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Hydrology and water resources in Caspian Sea

Kourosh Haddadi Moghaddam

International Sturgeon Research Institute (ISRI), P.O. Box 41635-3464, Rasht, Iran

Correspondence to: Kourosh Haddadi Moghaddam (khkhmoghadam@gmail.com)

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Abstract. Precipitation is the main driver of the water balance variability of the water over space and time, and changes in precipitation have very important implications for hydrology and water resources. Variations in precipitation over daily, seasonal, annual, and decadal time scales influence hydrological variability over time in a catchment. Flood frequency is affected by changes in the year-to-year variability in precipitation and by changes in short-term rainfall properties. Desiccation of the Caspian Sea is one of the world's most serious ecosystem catastrophes. The Persian Sturgeon (*Acipenser persicus*) caught under 10 m depth using bottom trawl net by research vessel during winter 2012, summer and winter 2013 and spring 2014 in east, central and west of southern parts of Caspian Sea, then, their diets were investigated. During 136 trawling in the aimed seasons, Persian sturgeon with 1 to 2 years old and 179.67×0.2 g (body weight) and 29.97 ± 0.4 cm (Total length) captured. Examination of stomach contents in the sturgeon specimens revealed that the food spectrum was composed of bony fishes (*Neogobius* sp., *Atherina* sp. and *Clupeonella delicatula*), invertebrates belonging to the family Ampharetidae polychaeta worms including (*Hypanai* sp. and *Nereis diversicolor*), various crustaceans (*Gammarus* sp. and *Paramysis* sp.). Investigation on stomach contents of sturgeon *Acipenser persicus* caught under 10 m depth in 2012 to 2013 surveys showed that there is significant difference in the consumed food. The most food diversity have been observed in winter 2013, also Polychaeta is the primary consumed food and crustacean is the secondary one ($P > 0.05$), no new types of food (such as bony fishes or benthics) have been observed on food chain of *Acipenser persicus* and shows no significant difference ($P > 0.05$).

1 Introduction

Prey abundance, feeding and food habits are important issues for both effective Caspian Sea fisheries management and conservation biology in aquatic environment, so Sturgeons one the most important and valuable fishes in the world and Caspian Sea is one of their most important habitat's which 90 % of total world Caviar belongs to it (Ivanov et al., 1999). In recent years sturgeon stock and catch has been decreased in their most important habitats (Pourkazemi, 1996; Ivanov et al., 1999; Moghim et al., 2006). Biological and feeding factors have great influence an sturgeon catch to determine these factors, we should investigate on sturgeon feeding competition and other relations between different habits of fishes in various places and time is of high importance (Moghim et al., 2006) therefore should navigate the previous studies of researchers in this regards. Initial studies carried out on sturgeon feeding in north, middle and south Caspian Sea (Shorygin, 1937; Salnikov et al., 1975; Begenal, 1978; Moiseev and Filatova, 1988 and Polyaninova and Molodtseva, 2002). During sturgeon stock assessment at southern part of Caspian Sea in 2006 to 2008, diets of Persian sturgeon investigated in different depths and various seasons. Although some studies conducted in Iran up to now, they were cyclical (Kashentseva, 2005; Hashemyan et al., 2005) considering that too ecological changes happened in Caspian Sea (Haddadi Moghaddam et al., 2003; Roohi et al., 2007) the previous studies don't include all dietary information of sturgeon. So, the aims of the study were (i) determine seasonal change on Persian sturgeon (ii) determine more details on sturgeon food composition and identification of food index to better understand Persian sturgeon feeding condition.

Table 1. Number, seasons and means body weight (BW), total length (TL) and condition factor in Persian Sturgeon (Mean ± SD).

Mean condition factor	Mean Total length (cm)	Mean body weight (g)	Seasons	Number
0.31 ± 0.01	25.5 ± 0.43	48.9 ± 0.6	Winter 2012	41
0.75 ± 0.25	35.07 ± 0.8	322.64 ± 0.3	Summer 2013	20
0.48 ± 0.08	25.91 ± 0.1	294.81 ± 0.7	Winter 2013	32
0.38 ± 0.07	33.4 ± 0.4	52.34 ± 0.3	Spring 2014	15

2 Materials and methods

The study carried out during March, February 2012, March, February 2013, July, August 2013 and April, May 2014. According to the area of regions, 34 station selected through stratified random sampling design (including 21 stations in east, 5 stations in middle and 8 station in west). The sampled stations were located between (32°2′ N, 50°29′ E and 37°2′ N , 53°4′ E).Trawling conducted in each trawling, GPS and map with scale (1, 100 000) used to determine swept distance and geographical conditions of stations. Also bottom trawl (trawl with 9 m upper rope) and research vessel (250 hsp) were applied in this regard.

During days for 30 min (07.00–16.00) in each station and the speed was 25 to 3 Knots along the coast .After catching and measuring of mean total length and body weight, the digestive system of samples removed (Tavakoli et al., 2007) In order to remove the digestive tract, an anal incision created along the middle ventral line up to gill. So, the digestive system removed completely from ventral region (Chugunova, 1963).

Fish diets were determined from stomach contents and the ingested food evaluated by enumeration (Biswas, 1993). The manual for Caspian Sea invertebrate identification key applied for identifying primary and secondary foods in stomach content (Pryshtin et al., 1988). For sturgeon diet assessment, prey items were taxonomically classified and four indices – the prey occurrence index F (%), the prey frequency index Cn (%), gastro somatic index GSI (%) and condition factor (CF), were calculated as follows:

- F (%) = 100 × (N_p/N_i) where
- N_p = the number of stomachs with a specific prey
- N_i = the total number of non-empty stomachs. Values of (F > 50 %) indicate main prey;
- 10 % < F < 50 %, secondary food items; and F < 10 %, occasional prey and
- Cn (%) = 100 × (N_i/N_p)
- N_i = is the number of the prey item in all nonempty stomachs
- N_p = the total number of food items in all stomachs in a sample
- GSI (%) = 100 × (W_s/W_c)
- W_s = weight of stomach
- W_c = weight of carcass (g)
- CF = W/TL3
- W = weight (g)
- TL = total length (cm) (Euzen, 1987; Saborowski and Buchholz, 1996).

3 Results

The diet of megrim is based on benthic, teleosts and bottom, Crustacea and polychaeta. In this study different foods observed in Persian sturgeon stomach including various teleosts such as *Neogobious* sp., *Atherina* sp., *Clupeonella cultriventris* and benthic invertebrates like Ampharitidae (Hypania sp. and Hypaniolla sp.) *Nereis diversicolor*, Crustacean (Paramysis sp. and Gammarus sp.). In this case 115 immature Persian Sturgeons in 1 to 2 years old captured for feeding examination 90 % of caught sturgeon had food in stomach. comparative study of condition factor in sturgeon caught under 10 m depth showed the highest condition factor in eastern region (0.75 ± 0.25) in summer 2013 and the lowest one (0.26 ± 0.13) in western region of Southern part of Caspian Sea in spring. The results showed no significant differences in condition factor of Persian sturgeon (P > 0.05) (Table 1).

GSI comparison in Persian sturgeon during different seasons showed that the mean GSI of Persian sturgeon was highest in winter 2013 (109.6 ± 14.7) and lowest (51.83 ± 3.8) in summer 2013. The results showed no significant difference in GSI in various regions and seasons (P > 0.05). Investigation of food frequency percent showed that Persian sturgeon used crustacean as basic food in winter 2012, but in order seasons consumed teleostes as secondary food. Statistical results indicate that there is not significant difference in the foods consumed in different seasons and regions (P > 0.05) (Table 2).

4 Discussion

Coastal zone is important nursery habitats for many fishes where they can feed upon a concentrated food supply. Study

Table 2. Prey frequency percent in Persian Sturgeon.

Seasons	Mean food (%)	Secondary food (%)
Winter 2012	Ampharitidae (80 %)	Crustacea (20 %)
Summer 2013	Ampharitidae (70 %)	Gobiidae (80 %)
Winter 2013	Ampharitidae (85 %)	(Gobiidae) (15 %)
Spring 2014	Ampharitidae (50 %)	(Gobiidae (25 %), Atherindiae (25 %))

on frequency and type of consumed prey in Persian sturgeon shows no regular pattern in their feeding behaviour under 10 m depth and Ampharitidae is their primary food. This could be due to unavailability of their food resources and factors like depth, temperature, type of bed and organic material rate. Teleosts consist the basic parts of food consumed by younger fishes (Hashemyan et al., 2005; Mirzajani et al., 2003; Holchick, 1989). But in lower ages considering the depth and environment geographical, conditions, polychaeta consumed by sturgeon. Examination of feeding intensity during recent surveys do not show any type of new food, but the rate and percent of ingested food has been changed and increased during warm seasons. Although factors such as type of bed, organic material rate and physico-chemical conditions can influence on feeding variety in aquatics (Holchick, 1989; Tavakoli et al., 2007; Gegadeesan and Ayyakkannu, 1992; Waldman, 1995). Basic changes occurred in ecological condition of Caspian Sea, which is due to increase in Caspian Sea water level up to 2.2 m from 1995 and elevation of oxygen level because entering urban and industrial pollution that leads to slugging of bed. These factors caused to specialization of food for some species and more large preys such as various species of teleosts observed in sturgeon stomach contents (Salnikov et al., 1975). Regarding these changes and new ecological condition of Caspian Sea, The results of study don't indicate any new feeding condition for Persian sturgeon. According to studies carried out under 10 m depth in east, middle and west of southern part in Caspian Sea (Gasemove, 1994) and considering the gradual warming of Caspian Sea water, it was determined that Sturgeon like to use larger preys which influence on the SI and condition factor of one's caught in warm seasons. Teleosts and benthic diversity become warmer seasons of year. Factors such as food frequency in region, food resources and population have the most influence on feeding rate and condition factor in these fishes (Nikolskii, 1963). Studies conducted on SI in 300 Persian sturgeon in eastern, northwest and south parts of Caspian Sea (Salnikov et al., 1975; Zolotarev et al., 1996) showed that SI was higher when Sturgeon consumed teleosts. The changes may be due to competition for using different types of food, sea waves and type of bed that fish inhabited (Graber, 1990; Kostyuchenko, 1994; Chechun, 1998). Study on variety in winter 2013 and spring 2014 is more than other seasons, which may be due to change in southern parts of Caspian Sea showed similar results by Cortest and Graber (1990). These modifications reflected changes in the availability of prey which influenced fish diet composition and were probably related to the loss of biodiversity in the Black Sea benthic communities which became dominated by some opportunistic species like polychaetes by Gomoiu et al. (2004).

5 Data availability

Analyses of Variance (ANOVA) were performed using the STATISTICA 6.1 program applied for data availability. The results identified by _SD and seasonal changes in stom ach content of Persian sturgeon determined by relative frequency. All statistical analyses were carried SAS version 9.0 software (SAS Institute, inc., USA).

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