

Project: LIFE ARTINA - LIFE17 NAT/HR/000594 „Seabird Conservation Network in the Adriatic“

## Report on Testing Modified Fishing Gear to Reduce Seabird Bycatch in Croatia, Project LIFE Artina



Association for Nature, Environment and Sustainable Development Sunce

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### Project LIFE Artina

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Projekt LIFE Artina sufinanciran je sredstvima Europske unije iz LIFE Programa, Ureda za udruge Republike Hrvatske te sredstvima Fonda za zaštitu okoliša i energetske učinkovitost.

## Report on Testing Modified Fishing Gear to Reduce Seabird Bycatch in Croatia

### Project LIFE Artina

#### Summary

During previous research in the Mediterranean, it was established that longlines and gill nets are fishing gear that represent the greatest threat to seabirds (Cooper et al. 2003, Lewison et al. 2004, Corte's et al. 2017, Corte's i Gonza'lez-Soli's 2018; Institute of Oceanography and Fisheries, 2019).

Reporting of seabird bycatch is hardly present in any official database on fisheries or nature protection in Croatia. In general, very little is known about seabird bycatch in the Adriatic Sea, while available data indicate that interaction with fisheries poses a certain threat to some seabird species. The data collected in the period from 2018 until now as part of the "LIFE Artina - Seabird Conservation Network in the Adriatic" and "Adriatic Seabird Guardians" projects, indicate rare examples of seabird bycatch during fishing in the central part of the Adriatic Sea (Association for Nature, Environment and Sustainable Development Sunce, 2021; Institute of Social Sciences Ivo Pilar, 2020). At the same time, monitoring activities on the condition of Scopoli's shearwater (*Calonectris diomedea*), Yelkouan shearwater (*Puffinus yelkouan*) and Audouin's gull (*Larus audouinii*) were implemented, as well as predator management activities that include the control of ship rat populations (*Rattus rattus*) and the Yellow-legged gull (*Larus michahellis*) in the Lastovo and Palagruža archipelagos with the associated islands, islets, and cliffs. A higher nesting success rate was observed in the Scopoli's shearwater and Yelkouan shearwater, while the number of nesting pairs of Yelkouan shearwater also increased one year after the implementation of conservation measures (Engelen, D., Ječmenica, B., Kapelj, S. & Rajković, Ž. 2020. Site assessment report for seabird populations in the Lastovo and Palagruža Archipelagos, Croatia. LIFE Artina (LIFE 17 ANAT/HR/000594) report for action A1. Association Biom (BirdLife Croatia). 28 pp.). In the future, an increased number of the mentioned species of seabirds can be expected in this area, and thus potentially greater interaction between fishermen and seabirds. These are sensitive and endangered species with small populations, that can be significantly negatively affected even by the loss of a few individuals.

In the period from April 11 to October 7, 2022, mitigation measures that include using modified fishing gear (Table 1) were tested with 6 fishermen to evaluate the possibility of applying these solutions in Croatia, considering the specificities of boats, gear, and fishing methods. During the testing of the gear, fishermen used demersal and pelagic longlines and set nets (gill nets and trammel nets) in the waters of the islands of Šolta, Brač, Hvar, Vis, Korčula and Lastovo. Signal (LED) lights for set nets, additional weights for demersal longlines and hookpods (devices for releasing the hooks of pelagic longlines under the sea) were tested.

All 3 mitigation measures to reduce seabird bycatch were tested for the first time with fishermen in Croatia. The primary purpose of this testing was to determine the possibilities and obstacles for the implementation of certain measures to reduce seabird bycatch in Croatia. A secondary, but equally important purpose, was to encourage fishermen to reflect on these issues and share experiences, as well as to introduce the topic of seabird bycatch and mitigation measures among relevant stakeholders at the local and national levels.

**Table 1.** Testing of modified fishing gear with fishermen

Modified fishing gear	Number of fishermen	Number of fishing trips
LED lights	3	10
Additional weights	2	6
Hookpods	2	2
<b>Total</b>	<b>6*</b>	<b>18</b>

\*1 fisherman participated in testing two different gear types (LED lights and additional weights)

Through the questionnaire, fishermen had to report on the implementation of measures and results, but also on the impact of measures on target catch, practicability, advantages and disadvantages, comparison with standard/conventional gear and opinion on the possibility of future use of such gear in Croatia.

There was no seabird bycatch during these testings. Among other commercial species, sharks were accidentally caught on longlines, smooth-hound (*Mustelus mustelus*) and blue shark (*Prionace glauca*), and pelagic stingray (*Dasyatis violacea*), which were released alive and back into the sea.

During the research, seabirds followed the fishing boat, especially when throwing unused bait and cleaning fish catches. The recommendation for future research on seabird mitigation measures is to be carried out during March and April since during that period seabirds are most active, respectively the presence and interaction of fishermen with seabirds are the greatest.

The best-rated and accepted measure by fishermen is the measure of using additional weights on demersal longlines because weights are the fastest, simplest, and easiest method to use. No additional time is spent, and it does not affect the fishing activity itself or the amount of fish catch. The weights are simply attached to the longline with a clip when the birds are active around the fishing gear. This method is also the cheapest of all three that were tested in this research. It is also applicable for fishing with a pelagic longline (according to the Agreement on the Conservation of Albatrosses and Petrels, 2019).

During this research, the largest number of fishermen on the largest number of fishing trips tested LED lights on gill nets. However, fishermen's opinions about their practicality and functionality are divided. The fact is that there is an increase in the time spent on fishing activities. Also, the price of LED lights per piece is quite high. Fishermen's opinions are that they could be useful in the case of bycatch of other species (turtles) and that the possibility of using them on trammel nets should also be examined.

The worst-rated and the least accepted measure by fishermen is the measure of using hookpods (devices for releasing the hooks of pelagic longlines under the sea). It was tested on the least number of fishing trips. It is very impractical to use, it interferes with the fishing gear, and the time required to carry out the fishing activity increases. The price of these devices per piece is also not cheap, especially considering that they should be used on every hook of the longline. This method is applicable only in pelagic longline fisheries.

The need for future use of such fishing gear in Croatia should be carefully considered, regarding the cost of the modified fishing gear used for this testing, opinions of fishermen and the fact that seabird bycatch is present, but on a small scale. Modification or improvement of fishing practices could be a





more effective and cheaper solution. For their implementation, it is necessary to raise fishermen's awareness and/or to introduce spatio-temporal fishing regulations, for example, night setting and minimization of lighting of longlines to reduce the visibility of the hooks and setting fishing activity at a time when seabirds are relatively inactive, offal and discard management i.e., avoid throwing fish waste when setting longlines or hauling nets, to avoid attracting large numbers of birds at this stage of fishing, avoiding fishing in areas where endangered seabirds feed and stay (seasonal or permanent). For measures to be effective and to ensure that they are implemented by fishermen, they should be simple, appropriate to the fishery type, cost-effective, practical, safe, and accompanied by economic or social incentives. In addition, it is important to raise the awareness of fishermen, and other key stakeholders, about seabird bycatch and their role in it.

Furthermore, it is important to emphasize that due to the fish stock reduction, and the increase in labor and fuel costs, fishing has become more expensive and time-consuming in the last few years. The participation of fishermen in equipment testing and other similar research activities takes up their time and brings additional costs to their work. The key is to find ways to financially compensate their participation in future research.



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## THANK YOU

*We would like to thank all the fishermen who have participated in the testing of measures to reduce seabird bycatch and selflessly shared their knowledge with us. You have helped us gain new knowledge and experiences, enabling us to better understand all the challenges in achieving sustainable fishing.*

## 1. Introduction

During previous research in the Mediterranean, it has been found that longlines and gill nets are the fishing gear posing greatest threat to seabirds (Cooper et al. 2003, Lewison et al. 2004, Corte's et al. 2017, Corte's and Gonza'lez-Soli's 2018).

The data collected in the period from 2018 to today under the "LIFE Artina - Seabird Conservation Network in the Adriatic" project indicate rare examples of seabird bycatch during fishing in Croatia, in the central part of the Adriatic. However, at the same time, in the area of the Lastovo and Palagruža archipelagos with the associated islands, islets and rocks, activities were carried out to monitor the state of the Scopoli's shearwater (*Calonectris diomedea*), Yelkouan shearwater (*Puffinus yelkouan*) and Audouin's gull (*Larus audouinii*) as well as predator management, which includes the control of the black rat (*Rattus rattus*) and the Yellow-legged gull (*Larus michahellis*). A higher nesting success rate has been found in Yelkouan shearwater, and the number of nesting pairs of Yelkouan shearwater also increased one year after the implementation of conservation measures. In this area in the future an increased number of the mentioned species of seabirds can be expected, and thus potentially greater interaction between fishermen and birds. These are vulnerable and endangered species of small populations that live long and breed slowly, thus the loss of a relatively small number of adult birds can have a negative effect on the entire population.

Also, most seabirds are extremely mobile species that use a wide area throughout their annual cycle. It is known that the majority of the Yelkouan shearwater population spends the winter at the Black Sea, while returning to their nesting colonies by February, sometimes even earlier. The Scopoli's shearwaters spend the winter at the Atlantic Ocean, while Audouin's gulls leave the Adriatic Sea in late summer and travel along the northern coast of Africa. During the feeding period of the young (May-July for the Yelkouan shearwater, July-September for the Scopoli's shearwater and June - July for the Audouin's gull), all three species regularly travel hundreds of kilometres from their colonies to the area where they hunt and return to their nests. Because of this, interactions with fishing gear are possible in a wider area than the one surrounding their colonies.

Therefore, research has been conducted on the interaction between fishermen and birds in order to determine the technical possibilities for the introduction of fishing gear, tools or measures that would reduce or completely eliminate bycatch of seabirds. It has been found that seabird bycatch is sporadic and that there is very little field knowledge about the technical specifications and effectiveness of alternative fishing gear. Hence, within the project framework, it has been decided to test replacement tools used by a lower number of fishermen, in order to evaluate the possibility of applying these



solutions in Croatia, taking into account the specificities of boats, gear and fishing methods. During 2022, the following measures of using modified fishing gear were tested by fishermen, namely: signal (LED) lights for set nets, additional weights for demersal (set) longlines and hookpoods - devices for releasing the hooks of pelagic (floating) longlines under the sea surface.

The research based on data collected in different project phases, which are available in the following documents:

- Association for Nature, Environment and Sustainable Development Sunce (2021): Seabirds and fishing activities interactions assessment report. Project: LIFE ARTINA - LIFE17 NAT/HR/000594 "Seabird Conservation Network in the Adriatic".
- Institute of Social Sciences Ivo Pilar (2020): Report on the extent of the use of fishing gear with a potential impact on seabirds, and on the scale of seabird bycatch. Project: LIFE ARTINA - LIFE17 NAT/HR/000594 "Seabird Conservation Network in the Adriatic"
- Institute of Oceanography and Fisheries (2019): Expert basis for assessing the impact of fishing activities on seabirds. Project: LIFE ARTINA - LIFE17 NAT/HR/000594 "Seabird Conservation Network in the Adriatic".



## 2. Testing measures to reduce seabird bycatch

Reporting seabird bycatch is hardly present in any fisheries database or nature protection in the Republic of Croatia. In general, very little is known about the seabird bycatch in the Adriatic Sea, while available data indicate that interaction with fisheries poses a threat to certain seabird species. The data collected so far indicate rare examples of seabird bycatch during fishing, especially the species that are in the focus of the LIFE Artina project (Scopoli's shearwater, Yelkouan shearwater, Audouin's gull). The primary purpose of this testing was to determine the possibilities and obstacles to the introduction of certain measures with the aim of reducing bycatch of seabirds in Croatia. A secondary but equally important purpose was to encourage fishermen to reflect on these issues and share their experiences, and to introduce the topic of seabird bycatch and measures to reduce it to relevant stakeholders at the local and national level.

Researching similar projects in other countries, we came across a number of experiences, activities and measures related to the reduction of seabird bycatch.

Depending on whether they are related to the fishing activity or fishing gear, seabird bycatch mitigation measures can be divided into two groups:

- Adaptation and/or improvement of fishing practices and
- Adaptation and/or improvement of fishing gear.

While the first group includes measures that change the fishing activity in a certain manner, i.e. for their implementation it is necessary to influence the awareness and behaviour of fishermen or introduce legal restrictions, the second group includes measures in which fishing gear is modified or replaced with the type of gear that contribute to reduction of seabird bycatch. This is done to repel or distract the birds from the fishing gear, speed up the sinking of baited hooks and make them less visible.

Within the project, Sunce has conducted research on the mutual impact between fishermen and seabirds, as well as tested measures of fishing gear adaptation and/or improvement. The research has been carried out in collaboration with the Institute for Oceanography and Fisheries (IOR), the Ivo Pilar Institute and the Association Biom. The research sought to determine the technical possibilities for the introduction of fishing gear, tools or measures that would reduce or eliminate seabird bycatch, as well as collect data on the actual implementation of the measures and the results, the impact on the targeted fish catch, practicality, advantages and disadvantages, comparison with standard (conventional) tools, and fishermen's opinions about the possibility of future use of such tools in Croatia.

The research was originally planned to be conducted among fishermen who fish within two Natura 2000 areas for bird conservation (SPA), SPA Lastovsko otočje and SPA Pučinski otoci, but it was conducted on a slightly wider area, due to the fact that the fishermen involved in the research fish in a much wider area. Fishermen who use demersal and pelagic longlines, gillnets and trammel nets who expressed their interest participated in the research.

Fishermen who participated in this research were given modified fishing gear to reduce seabird bycatch, namely: signal (LED) lights for set (gill nets and trammel nets), additional weight (weights) for demersal longlines and devices for releasing hooks of pelagic longlines under the sea surface (hookpods).

Modified fishing gear were selected for testing based on interviews with fishermen and available research results of measures aimed at reduction of seabird bycatch in other countries which suggested to be effective (BirdLife International, 2017; Association for Nature, Environment and Sustainable Development Sunce, 2021), and bearing in mind the availability/possibility of creating the gear and applying them to a certain type of fishing.

Nets are practically invisible to birds under the sea surface; therefore, their presence should be signalled so they can avoid them. For these purposes, **LED lights** are used, emitting green light when submerged. The positive impact on target fish catches rates, relatively low costs, ease of use and maintenance are stated as advantages of the method in various studies. They also contribute to the reduction of bycatch of other species, such as sea turtles. According to a study on measures to reduce seabird bycatch (European Commission, 2017), the fitting of signal lights (LED) is potentially a good measure in gill net fishing, but the study was conducted in locations where varied bird species are important.

Placing **additional weights** on the lines increases the sinking speed of the hooks and thus reduces the time the bait is exposed to the birds. Weighting is achieved by adding external attached lead weights or a pre-made longline with lead line. Various studies show a good efficiency of this method in reducing seabird bycatch, and fishermen are already using it to reduce the impact of sea currents during the sinking of longlines. For example, the best practice recommendations of ACAP (Agreement on the Conservation of Albatrosses and Petrels, 2019) in fishing with pelagic and demersal longlines include the use of additional weight/weights (in addition to the measures of setting scare lines/dissuading birds from fishing gear and night-time setting of longlines). During the conversation, the fishermen gave this measure their greatest support for use in demersal longlines, considering it simple, practical and cheap.

Advantages include applicability to demersal and pelagic longline fishing, increased fish catch, low cost and easy availability of weights, while disadvantages include potential practical difficulties of use, introduction of lead into the ecosystem, and crew safety due to the possibility of getting entangled in the attached weights.

It should also be noted that the future restriction on the use of lead in fishing, due to its highly toxic properties, should come into force in the near future. The European Chemicals Agency (ECHA) proposes a ban on the sale and use of various forms of fishing gear and equipment that contain lead (lead weights and lures, lead wire, lead in the rope of fishing nets...). As an alternative to lead, various substitute alloys and materials are being considered (bismuth, ceramics/glass, brass, bronze, concrete, various types of polymers, iron, steel, stones or gravel, tin, tungsten, zinc...). Due to the complexity and financial burden, ECHA proposes a schedule for the introduction of the ban, first for sport and then

for all fishing types, in the period from the entry into force of the ban and then gradually through a transitional period of 3 to 5 years (according to ECHA, 2022).

The use of **hookpods** (underwater pelagic longline hook release devices) reduces the exposure of baited hooks. The principle of operation is such that the devices cover the tip of the hook holding baits and release the hook only at a certain depth (10-20 m) under hydrostatic pressure. In this way, the baits are not exposed or accessible to birds near the sea surface. Various research state that the advantages of the method are its effectiveness in reducing seabird bycatch without affecting the target fish catch, its efficiency even during strong winds, and the possibility of repeated use. The disadvantage is the manual fitting/closing of each baited hook on an individual rig, which wastes time that would otherwise be used for multiple repetitions of dropping and retrieving the line. The [link](#) shows how these devices work. As of 2016, ACAP also recommends the use of these devices to reduce seabird bycatch.

All three measures aimed at reduction of seabird bycatch birds were tested for the first time in collaboration with fishermen in Croatia.

### 3. Testing results

A total of 6 fishermen (Table 1) participated in the testing of gear and equipment to reduce seabird bycatch. Fishermen provided feedback on their experience of using the tools by filling out a questionnaire (Appendix 1). Testing of the tool was carried out in the period from April 11 to October 7, 2022.

*Table 1 Testing of modified fishing gear with fishermen*

Modified fishing gear	Number of fishermen	Number of fishing trips
LED lights	3	10
Additional weights	2	6
Hookpods	2	2
<b>Total</b>	<b>6*</b>	<b>18</b>

*\*1 fisherman participated in the testing of two types of tools (LED lights and additional weighting)*

An overview of technical specifications, instructions for using modified fishing tools and their prices can be found in Appendices 2 and 3, and additional photos can be found in Appendix 4.

Project team representatives (Sunce and Biom associations employees) were present during a total of 9 fishing trips with 4 fishermen. These fishing trips included 2 testings of LED lights, 5 tests of additional weighting and 2 tests of hookpods. Representatives of the Institute for Oceanography and Fisheries



(IOF) were present during a total of 16 fishing trips with fishermen. Thanks to their participation in fishing trips, the representatives of the project team gained insight into the obligations of fishermen, the issues and challenges they face while fishing, but also while being at sea in general. Also, fishermen had the opportunity to get information about project activities, other measures to reduce seabird bycatch used in the world, and the like. The participation of representatives of the project team and/or IOR depended on the conditions and size of the vessel, the possibility of receiving a certain number of people while taking care of the safety of all those present, the selection of the fishing location with regard to the number of people on the vessel, etc.

During the testing of the gear, there was no seabird bycatch. In general, encounters with seabirds during this survey were rare. They followed the vessels during the setting up and retrieving fishing gear, and while throwing bait remains and cleaning caught fish. Since the birds are active in the earlier period of the year (Yellowlegs start nesting at the beginning of March) and the fishermen also state that period as the one with the greatest presence of birds and their interactions, future research should be carried out earlier during the year.

Of the other species, sharks were accidentally caught in fishing gear - smooth-hound (*Mustelus mustelus*), blue shark (*Prionace glauca*), and pelagic stingray (*Dasyatis violacea*), which were released alive back into the sea.

### 3.1. Signal (LED) lights for set nets

The fishermen who participated in this research used gill nets and trammel nets and their target catches were mainly cuttlefish (*Sepia officinalis*), gilthead bream (*Sparus aurata*) and red scorpionfish (*Scorpaena scrofa*).

LED lights for gill nets and trammel nets (Figure 1) were tested by 3 fishermen (30 pieces each), in 10 fishing trips in the waters of the islands of Vis, Lastovo and Brač. The lights were placed every 10 m of the net approximately and were attached to the gill net float with a line (Appendix 2). All the lights were in order and were lit during the lifting of the net.

During fitting and retrieving of the nets, seabirds followed the boat only in the case of Lastovo fisherman, namely Yellow-legged gulls and Scopoli's shearwaters. The fisherman states that birds are most numerous in March and April, usually around the islet of Glavat.

Two fishermen think that LED lights are not practical to use because they are difficult to fit on the gear and make it difficult to handle the net, while one fisherman thinks that they are practical for working on trammel nets with a smaller mesh size, because LED lights do not get entangled in the net during fishing operations. Also, the same fisherman believes that they are noticeable in the sea, and that they should be tested during the cuttlefish fishing season from February to May on trammel nets because birds are not caught in gill nets. The main disadvantages of using LED lights are that they slow down the work, the rope that is attached to the net breaks (*"During winch lifting, they can fall out because the rope attached to the nets gets untied. This happens due to great stress when lifting the nets from*

the depths." ). Also, mud and sea can get into the light, leaving it constantly lit, which can affect battery life. All three fishermen believe that use of LED lights leads to a significant increase in fishing time, because after each lifting of the net, the ropes on which the lights are attached to the nets must be tightened (*estimate 100% more time/three times longer/30-45 min longer*). They state that there was no change in the amount of catch when using the lights. Only one fisherman states that he would continue to use this type of tool - the one who tested it most times (6 fishing trips). Regarding the possibility of future use of such a tool in Croatia, this fisherman states that it could come to life, but that they should be tested on trammel nets. However, he also believes that not many seabirds are caught in gill nets, and that in case of trammel nets it would be best to avoid throwing them in areas with a large number of Mediterranean shags (*Phalacrocorax aristotelis desmarestii*). The other two fishermen believe that the lights are not necessary because there are no birds caught in the nets, but one states that they could be good for preventing the bycatch of other organisms, such as turtles, if they do not affect the fish catch.

The fishermen believe that seabird bycatch is very rare, negligible. Two fishermen state that they have caught a shag in their nets 3-4 times in their life. In addition to seabirds, they have caught other species such as turtles and common stingray (*Dasyatis pastinaca*), and returned them alive to the sea.

One fisherman states that he does not plan to enter data on bycatch of species in the logbook in the future, while the other two fishermen plan to enter them. However, one states that this part is a bit unclear and should be clarified by the Directorate of Fisheries.

All three fishermen rated participation in this research as a positive experience, with only one fisherman stating that participation changed his view of seabirds, in such a way that he became more aware of their presence while fishing. Fishermen are interested in participating in future research on the seabird and other species bycatch, but sometimes the interest depends on the assessment of whether the research makes sense or if it is done *pro forma*. A justified goal and research results would encourage one fisherman to participate.



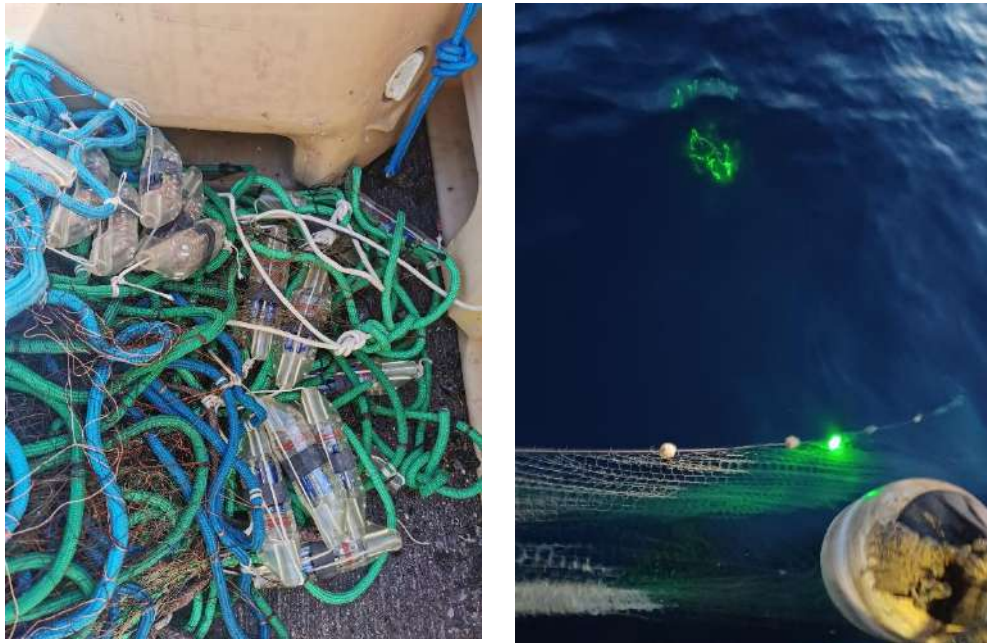


Figure 1 Testing LED lights on set gill nets

### 3.2. Additional weighting (weights) for demersal longlines

Demersal longlines with weights for additional weighting were tested by 2 fishermen, in 6 fishing trips in the waters of the islands of Korčula and Lastovo.

Fishermen who participated in this research used demersal longlines with 250 hooks, with additional weights of 0.5 kg (5 pieces) and 1 kg (5 pieces), attached to the longline by clips.

One fisherman used ball shaped weights, while the other used square shaped weights in the form of a cylinder (Figure 2). Before the research, fishermen emphasized the possibility of longline entanglement due to sea currents and depth, so two types of weighting were tested. During the research, no difference was noticed regarding the shape of the weights, but in conversations with the fishermen it was noticed that the 1 kg weight was too heavy, and that in the future it is recommended to use 100-200 grams weights. The weights are used in such a way that the weight is attached to the longline by a clip so that the hooks sink as quickly as possible, directly, in situations when the birds follow the boat during the setting of the longline and get stuck on the baited hooks.

Fishermen used sardines as bait, and the target species of fish catch for one fisherman were piper gurnard (*Trigla lyra*), European hake (*Merluccius merluccius*), turbot (*Scophthalmus maximus*), and for another fisherman John Dory (*Zeus faber*), common dentex (*Dentex dentex*), European hake and forkbeard (*Phycis phycis*).

The birds followed the boat during the setting and lifting of the longline, especially during throwing of the bait remains and cleaning of the caught fish, namely the Yellow-legged gull, Scopoli's shearwater

and Yelkouan shearwater (in addition to some other species we were unable to identify). A fisherman from Lastovo states that the birds sometimes take the bait off the hook while fishing, and that in March and April, when the longline is set, they can be aggressive for half an hour, and then they give up and leave. He thinks that birds are not a problem. A fisherman from Korčula also states that March and April are the most favourable period for observing the interaction with seabirds, and that in that period he caught them on longline hooks.

Both fishermen think that this measure is practical to use, because the weights are attached to the longline when there are birds. If there are no birds, it is not necessary to set the weights. They state that the main advantage of using this method is that the longline sinks faster and the current cannot carry it away, and it does not affect fishing. As the main disadvantage of using the test tool, one fisherman mentions the weight of the weights, i.e., it would be better if they were half their weight or about 100-200 grams, due to the lifting of the longline. Another fisherman believes that the amount of lead for the size of the longline might create issues, and that on smaller boats the total weight of the weights (when there are 1,000 hooks and more) can be a problem. Both fishermen state that the use of weights did not increase their fishing time. One fisherman believes that the latter depends on the situation, e.g. 900 hooks and the presence of birds would require a lot of lead, which would also increase the fishing time, because he is used to hanging a lead weight every 50 m whenever the birds are around. Also, they think that when they used weights, there was no to a change in the amount of target fish catch.

Due to its simplicity and practicality, both fishermen would continue to use this type of tool to reduce seabird bycatch, and they believe that there is a possibility of its future application in Croatia.

The fisherman from Lastovo has never caught a bird on a longline, while the fisherman from Korčula states that in March birds get caught the most, and that there are more of them than there should be, mostly around Lastovo islands, while some even come closer to the coast. In order to avoid catching a bird, besides using a lead, he sometimes drags a buoy behind him, but does not think this helps.

In addition to seabirds, they have been known to catch other species such as turtles, porcupine sharks (*Oxynotus centrina*) and puffer fish. The fisherman states that when he caught a turtle, he removed the hook with pliers and released it alive back into the sea.

One fisherman states that he does not plan to enter data on the bycatch of species in the logbook in the future, because this would complicate things for him, while the other one plans to do so, although he thinks that this part is a bit unclear and should be clarified by the Directorate of Fisheries.

When asked about rats, both fishermen state that they did not have them on their boat. Also, they are familiar with rat repelling devices, one fisherman even used them. The fisherman from Lastovo is aware of the threat that rats represent to seabird colonies (*They threaten the population, they eat the eggs. They can dive, and swim, approx. 5 km.*).

Both fishermen rated participation in this research as a positive experience, with only one fisherman stating that participation changed his view of seabirds. Fishermen are interested in participating in future research on bycatch of seabirds and other species, but sometimes the interest depends on the

assessment of whether the research makes sense or if it is done *pro forma*. A justified goal and research results would encourage one fisherman to participate.



Figure 2 Testing additional weighting (weights) on demersal longlines

### 3.3. Devices for releasing hooks under the sea surface (hookpods)

Devices for releasing the hooks of pelagic longlines under the sea surface (hookpods; Figure 3) were tested by 2 fishermen in 2 fishing trips in the waters of the islands of Hvar and Vis.

It was very difficult to arrange gear testing with fishermen who use pelagic longlines, mostly because during good weather they spend several days in the open sea, in international waters. Then they are not comfortable with the presence of other people on board or testing the tools. Therefore, a very small number of tests of these devices were performed, which is certainly not enough to draw conclusions.

For the purpose of the testing, fishermen used their longlines with 600 hooks, to which they attached hookpods (50+ pieces each). The principle of operation is such that the devices cover (encapsulate) the point and barb of a baited hook and protect it from scavenging seabirds during line setting operations. Once the hook reaches 20 m depth a mechanical pressure release mechanism is triggered that releases the baited hook (Appendix 2). In this way, the hooks are not exposed or accessible to birds near the sea surface. The fishermen used sardine, mackerel and artificial squid as bait, and their target species of catch were tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*).

In the case of the first fisherman, a total of 53 hookpods were placed. 12 of them fell out in the sea, and 5 of them did not open under the sea surface. 36 devices opened. On one hook with a hookpod



installed, a swordfish was caught (as well as on other hooks without hookpods installed). This fisherman chose the method of attaching the hookpod to the branchline at the same time while placing the baits on the hooks and throwing the longline into the sea. A second fisherman placed a total of 51 hookpods. Not a single hookpod fell into the sea, 44 opened under hydrostatic pressure while 7 did not open (Table 2). This fisherman attached all the hookpods on the branchline before baiting the hooks and throwing (setting) the longline into the sea. The assumption is that the hookpods that did not open under the sea surface were too shallow, i.e. close to the buoy that holds the longline in the water column. However, more testing of this type of gear should be performed in order to draw conclusions.

Table 2 Total number of installed hookpods, as well as those that opened in the sea under hydrostatic pressure or fell into the sea

Fisherman	Total No. of installed hookpods	No. of hookpods opened in the sea	No. of unopened hookpods	No. of hookpods that fell into the sea
1.	53	36	5	12
2.	51	44	7	0
<b>Total</b>	<b>104</b>	<b>80</b>	<b>12</b>	<b>12</b>

During the longline setting and hauling, the birds followed the boat and stole the baits, especially during the throwing of the bait remains, cleaning of the caught fish and throwing the fish offal into the sea, namely the Yellow-legged gull and Yelkouan shearwater (and some other species that we failed to identify).

Both fishermen find hookpods to be unpractical, time-consuming and easily tangled in the longline. They require effort, and fishermen think that there is no point of attaching them. However, one fisherman thinks that the product itself is well thought out. The main disadvantage of using this type of gear to reduce seabird bycatch is its impracticality. The fisherman from Vis thinks that the hookpod should be tested during the period when there are seabirds, but he thinks that it would drive the tuna away because it scares easily. He thinks that hookpods are more suitable for other fishing areas of the world and fish species, e.g. salmon (*Salmo salar*) which are voracious and will not be chased away by these devices.

Regarding the time spent on fishing activities when using the test gear, one fisherman believes that it did not increase, but that he would require assistance of an additional person and greater concentration. Another fisherman states that setting the longline is 50% slower with the device on,

and when a hand gets caught in it might be 30% (provided that he attached the hookpod to the branchline earlier, but has to drive more slowly), and hauling the longline is 15-20% slower. Also, if he had to attach a hookpod on each hook, he would have to rearrange all the gear containers, there would be fewer hooks in the container, and more containers, which is a problem for him because there is not that much space on the boat.

When talking about the amount of target fish catch using the test gear, one fisherman did not answer that question (although he had one catch of swordfish on a hook with hookpod), while another stated that there were no catches on hookpod hooks, but he could not safely conclude that this had to do with the hookpod.

Both fishermen believe that the future use of such gear in Croatia is unlikely, especially considering the small number of seabird bycatch, nor would they continue to use hookpods, especially if they had to attach them on every hook (600 pieces). One fisherman states the problem of plastic if hookpods fall into the sea, as well as an increase in work because he would have to hire another person to hand hookpods to him. He catches a bird about 5 times a year, and he thinks that this is rare and that it makes no sense to use these devices. Another fisherman states that he has been known to catch the gull type birds, e.g., the yellow-legged gull and Scopoli's shearwater.

Among other suggestions related to reducing the seabird bycatch by fishing gear, one fisherman mentioned the buckets they put up to drive the birds away, he thinks that this method is successful, but time-consuming. Also, he would like to try the bird scaring lines (streamer lines).

In addition to seabirds, fishermen have caught sharks, turtles, and common eagle ray, at times. One fisherman states that in June 2021 he caught a lot of turtles, mostly in front of the island of Vis. Mostly they are alive, so he takes off the hook and releases them back into the sea. If he catches a smaller shark, he removes the hook, and in larger sharks he leaves the hook in and releases them back into the sea. In most cases he caught a blue shark, he says that there are a lot of them. He also caught a common thresher (*Alopias vulpinus*) weighing 300 kg, in the island of Jabuka, and recently he caught a shortfin mako shark several times (*Isurus oxyrinchus*) (specimen larger than 300 kg).

None of the fishermen plan to enter data on the bycatch of species in the logbook because they believe that it is pointless, takes time and will entail new obligations. One fisherman reports a bycatch of species to the IOF.

One fisherman had rats on board, which came over the power cables. Both fishermen are familiar with rat-repelling devices, but one fisherman thinks that the rats from Jabuka skip everything. Another fisherman knows how to put a bottle on the line to prevent rats from entering the boat, and also states that there are rats on Jabuka.

One fisherman evaluated participation in this research as a positive experience, despite the fact it did not change his view of seabirds, while the other fisherman did not answer these questions.





Figure 3 Testing devices for releasing drifting longline hooks under sea surface (hookpods)

### 3.4. Functioning and practicality of tested fishing gear and devices

During this research, the largest number of fishermen tested signal (LED) lights in the largest number of fishing trips. As regard to these devices the fishermen disagreed about their functionality and practicality. While two fishermen think that the device is unpractical and it slows down the work, the fisherman who tested them during biggest number of fishing trips, thinks that they are practical to use. However, all three fishermen agree that the use of LED lights increases their fishing time. One of the disadvantages of this type of tool is that mud and sea can get into the light leaving it constantly on, which can affect battery life. There were no changes in the amount of target fish catch during the use of LED lights. Fishermen's opinions about the possibility of future use of LED lights in Croatia are again divided, since they believe that the seabird bycatch is not significant. However, they believe that they could be useful in bycatch of other species, such as turtles.

Even during the preparatory activities of the project, the fishermen evaluated the use of additional weighting on demersal longlines as a good measure. Some of them already use lead weights and stainless-steel clips (to connect them to the longlines) to speed up the sinking of longline hooks, and they think that weights are the fastest, simplest, and easiest to use. This research also speaks in favour of that because both fishermen believe that the use of additional weights is practical, functional, and effective. The weights are simply attached to the longline with a clip when the seabirds are active around the fishing gear. Before the research, the fishermen stressed the possibility of entanglement of longlines due to sea currents and depth, so two types of weights (ball-shaped and square-cylindrical weights) were tested. During the research, no difference was noticed regarding the shape of the

weights, but the recommendation of the fishermen is that due to the hauling of the longline, the weights should be lighter in the future, 100-200 grams each. The main advantage of using this type of gear is that the longline sinks faster when seabirds are around, the current cannot carry it away (potentially increasing catch efficiency), and the weights do not affect fishing. Also, when using additional weights, there was no increase in fishing time, nor a change in the amount of the target fish catch. Fishermen do not mention the disadvantages of this method, but they wonder what the amount of weight per number of longline hooks in situations with a greater presence of seabirds should be. In this case, there could be an increase in fishing time, as well as a problem of space for storing weights on the vessel. Both fishermen would continue to use this type of gear in the future. As stated earlier (chapter 2. Testing measures to reduce bycatch of seabirds), it is expected that in the future weights will not be made of lead but of alternative materials due to restrictions on the use of lead in fishing.

The future restriction on the use of lead in fishing, due to its highly toxic properties, should come into force in the near future. The European Chemicals Agency (ECHA) proposes a ban on the sale and use of various forms of fishing gear and equipment containing lead (lead weights and lures, lead wires, lead in the rope of fishing nets...). As an alternative to lead, various substitute alloys and materials are being considered (bismuth, ceramics/glass, brass, bronze, concrete, various types of polymers, iron, steel, stones or gravel, tin, tungsten, zinc...). Due to the complexity and financial burden, ECHA proposes a schedule for the introduction of the ban, first in sport and recreational fishery and then in the entire fishery, in the period from the entry into force of the ban and gradually through a transitional period of 3 to 5 years (according to ECHA, 2022).

The measure of attaching devices for releasing the hooks of pelagic longlines under the sea surface (hookpods) was tested in the lowest number of fishing trips. Fishermen used these devices in different ways. While one fisherman attached the hookpods to the branchline at the same time while baiting the hooks and throwing the longline into the sea, the other attached all the hookpods on the branchline before baiting the hooks and throwing (setting) the longline into the sea. With the first fisherman, the hookpods fell into the sea, while with the second this was not the case. To draw relevant conclusions, more testing of this type of tool should be done, in a period when seabirds are more active and present.

Both fishermen believe that the product itself is well designed, but that it is very impractical to use and gets tangled in the longline. The use of hookpods increases the time required to carry out fishing activities, and one fisherman believes that the help of an additional person is needed to set up these devices. Both fishermen agree that seabird bycatch is not frequent enough to use such devices, especially on longlines with a large number of hooks. During testing, one fisherman caught a swordfish on a hook with hookpod. However, fishermen could not assess whether the amount of target fish catch changes when using these devices. In addition, one fisherman expressed concern about the impact of these devices on tuna catches (scary fish), and another about the pollution of the sea with plastic if the hookpods fall into the sea. They would not use this type of device in the future. One fisherman expressed interest in testing bird scaring lines at a time of year when seabirds are more present.

Fishermen's opinions about the practicality and functionality of the tested modified fishing tools are presented in Table 3.



Table 3 Fishermen's opinions on practicality and functionality of tested modified fishing gear

Type of modified fishing gear → Fishermen's opinion ↓	Signal (LED) lights	Additional weighting (weights)	Hookpods
<b>Practicality</b>	+/-	+	-
<b>Advantages</b>	visibility in the sea	ease of use with clips when the seabirds are near the gear, faster sinking of the hooks, no impact on fishing, advantage of weighting due to sea currents (possible positive impact on fish catch efficiency)	/ (well-designed product)
<b>Disadvantages</b>	placement on net, lights falling out during winching of the nets, mud and sea getting in, so they stay on all the time (possible impact on battery life)	/	impracticality of use, tangling of longline
<b>Change in time spent</b>	yes	no	yes
<b>Change in the amount of target fish catch</b>	no	no	Impossible to assess
<b>Possibility of future application in Croatia</b>	maybe	yes	no
<b>Additional comments and suggestions from fishermen</b>	can be used to reduce by-catch of other species (turtles)	the weight of the test weights of 0.5/1kg is too large, a smaller weight of e.g., 100-200g is suggested, the amount of weights for the size of the longline when there is a greater presence of birds represents a problem, as in that case is the time spent on fishing and the space for weights on the vessel	requires effort during use, especially if it is put on every hook (e.g. on 600 hooks), concerns about the impact of the device on the catch of tuna (scary fish) and pollution of the sea with plastic if they fall into the sea

#### 4. Challenges faced during production of fishing tools and working with fishermen

Testing of modified fishing gear to reduce seabird bycatch with fishermen was initially planned to be carried out between February/March and May/June. In that period, all three target species of birds (Scolpoli's shearwater, Yelkouan shearwater, and Audouin's gull) are present in the Adriatic Sea, and the fishermen themselves state that during March and April, the presence and interaction with seabirds is at its peak.

Due to the epidemiological measures introduced to prevent the spread of the coronavirus infection and issues with the production and orders of fishing gear and equipment, tests were carried out in the period from April to October, which resulted in rare encounters with seabirds.

Also, the tests were planned to be carried out with fishermen who fish within two Natura 2000 areas for bird conservation (SPA), SPA Lastovsko otočje and SPA Pučinski otoci, but due to insufficient interest and/or non-use of the appropriate type of gear in a certain period of the year, they were conducted on a slightly wider area. Fishermen from the islands of Korčula, Lastovo, Vis, Brač and Vinišće near Trogir took part in the tests. During the gear testing, they used demersal and pelagic longlines and set nets (gill nets and trammel nets) in the waters of the islands of Šolta, Brač, Hvar, Vis, Korčula and Lastovo.

Most fishermen make their gear themselves, keeping detailed specifications in mind and ordering parts from within Croatia and abroad. The intention was that the tested, alternative fishing gear should be as similar as possible to the standard gear that fishermen use, so that they would affect fishing efficiency as little as possible, and fishermen could better compare them and give an opinion on their functionality and practicality. Such fishing gear, modified to reduce seabird bycatch have never been tested in Croatia and are not adapted to our market and the gear used by our fishermen. Therefore, one of the biggest challenges was determining the technical specifications for their procurement (e.g. optimum distance, quantity, weight and method of attaching weights/leads to the longline; total optimum weight of weights/leads on the vessel, method of attaching LED lights to nets and hookpods to longlines, size of hooks that match the hookpods, permitted hook sizes in Croatia, etc.), as well as finding a suitable company that manufactures such gear. This was a long-term process, which resulted in a cooperation with the Institute of Oceanography and Fisheries and the creation of demersal longlines for testing additional weighting (weights), while LED lights and hookpods were tested on fishing gear owned by the fishermen who participated in the tests.

When it comes to testing seabird bycatch reduction measures and collecting relevant data, it is always better to have more fishing trips. Also, it would be good to use a standard and a test gear in an area at the same time, thus allowing the results to be comparable. However, in practice this is not always possible. The work that includes going fishing with fishermen depends on many factors, such as the weather forecast, other obligations and free time of the fishermen, the conditions and size of the vessel and the possibility of receiving a certain number of people while taking care of the safety of everyone present on board, the selection of the fishing location with regard to the number of person on the vessel, the possibility of gear breaking, trust, etc. Although the intention was to test the gear in



situations and locations as similar as possible to those that fishermen normally visit, this was not always possible and locations closer to the coast were often chosen (mainly due to the impossibility of overnight stays, hygiene standards and working with a larger number of people on the vessel and the sensitivity of the participants to waves).

Fishermen provided feedback on their experience of using modified fishing gear by filling out a questionnaire, which was composed in 3 parts. The questionnaire is designed in such a way that the interviewers (Sunce/Biom/IOF employees) fill out the majority of it through a conversation with the fishermen, and one part is filled out by the fishermen independently during/after returning from a fishing trip where they tested the fishing gear. During the testing of the gear, it was noted that the questionnaire was too long. The conditions at sea vary, and sometimes it was difficult to enter data. Also, follow-up conversations about the conducted testing take the valuable time fishermen's time, so they are often unwilling to participate in them. Due to the collection of data, fishermen and interviewers both, were expected to do several things at the same time, which is not always easy to do on a vessel. In addition, it would be useful to have a bird identification expert on board.

It is important to emphasize that due to the reduction of the fish stock, increase in labour and fuel costs, fishing has become more expensive and time-consuming in the last few years. Fishermen's participation in equipment testing and other similar research activities takes their time and creates additional costs for their work. The key is to find ways to financially compensate their participation in testing/research, at least for fuel costs. However, even if such costs were planned within the project, their compensation would be very complicated from an administrative point of view. Solutions should be found for this in the future. Providing promotional materials and gifts to fishermen is welcome, but not enough in relation to the commitment required of them.

During field research and gear testing, fishermen selflessly shared their knowledge with us. This way they helped us to acquire new knowledge and experience, which is highly useful for understanding their work, but also for performing our own work more efficiently.

## 5. Conclusions and recommendations

The data collected so far under the LIFE Artina project indicate rare examples of seabird bycatch during fishing, especially species important for this project. However, through the LIFE Artina project, activities are being carried out to monitor the condition of the Scopoli's shearwater (*Calonectris diomedea*), Yelkouan shearwater (*Puffinus yelkouan*) and Audouin's gull (*Larus audouinii*) and predator management, which includes the control of the populations of the black rat (*Rattus rattus*) and the yellow-legged gull (*Larus michahellis*). The areas where the state of the population of the mentioned seabirds is monitored are the Lastovo and Palagruža archipelago with the associated islands, islets and cliffs (Kručica, Petrovac, Gornji and Srednji Lukovac, Zaklopatica, Veliki and Mali Maslovnjak, Veli Rutvenjak, Vlačnik, Bratin, Kopašće, Sušac, Smokvica, Glavat, Veli Tajan, Crnac, Petrovac, Pod Mrčaru, Obrovac, Velika and Mala Palagruža). After the execution of the rat population control, a higher nesting success rate was observed in Yelkouan shearwater. On some of the more isolated islands (Vrhovnjaci), efforts are made to remove rats entirely and permanently, while on most other islands, control must



be done periodically, year after year, because they are too close to the "main" island and rats can swim back to them. In addition to greater nesting success, the number of nesting Yelkouan shearwater pairs increased on Zaklopatica one year after the implementation of conservation measures, and an increasing presence of the above-mentioned species of seabirds is expected in this area in the future, and thus a potentially greater interaction between fishermen and birds.

An assessment of the spatial overlap between the movements of seabirds and fishing vessels is underway in order to collect additional data on the areas where seabirds and fishing activities interact. Seabird monitoring was carried out using tracking devices in combination with surveys from vessels, while spatial data on the movement of fishing vessels was analysed using the Automatic Identification System (AIS).

It is important to emphasize that the general opinion of the fishermen who participated in this research is that the seabird bycatch in Croatia is not frequent. Therefore, they believe that it is not necessary to implement measures to reduce their bycatch. Also, they think that the greatest interaction with seabirds occurs during March and April and that research and testing of gear should be carried out during this period.

Measures to reduce seabird bycatch include adaptation and/or improvement of fishing practices and modification and/or improvement of fishing gear. By applying different methods during fishing, the seabird bycatch can be reduced, and the effectiveness is greater if several different measures are combined at the same time. This research sought to collect data on the implementation of measures and the results of the use of signal lights (LED) on set nets, additional weights (weights) on demersal longlines and devices for releasing the hooks of pelagic longlines under the sea surface (hookpods), their impact on the target fish catch, practicality, advantages and disadvantages compared to standard (conventional) fishing gear, and fishermen's opinion about the possibility of future application of such gear in Croatia.

During the testing of the modified fishing gear, there were no seabird bycatch. During the research, the birds followed the fishing boats, especially when throwing remaining baits. It is recommended that the remains be thrown away when the fishing gear has already sunk into the sea to a certain depth, so as not to accidentally catch seabirds. Also, the recommendation of one fisherman is to avoid throwing trammel nets in areas where there are a large number of Mediterranean shag individuals (*Phalacrocorax aristotelis desmarestii*; unlike the Scopoli's shearwater, Yelkouan shearwater and Audouin's gull, the shag dives often and deep, its main food is demersal fish, and it is to be expected that they will come into contact with set nets and pots more often. Also, trammel nets are used in the earlier period of the year when seabirds are more present at sea). The mentioned measures belong to the fishing practice modification group.

The measure that was best graded and received by the fishermen is the use of additional weighting (weights) on demersal longlines, because weights are the fastest, simplest and easiest to use. No additional time is spent, it does not affect the fishing activity itself or the amount of caught fish. The weights are simply attached to the longline with a clip when the birds are active around the fishing gear. This method is also the cheapest of all three tested in this research. It is also applicable to fishing

with a pelagic longline (according to the Agreement on the Conservation of Albatrosses and Petrels, 2019).

When using signal lights (LED) on set nets, fishermen's opinions about practicality and functionality are divided. The fact is that there is an increase in the time spent on fishing activities. Also, the price of LED lights is quite high (8.66 eur/piece). However, they could be useful in bycatch of other species (turtles).

The measure that was rated worst and was least accepted by fishermen is the use of devices for releasing the hooks of pelagic longlines under the sea surface (hookpods). It is impractical to use, it gets tangled in the fishing gear, and the time required for fishing activity increases. The price of these devices is also not insignificant (5.94 eur/piece), especially considering that they should be used on every hook of the longline. This method is applicable only in fishing with a pelagic longline.

Taking into account the cost of the gear used for this test, the opinions of fishermen and the fact that seabird bycatch is present, but on a small scale, the need for future use of modified fishing gear in Croatia should be carefully considered. Modification and/or improvement of fishing practices could be a more effective and cheaper solution. For their implementation, it is necessary to make fishermen aware and/or introduce spatial-temporal regulation of fishing, for example: setting up and minimizing the lighting of longlines at night in order to reduce the visibility of hooks and carrying out fishing activities at a time when seabirds are relatively inactive, avoiding throwing remaining baits when setting longlines or hauling nets, in order to avoid attracting a large number of birds in this phase of fishing, avoiding fishing in areas where endangered seabirds feed and reside, primarily species from the order of Procellariiformes and Audouin's gulls (migratory or residents).

In order for the measures to be effective, i.e., to ensure that fishermen implement them, they should be simple, suitable for a particular type of fishing, profitable, practical, safe, and accompanied by economic or social incentives. In addition, it is important to increase the awareness of the fishermen and other key stakeholders about the seabird bycatch and their role in it.

As stated earlier, reporting of seabird bycatches is hardly present in any database on fisheries or nature protection in the Republic of Croatia. In general, very little is known about the seabird bycatch in the Adriatic Sea, while the available data indicate that the interaction with fisheries represents a certain threat to certain species of seabirds, in the Mediterranean the bycatch mostly affects the Audouin's gull, the shearwaters (Procellariiformes) and the Mediterranean shag, while in the Baltic the sea it affects a whole range of species of ducks and waterfalls (Anseriformes), auks (Charadriiformes) and sulids (Suliformes). It follows that Croatia is only in the phase of raising awareness of this problem at the national level.

In this survey, too, the majority of fishermen declared that in the future they do not plan to enter data on the seabird (and other species) bycatch in the fishing logbooks. They state that it takes time and entails new obligations. One fisherman believes that the part about registering bycatches is unclear and should be clarified by the ministry responsible for fisheries affairs. A desirable and necessary measure in fisheries is the training of the fishermen to make them aware of their impact on the entire

marine ecosystem and the importance of all vulnerable species for the ecosystem. Trainings on the recognition and handling of vulnerable species of seabirds and the importance of registering them in the logbooks is essential for fisheries management to have a comprehensive picture of bycatch. It is also important to ensure the transparency of data collection and to inform fishermen about the ultimate purpose of data collection, in order to potentially encourage fishermen to report bycatch.

Scientific observers also have an important role in reporting the seabird bycatch, and in the future work should also be done on their continuous education on species recognition and handling. The training of scientific observers is also crucial due to the special requirements and circumstances of working with fishermen. A high level of social and communication skills is necessary, which should be introduced as trainings in national programs of observer education. Educated observers could further serve to transfer knowledge to fishermen (identification of species, handling, importance of entry in the logbooks, importance of the species for the ecosystem) during direct data collection.

Only after many years of high-quality data collected by fishermen and official observers can conclusions be made about the extent of bycatch of sensitive species in Croatia, and certain legal measures can be proposed and adopted. Nevertheless, with the aim of preserving seabirds, measures of fishing practices adaptation should be tested and implemented in the meantime, and fishermen should be encouraged to participate in similar research.

Seabirds, along with sea turtles, dolphins, and crustaceans, are a very strong indicator of the health of the sea. While institutions in Croatia have been dealing with the bycatch of sea turtles for many years, this does not happen with the seabird bycatch. This is evident from the national Protocol for notification and action in case of finding dead, sick or injured strictly protected marine animals, which includes marine mammals, sea turtles and cartilaginous fish, but not seabirds. Also, there is no data on seabirds in the existing database of the System for notification and monitoring of caught, killed, injured and sick strictly protected animals.

In addition to all the above, it is also important to maintain contacts with fishermen and further transparent presentation of data and research results. In this way, trust is created, and knowledge transferred. In the future, it is also crucial to find ways to financially compensate the participation of fishermen in various research, which take up their time and entails additional costs in their work.

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## 7. Appendices

### *Appendix 1 Questionnaire for fishermen participating in the testing of fishing gear to reduce seabird bycatch*

#### **Questionnaire for fishermen participating in the testing of fishing gear to reduce seabird bycatch**

The project LIFE Artina - " Seabird Conservation Network in the Adriatic" aims to explore the main challenges and solutions for the conservation of seabirds. The project is financed by the funds of the European Union. Find out more about the project at [www.lifearтина.eu](http://www.lifearтина.eu).

Under the project, associations Sunce and Biom are conducting research on the mutual impact of fishermen and seabirds, in cooperation with the Institute for Oceanography and Fisheries (IOF). This research aims to determine the interest and technical possibilities for the introduction of fishing gear, equipment or measures that will reduce or eliminate seabird bycatch. The research is conducted among fishermen who fish within two areas of the Natura 2000 important for the conservation of birds (SPA), Lastovsko otočje and Pučinski otoci. Selected fishermen who use demersal (set) and pelagic (floating) longlines and set nets participate in the research.

Fishermen participating in this research were provided with modified fishing gear to reduce potential seabird bycatch. Fishermen will use these gear during 2022, for the purpose of testing their efficiency. A contract will be concluded with each fisherman, regulating the use of the equipment, the number of fishing trips during which the equipment will be tested, and feedback on the experience of using the modified fishing gear.

Fishermen will provide feedback on their experience on using the gear by filling out a questionnaire. The questionnaire consists of 3 parts (A, B, C). One part of the questionnaire is filled out by interviewers (employees of the Association Sunce/Biom/IOF) through conversations with fishermen (A, C), and the other is filled out by fishermen independently during/after returning from a fishing trip during which they tested the fishing gear (B).



### A. Basic owner, vessel, and fishing tool information

To be filled out by interviewers through conversation with fishermen (live and/or via phone) before the start of the tool testing.

Basic owner and vessel information	
Name and surname	
Contact number, e-mail	
Vessel registration and/or CFR number	
Home port	
Vessel length and engine power (kW)	
Number of crew members during fishing	
The most common fishing zone	
Fishing gear and target fish catch data	
Most used gear ( <i>circle</i> )	a) demersal (set) longline b) pelagic (dfloating) longline c) set nets
Target species of catch	
Demersal and pelagic longline	
Number of hooks and distance between hooks (m)	
Hook type ( <i>circle</i> )	a) traditional J hook b) circle hook
Hook size and brand	
Longline weighting ( <i>circle</i> )	a) yes, (please state weight and distance): b) no
Bait	
Set nets	
Type ( <i>circle</i> )	a) gill nets b) trammel nets

Length, height (mesh size number) and mesh size (one page or two pages)	
Type of fishing gear being tested (circle)	
a) signal lights (LED) b) demersal longline with additional weight (weights, lead...) c) devices for releasing hooks under the sea surfaces (hookpods)	



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## B. Information on the use of modified fishing gear during testing

To be filled out by fishermen after each fishing gear testing activity.

Set nets with signal (LED) lights					Please fill out in case of catching a seabird by fishing gear!				
No.	Date and time of setting the nets into the sea	Date and time of hauling the nets from the sea	Fishing locations (coordinates)	Net soaking depth	Species of bird* Scopoli's shearwater, Yelkouan shearwater, Audoin's gull, Mediterranean shag, other	Bird is: alive (A) dead (D)	Bird is caught during: a. Setting the net b. Hauling the net c. I don't know	Coordinates/distance from the coast	Have you entered the data on the seabird bycatch in the logbook?
1.									
2.									
3.									
4.									
5.									
6.									

\*if you happen to catch a seabird, please send the photo to the mobile phone number of the contact person. (Whatsapp, SMS)

Leave your comments or remarks here: \_\_\_\_\_



Demrsal longline with additional weight (weights, lead...)					Please fill out in case of catching a seabird by fishing gear!				
No.	Date and time of setting the longline into the sea	Date and time of hauling the longline from the sea	Fishing locations (coordinates)	Longline soaking depth	Species of bird* Scopoli's shearwater, Yelkouan shearwater, Audoin's gull, Mediterranean shag, other	Bird is: alive (A) dead (D)	Bird is caught during: a. Setting the longline b. Hauling the longline c. I don't know	Coordinates/distance from the coast	Have you entered the data on the seabird bycatch in the logbook?
1.									
2.									
3.									
4.									
5.									
6.									

Leave your comments or remarks here: \_\_\_\_\_



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Drifting longline with hookpods					Please fill out in case of catching a seabird by fishing gear!				
No.	Date and time of setting the longline into the sea	Date and time of hauling the longline from the sea	Fishing locations (coordinates)	Longline soaking depth	Species of bird* Scopoli's shearwater, Yelkouan shearwater, Audoin's gull, Mediterranean shag, other	Bird is: alive (A) dead (D)	Bird is caught during: d. Setting the longline e. Hauling the longline	Coordinates/distance from the coast	Have you entered the data on the seabird bycatch in the logbook?
1.									
2.									
3.									
4.									
5.									
6.									

Leave your comments or remarks here: \_\_\_\_\_



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### C. Information on the experience and effectiveness of using modified fishing gear

To be filled out by interviewers through conversation with the fishermen (live and/or via phone) after completing the tool testing.

#### Fisherman and seabird interaction

1. Did the birds follow the boat during placing and retrieving the tool (*circle*)? YES NO

- If yes, were you able to identify the species of birds (*please specify the species*)?

---

2. Have the birds disturbed your fishing activity (*circle*)? YES NO

- If yes, in what way (*circle*)?

a) removing the bait from the hook

b) removing the catch

c) other (*please specify*):

---

3. Have birds caused damage to your fishing gear (*circle*)? YES NO

- If yes, in what way (*circle*)?

a) tearing of fishing gear

b) tangling of fishing gear

c) interfering during soaking of fishing gear

d) other (*please specify*):

---

#### Functionality and practicality of the test fishing gear

4. Was the fishing gear you used for testing practical to use (*circle*)? YES NO

- Please clarify.

---

5. What are the main advantages and disadvantages of using test fishing gear? Can you make a comparison with the gear you normally use?

a) Advantages

---



b) Disadvantages

---

---

c) Other comments

6. Did the fishing time increase when using the test fishing gear? Can you estimate the time in hours/minutes (extension compared to the one spent using standard gear)?

---

---

7. Did you notice a change in the amount of target fish catch when using the test tool (*circle*)?

a) It decreased

b) It increased

c) There were no changes in the amount of caught fish

8. Would you continue to use this type of gear (*circle*)? YES NO PROVIDED THAT

- Please clarify.

---

---

9. What do you think of the possibility of this type of gear being applied In Croatia in the future?

---

---

10. Do you have other suggestions related to reducing the seabird bycatch by fishing gear?

---

---

### Species bycatch

11. What is your opinion on the frequency of seabird bycatch by fishing gear in Croatia?

---

12. While fishing, do you use "your own" method to avoid seabird bycatch? If yes, please specify:

a) Method used (*please describe*)

---

b) Successes and difficulties (*please specify*)

---

13. Did you accidentally catch other species while fishing (which are not part of your target catch)?



- a) turtle
  - b) shark
  - c) dolphin
  - d) other (*please specify what*)
- 

14. Do you plan to enter data on bycatch in the logbook in the future (*circle*)? YES NO

- If not, please state the reasons.

---

**Rats**

15. Have you ever had rats on your boat (*circle*)? YES NO

- If yes, how often? What did you do with them?

---

16. What is your opinion about how far rats can swim? (*resp. at least 750 meters*)

---

17. Are you aware of the threat rats pose to seabird colonies? (*res. predation of eggs and chicks, and sometimes of adult birds*)

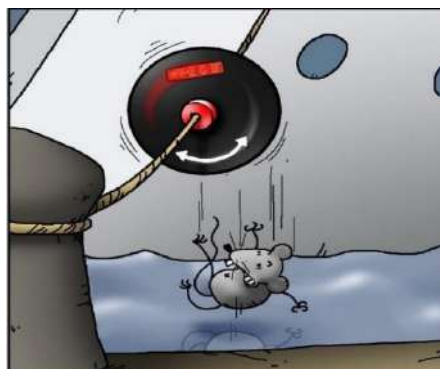
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18. Do you take any action to prevent rats from entering your boat?

---

19. Are you familiar with rat repellents and would you use them (*see pictures*)?

---



### Your participation in the research

20. How do you rate the experience of participating in this research (*circle*)?

- a) positive
- b) negative
- c) neither positive nor negative

21. Has participating in this research changed your view of seabirds? YES NO

- If so, in what way?

---

22. Are you interested in participating in future research related to the topic of bycatch (of seabirds, as well as of other species)? YES NO

- If not, what are the reasons?

---

- If something could encourage you to participate, what would that be?

---

Appendix 2 Technical specifications and instructions on how to use hookpods and LED lights



**A world without seabird bycatch is the world we want to see**

**Hookpod**  
Proven to virtually eliminate seabird bycatch

Encloses the point and barb of the hook during setting, so birds cannot be hooked and drowned. Once the Hookpod reaches 20m, the pod opens, releasing the hook and the bait. The pod is retrieved during hauling, closed and stored in standard setting bins/baskets until the next set.

**Benefits for fishers**

- **Easy operation**  
No need for streamer lines or additional lead line weighting.
- **Reduces bycatch to near zero**
- **No impact on target species catch rate**
- **Long lasting and reliable**
- **Flexible**  
Works with a range of hooks and lines
- **Reduces risk of flyback injury**
- **Cost effective**  
Low cost-per-setting rate
- **LED version available**  
Removes the need for light sticks, saving you time and money



**APPROVED**  
As a standard measure by the WCPFC, Australian & New Zealand Governments

**More about the Hookpod**

- The Hookpod LED weighs 68g and the Hookpod Mini weighs 44g, to rapidly sink below the diving depth of albatrosses and most petrels.
- Manufactured in strong polycarbonate with marine grade stainless steel springs.
- Operationally effective to a depth of 1000 metres
- Developed with the fishing industry over many years



**Hookpod Mini Technical Specifications**

Dimensions	H 17mm W 20.5mm D 25.8mm
Weight out of Water	49g
Weight in Water	20g
Depth Rating	1000m
Opening Depth	20m or 10m

**Hookpod LED Technical Specifications**

Dimensions	H 120mm W 31mm D 28mm
Weight out of Water	60g
Weight in Water	34g
Depth Rating	1000m
Battery Life	500 hours
Light Output	0.88 lumens
Light Colour	Green
Opening Depth	20m or 10m

**How to order Hookpod**  
To order Hookpods, simply email us direct at [info@hookpod.com](mailto:info@hookpod.com) for a quote.

Discounts available for bulk orders.

Hookpods are designed to work with many different types of pelagic longline gear and bait, as well as a range of line types and sizes.

If you would like to test the Hookpod before purchasing, please contact us and we can arrange a suitable number of samples for you to try out.

**hookpod**

Hookpod Limited  
1 Silchester Bridge  
Woburn Way  
DARKINGTON  
Barnes TR9 6JY  
UK

Tel: +44 (0) 1682 580068  
Mob: +44 (0) 7535 270077  
Tel Fax: +44 (0) 22 134 0395  
Email: [info@hookpod.com](mailto:info@hookpod.com)  
Web: [www.hookpod.com](http://www.hookpod.com)

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As a standard measure by the WCPFC, Australian & New Zealand Governments



**Simple, safe and effective seabird bycatch mitigation**

Recommended by ACAP as "best practice for the pelagic longline industry"

**hookpod**  
[www.hookpod.com](http://www.hookpod.com)



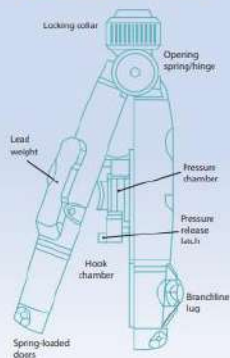
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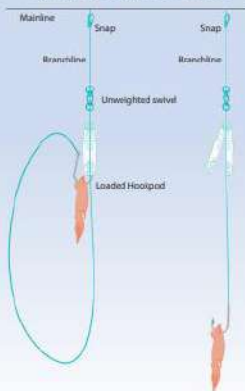
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**Hookpod components**



**Baited hook released at either 10 or 20 metres**



**The Hookpod**

**How it works**

- The Hookpod is a polycarbonate capsule that attaches to the branchline.
- During setting the baited hook clips into the Hookpod, preventing seabirds from becoming hooked.
- A pressure release system opens the Hookpod at a depth of 20m (see illustration above), beyond the diving depth of most seabirds.
- On hauling, the Hookpod remains in place on the line, ready for the next set.
- The pod has been designed to last several years - materials are durable and resistant to damage by UV rays and seawater.
- The Hookpod has been designed to open at either 10m or 20m, whichever best fits your fishing operation.



“

These Hookpods are a great invention and they are working well for us. It has taken away the dangers of using lead weights on our gear. At first I was a bit suspect about using them thinking it could affect our catch but after using them I have noticed that our fishing has not been affected in any way.

On a few occasions the Hookpods actually out-fished our regular gear and caught more fish! Not one single bird has been caught on the pods so far from the tests we have run and yes, we have caught the odd bird on our regular gear! Shooting and hauling is no different to how we do it with the regular gear. It just takes the crew a few sets to get used to them.

Mike Te Pou  
New Zealand skipper - FV Commission

”



**Hookpod storage**

When hauling, simply flick the Hookpod to ensure that water droplets are removed from the pressure chamber. The pods can then be sliced and stored, either hung from the hook in the swivel, which works best if pods are less than 1 metre from the hook, or simply fletted in the bin along with the branchlines.



“

Every day, hundreds of albatrosses die in longline fisheries. But there is a unique and exciting new solution to halt this.

It's called a Hookpod. Hookpods cover baited hooks as they enter the water and stop birds getting caught as they dive for baits. They are effective, easy to use, safe and economic for fishermen.

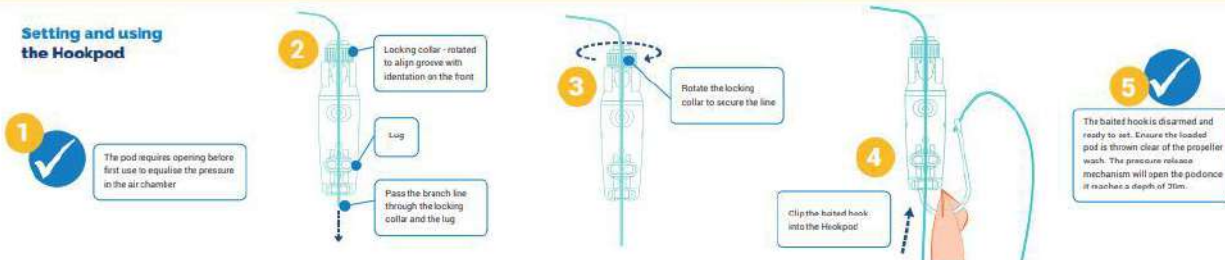
If every pelagic longline fishing fleet used Hookpods, I believe we can stop the accidental death of these magnificent ocean wanderers.

Sir David Attenborough

”



**Setting and using the Hookpod**



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## NETLIGHT (PAT.) FITTING INSTRUCTIONS

### BATTERY REPLACEMENT (ALSO SEE VIDEO ON WEBSITE)



Remove the NetLight from the rubber carrier

Use a small flat head screwdriver and prise off the end cap

Replace old batteries with new batteries ensuring the polarity is correct



Click the endcap back onto the NetLight. Test the light is working

Insert the NetLight back into the rubber carrier

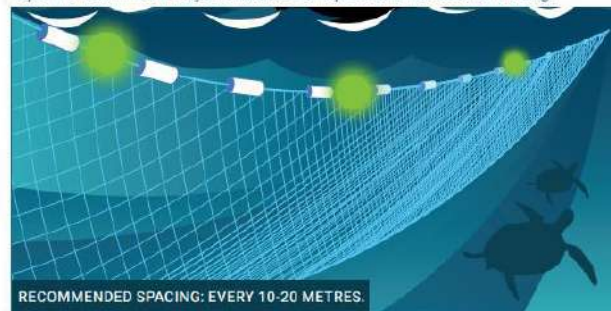
To prolong the life of the NetLight, batteries should be replaced in dry and dirt free environments.

### TECHNICAL SPECIFICATIONS

Dimensions	165mm x 47mm x 37mm
Weight (with batteries)	153 grams
In-water weight	25 grams
Depth rating	1200 m
Attachment	Dual point for attachment directly to net ropes (12mm diameter)
Battery Type	2 X AA Alkaline
Immersion Switch	Automatic Immersion switch
Light case	Tough, injection moulded polycarbonate
External carrier	Durable, TPE co-polymer rubber

### FITTING THE NETLIGHT ONTO THE NET

NetLights may be threaded onto ropes joining panels on either the head rope or foot rope. We recommend they are fitted to the rope that is not used for hauling.



RECOMMENDED SPACING: EVERY 10-20 METRES.

If nets are under extreme tension (for example if the NetLights are fitted to the hauling rope) a cable tie may be used around the NetLight (but under the rope for added security).

### COLOUR OPTIONS

Type	Colour	Battery Life**
Constantly on	Green	500 hours
	White	500 hours
Flashing	Green	800 hours
	White	800 hours

\*\*Battery durations are approximate and dependant on water temperature and battery quality.



**FISHTEK MARINE**

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Appendix 3 Technical specifications and prices of modified test gear and equipment

Information on modified fishing gear and equipment	Signal (LED) lights for set nets	Additional weighting (weights) for demersal longlines	Hookpods for pelagic longlines
<b>Production and procurement of test gear and equipment</b>	2 x AA batteries powered LED lights with a constantly lit green light. Supplier: <i>Fishtek Marine</i>	Two types of shapes: spherical and square weights, due to testing the possibility of longline tangling.  Demersal longlines with 250 hooks, hook size 7, base thickness 2 mm, fishing line thickness 0.8 mm, fishing line length 1 m and distance between hooks 8 m.  Made by: <i>FULIJA, production and services trade, owned by Frane Razlog</i>	The manufacturer's recommendation is to use hooks of size 9/0 or 10/0 for Hookpod Mini devices. However, in Croatia, fishermen also use smaller hooks.  Manufacturer: Hookpod Ltd  The production of pelagic longlines was not possible due to the lack of companies involved in their production, so the fishermen provided their own longlines for the hookpods testing.
<b>The method of placement of the equipment on the fishing gear</b>	The lights are attached by rope to the set net float at a 10-20 m distance.	The weights are attached to the longline with a clip at a certain distance in situations where seabirds are present. For research purposes, the weights were set at a distance of 25 hooks.	Hookpods are placed on each hook of pelagic longline. However, for the purposes of this research, a smaller number of hookpods were tested.

Information on modified fishing gear and equipment	Signal (LED) lights for set nets	Additional weighting (weights) for demersal longlines	Hookpods for pelagic longlines
Quantity of test gear and equipment used per vessel	30 LED lights on the gill nets and trammel nets	5 x 0.5 kg + 5 x 1 kg weights on a longline with 250 hooks	50 hookpods on a longline with 600 hooks
Price of used gear*	8,58 €	7 € **	€5.94
Gear specification related recommendations	/	During the research, it was noticed that the weight of 1 kg weights was too big; 100-200 g weights are recommended. The shape of the weights does not affect the entanglement.	During testing, it was noticed that the point of the hook fell out of the hookpods in case of one fisherman, while in another it was not noticed (possible connection with the method of attaching the hookpod on the longline) Production and purchase a hookpods with a smaller hook opening diameter is recommended for easier handling.

\*The cost of fishing gear is shown per piece. However, the method of placing the gear, i.e. the amount of equipment used during the fishing activity, should also be taken into account (for example, the hookpod must be attached on each hook of the pelagic longline, while the LED lights and weights are placed at a certain distance).

\*\*Cost shown based on estimate:

- € 6-7 for a 1kg lead weight,
- € 5-6 for a lead weight of 0.5 kg. The price depends on the weight and shape of the weights.
- € 1 for the clip attaching the weight to the longline.

Also, a set longline with 250 hooks at a price of €197 was made only for this type of gear/equipment used within the project.



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Appendix 4 Photos from the testing of modified fishing gear to reduce seabird bycatch (author: Ante Gugić)

