Assessment of the potential transboundary effects of the construction of the Bystre Deep-Water Navigation Channel on fish and fisheries

Final version

Report to the ESPOO Inquiry Commission

Stefan SCHMUTZ

Vienna

June 2006

Contents

Introduction

In general, the activities of concern comprise the creation of a deep-water navigation route. The engineering works are planned in a section with an overall length of 170.36 km. It involves the dredging of 14 sills in the riverine part of the delta and the construction of flow guidance and bank protection measures, seawards of Vilkove, in the Bystre Branch, the dredging of the seaward access channel and the building of a retaining dam offshore (report of the Inquiry Commission).

In May 2004 the Ukraine Minister of Transport approved Phase I of the Project, consisting of the deepening of the sandbar section of the Bystre Branch and the dredging of some sills in the River section between Ismail and Volkove and the construction of a part of the retaining dam into the sea perpendicular to the coastline. The waterway was opened for navigation in August 2004. Also in August 2004 an EIA was completed for Phase II of the project, addressing the dredging of various sills upstream and the location of the dump sites and the outbuilding of the retaining dam.

Phase 1 consists of the dredging of the sills in the Chilia Branch upstream of Vilkove; the dredging of the access channel in the sandbar at the mouth and the construction of a part of the retaining dam in the sea. This Phase I is almost finished by now, but from October 1, 2005 all dredging operations under Phase I were suspended by the Ukrainian Government, till the end of flooding and spawning period (2006). The Phase II envisages the deepening of the route in the River the construction of the engineering works seaward from Vilkove and the remaining part of the retaining dam. Phase II has not started yet.

1. Objective of this report

The concern of the Romanian Government resulted in the initiation of an inquiry procedure under the UNECE Convention on Environmental Impact Assessment in a Transboundary context (the 'EIA-Convention). In the context of this procedure an Inquiry Commission has been established and the author of this report, besides other experts, has been invited in April 2006 to advice the Inquiry Commission on the likelihood of significant transboundary impacts of the construction and use of the navigation route.

Due to the contract provided for advising the Inquire Commission this report is based on existing information. It was not the objective of this study to make new investigations in the study area.

2. Methodology

The subject of the focus of the Inquiry Commission is the transboundary impact of the dredging of a navigation route via the Bystroe Canal and the lower deltaic part of the Danube River on the territory of the Ukraine and in the River, being the border upstream of Vilkova, on the territory of Romania as well (Inquiry Commission report chapter 2).

2.1. Assessment method

Appendix IV of the ESPOO Convention describes the Inquiry Procedure. In Article 1 it is stated that the main subject of the Inquiry Commission is: " the question of whether a proposed activity, listed in Appendix 1 (of the Convention) is *likely to have a significant adverse transboundary impact.....".* The methodology used here follows the procedure described in "Current Policies, Strategies and Aspects of Environmental Impact Assessment in a Transboundary Context (lit.2) (Inquiry Commission report chapter 2).

The Commission has categorised the "likely significance of adverse transboundary impacts" as follows:

unlikely

hardly likely (inconclusive, without proof)

likely

very likely

For the purpose of this report we distinguish between

1. local impacts affecting the environment and the fish fauna at a comparable small scale not resulting in transboundary effects
2. transboundary impacts that have effects at larger scale so that the resulting impacts are likely to affect areas outside of the Ukrainian territory.

Transboundary effects are of concern in terms of fish and fisheries as fish are migratory organisms using different types of habitats during their life cycle. Diadromous fish species use both freshwater and seawater habitats, potamodromous species move between different habitats within rivers. Therefore, there are different spatial scales that have to be considered when discussing potential effects of the engineering activities of Deep Water Navigation Channel (DNC) project. Local effects on the fish fauna may occur close to and in the vicinity of engineering activities. Large scale effects of engineering activities may also result from cumulative local effects. Local effects might lead to local decrease of fish populations not affecting the entire population. Large scale effects might result in a depletion of the whole population and could increase the risk of population or species extinction.

In this report we distinguish among different levels of potential effects of the DNC project on fish and fishery.

1. At the first level we define, if the observed effects might be transboundary or not. That would mean that activities implemented at the Ukrainian territory have effects on fish and fishery at the Romanian territory
2. At the second level we try to identify, if the effects are adverse for fish and fishery. In this step we analyse if alteration of the physico-chemical conditions might have any effects on fish.
3. At the third level we estimate if the effects are likely significant. Negative effects could result in fish population decline and economic impacts on fishery
4. At the last step we try to classify the level of significance according to the classes set by the Inquiry Commission as unlikely, hardly likely (inconclusive), likely, very likely. This classification is mainly based on the severity and spatio-temporal extend of the effects.

2.2. Data and data quality

This report is mainly based on information provided by the members of the Inquiry Commission. In addition, scientific literature, grey literature, reports and internet information was collected and analysed for this report. Although we received the report of the EIA of Phase I (Environmental Assessment (EA) within the framework of the project "Creation of the Danube – the Black Sea deep-water navigable passage in the Ukrainian part of the delta. Stage 1. Ministry of Ecology and Natural Resources of Ukraine. Ukrainian Scientific Research Institute of Environmental Problems (USRIEP). KHARKOV – 2003. 199p.), we did not receive any EIA report of Phase II. Due to the limited time and resources we were not able to thoroughly validate the plausibility of provided data.

State-of-the-art environmental impact assessment consists of the following major steps:

1. Definition of the current status of the environmental conditions before project implementation (pre-monitoring).
2. Definition of potential impacts of proposed project measures.
3. Definition of mitigation and compensation measures in case of expected impacts.
4. Assessment of the status of the environmental conditions after project implementation (post-monitoring).

This general procedure has only partly been used for the DNC project as there was no adequate pre-monitoring and post-monitoring of the fish fauna (as documented by the data we have received). As a result, adequate data to assess the likeliness of impacts on fish and fisheries are lacking. Instead of fish monitoring data other information was used to assess the potential impacts. However, data used are less accurate and mainly refer to physical alteration of habitats allowing only an indirect assessment of effects on fish. Therefore, the uncertainty of judgements is often very high.

State-of-the-art assessment of surface waters in the European Union is regulated by the Water Framework Directive (WFD). For rivers, estuaries and coastal waters fish are used as indicators to assess the ecological status along a gradient of 5 classes. For example, for rivers *species composition, abundance, sensitive species*, and *the age structures of the fish communities* have to be analysed. The *high status* (class 1) is the reference condition and reflects the situation normally associated with that water body type under undisturbed conditions and show *no, or only very minor* evidence of distortion. In the good status the fish fauna show low levels of distortion resulting from human activity, but *deviate only slightly* from situations normally associated with the surface water body type under undisturbed conditions. The WFD strives for good water quality for all water bodies by the year 2015.

The information provided by the Inquiry Commission and additionally collected does not fulfil the requirements of the WFD. Hence, the level of precision in the final assessment is not in line with the WFD.

Although in the EIA Phase I the investigation within the frame of natural environment monitoring program of potential changes of fish migration routes in connection with the creation of hydraulic structures had been proposed (EIA phase 1, page 148), we did not receive any data on this topic. The same holds true for the research intended to investigate the (1) species composition of fish with separation of rare and endangered species, (2) the number and productive properties of fish populations, (3) Growth and development of fish and their juveniles, (4) distribution and migrations of fish and their juveniles (EIA phase, page 155).

The efforts undertaken in this report to collect additional available data for to compensate for missing information is by no way able to replace a thorough environmental impact assessment approach as indicated above.

3. Status of the fish fauna and fishery

3.1. Environmental conditions for the fish fauna of the Danube Delta

The estuary area of the Danube belongs to the river-delta type and consists of subdelta plot, the length of which is about 85 km (one of the largest in Europe), the territory of which is 5640 km^2 and estuary beach about 1360 km^2 (total 7000 km^2). The Danube Delta was designated a Biosphere Reserve in 1990. The length of delta on its main branch is 116 km, its top is the place of division of the river in two largest branches – the Chilia (left, 52 % of Danube flow) and the Tulcea (right, 48 % of Danube flow, 17 km long) branch, the latter splitting into Sulina (20 % of flow, 69 km long) and St. Georghe branch (26 % of low, 109 km long). The Bystre channel (17.6 % of flow) is one of the lower Chilia braches that runs directly into the sea. The extent of marine margin of delta is about 180 km (EIA Phase I, Ukr. Annex 4).

The Danube Delta, compared with other European Deltas, is still in a fairly good state despite significant human impact during the twentieth century (Buise et al. 2002). The main human impacts on the system include engineering to enhance navigation and fish production and the reclamation of some 20 % of the area for agriculture and fish ponds. A network of river branches and man-made canals interconnect the hundreds of lakes in the delta. Eutrophication of the Danube River has led to substantial changes in fish composition and aquatic vegetation. Average P and N concentrations increased 6- and 3.7-fold, respectively, during the last decades.

From the end of the 19th century a period of large-scale intervention to the natural regime of the Danube delta had begun. First of all, the Chilia branch was practically completely bilaterally reinforced along the riverbanks (from Renni to Vilkovo from the Ukrainian side practically completely and partially from Romanian). The Chilia branch has a sizeable depth with relatively small width of riverbed: in the area of Reni town the width makes 800-900 m, average depth reaches 10 m and maximal – 17m-19 m, near Izmail town the width of the arm makes 500 m. The arm has very low banks; due to this practically at the whole length of the left bank of the Danube protective dams have been built (length of the dams 212 km) (EIA phase 1, page 93).

The Bystre channel is branched off to the left from Stambylskiy, 7.2 km below its source, and flows between the islands of Stambylskiy and Kubanskiy, to the Black sea. The total length of the arm is 9 km, the width is 100-200 m, the depths change from 6 m to 13.1 m (EIA phase 1, page 93).

In the Danube Delta, more than 100,000 ha (most of them temporarily flooded areas) were embanked. However, between 1994 and 2003 about 15 % of the area with embankments has been reconnected to the natural influence of water, through ecological restoration works (ICPDR roof report 2005).

The Tulcea-Sulina branch (81 km) is completely canalised with all former meanders and side channels being cut off, and its length reduced from 85 to 62 km. The 80 m wide navigation route has to be permanently dredged to secure a depth of 7.3 m. The southern St. Georghe branch (109 km) is not used by sea ships but also affected by meander cut-offs since the 1960s (loss of app. 50 km) and by the ship waves destroying the unprotected banks (ICPDR 2005).

All transitional waters in the Danube branches are “at risk” of not meeting the environmental objectives of the WFD due to the presence of hazardous substances and nutrient pollution. Additional risks may exist from organic pollution but the available data is insufficient for a clear assessment of the risk. Sulina, the middle branch, is “at risk” due to hydromorphological alterations. The marine transitional waters are “at risk” due to nutrient pollution and due to insufficient data on organic pollution and hazardous substances are “possibly at risk” (ICPDR 2005).

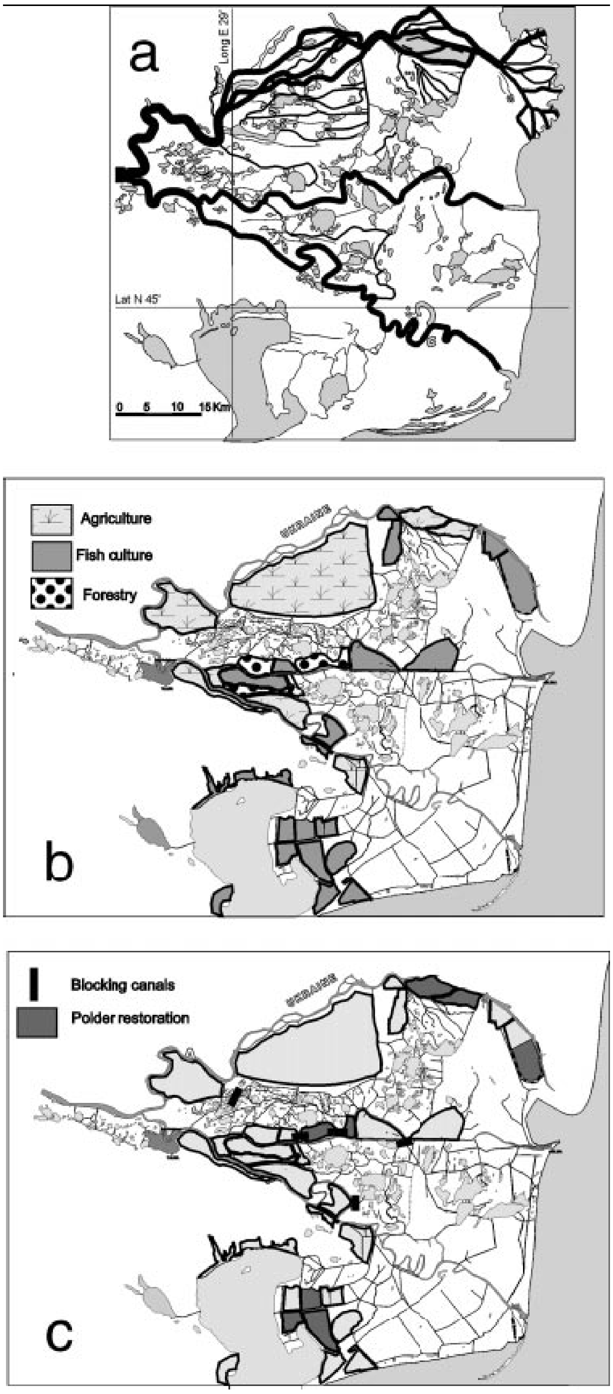


Figure 3-1: Danube delta in Romania. (a) Pristine situation around 1880, (b) Reclaimed land for agriculture, fish culture and forestry (1890–1989), and location of artificial canals. (c) Planned and realised restoration activities since 1994 including re-opening of polders and blocking of man-made canals (Buijse et al. 2002)

3.2. The fish fauna of the Danube Delta

The Danube Delta inhabits a very diverse and endangered fish fauna. The IUCN list of endangered fish species registers 28 (33 %) of the species 85 species occurring in the Danube Delta. Three species are critically endangered, 3 endangered, 2 of low risk and 5 are vulnerable. The same amount of fish species, 28 species (33 %), are listed in the Habitat Directive (Romanian fish data: annex 1-5).

Table 3-1: List of the fish species occurring in the Danube Delta, conservation status, ecological guilds (Romanian fish data: annex 1-5)

Family	*Species*	English name	Status in the Lower Danube (1)	Status in the Danube Delta (River arms, delta lakes, littoral lakes) (2)	IUCN red list (3)	FFH (4)
1. Petromyzonidae	*1. Eudontomyzon mariae*			K		A II
2. Acipenseridae	*1. Acipenser stellatus*	stellate sturgeon	T	V	EN	A V
	2. Acipenser guldenstaedti	danube sturgeon	T	V	EN	A V
	3. Huso huso	beluga	T	V	EN	A V
	4. Acipenser ruthenus	sterlet	L	E	VU	A V
	5. Acipenser nudiventris	ship sturgeon	EX	Ex?	CR	A V
	6. Acipenser sturio	atlantic surgeon	EX	I	CR	A IV
3. Anguillidae	*1. Anguilla anguilla*	eel				
4. Centrarchidae	*1. Lepomis gibbosus*	Pumpkin seed	E			
5. Clupeidae	*1. Alosa pontica*	pontic shad	S	nt	DD	A II A V
	2. Alosa caspia nordmani	caspian shad	S	nt		A II A V
	3. Alosa maeotica		Vu			A II A V
	4.Clupeonella cultriventris	black sea sprat	S		DD	
6. Aterinidae	*1. Aterina boyeri*				DD	
7. Esocidae	*1. Esox lucius*	pike	L			
8. Gadidae	*1. Lota lota*		Vu	R		
9. Ciprinidae	*1. Cyprinus carpio*	common carp	T		CR	
	2. Rutilus rutilus	roach	S			
	3.Scardinius erytrophtalmus	rudd	S			
	4. Blicca bjoerkna	silver bream	S			
	5. Alburnus alburnus	bleak	S			
	6. Tinca tinca	tench	Vu			
	7. Chondrostoma nasus	nase	S	nt		
	8. Aspius aspius	asp	S	nt	DD	A II
	9. Gobio albipinatus	danubian gudgeon	S	nt	DD	A II
	10. Gobio kessleri antipai		Vu	I		
	11. Vimba vimba	black sea bream	S	R		
	12. Leuciscus cephalus	chub	S			
	13. Leuciscus idus	ide	S	R		
	14. Leuciscus borystenicus	black sea chub	S	R	DD	
	15. Pelecus cultratus		S	nt	DD	
	16. Abramis brama	bream	S			
	17. Abramis sapa	White-eye bream	S	nt		
	18. Abramis ballerus		S			
	19. Barbus barbus	barbel	S	R		A V
	20. Carassius carassius	crucian carp	S	V	LR/nt	

	21. Leucaspius delineatus	sunbleak	L			
	22. Rhodeus sericeus amarus	bitterling	S	nt		A II
	23. Chalcalburnus chalcoides		EX	Ex?	DD	A II
	24. Carassius auratus gibelio	giebel carp	E			
	25. Ctenopharyngodon idella	grass carp	E			
	26. Hypophtalmich-thys molitrix	silver carp	E			
	27. Aristichthys nobilis	big head carp	E			
	28. Pseudorasbora parva	false harlequin	E			
10. Cobitidae	*1. Cobitis taenia*	spined loach	S	nt		A II
	2. Sabanejewia aurata	Golden loach	L	nt	DD	A II
	3. Misgurnus fossilis	weatherfish	Vu	R	LR/nt	A II
11. Percidae	*1. Stizostedion lucioperca*	pikeperch	S			
	2. Stizostedion volgense		EX	I	DD	
	3. Perca fluviatilis	perch	S			
	4. Gymnocephalus cernuus	ruffe	S			
	5. Gymnocephalus baloni		Vu	nt	DD	A IV
	6. Gymnocephalus schraetzer		Vu	nt	VU	A II A V
	7. Percarina demidofii					
	8. Zingel streber		Vu	K	VU	A II
	9. Zingel zingel		Vu	R	VU	A V
12. Siluridae	*1. Silurus glanis*	wels	L	nt		
13. Syngnatidae	*1. Syngnathus nigrolineatus*	shore pipefish	S			
14.Gasterosteidae	*1. Pungitius platygaster*	ninespine stickleback	L	nt		
	2. Gasterosteus aculeatus	stickleback	S			
15. Mugilidae	*1. Mugil cephalus*	mugil sp.		K		
	2.Liza auratus			K		
	3. Liza saliens			K		
16. Salmonidae	*1. Salmo trutta labrax*		T	R		
17. Pleuronectidae	*1. Platichthys flesus luscus*	flounder		R		
18. Gobiidae	*1. Neogobius melanostomus*		S		DD	
	2. Neogobius fluviatilis	monkey goby	S	nt	DD	
	3. Neogobius syrman		S	nt	DD	
	4. Neogobius gymnotrachelus	Racer goby	S		DD	
	5. Neogobius kessleri	Kessler’s goby	S	nt		
	6. Neogobius eurycephalus		S			
	7. Protherorhinus marmoratus	tube-nosed goby	S			
	8. Knipowitschia caucasicus		S			
	9. Knipowitschia cameliae			E		
	10. Benthofilus stellatus		S			
	11. Benthophiloides brauneri		T	Ex?		
	12. Zosterisessor ophiocephalus		EX	Ex?		
19. Umbridae	*1.Umbra krameri*	european mud-minnow	L	R	VU	

(1) E= exotic; EX= extinct, T= strongly threatened, Vu= vulnerable, L= little vulnerable, S= safe, (Banarescu, 1994);

(2) Ex= extinct, E= endangered, V= vulnerable, R= rare, I= not enough information to be included in E or V or R, K= insufficiently known, nt= not threatened locally but at European or international scale (Otel, 2000);

(3) IUCN red list: CR = critical, EN= endangered, VU= vulnerable, nt = near threatened, LR= lower risk, DD= data deficient;

(4) FFH=Flora, Fauna and Habitat Directive (92/43/EEC); Number of Annexes: A II=species of Community interest; A IV=strictly protected species; A V=species of exploitation subject to management measures;

3.2.1. Sturgeons

The lower Danube River extends from the river mouth, with three branches, to the Cerno River at river km 955 (Hensel and Holcik, 1997). This river reach has populations of three native diadromous sturgeon species, i.e., beluga (Great sturgeon), *Huso huso*; Russian sturgeon, *Acipenser gueldenstaedtii*; stellate sturgeon, *A. stellatus*, and one native riverine potamodromous species, the sterlet, *A. ruthenus* (Bacalbasa-Dobrovici, 1997). European Atlantic sturgeon, *A. sturio*, may be extirpated. Until the beginning of the 20ties century the Atlantic sturgeon entered the delta of the Danube River up to the Bulgarian sector. In Bulgaria there is no catch recorded since 1963. Rare individuals of ship sturgeon, *A. nudiventris*, are captured by fishermen. Besides overfishing, blockage of spawning migrations by damming: Iron Gates I Dam built in 1970 at rkm 939 and Iron Gates II Dam built in 1981 at rkm 859 caused sturgeon declines and spawning areas of migratory sturgeons were decreased more than two times (Bacalbasa-Dobrovici, 1997). For example, the most widely distributed anadromous species in the Danube River – the Russian and the stellate sturgeons have migrated regularly upstream to Bratislava (rkm 1869) and rarely reached the Austrian and the German parts of the Danube River. The main spawning sites of beluga (*H.huso*) were located between rkm 1 866 and rkm 1 766 in the contemporary Slovak-Hungarian stretch (Hensel & Holcik, 1997).

In the International Red book from 1996 (IUCN, Red List of Threatened Animals) all species of sturgeons inhabiting the Danube are included. *A. sturio* has the status of **critically endangered species,** *Huso huso, A. gueldenstaedti, A. stellatus* and *A. nudiventris* has the status of **endangered** species and *A. ruthenus* has a status of a **vulnerable** species. All Danube sturgeons are listed in the EU Habitat Directive (Annex V), in Appendix I and II of the Convention on International Trade in Endangered Species (CITES), in the Bern Convention and in the Bonn Convention. The Lower Danube remains the only main river in the Black Sea region ensuring natural reproduction of the migratory sturgeons (Vassilev 2005).

Great sturgeon, *Huso huso* (Linnaeus, 1758), beluga

The Great sturgeon belongs to type II sturgeons migrating, after spawning in the river, from fresh water into estuarine and brackish water and the juveniles follow more slowly (Rochard et al. 1990). In the sea the great sturgeon mainly inhabits the pelagic zone. In the Black Sea region, the great sturgeons can be found as deep as 180 m. Its vertical distribution depends on the presence of its food organisms.

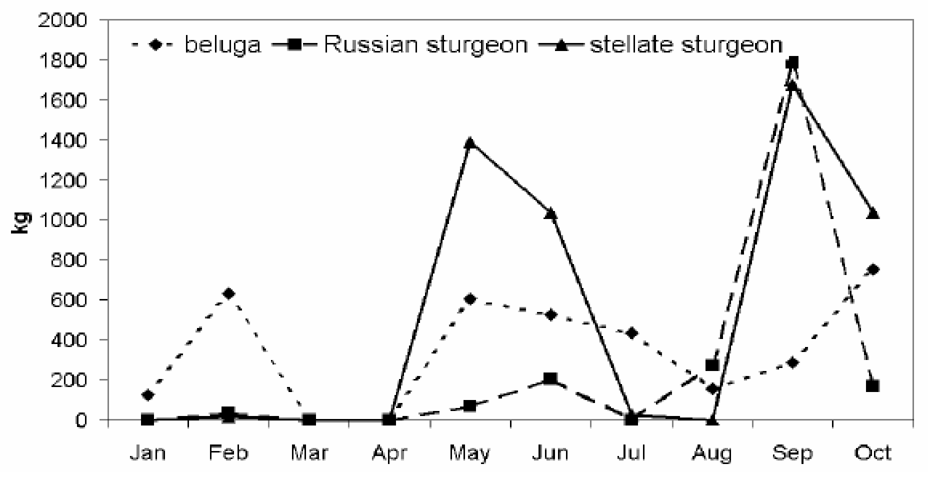


Figure 3-2: Seasonal dynamics of sturgeon catches in the Romanian sector of the Danube

Feeding: The diet of the Great sturgeon is variable during the course of the year. Great sturgeon is a true predator fish. In the Danube River the great sturgeon feeds on fishes: carp (*Cyprinus carpio*), asp (*Aspius aspius*), roach (*Rutilus rutilus*), bream (*Abramis brama*), sterlet (*Acipenser ruthenus*). Water birds were also found in its stomach.

In the Black Sea, near the coast, great sturgeon feeds on gobiids, anchovies, shrimps, crabs. During the winter they consume red mullet (*Mullus barbatus ponticus*), Black Sea whiting (*Merlangius merlangus*), flounder (*Platichthys flesus luscus*), gobiids, crustaceans (*Crangon*), molluscs (*Modiola*).

Spawning period: Spawning period is from March through May, with a maximum in April. Optimal temperature is between 9 to 17°C. It was reported that in the Danube great sturgeon also spawns during October and November but this information requires confirmation. Spawning of beluga sturgeon in the Lower Danube River systematically occurs 1 - 2 days after the water level has reached a peak when temperature is suitable, between 9 - 16 ºC (http://www.iucn.org/themes/ssc/sgs/sturgeon/suciu.html).

Spawning migration and sites: The great sturgeons undertake the longest spawning migration in comparison with the other anadromous migratory sturgeon. Therefore, the natural reproduction of this species was mostly affected by the regulation of the water flow and construction of dams. In the Danube River, spawning migrations can be observed almost all year round; nevertheless, two peak periods have been noted, one for the winter and one for the spring run. The spring run is observed from January (at a temperature of 4 to 5 C) through May – June with a peak in March or April. The autumn run begins in August and reaches its peak in October and November. The peak catch period for great sturgeon in the Danube River is in May, September, October and November. The autumn run is the more numerous, since more great sturgeons were caught by fishermen in autumn than in spring.

Spawning sites are at a river depth of 4 – 20 m, in places with gravel or even rocks (there were famous historical spawning grounds in the region of the "Iron Gates" canyon). Hard bottom formed by gravel or sand such those of higher sector of Romanian Danube River are typical spawning sites. A few similar places could be found also upstream at Calarasi Town (Ciolac and Partiche: 2004a). A small number of spawning grounds are located in the lower course of the river. (EIA phase, page 127). Spawning substrate consists of stones, pebbles and gravel in 4 to 15 m depth and at 1.5 to 2 m/s flow velocity (Billard & Lecointre 2001). Even when optimal conditions are missing, belugas are very likely reproducing also on different spots on the whole lower zone of Danube River, between 0 and 400 km (Ciolac and Partiche 2004a). Optimal spawning temperature is between 9 and 17 °C (Billard & Lecointre 2001).

Juvenile development: Depending on temperature hatching of eggs occurs 200–250 hours after spawning. The yolk sac larvae are pelagic for 7–8 days and are transported downstream (at a velocity of up to 45 cm s−1 i.e., 40 km day−1). After displacement from the spawning ground the yolk sac larvae settle down, usually in a much lower water velocity (1 to 5 cm s−1) on coarse substrate. They start feeding on both plankton and benthic organisms. After yolk absorption the larvae actively feed on benthic organisms and are usually found on homogenous sand substrate in places with water velocities < 10 cm/s (Billard & Lecointre 2001).

The Delta branches are important habitats for juvenile sturgeons. The juvenile sturgeons drift down from the upstream spawning grounds. It can be assumed that the drifting juveniles are distributed across the Delta braches relative to their flow. Therefore, about half of the juveniles are supposed to enter the Chilia arm.

The development of the osmoregulatory apparatus is already completed in their second month of life, and they are capable of enduring salinities as high as 12 ‰. During their first year of life, they develop the ability to survive in all parts of the sea (Reinartz 2002).

During their first 3 months, juveniles remain in shallow coastal waters where they rely on a diet of benthic invertebrates. During this period they grow quickly, and after reaching 8–10 cm they become largely piscivorous.

Environmental factors affecting beluga recruitment are poorly understood, however, predation and food availability are undoubtedly key factors. Although juveniles typically migrate to the sea shortly after the onset of exogenous feeding (Vecsei et al. 2002), Kynard et al. (2002) reported that significant numbers of age-0 juveniles over-winter in the main channel of the lower Danube. Drift netting captured one beluga larvae at rkm 238 (Harsova) on 26 May. It was captured in the channel (10–12 m water depth) at a water temperature of 19°C. The feeding larva was 23 mm TL and age was estimated at 14 days post-fertilization (Kynard et al. 2002).

Russian sturgeon, *Acipenser gueldenstaedti* (Brandt, 1833)

In the sea, the Russian sturgeon stays in shallow waters, according to the season, at depths from 2 to 100 m. In the rivers, *A. gueldenstaedti* remains at depths from 2 to 30 m.

Feeding: According to Manea (1980), in the Black Sea, Russian sturgeons feed on molluscs (*Corbulomya, Nassa, Cardium,* and other mollusks), crustaceans (shrimps, crabs), and fishes (anchovies, sprat, flounder, gobiids). In the Danube they feed on insect larvae (mainly Ephemeroptera) and fishes *(Alburnus alburnus)*.

Spawning period: The reproductive season lasts from the end of April through mid June. There are two capture peaks in the Danube River fisheries. Russian sturgeon migrate upstream the Danube River in the fall and spring but the most important season takes place during the spring months (March–May) rather than fall (September–October). The peak catch period for *A. gueldenstaedti* is in September and October. These fishes do not spawn in the fall; they enter the river but spawn in the following spring. The spring migration may last till late June and because this species is well adapted to fresh water, few biologists consider that some biological forms of Russian sturgeon remain all year long in Danube River (Ciolac and Partiche: 2004a).

Spawning places: Russian sturgeon adult individuals use almost the same sites for spawning places as beluga (Ciolac and Partiche: 2004a). Russian sturgeons spawn in rivers on substrate with stones, gravel and sand at depths of 4 to 25 m (Vlasenko *et al.*, 1989). According to Billard & Lecointre (2001) Russian sturgeon spawns in May and June at water temperatures of 8 to 15°C on gravel and 1.0-1.5 m/s flow velocity. In the Danube River, a small number of spawning shoal reproduces near the mouth, but the great majority migrate a considerable distance upstream before spawning (Reinartz 2002).

Juvenile development: Drift-net and dip-net captures in rivers indicate that Russian sturgeon embryos, larvae, or both migrate downstream from spawning sites (Amirkhanov 1967). Juveniles enter the sea a few months to a few years after hatching (Vlasenko et al. 1989). Larvae are also found in deeper water and rapid currents contributing to their rapid downstream movement. As growth process, the young sturgeons move from deeper water to shallow food rich stretches of the river. In the Danube River, the young sturgeons remain in deep water for a long time (Reinartz 2002).

Ship sturgeon (*Acipenser nudiventris* Lovetsky, 1828)

In the Danube River, the ship sturgeon is a freshwater resident form. In the Black Sea it occurs only accidentally. Its ecology is similar to *Acipenser ruthenus*: they have common wintering, feeding and spawning places. The biology of the ship sturgeon from the Danube River and from Caspian Sea is quite different.

Feeding habits: Ship sturgeon from the Danube River feeds on mayfly larvae (Ephemeroptera), other insects' larvae, mollusks, and crustaceans.

Spawning period: From end of April until end of May (water temperatures between 10 -15°C)

Spawning sites: According to Billard & Lecointre (2001) ship sturgeon spawns on gravel and pebbles in 4 to 15 m deep water and 1-2 m/s flow velocity. In the Danube River spawning takes place on sandy or gravel bottoms, not too elevated but with a high water velocity (in order to prevent eggs siltation). Ship sturgeons were frequently found in the Danube mainly at Ivancea and between Pisica and Isaccea (Mm 64 – 85).

Stellate sturgeon *(Acipenser stellatus* Pallas 1771)

The stellate sturgeon is a benthic inhabitant of coastal waters in seas and the lowland sections of rivers, but unlike other sturgeon species, it can be found in the middle and upper layers. The stellate sturgeon is an anadromous fish feeding in the sea and spawning in the rivers.

Feeding: In the Danube River, in the first stages of life the stellate sturgeon feeds on larvae of Chironomid, Trichoptera, Ephemeroptera as well as crustaceans. In the Black Sea, the juvenile feed on worms, molluscs and crustaceans. The adults feed on fishes, crustaceans.

Spawning: The stellate sturgeon migration in the Danube River takes place immediately after those of *Huso huso* and *Acipenser gueldenstaedti.* It is characterized by two peak periods. It begins in March at a water temperature of 8 to 11 C, reaches its peak intensity in April, and continues through May. A second, more intense migration begins in August and lasts until October. Peak catch period for *A. stellatus* in the Danube is in May. It is supposed that individuals that migrate in fall will spawn also in spring because their degree of gonad maturation is inferior to the one of the adults migrating in spring (usually at the beginning of March). The spawning usually takes place at the end of May in deep locations with fast current (Ciolac and Partiche: 2004a). Stellate sturgeon spawns on gravel and rocks in 2 to 14 m depth with 1.1.-1.9 m/s flow velocity (Billard & Lecointre 2001).

Juvenile development: The yolk sac larvae are pelagic for 2–3 days (Billard & Lecointre 2001) and drift downstream. In the Volga River juveniles (1.0-7.5 g) migrate downstream from June to November. In the Ural River the seaward migration includes larvae (5-17 mm). The most intensive migration is observed at the end of May and the first third of June. It was found, that in the Danube River, the distribution of juveniles on the river bed is influenced by the food supply, current and turbidity. Juveniles migrate downstream at depth of 4 to 6 m. The life span in the river lasts from May to October. As observed in the Sea of Azov the YOY (Young-Of-the-Year) juveniles stay near the river mouth after entering the sea in September and October. In the bays of the mouth of the Kuban River, juveniles inhabit waters with salinities from 0.01 to 8.72 ‰ . The osmoregulatory capacity increases with age and weight. Experiments showed that 15.2 cm and 10.6 cm long juveniles survived the transfer from fresh to brackish water with salinity of 12.5 ‰ at almost 100 % and 72 % (Reinartz 2002).

Sterlet, *Acipenser ruthenus*(Linnaeus, 1758)

Sterlet is a freshwater species. It is frequently in the Danube River. In the Black Sea it occurs only accidentally. It is rare in the Danube Delta and occurs more often in Braila region, on the Borcea Branch and upstream in the Danube. It usually stays in the current in deep depressions of the riverbed, over stone, gravel or sand bottom. Sterlet does not stand the turbid water, which is why, after the rain it redraws in deeper places. During the winter it hibernates in deep holes, together with the ship sturgeon. Sterlet is a sedentary species and does not undertake long migrations.

Feeding habits: Benthic organisms are the main food of the sterlet. In the Danube River it feeds almost exclusively on crustaceans and insects larvae, mainly Ephemeroptera, genus *Palingenia.* The larva of these insects develops at 6-8 m depths and here the sterlet aggregate for feeding. Sterlet also feeds on worms, larvae of Trichoptera and Chironomidae.

Spawning period: Middle of April till the end of May, sometimes until the beginning of June. The optimal water temperature range is between 12 and 17°C.

Spawning sites: In the Danube River, at a depth of 6 to 8 m, in a high current velocity to prevent eggs siltation. Spawning also takes place in flooded areas on gravel in 2-15 m deep water and 1-4 m/s flow velocity (Billard & Lecointre 2001). Development of Volga stellate sturgeon eggs requires 2 to 6.5 days, depending on the temperature (Reinartz 2002).

3.2.2. Sturgeon fishery

In the lower Danube and adjacent sea one can distinguish between freshwater fishery, migratory (anadromous fish) fishery and marine fishery. The most important fishery is the sturgeon fishery.

The information on the status of sturgeon fishery was mainly obtained from the Romanian part of the Inquiry Commission and beside cited literature sources from a recent report on the Bulgarian fishery (Paykova et al. 2003).

Sturgeon fishing dates back to more than 20 centuries. Sturgeons have been fished for caviar as well as for meat. It is considered that the human impact on population density of sturgeons starts after 17ieth century (Balon, 1968). A permanently decrease of sturgeon stocks can be observed since the end of 19-th century up to present days (Hensel & Holcik, 1997). The Black Sea region takes up the second place in the World (after the Caspian Sea region) by sturgeon catches and production of caviar.

The overfishing is especially negative during the spawning migration (in the rivers) and during spending the winter (both in the rivers and the sea). In the beginning of 20th century the annual sturgeon catches in the Lower Danube were about 1 000 metric tons, while in the end of the century they have dropped significantly (Bacalbasa-Dobrovici, 1997; Bacalbasa-Dobrovici & Patriche, 1999; Reinartz, 2002).

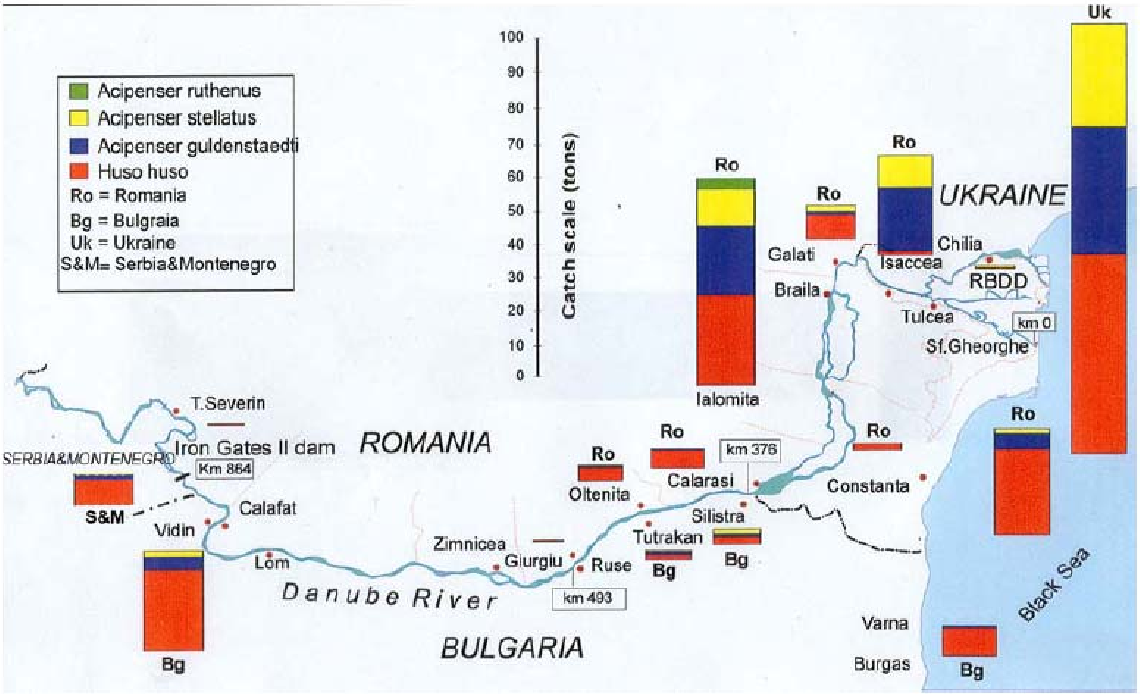


Figure 3-3: Distribution of sturgeon catches per fishing zones (Navodaru & Staras 2002 in Vassilev 2005)

Beluga is the most important species in commercial sturgeon fishery of the Lower Danube. The depletion of commercial stocks reflect the dramatic reduction of the wild stock within the last decades The real catch of *Huso huso* as well as of other sturgeon fishes is considered to be considerably greater because of poaching.

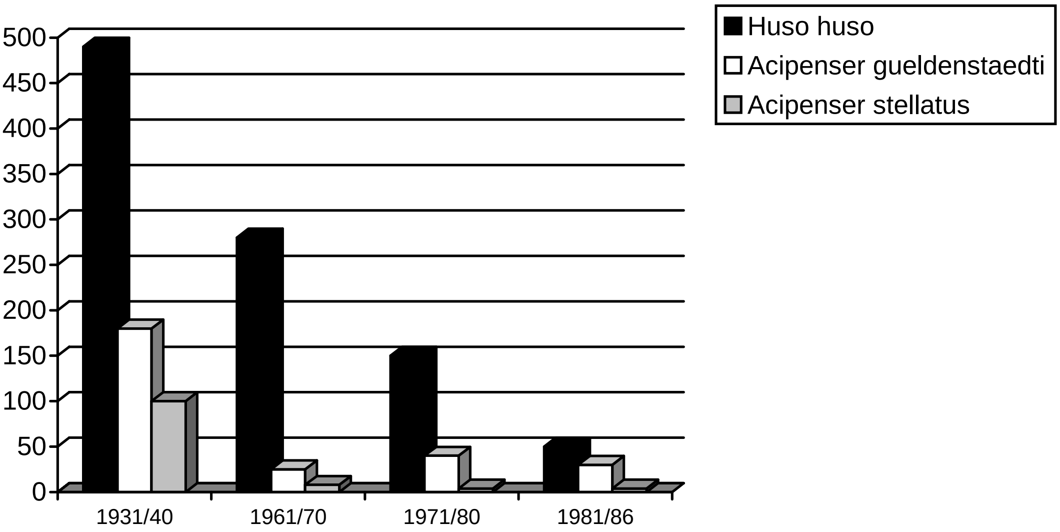


Figure 3-4: Structure of sturgeon catches (t) by species in lower stream of the Danube River for the period 1931-1986 (Navodaru et al. 1999)

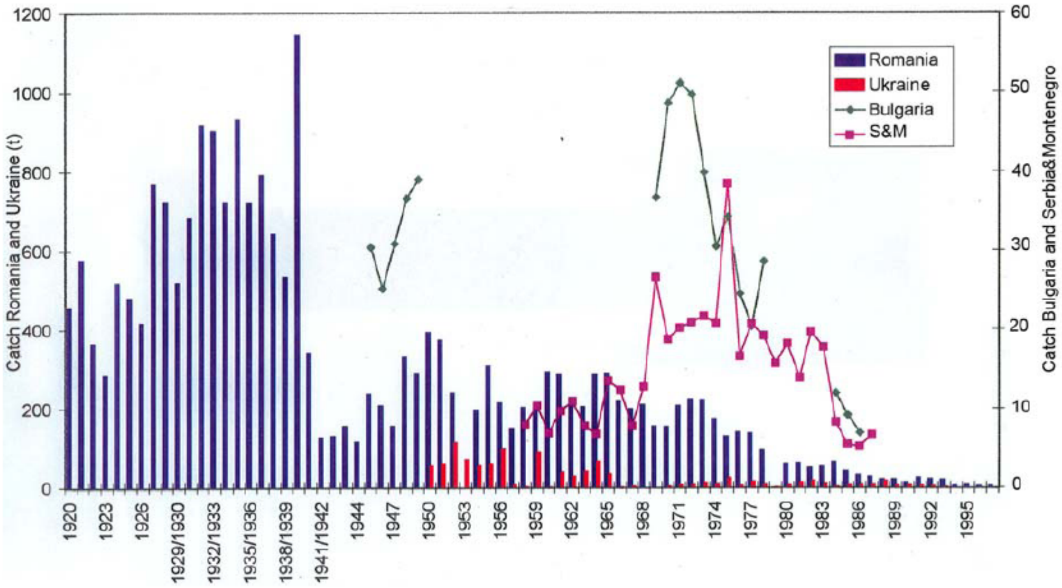


Figure 3-5: Sturgeon catches in the Lower Danube (Navodaru & Staras in Vassilev 2006)

According to Bacalbasa-Dobrovici & Patrishe (1999) during the last years the strength of juvenile sturgeon fishes from the species *Huso huso, Acipenser gueldenstaedti* and *Acipenser stellatus* has significantly decreased in the Northwestern part of the Black Sea. The authors give as example the fact that 30-40 years ago in occasional catches were caught between 20 and 50 juvenile specimen (15-80 cm long) per night per net. Nowadays not more than 5 specimens are caught per net.

The Juvenile Production Index is a fishery independent measurement of reproduction success in the Lower Danube. It is a Catch Per Unit Effort sampling technique that allows comparison among years (number of YOY captured by fishing with a 96 m long, 20 mm mesh sized gill net drifted over 850 m stretch of the Danube River at river km 119) As shown in Figure 3-6 highest recruitment was recorded in 2000 and 2005 (Rom. CommentsStarasJan2006add3to15-28).

In 1994, as beluga was included in the Red list of Ukraine, its catch was forbidden. That same year Ukraine unilaterally imposed a ban on catching sturgeons; and from 1995 only its scientific and experimental catch is carried out (EIA phase 1, page 127).

Facing the dramatic depletions of sturgeon stocks the Romanian government recently released an “Order on conservation of wild sturgeon populations and development of sturgeon aquaculture in Romania” forbidding commercial fishing of wild sturgeon for a ten years period.

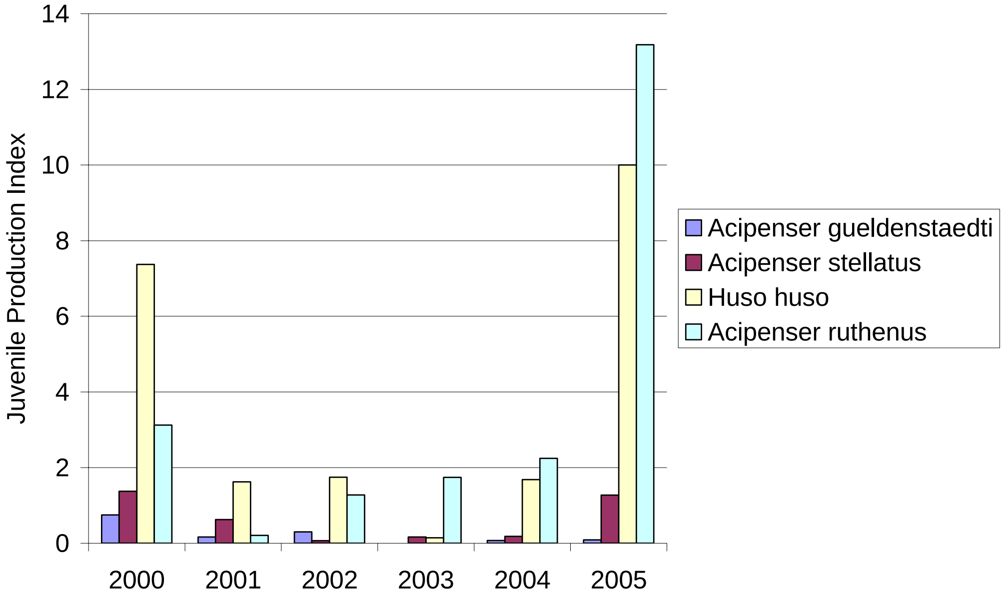


Figure 3-6: Natural recruitment of different sturgeon species in the lower Danube River during 2000 – 2005 assessed by monitoring downstream migration of YOY at river Km 119 (represented as Juvenile Production Index ,JPI) (Data from Rom. sturgeonmonitoring.doc).

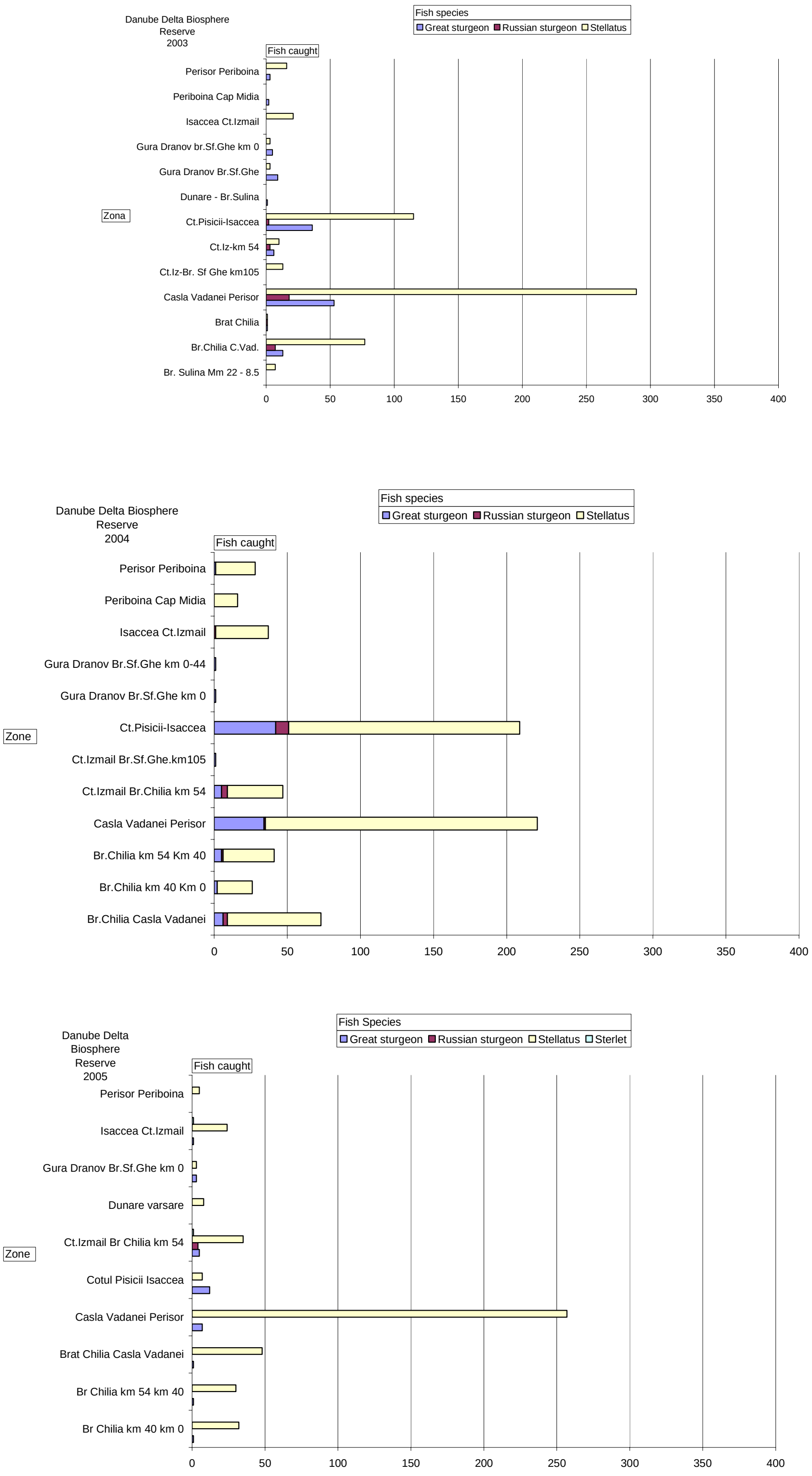


Figure 3-7: Location and number of sturgeons caught in 2003 to 2005 in the Danube Delta downstream of mile 75 managed by Danube Delta Biosphere Reserve (Data from "Sturgeons of Romania and CITES" http://rosturgeons.danubedelta.org)

Since 2003 sturgeon catches in the lower Danube are monitored and published at the "Sturgeons of Romania and CITES" web site, http://rosturgeons.danubedelta.org. According to the data presented there 555, 584 and 449 sturgeons were caught in the

Danube Delta below mile 75 in 2003, 2004 and 2005 (Figure 3-7). Sturgeons were caught in the Chilia branch in all years. There are no trends in the spatial variability of the commercial landings among years.

3.2.3. Conservation and sustainable management of sturgeon populations

Representatives of the Fisheries and CITES Management Authorities of countries of the N-W Black Sea and Lower Danube River agreed on a *Regional Strategy for the Conservation and Sustainable Management of Sturgeon Populations of the N-W Black Sea and Lower Danube River in accordance with CITES* (http://www.iucn.org/themes/ssc/sgs/sturgeon/activities-romania2.html#annexa) to improve knowledge on (sub-)population and life history, habitat requirements, stock enhancement options by stocking, fishery harvest, and management options.

3.2.4. Sturgeon farming

The combination of farming and stock enhancement started in Romania with *A. stellatus* and *A. gueldenstaedtii* and in Bulgaria with *H. huso* (Billard & Lecointre 2001). The objective is to start farming operations from wild juveniles, submature and mature adults taken from the Danube and reared in hatchery facilities at the Brates experimental fish in Galati (Patriche et al., 1999). Mature males and females captured from the Danube are transported to the experimental station to receive hormone induced spermiation/ovulation treatment. The larvae are hatched and grown in outdoor fertilized polyculture ponds (with cyprinids) so that the juveniles are exposed to a simulated wild environment. Juveniles and adult sturgeons and paddlefish are also reared in polyculture ponds, which are fertilized organically.

The restocking of Lower Danube with artificially propagated sturgeons was started in 1991 in Romania and in 1998 in Bulgaria (Bacalbasa-Dobrovici & Patriche, 1999; Vassilev, 2005). Till now, more than one million larvae, fingerlins and juveniles mainly of *A. guldenstaedtii* and *A. stellatus*, and considerably less *A. ruthenus* and *H. huso* have been released into the river. In Ukraine about half a million larvae (during the last years) of *A. guldenstaedtii* per year are restocked in Dnepr River (Voloshkevich, pers. comm. cited in Paykova et al. 2003).

Restocking with sturgeon fishes has been fulfilled in the Bulgarian section of the Danube River since 1998. For the period 1998-2001 (data from MoEW) in the river have been released in total 83820 individuals of *Acipenser gueldenstaedti* by weight of 20 grams to 1,8 kg; 3 650 numbers *Huso huso* by weight of 20 to 550 grams and 800 numbers *Acipenser ruthenus* - from 15 to 100 grams. In the year of 2002 in the Danube River are released 62 520 numbers *Acipenser gueldenstaedti* by weight of 12 to 300 grams; 2 125 numbers *Acipenser ruthenus* by weight 50 – 100 grams. Until the month of November 2003 in the river had been released 161 317 numbers *Acipenser gueldenstaedti* and 5 300 numbers of *Acipenser ruthenus*. For the year 2004 the number of released fingerlings is 211 126 (Table 3-1, Paykova et al. 2003). Evaluating the efficiency of stocking efforts will require a long-term monitoring programme.

Table 3-1. Aquaculture produced sturgeon fingerlings released in Danube River for 1998-2003 (Paykova et al. 2003)

Year	Total number	A.gulld.	Average weight (G)	H.huso	Average weight (G)	A.rutenus	Average weight (G)
1998	1 500	1000	250	200	300	300	180
1999	30100	27 400	230	2 700	320	-	-
2000	21150	20 400	200	750	350	-	-
2001	28 100	28 100	200	-	-	-	-
2002	23 530	22 530	280	-	-	1 000	-
2003	166 617	161 317	82	5 300	5	-	-
Total	**270 997**	**260 747**		**8 950**		**1 300**	

3.2.5. Danube herring, *Alosa pontica* (Eichenwald, 1838), Pontic shad

The Pontic shad lives in the Northwest part of the Black Sea and migrate into the Danube for spawning. In the past, isolated individuals migrated as far as Budapest (river kilometer 1,650) (Bãnãrescu 1964). The Pontic shad migration begins in early spring when the water temperature reaches 3-7.5°C, peaks in April-May when the water temperature reaches 9-17 °C, and ends in June-July, at 22-26 °C. Most of the spawning occurs between river kilometres 180 and 500. Eggs are pelagic and larvae and juveniles migrate passively to the sea. Zooplankton is the main food source for juveniles in the river habitat. Some fry remain in back waters over the summer and descend to the sea during autumn (Nãvodaru 1998). The drift takes place only in the upper two-meter layer (most of them drift in the water layer from the surface to the depth of 1 m – 90 pct). Herring fry are found any deeper sporadically. The downstream migration period of juvenile herring in the Danube lower course may take as long as 4 months, the mean annual downstream migration of juveniles in the Ukrainian section makes up 200-250 million specimens (EIA phase 1, page 129).

Shad fry in the first year (0+) and some in the second year (1+) feed near the coastal zone of the Black Sea. As they grow, shad move far off the coast. They overwinter at a depth of 100 meters and do not aggregate in shoals (Nãvodaru 1998). The large flow on the Chilia branch attracts Danube herring during its spawning migration. Wide river banks in the narrow strait and a greater depth are favorable for its successful catching. That is why in the nineties the average annual catches of herring in the Bystre branch made up 16.7 to 51.1 % (according to the DBR data – up to 21.1 %) of all herring catches in the delta of the Chilia branch of the Danube (EIA phase 1, page 130).

During the last five years, big catches of red-finned mullet have been registered in the area of the sand-bar, adjacent to the Bystre distributary. Shallow waters of this narrow strait are traditionally noted for good catches of рыбца (EIA phase 1, page 130).

.

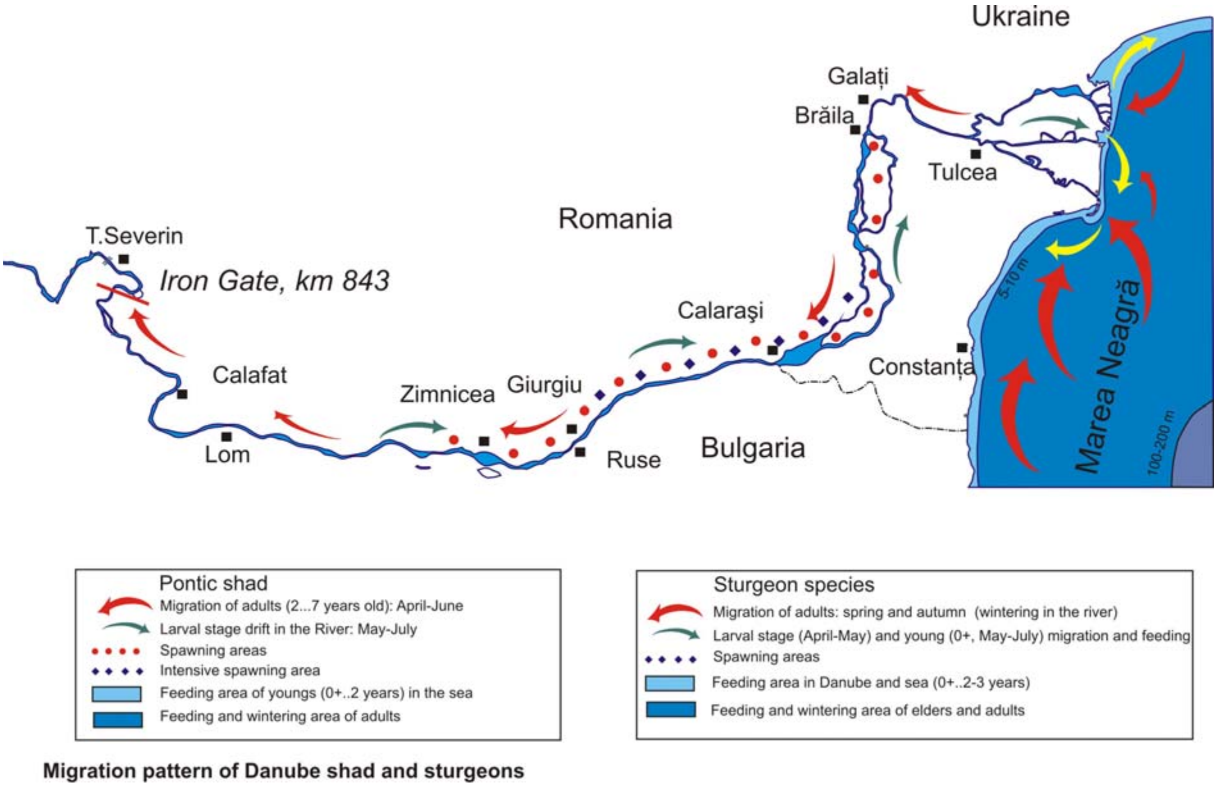


Figure 3-8: Summary of habitat requirements and spatial habitat arrangement of sturgeons and Pontic shad in the Lower Danube (Romanian fish data, annex 6b).

3.2.6. Other fish species

The fishery of the Danube Delta exploit a variety of habitats distributed over about 580 000 ha of wetlands. Fishery is practiced in about 100 000 ha of open water lakes, 11 500 ha of Danube Delta arms, about 3400 km of channels and canals, 162 000 ha of flooded reed beds and 121 000 ha of the Black Sea coast, all of which lie within the 580 000 ha of the Biosphere Reserve's wetlands. Fishery yield between 5000 and 10 000 t per year, equivalent in value to 6.3 million US$, making this one of the most important inland fisheries in Europe. Approximately 15 000 inhabitants within the Delta and a further 160 000 from adjacent regions depend fully or partly on the fishery resource (Navodaru et al. 2001).

The fisheries are diverse, consisting of lake, river, coastal and anadromous fisheries. More than 13 fish species are of commercially importance in the Danube Delta

Biosphere Reserve. Total catches decreased from 14 000 t in the 1960ies to about 3 000 t nowadays. The most important species are Crusian carp (*Carassius gibelio*) and bream (*Abramis brama, Abramis boerkna*). (Figure 3-9 , Romanian fish data: Annex 7-8). Sea fish (grey mullets, silverside, *Platichthys flesus luscus* and others) under favourable conditions enter estuary sections of the Chilia delta of the Danube, they are constantly found in shallow waters of estuarine seashore of the river delta (EIA phase 1, page 130).

The viability of potamodromous fish species of the Danube Delta depends on the available aquatic habitat in the Delta channels, lakes, flooded reeds and temporally flooded areas. The floodplains are mainly inundated during high flows in spring and represent the main spawning and nursery habitats for potamodromous fish species.

The fish stocks of the Black Sea have shown a pronounced decline. The fish catches have been dramatically reduced: at the level of the Black Sea, the catches were almost 3 times smaller in the early 1990s than they were in the 1960s and 1970s, on the Romanian sea-shore even 10 times smaller. In the early 1990s, out of 26 fish species of commercial interest annually captured in tens or hundreds of tons between 1960-1970, the commercial fishing of *Scomber scombrus, Trachurus mediterraneus, Thunnus thynus* and *Xiphias gladius* was stopped at the end of the 1970s. After the 1980s only 5 species (*Sprattus sprattus, Engraulis encrasicolus, Merlangius merlangus euxinus, Neogobius melanostomus and Atherina boyeri*) have had a commercial importance. As a consequence of the strong decline of the predator species, the small pelagic fish with a short life-time, in particular *Sprattus sprattus* and *Engraulis encrasicolus*, represented 80 % of the total fish catches (ICPDR 2005).

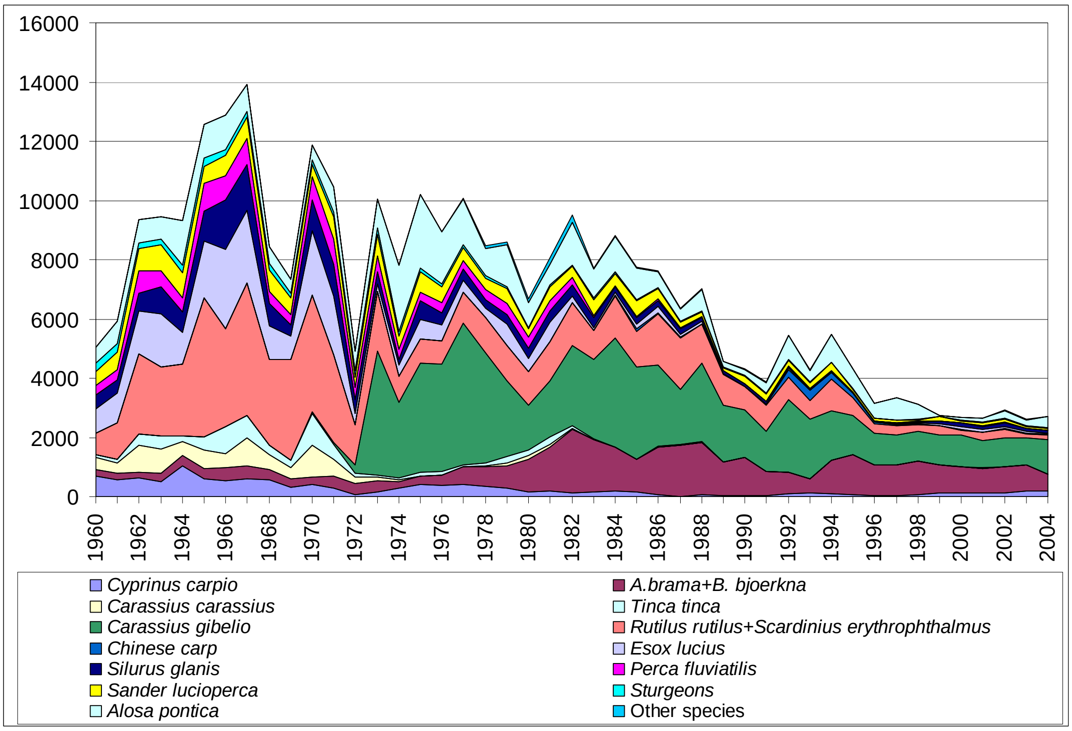


Figure 3-9: Commercial catch size statistics in the Danube Delta Biosphere Reserve, 1960-2004 (tons) (Romanian fish data: Annex 7-8)

CONCLUSIONS

1. Although the Danube Delta already has suffered under a variety of human pressures it still inhabits a very diverse and endangered fish fauna of high commercial value.
2. As demonstrated by commercial catch statistics, the populations of sturgeons have severely decreased within the last decades due to overfishing and other human impacts.
3. There are no data on real stock sizes available. Comparison between the total commercial catches and the fishing efficiency indicates that the total stocks of rare Danube sturgeon (sub)populations, e.g. Russian sturgeon and beluga, are probably below or not far above minimum viable population levels of 1 000 adults. As a result any further significant impact on these populations might increase the risk their extinction.
4. Migratory and commercially important species, i.e. sturgeons and Danube shad, use the Danube Delta and its branches (e.g. Chilia, Bystre channel) for various purposes:

   (1) migratory route for adult fish, spawning in upstream parts of the Danube

   (2) partly spawning in the Delta

   (3) nursery habitat for larval und juvenile fish in particulate during the first year of life

   (4) pathway for adult and larval/juvenile fish migrating to the Black sea
5. Sturgeons migrate and are present in the Danube Delta during the entire year.
6. Any impact on migratory species in the Chilia branch and Bystre channel resulting from engineering activities affects the entire Danube populations.
7. Besides long-distant migratory species, potamodromous species (riverine migrants) support a valuable fishery providing employment for several thousand fishermen. Potamodromous fish species heavily depend on the floodplains as spawning and nursery habitats.

Due to the migratory behavior of fish any significant impacts on the fish populations of the Chilia branch, Bystre channel and coastal area **at the Ukrainian territory may have transboundary effects** on the fish fauna and fishery **at the Romanian territory**.

4. Potential effects of the DNC project

Phase 1 of the project comprises:

- the dredging of the sandbar section at the mouth of the Bystry Branch;
- the clearance of sand reefs in the river section between Izmailsky Chatal and Vilkovo;
- the construction of (a part of) a retaining sea dam.

Phase 2 is planned to comprise

- the final adjustment of its elements and parameters in line with existing international standards, up to a navigable depth of 7.2 m;
- and the provision of protective hydraulic facilities designed to ensure its stable operation, including an extension of the retaining sea dam.

In the STATEMENT OF THE CONTROVERSIONS (Inquiry Commission report chapter 4) the Romanian side argued that transboundary impact is likely because of "changes in migration pattern of sturgeon species and Danube herring, disrupting fish migration routes, decrease in biodiversity, impact on threatened species and changes in species composition".(Rom.1, annex 1, point 3). It was further stated that an impact of the dredging on migratory fish species in most cases cannot be inferred immediately, but after a certain time span and therefore required long term systematic monitoring (Rom. 3, Re point 13-14).

The Ukrainian side stated, that the "impacts on reproduction conditions for fish stock.... is forecast to be not significant in the transboundary context" (Ukr. 1, page 3). This conclusion resulted also from the 2005 monitoring (Ukr. 2, Annex 26). However, no data of the fish monitoring are presented in the information provided by the Ukrainian side.

In the conclusions of the EIA Phase I it is stated that “exploitation of deep-water navigable channel creates certain handicaps to fishery” (EIA phase 1, page 75). However, there is no information provided how and to what extend fishery will be impacted.

4.1. Effects of dredging on fish

4.1.1. Dredging of sills

In Phase I the navigation channel in the river from the city of Ismail seawards has a projected design width of 120 m (some part 60 m) and a projected design depth of about 7 m with slopes ranging from 1:6 to 1:1.5. This involves a dredging volume of in total about 1.9 million m^3. Increase in depth over the sills ranges from some 0.5 m to 3.8 m. By October 2005 1.3 million m^3 has been dredged in the river. By October 1, 2005 all dredging operations under Phase 1 were suspended, thus channel widths in some river sections then were below the design values. The anticipated area of the river bed, affected by the dredging and storage covers some 1.7 million m^2 (Inquiry Commission report chapter 3). The riverine area affected by dredging is 1 121 105 m^2 from Ismail to Vilkovo.

In **Phase II**, the design depth of the Navigation Route in the riverine part is 8.4 m and in the Sandbar section 8.72-9.52 m. All other design parameters are similar to those of Phase 1. For Phase II this means an additional dredging of about 4.5 million m^3 in the river and sandbar sections and some 1.2 million m^3 in the Seaward Access Channel and some 0.03 million m^3 along the retaining dam. In total 5.73 million m^3. For comparison the total dredging volume for Phase 1 was 3.65 million m^3.

It is very difficult to present an estimate of the volume of **maintenance dredging** in the Lower Danube River. The reason is the great seasonal and yearly variability of the sediment load, associated with the variability in the river discharge. It is suggested that as a rough estimate up to some 10% of the total annual suspended load, carried via the Chilia arm is retained and deposited along the river section between Ismail and Vilkove. This results in estimated annual sedimentation rates ranging between 0.31 and 3.39 million m^3, with an average annual rate of 1.31 million m^3 over the period of 1980-2004. An unknown part of it will be deposited on the dredged sills and have to be removed. However, these figures suggest a yearly average volume of maintenance dredging in the order of magnitude several hundred-thousand m^3 (Inquiry Commission report chapter 3). In addition, the estimated volume of river-borne sediments, deposited in the seaward access channel of the Danube-Black Sea Navigation route in 2005 was between 0.8 and 1.2 million m^3. The average annual volume of sediments deposited in the sand bar section over the period 1980-2004 is 2.5 million m^3. This applies to the whole sand bar area. The seaward access channel is only a part of the sand bar area. The annual volume of sediments, deposited in the Access Channel accounts for up to 20-30% of the total volume of sediments deposited in the sandbar area; thus some 0.5- 0.75 million m^3, in the absence of the retaining dam. In the presence of the completed dam (Phase II) this volume is estimated to be reduced to some 0.25-0.35 million m^3 (Inquiry Commission report chapter 3).

This points to a yearly average volume of maintenance dredging of the order of several hundred-thousand m^3 in the access channel (Inquiry Commission report chapter 3).

In Phase II some 1 million m^3/year maintenance spoil will be dumped at the offshore site until it reaches its design capacity of some 5.4 million m^3 (Inquiry Commission report chapter 3). There is no indication in the EIA report provided where spoil will be dumped after the design capacity of some 5.4 million m^3 will have been reached.

4.1.2. Potential impacts of dredging

Dredging activities pose significant impacts to aquatic ecosystems by removing, disturbing and resuspending bottom sediments. Environmental impacts of dredging include the following: direct removal/burial of organisms (entrainment); turbidity/siltation effects; contaminant release and uptake; noise/disturbance; alterations to physical habitat. Indirect harm to fish from either mechanical or hydraulic dredging includes destruction of benthic feeding areas, disruption of spawning migrations, and deposition of resuspended fine sediments in spawning habitat (Chytalo 1996).

Potential impacts are well considered in the EIA Phase I report:

The main process of the impact taking place while dredging is an **increase of water turbidity**, **inflow of biogenic and polluting substances** from bottom sedimentation in soluted form and absorbed on the silt particles (EIA phase 1, page 101).

As a result of dredging **deterioration of water quality** of a number of evaluative and normative indexes, disruption of oxygen conditions and enhancement of eutrophication processes may occur (EIA phase 1, page 105).

More long impact is made by **changes in morphometry** and orthography of bottom surface, qualitative and granulometric structure of bottom grounds, which in turn brings in the change in hydrodynamic and lithodynamic conditions (EIA phase 1, page 105).

Recolonisation of dredged areas by benthic organisms takes place at the long-term (IMG-Golder Corporation 2004).

All the described processes lead to the change of water life biotope, their **partial destruction, failure of ichthyofauna reproduction** conditions (EIA phase 1, page 105).

During the work of excavation equipment the suspension density increases 20 times and more as compared to the natural one. This results in decrease of feed organisms' quantity and biomass, death of spawners, fry and juveniles; besides, death of plankton organisms happens in the volume of water-soil compound when water jet is used (EIA Phase I, page 137).

The increased content of suspended particles also has a negative effect on phytoplankton: its quantitative indicators decrease, the change of dominant types takes place. Suspension particles break large cells and colonies of water-plants, increase the speed of plankton forms settling, cover the submerged macrophytes. Due to the particles' small sizes, the rivers' self-cleaning happens too slowly, phytoplankton partial renovation takes place at a considerable distance from the work site. In the work sections with the increased content of suspended particles is much poorer in a quantitative and qualitative sense. The decrease of quantity, biomass and the depletion of zooplankton and benthos specific composition results from direct influence of suspension on search functions and breathing conditions of the organisms in the work zone. Topsoil removal or earth backfilling results in biocenoses reformation, disrupts the benthos structure, and makes organisms unstable to survival (EIA Phase I, page 138).

The impact of carrying out construction work on ichthyofauna may be expressed in death of juvenile fish, feed organisms, disruption of spawning grounds, crossing of fish migration and downstream migration routes. In the first place, the increase of suspended particles negatively affects the fry and the juveniles, whose organisms are weaker as compared to the grown up fish. In the increased turbidity area sexually mature fish undergo morphometric changes in the organism, in particular, body weight and size, fertility, which affect the quantity and the quality of the progeny (EIA Phase I, page 138).

Entrainment of aquatic organisms occurs from the indirect uptake of aquatic organisms by the suction field generated (Reine and Clarke 1998). Organisms are susceptible to suction dredges due to their inability to escape the suction field around the intake pipe (McNair and Banks 1986). If organisms survive uptake by the dredge, they may suffer from additional injuries or mortality from abrasion, entrapment or asphyxiation within the dredge. Rates of mortality tend to be highly dependent on the type of dredge used and the vulnerability of the organisms entrained (IMG-Golder Corporation 2004).

Increased sensory disturbance occurs from the noise that the dredge makes while operating. This noise may affect the movement and distribution of species in the area.

While carrying out construction work, the water areas lose their fishery significance, which results from the absence of feed organisms, the increased noise during the mechanisms' work, the increased turbidity. Adverse factors scare away fish, block the routes of spawning migrations and the juvenile downstream migration (EIA Phase I, page 138).

When carrying out phase I of the work, the nutritive base in the places of dredging will be terminated temporarily. Also, the water area in the zone of protective dam construction is forever withdrawn from fishery use. Besides, the change of environment state as a result of deepening the sand-bar part will result in the loss of these areas for feeding conditions of juveniles of the most valuable ichthyofauna representatives – sturgeons (EIA Phase I, page 138).

Carrying out the work, stipulated by the project, by phase I during nonspawning period rules out the impact on spawning migrations and downstream migration of anadromous fish whitebait (EIA Phase I, page 138).

4.1.3. Likeliness of impacts due to suspended solids and turbidity

Background concentration of suspended solids

In the Danube Delta, the average concentration of suspended solids is 277 g/m^3 (1961-1993). For 20 years since 1959 to 1979 the decrease was by one third (from 325 to 200-205 g/m^3). Annual average characteristics of turbidity for this period fluctuated within the limits 93-242 g/m^3; monthly average from 16.6 g/m^3 (XI. 1969) to 801 g/m^3

(X. 1972), and daily average made from a few grams up to 2000-3000 g/m^3. In May of 2000 the maximal concentration of SS made 528 g/m^3 (EIA phase 1, page 93).

Effects of suspended solids and turbidity on fish

Effects of suspended solids (SS) and turbidity on fish is a function of SS concentration, exposure duration and type of sediment. High concentrations and short exposure have the same effect as low concentrations over long exposure. In addition, size and shape of particles influences the response to SS. Effects depend on species of fish and life stage. Early life stages of fish, specifically egg and larvae, generally demonstrate greater sensitivity to stress than adult and juvenile fish.

Newcombe and Jensen (1996) developed dose-response relationships for various taxonomic groups of lotic, lentic and estuarine fishes to estimate the magnitude of adverse effect that may be expected when fish are exposed to a given concentration of sediment over a given time period. This dose response model uses TSS (total suspended solids) concentrations and duration of exposure to calculate Severity-of-Ill-Effects scores (SEV). The SEV is an estimate of the adverse effects that may be expected if fish were exposed to a given TSS concentration over a given specified time period. The predicted level of effect is represented by four general categories of effect: nil; behavioural; sublethal; and lethal and paralethal effects. The following equation from Newcombe and Jensen (1996) applies to adult estuarine nonsalmonids:

Adult estuarine nonsalmonids: $\mathrm{SEV} = 3.4969 + 1.9647 \cdot \ln(\mathrm{duration}) + 0.2669 \cdot \ln(\mathrm{TSS})$

The following effects on fish are known:

Behavioural or physiological effects may occur caused by the presence of suspended sediment particles:

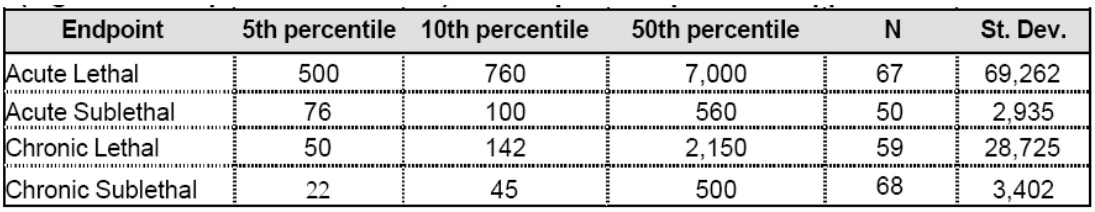
- Behavioural – alarm reaction, cover abandonment, avoidance, or attraction (as a potential food source or cover)
- Physiological – changes in respiration rate, choking, coughing, abrasion and puncturing of structures (e.g., gills/epidermis), reduced feeding, reduced water filtration rates, smothering, delayed or reduced hatching of eggs, reduced larval growth/development, abnormal larval development, or reduced response to physical stimulus.

These effects can in turn result in increased mortality and/or decreased growth and reproduction in general (Wilber and Clarke 2001, Newcomb and Jensen 1996).

Behavioural effects caused by changes in light penetration/scattering – alarm reaction, increased swimming, altered schooling behaviour, avoidance, displacement, attraction, and changes in prey capture rates (Nightingale and Simenstad 2001).

Acute (less than 96 hours) and chronic (greater than 96 hours) effects levels are distinguished. Overall, several researchers have suggested that use of effects data of acute durations is generally more appropriate for dredging operations (Wilber and Clarke 2001, Nightingale and Simenstad 2001).

Table 4-1: Summary statistics for physical effects concentrations (mg/L total suspended sediments) for fish (Anchor Environmental C.A.L.P. 2003)



Endpoint	5th percentile	10th percentile	50th percentile	N	St. Dev.
Acute Lethal	500	760	7,000	67	69,262
Acute Sublethal	76	100	560	50	2,935
Chronic Lethal	50	142	2,150	59	28,725
Chronic Sublethal	22	45	500	68	3,402

Nightingale and Simenstad (2001) reviewed much of the available literature on behavioural changes triggered by patches of increased turbidity. They suggested that: “It is unknown what threshold of turbidity might exist that serves as a cue to a fish to avoid light reducing turbidity.” However, they concluded that the primary determinant of risk level from dredging would likely be a factor of the spatial and temporal overlap between the area of turbidity, the degree of turbidity elevation, the occurrence of fish, and the options available to the fish relative to conducting critical function of the relevant life-history stage. This conclusion suggests that straightforward or simplistic standards or guidance to protect fish from dredging induced turbidity would be difficult to derive.

4.1.4. Loss of feeding, nursery and spawning habitat

The river bottom directly affected by the dredging activities is lost as habitat for aquatic biocoenoses. Bottom dwelling fish species die during dredging operations, lose their habitat, or are stressed and try to escape. The extent and nature of potential effects on fish from dredging will depend on the type of habitat present in the area and its use by fish. The habitat of benthic organisms that serve as food for fish is destroyed. Recovery of the impacted areas will take several years. Summarised monitoring results demonstrate that invertebrate fauna was found to have depleted significantly within a limited area....and the community structure of bottom species has been disturbed" (Ukr.1, Annex 6, point 15). The same conclusion appeared from the monitoring data of 2005 (Ukr. 2, annex 26)

Comparison of the bottom areas, damaged at dredging in the section of Reni - Vilkovo (1,129 km^2), total area of the riverbed in this section (about 80 km^2) shows that at the period of construction there will be totally about 1.4 % of bottom biocenosis damaged (EIA phase 1, page 102). It is argued that this low percentage of affected area will not result in significant damage of aquatic organisms at the larger scale.

Habitats downstream of dredging sites located within the dredge plume are affected by sedimentation. The effect of direct sedimentation on adult and juvenile fish is relatively benign as practically all fishes are sufficiently mobile to avoid burial. Additionally, fish usually return shortly after the disturbance. However, fish eggs are more vulnerable to the physical effects of sediment deposition. Species that have eggs that rest on the bottom are particularly susceptible to smothering by sedimentation. Sediment deposited onto developing herring eggs was found to increase egg mortality (Messieh et al. 1981). An experiment on white perch eggs found that hatch rates were not significantly affected by sediment layers 0.45 mm or less, but sediment layers between 0.50 to 1.0 mm deep resulted in 50% mortality, and sediment layers 2.0 mm deep resulted in 100% mortality of eggs (Morgan et al. 1983). Effects of sedimentation on fish eggs from proposed dredging would depend on the presence, abundance and species of eggs in the area where the sediment settles. However, there are no data provided for the DNC project to quantify potential effects.

During operation of the DNC continuous dredging is necessary to maintain navigable water depth. The amount of dredged volume for maintenance is estimated to be several hundred thousand m^3 a year compared with 1.9 million m^3 during construction (Ukr. 1 annex 2, Inquiry Commisson report chapter 3). As a result, new sites will be affected each year while old dredged sites are still not be recovered. This will lead to a continuous extension of affected sites. A quantification of the future affected area including maintenance work is not possible based on the available data. However, it is likely that a significant proportion of the available habitat will be affected causing impacts to the entire aquatic biocoenoses.

4.1.5. Morphological changes of dredged channels

Heterogeneous habitat conditions are very important to maintain a diverse fish fauna and to provide different types of habitat for different life stages. Dredging sills will result in homogenisation of mid-channel water depth. Dredging and maintaining the mid-channel navigation route will influence hydromorphology in the adjacent river bottom areas by erosion and sedimentation processes. The resulting destabilization may increase local scour or fill in parts of the streambed that were not directly disturbed. Navigation channels tend to transform into more homogeneous profiles across the whole channel cross section. In addition, bank enforcement measures are necessary and will impact the riparian habitats.

Sediments mobilised by dredging activities settle on river bottom downstream of dredging sites. This cause burial of benthic organisms, reduction of fish food organisms, destruction of fish spawning areas and alteration of the channel morphology.

Before flow regulations, the Danube Delta was characterised by a high dynamic multi-channel system. Nowadays, the majority of flow runs through 3 stabilised main channels. Comprehensive restoration activities are undertaken to improve the habitat conditions in the Danube Delta for fish and other organisms. The Water

Framework Directives requires restoring degraded habitats according to the reference condition approach. Applying this concept to the Danube Delta means that morphodynamic processes should be increased, new channels and side arms should to be initiated and constructed and channels should be further reconnected to the floodplains by allowing inundation during high flows. Supporting the further channelisation by constructing and maintaining the DNC contradicts necessary restoration measures to achieve the objectives of the Water Framework Directive.

4.1.6. Effects of dredging on water quality

The main impact on the water quality during dredging are related to re-suspension of pollutants from bottom sediments, increased eutrophication, and oxygen depletion.

Regarding heavy metals, the Danube Delta quality over the period 1996–2003 according to the Romanian Assessment System of water and sediments quality 1146/2002 (5 quality classes) is as follows: In the Danube and its arms, the concentrations of iron, cadmium and lead correspond to quality classes IV and V in all monitoring sites. In general, zinc and nickel show average concentrations corresponding to class II. Manganese concentrations correspond to the classes III and IV, except 2003 when the concentrations of this metal correspond to class II (ICPDR 2005).

Chemical effects are defined as those occurring either in the form of direct toxicity to the organisms or bioaccumulation of chemicals in the organism's tissues, organs, etc. Potential chemical effects to aquatic organisms as a result of dredging are a function of the type of contaminant; it's concentration within the sediment, the environmental conditions at the time of dredging (e.g., low oxygen or reducing environments) and the duration of the exposure

Suciu et al. (2005) analyzed *Acipenser stellatus* (10), *A. gueldenstaedti* (2), and *Huso huso* (9) for content in Cd, Cu, Zn, Pb, Mn, Fe and Ni, using VARIAN SpectraA 100. The highest concentrations of Zn, Cu and Cd were found in the liver and the smallest in muscles of sturgeons. The highest heavy metal content was detected in tissues of Stellate Sturgeon (*Acipenser stellatus*) , followed by Russian Sturgeon (*A. gueldenstaedti*). In all three species the Cd and Cu content of the liver surpasses the admitted limits for human consumption (Cd - 0,1; Zn - 50; Cu - 5,0; Pb - 0,5 [mg/kg FWT]). It was concluded that within the ecological index, the LDR and the Black Sea near the mouth of the river are mostly classified as waters medium (II - III) to highly (IV) contaminated with heavy metals.

The problem of potential effects of toxics and geochemical substances are not discussed here as it is the objective of another expert, Nico de Rooij, advising the Inquiry Commission. According to this report no toxicity problems are associated with the dredging activities.

4.1.7. Direct damage to fish during dredging operations

In addition to the above mentioned impacts, hydraulic dredging can directly harm fish by lethally sucking fish and food organisms up through the dredge dragarms and impeller pumps. The type of dredge method used tends to influence the mortality of the organism once it is entrained.

During the excavation of the rifts three hydraulic dredges can operate simultaneously (EIA phase 1, page 67). Soils excavation is planned to be done in the Izmailsky Chatal – Vilkovo section by "Dnieprovsky-5" type suction dredger of 1,000 m^3/h productivity (EIA phase 1, page 162). It is planned to carry out soils excavation in Vilkovo – Bystre section by "Skadovsk" type hydraulic dredge of 750 m^3/h productivity. (EIA phase 1, page 163).

Boyd (1975) reported 98.8% mortality for fish fry that entered a suction dredge. McGraw and Armstrong (1990) collected entrainment information on 28 species of fish; species with the highest entrainment rates included Pacific sanddabs (0.076 fish/cycle), Pacific staghorn sculpins (0.092 fish/cycle) and Pacific sandlance (0.594 fish/cycle). In a four year study in the Columbia River, Larson and Moehl (1990) found that the majority of entrained fishes were demersal (fish living close to the bottom); however, a few pelagic species were collected, including anchovy, herring and smelt. A study at the mouth of the Columbia River by Larson and Moehl (1990) found the entrainment of anadromous fishes was limited to eulachon (*Thaleichthys pacificus*). Based on their findings, they concluded that it is unlikely anadromous fishes are entrained significantly by dredges. Alternatively, studies in the Fraser River found that anadromous fish, specifically eulachon and juvenile salmonids, were the dominant taxa entrained (McGraw and Armstrong 1990). The primary difference between the study sites was the degree of constriction of the waterways in which the study took place. The Fraser River is largely confined compared to the mouth of the Columbia River, suggesting that the lower entrainment occurred when fish were able to disperse over a larger area (Reine and Clark 1998). An important factor to consider when assessing the impact of dredging on fish is the percentage of the total stock or population entrained by the dredge. Burton et al. (1992) used an Empirical Transport Model (ETM, Boreman et al. (1981)) to simulate a worst case scenario of entrainment for striped bass (*Morone saxatilis*), herring (*Alosa spp.*), and white perch (*Morone americana*) larvae involving the simultaneous operation of four hydraulic dredges in the Delaware River. For species such as striped bass, the study concluded that less than 1% of the total larval population would be entrained by the dredges. Burton et al. (1992) concluded that the effects of these entrainment rates on larval populations for these and similar species would be minimal.

No data on potential effects of fish entrainment have been provided for the DNC project. The effects on the Danube fish populations from dredging-related entrainment would depend on the location of the dredging and the timing of the dredging in relation to fish occurrence and movements. If dredging occurs during spring and summer it is likely that some fish would be entrained by dredging operations, as large numbers of juvenile sturgeons and Pontic herring live and pass through the Danube Delta at this time of year. Young-of-the year and juvenile fish would be more likely to be entrained, as most adult fish would be expected to avoid the dredge. Also bottom dwelling species are more likely to be entrained. Although some losses from entrainment would likely occur, it would probably be limited to a small percentage of the total number of fish living in and moving through the area.

4.1.8. Effects of dredging on floodplain dynamics and functioning

As documented by the expert for morphodynamics, Jos van Gils, it is difficult to predict potential effects of the DNC on floodplain dynamics. An indicative quantitative assessment of water level dynamics shows that the impact on the Kiliya branch is much smaller than the natural variability, for both phases (phase I and II). Therefore, no significant impact is assumed. The impact on the Bystre branch is of the same order as the natural variation, and therefore likely significant (phase I, no prediction available for Phase II). A similar observation can probably be made for the Starostambulskiye branch downstream of the bifurcation with Bystre. In the Bystre the frequency of high water levels will increase significantly. In Starostambulskiye branch downstream of the bifurcation with Bystre the frequency of high water levels will decrease.

It is difficult to predict impacts of the alteration of flooding frequencies on fish. In general, increased flooding frequencies might be beneficial for the fish fauna, as larger and longer floodings might provide more spawning and nursery habitat. However, the real available habitat and benefits depends on the topography of the floodplains, the timing of flooding and the connectivity between channels and floodplains. Decreased flooding frequencies, in general, result in loss of aquatic floodplain habitat. Based on the information provided it is not possible to quantify if the "gain" in floodplain habitat at the Bystre channel is able to compensate the loss at the Starostambulskiye branch. **As a significant loss of floodplain habitat can not be discarded we assume that the effects for fish are likely.**

4.1.9. Conclusions on dredging effects

1. No monitoring data have been provided on the concentration of suspended sediments in and below the dredged area during operation. Therefore, we are not able to assess the likeliness of impacts due to suspended sediments based on data. However, comparing physical effects concentration with background concentration reflects that even comparable slight increases might cause **(sub)lethal effects on fish at and in the vicinity of dredging sites**.
2. Effects are not only locally as migratory fishes are affected passing the dredging area, using the area also temporally or shifting between different habitats across the border between Ukrainia and Romania within affected river sectors. **Therefore, we conclude that dredging activities during construction have likely transboundary impacts on the fish fauna.**

3. During maintenance dredging the area affected by dredging continuously will be increased as recovery processes of affected areas takes several years. **Therefore, it is likely that cumulative effects of DNC construction and maintenance will significantly affect the fish fauna and fishery in the long term.**
4. Morphological modifications resulting from dredging activities cause more uniform and degraded habitat conditions at a larger scale. No data have been provided on the expected morphological alterations and consequences for the fish fauna. Therefore, we are not able to quantify these effects. Channel fixation contradicts necessary side arm constructions to improve habitat quality in accordance with the Water Framework Directive. Based on the existing information it is **likely that morphological chances will have transboundary impacts on the long term**.
5. Alterations of hydromorphological dynamics can have significant effects on flooding magnitude and frequency. **It is likely that floodplain habitats, important for fish spawning and nursery, might be lost, causing transboundary effects on fish and fisheries.**
6. **Cumulative effects** of increased suspended sediments, habitat loss, behavioural impacts, water quality deterioration, habitat modification, floodplain habitat loss and unknown effects make it even more **likely that dredging activities have significant transboundary effects on fish and fishery**.

4.2. Saltwater penetration into the Bystre channel

The concentration of salinity in important habitat and rearing areas of the estuary and the longitudinal gradient of salinity between the freshwater and ocean environments that bound the estuary are important for anadromous fish species, i.e. sturgeon and Pontic shad using freshwater during juvenile development. Reduction of freshwater habitats limits nursery area for juveniles and consequently may result in decreased recruitment.

The seawaters as "wedge" of salted waters can penetrate into some delta branches during the low effluent and fetches. This is the shallow branch such as Belgorod one or rather large branches, the bars of which are deepened for the purposes of shipping industry (Prorva and Sulinsk). Seawaters regularly penetrate at the bottom of these branches during the low water. The maximum range of seawaters penetration has been fixed in Prorva on 20.11.90 - 16,8 km. The critical flow intensity in Prorva and Sulinsk branches, at the excess of which the seawaters do not penetrate in to the branches makes up 570 and 1350 m^3/s (EIA phase 1, page 28).

Because of its physico-geographical and ecologic-hydrological conditions, the Bystre branch plays a significant role in the Chilia delta of the Danube in whole and is of great importance for the territory and water area. That applies to biological diversity of water and land plants and animals, as well as to important ecological processes, in particular to passing of spawning migrations, feeding and wintering of water organisms. Under conditions of reserve system and a normal synoptic situation, water in the Bystre estuary remains fresh from surface to bottom. On the one hand, this results from a constant current towards the sea, and on the other hand, by existence of a shoal in the sea in front of the estuary. That is why zooplankton and zoobenthos in the Bystre branch are mainly of freshwater nature from surface to bottom (EIA phase 1, page 131-132).

Preliminary calculations for penetrating of salt field during organization of the sea approach channel, carried out by Institute of hydromechanics of National Academy of Science of Ukraine showed that creation of the opening will exceed the saltiness at the inlet into arm and result in increase by about 1.5-2 times the length of salt field. However, at all values of a differential of saltiness the salt field will not penetrate into arm at the flow rate over 800 - 900 m^3/s (EIA phase 1, page 110).

4.2.1. Conclusions on penetration of salt water into the Bystre channel

Construction of the DNC will increase the saltiness at the inlet into the arm by about 1.5-2 times the length of salt field. This will result in significant local effects on the freshwater biocoenoses. No monitoring data on fish have been provided to assess the effects. Predictions of the change of the salinity indicated that affected area is lost for juvenile sturgeons and Pontic shad during their freshwater development. This represents a significant local impact in the Bystre channel on Ukrainian territory. However, the affected area, compared with the entire available freshwater habitat available for juveniles in the Danube Delta is small. **Therefore the transboundary effect of increased saltwater intrusion is supposed to be hardly likely.**

4.3. Dredging of sandbar and construction of retaining dam

The navigation channel in the sand bar area has a length of 3432 m, with a design width of 100 m, a depth between 7.6 and 8.3 m and slopes of 1:9, with a projected dredging volume of 1.684 million m^3. By October 2005 some 1.687 million m^3 have been excavated, which also includes the dredging for the retaining dam. These dredging operations are also suspended by October 1, 2005 (Inquiry Commission report chapter 3).

On the sand-bar the excavation is only possible using the chain-bucket hydraulic dredges or a floating crane. Considering the aforesaid it is recommended to use four scoop hydraulic dredges simultaneously during the construction of the navigable channel on the sand-bar. (EIA phase 1, page 67).

The main purpose of the retaining dam is to reduce the siltation in the excavated access channel as a result of the sand transport driven by strong winds from the Northern direction. The construction of the seaward end of the dam was planned for

Phase I. In Phase II the remaining part is foreseen in shallower waters. At the moment of the suspension of the execution of phase I the length of the completed section was 360 m or 1/3 of the Phase I design length (Inquiry Commission report chapter 3).

In Phase II the remaining part of the retaining dam is foreseen in shallower waters. The total design length of the dam is 2830 m. Of this 1040 m were foreseen in Phase 1, of which 350 m is completed yet (Inquiry Commission report chapter 3).

One of the most remote consequences of building the protective dam can be the speeding up of natural process of advancing the Maritime Edge of the Delta in the area of sand-bar, building-up of near-estuary islands on the side of the dam and their junction with the shore (EIA phase 1, page 81).

As documented by the expert for morphodynamics, Jos van Gils, it is difficult to exactly predict the consequences of the measures at the sand bar and protection dam area. Due to the modifications caused by the DNC project there will be a lack of sediments in this area. This might cause erosion of the existing habitats and slow down the land building process of the delta entrance.

4.3.1. Effects of dredging the sandbar and constructing the retaining dam

The main concern of the hydromorphological alterations in the sand bar section and at the protection dam is that it might act as a barrier for adult sturgeons and Danube herring coming from the main feeding area, located N-W of the Black Sea for spawning migration in the Danube River" (Rom.1 page 3). There are no data on migration behaviour related to the DNC project available, although in the environment monitoring program of the DNC the investigation of potential changes of fish migration routes in connection with the creation of hydraulic structures was proposed (EIA phase 1, page 148).

The arrangement of the river outflow is critical for fish to find the entrance to the River for upstream migration. The knowledge about the mechanisms how sturgeons and shad are succeeding in finding the entrance is very low. Homing, the distinctness to migrate to natal spawning sites, is anticipated for several sturgeon species, but still needs further research (Stabile et al. 1996, Waldman et al. 1996a,b, Wirgin et al. 1997). As far as we know, there is no information on homing behaviour of Danube sturgeons available. It is hypothesized that olfaction might be essential for homing in sturgeons. If strong homing is coupled with reproduction isolation, several populations or races may be found in the same river system and can be recognized by different migration season, different spawning sites and/or migratory routes. Following this argumentation it could be speculated that different populations are present in the Danube Delta. It is important to know the degree of subpopulation and homing fidelity evolvement as a change of spawning sites and migration route conditions could severely affect reproduction and viability of distinct populations.

Contrarily, the mouth o delta braches are by nature very dynamic features that change their complete appearance within comparable short time frames. Cut off and filling of branches and creation of new braches is a typical phenomenon. It has to be anticipated that sturgeons and shad evolutionarily have developed strategies to react to these dynamic processes at delta entrances. They might find branch entrances even under changed conditions or are very flexible in using alternative braches to get into the river. **Therefore, based on existing information, we assume that effects on the migratory behaviour on sturgeon and shad are hardly likely.**

4.4. Dump sites in the Black Sea

The spoil was dumped in the Black Sea at a site almost 2 km offshore at a water depth of around 20 m. The projected volume of spoil to be dumped at the offshore site was in the order of 2.0 million m^3. The anticipated area of the sea bed, affected by the dredging and storage in the sand bar section covers some 0.6 million m^2 (Inquiry Commission report chapter 3).

The place of the ground dump is submitted to short duration hypoxia in the spring-summer period (approximately not more than 2–3 weeks). It means that during the last 30 years the deficit of the oxygen caused certain depression of the benthos in the bottom layer (EIA Phase I, page 66).

The planned capacity of the dump while filling the ground of 3 m thickness is determined as 5361 thousand m^3. At even distribution within the limits of the selected dump circle the masses of the shifted grounds at the first stage will be laid in a layer thickness of 0.6 – 0.7 m. In the area of dumping ground a local long-term pollution of the bottom and water mass is predicted. The consequences of the dumping are predicted by way of destruction of the bottom biocenosis, worsening of oxygen conditions, increase in trophic structures and toxic action on hydrobiotones (EIA phase 1, page 112).

Recently, the near bottom oxygen situation (% saturation) has considerably improved in the Romanian coastal waters and the number of benthic species has reached about 2/3 the level of the 1960ies again (ICPDR 2005).

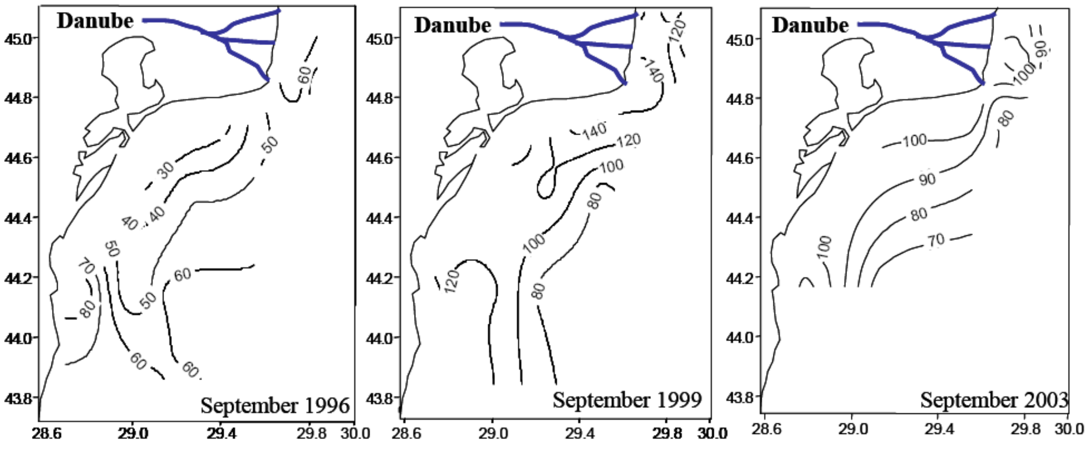


Figure 4-1: Improvement of the oxygen conditions in the Black Sea close to the Danube Delta during the last years (ICPDR).

Dumping dredged material in the sea causes similar effects as the dredging, i.e. dispersal and settlement of suspended sediments, altered bathymetry of the sea bottom, alteration of bottom habitat.

Groups of aquatic organisms' susceptible to dumping in marine and estuarine environments include fish and fish food organisms (shrimps, crabs, shellfish, benthic assemblages). Biological effects of dumping are similar to dredging and includes direct impacts of sediment deposition burial of organisms, habitat disturbance and habitat loss, suspended sediment; sediment deposition in the vicinity of the dump site

Direct habitat disturbance can include loss or alteration of specific habitat features that might ultimately lead to loss or impairment of habitat function. Disposal of dredge spoil will affect aquatic habitats directly. Direct effects may result from the physical disturbance of the sea bed, changes in composition or size of bed materials. Recolonization of spoil areas takes place only at the long-term (IMG-Golder Corporation 2004).

The effects of sediment deposition along the plume on the survival of benthic communities will generally depend on the organism's ability to migrate upward through the overlaying deposits. In the case of sedentary species, relatively small quantities of silt deposited from dredging may be enough to cause high rates of mortality (Saila et al. 1972; Rose 1973). In addition to direct smothering or burial, even a small layer of blanket silt (1-2 mm) can negatively affect the organism's ability to settle on hard substrates (Galtsoff 1964).

Once benthos communities are destroyed or removed in dredged habitats, they will recolonize the area if no further disturbance takes place. The time of recolonization is believed to vary between one and three years (Dome Petroleum Ltd. 1979). Based on a review by Newell et al. (1998), recovery rates within disturbed areas are reported to be most rapid in areas associated with soft sediments or where natural disturbance of bottom habitat is frequent. These authors found recovery rates of a few months for estuarine mud and two to three years in sand and gravel. Recovery rates of 5 to 10 years were also considered to be realistic, depending upon the community and the bottom habitat (Newell et al. 1998).

During dumping operations under conditions with southbound currents, the increase of the concentration of inorganic suspended matter at the Romanian state border is of the same order as the existing background, and the transboundary impact of such activities must therefore be characterised as "likely significant"

(ESPOO Expert Jos van Gils). A doubling of existing concentration would result in a concentration of less than 20 mg/l. A concentration of suspended sediments at this level is not supposed to cause any damage to fish (see above).

Consequently, it is **not likely that there is also a transboundary effect** on the environmental conditions for fish and the benthic biocoenoses outside the dump site at the Romanian border.

4.4.1. Effects of navigation

Vessels navigating through a waterway generate hydraulic disturbances in the form of waves and currents, mainly drawdown, return current, slope supply currents, wash waves, and propeller jet (Wolter & Arlinghaus 2003). Thus, in addition to the indirect effects of "navigation" on fish assemblages, direct negative effects on fish caused by navigation induced shear stress, shipwaves, drawdown, dewatering, backwash, and return currents have been commonly proposed but rarely tested in research studies with partially contradictory results documenting impacts or no impact. More often possible environmental effects of commercial navigation traffic have been estimated indirectly from observed fish assemblage changes. The direct effects of shear forces, waves and currents created by moving vessels on fish can be expressed as kills or injuries due to impact against the substrate or the vessel hull, and stranding out of water.

Indirect effects of navigation on fish are vessel-induced disturbances preventing fish from nest-guarding or feeding, dislodgement of eggs and redistribution of eggs and larvae in less suitable habitats, restricted food availability, increasing sediment resuspension and loss of shelter habitats especially. Direct entrainment of individuals through the propeller zone of passing commercial vessels was the main source of navigation-induced fish mortality for eggs, early life stages and adults due to shear stress created by the towboat propellers.

Another source of risk to the fish fauna and fishery are ship accidences and release of hazardous substances like toxic chemicals or oil products. The more traffic and the more hazardous substances are transported, the higher the risk of potential accidences with potentially detrimental effects on fish. However, at this stage it is not possible to assess the level of risk as there have not been provided any data on this issue.

Potential effects of navigation on fish as a consequence of the DNC project have not been covered by the EIA. There have no data been provided on potential effects of navigation on fish for the DNC project. Effects may occur during channel constructions and maintenance work caused by dredging and supportive vessels. However the main impact might occur during the use of the channel as a navigation route. Information on types and frequency of vessels passing would be necessary in combination with estimates of hydraulic impacts caused by propellers and waves. **Due to the lack of information it is not possible to quantify likely effects.**

4.5. Mitigation measures

4.5.1. Suspension of work

In the project, the suspension of the works is proposed during fish spawning and young fish motion for one month (EIA phase 1, page 109).

Termination of all construction and repair-and-renewal operations on the DNC track during spawning period and downstream migration of young fish is the main measure of decreasing the negative influence on ichthyofauna. While carrying it out, it is necessary to take into account that maximum downstream migration of ordinary fish fry takes place some time after the ban starts. This fry, that hatched upstream of the Danube, reaches the delta sections 10-15 days after the ban starts, sometimes later, for example, in 1984 in the first – second decades of June 96.2 % of the total number of herring fry migrated downstream to the sea (EIA phase 1, page 159).

Juvenile sturgeons and Pontic shad are present from spring after hatching to autumn before they migrate into the Black Sea. Adult sturgeons are present in the Danube Delta the whole year round (see above).

No information of real suspension of work during the construction was provided. If suspension lasted only for one month as proposed, this would have been not long enough to avoid damage to juvenile and migratory fish.

4.5.2. Construction of a fish farm

Damage to ichthyofauna resulting from deterioration of nutritive base, reproductive conditions and migration may be compensated by constructing a fish-farming installation in the given region. Such an installation just on the Danube may become a sturgeon factory on the Ochakovsky distributary (downstream of the town of Vilkovo), the feasibility study for which was devised by “Odessarybvod” (former ZapCherrybvod) (EIA phase 1, page 160). However, the fish farm project was not implemented so far.

4.5.3. Compensation fee

Preliminary evaluation of pecuniary compensation amount of irreparable damage to natural environment at the first stage of the DNC creation for the ichthyofauna due to damage to fish reserves amount to 1,061,597 UAH; during the construction period and 280,320 UAH annually during operation as a result of dumping and dredging (EIA phase 1, page 169).

The intended payment of compensation fee shows that damage to the fish fauna was part of the considerations in planning and implementing the DNC. The basis for the calculation of the compensation fee was not demonstrated in the EIA Phase I.

4.6. Evaluation of sturgeon monitoring data

As mentioned above no data on potential effects on the fish fauna and fishery as part of the environmental monitoring of the DNC project was provided. However, some other information on sturgeon as demonstrated in chapter 3 of this report is available.

Sturgeon catches are recorded regularly in the Lower Danube since a couple of years. According to CITES data, 555, 584 and 449 sturgeons were caught in the Danube Delta below mile 75 in 2003, 2004 and 2005 (Figure 3-7). Sturgeons were caught in the Chilia branch in all years of DNC construction. There is no trend in the spatial variability of the commercial landings before and during the construction of the DNC. That means that the Chilia branch was used in principle as migratory route by sturgeons during the DNC channel construction. However, as fishery data are biased by fishing effort these data do not allow any quantitative assessment.

Juvenile sturgeon recruitment is measured in the lower Danube River at river Km 119 using a relative measurement, the Juvenile Productivity Index. Compared with data from 2000 to 2003 the index was about the same level in 2004 and increased in 2005. There has not been any information provided how many samples are used for the calculation of the index and how stable the index is. Therefore, any interpretation of the index has to be done with causion. A plethora of factors are responsible for the magnitude of recruitment observed each year. It is not possible to link the index directly to DNC activities without condisdering other important biotic and abiotic factors. Furthermore, the data are collected upstream of the DNC. Potential effects on juvenile fish passsing downstream into the area of the DNC are not covered by the index. In conclusion, we will not make any assessment of the likeliness of impacts based this index.

5. Future monitoring and research requirements

Lack of data and missing analyses are the main limitation for a thorough, more detailed assessment of potential effects of the DNC on fish and fishery. For the future work, a transboundary monitoring and assessment programme should be developed and implemented to provide a better basis for impact assessment, development of mitigation measures and future management. This programme should be designed to allow monitoring of the fish communities with special focus on endangered and commercially valuable fish species in accordance with the monitoring requirements of the Water Framework Directive:

- Development of a representative monitoring network that is adequate to reflect the large scale and long term development of the fish fauna. Identification of standardised sampling methods (fishery and non-fishery sampling) and monitoring criteria is needed.
- Identification and implementation of special research programmes to study the effects of the DNC project on the fish fauna:
    - Monitoring of local effects by field studies (incl. migratory behaviour).
    - Modelling potential short and long-term effects for selected populations of major concern.

6. Summary

The objective of this report is to advice the Inquiry Commission on the likelihood of significant transboundary impacts of the construction and use of the Deep Water Navigation Channel (DNC) on fish and fishery. The report is mainly based on information provided by the members of the Inquiry Commission. In addition, scientific literature, grey literature, reports and internet information was collected and analysed for this report.

Although the Danube Delta already has suffered under a variety of human pressures it still inhabits a very divers and endangered fish fauna of high commercial value. All species of sturgeons inhabiting the Danube are included in the IUCN Red List of Threatened Animals. The Lower Danube remains the only main river in the Black Sea region ensuring natural reproduction of the migratory sturgeons. Some populations of Danube sturgeons are probably below or not far above minimum viable population levels. As a result any further significant impact on these populations might increase the risk their extinction.

The fisheries are diverse, consisting of lake, river, coastal and anadromous fisheries. More than 13 fish species are of commercially importance in the Danube Delta Biosphere Reserve. The Danube Delta supports a valuable fishery providing employment for several thousand fishermen.

Due to the migratory behavior of fish any significant impacts on the fish populations of the Chilia branch, Bystre channel and coastal area **at the Ukrainian territory may have transboundary effects** on the fish fauna and fishery **at the Romanian territory**.

As summarised in Table 6-1 two of the six identified operational activities, **dredging of sills for DNC construction and maintenance of the DNC, have likely transboundary effects on fish and fishery. Effects of navigation can be significant or not, depending on shipping traffic. Cumulative effects of the entire project are likely to be significant.**

Table 6-1: Summary of operational aims and activities and their consequences and impacts on fish (see chapter 4 for detailed explanations)

Operational aim	Operational activity	Consequences for fish	Impacts on fish	Level of significance
Construction of the navigation channel in the Chilia arm downstream to the sea	Dredging of sills	Increased turbidity at dredging sites	Fish kills at dredging sites	Severe effect, but at very small scale ⇒ **Unlikely significant**
		Fish and fish food entrainment by dredging machines	Lethal	Severe effect, but at very small scale ⇒ **Unlikely significant**
		Increased turbidity downstream of dredging sites	Behavioural and physiological changes in the plume – chronic effects	In total a significant area chronically affected ⇒ **Likely significant**
		Reduction of flooding magnitude and frequency	Potential loss of spawning and nursery floodplain habitat	Potentially large areas are affected at long-term ⇒ **Likely significant**
		Deterioration of water quality parameters incl. toxics	No significant exceedance of standards	No effects ⇒ **Unlikely significant**
		Saltwater intrusion	Loss of freshwater habitat	Long term, severe impacts but spatially limited ⇒ **Unlikely significant**

Operational aim	**Operational activity**	**Consequences for fish**	**Impacts on fish**	**Level of significance**
Channel maintenance	Maintenance dredging	The same effects as above but for longer time and larger space	The same impacts as above but cumulated across longer time and larger space	In total a significant area acute and chronically affected ⇒ **Likely significant**
Channel dredging and maintenance	Dredging riparian enforcement	Homogenisation of channel morphology and riparian habitat alteration	Channel and riparian habitat deterioration	In total a significant area affected at long time scale ⇒ **Likely significant**
Sea entrance	Dredging of sandbar and construction of retaining dam	Altered habitat and flow conditions	Disruption of migratory behaviour	⇒ **Hardly likely significant** as delta entrances are very dynamic by nature
Spoil dumping	Dumping in the sea	Sediment deposition, increased turbidity	Habitat loss at dump site	Severe effect, but at small scale ⇒ **Unlikely significant**
Navigation	Ship traffic	Hydraulic disturbances (waves) propeller ship accidences	Behavioural changes riparian habitat disturbance Injuries to fish fish kills	Large scale, long-term effects depending on intensity of ship traffic ⇒ **(Un)likely significant**
Entire project	All activities listed above	Cumulative effects	Cumulative impacts	Large-scale, long term effects ⇒ **Likely significant**

7. References

Amirkhanov, M.L. 1967. Descent of young sturgeon in the River Terek. J. Appl. Ichthyol. 9: 67–70.

Anchor Environmental C.A.L.P. 2003. LITERATURE REVIEW OF EFFECTS OF RESUSPENDED SEDIMENTS DUE TO DREDGING OPERATIONS. Los Angeles Contaminated Sediments Task Force, Los Angeles. 140p.

Bacalbasa-Dobrovici N., 1997: Endangered migratory Sturgeons of the Lower Danube River and its delta. Environmental Biology of Fishes, 48, 201-207.

Bacalbasa-Dobrovici N., N. Patriche, 1999: Environmental studies and recovery actions for sturgeons in the Lower Danube River system. Journal of Applied Ichthyology, 15, 4/5, 114-115.

Balon E., 1968: Einfluss des Fischfangs auf die Fischgemeinschaften der Donau. Archiv. Hydrobiol., 34, 228-249.

Billard, R. & Lecointre, G. 2001. Biology and conservation of sturgeon and paddlefish. Reviews in Fish Biology and Fisheries 10: 355–392.

Boreman, J., C. Goodyear and S. Christensen. 1981. An empirical transport methodology for estimating entrainment losses at power plants sited on estuaries. Transactions of the American Fisheries Society 110: 253-260.

Boyd, F.C. 1975. Fraser River Dredging Guide, Technical Report Series No. PAC/T-75-2, Southern Operations Branch, Fisheries and Marine Service, Environment Canada, Vancouver.

BUIJSE A.D., COOPS H., STARAS M., JANS L.H., VAN GEEST G.J., GRIFT R.E., IBELINGS B.W., OOSTERBERG W. ROOZEN F.C.J.M., (2002) Restoration strategies for river floodplains along large lowland rivers in Europe. Freshwater Biology 47, 889-907.

Burton, W., S. Weisberg and P. Jacobson. 1992. Entrainment effects of maintenance hydraulic dredging in the Delaware River Estuary on Striped Bass Ichthyoplankton. Report submitted to the Delaware Basin Fish and Wildlife Management Cooperative, Trenton, NJ, by Versar Inc.

Ciolac and Partiche: 2004. STUDY OF MIGRATORY STURGEON CAPTURES IN ROMANIAN SIDE OF DANUBE RIVER. MIGRATION OF FISHES IN

ROMANIAN DANUBE RIVER, № 3. APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 3(1): 73-78.

Ciolac and Partiche: 2004a. Biological aspects of sturgeons in Romanian Danube River. APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 3(2): 101-106.

Ciolac: A. 2004. Migration of fishes in Romania Danube river (Nº 1) - 143 –

Dome Petroleum. 1979. Environmental evaluation for a marine base at McKinley Bay, N.W.T. In: Environmental Sciences Limited, 1980. Annotated bibliography of pertinent reports dealing with the environmental impacts of dredging, artificial islands, and exploratory drilling in the Beaufort Sea.

Galtsoff, P.S. 1964. The American Oyster Crassostrea virginica Gmelin. Fishery Bulletin 64: 1-480.

Hensel K., J. Holcik, 1997: Past and current status of sturgeons in the Upper and Middle Danube River. Environmental Biology of Fishes, 48, 185-200.

ICPDR, 2005. Danube Basin Analysis - WFD Roof Report 2004. Part A - Basin-wide overview. ICPDR. 191p.

IMG-Golder Corporation 2004. REVIEW OF POTENTIAL EFFECTS OF DREDGING IN THE BEAUFORT SEA. Inuvik, Canada, 81p.

IUCN: The 2000 IUCN Red List of Treatened Species (http://www.redlist.org).

Kynard, B., Suciu, R., Horgan, M. (2002) Telemetry and tag return studies of Danube River sturgeons, 1998-2000. Proceedings of The 4th International Symposium on Sturgeon, Oshkosh, WI, J. Appl. Ichthyol. 18: 529 – 535

Larson, K. and K. Moehl, 1990. Fish entrainment by dredges in Grays Harbor, Washington. In Effects of dredging on anadromous Pacific Coast fishes. C.A. Simenstad, ed. Washington Sea Grant Program, University of Washington, Seattle, pp 102-112.

McGraw, K. and Armstrong, D. 1990. Fish entrainment by dredges in Grays Harbor, Washington. In Effects of dredging on anadromous Pacific Coast fishes. C.A. Simenstad, ed., Washington Sea Grant Program, University of Washington, Seattle.

McNair, E.C. Jr. and G.E. Banks. 1986. Prediction of flow fields near the suction of a cutterhead dredge. American Malacological Bulletin. Special Edition No. 3: 37-40.

Messieh, S.N., D.J. Wildish and R.H. Peterson. 1981. Possible impact from dredging and spoil disposal on the Miramichi Bay herring fishery. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1008.

Morgan, R.P., V.J. Rasin and L.A. Noe. 1983. Sediment effects on eggs and larvae of striped bass and white perch. Transactions of the American Fisheries Society 112:220 -224.

MOSER ML, ROSS SW: HABITAT USE AND MOVEMENTS OF SHORTNOSE AND ATLANTIC STURGEONS IN THE LOWER CAPE-FEAR RIVER, NORTH-CAROLINA. TRANSACTIONS OF THE AMERICAN FISHERIES SOCIETY 124 (2): 225-234 MAR 1995

Nãvodaru 1998: Pontic Shad: A Short Review of the Species and Its Fishery. Shad Journal Vol. 3(4)3-5.

Navodaru I., M. Staras, 2002: RRA training seminar, Sofia.

Navodaru I., M. Staras, I. Cernisencu, 1999: Management of the sturgeon stocks of the Lower Danube River system, Romulus Stuica and Iulian Nushersu, Conf. Proc., 220-237.

NAVODARU, I., M. STARAS & I . CERNI SENCU. 2001. The challenge of sustainable use of the Danube Delta Fisheries, Romania. Fisheries Management and Ecology, 2001, 8, 323±332

Newcombe, C.P. und J.O.T. Jensen, 1996. Channel Suspended Sediment und Fisheries: a Synthesis for Quantitative Assessment of Risk und Impact. North American Journal of Fisheries Management 16:693-694.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. 1998. The impact of dredging works in coastal waters: a review of the sensitivity to disturbance and subsequent recovery of biological resources on the sea bed. Oceanography and Marine Biology: an Annual Review 36: 127–178.

Nightingale, B., Simenstad, C., July 2001. “Dredging Activities: Marine Issues”, White Paper, Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington Department of Transportation.

Patriche, N., Pecheanu, C. and Mirea, D. (1999) Contribution to the artificial propagation and development in the first stages of Acipenser stellatus fry in mobile facilities on the Danube (Abstract). J. Appl. Ichthyol. 15, 330.

Paykova, G., Jivkov, M., G. Miloshev, M. Vassilev, E. Usunova, 2003. ACTION PLAN ON CONSERVATION OF STURGEONS IN THE BULGARIAN AQUATORIES OF THE DANUBE RIVER AND THE BLACK SEA. Report of the Ministry of the Environment and Water. Contract No. 2963-6884/19.11.2001. Sofia. Report summary, p25 (http://chm.moew.government.bg/nnps/files/Action%20plan%20(resume)_eng 2.doc).

Rand, G.M., Petrocelli, S., R., 1985. Fundamentals of Aquatic Toxicology, Methods and Applications. Hemisphere Publishing Corp.

Reinartz R., 2002: Sturgeons in the Danube River: Biology, Status, Conservation, 150 p.

Reine, K. and D. Clarke. 1998. U.S. Entrainment by hydraulic dredges – A review of potential impacts. Technical Note DOER – E1. Army Corp Engineer Research and Development Center, Vicksburg, MS.

ROCHARD, E. G, CASTELNAUD & M. LEPAGE 1990. Sturgeons (Pisces: Acipenseridae); threats and prospects Journd of Fish Biology 37 (Supplement A), 123-132

Rose, C.D. 1973. Mortality of market-sized oysters (Crassostrea virginica) in the vicinity of a dredging operation. Chesapeake Science 14:135-138.

Saila, S.B., S.D. Pratt and T.T. Polgar. 1972. Dredge spoil disposal in Rhode Island sound, University of Rhode Island Marine Technical Report 2, Kingston, RI.

Stabile, J., Waldman, J.R., Parauka, F., and Wirgin, I. 1996. Stock structure and homing fidelity in Gulf of Mexico sturgeon (Acipenser oxyrinchus desotoi) based on restriction fragment length polymorphism and sequence analyses of mitochondrial DNA. Genetics, 144: 767–775.

Suciu R., Tudor D., Paraschiv M., Suciu M. (2005) Heavy metal bio-accumulation in tissues of sturgeon species of the lower Danube River, Romania. Scientific Annals of Danube Delta Institute, vol. 11. Tulcea.

Suter, G.W., Efroympson, R.A., Sample, B.E., Jones, D.S., 2000. Ecological Risk Assessment for Contaminated Sites. Boca Raton: Lewis Publishers.

Vassilev M., 2003: Spawning sites of Beluga sturgeon (Huso huso L.) located along the Bulgarian-Romanian Danube River. Acta zoologica bulgarica, 55, 2, 91-94.

Vassilev M., 2005: Restocking of the Bulgarian Danube River section with juvenile sturgeons. DanubeNews, 11, 7-8.

Vassilev M., L. Pehlivanov, 2003: Structural changes of sturgeon catches in the Bulgarian Danube section. Acta zoologica bulgarica, 55, 3, 97-102.

Vassilev M., L. Pehlivanov, 2005: Checklist of Bulgarian freshwater fishes. Acta zoologica bulgarica,57, 2, 161-190.

Vassilev, M., 2006. Lower Danube – The Last Refuge For Surviving Of Sturgeon Fishes In The Black Sea Region. (http://balwois.mpl.ird.fr/balwois/administration/full_paper/ffp-858.pdf, 15.5.2006)

Vecsei, P. R. Sucuib & D. Peterson. 2002. Threatened fishes of the world: Huso huso (Linnaeus, 1758) (Acipenseridae). Environmental Biology of Fishes 65: 363–365, 2002.

Vlasenko, A.D., A.V. Pavlov, L.I. Sokolov & V.P. Vasilev. 1989. Acipenser gueldenstaedti Brandt, 1833. pp. 295–344. In: J. Holcık (ed.) The Freshwater Fishes of Europe; Vol. 1, Part II, General introduction to the fishes, Acipenseriformes. AULA-Verlag, Wiesbaden.

Waldman, J.R., J.T. Hart & I.I. Wirgin. 1996a. Stock composition of the New York Bight Atlantic sturgeon fishery based on analysis of mitochondrial DNA. Trans. Amer. Fish. Soc. .

Waldman, J.R., K. Nolan, J. Hart & I.I. Wirgin. 1996b. Genetic differentiation of three key anadromous fish populations of the Hudson River. Estuaries 19: 759–768.

Wilber, D.H., Clark, D.G., 2001. “Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries”, North American Journal of Fisheries Management 21:855–875.

Wirgin, I.I., J.E. Stabile & J.R. Waldman. 1997. Molecular analysis in the conservation of sturgeons and paddlefish. Env. Biol. Fish.

Wolter, C. R. Arlinghaus, 2003: Navigation impacts on freshwater fish assemblages: the ecological relevance of swimming performance. Reviews in Fish Biology and Fisheries 13: 63–89.