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

<table>
<thead>
<tr>
<th>Replicate</th>
<th>$^{14}$C ingested*</th>
<th>$^{14}$C retained</th>
<th>$^{14}$CO$_2$ respired</th>
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<tr>
<td>1</td>
<td>55.6</td>
<td>37.4</td>
<td>5.7</td>
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<tr>
<td>2</td>
<td>41.4</td>
<td>14.3</td>
<td>4.5</td>
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<td>3</td>
<td>14.5</td>
<td>19.2</td>
<td>3.8</td>
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<td>4</td>
<td>21.7</td>
<td>40.5</td>
<td>7.1</td>
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<tr>
<td>5</td>
<td>48.7</td>
<td>35.2</td>
<td>5.0</td>
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</table>

$\bar{x} \pm \text{SE}_{\bar{x}}$ 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

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Pseudoalteromonas atlantica EPS*</th>
<th>Nitzschia EPS*</th>
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<tbody>
<tr>
<td>Sediment-bound</td>
<td>92.2 + 1.86</td>
<td>90.1 + 1.15</td>
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<tr>
<td>Dissolved**</td>
<td>83.3 + 3.49</td>
<td>&gt;99.9 + 3.62</td>
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<table>
<thead>
<tr>
<th>Individual</th>
<th>Bacterial EPS</th>
<th>Algal EPS</th>
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<tbody>
<tr>
<td>1</td>
<td>0.0537</td>
<td>14.64</td>
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<tr>
<td>2</td>
<td>0.774</td>
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<tr>
<td>3</td>
<td>0.0198</td>
<td>1.99</td>
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<td>4</td>
<td>lost</td>
<td>18.45</td>
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<tr>
<td>Mean</td>
<td>0.025 ± 0.01</td>
<td>4.86 ± 2.02</td>
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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.