Marine Pollution Bulletin 129 (2018) 253–261

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Review

Technologies for the marking of fishing gear to identify gear components entangled on marine animals and to reduce abandoned, lost or otherwise discarded fishing gear

Pingguo He[a,b,*], Petri Suuronen[c]

[a] School for Marine Science and Technology, University of Massachusetts Dartmouth, 836 Rodney French Boulevard South, New Bedford, MA 02744, USA
[b] Fishing Operations and Technology Branch, Fisheries and Aquaculture Department, Food and Agriculture Organisation of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy
[c] Natural Resources Institute Finland, FI 00790, Helsinki, Finland

ARTICLE INFO

Keywords:
Gear marking
ALDFG
Gear recovery
Ghostfishing
Marine litter

ABSTRACT

Fishing gears are marked to establish and inform origin, ownership and position. More recently, fishing gears are marked to aid in capacity control, reduce marine litter due to abandoned, lost or otherwise discarded fishing gear (ALDFG) and assist in its recovery, and to combat illegal, unreported and unregulated (IUU) fishing. Traditionally, physical marking, inscription, writing, color, shape, and tags have been used for ownership and capacity purposes. Buoys, lights, flags, and radar reflectors are used for marking of position. More recently, electronic devices have been installed on marker buoys to enable easier relocation of the gear by owner vessels. This paper reviews gear marking technologies with focus on coded wire tags, radio frequency identification tags, Automatic Identification Systems, advanced electronic buoys for pelagic longlines and fish aggregating devices, and re-location technology if the gear becomes lost.

1. Introduction

Fishing gears are marked to establish their ownership and legality of their use. Gear marking has been considered as an important tool to reduce abandoned, lost, or otherwise discarded fishing gear (ALDFG) and to fight illegal, unreported, and unregulated (IUU) fishing (FAO, 2016, 2018). Fishing gears are also marked to inform the origin of the gear when entangled in marine animals, and to indicate position to reduce gear conflicts and improve safety at sea. Traditionally physical marking, inscription, writing, color, shape, and tags have been used for ownership and legality purposes, and buoys, lights, flags, and radar reflectors are used for marking of position. More recently, electronic devices including radio and satellite transmitter have been use in some fisheries for easier location from a distance or unlimited tracking, even from the land.

From the purely technical point of view, there is a need to identify the origin of fishing gear or its components (and where it was fished) when they become lost or entangled on marine animals (Johnson et al., 2005). Understanding the origin (area, fishery and gear type) would provide valuable information for fishing gear modification, area/season closure, and other management measures to reduce entanglement and potential mortality of venerable animals such a whales, porpoises, and turtles (Wilcox et al., 2015). This is especially applicable to fixed gears such as pots,[1] gillnets, longlines, and traps. While the United States has invested considerable effort to identify fishing gear remnants entangled in marine megafauna species, yet only 45% of entangled gear materials on North Atlantic right whales (*Eubalaena glacialis*) and humpback whales (*Megaptera novaeangliae*) could be identified for its origin (region/fishery) (Johnson et al., 2005). It is likely that less proportions of entangled gear have been identified in other regions. Currently, a scheme of colored rope sections for different regions and fisheries is implemented by the United States to aid the identification of origin if they become entangled on an animal (NOAA, 2015). The International Whaling Commission (IWC, 2014) considered fishing gear marking as an important issue in protection of cetaceans and encouraged the Food and Agriculture Organization of the United Nations (FAO) complete its work on the guidelines for the marking of fishing gear (FAO, 2016). The Voluntary Guidelines on the Marking of Fishing Gear have just been approved by the Technical Consultation on the Marking of Fishing Gear of FAO Members States (FAO, 2018).

Gear marking for ownership, legality, and capacity management is especially important in capacity-controlled fisheries such pots and

* Corresponding author.
E-mail address: phe@umassd.edu (P. He).

[1] Pots and traps have been interchangeably used in many literatures. In this paper, a pot refers to a small baited enclosure, while a trap refers to a large un-baited structure.

https://doi.org/10.1016/j.marpolbul.2018.02.033
Received 13 November 2017; Received in revised form 17 February 2018; Accepted 19 February 2018

gillnet fisheries. The maximum amount of gear that is allowed for each licensed fisher or fishing enterprise is regulated by many nations, states or Regional Fishery Management Organizations (RFMO) to either limit fishing effort, or to reduce gear loss. Traditionally, various physical tags have been used, usually inscribed with the permit number of its owner. In some fisheries, tags are fixed in the gear itself (e.g., gillnets) or attached to its surface markers (e.g., buoy of a pot). These physical tags can only contain limited information (e.g., license number). More advanced tags that contain static information (e.g., license number, owner, vessel) as well as dynamic information (such as time in water, location deployed) would have advantages both for fishers and for management. Advanced tags that can be detected over a longer distance would help fishery enforcement in combating IUU fishing.

Gear marking for position not only aids in the quicker recovery of gear by its owner, but also aids to navigation to other users, and reduces gear conflicts between gear sectors (e.g., fixed and mobile gear sectors), reducing the probability of gear loss. Flags, lights, and radar reflectors are still the main position markers for coastal fisheries. More advanced gear markers have been used by offshore longliners and purse seiners using fish aggregating devices (FADs). There are > 100,000 drifting FADs (dFADs) in use by world's tuna purse seine fisheries (Baske et al., 2012). With advances in electronics technology and satellite communication, the use of advanced longline and FAD buoys not only increases catch per unit effort, but also has implications in effort monitoring and in combating IUU fishing by various levels of authorities (Agnew et al., 2009).

Fishing gears become lost due to various reasons; some of these lost gears (e.g., gillnets and pots) continue to catch fish, causing ghostfishing (Macfadyen et al., 2009). There are a few measures to deal with ghostfishing issues of abandoned, lost, or otherwise discarded fishing gear (ALDFG), including measure to prevent gear loss, retrieval of lost gear, and mechanisms to reduce fishing efficiency of lost gear (deghosting technology) (DFO, 1995; Macfadyen et al., 2009). Prevention of ghostfishing includes measures for proper gear marking to prevent loss and to discourage intentional abandonment or discard of gear. Gear marking technologies that can help relocating lost gear facilitate quicker recovery.

The FAO Code of Conduct for Responsible Fisheries requested that "*fishing gear should be marked in accordance with national legislation so that the owner of the gear can be identified*" and "*gear marking requirements should take into account uniform and internationally recognizable gear marking systems*" (FAO, 1995, Para. 8.2.4). Only few governments or Regional Fishery Management Organizations (RFMOs), however, have properly implemented or enforced this requirement. Accordingly, ALDFG is often impossible to identify to the owner of the gear, and to fishery of origin. Appropriate marking of fishing gear would be beneficial in many respects. Among others, it would assist in the prevention and reduction of ALDFG and ghost fishing, assist recovery of ALDFG, improve the safety at sea, and enhance the ability to apply fisheries regulatory measures, including those for the control of fishing capacity and the prevention or elimination of IUU fishing (FAO, 2018).

2. Gear marking for the identification of origin

One of the important benefits of proper gear marking is the identification of origin of gear components, especially fishing ropes, entangled on marine mammals and other marine megafauna species that are also often endangered and/or threatened species (NOAA, 2015). Here the word "origin" means the region, fishery, and gear type that the gear was used before it became ALDFG or entangled on an animal. Understanding the origin of gear component on dead or impaired marine mammal is important for spatial and tempo management of gear use. Currently, colored ropes or tracers are being implemented in the northeastern water of the United States (NOAA, 2015). There are limited color shades that can easily be distinguished after rugged use in the sea. Embedding codes or more advanced identification tags in fishing ropes would provide much more information, including gear ownership, set location, time, fishery, and specific component of the gear. More recently, coded wire tags (CWT) and radio frequency identification tags (RFID) have been tested for possible inclusion in fishing ropes to provide additional information.

2.1. Color coding and tracers

Colored coding of buoy lines used in stationary gears is enforced by NOAA (2015). Colored marks may be applied by seizing colored twines, by spraying colored paint, or by attaching colored tapes to the rope. The colored sections have 25.4 cm minimum length, and marked at the surface and bottom ends, and at the middle of the rope. Different regions in the United States are assigned different colors or color combinations (NOAA, 2015).

Tracer yarns or strips may be woven into ropes or twines. The tracer may bear different colors, and information such as manufacturer, batch number, and/or material specification can be printed on to the tracer before it is woven into the rope or twine (P. He, personal observation). Tracers embedded as center core of braided ropes or twines may be less likely to wear off and would retain information for the life of the rope or twine. With corresponding book-keeping, the rope or twine with specific batch number may be traced or tracked from its manufacture, shipment, usage, recycle and disposal. Ropes or nets made of these twines recovered from sea or entangled in marine animals can thus be traced to the owner/operator of the gear, and location they were deployed or lost. This would aid in gear modifications and/or management measures that would reduce gear entanglement on animals (Henry et al., 2017).

2.2. Coded wire tags

Coded wired tags (CWTs) are minute magnetized tags that were invented over half a century ago for tagging juvenile salmonids on the US west coast (Jefferts et al., 1963). The tags are made of stainless steels and can be detected by specialized hand-hold electronic detectors, and read under a microscope. Coded wire tags may be assigned a unique code for each tag, called sequential CWT, thus allowing identification of individual tagged objects. For the purpose of fishing gear marking, these numbers may be associated with region/nation, license number, gear type, and other characteristics.

Only one study has tested the feasibility of using CWTs for marking the origin of fishing rope, specifically ropes for use in fixed gears (pots, gillnet and longlines) in Massachusetts (USA) (Krutzikowsky et al., 2009). They tested how the CWT tags might be inserted into ropes that are used as buoy lines in pot and gillnet fisheries, their durability under stimulated operating conditions, as well as handling in normal fishing operations.

Two methods were used to implant CWTs to ropes: injection with adhesive and implanting within a braided twine (Fig. 1 A & B). Direct injected tags were better in retention than those implanted using braided twines (Krutzikowsky et al., 2009).

Both types of ropes were tested in a rope-testing machine (Lyman et al., 2005) to simulate five-year fishing effort under normal fishing conditions. Severe wear was evident after five years simulated fishing, with some tag-implanted twines completely worn off (Fig. 1 C).

Coded wire tags seem to be a possible means for tagging ropes for identification of ropes entangled on marine animals, or recovered ALDFG. No further work has been carried out since the 2009 Massachusetts study, probably due to prohibitive costs to mark the gear that would result in a satisfactory degree of identification in the fishery (E. Burke, personal communication).

2.3. Radio frequency identification tags

Radio Frequency Identification (RFID) refers to technologies that