FISH COMMUNITY SUCCESSIONS IN LAKE ULUNGUR: A CASE OF FISH INVASIONS IN FRAGILE OASIS

© 2011 Tang F.J.[1], Brown A.[2], Keerjiang A.[3]

[1] Heilongjiang River Fisheries Research Institute of Chinese Academy of Fishery Sciences, Harbin 150070, China; e-mail: rivery2008@163.com
[2] U.S. Fish and Wildlife Service, Atlanta, GA; E-mail: allan_brown@fws.gov
[3] Fisheries Research Institute of Xinjiang Uygur Autonemous Province, Urumqi 830000, China

Received 18.04.2011

Lake Ulungur, located in the desert region of northwest China, is one of the most important fishing grounds in the Chinese inland area. Ulungur possessed a simple fish assemblage of 7 indigenous species of fish, dominated by the common perch, *Perca fluviatilis* Linnaeus and *Leuciscus dzungaricus*. Over the last 40 years, 14 non-indigenous species of fish have been introduced into this fragile ecosystem via intentional or unintentional human activities. Over the decades since these introductions, the fish community of Ulungur has been severely altered. Most of the niches that had inhabited by the native species of fishes are now occupied by these non-native species. The two, once dominate species, the common perch and *Leuciscus dzungaricus*, have become endangered and threatened with extinction, while the non-native Pond smelt (*Hypomesus olidus* Pallas), the Aral bream (*Abramis brama orientalis* Berg) and the Northern pike (*Esox lucius* Linnaeus), have become the most prevalent species. In this paper, non-indigenous fish introductions and the corresponding changes in native fish communities in Ulungur are outlined. Possible mechanisms of community succession were analyzed to provide information for the management of fish introduction.

Keywords: Ulungur Lake, fish invasion, community succession, endangered species.

INTRODUCTION

Aquatic organism's invasion ecology has gained considerable attention in recent years, and has been studied in great detail (e.g., Ross et al. 2001; Kolar & Lodge 2002; Townsend 2003; Gido 2004; Jia et al. 2007; Gido & Franssen 2007; Ribeiro et al. 2008; Mitchell & Knouft 2009; Copp et al. 2010; Britton et al. 2010; Sato et al. 2010). However, the success of these exotic species establishment and the effects of these introductions on the receiving communities are often difficult to predict due to the idiosyncratic nature of so many introduction attempts (Arthington & Mitchell 1986; Townsend 1996; Ribeiro et al. 2008).

Non-indigenous fishes establish much easier in a recipient lakes than in rivers because lakes provide more stable environmental conditions (Gido 2004), and the lake with simple fish communities, maybe exceptionally susceptible to non-native fish. Ulungur Lake is a typical case of this dynamic, where a native fish community is dramatically altered after the intentional and unintentional introduction of non-native fish by human activities for more than 40 years. This paper is presented to those who study the movement and affects of non-native introductions as a case study on the changes to fish communities after invasive species introductions.

MATERIALS AND METHODS

Lake Ulungur

Lake Ulungur (46°59′~47°25′N, 87°1′~87°35′E), one of China's most northwestern desert lakes, is also one of the most important fishing ground in

Chinese inland area. Located in Ertix River basin at an altitude of 468m, it is divided into two sections, Buluntuo Lake and the smaller, Jili Lake, covering 917km^2 in total (Yan & Xia 1962). In 1971, a channel between Ertix River and Ulungur Lake was completed in order to divert water into the lake.

Information source

In an investigation of aquatic species inventory project, organized by the Chinese Ministry of Environmental Protection, we found great changes have taken place in the fish community of Ulungur Lake. To get the information on fish assemblage and community change, we compiled the related, former literatures citations (Li et al. 1966; Ren et al. 1990 & 2002; Keerjiang et al. 2006). The yield data used in this paper were collected from the local fisheries bureau of Fuhai County. Dominant species mentioned in this paper, were defined when their proportion exceeded 10% in wet weight.

Sampling methods

To get the novel species assemblage in Ulungur complementary investigation was conducted in January, May, August and October covering four seasons in 2008, using gill nets (length, 80m; depth, 5m; mesh sizes, 1.0cm-16.0cm between the opposite knots) and trap (mesh sizes, 0.6cm between the opposite knots). 13 sampling locations around the lake were chosen to maximize variation in environmental condition and cover the preference habitat of different fish (shown in Fig.1). The nets remained exposed for 24 h a day and 10 days a season, which were checked in the morning (08:00) for sampling.

RESULTS

Fish fauna

Ulungur Lake possessed a simple fish assemblage of 7 indigenous species of fish before 1965: the common Perch *Perca fluviatilis* (Linnaeus 1758), *Leuciscus dzungaricus* (Paepke & Koch, 1998), Tench *Tinca tinca* (Linnaeus 1758), Gobio *gobio acutipinnatus* (Men'schikov 1939), Siberian spined loach *Cobitis melanoleuca* (Nichols 1925), Siberian stone loach *Orthrias toni* (Dybowski 1869) and Prussian Carp *Carassius auratus gibelio* (Bloch 1782) (Li et al.1966).

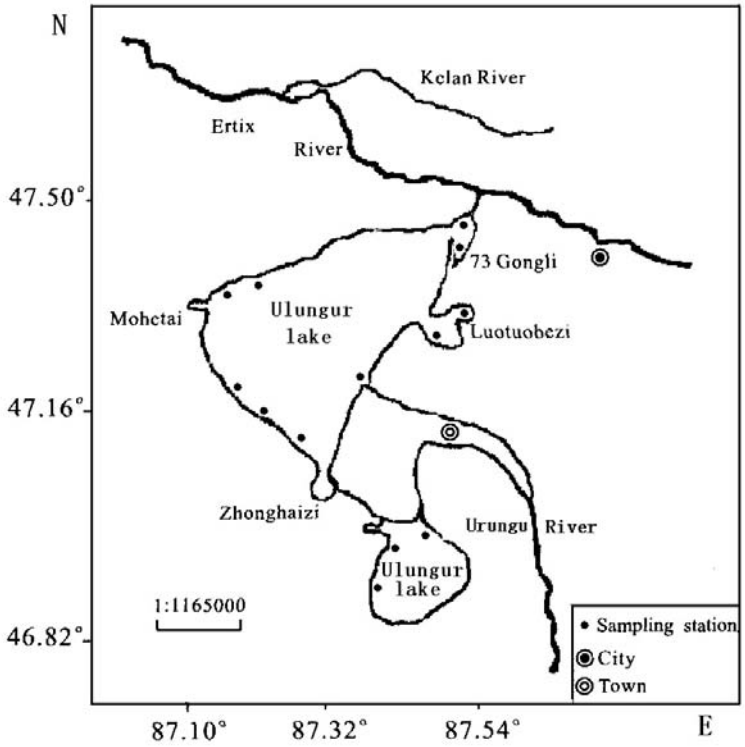

FIG. 1. SKETCH MAP OF ULUNGUR LAKE AND THE SAMPLING LOCATIONS.

Human activities resulting in the introduction on non-natives species began in 1965, and since then, 14 species exotic fishes in 6 families have been introduced into Ulungur Lake (Table). During the period of 1965-1970, 4 exotic species of fish, the common carp Cyprinus *Cyprinus carpio* (Linnaeus 1758), Aral bream *Abramis brama orientalis* (Berg 1949), Siberian roach *Rutilus rutilus lacustris* (Pallas 1811) and the grass carp *Ctenopharyngodon idellus* (Valenciennes 1844), were introduced into Ulungur Lake from the Ertix River, for commercial use. In 1971, a channel was constructed between the Ertrix River and Ulungur Lake which allowed for the introduction of the Northern pike *Esox lucius* (Linnaeus 1758), Pike perch *Sander lucioperca* (Linnaeus 1758), Burbot *Lota lota* (Linnaeus 1758), Ide *Leuciscus idus* (Linnaeus 1758), Taimen *Hucho taimen* (Pallas 1773), and the *Acerina cernua* (Linnaeus 1758). In 1980, Silver carp *Hypophthalmichthys molitrix* (Valenciennes, 1844) and Bighead carp *Aristichthys nobilis* (Richardson, 1844) were introduced for economic purposes, with the unintentional importation of their associated Stone moroko *Pseudorasbora parva* (Temminck et schlegal, 1842). In 1991, Pond smelt *Hypomesus transpacificus nipponesis* (McAllister, 1963) was introduced to the lake to more fully utilize the lake resources more effectively. In all, 14 exotic species have been introduced to Ulungur Lake in the last 40 years (Keerjiang et al. 2006).

Table. List and occurrence year of exotic fish in Ulungur Lake

	Scientific name	Author	Year of occurrence
Salmonidae			
Taimen	*Hucho taimen*	(Pallas, 1773)	1971
Esocidae			
Northern pike	*Esox lucius*	(Linnaeus, 1758)	1971
Osmeridae			
Pond smelt	*Hypomesus transpacificus nipponesis*	(McAllister, 1963)	1991
Cyprinidae			
Common carp	*Cyprinus (Cyprinus) carpio*	(Linnaeus, 1758)	1965
Aral bream	*Abramis brama orientalis*	(Berg, 1949)	1968
Siberian roach	*Rutilus rutilus lacustris*	(Pallas, 1811)	1968
Grass carp	*Ctenopharyngodon idellus*	(Valenciennes, 1844)	1970
Ide	*Leucicus idus*	(Linnaeus, 1758)	1971
Silver carp	*Hypophthalmichthys molitrix*	(Valenciennes, 1844)	1980
Big head carp	*Aristichthys nobilis*	(Richardson, 1844)	1980
Stone moroko	*Pseudorasbora parva*	(Temminck et Schlegal, 1842)	1980
Percidae			
Pike perch	*Sander lucioperca*	(Linnaeus, 1758)	1971
	Acerina cernua	(Linnaeus, 1758)	1971
Gadidae			
Burbot	*Lota lota*	(Linnaeus, 1758)	1971

Predominant fish displacement and community Succession

In 1987, annual total fish catch in Ulungur Lake was 2,500t; the indigenous fish Perch and *Leuciscus dzungaricus*, were the dominant catches at 259.8t and 1829.6t respectively. In 1995, annual total fish catch of Ulungur Lake was 3,150t; with the introduced Aral bream, Northern pike and the Siberian roach becoming the new dominant fishes at 1245.2t, 658.1t and 382.8t respectively, while the annual production of common perch and *Leuciscus dzungaricus* had been sharply reduced to 35.5t and 49.2 t respectively. Even with the sharp decline in native catches, neither of these two species was considered for listing as endangered. In 2000, annual fish catch in Ulungur Lake was 3980t; and the introduced Pond smelt, the Aral bream, and the Northern pike becoming the new three dominant fishes at 1602.7t, 1163.1t, and 699.8t respectively, while Kirgize dace and the common perch became listed as endangered. In 2008, annual fish catches of Ulungur Lake was 2803t, Pond smelt production rose to 1676.2t, and Aral bream reduced to 316.7, while Northern pike catch was 597.0t, Catches of both the common perch and *Leuciscus dzungaricus* were very sparse and could hardly be found. (All the data above was collected from the fisheries bureau of Fuhai County).

From the yield proportions of dominant species variation in the years since the non-native species were first introduced (shown in Fig.2), we can see a fish community trend developing, based on when certain species were first introduced. Early in the succession stages, we can see the indigenous common Perch and *Leuciscus dzungaricus* were displaced by exotic Aral bream, Northern pike, and the Siberian roach and were no longer the dominate lake species. Pond smelt soon displaced the Siberian roach and reduced the Aral bream. This fish assemblage depleted the common perch and *Leuciscus dzungaricus* to the point of being declared and endangered species, while the Pond smelt and Northern pike continued to increase their population size.

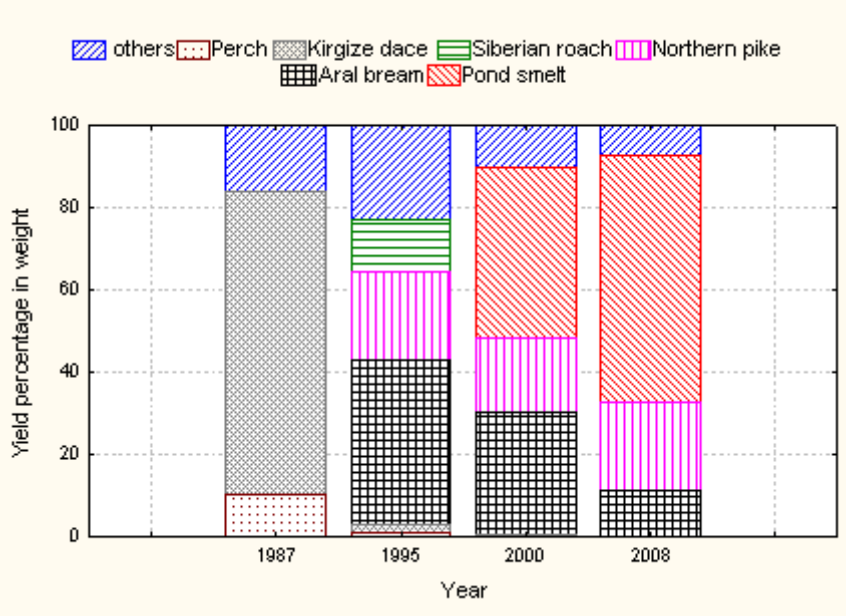

FIG. 2. DOMINANT FISH SUCCESSIONS IN ULUNGUR LAKE.

DISCUSSION

Fishes that can feed at low trophic levels (i.e., omnivores/detritivores) become successful invaders due mainly to available food resources during the colonization and integration phases of the invasion, which are rarely limiting (Gido, 2007). Alien fishes with lower trophic positions can competitively displace species that share

similar resources (e.g., Douglas et al. 1994; Taniguchi et al. 2002). Aral bream and Siberian roach are both omnivores that feed at low trophic levels (Ren et al. 2002). Both of these introduced species share a similar diet with the native Kirgize dace which gives some explanation to their successful population establishment and the decrease in the native *Leuciscus dzungaricus*. But northern pike is a well developed predator that has a wide range of prey of fish from perch to Kirgize dace (Persson, 1996; Tang et. al. 2008), so its introduction and population development may played an important role in decreasing indigenous fish population both of perch and Kirgize dace.

Pond smelt is an omnivorous fish with an r-pattern life history, having relatively high fecundity and the ability to utilize detritus and plankton (Guo et al. 2005), which helped it outcompete the other fish which share a similar base. However, Northern pike become the unique fish which developed its population very well even under fishing pressure, lie in Pond smelt its abundant food both in larval and adult stages (Tang et al. 2008a; Huo et al. 2009).

These investigations conducted in 2008 indicated a sharp reduction in the biomass of plankton and benthic biomass since 1986 in Ulungur Lake (Tang et al. 2008b), which means that introduced fish have overall changed the nutrient circulation of Ulungur Lake. Further studies need to be conducted to determine the food competition between native and non-native fishes, especially during the early life stages.

ACKNOWLEDGEMENTS

We would like to thank all the researchers who have recorded the data on the fish community changes of Ulungur Lake. We are also grateful to Professor Jiang zuofa for the support through "Chinese Wildlife Species Inventory Project" organized by the Chinese Ministry of Environmental Protection.

REFERENCES

Arthington A.H. and Mitchell D.S., Aquatic invading species, in: Groves R.H., Burdon J.J., *Ecology of Biological Invasions: An Australian perspective*, Canberra: Australian Academy of science, 1986, pp 34–53.

Britton J.R., Harper D.M., Oyugi D.O., Gray J., The introduced *Micropterus salmoides* in an equatorial lake: a paradoxical loser in an invasion meltdown scenario? *Biol Invasions*, 2010, 12: 3439–3448.

Copp G.H., Vilizzi L., Gozlan R.E., The demography of introduction pathways, propagule pressure and occurrences of non-native freshwater fish in England, Aquatic Conservation: *Marine and Freshwater Ecosystems*, 2010, 20(5): 595–601.

Douglas M.E., Marsh, P.C. & Minckley W.L. Indigenous fishes of western North America and the hypothesis of competitive displacement: Meda fulgida (Cyprinidae) as a case study, *Copeia*, 1994, 1: 9–19.

Gido K.B., Patterns of fish invasions in the Great Plains of North America, *Biol Conserv*, 2004, 118: 121–131.

Gido K.B., Franssen N.R., Invasion of stream fishes into low trophic positions, *Ecology of Freshwater Fish*, 2007, 16: 457–464.

Guo Y., Zhang R.M., Cai L.G., *Fish resources and fisheries of Bosten lake*, Urimqi, Science and Technology Press of Sinkiang (in Chinese with a English abstract), 2005.

Huo T.B., Ma B., Keerjiang, A., The study on feeding behavior and ecological niche and of Esox lucius in Lake Ulungur, *Chinese Journal of Fisheries*, 2009, 3: 6–9 (in Chinese with a English abstract).

Jia Y., Chen Y., Xie S., Physiological advantages may contribute to successful invasion of the exotic *Cyprinus carpio* into the Xingyun Lake, China, *Environ Biol Fish*, 2007, 81: 457–463.

Keejiang A., Su D., Yang Y., The current situation and the countermeasures of protection and development of fish resources in Ulungur Lake, *J. Shanghai fish. univ.*, 2006, 3: 308–314 (in Chinese with a English abstract).

Kolar C.S. and Lodge D.M., Ecological predictions and risk assessment for alien fishes in North America, *Science*, 2002, 298: 1233–1236.

Li S., Dai D., Ma G., Notes on a collection of fish from north sinkiang, china, *Acta Zoologica Sinica*, 1966, 1: 41–56 (in Chinese with a Russian abstract).

Mitchell A, Knouft J. Non-native fishes and native species diversity in freshwater fish assemblages across the United States. *Biological Invasion*s, 2009, 11:1441–1450.

Persson L., Size-specific interactions in lake systems: predator gape limitation and prey growth rate and mortality, *Ecology*, 1996, 77: 900–911.

Ren M.L. et al., *Fish and Fisheries in Jili lake of China*, Harbin: Science and Technology Press of Heilongjiang Province, 1990, (in Chinese with a English abstract).

Ren M.L., Guo Y., Zhang R.M., *Fishery resources and fisheries of the Ertixhe river in China*, Urumqi, Science and Technology Press of Xinjiang Province, 1990, (in Chinese with a English abstract).

Ribeiro F., Maria B.E., Pereira J.C., Life-history traits of non-native fishes in Iberian watersheds across several invasion stages: a first approach, *Biol. Invasions*, 2008, 10: 89–102.

Sato M, Kawaguchi Y, Nakajima J et al. A review of the research on introduced freshwater fishes: new perspectives, the need for research, and management implications, *Landscape and Ecological Engineering*, 2010, 6: 99–108.

Ribeiro F., Maria B.E., Pereira J.C., Life-history traits of non-native fishes in Iberian watersheds across several invasion stages: a first approach, *Biol. Invasions*, 2008, 10: 89–102.

Ross R.M., Lellis W.A., Bennett R.M., Landscape determinants of non-indigenous fish invasions, *Biol. Invasions*, 2001, 3: 347–361.

Tang F.J., Jiang Z.F., Cai L.G., Diet composition variation of Perch (*Perca fluviatilis* Linnaeus) in Ulungur Lake, *Chinese Journal of Fisheries*, 2008a, 1: 55–58 (in Chinese with a English abstract).

Tang F.J., Study on mechanism of perch *Perca fluviatilis* invaded by alien fish in Ulungur Lake, *Cand. Sci. Dissertation*, Chongqing: Southwestern University of China, 2008b (in Chinese with a English abstract).

Taniguchi Y., Fausch K.D. & Nakano S., Size-structured interactions between native and introduced species: can intraguild predation facilitate invasion by stream salmonids. *Biol. Invasions*, 2002, 4: 223–233.

Townsend C., Invasion biology and ecological impacts of brown trout S*almo trutta* in New Zealand, *Biol. Conserv*, 1996, 78: 13–22.

Townsend C.R., Individual, population, community, and ecosystem consequences of a fish invader in New Zealand streams, *Conserv. Biol.*, 2003, 17: 38–47.

Yan S., Xia X., Physiognomy development of Ertixhe river in china, *Acta Geogrophica Sinica*, 1962, 4: 257–273 (in Chinese with a Russian abstract).