YUNUS Research Bulletin 2017 (1): 41-57
www.yunus.gov.tr
ISSN 1303 - 4456
DOI: 10.17693/yunusae.v17i26557.281581

Araştırma Makalesi
Research Article

The Current Status of Gibel Carp and Sand Smelt in Turkey's Inland Fisheries

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Received: 27.06.2016
Accepted: 23.12.2016

Abstract

Turkey has potentially important inland fisheries, with extensive freshwater resources. Although the freshwater ichthyofauna in Turkey is very rich, with about 340 species, inland fisheries depend primarily on 4 species, of which 2 are indigenous (tarek-*Alburnus tarichi*, carp-*Cyprinus carpio*), 1 is non-indigenous (gibel carp-*Carassius gibelio*) and 1 is a translocated marine fish (sand smelt-*Atherina boyeri*), accounting for 78% of the entire catch. Both gibel carp and sand smelt species have been considered invasive species in Turkey, although they are of increasing commercial importance. Currently, the yield of sand smelt and gibel carp are increasing, whereas the yield of carp and tarek are decreasing sharply; however, demand for carp and its economic value are higher in local markets and the contribution of carp to the inland fishery economy (37%) is higher than that of both sand smelt (4%) and gibel carp (4%). Neither gibel carp nor sand smelt are consumed locally, and both species are exported to other countries. Hence, some suggest these 2 species have adverse effects on Turkey's ecosystem and fisheries. In order to ensure a sustainable inland fishery and to obtain a thorough understanding of the ecological interactions there is an urgent need to fill the data gap related to the ecological, fishery, and socioeconomic structures in an exploited system.

Keywords:*Atherina boyeri*, *Carassius gibelio*, *Alburnus tarichi*, *Cyprinus carpio*, alien species.

Öz

Gümüşi Havuz Balığı ve Gümüş Balığının Türkiye İçsu Balıkçılığındaki Mevcut Durumu

Türkiye, sahip olduğu tatlısu kaynakları sayesinde, önemli bir içsu balıkçılığı potansiyeline sahiptir. Türkiye tatlısu balık faunası yaklaşık 340 tür içermesine rağmen; içsu balıkçılığı, toplam avın %78'ini oluşturan başlıca (yerli türlerden inci balığı- *Alburnus tarichi* ve sazan-*Cyprinus carpio,* yabancı türlerden gümüşi havuz balığı-*Carassius gibelio*ve denizlerden tatlısulara taşınan gümüş balığı-*Atherina boyeri*) dört türe bağımlıdır. Gümüşi havuz balığı ve gümüş balığının ekonomik önemi olmasına rağmen, her iki tür de Türkiye içsularında istilacı olarak kabul edilmektedir. Sazanın iç pazarda gördüğü talep ve ticari değeri daha yüksek ve içsu balıkçılık ekonomisine katkısı (%37), gümüş balığı (%4) ve gümüş havuz balığı (%4)'nın katkısından daha fazla olmakla birlikte; günümüzde, sazan ve inci balığının av oranı gittikçe düşerken, gümüş balığı ve gümüşi havuz balığının av oranı artmaktadır. Gümüşi havuz balığının ve gümüş balığı iç pazarda tüketilmemekte, diğer ülkelere ihraç edilmektedir. Bu iki türün Türkiye'de tatlısu ekosistemleri ve balıkçılık açısından olumsuz etkiler yarattığı düşünülmektedir. Sürdürülebilir içsu balıkçılığını garanti altına almak ve ekolojik etkileşimlerin tam olarak anlaşılmasını sağlamak üzere, balıkçılık yapılan sistemlerdeki ekolojik, balıkçılık ve sosyo-ekonomik yapı ile ilgili bilgi boşluğunun acilen doldurulmasına ihtiyaç vardır.

Anahtar Kelimeler:*Atherina boyeri*, *Carassius gibelio*, *Alburnus tarichi*, *Cyprinus carpio*, yabancı türler

Introduction

Excessive human population growth, urbanization and industrialization, and massive disturbances caused by human activity have destroyed many ecosystems, threatening the Earth's biodiversity (Primack, 2010). Due to the complex linkage between ecosystem components, human-induced effects, such as habitat fragmentation and destruction, ove-rexploitation of species, and introduction of non-indigenous species, can result in changes in ecosystem functioning due to alterations in communities, physical habitats, nutrient cycling, and primary production or natural disturbance regimes, which can result in unpredictable economic loss (Primack, 2010; Ricciardi et al., 2011).

Currently, the introduction of non-indigenous species into novel geographic regions is among the most serious threats to indigenous environments worldwide. Indeed, species have spread into new regions via natural process of dispersal, but under the influence of human activity they are doing so at a faster rate, at greater distances, and in greater numbers than ever before (Ricciardi, 2007). Although the great majority of non-indigenous species do not become established in new environments, some percentage of such species do establish themselves, and alter habitat and species diversity via such activities as predation and competition (Clavero and Garcia-Berthou, 2005). In terms of disrupting ecological interactions, invasive species are also a major cause of the decline and extinction of indigenous species (Clavero and García-Berthou, 2005).Aquatic ecosystems, especially isolated lake and stream systems, are very vulnerable to the introduction of non-indigenous species. During last decades, many species introductions have occured via aquaculture, recreational and ornamental fisheries, accidental transport, and biological control in aquatic habitats, and some of these species have become invasive (Primack, 2010). Life history traits, such as a short life span, a prolonged reproductive period, diverse diet, and environmental tolerance, can facilitate invasion of freshwater fish in the European bioregion (Grabowska and Przybylski, 2014). Invasive fish species can cause great harm to indigenous biodiversity via predation, competition, hybridization, disease transmission, and habitat alteration (Crivelli, 1995; Gozlan *et al.,* 2005; Caiola and de Sostoa, 2005; Hanfling *et al.,* 2005; Britton *et al.,* 2010). Although some non-indigenous species provide new sources of income due to their commercial, recreational, and ornamental value, invasive non-indigenous species frequently result in economic loss, both locally and globally.

Today, invasive fish species cause enormous global economic loss; in the US the annual economic loss attributed to invasive fish species is $5.4 billion (Pimentel *et al.,* 2005), whereas annually €12.5 billion is spent in the EU for monitoring, controlling, preventing, and eradicating invasive fish species, and for reversing the damage they cause to fisheries, agriculture, forestry, and public health (Kettunen *et al.,* 2008).

Turkey is an extremely interesting region, as it is located at the junction of 3 important zoogeographic regions. Turkey has many rivers, and natural and dam lakes of varying ecological properties, which are host to a rich biodiversity of approximately 340 freshwater fish species. In addition to endemic species, Turkey's freshwater ichthyofauna includes Euro-Mediterranean, Syrian-Mesopotamian, and Ponto-Aralo-Caspian species.

The present climate favors and the paleoclimate conditions favored the establishment and diversification of Turkey's fish species. Although Turkey has the richest freshwater ichthyofauna in the Mediterranean Region (Froese and Pauly, 2013), its biodiversity is threatened; 33% of the freshwater fish species are threatened and 2 species have already become extinct (Ekmekçi et al., 2013). In addition to pollution, overuse of groundwater, construction of dams and other management projects, overfishing and harvesting of aquatic resources, and invasive species all pose a serious threat to Turkey's freshwater fish biodiversity. At present, around 25 introduced or translocated fish species, primarily gibel carp, send smelt, topmouth gudgeon, rainbow trout, and mosquito fish, have spread to almost all water basins in Turkey (Ekmekçi *et al*., 2013). This spread occurs accidentally or intentionally via such human activities as aquaculture, and ornamental, recreational, and commercial fisheries. As in many European countries, gibel carp has successfully established itself in most of Turkey's freshwater environments (Ekmekçi *et al.,* 2013), with serious negative environmental consequences, as elsewhere (Savini *et al.*, 2010; Winfield et al., 2010).

Turkey has potentially important inland fisheries, with extensive freshwater resources; however, invasive and non-indigenous species are increasing in commercial importance. Recently, both gibel carp and sand smelt have become widespread in Turkey's freshwaters, and have established successful populations in inland waters. According to the statistics, two indigenous species (*Alburnus tarichi* and *Cyprinus carpio*), a non-indigenous species (*Carassius gibelio*), and a translocated marine fish (*Atherina boyeri*) were the mostly commonly caught species in Turkey (TURKSTAT, 2013).

In order to develop a roadmap for fishery management of non-indigenous/invasive freshwater fishes in Turkey it is necessary to review the present status of Turkey's inland fisheries and to understand the role of non-indigenous/translocated fishes, in both economic and ecological terms. The present study aimed to analyze the role of invasive species in Turkey's inland freshwater fisheries.

Materials and Methods

Data on freshwater and aquaculture production were obtained from the Turkish Ministry of Food, Agriculture, and Livestock, but primarily from annual fishery statistics reports prepared by the Turkish Statistical Institute (TURKSTAT, 2012 and 2013; Anonymous, 2014). *A. boyeri* established in inland waters since 1970s and its distribution area is widening from west to eastern Anatolia. Although, *A. boyeri* has a significant fishery potential for last 3-4 decades, *C. gibelio* has an commercial importance since 2012 as it can be seen in data of TUİK (TURKSTAT, 2012). The current distribution areas of *A. boyeri* and *C. gibelio* were delineated based on data previously published by the present study's authors Ekmekçi *et al.* (2013) and other studies (Özuluğ et al., 2004; Özuluğ vd., 2013; Yerli *et al.*, 2014).

Results

Production: Turkey has a great potential for fish production, due to its various marine and freshwater environments that are suitable for fishing and aquaculture. Although aquaculture is a relatively young industry in Turkey, fishery products-including aquaculture-are considered an important agricultural resource.

According to the statistics data for the fishery sector in Turkey, the amount and percentage of fish harvested from both marine and inland waters gradually decreased between 2002 and 2013, whereas a remarkable increase of approximately 282% was observed for aquaculture production during the same period (Table 1). The data indicate that aquaculture production has rapidly increased in Turkey. In 2013 the total reported aquaculture production reached 233,394 tons, of which 123,000 tons came from inland aquaculture production. Rainbow trout dominates aquaculture in Turkey's inland waters. In addition to non-indigenous tilapia and rainbow trout, such indigenous species as carp, sturgeon, eel, and trout are also cultured commercially in Turkey.

Although about 90% of yield from capture fisheries were harvested from marine environments, Turkey has freshwater fisheries of great capacity. Fisheries statistics for 2008-2013 indicate that captured freshwater fish have a higher economic value and commercial value than marine fish, although freshwater fish yields were equal to 10% of the total capture fisheries production (Table 2). If the produc-

Table 1. Annual variation in total fishery production (tons) (TURKSTAT 2012, 2013; Anonymous, 2014)

Years	Total Fishery Production (tons)						
	Fisheries				Aquaculture		Total
	Marine		Freshwater				
	Amount	%	Amount	%	Amount	%	
2002	522,744	83.3	43,938	7.0	61,165	9.7	627,847
2003	463,074	78.8	44,698	7.6	79,943	13.6	587,715
2004	504,897	78.3	45,585	7.1	94,010	14.6	644,492
2005	380,381	69.8	46,115	8.5	118,277	21.7	544,773
2006	488,966	73.9	44,082	6.7	128,943	19.5	662,103
2007	589,129	76.3	43,321	5.6	139,873	18.1	772,323
2008	453,113	70.1	41,011	6.3	152,186	23.5	646,310
2009	425,275	68.2	39,187	6.3	158,729	25.5	623,191
2010	445,680	68.2	40,259	6.2	167,141	25.6	653,080
2011	477,658	67.9	37,097	5.3	188,790	26.8	703,545
2012	396,322	61.5	36,120	5.6	212,410	32.9	644,852
2013	339,047	55.8	35,074	5.8	233,394	38.4	607,515

tion of freshwater products is compared to that of marine fishes although the proportion of freshwater production was roughly 10%, its total income was 19.27% of capture fisheries in 2009

The Turkish General Directorate of Fisheries and Aquaculture (Anonymous, 2014) reported that among European countries, Turkey had the highest yield of freshwater products; however, the contribution of the freshwater catch to total fishery production was relatively small compared to catch from sea and the annual catch of freshwater fish decreased from 46,115 tons in 2005 to 35,074 tons in 2013 (Table 1).

Marine fisheries appear to be the most important fishery sector in Turkey, but the total catch from marine capture fisheries varies (Table 1). More than 50% of the total marine catch consisted of Black Sea anchovy (FAO, 2008); therefore, any change in the distribution of anchovy and the total catch in any year or season have a significant impact on the total annual catch. In contrast, inland fisheries depend primarily on 4 species-tarek, carp, gibel carp, and sand smelt-even though there are 21 commercially valuable freshwater species distributed throughout Turkey's inland environments (Table 3).

The most important native inland fisheries species are tarek and carp. Tarek is an endemic species to the alkaline waters of Lake Van (Rad, 2002). Thus, tarek is caught only in Lake Van (the largest lake in Turkey) and its tributaries (Karakaş and Türkoğlu, 2005). Common carp is a popular species caught from inland waters throughout Turkey (Harlıoğlu, 2011).

Additionally, the contribution of non-indigenous gibel carp and sand smelt (a translocated marine fish) to the total catch of inland fisheries has gradually increased in recent years. Gibel carp and sand smelt are widespread in in Turkey's freshwater systems;

Table 2. Quantity (tons) and value (USD*) of fishery products between 2008 and 2013

Year		Fisheries		Aquaculture		Freshwater Products	Inland Water/ Marine Fish Products (%)
		Marine Fish	Other Marine Products	Inland	Marine		
2008	Quantity	395,660	57,453	66,557	85,629	41,011	10.37
	Value	699 273 297	90 390 424	214 134 865	469 224 775	91 745 662	13.12
2009	Quantity	380,636	44,410	76,248	82,481	39,187	10.30
	Value	419 024 898	41 649 098	209 799 734	406 309 077	80 715 982	19.27
2010	Quantity	399,656	46,024	78,568	88,573	40,259	10.07
	Value	531 551 645	61 754 067	214 420 275	461 911 811	90 467 318	17.02
2011	Quantity	432,246	45,412	100,446	88,344	37,096	8.58
	Value	581 527 707	62 546 066	294 735 391	501 221 076	72 386 599	12.46
2012	Quantity	315,636	80,685	111,557	100,853	36,120	11.44
	Value	540 662 224	66 220 817	306 597 978	577 715 193	59 138 236	10.94
2013	Quantity	295,168	43,879	123,019	110,375	35,074	11.88
	Value	523 588 038	60 841 242	308 912 818	605 453 981	53 107 613	10.09

* Modified from TURKSTAT (2012, 2013) and Anonymous (2014)

both species have rapidly expanded their range during the last decade, and have establish successful populations in many inland waters (Ekmekçi *et al.,* 2013). These 4 species accounted for 79% of the total catch (35,074 tons) in 2013 (Table 3). Similarly, 73.3% of the mean value of total production consisted of tarek, carp, gibel carp, and sand smelt since 2009, whereas approximately 33% of the total catch consisted of both gibel carp and sand smelt during the same period (Table 3).

Statistical data for 2000-2013 on the 21 most commercially valuable freshwater species were analyzed. The results indicate that total catch of invasive sand smelt increased from 1583 tons in 2000 to 5000 tons in 2013, while the total catch of indigenous species gradually decreased during the same period (Table 3). The other invasive species, gibel carp, has been considered a commercially valuable species since 2012; therefore, data on gibel carp have been included in fisheries statistics only since 2012. Recently, both sand smelt and gibel carp rapidly extended their range and became the dominant fish species in many natural and artificial freshwater bodies in Turkey (Ekmekçi et al., 2013).

Fisheries data for 2013 show that primarily 4 species-tarek, carp, gibel carp, and sand smelt-constituted 78.1% of the total catch and 64.3% of total income (Fig. 1).

In addition to these 4 species, trout, mullet, and wels catfish were also of high production and economic value to Turkey's inland fisheries. On the other hand, there is remarkable incompatibility between the catch and income proportions of each of the 4 primary species. Although carp constituted 23.4% of the total catch, its income accounted for 37.4% of the total, versus 15.7% of total catch and 3.9% of total income for gibel carp. These findings clearly show carp is more profitable.

Gibel carp fishery: Gibel carp is one of the most abundant non-indigenous species in Turkey. Since last decade, gibel carp increased in popularity among fishermen. It was first recorded in the Thrace Region in 1988 (Baran and Ongan, 1988), and then rapidly expanded its range in Anatolia during the following 2 decades (Ekmekçi *et al.*, 2013). Gibel carp has the potential to adversely affect indigenous fish populations via competition for food resources and space; therefore, it is considered Among

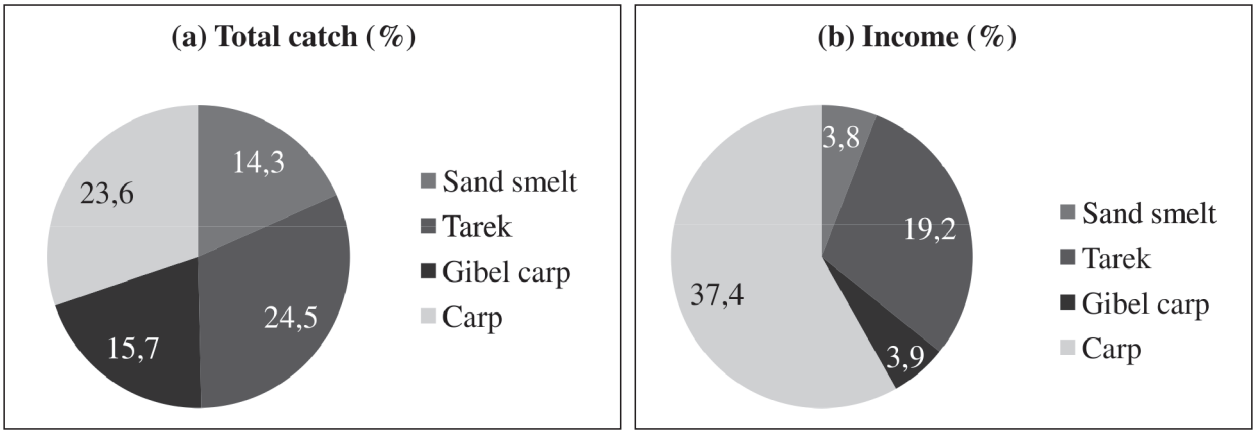

Figure 1. The percentage of total catch (a) and value (b) for the 4 primary freshwater fish species in Turkey.

Table 3. Total Catch (tons) of commercially important inland fishes in Turkey between 2009 and 2013 (TURKSTAT 2012, 2013; Anonymous, 2014)

Year		Trout	Sand Smelt	Gibel Carp	Tarek	Tench	Catfish	Mullet	Pike perch	Carp	Transca-ucasian barb	Pike	Wels	Eel	Other*	Total
2000	Amount	277	1583	-	15 654	690	576	698	1633	14 137	1124	224	1019	176	5033	42 824
	%	0.6	3.7	-	36.6	1.6	1.3	1.6	3.8	33	2.6	0.5	2.4	0.4	11.8	100
2001	Amount	364	1685	-	15 848	778	520	710	1644	12 265	1009	192	813	122	7373	43 323
	%	0.8	3.9	-	36.6	1.8	1.2	1.6	3.8	28.3	2.3	0.4	1.9	0.3	17.0	100
2002	Amount	352	1733	-	14 930	800	495	659	1850	12 965	918	217	987	147	7885	43 938
	%	0.8	3.9	-	34.0	1.8	1.1	1.5	4.2	29.5	2.1	0.5	2.2	0.3	17.9	100
2003	Amount	393	1826	-	14 215	785	507	738	1751	13 820	1013	237	912	158	8343	44 698
	%	0.9	4.1		31.8	1.8	1.1	1.7	3.9	30.9	2.3	0.5	2.0	0.4	18.7	100
2004	Amount	352	2107	-	14 259	1875	487	820	1852	13 451	1027	253	897	165	8040	45 585
	%	0.8	4.6	-	31.3	4.1	1.1	1.8	4.1	29.5	2.3	0.6	2.0	0.4	17.6	100
2005	Amount	376	5248	-	14 103	1792	480	830	1768	13 718	971	249	804	176	5600	46 115
	%	0.8	11.4	-	30.6	3.9	1.0	1.8	3.8	29.7	2.1	0.5	1.7	0.4	12.1	100
2006	Amount	374	6677	-	11 978	1953	478	948	1656	12 116	967	279	1245	162	5249	44 082
	%	0.8	15.1	-	27.2	4.4	1.1	2.2	3.8	27.5	2.2	0.6	2.8	0.4	11.9	100
2007	Amount	550	6540	-	11 623	1884	486	927	1586	12 286	985	242	1293	179	4740	43 321
	%	1.3	15.1	-	26.8	4.3	1.1	2.1	3.7	28.4	2.3	0.6	3.0	0.4	10.9	100
2008	Amount	630	6630	-	11 758	1632	339	1023	1346	11 625	993	213	1275	171	3376	41 011
	%	1.5	16.2	-	28.7	4.0	0.8	2.5	3.3	28.3	2.4	0.5	3.1	0.4	8.2	100
2009	Amount	557	6184	-	10 685	1482	310	970	1234	10 964	891	197	1193	158	4362	39 187
	%	1.4	15.8	-	27.3	3.8	0.8	2.5	3.1	28	2.3	0.5	3.0	0.4	11.1	100
2010	Amount	738	4438	-	11 382	1162	341	1512	1476	12 058	962	228	1178	182	4602	40 259
	%	1.8	11.0		28.3	2.9	0.8	3.8	3.7	30	2.4	0.6	2.9	0.5	11.4	100
2011	Amount	519	6705	-	9168	624	362	1325	737	9998	924	238	946	28	5523	37 097
	%	1.4	18.1	-	24.7	1.7	1.0	3.6	2.0	27	2.5	0.6	2.6	0.1	14.9	100
2012	Amount	444	3609	5090	9621	63	299	1138	593	9973	813	215	816	38	3409	36 120
	%	1.2	10.0	14.1	26.6	0.2	0.8	3.2	1.6	27.6	2.2	0.6	2.3	0.1	9.4	100
2013	Amount	438	5012	5495	8600	65	345	1094	491	8277	736	213	618	48	3643	35 074
	%	1.2	14.3	15.7	24.5	0.2	1.0	3.12	1.4	23.6	2.1	0.6	1.8	0.1	10.4	100

*Chub, Bream, Roach, Goby, Crayfish, Frog, Snail

Turkey's most invasive species (Crivelli, 1995; Tarkan *et al.,* 2012a). Environmental degradation can be an advantage for the invasive success of gibel carp (Leonardos et al., 2008; Liasko *et al.,* 2011), as is introduction of the fish into water bodies (especially artificial reservoirs) to sup-port commercial or recreational fisheries (Özuluğ *et al.*, 2004; Tarkan *et al.*, 2006). A comprehensive study by Tarkan *et al.* (2012a,b) reported that gibel carp has higher growth performance in artificial water bodies in Turkey than in natural waters.

In terms of the freshwater fishery sector in Turkey, the gibel carp catch accounted for 15%-16% of the total fish catch for the last 2 years, but only data since 2012 are available. Gibel carp is popular in many natural lakes and reservoirs located in various provinces in Turkey (Fig. 2); however, gibel carp provide only 3.9% of total economic profit to the sector during the same period. As such, gibel carp has less economic income and commercial value in Turkey, although it is popular in the Far East and some Middle Eastern countries such as Iraq (Yin *et al*., 2014).The negative ecological effects of gibel carp introductions on indigenous species have recently been recognized in many countries, including Turkey (Paulovits *et al.*, 1998; Gaygusuz *et al.*, 2007; Liasko *et al.*, 2011). The density of indigenous species is adversely affected by gibel carp introduction (Tarkan *et al.*, 2012a); therefore, it is considered among the most dangerous invasive species to indigenous fish populations (Crivelli, 1995; Kalous *et al*., 2004). In Turkey, commercially important indigenous fishes, including *Vimba vimba* (vimba), *Cyprinus carpio* (common carp), *Scardinius erythrophthalmus* (rudd), and endemic fish species such as *Alburnus istanbulensis* (shemaya) are thought to have suffered most from gibel carp introductions (Balık *et al.*, 2004; Gaygusuz *et al.,* 2007).

Sand smelt fishery: The marine fish sand smelt is also widespread in Turkey's freshwater environments and the dense freshwater populations of sand smelt are commercially exploited (Fig. 3); however, similar to gibel carp, sand smelt is of less economic and commercial value than carp and tarek. Sand smelt accounts for 14%-15% of total freshwater fish catch, but its economic contribution is only 3.8% of total income (Fig. 1).

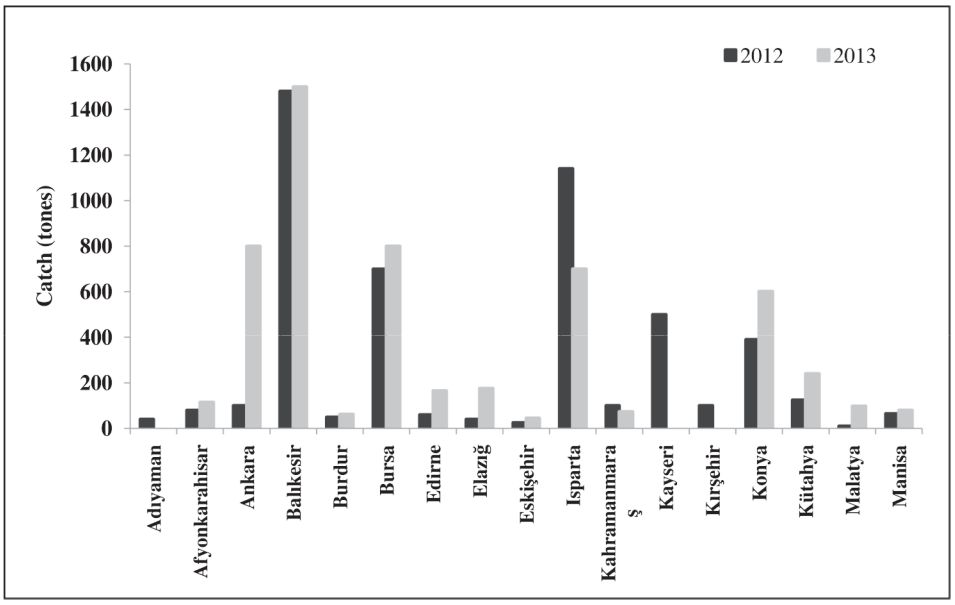

Figure 2. Gibel carp fisheries in various provinces of Turkey.

At the first glance exploitation of non-indigenous species can be considered useful for controlling population size, but the possible effects of overfishing should be also considered, as fishing pressure plays a major role in life history changes observed in commercial fish stocks. For example, overfishing commonly leads to evolution of a reduction in age and size at maturity (Palkovacs, 2011). The potential for fisheries-induced evolution appears strong, as almost all modern commercial fisheries are highly selective, especially with respect to age and size; fisheries sometimes remove as much as 50% of a population annually and life history traits in fish are at least moderately heritable (Sharpe and Hendry, 2009).

Tarek fishery: As mentioned previously, tarek is an endemic species in the Lake Van Region. In addition to its ecological importance, the species is also an economically valuable freshwater product in Van and Bitlis Provinces (Fig. 4), and it is considerably consumed by the local populations because it is an inexpensive and easily obtained source of protein.

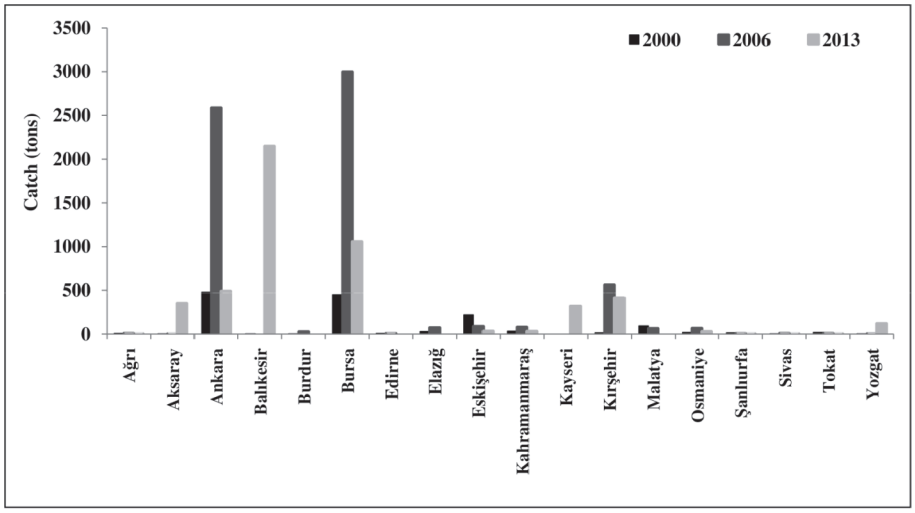

Figure 3. Sand smelt fisheries in various provinces of Turkey.

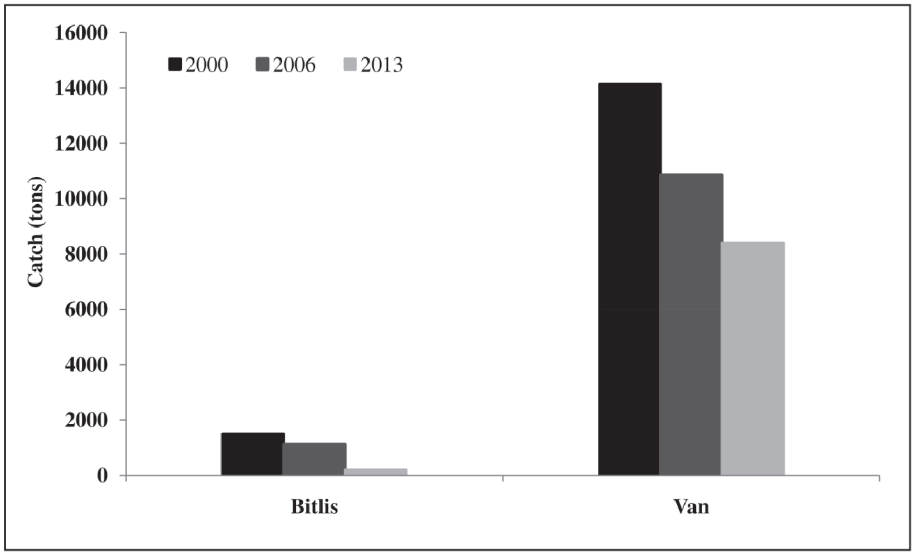

Figure 4. Tarek fisheries in Turkey.

It is also of great market value locally and nationally. The yield of tarek constitutes 25% of the total freshwater catch in Turkey, and its proportion of total income of freshwater fish is 19.2%; therefore, tarek is among the most important inland fishery species in Turkey.

Common carp fishery: The common carp is globally one of the most widespread freshwater fish species. It is cultivated in large quantities for human food and is stocked for sport fishing (Kottelat and Freyhof, 2007). Historically, carp is thought to have first been introduced to Anatolia during the Roman period, although some researchers have posited that the common carp is naturally distributed in freshwater bodies in Anatolia (Vilizzi, 2012; Balon, 1995). The carp is also an important component of the ecosystem due to its effects on the foodweb, water quality, and biodiversity (Vilizzi et al., 2014; Tarkan et al., 2014).

Today, carp is among the most common species in Turkey's lakes, ponds, and reservoirs. It is consumed by local people in large amounts; therefore, carp is an important species for both commercial and recreational fishermen (Fig. 5).

The contribution of carp to the total catch is 23.6%, while it generates 37.4% of total income (Fig. 1); however, demand for carp and its economic value are higher in local markets, and the contribution of carp to the inland fishery economy is higher than that of tarek, sand smelt, and gibel carp. Periodically, the Fisheries and Aquaculture Directorate of the Ministry of Food, Agriculture, and Livestock augment carp populations with carp fry, as existing carp stocks are over-exploited. For optimal fishery management carp should be re-evaluated, but issues including restocking strategies, fishing pressure, minimum catch size, fishing season, and even genetic effects should be considered when formulating new management strategies.

Trends in freshwater fishery: Since 2005, the catch of sand smelt and gibel carp relatively increased, whereas that of carp and tarek gradually decreased (Fig. 6).

The most probable cause for the decrease in carp production is over-exploitation of the existing stocks. On the other hand, sand smelt and gibel carp rapidly extended their range in many lakes, ponds, are reservoirs since the early 2000s; therefore; these invasive species might have put competitive pressure on the local carp populations. For instance, fishery statistics for 2013 From important fishing areas

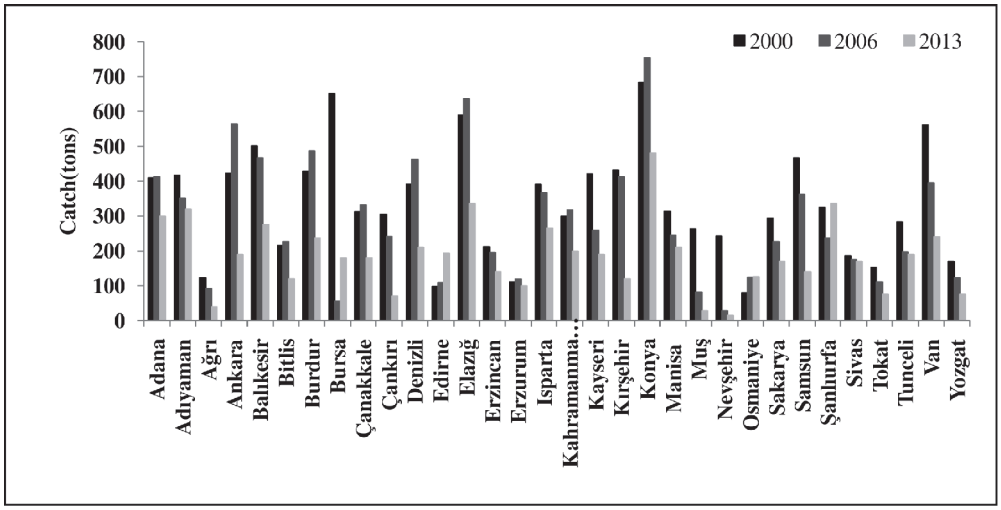

Figure 5. Carp fisheries in various provinces of Turkey.

such as lakes İznik, Uluabat, Eğirdir, and Suğla, and reservoirs Hirfanlı, Yamula, and Gelingüllü show that the proportion of carp in the total catch is less than that of gibel carp and sand smelt (Fig. 7).

Despite efforts to increase the carp catch, it has remained low and invasive species-gibel carp and/or sand smelt-were dominant in the total catch. The lower proportion of carp in the total catch can be attributed to the adverse ecological effects of the invasive species gibel carp and sand smelt.

As tarek is a primary source of protein in the Lake Van Region, over-exploitation is the most probable factor for the decline in the tarek catch. Data show that tarek stocks have been overfished since 2000. In recent years, tarek fishing inspections have increased and new regulations (e.g. fishing season and minimum size of fish) were introduced. Indeed, to recover

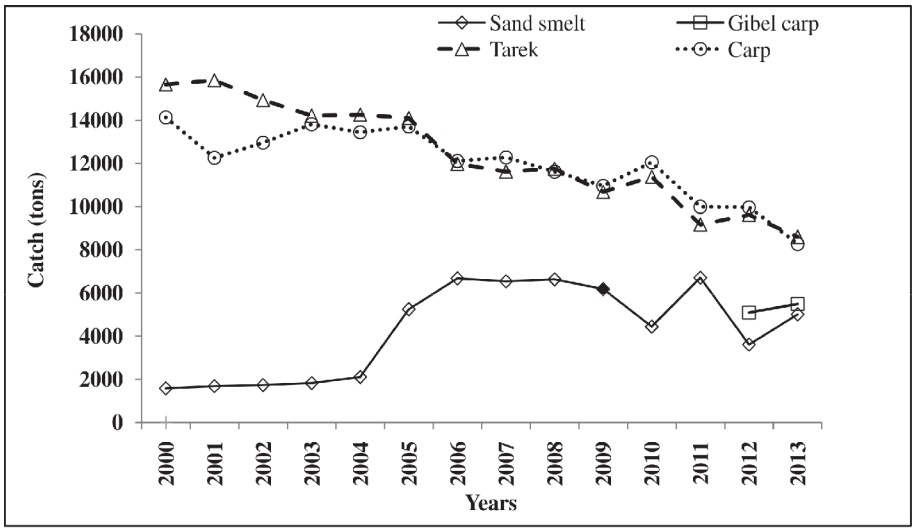

Figure 6. Variation in production of 4 fish species in the inland waters of Turkey.

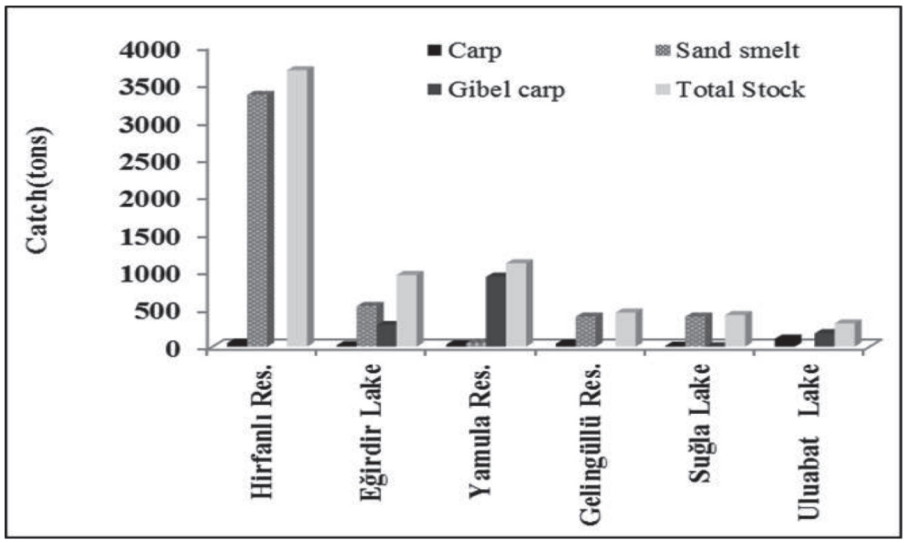

Figure 7. Total catch of the 4 primary freshwater fish species in various lakes and reservoirs.

overexploited populations, once fishing pressure should be removed by restrictions. Fishing stocks can take long time to recover, because fish density might be too low for successful reproduction, competing species might have established themselves, or most years may be unsuitable for reproduction (Primack, 2010). Classic expectation of fishing is rapid population recovery when fishing is ceased, but in practice recovery rates have been much slower than predicted, and in some cases the expected recovery has not taken place at all (Enberg *et al.*, 2009). As such, tarek stocks should be monitored long term. Moreover, the possible effects of gibel carp on tarek should be carefully assessed because the Lake Nazik tarek population declined after the introduction of gibel carp.

Discussion

Introduction of non-indigenous freshwater fishes can have direct and indirect adverse effects on indifenous flora and fauna, and ecosystems, as well as on national economies (Gozlan *et al.,* 2010). Despite the existence of a large body of data on non-indigenous fish and fish introductions, their effects have not been adequately studied (Savini *et al.*, 2010). According to a United Nations Food and Agriculture Organization report, 25% of the world's fish stocks are overexploited, depleted, or recovering (FAO, 2009). Although biological extinction is a slow process (Primack, 2010), decreases in several fish stocks have lead to the collapse of fishing activities, and consequently, commercial viability (Enberg *et al.*, 2009). Today, invasive species are a major cause of the decline and extinction of indigenous species, and invasion by non-indigenous species is extremely difficult to control and predict (Ricciardi *et al.*, 2011). Although damage to indigenous species is often the end result of invasions, there are other ecological and evolutionary effects of biotic homogenization that are less understood; therefore, prevention and the precautionary principle are of particular relevance to invasive species (Clavero and García-Berthou, 2005; Mooney and Cleland, 2001).

Collapse of commercially valuable fish stocks has enormous negative social and economic results, and politicians and fishery management institutions have gradually shifted their focus from 'how much to catch' to 'how to make sure there is something to catch' (Enberg *et al.,* 2009). Due to the introduction of pikeperch for fishery management, by the end of the 1980s Turkey experienced the extinction of 2 endemic freshwater fish species (*Alburnus akili* and *Pseudophoxinus handlirchi*) and sharp decreases in fish stocks (Ekmekçi and Erk'akan, 1997; Küçük, 2012). New fishery management strategies must include conservation of endemic species, and viable methods of preventing accidental introduction of non-indigenous fish species.

Environmental impact is not related to the successful establishment of a species. Some invasive species that have established extensive populations in Europe, such as *Carassius auratus* (29 countries) and *O. mykiss* (28 countries), are not associated with severe environmental effects. On the other hand, *C. gibelio* (in 7 countries) had significant negative effects in all countries in which it was introduced. Moreover, the level of impact in Europe of an introduced species can vary by country (Savini *et al.*, 2010). In Turkey *C. gibelio* was reportedto be a highly invasive species, based on its rapid increase in abundance and distribution (Kırankaya and Ekmekçi, 2013), and its negative effects on endemic fish populations (Tarkan *et al.*, 2012a).

Capture fishery resources are highly diverse and depend on responsible management decisions and practices for their sustainability. Additionally, management of non-indigenous species is also crucial for maintaining indigenous biodiversity and normal ecosystem functions (Byers *et al.,* 2002). According to statistical data (Table 3), the decrease in carp populations in Turkey might have been due to competition with gibel carp. Instead of fishery of gibel carp, the fishery of carp may be promoted by increasing carp fishery through introduction of this species by governmental organizations. To reduce the negative effects of non-indigenous species, data on the distribution, ecological effects, and control of non-indigenous species are required. Gaps between ecological theory and the practical needs of conservationists, land managers, planners, and policymakers have resulted in the inability to address critical problems caused by invasive non-indigenous species (Byers *et al.,* 2002). A national web collecting that evaluates and compiles data on the distribution and effects of invasive species is urgently needed in Turkey; the governmental organization responsible from fishery management may lead this mission by a project.

Frésard and Ropars-Collet (2014) suggest a bioeconomic model for a commercial fishery invaded by a non-indigenous species. Accordingly, when an indigenous species is sustainably harvested and an invasive species is controlled-provided that the unit costs of indigenous species harvesting and cleaning invaded areas are quite low-natural and anthropogenic dispersal coefficients of invasion, and the time-discount rate are moderate. Fishery management may be used as a tool for controlling the invasion of gibel carp and sand smelt in Turkey, which will require careful and detailed planning. While devising such a plan it must be considered that fishing pressure plays a major role in life history changes in commercially exploited stocks (Sharpe and Hendry, 2009; Palkovacks, 2011), and that such changes must be predicted using realistic models.

Today, unauthorized fish introductions are a serious problem for fisheries. Although in Turkey some legislation concerning fish introductions has been enacted, (Atalay and Toslak, 2013), more detailed and specific regulations may be effective in preventing/regulating future introductions. The long-term solution must include public education about the negative consequences of transferring fish to new water bodies. In many cases, unauthorized species introduction may have to be accepted as a permanent part of the biota. The long-term monitoring of species introductions is critical to preserving existing fisheries and maintaining biological integrity in aquatic systems (Rahel, 2004).

We strongly recommend focusing on the effectiveness of public awareness and education in reducing the spread of non-indigenous invasive species, which is an often-neglected area of research. Eiswerth *et al.,* (2011) reported that there is a tradeoff between using funds for education programs to increase awareness and knowledge, and using funds for monitoring and management of aquatic invasive species. People likely play an important role in spreading invasive species (e.g. via boat use and transport). In constructing public aware-ness and education programs, it may be necessary to consider the need to educate both commercial and recreational fishermen, and recreational boaters on lakes and reservoirs alt-hough fish and fishery products are a very valuable source of protein and essential micronutrients for balanced nutrition, in Turkey the mean annual

per capita consumption of fishery products was about 6.3 kg in 2013, ver-sus 8.6 kg in 2007 (Anonymous, 2014). As the human population increases, its food supply becomes a more critical problem. People in Turkey mostly consume marine fish products, but environment friendly aquaculture, such as trout farming in inland waters, may contribute as a very valuable source of food. To ensure food security it is important to improve inland fishery and aquaculture.

In Turkey the invasive species gibel carp and sand smelt are considered a threat to inland fisheries and commercially valuable endemic species; both species were introduced by fishermen into novel freshwater environments. Neither gibel carp nor sand smelt are consumed locally-both species are exported to other countries; therefore, the market value of gibel carp and sand smelt is low. Exportation is not stable because of regional and global economic and political issues. On the other hand, the negative effects of these species on the ecosystem and fisheries are a contentious issue (Tarkan *et al.*, 2012b). In order to clearly prove that these 2 invasive species are causing negative effects, detailed studies on competition between gibel carp and sand smelt, and indigenous fish species in different ecosystems should be performed. Additionally, illegal introduction of gibel carp by fishermen should be strictly prohibited. Academics, governmental organizations, non-governmental organizations, fishermen, and local communities need to cooperate/communicate to establish strategies for non-indigenous and translocated aquatic species. Instead of farming and introduction of non-indigenous species (e.g. gibel carp) or potentially invasive species (e.g. sand smelt), husbandry of indigenous species, such as carp, shabut *(Arabibarbus grypus),* pikeperch, pike, wels catfish, and yağbalığı (*Pseudophoxinus* sp.), in closed and environmentally friendly systems should be promoted by governmental organizations.

References

Anonymous, 2014. Statistics of water products, The General Directorate of Fisheries and Aquaculture (BSGM), Ministry of Food, Agriculture and Livestock. http: //www.tarim.gov.tr/BSGM/Belgeler/Icerikler / BSGM_Kasim 2014. pdf. (accessed November 2014)

Atalay, M.A. and Toslak, C.2013. Balıklandırma ve İstilacı Balık Türleri ile İlgili Ulusal-Uluslararası Mevzuat. (in Turkish with English abstract). İstanbul Üniversitesi Su Ürünleri Dergisi/Journal Of Fisheries & Aquatic Sciences, 28 (1), 63-105.

Balık, I., Ozkök, R., Çubuk, H. and Uysal, R. 2004. Investigation of some biological characteristics of the silver crucian carp, *Carassius gibelio* (Bloch, 1782) population in Lake Eğirdir. Turkish Journal of Zoology, 28, 19-28.

Balon, E.K. 1995. The common carp, *Cyprinus carpio*: its wild origin, domestication in aquaculture and selection as colour nishiki goi. Guelph Ichthyology Reviews, 3, 1-15.

Baran, İ. and Ongan, T. 1988. Gala Gölü'nün Limnolojik Özellikleri, Balıkçılık Sorunları ve Öneriler. Gala Gölü ve Sorunları Sempozyumu, Doğal Hayatı Koruma Derneği Bilimsel Yayınlar Serisi, 46-54, İstanbul.

Britton, J.R., Davies, G.D. and Harrod, C. 2010. Trophic interactions and consequent impacts of the invasive fish *Pseudorasbora parva* in a native aquatic foodweb: a field investigation in the UK. Biological Invasions 12, 1533-1542. Doi: 10.1007/s10530-009-9566-5

Byers, J.E., Reichard, S., Randall, J.M., Parker, I.M., Smith, C.S., Lonsdale, W.M., Atkinson, I.A.E., Seasted, T.R., Williamson, M., Chornesky, E. and Hayes, D. 2002. Directing Research to Reduce the Impacts of Nonindigenous Species. Conservation Biology, 16 (3):630-640.

Caiola, N. and De Sostoa, A. 2005. Possible reasons for the decline of two native toothcarps in the Iberian Peninsula: evidence of competition with the introduced Eastern mosquitofish. Journal of Applied Ichthyology, 21, 358-363. Doi: 10.1111/j.1439-0426.2005.00684.x

Clavero, M. and García-Berthou, B. 2005. Invasive species are a leading cause of animal extinctions. Trends in Ecology and Evolution, 20(3), 110. Doi:10.1016/j.tree.2005.01.003

Crivelli, A.J. 1995. Are fish introductions a threat to endemic freshwater fishes in the Northern Mediterranean Region?. Biological Conservation, 72, 311-319.

Eiswerth, M.E., Yen, S.T. and van Kooten, G.C. 2011. Factors determining awareness and knowledge of aquatic invasive species. Ecological Economics, 70, 1672-1679. Doi:10.1016/j.ecolecon.2011.04.012

Ekmekçi, F.G. and Erk'akan, F. 1997. Eğirdir Gölündeki Sudak *Stizostedion lucioperca* (Linneaus, 1758) Populasyonunda Ortaya Çıkan Değişimlerin Değerlendirilmesi. (in Turkish with English abstract) Turkish Journal of Zoology, 21, 421-430.

Ekmekçi, F.G., Kırankaya, Ş.G., Gençoğlu, L. and Yoğurtçuoğlu, B. 2013. Türkiye İçsularındaki İstilacı Balıkların Güncel Durumu ve İstilanın Etkilerinin Değerlendirilmesi. (in Turkish with English abstract) İstanbul Üniversitesi Su Ürünleri Dergisi / Journal of Fisheries & Aquatic Sciences, 28 (1), 105-140.

Enberg, K., Jørgensen, C., Dunlop, E.S., Heino, M. and Dieckmann, U. 2009. Implications of fisheries-induced evolution for stock rebuilding and recovery. Evolutionary Applications, 2 (3), 394-414. Doi: 10.1111/j.1752-4571.2009.00077.x

FAO, 2008. Fishery Country Profile. Food and Agriculture Organization of the United Nations, Rome.

FAO, 2009. The State of World Fisheries and Aquaculture 2008. Food and Agriculture Organization of the United Nations, Rome.

Frésard, M. and Ropars-Collet, C. 2014. Sustainable harvest of a native species and control of an invasive species: A bioeconomic model of a commercialfishery invaded by a space competitor. Ecological Economics, 106, 1-11. Doi:http://dx.doi.org/10.1016/j.ecolecon.2014.06.020

Froese, R. and Pauly, D. 2013. FishBase. World Wide Web electronic publication.,www.fishbase.org. Version (07/2014). Accessed August 2013.

Gaygusuz, Ö., Tarkan, A.S. and Gürsoy Gaygusuz, Ç. 2007. Changes in the fish community of the Omerli Reservoir (Turkey) following to introduction of non-native gibel carp Carassius gibelio (Bloch, 1782) and other human impacts. Aquatic Invasions, 2(2), 117-120. Doi: http://dx.doi.org/10.3391/ai.2007.2.2.6

Gozlan, R.E., St-Hilaire, S., Feist, S.W., Martin, P. and Kent, M. L. 2005. Disese threat to European fish. Nature, 435, 1046. Doi:10.1038/4351046a.

Gozlan, R.E., Britton, J.R., Cowx, I. and Copp, G.H. 2010. Current knowledge on non-native freshwater fish introductions. Journal of Fish Biology, 76: 751-786. Doi: 10.1111/j.1095-8649. 2010. 02566.x

Grabowska, J. And Przybylski, M. 2014. Life-history traits of non-native freshwater fish invaders differentiate them from natives in the Central European bioregion. Reviews in Fish Biology and Fisheries. Doi: 10.1007/s11160-014-9375-5.

Hanfling, B., Bolton, P., Harley, M. and Carvalho, G.R. 2005. A molecular approach to detect hybridisation between crucian carp (*Carassius carassius*) and non-indigenous carpspecies (*Carassius* spp. and *Cyprinus carpio*). Fresh-water Biology, 52, 403-417. Doi:10.1111/j.1365-2427. 2004.01330x

Harlıoğlu, A.G. 2011. Present status of fisheries in Turkey. Reviews in Fish Biology and Fisheries, 21, 667-680. Doi: 10.1007/s11160-011-9204-z.

Kalous, L., Memiş, D. and Bohlen, J. 2004. Finding of triploid *Carassius gibelio* (Bloch, 1780) (Cypriniformes, Cyprinidae) in Turkey. Cybium, 28 (1), 77-79.

Karakaş, H.H. and Türkoğlu, H. 2005. Su ürünlerinin dünyada ve Türkiye'deki durumu (in Turkish with English abstract). Journal of Agriculture Faculty of Harran University , 9(3), 21–28.

Kettunen, M., Genoveai, P., Gollasch, S., Pagad, S., Starfinger U., Brink, P. and Shine, C. 2008. Technical support to EU strategy on invasive species (IS)-Assessment of the impacts of IS in Europea and the EU (Final module report for the European Commission) Institute for European Environmental Policy (IEPP), Brussels, Belgium. 40 pp. +Annexes, May 2008, (DG ENV contact).

Kırankaya, Ş.G. and Ekmekçi, F.G. 2013. Life-history traits of the invasive population of prussian carp, *Carassius gibelio* (Actinopterigi: Cypriniformes: Cyprinidae), from Gelingüllü Reservoir, Yozgat, Turkey. Acta Ichthyologica et Piscatoria, 43 (1), 31- 40. Doi: 10.3750/AIP2013.43.1.05.

Kottelat, M. and Freyhof, J. 2007. Handbook of Euro-

pean Freshwater Fishes. Berlin, Germany: Kottelat, Cornol, Switzerland and Freyhof.

Küçük, F. 2012. Extict endemic fishes of Turkey: *Alburnus akili* (Gövce) and *Pseudophoxinus handlirschi* (Kavinne) (Pisces: Cyprinidae). Turkish Journal of Fisheries and Aquatic Sciences, 12: 345-347.

Leonardos, I.D., Tsikliras, A.C., Eleftheriou, V., Cladas, Y., Kagalou, I., Chortatou, R. and Papigioti, O. 2008. Life history characteristics of an invasive cyprinid fish (*Carassius gibelio*) in Chimaditis Lake (northern Greece). Journal of Applied Ichthyology, 24(2), 213-217. Doi: 10.1111/j.-1439-0426.2007.01031.x

Liasko, R., Koulish, A., Pogrebniak, A., Papiggioti, O., Taranenko, L. and Leonardos, I. 2011. Influence of environ-mental parameters on growth pattern and population struc-ture of *Carassius auratus gibelio* in eastern Ukraine. Hydrobiologia, 658 (1), 317-328. Doi: 10.1007/s10750-010-0502-6

Mooney, H.A. and Cleland, E.E. 2001. The evolutionary impact of invasive species. Proceeding of the National Academy of Sciences of the United States of America, 98, 5446-5451. Doi: 10. 1073/ pnas. 091093398

Özuluğ, M., Meriç, N. and Freyhof, J. 2004. The distribution of *Carassius gibelio* (Bloch, 1782) (Teleostei: Cyprinidae) in Thrace (Turkey). Zoology in the Middle East, 31, 63-66.

Özuluğ, M., Saç, G. ve Gaygusuz, Ö. 2013. İstilacı özellikteki *Gambusia holbrooki*, *Carassius gibelio* ve *Pseudorasbora parva* (Teleostei) türleri için Türkiye'den yeni yayılım alanları. İstanbul Üniversitesi Su Ürünleri Dergisi, 28:1-22.

Palkovacs, E.P. 2011. The overfishing debate: an eco-evolutionary perspective. Trends in Ecology & Evolution, 26, 616-617. Doi: 10.1016/j.tree. 2011.08.004.

Paulovits, G., Tátrai, I., Mátyás, K., Korponai, J. and Kováts, N. 1998. Role of gibel carp (*Carassius auratus gibelio* Bloch) in the nutrient cycle of the Kis-Balaton reservoir. International Revue of Hydrobiology, 83(Suppl), 467-470.

Pimentel, D., Zuniga, R. and Morrison, D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics, 52, 273-288. Doi:10.1016/j.ecolecon.2004.10.002.

Primack, R.B. 2010. Essentials of Conservation Biology. 5th Ed. USA: Sinauer Associates, Inc.

Rad, F. 2002. "Country Report", Proceedings of seminar on Seafood Market Studies for the Introduction of New Aquaculture Products, jointly organized by CIHEAM, The FAO and the EU Concerted Action MASMANAP, 21-22 June 2001, Zaragoza/Spain. In: Cahiers options Mediterraneennes, vol. 59. CIHEAM.

Rahel, F. 2004. Unauthorized Fish Introductions: Fisheries Management of the People, for the People, or by the People?. American Fisheries Society Symposium, 44, 431-443.

Ricciardi, A. 2007. Are modern biological invasions an unprecedented form of global change?. Conservation Biology, 21, 329-336. Doi: 10.1111/j.1523-1739.2006.00615.x

Ricciardi, A., Palmer, M.E. and Yan, N.D. 2011. Should Biological Invasions Be Managed as Natural Disasters?. BioScience, 61 (4), 312-317. Doi:10.1525/bio.2011.61.4.11.

Savini, D., Occhipinti-Ambrogi, A., Marchini, A., Tricarico, E., Gherardi, F., Olenin, S. and Gollasch, S. 2010. The top 27 animal alien species introduced into Europe for aquaculture and related activities. Journal of Applied Ichthyology, 26 (Suppl. 2), 1-7. Doi: 10.1111/j.1439-0426. 2010. 01503.

Sharpe, D.M.T. and Hendry, A.P. 2009. Life history change in commercially exploited fish stocks: an analysis of trends across studies. Evolutionary Applications, 2, 260-275. Doi:10.1111/j.1752-4571.2009.00080.x

Tarkan, A.S., Gaygusuz, Ö., Gürsoy, Ç., Acıpınar, H., and Bilge, G. 2006. Marmara Bölgesi'nde yeni bir istilacı tür *Carassius gibelio* (Bloch, 1782): Başarılı mı, Başarısız mı? [A new invasive species Carassius gibelio (Bloch, 1782) in Marmara Region: successful or unsuccesful?] pp. 193-203. In: 1. Ulusal Balıklandırma ve Rezervuar Yönetimi Sempozyumu, 7–9 February 2006, Antalya, Turkey. [In Turkish.]

Tarkan, A.S., Gaygusuz, Ö., Gürsoy Gaygusuz, Ç., Saç, G. and Copp, G. 2012a. Circumstantial evidence of gibel carp, *Carassius gibelio*, reproductive competition exerted on native fish species in a mesotrophic reservoir. Fisheries Management and Ecology, 19 (2), 167-177. Doi: 10.1111/j. 1365- 2400. 2011.00839.

Tarkan, A.S., Copp ,G., Top, N., Özdemir, N., Önsoy, B., Bilge, G., Filiz, H., Yapıcı, S., Ekmekçi, F.G., Kırankaya, Ş.G., Emiroğlu, Ö., Gaygusuz, Ö., Gürsoy Gaygusuz, Ç., Oymak, A., Özcan, G. and Saç, G. 2012b. Are introduced gibel carp *Carassius gibelio* in Turkey more invasive in artificial than in natural waters?. Fisheries Management and Ecology, 19(2), 178-187. Doi: 10.1111/j.1365-2400.2011.00841.x

Tarkan, A.S., Ekmekçi, F.G., Vilizzi, L. and Copp, G.H. 2014. Risk screening of non-native freshwater fishes at the frontier between Asia and Europe: first application in Turkey of the Fish Invasiveness Screening Kit (FISK). Journal of Applied Ichthyology, 30, 392-398. doi: 10.1111/jai.123.

TURKSTAT, 2012. Yearly Fishery Statistics. Prime Ministry of Turkey, Turkish Statistical Institute (TURKSTAT), Ankara, Turkey.

TURKSTAT, 2013. Yearly Fishery Statistics. Prime Ministry of Turkey, Turkish Statistical Institute (TURKSTAT), Ankara, Turkey.

Vilizzi, L. 2012. The common carp, *Cyprinus carpio*, in the Mediteranean Region: Origin, distribution, economic benefits, impact and management. Fisheries Management and Ecology, 19, 93-110. Doi:10.1111/j.1365-2400.2011.00823.x

Vilizzi, L., Ekmekçi, F.G. and Tarkan, A.S. 2014. Natural diet of common carp (*Cyprinus carpio* L., 1758) in Anatolia (Turkey): a review. Mediterranean Marine Science, 15(1), 216-218. Doi: http://dx.doi. org/10. 12681/mms.738

Winfield, J.M., Fletcher, J.M. and James J. B. 2010. An overview of fish species introductions to the English Lake District, UK, an area of outstanding conservation and fisheries importance. Journal of Applied Ichthyology, 26 (Suppl. 2), 60-65. doi: 10.1111/j.1439-0426.2010.01504.x

Yerli, S.V., Mangıt, F., Emiroğlu, Ö., Yeğen, V., Uysal, R., Ünlü, E., Alp, A., Buhan, E., Yıldırım, T. and Zengin, M. 2014. Distribution of Invasive *Carassius gibelio* (Bloch, 1872) (Teleostei: Cyprinidae) in Turkey. Turkish Journal of Fisheries and Aquatic Sciences, 14: 581-590.

Yin, X., Wang, A., Zhou, H., Wang, Q., Li Z. and Shao, P. 2014. Economic Efficiency of Crucian carp (*Carassius auratus gibelio*) Polyculture Farmers in the Coastal Area of Yancheng City, China. Turkish Journal of Fisheries and Aquatic Sciences, 14, 429-437. Doi: 10.4194/1303-2712-v14_2_13.