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Study of pike-perch (*Sander lucioperca*) fishery from Razim Lake, Danube delta Romania

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Abstract: The Razim Lake is a great part of the Danube Delta Biosphere Reserve (DDBR), with a surface of 54,000 ha. Fish fauna from Razim lake include pike-perch (*Sander lucioperca*) as one of the main top predators of fish community, however ecological significance indicates accessory species, recedent as dominance, sometimes been subrecedent species like in 2011 and 2012 sampling, but constant species regarding frequency in sampling. Otherwise, pike-perch is an important value DDBR fishery species with an average of 5% in total catch, range 2-10%, from what Razim lake contributes with average 71%, range 41-95% in the 1960-2015 period. Razim Lake has been in average 13%, range 1-40% from total Razim lake catch, in the same period of time. Since in RBDD has been fishing up to 2000 fisherman, in Razim lake activated up to 500 fishermen, however nowadays number of fishermen was regulated at lower range. Catch data series shows a continuous stock decline trend, considered to be a consequences of habitat degradation and over-exploitation. Fish stock estimation in last 15 years (2001-2016) support the hypothesis of over-exploitation. Based on length frequency structure of landings, the growth and exploitation parameters have been estimated as well as the average biomass and the maximum sustainable yields for the Razim lake pike-perch stock. Recommendation concerning fisheries management towards sustainable fishing of pike-perch stock, as increasing of cod-end seine mesh size and decreasing of fishing effort regulation are outlined.

Keywords: Razim, fish stock, Danube delta, sustainable use

INTRODUCTION

Razim Lake, part of the Razim-Sinoie lakes complex, is located in the southern part of the Danube Delta Biosphere Reserve and has a total area of approx. 54,000 ha, of which approx. 40,000-45,000 hectares open fishing waters.

Pike-perch (*Sander lucioperca*) is an important fishing stock by commercial value and catch volume of DDBR fishery with an average of 5% in total catch, range 2-10%, from what Razim lake contributes with average 71%, range 41-95% in the 1960-2015 period. Razim Lake has been in average 13%, range 1-40% from total Razim lake catch, in the same period of time. Since in RBDD has been fishing up to 2000 fisherman, in Razim lake activated up to 500 fishermen, however nowadays number of fishermen was regulated at lower range.

Most of the catches are fished with seine nets with a total length of those two wings of 400 m and mesh size of cod-end of 50 mm, being active between October and March month.

Over the past 10 years, it has seen an increase in the magnitude of catch size variations, probably due to instability of the population size in the context of the changing of the environment state of the entire ecosystem. Under new environmental conditions, the increase of the exploitation can become a pressure factor for balancing the population effectives and even more contribute to changing of the structure of the ichthyofauna. The papers has proposed to support management measures for sustainable exploitation of fish resources and conservation of fish species population in Razim Lake.

MATERIALS AND METHODS

For the assessment of the stock fish from Razim Lake, used analytical models. This approach assumes to know the length-frequency/specie and it working with population's parameters. The processing and analysing of the collected samples made after FAO related publications (Jones, 1984; Sims, 1988; Sparre et al., 1998; Staras et al., 1992; Staras et al., 1996; Navodaru et al., 2008).

The pike-perch fish catch was sampled at the Razim Lake landing points, especially in Jurilovca fishery village in October-November of each year of 2001-2016 period. The size of the samples was approx. 1000 individuals for what the total length (TL), total weight (TW) was measured and scales from 100-200 individuals were collected.

The historical analysis of the state of conservation and exploitation of the fishery resources was carried out on the basis of the studies carried out during the period 2001-2016 by the team from INCDDD Tulcea, which took over the sustainable management of the fish resources from DDBR.

Research fishing

Razim lake was sampled in last 10 years as follow:

- Research seine fishing – most relevant gear for this type of lake.
- Electric fishing near shoreline, but mostly inside canals or backwater (gear used only for identification of small and short distance swimming fish species).
- Nordic gillnets relon multifilaments (very rare used in this lake)

Ecological parameters (dominance, frequency and ecological significance) was calculated in accordance with CPUE (Catch per Unit Effort) (Table 1).

Table 1 Ecological parameters classes and percentage limits used in analyses: D= dominance, C=constancy, W=ecological significance (according Şindrilariu et al. 2002, Botnariuc and Vădineanu, 1982, Gomoiu and Skolka, 2001)

Abundance /Dominance (D)			Frequency /Constancy (C)		Ecological significance (W)	
Class		%	Class	%	Class	%
sporadic	D1	<1	very rare	C1=0-10	accidental	W1< 0.1
subrecedent		1 (2 ⁰) - <2	rare	C2=10.1-25	accessory	W2=0.1-1
recedent	D3	2 (2 ¹) - <4	accessory	C3=25.1-45	associate	W3=1-5
subdominant		4 (2 ²) - <8	Frequent	C4=45.1-70	complementary	W4=5-10
dominant	D5	8 (2 ³) – 16	very constant	C5=70.1-100	characteristic	W5=10-20
eudominant	D6	>16 (2 ⁴)			main, leading	W6>20

RESULTS AND DISCUSSIONS

Pike-perch commercial fishery

Razim Lake pike-perch fishery with an average of 75% of capture from total RBDD pike-perch capture in the period of 1961-2016, is one of most important fishery by value of market species and volume of catch (Annex 1). In the last 56 years, pike perch capture trend continuously declined from. 730 t/year to 227 t/year in Razim lake as well as in other RBDD waters from approx. 441 t/year to 100 t/year (Fig.1).

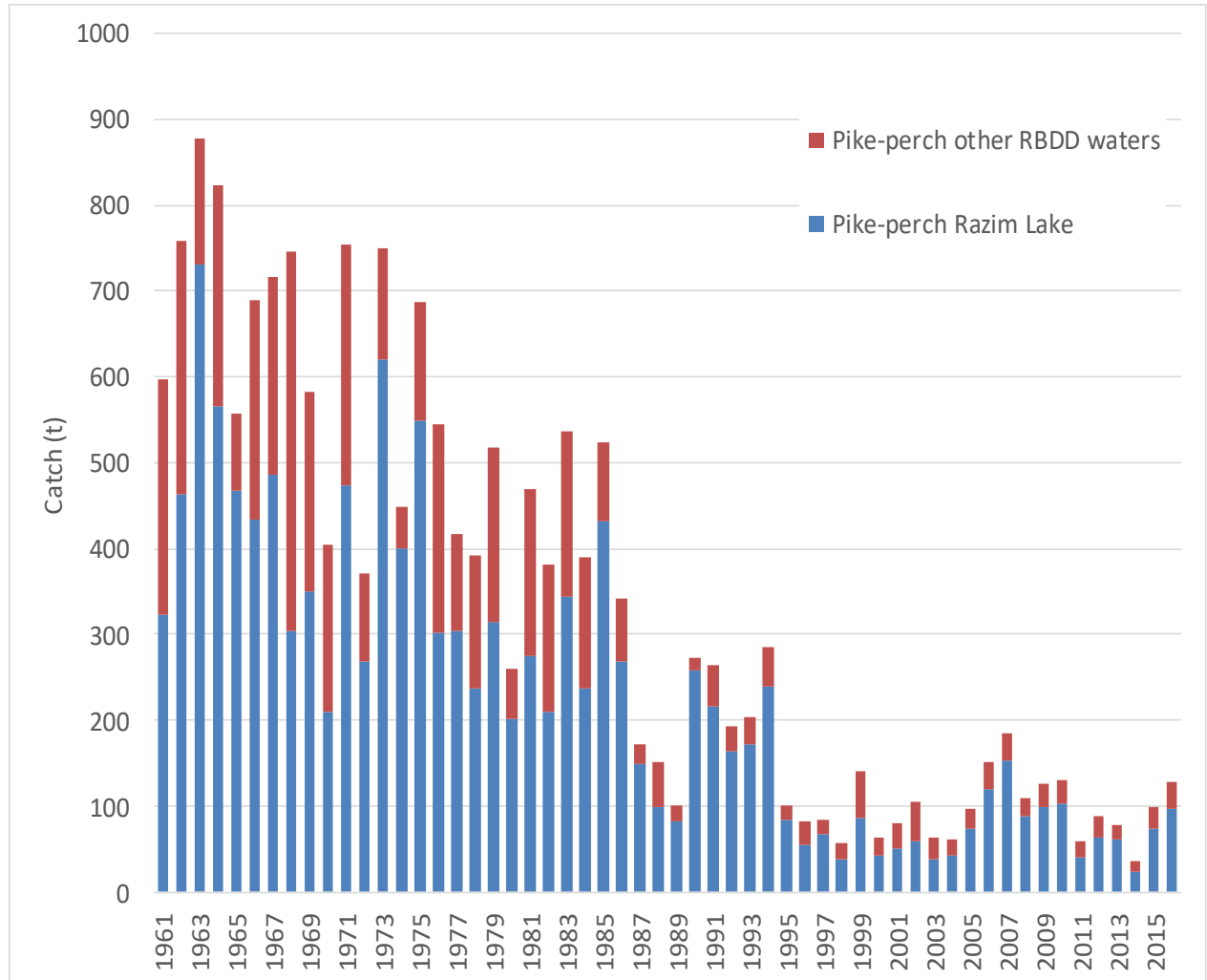


Fig. 1 - Global Capture Production for *Sander lucioperca* (tonnes) Source: FAO FishStat

Possible cause of this decline should be, habitat degradation (changing in sediment and nutrients loads) and overexploitation in last half of century. However, Razim lake has changed in last century from a lagoon lake with sandy bottom and brackish water to a freshwater lake with bottom siltation.

Fish stock estimation

Between 2001 and 2016, 10,708 pike-perch specimens with a total weight of 9094.1 kg were sampled from commercial fish landings. The individual length ranges between 29 and 84 cm with an average weight of between 521 and 1255 g. (Table 2).

Table 2 - Structure of pike-perch commercial catches samples by length-weight frequency

Year	No. ind.	Weight (kg)	Average Total Length (TL) (cm)	Average weight (TW) (g)	TL limits (cm)	The most frequent Total Length (cm)
2001	906	472.2	37.3	521	29-60	35
2003	1305	1074.6	41.2	766	29-80	37
2004	1154	1084.4	44.2	940	30-72	44
2005	995	850.9	43.7	855	33-84	41.5
2006	1062	1061	44	999	31-68.5	41
2007	1022	1167.8	46.3	1143	33-71	46

2008	1146	1307	45.5	1140	32-78	39
2010	1172	1207.1	43.9	1030	31-78	38
2011	1067	1338.9	46.2	1255	32-80	40
2016	879	614.6	39.3	699	31-70	38
	10708	9094.1	37.3-46.3	521-1255	29-84	35-46

Growth and exploitation parameters

Based on the structure samples of the frequency over the length of the commercial catches, the analytical methods, the growth and exploitation parameters of the Razim Lake pike-perch stock were estimated (Table 3).

The growth parameters was estimated using the methods based on the length and frequency analyse with the model "ELEFAN" (Sparre et. al. 1998) which are included in the ESP packet (Staraş et al., 1996).

Table 3. Growth and exploitation parameters, length-growth relation estimated in 2001-2016 period

L_{∞} - the maximum total length (cm) that individuals can reach at which growth ceases, asymptotic length

k - a curve parameter that determines the speed at which fish approaching to L_{∞} ,

t_0 - the theoretical age at which the length is "0", without biological significance,

L_r - the length at which the fish enter the exploitation phase, length at recruitment to the fishery

L_c - the length of the first catch, the length at which 50% of the fish is retained by gear

M - natural mortality, F - fishing mortality coefficient, Z - total mortality coefficient

$W = a \times L^b$ is the relation length (L_t) -weight (W_t), in which a and b are the equation coefficients

Year	L_{∞}	K	t_0	L_r	L_c	M	F	Z	$W = a \times L^b$	
									a	b
2001	89	0.147	-1	29	40	0.27	1.36	1.63	0.0152	2.8772
2003	90	0.15	-0.7	29	45	0.27	0.52	0.79	0.008	3.0562
2004	90.4	0.16	-0.6	30	40	0.3	0.9	1.2	0.0086	3.0482
2005	91.4	0.16	-0.3	32	41	0.28	1.2	1.48	0.0092	3.0154
2006	91	0.167	-0.58	30	42	0.29	1.36	1.65	0.0094	3.0407
2007	91.2	0.163	-0.7	33	40	0.29	0.7	0.99	0.0102	3.0174
2008	92	0.159	-1	31	40	0.3	0.5	0.8	0.0073	3.0926
2010	90.9	0.165	-0.51	31	40	0.28	0.55	0.83	0.01120	2.9945
2011	92	0.164	-0.9	32	45	0.28	0.64	0.92	0.00552	3.1911
2016	90.8	0.163	-0.6	31	40	0.28	2.13	2.41	0.0187	2.8598

Estimating the state and exploitation of stocks (Beverton – Holt model)

The state of exploitation of the Razim Lake pike-perch stock was analysed annually by positioning the current point of exploitation (P_c) with the coordinates expressing the length at which the selectivity of the fishing gear (seine cod-end) is $L_c = 0.5$ and the exploitation intensity (F), on the Y / R , resulting from the application of the Beverton - Holt model (Figure 2).

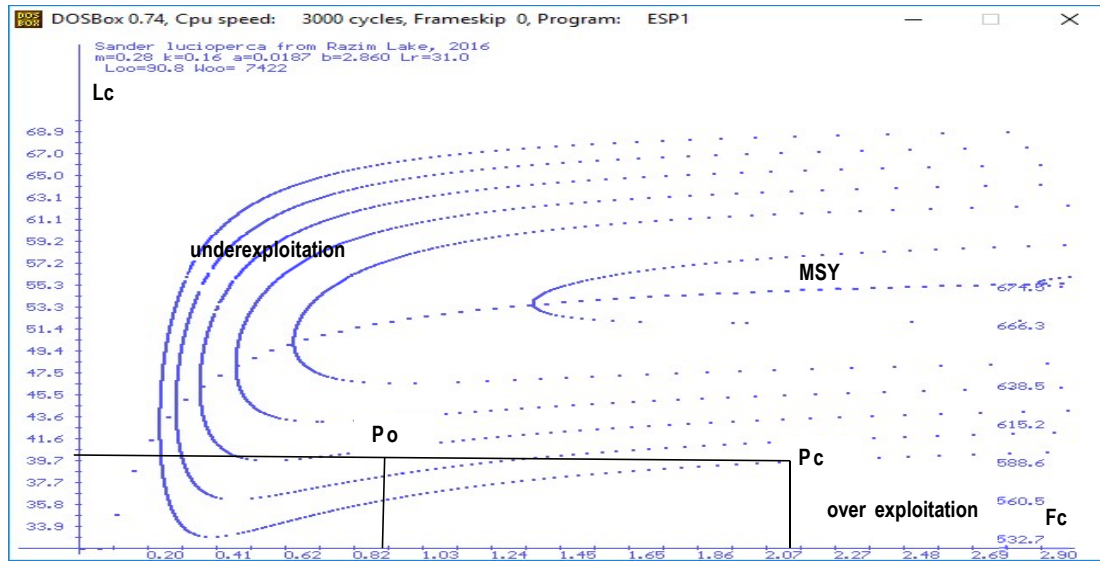


Figure 2 Status and optimum exploitation of the pike-perch stock – Beverton & Holt model Yield per Recruit (Y/R) diagram – *Sander lucioperca*

Since the optimization of the length of the first catch (Lc or L50%) was made in the previous years, this parameter depending on the size of the mesh and the selectivity of the fishing net, the optimization of the fishing was done by modelling the exploitation by changing the fishing effort (F), and optimal biomass recalculation and Maximum Sustainable Yield (MSY) through the Virtual Population Analysis (VPA) and Thomson-Bell analytical model (Table 4). The analysis and optimization was done annually for a standard catch of 10 tons of fish.

Table 4 Assessment of the current state of exploitation during the period 2001-2016 and optimization measures (Fc - current fishing mortality coefficient, Fo - optimum fishing mortality coefficient, Lc - the length of the first catch, the length at which 50% of the fish is retained by gear, Ca – actual catch (tonnes), Co – Maximum Sustainable Yield (MSY), Ba – actual biomass, Bo – optimum biomass, Y/Rc – Current Yield per recruit, Y/Ro – Optimum Yield per recruit, $\alpha = \text{MSY}_{10\text{tons}}/10$)

Year	Fc	Lc	Ca	Ba	Fc→Fo	Fo	Y/Rc	Y/Ro	Bo	Co	α
					%					MSY	
2001	1,36	40	10	10,2	43	0,58	440	455	20,8	10,7	1,07
2003	0,43	45	10	21,2	72	0,31	565	575	29,7	10,18	1,018
2004	0,9	40	10	16,9	67	0,6	594	594	16,5	10,07	1,007
2005	1,2	41	10	13	67	0,8	598	623	18,2	10,2	1,02
2006	1,36	42	10	14,3	68	0,92	695	710	18,66	10,1	1,01
2007	0,7	40	10	16,7	71	0,5	709	711	21,7	10,2	1,02
2008	0,5	40	10	21,3	90	0,45	642	644	23,53	10,05	1,005
2010	0,55	40	10	22	89	0,49	650	652	24,4	10	1,00
2011	0,64	45	10	19,7	72	0,46	900	875	26,65	10,1	1,010
2016	2,13	40	10	9	42	0,9	533	575	18	10,98	1,098

The sustainable catch of fish stocks for the following year is calculated as follows:

$$MSY_{n+1} = \alpha * C_n$$

where α is a coefficient: $\alpha = MSY_{10\text{tons}} / 10$;

The state and exploitation of the pike-perch stock in Razim Lake during 2001-2016

The structure of samples taken from commercial catches in 2001-2016 in Razim Lake is in the range 29-84 cm with an average length of 37.3-46.3 cm and average weight of 521-1255g. The dominant length classes of catches are 40-48 cm 4-5 years, and the age of 2-3 years (30-38 cm) was generally poorly represented, with the exception of 2001, 2003 and 2016. The absence of this class of age is due to either excessive fishing in previous years or to a poorly recruited age class. Annually, there are specimens below the legal fishing size sampled from commercial catches, with a larger proportion in the years when recruitment was strong.

The sustainable state of exploitation of the pike-perch from the Razim Lake requires a reduction in fishing effort and compliance with actual landing legal size (40 cm). Overexploitation, in particular, of specimens under legal size will be reflected in the following years by reducing catches.

Pike-perch ecological state in the lake ichthyodiversity

In the fish community of Razim Lake (**photo 2**) ecological state of pike-perch (*Sander lucioperca*) is constant species in the frequency, recedent and accessory, associate species, except in years 2011 and 2012 when decreased to subrecedent, accesory species. Good ecological state for pike-perch is year 2016 (Table 5).

Total number of fish species sampled in Razim Lake differ year by year from 17 species (some methods of sampling are missing) to 40 species, where *pike-perch* is constant present in samples (Table 5).

Table 5 Dynamics of ecological state of *pike-perch* in Razim Lake fish community in last 10 years

Ecological parameters/Years	2005	2007	2008	2010	2011	2012	2015	2016
Dominance (D)	D3	D3	D3	D3	D2	D2	D3	D4
Frequency (Constancy) (C)	C4	C4	C4	C4	C3	C3	C5	C5
Ecological significance (W)	W3	W3	W3	W3	W2	W2	W3	W3
Total number of captured fish species	36	37	17	40	27	34	31	33

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Annex 1 Pike-perch capture from RBDD in the period of 1961-2016

	Pike-perch Razim Lake	Pike-perch other RBDD waters	Pike-perch total RBDD	% of Razim Lake pike-perch
1961	322	274	596	54
1962	464	294	758	61
1963	730	147	877	83
1964	565	257	822	69
1965	467	90	557	84
1966	434	255	689	63
1967	487	229	716	68
1968	304	441	745	41
1969	350	233	583	60
1970	209	196	405	52
1971	473	280	753	63
1972	269	102	371	73
1973	619	131	750	83
1974	400	49	449	89
1975	548	140	688	80
1976	301	244	545	55
1977	303	115	418	72
1978	238	154	392	61
1979	315	202	517	61
1980	201	60	261	77
1981	275	195	470	59
1982	210	171	381	55
1983	344	193	537	64
1984	238	152	390	61
1985	432	92	524	82
1986	268	73	341	79
1987	149	24	173	86
1988	99	53	152	65
1989	83	18	101	82
1990	258	15	273	95
1991	216	48	264	82
1992	163	31	194	84
1993	173	30	203	85
1994	239	47	286	84
1995	84	16	100	84
1996	55	27	82	67
1997	68	17	85	80
1998	38	19	57	67
1999	87	55	141	61
2000	42	21	63	67
2001	50	30	80	62
2002	59	45	104	57
2003	37	26	64	59
2004	42	20	62	68
2005	75	23	97	77

2006	119	32	151	79
2007	153	30	184	83
2008	89	21	109	81
2009	98	29	127	77
2010	102	29	131	78
2011	41	18	60	69
2012	64	25	89	72
2013	62	16	78	79
2014	25	13	37	66
2015	73	26	100	74
2016	96	32	128	75
Min	25	13	37	41
average	227	100	327	71
Max	730	441	877	95

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