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Monitoring and manipulation of a sublittoral hard bottom biocoenosis in Balsfjord, northern Norway

O. K. Sandnes & B. Gulliksen

Marine Biological Station; Tromsø, Norway

ABSTRACT: Sublittoral hard bottom biocoenoses in Balsfjord, Norway (69°31' N, 19°1' E), were monitored using underwater stereophotogrammetry. The study includes manipulation of natural densities of organisms and testing the importance of biological interactions and "key species" for the structure of biocoenoses. Underwater photography has the advantages of being a non-destructive method, but it is selective because small or hidden organisms cannot always be observed. Field experiments with exclusion of organisms from cages seem suitable for testing hypotheses concerning which animals are "key species" in certain biocoenoses. Sea-urchins *(Strongylocentrotus droebachiensis, S. pallidus)* were suspected to be "key species" in the present study, and their removal from cages caused an increase in abundance of barnacles *(Balanus balanoides)*, the limpet *Acmaea testudinalis* and algal cover.

INTRODUCTION

Ecological monitoring aims at the recognition of natural variability in biocoenoses, and to distinguish this variability from changes due to pollution. In order to identify the range of natural variability, it is helpful to understand the mechanisms behind the changes.

Variability in species composition and densities of organisms in biocoenoses may be caused by both abiotic and biotic factors. Each species has its own tolerance limits for such factors as temperature, salinity, oxygen content, water current, sedimentation, light, depth, wave-exposure, and consistency and angle of the substrate. A given biocoenosis can also be influenced by biotic factors such as the timing of reproduction of individual species, predation and competition between species.

Earlier studies indicate that one or a few species, often called "keystone species" (Paine, 1969), "foundation species" (Dayton, 1971) or "key species" (Lewis, 1978), may largely control the structure of biocoenosis.

Results from a study from Haugbergnes in Balsfjord, northern Norway, are presented with special emphasis on biological interactions and the evaluation of the importance of suspected "key species."

STUDY AREA, MATERIALS AND METHODS

Haugbergnes (69°31' N, 19°01' E), northern Norway, is located in Balsfjord about 15 km south of Tromsø (Fig. 1). The study area, a steep rocky wall which extends from the surface down to about 100 m, is fairly sheltered. Data treated in the present paper were

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collected between depths of 3 and 16 m. Within this depth range, temperature usually varies between 1 °–10 °C, and salinity between 32–34 ‰ throughout the year (Sælen, 1950; Schei, 1977; Eilertsen, 1979).

The distribution of benthic animals and plants shows clear vertical gradients (Evans et al., 1979). Sedimentation increases with depth, and probably has an increasing importance with depth in determining the structure of the biocoenosis (Evans et al., 1979). The more common animals at Haugbergnes include browsing snails *Acmaea testudinalis* (Müller), *A. virginia* (Müller), *Margarites groenlandicus* (Gmelin), *M. helicinus* (Fabricius) and sea-urchins, *Strongylocentrotus droebachiensis* (O. F. Müller), *S. pallidus* (Sars). The sea-urchins, due to their high densities and predatory behaviour, were suspected to be the "key species" in the study area.

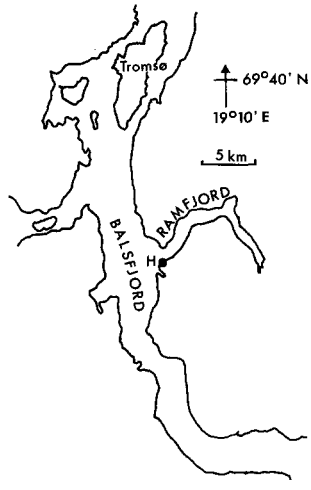

Fig. 1. Map of localities mentioned in the text. H = the study locality at Haugbergnes (Norway)

Encrusting corallines, *Clathromorphum compactum* (Kjellm.) Fosl., *Phymatolithon polymorphum* (L.) Fosl. and *Lithothamnion glaciale* Kjellm., are abundant. Other algae recorded frequently are *Desmarestia viridis* (O. F. Müller) Lamour, *Polysiphonia urceolata* (Lightf. ex Dillw.) Grew., *Ectocarpus siliculosus* (Dillw.) Lyngb., *Phycodrys rubens* (L.) Batt., and *Eudesme virescens* (Carm. ex. Harv. in Hook) J. Ag.

The control and experimental areas were adjacent to each other at 8 m depth. The control area was 1.5 m^2, and the experimental area was 2.0 m^2 and covered by a cage.

As the effects of the cages on the natural environment should be as small as possible, several types of cages were tested. The first cages tried had an aluminum frame covered with 1-cm mesh-size fish netting and were bolted to the substrate. The smallest cages covered an area of 1/16 m^2; this proved to be too small: much sediment, especially faecal pellets of sea-urchins, accumulated along the edges and resulted in the effects of manipulations of suspected "key species" being difficult to separate from the effects caused by the cages. A cage covering 2 m^2 of substrate was found large enough to record changes due to manipulations in sea-urchin density. The fish netting, however, was easily fouled and had to be cleaned at 1–2 week intervals. To prevent the entry of

unwanted organisms under the cages, plastic bags with sand were placed on the netting around the bottom of the cage.

All sea-urchins were removed from the experimental area before the cage enclosing 2 m^2 was put in place. A few other large predators, including *Asterias rubens* (L.), *Solaster endeca* (L.), *Crossaster papposus* (L.), *Eupagurus* spp., and *Gadus morhua* (L.) occur within the study area, but are considerably less abundant than *Strongylocentrotus*. Individuals larger than the mesh-size of the netting could not enter the cages and smaller individuals of these species were removed when the cages were inspected. *Acmaea* and *Margarites* were not removed as they usually are smaller than the mesh-size.

Sites were monitored photographically from August 1977 to December 1978 in the control area, and from November 1977 to December 1978 in the experimental area. Both areas were permanently marked and stereophotographed using the method described in Lundälv (1971) and Torlegård & Lundälv (1974). The camera used was a Hasselblad SWC with a Biogon 38-mm lens in a standard underwater casing fitted with a Zeiss corrective glass lens, and the film was Ektachrome 200.

The photographs were analyzed using a Wild micro-stereocomparator. The percentage cover of organisms was calculated by a point method: 400 points were spaced equidistantly over the area to be studied on the photograph. A subsample of 100 points was selected at random from the original 400 points. Sixty template transparencies, each with 100 such points, were prepared. To calculate the cover, a template drawn at random was placed over a photograph, and the species below each point was recorded. This process was repeated on each photograph using a different template, and mean values were calculated. Solitary organisms were also counted separately from the entire photograph.

RESULTS

During the study, there was little change in the biocoenoses within the control area, while changes in both species composition and numbers of individuals were recorded within the caged area (Figs 2 and 3).

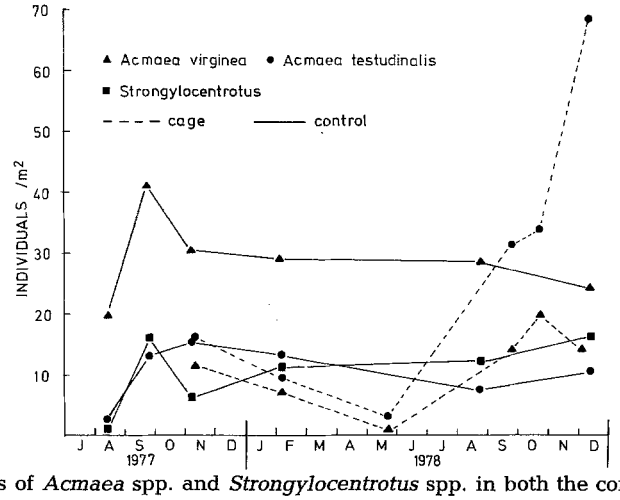

Fig. 2. Fluctuations of *Acmaea* spp. and *Strongylocentrotus* spp. in both the control area and the caged area at Haugbergnes

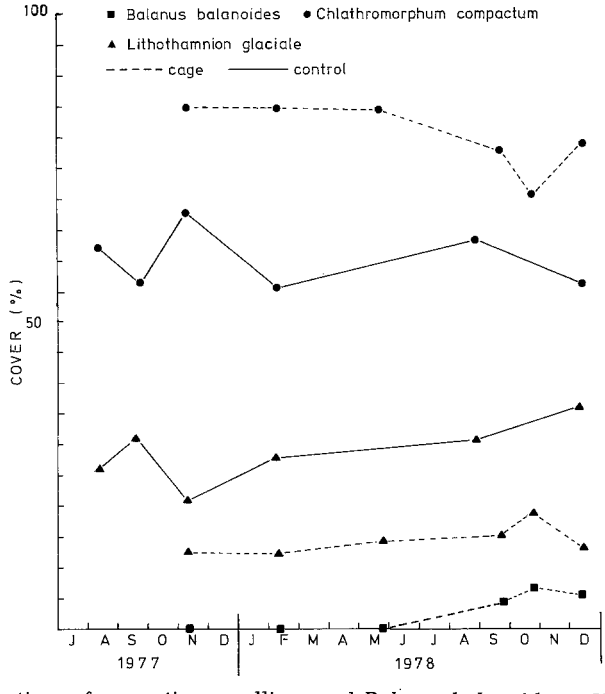

Fig. 3. Fluctuations of encrusting corallines and *Balanus balanoides* at Haugbergnes

In the control area, *Clathromorphum* and *Lithothamnion* were the only algae present and provided nearly 100 % cover. Bare rock did not exceed 5 % of the area. In the caged area, however, there was additional, but little growth of the algae *Chordaria flagelliformis* (O. F. Müller) C. Ag., *Desmarestia viridis, Ectocarpus siliculosus* corresponding to the autumn decrease in *Clathromorphum* (Fig. 3).

Specimens of *Margarites* were rare, and are not indicated in the figures. Young barnacles were observed in the control area by divers during the summer, but none had survived to September when the photographic samples were taken. Within the cages, however, a conspicuous settlement of *Balanus balanoides* (L.) was recorded in the autumn of 1978 (Fig. 3). In December 1978, the cage was slightly damaged by a storm, and five sea-urchins broke into it. They removed most of the barnacles in less than a week. Throughout the study a thin layer of sediment continuously accumulated on the substrate inside the cage and seemed to kill some of the barnacles. This layer was swept away by hand each time the cage was removed for photographing. A similar sediment layer was lacking in the control area probably due to sea-urchin activity.

Two acmaeids, *A. virginea* and *A. testudinalis*, were present in both the control and the experimental areas. *A. testudinalis* showed a significant increase in density in the caged area.

DISCUSSION AND CONCLUSIONS

Stereophotography has proved to be a convenient method of observation in the present area of study, especially because it is non-destructive. The topography is

relatively even, and there is a low diversity of species, with the larger species (secondary cover) being less numerous. In another study in Balsfjord (Sandnes et al., in preparation) *Modiolus modiolus* was so abundant that it obscured polychaetes, bivalves, gastropods, and small echinoderms in the photographs. This observation was verified by comparing photographs with samples collected with a diver-operated air-lift (Barnett & Hardy, 1967; Hiscock & Hoare, 1973). The point method of subsampling provided reliable estimates of percent cover for colonial species and highly abundant species, e. g. *Balanus*. Subsampling does however increase variability in the estimates and this is seen in the variability of cover of the two coralline algae. An increase in sample size decreases variability; and as expected, the variability of the cover of the two algae combined is markedly reduced. The drop in the cover of *Clathromorphum* within the cage from June to October can be explained by the increase in the cover of *Balanus* which settled only on the *Clathromorphum* encrustation.

The subsampling method was unreliable for estimating the abundance of *Acmaea* and *Strongylocentrotus*, but due to their low density, it was just as easy to count them from the entire photograph.

The absence of algae other than the two encrusting species outside the cages is probably due to heavy grazing by the sea-urchins. Within the cage some algae appear both on the substrate and on the inside of the cage. That a greater abundance of these algae is not recorded in the cage may be due to reduced light and the accumulation of sediment within the cage.

B. balanoides settle in the study area, but under natural conditions they are quickly removed by predators. When the predators are removed, as in the cages, the species is able to survive. Therefore *Strongylocentrotus*, the primary predator and grazer, is shown to have an important effect on the composition of the community, and may be labelled a "key species." The fact that the natural biotope of the area is overgrazed by the "key species" is a common phenomenon in marine habitats where herbivores often eliminate the food source (Jones & Kain, 1967; Paine & Vadas, 1969).

The conspicuous increase in *Acmaea testudinalis* within the cage from May to December could be due to the individuals seeking the increased food source (microalgae) or their escaping from the predators outside the cage. More needs to be understood about the niche separation of the two limpets to explain the concurrent lack of increase in the other species.

At Haugbergnes, sea-urchins decrease in abundance with increased depth (Evans et al., 1979). This is probably due to both an increasing sedimentation with depth and a reduction of light resulting in a reduced algal cover.

Our studies indicate that it is to some extent, possible to identify the importance of a "key species" in the structure of a biocoenosis. They also show that the combination of photography and field experiments are valuable methods in such studies.

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