Long-term variability of sublittoral macrobenthos of the Sakhalin’s shelf of Tatar Strait (Sea of Japan)

Labay V. S.
Sakhalin Fishery Institute
The research reasons

- Last decades fishing industry has faced falloff of fish capacity in a northwest part of sea of Japan. Almost all stocks of mass benthic fishes and crabs are now on a low level abundances.

Two basic areas of a fishery:

- Northern area
- Southern area
The research reasons

- Last decades fishing industry has faced falloff of fish capacity in a northwest part of sea of Japan. Almost all stocks of mass benthic fishes and crabs are now on a low level abundances.

**Catch of flounders in Chehovo-Illinskoe shoal (southern district):**

The research reasons

- Last decades fishing industry has faced falloff of fish capacity in a northwest part of sea of Japan. Almost all stocks of mass benthic fishes and crabs are now on a low level abundances.

**Catch of king crabs in Chehovo-Illinskoe shoal (southern district):**

Data source: Data is given by A. K. Klitin
The research reasons

- Last decades fishing industry has faced falloff of fish capacity in a northwest part of sea of Japan. Almost all stocks of mass benthic fishes and crabs are now on a low level abundances.

Yellow-finned sole in Aleksandrovsk-Sakhalinskiy shoal (southern district):

Data source: Model of calculation of a stock by S. N. Tarasjuk (retrospective)
The research reasons

What reasons of decrease in a stock?

• Official fishing science: Injurious overfishing.

• There are questions:

1. Why the discord between northern and southern fishing areas is observed?

2. Why the released trophic niches have not been occupied by other species?

The work purpose

To describe a current state of food supply of bottom-dwelling fishes and invertebrates and to establish the decrease causes of fish capacity in Tatar strait of Sea of Japan.
METHODS: Data source

**Interval of depths: 20 – 75 m**

- **1977–1979**: Fadeev, 1988
- **2010**: Own researches:

  Sample drawing was made from a research vessel “Dmitry Peskov” in May-June, 2010.
  Two polygons: northern and southern.
  Samples have been collected in 20 points on each polygon.
  From each point it has been collected three samples by the Van-Veen bottom sampler (0,2 m²).
RESULTS: 2010

- Northern polygon: 159 species, $417\pm41$ ind./m$^2$, $81,63\pm11,57$ g/m$^2$
- Southern polygon: 273 species, $514\pm62$ ind./m$^2$, $89,82\pm14,53$ g/m$^2$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Northern polygon</th>
<th>Southern polygon</th>
</tr>
</thead>
<tbody>
<tr>
<td>19–20 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of species</td>
<td>$86$</td>
<td>$89$</td>
</tr>
<tr>
<td>$N$, ind./m$^2$</td>
<td>$558\pm59$</td>
<td>$566\pm101$</td>
</tr>
<tr>
<td>$B$, g/m$^2$</td>
<td>$36,12\pm5,49$</td>
<td>$42,44\pm7,97$</td>
</tr>
<tr>
<td>29–33 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of species</td>
<td>$96$</td>
<td>$110$</td>
</tr>
<tr>
<td>$N$, ind./m$^2$</td>
<td>$727\pm68$</td>
<td>$502\pm59$</td>
</tr>
<tr>
<td>$B$, g/m$^2$</td>
<td>$24,24\pm2,73$</td>
<td>$22,17\pm2,48$</td>
</tr>
<tr>
<td>45–55 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of species</td>
<td>$59$</td>
<td>$150$</td>
</tr>
<tr>
<td>$N$, ind./m$^2$</td>
<td>$231\pm26$</td>
<td>$547\pm54$</td>
</tr>
<tr>
<td>$B$, g/m$^2$</td>
<td>$134,43\pm17,28$</td>
<td>$178,42\pm26,15$</td>
</tr>
<tr>
<td>66–75 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of species</td>
<td>$59$</td>
<td>$168$</td>
</tr>
<tr>
<td>$N$, ind./m$^2$</td>
<td>$152\pm20$</td>
<td>$375\pm37$</td>
</tr>
<tr>
<td>$B$, g/m$^2$</td>
<td>$131,72\pm16,92$</td>
<td>$99,4\pm11,89$</td>
</tr>
</tbody>
</table>
RESULTS: 2010
Ordination analysis: CCA

Nonrotating

Rotating

Northern polygon

<table>
<thead>
<tr>
<th>Species</th>
<th>Associated factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megayoldia thraciaeformis</td>
<td>Depth, ground</td>
</tr>
<tr>
<td>Maldane sarsi</td>
<td>?</td>
</tr>
<tr>
<td>Yoldia seminuda</td>
<td>Ground</td>
</tr>
<tr>
<td>Ophiura sarsi</td>
<td>Ground, D O₂</td>
</tr>
<tr>
<td>Amphiodia rossica</td>
<td>?</td>
</tr>
<tr>
<td>Macoma calcarea</td>
<td>?</td>
</tr>
</tbody>
</table>

Factor 1: Factor 2; 53% of dispersion

Factor 1: Factor 3; 52% of dispersion

Factor 2: Factor 3; 28% of dispersion
RESULTS: 2010
Ordination analysis: CCA

Nonrotating

Rotating

Southern polygon

Associated factors

S  Depth, T, Ground
N  Ground, Depth
B  Depth (?)
Echinarchnius parma  ?
Strongylocentrotus pallidus  Depth (?)
Yoldia keppeliana  Depth (?)
Lumbrineridae  Ground, Depth
Amphiodia rossica  ?
Macoma calcarea  Depth
RESULTS: 2010
Basic communities

- **Macoma calcarea**
- **Strongylocentrotus pallidus**
- **Echinarchnius parma**
- **Yoldia seminuda + Maldane sarsi**
- **Ophiura sarsi vadicola**

**Echiurida**
**Ciliatocardium ciliatum tchuktchense**
RESULTS: 2010
Basic communities

A

North

B

South

- *Ciliatocardium ciliatum*
- *Yoldia seminuda*
- *Echiurida*
- *Macoma calcarea*
- *Ophiura sarsi*
- *Strongylocentrotus pallidus*

Sea of Okhotsk
Tatartsk straight Sea of Japan
Sakhalin Island
## RESULTS: 2010

### Basic communities

<table>
<thead>
<tr>
<th>Community</th>
<th>Depth, m</th>
<th>S, species</th>
<th>N, ind./m²</th>
<th>B, g/m²</th>
<th>B dominant %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macoma calcarea</td>
<td>2010</td>
<td>45–70</td>
<td>87</td>
<td>424±42</td>
<td>130,5±15,4</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>≈ 60</td>
<td>184</td>
<td>524</td>
<td>142</td>
</tr>
<tr>
<td>Strongylocentrotus pallidus</td>
<td>2010</td>
<td>48–50</td>
<td>99</td>
<td>678±71</td>
<td>136,3±15,8</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Echinarachnius parma</td>
<td>2010</td>
<td>48–70</td>
<td>109</td>
<td>420±41</td>
<td>223,5±32,9</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>10–100</td>
<td>245</td>
<td>828</td>
<td>295</td>
</tr>
<tr>
<td>Yoldia seminuda + Maldane sarsi</td>
<td>2010</td>
<td>29–33</td>
<td>89</td>
<td>735±71</td>
<td>16,3±1,6</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ophiura sarsi</td>
<td>2010</td>
<td>19–29</td>
<td>66</td>
<td>587±58</td>
<td>35,4±3,8</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>15–40</td>
<td>60</td>
<td>2130</td>
<td>67</td>
</tr>
<tr>
<td>Echiurida</td>
<td>2010</td>
<td>50–75</td>
<td>58</td>
<td>175±22</td>
<td>223,0±22,9</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ciliatocardium ciliatum</td>
<td>2010</td>
<td>50–55</td>
<td>32</td>
<td>104±11</td>
<td>101,3±14,0</td>
</tr>
<tr>
<td></td>
<td>1977–1979</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Data source:** Fadeev, 1988

The basic changes in communities for 30 years: Disappearance of some communities marked earlier; Occurrence of several new communities; Change of dominating species; The general decrease in an abundance of a macrobenthos.
DISCUSSION:
Probable scenarios of event

Three variants

1) Stock decrease is caused by overfishing (The official)

2) Decrease in a store of bottom-dwelling fishes is caused by changes at the inferior trophic level.

3) Combining hypothesis
DISCUSSION:

Interannual changes of a biomass

Southern polygon

Biomass decreasing in the upper sublittoral (30-50) and in the inferior sublittoral (70) is observed. Average values of a biomass on the compared periods are not overlaped by a centre error that allows to speak about objectivity of observed process. The greatest falling of a biomass is noted for the top sublittoral where the index has decreased almost 7 times last 60 years. In the lower sublittoral the biomass has dropped in 2,4 times. **Biomass changes are accompanied by change of communities and change of its structure** (see above).
DISCUSSION:
Interannual changes of a biomass

Northern polygon
Biomass decrease to the middle of the seventieth years of past century is observed. Average values of a biomass on the compared periods are overlaped by a centre error.

H₀: Comparison of the data of the end of the fortieth years of past century and the data of the beginning of the present century has shown weak variability of a macrobenthos biomass for the last period.

T-test: P = 0.96

Thus distinctions in long-term variability of a macrobenthos biomass in southern and northern parts of Tatar strait are observed.
DISCUSSION:
Influence on the top trophic levels

Southern polygon
Catching change precisely enough corresponds to dynamics of a macrobenthos biomass.
Spearman's rho: $\rho = 1,0$
DISCUSSION:
Influence on the top trophic levels: step 1

Southern polygon
Crab’s catching change precisely enough corresponds to dynamics of a macrobenthos biomass.
Spearman's rho: $\rho = 1.0$
DISCUSSION:
Influence on the top trophic levels: step 1

Northern polygon
Yellow-finned sole stock change precisely enough corresponds to dynamics of a macrobenthos biomass.
Spearman's rho: $\rho = 1.0$
DISCUSSION:
Influence on the top trophic levels

step 2 – Whether fish capacity falloff only is caused by decrease in a biomass of a fodder macrobenthos?

Southern polygon
The macrobenthos biomass decreased in 6 times for 60 years.
Fish stock decreased in 140 times (!) for the same period.
The equation connecting a macrobenthos biomass and production of a bottom fishes:
\[ P_f = \frac{B \cdot P}{B \cdot K_E \cdot K_3} \]
were: \( P_f \) – a production of a bottom fishes, \( B \) – a macrobenthos biomass, \( P/B \) – coefficient of transfer of a benthos biomass in a benthos production, \( K_E \) – effectiveness ratio of use of food on growth of fishes, \( K_3 \) – average for the given ecosystem coefficient (share) of use of a forage reserve by bottom fishes.

Predicted decreasing of fishes production (multiplicity):

\[ \frac{P_f}{P_f} = \frac{B \cdot P / B \cdot K_E \cdot K_3}{B / 6 \cdot P / B \cdot K_E \cdot K_3} = 6 \]

Hence the combining hypothesis proves to be true.
The reasons of lowering of fish capacity: overfishing + global changes of the ecosystem (inferior trophic level).
Instead of the conclusion: water areas of global changes last 60 years

Source:
1) Nadtochy & Budnikova, 2004; own data
2) Samatov & Labay, 2009; Labay & Kochnev, 2009
3) The present data

Thank you for attention!