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REVIEW ARTICLE

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TECHNICAL MEASURES IN ORDER TO DECREASE INTERACTIONS BETWEEN DOLPHINS AND FISHERMEN: PINGERS

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Abstract:

Almost all marine mammal species are in interaction with fishing activities and this interaction frequently results with the death of marine mammals in gillnet fisheries. This situation which results with the death of thousands of harbor porpoise (*Phocoena phocoena*) and bottlenose dolphin (*Tursiops truncatus*) is defined as by-catch (non-target catch) in gillnet fisheries and in this way it is legalized at least partially. These interactions between fisheries and dolphins cause ecologic and social concerns, while that means much more economic losses from the perspective of fishermen. In most of studies which aim to determine necessary measures to reduce by-catch of dolphins, gillnet fisheries is taken as basis and dolphin deterrent devices called pingers are used. In this subject many studies have been carried out in world, while only a few in Black Sea. However, it is still difficult to make an assessment for effectiveness of pingers. In addition to this, many studies including those of performed in Black Sea outline that pingers can keep harbor porpoise (*Phocoena phocoena*) and bottlenose dolphin (*Tursiops truncatus*) away from gillnets for 1-2 years but it is vital that monitoring the situation after this period.

Keywords: Dolphins, Pingers, Fisheries, Black Sea

Introduction

Whale and Dolphin Conservation Society (WDCS) indicates that 300.000 marine mammals have been recorded as by-catch. According to Read et al. (Read et al., 2006), average marine mammal by-catch is determined as 307.753 ±98.303 individuals while most of those consist of harbor porpoise. It is estimated that 10.000 harbor porpoises, which are more common than other marine mammals, are obtained as by-catch per year in only North European Seas. From a broader scale, the rapid decreases in number of harbor porpoises and the occurrence of a serious threat for this species can be barely seen (Franse, 2005). In general, pingers can be considered as a new development in marine mammal conservation and management. Therefore, it is aimed to sought an answer to how effective pingers are to mitigate incidental catch (bycatch) of marine mammals and the depredation that they cause. However, it should be explained that how pingers work and the presence of possible repercussions.

Interactions Between Dolphins and Gillnet Fisheries

Lengths of gillnets used in artisanal fishing reach 50-60 meters starting from a minimum 30 meters as in the case of pelagic driftnet. Studies show that harbor porpoises can detect gillnets via their main ropes, float lines, lead line ropes or floaters, so gillnets can be perceived by harbor porpoises (Row, 2007). However, Goodson et al. (1994) and Au & Jones (1991) report that a case of echolocation which is defined as return of sound pulses transmitted by dolphins after hit an object is not so easy and dolphins may fail sometimes about that. Because; distance of sensing an object may change up to enviromental parameters such as water temperature, turbidity, salinity, underwater noise level. At the same time, it can be vary up to species of dolphins and approach angle to an object. For example; sensing distance in common bottlenose dolphins is between 25-55 m despite to high ambient noise while it is 3-6 m for harbor porpoise even in low noise level (Franse, 2005; Kastelein et al., 1999).

Dolphin by-catches in gillnets can be defined as follows;

- Dolphins do not move in echolocation status always, so that they can be failed to sense fishing nets.
- Dolphins can fail to detect gillnets when they feed in the area where gillnets are located in or vertical water column
- They may easily get caught by gillnets although they are aware of dangerous
- Fish caught in the gillnet can mask the presence of gillnet
- Dolphins can detect nets from adequate distance, however they may not assess the nets as an object which could not be passed over (Au and Jones, 1991; Dawson, 1994, Bordino et al., 2002).

It is possible to examine these interactions or competitions between fishing activities or fishermen and dolphins in two categories: operational and ecological. Operational (direct) competition refers to interactions between fishing gears and dolphins while ecological (indirect) competition defines struggle for same food resources. Such interactions in Blacksea can be defined in two ways. The first one of those is stealing of fish such as red-mullet caught in gillnets with 32-44 mm stretched mesh-size by dolphins (especially bottlenose dolphins) and rupturing of net meanwhile. This situation is named as depredation by certain scientists. The second one is entanglement of dolphins especially harbor porpoises to turbot-gillnets with 280-360 mm stretched mesh-size and resulting with death. This situation is named as by-catch which can be seen in Figure 1. (Gönener and Bilgin, 2007; Gönener and Özdemir, 2012).

Both depredation and by-catch may occur in the same fishing season, however, second situation that is always affected by first situation and interaction largely results with the death of dolphin even if dolphin is still alive in the net as entangled. Because, fishermen look upon both interactions as decreasing fishing catch rate, losses of fish and net, rupturing of nets, loss of time and labor. Furthermore, fishermen assess those interactions as economical and financial loss (Gönener and Bilgin, 2007; Lifelinda, 2007).



Figure 1. Bycatch of dolphin in turbot gillnet (original) (*Phocoena phocoena*)

Reduction of Interactions (Conflicts) Between Dolphins and Fishermen

Rowe, (2007) sorts measures required to reduce by-catches of dolphins in gillnets as follows;

- Fishing activities should be restricted in certain times and areas.
- Fishing nets should be designed to be perceptible danger or obstacle for dolphins.
- Materials which is hard to be detected by dolphins such as monofilament fishing nets should not be used in fisheries, especially in the nights.
- Safe passing zones should be placed on the nets.
- Dolphins approaching the area where the fishing nets should be acoustically warned and deterred.

Efforts to warn dolphins about presence of fishing nets using passive or active acoustic features lay in the center of implementations to reduce dolphin by-catches in gill nets (Dawson, 1991, Rowe,

2007). Additionally, researches to improve auxiliary measures which can provide success of main measures to reduce by-catch of dolphins should be carried out (Au and Jones, 1991).

Dawson, (1994) and Rowe, (2007) indicates that certain changes that aim to reduce dolphin by-catch in gillnets or increase detectability of gillnets by dolphins can be done. These are;

- Coating of all or certain parts of gillnet with materials such as iron-oxide, barium-sulphate
- Obtaining high density monofilament fishing nets with adding metal compounds into polymer
- Placing 2x2 passing grids in the certain parts of gillnet
- Increasing or decreasing size of net
- Placing reflectors to different parts of net

However, these implementations and modifications are restricted with many factors. These factors can be sorted as;

- Modifications in fishing gears must be suitable to commercial fishing conditions (e.g.

coating nets with materials such as barium sulphate, iron-oxide which increase detectability causes them to occupy a large area on the deck and increased net weight which can make towing and hauling more difficult)

- Modifications in fishing gears must be long lasting and durable in commercial fishing conditions
- Changes to be made in structure of fishing net should not cause the danger
- Modifications should be comparatively economic and cheap
- Modifications absolutely should not cause decreasing in catching rates of target species as in the case of obtaining high density monofilament fishing nets with adding metal compounds into polymer
- Changes should be economic and socially applicable.

Therefore, studies and efforts aiming to keep dolphins away from fishing nets using acoustic features are becoming more important. So that, using of

pingers has become mandatory in certain countries. For instance, , fisheries activities without use of pinger devices were prohibited for vessels of 12 m or over in total length in certain areas of European Community waters in accordance with “COUNCIL REGULATION (EC) No: 812/2004” (Caddell, 2005).

What Are Pingers?

Pingers should be defined in two groups in order to reveal differences between them. Acoustic Deterrent Devices (ADD): These are devices with a low intensity (source level: < 150 dB re 1 μ Pa at 1 m) and emits signal in the middle to high frequencies (2.5 – 10 kHz) with higher harmonic frequencies (up to 160 – 180 kHz). ADD pingers can be fixed to fishing nets with hand and are designed to prevent incidental catch of dolphins using ultrasound. Different batteries which last a year, a month or a week are used as energy resource in ADD pingers (Figure 2) (Franse, 2005; Rowe 2007).

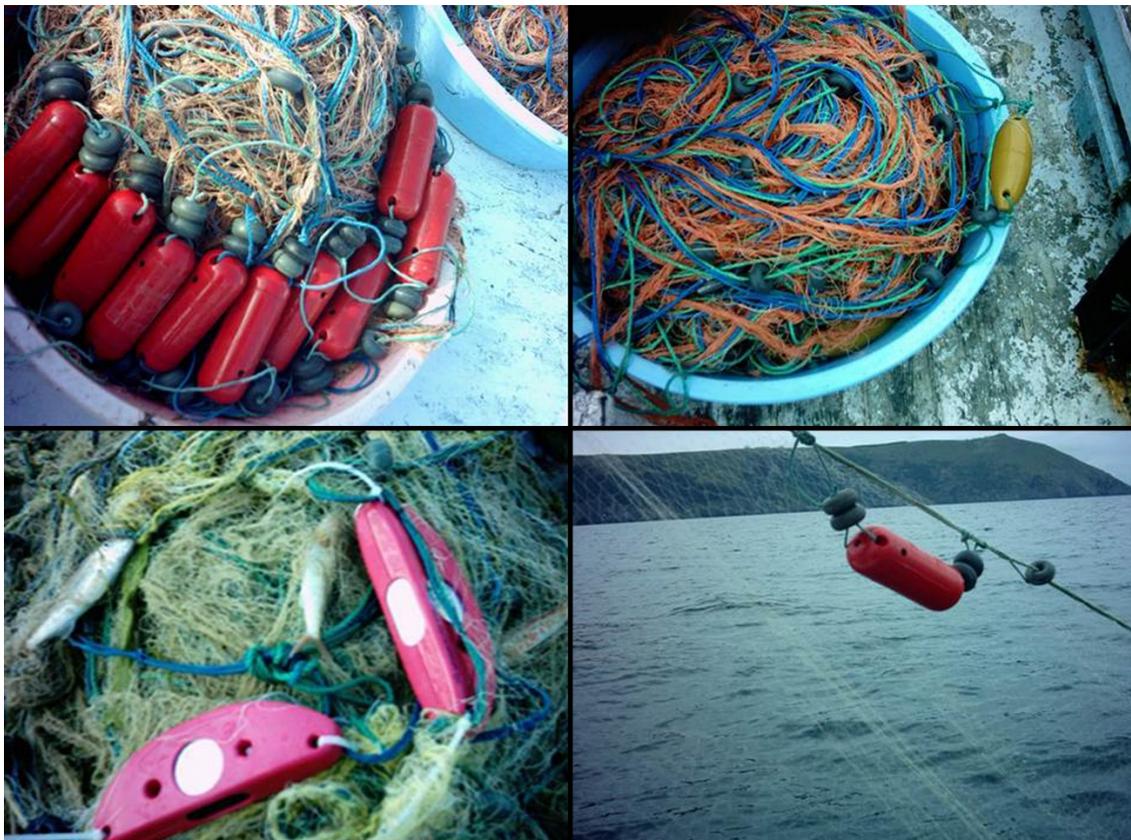


Figure 2. Various ADD pingers (original)

Acoustic Harassment Devices (AHD): Conversely to ADD devices, AHD devices use equipments such as mains electricity or large lead-acid batteries and storage battery as energy resource and they are quite bulky. Those type of devices are mostly used in off-shore fish farming units in order to prevent pinnepids steal fish, keep them away from cages by harrasing them. Therefore an AHD has a relative high source level (>185 dB re 1 μ Pa at 1 m) and emits signals in the middle to high frequencies (5 – 30 kHz) (Franse, 2005; Rowe 2007).

Audiogram of animals desired to be kept away from fishing nets or cages should be known for an effective pinger. According to Kastelein et al., (2002), this audiogram varies between 16 kHz – 140 kHz for harbor porpoises. Hearing accuracy is comparatively low in 64 kHz and at the highest level in frequencies between 100 kHz-140 kHz. This also shows frequency range equaled to echolocation period of harbor porpoises. On the other hand, studies (Au, 1993, Kastelein et al., 2002) outline that bottlenose dolphins have larger hearing frequency range, which is between 75 Hz and 150 kHz. The most sensitive frequency range of bottlenose dolphins changes between 15 kHz and 110 kHz while they emit pulses up to 100 kHz during echolocation period (Franse, 2005).

Some studies which were carried out to estimate effectiveness of pingers in the world are given in Table 1. In most of these studies, it is outlined that pingers can be effective in mitigating incidental catch of dolphins. Nonetheless, many hypothesis were asserted about in which way pingers work and how they can be effective. Most of those hypothesis argue that stimulus and deterrent effects of pingers cause dolphins to move away from area. Beside, there are also a few marginal opinions related to subject such as dolphins move away from area as a result of reaction to conflicts of pulses emitted by dolphins in echolocation period with those emitted by pingers or dolphins swim away from area because they follow fish schools such as herrings fleeing from pulses emitted by pingers.

Possible Side Effects of Using Pingers

Reduction of Catch Rate

Although in many studies (Trippel et al., 1999; Gearin et al, 2000, Culik et al., 2001, Wilson and Dill, 2002), it is proved that pingers do not negatively effect the catch rate of target species, Kraus

et al. (Kraus et al., 1997), asserted that pingers cause reduction in target catch rate in a study performed on Atlantic herring (*Clupea harengus*).

Habitat Exclusion

Another possible side effect of pingers is causing dolphins to move away from their large part of habitats. Especially areas where the river meets the sea are represent gathering, association and reproduction points of dolphins. Therefore, using pingers in these areas may cause considerable issues (Franse, 2005). In their review, Dawson et al., (2013) indicated that the permanent use of pingers in adequate habitats may cause displacement of dolphins from their important habitats especially for species which have small home ranges. On the other hand, considering the fact that pinger signals from the entire Danish gillnet fleet could potentially cover <1% of the porpoises' habitat, displacement does not seem to be a trouble.

Hearing Disorders/Noise Pollution

An effective pinger spreads out sounds, which can be heard by dolphins. However, all dolphins have optimum hearing level, which is up to sound intensity. While pinger pulses at certain level are hardly sensed by some species such as bottlenose dolphins, it may cause hearing disorders in harbor porpoises. As dolphin species are not spatially distributed, it is hard to make a pinger, which will be effective on each dolphin species. (Franse, 2005). On the other hand, since marine animals are tend to be disturbed by human origin noise in their environment, intense sounds may cause negative physiological, auditory, and behavioural effects (Richardson et al., 1995). For this reason, sounds produced by pingers should reduce bycatch of dolphins and other marine mammals, but should not cause noise pollution for other marine fauna (Kastelein et al., 2007).

According to Gordon & Northridge (2002), hearing damage can occur when dolphin get close to active pinger by more than 2 or 3 meters. While Taylor et al. (1997) states that the worst hearing damage occurs in 30 meters distance from pinger, Reeves et al., (2001) indicates that dolphins which are regularly exposed to pinger pulses may also have hearing disorder. Particularly considering the echolocation period, hearing losses or disorders can cause serious physical injuries, which may lead to death (Franse, 2005).

Table 1. Some studies related to determine effectiveness of various acoustic deterrent and harassment devices

| Device | Area | Period | Species | Result | Author(s) |
|---------------------|---------------------------------------|------------------------------|---|--|------------------------------|
| Dukane Netmark 1000 | Bay of Fundy | Summer 1996 and Summer 1997 | Harbor porpoise | Effective reduction in bycatch (77%) | Trippel et al. (1999) |
| Dukane Netmark 1000 | California | August 1996 – October 1997 | Short-beaked common dolphin | Significant reduction in bycatch rate | Barlow & Cameron, (2003) |
| Dukane Netmark 1000 | Iracema Beach, Fortaleza | November 1996 – August 1998 | Gray dolphin (<i>Sotalia fluviatilis</i>) | Effective in keep away dolphins from area | Monteiro-Neto et al. (2004) |
| SaveWave (ADD) | Sinop Peninsula | April 2007 – February 2008 | Bottlenose dolphin | 69.8% reduction in economic loss caused by depredation | Gönener & Özdemir (2012) |
| Aquamark 200 | Sinop Peninsula | December 2005 – January 2006 | | Effective reduction in depredation | Gönener & Bilgin (2007) |
| Dukane Netmark 1000 | Sinop Peninsula | March – April 2006 | Harbor porpoise | Effective reduction in bycatch | Gönener & Bilgin (2009) |
| Dukane Netmark 1000 | Grand Manan Island | June – September 1998 | Harbor porpoise | Habituation occurred | Cox et al. (2001) |
| Future Oceans | Bulgarian Black Sea Coast | April –July 2015 | | Effective reduction in net damage | Zaharieva et al. (2016) |
| AHD (ICA S.L) | North-eastern coast of Sardinia | February – June 2009 | Bottlenose Dolphin | Ineffective | Diaz Lopez and Marino (2011) |
| DDD02 | Favignana Island, Sicily | Spring - 2006 | Bottlenose Dolphin | Effective reduction in depredation (31%) | Buscaino et al. (2009) |
| Dukane Netmark 1000 | Bloody Bay and Lagabay, West Scotland | April – August 2001 | Harbor porpoise | Effective reduction in bycatch, Habituation occurred | Carlström et al. (2009) |

Another issue which is dependent or independent from hearing disorder is the occurrence of background noise/noise pollution. Failing in echolocation causes dolphins unable to determine fish schools and accordingly serious vital issues may come up (Franse, 2005; Gordon and Northridge, 2002).

Habituation

Thorpe defined behavioral habituation as “gradual waning of responses when a repeated or ongoing stimulus lacks any significant consequences for the animal” (as cited in Richardson et al., 1995). The most indicated side effect stated by researchers such as Cox et al., (2001); Barlow & Cameron, (2003); Dawson et al., (1998) Gordon and Northridge, (2002); Kraus, (1999); Laake et al., (1998); Reeves et al., (2001); Richardson et al., (1995); Trippel et al., (1999) is habituation. Habituation can be defined as ignoring of pinger pulses by dolphins. In this case, presence of pingers have no value. Researches associated with habituation effect are few and carried out in limited time periods. However, long term researches are necessary to investigate habituation effect as it is a major threat to the effectiveness of the pinger (Franse, 2005).

Dinner bell effect

Dinner bell effect is a situation that causes dolphins to learn that they can find a feed at the location of sound resource and gather in that area. In this case, pingers work conversely. It is significantly important to carry out researches to investigate that if dinner bell effect which occurs especially with pinnipeds is a real threat for dolphins or not (Franse, 2005). In a long term study conducted by Carretta and Barlow (2011) between 1990 - 2009, although habituation was not apparent in the in the drift gillnet fishery for swordfish and thresher shark in California, it was outlined that depredation of swordfish catch by California sea lions and bycatch of those animals increased over time with pinger usage pointing the “dinner bell effect”. However authors argued that continuing increase in California sea lion numbers were more likely responsible rather than pinger usage. In another study, it was mentioned that encounter of bottlenose dolphins to fish farming area may increase by the use of AHDs due to animals could realize that there is food near to the sound source (Diaz Lopez and Marino, 2011).

Conclusion

Increasing pinger effectiveness intended for the reduction of harbor porpoise by-catch and prevention of depredation especially caused by bottlenose dolphin is possible with random working principle of pinger. However, even if the pulse frequency, duration and interval is variable, pingers should be considered as short term (e.g two years) solutions for now.

Maintaining researches to investigate the effectiveness of pingers and side effects is the most important subject. Monitoring studies are also very important and suggested by international organizations such as International Council for the Exploration of the Sea, Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas and International Whaling Commission. In this way, long term effectiveness of pingers can be monitored and determined.

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