Multiple stressors impact on the ecosystem of Peter the Great Bay (Japan/East Sea)

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The density of population in the Russian Far East is low, 120 persons per 100 sq. km in average.

The maximal density is in Primorye, on the south of the district, coastal zone of Peter the Great Bay, approximately 1600 persons per 100 sq. km.
Sea surface temperature (°C) in the Amur Bay on August 16-18, 2010

Sea surface salinity (psu) in the Amur Bay on August 16-18, 2010

Hydrogen ion exponent (pH) at the sea surface in the Amur Bay in August 2010 (left) and 2009 (right)

(courtesy of V. Rachkov, TINRO)
Year-to-year fluctuations of air temperature and SST according the data of 4 meteorological stations in Peter the Great Bay

Vladivostok --- Possyet ---- Gamov – – – Nakhodka

Increase of SST and air temperature in Peter the Great Bay from 1934 to 2009

<table>
<thead>
<tr>
<th>Stations</th>
<th>SST</th>
<th>Air T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possyet</td>
<td>0.59</td>
<td>1.33</td>
</tr>
<tr>
<td>Gamov</td>
<td>0.37</td>
<td>0.81</td>
</tr>
<tr>
<td>Vladivostok</td>
<td>0.96</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>0.79*</td>
<td>1.68*</td>
</tr>
<tr>
<td>Tokarevsky</td>
<td>0.15</td>
<td>1.70</td>
</tr>
<tr>
<td>Nakhodka</td>
<td>-0.22</td>
<td>2.07</td>
</tr>
</tbody>
</table>

* – 1909–2008

Gayko, 2009
Pollutant discharge to Amur bay
(1988 - 2005)

The main components of waste waters

(Nigmatulina, 2008)
Distribution of petroleum hydrocarbons in seawater (1) and bottom sediments (2)
Spatial distribution of toxic metals: Cd, Cu, Hg, Pb in the bottom sediments of Amur Bay (1) and Ussury Bay (2), mg/kg dry wt
Organochlorine pesticides in mollusks, fish and seabirds from Peter the Great Bay

The bar chart shows the concentration of organochlorine pesticides (in Ig C) for different locations and species. The locations include Sivuchya Bay, Amursky Bay, Perevaznaya Bay, and others. The species are classified into molluscs, fish, and Sea gulls, each represented by a different color (molluscs: yellow, fish: purple, Sea gulls: green). The concentrations vary across the locations, with some areas showing higher concentrations than others.
Data of Mussel Watch program on OCP content in mussels from Asia-Pacific region (Monirith et al., 2004).

Peter the Great Bay (PGB) – our data. Total OCP content in mussels from Peter the Great Bay is lower than in mussels from Hong Kong, China and Vietnam. Normally HCCH level in soft tissues of mussels from PGB was higher than DDT content, on the contrary to mussels from other countries of Asia-Pacific region where DDT is dominated pesticides.
Non-indigenous species

- 45 species of microalgae, 24 species of zooplankton, 22 species of meroplankton, 10 taxa of meiofauna, 24 species of microscopic fungi, and 28 strains of bacteria were revealed in the seawater of the port of Vladivostok and ballast waters of the vessels of Russian-Japanese and Russian-Chinese lines (Zvyagintsev, Seliftonova, 2008).

- 11 non-indigenous fish species were registered in the estuary of Razdolnaya river input to the Peter the Great Bay (Kolpakov et al., 2008), as a result of aquaculture activity mainly. Share of non-indigenous species in fish community during the summer and fall varied from 7 to 30%.

List of non-indigenous species of fish
Abbottina rivularis (Basilewsky, 1855)
Acanthorhodeus chankaensis (Dybowski, 1872)
Acanthorhodeus sp.
Aristichthys nobilis (Richardson, 1845)
Ctenopharyngodon idella (Valenciennes in Cuvier, Valenciennes, 1844)
Culter alburnus Basilewsky, 1855
Hemiculter leucisculus (Basilewsky, 1855)
Hypophthalmichthys molitrix (Valenciennes in Cuvier, Valenciennes, 1844)
Silurus soldatovii Nikolsky et Soin, 1948
Sander lucioperca (Linnaeus, 1758)
Channa argus (Cantor, 1842)

List of non-indigenous copepod species of ships' ballast water in the port of Vladivostok
Pseudodiaptomus inopinus
Labidocera euchaeta
Calanus sinicus
Acartia bifilosa
Parvocalanus crassirostris
Oithona davisae
Dioithona rigida
Tortanus spinicaudatus (Kasyan, 2010)
Sites of blue king crab *Paralithodes platypus* detection in Peter the Great Bay

The distribution of crab in July-August 2008

Commercial males, March-May 2009

trawl survey

trap survey

(Koblikov et al., 2010)
DOMOIC ACID CONCENTRATION IN
SOFT TISSUES OF TESTED BIVALVES
from Peter the Great Bay

<table>
<thead>
<tr>
<th>Molluscs</th>
<th>Domoic acid, mkg/kg wet weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Modiolus difficilis</em></td>
<td>0.054</td>
</tr>
<tr>
<td><em>Mytilus trossulus</em></td>
<td>0.111</td>
</tr>
</tbody>
</table>

(Pavel et al., 2007)
CONCENTRATION OF PSP-TOXINS IN ECHINODERMS AND MOLLUSCS from Peter the Great Bay (mkg/kg wet weight)

Pavel et al., 2007
Relative abundance of mysids species as bioindicator of ecosystem’s state (1991 – 2009)

- natural state (relative abundance of Paracanthomysis sp. is more than 50% of the total amount of mysids)
- balanced state (relative abundance of Paracanthomysis sp. is 1 to 50%)
- crisis state (Paracanthomysis sp. is lacking or it’s abundance is less than 1%)
- critical state (mysids are single or number of N. awatschensis predominates)
- catastrophic state (mysids lack completely)
Glutathione-S-transpherase activity in organs of *Crenomytilus grayanus* from Peter the Great Bay
Glutathione-S-transpherase in the liver of flounder *Liopsetta pinnifasciata* from Amursky and Ussuriisky bays

Amur bay

Ussury bay

- Maximal level (nmoles/min/mg protein)
- Minimal level during annual cycle
Molecular biomarkers of oxidative damage in the gills of Japanese mitten crab and liver of haarder from the estuarine zones of Peter the Great Bay

**GST, crab**

<table>
<thead>
<tr>
<th>Location</th>
<th>2007</th>
<th>2008</th>
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<tbody>
<tr>
<td>Razdolnaya</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Sukhodol</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Artemovka</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Tesnya</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>Shkotovka</td>
<td>20</td>
<td>15</td>
</tr>
</tbody>
</table>

**Molecular biomarkers, Haarer,**

- Optical density, %
- **GST**
- **Catalase**
- **LP**
- **Glutathione**

**Crab Eriocheir japonica**

**Haarder Liza haematocheila**
Macrozoobenthos total biomass (g/sq. m) in Peter the Great Bay

(Nadtochiy et al., 2005)
## Overall commercial stock and value of biological resources of Peter the Great Bay

<table>
<thead>
<tr>
<th></th>
<th>1999*</th>
<th>2001*</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>95 130</td>
<td>162 027</td>
<td>87 700</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>59 590</td>
<td>305 422</td>
<td>106 310</td>
</tr>
<tr>
<td>Seaweeds</td>
<td>89 750</td>
<td>127 625</td>
<td>63 293</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>244 470</strong></td>
<td><strong>595 074</strong></td>
<td><strong>257 303</strong></td>
</tr>
</tbody>
</table>

* - Ogorodnikova, 2001
The main ecosystem services of Peter the Great Bay:

- Gas regulation
- Nutrient cycling
- Biological control
- Food production
- Raw materials
- Cultural and recreation.

The total value of ecosystem services of the Bay is $1,706,6 \times 10^6 \text{ yr}^{-1}$.

The value of biological resources of the Bay is $870 \times 10^6 \text{ yr}^{-1}$.

The value of biological resources of the Bay without the expenses is $52,3 \times 10^6$. 
The value of ecosystem services and biological resources of Peter the Great Bay
Conclusion

Impact of multiple stressors – chemical pollution and biological hazards - do not disturb chemical-biological balance and homeostasis of Peter the Great Bay at the end of 2010s.

**Pollution** of the Bay due to human activity is **moderate** for the Bay at whole and **significant** for some internal bays - Amur Bay, Ussury Bay, Nakhodka Bay and Possyet Bay.

Chemical and biological monitoring of the Bay is a required step for sustainable development of local economy at whole and fisheries in particular and conservation of biodiversity.
Thank you for your attention