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Fishery in the Russian part of the Vistula lagoon

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Abstract

Goushchin A.V. Fishery in the Russian part of the Vistula lagoon. 40 p., 19 fig.

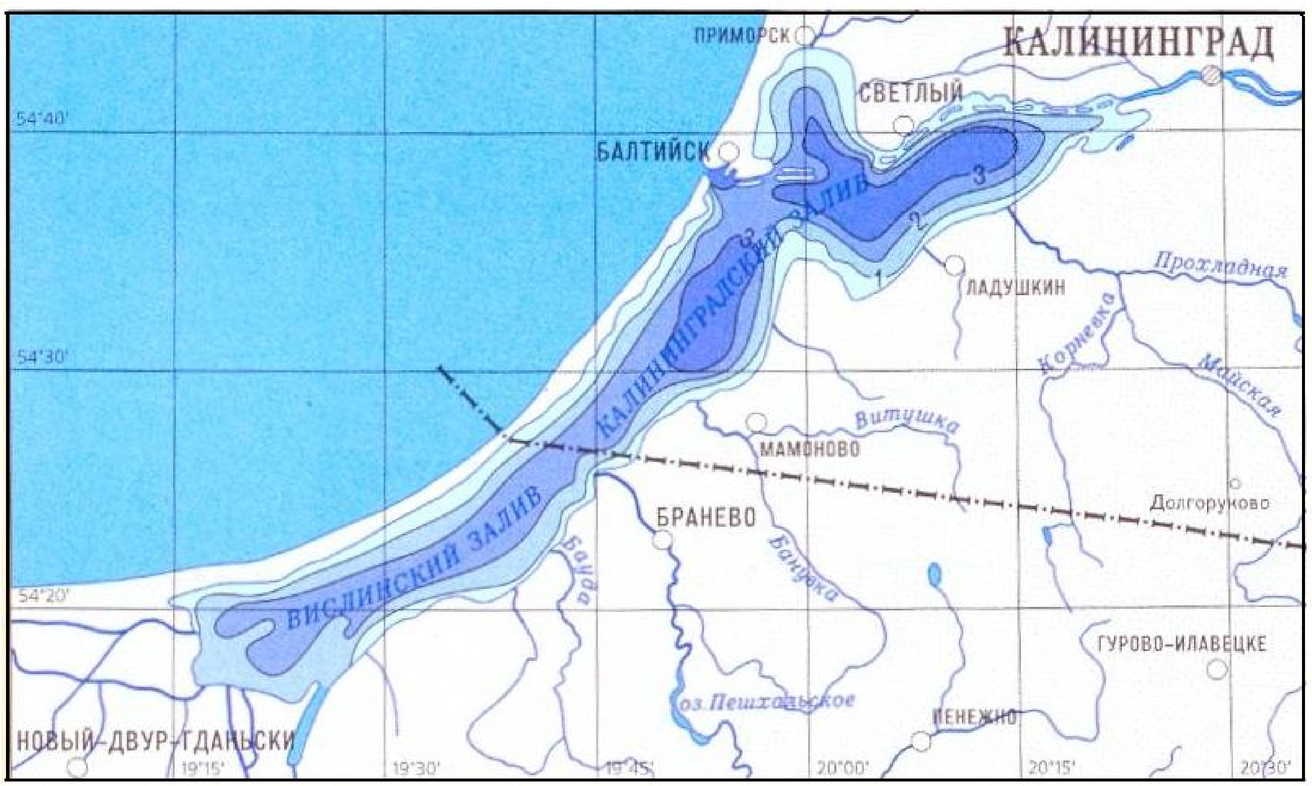
Modern state of fishery in the Russian part of the Vistula lagoon is estimated. The list of lagoon ichthyofauna and information on main fishery species are given. The factors influencing fishery state including industrial, sport and recreational, illegal (poaching) fishing, bird coercion, parasite illness and toxic pressure of blue – green alga are marked. The tendency for fishery development and suggestions on its improvement are given.

Содержание

1.1. Hydrological and morphological characteristics of the Vistula lagoon

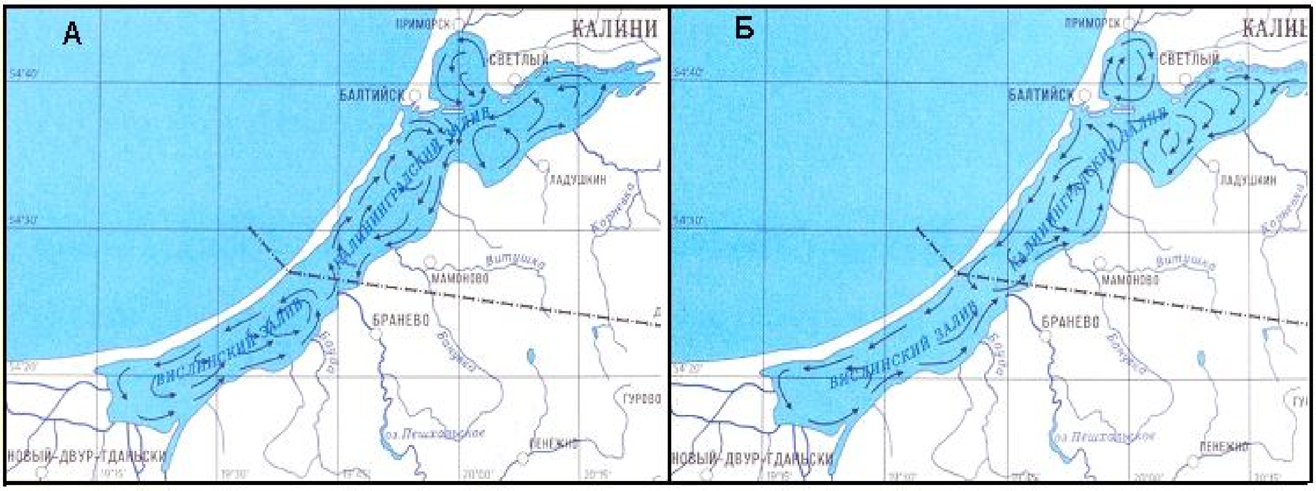
The Vistula lagoon stretches from the south-west to the north-east. It is connected to the Baltic Sea with the ship strait in the region of the city Baltiysk, the narrow sand spit separates the sea and the lagoon. Total water area of the Vistula lagoon is 838 square kilometers. The lagoon is divided into two parts: actually the Vistula lagoon and the Kaliningrad lagoon, the water area of the Russian Federation with the square of 472 km^2 (Orlenok et al., 2002). The part of the lagoon to the west from the traverse the Baltic Strait – the cape Northern (the semi-island Balga) is implied as the Kaliningrad lagoon in the last years. The water area of the Russian Federation is 472 km^2 (Orlenok et al., 2002). The mean depth of the lagoon is 2,8 m, the maximal depth is 5,2 m.

Hydrological conditions of the Kaliningrad lagoon are developed due to the fluctuations of the Baltic Sea level, wind activity and water flow from the land. Usually water level in the lagoon is 5-8 cm higher than the Baltic Sea level. Water fluctuations in the lagoon are 19-21 cm. Raisings of water level may consist more than 83 cm in the period of autumn-winter storms (Lazarenko, Maevskiy and others, 1971; Orlenok et al., 2002). The lagoon is related to brackish water bodies of lagoon type.



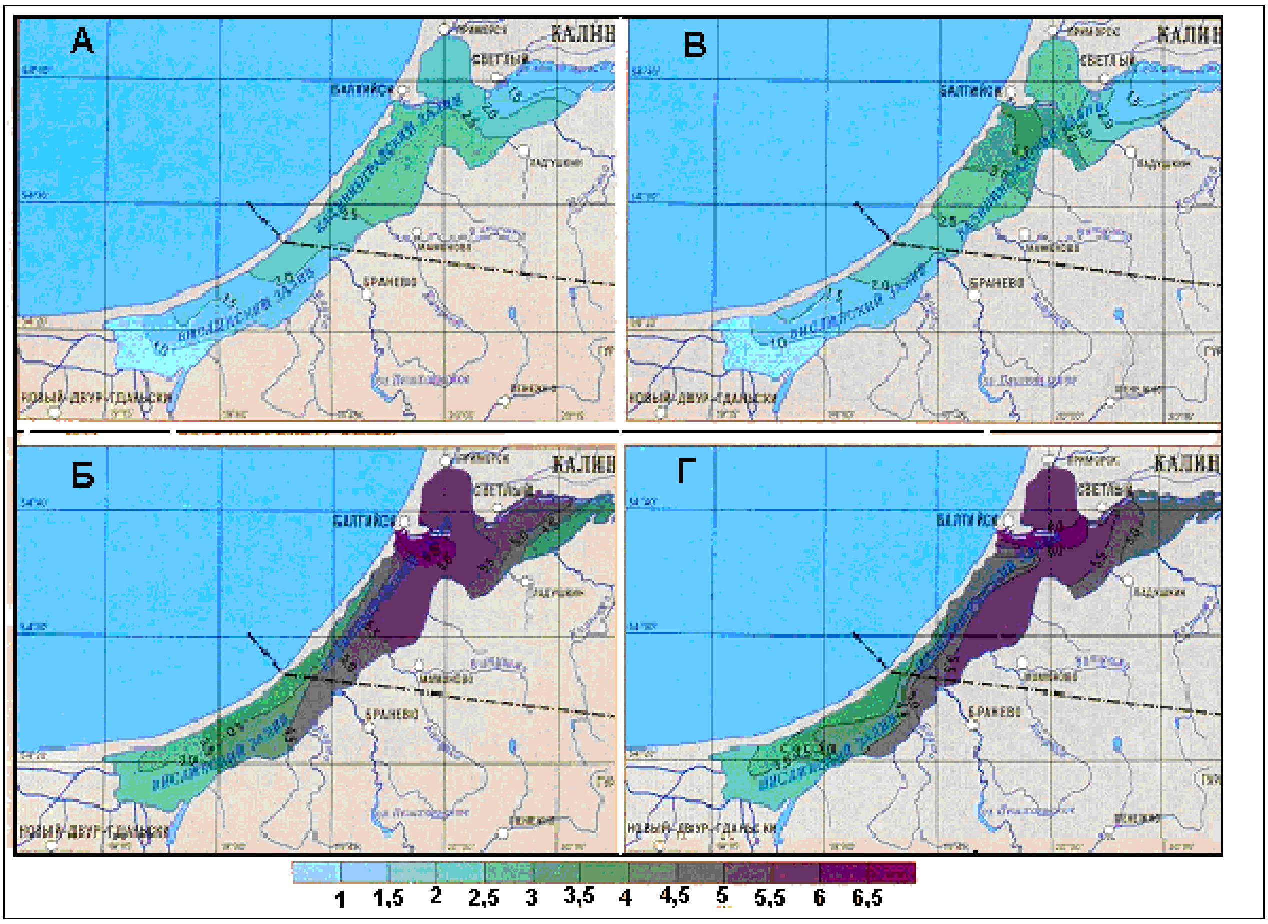
Bathymetric map of the Vistula lagoon (Orlenok et al., 2002).

The currents in the lagoon are stipulated by the wind, river flow, contours of the shore and water exchange with the Baltic Sea. The currents are not stable and steady.



Scheme of the currents in the Vistula lagoon (Orlenok et al., 2002).

А- the currents at the southern, west-southern and western winds.
Б –the currents at the northern, east-northern and eastern winds.



Salinity distribution S%o in the Vistula lagoon (Orlenok et al., 2002).

А- salinity in the upper layer at the period of outgoing currents;
Б - salinity in the bottom layer at the period of outgoing currents
В –salinity in the upper layer at the period of water raising currents;
Г- salinity in the bottom layer at the period of water raising currents.

Water exchange with the sea consists 88% of water balance of the gulf and it is fulfilled through the Baltic Sea Strait. The existence of the regions that differ greatly on hydrological parameters with distinct horizontal gradient of salinity where salinity can change from 0,5 - 55 ‰ to 3,7 – 5,9‰ during the year is the peculiarity of this water area (Chubarenko, 2007).

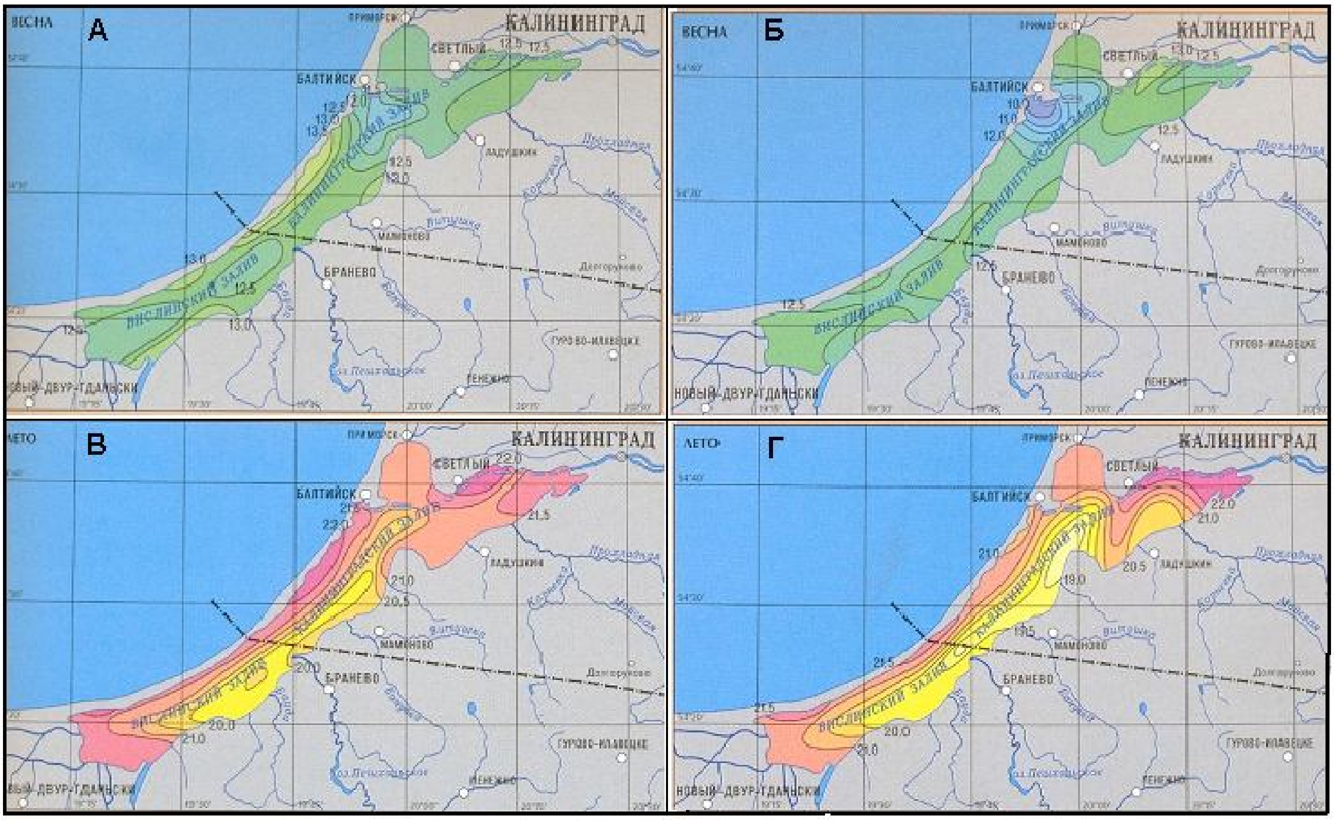
At the period of northwestern winds the Baltic Sea water penetrates the lagoon and salinity in the northern part increases up to 5,5%o. Average salinity of lagoon water is 1-3%o.

Thermal regime of the lagoon is characterized with isotherm due to its shallows, but vertical thermal gradient can be observed in spring-summer period. Intensive heating of lagoon water occurs in April-May. The lowest temperature is marked in the northern part of the lagoon (11˚C). In summer temperature improves and makes 20-22˚. In autumn temperature lows to 8-10˚C, the highest temperature is in the region of the Strait due to inflow of warm water from the Baltic Sea (Fig.4). Oxygen content is usually in the limits of thermal norm as the result of constant intermixing by the wind. Shortage of oxygen is marked with the lack of the wind and mortality is possible at the period of phytoplankton florescence.

The rivers Pregel, Prokhladnaya, Nelma, Mamonovka flow into the Kaliningrad lagoon. The southern part of the lagoon is under the influence of the Vistula flow. River flow consists 1/5 of lagoon water volume, it brings big amount of sand, silt, biogenic elements and organic matters. The largest amount of biogenic and other pollutants approaches the northern part of the lagoon with the Pregel River water and through rain and waste water of Kaliningrad in the Primorskaya bay. Acid reaction, low quantity of dissolved oxygen and big quantity of H_2S are observed here in water flow.

Water area of the lagoon can be divided into four zones: estuary, central, south-western and the Primorskaya bay according to hydrological characteristics, bottom grounds types and peculiarities of suspension substance distribution. High concentration of suspension substance (SS) is marked in the lagoon, it is 10-fold higher than in the Baltic Sea (Chechko, 2002).

In winter period the lagoon is covered with ice. Steady ice cover is not formed in mild and moderate winters. As a rule the Vistula lagoon is covered with still ice in the second decade of December. Ice melts at the end of February in mild winters and at the beginning of April after the severe winters.

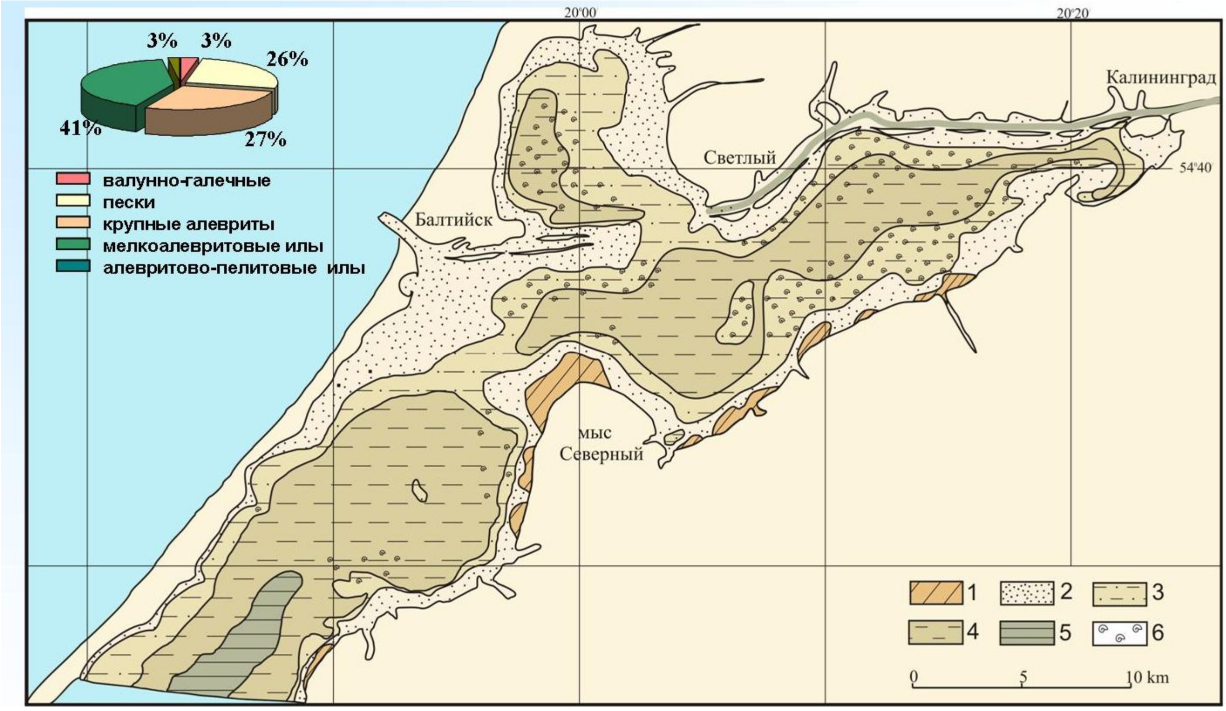


Water temperature in the lagoon in spring and summer seasons (Orlenok and others, 2002)

А- temperature distribution on the surface in spring;
Б - temperature distribution in the bottom layer in spring;
В - temperature distribution on the surface in summer;
Г - temperature distribution in the bottom layer in summer/

1.2. Characteristic of the bottom grounds in the Russian part of the Vistula lagoon

Small aleurites silts - 41%, large aleurites - 27% and sands - 26% (Chechko, Blazhchishin, 20020) cover the main bottom of the Russian part of the Vistula and the Kaliningrad lagoons. Sands are in the north-eastern part of the lagoon at the depths to 2 m, aleurites with silts and cockle-shells at the depth more than 2 m. Boulder-pebble banks surrounded with sands are located southward along the shore. Several silt-sand and stone shallows are marked in the south-eastern part of the lagoon (Shchukinskaya, Veselovskaya, Lozovskaya shallows). Shchukinskaya shallow possesses the largest square with the depth of 1,5 m and stretches for 2,5 km into the lagoon. Sand-silt bar with the depths of 0,5-1,0 m separates the Vistula lagoon at the distance of 2 km from the Strait into two hollows – the Vistula lagoon and the Kaliningrad lagoon. The sea canal cuts the bar eastward. The canal contributes to salt water intrusion into the northern hollow and withstands water intrusion into the southern part of the lagoon. The vast Primorskaya bay with sand and aleurites-silt grounds are in the northern part of the lagoon, the cape Northern (the semi-island Balga) is in the central part. Vast boulder-pebble banks with the sands of different sizes are located along the shore.



Scheme of bottom sediments distribution in the Kaliningrad lagoon (according to Chechko, Blazhchishin, 2002).

Sediments types: 1- boulder-pebble; 2 - different granular sands (1- 0,1 mm); 3 - large granular aleurites (0,1- 0,05 mm); 4 - small aleurites silt (0,05- 0,01 mm); 5 - aleurites-pelitic silt (< 0,01); 6 - cockle shells with the layer of silt or aleurites.

According to hydrological characteristics, bottom grounds types and distribution peculiarities of suspension substance, water area of the lagoon can be divided into four zones: estuary, central, south-western and the Primorskaya bay. The lagoon zones are characterized with different concentrations, the sizes of the fractions in suspended substance and the part of the organics in the total substance of suspension (Chechko, 2002).

Availability of large bottom squares covered with soft grounds is favourable for the development of zoobenthic organisms that serve as food resources for many fish species.

2. Description of ichthyofauna state in the Vistula lagoon

2.1. Ichthyofauna of the Vistula lagoon

The list of species inhabiting the Vistula lagoon was first published by Benecke (Benecke, 1881). 35 fish species of the lagoon were given in the work by Dzukovsky G.M. in the 20-th century (Dzukovsky, 1947). The list of fish consisting of 48 species was presented by Alekseev N.K. and

Probatov A.I. in "Zoogeographical article of freshwater inchthyofauna of Kaliningrad region" (Alekseev, Probatov, 1969). The last data on composition of the Vistula lagoon ichthyofauna are given in the dissertation of Fedorov L.C. (Fedorov, 2002). According to Fedorov L.C., ichthyofauna of the Vistula lagoon possesses 53 species. But in this list are presented some species the catch of which is hardly reliable, and some species that have got into the lagoon from aquacultural enterprises. Fish species number in the Vistula lagoon is likely to be 40-47 sp. (Winkler et al., 2000), but if we take into consideration that the official discovery must consist not less than 10 items of each species catch, the most reliable data is 33 fish species inhabiting the Kaliningrad lagoon (Appendix).

According to hydrological and hydroclimatic data the Vistula lagoon is the border water basin between fresh water of the continent and the Baltic Sea water. This fact explains the presence of several ecological groups of fresh water, brackish water and sea water species in ichthyocene.

Catch sorting

Fresh water species dominate on frequency of occurrence, biomass and their positions in trophic system: bream - *Abramis brama* (Linnaeus, 1758), roach - *Rutilus rutilus* (Linnaeus, 1758), perch - *Perca fluviatilis* Linnaeus, 1758, pope (ruff) - *Gymnocephalus cernua* (Linnaeus, 1758) and ziege – *Pelecus cultratus* (Linnaeus, 1758). Brackish water fish: sander - *Sander lucioperca* (Linnaeus, 1758); sea species: Baltic herring - *Clupea harengus membras* Linnaeus, 1758, Atlantic salmon- *Salmo salar* Linnaeus, 1758, European smelt - *Osmerus eperlanus* (Linnaeus, 1758) are represented with living, semi-migrating and migrating species. Sander is a living species, but part of its population performs short trophic migrations into the Baltic Sea. Baltic herring is semi-migrating species for which the Vistula lagoon is one of the most important spawning grounds in the Baltic Sea. The number of migrating species is not big, they are represented with catadromous species – European eel *Anguilla anguilla* (Linnaeus, 1758) that lives in the lagoon at nourishing period of its life cycle, and anadromous species: lampern *Lampetra fluviatilis* (Linnaeus, 1758), shad *Alosa fallax* (Lacepède, 1803), European smelt, brook trout *Salmo trutta* Linnaeus, 1758, Atlantic salmon. Sea sturgeon, *Acipenser oxyrinchus oxyrinchus* Mitchill, 1815, may join up with these species in the nearest future. The program for sturgeon stock restoration is being successfully realized now through the release of juveniles in the basin of the Vistula River (Kolman, 2006; 2010).

European eel has practically lost its trade fishery importance now because of discontinuance of young eel release in the lagoon. Natural replenishment is insufficient for eel stock support. European Fishery Committee (EC) being worried of crucial decrease of eel stock accepted a decision of putting into operation "Polish Eel Management Plan" (2005/0201 (CNS). Realization of the above mentioned plan can possibly solve the problem of eel stock decrease. Shad relates to the group of rear and practically disappeared species in the Vistula lagoon. Shad catches in the first part of the twentieth century amounted hundreds of tons, but it disappeared in the fiftieth years. Luckily at the end of the ninetieth this species restored its stock in the Curonian lagoon. Now it comes for spawning in mass quantities in the Curronian lagoon and the Neman River (Gushchin, Tverdokhleb, 2009), but in the Vistula lagoon shad is still met only in singles. This fact confirms the suggestion that only shad population from the Neman River is preserved now. Stock restoration in the Curronian lagoon was the reason for withdrawal of shad from the Red Book of the Russian Federation.

Fish from the next group are met everywhere, but they don't form fishery congestions. These are bleak - *Alburnus alburnus* (Linnaeus, 1758), owsianka - *Leucaspius delineatus* (Heckel, 1843), burnstickle - *Gasterosteus aculeatus* Linnaeus, 1758 and needle-mackerol - *Gasterosteus pungitius* (Linnaeus, 1758), bullhead - *Neogobius melanostomus* (Pallas, 1814). The stock of these fish is undetermined, but they form the background of ichthyocene and present important food resource for predator fish. Carp family is represented with the biggest number of species in the lagoon. Bream, roach and ziege are the species of important fishery significance. Asp - *Aspius aspius* (Linnaeus, 1758) and breamflat - *Blicca bjoerkna* (Linnaeus, 1758) are the secondary objects of fishery. Important fishery significance belongs to sander and perch - *Perca fluviatilis* Linnaeus, 1758. Pope - *Gymnocephalus cernua* (Linnaeus, 1758) doesn't possess industrial fishery significance, but this species is very important for ichthyofauna as it is food object for sander (Khlopnikov, 1992; 1994). Burbot - *Lota lota* (Linnaeus, 1758), pike - *Esox lucius* Linnaeus, 1758 and flounder - *Platichthys flesus* (Linnaeus, 1758) are met in small quantities in the lagoon. These are mainly the young that enter the lagoon in spring and consume Baltic herring eggs. Untypical for the Vistula lagoon fish species started to appear in ichthyofauna in the last years. About 200 items of Siberian sturgeon young (*Acipenser baerii* Brandt) were caught at two catches in water area of the Baltic spit (Vistula spit) in 2011 and such discoveries become rather ordinary in the water basin of the Southern Baltic (Skóra, 2012).

Ichthyofauna of the Vistula lagoon possesses marked anthropogenic character. It is an outcome of utilization the measures for fishery regulations determined by the National Rules for Fishery of Russia and Poland starting from the fiftieth years of the twentieth century.

2.2. Spawning grounds and migrating routes of fish in the Vistula lagoon

The Vistula lagoon in its northern and central parts is the zone of migrating convergence of fish from different ecological groups.

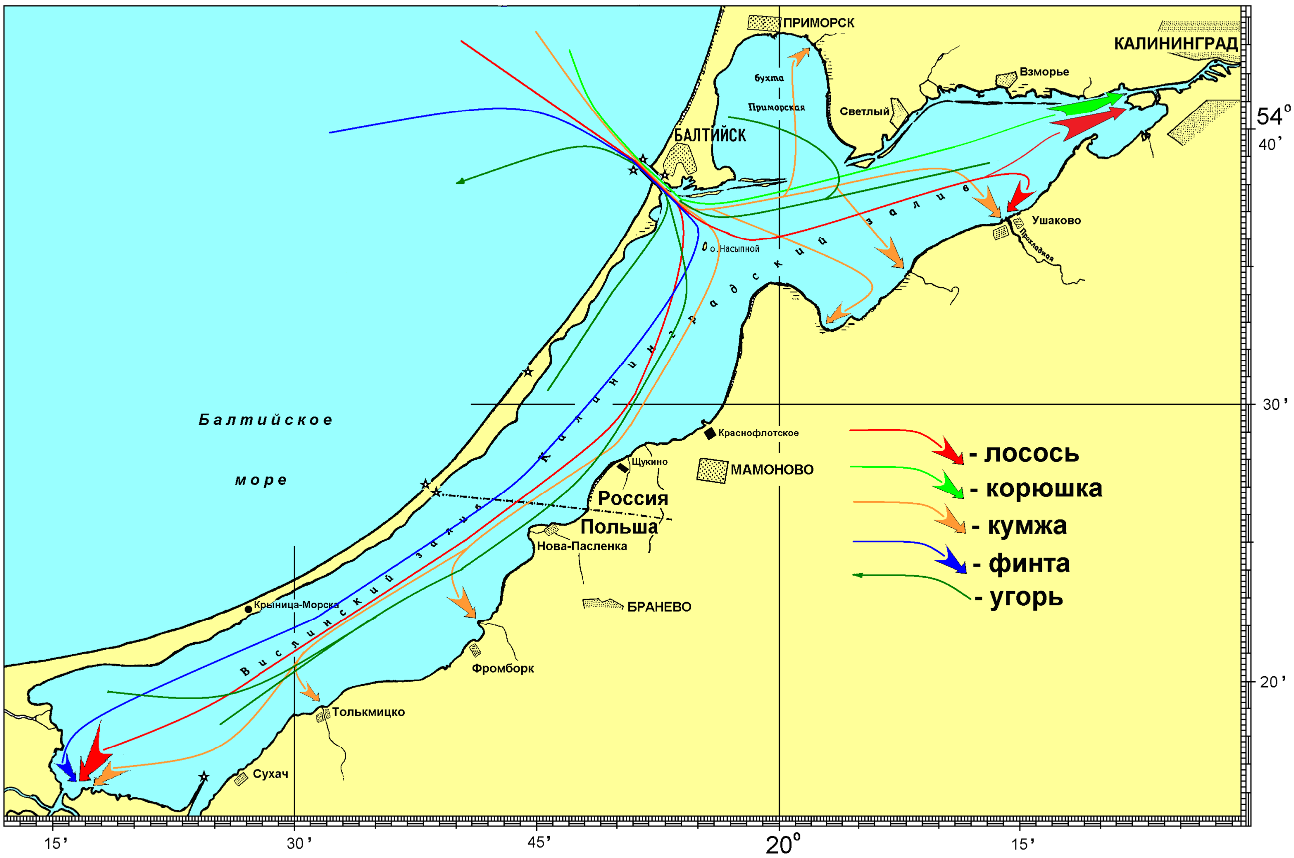
Anadromous species: lampern, Atlantic salmon, brook trout, European smelt, shad, Baltic sturgeon and single catadromous species - European eel pass this place through migration routs. Salmon and brook trout perform spawning migration in autumn, in October-November. Spring migrations are not distinct in the southern Baltic.

Salmon approaches rather high up into the big rivers, and brook trout prefers the small rivers (Bartel and others, 2008; Bartel et al., 2005). Salmon approaches into the River Pregel were observed starting from 2000 year. The intensity of such approaches is not great, but the increased number of salmon approaches can be expected as the result of ecological situation improvement and restoration of spawning grounds in its upper water.

The spawning ground for brook trout is the small river flowing into the lagoon in Primorskoe-Novoe on the semi-island Balga. Brook trout approaches the Prokhladnanya River regularly and the Nelma River episodically.

The approaches of European smelt into the Pregel River and even its passage up to Chernyakhovsk city were marked last years as a result of improvement of ecological situation. Lampern approaches the small rivers of the lagoon in spring and autumn.

Semi-migrating fish spawn directly in the lagoon, and Baltic herring, the most important species for fishery in the Kaliningrad lagoon, is on the first place among them. Sand-pebbles grounds serve as spawning substrate for Baltic herring. Baltic herring spawning grounds are located on the whole water area of the Vistula lagoon. Vast spawning ground of Baltic herring is around the semi-island Balga on the abrasive outcropping of moraine debris. According to fishermen reports, the thickness of the layer of Baltic herring eggs reaches 3-5 cm on the bottom in this place.



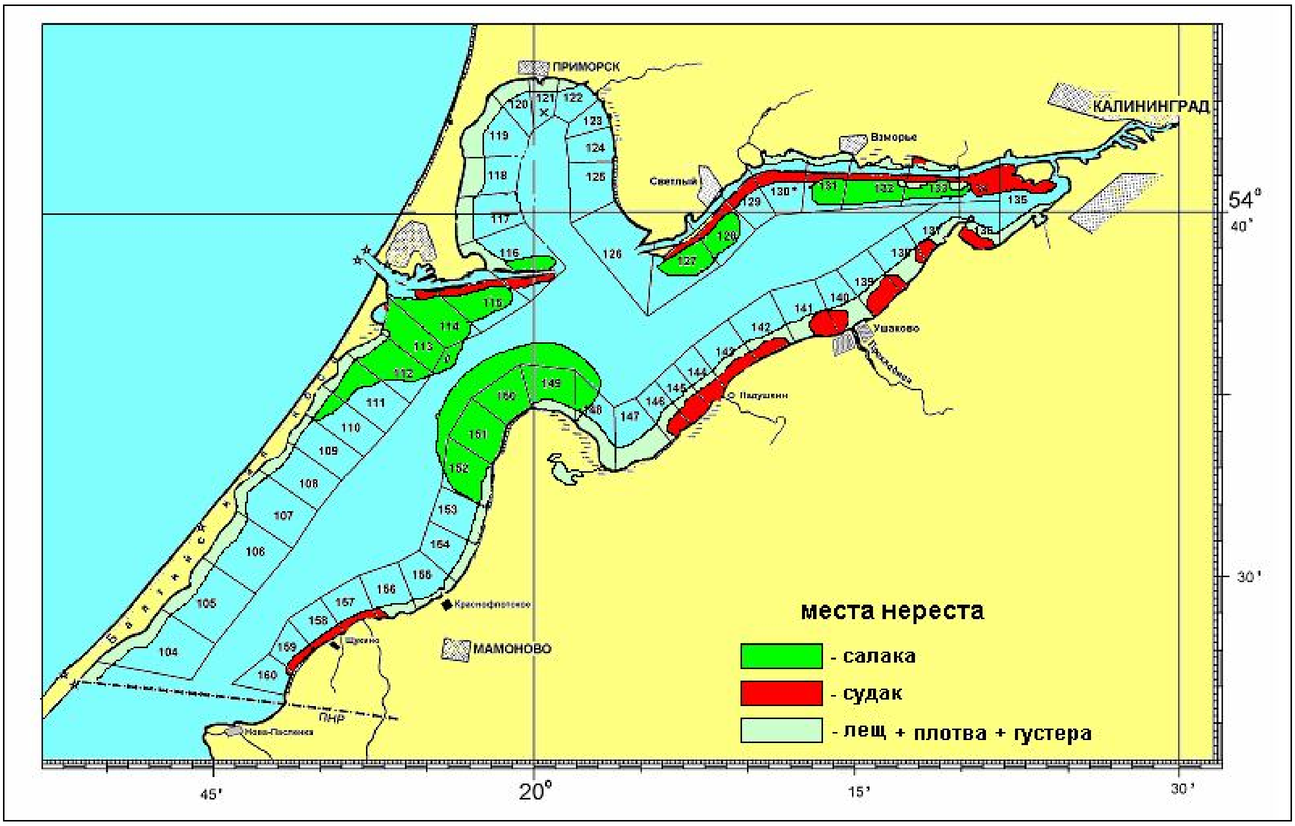
Routs of migrating species –salmon, European smelt, brook trout, shad and eel - in the Vistula lagoon.

Locations of spawning grounds for other fishery species (and sander too) are restricted to coastal zone. Some fish inhabiting the lagoon –tench, pike, red-eye, Crucian carp, German carp, roach and perch spawns not only in the coastal part of the lagoon, but approaches the Pregel River, the small rivers flowing into the lagoon and the canals of the polder system.

In summer period, when water salinity decreases, sander, big bream, perch and roach enter coastal water of the Baltic Sea for nourishing. These species are typical for net catches in coastal zone from the city Baltiysk to the cape Taran. Number of fresh water species decreases north-eastward of the cape Taran, sander and big bream are met in singles here.

Flounder young enter the Vistula lagoon at spawning migration of Baltic herring and nourish on spawned Baltic herring eggs. After the end of Baltic herring spawning flounder young stay for some time in the lagoon, but then approach the sea by the autumn.

Some fish species inhabiting the lagoon like tench, pike, red-eye, Crucian carp, German carp, roach and perch spawns not only in the coastal part of the lagoon, but approaches the Pregel River, the small rivers flowing into the lagoon and the canals of the polder system.



Spawning grounds of main fishery species from the Kaliningrad lagoon

Migrational characteristic of the Vistula lagoon fish.

Species	Migration type	Time	End place of migration	Notes
Interzonal, anadromous and catadromous migrations				
Atlantic salmon	Spawning, sea - river	November - December	Upper stream of the Pregel River	Makes nests, strews the eggs with sand and gravel
Brook trout	Spawning, sea - river	October-December	The Pregel River and the small rivers flowing into its middle stream, the rivers Nelma, Prokhladnaya	Spawning on the sand-pebble ground
Sturgeon*	Spawning, sea - river	June-July	Region of the city Chernyakhovsk, the Angrapa River	Spawning on the stone-pebble ground
European smelt	Spawning sea - river	March-April	Middle stream of the Pregel River	Spawning on the sand-stone-pebble ground
Eel	Spawning, river-sea - ocean	April-November	The Atlantic Ocean, the Sargasso sea	
Shad**	Spawning sea - river	June-July	Middle stream of the Pregel River	Pelagic spawning, the eggs and later larvae are brought by the stream

Local migrations of the types: river-lagoon, lagoon –river, lagoon-sea				
Pike	Spawning	March-April	Low and middle streams of the rivers	Spawning on the riversides, water-meadows and the water weed
Bream	Spawning, lagoon-river	May-June	Low streams of the rivers, water weeds areas of the lagoon	Spawning on the riversides, sometimes on the water-meadows and the water weed
	Nourishing	July-August	Lagoon, sea coastal area	Back approach into the rivers in October, the main part of fish stays in the lagoon
Breamflat	Spawning	May-June	Low streams of the rivers, water weeds areas of the lagoon	Spawning on the riversides, sometimes on the water-meadows and the water weed
	Nourishing	July-August	Lagoon	Back approach in the rivers in October-November, a part of fish stays in the lagoon
Roach	Spawning	April-May	Low streams of the rivers, water weeds areas of the lagoon	Spawning on the water weeds
	Nourishing	July-August	Lagoon, coastal sea area	Back approach into the rivers in September, a part of fish stays in the lagoon
Asp	Spawning	Апрель-май	Low and middle streams of the rivers	Stone ground, quick current
	Nourishing	June-July	Lagoon	Back approach into the rivers in November
Ziege	Spawning	Апрель-май	Low and middle streams of the rivers	The weeds on the water meadows
	Nourishing	June-August	Lagoon	Back approach into the rivers in September
Burbot	Spawning	December-March	Low streams, lagoon	Stone-pebble ground, seldom clay ground
Sander	Nourishing	June-September	Lagoon, sea coastal area	Back river approach in September-November
Perch	Nourishing	June-September	Lagoon, sea coastal area	Back approach into the rivers in September-November

3. Condition of fishery

Fishery in the Russian part of the Vistula lagoon is regulated with “Fishery Rules for western fishing industry basin” according to Federal Law No 166-FL “Fishery and water biological resources restoration” from 20.12.2004. Fish resources of the Vistula lagoon are of trans-border origin, so fishery rules that serve as the measures for trade fishery regulation are coordinated between Russia and Poland. National Fishery Rules distinguish an order and the places for fishery, the weapons, their characteristics and quantity, fishery terms and other aspects of industrial and recreational fishery. Catch volume for the users is allocated based on the national quotas for catch distinguished by Russian-Poland mixed committee for fishery industry.

3.1. Industrial fishery.

Despite diversity of lagoon ichthyofauna, six species – Baltic herring, bream, sander, roach, perch and shad are the main fishing objects of the lagoon. Another six species – burbot, pike, asp, breamflat, flounder and pope are of secondary industrial importance.

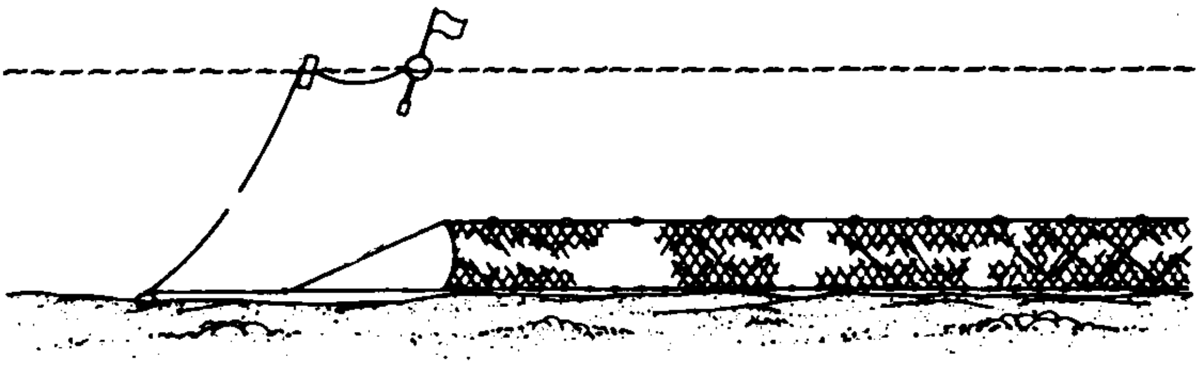
Catches in the Russian zone of the Vistula lagoon (t/year) in 2007-2012

Species	2007	2008	2009	2010	2011	2012
Baltic herring	1997,49	1932,56	1991,53	1997,45	1998,58	1969,91
Bream	242,80	198,43	270,40	273,39	282,25	272,19
Sander	124,92	119,47	143,74	135,00	143,21	133,83
European eel	35,83	15,40	9,06	15,48	7,90	4,84
Roach	72,01	55,87	66,41	72,83	80,83	74,06
Perch	10,07	9,16	23,81	30,57	42,68	31,55
Ziege	74,15	65,69	67,04	68,16	71,82	64,47
Lampern	0,13	0,07	-	-	-	-
Breamflat	0,57	-	4,87	-	-	-
Asp	0,10	-	0,28	-	-	-
Pope	-	-	0,01	-	-	-
Burbot	1,00	-	0,33	0,33	0,87	0,19
Pike	0,72	-	0,26	0,17	0,72	0,17
Others	3,08	2,17	-	11,09	6,95	21,87
Users	38	41	36	36	35	36

Baltic herring predominate in the industry in catch volume which is about 2000 t in the Russian part of the lagoon for the last years, than follow bream and sander. We should mark the decrease in the catches of pike and burbot.

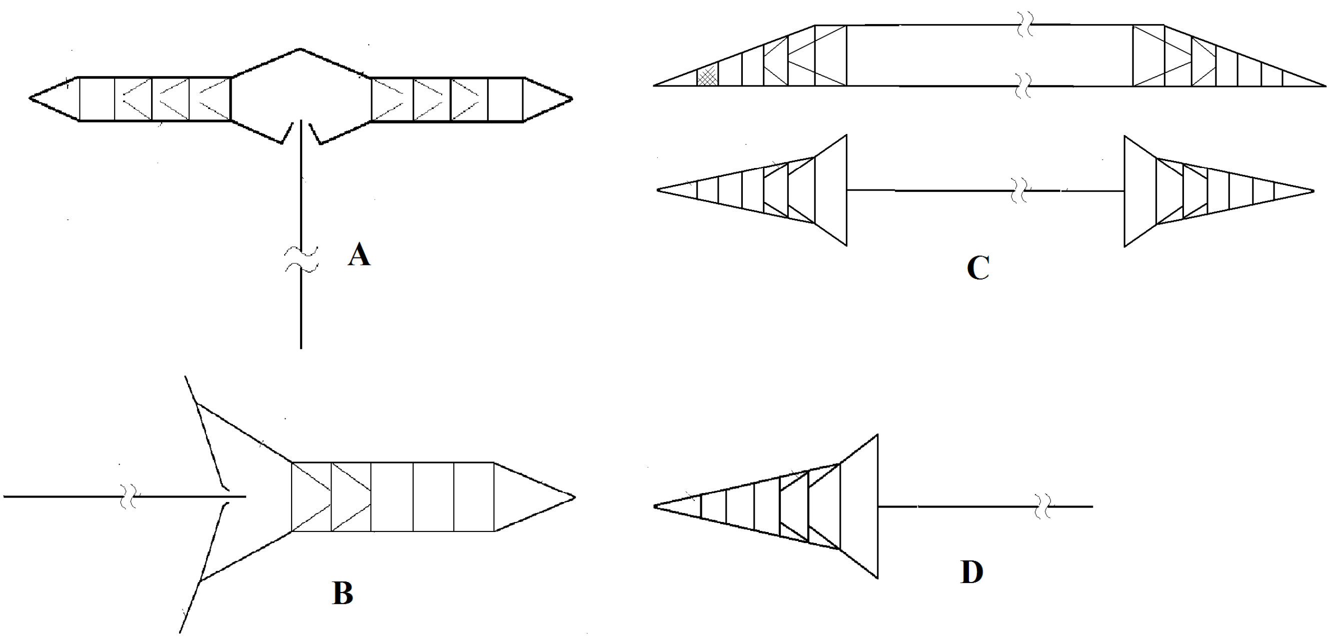
Fishing gears used for fishery in the Russian part of the Vistula lagoon:

- The nets with minimal mesh size of 70 mm are used for big species fishing such as bream and sander. Net length is from 18 to 22 m and height from 2,5 to 3,0 m. Standard fleet consists of 8-10 nets.
- The nets with minimal mesh size of 40 (36) mm are used for fishing of small fish species such as roach, ziege, perch. Net length is from 18 to 22 m and height from 2,0 to 2,5 m. The fleet of 10 nets is used for this type of the nets.



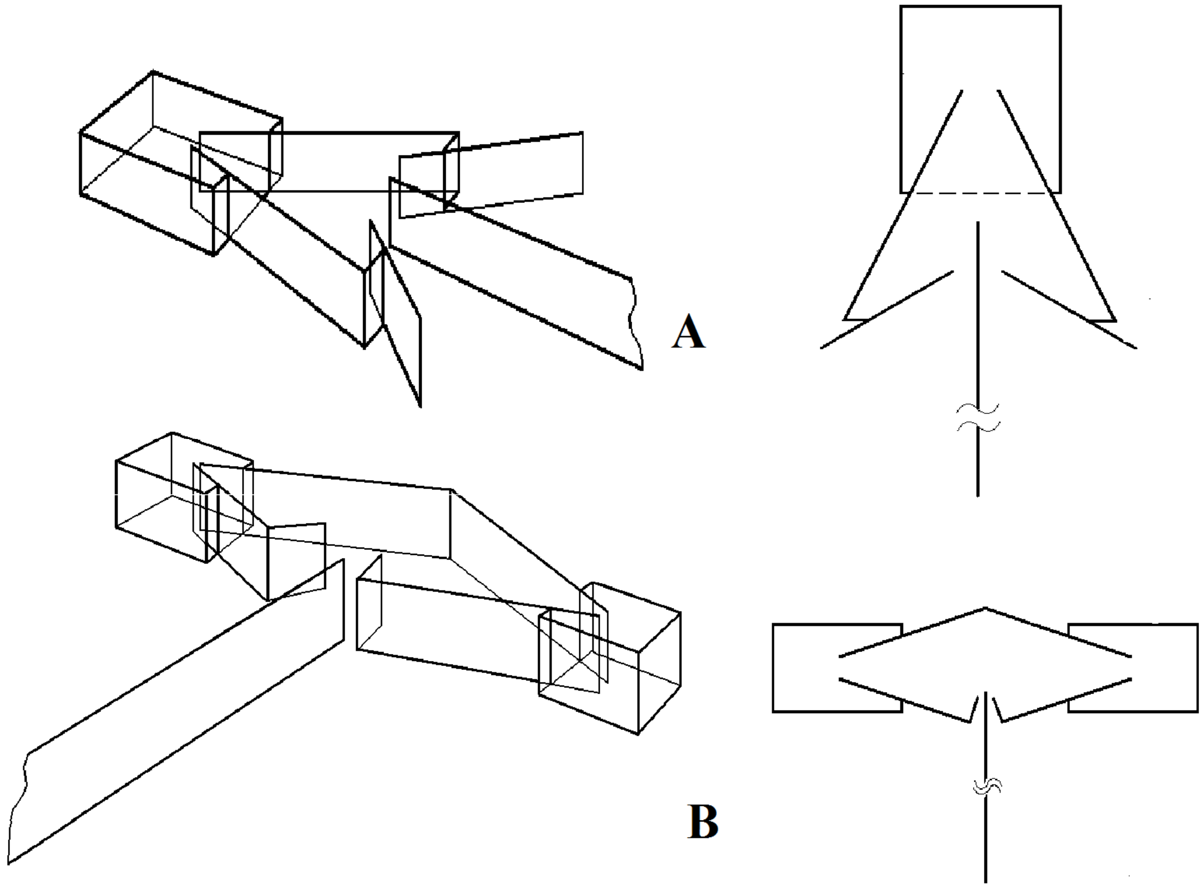
Gill net for bream and sander catch with mesh size of 70 mm and 40 (36) mm mesh size for roach, ziege, perch.

- Eel traps and eel fyke nets are used for eel fishing. Fishery rules permits minimal mesh size of 14 mm for eel traps and eel fyke nets. Maximal length of the fleet traps is 120 m. Four modifications of the traps are used: two bags fyke net trap with 14 mm mesh; two bags fyke net trap with 16 mm mesh; two bags fyke net with 14 mm mesh; two bags fyke net with 16 mm mesh.



Eel fyke nets; A - two bags fyke net; B – one bag fyke net. Eel traps: C – two bags trap; D – one bag trap.

- Stationary uncovered pound nets are used for Baltic herring fishing. Stationary uncovered pound nets used in the lagoon are of two designs: one chamber net and two chambers net. Minimal mesh size for the nets permitted by Fishery Rules is 12 mm. Maximal allowed wing length is 200 m.



Stationary uncovered pound net: A - one chamber net; B - two chambers net.

3.2. Sport and recreational fishery

In Kaliningrad region there are at least 50-60 thousands amateur fishermen, they spend 800 thousand days for fishery at average yearly. Their catch is at least 250 t per year, but the figures of 500-800 t per year are more realistic considering two lagoons (Gushchin et al., 2010). Our Lithuanian colleagues determined amateur fishermen catch as 742 t per year only for the Curonian lagoon (Domarkas et al., 2008). From expert point of view the volume of amateur fishery in the Russian part of the Vistula lagoon may amount to 120-400 t and thus can be compared with the industrial withdrawal of fish.

Stationary uncovered pound net catch

3.3. Poaching

Level of poaching in the lagoon is high regardless of the active actions of the regional authorities. Thus, 7 t of caught fish, 4692 fishing gears, 192 transport means were confiscated from the poachers in 2012 with the inspectors of West Baltic territorial administration of Federal Agency for Fishery (WBTA, 2013).

Comparison of registered legal landing with declared fish export at the Customs may serve another indicator of illegal fish withdrawal. Kaliningrad TV Company “Kaskad” made public the following data: legal registered catch of bream was 1148 t in 2005, declared export of bream at the Customs was 2061 t; legal registered catch of sander was 319 t, declared export of sander was 3033 t. Note, the volume of catch consumed by the local market was not considered in these figures. In 2006 joined actions of Kaliningrad regional administration and the Customs allowed to decrease the difference between legal catch and declared export of bream up to 406 t and sander up to 380 t (Gushchin et al., 2010). Positive dynamic of poaching decrease can be seen, but great chance still exists that new ways were created of poached catches concealment and sell. Thus, we may consider that even at the most positive estimation poached fish catch is at the level of amateur fishermen catch.

3.4. General expert estimation of fish withdrawal in the Vistula lagoon with all types of fishery.

General fish withdrawal in the Russian part of the Vistula lagoon in 2012 with all types of fishery may form 2813 – 3373 t/year.

Fish catch in the Russian part of the Vistula lagoon with all types of fishery.

Type of fishery	Official catch t/year	Minimal catch according to expert estimation, t/year	Maximal catch according to expert estimation, t/year
Industrial	**2573**	2573	2573
Sporting	-	120	400
Illegal	-	120	400
Total with all types of fishery		**2813**	**3373**

4. Other factors that influence the fishery.

4.1. Birds – ichthyophagans

In the water basin of the north-eastern part of the Vistula lagoon is marked 73 bird species (Anonim, 2013). The most part of these species occur in the area of the lagoon at spring and autumn migrations (Grishanov, Belyakov, 2000) and their pressure to ichthyofauna is minimal.

Piscivorous fish

Certain influence for ichthyofauna of the lagoon exercise ichthyophagous birds: cormorants - *Phalacrocorax carbo*, herons - *Ardea cinerea*, black-headed gull - *Larus ridibundus*, herring gull - *Larus argentatus*, sea gull - *Larus marinus,* goosander- *Mergus merganser,* great bittern - *Botaurus stellaris*, sea hawk - *Pandion haliaetus*; white-tailed sea eagle - *Haliaeetus albicilla*.

The great cormorant exercises the most coercion for fish, the size of this species population increased considerably during last twenty years. The great cormorant appeared in the water basin of the lagoon at beginning of the 80-th years (Grishanov, Belyakov, 2000). Great cormorant colonies exist on the Vistula spit, another big colony of the cormorants is on the eastern end of the dam No 2 off the Strait and Primorskaya bay (Anonin, 2013). Progressive size of great cormorant population is evident by the data of Katy-Rybacki sanctuary where there were 4000 birds in 1987 and about 24000 birds in 2006 (Beletskaya and others, 2013). Each cormorant consumes 0,3-0,4 kg of fish a day (Gladkov,1970), thus for eight months of living in the are of the lagoon from March till November each bird eats up about 72-96 kg of fish and the whole great cormorant population of Katy-Rybacki consumes about 1728 -2304 t. These figures should be increased significantly taking into consideration that this amount of fish is consumed only by the single colony from several known and the fact that great cormorant size is not studied yet in the nodifications in the Russian area of the lagoon.

Other birds, except gulls, are not numerous, and they don't exercise considerable coercion for fish population.

Transference of the different parasites and fish decease agents with the birds is another important factor influencing the size and fish species composition of the lagoon. The birds transfer diphyllobotriosis, dilepidosis, ligulesis, ichthyophtiriosis, branchiomicosis, branchionecrosis and other deceases, a part of them is dangerous for people.

4.2. Parasitic fauna and the deceases of fish from the Vistula lagoon

Parasitic fauna of fish from the Vistula lagoon consists of more than 100 organisms. According to Zaostrovtzeva S.K. (Zaostrovtzeva, 2007) the most number of the parasites were discovered in bream, roach, red-eye, perch, pike and eel. Other fish species were infected with less number of parasite species. Carp fish were infected mainly with microsporidiums from the genus of Myxobolus (*M.bramae, M.dispar, M.muelleri and M.pseudodispar*) at single invasion. Four species of parasitic infusoria - *Chilodonella piscicola, Ichthyophthirius multifiliis, Trichodina jadranica* and *Paratrichodina incisa* were discovered in the Vistula lagoon. They locate on the gills and the skin of carp, breamflat, perch, roach, bream, sander and flounder. Parasitic monogenea of the Vistula lagoon fish are represented with four species from the genus of *Dactylogyrus*, three species from the genus *Paradiplozoon*, two species from the genus *Diplozoon* and with single species from the genera

Gyrodactylus, Tetraonchus and *Ancyrocephalus*. All discovered species are of freshwater origin. Carp fish are infected with monogenea most of all. *D.paradoxum* was discovered in perch and eel. Sander and pike were infected with *Ancyrocephalus paradoxus* and *Tetraonchus monenteron* that are specific for these species. Class Cestoda was represented with four species from family *Caryophyllaeidae*, two species from family *Proteocephalidae* and with single species from families *Triaenophoridae*, *Amphicotylidae* and *Ligulidae*. Freshwater species prevail and only one species - *Eubotrium rugosum* represents sea fauna. All four species *Caryophyllaeidae* were found in the fish from the south-eastern part of the lagoon. They parasite in the intestines of the end host – carp fish, oligochetes are the intermidiate hosts. Other cestodes use Copepoda as the first intermidiate hosts. Thrematodes fauna is represented with four species - *Azygia lucii, Bunodera luciopercae, Allocreadium isoporum* and *Nicolla skrjabini*, and fish is their end host. Seven species from family Diplostomidae (genera *Diplostomum, Tylodelphys*) and single species - *Ichthyocotylurus variegatus* (family *Strigeidae*) occur at the stage of metacerkaria in fish in the whole water area of the lagoon. Thrematodes of genera *Diplostomum, Posthodiplostomum, Tylodelphys* develop through the moluscs of familiy *Lymneidea*. Carp and predator fish are infected with these parasites approximately in equal state. The peculiarity of thrematodes fauna in the lagoon fish is the considerable number of the species from genus *Diplostomum*. Nematodes are represented with four sea species - *Anguillicola crassum, Cucullanellus minutus, Cucullanus cirratus* and *Hysterothylacium aduncum,* the rest are freshwater species. Zooplankton is the intermediate host for these species. Thorny-headed worms fauna consists of six species. Four species are of freshwater origin - *Metechinorhynchus salmonis, Acanthocephalus anguillae, A.lucii* and *Pomphorhynchus laevis*, and two sea water species - *Acanthocephalus clavula* and *Pseudoechinorhynchus borealis*. Parastic crustaceous fauna consists of four species. *Ergasilus gibbus* and *Lernaeocera branchialis* are sea species, and *Ergasilus sieboldi* and *Achtheres percarum* are freshwater species. *Achtheres percarum* was found in its specific host - sander. Conducted investigations of parasitic fauna of the Vistula lagoon fish showed the mixture of freshwater (86,4%) and seawater (13,6 %) parasite species.

In the opinion of several authors: Avdeeva E.V., Evdokimova E.B., Zaostrovtzeva S.K. (Avdeeva et al., 2012), based on long observations of parasitic fauna formation in the Vistula lagoon fish, the increased processes of euthrophication contribute considerably to the development of helminthous epizooties.

4.3. Toxic influence of blue-green alga

Intensive blue-green algal bloom in summer causes mortality of significant number of fish every year. High euthrophication, thermal water increase in summer period, absence of vertical ventilation during windless period facilitate blue-green algal bloom.

Special extreme situation occurs when steady wind arises after the outburst of bloom and carries algal mass into the certain part of the lagoon. Thus in 2011 and 2012 years the wind carried alga in the north-eastern part of the lagoon and algal field occupied water area from the exit of the Baltic Canal and the semi-island Balga up to the mouth of the Pregel River. Algal layer thickness was 2-3 cm on the water surface at that period.

Plankton sampling at the period of blue-green algal bloom

Main mass of blue-green alga at algal bloom is formed with potential toxic species from genera *Aphanizomenon, Anabaena, Microcystis, Planktothrix, Woronichinia* and *Nodular*. Such blooms became regular from the early 90-th in 20 century. Mass mortality of piscivorous birds, cormorants and seagulls, and bottom invertebrates were often marked in hot windless summer days at algal bloom. Sometimes mass fish mortality was marked in cool spring period with sufficient content of dissolved oxygen in water. Death of piscivorous birds occurred after dead fish consumption. The cases of behavior that are typical for intoxication with blue-algal neurotoxins were observed with piscivorous birds. The cases of mass paralysis were marked of *Chironmomus plumosus* larva, and the paralysis of some specimen disappeared after placing the larva in clean water. All these observations allowed us to suggest that in many cases mass mortality of the organisms was caused not with the deficit of dissolved oxygen at mass algal bloom, but the mortality was caused under the action of toxic metabolites of phytoplankton that are excreted alive or after cells death at bloom peak. The conducted investigations for phytotoxins presence in water showed that total content of microcystines after phytoplankton cells lysis was 5-10mkg/l during the whole period of observations, in some cases the concentration was height up to 20mkg/l. According to classification of World Health Organization these are medium and serious threats for health (Ezhova et al., 2012).

The situation with phytotoxins influence for ichthyofauna of the Vistula lagoon is close to the situation in the Curonian lagoon where in the years of algal hyperbloom maximal biomass of potential toxic species reached 120–1069 g/m^3 and was higher than the level of biological contamination of the basin (Belykh et al., 2013).

5. Measures for preservation and protection of the Vistula lagoon ichthyofauna.

Preservation and protection of the Vistula lagoon ichthyofauna are ensured on two levels. The first level is stated in the legislation of the Russian Federation.

Federal Law issued 20 of December 2004 “Fishery and Preservation of water biological resources” No166- FL is the direct law for fishery regulation and determination of preserving measures for fish protection in water area of the Russian Federation. The next laws render indirect management for fish resources:

- Federal law “Protection of the environment” issued 22.08.2004, No 122-Fl;
- Federal law “Water Code of the Russian Federation” issued 16.11.1995, No 167-FL;
- Federal law “ About Wild Life” issued 24.4.1995, No 52-FL

Apart from the above mentioned Federal Laws the Russian Federation ratified a number of international conventions defining preservation and protection of fish.

- Convention for protection and utilization of trans-border water and international lakes. Helsinky, 17. 03.1992.
- Convention for biological biodiversity, 05.06.1992.

Convention for international trade of wild fauna and flora species under threat of disappearance (CITES), 01.07.1975.

Preservation and protection of fish at the second level is decided with the resolutions of the government of the Russian Federation and a number of law acts. “Fishery Rules for West Fishing Water Basin” is the main document according to the order No 393 of Federal Agency for Fishery from 10.12.2008, Moscow.

West Baltic territorial administration of Federal agency for fishery (WBTA), State Sea Inspection of Borders Administration of FSS RF in Kaliningrad region and police control the fulfillment of the Fishery Rules. State Inspection for small vessels takes the indirect part in control measures.

"Fishery Rules for West Fishing Water Basin" are divided into two parts: "Fishery Rules for industrial fishery" and "Fishery Rules for recreational and sport fishery".

"Fishery Rules for industrial fishery" in its general part prohibits:

- conduct the catch of acclimatized species of water bio-resources. All the above mentioned objects, caught with the fishing gears, shall be immediately released in the natural habitat and their catch shall be registered in the fishing log (P.p.13.12);

- gill nets immersion time more than 48 hours in spring-summer period and 72 hours in autumn-winter period from the time of their full installation, fixed in the log, to the moment of sorting or withdrawal on board of a vessel or ashore(P.p.13.13);

- catch of vimba and whitefish species with all fishing gears and in all places during the whole year (P.P.14.2);

- by-catch of the species not mentioned in the permit should not exceed 49% of catch mass (P.p.14.6.2).

"Fishery Rules for industrial fishery" in its special part prohibits in the Vistula lagoon:

- conduct fishery of all water bio-resources species during the whole year in the water area from the cape "Chayachiy" (54º 35' 36 N., 19º 51' 06 W.) to the dam No 1 of Kaliningrad sea canal (54 º 37' 59 N., 19 º 57'W.) (P.p.16.1);

- conduct fishery, except of eel and Baltic herring, in the period from 20 of April to 20 of June with all fishing gears in the water area of 2 km from the shore except the stationary uncovered pound nets and the traps and from 20 of April to 20 of August conduct fishery with the beach and Danish seines with the mesh size of 70 mm and more (P.p.16.2);

- conduct fishery using the trawls, the otter twin trawls and other trawling gears; the seine nets; the hook-and-line gears with the worms and other invertebrates as the bites; the beach seines with the length more than 500m; the fleet of the traps with the length more than 120 m and with the intervals between the fleets not less than 100 m in all directions; the gill nets with the length of 200m and with the distance of 150 m in the line and with the distance not less 200m between the lines, total length of gill nets should not exceed 1000m (P.p.16.4);

- conduct fishery using the stationary uncovered pound nets, the beach nets, the traps with the mesh size less than 30 mm for sander and bream; 20 mm for roach, perch, ziege; 5 mm for European smelt, smelt, pope, needle-mackerol, bleak, lampern ; 12 mm for Baltic herring ; 14 mm for eel; using the stationary uncovered pound nets with the mesh size less than 70 mm for sander and bream; 36 mm for roach, bream and ziege; 16mm for European smelt and bleak (p.p.16.5.2.);

- conduct catch, landing, processing of water bio-resources with the live length not less industrial fishery length (total length), except permitted by-catch, 45 cm for eel, 46 cm for sander, 35 cm for bream, 50 cm for pike, burbot, asp and roach, 18 cm for perch, 32 cm for ziege, 75 cm for sheat-fish, 28 cm for vimba, 36 cm for white-fish, 15 cm for Baltic herring (P.p.16.6.1);

- by-catch of fish of nonindustrial size is permitted not more than 10% of the catch. The by-catch of fish of nonindustrial size is permitted not more than 5% of catch mass at Baltic herring fishing (P.p.16.6.2, 16.6.3);

- catch brook-trout, Atlantic sturgeon (P.p.17.3).

“Fishery Rules for recreational and sport fishery” in its special part prohibit in Kaliningrad region:

- conduct fishing at the distance of 0,3 km and less from the stationary fishing gears (or the fish-ponds for fish breeding) in the Vistula (Kaliningrad) lagoons and at the distance of 0,1 km and less in the rivers of Kaliningrad region and from the vessels in the dark time (P.p.26.1);

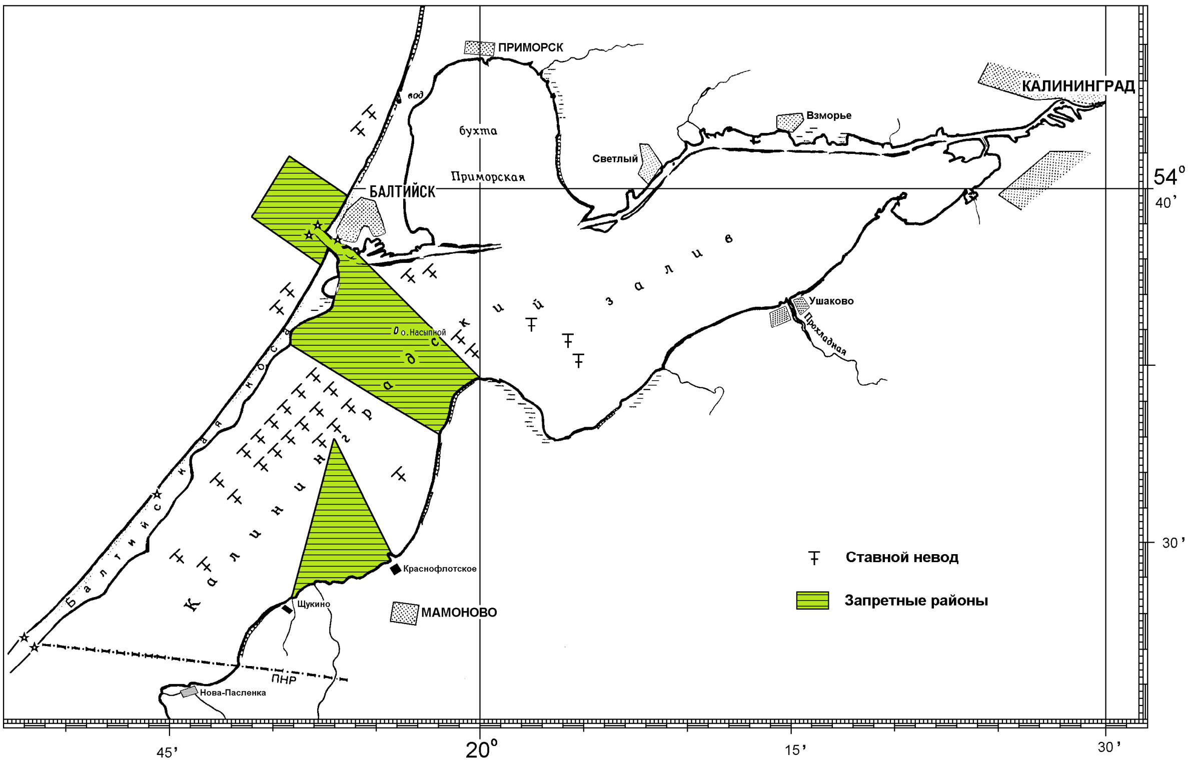
- conduct fishing (except the fishing grounds for recreational and sport fishery) at the period from 20 of April to 20 of June (the period for spring fish spawning protection) in the coastal zone of the Kaliningrad lagoon at the distance of 0,5 km from the weeds, in case of weeds absence at the distance of 1 km from the shore; in the Kaliningrad lagoon to the west of the line connecting the cape Tupoy (the village Rybachy) and the village Vzmorye; from the artificial islands in Kaliningrad sea canal; from the vessels off Kaliningrad to ship repairing plant in the town Svetliy; in the Nelma River to 9 km up the stream; in the Prokhladnaya River with its tributories and the canals; to conduct underwater hunting in the period from 20 of April to 20 of June (P.p.26.2.2.);

- conduct fishing of Atlantic salmon in the Vistula lagoon and its tributories (P.p.26.30);

- usage of any entangling or enmeshing fishing gears except lift nets with the dimensions not more than 100x100cm and mesh size not more 10mm; harpoons; traps; electric current; fire and pneumatic weapons (except underwater guns); seines; any hooked gears with total number of the hooks more than 10 for a person; double hooks and multiplied hooks are considered as a single hook; to conduct the catch with the gaff, with the light from the vessels, with the fences and the weirs that close partly or totally river-beds and prevent free fish shift; trawling with usage of more than two bites (P.p.26.4).

- catch of fish with total length less than 45 cm for eel, 46 cm for sander, 35 cm for bream,50 cm for pike, burbot and asp, 75 cm for sheat-fish (P.p.26.5).

Except the above mentioned items of the “Fishery Rules “ the governmental bodies of RF and the main users of water bio-resources each year determine the positions of stationary uncovered pound nets for Baltic herring fishing. The number of stationary uncovered pound nets depends on quota for each user. Stationary uncovered pound nets positions are appointed to ensure unimpeded migration of the Baltic herring to the spawning grounds.



Exemplary scheme of stationary uncovered pound nets positions for spring fishery of Baltic herring. Prohibited water areas are marked green.

6. Perspectives for fishery development in the Vistula lagoon.

One of the easiest methods to consider the state of water basin ichthyofauna is to monitor the dynamic of fishery catches. It shows best of all the trend of ichthyofauna development as the basis of water basin resource. This tendency can be seen if we monitor many year changes of water basin value as the result of anthropogenious influence for ichthyocene (Gushchin, Fedorov, 2013).

The coefficient of fishing value was given to the main fish of the Vistula lagoon that reflects their commercial attraction. The coefficients are the next: sander – 4, bream – 3, eel – 5, roach – 2, Baltic herring – 2, ziege – 2.

Fishing value calculation of the basin was made according to the following formula:

$$F_i = \sum(W_a \cdot k_a + W_b \cdot k_b + W_c \cdot k_c + \ldots + W_n \cdot k_n) \quad (1)$$

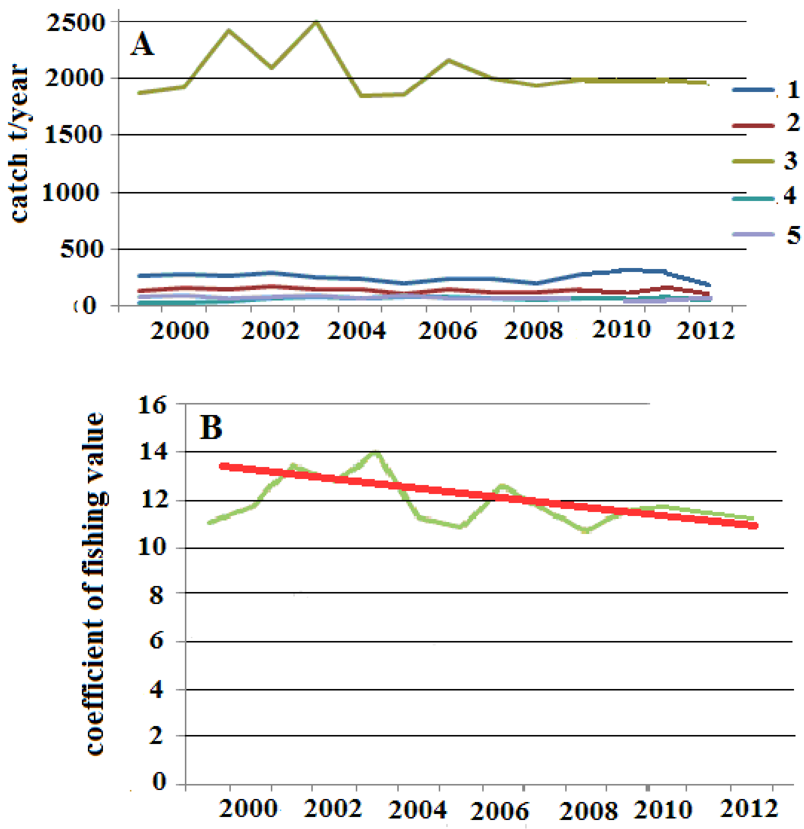
Where: F_i - Fishing value of the basin in i -year;

W_a - type of catch– a, in i -year;

k_a - coefficient of fishing value of the species – a;

W_n – species catch – n, in i -year;

K_n - coefficient of fishing value of the species – n;



Industrial catch in the Russian zone of the Vistula lagoon t/year (A): 1 – bream; 2 – sander; 3 – Baltic herring; 4 – roach; 5- ziege and changes of fishery value of the water area (B). Trend direction is marked red.

Modern fishery state in the Russian zone of the Vistula lagoon is sufficiently stable last decade, but fishery results are determined only with single species – Baltic herring, and Baltic herring stock is at constant low level. Coefficient of fishing value reflects the tendency for small decrease in fishery value of the Russian part of the Vistula lagoon.

As it was mentioned above, fishing industry in the Vistula lagoon extracts only part of fish stock in the lagoon. The volumes of other types of fishery – recreational, sport, illegal (poaching) –are not taken by the statistic of the catches. It is obvious that the correlation of legal, recreational and illegal catches preserves its proportion for rather long time and that correlation reflects on the stability of the stock. But last years the trend for decrease in fishery value of the lagoon shows that present stability is rather comparative and it is necessary to undertake some regulating measures to preserve fishery stability in the Vistula lagoon. The first measure is to decrease the illegal catch and the released resource to turn over for the legal users. The other measure is to increase the control for recreational fishing, but this measure may cause social aftereffects.

Another very important factor that defines the tendency for fishery development in the Russian part of the Vistula lagoon is water euthrophication and blue-green algal bloom. The level of euthrophication (phosphorus and nitrogen content) is very important factor to determine fish species that can inhabit this or that water basin. The level of euthrophication in the Curonian and the Vistula lagoons increased from 0,017- 0,060 (Urevich, 1956) to 0,045- 0,750 (Alexandrov, 2010) in the last 50 years. Water acquired greenish colour because of alga reproduction, bottom vegetation decreased considerably. Large scale algal bloom in summer period due to microalga, (blue- green alga too), brings to constant summer mortality. Large quantity of the organics, united by bacteria and microalga and not used in food chains, is accumulated as the silts. Benthic organisms don't cope with large quantity of organic substance on the bottom. Silt zone expands and potential spawning grounds of lithophilous fish decreases. Size decrease of pike, perch, smelt and tench are observed on this background. The catches of bream, breamflat, roach and sander are rather stable.

Such situation is typical for many water basins of Europe. The tendency, observed now in the Curonian and the Vistula lagoons, coincides greatly with the tendency well investigated in the Danube River, where in the middle of the 70-th in the last century the concentration of phosphorus started to increase and reached very high level of 0,1-0,15mg/l and water acquired greenish colour. Pike and tench lost their favourable environment, and bream, roach, sander and Crucian carp of artificial breed started to dominate in the ecosystem. From 1980 under the influence of such factors as diminishing of water transparency, changes in zooplankton composition and intensive programs for Crucian carp reproduction its population began to increase quickly and partly superseded roach. Instead of pike, using its sight while prey, appeared sander as for this predator water transparency is not so important at prey. Disappearance of the pikes, the biggest predators of this ecosystem, brought to considerable increase of bream stock and the stock of other carp fish (FAO, 2010).

Correlation of the changes in ichythiocene composition with the quantity of phosphorus in water permitted to select the change in the dominance of species in water ecosystem of the Danube River: PERCH → PIKE - TENCH→ BREAM - SANDER (FAO, 2010).

Proceed from more high level of water euthrophication of the Danube River, continued euthrophication of the Vistula lagoon and supposition that the level of its euthrophication is unlikely to decrease in the nearest future it is possible to suggest that ichthyofauna will acquire distinct carp character in the Vistula lagoon in future. Beside that, it is difficult to suppose how Baltic herring, (and its young that nourish in the lagoon in summer period), will counter react for the increase of euthrophication level.

Long period climatic changes may appear a serious factor influencing fish resource of the lagoon. Several different views exist now for climatic change in the nearest century, from global thermal increase to global thermal decrease, but the most investigators agree that present time is a transient period and it will be followed with significant climatic changes. Restoration of shad population in the basin of the Neman River may serves as an example (Gushchin, Tverdokhleb, 2010).

The appearance of thermophilous lodgers are observed now in the lagoon, and one of them is *Rangia cuneata* inhabiting the Mexican gulf and serving as an indicator of temperature increase in the lagoon (Lyatun et all., 2012). Possible climatic changes may be reflected in thermal increase, oxygen decrease, pH displacement to alkali and enlargement of phosphorus and nitrogen concentration in water. All these will strengthen the process of euthrophication of the lagoon and the reduction of stock size of pike, perch, whitefish, European smelt, smelt and tench will be observed on this background. But the rise of the catches of bream, breamflat, roach, sander and small carp fish will follow also and large share of carp fish in the catches will decrease fishery value of the basin.

7. Suggestions for fishery state improvement.

7.1. Reduction of euthrophication level in the lagoon.

The problem of euthrophication reduction in the Baltic Sea basin is of global scale. It can't be solved in the nearest future as it is linked to several problems:

- Reduction of unpurified and low treated waste water. This problem started to be solved with putting into operation the water treatment plant in Kaliningrad. The problem with waste water improved, but the most villages and the towns in the region of the lagoon lack waste water treatment facilities of high grade. Rain waste waters are practically not treated. It is necessary to accelerate putting into commissioning local water treatment facilities, to strengthen responsibility for illegal waste water throw and to reduce the level of euthrophication by using modern agrochemical methods in agriculture.

- To conduct investigations for cleaning the lagoon from alga at the period of algal bloom using different methods, even the oil recovery vessels.

Nets operation

7.2. Artificial stock regulation for industrial fish species and their predators.

It was already written that ichthyofauna of the lagoon has expressed anthropogenic character and it was formed as the result of fishery regulation measures. But ordinary usage of the measures for fishery regulation is not sufficient at modern stage for preserving fishery in the lagoon. It is necessary to conduct measures for some species stocking to maintain their size. Eel, pike, salmon and Baltic sturgeon belong to such species. As fishery in the lagoon possesses trans-border character it is necessary to determine precisely the species for artificial reproduction, the number of the enterprises for stocking and their location together with the polish colleagues. Mutual program for fishery in the Vistula lagoon is needed with a parity financing of two states and enlisting the means of the users on the basis – contribution for reproduction = amount of quota for fish catch.

Despite direct stocking of lagoon water it is necessary to conduct fishery melioration of the rivers that flow into the lagoon and, maybe, to make some zones of artificial spawning grounds. In this case it is quite urgent to create ichthyologic reserve on the semi-island Balga because this area of wrecked polders serves now as the spawning ground for some fishery species.

Catch landing

Estimation of great cormorant size is a serious problem that needs urgent solution. It is obvious that its size increased the permitted level and the great cormorants make significant detriment for fishery and forest in the region of the lagoon and it is necessary to take measures for regulation of its size. The reduction of the nodifications, but not the destruction of the great cormorants as it will not cause social protest, may serve such a measure.

7.3. Recreational, sport and illegal fishery (poaching)

Recreational, sport and illegal fishery (poaching) in the Russian part of the Vistula lagoon is practically equal the volume of industrial fishery. It is obvious that all the attempts to regulate theses types of fishery by means of “Fishery Rules” and repressive measures of fishery inspection and police don’t bring necessary results. The inspector and the policeman are the enemies for the fisherman in the lagoon, it’s a deadlock. At the same time there are several associations of amateur fishermen for whom fishery is recreation and sport, but in Kaliningrad region doesn't exist an infrastructure that can unite these people and solve their requests. Obviously, the problem of recreational-sport fishery and illegal fishery is more of social than economic character and the solution is in the social sphere. It is necessary to create negative image of a poacher by means of mass media and educate a fisherman from childhood. Fishermen clubs, communal ecological and fishermen patrols can help greatly in ecological education and nature preservation.

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Appendix

List of main fish species inhabiting the Russian part of the Vistula lagoon.

№	Species (Russian and Latin names)	Industrial importance	Characteristic	State of stock and precaution measures (Red Book of the Russian Federation and etc.)
1	Brook lamprey– *Lampetra fluviatilis* L.	Industrial	Migrating species. Length 30-50 cm. Approach the rivers for spawning in spring and autumn.	Not studied
2	Baltic sturgeon– *Acipenser oxyrhynchus* Mitchill	Nonindustrial	Migrating species. Length up to 250 cm. Approached the Vistula and the Pregel Rivers for spawning up to the end of IX century.	Species is in the artificial restoration state[i]
3	Shad - Alosa fallax (Lacepede)	Nonindustrial	Migrating species. Approaches the rivers (Vistula) for spawning. Feeding on zooplankton, fish young.	Not studied. Size restoration is observed in the Curonian lagoon. Industrial species up to the middle of XX century.
4	Herring - *Clupea harengus membras* L.	Industrial	Semi-migrating species. Spawning in the lagoon in spring and autumn. Length up to 37 cm, usually 14-16 cm. Maturity at 2-3 years. Zooplanktonphagan.	Satisfactory
5	Baltic salmon - *Salmo salar* L.	Industrial	Migrating species. Big fish with length up to 1,5 m, mass up to 39 кg. Life time 8-9 years. Autumn spawning. Feeding on crustaceous and fish. Aquacultural object.	Satisfactory. Stock is maintained through the artificial reproduction.
6	Brook trout - *Salmo trutta* L.	Nonindustrial	Migrating species. Big fish with length up to 70 cm, mass up to 14 кg. Life time 8-9 years. Autumn spawning. Feeding on fish. Aquacultural object.	Satisfactory. Red Book of the Russian Federation
7	European smelt - *Osmerus eperlanus* L.	Industrial	Migrating species. Length up to 30 cm, mass up to 40 g. Maturity at 3-4 years. Autumn spawning. Feeding on zooplankton.	Satisfactory
8	Smelt - *Osmerus eperlanus eperlanus m. spirinchus* (Pallas.)	Industrial	Living form. Length of 6-10 cm. Maturity at 1 year. Feeding on zooplankton.	Depressed
9	White fish – *Coregonus lavaretus* (L.)	Nonindustrial	Semi-migrating species. Length up to 50 cm. Maturity at 4-8 years. Feeding on invertebrates. No spawning grounds in the Russian water of the lagoon. Aquacultural object.	Depressed, practically does not meet in the lagoon.

10	European eel - *Anguilla anguilla* L.	Industrial	Catadromous species. Length 32-72 cm. Mass 0,5 – 1,0 kg. Maturity at 8 – 12 years. Euryphagan.	Depressed. An object of EU plan for restoration. A question for European eel insertion in CITEC Appendix is being considered.
11	Pike - *Esox lucius* L.	Industrial	Length up to 1,5 m. Mass up to 35 kg. Maturity at years. Spawning in April - beginning of May. Predator.	Satisfactory.
12	Bream - *Abramis brama* L.	Industrial	Length up to 0,5 m. Mass up to 5 кg. Maturity at 3-4 years. Spawning at the end of April – beginning of May. Feeding on bottom organisms, algae.	Satisfactory.
13	Zope - *Abramis ballerus* L.	Industrial	Length up to 0,3 m. Mass up to 1 kg. Maturity at 3 years. Spawning in May – July. Feeding on plankton, insects, algae.	Undistinguished
14	Bleak - *Alburnus alburnus* (L.)	Nonindustrial	Length up to 20 cm. Maturity at 3-4 years. Spawning at May –June. Feeding on bottom organisms.	Undistinguished
15	Asp - *Aspius aspius* (L.)	Industrial	Length up to 80 cm. Mass up to 12 kg. Maturity at 3-5years. Spawning in April – May. Feeding on bottom organisms, insects, fish larvae.	Undistinguished
16	Breamflat - *Blicca bjoerkna* (L.)	Industrial	Length up to 30 cm. Mass up to 400 g. Maturity at 3-4 years. Spawning in May – June. Feeding on bottom organisms, insects, algae.	Undistinguished
17	German carp - *Carassius auratus gibelio* (Bloch.)	Nonindustrial	Length up to 45 cm. Mass up to 1000 g. Maturity at 2-3 years. Spawning in May – June. Feeding on bottom organisms, zooplankton, insects, alga.	Undistinguished
18	Crucian carp - *Carassius carassius* (L.)	Nonindustrial	Length up to 45 cm. Mass up to 3 кg. Maturity at 4-5years. Spawning in May – June. Feeding on bottom organisms, zooplankton, insects, alga.	Undistinguished
19	Gudgeon - *Gobio gobio* (L.)	Nonindustrial	Length up to 15 cm. Mass up to 80 g. Maturity at 2-4 years. Spawning in April – June. Feeding on bottom organisms, insects, fish eggs.	Undistinguished
20	Owsianka - *Leucaspius delineatus* (Heckel)	Nonindustrial	Length up to 8 cm. Maturity at 2 years. Spawning in June – July. Feeding on insects, zooplankton.	Undistinguished
21	Ide - *Leuciscus idus* (L.)	Industrial	Length up to 70 cm. Mass 6-8 kg. Maturity at 4-6 years. Spawning in April – May. Feeding on benthos, insects, sea	Undistinguished

			weeds.	
22	Roach - *Rutilus rutilus* (L.)	Industrial	Length up to 30 cm. Mass up to 600-800 g. Maturity at 3-5years. Spawning in spring, in April – May. Feeding on bottom organisms.	Good
20	Red-eye - *Scardinius erythrophthalmus* (L.)	Industrial	Length up to 36 cm. Mass up to 1,5 kg. Maturity at 3-5yeas. Spawning in spring, in April-June. Feeding on alga, reed sprouts, eggs and larvae of the insects.	. Undistinguished
21	Tench - *Tinca tinca* (L.)	Nonindustrial	Length up to 60 cm. Mass up to 7,5 kg. Maturity at 3-4 years. Spawning by portions, in June –July. Feeding on invertebrates, insect larvae, algae.	Undistinguished
22	Ziege - *Pelecus cultratus* (L.)	Industrial	Semi-migrating. Length up to 50 cm. Maturity at 3-4 years. Spawning in May-June. Feeding on zooplankton, fish larvae.	Satisfactory
23	Vimba - *Vimba vimba* (L.)	Industrial	Semi-migrating. Length up to 50 cm. Maturity at 4-5 years. Feeding on bottom organisms.	Low
24	Spined loach - *Gobitis taenia vimba* (L.)	Nonindustrial	Length up to 12 cm. Maturity at the length of 5-6 cm. Spawning by portions, in June-July. Feeding on bottom organisms.	Undistinguished
25	Sheat-fish - *Silurus glanis* L.	Industrial	Length up to 200 cm. Spawning in summer. Predator.	Undistinguished
26	Burbot - *Lota lota* (L.)	Industrial	Length up to 100 cm. Mass up to 24 kg. Maturity at 3-4 years. Spawning by portions, in December – March. Predator.	Undistinguished
27	Burnstickle - *Gasterosteus aculeatus* L.	Nonindustrial	Length 4-12 cm. Maturity at 2 year. Spawning from April till June. Euryphagan.	Undistinguished
28	Needle-mackerol-*Gasterosteus pungitius* (L.)	Nonindustrial	Length 4-9 cm. Spawning from July till August. Euryphagan.	Undistinguished
29	Pope - *Gymnocephalus cernua* (L.)	Industrial	Length up to 20 cm. Maturity at 2 years. Spawning by portions, in April-June. Feeding on bottom invertebrates, eggs and fish young.	Good

30	Perch - *Perca fluviatilis* L.	Industrial	Length up to 50 cm. Mass up to 1,5 kg. Maturity at 2-4 years. Spawning in spring, in April-May. Feeding on bottom invertebrates, small fish.	Satisfactory
31	Sander - *Stizostedion lucioperca* (L.)	Industrial	Length up to 1,3 m. Mass up to 20 kg. Maturity at 4-7 years. Spawning in spring. Predator. .	Satisfactory
32	Bullhead - *Neogobius melanostomus* (Pallas)	Nonindustrial	New-comer. Length up to 25 cm. Maturity at 2 years. Euryphagan.	Undistinguished
33	Flounder - *Platichthys flesus* (L.)	Industrial	Young approach in spring for feeding. Length up to 45 cm. Maturity at 3-5 years. Benthosphagan.	Undistinguished