pp. 83-90

10. Does the monofilament nylon gillnets catch double more fishes than conventional multifilament gillnets in Danube delta: myth or reality?

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Abstract: The monofilament gillnets are prohibited by law for fishing in Romania. There is an untested myth among Romanian fishery stakeholders and folks that monofilament nylon gillnets have double times fishing catch than conventional multifilament gillnets. This myth provoked controversial debated between the fishermen, administrators and conservationist for the regulation purpose. To answer this dilemma in year 2014, fish fauna from Danube delta lakes was sampled with two type of research Nordic gillnets, multifilament (MF) gillnets versus monofilament (MO) gillnets (European Standard CEN EN14757:2015(E). Both types of fishing gears were randomly assembled from 12 mesh panels with mesh sizes of 5, 6.25, 8, 10, 12.5, 15.5, 19.5, 24, 29, 35, 43, 55 mm knot to knot. To compare fishing efficiency of two types of gillnet, 4 largest lakes inside of the Danube delta, respectively Furtuna, Merhei, Isac and Roșu lakes were sampled. The relative abundance and biomass, standardized as Catch per Unit of Fishing Effort (CPUE), expressed as number or weight per 100 m^2 of gillnets per night fishing, were estimated. Accordingly with sampling test, MO gillnets caught in average more than two times more fish in abundance and/or biomass than MF gillnets. The figures are different by species, season and lake. Considering this proven of evidence, it is a policy and societal choice for future MO gillnets fishing regulation. Management regulation of MO gillnets, should consider both, socio-economic benefits and environmental impacts for sustainable use of fish resources. Simply management approach of permitting double efficient MO gillnets for more effectiveness fishing, require at least half decrease of fishing effort or capacities. That means half cutting off of the number of the fishermen permits or fishing time or number of gears or a combination of these measures, in order to maintain at least actual fishing pressure and avoid overfishing risk. Since the result refer to research sampling gillnets, future fishing selectivity study of the commercial MO, MF as well as multi-monofilament gillnets (MM) is needs.

Keywords: Nordic gillnets, monofilament gillnets, multifilament gillnets, fishing, CPUE, Danube delta, freshwater fishes.

INTRODUCTION

Fishing is meaning harvesting of fish that was made at the beginning of human evolution with the hands, and afterward by using spears, hooks, and nets gears. The fishing technique has had evolving from artisanal for local consumption to industrial for world food supply in modern time. A revolutionary fishing efficiency was by replacing cotton material for fishing nets with synthetic fibres in years ‘1960s.
The hemp, was almost only material using for fishing nets until 1900 when it found competition in the form of cotton especially in herring nets, but hemp and cotton was replaced in years 1950’ by polyamde (nylon), synthetic fibres, which was described as a fever (Martinussen A.O, 2006). Japan and Norway was on the first nation fisheries that tested new synthetic material. The gillnets are one of the most used fishing gears that benefit from new synthetic fibres.
The change from cotton to nylon thread for gill nets in 1949–52 resulted in a sharp increase in the efficiency of the most important gear used for taking lake trout in Lake Superior, where nylon nets were 2.25 times more efficient as cotton nets for taking legal-sized fish and 2.8 times more efficient for undersized lake trout, since, the relative efficiency of cotton and nylon nets showed no trend during the season (Richard L. Pycha, 1962).

Modern gillnets are made of monofilament (MO), multimonofilament (MM) or multifilament nylon (MM). Monofilament nets are made by simply using the monofile nylon thread. Combining a number of such monofilaments in parallel makes a multimonofilament strong thread. Multifilament consists of thin synthetic fibres twisted together to form a strong string (Hovgård, H., Lassen, H., 2000).
The old gillnets made from cotton was used successfully in Romanian fishery between the two World Wars (Bacalbasa-Dobrovici N., 1965) and new multifilament synthetic gillnets are the most commonly actual used in Romania fisheries (Adam ***et al.***1981).
Multifilament nets (MF) are considered the least effective but the most sustainable and multi-monofilament nets (MM) are considered the most effective fishing. Same time, multifilament nets (MF) are considered the less selective compared to the others because of unwanted species such as crayfish tangling, crabs, fish with shields (sturgeon), and make untangling nets being undermined (Hovgård, H., Lassen, H., 2000).
Different material qualities nets lead to a fish species specific use. In Denmark for example multifilament nets (MF) are used as fishing for flatfish as trammel nets, multi-monofilament nets (MM) are used for fishing for cod and for hake certainly use monofilament (MO) nets (Hovgård, H., Lassen, H., 2000).
More scientific comparisons were made between monofilament nets (MO) and multifilament (MF) along the time. The results are quite contradictory. Some studies (Predel, 1963, Washington 1973) found multifilament nets (MF) superior to monofilament (MO), while other studies indicate otherwise (Hylen and Jacobsen 1979). Studies for several species have shown that differences could be species dependent, while other studies have observed a total catch equal between monofilament (MO) and multifilament (MF) nets (Jester 1973), while there is a clear difference between species. Henderson and Nepszy (1992) found a higher total catch in monofilament nets (MO), but captures a 7 of 23 species was higher in multifilament nets (MF). Machiels et al. (1994) found monofilament nets (MO) more effective for zander (*Sander lucioperca*) and multifilament nets (MF) effective for bream (*Abramis brama*).

Steward (1987) compared the nets used in the United Kingdom for code and found that multifilament nets (MF) captures better than multi-monofilament nets (MM) as well as the monofilament (MO). The differences can be attributed to how the fish is caught in the net, so monofilament nets (MO) captures better by yoking, the multifilament (MF) and multi-monofilament (MM) captures and entangling / suspension because the monofilament nets (MO) are more strong and elastic, and the two materials are softer.
The lack of understanding of the importance of accurate hardness / softness texture complicates their comparison between different materials. In a study of fisheries in the Bay of Biscay, using trammel nets Sole (*Solea solea*), multi-monofilament nets (MM) were generally found to be more effective than multifilament nets (MF) (EU 1997). However, due to limited availability of various materials for nets, the two sets of nets cannot be fully standardized and will notice considerable differences between the nets with the same eye catches of the two materials.
To capture of Common carp (*Cyprinus carpio*) and gibel carp (*Carassius gibelio*) in two lakes in Turkey, trammel nets with inner wall (thick) from monofilament net (MO) were 3.7 times more effective for carp and 2.7 times for gibel carp than multifilament (MF) (Balik & Cubuk 2004). No differences were observed due to the different material for outside walls net.
In conclusion the results of research shows "in general" greater efficiency for monofilament nets (MO) than the multifilament (MF), but result out of generality dependent on type of gill net, habitat, species, form and size of fish.
In Romania the using of MO or MM gillnet or trammel nets are prohibited by the law, considered by the administrators highly efficient, conservation fish threat used especially by the poachers. Since a large debate for allowing or not of using mono or multifilament nets in Romanian water and fish species, no studies are knowing.

MATERIAL AND METHODS

To answer to this issue, a comparative study on the effectiveness and efficiency of the different material type of Nordic gill nets (MO vs. MF) and their uses was conducted in four large (1000-5000 ha) and shallow (1.2-3.0 m depth) Danube delta lakes, respectively Furtuna, Isac, Merhei, Roșu lakes (**Fig.1**).

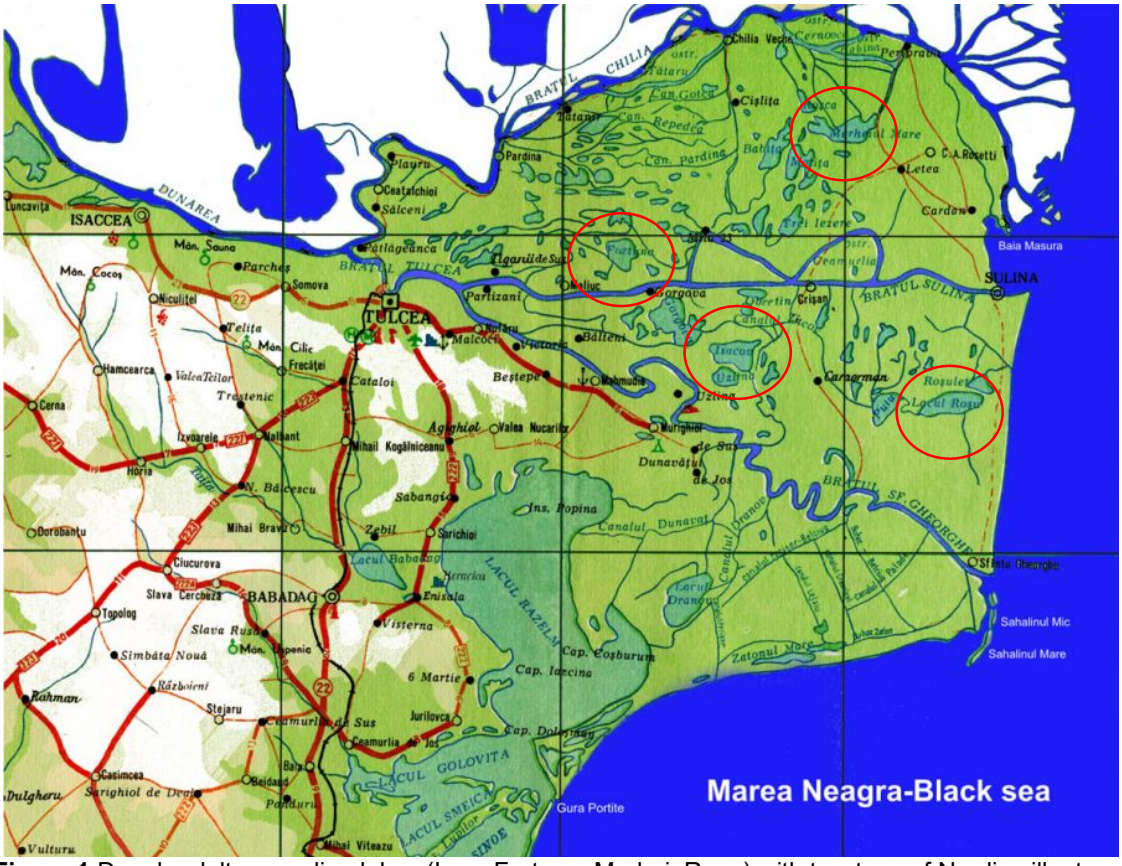

Figure 1 Danube delta sampling lakes (Isac, Furtuna, Merhei, Roșu) with two type of Nordic gillnets

Monofilament (MO) and Multifilament (MF) Nordic research gillnets, European standard type (CEN EN 14757:2015(E)) were tested for fish sampling efficiency comparison in Danube delta lakes. Both types of fishing gears were constructed from 12 panels with mesh sizes of 5, 6.25, 8, 10, 12.5, 15.5, 19.5, 24, 29, 35, 43, 55 mm knot to knot, randomly assembled. The MO gillnets were 1.5 m high since MF gillnet is 1.8 m high, both being 30 m long. In order to compare, fish abundance and biomass was calculated as Catch per Unit Effort (CPUE) to a standard surface of 100 m^2 gillnets, respectively no. of individual or kg per 100 m^2 gillnet.
To compare fishing efficiency of two types of gillnet, in year 2014, 4 largest lakes inside of Danube delta, respectively Furtuna, Merhei, Isac and Roșu lakes were sampled with an total fishing effort of 142 gillnets night, respectively 71 MO and 71 MF gillnets (**Tab.1**).

Table 1 Fish sampling effort (CPUE=no. gillnets nights) of MO and MF gillnets in 4 Danube Delta lakes in year 2014

Lake/Type of gillnets	May	July	Sep	Total 2014
Furtuna lake	10	12	12	34
MO	5	6	6	17
MF	5	6	6	17
Isac lake	12	12	12	36
MO	6	6	6	18
MF	6	6	6	18
Merhei lake	12	12	12	36
MO	6	6	6	18
MF	6	6	6	18
Roșu lake	12	12	12	36
MO	6	6	6	18
MF	6	6	6	18
Total lakes	46	48	48	144
MO	23	24	24	71
MF	23	24	24	71

RESULTS AND DISCUSSIONS

Monofilament MO gillnets caught in total more than two times fish in abundance and/or biomass than MF gillnets, with ratio MO:MF range between 2.4 and 2.8 (**Fig.2**)

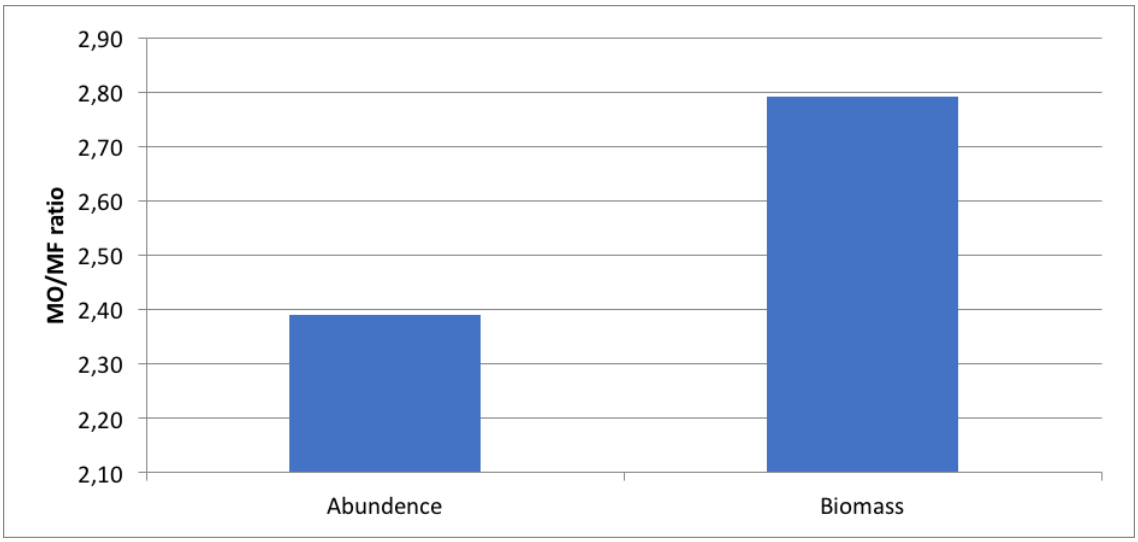

Figure 2 Total catch ratio of Momofilament (MO) : Multifilament (MF) in abundance and biomass

Overal, abundance and biomass were grater in MO gillnets (71-74%) than in MF gilnets (26-29%) (**Fig.3**).

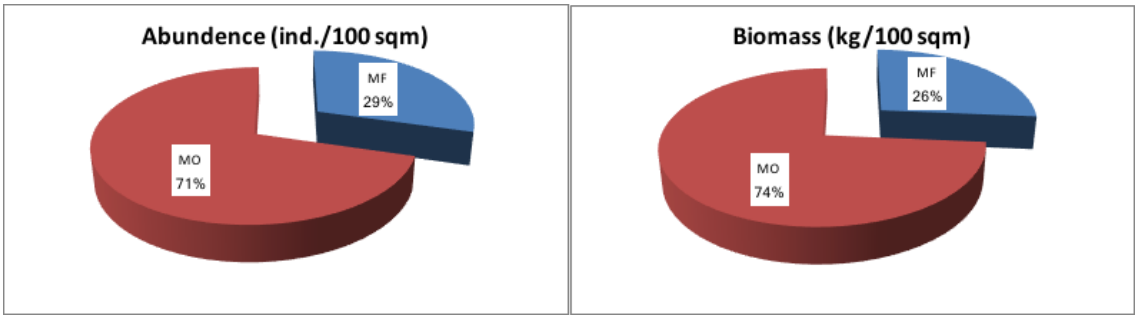

Figure 3 Relative of Abundance (left) and Biomass (right) of Momofilament (MO) vs Multifilament (MF) Nordic gillnet catches

From analysis of species richness, again MO gillnet are more efficient catching 32 fish species, while MF gillnets was caught 27 fish species, generally small size species as *Cobitis sp.*, *Knipowitschia caucasica, Leucaspius delineates* and *Pungitus platigaster*, beside large *Abramis brama* were caught only in MO gillnet (Table 2).

From those 27 species caught in both type of gillnets, analysed by abundance ratio (MO/MF), 20 species where more caught in MO gillnets, 5 more in MF gillnet (*Cobitis sp., Leuciscus aspius, Neogobius fluviatilis, Pseudorasbora parva, Sander lucioperca,* and *Tinca tinca*), and 2 were equal caught (*Lepomis gibbosus* and *Silurus glanis*). Analysing by biomass ratio (MO/MF), fish species where almost equally distributed between MO and MF gillnet, respectively 15 fish species with larger biomass were recorded in MO, while 12 species with larger biomass were caught in MF gillnets. However due to large average range of MO/MF ratio in both abundance (0.52-3.08) and biomass (0.62-6.23), per total catch, MO gillnets are more efficient than MF gillnets, and due to multiple mesh size, from 5 to 55 mm mesh size, sometime MO gillnet catch more individuals but with low biomass or less individuals but larger biomass, depending also from fish size.

Table 2 Fish species richness and fishing efficiency in monofilament (MO) gillnets vs multifilament (MF) gillnets

		Average abundance (ind/sqm net)			Average Biomass (g/sqm net)		
No	Species	MO	MF	MO/MF	MO	MF	MO/MF
1	*Abramis brama*	10.4	-	-	812.2	-	-
2	*Alburnus alburnus*	217.4	188.6	1.15	796.1	805.5	0.99
3	*Alosa tanaica*	30.1	16.9	1.78	1452.7	684.9	2.12
4	*Atherina boyeri*	12.0	7.0	1.71	69.3	24.1	2.88
5	*Blicca bjoerkna*	46.4	16.0	2.90	1162.5	933.1	1.25
6	*Carassius carassius*	2.2	1.9	1.20	17.0	94.4	0.18
7	*Carassius gibelio*	13.9	8.4	1.66	2504.4	1923.0	1.30
8	*Clupeonella cultriventris*	67.1	39.5	1.70	137.8	86.6	1.59
9	*Cobitis elongatoides*	52.3	50.0	1.05	145.6	186.8	0.78
10	*Cobitis megaspila*	2.2	-	-	6.7	-	
11	*Cyprinus carpio*	2.2	1.9	1.20	658.2	866.2	0.76
12	*Esox lucius*	13.6	10.3	1.32	6859.1	4495.8	1.53
13	*Gymnocephalus cernuus*	28.5	15.5	1.84	317.8	140.9	2.25
14	*Knipowitschia caucasica*	6.7	-	-	4.4	-	-
15	*Lepomis gibbosus*	22.6	22.7	1.00	564.9	912.0	0.62
16	*Leucaspius delineatus*	37.1	-	-	17.9	-	-
17	*Leuciscus aspius*	6.3	12.0	0.52	147.4	543.5	0.27
18	*Misgurnus fossilis*	3.3	1.9	1.80	96.7	35.2	2.75
19	*Neogobius fluviatilis*	11.6	15.0	0.77	46.2	66.0	0.70
20	*Perca fluviatilis*	50.9	24.9	2.05	1750.8	613.6	2.85
21	*Perccottus glenii*	16.6	9.5	1.75	147.2	23.6	6.23
22	*Petroleuciscus borysthenicus*	3.3	2.7	1.23	16.5	18.8	0.88
23	*Proterorhinus marmoratus*	33.9	12.0	2.81	57.6	13.9	4.15
24	*Pseudorasbora parva*	14.8	16.7	0.89	36.2	40.9	0.88
25	*Pungitius platygaster*	14.4	-	-	14.4	-	-
26	*Rhodeus amarus*	132.2	73.6	1.80	224.1	131.9	1.70
27	*Rutilus rutilus*	82.3	26.8	3.08	1146.0	504.8	2.27
28	*Sander lucioperca*	6.5	7.4	0.88	931.3	254.6	3.66
29	*Scardinius erythrophthalmus*	35.5	18.9	1.88	1446.8	914.0	1.58
30	*Silurus glanis*	7.7	7.7	1.00	3074.7	4209.3	0.73
31	*Tinca tinca*	9.9	12.6	0.78	1627.8	1831.0	0.89
32	*Vimba vimba*	3.7	1.9	2.00	63.0	74.1	0.85
	Species richness (no)	32	27		32	27	

Comparing lakes abundance expresed as average Number Per Unit Effort (NPUE ind/100 sqm gillnet) and biomassa as average Biomass Per Unit Effort (BPUE g/100 sqm gilnet), it shown same figure, two timeas greather catch in MO than in MF gilnets (**Fig.4**).

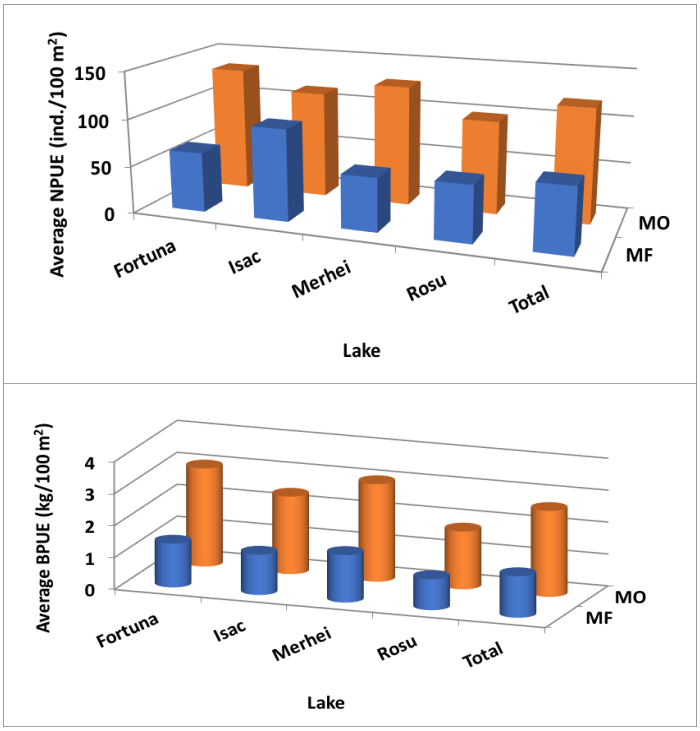

Figure 4 Comparation of MO and MF gillnets catch per lake in abundance (above) and biomassa (below)

Multifilament (MF) synthetic gillnets catch very well in turbid water and despite collect a lot of dirt and are more difficult to handle fast, they replaced old cotton nets and today are large used being only legally allowed for fishing in Romanian waters, since worldwide fisheries evolved to monofilament (MO) and multi-monofilament (MM) gillnets.
Multi-monofilament (MM) gillnets is almost exclusively used in modern gillnet fisheries in the world. These nets are easier to handle than monofilament nets and does not collect as much debris as the old multifilament nets. Their catch-efficiency is probably a bit less than monofilament, but in a modern gill-net fishery they would be seen as a natural solution, e.g. *Tinca tinca* is 2 time more caught in individuals in MO gillnets, but less 0.85 time in biomass.

However, results on efficiency are contradictory and different by location, species and fish size (Henderson and Nepszy 1992, Hylen and Jacobsen 1979, Jester 1973, Machiels et al., 1994P, Predel 1963, Washington 1973).
In France, in the Garonne basin for example, the fishermen report that the multi-mononofilament is more efficient than the monofilament because of the transparency of the (trammel) net and it constant behaviour in water (no change in weight). But all depends of the species and its specific behaviour, of the hydrodynamic context, this efficiency can vary and can be lower than for others kind of nets, made of different materials and differently weighted. It is a very complex question which has been certainly studied for a part by IFREMER in France but for which, only the experienced fishermen can give an answer.

Greek trials for sole show that the old multifilament nylon nets caught better than multi-monofilament nets.
Nobody can answer without a study whether these gillnets have a significant negative impact of fisheries resources. The impact largely depends on how much fishing effort there is, what is the mesh size of these gillnets and what is the condition of the stocks. It is believed that the amount of fishing effort, not the fishing gear, should be the main issue.
Not only the material of the net is significant, the regulation of the mesh size is also important to avoid the capture of juvenile fish, but the configuration and the operation of the net, in addition, the fishers may opt to use trammel nets, these nets use three panels of netting in the same net and may be classed as a gill net, these nets are less selective and not only catch the fish by gilling but also by entangling them.

CONCLUSIONS

Certainly, Nordic monofilament gillnets fishing efficiency is two time more than Nordic multifilament gillnets for total or average abundance and biomass on fish species from Danube delta lakes.
The fishing regulation of MO gillnets is a policy and societal choice. It should consider both, socio-economic benefits and environmental impacts for sustainable use of fish resources.
Management approach of permitting double efficient MO gillnets for more effectiveness fishing, require at least half decrease of fishing effort, in order to maintain at least actual fishing pressure and avoid overfishing risk.
Future fishing species and size selectivity for commercial MO, MF fishing gears as well as multi-monofilament gillnets (MM) is needed.

SUMMARY ON ROMANIAN LANGUAGES

Setcile monofilament sunt interzise prin lege la pescuit în România. Există un mit netestat printre părțile interesate din sectorul pescăresc din România și publicul larg și anume că setcile de nylon capturează de două ori mai mult decât setcile multifilament din fibre sintetice convenționale. Acest mit proavoacă controverse între pescari, administratori și ecologiști în privința reglementăriilor. Pentru a răspunde la această dilemă, în anul 2014 a fost eșantionată fauna piscicolă din lacurile din Delta Dunării cu ajutorul a două tipuri de setci nordice de cercetare, setci multifilament (MF) și setci monofilament (MO) (standard european CEN EN14757: 2015 (E) Ambele tipuri de unelte de pescuit au fost asamblate în mod aleatoriu cu 12 panouri din plasă cu ochiuri de dimensiuni de 5, 6,25, 8, 10, 12,5, 15,5, 19,5, 24, 29, 35, 43, 55 mm nod cu nod. Pentru a compara eficiența pescuitului acestor două tipuri de setcă, au fost eșantionate 4 din cele mai mari și reprezentative lacuri din interiorul Deltei Dunării, respectiv lacurile Furtuna, Merhei, Isac și Roșu. Abundența și biomasa relativă, standardizate la Captură Pe Unitate de efort de Pescuit (CPUE), au fost estimate ca număr sau greutate per 100 m^2 de setcă per noapte de pescuit. Rezultatele testului de eșantionare au demonstrat o capturtă medie a setcilor MO de cel puțin două ori mai mare în abundență și / sau biomasă decât captura medie a setcilor MF. Cifrele sunt diferite în funcție de specie, anotimp si lac. Având in vedere această dovadă, reglementare introducerii sau prohibirii la pescuit a setcilor monofilament este o decizie politică care trebuie să țină cont de nevoile actuale socio-economice ale comunităților pescărești și dezideratul pe termen lung al societății de conservare a biodiversității și resurselor pescărești. Managementul de reglementare a setcilor MO ar trebui să ia în considerare atât beneficiile socio-economice cât și impactul asupra mediului pentru utilizarea durabilă a resurselor de pește. Conceptul simplu de management al efortului de pescuit presupune că folosirea setcilor MO (cu dublă eficiență față de setcile MF) necesită cel puțin o înjumătățire a efortului sau a capacităților de pescuit. Asta înseamnă că trebuie reduse la jumătate fie numărul permiselor pescarilor sau a timpului de pescuit sau a numărul de unelte de pescuit sau o combinație a acestor măsuri, în scopul de a menține presiunea pescuitului la nivelul celui de utilizare actuală a setcilor MF, pentru a evita riscul de suprapescuit. Având în vedere că rezultatul se referă la eșantionarea ihtiofaunei cu setci Nordice de cercetare, sunt necesare viitoare studii comparative asupra selectivității pe specii, lungimi și greutăți a setcilor comerciale MO și MF precum și asupra setcilor multi-monofilamente (MM).

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