LIFE MEDTURTLES

COLLECTIVE ACTIONS FOR IMPROVING THE CONSERVATION STATUS OF THE EU SEA TURTLE POPULATIONS: BORDERING AREAS (LIFE18 NAT/IT/000103)

Action C4: Fishing gear modification for reducing turtle bycatch

Report on efficiency of modifications of longlines

August 2024

Collective actions for improving the conservation status of the EU sea turtle populations: bordering areas (LIFE18NAT/IT/000103). Project is carried out with the assistance of LIFE financial instrument of the European Union / **info@medturtles.eu**

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INTRODUCTION

Bycatch has emerged as a critical issue affecting both national and global fisheries management as well as marine ecology (Andrew and Pepperell, 1992; Hall et al., 2000). This phenomenon refers to the unintentional capture of non-target species during fishing operations, often resulting in significant ecological and economic consequences. Numerous studies suggest that bycatch stands out as the primary factor contributing to the injury and mortality of sea turtles and other sea creatures. This is largely due to the fishing gear utilized and the prevailing operating conditions in fisheries. The mortality rates associated with bycatch are frequently high enough to endanger populations and species. Data indicates that a minimum of 7.3 million tons of marine life is caught as bycatch each year (Gazo, 2020). Bycatch, especially in endangered and vulnerable species, resulting in deaths further exacerbates the problem. The fishing gear where bycatch is most common includes gillnets and entangling nets, longlines, purse seines with and without purse rope, trawls and traps (Sacchi, 2021; Carpentieri et al., 2021).

Faced with this situation, the European project LIFE Medturtles aims to contribute at the reduction of accidental sea turtle catches in the Mediterranean Sea by modifying fishing gear. For this, three fishing gears were targeted in five countries: Set nets (gillnets and trammel nets), trawl nets and longlines. For longlines, circle hooks were promoted in Tunisia and Turkey.

ON THE USE OF C-HOOKS IN LONGLINES

TO REDUCE INCIDENTAL CATCH OF VULNERABLE SPECIES

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Pelagic longline fishing has been observed to be associated with a significant number of sea turtle deaths. As these fisheries expand, the likelihood of sea turtle mortality from their operations increases, as noted by Gerosa and Casale (1999), Oravetz (1999) and Chaloupka and Limpus (2001). Longline fishing, both pelagic and bottom, interacts with numerous species, exposing them to bycatch. Seabirds, turtles, sharks, and rays are among the most prominent species affected (Sacchi, 2021; Carpentieri et al., 2021). Many of these species are endangered and vulnerable, further exacerbating the impact of bycatch. Protecting marine biodiversity, mitigating negative impacts on marine resources, and reducing bycatch are essential elements of sustainable fisheries management (Hall, 1996; Hall et al., 2000).

Within longline fishing operations, the primary elements enhancing catching efficiency are the hooks and bait utilized, as they directly interact with marine organisms. The descriptive name "J" hook reflects its shape, resembling the letter "J". A circular (C) hook is a type of fishing hook characterized by its sharp curvature in a circular shape, bending backward. This hook has gained popularity among fishers in recent years due to its ability to catch more fish and its rarity in being swallowed.

Circle hooks in longline fishing are another effective tool for reducing bycatch in longline fisheries. These hooks are designed to reduce the likelihood of deep hooking and injury to non-target species, such as sea turtles and sharks. Circle hooks have been shown to be highly effective in reducing sea turtle bycatch in longline fisheries, with reductions of up to 90% reported in some studies (Gilman et al., 2021). However, the use of circle hooks can result in reduced catch rates of some target species, such as tuna, which may have economic implications for the fishing industry.

1 TURKEY

ON THE USE OF C-HOOKS IN LONGLINES

TO REDUCE INCIDENTAL CATCH OF VULNERABLE SPECIES

Material and method

In this study, the effectiveness of C-shaped hooks with traditional J-shaped hooks were compared for capturing commercial and vulnerable species. For this, 3 hooks of different sizes (3.0 cm, 3.5 cm and 4.0 cm in length) were used both test C-hooks and control J-hooks. Trials were carried out on the coasts of Marmaris, Sarıgerme and Fethiye in 2022. Longline catches set up to a depth of 65 m from the shore. All trials were conducted using polyvalent wooden small-scale fishing boats equipped with passive fishing gear. In each trial, both standard Jhook (CTRL) and C-hook (TEST) longlines were used, with a total of 300 hooks in each.

Results

Compared to J-hooks, C-hooks reduced the biomass of commercial catch by a significantly higher percentage of 77%. In addition, findings revealed that C-hook was responsible for the capturing 11 bycatch species of elasmobranchs, comprising of 8 shark and 3 ray individuals. These vulnerable by-catch accounted for 51.8 percent by biomass of total catch captured by different sizes C-hooks. No vulnerable species were caught in the control group hooks (also in various sizes). The CPUE of biomass and abundance of vulnerable species calculated for the longline (standardized to 1000hook) are 3.535 kg with 1.112 individuals. These results showed that C-hook reduced the biomass of commercial species captured by the set longline, while causing the capture of vulnerable species.

CONCLUSION

the inclusion of circular hooks in longline has resulted in the capture of non-target vulnerable species. It would be beneficial to repeat these trials in fishing gear, areas, and fishing seasons where these species interact more intensively.

For more information and more detailed results on the use of C-hooks in longlines in Turkey, see report on Appendixes 1

IV- 2 TUNISIA

ON THE USE OF C-HOOKS IN LONGLINES

TO REDUCE INCIDENTAL CATCH OF VULNERABLE SPECIES

The bottom longline

The bottom longline is used to catch groupers mainly, and some other bony fish. Besides these target species, sea turtles are caught accidentally. The hooks are generally numbers 04 or 05 for groupers and 13, 14 and 15 mainly for fishing for bony fish. Soak time is 1 to 3 hours and the baits used are generally sardine.

Bottom longline fishing targeting groupers is practiced during the summer throughout the Gulf of Gabès region. The other fish are targeted mainly in autumn and winter.

Data collection

The observers proceed to the collection of information according to a standardized method and in accordance with the forms developed for the needs of the project.
The quantification of sea turtle bycatch rates was carried out in this study through onboard observations (by observers on board) and also through direct dialogues with fishermen (through interviews / questionnaires).
For observations at sea, accidental captures of sea turtles were reported by observers on board trained for this purpose. They were asked to:
• Obtain reliable information on the interaction of sea turtles with the bottom longline.
• Record the number, mass (or estimate) of the species caught during each fishing operation and, if possible, the position (GPS) of the bycatch event.

- Collect biological information on captured vulnerable species (length, sex, etc.).
- Collect gear and effort data and define parameters (number of hooks, bait, soak time, etc.).
- Collect general information necessary for a correct interpretation of the results such as:
  - ✓ Vessel characteristics (fleet segment tonnage, etc.);
  - ✓ Weight (or estimate in kilograms) and specific composition of the catch with indication of the main target species.
  - ✓ Percentage of discards on the total catch with indication of the main species discarded.

For interviews and to get an idea of the extent of bycatch of sea turtles, adequate sampling was carried out formally, with standardized questionnaires conducted in ports where fishers can best be gathered and approached.

The information collected during the experiments was used to determine:

- the bycatch rate per unit of fishing effort (BPUE) for sea turtles as well as the catch rate per unit of fishing effort (CPUE) for the target species.

The BPUE (or CPUE) is reported as the number of individuals caught per 1000 hooks deployed.

- Mortality rate (in percentage) is defined as the number of dead individuals compared to the total number of individuals captured.

Mitigation measures

Several studies and observations have shown that in the region of the Gulf of Gabes, sea turtles are captured accidentally. The bottom longline, targeting groupers mainly in the region of Zarzis in spring and summer, is among gears the most impacting on these species. To reduce bycatch, circular hooks were experimented for bottom longline.

Circle and J hooks were arranged in alternating sections; the control gear on one side and the experimental one on the other

Results

During the study period, 51 hauls using 'J' hooks (22161 hooks deployed) and 51 hauls using 'C' hooks (8565 hooks deployed) were performed by 8 to 82m depth with an average of 28.5m. Number or size of hooks varied from 4 to 7. The main baits were sardine and horse mackerel.

Composition of the catch

Elasmobranches are the main taxon fished in bottom longline representing 44% of the capture. Groupers, the targeted species in the past, represented only about 7.5%. This fishing gear impact sea turtles representing about 1 to 2%.

Mortality rate

Five sea turtles were captured during trips with bottom longlines, four during control operations using J hooks and one during experimental operations using C hooks. All sea turtles captured were loggerheads and were alive; the direct mortality is estimated at 0%.

Main results of the monitoring of sea turtle bycatch in bottom longline and the use of circular hooks as mitigation measure are compiled in the following table:

	J hooks (control)	Circular hooks (experimentation)
Number fishing operations	51	51
Hooks deployed	22161	8565
Loggerheads caught	4	1
Living turtles	4	1
Dead turtles	0	0
Mortality rate	0	0
BPUE/1000 hooks	0.23	0.06
95% CI =	0.0-0.55	0.0-0.17
all fish species caught	155	70
CPUE targeted species	5.89	8.00
95% CI =	3.48-8.65	4.03-12.98

Conclusion and recommendations

Results show that the main component of the capture is elasmobranches that are also vulnerable species to protect. Few loggerheads were captured in bottom longline and no mortality was registered.

Statistically, there is no difference in sea turtle bycatch with circular or J hooks. The use of circular hooks did not reduce bycatch. It seems that the shape of hooks is reducing bycatch of sea turtles with use of big size of hooks such as in the industrial tuna fisheries.

Results could be more significant with the following recommendations:

- Use the same number of either circular and J hooks:
- Harmonize the size of hooks;
- Use one bait if possible and the same baits (if more than one) for control and experimental longline;

Harmonize fishing areas (mainly depth).

For more information and more detailed results on the use of C-hooks in longlines in Tunisia, see report on Appendix 2

GENERAL CONCLUSION

The intended objectives of mitigating sea turtle species through the use of C fishing hooks have not materialized as anticipated. Contrary to documented achievements in mitigating sea turtle bycatch recorded in the literature, the conducted experiments have yielded in general inconclusive results. Furthermore, it merits attention that the efficacy of the test gear in capturing the species targeted by the equipment has exhibited a notable decline. This decrease in catch success, combined with the intricacies linked to the acceptance and integration of these mitigation tools within the fishing community, has introduced significant challenges.

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APPENDIX 1

TURKICH REPORT ON THE USE OF C-HOOKS IN LONGLINES TO REDUCE INCIDENTAL CATCH OF VULNERABLE SPECIES

LIFE MEDTURTLES
COLLECTIVE ACTIONS FOR IMPROVING THE CONSERVATION STATUS OF THE EU SEA TURTLE POPULATIONS: BORDERING AREAS

ACTION C4: Demonstration of fishing gear modification for reducing turtle bycatch

Report Date: 31.04.2024

LIFE18 NAT/IT/000103

ACTION C4: Demonstration of fishing gear modification for reducing turtle bycatch

Preliminary Results on the Use of C-Hooks in Longlines to Reduce Incidental Catch of Vulnerable Species

A marine coastal ecosystem refers to the complex network of living organisms and their physical environment that exists where the land meets the ocean. It encompasses a diverse range of habitats, including rocky shores, sandy beaches, tidal marshes, estuaries, coral reefs, mangrove forests, and coastal upwelling zones. Marine coastal ecosystems are incredibly diverse and dynamic because they occur at the interface of land and sea, where various environmental factors intersect to create a range of habitats (UNEP, 2006). Many species, including endangered and vulnerable species, interact with coastal and offshore areas in order to maintain many vital activities such as feeding, breeding and seeking protection etc.

Bycatch has emerged as a critical issue affecting both national and global fisheries management as well as marine ecology (Andrew and Pepperell, 1992; Hall et al., 2000). This phenomenon refers to the unintentional capture of non-target species during fishing operations, often resulting in significant ecological and economic consequences. Numerous studies suggest that bycatch stands out as the primary factor contributing to the injury and mortality of marine mammals and other sea creatures. This is largely due to the fishing gear utilized and the prevailing operating conditions in fisheries. The mortality rates associated with bycatch are frequently high enough to endanger populations and species. Data indicates that a minimum of 7.3 million tons of marine life is caught as bycatch each year (Gazo, 2020). Bycatch, especially in endangered and vulnerable species, resulting in deaths further exacerbates the problem. The fishing gear where bycatch is most common includes gillnets and entangling nets, longlines, purse seines with and without purse rope, trawls and traps (Sacchi, 2021; Carpentieri et al., 2021)

Turkey boasts diverse marine and coastal habitats that host a significant number and variety of species. The rich biodiversity, ecosystem functions, and services within its marine ecosystems offer numerous environmental, social, and economic values and benefits. The extensive Turkish coastline supports a wide range of marine capture fisheries activities, encompassing both large-scale operations such as trawl and purse seine fishing, as well as small-scale methods like gillnet and entangling nets and longline fishing. Additionally, recreational fisheries, including shore-based and boat-based activities, as well as spearfishing, contribute to the diverse fishing landscape (Ünal and Göncüoğlu, 2012).

Despite the presence of various fishing techniques, the marine capture fisheries in Turkey primarily exhibit small-scale characteristics (gillnet, trammel net, encircling net, longline, trap etc.) are predominantly considered coastal fisheries (Ünal and Göncüoğlu, 2012). As is the case worldwide, fishing gear used in coastal areas in Turkey inevitably interacts with vulnerable and endangered species. These interactions pose significant challenges to the conservation of vulnerable marine populations and ecosystems. The fishing gear employed in coastal areas are designed to capture target species but often result in unintentional bycatch of non-target species, including endangered and vulnerable marine animals such as sea turtles, marine mammals, sharks and rays and certain fish species. For example, sea turtles are particularly vulnerable to entanglement in fishing nets, while marine mammals may become accidentally caught in fishing gear or suffer injuries from vessel collisions. Additionally, certain fish species, including those with low reproductive rates or specialized habitat requirements, may face population declines due to overfishing or habitat degradation associated with fishing activities. The interactions between fishing gear and vulnerable species

underscore the importance of implementing sustainable fishing practices and mitigation measures to minimize bycatch and protect vulnerable marine populations.

After discovering the behaviour of many species of sea creatures towards artificial light, human beings have been using it for fishing purposes for thousands of years (Ben-Yami, 1976; 1978; Ben-Yami and Pichovich, 1988). Although initially the effect of this could not be explained scientifically, it was later generally defined as negative (moving away from the light source) or positive phototaxis (moving towards the light source) (Verheijen, 1960; Pascoe, 1990; Marchesan et al., 2005; Solomon and Ahmed, 2016). This simple method, which first started with lighting a fire on the beach and collecting and catching marine species with light, reached its industrial fishing potential by using more powerful, practical and cheap light-emitting devices in parallel with the development of technology. However, in recent years, the negative effect of light on fish stocks due to mass fishing methods is a separate matter of debate (Solomon and Ahmed, 2016; Mgana et al., 2019). Despite all the negative effects, it has been reported that in the last 20 years, many researchers have made significant positive contributions to important vulnerable species of the marine ecosystem and endangered species ones by using light sources of different colours and materials (Wang et al., 2010, 2013; Ortiz et al., 2016; Virgili et al., 2018; Melli et al., 2018; Nguyen and Winger, 2019; Darquea et al., 2020; Senko et al., 2020; Allman et al., 2020; Lucas and Berggren, 2023). Therefore, there is an urgent need for the use of more environmentally friendly light technologies and the decisions to be implemented for their sustainable management (Solomon and Ahmed, 2016; Nguyen and Winger, 2019) before fish stocks are on the verge of collapse and vulnerable species become extinct.

Globally, fisheries face challenges associated with bycatch, particularly the unintentional capture of vulnerable species. Gillnets/trammel nets and longlines are commonly used fishing gear that can inadvertently capture non-target marine life. To address this issue, researchers have explored the use of LED and UV lights to deter marine organisms from nets, as well as C-hooks to minimize injuries and improve escapement rates for non-target vulnerable species. This report presents initial findings on the effectiveness of employing LED and UV lights in gillnets/trammel nets and C-hooks in longlines to mitigate the incidental catch of vulnerable species. Bycatch in fisheries poses a significant threat to marine biodiversity, and innovative technologies such as light-based deterrents and modified hook designs offer promising solutions.

Field experiments were conducted in diverse marine environments to evaluate the impact of LED and UV lights in gillnets/trammel nets and C-hooks in longlines. Controlled trials were designed to assess changes in catch composition, with a focus on vulnerable species, under different lighting and hook configurations. Data collection involved monitoring catch rates, species diversity, and behavioural responses of both target and non-target species. Preliminary findings have revealed the importance of designing innovative technologies more suitable for fisheries in Turkish seas in order to find solutions to bycatch problems in fisheries.

Initial Findings on Circular Hooks to Potential Mitigate Vulnerable Species in Traditional Longlines

Pelagic longline fishing has been observed to be associated with a significant number of sea turtle deaths. As these fisheries expand, the likelihood of sea turtle mortality from their operations increases, as noted by Gerosa and Casale (1999), Oravetz (1999) and Chaloupka and Limpus (2001). Longline fishing, both pelagic and bottom, interacts with numerous species, exposing them to bycatch. Marine mammals, seabirds, turtles, sharks, and rays are among the most prominent species affected (Sacchi, 2021; Carpentieri et al., 2021). Many of these species are endangered and vulnerable, further exacerbating the impact of bycatch. Protecting marine biodiversity, mitigating negative impacts on marine resources, and reducing bycatch are essential elements of sustainable fisheries management (Hall, 1996; Hall et al., 2000).

Within longline fishing operations, the primary elements enhancing catching efficiency are the hooks and bait utilized, as they directly interact with marine organisms. The descriptive name "J" hook reflects its shape, resembling the letter "J". There is an eye to attach the hook to a leader line, a long and straight shaft, a rounded hook on the bottom and can be found with and without a barb (Paul, 2022). A circular (C) hook is a type of fishing hook characterized by its sharp curvature in a circular shape, bending backward. This hook has gained popularity among anglers in recent years due to its ability to catch more fish and its rarity in being swallowed (Prince et al., 2002). The circular hook is designed to catch fish by the lips at the corner of their mouths, minimizing damage to the fish and facilitating easy removal from the hook. However, it has been observed that the mortality rates resulting from the swallowing of the traditionally used J type hook, which does not harm the gills and vital organs of the fish, are relatively high (Cooke and Suski, 2004). Circular hooks use has been reported to be effective in reducing bycatch of sea turtles, but not for marine mammals (Bigelow et al., 2012). Because of the physical characteristics of the circular hook, its application in tuna and other comparable longline is considered a practical and cost-effective measure to decrease mortality rates (Promjinda et al., 2008; Afonso et al., 2011; Graves et al., 2012; Gilman et al., 2018). Domingo et al. (2012) also observed a decrease in the catch rate of pelagic rays when using circle hooks compared to J hooks when fishing for swordfish, tuna and pelagic sharks. Piovano et al. (2009), emphasizes that circular jigs used in longline swordfish fishing in the Strait of Sicily significantly reduce bycatch of juvenile *Caretta caretta* without significantly affecting the catch rate of target species. Sales et al. (2010) demonstrated that substituting circle hooks for J-hooks resulted in a 55 percent reduction in bycatch of loggerhead turtles and a 65 percent reduction in bycatch of leatherback turtles. There appears to be no significant difference between hook types when fishing for blue sharks, although J-type hooking has been observed to engage deeper digestive organ (e.g. oesophagus or stomach) than circle hooks. Hooks inserted into the mouth are less traumatic for the shark because the hook can be cut at the branch line and the hook will eventually rust and fall off (Patterson and Tudjman, 2009). On the other hand, an internal injury from an ingested hook is likely to reduce survival (Gilman et al., 2007).

An increasing body of research suggests that circle hooks are more efficient than J hooks in reducing sea turtle bycatch. Their larger width helps prevent deep hooking, while their curved shape reduces external hooking. The Working Group on Reducing Bycatch of Sea Turtles in EU Longline Fisheries (STECF, 2005), along with Watson (2004) and Gilman et al. (2007), highlighted that various hook shapes may not yield consistent effects across species. They emphasized that both bait and hook size are likely

more influential factors. The conclusion drawn was that the available scientific data were insufficient to support the implementation of circle hooks as an effective mitigation measure.

Circle hooks in longline fishing are another effective tool for reducing bycatch in longline fisheries. These hooks are designed to reduce the likelihood of deep hooking and injury to non-target species, such as sea turtles and sharks. Circle hooks have been shown to be highly effective in reducing sea turtle bycatch in longline fisheries, with reductions of up to 90% reported in some studies (Gilman et al., 2021). However, the use of circle hooks can result in reduced catch rates of some target species, such as tuna, which may have economic implications for the fishing industry.

In this study, the effectiveness of C-shaped hooks with traditional J-shaped hooks were compared for capturing commercial and vulnerable species. For this, 3 hooks of different sizes (3.0 cm, 3.5 cm and 4.0 cm in length) were used both test C-hooks and control J-hooks. Trials were carried out on the coasts of Marmaris, Sarıgerme and Fethiye in 2022. Longline catches set up to a depth of 65 m from the shore were evaluated in two categories: below 25 m and above 25 m. In addition, water temperature was evaluated in two categories: below 20 °C and above 20 °C. All trials were conducted using polyvalent wooden small-scale fishing boats equipped with passive fishing gear. In each trial, both standard J-hook (CTRL) and C-hook (TEST) longlines were used, with a total of 300 hooks in each.

A study involving the use of 33 pairs of longline sets was conducted to evaluate the effectiveness of C-shaped hooks in reducing the capture of vulnerable species. Three different sizes of C hooks were tested in the trials (Figure 1a) and were baited with round sardine (*Sardinella aurita*), available fresh or frozen (Figure 1b). Each pair consisted of a standard hook (Control J-shaped hook) and a test hook (C-shaped hook). The purpose of using hook pairs was to enable a direct comparison between two hook designs under similar conditions. To ensure comparability between the two hook types, biomass captured with different numbers of hooks was calculated based on standardization of hooks to 1000 pieces. This standardization allowed for accurate comparison of Catch Per Unit Effort (CPUE) obtained from trials with different hook configurations. Through this standardized comparison of CPUEs, the study comprehensively evaluated the mitigating effect of the C-shaped hook design on vulnerable species. By examining CPUEs in this way, the study examined the impact of hook design on catch rates of both commercial and vulnerable bycatch species.

Compared to J-hooks, C-hooks reduced the biomass of commercial catch by a significantly higher percentage of 77% (Table 1). In addition, findings revealed that C-hook was responsible for the capturing 11 bycatch species of elasmobranchs, comprising of 8 shark and 3 ray individuals. These vulnerable by-catch accounted for 51.8 percent by biomass of total catch captured by different sizes C-hooks. No vulnerable species were caught in the control group hooks (also in various sizes). The CPUE of biomass and abundance of vulnerable species calculated for the longline (standardized to 1000 hook) are 3.535 kg with 1.112 individuals. These results showed that C-hook reduced the biomass of commercial species captured by the set longline, while causing the capture of vulnerable species (Table 1). The commercial and vulnerable bycatch species caught by C-hook configuration are shown in Figure 2 and Figure 3, respectively.

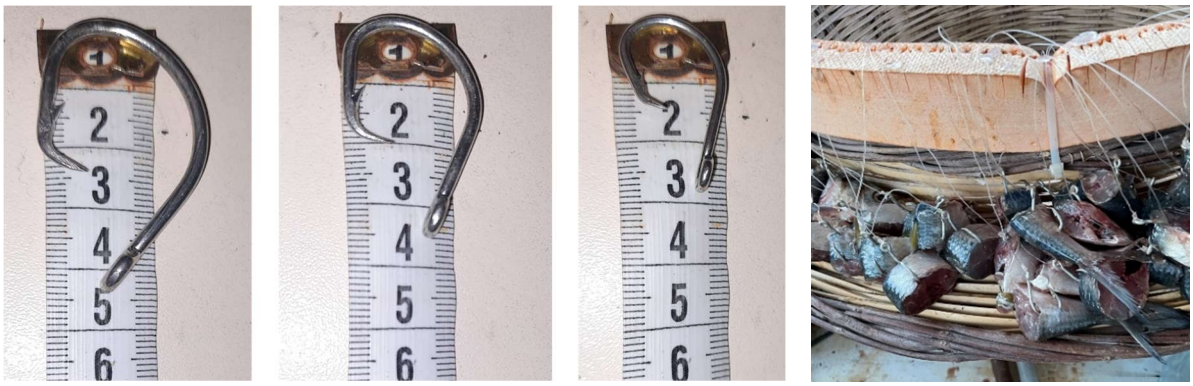

Figure 1. Dimensions of c-hooks and baited hooks with sardine.

Table 1. CPUE values of vulnerable species caught in in terms of their number and weight.

Hook Size (Length cm)		Haul No	Catch No	Hook Number	Commercial (kg)	Vulnerable Number	Vulnerable Weight-kg	Vulnerable CPUE Number	Vulnerable CPUE Weight-kg
3.0	**TEST**	12	7	3600	11.00	1	1.000	0.278	0.278
	CTRL	12	12	3600	44.50				
	Total	**12**	**12**	**7200**	**55.50**				
3.5	**TEST**	14	12	4200	13.85	10	34.00	2.381	8.095
	CTRL	14	14	4200	75.80				
	Total	**14**	**14**	**8400**	**89.65**				
4.0	**TEST**	7	4	2100	7.75				
	CTRL	7	5	2100	18.34				
	Total	**7**	**7**	**4200**	**26.09**				
All	**TEST**	33	23	9900	32.60	11	35.00	1.112	3.535
	CTRL	33	31	9900	138.64				

Among the total vulnerable species captured by C-hooks, 8 Picked dogfish (*Squalus acanthias*) were the most common, representing 73 percent of abundance and 72 percent of biomass (Figure 4 a-b). Whereas one individual of Spiny butterfly ray (*Gymnura altavela*) accounts for 21 percent of the total vulnerable biomass. It is worth noting that throughout the duration of the trials, which encompassed both the experimental (test) and control groups, no instances of sea turtle hooked were reported.

Figure 2. Commercial grouper species caught by C-hooks.

Figure 3. Vulnerable by-catch species captured by C-shaped hook.

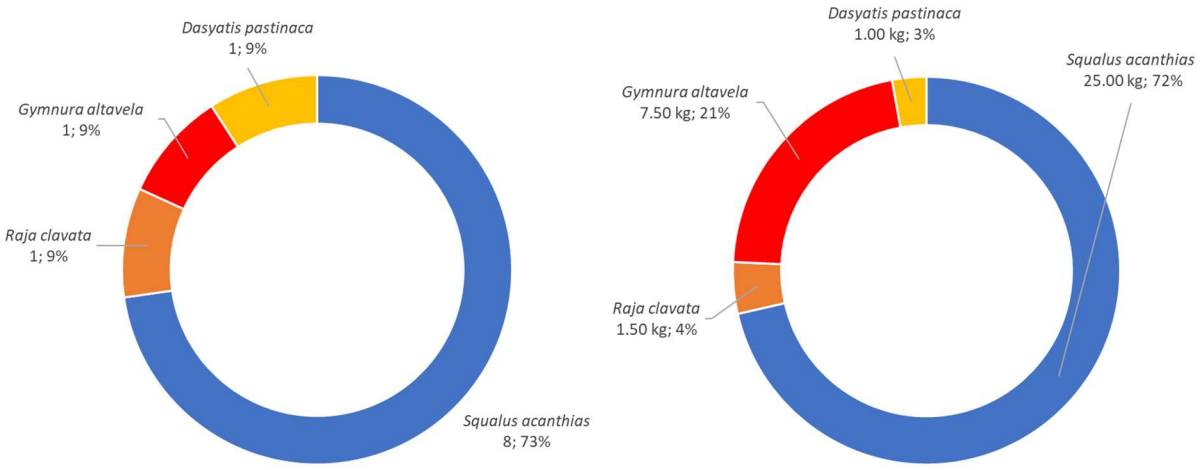

Figure 4a-b. Total number and weight of the vulnerable species caught by C-hooks.

There were eight incidents of endangered Picked dogfish caught by C-hooks out of 33 trials. Catch Per Unit Effort (CPUE) values of the vulnerable in terms of abundance and biomass are 0.808 individual and 2.525 kg, respectively (Table 2).

Table 2. CPUE values in terms of abundance and biomass for each of the vulnerable species captured by C-hooks.

Vulnerable Species	N	N-CPUE (no/1000hk/day)	W	W-CPUE (kg/1000hk/day)
Squalus acanthias	8	0.808	25.0	2.525
Raja clavata	1	0.101	1.5	0.152
Gymnura altavela	1	0.101	7.5	0.758
Dasyatis pastinaca	1	0.101	1.0	0.101
Total	**11**	**1.111**	**35.0**	**3.535**

The mean CPUE values of tested C-hooks and control J-hooks are 3.3 ± 3.8 and 12.4 ± 5.6 kg for 3.0 cm in length, 11.4 ± 23.9 and 18.1 ± 11.9 kg for 3.5 cm in length, 3.7 ± 5.4 and 8.7 ± 8.6 kg 4.0 cm in length and 6.8 ± 16.1 and 14.0 ± 9.8 for combined per 1000 hooks per 24 hours, respectively. There is a statistical difference between the mean CPUE values between C-hook and J-hook for 3.0, 3.5 cm in length and combined data (Figure 5). While control J-hook yield higher quantities of the commercial catch, there is a significant decrease in the longline with tested C-hooks. Notably, vulnerable species are also being captured in the tested longline with C-hook, whereas none were caught with standard hooks. The occurrence of extreme weights in C-hooks can be attributed to vulnerable species with high numbers and weights (Figure 5).

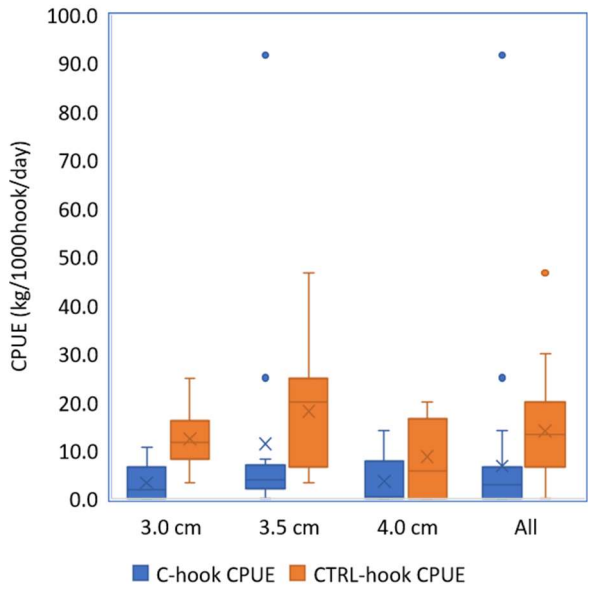

Figure 5. Box plot of CPUEs for 3.0 cm, 3.5 cm, 4.0 cm and combined C-hooks and J-hooks.

The number of hauls, total net length, total weight caught, and average CPUE values of longlines with test C-hooks and control J-hooks according to variables such as season, temperature, fishing area, and depth are detailed in Table 3. The mean CPUE values of J-hooks tends to be notably higher than those with C-hooks tested across various variables. However, a reverse change observed in the low number of hauls.

Table 3. Effects of various variables on total catch and mean CPUE values of test C-hooks and control J-hooks.

	Variables	C-hook Haul Number	CTRL Haul Number	C-hook Total Net Length (m)	CTRL Total Net Length (m)	C-hook Total Weight (kg)	CTRL Total Weight (kg)	C-hook Mean CPUE (kg/1000hk/day)	CTRL Mean CPUE (kg/1000hk/day)
Seasons	**Winter**	1	1	300	300	27.50	3.00	91.67	10.00
	Spring	1	1	300	300	0.60	2.50	2.00	8.33
	Summer	29	29	8700	8700	39.05	124.64	4.49±5.40	14.33±10.31
	Autumn	2	2	600	600	0.45	8.50	0.75±1.06	14.17±8.25
	Total	**33**	**33**	**9900**	**9900**	**67.60**	**138.64**	**6.83±16.08**	**14.00±9.83**
Tempe. (˚C)	**< 20**	2	2	600	600	28.10	5.50	46.83±63.40	9.17±1.18
	> 20	31	31	9300	9300	39.50	133.14	4.25±5.31	14.32±10.07
	Total	**33**	**33**	**9900**	**9900**	**67.60**	**138.64**	**6.83±16.08**	**14.00±9.83**
Fishing Areas	**Fethiye**	22	22	6600	6600	59.95	92.98	9.08±19.34	14.09±8.37
	Marmaris	7	7	2100	2100	6.5	20.165	3.10±3.21	9.60±7.34
	Sarıgerme	4	4	1200	1200	1.15	25.50	0.96±1.16	21.25±17.81
	Total	**33**	**33**	**9900**	**9900**	**67.6**	**138.64**	**6.83±16.08**	**14.00±9.83**
Depths (m)	**< 25**	21	21	6300	6300	29.40	98.73	4.67±6.25	15.67±10.99
	> 25	12	12	3600	3600	38.20	39.92	10.61±25.62	11.09±6.86
	Total	**33**	**33**	**9900**	**9900**	**67.60**	**138.64**	**6.83±16.08**	**14.00±9.83**
Hook sizes (cm)	**3.0 cm**	12	12	3600	3600	12.00	44.50	3.33±3.75	12.36±5.57
	3.5 cm	14	14	4200	4200	47.85	75.80	11.39±23.91	18.05±11.95
	4.0 cm	7	7	2100	2100	7.75	18.34	3.69±5.42	8.73±8.55
	Total	**33**	**33**	**9900**	**9900**	**67.6**	**138.64**	**6.83±16.08**	**14.00±9.83**

Conclusions

Diversity of trammel nets, set gillnets, and set longlines (multi-gear) are the predominant types of fishing gear utilized in Turkish small-scale fisheries. These gears are typically deployed in the late afternoon and retrieved at dawn, enabling continuous fishing throughout the night. Unfortunately, they can inadvertently capture various non-target species, particularly demersal sharks and rays. In areas where sea turtles inhabit, these gears may also unintentionally catch turtles.

Preserving sea turtle and elasmobranch populations in the Aegean Sea is a daunting task due to the intricate dynamics of fisheries in the region. Numerous species are targeted, and various fishing techniques are used. Consequently, effectively minimizing interactions between the species and fishing activities is challenging. Despite existing efforts, the adoption of measures to mitigate these interactions has been insufficient, leading to the ongoing decline of these populations.

In this study, the initial findings regarding the use of LED and UV lights in gillnet and trammel nets differ from the results of previous studies conducted elsewhere. It was found that the presence of these illuminations, reduced abundance and biomass of the commercial species caught by these fishing gear, while increasing the catch of endangered and vulnerable species. Similarly, the inclusion of circular hooks in longline has resulted in the capture of non-target vulnerable species. It would be beneficial to repeat these trials in fishing gear, areas, and fishing seasons where these species interact more intensively. As the pursuit of sustainable fishing practices continues, further inquiry into the efficacy of LED/UV lights and circle hooks is warranted. Finally, these mitigation methods stand poised to offer a pragmatic pathway toward the preservation of non-target species and the sustained viability of the small-scale fisheries.

Given the absence of statistically significant findings, it becomes imperative to embark on further comprehensive trials involving these specialized mitigation methodologies. Subsequent research endeavours should be dedicated to a thorough assessment of the viability and potential optimization of employing green LED and UV lights and circular hooks in achieving the coveted reduction in sea turtle bycatch.

In a different context, the intended objectives of mitigating sea turtle species through the application of green LED and UV lights and C fishing hooks have not materialized as anticipated. Contrary to documented achievements in mitigating sea turtle bycatch recorded in the literature, the conducted experiments within the Aegean Sea have yielded inconclusive results. Furthermore, it merits attention that the efficacy of the test gear in capturing the species targeted by the equipment has exhibited a notable decline. This decrease in catch success, combined with the intricacies linked to the acceptance and integration of these mitigation tools within the fishing community, has introduced significant challenges.

Collective actions for improving the conservation status
of the EU sea turtle population (**LIFE18 NAT/IT/000103**)
Project is carried out with the assistance of LIFE
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APPENDIX 2

TUNISIAN REPORT ON THE USE OF C-HOOKS IN LONGLINES TO REDUCE INCIDENTAL CATCH OF VULNERABLE SPECIES

Project "COLLECTIVE ACTIONS FOR IMPROVING THE CONSERVATION STATUS OF THE EU SEA TURTLE POPULATIONS: BORDERING AREAS » (LIFE MEDTURTLES)"

Report on Fishing gear modification for reducing turtle bycatch (C4)

B- Bottom longline

I- Introduction

I-1 Description of the coast and sea turtle's diversity (See report on gillnet)

I-2 fishing bycatch

In the Gulf of Gabès region, a large fishing fleet using many kinds of fishing gears operates during different seasons and targets a wide variety of commercially important species. These fishing activities interact with sea turtles. It is obvious that fishing poses a threat to loggerhead population in the Gulf of Gabès and mainly in the Zarzis zone (Jribi et al., 2007 and 2008, Echwikhi et al., 2010, Bradai et al., 2016).

In the frame of the project "COLLECTIVE ACTIONS FOR IMPROVING THE CONSERVATION STATUS OF THE EU SEA TURTLE POPULATIONS: BORDERING AREAS » (LIFE MEDTURTLES)" and particularly its action 4 that aims at the introduction of new methods for reduction of sea turtle bycatch in the fisheries of all 5 project countries. In Tunisia (Gulf of Gabes), target fishing gears for this Action are a special gillnet called locally "Garracia" and bottom longline, targeting groupers. Both represent major threats to sea turtles. The project will promote substitution of standard hooks with circle hooks for longliners.

I-3 The bottom longline

The bottom longline is used to catch groupers mainly, and some other bony fish. Besides these target species, sea turtles are caught accidentally. The hooks are generally numbers 04 or 05 for groupers and 13, 14 and 15 mainly for fishing for bony fish. Soak time is 1 to 3 hours and the baits used are generally sardine.

Bottom longline fishing targeting groupers is practiced during the summer throughout the Gulf of Gabès region. The other fish are targeted mainly in autumn and winter.

Bycatch in bottom longline is little studied.

II- Material and methods

II-1 Data collection

The observers proceed to the collection of information according to a standardized method and in accordance with the forms developed for the needs of the project.

The quantification of sea turtle bycatch rates was carried out in this study through onboard observations (by observers on board) and also through direct dialogues with fishermen (through interviews / questionnaires).

For observations at sea, accidental captures of sea turtles were reported by observers on board trained for this purpose. They were asked to:

• Obtain reliable information on the interaction of sea turtles with the bottom longline.

• Record the number, mass (or estimate) of the species caught during each fishing operation and, if possible, the position (GPS) of the bycatch event.

• Collect biological information on captured vulnerable species (length, sex, etc.).

• Collect gear and effort data and define parameters (number of hooks, bait, soak time, etc.).

• Collect general information necessary for a correct interpretation of the results such as:

- ✓ Vessel characteristics (fleet segment tonnage, etc.);
- ✓ Weight (or estimate in kilograms) and specific composition of the catch with indication of the main target species.
- ✓ Percentage of discards on the total catch with indication of the main species discarded.

For interviews and to get an idea of the extent of bycatch of sea turtles, adequate sampling was carried out formally, with standardized questionnaires conducted in ports where fishers can best be gathered and approached.

The information collected during the experiments was used to determine:

- the bycatch rate per unit of fishing effort (BPUE) for sea turtles as well as the catch rate per unit of fishing effort (CPUE) for the target species.

The BPUE (or CPUE) is reported as the number of individuals caught per 1000 hooks deployed.

- Mortality rate (in percentage) is defined as the number of dead individuals compared to the total number of individuals captured.

II-2 Mitigation measures

Several studies and observations have shown that in the region of the Gulf of Gabes, sea turtles are captured accidentally. The bottom longline, targeting groupers mainly in the region of Zarzis in spring and summer, is among gears the most impacting on these species. To reduce bycatch, circular hooks were experimented for bottom longline (Figure 1).

Circle and J hooks were arranged in alternating sections; the control gear on one side and the experimental one on the other. The positions of the different poses of the longline (experimental and control) are represented by Figures 2.

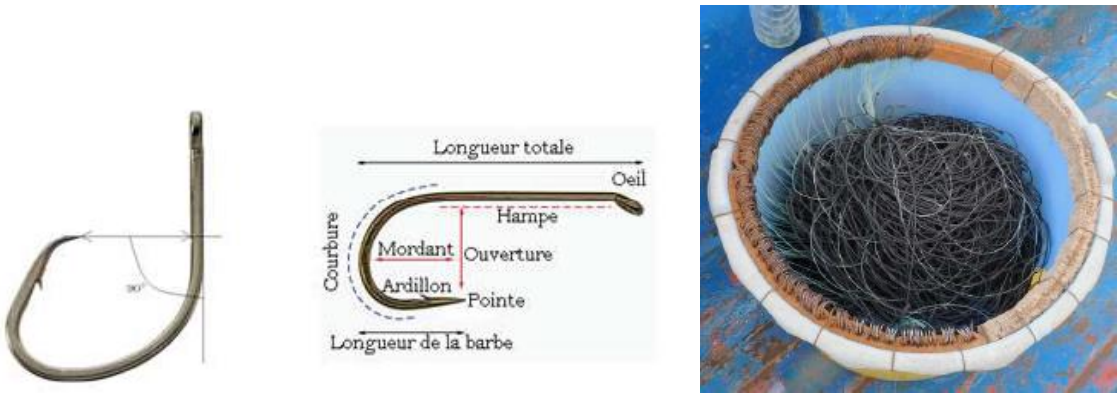

Figure 1: Bottom longline (1) circular and J hooks (2) bottom longline basket.

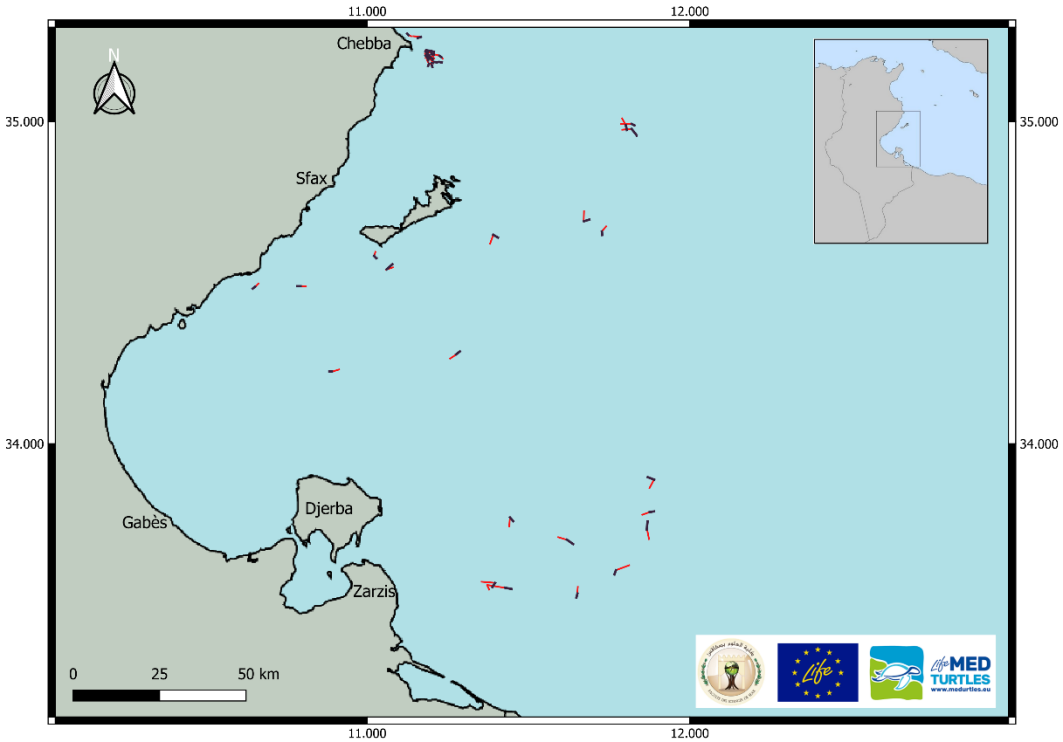

Figure 2: Positions of the control (Red) and experimental (Black) bottom longline

III- **Results**

During the study period, 51 hauls using 'J' hooks (22161 hooks deployed) and 51 hauls using 'C' hooks (8565 hooks deployed) were performed by 8 to 82m depth with an average of 28.5m (Tableau 3). Number or size of hooks varied from 4 to 7. The main baits were sardine and horse mackerel.

a- Composition of the catch

Elasmobranches are the main taxon fished in bottom longline representing 44% of the capture. Groupers, the targeted species in the past, represented only about 7.5%. This fishing gear impact sea turtles representing about 1 to 2% (Table 1).

Table 1 and figure 3 illustrate the composition of the catch of the bottom longline with J hooks and table 2 and figure 4 using C hooks. Figure 5 illustrate the bottom longline fishery.

Table 1: Composition of the captures in bottom longline (Control)

Species	Number	%
Elasmobranches	67	40
Groupers	12	7
Loggerhead	4	2
Other species	76	45
Species rejected	10	6

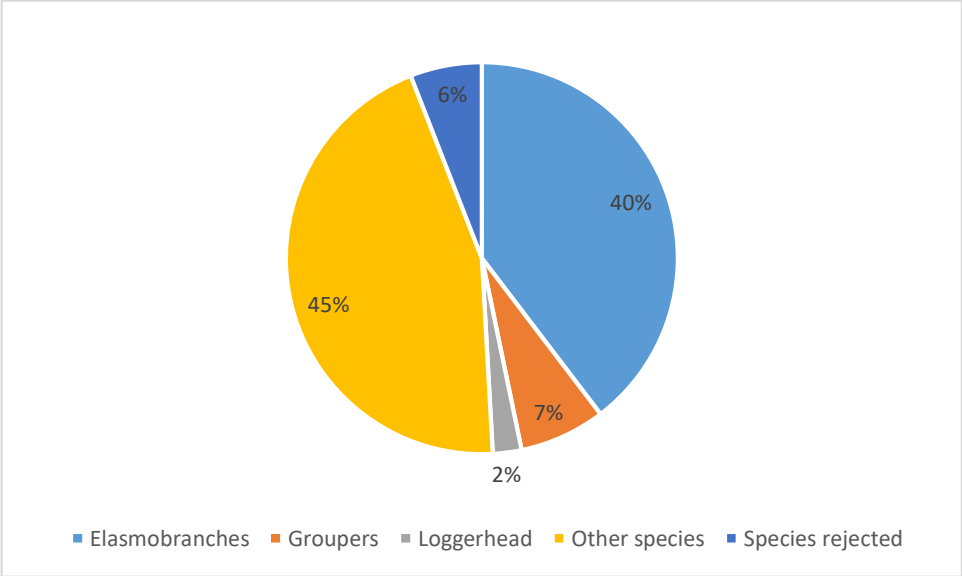

Figure 3: Composition of the captures in bottom longline using J hooks (Control)

Elasmobranches	2	28,57
Mérou	4	57,14
Tortues	0	0,00
Ind	1	14,29

Table 2: Composition of the captures in bottom longline using C hooks (Experimentation)

Species	Number	%
Elasmobranches	32	45
Groupers	5	7
Loggerhead	1	1
Other species	33	46
Species rejected	1	1

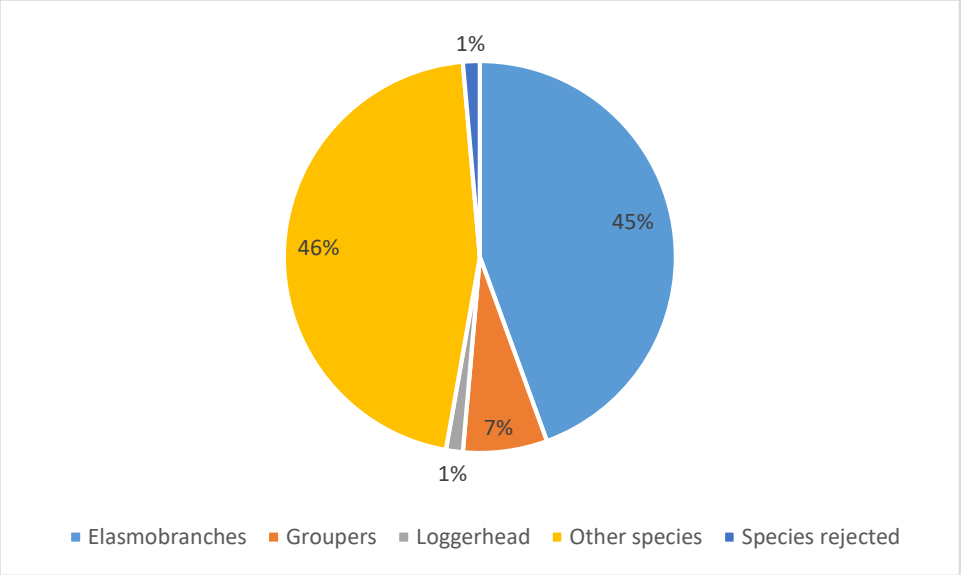

Figure 4: Composition of the captures in bottom longline using C hooks (Experimentation)

Figure 5: Bottom longline fishery (1) on board observation (2) bait (3) targeting species (groupers) (4 and 5) bycatch (elasmobranches and sea turtles).

b- Mortality rate (Table 3)

Five sea turtles were captured during trips with bottom longlines, four during control operations using J hooks and one during experimental operations using C hooks. All sea turtles captured were loggerheads and were alive; the direct mortality is estimated at 0%.

c- Sea turtle Bycaught Per Unit of Effort (BPUE) (Table 3)

The number of sea turtles caught during fishing operation with bottom longline is low which does not allow a good interpretation of the results. Despite a decrease in bycatch rate with the use of circle hooks, recorded (BPUE decreased from 0.23 to 0.06), statistical analysis showed that sea turtle bycatch rates are similar with both types of hooks (Wilcoxon Result (statistic=2.0, pvalue = 0.27) (Fig. 6)).

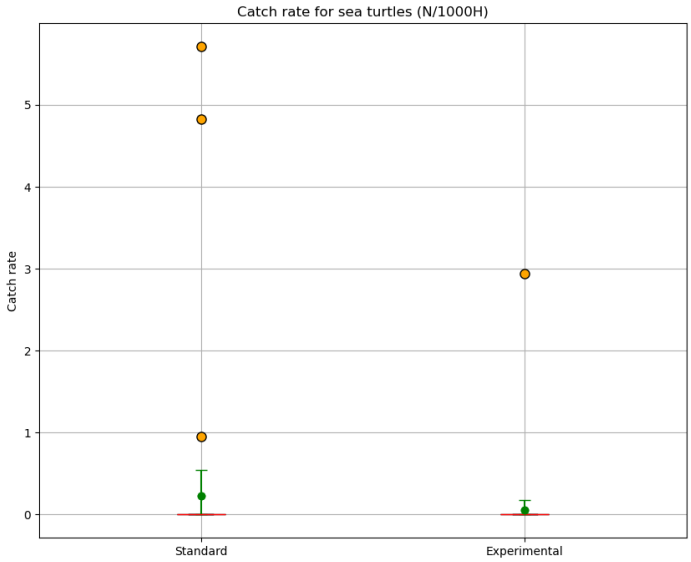

Figure 6: Boxplot of sea turtles catch rate by bottom longline (Standard vs Experimental)

d- Elasmobranches and groupers Capture Per Unit of Effort (CPUE) (Table 3)

Similarly, even if catches of commercialized species (all species) show a slight increase when circular hooks are used (CPUE increase from 5.89 to 8.00), the statistical analysis showed that the catch rates are similar with the two types of hooks (Wilcoxon Result (statistic=175.0, pvalue=0.36) (Fig. 7)).

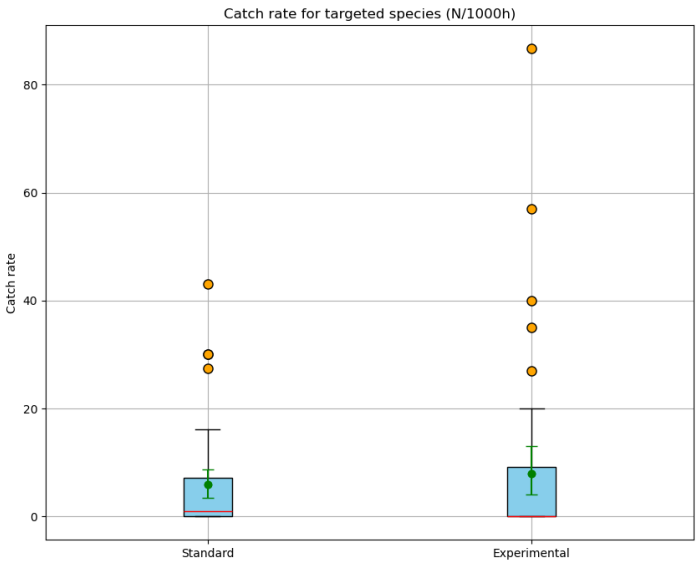

Figure 7: Boxplot of targeted species catch rate by bottom longline (Standard vs Experimental)

Table 3: Results of the monitoring of sea turtle bycatch in bottom longline and the use of circular hooks as mitigation measure

	J hooks (control)	Circular hooks (experimentation)
Number fishing operations	51	51
Hooks deployed	22161	8565
Loggerheads caught	4	1
Living turtles	4	1
Dead turtles	0	0
Mortality rate	0	0
BPUE/1000 hooks	0.23	0.06
95% CI =	0.0-0.55	0.0-0.17
all fish species caught	155	70
CPUE targeted species	5.89	8.00
95% CI =	3.48-8.65	4.03-12.98

II- Conclusion and recommendations

Results show that the main component of the capture is elasmobranches that are also vulnerable species to protect. Few loggerheads were captured in bottom longline and no mortality was registered.

Statistically, there is no difference in sea turtle bycatch with circular or J hooks. The use of circular hooks did not reduce bycatch. It seems that the shape of hooks is reducing bycatch of sea turtles with use of big size of hooks such as in the industrial tuna fisheries.

Results could be more significant with the following recommendations:

- Use the same number of either circular and J hooks:
- Harmonize the size of hooks;
- Use one bait if possible and the same baits (if more than one) for control and experimental longline;
- Harmonize fishing areas (mainly depth).

III- References

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