Climate change influence on development of *Laminaria japonica* early stages in the coastal waters of Primorye

Tatiana Krupnova, Yury Zuenko
Pacific Fisheries Research Center (TINRO), Russia
Stock of *Laminaria japonica* on the shelf of Primorye
(from the data of diving surveys)

Fields of coralline algae
Competitors of *Laminaria japonica* for substratum at Primorye coast

<table>
<thead>
<tr>
<th>Competitor</th>
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<tr>
<td><strong>Costaria costata</strong></td>
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<tr>
<td><strong>Desmarestia (Dichloria) viridis</strong></td>
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<tr>
<td><strong>Lithothamnium sp.</strong></td>
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<tr>
<td><strong>Lithophyllum sp.</strong></td>
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<tr>
<td><strong>Clathromorphum sp.</strong></td>
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<tr>
<td><strong>Bossiella cretaceae</strong></td>
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<tr>
<td><strong>Corallina pilulifera</strong></td>
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<tr>
<td><strong>Phyllospadix iwatensis</strong></td>
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Frequency (%) of the grounds occupied by *Laminaria japonica* (green) and coralline algae (orange) at the southern part of Primorye coast.

Recently the coralline algae occupy almost the whole (97 %) upper shelf of Primorye.
Daily temperature at the sea bottom for a station with depth 10 m located in the southern part of Primorye coast.
Periods (days) with the water temperature between 15° and 8°C favorable for Laminaria zoospores growth and gametophytes development at the **southern** part of Primorye coast.

The periods have a tendency to shortening in the last two decades.
Periods (days) with the water temperature between 15° and 8°C favorable for Laminaria zoospores growth and gametophytes development at the northern part of Primorye coast

The periods have a tendency to shortening in the last two decades.
Periods (days) with the water temperature between 15° and 8°C favorable for Laminaria zoospores growth and gametophytes development and with the temperature above 16°C unfavorable for them in Peter the Great Bay.

The unfavorable periods have a tendency to lengthening in 1980-1990s.
Correlation between the length of period with temperature 15-8°C in autumn and the number of *Laminaria japonica* germs in the next spring

\[ N = 67,870 \cdot D - 502,391 \]

\[ P < 0,0001 \]
\[ r = 0,990 \]
\[ r^2 = 98,048\% \]

D – length of the period with favorable temperature in autumn
N – number of germs (sp./m²) in the next spring
Scheme of cross-shelf water circulation at Primorye coast driven by summer and winter monsoons.
Abrupt cooling events at Primorye coast in the autumn of 2008

SST and currents at the sea surface in late September of 2008 (satellite data)

SST and water temperature at the 3 m depth in the Valentine Bay

SST in the Rifovaya Bay (Peter the Great Bay)
Time of monsoon change from summer to winter type as the time of change the sign (from positive to negative) of the meridional Katz index of atmospheric circulation for the JES region

Winter monsoon beginning has a tendency to delay in the last two decades
Relationship between the length of period with water temperature 15-8°C and the meridional Katz index for the JES region averaged for the period from September 10 to October 20 for the southern part of Primorye coast.
Relationship between the length of period with water temperature 15-8°C and the meridional Katz index for the JES region averaged for the period October 1-20 for the northern part of Primorye coast.
Scheme of *Laminaria japonica* fields available for commercial use

- **1960-1980s**
  - Vladivostok
  - Cape Zolotoy
  - Cape Povorotny

- **2009**
  - Vladivostok
  - Cape Zolotoy
  - Cape Povorotny
Recently the remnants of Laminaria occupy the most shallow part of the shelf.
Direction of the motion of zoospores after their output from the uterine thalluses
Empty rocky substrate (not occupied by coralline algae)
Mobile substrate (pebble) not occupied by coralline algae
Substrate occupied by coralline algae
Substrate occupied by coralline algae with sprouts of *Laminaria japonica*
Thank you for your attention!