Marine Biofilms: Part I Intertidal

OEST 740

033108

Outline

- Introduction
- Effects/Implications of biofilms to sediment properties
- Formation of Stromatolites
- Biofilms as a Refuge for pathogens
- Role in metal contamination
- Biofilms as food source
- Conclusion/Summary

Introduction

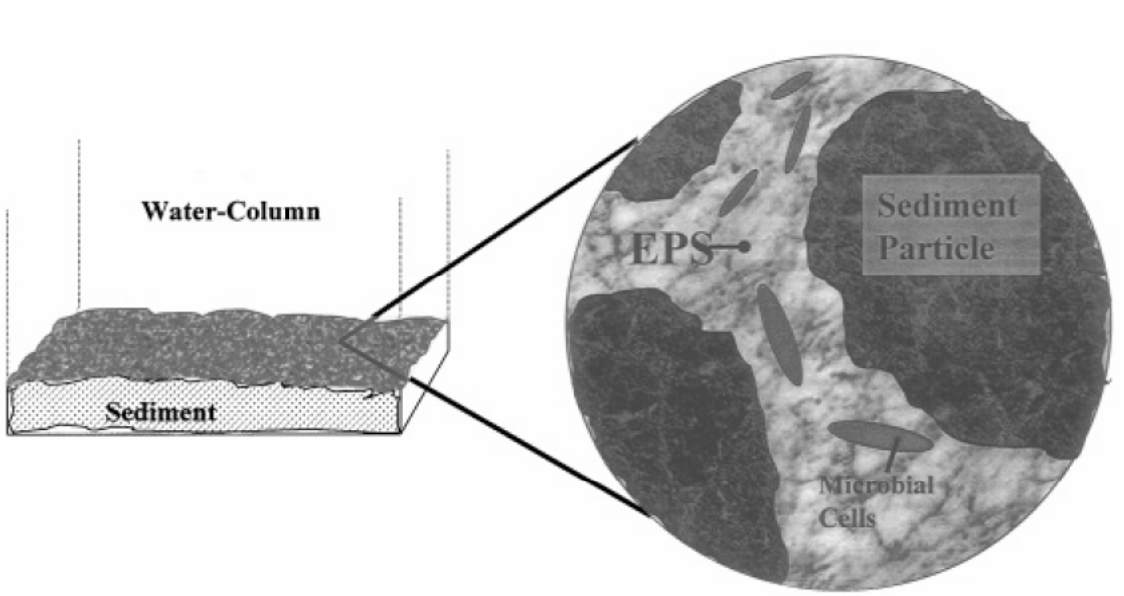
- **Intertidal**
  - **Highly dynamic system**
  - **Periodic fluctuations in environmental parameters**
  - **Microbial processes critical to remineralization of nutrients and primary production**
- **Biofilms**
  - **Provide a protective and stable microenvironment against fluctuating conditions**
- **Thus, it is important to understand small-scale influences of biofilms to fully understand larger-scale processes within intertidal systems**

Biofilms in the intertidal

- **The high density of cells in sediments increases potential quorum sensing activity**
  - **Facilitate more efficient utilization and biotransformation of carbon and other nutrients, waste removal and more effective resiliency to environmental stressors**
- **Localization of extracellular enzymes**
  - **Important in efficiencies of larger-scale transformations of OM by bacteria**
    - **Conversion of DOC to POC**

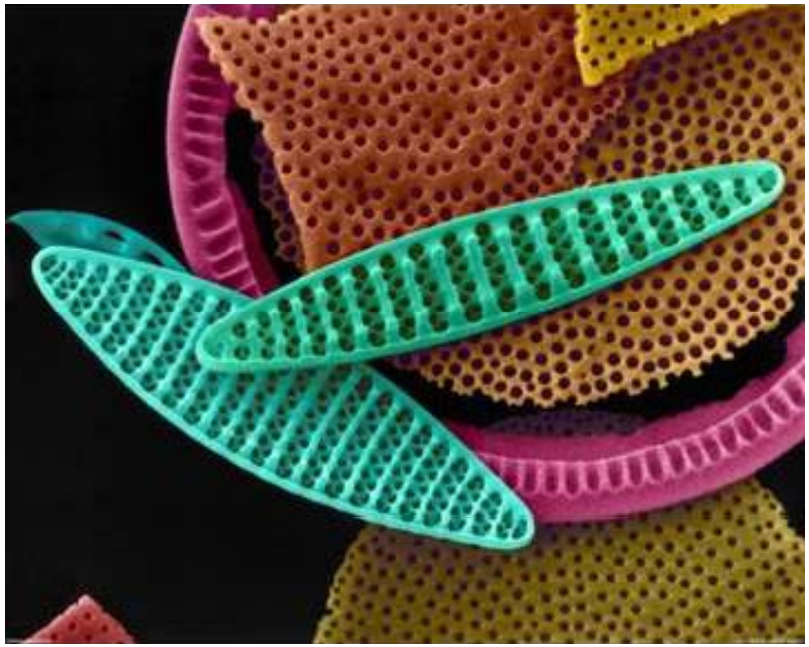
Biofilms in the intertidal

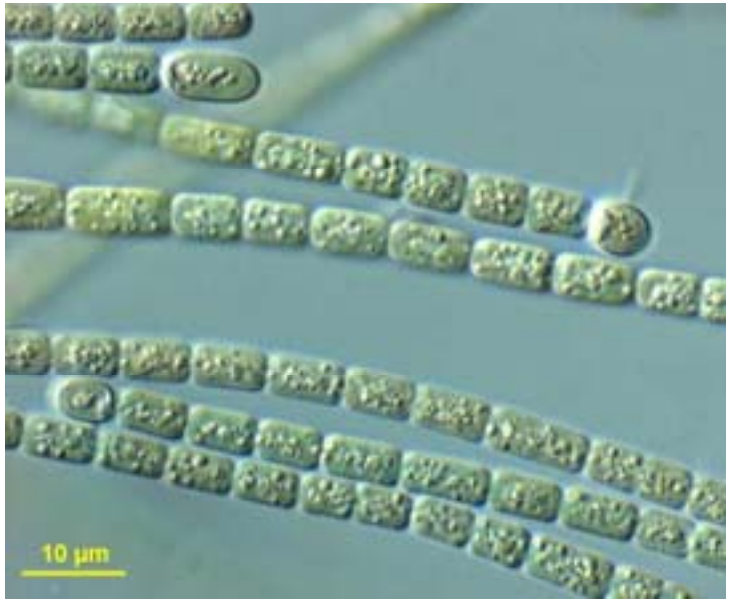
- **Biofilm EPS forms cohesive matrix surrounding particles in intertidal sediments**
- **Important consequences for sediment properties**



Biofilms in intertidal

- **Diatoms and cyanobacteria can be large contributors to biofilms in intertidal sediments**

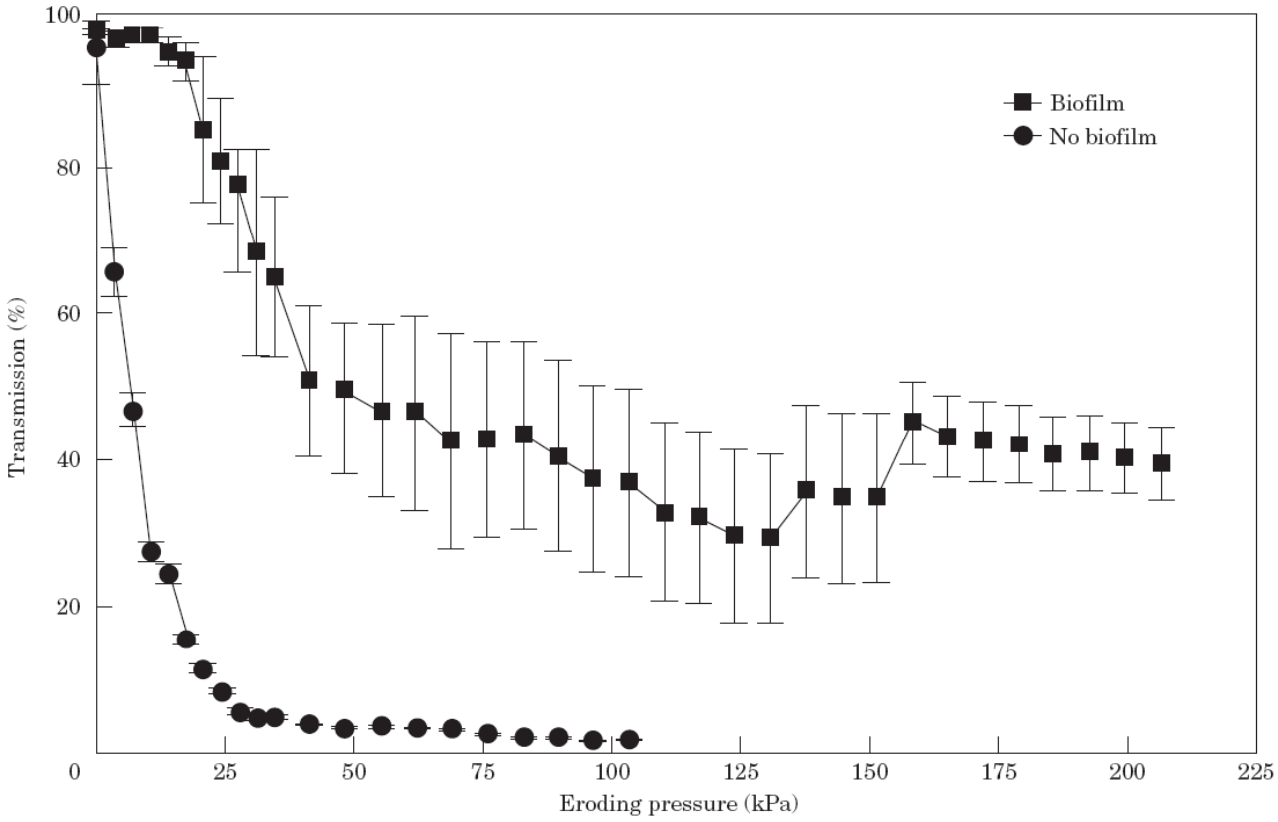




EPS in sediments

- **Donan Trap – sequestering and concentrating ions (e.g. Ca^{2+})**
- **Form hydrated gel – protects against desiccation**
- **UV irradiation can alter polymer matrix – acts as ‘pliant matrix’ responding to environmental conditions**

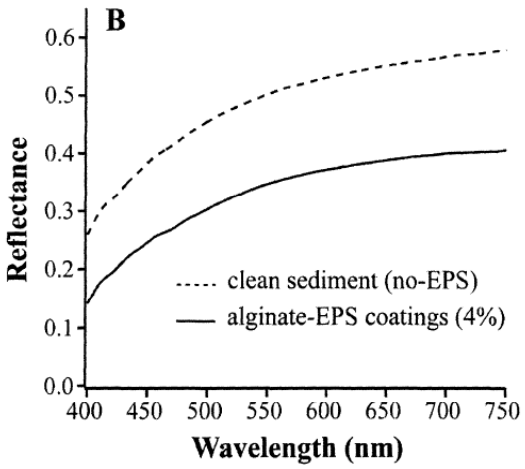
Roles in sediment stability

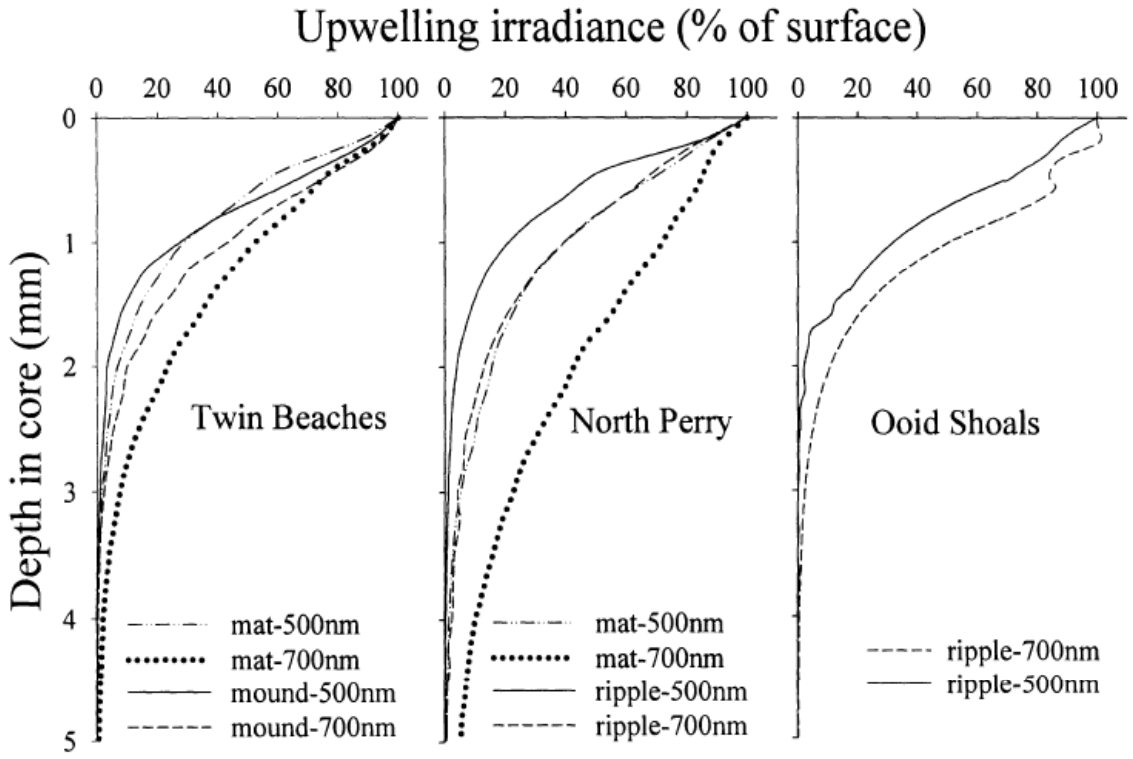


Tolhurst et al. 2003

Biofilm effects on sediment properties

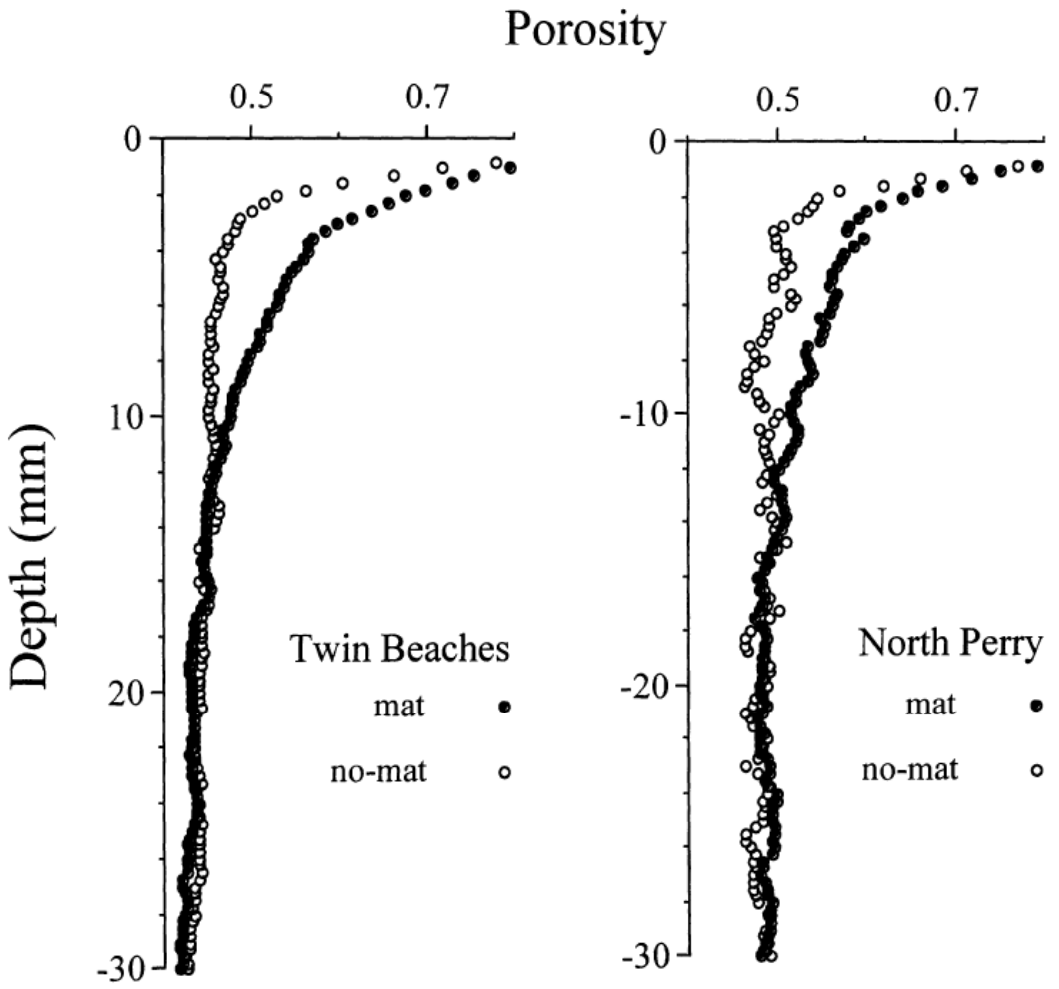
- **“biofilm gel effect”**





Decho et al. 2003

Biofilm effects on sediment properties



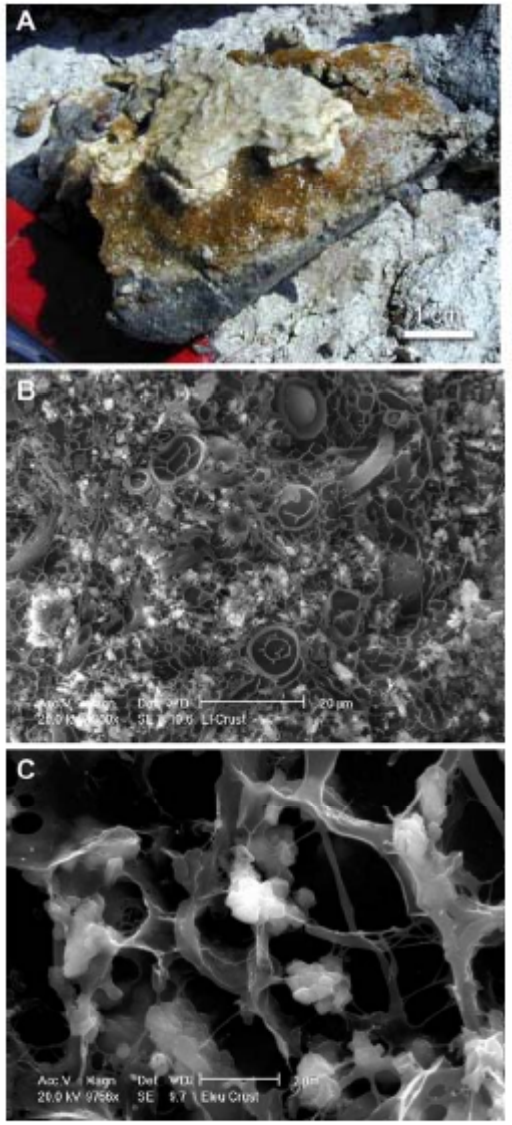
Decho et al. 2003

Biofilm effects on sediment properties

- **“Biofilm gel effect”**
  - **EPS-sediment traps photons more effectively**
  - **Enhances forward scattering**
  - **Increases porosity**
- **Implications**
  - **Down-welling photons can penetrate deeper**
  - **Photosynthesis can occur at greater depths**
    - **Reduces shading effects and increases ability of surface-associated and densely packed cells to acquire solar energy**

Intertidal Stromatolites

- Layered sediment macrostructures formed through interactions of biological organisms
- Example of extreme biological mediated sediment stabilization
- EPS binds Ca^{2+} and inhibits geochemical precipitation of $CaCO_3$
- Partial degradation of EPS by SRB leads to restricted $CaCO_3$ precipitation



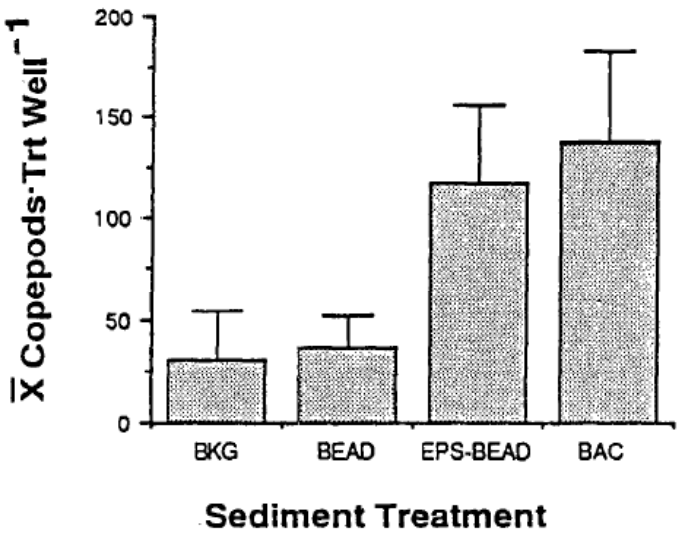
Refuge of pathogens

- Pathogenic bacteria enter intertidal systems from terrestrial and freshwater sources
- Survival is linked to association with aggregated flocs
- When freshwater meets saline water: increase in cations and enhanced floc formation and aggregation of suspended DOC, silts, and clays
  - EPS acts as protective refuge and buffers cells against potential stresses

Concentration of contamination

- EPS can bind and concentrate a range of metal ions
- Microbial EPS – range of pyruvate ketals uronic acids, phosphate groups
  - Ionic binding capacity
- Cd^{2+}, Cu^{2+}, Cr^{3+}, Pb^{2+}, etc. are efficiently chelated by EPS
- Potential increased by UV exposure

Biofilm as food source



Replicate	^{14}C ingested*	^{14}C retained	$^{14}CO_2$ respired
1	55.6	37.4	5.7
2	41.4	14.3	4.5
3	14.5	19.2	3.8
4	21.7	40.5	7.1
5	48.7	35.2	5.0
$\bar{x}\pm SE_{\bar{x}}$	36.05±8.0	29.3±5.2	5.2±0.6

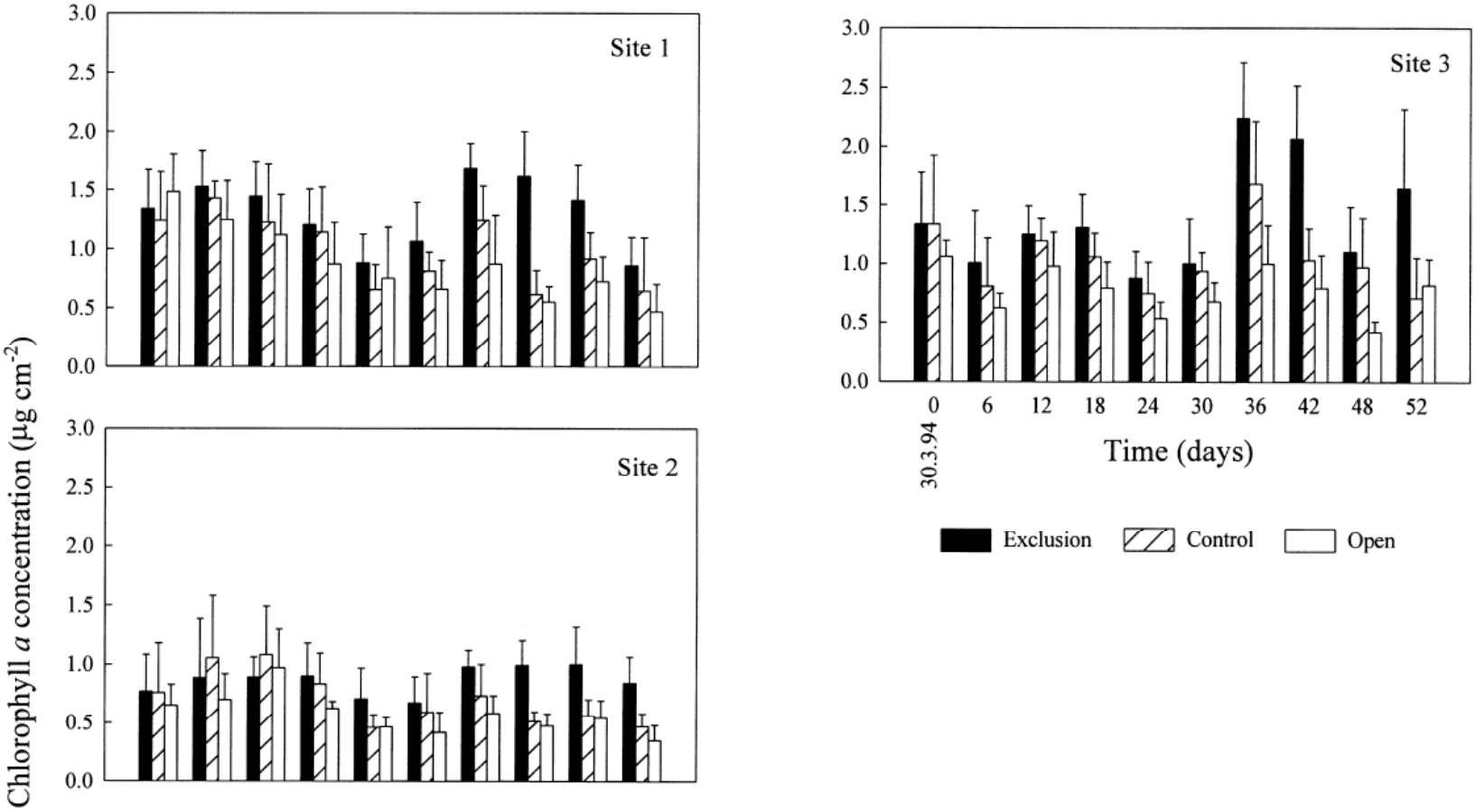
* Within a given replicate, the ^{14}C-ingested category represents measurements taken from a different group of individuals than those used in ^{14}C-retained and $^{14}CO_2$-respired categories.

Biofilm as food source

Exposure	Polymer type	
	Pseudoalteromonas atlantica EPS*	*Nitzschia* EPS*
Sediment-bound	92.2 + 1.86	90.1 + 1.15
Dissolved**	83.3 + 3.49	>99.9 + 3.62

Individual	Bacterial EPS	Algal EPS
1	0.0537	14.64
2	0.774	3.82
3	0.0198	1.99
4	lost	18.45
Mean	0.025 ± 0.01	4.86 ± 2.02

Grazing as a control of biofilm abundance



Trophic transfer

- **Association of metal-EPS may significantly enhance bioavailability of metals in marine systems**

Summary

- **The presence of a biofilm matrix alters a number of physical and biological properties of intertidal sediment environments.**
- **Biofilms occurring within the intertidal also influence human health providing a refuge for human pathogens and providing a pathway for trophic transfer of metal contaminates.**
- **However, the overall contribution of intertidal biofilms to larger-scale ocean processes remains largely unknown.**
- **In order to fully understand larger-scale processes within intertidal systems it is important to understand the small-scale contributions of biofilms.**