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BIOFILTER COMMUNITY OXYGEN CONSUMPTION RATES

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ABSTRACT

Biofilter communities have been incubated in-situ *in UK, Israel and Slovenia. Oxygen fluxes for light and dark experiments have been normalised using the ash free dry weight of the biota. Respiration rates for different communities, whether dominated by ascidians, hydroids, worms or sponges, show a remarkably consistent trend with temperature, over the range 6-27°C. It is planned to link respiration to rates of growth, filtering and nutrient release.*

Key words: community respiration, *in-situ* incubation, ascidians, hydroids, tube worms

TASSI DI CONSUMO DI OSSIGENO IN COMUNITÀ DI BIOFILTRI

SINTESI

Gli autori hanno studiato la crescita sovrabbondante di comunità di biofiltri in-situ *in Regno Unito, Israele e Slovenia. I risultati dei flussi di ossigeno in esperimenti di luce e buio sono stati normalizzati in base al peso secco privo di cenere del biota. A prescindere dalla composizione delle comunità, dominate a turno da ascidiacei, idrozoi, policheti sedentari o spugne, i tassi respiratori hanno evidenziato una tendenza notevolmente uniforme con temperature nell'intervallo tra i 6 ed i 27°C. Gli autori intendono correlare i risultati delle misurazioni della respirazione con i tassi di crescita e filtrazione degli organismi ed il rilascio di nutrienti.*

Parole chiave: respirazione di comunità, incubazione *in-situ*, ascidiacei, idrozoi, policheti sedentari

INTRODUCTION

Ecological modelling of systems requires knowledge of the rates of energy flow. Thus, as well as the biomass in a system, its rate of growth or turnover should be determined. The growth rate of reef epibiota rate could be determined by measuring change in biomass per unit area, with time. This is likely to underestimate the true growth rate since this cannot account for loss by predation or other means. For a number of benthic infauna species the annual production per unit biomass has been calculated (Schwinghamer *et al.*, 1986). This approach has been widely adopted for determining the productivity and energy flows through benthic systems. However for many of the groups, which grow on hard substrates including artificial reefs (bryozoans, hydroids, sponges and ascidians) there is little or no information on their production to biomass ratios. Enclosed chamber (respirometer) experiments have a long history in examining the respiratory exchange and thus the energy utilization of animals (Collins *et al.*, 2002). The BIOFAQs programme (Black *et al.*, 2001; plus other papers in this volume) has deployed experimental biofilters next to fish farms in order to determine the potential for the colonizing biota to remove wastes (particulate organic carbon and nutrients) from the water column downstream of the aquaculture facilities. This paper describes the results of *in-situ* incubation chamber experiments to determine direct measurement of oxygen fluxes (and thus carbon fluxes) of biofilter epibiota.

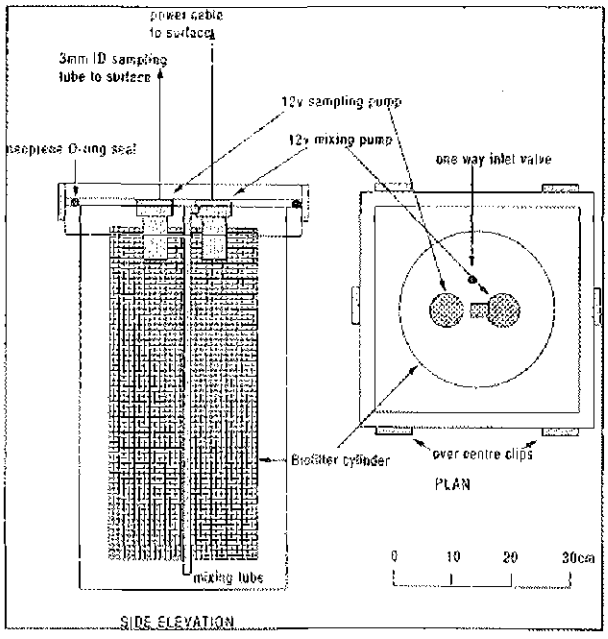

Fig.1: Diagram of the biofilter incubation chamber.
Fig. 1: Shema biofiltrske inkubacijske posode.

MATERIALS & METHODS

The biofilter incubation apparatus (Fig. 1) consisted of a specially constructed clear acrylic box (35 x 35 cm cross section, 65 cm high) which accommodated a whole biofilter, (a plastic mesh cylinder 50 cm long x 25 cm diameter) transferred underwater by divers. The top lid with neoprene seal was clamped shut with over-centre clips. An internal water pump (Rule, USA, bilge pump, 12 V, 380 min^{-1}) was used to continuously mix the water in the chamber. A similar second pump was used to sample the chamber (30-40 min intervals) pumping water to the surface through 3 mm ID polythene tubing. The chamber water samples (160 ml, 3 replicates) were fixed for subsequent Winkler titration, to accurately measure the oxygen concentration. An oxygen electrode (YSI, model 5239) was used to monitor the progress of the incubation. Further Winkler titration bottles filled with water pumped from the chamber at the beginning of the experiment, were incubated *in-situ* under dark and light, to provide blanks, giving the magnitude of water column respiration and net photosynthesis respectively. Typically the chamber was incubated in the light for 2 hours then a further 2 hours in the dark, enclosed in a heavy-duty black polythene bag. This was considered to be a sufficiently short enough time to discount bacterial activity on the surface as of the chamber and not to cause starvation of the suspension feeders. Records of light intensity and temperature during the experiment and longer term enable extrapolation of the results of experiments over the whole year.

At the end of the incubation the biofilter was recovered and the epibiota removed, sorted into taxonomic groups and dried in aluminum foil trays to constant weight at 80°C. The dry samples were heated in a muffle furnace to 550°C for 4 hours to determine the organic content, ash free dry weight (AFDW). AFDW was used in this study as it was considered to be a good measure of the amount of living substance (Crisp, 1984). This is especially true given the number of calcareous organisms: hydroids, bryozoans and serpulid worm tubes that were present on the biofilters.

Oxygen analysis was done by a modification of the manual Winkler titration (Strickland & Parsons, 1968). Fixed samples were acidified with concentrated sulphuric acid and titrated with sodium thiosulphate solution in the sample bottle with an automated burette and photo-detector system to monitor the end point (Williams and Jenkinson, 1982). This system gave a repeatability of measurement in the order of ±0.2%.

RESULTS AND DISCUSSION

Bio-filter cylinders were deployed in July 2000, 2001 and 2002, 3 m below a pontoon in the Southampton Oceanography Centre dock and incubated at different

Tab. 1: Oxygen consumption rates for certain benthic invertebrates ($\Phi molO_2\ gAFDW^{-1}\ hr^{-1}$).
Tab. 1: Poraba kisika ($\Phi molO_2\ gAFDW^{-1}\ hr^{-1}$) pri nekaterih bentoških nevretenčarjih.

Taxon	Taxon. Group	Oxygen consumption ($\Phi molO_2\ gAFDW^{-1}\ hr^{-1}$)	source
Pyura stolonifera	Ascidiacea	33	(Klumnp, 1984)
Styella plicata	Ascidiacea	66	(Klumnp, 1984)
Ciona intestinalis	Ascidiacea	47	(Klumnp, 1984)
Aglaophenia sp.	Hydroidea	75	(Gili & Hughes, 1995)
Eudendrium racemosum	Hydroidea	72	(Gili & Hughes, 1995)

times of the year to determine the response to temperature. These were originally intended simply to provide material for testing oxygen incubation chambers and refining the techniques. Prolific growth of the ascidian, *Ascidiella aspersa*, dominated the fouling community, reaching massive densities (27 kg wet weight per biofilter after 9 months) (Plate II, Fig. 11). A similar pattern of ascidian dominance and mass was found on the Scottish biofilters deployed at 12 m off Oban, Scotland. *In-situ* incubation experiments were conducted here in September 2002. The comparability of the two sites may be explained by the fact that they are both in temperate waters and receive high levels of organic particulates, from the adjacent fish farm in Scotland and from effluent discharges into the estuary in Southampton. The fast growth of ascidians which have high filtration rates suggests potential for significant removal of particulate effluents in temperate seas. In May 2003 *in-situ* incubation experiments at 5 m were carried out off Piran, Slovenia (Plate II, Fig. 14). These biofilters were dominated by calcareous tube worms (*Pomatoceros* sp.). Since all three sites were fauna dominated, only the respiration rates are reported The rate of change in incubation chamber oxygen concentration with time was determined by linear regression (typically with an r^2 >0.95). After allowing for the water column blank, the values were related to the AFDW of the biofilter. Figure 2 shows this biofilter oxygen consumption data compared to that obtained from the Poole Bay, UK artificial reef. (Collins *et al.*, 2002). In the latter case whole colonized concrete reef blocks (20 x 20 x 40 cm) were incubated *in-situ* at 12 m. These were dominated by hydroids (*Halecium* spp.), bryozoans (*Bugula plumosa*) and calcareous tube worms (*Pomatoceros* sp.). One of the Southampton biofilters (20°C) was dominated by the fan worm *Sabella pavonina*.

Schwinghamer *et al.* (1986) demonstrate that production/biomass and other biological processes including respiration depend on size class. The biofilters and artificial reefs communities are dominated by macro fauna of sizes within 1-2 orders of magnitude, which may explain both the correspondence and variation in the data.

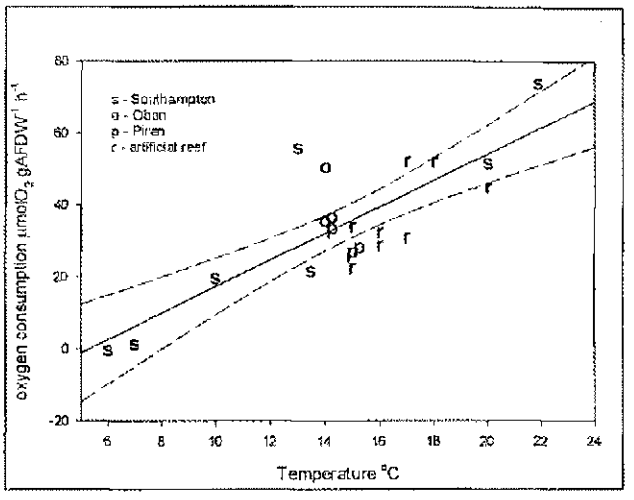

Fig. 2: Oxygen consumption by different communities plotted against incubation temperature: experimental biofilters from Southampton, Oban and Piran and concrete artificial reef blocks from Poole Bay (Collins et al., 2002), showing a linear regression line with 95% confidence intervals.
Fig. 2: Poraba kisika pri različnih združbah v korelaciji z inkubacijsko temperaturo: poskusni biofiltri iz Southamptna, Obana in Pirana in betonski umetni podvodni grebeni iz Poole Bay (Collins et al., 2002) so premočrtno povezani (linearna regresija z 95% intervalom zaupanja).

Knowledge of instantaneous respiration rate of the biofilter community provides direct information on carbon and indirectly nitrogen and phosphorous fluxes. Current work is determining the nutrient release associated with biofilter community respiration. This will be combined with data from the other groups within the BIOFAQs project. Part of the energy derived from is devoted to growth (production). Published production/biomass ratios (Klumpp, 1984; Schwinghamer *et al.*,1986; Petersen *et al.*, 1995) vary greatly, for the biofilter organisms values are in the range 10-40%. Comparison with known biofilter mass accumulation rates will help set limits to this. The filtration rates of biofilter organisms have been reviewed within the BIOFAQs

programme. For some organisms there is published information on the relationship of filtering rate to oxygen consumption: the ascidians *Pyura stolonifera* (Klumpp, 1984) and *Ciona intestinalis* (Petersen *et al.*, 1995). As with production it is hoped to partition part of the energy to filtration to derive a simple model of the functioning of biofilters for aquaculture or in a wider context the ability of hard substrate (natural or artificial) communities in coastal waters to remove particulate matter from the water column.

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PORABA KISIKA NA BIOFILTRIH

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POVZETEK

V Veliki Britaniji, Izraelu in Sloveniji sta avtorja spremljala proces obraščanja biofiltrskih združb in situ. *Rezultati meritev kisika v svetlih in temnih razmerah so bili normalizirani na enoto organskega deleža biomase obrasti. Ne glede na sestavo združb in prevlado različnih skupin nevretenčarjev (kozolnjaki, trdoživnjaki, mnogoščetinci ali spužve) so rezultati respirometrije pokazali izredno enakomeren trend povezave s temperaturo v razponu med 6 in 27°C. Avtorja nameravata povezati rezultate respiracijskih meritev s stopnjo rasti filtratorjev in sproščanja hranil.*

Ključne besede: respiracija združbe, inkubacija *in situ*, kozolnjaki, trdoživnjaki, cevkasti mnogoščetinci

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