*J. mar. biol. Ass. U.K.* (1959) 38, 361–367
Printed in Great Britain



# THE ECOLOGY OF *ECHINUS ESCULENTUS* L. QUANTITATIVE DISTRIBUTION AND RATE OF FEEDING

By G. R. FORSTER

The Plymouth Laboratory

(With Plates I and II and Text-figs. 1 and 2)

In order to provide more factual information on the effect of *Echinus* predation (Forster, 1958), further diving observations have been made during 1958. A rocky area just west of the Tinker Shoal was explored by chance and a population of *Echinus* discovered. As this area is much more readily accessible than Stoke Point rock, where most of the diving has been carried out, it was possible to establish a marker buoy and make a number of dives on exactly the same position. In the course of these dives I have attempted to measure the numerical density of the urchins and the rate of their browsing on the rock surface. Later *Echinus* 'counts' were made at many other positions near Plymouth (Text-fig. 1).

The abundance of *Echinus* has been measured by counting the number of urchins observed in a known area of sea-floor. A terylene line roughly 50 m long is laid out on a rocky part of the sea bed as is shown diagrammatically (Text-fig. 2). One end of the line is attached to the bottom of a shot rope or to the boat's anchor. The line is then drawn out to its full length with the aid of a dinghy. The diver swims along the line with a $2\frac{1}{2}$ m rod ($\frac{5}{16}$ in. galvanized wire) held at right angle to the line, counting the numbers of urchins first on one side of the line and returning along the other side; in this way a strip of rock surface 5 m wide is covered. If the line is found to be suspended between pinnacles of rock the diver can lift the 7 lb. lead at the distant end and drag it slightly until the line just touches the rocks' surface. Should part of the line be lying on sand, the actual area where urchins are being counted can be marked off by tying knots in the line.

The rate of browsing was measured by turning over a few large boulders in a position where *Echinus* were present, and placing one urchin on the newly exposed surface of each boulder. On the next dive 24 h later, if the *Echinus* was still occupying a position on the boulder, it was removed and the outline of the area which had been browsed was traced on a sheet of Ethulon. It was hoped that the undersides of these boulders, usually covered with many small barnacles (*Verruca stroemia*) would prove attractive to the *Echinus*, since *Verruca* are readily browsed on by urchins in an aquarium tank. In addition a

pair of wire frames covered with large mesh nylon netting have been used to confine a number of urchins in a small area. These frames were 1 $m^2$ in area and about 18 in. high. A heavy chain was laced to the edge of the netting to keep it in contact with the rock all the way round, also serving to prevent the

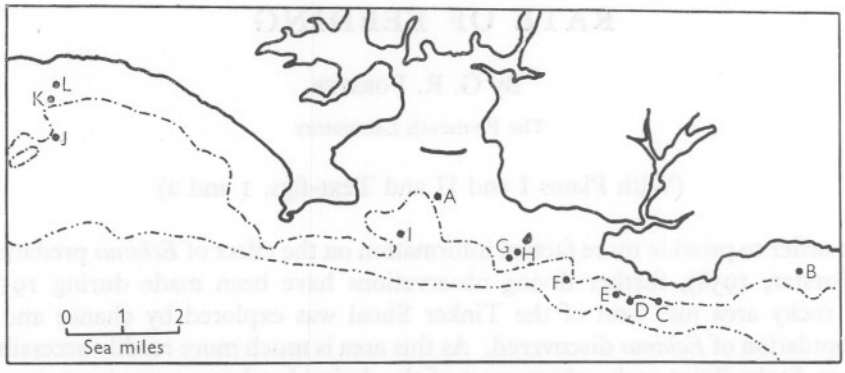



Fig. 1. Outline chart of Plymouth Sound and neighbourhood showing positions A–L, described in Table 1. The 10 and 20 fm lines are represented by lines with single and double dots respectively.

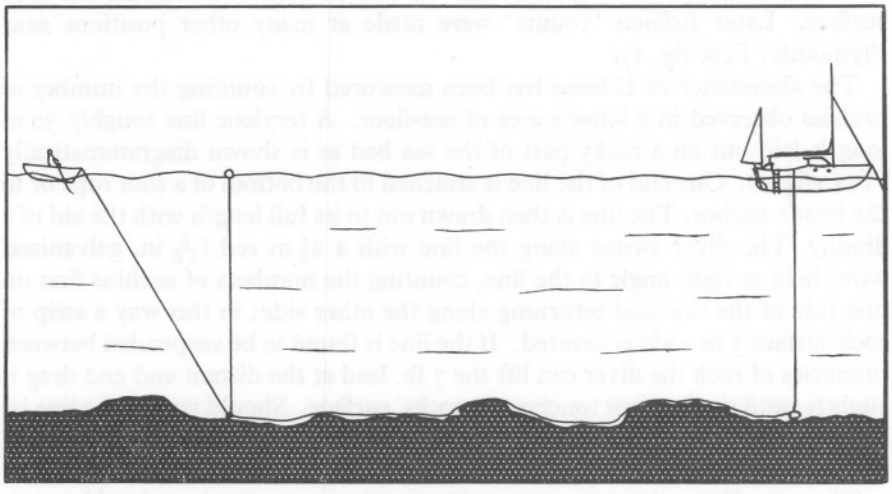


Fig. 2. Diagram showing the method of laying out the 50 m line over the rocky sea floor.

frame being moved about by wave action. After a period of several weeks the browsed area under the frame can be compared with a control area under the second frame from which *Echinus* have been excluded, or simply with the immediate surrounding rock surface if this has been kept clear of urchins during the course of the experiment.

Some tests on the browsing of *Echinus* in aquarium tanks have also been

made. The area of algal film swept clear by an urchin over a known period can be marked on the glass surface or traced directly on to Ethulon so that the area can be measured. The urchins used in these tests had all been allowed to acclimatize themselves to aquarium conditions for several weeks.

## RESULTS

Table 1 shows the results of *Echinus* counts made chiefly during September and October 1958.

The average distribution of *Echinus* in the areas examined is therefore one per $4\frac{2}{3}$ m², or 868 per acre. Thus in the 4 mile strip of coast between the Mewstone and Revelstoke Point, it may be assumed from the chart that there is generally about $\frac{1}{2}$ mile separating the 7 fm from 17 fm contour; in this narrow strip alone there should be a population of nearly 1,400,000 urchins.

All the underwater observations on browsing were made in the immediate vicinity of a marker buoy situated 4 cables west of the Tinker Shoal. The marker buoy cable was attached to a projecting rock on the bottom. The following transits make it a simple matter to locate the position if the buoy should be submerged or lost. The higher anchorage beacon on Ramscliff Point is in line with the beacon on the east end of the breakwater, and the north-west corner of the Mewstone appears to be almost touching the southernmost tip of Stoke (Hilsea) Point.

The results of tests on the rate of browsing are shown in Table 2. The algal films in the last two tests were composed of *Hildenbrandia prototypus* Nardo (red) and a mixture of various green and blue-green algae. The average browsing rate for the 8 tests is 2·9 cm²/h.

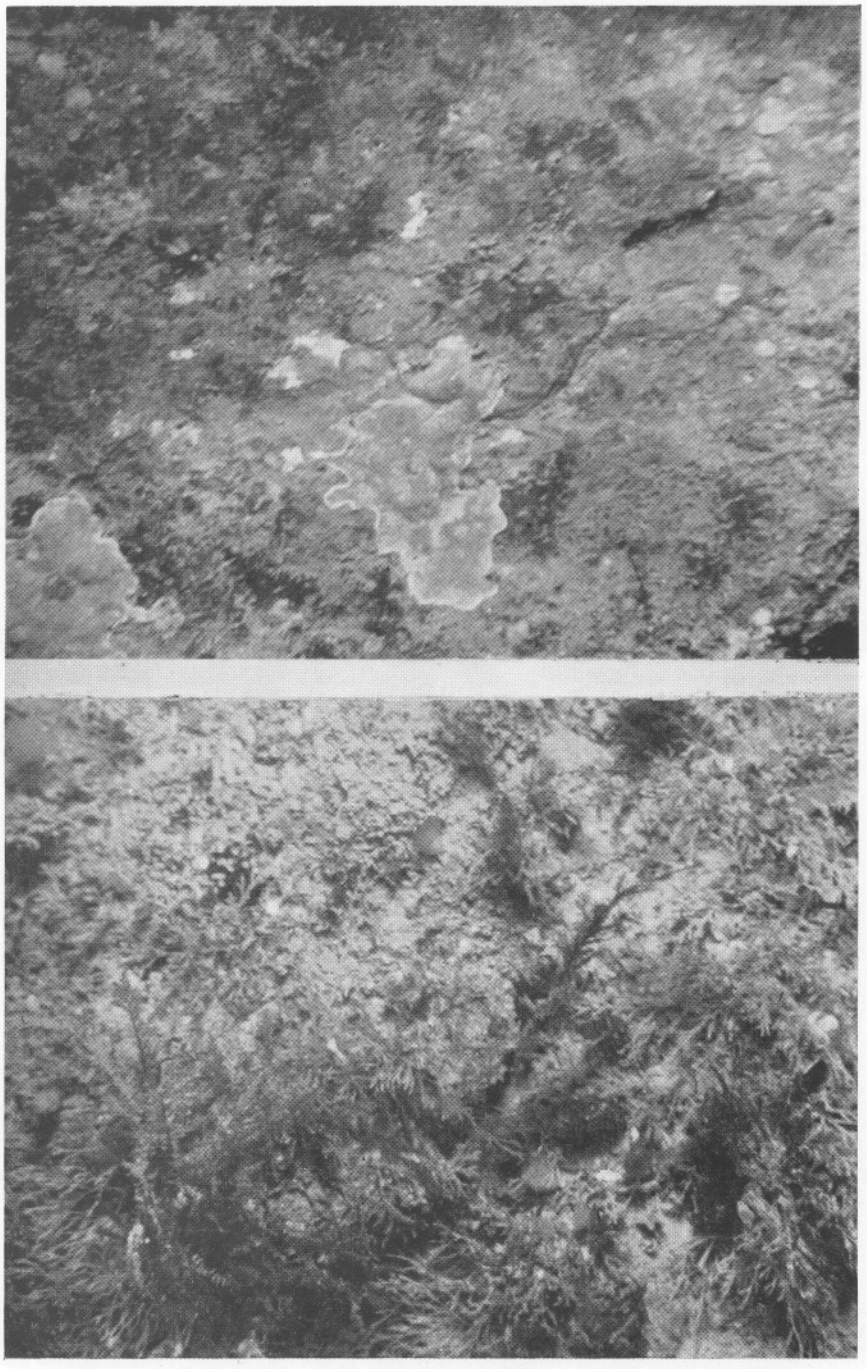
## GENERAL NOTES ON BROWSING AND HABITS

### *Underwater observations*

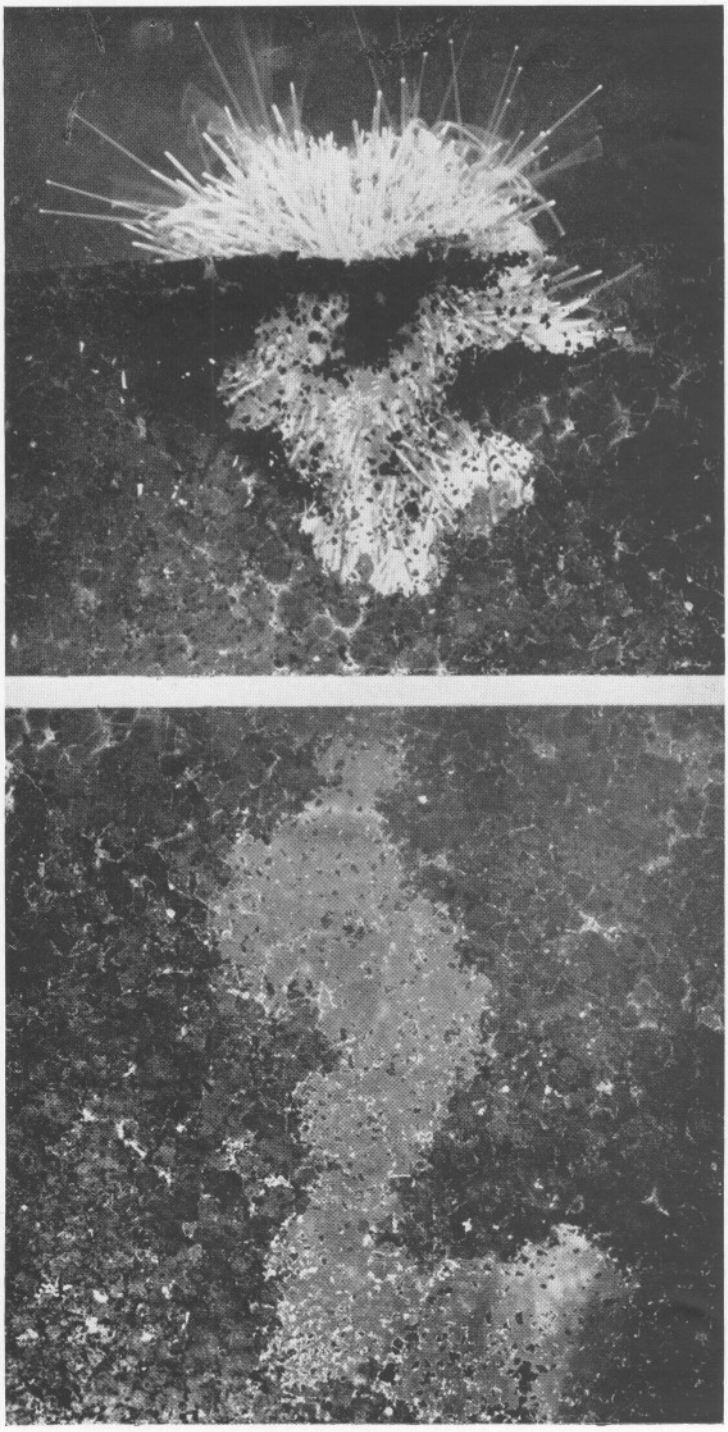
A browsed area of about $\frac{1}{4}$ to $\frac{1}{2}$ m² is usually recognizable around most of the *Echinus* examined underwater. This is not completely bare rock but is devoid of any normal brown 'fur' composed of very small filamentous algal growths encrusted by diatoms, etc., the remains of hydroid colonies similarly overgrown besides muddy tubes of amphipods and various polychaetes; it can best be described as presenting a clean 'scrubbed' appearance. In Plate I two underwater photographs show the contrast between browsed and normal rock surfaces. The browsed area formed a small part of the rock covered by a netting frame which confined six *Echinus* to 1 m² and was photographed after a month. The second photograph shows the normal appearance of the rock and was taken about 1–2 m away from the netting frame. *Lithothamnion* is usually very common in the browsed areas. Whether this browsed area is in any way similar to the territory of a limpet is not yet known. It will also be of interest to ascertain if there is any tendency for the *Echinus* to home

TABLE 1

| | Position | Depth (fm) | Length measuring line (m) | Area ($m^2$) | No. *Echinus* | Notes |
|---|---|---|---|---|---|---|
| A | 4 cables west from Tinker Shoa | 8½–9 | 54 | 135 | 14 | Line arranged east from marker buoy |
| | | 8½–9 | 54 | 135 | 11 | |
| | | 8½–9 | 54 | 135 | 22 | Line arranged north from marker buoy |
| | | 8½–9 | 54 | 135 | 14 | |
| | | 8½–9 | 54 | 135 | 20 | |
| | | 8½–9 | 54 | 135 | 4 | Line arranged south from marker buoy |
| | | 8½–9 | 54 | 135 | 8 | |
| | | 8½–9 | 54 | 135 | 18 | Line arranged west from marker buoy |
| | | 8½–9 | 54 | 135 | 6 | |
| | | 8½–9 | 50 | 125 | 17 | Line running along a gully wall |
| B | Bigbury Bay ½ mile south of St Anchorite's rock | 9 | 36 | 90 | 2 | Line often close to or cutting across gravel patches |
| | | 9 | 36 | 90 | 5 | |
| C | About 30 yards south-west from Stoke Pt (=Hilsea Pt) rock | 14–15 | 54 | 135 | 36 | Normal rock bottom |
| | | 14–15 | 54 | 135 | 29 | |
| D | ½ mile south-west of Stoke Pt | 13 | 36 | 90 | 8 | |
| | | 13 | 36 | 90 | 11 | |
| E | *ca.* ½ mile south-west of small headland just west of Stoke Pt | — | 54 | 135 | 11 | Some gravel patches in vicinity |
| | | — | 54 | 135 | 8 | |
| F | *ca.* ¾ mile south-west of Gara Pt | 10–11 | 54 | 135 | 34 | — |
| | | 10–11 | 54 | 135 | 29 | — |
| | | 10–11 | 54 | 135 | 18 | — |
| | | 10–11 | 54 | 135 | 35 | — |
| | | 10–11 | 54 | 135 | 29 | — |
| | | 10–11 | 54 | 135 | 23 | — |
| G | *ca.* 4 cables south-west of Mewstone | 14 | 36 | 90 | 30 | — |
| | | 14 | 36 | 90 | 32 | — |
| | | 12 | 30 | 75 | 26 | — |
| | | 12 | 30 | 75 | 35 | — |
| H | *ca.* 3 cables south-west of Mewstone | 10–11 | 54 | 135 | 29 | — |
| | | 10–11 | 54 | 135 | 19 | — |
| | | 10–11 | 54 | 135 | 37 | — |
| | | 10–11 | 54 | 135 | 28 | — |
| I | 1 mile south-east of Penlee Pt | 9–10 | 54 | 135 | 41 | Line running west parallel to ridges of rock |
| | | 9–10 | 54 | 135 | 43 | |
| | | 9–10 | 54 | 135 | 7 | Line running south cutting across ridges of rock and gullies of muddy gravel |
| | | 9–10 | 54 | 135 | 10 | |
| J | Whitsand Bay *ca.* 1½ miles south of Brawn Rk (between Portwrinkle and Downderry) | 10½ | 54 | 135 | 46 | Low reefs of rock; *Echinus* slightly smaller than usual (mean diam. of 6–7·7 cm, cf. mean diam. of 8–11·3 cm from marker buoy position) |
| | | 10½ | 54 | 135 | 41 | |
| | | 10½ | 54 | 135 | 75 | |
| | | 10½ | 54 | 135 | 78 | |
| K | Slightly closer inshore | 9 | 54 | 135 | 63 | |
| | | 9 | 54 | 135 | 52 | |
| | | 7½–8 | 54 | 135 | 50 | |
| | | 7½–8 | 54 | 135 | 33 | |
| | | | Totals | 5540 | 1187 | |



(*Facing p.* 364)



when they are moved from these positions. At the position in Whitsand Bay where large numbers of *Echinus* were counted, all horizontal rock surfaces were almost wholly covered by *Lithothamnion* and another encrusting red alga *Cruoria pellita* (Lyngb.) Fries. Presumably the *Lithothamnion* is either not browsed on heavily or else regenerates more quickly than other species.

At the position near the Tinker Shoal, depth 9 fm, which is near the upper limit for *Echinus* at Plymouth, almost every specimen was partly covered with algal fragments in a similar manner to *Psammechinus miliaris*, though the covering is generally rather more scanty. This form of behaviour is not usually exhibited by *Echinus* in aquaria.

TABLE 2

| Type of observation | No. of *Echinus* | Area browsed | Time | Rate of browsing ($cm^2$/h) |
|---|---|---|---|---|
| Netting frame on rock, *ca.* 9 fm | 6 | 1 $m^2$ | 25 days | 2·78 |
| Netting frame on rock, *ca.* 9 fm | 3 | ¼ $m^2$ | 11 days | 3·2 |
| Surface of upturned boulder, *ca.* 9 fm | 1 | 99 $cm^2$ | 22 h | 4·5 |
| | 1 | 46 $cm^2$ | 22 h | 2·1 |
| | 1 | 52 $cm^2$ | 18·5 h | 2·9 |
| | 1 | 73 $cm^2$ | 18·5 h | 3·9 |
| Aquarium tank glass. Red algal film | 1 | 161 $cm^2$ | 2 days 19 h | 2·4 |
| Aquarium tank glass. Green algal film | 1 | 271 $cm^2$ | 8 days | 1·4 |

*Feeding in aquaria*

*Echinus* will feed readily on the algal film growing on the glass of an aquarium tank. The *Echinus* browses steadily in one spot until after a few hours a small clear area can be observed. This area is slowly enlarged by the urchin working round its periphery leaving remarkably few remnants of the algal film (Plate II). Browsing goes on steadily both during day and night but is not generally continuous for more than a day or two. In one series of observations the rate of browsing for 24 h, apparently continuous browsing, was 5·8 $cm^2$/h, while for just under 3 days the rate was reduced to 2·4 $cm^2$/h.

EXPLANATION OF PLATES I AND II

I

Views of the rock surface near Tinker Shoal (depth 9 fm), showing (above) the effect of browsing by *Echinus*, as compared with (below) the state in the absence of *Echinus*.

II

Photographs of the glass front of an aquarium tank showing the results of browsing by *Echinus*. In the upper illustration the *Echinus* is seen in the act of feeding on the thick film of reddish-brown encrusting alga, with its mouth slightly to the left of the centre. The lower illustration shows the clear trail where the algal film has been eaten by an *Echinus*.

Sometimes a second patch on another side of the tank may be browsed for a while with the urchin subsequently feeding alternately on the two distinct areas.

## DISCUSSION

The results of the *Echinus* counts show that the urchins are very abundant, particularly below 10 fm. From 10 to 15 fm they may well be considered the dominant species, for in this depth zone the average distribution is one urchin to 4·1 $m^2$ of rock surface. From the browsing tests (Table 2) it may be seen that 2 $cm^2/h$ is a reasonably conservative rate to assume. Thus if an *Echinus* browses at this rate for four months of the year and at 1 $cm^2/h$ for the remaining 8 colder months it would have covered 1·2 $m^2$ in the course of the year. On this basis the *Echinus* population is clearing about one-third of the rock surface every year. Naturally the browsed areas would soon be recolonized, but any feeding preferences on the part of the urchins would exercise considerable influence on the proportions of different sessile species. Further predation, possibly rather selective, must be expected from the numerous *Marthasterias glacialis*, occasional *Maia squinado* and from the various species of wrasse.

The distribution of *Echinus* in shallow water or on the shore has attracted much attention in the past. In the north of England and Scotland the species is normally present in quite shallow water—less than 5 fm and in early spring there is a small inshore migration before spawning as far as L.W.S.T. level (Elmhirst, 1922; Stott, 1931). In the south the only records of urchins found on the shore are near Mousehole (Trewavas, 1922) and in the Isles of Scilly (G. M. Spooner, unpublished notes, 1936–7). At Mousehole for the first mile of coast running southwards the 10 fm line lies only 200 yd offshore so that from low water down to 10 fm there is an average gradient of 1 in 10, a situation which is unique for South Devon and Cornwall. It therefore seems very probable that the occasional urchins taken both in this locality and at Scilly are merely strays from deeper water nearby. Reid (1935) postulates a correlation of the intertidal distribution of *Echinus* with the course of the Gulf Stream. This theory will not, however, bear any close examination, for even with the current chart as shown by Reid (for which no reference is given) *Echinus* should be present not only on the shore of north Spain but also along the French coast towards Finistère. But there are no published records of the presence of *Echinus* along the north Spanish coast, and, in a letter from the oceanographic laboratory of Santander, Dr Cuesta writes that it is present but not common. The only two French records, Roscoff and Lanvéoc near Brest (Station biologique de Roscoff, 1951; and Anthony, 1925), are also for places quite close to deeper water. Thus for the whole southern part of its range the species is basically sublittoral and it seems much more reasonable to suppose that a slightly different race is present in the northern part where there is a definite change in behaviour.

SUMMARY

The numbers of *Echinus esculentus* present in known areas have been counted at several positions near Plymouth. A total area of over 5,000 m² has been covered, and in this area the average density of *Echinus* is 868 per acre (1–4·7 m²). A few tests on the rate at which *Echinus* browse on algae and sessile animals have also been made. From these results it has been possible to estimate that where urchins are abundant they are capable of sweeping clear at least one-third of the whole rock surface in the course of a year.

The species is sublittoral for the southern part of its range.

REFERENCES

ANTHONY, R., 1925. Première note sur la faune échinologique littorale de Lanvéoc. *Bull. Soc. zool. Fr.*, T. 50, pp. 319–35.

ELMHIRST, R., 1922. Habits of *Echinus esculentus*. *Nature, Lond.*, Vol. 110, p. 667.

FORSTER, G. R., 1958. Underwater observations on shallow rocky areas in the neighbourhood of Plymouth. *J. mar. biol. Ass. U.K.*, Vol. 37, pp. 473–82.

REID, D. M., 1935. The range of the sea-urchin *Echinus esculentus*. *J. Anim. Ecol.*, Vol. 4, pp. 7–16.

STATION BIOLOGIQUE DE ROSCOFF, 1951. Inventaire de la faune marine de Roscoff: Bryozoaires Echinodermes. *Trav. Sta. biol. Roscoff*, T. 2, Suppl. 4.

STOTT, F. C., 1931. The spawning of *Echinus esculentus* and some changes in gonad composition. *J. exp. Biol.*, Vol. 8, pp. 133–50.

TREWAVAS, E., 1922. Note on the occurrence of *Echinus esculentus* above low tide mark on the Cornish coast. *J. mar. biol. Ass. U.K.*, Vol. 12, pp. 833–4.