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EARLY COLONISATION OF BIOLOGICAL FILTERS SUSPENDED IN WATERS ADJACENT TO CAGED MARICULTURE ACTIVITY, WEST SCOTLAND

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ABSTRACT

Patterns in recruitment and colonisation of hard substrata communities in close vicinity to caged mariculture activity were studied in the Lynne of Lorne, west coast of Scotland. Despite the increase in nutrient status and suspended particulate loading near fish farm the larval settlement and the subsequent successional processes did not appear to be seriously affected. Similar invertebrate species were present in both fish farm and control site. A total of 40 invertebrate species, attached to the mesh cylinders were identified over the experimental period and the diversity index was bigger at the fish farm compared to control site.

Key words: colonisation, biological filter, sub-littoral macrofauna, mariculture, Scotland

COLONIZZAZIONE PRECOCE DI BIOFILTRI SOSPESI ADIACENTI AD ATTIVITÀ DI MARICOLTURA IN GABBIE, SCOZIA OCCIDENTALE

SINTESI

Esempi di reclutamento e colonizzazione di substrati solidi nelle vicinanze di attività di maricoltura in gabbie sono stati studiati in Lynne of Lorne, costa occidentale della Scozia. Malgrado l'incremento nel livello di nutrienti e nel carico di particellato sospeso in prossimità dell'allevamento di pesci, la colonizzazione larvale e i processi successionali a seguire, non sono risultati seriamente disturbati. Specie simili di invertebrati erano presenti sia nell'allevamento di pesci che nella stazione di controllo. Quaranta specie sono state identificate durante il periodo sperimentale attaccate alle maglie dei cilindri e l'indice di diversità è risultato maggiore all'allevamento di pesci che nella stazione di controllo.

Parole chiave: colonizzazione, filtri biologici, macrofauna sub-litorale, maricoltura, Scozia

INTRODUCTION

The colonization of artificial substrata has been widely documented and a large range of marine organisms have been shown to readily settle, recruit and colonise a variety of artificial structures, including plastics, cement and ceramic tiles (Todd & Turner, 1986). Various factors have been identified as contributing to the colonisation of artificial habitats, including both physical and biological factors that can either facilitate or inhibit the survival of organisms (Rodriguez *et al.*, 1993). Food availability and quality is one factor that can play an important role in the length of settlement competence in larval marine invertebrates (Kelly *et al.*, 2000), the nature of the existing biota on the artificial substrata and the subsequent growth and succession of marine organisms that successfully recruit to a particular location (Fleury *et al.*, 2000).

A large proportion of the caged mariculture activity in the U.K. is concentrated on the west coast of Scotland. Only a minority of the nutrients added as feed to the caged systems is removed in the harvest and the remainder is lost into the environment. The annual discharge per ton of salmon is estimated to be 750 kg carbon (Hall *et al.*, 1990), 35.0 kg nitrogen and 7.0 kg phoshorus (Chopin *et al.*, 1999). This loss consists of wasted feed and small feed fragments, faecal particles and dissolved organic and inorganic components. While most of the dissolved components are recycled by the micropelagic food web, particulates either fall to the seabed causing localised seabed enrichment around the cages or remain suspended until consumed by marine organisms or remineralised (reviewed by Pearson & Black, 2001). Whilst a number of studies have found that an increase in organic material can alter the species diversity of soft sediment communities (reviewed by Pearson & Black, 2001), very few have studied hard substrata communities and there is a distinct paucity of information on the influence of enhanced food availability on recruitment and succession in this habitat type.

The aims of this study are to assess patterns in recruitment and colonisation of hard substrata communities in close vicinity to caged mariculture activity.

MATERIALS AND METHODS

The two study sites were located in the Lynne of Lorne, west coast of Scotland. The first site was approximately 10 m from a commercial Atlantic salmon *(Salmo salar)* fish farm (56°27.09'N; 05°27.68'W) and the second site (termed the 'reference site') was located 500 m north-east of the fish farm (56°27.03'N; 05°27.40'W). The second site was located in an area outwith the influence of the enriched water source but within similar hydrological conditions. The farm consisted of 12 circular net cages (25 m diameter and 22 m depth) and the biomass of the fish farm site averaged 650 tonnes over the 6 month experimental period.

Black square mesh (NETLON ™; mesh diameter 25 mm) was formed into a cylindrical shape (500 mm height; 250 mm diameter) and mounted on a rectangular support frames. Each frame held eight randomly attached cylinders at a distance apart of 250 mm. Four frames were deployed at the fish farm (FF) and the reference site (RS) on 18 June 2001. The frames were held vertically in the water column by anchor weights and buoys and oriented perpendicular to the predominant current direction at a depth of 8 m. Temperature loggers (Tinytag ™) were attached to the support frames at both experimental sites. Seawater temperature was recorded on a daily basis.

Mesh cylinders were sampled monthly between July and December 2001, with the exception of November 2001, when storms prevented sampling. At each sampling time, four cylinders were randomly selected at each site, one from each frame. The fouling community was assessed by identification to the lowest possible taxon. The abundance of individual organisms attached to the cylinders was recorded. Distinct colonies of each colonial species were counted as one individual. After taxonomic assessment, the biomass of each dominant group of fouling organisms and the biomass of the materials remaining on the mesh was calculated by drying the samples and 3 sub-samples of the mesh (150 x 150 mm) at 45 °C until constant dry weight. The biological material was then combusted at 450 °C for 5 hours to obtain the ash free dry weight (AFDW).

Community structure was described by calculating the total abundance and biomass of individuals, the total number of species, the total number and biomass of individuals of each species and the Shannon-Wiener diversity index *(H')*. Bartlett's test was used to test for homogeneity of variances (Zar, 1996). Sampling time and site were used as fixed factors in a two-way ANOVA to test for differences in species diversity, abundance and biomass of the dominant species between the treatments (MINITAB, Release 13.32 for Windows). The Tukey multiple comparison test was used to assess where significant differences occurred.

RESULTS AND DISCUSSION

During the experimental period (July to December 2001), seawater temperature at the sites ranged from a maximum of 12.8 °C in August 2001 to a minimum of 9.1 °C in December 2001.

The total biomass of macrofauna increased significantly over the experimental period and the biomass was significantly higher at the FF compared with the RS ($p < 0.05$; $F = 7.69$) (Fig. 1a, Plate 1: Figs. 4a, b). The significant increase in biomass ($p < 0.001$; $F = 348.5$), particularly in the first 4 months after deployment was primarily due to an increase in the biomass of the ascidian, *Ascidiella aspersa*, at the both the FF and RS. *A. aspersa* accounted for a high percentage of the total biomass attached to the panels at all the sampling times, with the exception of the first 2 sampling periods (Plate II, Fig. 11). In the first two months, the hydroid, *Obelia longissima* accounted for the highest proportion of the total biomass at both sites. Other species, including the non-native caprellid, *Caprella mutica* ($p < 0.001$; $F = 81.39$) and the bivalve, *Mytilus edulis* ($p < 0.01$; $F = 161.73$) were recorded at a significantly higher biomass at the FF compared to the RS at each sampling time throughout the experimental period.

A statistically higher number of individuals were observed on the mesh cylinders at the FF site compared to the RS over the experimental period ($p < 0.001$; $F = 96.36$) (Fig. 1b). This difference was due to higher numbers of *C. mutica* and *M. edulis* at the FF, particularly in months 3 and 4. These species accounted for a high percentage of the total number of individuals attached to the structures at these two sampling times.

A total of 40 species were identified over the experimental period attached to the mesh cylinders. The Shannon-Wiener diversity index (*H'*) for the macrofaunal communities attached to the mesh cylinders indicated a significant increase ($p < 0.001$, $F = 98.09$) in diversity over the first 2 months after deployment, followed by a plateauing in species diversity for the remainder of the experimental period at both the FF and the RS. The diversity index, however, was higher at the FF compared to the RS at each sampling time, although this difference was only significant in the first month (July 2001) ($p < 0.05$, $F = 8.47$).

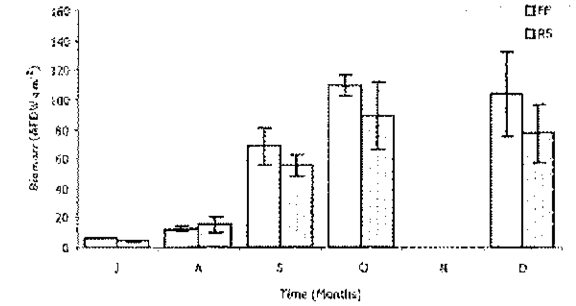
A number of key observations can be made from the results of this study:

1. Despite the increase in nutrient status and suspended particulate loading that might be expected in the effluent stream from a large fish farm, larval settlement and the subsequent successional processes did not appear to be negatively affected in this study, as shown by the comparatively high biomass at the FF and the similar species diversity at the 2 experimental sites.

2. As similar species were present on both sites there is no evidence that proximity to the farm excludes sensitive taxa. The main difference between the sites was the higher numbers of *C. mutica* and *M. edulis* at the FF. It is thought that the main mode of introduction for *C. mutica* is in association with aquaculture activities, which might explain its increased abundance near to the fish farm compared to the reference site.

3. The presence of the farm does appear to be able to influence the biomass of hard substrate macrofauna inhabiting structures in close proximity to the farm and, therefore, further study is required in terms of a) their potential in reducing the environmental output of nutrients from the farm and/or b) the use of the farm as a nutrient source for growing a secondary aquaculture crop.

a



b

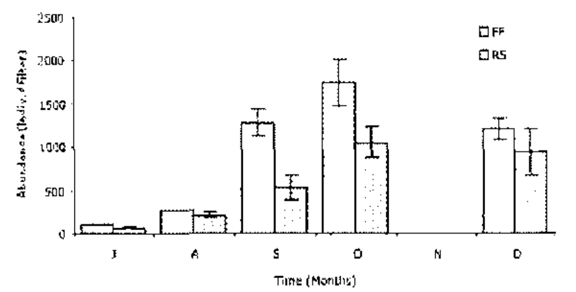


Fig. 1. Biomass (AFDW g m^{-2}) (a) and abundance (No. individuals cylinder^{-1}) (b) of macrofauna on mesh cylinders at the fish farm (FF) and reference site (RS) in the Lynne of Lorne, west Scotland at the monthly sampling periods (July – December 2001). Mean values (n = 4) and standard deviations (error bars) are shown.
Sl. 1: Biomasa (AFDW g m^{-2}) (a) in abundanca (No. osebkov cilinder^{-1}) (b) makrofavne na biofiltrih ob ribogojnici (FF) in na referenčni postaji (RS) v Lynne of Lorne (zahodna Škotska) na posameznih mesečnih vzorčevanjih (julij – December 2001). Prikazane so povprečne vrednosti (n = 4) in standardne deviacije.

ZGODNJE PORAŠČANJE BIOFILTROV, VISEČIH V MORJU OB RIBOGOJNICI NA ZAHODNEM ŠKOTSKEM

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POVZETEK

V kraju Lynne of Lorne na zahodnem škotskem obrežju sta avtorja preučevala vzorce naseljevanja združb obrasti na trdi podlagi v neposredni bližini marikulturnih kletk. Kljub povečanim hranilom in suspendiranim snovem v bližini ribogojnice se zdi, da proces naselitve ličink in kasnejše sukcesije ni bil resneje prizadet. Tako v ribogojnici kot na kontrolni postaji so bile zabeležene podobne vrste nevretenčarjev. V eksperimentalnem obdobju je bilo identificiranih 40 vrst nevretenčarjev, pričvrščenih na mrežaste cilindre. Diverzitetni indeks je bil večji v ribogojnici kot na kontrolni postaji.

Ključne besede: poraščanje, biofiltri, sublitoralna favna, marikultura, Škotska

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