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The current state of Vistula Lagoon Polish fisheries

Perspectives for development

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1. Introduction

The principal cause underlying the stressed ecological environment of the Vistula Lagoon is the mixing of fresh water and saline water from the Baltic Sea. The most important change effected by humans was when the main flow of the Nogat River was redirected from the lagoon in 1914, which caused increased salinity. Until 1945, the Vistula Lagoon was situated in Germany, but after World War II it was divided between Poland and the USSR. Rapid urbanization and the development of industry and tourism without adequate waste-water management subjected the Vistula Lagoon environment to new disturbances including eutrophication, massive algae blooming, and the decline of macrophytes. Decreases in catches of the most valuable fish species occurred simultaneously. The transition to a market economy after 1989 intensified this trend, but not only fishery exploitation impacted the fish assemblages. Other potentially important factors included alien species, the drastic increase of the black cormorant breeding colony, and herring reproduction issues.

The intensive mixing in the Vistula Lagoon creates favorable conditions for primary production and the respective development of consumer assemblages on the trophic pyramid. This means that the lagoon provides spawning grounds for typically marine species, such as herring, *Clupea harengus*, as well as different freshwater species, including pikeperch, *Stizostedion lucioperca*; bream, *Abramis brama*; roach, *Rutilus rutilus*; and perch, *Perca fluviatilis*. Observations of the Vistula Lagoon confirmed that this basin supports over forty fish species of various ecotype. The mixing of freshwater and marine water inflows causes high environmental stress for the organisms that inhabit this basin. Together with anthropogenic pressure caused by fishery and pollution, the fish assemblages in these transitional waters are believed to be sensitive to changes.

The Vistula Lagoon is classified as Polish internal marine waters. Consequently, catches in this basin are regulated by the Act of 19 February 2004 on fisheries (Journal of Laws No. 62, item 574). According to this law, fishing vessels which have fishing licenses and special fishing permits are allowed to fish in this region. Special fishing permits are issued by the Regional Maritime Fisheries Inspectorate (RMFI) in Gdynia, and they are valid for a calendar year. Vessel captains who wish to fish in subsequent years must apply for special fishing permits by 31 October of the preceding year.

2. Fishery conditions in the Polish part of the Vistula Lagoon

2.1 Natural conditions

Today's Vistula Lagoon and its hydrological regime have existed for just under a century, which means that the fish assemblages inhabiting it were formed relatively recently. The Vistula Spit, which lies between the Baltic Sea and the lagoon, which prior to World Was II was known in German as the *Frisches Haff*, has changed position at least several times as the result of natural formation processes (Długokęcki, 1996). Until the early twentieth century, the lagoon was nearly exclusively a freshwater basin with high inflow dynamics supplied by the waters of the Vistula and Pregolya rivers. However, because of repeated flooding in Gdańsk, in 1895 Vistula River waters were channeled directly into the Gdańsk Bay through the Wisła Śmiała Canal, and then in 1914 the Nogat River, which is a branch of the Vistula River, was cut off definitively from the main flow by a system of locks. From that moment, the volume of water flowing there decreased from 8 to 9 km^3 to 0.7 km^3 annually (Łazarenko and Majewski 1971). This initiated revolutionary changes in the aquatic ecosystem of the lagoon such as increased salinity and altered water circulation, which are of great consequence to living organisms, including fish assemblages (Willer 1925, Pliński 2005). The construction of the navigable Pregolya Channel, through which shipping traffic was directed from Königsberg (today's Kaliningrad) to the waters of the Gdańsk Bay, had a slightly lesser impact on the whole lagoon. The deepened fairway was shielded from the waters of the lagoon by a system of artificial dikes which shifted the flow of waters from the Pregolya River. The last construction project that had an impact on water circulation in the lagoon was the enlarging of the Piława Strait in 1960s to its presently-maintained size of 460 m in width and a mean depth of 12 m (Łazarenko and Majewski 1971).

The eutrophication of the lagoon waters has a substantial impact on fish assemblages. Increasing eutrophication is the result of industrial development in Poland and increasing numbers of residents in the Vistula Lagoon drainage basin along with the simultaneous lack of sewage treatment facilities. The first mechanical treatment plant in a community adjacent to the lagoon did not open until 1988, and the largest city on the Polish side of the lagoon – Elbąg, did not finish construction on its mechanical-biological sewage treatment plant until 1992. Communal waste waters remain an issue today, especially in summer among the summer resorts on the Vistula Spit since solutions have yet to be fully implemented. This is reflected in the high numbers of fecal coliforms in these waters that have been confirmed by monitoring performed by the Border Sanitary and Epidemiological Station in Elbląg. The trophic status of the lagoon currently oscillates between polytrophy and eutrophy. Significant quantities of nutrients are deposited in the sediments, which are re-suspended in the water column by wind action nearly continually (Chubarenko and

Margoński 2008).

Other significant ecosystem changes that could potentially have a significant impact on fish assemblages include:

i) area of shallow waters in the lagoon that are overgrown with higher vegetation;

ii) changes in zooplankton composition;

iii) changes in zoobenthos composition and biomass;

iv) increased abundance in cormorant colonies;

(i) In the mid 1970s, the total area covered with higher vegetation was nearly 2,200 ha, which was 6.86% of the surface area of the Polish part of the lagoon (Pliński et al. 1978). Later studies (Pliński 1995) indicated significant changes had occurred: areas covered with vegetation decreased, especially those with narrowleaf cattail as well as vegetation with submerged or floating leaves. Submerged vegetation and that which grows at a greater distance from the shore both disappeared. This could have been caused by increased water turbidity that limited photosynthesis as well as by changes in sediment structure. Limitations on the areas of occurrence of higher vegetation were very disadvantageous for fish that use these plants as a spawning substrate or as a fry nursery area.

(ii) The mass development of the zooplankton *Cercopagis pengoi*, a predatory cladoceran (Naumenko and Polunina 2000) and an invasive species in the Baltic, was observed. From 1998 to 2005 in some periods of the year, this zooplankton species caused considerable damage to the fisheries as thick mats of these organisms became entangled in fyke nets and set gear thus blocking meshes and snapping ground stakes. To date, the changes which supported the occurrence of these cladocerans in the trophic structure and fish diets in the Vistula Lagoon remains unknown.

(iii) The macrozoobenthos is dominated by euryhaline marine and freshwater organisms, but on the Polish side these organisms are mostly freshwater species that are typical of eutrophoic waters. Invasive species also occurred (Jażdżewski et al. 2005) including the polychete *Marenzelleria neglect*, which very quickly dominated nearly the entire area and in some regions comprised more than 90% of the biomass (Andrulewicz 1997). Significantly, *M. neglecta* occupies the deeper parts of bottom areas than do other benthic organisms, which means it is unavailable for most benthic-feeding fish. Prior to this, the greatest qualitative and quantitative change had been linked to the invasive zebra mussel (*Dreissena polymorpha*) at the end of the nineteenth century. The crab *Rhithropanopeus harrisi* is an abundant representative of mobile, near-bottom fauna, but it is also an alien species that was introduced to the southern Baltic in the 1950s (Demel 1953). Observations

of fyke nets, on which large numbers of these small crabs are found periodically, and the analyses of perch and eel stomach contents (author's own observations) are evidence that this organism is currently an important element of the ecosystem. The occurrence of large number of these small crabs might be the reason for the higher abundance of flounder that have entered the Vistula Lagoon in increasing numbers in recent years. The numbers of Chinese mitten crabs, *Eriocheir sinensis*, an alien species introduced to the Baltic Sea from China in the early twentieth century, found in fishing gear have increased in recent years (Ojaveer et al. 2007), and they might also be responsible for damage to gear.

A Chinese mitten crab from the Vistula Lagoon

(iv) The rapid increase in the abundance of the breeding colony of great cormorants, *Phalacrocorax carbo sinensis*, in Kąty Rybacki is one of the significant biological factors affecting the Vistula Lagoon ecosystem. Although the establishment of the colony dates to the 1940s, a sudden population increase occurred in the 1990s. The number of nests in 1986 was estimated to be 3,860 (Kopciewicz et al. 2003), while in 2006 there were an estimated 11,376. In the next period (2008-2010) it stabilized at the level of 8-9 ths nests (HELCOM Indicator Fact sheets 2010), which means that this is the largest great cormorant breeding colony in Europe. It is believed the colony's success is due to the availability of fish, which is this predator's primary feed base, in both the Vistula Lagoon and the Gdańsk Bay. This, in turn, is the result of increased production of the waters and the overfishing of predatory fish. The most frequent components of the Kąty Rybacki great cormorant population diet were ruffe, stickleback, round goby, and flounder (Stempniewicz et al. 2003).

2.2. Fish assemblages and seasonal movements

Some forty fish species have been recorded in the Vistula Lagoon, of which only eel, pikeperch, bream, and herring have been constant target species in Polish lagoon fisheries. Other species, such as perch, roach, trout, ziege, and burbot are landed as commercially important by-catch, while the remaining species are often caught as by-catch but are discarded (Borowski and Dąbrowski 1998, Psuty-Lipska 2005). This means that only observer-based analyses of catches or information independent from fishery sources can be used to estimate abundance.

The fish assemblages in the Polish part of the Vistula Lagoon exhibit seasonal changes in both abundance and occurrence. From December to February during the spawning season of cold-water species, high concentrations of burbot and anadromous species heading for rivers, such as trout or river lamprey, are typical. Pike spawning concentrations occur from February to March, followed by those of herring from Baltic coastal regions, as well as perch and ruffe. Pikeperch usually follow these species, spawning in April, while ziege, smelt, and common bream spawn at the end of April and the beginning of May. Roach, silver bream, and rudd spawn in May. The spawning season ends in July with tench and Crucian carp. After spawning, adult individuals of species such as pikeperch, bream, and smelt leave the Polish waters of the Vistula Lagoon in search of the best feeding conditions, which are in the deeper Russian waters of the lagoon or even in the coastal areas of the Baltic Sea (Filuk 1955, Filuk 1957). Young of the year (YOY) individuals of most species are typical of the littoral habitat of the Vistula Lagoon. Juvenile pikeperch become piscivorous when they reach 12-15 cm TL (Total Length; Żelepień and Wilkońska 1999), and this is when juveniles are noted in the mid lagoon area in great numbers. YOY common bream stay in the littoral habitat longer, while it is common to find ruffe, YOY bream, white bream, and stickleback in the coastal areas of the Polish part of the Vistula Lagoon. The pelagic area is used mainly by YOY herring and smelt, and by both juvenile and adult sabre fish. The species occupying the different niches in the Vistula Lagoon habitats depends on prevailing environmental factors, including temperature, which influences spawning time and larval growth rates (Fey 2001, Margoński et al. 2006, Grzyb 2007). The availability of zooplankton prey also plays an important role. All these factors combine to shape the prey-predator relationships in fish assemblages. A great number of Vistula Lagoon fish species have been identified as opportunistic feeders, which means they are not selective in their search for energy (Filuk and Żmudziński 1965, Wilkońska and Żelepień 1995, Żelepień and Wilkońska 1999). Ziege can prey upon pelagic fish larvae even though it is known to be zooplanktivorous (Terlecki 1987). Perch and ruffe will consume any kind of food available on bottom surfaces as well in pelagic areas (Filuk and Żmudziński 1965). When herring are spawning, all other fish exploit them as a source of energy. Pikeperch, burbot, and large perch

feed on adult herring, perch, roach, and ruffe, while smaller pikeperch and ruffe have been known to eat herring eggs. Extensive research has been conducted on the feeding patterns of some life stages of selected fish species and groups (Filuk and Żmudziński 1965, Żelepień and Wilkońska 1999), but no comprehensive model has yet been devised, with the exception of an attempt by Horbowy (1998).

Most of the spawners leave the Polish waters of the lagoon after spring. The open water zone is open to fisheries and catches comprise mainly perch, roach, and ziege (Borowski et al. 1995, Psuty 2010). In the littoral zone, tench, Crucian carp, perch, and roach form fish assemblages together with stickleback (Psuty-Lipska and Borowski 2003). Eel abundance peaks twice a year (Psuty and Draganik 2008a). The first is in spring when a substantial quantity of relatively young fish is caught in fishing gear. The second peak coincides with the silver eel migration phase and occurs mainly in September. In the months of October and November, anadromous species such as river lamprey and trout migrate to their spawning grounds in small rivers and streams such as the Pasłęka, Bauda, and Narusa (Żarnecki 1952, Jokiel 1954). Meanwhile, the activity of burbot increases (Borowski and Dąbrowski 1996, Borowski and Dąbrowski 1997). In winter, if there is no ice cover or fishing gear is used under the ice, larger specimens of pikeperch are caught (Borowski, personal communication).

The fishers working the lagoon believe that fish migrations, mainly those of pikeperch outside of the spawning season, are determined by the direction and strength of the wind. In the case of eel before stocking was initiated in 1970 (Psuty and Draganik 2008b), the main fishing season was in the spring and summer months from May to July (Filuk 1965b), but by the end of the 1970s, the peak of the eel fishing season has shifted to the fall months of September to November.

Eel fishery is no longer a primary source of income for Polish fishers because of drastic decreases in biomass and the cessation of stocking resulting from the lack of an agreement with the Russian side. This situation should change soon since stocking cultured eel was begun again in 2005 in the Polish part of the lagoon, and since 2011 additional measures have been implemented as part of the European Eel Management Plan (Council Regulation (EC) No 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel. Stocking eel was begun as early as in the beginning of the twentieth century. The Vistula Lagoon was first stocked prior to the First World War in 1910 when 6 tons of eel were released into the lower Elbe River, and this was likely continued until 1915 (Sakowicz 1930). The effects of the first stocking series were noted in Vistula Lagoon catches which increased fourfold in ten years from 150 tons in 1910 to 500 tons in 1925. The subsequent series of stocking began in 1925 and was probably continued until 1941 (Roehler 1942). These were fish that were mainly caught in the Elbe River

mouth and measured from 20-24 cm t.l. and weighed about 16 g (these figures refer to stocking performed in 1928 of a total weight of 2 tons). The effects of this stocking were maintained until the early 1960s when Filuk (1972) observed a decrease in the catch per unit effort. Since that period, Filuk worked on promoting the stocking of the Vistula Lagoon with eel montees, as was done in inland waters. Finally, the lagoon was stocked from 1970 to 1994 (with the exceptions of 1985, 1990, and 1993) and again in the 2005-2008 period (Psuty and Draganik 2008b). Stocking the Vistula Lagoon is included in the measures of the 2011-2015 Polish Eel Management Plan (WGEEL 2008).

Eel stocking in the Vistula Lagoon, 2007

3. Fisheries in the Polish part of the Vistula Lagoon

Many different species of fish are exploited by the fisheries in the Vistula Lagoon using two basic types of gear. Trap gear, such as fyke nets and type II fyke nets, target eel and herring in the spring (set net). Depending on mesh size, set gillnets target smaller fish such as perch or roach or larger fish such as pikeperch or bream. Both of these gear types can have a negative impact on fish resources and lead to tragedies with common property resources if their exploitation is managed inappropriately. Trap gear result in high fry mortality among other fish species, including pikeperch and bream which are both important species to commercial fisheries. Set gear with a small mesh size have a similar impact. When there is a lack of fisheries regulation, both gillnets and fyke nets can inhibit fish migrations along the length of the basin.

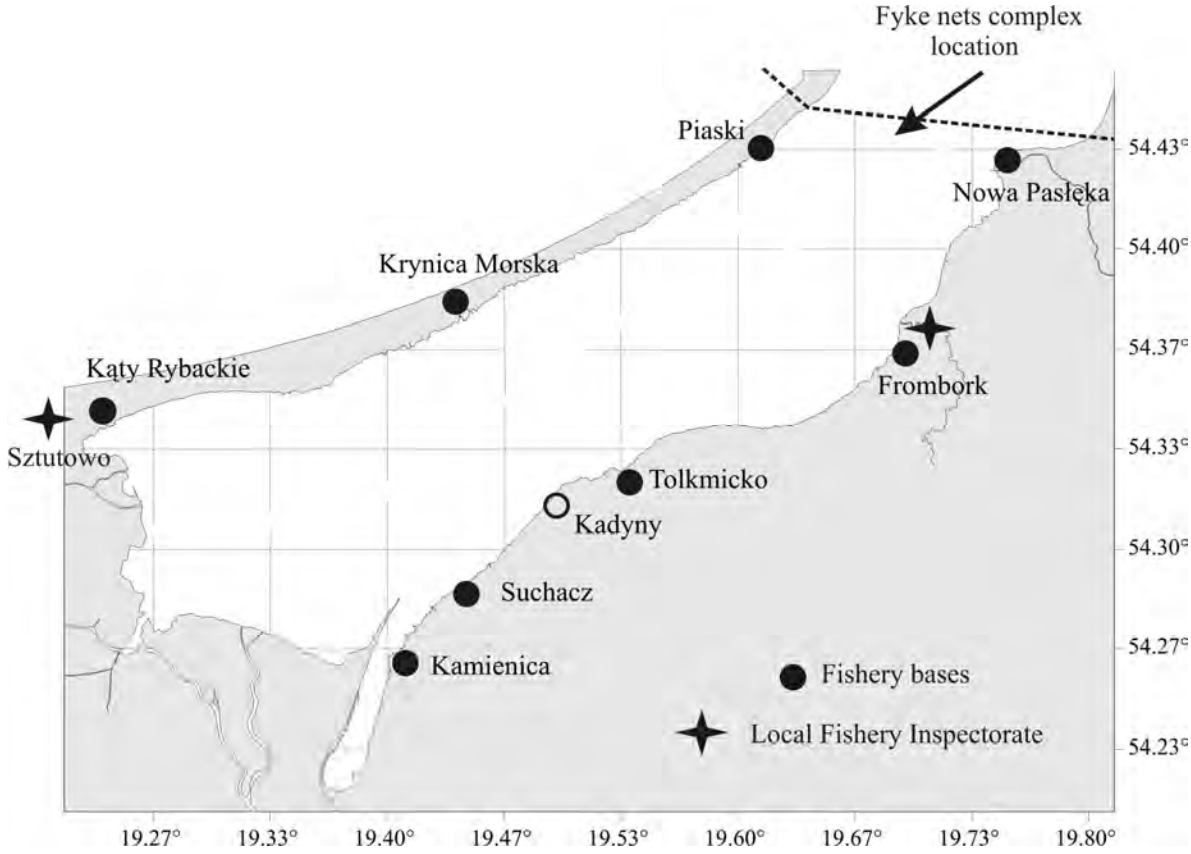
The 2004 Vistula Lagoon fishing fleet comprised 124 vessels registered on the registry of fishing vessels. These vessels were licensed and had special fishing permits. Additionally, 22 so-called fishing boats were allowed to exploit the fisheries under special conditions. These were used as auxiliary boats during the spring herring catch and were charged with servicing gillnets and transporting fish and equipment. These boats were withdrawn from the fisheries in 2010. As part of the Sectoral Operational Program entitled "Fisheries and Fish Processing 2004-2006", financial compensation is offered in exchange for permanently ceasing fishing activities. To date, 60 owners of fishing vessels operating in the Vistula Lagoon have volunteered to participate in this program, with four of them volunteering for the vessel scrapping program in 2011-2012.

Some of the fishers who had participated in the vessel scrapping program returned to the profession. In an effort to resume fishing in the Vistula Lagoon, these fishers purchased vessels in other Baltic Sea regions and then registered them in the lagoon. Some fishers increased their so-called fishing capacity (which is calculated as engine power plus vessel GT) by modernizing vessels and then registering the new vessel. In 2008, fishers were given the opportunity to participate in a program entitled "Temporary suspension of fisheries to permit resource recovery". In practice, participants received relatively high financial compensation for ceasing all fishing operations for any three months in a calendar year. The ban on further exploitation of auxiliary boats and the possibility of obtaining subsidies for the temporary suspension of fishing prompted many vessel owners to search for ways of registering additional vessels. One way of achieving this was to decrease the fishing capacity of large vessels owned, thus becoming eligible to register additional vessels. Another possibility was to remove one vessel from the register, and then register two, or in some cases, even three new vessels.

Various fishing vessels in the Polish part of the Vistula Lagoon

Following consultation with the fishing community, individual catch quotas were introduced in 2008 for bream and pikeperch in an effort to halt the troubling phenomenon of increasing fishing pressure in the Vistula Lagoon. This was followed in 2009 by designating the total maximum number of gears that can be utilized in Vistula Lagoon fishing grounds. In accordance with § 3 item 2 of Ordinance No. 1 of the District Inspectorate of Marine Fisheries in Gdynia of 19 March 2009, "...the total combined number of gears designated in special fishing permits shall not exceed 1680 sets of fyke nets, gillnets, hook lines, and herring gillnets". This regulation is relatively difficult to enforce, but it does prevent the movement and introduction of fishing vessels from other marine waters into the Vistula Lagoon. The Ordinance of the District Inspectorate of Marine Fisheries in Gdynia of 21 September 2010 introduced a regulation regarding the division of the overall fishing quota in order to limit access to fishing quotas for bream and pikeperch. Since this date, the division of this quota applies only those fishing vessels that had individual bream and pikeperch fishing quotas in 2009.

Currently, eight fishing ports and bases are operational in the Vistula Lagoon where the vessels permitted to fish in this aquatic basin are based. All of these ports and bases are presently supervised by the Director of the Maritime Office in Gdynia.



Fishing bases in the Vistula Lagoon

Fishers operating in the waters of the Vistula Lagoon maintain themselves by exploiting two primary groups of resources. The first of these is the short-term, mass catches of herring in the spring, while the second is the year-round exploitation of bream and pikeperch stocks, excluding periods when these fisheries are closed. Eel catches are currently not a basic source of income for Polish fishers because of drastic declines in eel biomass and the cessation of eel stocking that resulted from the failure to come to an agreement with the Russian side. This situation should change in the near future since eel stocking in the Polish part of the lagoon was begun again with cultured material in 2005, and additional measures began to be implemented in 2009 within the framework of the European Eel Management Plan (Council Regulation (EC) No. 1100/2007 of 18 September 2007 establishing measures for the recovery of the stock of European eel).

The fishers working on the Vistula Lagoon presently use two basic kinds of fishing gear: fyke nets that target eel and gillnets of two varieties – one targets pikeperch and bream, while the other targets perch and roach. Eel long-lines are used sporadically.

In the lagoon, each special fishing permit stipulates the permanent number of gears that can be used, e.g., 24 sets of fishing gear. A set can comprise gear with a maximum length of 120 meters regardless of whether it is a fyke net or a gillnet. The maximum permissible number of gears in the Polish part of the Vistula Lagoon was designated in the beginning of 2009 at 1680 gears. The lateral distance between sets of fishing gear must be no less than 120 m (between two sets of fyke nets placed in one line), while the frontal distance between two sets of fyke nets cannot be less than 300 m.

The fyke nets currently used in the Vistula Lagoon have a nearly identical construction (i.e., the so-called 200-mesh fyke net). Only in the southwestern past of the lagoon are smaller fyke nets used. Since fyke nets are used on a large scale in the lagoon, and they have a negative impact on other fish species, regulations were introduced to require a selective sieve to be installed in the last chamber of the gear. This requirement was introduced with the Regulation of the Minister of Agriculture and Rural Development of 16 July 2002 regarding specific conditions for marine fisheries; however, the regulation did not come into force until the 2003 fishing season. According to § 35 (Chapter 4) of this regulation, selective sieves must be used from 1 May to 31 December.

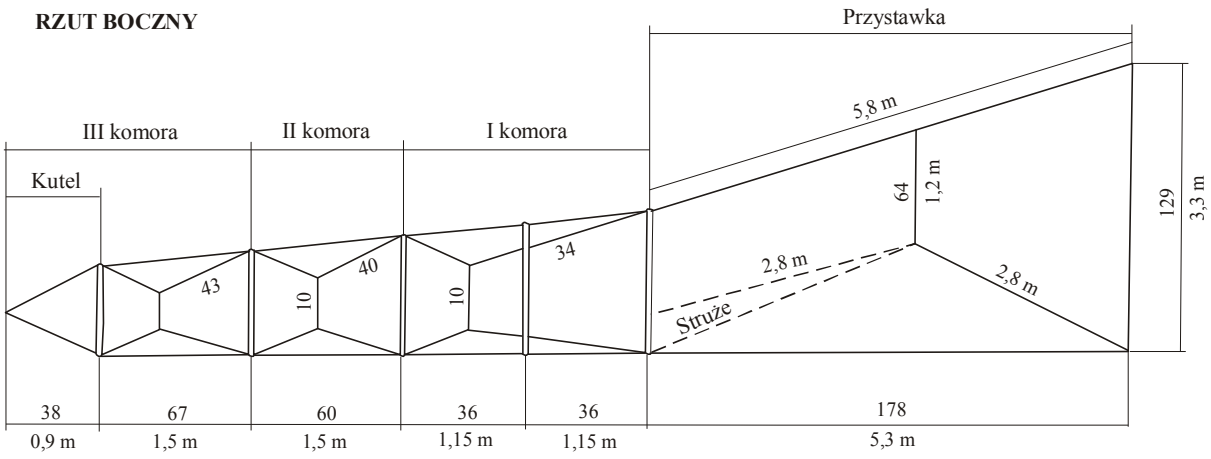


Diagram of the 200-mesh fyke nets used in the Vistula Lagoon

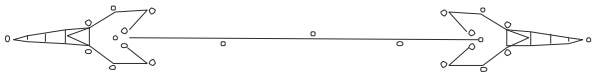


Diagram of fyke net use in the Vistula Lagoon (most common use)

Fyke net equipped with a selective sieve

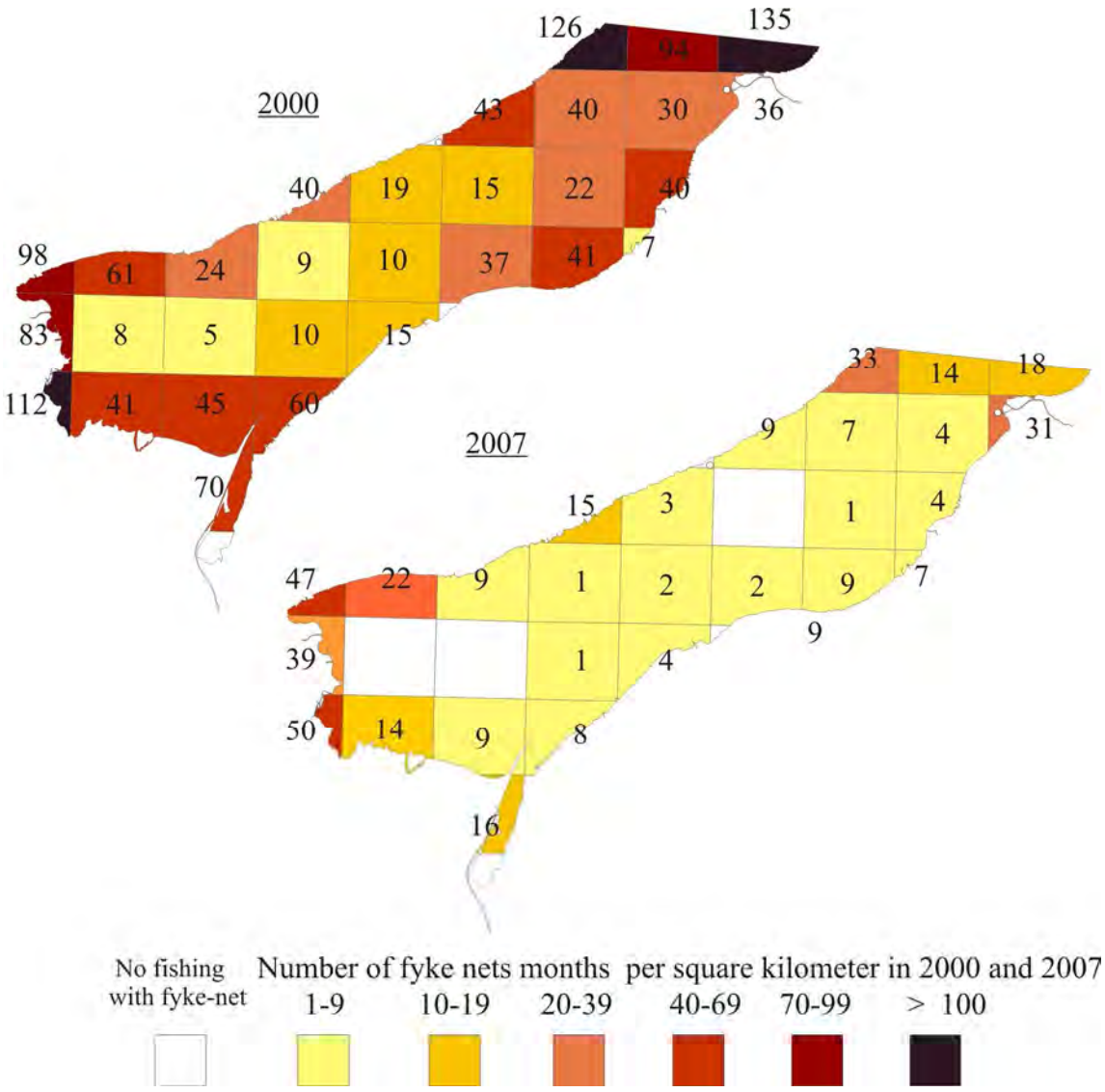
Since the profitability of using eel fyke nets is low, gillnets have gained in popularity. They are relatively cheap, are easy to replace if they become damaged, and provide the fisher with greater flexibility in changing fishing location.

The minimum mesh size for gear targeting pikeperch is 60 mm, but fishers are working to change this regulation. They feel that fishing gear with a mesh size of 55 mm also catches large quantities of pikeperch above the minimum protected size of 46 cm l.t., while also being more efficient. However, studies to date on the selectivity of set gear (Psuty 1996) have contradicted this opinion. It should also be emphasized that observations in differences in the construction of gear especially those pertaining to the hanging coefficient and additional net reinforcements (such as additional vertical lines known as *stróże*, or keepers) can have a greater impact on selectivity than the minimum mesh size stipulated in regulations.

Pikeperch-bream gillnets

Perch-roach nets with a mesh size of 36 mm are permitted for use only in near-shore areas (800 m from the border of submerged vegetation or the shoreline). This regulation was introduced because of the detrimental impact this size mesh can have on pikeperch under the protected size. Additionally, a variety of modifications in perch-roach net construction are used in the Vistula Lagoon, some of these are considered to be less detrimental, while others are more harmful. Classic perch nets, in which the headline is longer than the footline thus permitting the nets to form folds in the water, are considered to be of especially low selectivity.

Registering the distribution of fishing gear in the Vistula Lagoon indicates there are three regions with concentrations of eel, and, consequently, these are the fishing grounds with the highest yield. They are located in the east along the border separating the Polish and Russian sides of the lagoon, the northwest part of the lagoon, and the middle section of the shore located between Frombork and Kadyny. In the mid 1980s, fishers began to compete for fishing grounds near the Polish-Russian border. In preparation for the beginning of the fishing season, the fishers would build lightweight, flat-bottomed boats equipped with powerful engines (as much as 250 hp), to be able to compete for sites based on the premise that "...whoever claims a fishing site (…) cannot be removed from it...". The opening of the lagoon to shipping and fisheries by the Maritime Office after the ice cover had melted was accompanied by fierce competition among fishers. Additional regulations issued by the Director of the Maritime Office in Gdynia designated the time in minutes (in other words a handicap) when boats would be allowed to start from the individual fishing ports and bases. This was the source of many conflicts within fishing communities, among fishers, as well as with the fisheries administration. In 1995, the Director of the RMFI in Gdynia issued a declaration to settle these issues. In §1, item 1 it states that "Fishing sites operated by the crews of individual vessels using fyke net gear in the 1995 season shall remain at the disposal of that crew." This regulation is still in force today. Conflicts among fishers from different fishing bases regarding the border area were resolved definitively by consolidating gear positions in this area (first five lines from the border) based on the locations of fyke nets following the 1995 spring competition for positions. Despite regulation, conflict still flares up within the fishing communities regarding fishing positions in the first line from the border, this was especially notable after vessel scrapping and the opening up of the positions these crews had held.



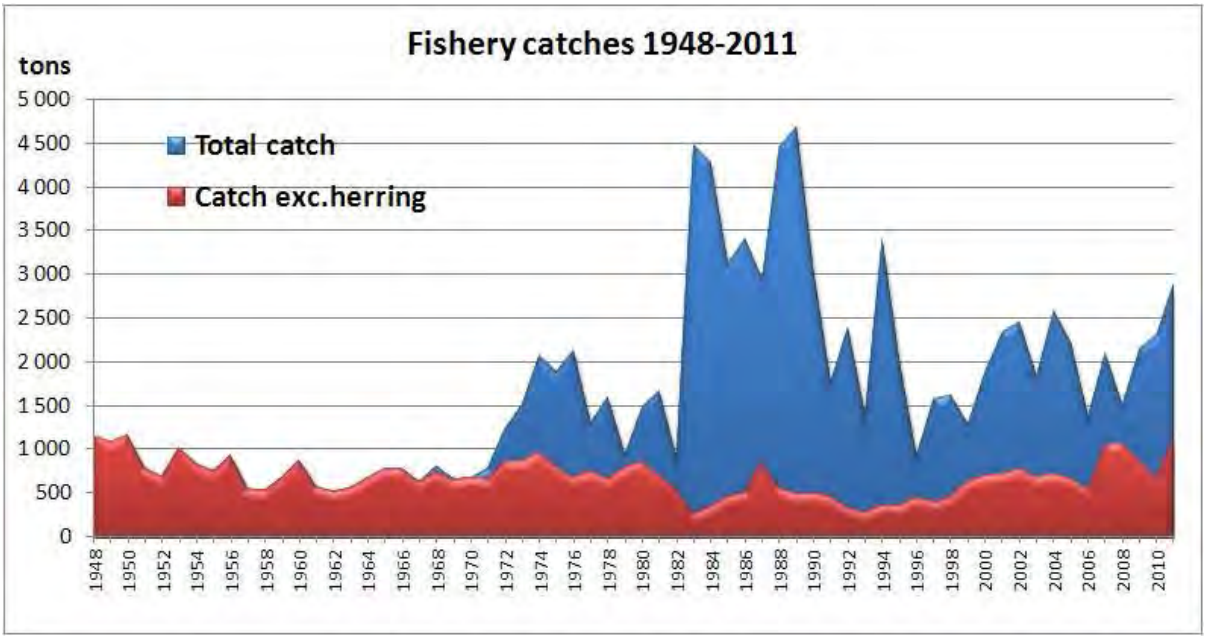
Comparison of the intensity and distribution of the fyke net fishing effort in the Polish part of the Vistula Lagoon. (Developed by Iwona Psuty and Lena Szymanek).

4. Fisheries use of fish species

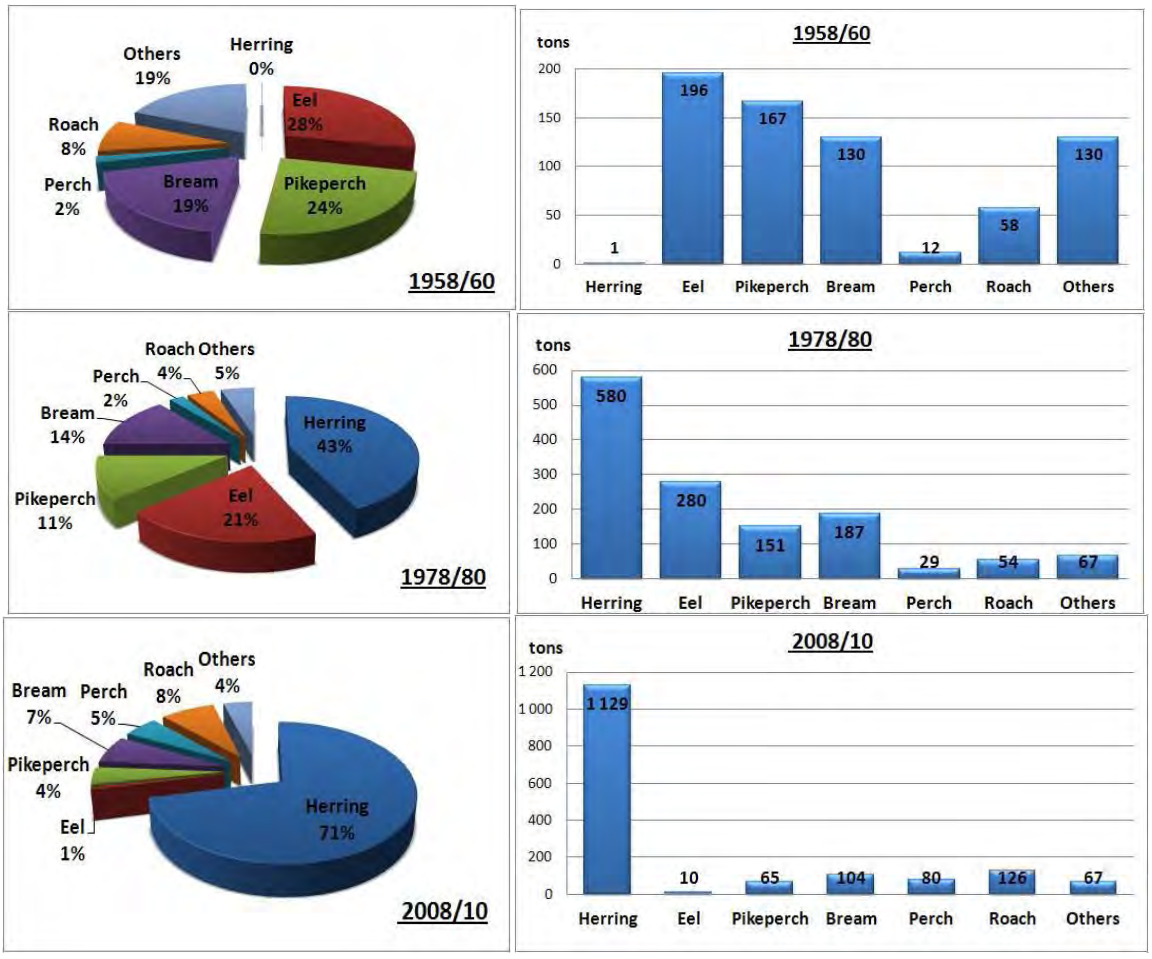
Total catch

With the exception of herring catches, the total catch in the Vistula Lagoon has remained on a comparable level of 600-800 tons for many years at an annual mean for the 1948-2010 period of 678 tons. The structure of the catch, however, has shifted towards species that command lower prices, which means they are less satisfactory to the fishers. Currently, roach, bream, and perch comprise the bulk of the catch with decreasing contributions of pikeperch and eel. Herring catches did not became an important element of Vistula Lagoon fisheries until the early 1970s, but the size of these catches is highly variable with environmental factors such as ice cover, water thermal regime, and generation strength of the southern Baltic population, and economic factors impacting it. The size of catches of this species is currently primarily regulated by demand and the quality of the fish as raw material.

Some species including smelt, ruffe, pike, carp, and vimba disappeared from landing records in the 1960s and 1970s, while others such as ziege, round goby, and flounder, have begun appearing in records in the last ten to 20 years. Still other species such as tench, Crucian carp, and burbot, have been appearing and then disappearing from landing records since the 1980s, and each of these species has its own history depending on the availability of fish and the type of fishery. Another important factor that influences the composition of local fish assemblages is stocking. The comparison of the size and structure of catches among three periods (1958/1960, 1978/1980, 2008/2010) indicate there have been fundamental changes in the catches. During the first period, the primary species were eel, pikeperch, and bream, but by the end of the 1970s while catches of these three species remained at similar levels, herring began to dominate in terms of weight. Currently, herring comprises about 70% of all catches, while there have been simultaneous drastic decrease in catches of eel and pikeperch, and to a lesser degree of bream.



Total landings in the Polish part of the Vistula Lagoon 1948-2011



Catches in the Polish part of the Vistula Lagoon in different periods

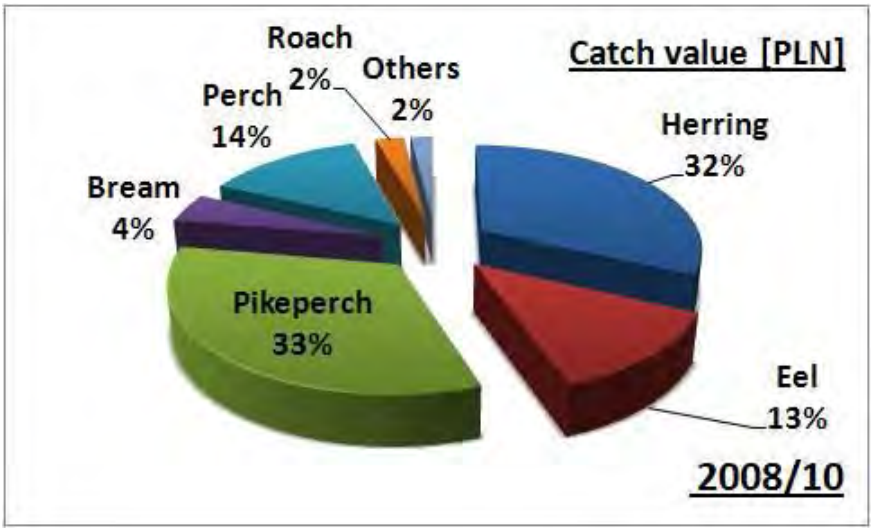
The composition of catches registered in 2010 (see table below) indicate that, in addition to herring, roach and perch are important.

Catches of fish in the Vistula Lagoon in 2010

	Catches in the Polish part of the lagoon [kg]	Catches in the Russian part of the lagoon [kg]	Share of Polish catches in the total catches in the Vistula Lagoon [%]
Eel	9 793	15 479	38.8
Pikeperch	65 122	135 000	32.5
Bream	109 339	273 395	28.6
Ziege	19 174	68 165	
Perch	80 199	30 570	72.4
Roach	95 772	72 832	56.8
Smelt	401		
Pike	113	169	
Tench	529		
Crucian carp	14 474		
White bream	15 538		
Burbot	701	332	
Round goby	634		
Flounder	9 720		
Herring	1 637 003	1 997 453	45.0
Other		11 098	
Salmon [indiv.]	17		
Sea trout [indiv.]	241		
Total	2 317 157	2 604 493	
Total without herring	680 154	607 040	52.8

According to data from the Fisheries Monitoring Center (FMC) and RMFI. Data from the Russian part the lagoon are based in the results of ichthyological studies forwarded by ATLATNIRO as required by the Joint Commission.

Considering the mean sale price of fish, the revenues from the various species differ. Despite small catches of eel, the high sale price for this fish means that it retains its significant revenue position. Similarly, the nearly twenty-fold higher sale price that fishers can command per kg of pikeperch equalizes the small catches and places this species on a par with the revenues earned from high herring catches. Significant revenues are also earned from the sale of perch, which contrasts with those for roach since the sale price is severalfold lower than that of perch.

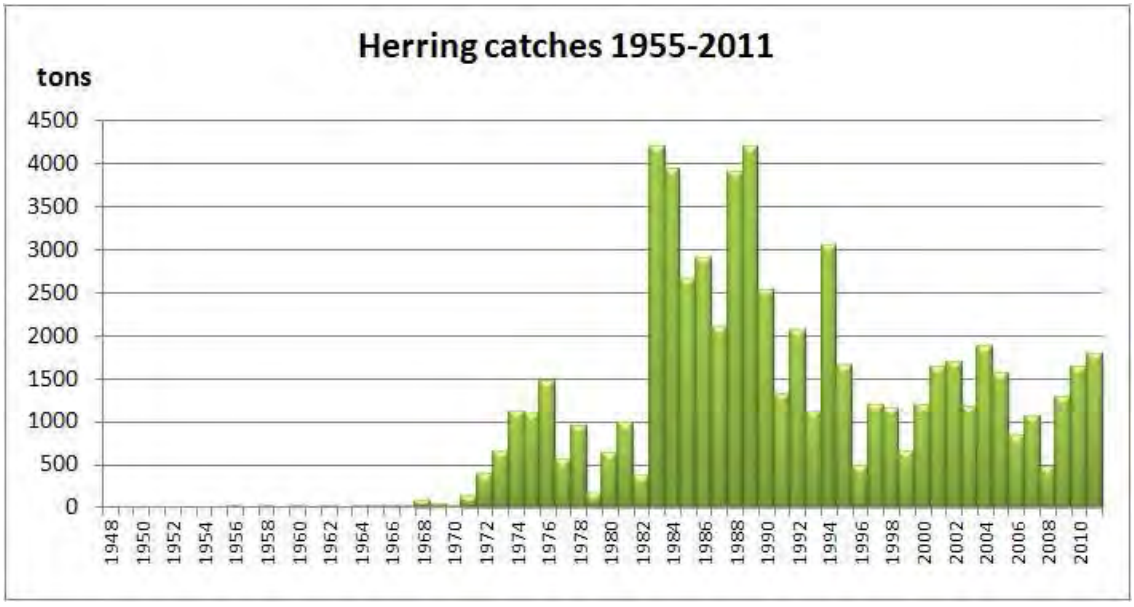


Mean catches in 2008/2010 in terms of revenue

Herring

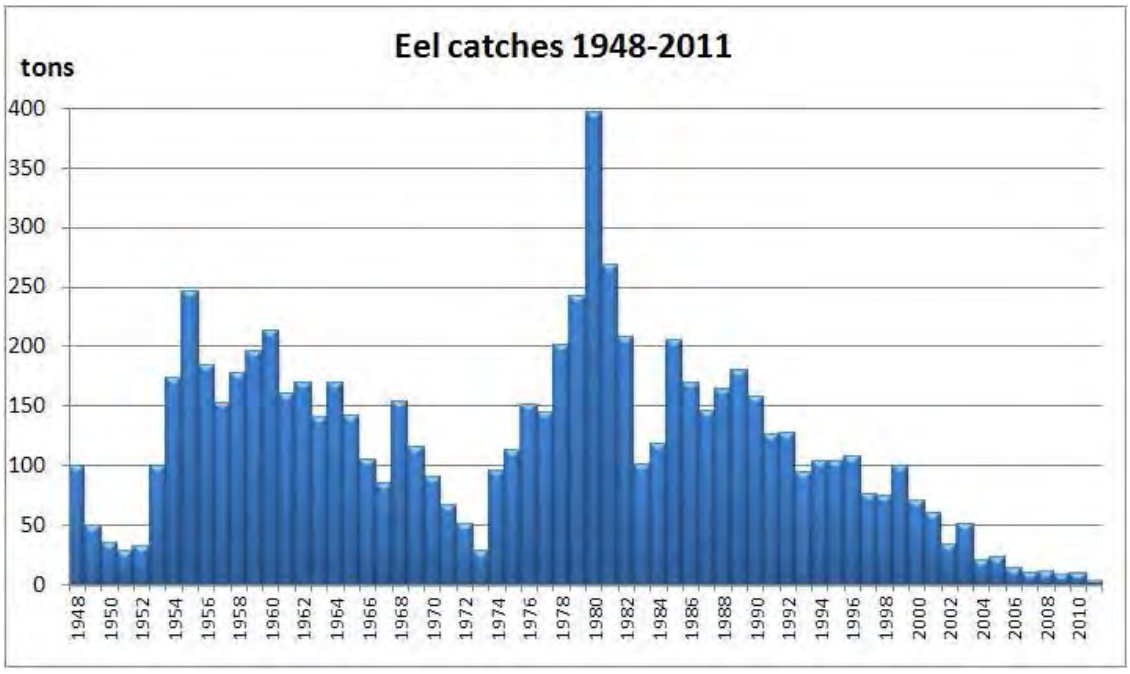
Over the course of sixty years, the most important aspect of herring catches has been its dynamics. Notable landings were recorded in the early 1970s, but herring catches have fluctuated strongly, and have been very weak in some years (e.g., 1977-1982, 1996, 1999). These changes have been studied by Russian scientists since herring plays an important role in the former Soviet and current Russian fishery in the Vistula Lagoon. Generally, temperature and salinity provide the most important information for herring spawners, which have to pass through the narrow Piława Straits (400 m wide) to reach the Vistula Lagoon. Landings in the Polish part of the lagoon do not precisely reflect the size of spawning aggregations over the year since catches are largely dependent on transport capacity and market demand. Just a few years ago, newly-designed gear targeting herring was introduced. Known as the pound net, this gear was popularized by the Russians (Kanin 1950). Previously, herring was caught with fyke nets and gillnets.

Herring catches with pound nets during the spring season



Eel

Eel occupies a special position in Vistula Lagoon fisheries. This fish species is mentioned in the oldest written sources, and it has proved to be the most valuable species for lagoon fisheries (Bartel et al 1996). Eel catches were the highest in the mid 1950s, but they have exhibited a steadily decreasing trend since 1980.

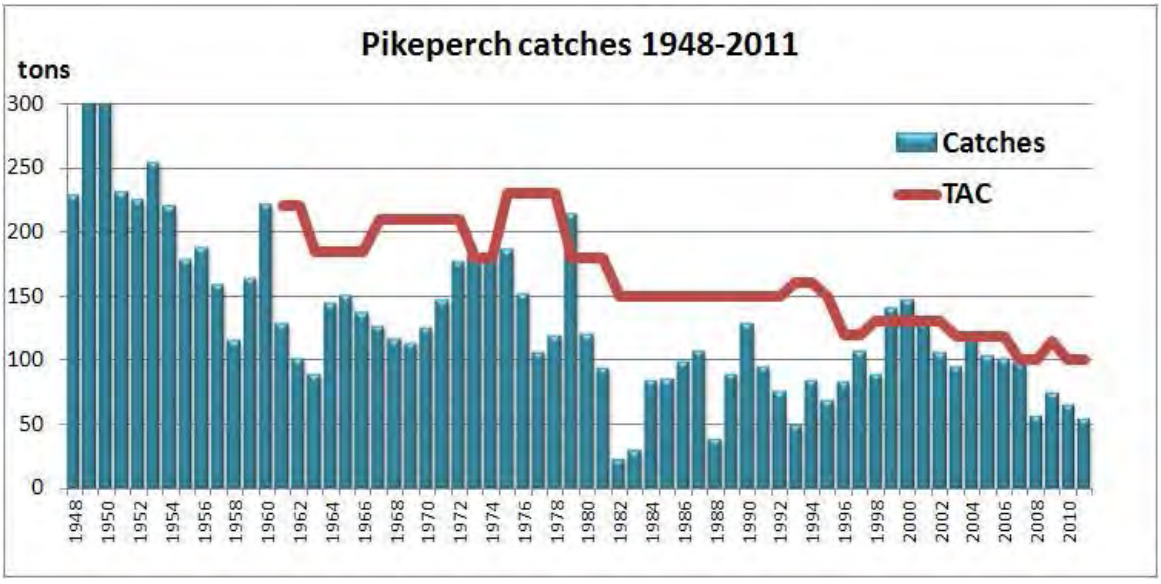


Until the late 1970s, the eel fishery was based on yellow eels. September was a closed moth to this fishery, which meant that most eel were landed in the spring-summer period (Filuk 1965, Filuk 1973). This situation changed dramatically, and the most important eel fishing period shifted to the fall in September and October with huge catches of migrating silver eels. This was clearly

linked to glass eel stocking that began in 1970 (Filuk and Draganik 1980). Prior to the stocking program, the fish originated from natural recruitment in the Piława Straits, the Vistula River, or from stocking programs conducted in the inland waters of Poland. The shift in the characteristics of commercial catches was noted as early as 1973, when eel from age class 3 appeared in the catches (Filuk 1978). The estimated stocking efficiency indicated that one unit of glass eel biomass returned 120 units of marketable eel after nine years (Filuk and Draganik 1980, Draganik 1996). Due to a lack of funding, stocking was concluded in 1994, and by 2000, landings had decreased dramatically (Psuty and Draganik 2008b). Low profitability caused a decrease in fyke net fishing effort except close to the border area. Stocking in the Polish part of the Vistula Lagoon was begun again in 2005 with cultured eel, and from 2009 additional measures began to be implemented as part of the European Eel Management Plan (Council Regulation (EC) No. 1100/2007 of 18 September 2007 to establish measures for the recovery of the stock of European eel).

Pikeperch

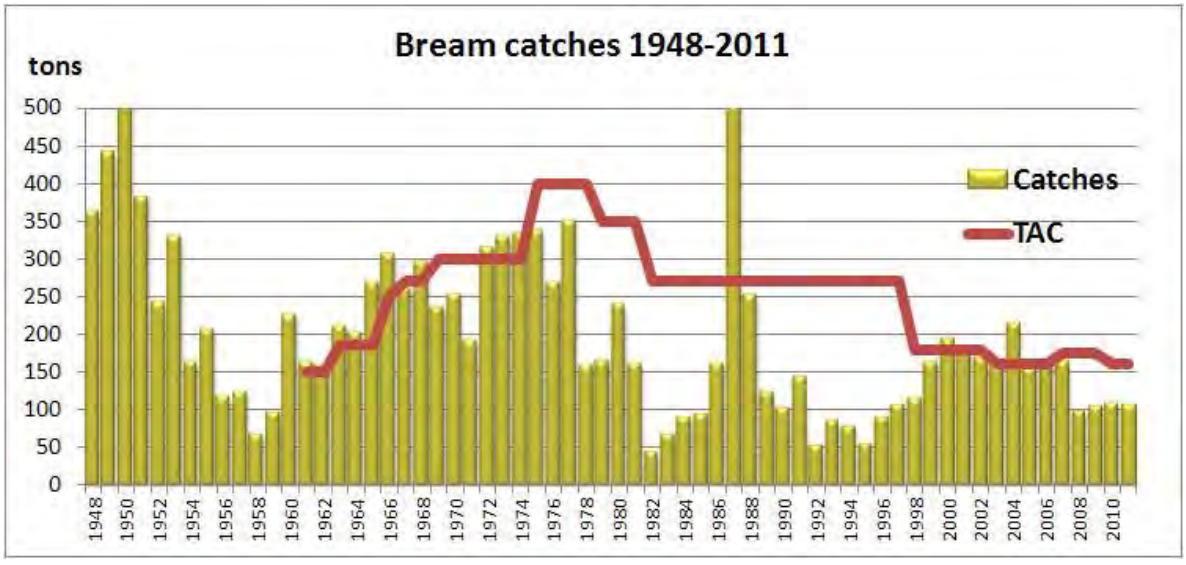
Pikeperch is caught mainly with gillnets, with an approximate 5% of the catch of this species from fyke net fishing targeting eel (Psuty-Lipska 2005). Changes in minimum landing length (MLL) impacted the characteristics of commercial landings. Despite catch limits, the length and age frequency of the exploited population has narrowed over the years from the occurrence of several year classes to only two or three (age groups 3 to 5). It is hypothesized that huge loads of nutrients in the late 1970s and early 1980s (Pliński 2005) caused dramatic decreases in the stock, but no direct research has yet confirmed this.



During the 1990s, some stock recovery was noted (Golubkova et al. 2005), but decreases in eel populations resulting from discontinued stocking, the fishing effort turned to pikeperch. Once again, both the age and length frequencies narrowed. Although the abundance indexes of young-of-the-year (YOY) and age class 1 fish are high, which indicates that spawning is successful almost annually, there is a considerable decrease in the abundance of older fish (Psuty and Wilkońska 2009). This has likely resulted from pikeperch by-catch in gillnets and fyke nets targeting perch (Psuty-Lipska 2003). In the author's opinion, this will cause the pikeperch stock to collapse in approximately five to ten years unless the fisheries administration increases monitoring of fish markets to reduce demand for undersized pikeperch.

Bream

Bream exploitation is connected to that of pikeperch since the same gillnets are used for both species. The length and age structures of landings were flattened except during the 1970s and 1980s, probably due to the loss of macrophyte spawning substrates, even though catch statistics did not decrease until after the 1970s (1982-1985 and 1992-1996). The most frequently caught age classes were 4, 5, and 6 (Psuty 2010). The reasons for the narrow shape of the length catch curves in the 1970s are not clear; this could have been caused by closed season limitations since the larger, older fish were more readily available to the Polish fishery close to the spawning period. In comparison with the 1950s and 1960s, the differences in length ranges beginning in the 1990s were connected with the increase of MLL and true market demand. Currently, bream under approximately 45 cm TL are not of a sufficient price, thus smaller fish are often discarded. Consequently, the exploited bream stock now comprises many year-classes with a notable part of the fish aged 13+ and older.



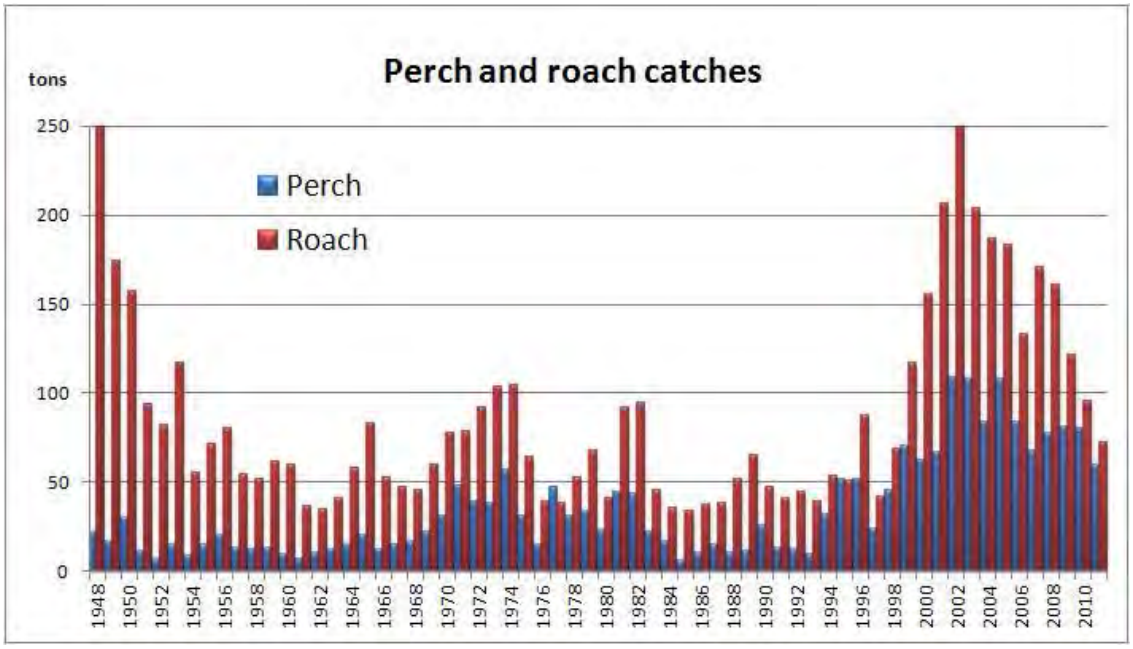
Perch

Until the mid-1990s, perch was not targeted directly and was usually considered to be an undesirable, unwanted by-catch species. The smallest perch class was considered to be trash fish that competed for pike and pikeperch food and habitats. In an effort to reduce the numbers of perch, ruffe, and stickleback from the Vistula Lagoon, catches were made with small-sized beach seines. The low price paid for this third-class fish meant that fishers were unwilling to help with this project. However, thanks to their good export price, perch became a targeted species. Gillnets targeting perch have been employed in large quantities since 1994, and perch landing records therefore likely reflect economic factors.

Mixture of perch and roach in catches

Roach

Roach has traditionally been a by-catch species in fyke net fisheries. This species has never had an MLL in the Vistula Lagoon. Although landing statistics from the past 60 years have fluctuated significantly, this was not linked to changes in either fishery gear or prices. Thus, roach is one of several species for which long-term trends in official records could be viewed as a true index of population size.



Other fish species

At the end of World War II, habitat conditions were optimal for pike reproduction as well as larval and juvenile growth since the levee separating the Vistula Lagoon from the Żuławy depression had been destroyed (the area between the Vistula and Nogat rivers). This area provided good spawning areas and conditions for YOY feeding. Pike catches decreased as early as in the 1950s. Neither stocking programs nor the enforcement of new protection guidelines including a total ban on pike catches using specialized gear produced anticipated results. Currently, pike is rare in the Vistula Lagoon although stocking efforts have been undertaken for some years.

Anadromous species such as vimba, trout, and lamprey have been noted to spawn in the Vistula Lagoon tributaries in the past, especially in the Pasłęka River. The river was dammed in Braniewo, and the fish pass which allows fish to move upstream to spawning grounds only became operational in 2001. Trout was stocked in the Pasłęka and Bauda rivers in some years. Anadromous species are caught locally (close to rivers) and fishing seasons are only during spawning migrations. Lamprey catches were high in some years, and lamprey have always been landed to meet market demand. Thus, lamprey landing records are rather reliable, and they can be regarded as stock size estimates. Lamprey are now protected because of their vulnerable status and are threatened in Poland (Polish Red Book 2001).

Although natural spawning conditions for carp are unsuitable in the north of Poland, farming is common in mid and southern Poland. This species has been stocked irregularly using age class 2 fish and YOY in some periods (Psuty 2010). Carp is considered to be difficult to catch in natural aquatic basins, so no permanent stocking of this species has been performed. Landing records indicate that only a small amount of carp was caught in the years when stocking was performed.

Lamprey (in the middle of photo) from the Vistula Lagoon

Ziege was a common species in the southern Baltic in the nineteenth century, and it was reported in German landing statistics from the Vistula Lagoon (Bartel et al. 1996). Ziege did not appear in Polish lagoon catch records before 1985, but once it did, the quantities of it were quite large. This is a problem in Poland, because ziege is on the list of endangered fish species. Many letters were sent to the authorities requesting permission for fishers to catch ziege without penalty, and in 1987, the Vistula Lagoon ziege was removed from the list of protected species. The reason behind the abundance of ziege in the Vistula Lagoon remains unclear. It is only caught as by-catch in both small-sized gillnet and fyke net fisheries. Although the price for ziege is not high, it is sufficient to get it to wholesalers. Hence, landing records are correlated with both fish species abundance and gear effort. Monitoring of fyke net catches suggested an increasing trend in ziege numbers during the 1995-2006 period.

The round goby is a non-indigenous species that was observed for the first time in the lagoon in 1997 (Borowski 1999). Its numbers increased over the subsequent four to five years to a notable level, and this species has become a stable part of fyke net catches. In the case of the round goby, catch statistics indicate the timing of its increase; however, they do not reflect the actual abundance. Currently, some wholesalers buy it from fishers, while others do not. Observations of fyke net catches indicate that shortly after their invasion, the abundance of round goby increased rapidly, but that it had stabilized by 2002.

Round goby – a new fish component (from 1997) in the Vistula Lagoon

Flounder is a marine species, but it has formed a local brackish water population. In the last decade, the number of specimens caught in fyke nets has increased, but the size of the fish is small compared with those in nearby coastal sea catches (Psuty and Wilkońska 2009). Thus, fishers discard lagoon flounder as there is no market demand for fish smaller than 23-25 cm TL. Landings recorded over the last three years likely reflect an erroneous allocation of fishing effort on the new reporting forms rather than the real species catch in the Vistula Lagoon (Jachimowicz, personal communication). On the other hand, a great number of newcomers, such as the shrimp *Palaemon elegans* (Jażdżewski et al. 2005), made the Vistula Lagoon more beneficial for this species.

Smelt and ruffe have been caught as by-catch for the past 60 years, but the use of these species has differed over time. When the economy was centrally planned, ruffe, together with small perch and stickleback, were considered to be pests since they competed with pikeperch for food and preyed on the eggs and larvae of other species. For some years, the administration attempted to perform special fishing using trawls and beach seines and then send the catch to the cooperative for processing through the brokerage of a governmental agency. In reality, however, management was not a priority. It should be mentioned that under German management prior to World War II, ruffe was one of the most common species landed from small-sized trawls. Although smelt is popular in the Russian market, the higher landings in the Polish waters of lagoon should be viewed as incidental and not dependent on the real abundance of the species.

Typical mixture of fish species in fyke net catches

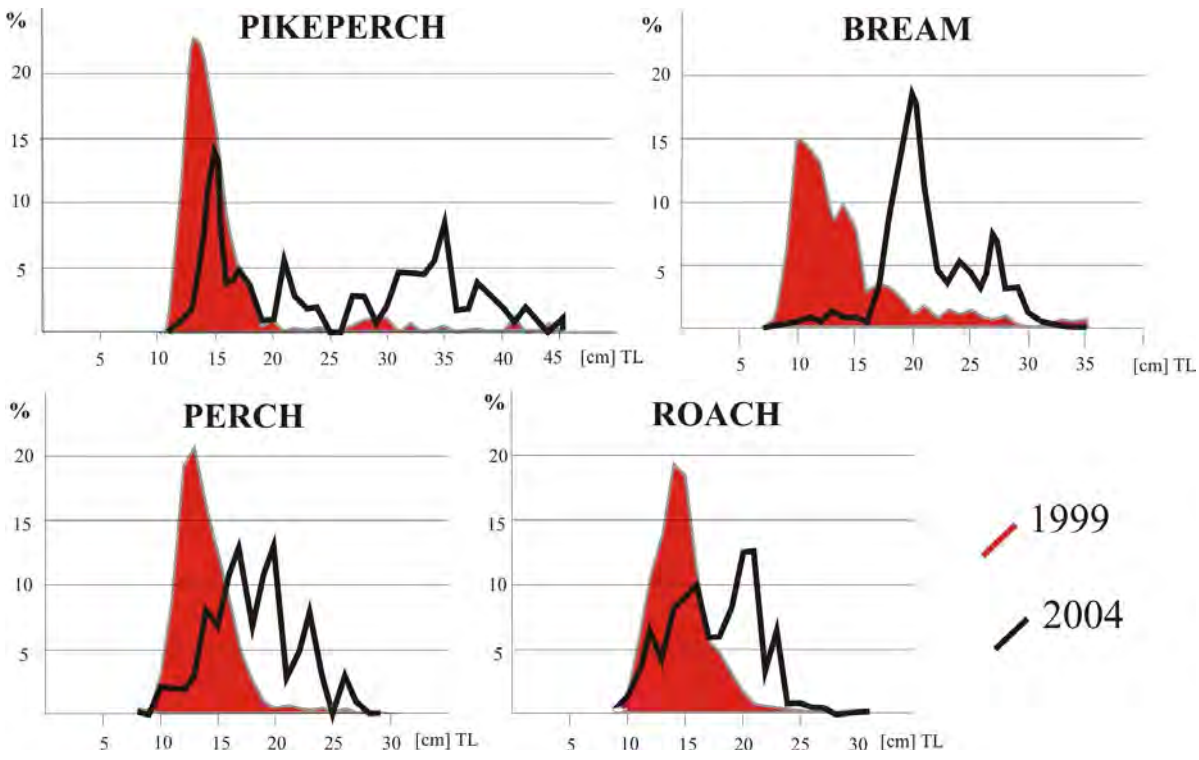
5. Impact of fisheries on fish species structure and the natural environment

The impact of fisheries on the natural environment depends on the types of fishing gear used. The most destructive fishing gears in the Vistula Lagoon were banned by the mid 1970s. Increased profitability from eel fyke net fisheries combined with new methods for protecting gears from algal overgrowth (tributyltin oxide - TBTO) led to the widespread use of these gears. TBTO, which is an organotin compound, was used widely as a component in exterior vessel paints. Since it can bioaccumulate in aquatic organisms causing neurotoxic, hormonal, and genetic pathology (Zaucha and Matulaniec 1997), the use of this compound was banned in 2001 by the International Maritime Organization (IMO); however, it is not known how much TBTO has remained in the bottom sediments of the Vistula Lagoon.

The intense use of fyke nets targeting eel caused large quantities of other species of fish fry to be caught, including that of pikeperch and bream. It should be underscored that the number share of eel in total catches in the 1995-2003 period ranged from 1% to a maximum of 5% of all fish (Borowski and Dąbrowski 1998). The fish discarded after catches are sorted dry aboard vessels are either already dead or stunned. Aquatic birds, mainly gulls, take advantage of this causing increased fish mortality that is not calculated as part of catch mortality. In light of this negative impact, the Sea Fisheries Institute (now the National Marine Fisheries Research Institute) conducted a range of studies in the 1995-2000 period with the aim of improving the selectivity of eel fyke nets. The selective sieve, which was the solution developed through this research, is now required in all fyke

nets used in the Polish part of the Vistula Lagoon (Draganik et al 2004, Psuty-Lipska and Draganik 2005).

Discards from fyke net catches



Fish length distribution in fyke net catches with and without selective sieves
1999 – fyke net catches before the introduction of sieves into common use.
2004 – catches with fyke nets equipped with selective sieves (Draganik et al. 2004)

The lack of alternative, efficient, and profitable fishing tactics following the decrease in eel biomass resulted in the occurrence of another problem linked to the selectivity of gears. Many fishers seeking ways to maintain reasonable revenues in the face of limited access to resources began using gears that are commonly known in Polish as *okoniówki*, or perch nets. These are gill nets of diverse construction with mesh bar lengths of 36 mm. Until the early 1990s, these types of nets were used infrequently, but increased market demand for perch and the lack of a profitable alternative resulted in an increase of catch effort targeting this species. Unfortunately, under the conditions in the Vistula Lagoon, no gear is selective with regard to single species. Studies conducted in 1999 and 2000 indicated that gill nets with a mesh size of 36 mm capture not only perch and roach, but, most importantly, a large number of pikeperch under the minimum protected size (Psuty-Lipska 2003). The negative impact of small-mesh nets is not the same with regard to catch location or month. The largest share of pikeperch is recorded in late spring in May and June, which is also the period during which the lowest yield is noted for perch and roach.

6. Social aspects of fisheries management in the Vistula Lagoon

The southern part of the Vistula Lagoon lies within the Warmia and Mazury Voivodeship, which has one of the highest rates of unemployment in Poland. However, the magnitude of this problem varies widely in the municipalities located along the shores of the Vistula Lagoon. The highest unemployment is in Braniewo, where the unemployment rate was 18.3% as of 31.12.2008. A large number of the unemployed are persons living in rural areas where former state-run farms, cooperatives and other enterprises were formerly the main employers.

The attitudes of unemployed persons often include a lack of initiative and feelings of helplessness. On the other hand, a learned sense of helplessness can be a strategy for more easily taking advantage of the social services offered by social welfare institutions. Simultaneously, many small enterprises that were established in the mid 1990s have been liquidated.

Residents of the rural municipality of Elbląg are in a better position since unemployment there is the lowest of the four municipalities located on the lagoon (9.4% as of 31.12.2008). This is certainly impacted by the proximity of the large urban center of the city of Elbląg. Most of the enterprises in the municipalities located on the lagoon are small and are often single-person businesses based on self-employment or small family-run businesses. The only large industrial enterprise in the region is the fish processing concern Masfrost Ltd. in Tolkmicko. The development of more intense industrial activity is not possible in this region because of limitations imposed by the Natura 2000 program to conserve the natural environment as well as regulations requiring the

preservation of architectural monuments. Thus, the largest employers in this area are local schools, hospitals, and municipal services. The economic engine in some areas, such as Frombork and Kadyny, is the tourism sector. Restaurants and food service outlets, private room rental, hotels, bed and breakfast inns, and camping grounds offer tourists a wide range of accommodation standards. One example of developing tourism potential is the coastal town of Suchacz, where a small yacht harbor and essential infrastructure were recently created. This is key since it provides an alternative to fisheries as a way of utilizing the Vistula Lagoon.

The majority of the unemployed are persons with the least education from rural areas. Unemployment among women is always higher since they have little opportunity of finding employment on the dynamic job market, especially following long periods away from the workforce for maternity leave and child rearing.

Selected indexes describing the municipal communities with direct access to the Vistula Lagoon as of 31.12.2008 (source: Local Data Bank, Central Statistical Office)

		Elbląg-rural municipality	Tolkmicko-urban/rural municipality	Frombork-urban/rural municipality	Braniewo-rural municipality	Total
Total population		6,644	6,719	3,715	6,464	23,542
Women per 100 men		96	102	107	96	
Demographic dependency index [persons of non-working age per 100 persons of working age]		52.2	54.6	52.2	57.7	
Percentage the working age population registered as unemployed	Total	9.4	10.2	14.8	18.3	
	Women	11.4	13.0	17.2	23.7	
	Men	7.7	7.8	12.6	13.7	
Polish economic entities in the REGON register	Total	489	472	297	286	
	Physical persons conducting business	356	304	215	226	

The southern shore of the Vistula Lagoon has a long tradition of fisheries. In the aftermath of World War II nearly all of the German fishers were relocated. The abandoned vessels and gear were taken over by the new residents, most of whom had no previous experience with coastal sea fisheries. The formation of fishing cooperatives in which fishers shared commonly-owned gear and vessels was promoted in accordance with the principles of the centrally-planned economy. These principles were quickly applied in practice, and first the gear followed by vessels became the property of the cooperatives. Simultaneously, some fishers chose to operate outside of the Cooperative system and remained outside of it for the duration of the centrally-planned economy. These fishers were, however, required to deliver supplies according to a contract plan. The fishing cooperatives did not survive the economic transformation period. The Zalew Cooperative in Tolkmicko closed in the mid 1990s, while the Kopernik Cooperative in Frombork survived a decade

longer. Although all vessel owners are currently self-employed, social differences remain between the former cooperative fishers from Tolkmicko and Frombork and those who had continued to fish individually. It is perhaps telling that most of the participants in the vessel scrapping program had previously been employed by the cooperative in Tolkmicko. This issue certainly requires further study.

Interviews conducted with fishers from fishing bases in the Vistula Lagoon lead to the conclusion that fishing has played and continues to play a more significant role in local communities than is indicated by statistics. Above all else, fishing remains a family enterprise even if hands-on participation in fishing itself or with fishing gear is limited today. Additionally, more people are hired to perform seasonal work than is evidenced in business costs. This type of undocumented employment is maintained because of the high costs of hiring and employing workers and the restrictions imposed on dismissal. This is especially relevant to fisheries since they are seasonal. During the large-scale herring catches in spring, anybody willing to work for a daily wage is hired for sorting and landing fish, while in other periods, work of this type is paid for in fish. Although the scale of undocumented employment in Vistula Lagoon fisheries remains unknown, the number of conflicts that arose between fishing crews and fishing vessel owners with regard to vessel scrapping or temporary cessation of fishing can be viewed as symptomatic. Since financial compensation was paid to crew members based on proof of legal employment, many of these workers were only entitled to partial compensation or none whatsoever.

Local Fishermen feast (St. Peter and Paul's name days) in Kąty Rybackie

7. Factors other than fisheries impacting fish mortality

Illegal and unreported catches

Discrepancies between catches, as described at the beginning of this section, and fishing statistics have existed since reporting catches was made obligatory. During the period before the World Was II, German catch statistics were based on weekly reporting that did not include fish caught for personal consumption or that which was sold directly by the fishers and their families. In the post-war period of fishing cooperatives and contractual agreements with individual fishers, fisheries statistics were compiled based on fish purchasing. Thus, by definition these could not have comprised data regarding other aspects of the fisheries. In the 1950s and 1960s, fishers had a fish allowance, which was the amount they were allowed to keep for personal use, and despite this amount being prescribed, it was not included in the catch statistics. In the 1970s and later, it was noted that increasing amounts of fish were being sold outside of the official purchasing system. This trend peaked in 1989 when newly-formed private enterprises were not required to report information regarding catches, while the fishing cooperatives had fewer and fewer fishers. In an attempt to bring catch statistics into line with reality, in the 1990s the fisheries administration required field inspectors to include estimated catches in their monthly reports. In 1995, the Directors of the Regional Fisheries Maritime Inspectorate introduced the requirement of submitting statements regarding the size of catches made. This was sanctioned by the Act of 18 January 1996 on marine fisheries, and the Act of 19 February 2004 set forth detailed requirements regarding monthly catch reports, and since then they have been forwarded to the Fisheries Monitoring Center (FMC). Despite statutory obligations to categorize and report catches and to include that retained for personal consumption, this legislation remains ineffective. The catch statistics only reflect those fish whose sale must be documented. The author's own estimates based on observations of fishing, turnover in fish sales, and field interviews indicate that reported catches of pikeperch and eel could be as little as one third of the actual catches. This has a substantial impact on estimated values of catch mortality.

Recreational catches

Recreational fisheries in recent years have grown from cutter and boat fishing to include shore fishing, which is conducted directly from the shore. The greatest concentrations of recreational fishers are near river mouths where they can take advantage of spawning migrations of freshwater fish that inhabit the sea and which are not protected by any closed periods. Ordinance No. 2 of the Director of the Maritime Office of 23 April 2002 which is binding in marine waters

permits sport fishing from vessels of a total length of less than 8 m, from dawn to dusk, when visibility is above 2 nautical miles, winds do not exceed 4°B, and within 2 nautical miles of the shore without special permits. No permit is needed for motorboats with an engine capacity of less than 11 hp. The relatively low cost of recreational fishing permits is also encouraging; annual sea fishing permits cost 49 pln and monthly permits cost 16 pln. Retirees, persons on disability benefits, and students to age 24 pay 31 pln annually. The Marine Fisheries Inspectorates in Frombork and Sztutowo have in the last decade noted severalfold increases in the number of permits issued. In 2008, 661 permits were sold in comparison to just 138 in 1998. Preliminary research results by Ramutkowski (2008) permit concluding that the mean annual catches of pikeperch and perch at Różaniec, the most popular recreational fishing grounds in the Vistula Lagoon, was 6.5 tons. In comparison to commercial fisheries, this is not a significant amount, but the growing popularity of the lagoon among recreational fishers must be borne in mind.

Mortality caused by aquatic birds

The largest great cormorant breeding colony in Europe is in Kąty Rybacki on the Vistula Spit. This is also where more than half of the cormorant breeding population is located in Poland. The Kąty Rybacki cormorant colony began to grow rapidly in the early 1990s, and by 1998 it numbered 6,337 pairs, while by 2005-2006 this number had increased to 11,500 pairs (HELCOM Indicator Fact Sheets). No other colony in Europe has previously numbered so many pairs of cormorants. The birds in this colony feed in both the Vistula Lagoon and in the Gdańsk Bay. It is estimated that annually during the breeding season 65% of feeding flights are undertaken in the direction of the Vistula Lagoon, while the remaining 35% are taken to the Gdańsk Bay (Bzoma et al. 2003). Cormorants are opportunistic feeders, which means that the numbers of their prey are usually proportional to fish assemblage species structure. Colony development is only possible when feeding conditions are suitable. In the case of Kąty Rybacki, a variety of factors contributed to this including the mass occurrence of ruffe in the Vistula Lagoon and the ecological success of a newcomer – the round goby (Borowski 1999). These two species comprised the basic diet of the great cormorant. Of course, these birds also feed on other fish species, including eel. Wziątek (2002) published a detailed analysis of the food composition of the great cormorants from the Kąty Rybacki colony in the 1998-2000 period, and calculated that 52 tons of eel with a mean weight of about 300 g fall prey to these birds annually. Bzoma (2008) estimates that in the region of the Gdańsk Bay and the Vistula Lagoon, non-breeding great cormorants consumed from one to seven tons of eel annually in the 2005-2006 period, while another 20 tons were caught by the great cormorants from Kąty Rybacki.

Ligthouse in the middle of Lagoon

The pressure from other piscivorous birds is limited to their feeding on the half of the eel catch that is discarded from eel fyke nets. Dead or stunned fish that are sorted dry aboard vessels and then discarded overboard usually drift on the water surface. The majority of these fish, but especially juvenile pikeperch, need at least a minute before they can take cover beneath the water surface. Unfortunately, the time in which it takes gulls to attack is usually much shorter. It is estimated that, especially during summer among some species, mortality from having been caught in fyke nets and avian pressure could be as high as 100%.

Gulls feeding on fyke net discards immediately after sorting aboard vessels

Mortality caused by pathogens

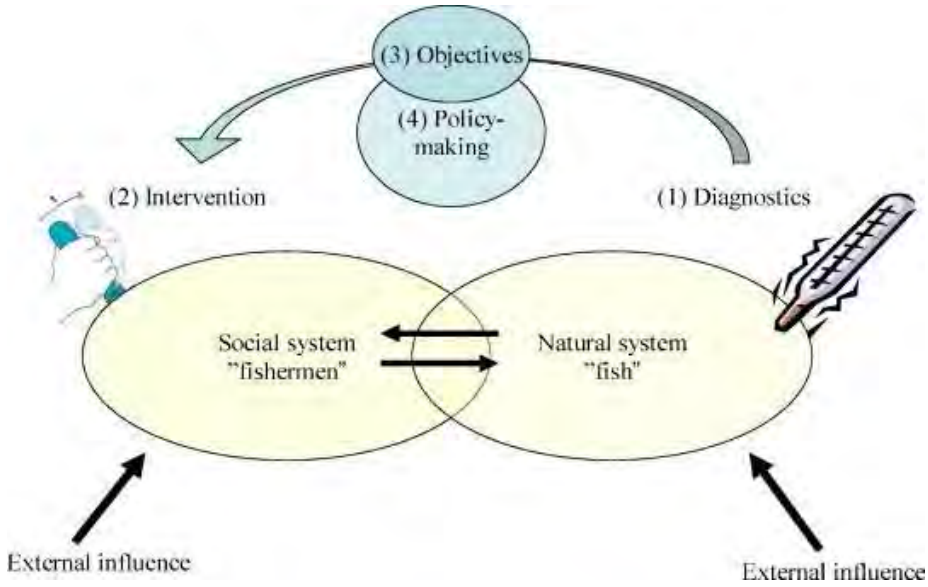
Since the Vistula Lagoon was heavily polluted, especially in the 1980s, the fish inhabiting it faced significant threats of bacterial, viral, and fungal infections. These infections manifest as various types of skin spots and ulcerations. *Anguilicolla crassus*, an alien eel swim bladder parasite, was also noted during this period, and this parasitic infection is believed to be one of the main reasons that eel stocks have declined. This nematode was introduced in Europe in the early 1980s from Asia, and it quickly spread to infect a large segment of the European eel population on the continent. The immediate cause of weakness in infected fish is the way this nematode feeds slowly on the hosts blood causing energy loss. This parasite can also inflict damage to the swim bladder itself (Palstra et al. 2007). Parasite infection in Vistula Lagoon eel is currently estimated to be nearly 40% of the overall population.

Black spot disease is another common disease among fish that occurs on a massive scale among perch during the summer. This disease is caused by *Posthodiplostomum cuticola* fluke metacercariae for which fish are the intermediate host following snails (Prost 1994). This causes weakness and can lead to death; it also means that such unattractive fish cannot be sold.

Roach from the Vistula Lagoon with black spot disease

8. Protection of Vistula Lagoon fish resources

The Vistula Lagoon fisheries administration developed a relatively effective, traditional management system in the post-war period that included elements which permitted it to adapt to changing environmental and economic conditions.



Fisheries resource management as a system of feed-back control imposed on a fishery (Nielsen and Holm 2007)

Vistula Lagoon fisheries are currently regulated with the following measures:

- limiting fishing effort – number of vessels, maximum number of fishing gear per vessel, length of net sets and fyke nets;
- designating minimum protected fish size and the associated minimum mesh size in gillnets;
- requiring the installation of protective sieves in the last chamber of fyke nets from 1 June to 31 December;
- limiting regions in which small-mesh gillnets (perch-roach nets) can be used;
- designating gear-free zones in waters known as mass fish migration corridors;
- designating spawning ground and river mouth protected areas;
- designating closed seasons for pike, pikeperch, bream, sea trout, salmon, and eel;
- catch limits or Total Allowable Catch (TAC) for bream and pikeperch set by the Polish-Russian Joint Commission for Vistula Lagoon Fisheries.

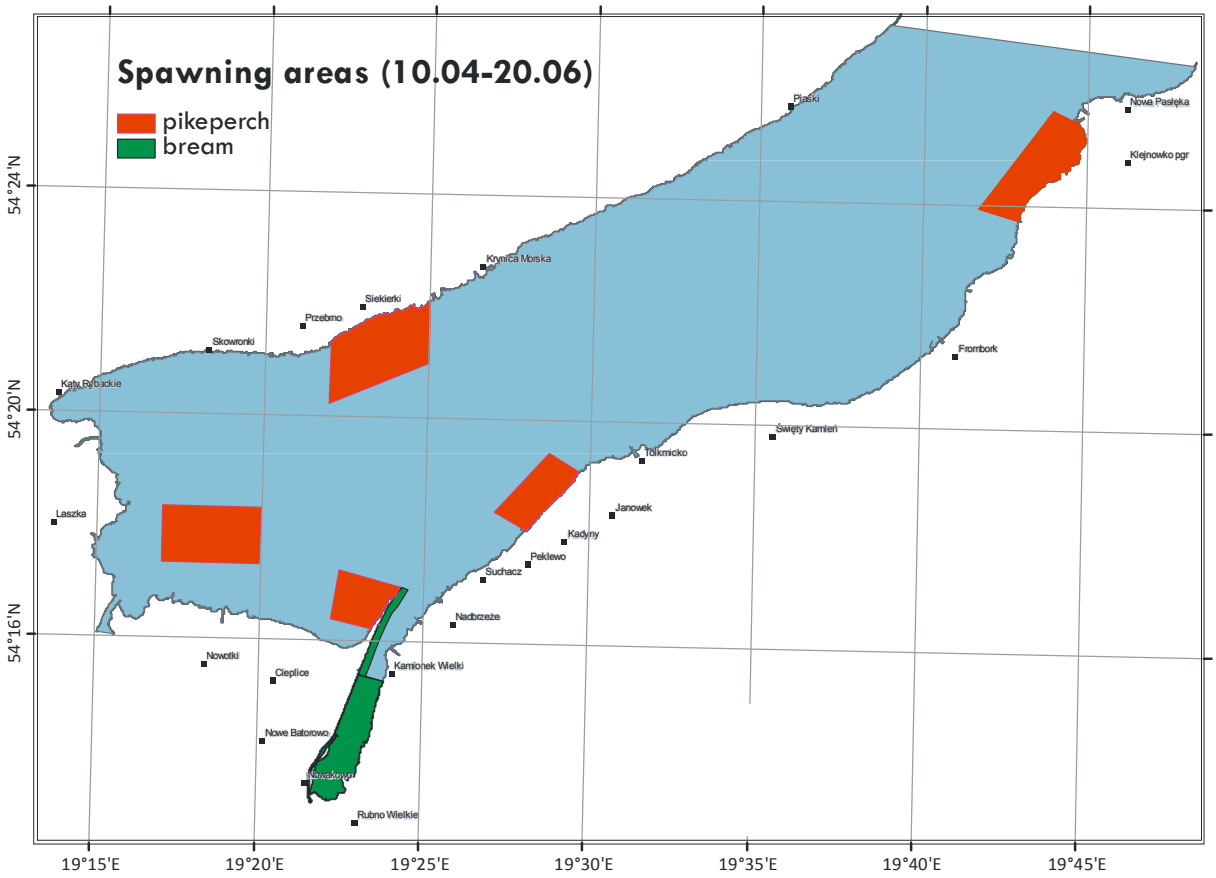
Numerous interviews and observations conducted on this topic indicate that as long as there is demand for undersized fish, the effectiveness of the measures outlined above will be insufficient.

More effective monitoring at all stages of the fish trade, in addition to existing monitoring of catches and first sales, could likely produce better results.

Protected spawning areas

The state of pikeperch and bream resources depends on their successful spawning in the shallow regions of the Polish part of the lagoon. The state of these spawning grounds, in turn, is determined largely by the physicochemical conditions of the aquatic environment and the substrates on which the fish deposit their eggs. In order for spawning to be successful, conditions must allow the spawn to be deposited on suitable environmental substrates with properties that allow for the optimal development not only of eggs, but also of the subsequent developmental stages of hatch, larval, and juvenile stages.

Six spawning ground areas are protected periodically throughout the lagoon, but one was temporarily degraded from dredging in the Elbląg Canal in the 1994-1997 period. Fishing is closed in these areas from 10 April to 20 June.



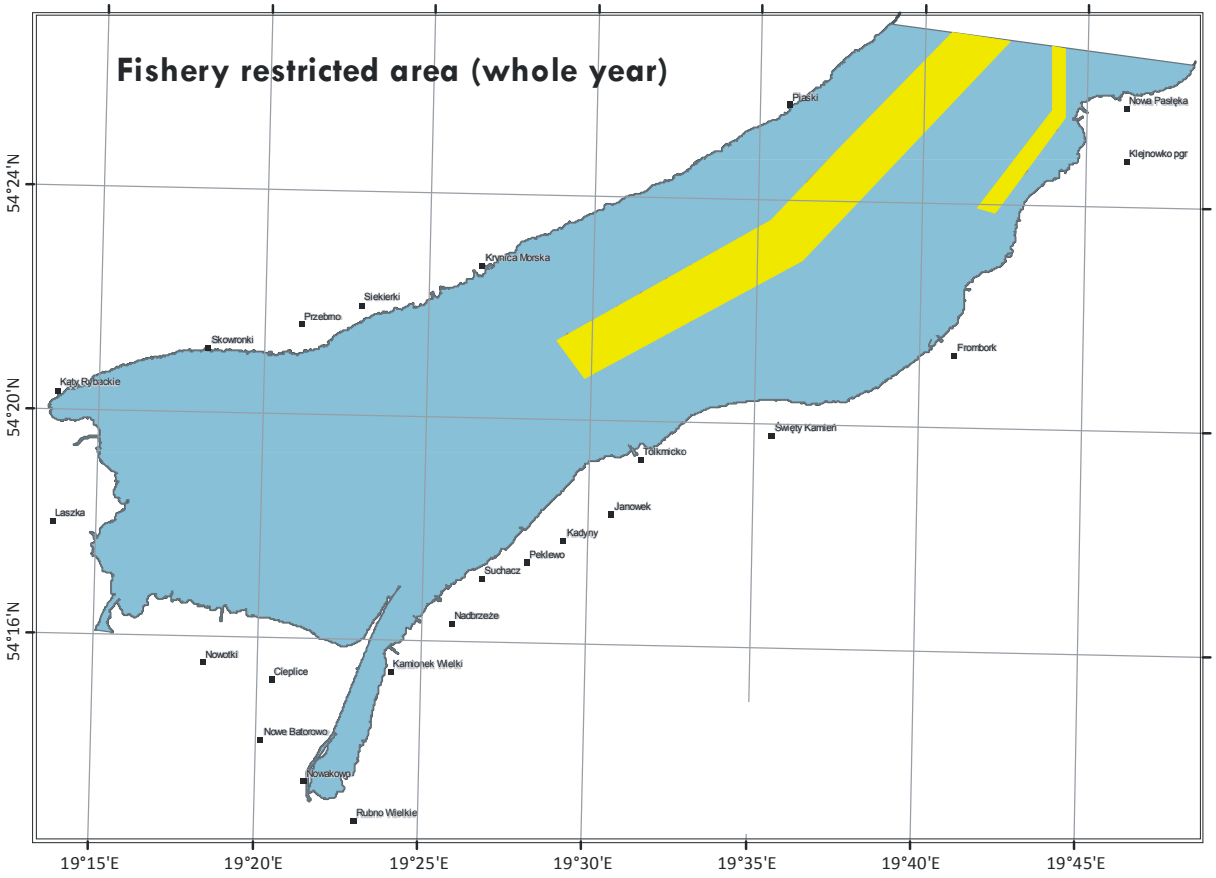
Areas closed to fishery because of pikeperch and bream spawning

The closed bream and pikeperch spawning grounds are susceptible to poaching since nearly all of these areas are easily accessible even to those without vessels because of the very shallow depths in the coastal zone. However, when evaluating the scale of poaching in this regions, one has to consider the poaching committed by commercial fishers using professional gear rather than that of traditional poachers. It must be emphasized that increased poaching in closed periods of pikeperch and bream spawning has been curtailed effectively in recent years. This has been possible thanks to outfitting fisheries inspectors with very fast patrol boats, as well as more intense monitoring with the assistance of Border Guard functionaries and, in the western part of the lagoon, officers of both the Polish Angling Association and the National Fisheries Guard.

Fisheries inspectors patrol boats

Year-round protected corridors

Two corridors have been established in the Vistula Lagoon in an effort to ensure unhindered fish migrations in the border zone, where the most intense fishing pressure is since this area provides the highest catch yields. The northern corridor is 1500 m wide and extends from the Polish border to the Tolkmicko-Krynica Morska fairway. The southern corridor is 600 m wide and extends from the Polish border to the spawning grounds located in the coastal zone known as the Różaniec spawning grounds. These two regions are closed to fishing and the use of any type of gear is banned throughout the year.



Fish migration areas closed to fisheries in the Vistula Lagoon

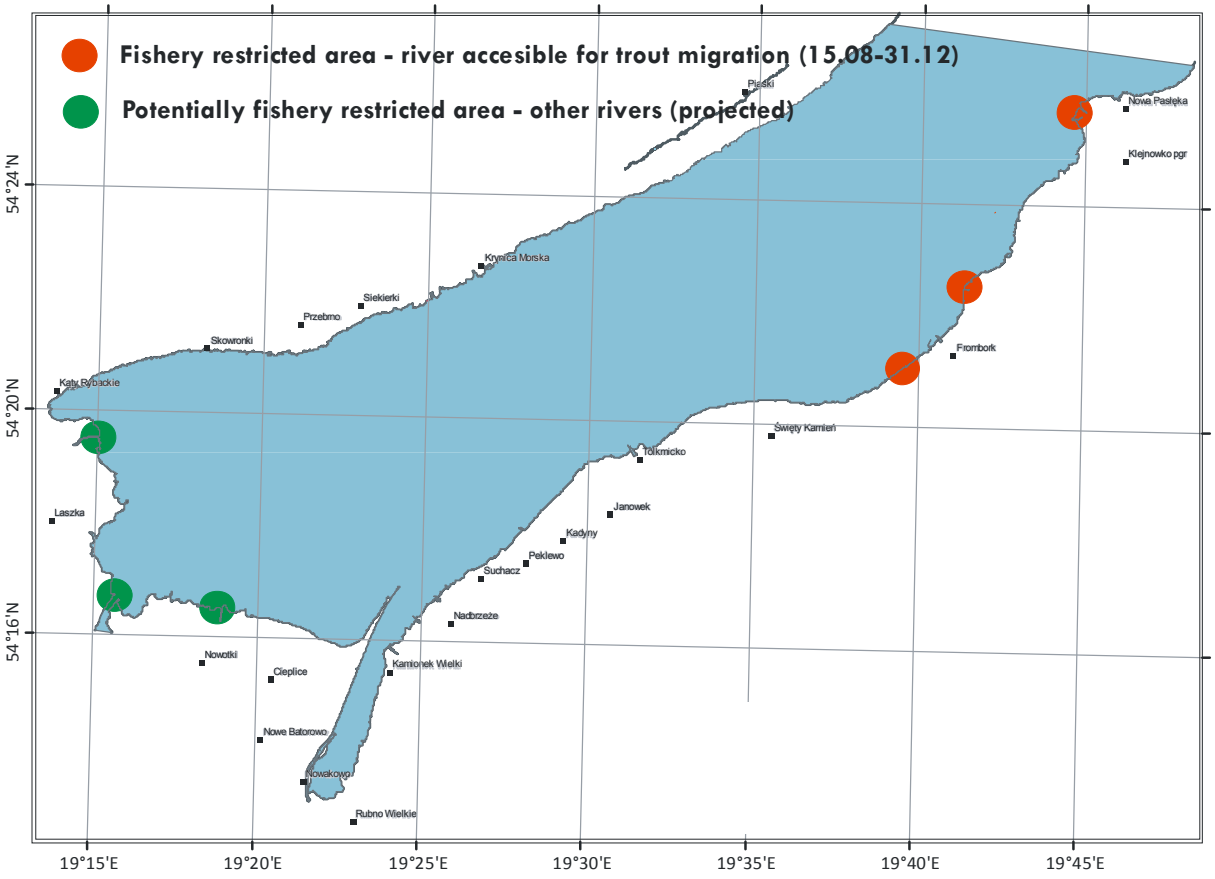
These closed areas are located far from the shore which means they are subjected almost exclusively to poaching committed by commercial fishers. For many years the northern corridor in the border zone in the immediate vicinity of the Russian side was the focus of interest of a certain group of fishers. The gear here was set without any signs on the water surface, and in order to locate gear that had been set here in violation of regulations small floating corks, reeds, or sticks were used. GPS devices have begun to be used recently thus eliminating the need for any water surface makings of net locations.

With Polish accession to the European Union and the extension of the Schengen Area to the border fishing grounds, the closed areas have come under 24-hour monitoring with cameras, radar, night-vision equipment, modern vessels, hovercraft, and aerial patrols. Daily information exchange between the Marine Fisheries Inspectorate and the Marine Unit of the Border Guards has led to substantial reduction in illegal fishing in the lagoon. Awareness has grown in the fishing community that the free movement of fishes in closed corridors leads to increased catches in fishing grounds located farther from the state border.

Protected areas near river mouths

An ordinance issued by the Regional Maritime Fisheries Inspectorate in Gdynia designated closed areas in the Vistula Lagoon in the vicinity of river mouths in order to protect spawning migrations of sea trout ascending rivers. Fishing in these areas is closed from 15 August to 31 December. Upon the initiative of the Polish Angling Association and the observation that fish other than commercial species require protection, other river segments near mouths must be closed to fisheries exploitation. Such areas will most likely be designated within the framework of the Protection Plan currently in development for the Natura 2000 Vistula Lagoon and Vistula Spit regions.

Protected areas near the mouths of the rivers Narusa and Bauda are virtually inaccessible to commercial fishers or any type of vessel because of the shallow water depths. The Pasłęka River mouth on the lagoon side is somewhat deeper which permits setting fishing gear. Fishing grounds in protected areas near river mouths have not been of much interest to either poachers or commercial fishers in recent years since brook lamprey was placed under full protection. The mouths of the Bauda and Pasłęka rivers are both in the border area and are thus monitored by the Border Guard and the numerous recreational fishers there who report their observations on an ongoing basis to inspectors from the Polish Angling Association and the Marine Fisheries Inspectorate in Frombork.



Minimum fish sizes and closed seasons

According to an ordinance issued by the Regional Maritime Fisheries Inspectorate in Gdynia, catches of the following fish species are forbidden in the Vistula Lagoon if the lengths measured from the beginning of the head to the end of the longest tail fin ray are less than that given as follows:

- salmon (Salmo sala L.) - 60 cm
- sea trout (Salmo truta L.) - 50 cm
- eel (Anguilla Anguilla L.) - 50 cm
- pikeperch (Stisostedion lucioperca L.) - 46 cm
- pike (Esox lucius L.) - 45 cm
- bream (Abramis brama L.) - 35 cm
- common carp (Cyprinus Carpio L.) - 30 cm
- tench (Tica tinca L.) - 28 cm
- crucian carp (Carasius sp) - 20 cm

This regulation also bans catches of the following species in the periods specified:

- pikeperch and bream from 20 April to 10 June;
- pike from 1 March to 30 April.

The premise of minimum fish lengths is that they permit given individuals to spawn at least once during their life cycle. In the case of species such as perch or roach, for which no minimum size has been designated, market demand force fishers to catch and trade fish that are relatively large.

The minimum length of bream is 35 cm, and since there is very little demand for fish under 40 cm in length, this regulation is generally obeyed.

The minimum eel size until 2010 was 50 cm, which was also the highest for this species in all of Poland. In other basins the minimum eel length is sometimes only 35 cm. Because of this, nearly every eel caught in the lagoon is of economic significance to fishers. In the 1980-2000 period, the price of exported eel in the weight class above 700 g was the highest, while currently, medium-sized eel from the 300 to 600g weight class are the most popular.

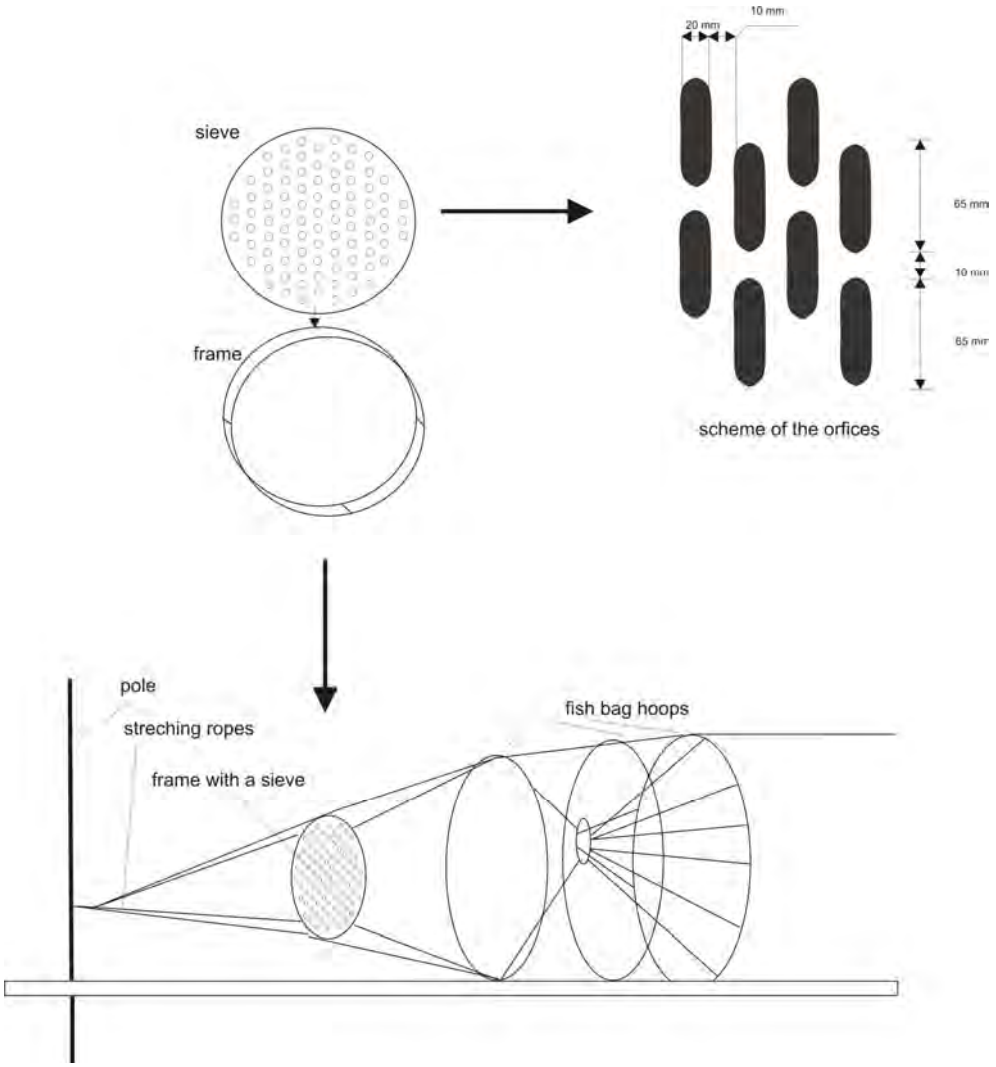
The minimum length of pikeperch of 46 is also higher than that in many other basins. Except during the period with ice cover and the closed season during spawning, this species is subjected to the strongest fishing pressure. Pikeperch measuring from 30 cm are sold illegally, and can prove to be quite profitable.

Minimum mesh size in nets and selective sieves in fyke nets

In accordance with an ordinance of the District Inspectorate of Marine Fisheries in Gdynia, the minimum netting material bar lengths for the following gear are binding in the Vistula Lagoon:

- fyke nets and type II fyke nets: bar length in the wing - 20 mm, and in the bag - 16 mm;
- stationary herring pound nets: bar length in the wing - 28 mm, in the intermediate section and bag - 16 mm;
- pikeperch-bream beach seine (currently not in use): bar length in the wing - 42 mm, in the intermediate section - 38 mm and the bag - 36 mm;
- gillnets targeting salmon and sea trout - bar length 65 mm;
- gillnets targeting bream and pikeperch - bar length 60 mm;
- gillnets targeting roach, perch, Crucian carp, and tench - bar length - 36 mm.

Additionally, fyke nets and type II fyke nets that are not fitted with selective sieves cannot be used from from 1 May to 31 December. The construction and installation of sieves is described in the regulations. Square or round sieves are permissible, but most fishers opted for round sieves since financing for these was subsidized by the state. Fishers were eligible for subsidies to purchase any number of frame and sieve sets. Some vessel owners expressed very reluctant attitudes towards the selective sieve regulation during the initial period of its implementation. In fishing grounds where monitoring was infrequent, the sieves were sometimes not installed in fyke nets, and authorities received reports of plastic bags being placed over sieves or the installation of two sieves within one frame to reduce selectivity. These measures were taken to increase the numbers of eel caught, especially those of lengths close to the minimum size. It was widely rumored that eel weighing as much as 300 g could escape through the sieve openings (at a minimum size of 50 cm and weight of about 200 g). Fishers quickly became convinced that fyke nets with selective sieves were more efficient because the fish caught were largely of commercial size without small fish of economic insignificance. In order to increase the effectiveness of sieve installation, fyke net monitoring was introduced as the gear was being loaded on vessels.



Construction and operating principle of protective sieves in eel fyke-nets used in the Vistula Lagoon

The most commonly used gear in the Vistula Lagoon is the so-called pikeperch-bream gillnet with a bar length of 60 mm. In the opinion of many fishers, this is the worst gear since it catches many small, legal-sized bream, and is also very ineffective in catching pikeperch. In recent years, fishers have begun using netting with mesh bar lengths of 75 mm and even 80 and 90 mm for bream catches. The prevailing opinion in the fishing community is that netting with a bar length of 55 mm would be the most suitable for pikeperch catches. The illegal use of netting with smaller and smaller mesh bar lengths of 50, 48, and 45 mm is a worrying phenomenon, as are observations of pikeperch catches being made with so-called perch nets with a bar length of 36 mm that are designed for catches of perch, roach, Crucian carp, and tench.

Nets with illegal mesh bar lengths and the associated undersized catches of pikeperch is currently one of the primary challenges in the protection of Vistula Lagoon fisheries. Most inspections by marine fisheries inspectors focus on checking netting and minimum fish size. During inspections from monitoring vessels, measurements of bar length are taken of gear in use in the

fishing grounds. If identifiable gear is discovered to have illegal mesh sizes, then administrative procedures are initiated against the vessel owner or captain. Netting with illegal mesh can also be discovered during inspections when the gear is being transported aboard fishing vessels. Each year, numerous cases of administrative procedures end in the issuance of fines for having fished with netting with illegal bar lengths. Eradicating catches of undersized fish, which recently have comprised mainly pikeperch, and the illegal sale of such fish is the second fundamental challenge facing the protection of Vistula Lagoon fisheries. While transporting undersized fish on both water and land, dishonest fishers track the position of inspectors and monitoring vessels; one method is to use cellular telephones to pass information. If there is a threat of inspection, then the fish in question are dumped overboard. While transporting fish over land, the majority of the illegal catch is loaded into a second vehicle to provide safe transport.

As long as there is a market for illegal fish, the impact of the measures described above will be insufficient. Increasing the effectiveness of monitoring at every stage of the fisheries trade and not just at catch and first sale will result in mores satisfactory results.

Catch limits

The agreement on mutual cooperation regarding fisheries between the governments of the Republic of Poland and the Russian Federation which was entered into on 5 June 1995 renewed the obligation for both sides to meet annually under the auspices of the Polish-Russian Joint Commission for fisheries. The first bilateral meeting at the ministerial level took place in 1952, and the first agreement concerned fishery gear issues, minimum mesh sizes, and fish landing size. It was concluded that a ban on trawling with small mesh sizes should be implemented since this threatened juvenile fish. At the next meeting, in 1958, the most important issue was determined to be keeping pikeperch and bream catches at the level of the 1957 landings. In 1960, it was decided that catch limits (TAC - total allowable catch) for these two species should be set at the level suggested by Polish and Russian scientists. Meetings were held every two years except between 1988 and 1993. During this period of rapid socioeconomic change in Poland, contact was suspended with the Russian Kaliningrad district (following the collapse of the Soviet Union in 1992). A new treaty based on prior cooperation was signed in 1993, and it was agreed that the tradition of biannual meetings should be maintained. By the end of 2011, there had been 11 sessions of the joint commission.

Until the end of the 1990s, the designated TAC was rarely utilized in the Polish side of the lagoon, so until the mid 1990s this did not curtail fishing on the Polish side. On the one hand, this was because of great interest in catches of another species (eel), and on the other hand, by the high

estimated biomass of pikeperch (Goloubkova et al. 2005). Catch limits did not become a significant limiting factor until the second half of the 1990s when the estimated biomass of the stocks declines thus resulting in lowered TAC.

The method used for estimating bream and pikeperch biomass should be mentioned here. The data required for correctly estimating and then verifying stock size is as follows:

(i) structure and size of commercial catches;

(ii) structure and size of other other catches;

(iii) monitoring data series characterizing the state of stocks collected independently from fisheries.

To date, estimations of biomass have been based on just the first type of data without evaluating the risk of the actual size of catches in relation to reported catches. Rough estimates of the size of catches other than reported commercial catches are unknown, as follows:

- recreational catches;

- illegal and unreported catches;

- discarded catches, i.e., fish caught in gear but released back into the water by fishers because they are undersized, caught during closed seasons, or the limit for that species has been exhausted.

The results obtained from modeling have to be referenced to data obtained independently of fisheries in order to verify the accuracy of the model prognosis. Unfortunately, the system is not currently functioning properly. The meeting schedule for the working groups assigned with designating TAC are set during joint Polish-Russian meetings. However, these working groups have served to date only to exchange information regarding reported catches of bream and pikeperch and other basic biological data regarding the exploited segment of these fish populations. This meets only the first point required for correctly estimating biomass and excludes the risk linked to incomplete reporting of commercial catches.

9. Evaluation of strengths, weaknesses, opportunities, and threats and the developmental potential of Vistula Lagoon fisheries

SWOT analysis of Vistula Lagoon fisheries

STRENGTHS	WEAKNESSES
Efficiency and professionalism of fishers	Conflicts among fishers (lack of community solidarity)
Existing fisheries associations that can potentially provide a platform for discussions outside of the community and act a strong partners in trade and administrative negotiations	No tradition of negotiation or community consultation (low social capital), lack of strong producer organizations that could represent the common interests of fishers which results in the fragmentation of commercial contacts for fish sales and low sale prices
Specialized and significantly modernized fishing fleet (achieved through SOP Fisheries and Fish Processing 2004-2006)	Lack of or limited fishing base and port infrastructure for raw fish storage and initial processing that would increase product value
High ecological capacity of the lagoon that ensures a food base for large eel and predatory populations	Dependencies on the natural regeneration of local fish resources and European eel stocking
	Catch limits too low for bream and pikeperch and low eel biomass
OPPORTUNITIES	**THREATS**
Implementing of the Polish Eel Management Plan with its planned intensive stocking in the Vistula Lagoon	Excessive feeding pressure from the great cormorant colony in Kąty Rybacki could disqualify the lagoon from planned stocking or limit its effectiveness
Forging an agreement with the Kaliningrad Oblast fisheries administration regarding bilateral regulations for protecting fish and monitoring illegal catches	Uncertainty regarding the effectiveness of the functioning of the Russian fisheries administration
Restoring permanent connections by water with the Kaliningrad Oblast	Increased smuggling and illegal trade
Developing alternative sources of income from access to the waters of the Vistula Lagoon (restructuring and reorienting businesses)	Lack of possibilities for exploiting the potential of he Vistula Lagoon (no swimming access, blue-green algae blooms in summer, fecal coliforms), underdeveloped infrastructure (roads, accommodation)
Increasing catch profitability by increasing product value (adjusting catches to meet market demand, improving product quality)	Lack of funding for development and modernization or the lack of skills to apply funding
Effectively protecting fish resources from overfishing (catching undersized fish, disturbing fish during spawning)	Increased illegal and unreported catches (no tracking system for product origin)
Investing in stocking valuable fish species	Lack of funding for stocking
Developing social capital (horizontal relationships) through creating Local Fishing Groups	Local conflicts preventing cooperation

10. Development perspectives for Vistula Lagoon fisheries

The aims of projects that would increase opportunities for the sustainable development of Vistula Lagoon fisheries should focus on the following:

- improving the profitability of catches;
- undertaking measures to maintain the stability of natural resources;
- promoting the region;
- facilitating increased exchange of information, resources, and services between Poland and the Kaliningrad Oblast;
- diversifying employment in local communities and supporting integration.

The basic principle lying at the foundation of the proposed development perspectives is the assertion that the more fishery income becomes independent of catch size, the more effective will be measures taken to ensure the sustainability and ecological exploitation of resources.

The developmental perspectives for Vistula Lagoon fisheries are currently dependent on absorbing funding from the Operational Program Fish 2007-2013. The creation and functioning of Local Fisheries Groups facilitates the development of undertakings that are consistent with the local developmental strategies of municipalities. Linking the interests of local administrations and fisheries areas in this way provides opportunities for improved information flow and the building of networks and social capital through the transparent flow of funding and investment.

The objectives of projects for increasing opportunities for sustainable development in the coastal areas of the Vistula Lagoon should focus on improving the profitability of catches (developing infrastructure for preliminary fish processing and creating producers' organizations), increasing natural resources (stocking, protecting spawning fish and fry, increasing gear selectivity, improving river continuity, improving water quality), and diversifying employment in coastal fisheries areas (fisheries projects in basins other than the lagoon, developing infrastructure for Vistula Lagoon recreational fishing and general tourism, promoting traditional local crafts, organizing educational and cultural events). Making the sources of local incomes less dependent on the size of fish catches would facilitate the sustainable, ecological management of fish resources along with the application of such regulatory measures as periodic closed seasons, which currently provoke justified social opposition. If fish resources are managed sustainably, illegal and unreported catches are curtailed, and cooperation to co-manage the lagoon runs smoothly between Poland and the Russian Federation, then local resources of breeding fish will have increased by 2020. In the case of eel, stocking the lagoon with this species can be performed within the framework of the Polish Eel Management Plan. The highly effective eel stocking performed in the 1970-1994 period

indicates that the lagoon is suitable for the production of silver eel that will increase the biomass of the spawning stock. If, however, the conditions set forth above are not met in the coastal areas of the Vistula Lagoon, and the incomes of local communities continue to depend on the sale of large quantities of low-priced fish, resources of fish will decrease successively leading to the ecological and social degradation of these areas by 2020.

Objective 1. Increase first sale price by (i) improving consumer demand by making products more attractive with initial processing, (ii) exploiting profit potential of fish other than pikeperch and eel.

Objective 2. Diversifying market demand by increasing supply flexibility by (i) storing and transporting fish without distributors, (ii) monitoring and reacting quickly to market demand, (iii) creating new market demands in accordance with catch potential.

Objective 3. Creating recognizable local products and a certification system.

Objective 4. Developing specialized tourism in relation to the tourism network throughout the voivodeship.

Objective 5. Monitoring the state of the ichthyofauna and the effectiveness of the protection of exploited fish resources, specifically (i) monitoring the state of eel and pikeperch resources, (ii) effectively protecting spawning fish as well as optimum, undisturbed conditions for juvenile growth, (iii) effectively protecting the continuity of ecological corridors, river mouths, and other sites important for mass fish migrations, (iv) counteracting illegal fishing, and (v) monitoring the states of protected fish species which are of special interest to the EU.

Objective 6. Counteracting negative environmental changes that are detrimental to fisheries and sustainability, specifically (i) stocking valuable fish species, (ii) monitoring natural mortality trends and preventing excessive numbers of predatory fish that can disrupt ecosystem equilibrium, and (iii) monitoring the purity of the waters of the Vistula, its catchment basin, and coastal areas.

Objective 7. Developing multidirectional cooperation with the Kaliningrad Oblast in Russia, specifically in (i) facilitating administrative contact for trade, the flow of goods, services, and tourism, (ii) coordinating measures to promote ecosystem sustainability, and (iii) organizing joint, trans-border undertakings.

Objective 8. Popularizing knowledge about the region through its fisheries tradition and the health benefits of consuming wild fish.

Objective 9. Integrating fisheries communities and increasing the significance of fisheries organizations.

Proposed solutions

Objective 1. When animal protein is available in excess, the issue of fisheries profitability ceases to be catch size and begins to be the price paid for a given product. Currently, the bulk of the price consumers pay for fish is the profit of distributors. The importance of the distribution link in fish sales is the result of many factors; however, the form in which fish are transferred from the fisher to first sale is significant. The type of fish product for sale, whether it is refrigerated, gutted, headed and gutted, filleted, or even packaged and labeled, determines its marketability and the price it can command. This requires coastal infrastructure such as refrigerated warehouses, facilities for initial processing (filleting and packaging), ice-making equipment, washers, means of transport, and even containers for live fish. This also requires vessels that are properly equipped, for example, with ice containers and wet tanks for live fish, and knowledge of how to increase the value of fish sold on the available markets. Significantly, this last factor is lacking in fisheries practice, and ignorance of market trends and potential markets often prevents fishers from exploiting the full profit potential of their catches. In the meantime, even fish species that have not been popular to date can be sold to good advantage if the right product is offered on the right market. Examples of this include species and product varieties such as small perch (10-15 cm in length) that can be sold as fries made of small fillets, which are very popular on the German market; gutted, headed, and skinned round goby sold under the name *byczkek*; or flounder, which demanded high prices in the summer of 2011 when most coastal fishers operating in the Polish Baltic Sea Areas suspended fishing. As catches decline of pikeperch and eel – species that command high prices and are esteemed by consumers, income derived from catches of more stable or growing resources of other fish species such as perch, roach, bream, smelt, round goby, and flounder must be increased.

Objective 2.

As in objective 1, the strategic factor currently determining the profitability of fisheries is not a simple dependence on the amount of fish caught. The price commanded by the catch is more important, and this is dependent on the possibilities for selling it. When these possibilities are limited, as they largely are currently, the catches brought into port have to be sold quickly and at low prices since there is are no widely available, accessible facilities for initial processing or refrigerated storage or transport. The possibility to perform initial processing (filleting, smoking, packaging) and to store and transport catches increases market opportunities that permits commanding higher prices. Information about these markets and monitoring them continually is key to knowing which products should be sold where and when. This can be achieved by using the services of specialized marketing agencies or by creating one's own

network of commercial contacts. One of the problems remains coordinating with other fishers in the case of larger orders and the ability to react quickly (storing fish under refrigeration and transport). A complementary direction for action should be creating new market demand with the goal of selling more fish for which demand is unsatisfactory such as roach, smaller varieties of bream, flounder, and round goby. These efforts should be undertaken in cooperation with specialized marketing agencies using European Union funding for marketing and certification. Potentially, products made from these fish could capture a large market segment of customers who want to eat a healthy diet (wild, genetically unmodified fish) that is ecologically sustainable (catches that preserve predatory fish).

Regulations that increase costs of initial fish processing and storage enterprises, or even render them unfeasible, place significant limitations on the realization of this objective and should be revised.

Objective 3.

Local products currently hold a strong position on the market. Consumers are increasingly willing to purchase somewhat more expensive original products of sure origin rather than foodstuffs produced outside of Poland. The feeling that one is supporting local producers and compatriots is important, but more significantly this support is lent without having to make any special effort or denying oneself purchases of a certain type. This should be exploited by creating, promoting, and continually building on the position of local products while also taking into consideration the fisheries tradition of the Vistula Lagoon. The concept of local products encompasses both goods and services beginning with fish dishes and products not available in other regions such as dried smelt and bream chips as an accompaniment to beer, fish soups, and dumplings with fish stuffing through to tourist attractions such as the aquarium with exhibits of Vistula Lagoon fishes, living re-creations of the crafts associated with fisheries, reconstructions of regional history on topics such as Nicolaus Copernicus or the battle with the Teutonic Knights at Suchacz. Regional products should always be available; for example, specialty fish dishes should be based on fish that are nearly always available and in sufficient supply such as roach and perch rather than eel and pikeperch. Additionally, these should not be a luxury goods so as not to exceed price criterion, and the method of its production should be common knowledge; for example, recipes should be available to all interested. It is significant that the production of regional products is accompanied by a certification system to curtail the production of counterfeit products. Lastly, as was the case in the previous objective, existing administrative limitations that unreasonably increase business costs and the production of local products should also be revised.

Objective 4.

The short summers of unpredictable weather and the lack of typical seashore beaches mean that the southern shore of the Vistula Lagoon will never be a typical, passive vacation spot. The habits and preferences of tourists change over time, and there is currently greater demand for specialized tourism and active vacations with a focus on sporting activities. Advances in technology make it possible to participate in water sports outside of the summer season. The Vistula Lagoon has unexploited tourism potential that can be based on both traditional water sports such as yachting, kayaking, and sand-yachting and new sports such as kite- and windsurfing. Recreational fishing and photographic tourism could also be developed. Suitable tourism infrastructure is required for this including designating, describing, and maintaining tourist routes on the water and on land for pedestrians, bicycles, and automobiles. It is also very important to disseminate information regarding existing attractions and events. When designing cycling and automobile tourism routes it is essential to coordinate with sites that are linked historically or through fisheries with the traditions of the Vistula Lagoon.

Objective 5.

The stability of businesses based on fisheries resources rely on knowledge of their size and the possibilities of exploiting them now and in the future; otherwise, investments will prove to have been made erroneously. Fish resources are an example of something referred to in economics as common-pool resources. If they are not managed, such resources are usually subjected to over-exploitation, which is overfishing in this instance, because the interests of the individual exploiting commonly-available resources, which are to maximize short-term profits, conflict with the common interests, which are to maximize profits for all those exploiting the common resources in the long term. The most important element of effectively managing resources is to know the state they are in and the trends of changes. The goal of research conducted in the Vistula Lagoon by Poland and Russia is to evaluate the state of bream and pikeperch stocks. In light of the requirement for creating and implementing the Polish Eel Management Plan, resources of eel have also been evaluated. These studies, however, do not take into consideration many factors that are known, above all, to fishers. The lack of their own, reliable scientific data makes substantive discussion impossible when conflicts arise. It would, thus, be advantageous for the fishers to implement their own program of basic research that would aim to evaluate the state of resources and the ecosystem. The results of these studies could be the basis for irrefutable arguments such as those that arise regarding the selectivity of fishing gear, catch limits (pikeperch and bream TAC for the Polish and Russian parts of the lagoon are designated annually based on a Polish-Russian agreement) and the quantities of

stocking, for example of eel, salmonids, and pikeperch, and programs for protecting some of the species that are of interest in the EU such as anadromous river lamprey and twait shad.

A stable fisheries ecosystem in the Vistula Lagoon comprises factors such as providing protected spawning grounds for pikeperch and bream with protected areas and closed fishing seasons and protective corridors that provide fish with undisturbed migration routes. Information about these should be collected continually since this allows for substantive discussions concerning proposed projects such as regulating rivers, building artificial islands, and wind farms which could threaten the stability of catches. All activities undertaken to collect scientific data must be performed under the supervision of experienced scientists and any reports should be subject to usual peer-review.

To conclude, it must be underscored that even the best knowledge and forecasting are incapable of taking into consideration illegal activity such as poaching and other unreported catches. It is extraordinarily difficult in practice to realize this objective in detail in the Vistula Lagoon since it depends on excluding these phenomenon. One of the only realistic solutions presently is to establish permanent cooperation with the field organizations of the fisheries administration (District Inspectorate of Marine Fisheries), the Border Guard, and the police. Disseminating information on just how detrimental illegal fishing is to both the environment and local communities could have a significant impact on poaching; however, in light of the profits poachers earn and the ease with which slogans can be misinterpreted by certain ecological organizations, the methods used for prevention and disseminating information must be carefully formulated.

Objective 6.

The state of fish resources is shaped by the natural environment and anthropogenic pressure. While it is impossible to influence the former, the Vistula Lagoon has been being manipulated by humans for over a century from the moment the main flow of the Vistula River was redirected thus reshaping the hydrological regime and, consequently, the environment of this basin. Poorly-operating waste water treatment facilities (or the lack thereof) and excessive agricultural fertilization in the Vistula catchment basin caused rapidly progressing eutrophication in the waters of the lagoon in the 1980s. Massive algal blooms in lagoon waters and contamination with fecal coliforms also deterred tourists from spending their vacations in this region. The rapid growth in the abundance the piscivorous great cormorant colony located in Kąty Rybacki on the Vistula Spit (which has become the largest of its kind in Europe) was also the effect of many factors, including anthropogenic pressure, in addition to climate warming and the elimination of harmful factors such as compounds containing DDT. Such a

large number of predators increases the natural mortality of fish, including those originating from stocking. This is particularly significant in the instance of eel, for which the Vistula Lagoon was and remains an important basin for growth, and, more importantly, a barrier-free migration route for silver eel to reach the sea. Although this was emphasized in the Polish Eel Management Plan, the increased abundance of the great cormorant is interpreted by some scientists as advantageous for the basin where they feed. Despite this, attempts should be undertaken to designate the maximum number of predators which can sustainably exist in the system in consideration of other environmental elements and businesses. After determining the maximum number of predators, measures should be taken to regulate their numbers.

On the other hand, the disadvantageous impacts of fisheries must be counteracted through stocking, especially of species that do not reproduce naturally in the lagoon or its catchment basin such as eel or species including salmonids and pike that cannot reach spawning grounds because the routes to them are either limited or blocked. Simultaneously, water quality in the lagoon and in neighboring areas must be monitored which will permit the healthy development of ichthyofauna as well as an influx of tourists. All activities undertaken to collect scientific data must be performed under the supervision of experienced scientists and any reports should be subject to usual peer-review.

Objective 7.

The Vistula Lagoon and neighboring areas are largely dependent on measures implemented the authorities in the Kaliningrad Oblast, which is co-responsible for its management. Because of its international aspects, this cooperation is often difficult and coming to any agreement seems impossible. One example of this conflict of interest in which agreement has yet to be reached is the proposal of the Vistula Spit canal and its impact on the Vistula Lagoon ecosystem. Procedural differences between Poland and Russia and the fact that Poland is a member of the European Union have resulted in many difficulties for regional cooperation. Many of these problems stem from the ignorance of local public officials and entrepreneurs regarding conditions limiting activities in the other country. This is why every possibility to simplify cross-border cooperation is significant whether it concerns joint projects and undertakings, tourism routes, events spanning the borders of the two countries, and joint scientific research. The most important short-term objective is to re-establish water routes for tourism between the port of Elbląg and other ports in the Vistula Lagoon and Kaliningrad.

Objective 8.

It is clear from reading brochures that disseminate “knowledge” about desirable pro-ecological behaviors promoted by NGOs such as the WWF that fisheries are generally viewed

as a human activity that negatively impacts the environment and aquatic ecosystems. The arguments used include overfishing, by-catch of unwanted birds, mammals, and protected species, and disadvantageous changes in fish stocks. Protests by fishers are interpreted as the defense of individual interests which is contrary to those of society as a whole. In effect, the public is warned to not buy or consume many commercial fish species. This is, of course, only part of the truth since there is no information on the advantages to the public or "environmental equilibrium" from the consumption of wild fish protein. Disseminating knowledge about the advantages of consuming Vistula Lagoon fish as well as about the history and interesting traditions of fisheries and presenting how resources can be exploited sustainably by promoting the consumption of fish that have not been popular among consumers to date should at least provide a counterbalance to negative information regarding the consumption of fish from commercial fisheries.

Objective 9.

Despite requirements for consulting the public when amending various types of regulations, the opinions of the fishing community are often ignored. This often results from a lack of substantive preparation regarding legal questions and also a lack of evidenced based on verifiable scientific knowledge, as well as from conflicts within the communities themselves. Developing strong fishery and fish processing organizations remains relatively slow despite the strong financial support of the European Union. These organizations also do not have a strong influence on local communities, unlike they once did. The aims of the newly-formed Local Fishery Groups is to change this situation. Integrating fishery communities is difficult, as is evidenced by differing opinions issued by various fishery organizations regarding ordinances issued by the District Inspectorate for Marine Fisheries. Despite this, the policy of promoting dialogue should be continued, and the fishery community should continue to be included in the process of fish stock management and environmental protection linked to fisheries exploitation because there is no better way to develop competent lobbying skills than continual practice. As the voice of the fishery community gains experience and the substantive level of its argumentation increases, it reasonable to expect that the competence of the fishers to contribute to decisions regarding the fisheries such as the effectiveness of fish protection methods will be reflected in the law.

Objective 10.

Anticipated effects

Realizing the objectives in this section on strategy meets all of the criteria of sustainable development in a way that renders the fisheries practiced in the Vistula Lagoon necessary for

communities, economically justifiable, and safe from an ecological viewpoint. With this assumption, this will be an important incentive to develop and maintain the entire region. In detail, the realization of this strategy should lead to the following:

- exploit fisheries potential and the resources of the Vistula Lagoon in an ecologically sustainable and economically justifiable manner;
- increase fisheries profits while maintaining exploitation at the current level;
- increase tourism draw in the region;
- develop and promote local products;
- increase substantive knowledge regarding threats to resources from within the ecosystem (great cormorant abundance) as well as from human activities (discharges of waste waters, illegal fishing) effectively monitor and actively counteract them;
- integration of local communities;
- increase the competence of and significance of local fisheries organizations.

Summation

Perspectives for the development of Vistula Lagoon fisheries are dependent on the absorption of funding from the Operational Program Fish 2007-2013 and directing it to the objectives detailed above. Other significant factors include the integration of local communities and the development of cooperation with the Kaliningrad region. The creation and functioning of Local Fisheries Groups will facilitate developing undertakings that are consistent with the local development strategies of municipalities. Linking the interests of local administrations and fishing regions in this way provides an opportunity for increased information flow, the building of networks and social capital as an effect of the transparent flow of financial and investment means. The project objectives which would increase the chances for the sustainable development of the coastal areas of the Vistula Lagoon should be linked to improving the the profitability of fisheries (developing infrastructure for initial fish processing, creating processor organizations), tasks aimed at increasing natural resources (stocking, protecting spawning and fish fry, increasing gear selectivity, restoring river continuity, improving water quality), and tasks linked to the diversification of employment in coastal fishery zones (investing in aquatic basins outside of the lagoon, developing tourism infrastructure linked with the Vistula Lagoon fisheries and ecosystem, promoting the crafts of local traditions, organizing cultural and educational events). Making sources of income in local communities independent from the size of catches will permit the sustainable, ecosystem management of fish resources through the application of fisheries regulation measures such as closed seasons, which currently draw justified community opposition. If fish resources are managed

sustainably, illegal and unreported fishing are dealt with effectively, and good cooperation with Kaliningrad is established then by 2020 there will be greater resources of fish that breed locally. In the case of eel, stocking in the Vistula Lagoon can be done within the Polish Eel Management Plan. The highly effective eel stocking performed in the 1970-1994 period indicates that the lagoon is suitable for the production of silver eel that will increase the biomass of the spawning stock. If, however, the conditions set forth above are not met in the coastal areas of the Vistula Lagoon, and the incomes of local communities continue to depend on the sale of large quantities of low-priced fish, resources of fish will decrease successively leading to the ecological and social degradation of these areas by 2020.

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