Two sources of primary production of sand bank ecosystems in the Seto Inland Sea, Japan

Koji Omori, Hidejiro Ohnishi, Toru Fukumoto, Shunsuke Takahashi, Hideki Hamaoka, Miyuki Ohnishi, Kenji Yoshino, Motomi Kato and Todd W. Miller

Center for Marine Environmental Studies, Ehime University, 2-5 Bunkyo-cho, Matsuyama, Ehime, 790-0826, Japan
Sand banks in study area

(Sekiguchi et al. 2005)
Sand banks in study area

(Sekiguchi et al. 2005)
Sand banks in study area

(Sekiguchi et al. 2005)
δ15N (‰) δ13C (‰)

Phytoplankton  Benthic Algae

Food Web around the sand bank
Higher trophic groups depend on both phytoplankton and benthic algae productions.

Food Web around the sand bank.
Study Site

Three times 12 hours survey by a research boat

- ADCP observation
- Collecting water samples

(Sekiguchi et al. 2005)
Two sources of primary production in sand bank ecosystems

A) Primary production of phytoplankton in the water column
   a) relationship between concentrations of nutrients and chl a

B) Primary production of benthic algae on the bottom sediment
   a) relationship between current speed and reflection intensity of ADCP signal
   b) relationship between current speed and concentration of chl a
   c) suspension of benthic algae
A) primary production of phytoplankton in the water column

a) relationship between concentrations of nutrients and chl a

<table>
<thead>
<tr>
<th></th>
<th>NO$_3$-N (μg/L)</th>
<th>PO$_4$-P (μg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>neap</td>
<td>37.73</td>
<td>13.38</td>
</tr>
<tr>
<td>neap to spring</td>
<td>33.08</td>
<td>10.39</td>
</tr>
<tr>
<td>spring</td>
<td>102.95</td>
<td>13.62</td>
</tr>
</tbody>
</table>

NO$_3$-N, PO$_4$-P lower concentration at neap to spring tide than at spring tide

Consumption of nutrients by primary producer?

A negative correlation between concentrations of chl a and nutrients.
A) primary production of phytoplankton in the water column
a) relationship between concentrations of nutrients and chl a

- **neap**
  - $y = -3.5098x + 44.386$
  - $R^2 = 0.3168$
  - $P=0.244$

- **spring**
  - $y = -18.218x + 80.995$
  - $R^2 = 0.028$
  - $P=0.477$

- **neap to spring**
  - $y = -3.7018x + 49.166$
  - $R^2 = 0.3083$
  - $P=0.011$

**active production!!**

- neap no correlation
- neap to spring negative correlation
- spring no correlation
B) primary production of benthic algae on the bottom sediment
  • suspension of sands and benthic algae
a) relationship between current speed and reflection intensity of ADCP signal
a) relationship between current speed and reflection intensity of ADCP signal

- **Neap**
  - $y = 84.41 - 0.093X$
  - $R^2 = 0.275$
  - $P < 0.0001$

- **Spring**
  - $y = 81.334 + 0.049X$
  - $R^2 = 0.308$
  - $P < 0.0001$

**Neap to Spring**
- No correlation

**Spring to Neap**
- Negative correlation

**Neap to Spring**
- Positive correlation
b) relationship between current speed and concentration of chl a

- **Neap**
  - Equation: $y = 1.058 - 0.004X$
  - $R^2 = 0.392$
  - $P = 0.029$

- **Spring**
  - Equation: $y = 0.904 + 0.009X$
  - $R^2 = 0.534$
  - $P = 0.025$

- Neap to Spring
  - No correlation

- Spring
  - Positive correlation

- Neap to Spring
  - Negative correlation
c) suspension of benthic algae

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Tidal Level</th>
<th>Tidal Zone</th>
<th>Tidal Level</th>
<th>Tidal Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Jul. 25</td>
<td>296.4cm</td>
<td>Neap to Spring</td>
<td>296.4cm</td>
<td>Neap to Spring</td>
</tr>
<tr>
<td></td>
<td>Sep. 8</td>
<td>314.5cm</td>
<td>Neap to Spring</td>
<td>314.5cm</td>
<td>Neap to Spring</td>
</tr>
<tr>
<td></td>
<td>Nov. 4</td>
<td>337.5cm</td>
<td>Neap to Spring</td>
<td>337.5cm</td>
<td>Neap to Spring</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Neap</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeletonema spp.</td>
<td>47.94 %</td>
<td></td>
</tr>
<tr>
<td>Chaetoceros spp.</td>
<td>31.44 %</td>
<td></td>
</tr>
<tr>
<td>Nitzschia spp.</td>
<td>20.62 %</td>
<td></td>
</tr>
<tr>
<td>Skeletonema spp.</td>
<td>35.65 %</td>
<td></td>
</tr>
<tr>
<td>Chaetoceros spp.</td>
<td>32.17 %</td>
<td></td>
</tr>
<tr>
<td>Nitzschia spp.</td>
<td>32.17 %</td>
<td></td>
</tr>
<tr>
<td>Melosira spp.</td>
<td>53.39 %</td>
<td></td>
</tr>
<tr>
<td>Asterionella spp.</td>
<td>23.76 %</td>
<td></td>
</tr>
<tr>
<td>Navicula spp.</td>
<td>11.41%</td>
<td></td>
</tr>
<tr>
<td>Thalassiothrix sp.</td>
<td>11.41%</td>
<td></td>
</tr>
<tr>
<td>Nitzschia spp.</td>
<td>29.85 %</td>
<td></td>
</tr>
</tbody>
</table>
Two sources of primary production in sand bank ecosystems

A) primary production of phytoplankton in the water column
   a) **negative** relationship between concentrations of nutrients and chl a

B) primary production of benthic algae on the bottom sediment
   a) **positive** relationship between current speed and reflection intensity of ADCP signal
   b) **positive** relationship between current speed and concentration of chl a
   c) **occurrence** of suspension of benthic algae
In conclusion: Estimated production process around sand banks

**Spring tide**

At spring tide, large water movement supplies nutrients around sand banks. Also, it reduces primary production of phytoplankton through water mixing.

**Neap tide**

At neap tide, small water movement promotes primary production of phytoplankton. Sometimes, a bloom of phytoplankton can be found at thin surface layer. In addition, production of benthic micro- and macroalgae will be promoted.

**Spring tide**

Production of phytoplankton during neap tide will be scattered over coastal areas. Also, benthic production will be suspended and dispersed by large water movement.
In conclusion: Estimated production process around sand banks

Spring tide

At spring tide, large water movement supplies nutrients around sand banks. Also, it reduces primary production of phytoplankton through water mixing.

Neap tide

At neap tide, small water movement promotes primary production of phytoplankton. Sometimes, a bloom of phytoplankton can be found at thin surface layer. In addition, production of benthic micro- and macroalgae will be promoted.

Spring tide

Production of phytoplankton during spring tide will be scattered over coastal areas. Also, benthic production will be suspended and dispersed by large water movement.