http://dx.doi.org/10.14798/72.2.720 **CODEN RIBAEG ISSN 1330-061X**

STOCK ASSESSMENT OF FRESHWATER MULLET, *Liza abu* (HECKEL, 1843) POPULATIONS IN THREE RESTORED SOUTHERN MARSHES, IRAQ

Abdul-Razak M. Mohamed

Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq
Corresponding author, E-mail: abdul19532001@yahoo.com

ARTICLE INFO

Received: 13 November 2013
Received in revised form: 5 March 2014
Accepted: 7 March 2014
Available online: 21 March 2014

Keywords:
Abu mullet
Liza abu
Growth parameters
Mortality rates
Southern marshes

ABSTRACT

The stock of freshwater mullet, *Liza abu* (Heckel, 1843), in the East Hammar, Huwazah and Chybaish marshes, south Iraq, was assessed between October 2005 and September 2006. The relative abundance of the species formed 35.9, 37.1 and 62% of the total catches in the three marshes, respectively. Length–weight relationships calculated for *L. abu* were: $W = 0.0149\ L^{2.899}$ (East Hammar), $W = 0.0132\ L^{2.910}$ (Huwazah) and $W = 0.0252\ L^{2.662}$ (Chybaish). Mean values of relative condition factor were 1.00, 1.02 and 0.98 for the three marshes, respectively. Growth and mortality parameters estimated for the species were $L\infty = 23.2$cm, $K = 0.37$, $Z = 2.125$, $M = 0.903$ and $F = 1.222$ (East Hammar), $L\infty = 21.1$cm, $K = 0.44$, $Z = 1.688$, $M = 1.055$ and $F = 0.632$ (Huwazah) and $L\infty = 20.0$cm, $K = 0.41$, $Z = 2.297$, $M = 1.006$ and $F = 1.291$ (Chybaish). The stock of *L. abu* in the Huwazah marsh was unexploited ($E = 0.375$), while those of the East Hammar and Chybaish marshes were overexploited, $E = 0.575$ and 0.562, respectively. It is necessary to enforce immediate fishing regulation measures on the fish stock in the investigated locations and this can be assessed by activating the national law of fisheries management.

INTRODUCTION

The Mesopotamian marshes used to be the largest wetlands in the Levant and South West Asia, covering more than 15,000 km² (Richardson and Hussain, 2006). These marshes were characterized by their high productivity (Al-Hilli et al., 2009) and considered as natural refuge for many aquatic organisms and major source of inland fisheries in Iraq (FAO, 1999). They served as permanent habitat to harbor millions of waterfowls, and as a flyway for migrating birds between Siberia and Africa (Evans, 2002).

The southern marshlands encountered various issues during the last three decades such as construction of new hydrological projects in the upper parts of the Euphrates and Tigris Rivers and drainage activities in the 1990s desiccating the southern marshlands. In 2002, only 3% of the Chybaish marsh, 14.5% of the Hammar marsh and 35% of the Huwazah marsh remained (Richardson and Hussain, 2006). Since mid-2003, great efforts were made to restore the marshlands and just 58% of their former area in 1972 were recovered in 2007 (UNEP, 2007).

The freshwater mullet or Khishni, *Liza abu* (Heckel, 1843), is a mugilid that is endemic and widely distributed in the Tigris-Euphrates River basins and Pakistani waters (Coad, 2010). This species is considered as one of the most important species for artisanal fisheries and is widely consumed. The total landing of this species at Basrah fish markets, southern Iraq, during 1975–1977 was 212,850 kg (Sharma, 1980). However, Mohamed et al. (2008) deduced that this species constituted 6.3 and 8.1% of the entire fish landing in the lower parts of the Tigris and Euphrates Rivers, at Quran during 2005, respectively. Several studies were carried out on the growth of *L. abu* at various Iraqi water bodies, including the Hammar marsh (Na'ama, 1982), Diyala River (Khalaf et al., 1986), Shatt Al-Basrah Canal (Wahab, 1986) and East Hammar marsh (Mutlak, 2012), but unfortunately only one study was detected dealing with its stock assessment (Mutlak, 2012).

The objective of the present study is to determine abundance, growth, mortality and exploitation rates of *L. abu* in the three southern marshes following two years of restoration.

MATERIALS AND METHODS

Fishes were collected on monthly basis from the East Hammar, Huwazah and Chybaish marshes (Fig 1.). Sampling was carried out using seine net (20 m long with a 2.5 cm mesh), fixed gill nets (500 to 100 m long with 25 mm to 100 mm mesh size) and electro-fishing gears (Hussain et al., 2009; Mohamed et al., 2008, 2012a). Fishes were individually identified, counted and measured. The total length (L) of each fish was measured to the nearest mm using a measurement

board. The length-weight relationships (Le Cren, 1951): $W=aL^b$, were calculated, where W is the total weight (g) and L the total length (cm). The relative condition factor (Kn) was calculated from the formula Kn= W'/W, where W'= the observed weight and W = the calculated weight.

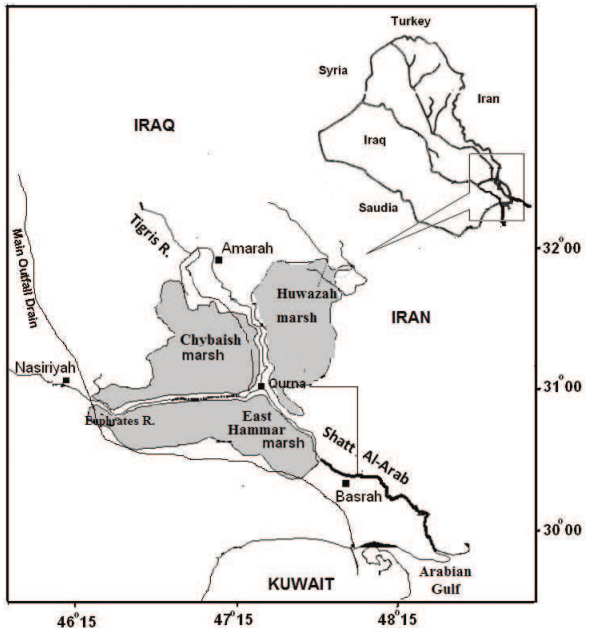

Fig 1. The map of southern Iraq, showing the location of the three marshes

The relative abundance (%) of the species was calculated (Odum, 1970) as: ni/ N * 100, where, ni = number of individuals of the species in the monthly sample and N = the total number in the monthly sample.

The length cohort analysis (Jones, 1984) was applied to obtain size-at-relative age data, from which growth and mortality rates were calculated. Lengths were grouped at 10 mm length classes for this purpose. The values of $L\infty$ were calculated using Taylor's equation (Taylor, 1958): $L\infty=L_{max}/0.95$ (where $L\infty$ is the asymptotic length and L_{max} is the largest fish measured in the samples). Values of $L\infty$ for *L. abu* were taken as 23.2, 21.1 and 20.0 cm in the East Hammar, Huwazah and Chybaish marshes, respectively. However, as a comparison, the largest individuals measured in the samples were 22, 20 and 19 cm, respectively. To estimate K value (growth coefficient), the following equation was used: $(K= \ln [((L\infty-L_1)/(L\infty-L_2))1/t)$, where L_1 and L_2 are observed lengths relevant to two age groups of time t apart (Jones, 1984). The obtained K values of *L. abu* were 0.37, 0.44 and 0.41 for the three marshes, respectively. The growth performance index (Φ) was calculated as $\log_{10} K + 2 \log_{10} L\infty$ (Pauly and Munro, 1984).

The total mortality coefficient (Z) was obtained consulting the length-converted catch curve (Pauly, 1983). Z was estimated from the slope b (with sign changed) of the descending right arm of the curve. The natural mortality coefficient (M) was calculated by using Pauly's equation (Pauly, 1980):

$$\log (M) = -0.0066 -0.279 \log (L^{\infty})+0.6543 \log (k) + 0.4634 \log (T)$$

where T is the annual mean water temperature of the three marshes (20.9, 23.2 and 22.4°C, respectively). The fishing mortality rate (F) was calculated from F=Z-M (Beverton and Holt, 1957), and the exploitation rate (E) from E = F/Z (Gulland, 1969). Analysis of variance (ANOVA) was made based on SPSS software (version 11, 2001) statistical package.

RESULTS

Relative abundance

Fig 2. illustrates monthly variations in the percentages of *L. abu* in the three investigated marshes for the period between October 2005 and September 2006. *L. abu* was the most dominated species in the East Hammar marsh comprising 35.9% of the total catch and its abundance ranged from 20.8% in March to 60.8% in August (Fig 2.). *L. abu* came first to this marsh throughout the year, except October and March. Meanwhile, *L. abu* formed 37.1% of the total catch in the Huwazah marsh and its abundance fluctuated from 10.8% in December to 58.5% in February (Fig 2.). *L. abu* constituted the highest proportion in this marsh for seven months. However, the most abundant species in the Chybaish marsh was also *L. abu* comprising 62% of the total catch. The relative abundance fluctuates from 40.7% in May to 77.2% in August (Fig 2.), and was occupying the first position throughout the year.

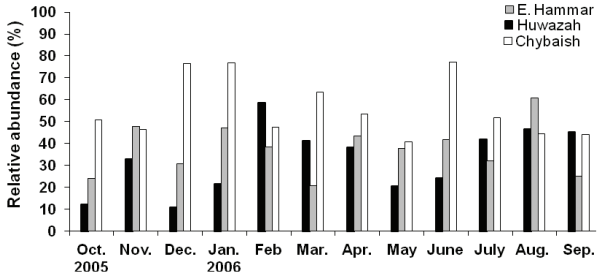

Fig 2. The relative abundance of *L. abu* in the three marshes

Growth

Histograms were plotted to compare the length frequency distributions of *L. abu* between the three marshes (Fig 3.). The length frequency distributions confirmed the availability of juveniles, sub-adults and adults in the three marshes. The smallest fish recorded in the East Hammar marsh was 20 mm (captured in April) and the largest one was 220 mm (collected in March). The fish at length groups 90 to 120 mm formed 66.2% of the total catch. The smallest individual in the Huwazah marsh was 40 mm and appeared in the catch in February and September, and the largest (200 mm) in November. The major peaks were detected at lengths 70 and 120 mm, constituting 14.1 and 14.3% of the total catch of the species in this marsh, respectively. Sizes of *L. abu* in the Chybaish ranged from 30 mm (caught in August) to 190 mm in October. The length group of 80 mm was prevailing and formed 19.2%, followed by the length group of 120 mm, comprising 15.3% of the total catch.

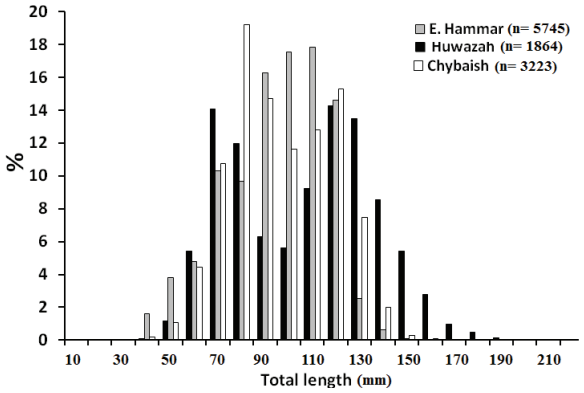

Fig 3. The overall length frequencies of *L. abu* in the three marshes

Length–weight relationships calculated from the three marshes were as follows (Fig 4.):

East Hammar: W = 0.0149 L2.899 (n= 711; r^2= 0.973)
Huwazah: W = 0.0132 L2.910 (n= 638; r^2= 0.968)
Chybaish: W = 0.0252 L2.662 (n= 625; r^2= 0.948)

T-test indicates that the b-values found for the species in the East Hammar, Huwazah and Chybaish marshes departed significantly from the isometric value '3' (t=5.62, 4.26 and 13.47 respectively, p>0.05). Also, analysis of t-test to compare slopes of regression lines between the East Hammar and Huwazah marshes was insignificant (t=0.414, p>0.05), whereas both of them were significantly different from the Chybaish marsh (t=7.79 and 7.59 respectively, p>0.05).

The relative condition "Kn" calculated for different size ranges in the three marshes is illustrated in Table 1. Kn values in the East Hammar and Huwazah marshes exceeded 1.00 for most length groups, with overall mean values (±sd) 1.00 ±0.044 and 1.02 ±0.036, respectively, whereas in the Chybaish marsh, it was lower than 1.00 for most length groups, with the overall mean value 0.98 ±0.074.

Results of length cohort analysis of *L. abu* in the three marshes are presented in Table 2. Growth of *L. abu* in the East Hammar marsh has high L∞ (232 mm) and a lower K (0.37) than those occupying the Huwazah and Chybaish (L∞=211 mm, K=0.44 and L∞=200 mm, K=0.41, respectively). These results offer growth performance index (ø) values of 2.30, 2.29 and 2.22 in the three marshes, respectively. Length of the species at the end of age 1, 2, 3, 4 and 5 was found to be 75, 125, 155, 182 and 201 mm in the East Hammar, 75, 125, 155, 175 and 193 mm in the Huwazah and 65, 115, 145, 167 and 178 mm in the Chybaish.

Table 1. The relative condition factor (Kn) of *L. abu* in the three marshes

Length group (mm)	East Hammar		Huwazah		Chybaish	
	N	*Kn*	*N*	*Kn*	*N*	*Kn*
30-39	-	-	-	-	1	0.975
40-49	13	0.943	-	-	6	0.820
50-59	29	1.007	2	1.052	16	0.849
60-69	39	1.051	33	1.062	38	1.021
70-79	38	1.015	77	1.007	56	1.002
80-89	53	1.027	65	1.010	103	1.045
90-99	116	1.025	38	0.982	86	1.040
100-109	197	1.039	43	0.998	69	1.028
110-119	139	1.003	53	0.973	66	1.031
120-129	40	0.984	72	0.959	83	0.985
130-139	9	1.008	84	1.022	68	0.966
140-149	2	1.002	78	1.086	22	0.963
150-159	21	0.927	57	1.011	3	0.888
160-169	8	0.940	21	1.005	1	1.048
170-179	5	0.923	8	1.002	3	0.974
180-189	1	0.991	5	1.060	3	0.994
190-199	1	1.045	1	1.062	1	1.005
200-209	13	1.119	1	1.096	-	-
	∑711	1.003	∑638	1.024	∑624	0.978
Mean (sd*)		(±0.042)		(±0.036)		(±0.074)

* sd = standard deviation

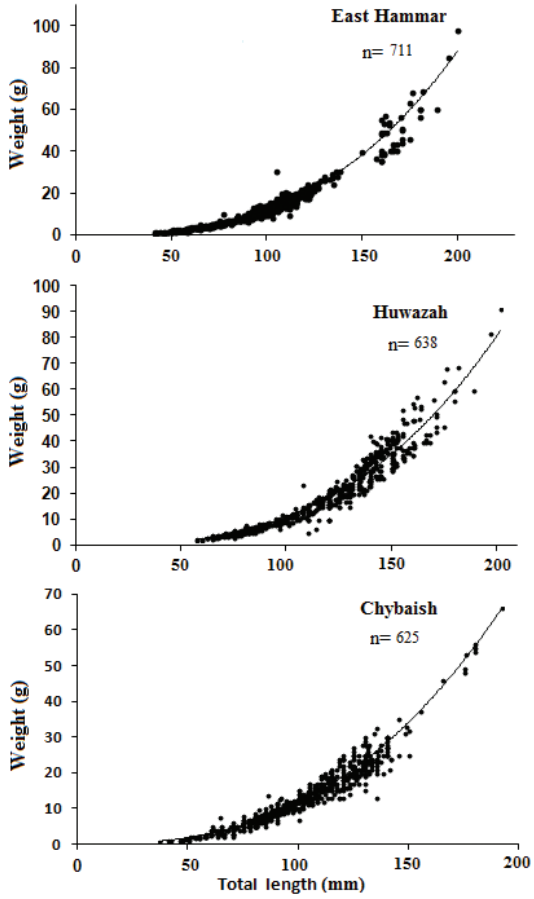

Fig 4. The length-weight relationships of *L. abu* in the three marshes

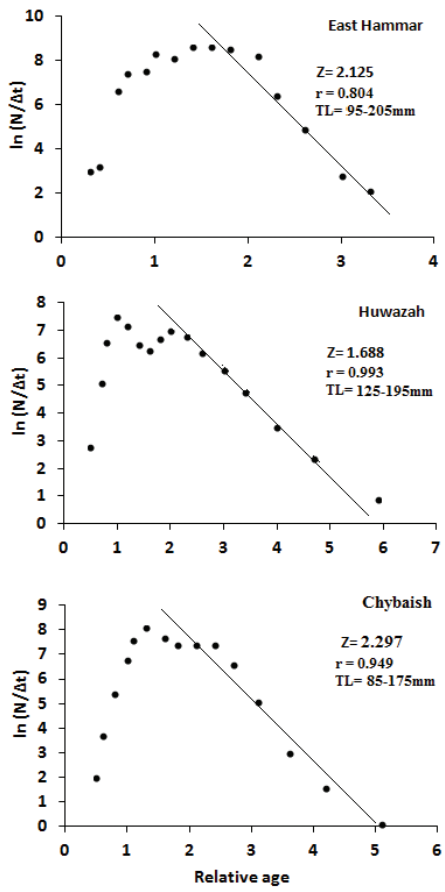

Fig 5. The catch curves of *L. abu* in the three marshes

Table 2. Length cohort analysis of *L. abu* in the three marshes

Length group (mm)	East Hammar			Huwazah			Chybaish		
	N	*ln* (*N*/Δ*t*)	*t`*	*N*	*ln* (*N*/Δ*t*)	*t`*	*N*	*ln* (*N*/Δ*t*)	*t`*
20-29	3	3.0	0.3	-	-	-	-	-	-
30-39	3	3.2	0.4	-	-	-	1	2.0	0.5
40-49	92	6.6	0.6	2	2.8	0.5	6	3.7	0.6
50-59	219	7.4	0.7	22	5.1	0.7	34	5.4	0.8
60-69	274	7.5	0.9	100	6.6	0.8	143	6.8	1.0
70-79	592	8.3	1.0	262	7.5	1.0	347	7.6	1.1
80-89	556	8.1	1.2	223	7.2	1.2	618	8.1	1.3
90-99	935	8.6	1.4	117	6.5	1.4	474	7.7	1.6
100-109	1008	8.6	1.6	105	6.3	1.6	375	7.4	1.8
110-119	1023	8.5	1.8	172	6.7	1.8	412	7.4	2.1
120-129	839	8.2	2.1	266	7.0	2.0	491	7.4	2.4
130-139	146	6.4	2.3	251	6.8	2.3	240	6.6	2.7
140-149	36	4.9	2.6	159	6.2	2.6	64	5.1	3.1
150-159	5	2.8	3.0	101	5.6	3.0	10	3.0	3.6
160-169	3	2.1	3.3	52	4.8	3.4	3	1.6	4.2
170-179	1	0.9	3.8	18	3.5	4.0	1	0.1	5.1
180-189	3	1.8	4.3	9	2.4	4.7	1	-0.4	6.3
190-199	3	1.5	4.9	3	0.9	5.9	1	-1.7	10.1
200-209	2	0.8	5.8	1	-1.4	8.7	-	-	-
210-219	1	-0.4	7.1	-	-	-	-	-	-
220-229	1	-1.3	9.9	-	-	-	-	-	-

Table 3. Growth parameters estimates of *L. abu* in different ecosystems

Ecosystem		*b*	*L*∞ (cm)	*K*	Φ	Reference
Al-Hammar marsh	♂	2.770	29.8	0.19	2.23	Na'ama (1982)
	♀	2.794	23.5	0.39	2.33	
Shatt Al-Basrah		3.181	21.4	0.52	2.38	Wahab (1986)
Diyala River		2.700	-	-	-	Khalaf et al. (1986)
Fish farm		3.01	-	-	-	Al-Asadiy et al. (2000)
Tigris River (Turkey)	♂	-	21.3	0.305	2.14	Unlü et al. (2000)
	♀	-	20.7	0.513	2.34	
Garmat Ali River		-	21.3	0.53	2.38	Abdul-Samad (2001)
Euphrates River		-	24.0	0.36	2.32	Abbas and Al-Rudainy (2006)
Tharthar Lake		-	23.8	0.52	2.47	Shawardi (2006)
East Hammar marsh		2.934	23.3	0.43	2.36	Mutlak (2012)
Atatürk Lake (Turkey)	♂	2.080	24.6	0.28	2.23	Doğu et al. (2013)
	♀	2.870				
East Hammar marsh		2.899	23.2	0.37	2.30	Present study
Huwazah marsh		2.910	21.1	0.44	2.29	Present study
Chybaish marsh		2.662	20.0	0.41	2.22	Present study

Mortality

Length-converted catch curves are presented in Fig 5. based on the data presented in Table 1. The total annual mortality rates (Z) were found to be 2.125, 1.688 and 2.297 in the East Hammar, Huwazah and Chybaish marshes, respectively. The related natural mortality rates (M) were 0.903, 1.055 and 1.006; consequently, fishing mortality rates (F) were 1.222, 0.632 and 1.291, and the exploitation rates (E) were 0.575, 0.375 and 0.562 for the three marshes, respectively. Values of natural mortality rate to growth coefficient (M/K) in the three marshes were 2.44, 2.40 and 2.45, respectively.

DISCUSSION

Results revealed that *L. abu* was dominant in the three marshes. This coincides with the findings of other scientists in several waters in middle and southern Iraq, such as Habbaniyah, Tharthar and Razzazah Lakes (Epler et al., 2001), Qadisiya Reservoir (Al-Rudainy et al., 2001), the Shatt Al-Arab River (Mohamed et al., 2012b) and Garmat Ali River (Mohamed et al., 2013). Availability of detritus could lead to the increased number of *L abu* since it serves as the main food constituent for the species (Mohamed and Hussain, 2012).

For comparison purposes, the growth parameters of the species in different waters are presented in Table 3. The growth patterns of this species in all water were isometric, indicating that the weights of fish were not too much for their lengths. This may explain its robustness and feebly compressed body, coinciding with what Smith and Deguara (2002) deduced on the Australian mullet.

Huwazah population exhibited the best relative condition among others, but Chybaish stock came last. The latter, however, was heavily desiccated and led to devastation of the habitat (Richardson and Hussain, 2006). As a consequence of inundation, water was flowing from the southward, against the slope of the marsh, which led to stagnation, low water quality and high salinity, which hindered the growth of vegetation in the Chybaish (Hamdan et al., 2010). The overall condition of *L. abu* in the three marshes is in accordance with other findings, namely the Al-Hammar marsh (Na'ama, 1982) and Habbaniya Lake, Tharthar Reservoir and Razzazah Lake (Epler et al., 2001).

The values of L∞ and the growth performance index (Φ) of *L. abu* are almost similar to those recorded for the species in other waters (Table 4). However, other studies relied on scales or otoliths for age determination. This indicates the validity of applying the cohort length analysis technique (Jones, 1984) for stock assessment of *L. abu.*

Comparisons were made between the lengths at ages of *L. abu* in the three marshes and those from other Iraqi and Turkish waters (Table 4). The lengths of the species in the Tigris River (Turkey) were converted to total lengths from fork lengths, adopting the conversion equations stated by Unlü et al. (2000). It is clear that the growth patterns of *L. abu* in the investigated locations are coincided with those in other waters, except the first year group in the Chybaish. It is lower than the values reported by Unlü et al. (2000) and Doğu et al. (2013) in Turkish waters. It has been reported that there must be some differences between growth characteristics among localities as a result of diversity and availability of dietary items, hydrographical and climatic conditions (Bartulovic et al., 2004).

Values of natural mortality rate to growth coefficient (M/K) in the three marshes were 2.44, 2.40 and 2.45, respectively. Beverton and Holt (1957) mentioned that the value of M/K is ranging from 1.5 to 2.5 and the ideal one is 2.0. However, any excess on this value may expose the stock to be more vulnerable for considerable natural mor-

Table 4. Growth comparison of *L. abu* in different ecosystems

Ecosystem		Mean total length (cm) at each age						Reference
		1	2	3	4	5	6	
Al-Hammar marsh		13.3	16.2	18.4	20.1	-	-	Na'ama (1982)
Shatt Al-Basrah		12.1	15.9	18.2	19.5	-	-	Wahab (1986)
Diyala River		10.6	12.7	14.0	16.1	18.4	20.4	Khalaf et al. (1986)
Tigris River (Turkey)	♂	13.1	15.8	16.6	18.2	20.7	-	Unlü et al. (2000)
	♀	13.7	15.8	16.8	18.3	21.3	-	
Fish farm, Babylon		8.4	11.0	13.2	15.3	17.0	18.6	Al-Asadiy et al. (2000)
Garmat Ali River		10.9	12.9	14.8	16.2	17.1	-	Abdul-Samad (2001)
Euphrates River		6.9	10.9	14.9	17.9	-	-	Abbas and Al-Rudainy (2006)
Tharthar Lake		9.5	10.9	12.8	14.7	-	-	Shawardi (2006)
Hilla River		10.2	12.2	15.3	18.4	-	-	Al-Emari (2011)
East Hammar marsh		10.6	14.7	17.8	19.8	-	-	Mutlak (2012)
Atatürk Lake (Turkey)		11.4	14.9	17.5	18.9	20.2	-	Doğu et al. (2013)
East Hammar marsh		7.5	12.5	15.5	18.2	20.1	-	Present study
Huwazah marsh		7.5	12.5	15.5	17.5	19.3	-	Present study
Chybaish marsh		6.5	11.5	14.5	16.7	17.8	-	Present study

tality before attaining the stage of aging.

Results of exploitation rate (E) indicate that the stock of *L. abu* in the Huwazah marsh is underexploited, while those of the East Hammar and Chybaish marshes endure overexploitation. According to Gulland (1970), the yield is optimized when F= M; therefore, when E is more than 0.5, the stock is overfished. Mutlak (2012) recorded higher values of F (2.24) and E (0.68) for this species in the East Hammar marsh during 2009-2010. The comparatively high values of exploitation rate of this species in these marshes may be attributed to several factors including illegal fishing gears, use of explosives, poisons and long-term use of illegal small-meshed nets (Jawad, 2006), moreover the substantial reduction in water quality and quantity, and effective absence of the flood pulses that sustained wetland ecosystems in the lower Tigris-Euphrates basin (Partow, 2001).

However, it is urgent to enforce immediate fish regulations in marshes and this can be achieved by activating the national law on fishing, exploiting and protecting aquatic resources, in particular preventing illegal fishing methods, restricting fishing at certain seasons, including declaring fish sanctuaries in certain areas, especially in spawning sites.

ACKNOWLEDGEMENTS

The data on which this paper is based were collected under the Canadian International Development Agency (CIDA)-funded project. My thanks and gratitude goes to my colleague's team of biologists in the project, Prof. N. A. Hussain and Prof. S. S. Al-Noor. I am also thankful to Prof. S. A. Hussein for reading and commenting on the manuscript.

Sažetak

PROCJENA STOKA SLATKOVODNOG CIPLA, *Liza abu* (HECKEL, 1843), U TRIMA OBNOVLJENIM JUŽNIM MOČVARAMA IRAKA

Procjena stoka slatkovodnog cipla, *Liza abu* (Heckel, 1843), provodila se u močvarama Istočni Hammar, Huwazah i Chybaish na jugu Iraka od listopada 2005. do rujna 2006. godine. Relativna zastupljenost ove vrste bila je 35,9, 37,1 i 62 % od ukupnog ulova u trima močvarama. Dobivene vrijednosti dužinsko-masenih odnosa kod *L. abu* bile su: W = 0,0149 L2.899 (Istočni Hammar), W = 0,0132 L2.910 (Huwazah) i W = 0,0252 L2.662 (Chybaish). Srednje vrijednosti kondicijskog faktora triju istraživanih močvara iznosile su 1,00, 1,02 i 0,98. Parametri rasta i mortaliteta pojedine vrste bili su: L∞ = 23.2 cm, K = 0,37, Z = 2.125, M = 0,903 i P = 1.222 (Istočni Hammar), L∞ = 21.1 cm , K = 0,44, Z = 1.688 , M = 1.055 i F = 0.632 (Huwazah) i L∞ = 20.0 cm, K = 0,41, Z = 2.297, M = 1.006 i F = 1.291 (Chybaish). Stok *L. abu* u močvari Huwazah bio je neiskorišten (E = 0,375), dok su močvare Istočni Hammar i Chybaish bile previše iskorištavane (E = 0.575; E = 0.562). Nužna je provedba ribolovnih mjera za riblji fond na istraživanim lokacijama, a to se može procijeniti jedino primjenom nacionalnog zakona o upravljanju u ribarstvu.

Ključne riječi: Abu mullet, *Liza abu*, parametri rasta, stopa mortaliteta, južne močvare

REFERENCES

Abbas, L.M., Al-Rudainy, A.J. (2006): Ecology and biology of two freshwater fish species in Euphrates River, middle of Iraq. Proceedings of the International Conference on Underwater System Technology: Theory and Applications July 18-20, Penang, Malaysia.

Abdul-Samad, S.M.S. (2001): Effect of some ecological factor on growth and reproduction of Liza abu (Heckel, 1843) in Qarmat Ali River, South Iraq. M.Sc thesis: University of Basrah, Iraq.99p.

Al-Asadiy, Y.D., Mhaisen, F. T.,Dauod, A.A.M. (2000): Observations of the age and growth of the mugilid fish Liza abu (Heckel) in a fish farm at Babylon province, mid Iraq. Ibn Al-Haitham Journal for Pure and Application Science, 13, 2, 20-30.

Al-Emari, M.J.Y. (2011): Study of some biological and ecological of fish

assemblage in Hilla River, Iraq. Ph.D thesis: University of Babylon, Iraq. 144p.

Al-Hilli, M. R., Warner, B. G., Asada, T., Douabul, A. (2009): An assessment of vegetation and environmental controls in the 1970s of the Mesopotamian wetlands of southern Iraq. Wetlands Ecology and Management, 17, 207 – 223.

Al-Rudainy, A. M. J., Mossa, M., Abu Al-Hana, A. K. J., Rehauge, A. S. M., Hassan, A. A. (2001): Study some biological aspect of fishes in two districts of Al-Qadisiya Lake. Journal of Iraqi Atomic Energy Organization, 3, 26 – 39.

Bartulovic, V., Glamuzina, B., Conides, A., Dulcic, J., Lucic, D., Njire, J., Kozul, V. (2004): Age, Growth, Mortality and Sex Ratio of Sand Smelt, *Atherina boyeri,* Risso, 1810 (Pisces: Atherinidae) in the Estuary of the Mala Neretva River (Middle-Eastern Adriatic, Croatia), Journal of Applied Ichthyology, 20, 427 – 430.

Beverton, R. J., Holt, S. J. (1957): On the dynamics of exploited fish population. Fishery Investigation, London, Ser. 11, 19, 1 – 533.

Coad, B. W. (2010): Freshwater Fishes of Iraq. Pensoft Publishers, Sofia, Bulgaria, 274 pp.

Doğu, Z., Şahinoz, E., Faruk Aral, F., Şevik, R. (2013): The growth characteristics of *Liza (Mugil) abu* (Heckel, 1843) in Atatürk Dam Lake. African Journal of Agricultural Research, 8, 34, 4434 – 4440.

Epler, P., Bartal, R., Szczerbowski, J. A., Szypula, J. (2001): The ichthyofuna of lakes Habbaniya, Tharthar and Razzazah. Archives of Polish Fisheries, 9, 171 – 184.

Evans, M. I. (2002): The ecosystem. In: Nicholson, E., Clark, P. (eds.), The Iraqi Marshlands: A human and environmental study, pp. 201–219. AMAR International Charitable Foundation, 299 pp.

FAO (1999): Fishery Country Profile. FID/CP/IRQ Rev. 2

Gulland, J. A. (1969): Manual of methods for fish stock assessment. Part 1. Fish population. FAO Manuals in Fisheries Science, No. 4, 154 pp.

Gulland, J. A. (1970): The fish resources of the ocean. FAO Fisheries Technical Paper, No. 97, FAO, Rome, 425 pp.

Hamdan, M. A., Asada, T., Hassan, F. M., Warner, B. G., Douable, A., Al-Hilli, M. R., Alwan, A. A. (2010): Vegetation response to re-flooding in the Mesopotamian wetlands, Southern Iraq. Wetlands, 30, 177 – 188.

Hussain, N. A., Mohamed, A. R. M., Al Noor, S. S., Mutlak, F. M., Abed, I. M., Coad, B. W. (2009): Structure and ecological indices of fish assemblages in the recently restored Al-Hammar Marsh, southern Iraq. BioRisk, 3, 173 – 186.

Jawad, L. A. (2006): Fishing gear and methods of the Lower Mesopotamian Plain with reference to fisheries management. Marina Mesopotamica, 1, 1, 1 – 39.

Jones, R. (1984): Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). FAO Fisheries Technical Paper, No. 256, FAO, Rome, 118 pp.

Khalaf, A. N., Al-Yamour, K. Y., Allouse, S. B., Al-Jafary, A., Sadek, S. E. (1986): Age, growth, length-weight relationships and distribution of Khishni *Liza abu* (Heckel) (Mugilidae) in a polluted habitat. Journal of Biological Sciences Research, 17, 2, 63 – 81.

Le Cren, E. D. (1951): The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology, 20, 201–219.

Mohamed, A. R. M., Hussain, N. A. (2012): Trophic strains and diet shift of the fish assemblage in the recently restored Al-Hammar marsh, southern Iraq. Journal of University of Duhok, 15, 1, 119 – 127.

Mohamed, A. R. M., Hussain, N. A., Al Noor, S. S, Mutlak, F. M., Al-Sudani, I. M., Mojer, A. M., Toman, A. J. (2008): Fish assemblage of restored Al-Hawizeh marsh, Southern Iraq. Ecohydrology and Hydrobiology, 8, 375 – 384.

Mohamed, A. R. M., Hussain, N. A., Al-Noor, S. S., Mutlak, F. M. (2012a): Ecological and biological aspects of fish assemblage in the Chybayish marsh, Southern Iraq. Ecohydrology & Hydrobiology, 12, 1, 65 – 74.

Mohamed, A. R. M., Resen, A. K., Taher, M. M. (2012b): Longitudinal patterns of fish community structure in the Shatt Al-Arab River, Iraq. Basrah Journal of Science, 30, 2, 65 – 86.

Mohamed, A. R. M., Hussein, S. A., Lazem, L. F. (2013): Fish assemblage of Garmat Ali River, north of Basrah, Iraq. Basrah Journal of Agriculture Sciences, 26, 1, 150 – 166.

Mutlak, F. M. (2012): Stock assessment of some fish species from East Hammar marsh, Southern Iraq. Ph.D thesis: University of Basrah, Iraq. 193 pp.

Na'ama, A. K. (1982): Some biological aspects of two freshwater fishes, *Liza abu* (Heckel) and *Mugil dussumieri* (Val. and Cuv.) (Fam. Mugilidae) from the Hor al-Hammar, north Basrah, Iraq. M.Sc. thesis: University of Basrah, Iraq. 161 pp.

Odum, W. A. (1970): Insidious alteration of the estuarine environment. Transactions of the American Fisheries Society, 99, 836 – 847.

Partow, H. (2001): The Mesopotamian Marshlands, Demise of an ecosystem. Nairobi (Kenya): Division of early warning and assessment, United Nation for Environmental Programs: UNEP publication UNEP/DEWA/, 103 pp.

Pauly, D. (1980): On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. Journal du Conseil Permanent International pour l'Exploration de la Mer, 39, 175 – 192.

Pauly, D. A. (1983): Some simple methods for the assessment of tropical fish stocks. FAO Fish, Technical Papers, 234, 52 pp.

Pauly, D., Munro, J. L. (1984): Once more on the comparison of growth in fish and invertebrates. Fishbyte, 2, 21.

Richardson, C. J., Hussain, N. A. (2006): Restoring the garden of Eden: an ecological assessment of the marshes of Iraq. BioScience, 56, 6, 477 – 489.

Sharma, K. P. (1980): Further studies on the fish marketing conditions of southern Iraq. The Arab Gulf, 2, 1, 223 – 226.

Shawardi, A. A. (2006): Ecology and biology of *Carassius carassius* (L. 1758) and *Liza abu* (Heckel, 1843) in Tharthar lake. Ph.D thesis: University of Al-Mustansiria, Iraq, 142 pp.

Smith, K. A., Deguara K. (2002): Review of biological information and stock assessment for the NSW sea mullet resource. NSW Fish. Res. Assess. Ser. 12, 19 pp.

Taylor, C. C. (1958): Cod growth and temperature. Journal du Conseil/Conseil Permanent International pour l'Exploration de la Mer, 23, 366 – 370.

Unlü, E., Balci, K., Meriç, N. (2000): Aspects of the biology of *Liza abu* (Mugilidae) in the Tigris River (Turkey). Cybium, 24, 1, 27 – 43.

UNEP (2007): Iraqi marshland observation system (UNEP/IMOS). Available from: //imos.grid. unep.ch/

Wahab, N. K. (1986): Ecology and biology of three species of mugilid fishes in Shatt Al-Basrah Canal. M.Sc. thesis, University of Basrah, Iraq, 155 pp.

