PRELIMINARY OBSERVATIONS ON THE INFLUENCE OF WATER MOVEMENT ON POPULATION STRUCTURE IN *ANCORINA CORTICATA* (CARTER) (CHORISTIDA: DEMOSPONGIAE)

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SUMMARY: The influence of water movement on sponge population structure was investigated in the marine sponge *Ancorina corticata* (Carter) from Westernport Bay, Victoria, Australia. Population characteristics studied were dispersion, population density, biomass and size-frequency distributions. Strong continuous water movement facilitated the growth of the sponge but no effects were found on the dispersion patterns of the population.

INTRODUCTION

Little information is available on the ecological dynamics of sponge populations, even though members of the phylum are frequently dominant components of benthic communities. The present study measures biotic parameters for a population, the members of which are subject to differing environmental stresses. A subtidal population of the sponge *Ancorina corticata* (Carter) (Choristida; Demospongiae) inhabiting a reef in Westernport Bay, Victoria, Australia, was selected for the study.

The Reef

The study site lies in the most northerly part of Westernport Bay (Fig. 1), in Bagge Harbour. This small reef, known as Crawfish Rock, is emergent to an area of approximately 0.2 hectares at low water and lies in the main deep water channel of North Arm.

The northern and eastern sides of the reef abut the deepwater channel, while a long sandspit, Middle Spit, has been built onto the southern and western sides.

Tide rise and fall in Bagge Harbour is three metres. This large vertical movement in a relatively small body of water generates strong currents in the channel system. Crawfish Rock, situated near the centre of Bagge Harbour, thus offers a restriction to free flow of the currents, resulting in local increases of current velocities, and break-up of the regular

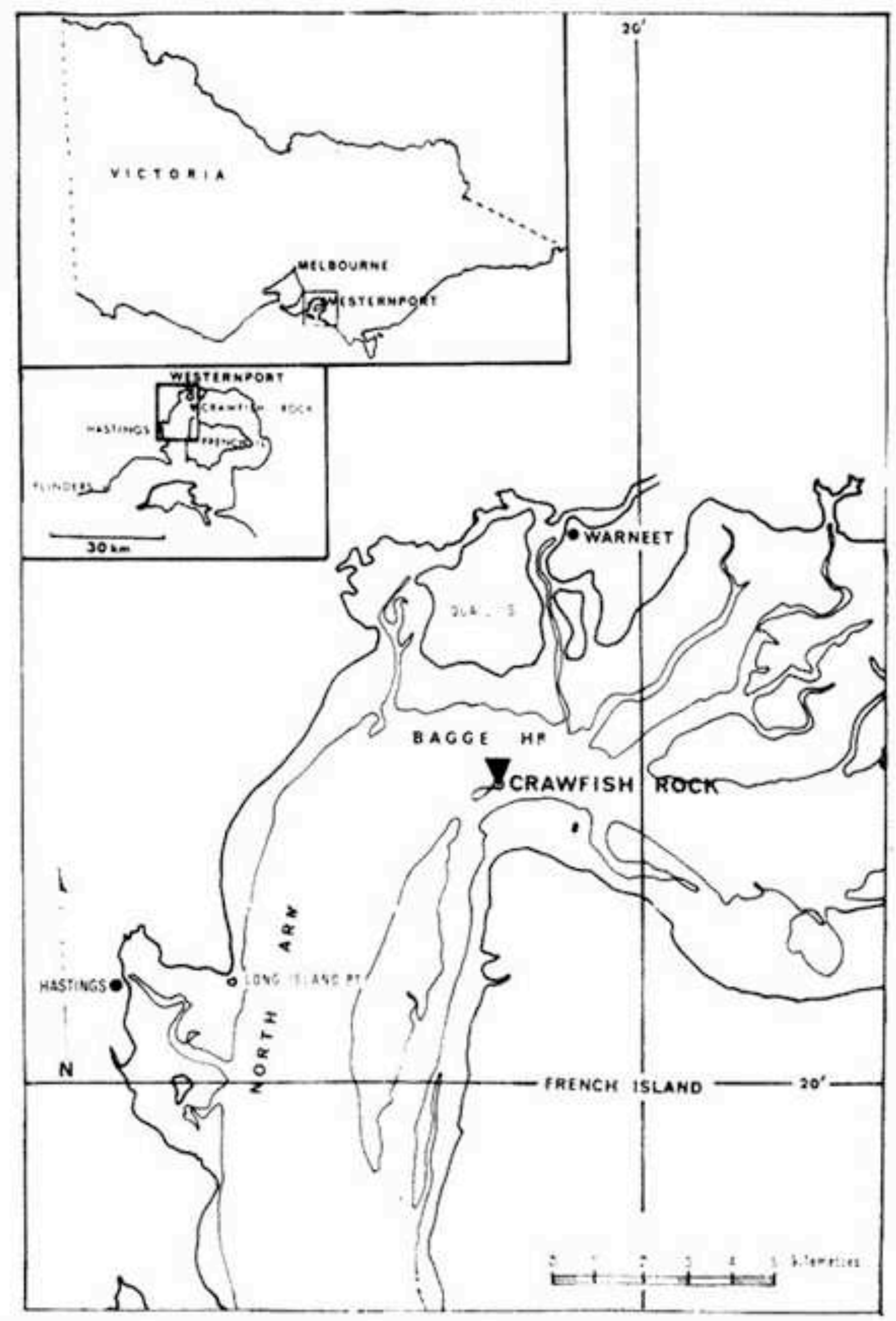

FIGURE 1. *Location of Crawfish Rock in Westernport Bay.*

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flow into patterns of turbulence.

The Reef Community

The reef community of which *A. corticata* is a part, is diverse in terms of species. The fauna is distinctive, containing many sheltered water species, some of warm temperate affinities, and species which normally are found only in the deeper waters of the southern Australian coastline (Watson, 1971).

Sponges are the dominant sessile macrobethic organisms of the reef community (estimated 300 species). They contribute perhaps 80 percent of the total biomass of invertebrate animals on the reef.

Ancorina corticata

A. corticata is one of the larger, globose sponges at Crawfish Rock, reaching a maximum height of 30 cm and averaging 37 cm in diameter. The basal attachments are several root-like processes which may, however, be obscured by a plate-like growth of the sponge over the substratum. The body of the sponge is very compact and difficult to penetrate with a knife. The surface is commonly a maroon colour (2.5 R 5/4), shading into brown (7.5 YR 7/4) and buff (7.5 YR 8/4), and cream (2.57 Y 8/4) at the base.

METHODS

All underwater measurements and observations of *A. corticata* were carried out using SCUBA equipment.

For the study, Crawfish Rock was divided into regimes with different water movement characteristics. These were:

(i) East subregion—Extending from the surface to the channel floor at a depth of 20 m. This subregion is subject to variable current velocities and supports an estimated population of 80 *A. corticata* in an area of 995 m^2.

(ii) North-east subregion—The smallest geographical subdivision, 385 m^2, located on the corner between the other two subregions. The subregion extends to a depth of 20 m and is subject to very high current velocities. Supports a large population (350 sponges) of *A. corticata*.

(iii) North subregion—Extending to a depth of 18 m, with an area of 1,420 m^2, low current velocities and few (40 sponges) *A. corticata*.

These subregions are shown in Figure 2.

Measurement of Water Movement

Clod-cards (Dotty, 1971) were used to measure water movement. These are cubes of plaster of Paris which are placed on the substratum adjacent to the organisms being studied, then left over one or more tidal cycles—12, 24, 36 hours or longer depending on the degree of water movement. The rate of dissolution of calcium sulphate in seawater is sufficiently high to be measurable by loss of weight, and thus may be related to total water movement over the clod-card. The method does not distinguish between water movement due to wave action or currents, but in Westernport Bay, where wave action is negligible, results may be interpreted as a direct measure of current action.

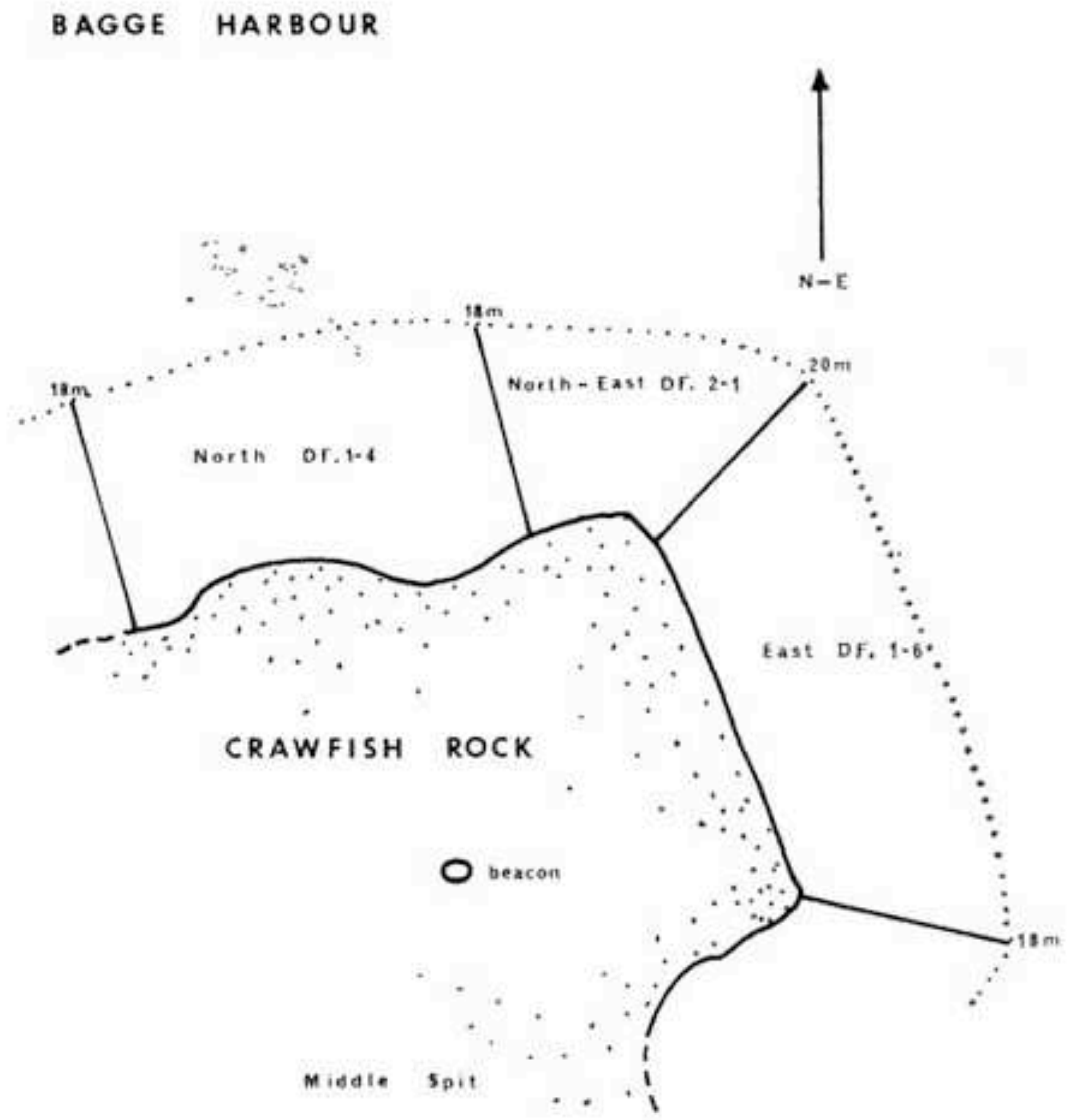

FIGURE 2. *Subregions of Crawfish Rock with water movement DF values.*

Cubes were attached to a polymethacrylate base and then wired onto housebricks ready for immersion at various sites on the face of the reef. Two sites of maximum exposure to water movement were chosen in each subregion, one in shallow water, one in deeper water. Duplicate clod-cards were thus placed from 0.8 m depth and 8-16 m depth. The clod-cards were retrieved after 24 hours exposure. The procedure was repeated on three different occasions during both spring and neap tides, giving a total of 36 separate observations.

A clod-card index (CV), or the loss of weight of the clod during immersion is calculated in the following way:

$$\frac{CV}{k} = DF$$

where k the still-water immersion value is divided into the CV to obtain a Diffusion Factor Index (DF). The DF is a measure of the degree to which normal dissolution is enhanced by water movement.

Size-mass-frequency and Biomass measurements

The maximum circumference of a sample of at least 50 sponges from each subregion was measured. Circumference was chosen to estimate biomass (see Fig. 3) as this measurement could be made *in situ* without depletion of the population. The only errors which could result from this method would be caused by irregularities in shape and internal death in some of the larger specimens.

Population Density Measurement

To establish population density, the number of individuals in eight quadrats each of 5 m^2 was sampled in each subregion.

Dispersion Measurement

Dispersion was characterised by nearest neighbour sampling (Cottam and Curtis, 1956). In the north-east and east subregions thirty-four distances to nearest neighbour were taken, and the entire population sampled in the north subregion. A rope weighted at each end was used to draw a radius around each sponge in a search for the nearest *A. corticata* neighbour. This distance was recorded and the procedure repeated. Thus gradually the positions of a sample of the *A. corticata* population was plotted.

RESULTS

Current Patterns

Diffusion Factor Indices for Crawfish Rock are given in Table 1. Since measurements taken in shallow and deep water zones of each subregion showed no significant differences, results for each subregion have been combined.

TABLE 1. *Diffusion Factor Indices for subregions of Crawfish Rock.*

Subregion	Mean Diffusion Factor Index
North-east	2.1
East	1.6
North	1.4

The high DF value for the north-east subregion agrees with the observation that strong continuous currents operate on this side of the reef. Slack water only occupies a few minutes to half an hour, beginning and ending abruptly, hence still-water conditions seldom occur.

In the east subregion (DF 1.6) there are variable

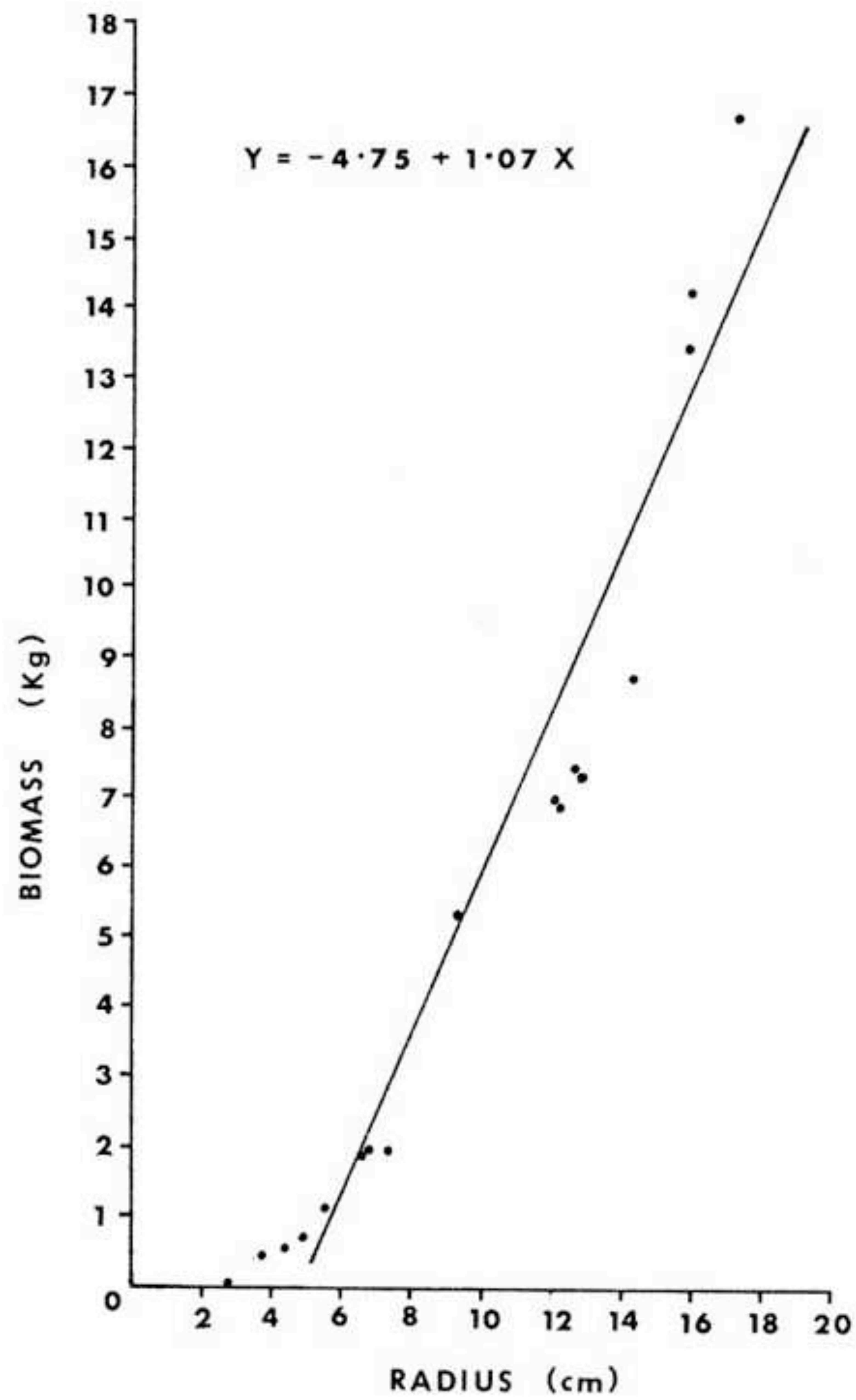

FIGURE 3. *Relationship between radius and biomass of* A. corticata.

water movements created by the presence of angular extremities from the reef which obstruct and cause separation of flow and form eddies. Thus the population of *A. corticata* in this subregion experiences intermittent fluctuations from calm to rapid water movement, particularly on the ebbing tide. These eddying movements do not provide the continuous dissolution of the cubes that may be found in the north-east subregion, the DF values are therefore lower.

Incoming tides are deflected northwards by Crawfish Rock, resulting in long periods of relatively slack water in the north subregion when there is little exchange with the main stream. However, a strong upward flow occurs along the north face during the first hours of the ebbing tide, until emergence of the reef causes flow to be directed laterally around the sides. The longer periods of relatively quiet conditions are reflected in the lowest DF value (1.4) for the entire reef.

Current related physical features lend some support to the above water movement observations. The north-east subregion, a projecting corner of Crawfish Rock, has a topography that is irregular, composed of boulders. To the north the shelter provided by the embayment of the north subregion allows deposition of sediment and some detritus. To the east the reef has been dissected into gullies, some four metres in depth. Through this east subregion suspended material has been observed to move with the turbulent stream in a series of rapid depositions and resuspensions with the abrupt changes in current.

Biomass

Circumference measurements were used to obtain the standing crop, average biomass of individuals and size-mass-frequency distributions for each subregion. The size-mass-frequency of a random sample of the population (Fig. 4) clearly shows

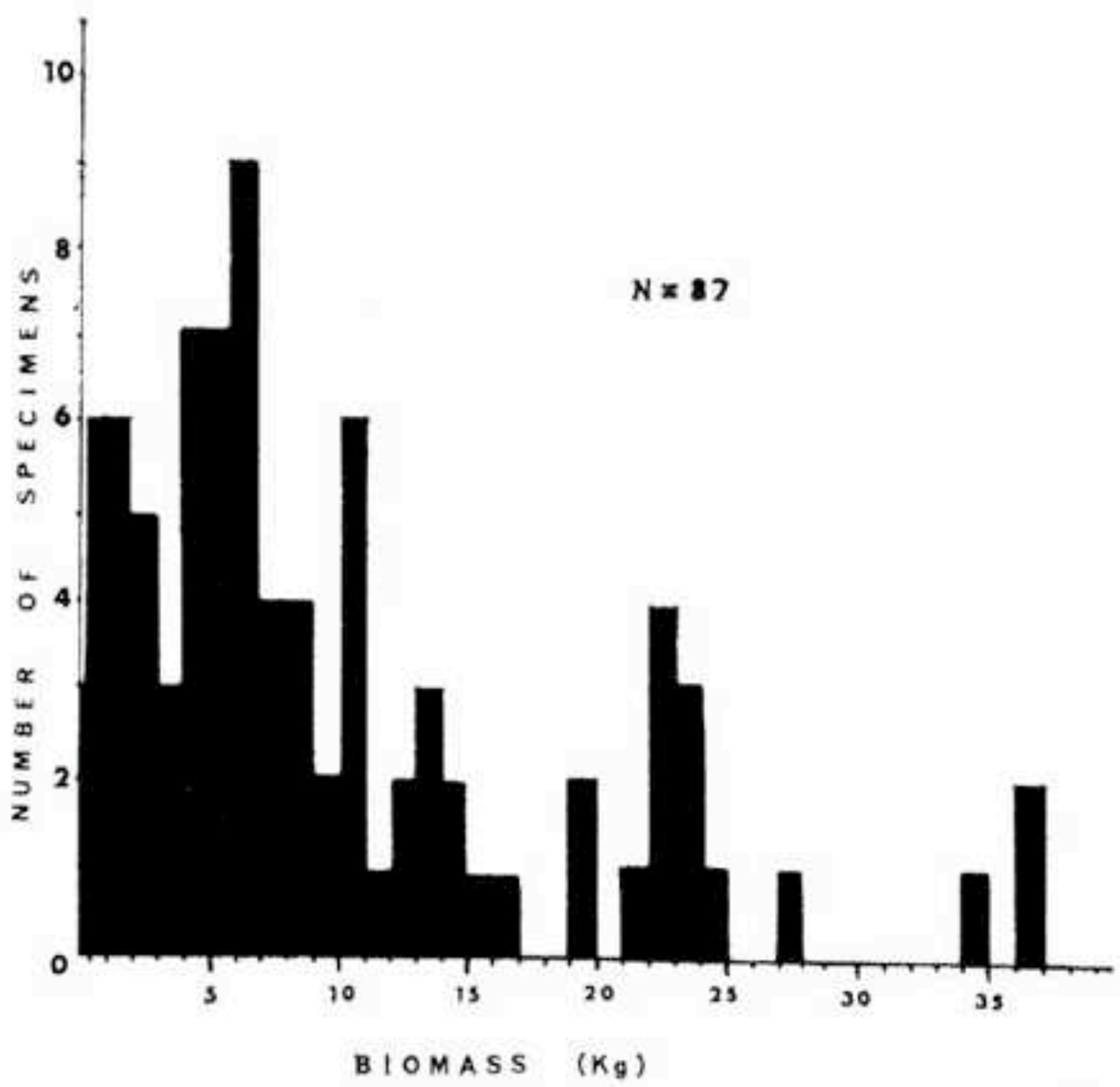

FIGURE 4. *Size-mass-frequency of the sampled population of* A. corticata.

skewing to the left with a majority of individuals in the 0-15 kilogram range (80.5%). There are two other modes in the distribution, between 16-25 kg (15.0%) and 34-37 kg (4.5%).

The percentage contribution of numbers of individuals in the different ranges for each subregion is shown in Table 2. There is a general trend for

TABLE 2. *Percentage size-mass-frequency of the* A. corticata *population for each subregion.*

Subregion	North-east		East		North	
	No.	%	No.	%	No.	%
Small <15 kg	47	70	35	70	37	92.5
Medium 16-25 kg	15	22.5	9	18	3	7.5
Large >26 kg	5	7.6	6	12	—	—

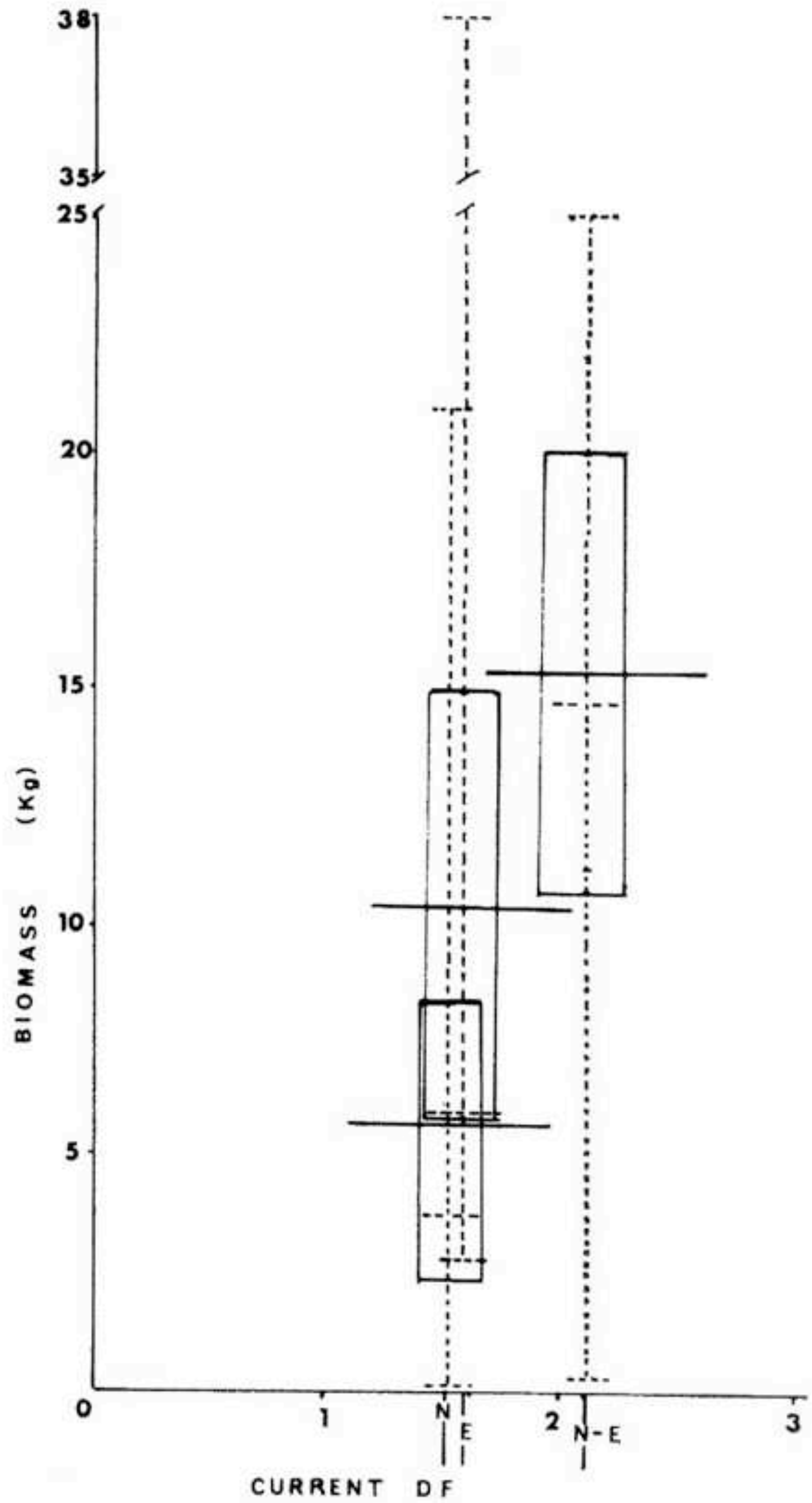

FIGURE 5. *Relationship between water movement and biomass of* A. corticata: *dotted line represents the range and median, the solid line, the average and standard deviation.*

lower numbers of small sponges in places of strong water movement accompanied by an increase in the percentage of medium and large sponges. The standing crop for each subregion (Table 3) indicates a similar trend. In the subregion where water movement is strongest the biomass of the population per metre square is highest.

TABLE 3. *Standing crop* (Kg/m^2) of A. corticata for each subregion.

Subregion	North-east	East	North
Mean	12.66	2.14	0.25
Standard deviation	11.33	1.16	0.16
Median	7.33	3.37	0.24

The average biomass for each subregion when plotted against the water movement DF values (Fig. 5) shows the increase in biomass of individuals between the north and north-east subregions. Between the north and east subregions there has been an increase in biomass of 2.1 kg (using the median) accompanying an increase in water movement DF values of 0.2. Between the east and north-east subregions an increase in biomass of 7.5 kg is accompanied by an increase in DF values of 0.5.

Population Density

The population density of *A. corticata* in each subregion, given in Table 4, again emphasises the importance of continuous water movement to *A. corticata,* high population densities occurring in the region of strongest water movement.

TABLE 4. *Population density of* A. corticata *in each subregion.*

Subregion	North-east	East	North
Population density /$5m^2$	4.15	0.95	0.17

Dispersion

Nearest neighbour analysis of the dispersion patterns of the population of *A. corticata* (Table 5) indicates a predominant regular distribution.

TABLE 5. *Nearest neighbour analysis of* A. corticata.

Subregion	North-east	East	North
Dispersion*	1.378	1.473	1.184
Significance	3.835	4.533	1.927
Level of significance	0.001	0.001	0.05
S_E	0.054	0.119	0.239
Average distance to nearest neighbour	0.756	1.69	2.96

* Note on dispersion values. When R = 1, random; R = O, maximum aggregation; R = 2.1491, equidistant.

DISCUSSION

Strong continuous water movements appear to facilitate the growth of *A. corticata.* A thicker body wall can be supported in such regimes. Vogel (1974) proposed that if passive flow were important to sponges it may be energetically economic to reside in areas of strong current. By the large number of *A. corticata* in such regions passive flow could indeed be of some significance. Reiswig (1971) notes that maximal pumping activity occurs in maximum water circulation conditions, allowing maximum feeding. Where strong water movement is not continuously available, as in the east and north subregions of Crawfish Rock, maximum pumping and therefore feeding cannot be maintained, biomass is thus constrained by time for feeding at different rates.

The deposition of suspended material in areas of intermittent water movement may also effect feeding, in the time available for pumping activities. Sponges covered in a layer of detritus and sediment (on occasions observed to be 3 cm thick) may not be able to feed as successfully as those in regions of strong water movement where deposition is minimal.

Water movement would appear to have little effect on the dispersion patterns of *A. corticata.* Water movement does however effect the erosional topography of the face of the reef, providing prominances upon which sponges may perch. Thus water movement may indirectly effect dispersion and population density by provision of more suitable substrata in one place than another.

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