Long-term changes in the phytoplankton of the coastal waters off Vladivostok (Amurskii Bay, the Sea of Japan), 1992-2007

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Location and boundary

- The target sea area (monitoring station in Amurskii Bay, latitude 43°11' and longitude 131°54') is situated in the northwestern of Peter the Great Bay (Sea of Japan / East Sea).
- Amurskii Bay are characterized by the greatest eutrophic level in Peter the Great Bay. These water areas are adversely affected by industrial waste products and municipal sewage of Vladivostok as well as by agricultural sewage that are transported to the sea by terrigenous runoff and by the waters of Razdolnaya River.

Hydrological regime

- Hydrological regime of Amurskii Bay depends on currents flowing round Muravyev-Amurskii Peninsula, river runoff distribution, and bottom and shore relief.
- The system of currents in Amurskii Bay presents the layout of the permanent branches of the Primorskoye Current flowing into Peter the Great Bay Ice period lasts for 120-150 days depending on synoptic conditions of a year.
- Water temperature in Amurskii Bay shows distinct annual trend: minimum monthly temperature is registered for January and February (from –1.8°C to –1.9°C) and maximum for August (20.8°C to 23.1°C). Average annual temperature of surface water is 7.8-8.3°C .
- The estuarine part of the bay completely freezes in late December, and in April the water area becomes cleared. The ice cover thickness ranges from 0.6 - 1.0 m, at the river mouth bar, 1.5-2.0 m.
- Yearly salinity trend shows a maximum in January-February (32.9-35.4‰) and a minimum in July-August (20.4-31.0 ‰). Long-time average annual salinity grows from north to south from 26,5 to 33.5‰, surface water of the inner part of Amurskii Bay are eubject to freshening to a salinity value of 20-32‰, which at some sites may be as low as 1-12‰.

Methodology used in the case study

In the case study, red-tide (bloom-forming) and toxin-producing species are referred as HAB species.

In Russia, red tide refers to phenomena in which
the coloring of sea water is observed due to the proliferation
of plankton algae (so-called “algal blooms”), when the concentration
of plankton microalgae up to million cells per liter.

HAB monitoring organization and monitored sea area

Monitoring organization	Monitored sea area
-Institute of Marine Biology FEB RAS http://www.imb.dvo.ru (1991-2008) -Center of Monitoring of HABs & Biotoxins of the Institute of Marine Biology FEB RAS http://www.imb.dvo.ru/misc/toxicalgae/index.htm (since 2007)	Amurskii Bay (HAB monitoring station of Institute of Marine Biology FEB RAS Amurskii Bay (HAB monitoring station of the Institute of Marine Biology FEB RAS

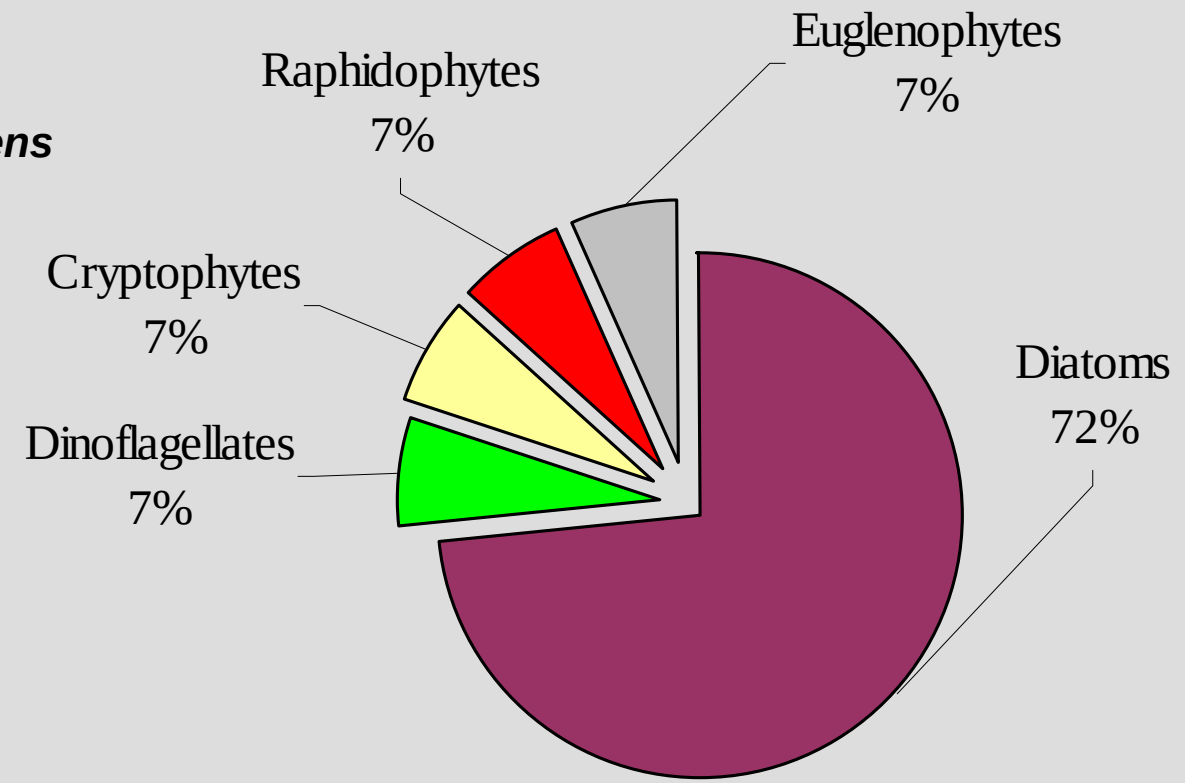
Safety limits

In the target sea area shellfish are monitored to check the presence of algal toxins (DSP, ASP, PSP).
Safety limits are established by the Government, which are
for PSP – 0.8 mg/kg of saxitoxin (mollusks);
for DSP- 0.16 mg/kg of okadaic acid (mollusks) and
for ASP - 20 mg/kg of domoic acid (mollusks)
and 30 mg/kg of domoic acid (crab's internal)
(The Federal Legislative Act SanPIN 2.3.2.2401-08).

There are no any data on fishery damage in the target sea area.
In this case study, the following type of HAB species are targeted and referred to as "target HAB species": red-tide causative (bloom-forming) species in the target sea area; toxin-producing plankton (toxic and potentially toxic species).

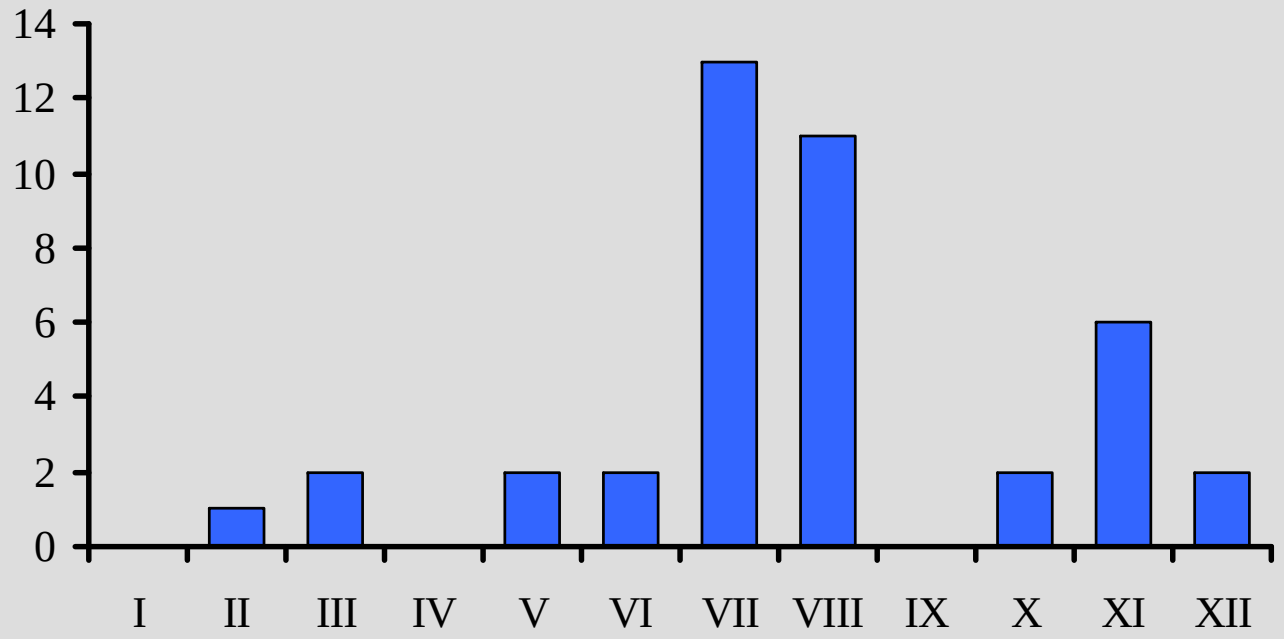
During the 17 years between 1991 and 2007, a total 28 HAB species were recorded in which 13 species are known as potentially toxic species and 18 species cause water blooms.Those species are belonging to 5 taxonomic groups of phytoplankton. The most common and abundant bloom-forming species were diatoms.

Pseudo-nitzschia calliantha
Pseudo-nitzschia delicatissima
Pseudo-nitzschia fraudulenta
Pseudo-nitzschia multistriata
Pseudo-nitzschia multiseries
Pseudo-nitzschia seriata/pungens
Dinophysis acuminata
Dinophysis acuta
Dinophysis fortii
Dinophysis norvegica
Dinophysis rotundata
Karenia mikimotoi
Noctiluca scintillans
Prorocentrum minimum
Protoceratium reticulatum
Chattonella sp.
Heterosigma akashiwo



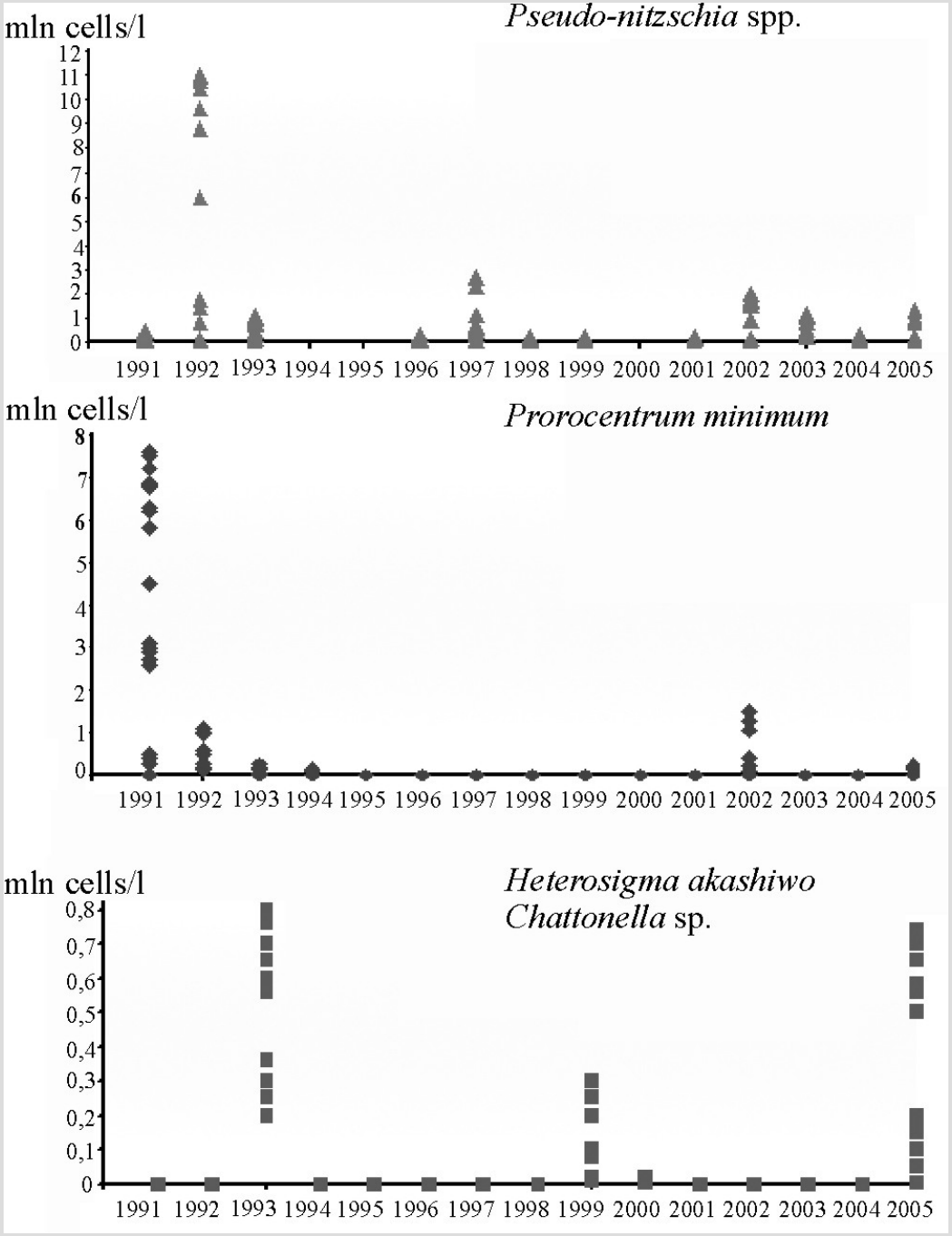
Monthly trends of HAB events

During the 17 years between 1991 and 2007, a total 41 bloom events were recorded, in which no any events induce damage or human poisoning. HAB events occurred most frequently during July-August and November.



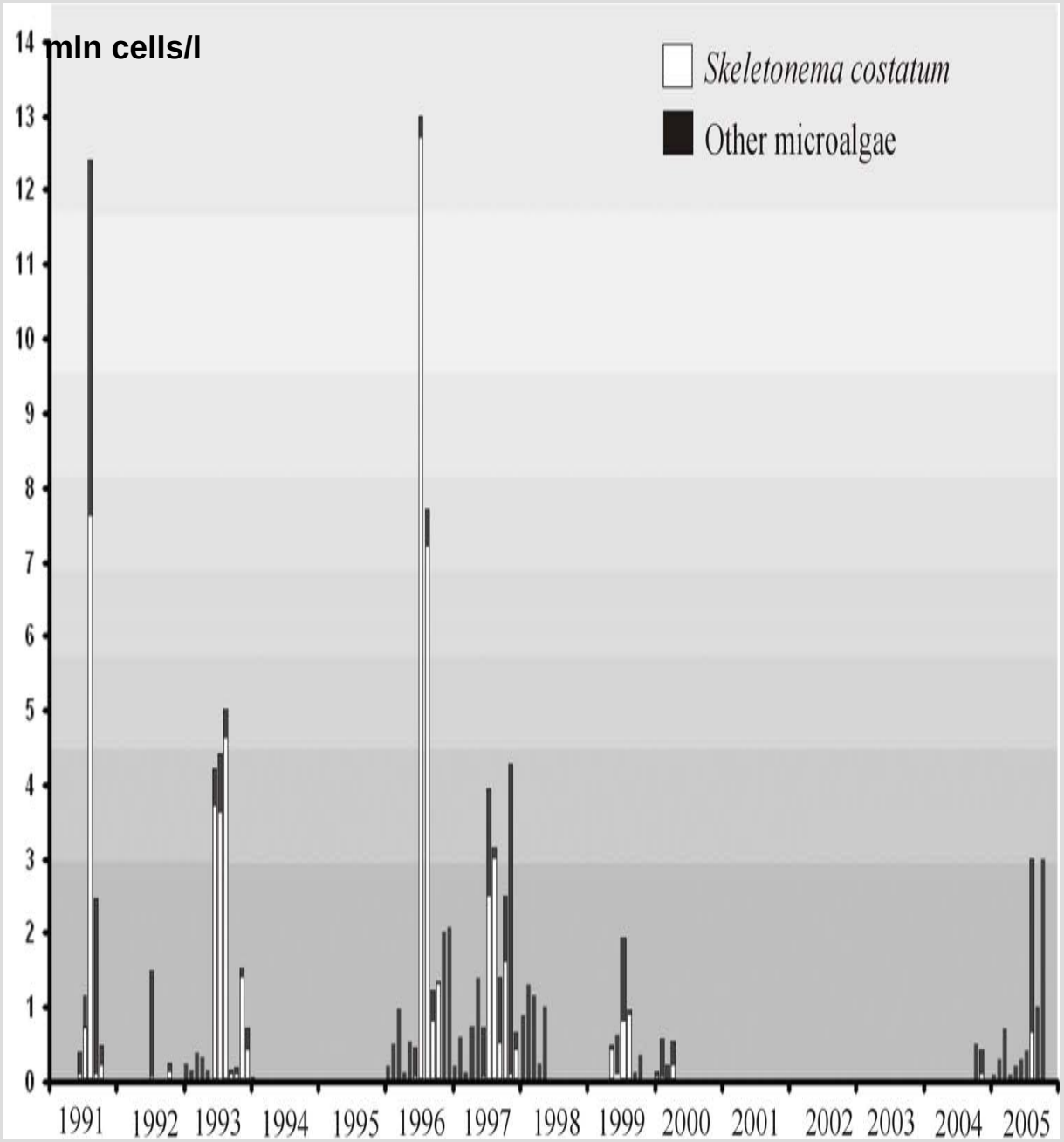
Number of bloom events by month in Amurskii Bay (1991–2007)

Source: Center of Monitoring of HABs & Biotoxins of the Institute of Marine Biology FEB RAS http://www.imb.dvo.ru/misc/toxicalgae/index.htm



- In the 1990s, water blooms in Amurskii Bay were more frequent than in previous years.
- They were caused by mass development of potentially toxic and harmful diatom, dynoflagellate, and raphidophyte algae, previously not reported for this region.

Long-term changes in density of potentially toxic and harmful species from 1991 until 2005.

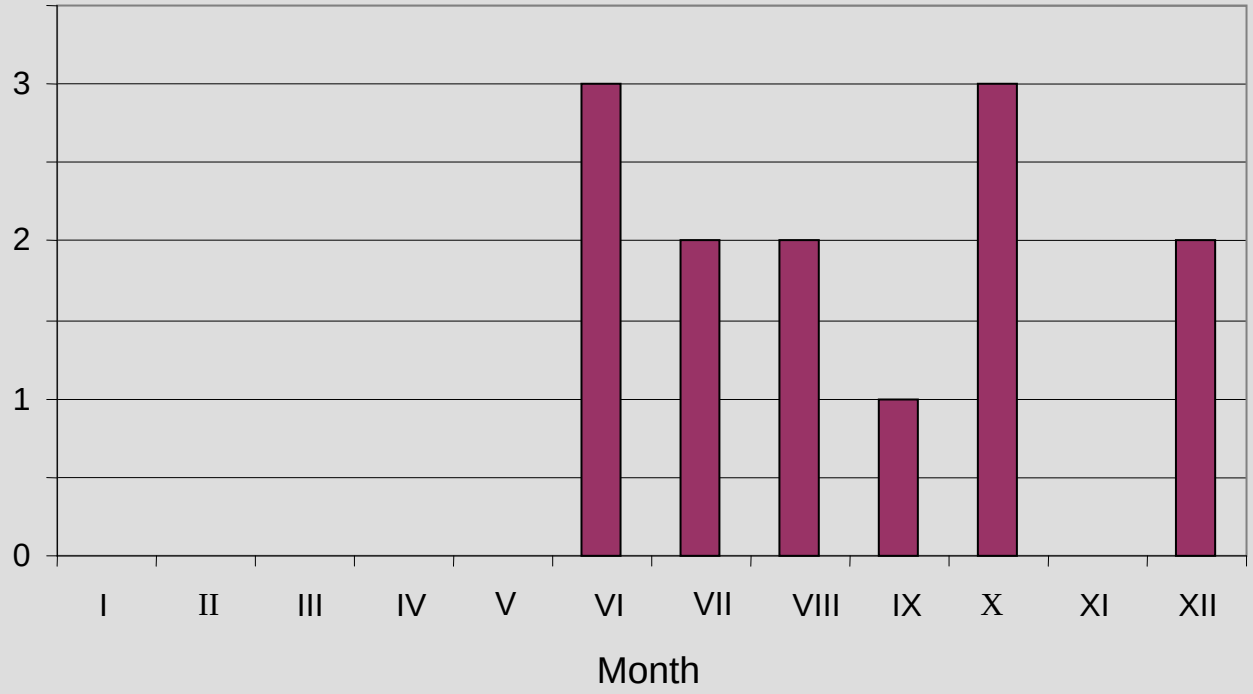


- The greatest peaks of phytoplankton densities were observed in August 1991 (12.4 million cells/l) and July 1996 (13 million cells/l).
- High values of phytoplankton density in that period were due to mass development of the diatom *S. costatum.*

Long-term changes in density of *Skeletonema costatum* and other phytoplankton species from 1991 until 2005.

Status of recent HAB events and results of environmental monitoring

In September 2005 - September 2006, the most frequently observed species was bloom-forming diatom *Thalassionema nitzschioides.* The most frequently observed potentially toxic species were diatoms *Pseudo-nitzschia delicatissima* and *P. pungens.* HAB events occurred during June – December, and observed more frequently in June and October



Number of HAB events by month in Amurskii Bay in September 2005 – September 2006

Status of recent HAB events and results of environmental monitoring

The table shows the number of HAB events by duration (no. of days) from September 2005 to September 2006. A total of 13 events occurred from September 2005 to September 2006, in which 6 events were under 5 days, 2 events between 6-10 days, 5 events between 11-30 days. The longest HAB duration was 28 days by bloom-forming diatom *Thalassionema nitzschioides,* which occurred during June-July. The longest HAB duration by potentially toxic species was 25 days. It was caused by *Pseudo-nitzschia delicatissima* in December.

Number of HAB events by duration (no. pf days)

	≤5	6-10	11-30	Total
Amurskii Bay	6	2	5	13
Total	6	2	5	13

Source: Center of Monitoring of HABs & Biotoxins of the Institute of Marine Biology FEB RAS (2007)
http://www.imb.dvo.ru/misc/toxicalgae/index.htm

Maximum density of HAB event that occurred in Amurskii Bay in September 2005-September 2006

Year	Event No.	Causative species	Maximum density (cellsL^{-1})
2005	AB200501	*Pseudo-nitzschia calliantha*	200 000
2005	AB200502	*Pseudo-nitzschia fraudulenta*	38 000
2005	AB200503	*Pseudo-nitzschia multistriata*	800 000
2005	AB200504	*Pseudo-nitzschia delicatissima*	80 000
2005	AB200505	*Pseudo-nitzschia pungens*	60 000
2005	AB200506	*Prorocentrum minimum*	100 000
2005	AB200507	*Pseudo-nitzschia seriata*	9 100
2006	AB200601	*Dinophysis rotundata*	500
2006	AB200602	*Thalassionema nitzschioides*	2 000 000
2006	AB200603	*Dinophysis acuminate*	12 800
2006	AB200604	*Dinophysis acuta*	500
2006	AB200605	*Karenia mikimotoi*	18 000
2006	AB200606	*Chaetoceros salsugineus*	1 600 000

Source: Center of Monitoring of HABs & Biotoxins of the Institute of Marine Biology FEB RAS (2007) http://www.imb.dvo.ru/misc/toxicalgae/index.htm

Data of post-HAB surveys in Amurskii Bay

Year	HAB Event No.	Species	Water temp. (C^0)	Salinity, ‰
2005	AB200501	*Pseudo-nitzschia calliantha*	6 - 12	32 - 33
2005	AB200502	*Pseudo-nitzschia fraudulenta*	8	34
2005	AB200503	*Pseudo-nitzschia multistriata*	15	33
2005	Ab200504	*Pseudo-nitzschia delicatissima*	-1.7 – -1.8	33 – 35
2005	AB200505	*Pseudo-nitzschia pungens*	-1.7	34 - 35
2005	AB200506	*Prorocentrum minimum*	12	33
2005	AB200507	*Pseudo-nitzschia seriata*	20	31
2006	AB200601	*Dinophysis rotundata*	-1.7	34
2006	AB200602	*Thalassionema nitzschioides*	13 - 20	20 - 29
2006	AB200603	*Dinophysis acuminata*	13 - 22	17 – 20
2006	AB200604	*Dinophysis acuta*	13	17
2006	AB200605	*Karenia mikimotoi*	20	20
2006	AB200606	*Chaetoceros salsugineus*	5	33

- **In summary, the following trends in phytoplankton community were revealed:**
- **changes in the dominant species,**
- **total density and biomass increased,**

- **The relative decrease in the intensity of HABs since the late 90s does not suggest that any positive changes in anthropogenic influences on the coastal ecosystem have occurred.**