Turk. J. Fish.& Aquat. Sci. 19(8), 699-705
http://doi.org/10.4194/1303-2712-v19_8_08

RESEARCH PAPER

Turkish Journal of FISHERIES and AQUATIC SCIENCES

Rate and Causes of Lost "Gillnets and Entangling Nets" in The Black Sea Coasts of Turkey

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Article History
Received 30 October 2017
Accepted 07 August 2018
First Online 29 August 2018

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Keywords
Abandoned
Lost or discarded fishing gear (ALDFG)
Derelict fishing gear (DFG)
Gillnet
Ghost fishing

Abstract

In this study, we determined the numbers of gillnets and entangling nets used throughout the Black Sea coasts of Turkey. In addition the number of nets lost over a one year period and principal causes of loss were also calculated. Field studies were carried out at 158 fishing ports in 15 provinces between February 2015 and December 2016. All nets from 3372 fishing boats were counted to determine the total number of gillnets and entangling nets. In order to determine numbers of lost nets, we conducted personal interviews with the skippers of 315 randomly selected fishing boats. Gillnets and entangling nets in the region were divided into 5 categories (Turbot, Whiting, Bonito, Red mullet and Other sp. net) according to target species. Calculations revealed the total number of net panels as 107331 panels. The total number of Turbot, Whiting, Bonito, Red mullet nets and Other sp. net panels were found to be 47144 (43.92%), 22919 (21.35%), 17366 (16.18%), 10461 (9.75%) and 9441 (8.80%) respectively. The average amounts of nets lost per fishing boat were estimated as 2.22±0.74, 1.54±0.47, 0.83±0.43, 1.57±0.57 and 1.56±0.11 panels respectively. The total amount of panels lost throughout the Black Sea was determined as 1626.83 (1.52%) panels/year.

Introduction

Throughout human history since fishing activity began, fishing gear has been abandoned or lost at sea. However, expansion in the fishing industry and recent developments in technology have led to a significant increase in the quantity of fishing gear. In addition, non-degradable synthetic materials are now used in the construction of fishing gear (plastic particles may take up to 500 years to decompose (UNESCO, 1994) - resulting in long-term effects on and persistence in the marine environment. Such changes have enabled the negative effects of lost fishing gear on marine organisms and environment to reach a remarkable scale, apparent from the broad range of topics investigated by many researchers: Effects of lost fishing gear on the economically viable stocks (Breen, 1987; Humborstad, Løkkeborg, Hareide, & Furevik, 2003; Santos, Saldanha, Gaspar, & Monteiro, 2003b), Mortality of sea mammals, turtles and marine birds by accidental entanglement (Derraik, 2002; Laist, 1997; Schrey & Vauk, 1987), Damage to seabed and coral reef habitats (Chiappone, Dienes, Swanson, & Miller, 2005; Eno *et al*., 2001; Matsuoka, Nakashima, & Nagasawa, 2005), Risks for sea navigation and economic losses (Brown & Macfadyen, 2007; Macfadyen, Huntington, & Cappel, 2009; Morishige & McElwee, 2012).

Lost or abandoned fishing gear which continues to capture fish and other marine life without human control is defined as Ghost fishing. The impact of ghost fishing is also dependent on the type of derelict fishing gear. Fishing gear requiring active human control such as trawl nets and purse seines, may become virtually inert and probably catches insignificant numbers of animals after becoming derelict. By contrast, gear which normally fishes passively, such as traps, and gillnets, may continue to fish at significant rates after loss/abandonment. The main issues caused by ghost fishing are therefore related to passive fishing gear and the subsequent mortality caused. In order to estimate mortality rates, it is first necessary to determine the amount of fishing gear lost over a specified time period, however, such relevant information is limited. The lack of data makes it difficult to predict the extent of the effects of lost fishing gear on marine organisms and the surrounding ecosystem. A number of researchers have tried different methods to determine amounts of lost fishing gear. Matsuoka, Osako, and Miyagi (1997) determined the numbers of lost finfish cages in Japan by scuba diving. Stevens, Vining, Biersdorfer and Donaldson (2000) employed side scan sonar to estimate the amount of lost crab cages in Alaska. Needless to say, the use of direct underwater observation methods such as scuba in large marine areas and under different environmental conditions requires intensive labor costs and other expenses. For these reasons, in recent studies, it has been preferred to establish quantities of lost fishing gear through dialogue with fishermen (Ozyurt, Mavruk, & Kiyaga, 2012; Santos, Saldanha, Gaspar, & Monteiro, 2003a; Yildiz & Karakulak, 2016).

The most important marine fishing region of Turkey is the Black Sea from which more than 70% of the total fishery production is obtained. For this reason, there is a large fishing fleet operating in the region. An important of this fishing fleet operates using different types of gillnets and entangling nets (set gillnets, drifting gillnets, encircling gillnets and trammel nets) to catch target species such as Turbot, Whiting, Bonito and Red mullet. However, no numerical data exists about total numbers of gill nets and entangling nets used and lost in the region.

In this study, we determine the total numbers of gillnets and entangling nets used throughout the Black Sea coasts of Turkey. In addition, the numbers and causes of gillnets and entangling nets lost during one year were identified.

Materials and Methods

Fieldwork was carried out between February 2015 and December 2016, at 158 fishing ports of 15 provinces on the Black Sea coast of Turkey (Figure 1). In order to determine total numbers of gillnets and entangling nets, 5141 fishing boat captains were interviewed. In order to meet with fishermen, firstly, informative meetings were organized with the Provincial Directorate of the Ministry of Food, Agriculture and Livestock and Regional Fisheries Cooperatives. A work program was devised for each fishing port as an outcome of the meetings. Within the scope of the program, project personnel met with fishing boat captains at the fishing ports and a questionnaire was conducted. The questionnaire is shown in Appendix 1.

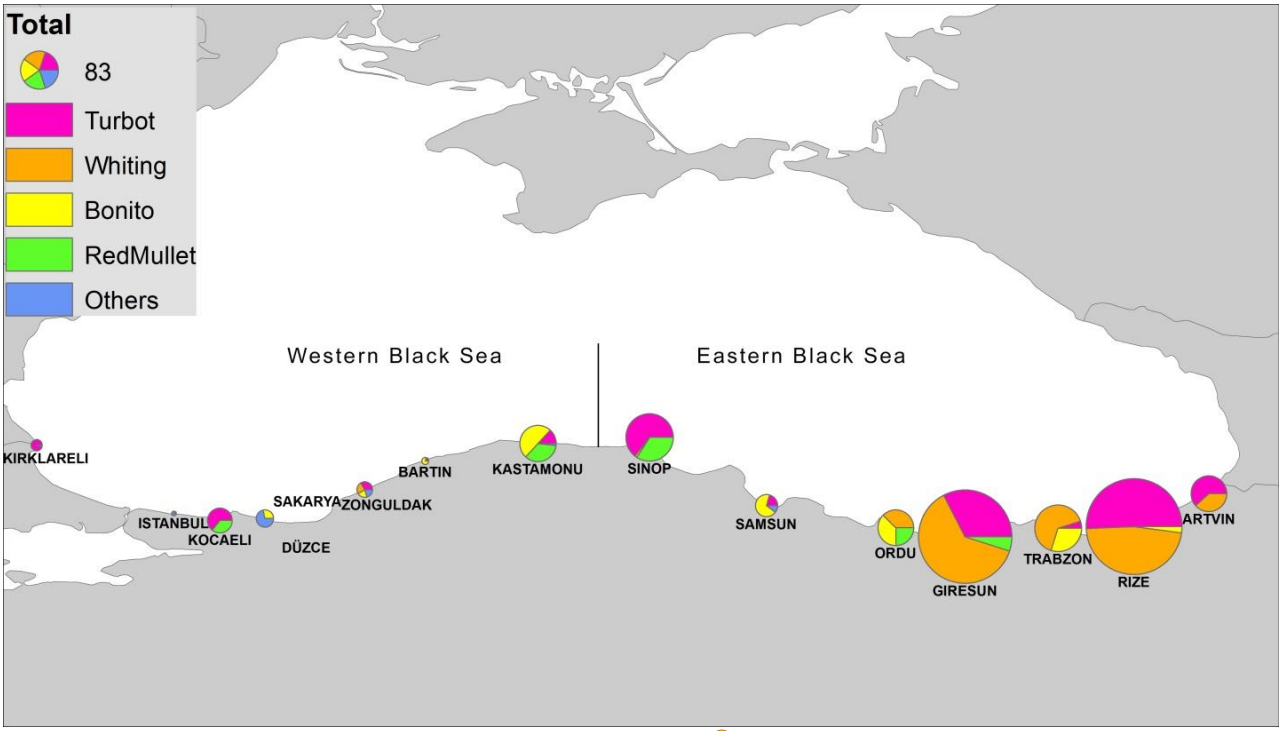

Figure 1. Study area and number of lost set nets according to provinces (: The diameter of the circle shows 83 lost panels)

A simple random sampling method was used to determine the number of lost gillnets and entangling nets. Since the size of the target population was known in the study, the number of questionnaires to be applied was calculated using the following equation (Yamane, 1967);

$$n = \frac{\mathrm{N} * d^2 * p * q}{\mathrm{d}^2 * (\mathrm{N}-1) + \mathrm{t}^2 * \mathrm{p} * \mathrm{q}}$$

N=Total number of boats using gillnets and entangling nets

n=Number of boats to be sampled

p=Probability of loss of gillnets and entangling nets

q=Probability of no loss of gillnets and entangling nets

t=Theoretical value for a determined confidence interval, (95%)

d=Error proportion assumed with respect to the obtained frequency of the determined event (5%).

With the help of this equation, the number of fishing boats to be sampled was determined as 315 which was proportionally distributed to the provinces.

Gillnets and entangling nets are divided into 5 groups considering target species (Turbot net, Whiting net, Bonito net, Red mullet net and Other nets). The total number of gillnets and entangling nets and loss rates for these five groups were examined separately. Other nets are gillnets and entangling nets which are relatively few in number, used to capture different species such as scorpion fish, horse mackerel, sea bass, shad etc.

Using the survey data, the “total lost net” count for Turbot, Whiting, Bonito, Red mullet and Other nets was determined using the equation given below (Yamane, 1967),

$$\hat{X} = \sum_{i=1}^{M} \frac{N_i}{n_i} \sum_{j=1}^{n_i} x_{ij}$$

M: Total number of fishery ports

Ni: Total number of boats using relevant net type in fishery port (i)

ni: Number of sampled boats using relevant net type in fishery port (i)

xij: Number of relevant lost nets of boat (j) in fishery port (i)

Average number of nets lost per boat was calculated with the equation given below (Yamane, 1967);

$$\bar{X} = \frac{\hat{X}}{N}$$

Variance and standard error of average number of nets lost per boat were calculated with the equation given below (Yamane, 1967).

$$Var(\bar{X}) = \frac{\sum_{i=1}^{M} N_i^2 \frac{(N_i - n_i)}{N_i} \frac{Var_i}{n_i}}{N^2}$$

Var: Variance of the average numbers of nets lost from boats sampled in fishery port (i).

The causes of loss were divided into three groups: Poor weather conditions, Conflict with other fishing gear and Other reason. Other reasons included vandalism, effects of current, failure during fishing operations and inadvertent net damage by marine organisms such as dolphins.

Results

It was determined that 3372 of a total 5141 fishing boats were fishing with gillnets and entangling nets. The total number of gillnets and entangling nets in the boats comprised 107331 panels. The number of gillnets and entangling nets for Turbot, Whiting, Bonito and Red mullet constitute 91% of the total number of nets. According to the net classification by considering target species; the numbers of Turbot, Whiting, Bonito, Red mullet and Other nets were determined as 47144 (43.92%), 22919 (21.35%), 17366 (16.18%), 10461 (9.75%) and 944116 (8.80%), respectively (Table 1). The Turkish Black Sea coast is divided into two fishing regions known as the "Eastern Black Sea" and the "Western Black Sea" (Figure 1). The obtained data reveals that over 70% of “gillnet and entangling nets” were employed in the Eastern Black Sea.

In the Black Sea coast of Turkey, the number of lost “gillnets and entangling nets” within a year was determined as 1626.83 panels/year. According to this data, the loss rate was calculated at 1.52%. In addition, it was determined that 92% of these losses occurred in the Eastern Black Sea Region (Figure 1). The results showed that the most important cause of the loss was poor weather conditions (52%), followed by conflict with other fishing gear (41.40%) and Other reasons (5.73%).

Turbot nets are demersal set gillnets made of polyimide material with mesh size of 300-360 mm and twine thickness of 210 D/6-9 no. The overall dimension of each panel is approx. 70 m length by 2 m depth. The commercial fishing season for turbot nets is between one-two months carried out mainly in spring. Turbot demersal set gillnets constitute approx. 43.92% of total nets in the Black Sea (47144 panels). Approximately 61% of these nets are employed in the Eastern Black Sea. The results obtained showed that the average loss of nets per boat was 2.22±0.74 panels. It was also found that within a one year period, 279 fishing boats had lost their turbot net. According to this data, the total loss of turbot nets was calculated as 619.38 (1.31%) panels/year. It was also determined that 90% of losses occurred in the Eastern Black Sea. The most important reason for loss of turbot nets was determined to be conflict (50%),

Table 1. Total numbers of lost set nets in Black Sea

Type of Net	Numbers of Nets	Average Loss per Boat	Numbers of Boats that lost nets	Total Loss	Loss Rate (%)	Reasons for Loss		
						Conflict	Poor Weather Conditions	Other
Turbot	47144	2.22±0.74	279	619.38	1.31	50	39.47	10.53
Whiting	22919	1.54±0.47	460	708.4	3.09	48.21	50.00	1.79
Bonito	17366	0.83±0.43	177	146.91	0.85	42.86	47.62	9.52
Red mullet	10461	1.57±0.57	82	128.74	1.23	23.53	70.59	5.88
Other	9441	1.56±0.11	15	23.4	0.25	24	72.00	4.00
Total	107331	-	-	1626.83	1.52	-	-	-

followed by Poor weather conditions (39.47%) and Other reasons (10.53%).

Both demersal set gillnets and trammel nets are used in the Whiting fishery. Gillnets and the inner panels of trammel nets are of the same mesh size (30-40mm) and twine thickness (Polyimide 210D/1-2 no). Mesh size of the outer section of the trammel net measured 160-200mm with a twine thickness of 210D/6-9no. The overall dimension of one panel was approx. 110-130 m length and 2-2.5 m depth. The commercial fishing season for Whiting is continuous throughout the year. Whiting nets constitute 21.35% of total nets in the Black Sea (22919 panels), 95% of which are employed in the Eastern Black Sea. The average loss of nets per boat equalled 1.54±0.47 panels with total loss calculated as 708.40 panels (3.09%) from a total of 460 boats. It was further determined that more than 98% of losses occurred in the Eastern Black Sea. The most important causes for loss of whiting nets were determined as Poor weather conditions (50%), followed by Conflict (41.40%) and Other reasons (5.73%). These results show that losses of whiting nets were highest both numerically and proportionally.

Bonito nets are drift nets with mesh sizes varying between 44-88 mm and a twine thickness of 210d/2-4 no. In general, 3-9 horizontal panels and 4-8 vertical panels are combined for a drifting gillnet. The dimensions of each panel range between 100-160 m length and 30-100 mesh depth. Drifting gillnets can be used as encircling gillnets at certain times by only increasing the weight of the footrope. In our study, the number of Bonito nets in operation in the Black Sea totaled 17366 panels with more than 70% being used in the Eastern Black Sea region. The average loss of nets per boat numbered 0.83±0.43 panels with 177 boats losing Bonito nets. According our data, the total number of losses was 146.91 panels (0.85%) with approximately 75% of losses occurring in the Eastern Black Sea. It was found that the most important causes of loss were Poor weather conditions (47.62%), followed by Conflict (42.86%) and Other reasons (9.52%).

Both Demersal set gillnets and Trammel nets are used in Red mullet fishing. Gillnets and the inner panels of trammel nets are of the same mesh sizes (28-44mm) and twine thickness (Polyimide 210D/1-110D/2 no). The mesh size of the outer net of the Trammel net was 140-220 mm with a twine thickness of 210D/6 no. The overall dimensions of each panel were approx. 100 m length and 50-70 mesh depth. The commercial fishing season for Red mullet is continuous throughout the year. However, fishery operations are concentrated in autumn and from mid-spring to mid-summer. It was determined that a total of 10461 Red mullet net panels were used, of which 8190 (78.3%) were employed in the Eastern Black Sea and 2271 (21.7%) in the Western Black Sea. A total of 82 boats lost nets with the average loss per boat of red mullet nets being 1.57±0.57 panels According to these data, the total loss amounted to 128.74 (1.23%) panels/year. The most important causes of net losses were Poor weather conditions (52.87%) followed by Conflict (41.40%) and Other reasons (5.73).

Other gillnets and entangling nets operated at virtually the same levels in both the eastern and western Black Sea with the total number of nets used in the region determined as 9441 panels. The average number of losses per boat was 1.56±0.11 and the number of boats that lost nets was 15. According to these data, the total number of lost nets was calculated as 23.40 (0.25%) panels. Poor weather conditions were identified as the most important cause of net loss (52.87%) followed by Conflict (41.40%) and Other reason (5.73%).

Discussion

Fishing gear can be lost for many reasons such as conflict with other fishing gear, poor weather conditions, vandalism, and operational fishing factors. However, the cause and extent of loss are determined by parameters such as operational depth and area, fishing activity intensity and fishing season. For example, Santos *et al*. (2003a) found that the rate of loss per vessel in local, coastal and hake fishing in the Algarve to be 3.2, 5.1 and 7.4 panels, respectively. The boats in the local category were defined as fishing boats less than 9 m operating at distances of up to 3 nm from the shore. Coastal boats were defined as fishing boats larger than 9 m working up to 10 km from the shore. Hake boats were classified as operational in the coastal category

with the fishing depth varying between 100-700m. Ozyurt *et al*. (2012) investigating in Iskenderun Bay determined the average number of lost nets per boat for the Solea trammel net, Shrimp trammel net and Other gill and trammel net as 5.35, 4.33 and 3.33 panels, respectively. Researchers stated that common sole nets are employed at greater depths than shrimp and other nets. These results reinforce the hypothesis that there is a positive relationship between the number of lost panels and depth of fishery operation. The reason for this was explained by the lower possibility of retrieval of lost nets in deep waters compared to shallow waters (Ozyurt *et al*., 2012; Santos *et al*., 2003a). In this study, the highest numbers of lost net were identified as whiting and turbot nets (708 and 619 panel/year, respectively). In the Black Sea, turbot and whiting fishing is usually carried out to depths of 100 m. For Bonito, Red mullet and Other nets used mainly in the coastal waters, lost nets were determined as 147, 129 and 23 panels/year, respectively. These results support the opinion that there is an increase in the number of nets astray with increasing seawater depth.

The number of turbot nets in operation in the Black Sea was found to be more than twice that of whiting nets. In addition, the average number of nets astray per boat was higher for turbot nets (2.22±0.74 panels/year) than for whiting nets (1.54±0.47 panels/year). However, a higher number of boats lost whiting nets (460 vessels) than turbot nets (279 vessels). As a result, the total number of losses (708 panels/year) determined for whiting nets was higher than for turbot nets (619 panels/year). This was most likely due to the longer whiting fishing season (all-year round) as opposed to the turbot fishing season which is normally carried out in spring (1-2 month period). The extended net exposure would lead to an increased risk of losing whiting nets. In addition, fishermen believe that the edges of the holes (area that increases the depth very quickly) were more efficient in term of whiting fishing than the other regions. For this reason, whiting nets were set as close as possible to the edge of holes. However, due to poor weather conditions, currents and conflict with other gear the nets could easily slide into the holes and therefore cannot be retrieved by fishermen, naturally, the possibility of the loss of whiting nets increases. These results indicate that the operational area and the length of fishing season are parameters affecting numbers of nets lost.

For almost all net types, the most important causes of loss were determined as poor weather conditions. However, for turbot nets the main cause of loss was identified as conflict. In turbot fishing, the nets remain for a of fifteen days upon deployment to the bottom, after which the net is retrieved by fishermen, individuals caught are collected and the net is reset in the same area. The lengthy duration of the operation will increase the risk of conflict with other fishing gear especially purse seine.

In this study, the eastern and western regions of the Black Sea were compared in terms of total net numbers and loss rates. Our results show that the eastern Black Sea displays very high values in terms of both the total number of nets in operation (61%, 95%, 70%, 78% for turbot, whiting, bonito and red mullet nets respectively) and net loss rates (89%, 98%, 75% %88 for turbot, whiting, bonito and red mullet nets respectively). Although the number of Other nets was high in the western Black Sea, it was seen that the loss rate of Oter nets (80%) was high in the eastern Black Sea. This suggests that net loss is highest in areas where fishing activity is intense.

The data obtained in this study show that the ratio of total loss gillnets and entangling nets in Turkish Black Sea coastal waters was 1.59%. Poor weather conditions were determined as the most important cause of loss for all net types with the exception of turbot nets, which were more adversely affected by conflict. It was also seen that the rates of nets adrift in the eastern Black Sea region were very high compared to those for the western Black Sea region.

Acknowledgment

This study was funded by the General Directorate of Agricultural Research and Policies. The data were collected within the framework of TAGEM /HAYSUD/2015/A11/P-09/02 “Investigation of Gillnets and Effects in Black Sea Fisheries" project. The authors are grateful to the anonymous referee for their valuable input on an earlier version of the article and to Alison Kideyş for her linguistic corrections. Also, we thank Serdar Sakınan for his contribution.

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Annex 1. Survey form used in field studies (*:Continues up to Fishing Gear 5)

Survey Form

Fishing Boat Information

Province		Home Port	
District		Boat Material	
Fishing Port		Boat Age	
Name and surname		Boat Length	
Telephone		Engine Number	
Boat Name		Engine Power	
License Number		Crew number	

Fishing Information		Fishing Gears		Fishing Effort Day/Year
Fishing Effort (Day/year)		Fishing Gear 1		
		Fishing Gear 2		
Fishing Effort (Hour/Day)		Fishing Gear 3		
		Fishing Gear 4		
		Fishing Gear 5		

		Target Species	**Technical specifications of the Fishing Gear**
Fishing Gear 1	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
Fishing Gear 2*	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		

Fishing Gear	Number of Lost Net (panel/year)	Lost Reason	Lost Area	Other Notes
Fishing Gear 1				
Fishing Gear 2				
Fishing Gear 3				
Fishing Gear 4				
Fishing Gear 5				

Questionnaire Date:
Name and Surname:

Signature: