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THE EFFECTS OF A MARINE FISH-FARM ON THE SPECIES RICHNESS AND ABUNDANCE OF MOLLUSCS, DECAPODS AND ECHINODERMS ASSOCIATED WITH A *POSIDONIA OCEANICA* MEADOW IN MALTA (CENTRAL MEDITERRANEAN).

Abstract

The composition of the echinoderm, mollusc and decapod assemblages associated with a Posidonia oceanica *meadow located close to a fish-farmvaried with distance from the cages Three ecological zones were identified. The intermediate zone II (40-160m from the cages) had a higher species richness and abundance than either zones I (nearest the cages) and III (320m from the cages), probably due to the higher production resulting from a moderate level of nutrient enrichment at intermediate distances from the source of pollution.*

Key-words: Fish-farms, Invertebrates, Mediterranean, *Posidonia oceanica*, Pollution.

Introduction

Fish-farming generates considerable waste organic matter in the form of uneaten food and faecal pellets. In sheltered localities, most of this waste settles below and in the vicinity of the cages (Hevia *et al*., 1996) where it can have a profound influence on the structure of the benthic communities originally present (Johannessen *et al*., 1994). Although the diversity of macroinvertebrates below the cages usually decreases (Brown *et al*., 1987), species richness and biomass further away from the cages may increase due to the enhanced food supply (Brown *et al*., 1987;).

In the Mediterranean, aquaculture has developed mainly in lagoons and sheltered embayments. Such localities often support extensive meadows of the endemic seagrass *Posidonia oceanica* (L.) Delile above which the fish-farm cages are frequently located. Despite the increase of aquaculture in the Mediterranean (Mendez *et al*., 1997) and the ecological importance of *P. oceanica* meadows (Mazzella *et al*., 1992), studies of the impact of fish-farms on this community type are lacking.

The present work studies the effects of organic waste generated by fish-farm cages on the species richness and abundance of molluscs, decapods and echinoderms associated with a *Posidonia oceanica* meadow in a Maltese embayment.

Material and Methods

The study area was located in St Paul's Bay on the northwestern coast of the island of Malta (Central Mediterranean) (Fig 1), where a fish-farm has been producing *Sparus aurata* since 1991. The marine unit consists of eight cages and is located above *Posidonia oceanica* meadows in waters 12—16 m deep. No *P. oceanica* is now present directly below the cages, however, a meadow of this seagrass starts 10m from the periphery of the cages.

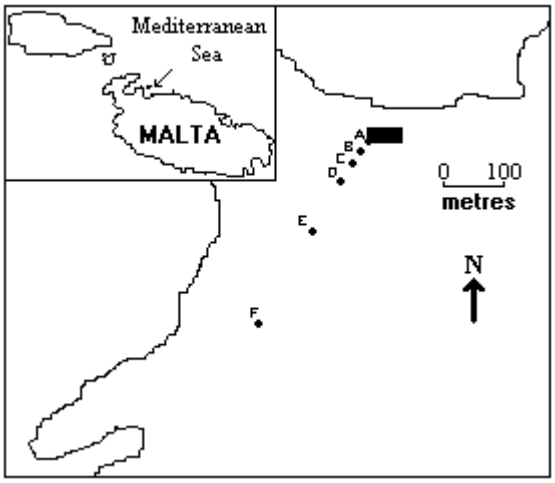

Fig. 1 The Maltese Islands showing location of the study area and map of St. Paul`s Bay showing the fish-farm (black rectangle) and the six sampling stations (A-F).

Three replicate samples per station were collected by SCUBA diving using a corer (internal diameter 35 cms, length 50 cms) to which a 0.5 mm mesh net was attached. During sample collection, the corer was pushed over *P. oceanica* leaves and into the matte down to a depth of c. 10 cms. All the sampling stations were located at the same depth (12m) but at increasing distances from the cages as follows: 10m, 30m, 50m, 90m, 170m, 330m (Fig 1). Samples were collected during August 1998. In the laboratory, the samples were passed through a 0.5mm mesh sieve and the retained fauna were sorted, identified and counted.

Sediment from a single sample collected from each station using a small PVC corer (internal diameter 10cm, length 10cm) was analysed forgrain size and organic content (Walkley & Black titration method) according to the procedures in Buchanan (1984).

The macrofaunal abundance data were analysed by non-metric multidimensional scaling after double square-root transformation and calculation of the Bray-Curtis similarity measure (Clarke and Warwick, 1994). Analysis of similarities (ANOSIM) was used to test for any differences in faunal composition between stations (Clarke and Warwick, 1994).

Results

The sediment at all six stations was predominantly sandy, however, the gravel fraction was relatively low in the two stations closest to the farm and was highest in station F (Table 1). The percent organic carbon in the sediment showed an overall decrease with distance from the cages, except for station E where it was anomalously high (Table 1).

Table 1. Relative abundance of gravel, sand and mud (silt + clay) and the percent organic carbon (as determined by the Walkley & Black method) for each of the six stations.

Station	Distance (m)	Gravel (%)	Sand (%)	Silt & Clay (%)	Organic carbon (%)
A	10	0.97	82.21	16.82	2.30
B	30	0.80	85.58	13.62	1.60
C	50	2.19	83.20	14.62	1.58
D	90	2.04	84.08	13.88	1.54
E	170	1.52	82.18	16.30	2.56
F	330	3.61	88.21	8.18	0.57

Macrofaunal abundance (Fig 2a) and species richness (Fig 2b) reached a peak value 90m from the cages.

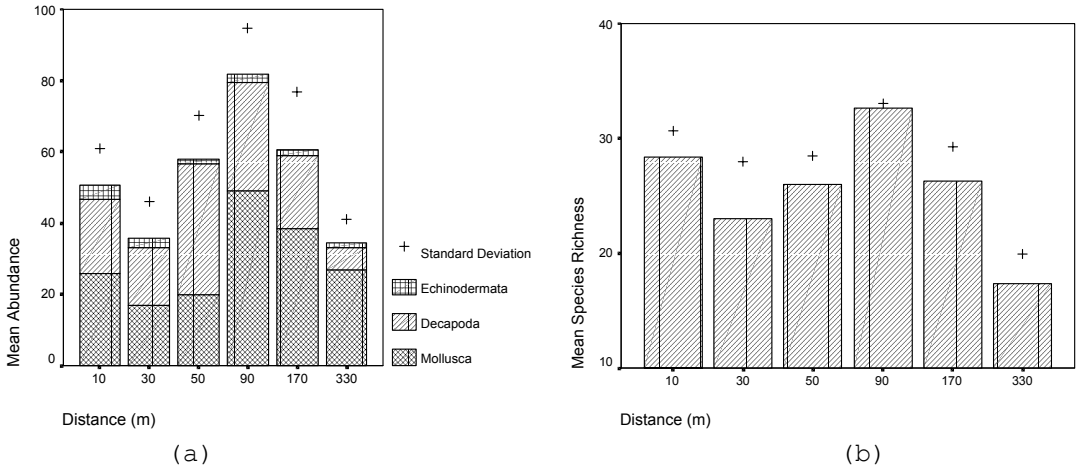

Fig 2. Variation of (a) mean macrofaunal abundance, and (b) mean number of species, with distance from the cages.

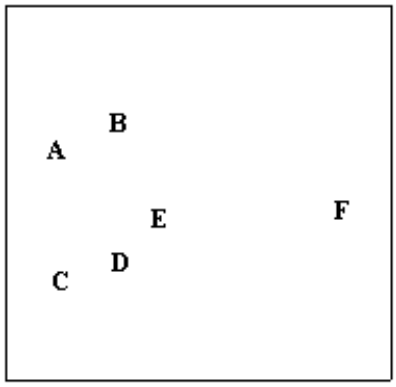

Fig 3. Non-metric multidimensional scaling (MDS) plot for the six stations based on the mean abundance of macrofauna in three replicate core samples. Mean Stress = 0.3.

The two-dimensional NMDS plot indicated three groups: one consisting only of station F, which was the furthest from the cages, another which included the two stations closest to the cages (A and B) and a third with the three intermediate stations (C, D and E).

The ANOSIM test showed an increasing difference in faunal composition (as a trend of increasing R statistic) with increasing distance from the cages(R ranged between 0.33 and 0.89; R = 1 if all replicates at a given site are more similar to each other than to any replicate from any other site; R = 0 if there are no differences between the sites).

Discussion

The NMDS results suggest that the composition of the invertebrate assemblages varies with distance from the cages and that three zones are present. The species recorded from all three are typical of *P. oceanica* meadows. However, zone II, which includes the intermediate stations C, D and E, has a higher species richness and abundance than either zones I and III. The maxima in species richness and abundance in zone II are not a result of corresponding maxima in seagrass shoot density and biomass since these two parameters increased with distance from the cages (Dimech *et al.*, submitted). Rather, it appears that nutrient enrichment at the intermediate stations is having a beneficial effect and thus zone II is able to support a more abundant and diverse fauna. The sediment in Zone II has a high organic carbon content, which backs up this hypothesis.

The observed zonation is similar to that described by Brown *et al.*, (1987) for the distribution of macrobenthos near a fish-farm in a Scottish sea loch. These authors found four distinct zones: (i) an azoic zone under the cages; (ii) a highly enriched zone from the edge

to ~8m; (iii) a slightly enriched "transitional" zone at <25m; and (iv) a clean zone at distance >25m.

Our study shows that in Maltese coastal waters, waste generated by fish cages influences the composition of the macrobenthic invertebrate assemblages present below and in the vicinity of the cages and resuts in distinct ecological zones that differ in species richness and abundance. The width of these zones is expected to vary with amount of waste generated, current regime and depth.

Acknowledgements

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