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(Response received from Germany)

Modification of gill nets to minimize by-catch of sturgeons
(A paper from Gessner and Arndt)

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Modification of gill nets to minimize by-catch of sturgeons

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Summary

As a prerequisite for the planned restocking of Baltic sturgeon under a Federal remediation programme, the effects of different fishing methods on by-catch of sturgeons were assessed. This assessment was based on survey data for exotic sturgeon species in German coastal waters between 1994 and 2003. The highest proportion of catches observed in commercial fisheries resulted from gill-nets, comprising 37% of the total catch. Only angling accounted for higher proportions (53%) of the total reported catch. Since gill nets are the predominant gear utilized in the coastal waters of the Baltic, trials were performed to modify the nets to reduce the potential by-catch of sturgeons while maintaining the selectivity for the main target species in the inner coastal waters, namely pikeperch (*Sander lucioperca*) and Eurasian perch (*Perca fluviatilis*). For this purpose the modified nets were equipped with spacers of nylon rope with a length of either 30 or 50 cm between the net wall and the lead-line. The nets were stretched vertically by a floatline, thus providing "windows" on the bottom of the net with 0.3-0.5 m^2 each. The effect of the modifications on the by-catch of sturgeons was tested in a 5 ha pond stocked with 2,000 kg Siberian sturgeon (*A. baerii)* with an individual weight of 0.8 to 4.5 kg. With the modified nets, the CPUE for sturgeons was reduced by 97-100% when compared to standard gill nets of the same mesh sizes (33, 50 and 80 mm stretched mesh). Secondly, the effectiveness of the modified nets for the main target species pikeperch (*Sander lucioperca*) and Eurasian perch (*Perca fluviatilis*) as well as for major by-catch such as roach (*Rutilus rutilus*) and bream (*Abramis brama*) was evaluated in the Szczecin lagoon, the Odra river mouth. The nets were compared with standard nets during 11 fishing trials. Species specific performance of the modified nets revealed a significant decrease in CPUE of Eurasian perch whereas the CPUE for the other species remained at a comparable level.

Introduction

Sturgeon are especially vulnerable to overfishing (Boreman, 1997) due to their late maturation and their low absolute fecundity. Besides fisheries targeting for sturgeons, by-catch is considered a major threat. Fisheries techniques that are considered especially harmful include bottom gill nets, driftnets and trawls (Collins *et al*., 1996; Rochard *et al*. 1997; Lepage *et al*. 2003). Sturgeon remediation in the Baltic Sea drainage area is to begin in Odra River in 2006 (Gessner and Ritterhoff, 2004) with experimental stocking. This makes it necessary to identify the potential impact of the current fishery upon the planned remediation attempts (Beamesderfer, & Farr, 1997).

The lower reaches of the Odra River are the border between Germany and Poland. It enters the Baltic Sea north of the city of Szczecin via the Szczecin Lagoon, a brackish water lake connected to the Pomeranian Bight by the Peene, Swina, and Dzwiena rivers. Intensive fishery takes place in the lower 20 km of the river and the Lagoon. Mainly targeting pikeperch, perch, whitefish (*Coregonus lavaretus* f. *balticus*) and eel (*Anguilla anguilla*). On the Polish side also bream (*Abramis brama*) and roach (*Rutilus rutilus*) are harvested commercially. Predominantly, passive gear is used such as gill-nets, trammel nets, fyke nets, eel hooks and traps. To assess fisheries intensity for the Szczecin lagoon and the lower Odra river unpublished data provided by the German and Polish fisheries inspections on the registered number and size of nets were used. on the registered number and size of nets were used. In total 267 km of gill-nets with various mesh sizes were legally used in the 6 800 ha lagoon in 1996. Additionally, approximately 5000 fyke nets and fish traps were employed.

Previous studies, based on reports on by-catch of sturgeons in the fishery (Arndt *et al*. 2000; Debus, 1997; Spratte and Rosenthal, 1998; Fillipiak, 1996; Keszka and Stepanowka, 1997) revealed that gill nets (including trammel nets) were the most effective commercial gear (Arndt *et al.* 2002). This is congruent with studies from the Atlantic coast of the USA and the Gulf of Mexico (Collins *et al*., 1996; Murawski and Pacheco, 1977) as well as from France (Rochard *et al*., 1997). Only anglers comprised a higher percentage of returns. A fact that was attributed to the more comprehensive reporting compared to commercial fishermen (Arndt *et al*., 2000).

Since gill nets are one of the main fishing techniques in the Lower Odra River and in the Szczecin Lagoon, a limitation is not considered feasible due to political concerns (J. Jennerich, Regional Research Institute for Agriculture and Fisheries of Mecklenburg-Vorpommern, pers. comm.). Attempts were therefore made to increase selectivity for of the gill nets and reduce sturgeon by-catch. The modifications of the gill nets were tested for their efficiency towards sturgeon in a pond trial prior to the test for their efficiency for the target species in the Szczecin Lagoon.

Material and Methods

Nets

Three mesh sizes are predominantly used in the gill net fishery in Szczecin Lagoon: 33, 50 and 80 mm stretched mesh. The nets were

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restricted to a height of 2.0 m to allow utilization in waters exceeding 2 m depth. Two or three nets were combined, depending upon the length of individual nets, resulting in fleets with approx. 90 - 96m in length.

The standard nets were set with the lead line holding the mesh on the bottom. Experimental nets were set with a defined space between the bottom and the net by tying the net to the lead line with spacers of nylon rope with a length of 30 and 50 cm. Thus providing “windows” on the bottom of the net being 0.3 - 0.5 m high each (Figure 1). The height of the mesh wall of the modified nets was restricted to 1.5m in order not to exceed a total height of the net of 2.0 m. The reduced surface area of the net was considered in CPUE data accordingly. Details concerning the design of the nets used are given in Table 1.

All nets were obtained from a manufacturer in the Lagoon area (TOP Marin, Stralsund) to ensure similar construcion and material as commercial nets.

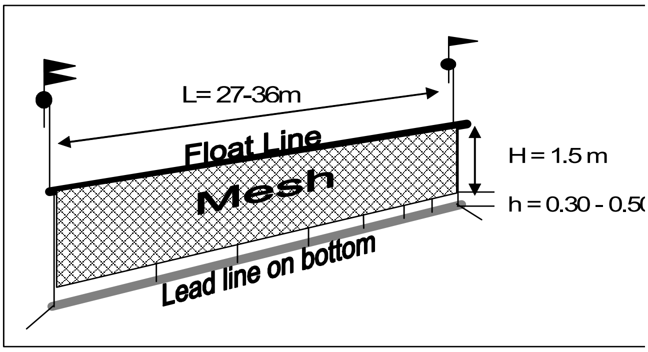

Fig. 1. Schematic model of the gill-net modification with “bottom escape windows” to reduce sturgeon by-catch in perch and pikeperch fisheries by using spacers between the bottom line and the lead line (detailed information on net characteristics are given in Table 1)

Fisheries trial 1: Sturgeon bycatch

To estimate sturgeon by-catch a stagnant earthen pond of 5 ha was stocked with 2 000 kg equalling 1 250 Siberian sturgeon (*Acipenser baerii*) with a median weight of 1,6 kg (range 0.8 – 4.5 kg, from intensive rearing at stocking densities of 20 kg/m^3 to density below 0.04 kg/ m^2. The pond was elongate, being 500 m long and 100 m wide. Towards the outlet it had an average depth of 1.8m with a maximum of 2.2m and minima of 1.5 m along the banks. The far end of the pond (40% of the surface area) was shallow, not exceeding 1.2 m being devoid of fish. The bottom of the pond was composed of sand and muddy substrate, resembling the substrate quality in the Szczecin lagoon.

The fish were allowed to adapt to the pond conditions for 6 months. The fisheries trial was started in September 2002 at water temperatures of 15°C. Trials were repeated until November 2002 when water temperatures dropped below 8°C.

In total 4 fishing trials were performed during daytime. Three nets were set in parallel to each other at a distance of 20 m. Standard nets were fished for 5 minutes, then being retrieved and cleaned. The modified nets were employed for 15 minutes before being retrieved and fish were removed. All mesh sizes were fished randomly, the relative position of the nets varied between the standard and the two modified nets from set to set. Fish were measured for total length using a meter board and collected in an aerated live-well. After nets were retrieved completely, fish were released into the pond again.

Fisheries trial 2: Catch of target species

Fisheries trials on the German part of the Szczecin Lagoon were carried out at the “Harte Schaar” on the southern banks between spring 2002 and fall 2004 at 11 occasions. Fisheries effort peaked in late fall, during the main season for perch and pikeperch.

For each trial of the 11 trials the fleets of 33 and 50 mm mesh were set, the 80mm mesh net were used on 7 occasions only. Nets were set in the evening and were retrieved in the mornings. The positions of the nets were recorded by GPS. Retrieved nets were collected in boxes. The time in the water was noted. The nets were cleaned upon return to the harbour. Fish were identified, size was measured as total length, and weight was determined at 1g below (Sartorius, Germany).

Catch data were transformed to Catch per Unit Effort (CPUE) expressed as N per m^2 per hour following the equation below:

$$CPUE= N/t/l_n/h_n.$$

Table 1
Specifications of modified and standard nets for 3 different mesh sizes used in the experimental fisheries trials between 2002 and 2004 (net code xx/yy/zz reads as xx= mesh sizes (mm); yy= height mesh wall; zz = height of bottom escape window (cm))

Net type:	XX/YY/ZZ 30 cm modified			XX/YY/ZZ 50 cm modified			XX/YY/ZZ Standard		
Stretched mesh (mm) XX	33	50	80	33	50	80	33	50	80
Height mesh wall (cm): YY	150	150	150	150	150	150	200	200	200
Spacer height (cm): ZZ	30	30	30	50	50	50	0	0	0
Dia Nylon (mm):	0.18	0.22	0.28	0.18	0.22	0.28	0.18	0.22	0.28
Floatline lift (% of lead line weight)	70%			70%			60%		
Mesh ratio (N/height)	2:1			2:1			2:1		
Length of net (cm):	3200	3200	3200	3200	3200	3200	4500	4500	4500
Length of fleet (cm):	9600	9600	9600	9600	9600	9600	9000	9000	9000

With N = Number of fish caught, t = time of net in water, l_n = Length of net, h_n = Height of net mesh area

Statistical analysis

Results are presented as the mean ± SD of *n* replicates. Data were analysed for normal distribution and equal variance (passed if $p < 0.05$) using Sigma Stat 2.0 for Windows. For pairwise comparison, the non-parametric Mann-Whitney rank sum test or parametric t-Test was applied (Zar, 1996). For multiple comparisons Tukey test or Dunn's non parametric post - hoc test was used.

Results

Sturgeon bycatch

Figure 2 gives the CPUE of sturgeons according to modifications applied. The standard gill nets resulted in such large numbers of sturgeons caught that time of the net in the water had to be reduced to 5 minutes to ensure effective net performance and subsequent survival of the fish. The total catch comprised 36, 54 and 88 fish on the 33, 50 and 80 mm mesh standard nets respectively. Average CPUE was 0.4, 0.6 and 1.07 fish/m^2/h for the 33mm, 50mm and 80 mm mesh standard nets respectively (Figure 2). The differences in CPUE between mesh sizes were statistically different (Tukey, n=6, p<0.005) for the 33 mm mesh and the 50 mm mesh when compared to the 80 mm mesh size.

Nets with 30 cm spacers totaled a catch of four fish in 9 trials. The nets with 50 cm spacers did not catch any fish. The mean CPUE data for the standard nets (0.688) exceeded those for the modified nets with 0.008 and 0.00 N/h/m^2 for the 30 and 50 cm window nets, respectively. The comparison between the standard and the modified nets revealed highly significant differences in CPUE regardless of mesh size as indicated in Figure 2.

The modified nets with 30 cm "windows" resulted in a total of four fish, the nets with 50 cm "windows" did not catch any sturgeon. Statistically, the catch in the 50 cm window size nets wasn't significantly lower than in the 30 cm window nets (Tukey, n=9, p=0,744)

Performance for target fish

The fisheries trials for target fish in the Szczecin Lagoon resulted in a major proportion of the catches occurring in the nets with the smallest mesh size. This was also reflected in the size range of the main target species. The total catch in the 33 mm mesh size exceeded that in 50mm mesh size by 95.5% in perch, 94.1% in pikeperch, and 85.8% in roach. The only exception was observed in bream where catches were similar in 50mm and the 33mm stretched mesh nets (48.4.% of the fish were caught in the 50 mm and 44.4% in the 33 mm mesh nets). Systematic comparison of catches between nets with 50 and 80 mm mesh-sizes was rendered impossible due to the low sample sizes that did not allow statistical treatment between different groups. To avoid misinterpretation, the detailed analysis of the data is restricted to the catch of the 33 mm nets.

CPUE data in the 33 mm mesh nets revealed different trends for the different species according to net type (Figure 3). In pikeperch, the nets with 30 cm "windows" did result in comparable CPUE data as in the standard nets while the 50 cm "window" net comprised approximately 50% of the catch in standard nets, being significantly lower (Mann Whitney, P<0.001).

In perch, the modified nets with 30 cm and 50 cm "windows" resulted in CPUE of 0.001 and 0.0006, respectively, this comprising only 25 and 12% of the CPUE with standard gear (CPUE = 0.004). This was the most significant (30 cm windows; 50 cm windows) reduction in CPUE in all species investigated.

In roach the standard and 30 cm "window" nets resulted in CPUE values (0.018 and 0.011 respectively) not being significantly different (Tukey, n=10, p>0.05). The 50 cm "window" nets only accounted for 50% of these values and resulted in a signifi-

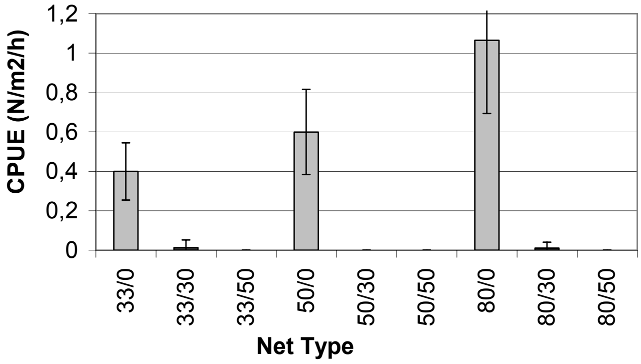

Fig. 2. Catch per unit effort (CPUE = N/m^2/h) of sturgeon in fishing trials under pond conditions given as mean values and standard deviation (vertical bars) with standard and modified gill-nets on the ordinate (net code xx/yyy/zz reads as xx= mesh sizes (mm); yyy= height of mesh wall (cm); zz = height of bottom escape window (cm))

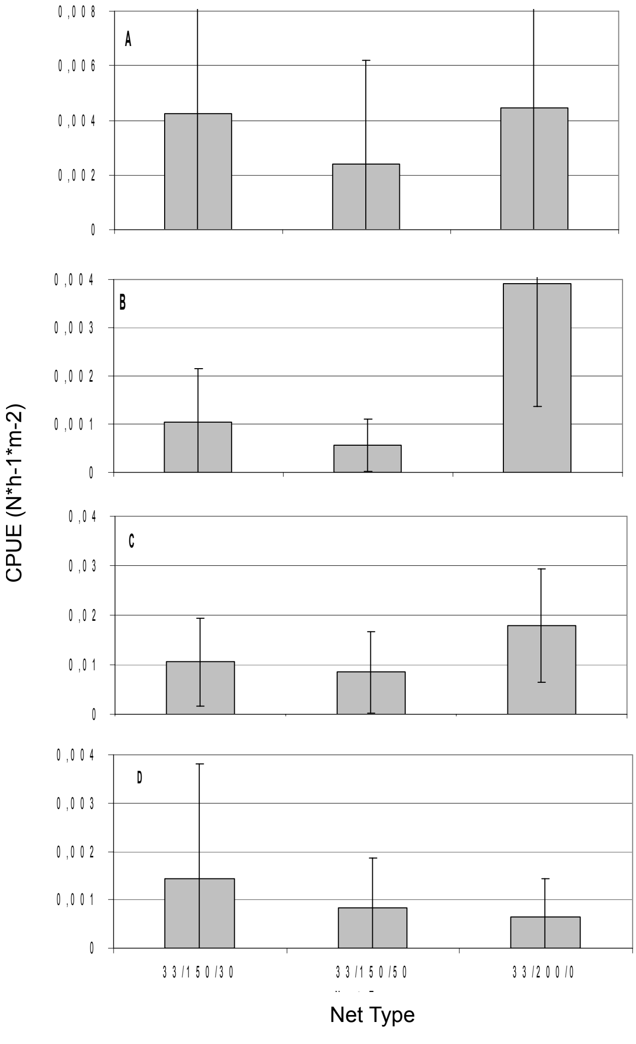

Fig. 3. Catch per unit effort (CPUE = N/m^2/h) with modified and standard of 33 mm mesh size (net code xx/yyy/zz reads as xx= mesh sizes (mm); yyy= height of mesh wall (cm); zz = height of bottom escape window (cm)) for four main commercial species (*A=Sander lucioperca, B=Perca fluviatilis, C=Rutilus rutilus,* and *D=Abramis brama*) during 11 fisheries trials in Szczecin Lagoon

cant difference (Tukey, n=10, p<0.05). No significant effect was observed between the CPUE for bream catches in different nets.

No statistical significant differences were found in the length composition (Figure 4) of the catches for the standard with the 30 and 50 cm "Window" nets of 33mm mesh for pikeperch, perch, roach or bream. Nevertheless, despite of the differences not being significant, the fish caught in nets with 50 cm "windows" were apparently larger (34.05 cm) than in 30 cm "window" and standard nets (29.87 cm and 29.88 cm, respectively).

The 0-catch for all species in the 30 cm "window" nets attributed to 35% of the fishing effort whereas in the standard nets the 0-catch only comprised 17.5% of the effort (Figure 5). No significance was detected in the differences between the standard and the modified nets for this criterion (Dunn's, p>0.05). The 50 cm "window" nets, resulting in 37.5% of the trials being 0-catch, did not differ significantly (Dunn's, n=10, p>0.05) from the values for the standard and the 30 cm nets neither.

For pikeperch the 30 cm window nets resulted in 70 % of the trials that did not catch a fish. This result was significantly (Mann Whitney, n=10, p<0.024) lower than that in the standard nets with 20% of the trials being without success (Figure 6). In the 50 cm "window" and standard nets 0-catches attributed to 50 % of the trials. This result was not significantly different from that of the standard net. In roach and perch, standard gear did result in 0-10% of 0-catches and provided a rate catch in the modified nets.

Discussion

The experiments under pond conditions have shown, that lifting the nets from the bottom for as little as 30 cm is sufficient to substantially reduce the by-catch of sturgeons in this type of gear in the pond trials. This modification resulted in an efficient reduction in catch of Siberian sturgeon from an average Catch Per Unit Effort (CPUE) of 0.4 – 1.05 fish per hour per m^2 for the standard net by 99% for the modified nets respectively.

The fact that the CPUE of the nets increased with mesh size is attributed to the size of the sturgeons in the pond trial. For the average size fish of 72.4 ± 10.56 cm to be caught in the 33 mm mesh, it was necessary to completely entangle in the smaller mesh sizes since the mesh was too small to trap the fish by the gills. This explanation obviously was valid for the 50 mm mesh too, which

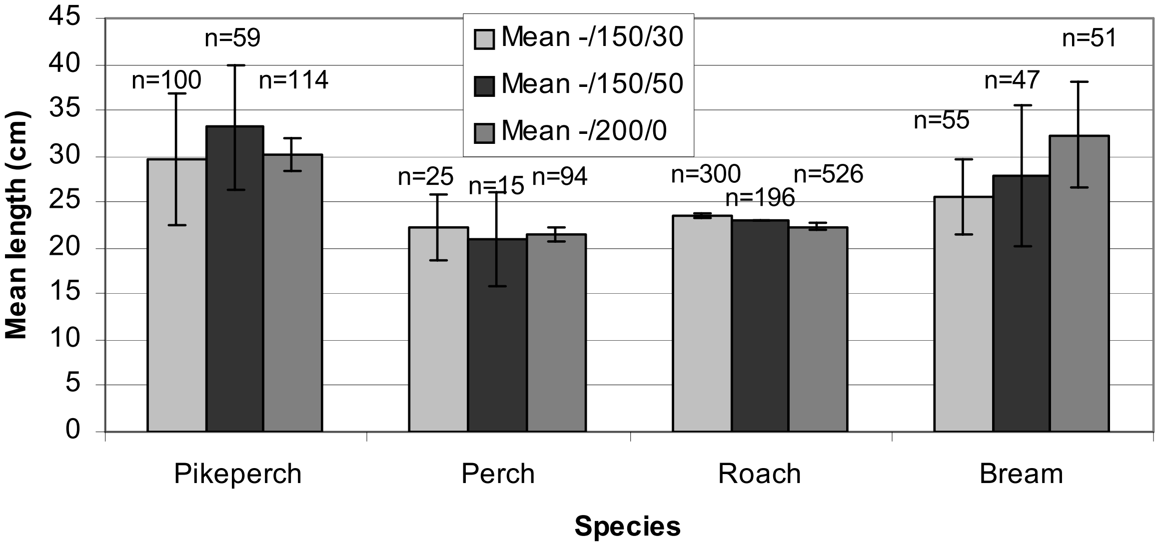

Fig. 4. Length distribution (mean and standard deviation) of four main commercial species (*Sander lucioperca, Perca fluviatilis, Rutilus rutilus,* and *Abramis brama*) in Szczecin Lagoon with modified and standard nets (net code xx/yyy/zz reads as xx= mesh sizes (mm); yyy= height of mesh wall (cm); zz = height of bottom escape window (cm)) of all mesh sizes in a total of 29 fisheries trials; the number of fish caught are indicated as n

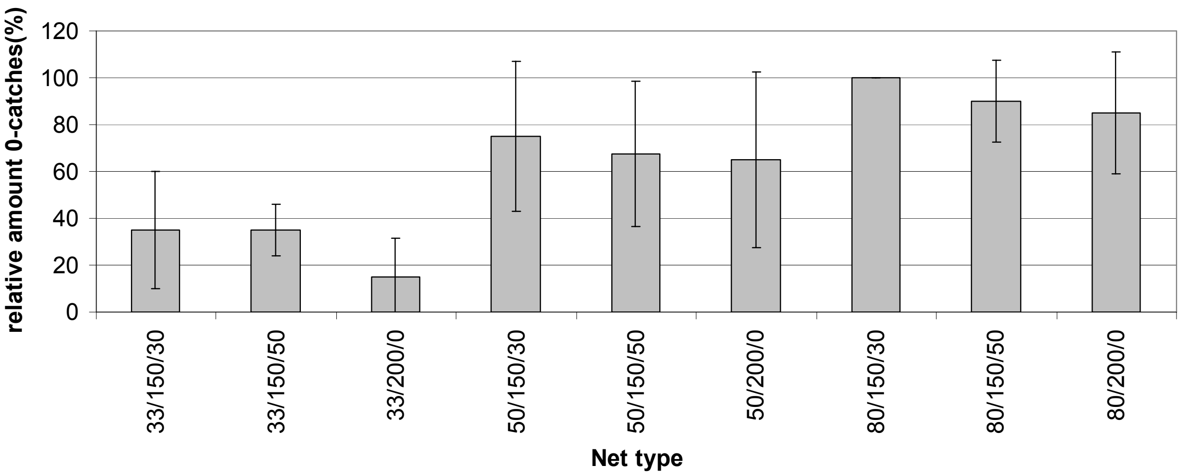

Fig. 5. Mean number of 0-catches of standard and experimental nets during the fishing trials in Szczecin Lagoon according (net code xx/yyy/zz reads as xx= mesh sizes (mm); yyy= height of mesh wall (cm); zz = height of bottom escape window (cm))

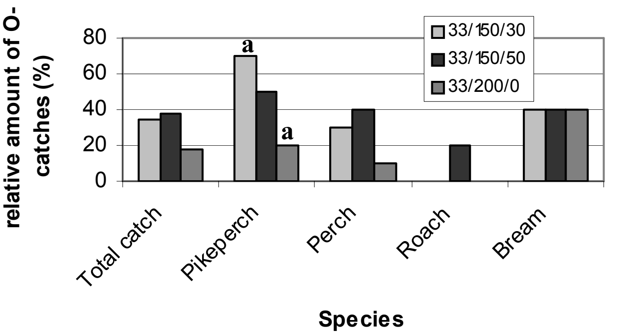

Fig. 6: Proportion of 0-catches according to species in 33mm mesh nets with standard and experimental nets (net code xx/yyy/zz reads as xx= mesh sizes (mm); yyy= height of mesh wall (cm); zz = height of bottom escape window (cm)), similar letters in the figure indicate significant intraspecific differences (Mann-Whitney , p>0.05)

revealed a significantly (0.6±0.21 vs 1.06±0.27, Mann Whitney, P< 0.05) lower CPUE than the 80mm mesh.

In the catch trials for target fish, carried out in Szczecin Lagoon, the main drawback resulted from the size distribution of the catch. This was comprised to a large extent of sub-legal size fish on the 33 mm mesh. Larger mesh sizes as a consequence did reveal significantly (Dunn's, n=20, p<0.05) higher proportions of 0-catches (68.4% vs 28.3% in 33mm mesh). This circumstance was accompanied by low mean lengths of the main target fish in the catch of the larger size mesh, indicating that the stocks suffer from severe overexploitation. This lack of sufficient sized target fish does limit the conclusions based on the results of the study.

Nevertheless, the CPUE for the different net types indicate that significant differences were observed between standard and modified nets in perch, where modified nets resulted in a total catch that comprised 26-27% of the standard net only. In pikeperch, the results for the different nets were comparable for the 30 cm and for the standard nets. Nevertheless, the results are strongly influenced by mass catches in two out of 10 trials that dominate the overall results. The 0-catches for pikeperch in the standard compared to the 30cm window nets are statistically significant –lower. . A fact that was not observed in perch, roach and bream. This result indicates that caution is required with regard to the effectivity of the 30cm window nets. There is at least a chance that these nets might catch lower numbers of pikeperch compared to the standard nets.

Fishing intensity in the lower Odra River is considered to be a major obstacle for the success for the remediation of the Baltic sturgeon (Gessner and von Nordheim, 1998; Gessner *et al*. 1997). Based on the catch data of exotic sturgeon species (Arndt *et al*., 2000) the main commercial fishing technique contributing to the recorded catches is gill-netting. Based on the available data on bycatch, the potential impact of the gillnet fishery in the coastal Baltic waters could be detrimental for the planned sturgeon remediation because the main target fishes are demersal too (Szczerbowski, 1995). For this reason the attempt to modify the nets in order to improve the survival of the sturgeon was considered inevitable (Gessner *et al*. 2003).

The introduction of the modified nets in the commercial fishery of the Szczecin Lagoon will have to be preceded by additional tests to evaluate the effect of the modification in the commercial fishery with increased proportions of legal sized fishes. Other alternatives to reduce by-catch include closed seasons and closed areas as well as materials to make the nets less efficient for sturgeons. One prerequisite is a detailed study on the size and migration of sturgeons upon release to identify the critical size windows and time slots for the fishery. This might help to select mesh sizes that are more probable to result in low by-catch ratios. Additionally, the coloration of the mesh as performed in gill net fisheries along the Caspian Sea (M. Pourkazemi, pers. comm.) might be a feasible approach to reduce the by-catch efficiently.

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