

Preliminary study on the status of sturgeon populations (*Acipenser* sp) in the South Eastern Black Sea Coast (Kızılırmak-Yeşilirmak Basin) in the early 21st century

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Abstract The Kızılırmak and Yeşilirmak regions were the most important spawning areas of anadromous sturgeons in the Black Sea coast of Turkey until the end of 1980s. Since then, four hydroelectric and irrigation dams were built on these rivers and they blocked spawning migrations and destroyed spawning habitat of sturgeons. However, overfishing of sturgeon for caviar production at the river mouth caused a dramatic decline of stocks in the second half of the 20th century. Nowadays, sturgeon are extremely rare in the South Eastern Black Sea and they are listed under CITES as an endangered species. This study gives information about the current status of sturgeon populations (*A. stellatus*, *A. gueldenstaedti*, *Huso huso*) around the Black Sea coast of Turkey between 2004 and 2008 based on accidentally captures in different fishing nets and from illegal marketing in the early 21st century. It is recommended a management strategy is implemented for the Yeşilirmak Basin to protect and recover the sturgeon populations.

Introduction

Sturgeons were fished intensively in the Yeşilirmak-Kızılırmak basin (Samsun) between 1940 and 1970 with catches up to 150 t in some years, but these have declined gradually due to the overfishing, pollution and the construction of two dams on these rivers since the 1980s (Çelikkale *et al.* 2004; Ustaoglu and Okumuş 2004) and today they are near extinction. As a result, a legal arrangement was put into place in 1973 to ban sturgeon fishing in mouths of rivers flowing into the Black Sea (Anon 1975). As from 1977, catches of all sturgeon species bigger than 140 cm except *Huso huso* were banned (Anon 1977). This status was kept until 1997. After 1997, all the species were protect (Anon 1997). Since the beginning of the 1990s sturgeon populations have become critically endangered but they are still being fished. In the Yeşilirmak-Kızılırmak basin they are captured as a bycatch in bottom trawls and the individuals > 1.5-2 kg are marketed illegally. This study examines habitat-population interactions and fishing of sturgeon in the Yeşilirmak-Kızılırmak basin which is an important spawning and feeding area for the Turkish Black Sea basin.

Materials and methods

This study was conducted in the Samsun fishing area, in the middle of the Black Sea, between 2004 and 2007. This area is located along the middle of the Black Sea coast of Turkey; between $37^{\circ}47' L, 41^{\circ}09' N$ east and $35^{\circ}57' E, 41^{\circ}47' N$ west (Fig. 1). The continental shelf into which the Yeşilırmak and Kızılırmak rivers discharge is situated between Ünye and Bulancak in the east, Sinop and Gerze in the west and the river areas in which the sturgeons historically migrate most frequently for spawning are along the southern cost of the Black Sea. The Yeşilırmak and Kızılırmak rivers have been heavily degraded by human activities since 1980. The region is an important trawl fishing ground and the other fishing occurs (Zengin 2006). Despite the area being an important fishery, it is more productive than other regions with regard to benthic macro fauna. This is because the continental shelf of the Southern Black Sea coast is generally very narrow and around Samsun, deposits from the rivers Kızılırmak and Yeşilırmak have created extensive shallow grounds. These shallow grounds support productive benthic macro fauna which support the fish stocks. There is reason to believe, however, that intensive trawling in this region has a negative effect upon spawning grounds and regeneration of a range of species (Knudsen & Zengin 2006).

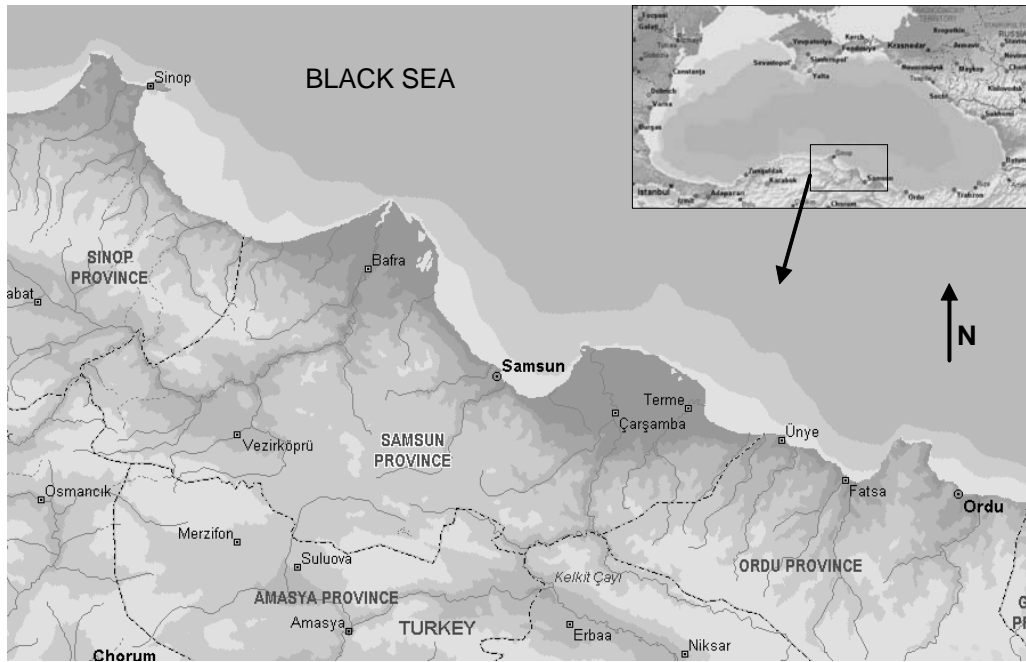


Figure 1. Study area.

Data were provided from different sources; mostly by indirect ways since sturgeon fishing is forbidden by Turkish authority. A strong cooperation and communication network (fax, telephone, website, email) was set up between fisheries cooperatives, fishermen and researchers to report accidental catches of alive or dead fish. “Local contact persons” in Provincial and District Directorates of MARA Samsun, Ordu, Sinop cities were appointed. Direct observation was carried out monthly around feeding habitats and spawning migrations in the Yeşilırmak and Kızılırmak rivers.

Some live sturgeons were tagged and released at different locations (Hopa-Trabzon-Ordu-Samsun-Kızılırmak&Yeşilırmak basin-Sinop-Sakarya). The tags used were plastic

with special marks on (*number and address*). The tags were placed on the end of the dorsal fin. In order to ease collection of samples, small rewards such as t-shirts, caps, some fishing equipment and posters were offered. A total of 40 individuals were tagged between 2007 and 2008. The mean length and weight of tagged sturgeons released were 58.1 (37-91) cm and 895.9 (168-2900) g, respectively.

The reported and directly measured data were recorded on standard Survey- Information Registration forms. This form held information on; (1) date, (2) fishing zone (sea, river, fish market, store, and restaurant), (3) the fish sample (dead-alive), (4) fishing gear / fishing method, (5) the distance from coast, (6) fishing depth, (7) the fish species (morphological features were taken into consideration for identification of the fish species (Holcik 1989)), (8) total length, (9) body weight ,(10) sex (M/F), (11) gonad weight, (12) gonad maturation stages, (13) stomach content, (14) market price of the fish.

Results

Species and seasonal distributions

Three species were caught around the Yeşilırmak-Kızılırmak basins; *Huso huso* (44.3%), *Acipenser stellatus* (35%), and *Acipenser gueldenstaedti* (20.8%). In the early 1980s five species *H. huso*, *A. gueldenstaedti*, *A. stellatus*, *A. sturio* and *A. nudiventris*. (Geldiay & Balık 1988; Edwards & Doroshov 1989) were reported around the Turkish Black Sea coast. *Acipenser sturio* was considered very vulnerable to fishing in the Kızılırmak-Yeşilırmak basin by Edwards and Doroshov (1989).

Bycatch of sturgeon species was higher in autumn, winter and spring than in summer (Table 1). This trend was mainly associated with intensive trawling, especially in Samsun during all seasons except the summer, and spawning and feeding migrations of the sturgeon towards the Southern Black Sea coast occur during the autumn, winter and spring periods.

Table 1. Seasonal distribution of the sturgeon species between 2004 and 2008 in the Kızılırmak-Yeşilırmak basin

Seasons	<i>A. gueldenstaedti</i>	<i>Huso huso</i>	<i>A. stellatus</i>	Total
Spring	8	20	24	52
Summer	7	6	5	18
Autumn	11	11	10	32
Winter	5	29	13	47
General (%)	31 (20.8)	66 (44.3)	52 (35)	149

Illegal fishing and bycatch rates

Fifty-five percent of the bycatch of sturgeon species was in commercial bottom trawl nets in Samsun. This was followed by gill-nets (35%) (bottom and pelagic). A small number were caught by encircling nets (5.4%), dredge nets (2%) and line and hook (2.6%). The trawl fishery operates along the Black Sea coast of Turkey and targets other fish species. (Knudsen & Zengin 2006). Gill-nets operate in the waters near the coast; note bottom gill-nets (demersal-benthic) are more destructive at catching sturgeon

than surface gill-nets. Fishing with encircling nets for bonito and Pacific mullet operate between September and December, and May and June, respectively. Almost all of the captured individuals in the river were caught by traps and heavy hook and line gear.

Sturgeons are mostly caught illegally or accidentally between October and April when commercial trawl fishing intensifies in the fishing grounds beyond 3 miles from the shoreline in the province of Samsun (Anon 2006). Most beluga (*H. huso*) are caught by bottom trawl nets (54.7%).

The majority of the accidentally caught sturgeons (65.4%) were sold illegally on local or public markets (Fig. 2). Although the sturgeons are caught accidentally, the high value of the flesh in large cities encourages the illegal sale of individuals larger 1.5-2 kg; the majority of fish released after capture were <2 kg, mainly *A. gueldenstaedti* and *A. stellatus*. Forty of the 62 individuals released to the sea were done so to determine bio-ecological characteristics of the species.

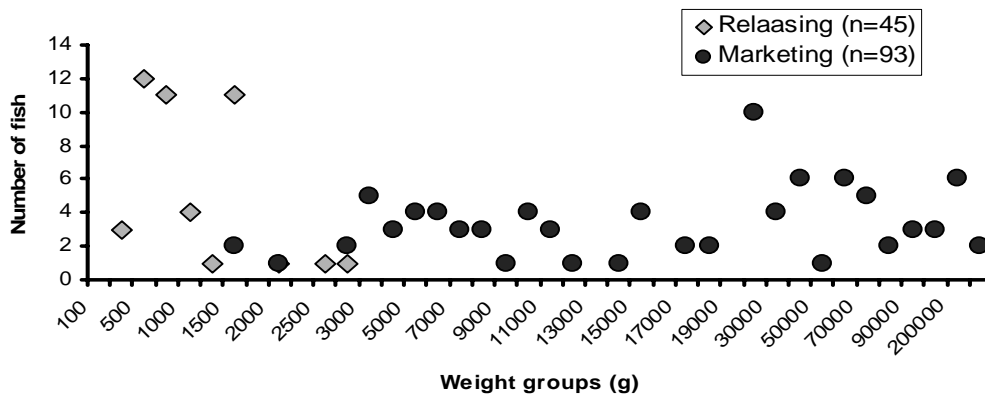


Figure 2. Distribution of the released and tagged sturgeons that were caught accidentally, in terms of weight s (pooled data; 2004-2008).

The price of sturgeon in local stores and luxury restaurants' counters is 40-45 Turkish new liras (TRY)/ kg. The market is mainly *Huso huso* because the growth characteristics of the species (due to its larger size) and spawning and feeding migration behaviour from the northern Black Sea towards the south during the autumn–winter period mean it is caught and retained in the trawl fishery. Beluga sturgeons reaching weights of 250-300 kg are highly sought after and encourage sales.

Migrations: sea and river

In the southern Black Sea, sturgeons are found as deep as 120 m with an average depth of 50.2 (2-123.3) m, but there is no evidence of seasonal variation in depth distribution (Fig. 3). All three species were mainly found between October and May. This may be related to fishing being banned in the region during the summer period. Adult populations move towards the river mouth during the spring period (April- May) as they migrate into the fresh water (river). Nine individuals were reported from the Yeşilirmak River in the studies on Yeşilirmak-Kızılırmak Rivers between the 2004-2008 years, but none was reported from the Kızılırmak River; four individuals were *A. gueldenstaedti*

and five *Huso huso* (Fig. 4). The fish were sexually mature, except for two *A. Gueldenstaedti*, observed in August some 55-56 km upstream near the Hasan Uğurlu Dam and Hydroelectric Power Station.

Length-weight relation

The length weight relation parameters for the sturgeon species are given (Table 2). The majority of fish caught were in the range of 30-80 cm, but with an average length of 60.1 cm for *A. stellatus*, 78.0 cm for *Huso huso* and 78.7 cm as for *A. gueldenstaedti*, equivalent to 1967.6, 52752.1 and 7569.9 g, respectively. The maximum size of *H. huso* was 395 cm (353 kg) compared with 100 (10 kg) and 200 cm (60 kg), respectively for *A. stellatus* and *A. gueldenstaedti* (Fig. 5). The differences in the length and weight parameters of these species, were due to differences in growth characteristics; the length weight coefficient b was higher than 3 for *H. huso* indicating allometric growth, suggesting this species increases proportionally more in weight more than length as it gets larger. Length and weight composition for each species in the Southern Black Sea are similar to the Northwest Black Sea-Danube delta at 100-120 cm (6-8 kg), 150-200 cm (40-70 kg) and 200-256 cm (145-400 kg) respectively for *A. stellatus*, *A. gueldenstaedti* and *H. Huso* (Vassilev & Pehlivanov 2003; Ciolac & Patriche 2005).

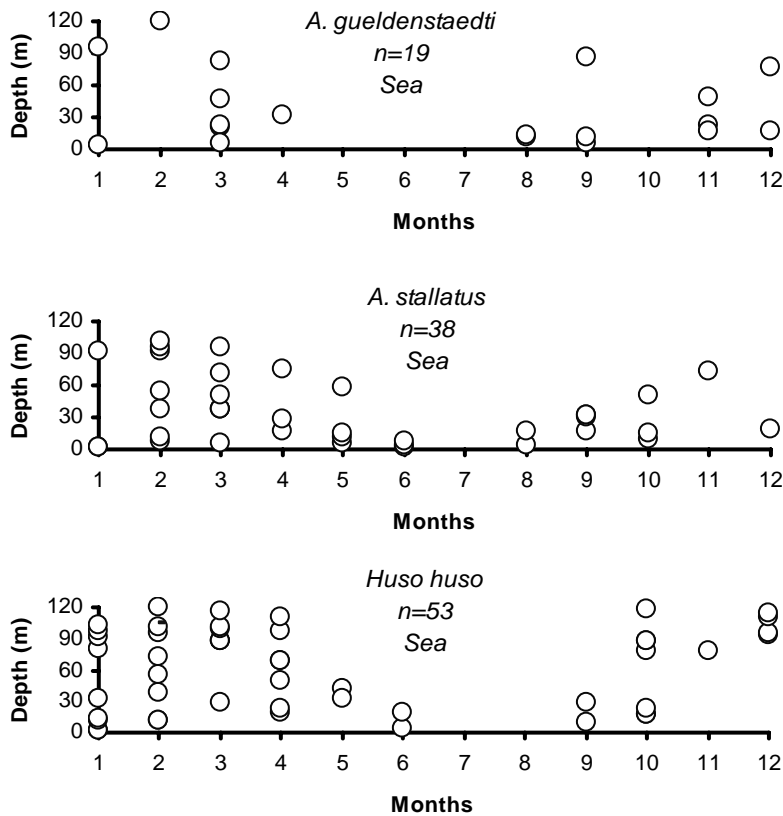


Figure 3. Monthly vertical distributions of the sturgeon's populations in the Kızılırmak-Yeşilirmak littoral.

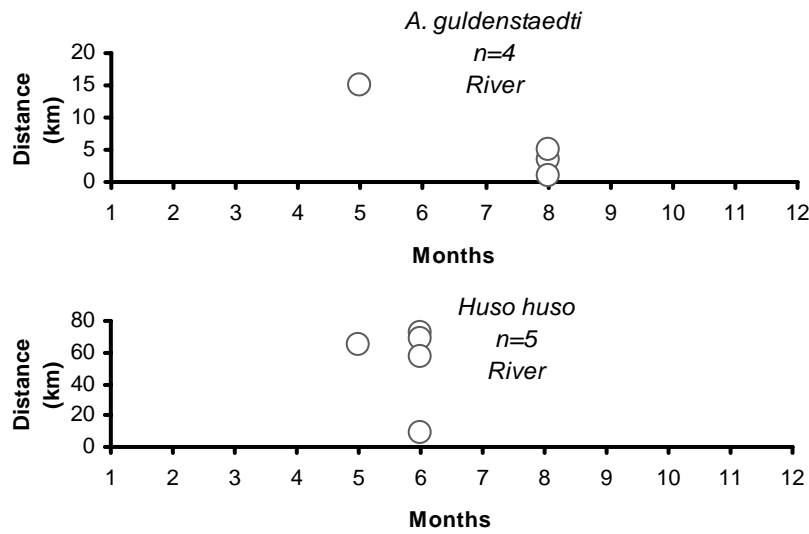


Figure 4. Monthly migration of the sturgeon's population in the Yeşilırmak river (distance is from river mouth to sampled localities).

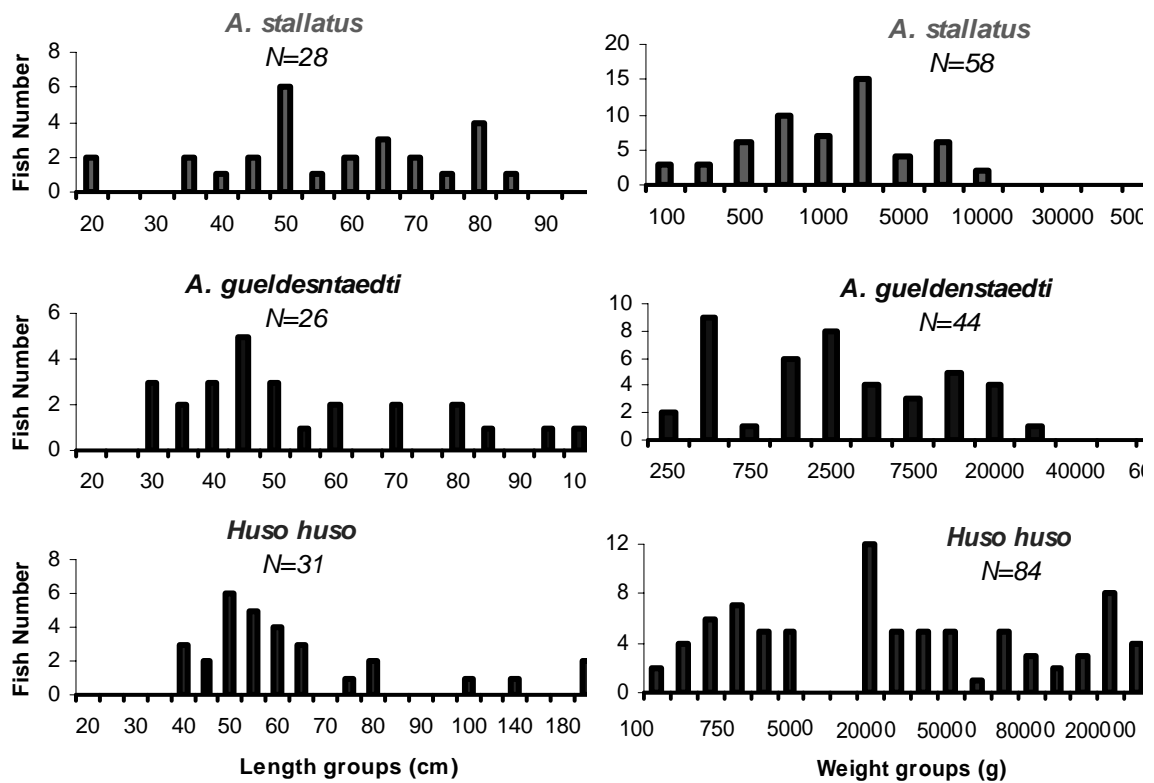


Figure 5. Length and weight compositions of sturgeon in the Kızılırmak-Yeşilırmak basin (2004-2008 period; pooled data).

Table 2. Length weight relationship parameters for sturgeons (2004-2008 pooled data)

Species	a	b	r^2	n	Length range (cm)	Weight range (g)
<i>A. gueldenstaedti</i>	0.0037	3.0609	0.9552	26	78.7 (40-200)	7569.9 (217.7-60000)
<i>A. stellatus</i>	0.0031	3.0081	0.7513	26	60.1 (37-100)	1967.6 (125-10500)
<i>Huso huso</i>	0.0007	3.4665	0.9506	31	78.0 (40-359)	52752.1 (196-353000)

Reproductive behaviour

Observations on spawning migrations were limited (Table 3): (1) reproduction migration was observed only in the Yeşilirmak River and its shelf area; (2) adult sturgeons (*Huso huso*, and *Acipenser gueldenstaedtii*) migrate in spring and early summer in this river (similar to the Danube; Ciolac & Patriche 2005); (3) all fish caught had mature gonads - immature and early maturity stages were generally found in the sea. Although adult sturgeons were found in the Yeşilirmak River, no evidence of spawning was found based larvae and juvenile surveys. It is possible mature fish return to the sea without any finding suitable spawning opportunities and suitable habitat. This is because dams on the Yeşilirmak and Kızılırmak rivers now block access to the most important areas for spawning, especially on the Kızılırmak River where three barriers/dikes have been constructed on different sections for flood prevention along the Bafra plain. This situation is less impacting on the Yeşilirmak River with no barriers on the first 65 km stretch from the river mouth. Also the stream bed in the Yeşilirmak, across the Çarşamba flat, is a deeper and larger delta area than in the Kızılırmak. However, increasingly unfavourable environmental conditions and illegal catching on the river prevent fish from spawning.

Table 3. Reproduction parameters for sturgeon populations in the Kızılırmak-Yeşilirmak basin (TL: total length, W: body weight, GW: gonad weight)

Species	Date	Locality	Habitat	Depth (m)	TL-W (cm-kg)	Sex	GW (g)	Gonad maturity stage
<i>A. gueldenstaedti</i>	15.3.05	Yakakent	Sea	21	150-14.5	F	2000	Immature
	15.4.05	Kızılırmak	Sea	18.3	200-30	F	3600	Early mature
	22.8.05	Yeşilirmak	Sea	12	?-10	M	?	?
	1.1.05	Yeşilirmak	Sea	12	?-20	M	?	?
	10.4.07	Kızılırmak	Sea	inshore	?-27	F	5000	Early mature
	9.5.07	Yeşilirmak	River	-	170-60	F	9700	Mature
	14.5.07	Yeşilirmak	River	-	?-70	F	8500	Mature
	24.10.07	Samsun	Sea	-	?-25	F	8000	Early mature
	25.11.07	Samsun	Sea	-	?-25	F	3500	Early mature
	2.12.07	Dereköy	Sea	77.8	107-5.5	F	92	Immature
<i>A. stellatus</i>	27.12.07	Samsun	Sea	-	?-21	F	?	Immature
	25.3.05	Terme	Sea	95.2	80.2-2	F	?	Immature
	26.4.07	Samsun	Sea	inshore	?-6.5	F	2800	Mature
	16.4.05	Kızılırmak	Sea	50.3	?-18.7	F	2700	Immature
	2.6.05	Yeşilirmak	River	-	?-77.5	F	16000	Mature
	15.2.06	Yeşilirmak	Sea	73.2	?-150	F	?	Immature
<i>Huso huso</i>	18.2.06	Terme	Sea	104.3	?-300	M	?	Immature
	10.5.07	Yakakent	Sea	32	?-60	M	?	Immature
	16.5.07	Yeşilirmak	River	-	?-36	F	?	Mature
	16.6.07	Yeşilirmak	River	-	?-42	F	7400	Mature
	3.12.07	Kızılırmak	Sea	93.3	220-90	F	2152	Immature
	26.1.08	Terme	Sea	110	265-152	F	2873	Immature
	24.2.08	Terme	Sea	100.7	359-353	F	18500	Immature

Feeding habits

The stomach contents of sturgeons from throughout the southern Black Sea littoral suggest they feed on benthic and benthopelagic macrofauna (Table 4). A variety of factors such as; feeding ground characteristics, season, water temperature, food availability (Polyaninova 1996) and predator species determine feeding behaviour. While *H. Huso* feeds in the benthopelagic (horse mackerel, whiting, and gobies) and pelagic (anchovy), *A. Gueldenstaedti* feeds on crustaceans and molluscs in the benthic. The diet of beluga was predominantly anchovy (Berg 1948) reinforcing the impression that this species is connected with the anchovy autumn-winter migration along the southern Black Sea. On the contrary, *A. gueldenstaedti* shows a feeding strategy depending on benthic (Table 4) (Berg 1948; Zolotarev *et al.* 1996).

Discussion

Historically, few studies have been performed on the abundance and distribution and bio ecology sturgeon in the southern Black sea coast. There is a study on taxonomic features of the sturgeon species distributed in a region (Geldiay & Balık 1988). Edwards & Doroshov (1989) compared habitat-population-migration and fishing relations of sturgeon populations in the early 1980s with the 1940s. Accordingly, it is possible compare the status in the Kızılırmak-Yeşilirmak basin described in this paper with the period between 1940 and 1980, between 1980 and 2000, a period of transition in the market economy in Turkey. The features that designate the state of sturgeon populations for each period are given in Table 5.

Table 4. Some feeding parameters about on the sturgeon’s populations in the Kızılırmak- Yeşilirmak basin (TL: total length, W: body weight)

Species	Date	Locality	Habitat	Depth (m)	TL-W (cm-kg)	Stomach contents	
						Prey name	Number-weight (g)
<i>A. gueldenstaedti</i>	8.10.06	Samsun	Sea	7.5	71-1.6	<i>C. gallina</i>	1-?
	2.12.07	Dereköy	Sea	77.8	107-5.5	<i>C. gallina</i>	4-?
						<i>A. cornea</i>	1-?
						<i>M. galloprovincialis</i>	1-?
						<i>C. crangon</i>	2-?
12.8.07	Yeşilirmak	River	-	41.7-0.2	<i>C. gallina</i>	1-?	
<i>Huso huso</i>	3.12.07	Dereköy	Sea	93.3	220-90	<i>C. gallina</i>	1-?
	26.1.08	Terme	Sea	110	265-152	<i>E. encrasicolus</i>	78-741
						<i>E. encrasicolus</i>	88-834.6
						<i>T. trachurus</i>	9-148.5
						<i>E. encrasicolus</i>	129-1225
24.2.08	Yeşilirmak	Sea	100.7	359-353	<i>T. trachurus</i>	2-33.7	
					<i>M. m. euxinus</i>	2-31.2	
					<i>G. niger</i>	3-29.1	

Sturgeon stocks were overexploited in terms of both species number and amount from the early 1940s and stocks along the coast of Turkey are now included in the CITES “Endangered species” list (CITES 2006). Prior to construction of dams on the rivers in the late 1970s, 6 sturgeon species were found; *H. huso*, *A. gueldenstaedti*, *A. stellatus*, *A. sturio*, *A. nudiventris*, *A. ruthenus* (Çelikkale 2004); the number of species

decreased to 4 at the end of the 1980s (*H. huso*, *A. gueldenstaedti*, *A. stellatus*, *A. sturio* (Edwards & Doroshova 1989)), and 3 at the beginning of the 2000s (*H. huso*, *A. gueldenstaedti*, *A. stellatus*). Despite legal protection, sturgeon are still captured as bycatch in the trawl fishery in the Samsun region and sold illegally. In addition, gillnetting in the coastal areas and mollusc dredging increase pressure on the sturgeon stocks along the coast.

Along the southern coast of Turkey the main sturgeon species caught was the beluga in the Yeşilirmak-Kızılırmak littoral; most weighed between 100-350 kg but did not contain caviar. The majority of fish caught now are immature female *H. huso* suggesting that *H. huso* does not migrate for spawning to the rivers in this region. Instead it is likely that *H. huso* and *A. gueldenstaedti* migrate along the southern coast of the Black Sea in the autumn-winter to coincide with the pelagic anchovy migration followed by migration to the rivers for spawning. Further evidence of migration was gained from fish caught that had suture marks that were possibly the result of fish released after aquaculture experiments at Batum Oceanography and Fishery Institute, Georgia, and Kerch YugNiro Research Institute, Ukraine, before and after 2000 (Shlyakhov 2003). These aquaculture studies were performed on the mature individuals caught from the wild. Alternatively, the suture scars could be from fishes harvested for caviar via the surgical operation and returned to the wild.

Another indication in relation to the migration behaviours of the sturgeon species, distributed on the coast of the southern Black Sea is the results, gathered from the marking experiments. Further evidence of migration was gained from a marked individual *A. gueldenstaedti* weighing around 2 kg, caught on the Bulgarian coast at Galata on 10 December 2006; this fish was reared at Sapanca foundation, İstanbul University Faculty of Aquaculture and released at the mouth of the Sakarya River in July 2006. Also *A. gueldenstaedti* caught on the coast of the River Kızılırmak on 8 December 2006, one *A. stellatus* caught in the River Perşembe on 13 February 2007, one *H. Huso* caught at the mouth of the River Sakarya on 4 December 2007. were marked, released and recaptured 275 km west (143 days), 15 km east (9 days) and 4 km-west (2 days) respectively from the localities where they were released. Sturgeon population thus appear to exhibit long distance migration over in short time intervals.

Data on catch, population, habitat and migration characteristics migrate into the Yeşilirmak River to spawning; no data were available for the Kızılırmak River suggesting it is no longer used for spawning. It is crucial to create a conservation area below the first dam in the north of the Kızılırmak Rive and downstream of the Yeşilirmak basin and Çarşamba delta. The Yeşilirmak delta, wetland area in terms of freshwater fishes and bird variety, is under pressure from uncontrolled agriculture and urbanization and has not been conserved adequately, but an administration plan study has been started by the Ministry of Environment and Forestry for this region. Its actions include closing down the gravel extractions from the stream beds, assigning appropriate spawning areas over the river, and immediate rehabilitation of the stream bed.

Despite unfavourable ambient conditions and anthropogenic affects, the region provides valuable opportunities to recover the sturgeon stocks and effort must be put in to conserve these important, critically endangered species.

Table 5. Historically changes in the status of sturgeon populations in the Kızılırmak-Yeşilirmak basin

<p>I. PERIOD (1940-1980)</p>	<p>-No environmental degradations in the Kızılırmak and Yeşilirmak river basins -Low level of urbanization and population growth (Özesmi 1999). -No pollution -Dams not yet constructed - fishing technology not developed -Only 27 trawlers in the late 1970s (Knudsen & Zengin 2006)</p>	<p>-6 species exist and stocks exploited (<i>H. huso</i>, <i>A. gueldenstaedti</i>, <i>A. stellatus</i>, <i>A. sturio</i>, <i>A. nudiventris</i>, <i>A. ruthenus</i>) (Çelikkale <i>et al.</i> 2004) -Ongoing anadromous migration</p>	<p>-Primitive “<i>karmak/hook</i>” estuarine fishing -Fishing mainly between Feb. and Jun. -High price of caviar -Best capture fisheries between 1950s and 1970s (Öker 1956) -A little caviar export to Europe (DPT 1962)</p>	<p>-First expert on caviar processing was invited from Germany (Anonym 1966) -First measures were taken to protect stocks and caviar production in 1960s (Çakıroğlu 1968) - Fishing first prohibited in estuaries in 1973 -Fishing all species except <i>Huso huso</i> bigger than 140 cm prohibited in 1977 (Çelikkale <i>et al.</i> 2004)</p>
<p>II. PERIOD (1980-2000)</p>	<p>-Rapid urbanization, industrialisation and population growth -4 dams constructed on Kizilirmak and Yesilirmak -Bafra and Carsamba plains improved for cultivation (Özesmi 1999). -Rivers basin degradations started -High dikes constructed on Kizilirmak -Pollution increased -Fishing technology and effort increased after liberalisation in early 1980s</p>	<p>-Main species are <i>H. huso</i>, <i>A. sturio</i>, <i>A. stellatus</i> and <i>A. gueldenstaedti</i> -Few migrate for spawning -Pressure on <i>A. sturio</i> -Not many beluga over 250 kg contain caviar (Edwards & Doroshova 1989)</p>	<p>-Illegal fishing and very low caviar production -Low productivity of fishing in estuaries -Spring fishing with so-called <i>morina nets</i> -45 fishermen were active at the end of 1980s (Zengin <i>et al.</i> 1992) - Fishing effort increased (104 trawlers) -Big pressure on sturgeons due to illegal fishing and trawling (Knudsen & Zengin 2006)</p>	<p>-Fishing banned for all species (Anon 1997) -The first experts invited from FAO to advise on stock enhancement (Edwards & Doroshova 1989) -Insufficient and inefficient control mechanism -Caviar and flesh on black market</p>
<p>III. PERIOD (2000-)</p>	<p>- Serious degradation on rivers and estuaries -Intensive urbanization, industrialization and population growth -A new dam on Yesilirmak -Pollution originated from industrial, domestic and agriculture -Very high fishing effort -Demersal stocks collapsed in littoral zone (Knudsen & Zengin 2006)</p>	<p>-Very few specimens belonging 3 species (<i>H. huso</i>, <i>A. stellatus</i> and <i>A. gueldenstaedti</i>) -Reproduction migration only in Yeşilirmak river (This study) -Large beluga migrate for feeding depending on anchovy (This study)</p>	<p>-Some catch occurs mainly in trawl fishing and gillnets as by-catch (This study) -123 trawlers (Knudsen & Zengin 2006) -Ongoing black market for flesh from fish > 1.5-2 kg</p>	<p>-Under protection in CITES as endangered stocks (CITES 2006) -Insufficient protection and control measures -Little awareness in fishermen community for protection -Some civil initiative-MERKODER- and nationwide research projects-CFRI-started in early 2000s</p>

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