter months and the onset of spring when the temperature is low. Approximately 70% of the annual growth in length takes place during the other six months of the year.

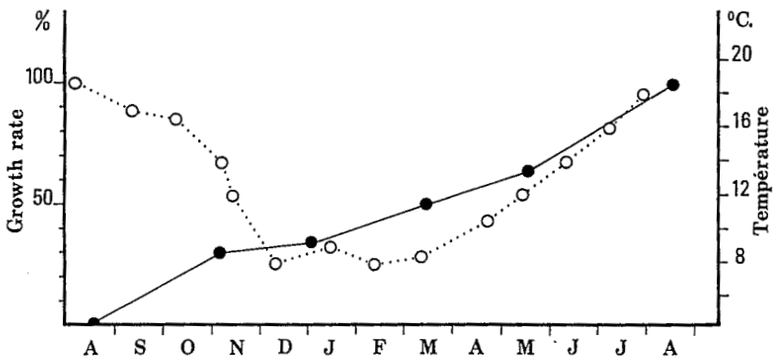

Fig. 4. Evolution during one year of the mean rate of increase (G) in length of the ormer (——). The range of sea water temperatures during the experiment is also shown (. . . . .).

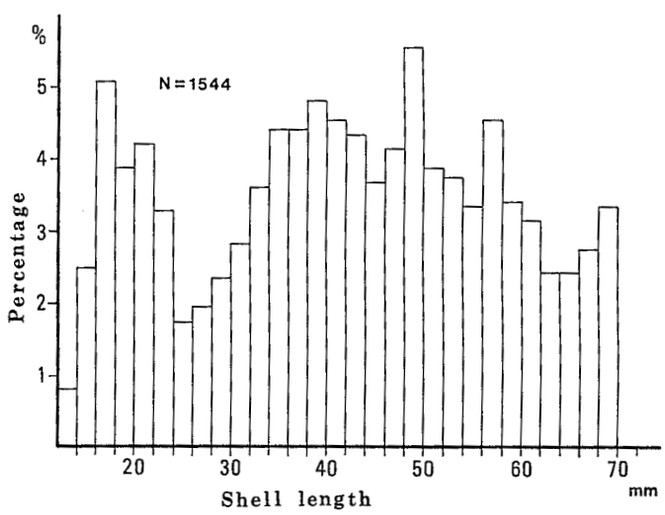

Fig. 5. Size frequency distribution of ormers measured at La Pointe du Nid.

To consolidate these results, a large sample of young ormers ($n = 1544$) was taken using SCUBA equipment at the end of May, at a subtidal site in open sea near La Pointe du Nid (Fig. 1). The length frequency distribution (Fig. 5) shows, after transformation into normal curves, three distinct cohorts with respective means of 19, 39·5 and 58 mm. These lengths do not differ significantly from those obtained in the Rance basin at the same time (t test, $P > 0{\cdot}05$) and confirm the size order of the values obtained.

DISCUSSION

Haliotis tuberculata lays its eggs in the summer (Girard, 1972; Cochard, 1980; Hayashi, 1980*b*). More precisely in the Saint-Malo region, the majority of the gametes are shed in August (Clavier & Richard, 1983) and we presume that the

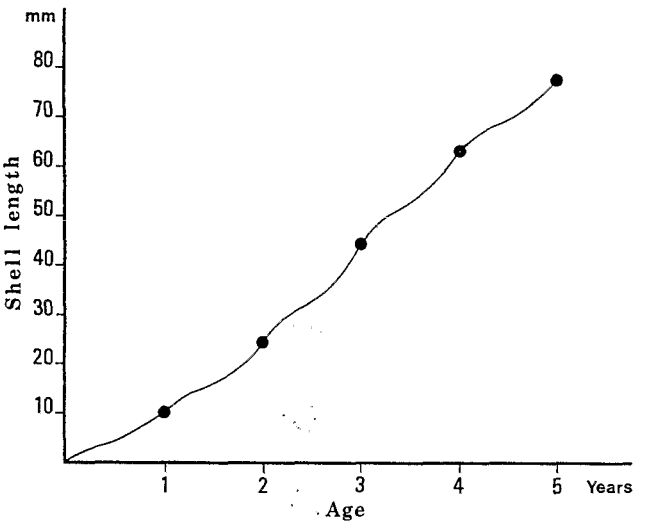

Fig. 6. Mean growth observed for the ormers up to the age of 5 years.

annual cohort appears at this date. The species reproduces at only one time in the year, the cohorts defined by the transformation of size frequency distribution histograms correspond to the generations.

The first generation was detected in November at a mean length of 3 mm, the following May its mean length was only 4·5 mm due to winter reduction in growth rate. This cohort corresponds to the generation hatched during the preceding summer. According to our results, the ormer reaches a length of 10 mm after about one year.

In this way we can establish a growth curve for the ormer up to 5 years of age (Fig. 6) and attribute an age to the different generations. This graph has a point of inflexion at a length of 35 mm corresponding to an age of 2·5 years. Thus, the growth rate increases up until this age and decreases afterwards.

Koike (1978) observed for the same species, a growth of 18 mm during the first year of rearing in a hatchery, at a constant temperature of 20 ± 1 °C, therefore lacking the winter reduction in growth rate. Comparison of these results with those we obtained in the natural environment, proves the viability of rearing in a controlled environment during the early life of the ormer. In fact, at constant temperature, obtaining ormers of a length of 45 mm should be possible in 2 years instead of 3 in the natural environment.

REFERENCES

CASSIE, R. M., 1954. Some uses of probability paper in the analysis of size frequency distributions. *Australian Journal of Marine and Freshwater Research*, 5, 513–522.

CLAVIER, J., 1983. Etude en vue de l'exploitation des ormeaux dans la région de Saint-Malo, méthodes et résultats préliminaires. *Oceanis*, 9, 1–11.

CLAVIER, J. & RICHARD, O., 1983. *Contribution à la Connaissance Écologique de l'Ormeau dans la Région de Saint-Malo*. Rapport d'étude A.M.V.L.C.E.

CLAVIER, J. & RICHARD, O., 1984. Etude expérimentale du déplacement de l'ormeau (*Haliotis tuberculata*) dans le milieu naturel. *Revue des travaux. Institut des pêches maritimes*, **46**, 315–326.

COCHARD, J. C., 1980. *Recherches sur les Facteurs Déterminant la Sexualité et la Reproduction chez Haliotis tuberculata L.* Thèse de 3ième cycle, Université de Bretagne Occidentale.

COCHARD, J. C., 1982. La croissance de l'ormeau *Haliotis tuberculata* L. en rade de Brest. *Haliotis*, **12**, 61–69.

FORSTER, G. R., 1967. The growth of *Haliotis tuberculata*: results of tagging experiments in Guernsey 1963–65. *Journal of the Marine Biological Association of the United Kingdom*, **47**, 287–300.

GIRARD, A., 1972. La reproduction de l'ormeau *Haliotis tuberculata* L. *Revue des travaux. Institut des pêches maritimes*, **36**, 163–184.

HARDING, J. P., 1949. The use of probability paper for the graphical analysis of polymodal frequency distributions. *Journal of the Marine Biological Association of the United Kingdom*, **28**, 141–153.

HAYASHI, I., 1980*a*. Structure and growth of a shore population of the ormer, *Haliotis tuberculata*. *Journal of the Marine Biological Association of the United Kingdom*, **60**, 431–437.

HAYASHI, I., 1980*b*. The reproductive biology of the ormer, *Haliotis tuberculata*. *Journal of the Marine Biological Association of the United Kingdom*, **60**, 415–430.

KOIKE, Y., 1978. Biological and ecological studies on the propagation of the ormer, *Haliotis tuberculata* Linnaeus. I. Larval development and growth of juveniles. *Mer* (*Bulletin de la Société franco-japonaise d'océanographie*), **16**, 124–136.

MORSE, A. N. C. & MORSE, D. E., 1984. Recruitment and metamorphosis of *Haliotis* larvae induced by molecules uniquely available at the surfaces of crustose red algae. *Journal of Experimental Marine Biology and Ecology*, **75**, 191–215.

SAITO, K., 1981. The appearance and growth of 0-year-old Ezo abalone. *Bulletin of the Japanese Society of Scientific Fisheries*, **47**, 1393–1400.