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# ANTHROPIC IMPACT ON THE DANUBE DELTA FISHERIES – ROMANIA

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**Abstract.** In the last forty years, the total fish catches of the Danube delta have declined from some 12 000 t/year to less than 4000 t/year, while high-valued species like sturgeons, pike and tench almost completely disappeared from the catches. These changes were caused by structural alterations of the floodplain–river–delta complex (physical barriers in the forms of dams and weirs have reduced migrations routes by forming obstacles to fish migration), increasing concentrations of nutrients and heavy metals in the water, poaching and by overexploitation. This study shows considerable changes in the fish fauna of the Danube delta attributed to human interference. The combined effect of human activities has been a degradation of water quality and reduction or elimination of populations of sensitive fish species. Exploited fish populations are considered good indicators of environmental alteration. Fisheries and independent data were collected in recent years in order to account for the actual state of the stocks. Basic results (estimates of fish recruitment, biomass, mortality rates, etc.) are interpreted in the ecosystem context and the interactions between fish stocks, fishing and environment. Structure and dynamics of fish fauna from Danube delta lakes reflect the response of fish populations to changes of biotop features, anthropic impact, overfishing, and eutrophication, which determined the simplification of species structure in catches and the proliferation of cyprinids. Some recommendations concerning fisheries management are outlined in the end of the paper.

*Keywords*: anthropic impact, fisheries, Danube delta.

## AIMS AND BACKGROUND

The capacity and function of deltas all over the world as natural aquatic resources have been affected by human impact. Reduction of human impact and sustainable use of natural resources are the actual priorities for countries that have joined the Rio de Janeiro Convention, concerning biodiversity conservation.

This paper aims to identificate the main impact factors on the Danube delta fisheries in order to evidence their effects and to establish some measures to reduce those unfavourable influences.

The Danube delta is one of the largest wetlands in Europe, situated in S-E Romania and N-W of the Black sea, between north latitude 44°30′ and 45°30′ and east longitude 28°40′ and 29°50′.

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The Romanian government law declared this territory as the Danube Delta Biosphere Reserve (DDBR) in 1990, and in 1993 this status was recognised through a special law. The main objectives of this Reserve are biodiversity conservation and sustainable use of the natural resources. According to the DDBR objectives, sustainable use of fish stocks has to be implemented in its territory. During the communist period (1953-1989) fisheries and fish trade were fully regulated by state. After 1989, Romania changed from command economy to free market economy. The major political changes required fundamental changes of the socio-economic systems.

The ecological significance of this area was recognised also as a Ramsar Convention and World Heritage site. The DDBR's total surface area is 580 000 ha, including the Romanian section of the Danube delta, the lagoon complex Razim–Sinoie, the area adjacent to the Black sea till 20 m depth, and also a floodplain area upstream the delta.

The territory contains 50 600 ha strictly protected core areas, 223 300 ha buffer zones and 306 100 ha economic zones, with 86 000 ha of polders for agriculture, fish farming and forestry.

## FISHERIES STATUS AND EVOLUTION

Fishery is the main traditional activity in the Danube Delta Biosphere Reserve.

The three main fishery categories, according to fish species, methods and fishing areas, are:

- the fresh water fishery (delta, Razim–Sinoie, the Danube river);
- the fishery of migratory fish (Pontic shad and sturgeons);
- the marine fishery.

According to the size and structure of captures, the fisheries in the actual territory of the Danube Delta Biosphere Reserve have past through several periods (Fig. 1):

1. The period before the 1960's, with variable captures, between 10 000 and 20 000 t, influenced by natural factors, especially the Danube river's hydrological regime upstream the delta, in the Danube floodplain system.

2. The period between 1960 and 1970, with variable annual catches, between 10 000 and 20 000 t, influenced by natural factors, especially the Danube river's hydrological regime in the delta area and the river mouths.

3. The period between 1970 and 1984, with approximately constant annual catches around 15 000 t, a period with important changes in the environment.

4. The period after 1984, in which fisheries annual catches declined to 3000-4000 t.

*The freshwater fishery.* In the 1920's catch was dominated by *C. carpio* (21%), *E. lucius* (20%), 35% of catch comprised piscivorous fish (*S. lucioperca*, *S. glanis*, *P. fluviatilis*) and *R. rutilus*/*S. erythrophthalmus* (16%) (Ref. 1).

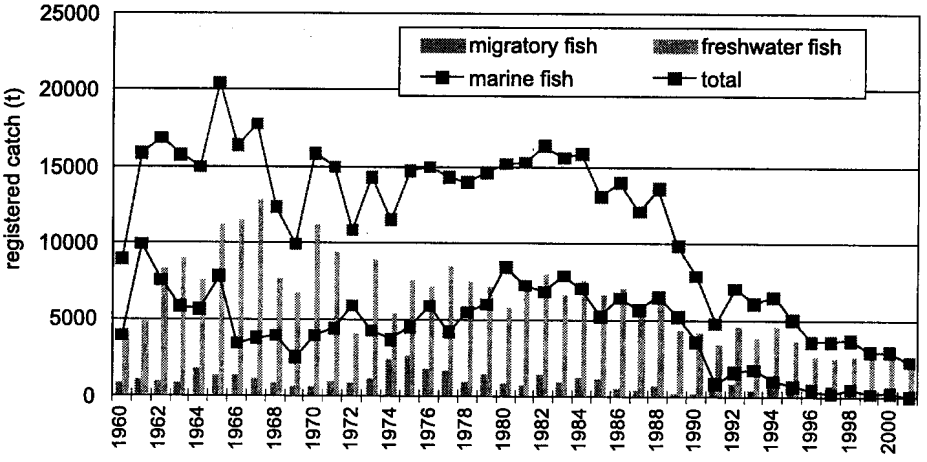


**Fig. 1.** Evolution of catch dynamic by type of fisheries

The structure and size of the catches recorded in statistics by the years show quite obviously the response of the fish population to environmental changes.

The influence of natural factors on the stock dynamics has decreased in favour of human factors in the period 1970-1980, as a result of habitat loss and degradation, especially in the delta.

The commercial fish catch from the Danube delta lakes decreased from 8640 t (average catch from the period 1960-1970) to 3223 t (1990-2001). The fish catch structure was dominated by roach/rudd (33.8%), pike (18.2%) and wels (10%) in the period 1960-1970 and by giebel carp (42%), bream (27.8%), roach/rudd (15.5%) and wels + pike (2.8%) in the period 1990-2001 (Fig. 2). Cyprinids

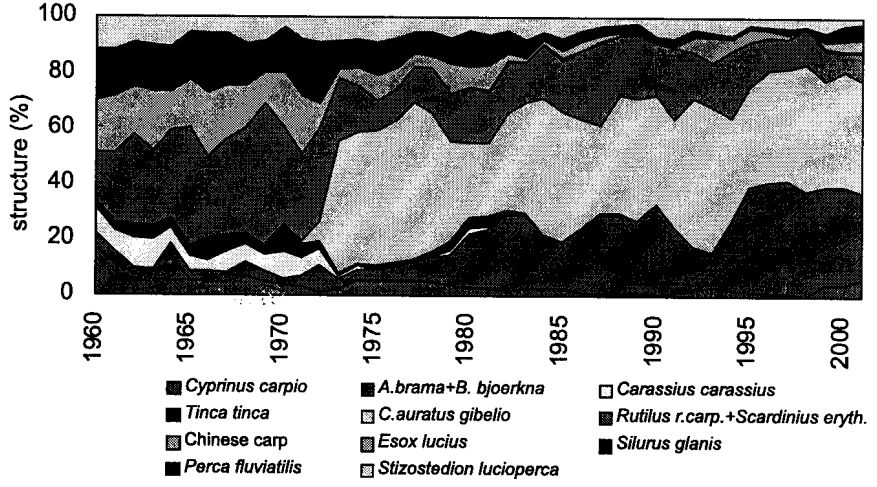


**Fig. 2.** Commercial freshwater species structure (%) in Danube delta lakes

may comprise even up to 98% of the total catch with 78% giebel carp in 1995 in Rosu–Puiu lakes[2].

*Marine fishery.* In the 1950's and 60's, the sea fishing statistics registered a highly productive period, based on small sized fish species and valuable mackerel and flat fish species.

The decline of predator fish stocks has determined the collapse of the fishing fleet in 1966-1967, and the transfer of fishing activity near the coastal zone, based on the seasonal and successive migration of 5-6 species, the level of catches being maintained at 7000-8000 t/year until 1988.

The deterioration of environmental conditions, due to the Danube river pollution, resulted in the reduction of species diversity and the collapse of sea fish fisheries, the annual catches in the last years going down to less than 1000 t, based on one small sized species *Sprattus sprattus*[3].

*Fishery of migratory fish.* The fishery of migratory fish is based on the Pontic shad and three sturgeon species, which migrate from the Black sea into the Danube, to the spawning sites.

– the Pontic shad shows a cyclic pattern of migration intensity with a period of 10-11 years. In the period 1960-2001, the annual catches ranged between 22 (in 1999) and 2507 t (in 1975);

– the sturgeon population is on a continuous decline. In the last 40 years, their catches decreased for 50 times, due to overfishing against the background of the reduction and degradation of habitats. However, a recent study of the authors reveals that in spite of statistics, the important sturgeon fishery still exists, shadowed by a large black-market[4].

## INFLUENCE OF ANTHROPIC IMPACT FACTORS ON FISHERIES

*Hydrological regime.* In the period before 1970-1972, the stock and catch sizes were determined by natural factors, the hydrological regime being the most important.

By the end of 1960's, the hydrological regime was the factor determining the good spawning results of carp in the flooding area, upstream the delta. This area was the source of fingerling dispersion for the whole delta and adjacent zones. The recruitment size influenced the capture size in the next 3-4 years.

After the carp population decline, as a result of upstream damming, in the period 1961-1972, a new balance in the structure of communities was established, based on sedentary cyprinids.

The dynamics of stocks was still depending on hydrological factors, through increasing or reducing the spawning and growing area as well as the biological productivity in the delta itself. There is a clear relationship between the size of cyprinid catches and the level of the Danube river, in the period May–Septem-

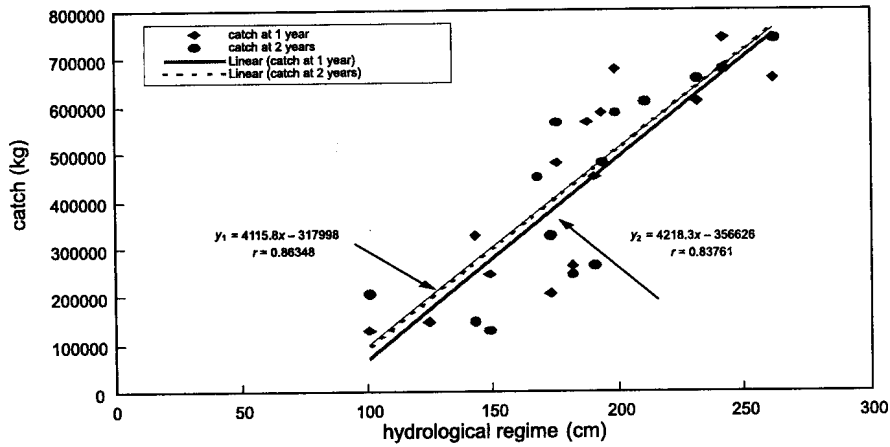


**Fig. 3.** Correlation between the hydrological regime and size captures from Rosu–Puiu lakes, in the following and after two years

ber, in the same year. This correlation illustrates the permanent existence of large amounts of recruits, the limiting factor being the flooding area, not the level of recruitment.

The correlation between the hydrological regime and the size of captures in the same year has disappeared after 1972, as a result of environmental changes[5].

So, after 1980, a clear correlation between the hydrological regime and the size of captures from Rosu–Puiu lakes in the following year and after two years was found (Fig. 3), being a signification of changes in environmental conditions and of the interrelations[6].

The increase of captures size after two years, confirming the established relation by Welcomme, in accordance with it, the high flood effect is for long time if the water volume from lake is bigger and reverse[7].

*Relations between species.* The competition for food and the relation prey–predator is illustrated also by the captures dynamics.

By the end of 1960's, the competition for food between carp and roach maintained the roach stocks at a low level[8].

The carp's decline was followed by an increase of roach stocks and then of pike stocks, these evolutions suggesting that the prey–predator relationship constituted a natural control factor until 1970-1972. The piscivorous species represented over 40% of the total catch in 1960-1970 period but in 1995 it reached only 3%. There is a linear correlation between piscivorous catch ($x$) and total freshwater catch ($y$) in 1980-1997 from Rosu–Puiu lakes, where $y=0.3688x - 62.966$ ($r=0.913236$) (Ref. 2). The sedentary species become dominant in the captures from the Danube delta lakes (Fig. 4).

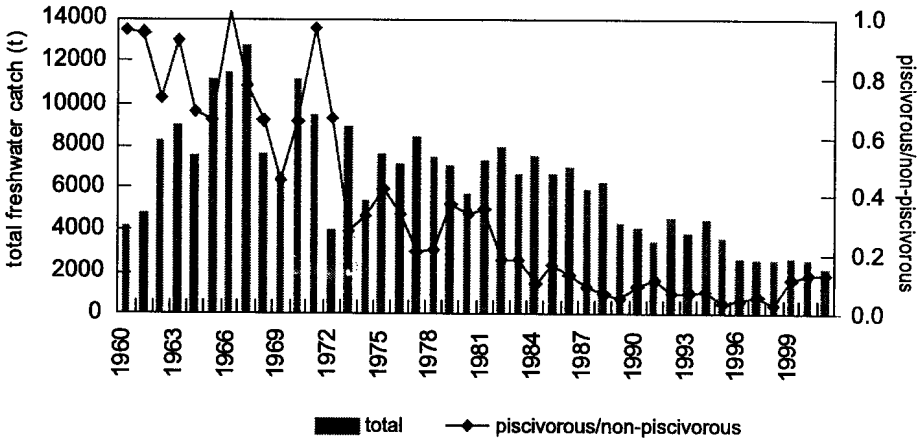


**Fig. 4.** Dynamics of non-piscivorous and piscivorous ratio for freshwater species

*Hydrotechnical works.* The main actions that made geographical changes in the lower Danube are the hydrotechnical works (dams and dykes) which have reduced the flooding area from 500 000 ha to only 15% at present. All these humans' interventions lead to morphological, hydrological and biological perturbations.

The Danube's floodplain upstream the delta had a total surface area of 466 000 ha. In 1957, 50% of the surface area was dammed or in course of damming in, followed by decreasing of carp catches in the delta from 3400 t in 1956 to 400 t in 1960.

The damming of 85% of the floodplain resulted in a decline of populations of other half-migratory species from the delta as well[9].

The building of the two barrages upstream the delta in 1969 and 1983 limited the migration way of sturgeons to 863 km from the Black sea, having an impact on spawning results[10].

Damming of 103 000 ha surface in the period 1960-1989 in the delta has affected recruitment level by reducing the spawning and growing area.

The correlation between the damming area in the Delta and the decrease of cyprinid catches shows clearly the impact of polder making on fisheries[5].

*Pollution and habitat modification.* The increase of N and P from the Danube's water at the end of 70's and in the next period, to values of 1-8 mg N/l, and 0.1-0.4 mg/l P, has determined values of 0.5-3 mg/l N, and 0.08-1.4 mg/l P, in the water of the delta's ecosystems.

In the period between 1956-1964, 700 km canals were built, the length of man-made canals reaching about 1000 km, determining three times more water and nutrients flow from the river to the delta[11].

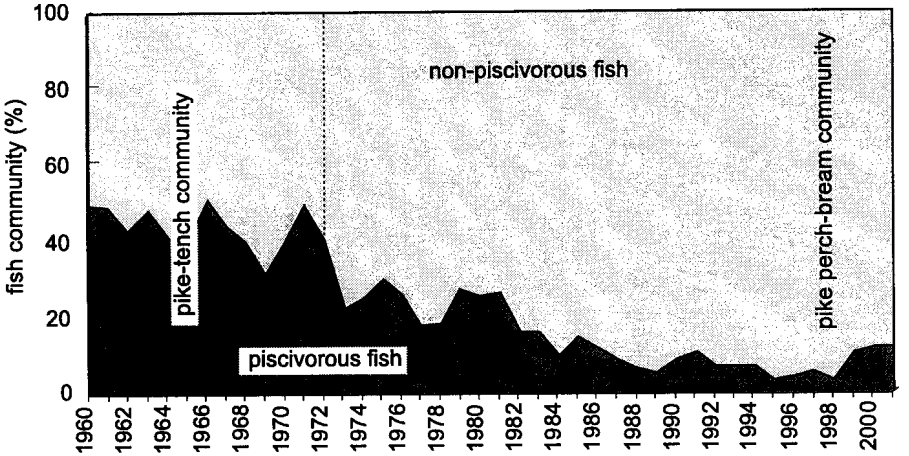


**Fig. 5.** Changes in fish community reflected by catches dynamics

The reduction in the area mesotrophic clear water habitats caused the decline of typical species like pike and tench, which were dominant in the commercial captures before. The response of the fish fauna to the increasing trophic level of the lakes was a shift from pike/tench communities to pike perch/bream communities (Fig. 5), a decline of piscivorous fish and the dominance of non-piscivorous fish. Giebel carp and bream took advantage of this new condition.

The main effects of eutrophication were:

– loss of biodiversity (decreasing over 50% of number of the fytoplanctonic species and in the following trophic chain);

– inhibition of the development of submerged macrophytes (decreasing water transparency) and reduction of the number of taxonomic groups of the fytophile fauna, which are affecting the trophic chain;

– proliferation of algal blooms;

– appearance of the anoxia periods.

The cyprinids with non-specific habitat requirements have proliferated[12]. The phenomenon is typical for eutrophicated waters in European temperate areas, and is caused by nutrient pollution.

Pollution with pesticide, heavy metals and oil products over the admissible limits and their interaction with other biological and non-biotic factors influenced the structure and the function of the biocenose. The presence of that pollution affects the physiology of fish in diverse developmental and growth stages and these elements are accumulated and transferred in the trophic chain.

The response of the fish fauna is generally reflected in disturbed spawning function, as asymmetrical development of the gonads, structural deformation, reduced fecundity, and sexual cells resorption[13].

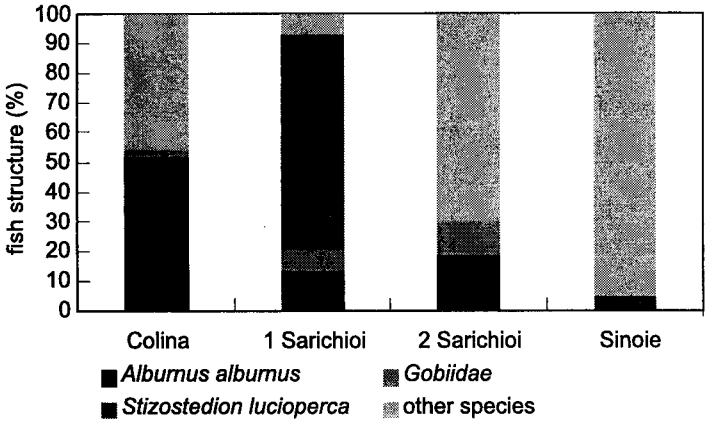


**Fig. 6.** The fish structure absorbed in the pumping stations for irrigation (1992)

Also, the naval traffic pollution represent an impact on the environment of the delta[14] and placing of the pumping station close to the growth and spawning area has a direct impact on fingerlings. Yearly damage was estimated to 220 million individuals[15] (Fig. 6).

*Exotic species.* In the fresh waters of the DDBR's territory, about 53 native species and 6 introduced ones were recently inventoried.

The Giebel carp's invasion in the whole Danube river basin, after 1970, pointed to changes in the structure of fish fauna. This species became dominant by competing out native species (Fig. 7).

The Chinese species introduced in the fish farming system after 1960 escaped in the natural river system. From those species, the silver carp catches

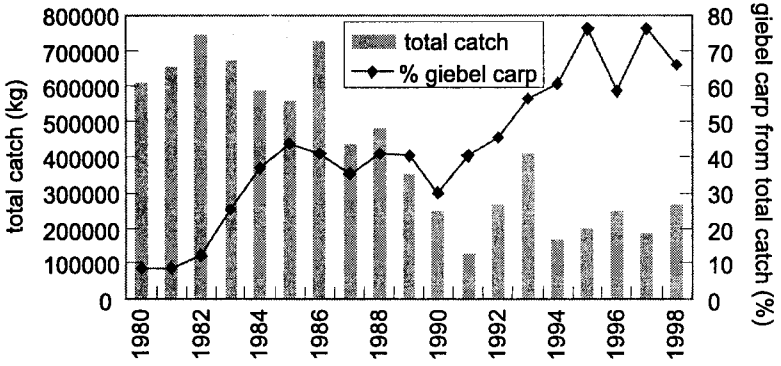


**Fig. 7.** Giebel carp catch evolution from Rosu–Puiu lakes – Danube delta

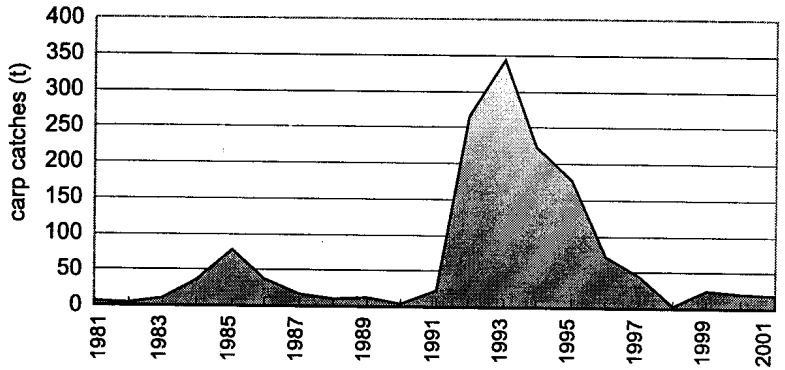


**Fig. 8.** Chinese carp catches evolution

mounted 300-400 t/year after 1990, being considered potentially invasive (Fig. 8). The impact on the indigenous species and generally, on the fishery, is still unknown.

The silver carp population invasion in the Danube river basin is hardly predictable, but a great number of fingerlings have been recorded in some years. The hypothesis of natural spawning, was confirmed by recording of large amounts of silver carp larvae[16,17].

Other introduced species comprise: Buffalo genus (not acclimatised yet in the delta but raised in fish culture), *Pseudorasbora parva* (accidentally introduced with Chinese carp, not appeared yet in captures due to the small size), and *Lepomis gibbosus*.

*Fishing activity.* The transition to market economy has resulted in an increase in fishing effort, both in the delta and upstream. The fishfarming collapse has determined the labour force migration towards fishing activities in natural waters. The number of fishermen increased by 2-3 times in 1995-2001 relative to the period before 1990. Poaching and black-market have become common practices since 1989. The fish unrecorded catches exceed 50% after 1993. Due to this fact the recorded catch statistics are unreliable[18]. Unregistered catches are especially for the valuable species (carp, pike, and catfish) (Fig. 9).

Sturgeon fishery has become more intensive in the migration ways upstream the delta, and the existence of barrages determined an increase of fishing productivity, due to the concentration of fish spawners[10,19]. The reduced size of sturgeons captured in the Danube river signifies low chances for spawners to survive, due to overfishing[20].

Overfishing represents an important impact factor, especially in conditions in which the fish population is in decline due to loss or degradation of habitats. This particularly holds for pike, pikeperch, and tench for which special conser-

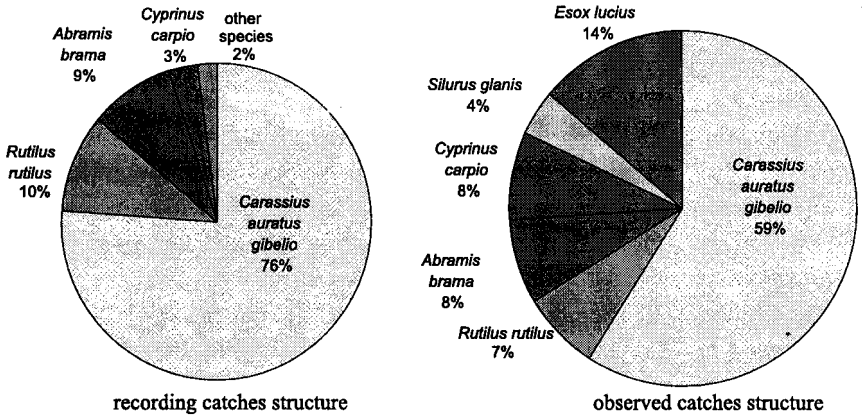


**Fig. 9.** Difference between official and real catch structure

vation measures are necessary. The increase of small sized fish in the captures in the last years also indicates overfished conditions.

After 1989, fishing effort, both the numbers of fishermen and nets, increased continuously, reflected in a decrease of the catch per unit effort. The increase of overfishing was slowed down through increasing mesh size (from 40 to 50 mm in Razim-Sinoie lake complex and from 26/28 to 32 in delta lakes) since 1994.

Overfishing is also demonstrated for bream in Rosu–Puiu lakes. Recruited individuals (2+) in 1991 were strongly reduced in numbers in 1992 and disappeared completely in 1993. The excessive fishing on this new recruited class resulted in a considerably smaller catch in the next year. The intense fishery in 1991 caught effectively 108 000 ex. with an average weight 256 g/ex. (fishing mortality 1.3 or 73%). This suggests that this year class was excessively fished (rather than migration from adjacent canals or because of the poor recruitment from the 1991-yearclass)[6].

In order to assist the DDBR Authority for sustainable management of fish stocks, the Danube Delta National Institute carries out a research program to asses maximum sustainable yield (MSY), and corresponding fishing effort using fish stock assessment models. The total catches and fishing effort due to the black-market, poaching and missing fishing data have introduced uncertainties on data input and the results have become more unsure after 1995 (Refs 21 and 22).

Overfilling the recommended total admissible catch (TAC) up to 40%, in most Danube delta lakes. increasing fishing effort, tendency of the economical agents to overfishing the fish stock indifferently by the age structure of the fish population, followed to declining of the catches and to an unbalanced fish stock.

In order to improve the control of fisheries and limit fishing effort, the Danube Delta Biosphere Reserve authority allocates fishing rights directly to fishermen since 1999 (Ref. 23).

## CONCLUSIONS

Fishing is the strongest direct man-made impact on fish populations influencing also other components of delta systems. The recent crisis in the Danube delta fisheries and the abrupt changes in the fisheries communities imposed the necessity of improving our knowledge of the fish population dynamics and creating the scientific basis for responsible fisheries ecosystem management.

As a result of upstream damming and habitat degradation, in recent years, fish communities shifted to a dominance of sedentary cyprinids.

Eutrophication of the lakes and changes and decreasing of the habitat area were followed by changes in fish community from pike/tench to pike perch/bream community reflected by catch dynamics.

The endangered species are subject to protection by special enforcement rules, saving zones and strictly protected areas.

Fishermen welcomed some protection measures as mesh size increasing but not those concerning the establishment of some protected areas in the productive fishing zones, which measures are often disobeyed.

Starting from 1997-1998, the reshaping of DDBR fishery is based on the individual fishing license, granted to fishermen, as a first step in the establishment of private fishermen associations.

The fish trading system still has many deficiencies, creating conflicts and encouraging the black-market.

Measures to improve the hydrological regime include for example the ecological restoration of the 11 425 ha of polders to wetlands or connected to the natural flooding system.

The present status of the Danube delta fisheries is a combined effect of decrease and degradation of the habitats, as following of the hydrotechnical works, Danube river nutrient, heavy metals, pesticides, oil products pollution, exotic fish species entered (*Carassius auratus gibelio*, Chinese species), the poaching, black-market from the last period, overfishing and lack of a settlements concerning a fish market.

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