



New marking system to reduce ghost fishing in recreational fishing gear

Purpose and target group

The following memorandum is written on behalf of the Swedish Agency for Marine and Water Management (SwAM) as part of the efforts to reduce ghost fishing by passive recreational fishing gear. It aims to provide a basis for action in this area and is directed at regulatory authorities, other stakeholders and the public.

Summary

Part of the recreational fishery in Swedish coastal and inland waters is carried out using passive fishing gear (e.g. gill nets and traps). Some of these are lost and become ghost gear (continue to catch and kill fish and shellfish for a long time). Suggestions are given on how ghost fishing can be reduced in different ways:

- Better marking of the gear with regard to the owner's identity ("ID tags"). This clarifies the responsibility and increases the incentive for the fisher to reduce the risk of losing the gear.
- Administrative measures like; a mandatory ID tag on the gear to be able to fish, a lost tag means that a new must be purchased, introducing a "ghost fee" (penalty) for lost gear not reported in time and detailed information on ghost fishing in connection with the receipt of ID tags.
- The importance that new regulations are logical, based on real facts (e.g. salvage costs) and easy to follow is stressed.
- There is a need for a dedicated organization or unit (like Ghost Guard) to coordinate efforts to reduce ghost fishing.
- There are technical devices available on the market with good potential to prevent losses and facilitate salvage (localization via hydroacoustic transmitters or passive reflectors, pop-up buoys, etc.). However, these are normally too expensive to use in recreational fishing but technical development is expected to provide useful alternatives, which will hopefully be useful in commercial fisheries as well.

Some concrete examples are provided on how a new system for marking, with described components, may be designed. Suggestions are adjusted to the needs of fishing regulators in the field.

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1. Background

According to SwAM's latest major survey (a questionnaire in 2013), the number of individuals that performed recreational fishing was 1.6 million, of which half of them (780,000) fished in the coastal areas. The total fishing effort of mass catching fishing gear (gill nets, pots and fyke nets) on the coast was estimated at 4.2 million 'gear days'. A certain but today unknown share of these gears are lost annually and become ghost gear.

Marking and tracking passive fishing gear is important in order for lost gear to be returned and to maintain fishery regulations.

Today's marking system does not work optimally according to those who are responsible for checking compliance with regulations.

Today's marking regulations do not include systems for finding lost fishing gear and to safely identify the gear owner.

A discussion is ongoing at international level on the type of marking that should be used in a future common marking system. The process can take time and an option is that Sweden, for now, introduces its own, intermediate marking system for recreational fishing gears.

The basic purpose of these intermediate regulations would be to determine who uses the gears. The marking should be such that supervision is facilitated and made as simple and effective as possible.

2. Research questions

- Which marking systems are currently available for passive fishing gear for Swedish recreational fishers?
- Describe pros and cons as well as the marking systems: Bar code, Wet tag, Ping and Acoustic transponder. Specify today's price and if the price would change in a full implementation.
- Which of the marking systems are able to solve/contribute to solving both the problem of finding lost fishing gear and identifying the owner of the gear?
- Do different types of passive fishing gear require different marking systems or can they all be part of the same system?
- Indicate differences in searching lost gears in a time perspective (direct/ 2 years).
- Can suggested systems be useful also for commercial fishers?

3. Definitions

3.1 Recreational fishing

This report focuses on fishing that is carried out with mass catching passive gear, which is not carried out with the support of commercial fishing license/personal fishing license, in this PM referred to as "recreational fishing". Usually, this type of fishing takes place during free time and without the catch being marketed, however some sales of fish in the freshwater area occur¹.

3.2 Ghost fishing

Lost or abandoned fishing gear that continue to catch and kill fish and/or other organisms. Gears remaining visibly over the surface (e.g. buoys, flags) do not constitute ghost fishing gear.

3.3 Recreational fishers' equipment

Fishing gear that during normal use are passive (laying still) and independent (does not require constant supervision). The most common are gill nets (the fish penetrates the mesh with the head but is then stuck), fyke nets/salmon traps, cages/pots, as well as set lines.

3.4 Other equipment of recreational fishers

Boats are often small (<6 m) and without advanced equipment. However, there are some larger boats with moderately advanced equipment (echo sounder, GPS, net hauler). The echo sounder (and sonars) continuously send short sound pulses from a sensor down to the seabed. Recurring echoes are represented graphically on a display. The time it takes before the echo arrives from the bottom is used to calculate the depth of the water. Other echoes can show fish shoals or even individual fishes.

3.5 Marking system

Technical, methodical and administrative arrangements or combinations of these, for the identification and location of fishing gear. "Mark" refers to technical devices for the purpose.

3.6 Mode of operation of marks

Passive

Lacks internal power source but data can be read in alternative ways. CWT (Coded Wire Tags) are millimetre-long pieces of solid steel wire with a branded (laser) ID number. The marks are read visually using a loupe/microscope.

Barcodes are printed patterns that are read with optical equipment at a distance (max 10-15 m). The scanner uses a weak laser beam and patterns are decoded in a processor.

RFID (Radio Frequency IDentification) tags use radio technology and consist essentially of a passive circuit (antenna/coil) and a memory circuit. The memory of a passive RFID is strongly limited. The scanner sends out a weak radio signal that is superimposed with ID information before return. There are also variants with an internal power source (battery).

¹ ANON 2005. Fiskevårdens finansiering. SOU2005:76.

A hydroacoustic transponder receives and reflects a hydroacoustic signal from an echo sounder or sonar in such a way that it creates a recognizable pattern on the display.

Semi-passive

Have their own power source but uses it only for internal processes, not for transmission. Memory capacity can be significant (e.g. logging environment data). They are usually dormant, but can be triggered/activated and send response signal (radio, hydroacoustic signals) or generate an activity.

One example is Wet tags that use RFID for storing environment data, which can then be downloaded via a reader. Several variants of RFID are available.

Another example of semi-passive marks is the release-system, which after activation via a hydroacoustic signal from a vessel, releases a buoy that rises to the surface.

Active

Have their own power source. Send out signals according to a preprogrammed schedule. Acoustic transponders continuously send out signals that can be plotted by electronic equipment. They are common in the offshore industry, but they are also used in deep-sea fishing operations. A geographically more nearby example is when pingers are used to scare away porpoises in Swedish fishing.

3.7 Affected areas

In essence, coastal areas with relatively shallow waters and lakes are affected. To a lesser extent also running water.

3.8 Requirements for the introduction of new regulations

The introduction of new regulations for recreational fishing involves considerable work. A very large number of people are fishing. Owners, fishing rights holders and fishers are all involved, and operators frequently belong to more than one of these groups. Fishing activity varies greatly throughout the year, as well as target species and gears used. The geographical spread is also vast (the whole country, both lakes and coasts). In addition, the economy in this activity is often weak, as most fishers do not sell their catch, which may reduce the incentive to supply the gears with expensive tags. Therefore, there are high requirements on good quality information and careful design of new regulations.

4. Delimitations and considerations

Only tags on the gear and its surface marking are included in this review, not external equipment (e.g. radio buoys, radar reflectors).

Loss of gear can be prevented/minimized by good seamanship (cautiousness as to time, location and weather, as well as thoroughness in navigation/positioning, and use of multiple surface markings per gear, etc.). However, these factors are not treated here, only the direct effects of marking systems.

"Owner of the gear" refers here to the person who is legally responsible for the specific fishing operation. This statement is to avoid unnecessary discussions whether it is formally the owner of the gear, or the person using the gear, which is responsible for the fishing.

Administrative arrangements for supervision, handling of data etc. are not discussed in this report.

One factor to consider when drawing up regulations for marking is how the gears are used. Some fishing gear are usually set in fleets (groups; e.g. gill nets, eel fyke nets, crayfish traps) while others are usually set one on one (e.g. salmon-, lobster- and crab traps as well as pots and longlines). A common cause to the formation of ghost gear is that merged gears are separated or teared. For the sake of safe identification, it is therefore considered important that each individual gear is marked. This in turn means that such a marking must be made at a very low cost to be reasonable and feasible.

Another factor to consider is the wide range of dimensions, e.g. gear costs and catch value between gears. Traps for freshwater crayfish can have a dimension of some decimetres and a value of a few euros while a salmon trap (however unusual in recreational fishing) can have a total length of more than a hundred meter and a value of more than 100k SEK. The statistical risk that a gear will be lost and subsequently begin ghost fishing does also vary considerably with type of gear, areas for fishing, etc. This, together with a large diversity in recreational fishing, when it comes to types of gear, geographical distribution, target species, intensity, etc., makes it less appropriate to specify specific marking methods for individual gear types.

5. Technical marking systems available on the market

The Food and Agriculture Organization (FAO) conducted in 2016 an expert meeting on the marking of fishing gear, having the perspective of ghost fishing in mind. The main report² is comprehensive with guidelines, definitions etc. A sub-report³ provides an overview of technical alternatives for marking and localizing fishing gear. An appendix⁴ contains product data sheets for some of the alternatives.

Regardless of which technical solution is chosen to mark recreational fishing gear in Swedish waters, it is assumed that supervisors have all the equipment necessary to read IDs, access the internet, an ID register as well as equipment to handle gears of different kinds. Tags should have the information (ID number, name) in plain text and be easy to read. The tag should also contain a reflector to facilitate the discovery in dim light.

For the identification of owners/users during physical inspection of the gear (when lifting it to the water surface, or after it is taken on board) there are several technical alternatives (see the following table).

² FAO (2016) Expert Consultation on the Marking of Fishing Gear, Report. Expert consultation on the Marking of Fishing Gear, Rome, Italy. FAO Fisheries and Aquaculture Report, 46pp.

³ FAO (2016) Expert consultation on the Marking of Fishing Gear, Draft. New Technologies for Marking of Fishing Gear, Rome, Italy. FAO Fisheries and Aquaculture Report, 47pp.

⁴ FAO (2016) Expert consultation on the Marking of Fishing Gear, Appendices. New Technologies for Marking of Fishing Gear, Rome, Italy. FAO Fisheries and Aquaculture Report, 84pp

Table. Equipment for identification of recreational fishing gear.

Type	Size (mm)	Principle for communication	Provides ID	Position	Operating time	Reduces ghost fishing	Relevance recreational fishing	Cost/pc (SEK)	Pros and cons	Note
CWT	1-2	visual reading (laser engraving)	full	no	unlimited	indirectly	uncertain	2-3	difficult handling (very small)	
Barcode	10-50	optical (reader)	full	no	unlimited	indirectly	high	1-2	easy to read, necessary with clean surface and free view	
RFID	10-50	passive radio circuit (scanner)	full	no	unlimited	indirectly	high	10-200	easy to read	several variants
Wet tag	50-100	passive radio circuit (scanner)	full	no	5 years	indirectly	high	500-1,000	easy to read, extra features (data storage)	
Hydro-acoustic transponder	100-150	active (hydro-acoustic beacon)	no	yes	6 months-5 years	directly	high	500-15,000	battery changes	pinger is a simple variant
Hydro-acoustic responder	50-200	passive (sounder, sonar)	no	yes	unlimited	directly	high	2,500-15,000	detection distance > 100m, no individual ID, expensive	4kHz-900kHz

Barcodes are simple, well proven, robust and low-priced. They are used almost everywhere in society for the identification of goods etc. The benefits are several, they are easy to handle and very secure. The disadvantages are primarily that the barcode needs free sight and that it is clean and undamaged. A barcode that is in a pile of gears cannot be detected. Each barcode must therefore be handled and read individually.

RFID tags are also simple, well proven and low-priced. The technology is used widely (trademarks, pass cards, railway wagons, etc.) and many advanced variants are available. Performance (for example range) varies with the frequency of the radio circuit and the environment in which it is used. A high frequency can provide a relatively long range (10 m) in good conditions but an extremely short (cm) in poor conditions (e.g. in a pile of humid equipment). When the range is relatively long or marks are close to each other (several marks are reached), they can interfere with each other. For this reason, RFID tags with a relatively low frequency are best suited for the use in recreational fishing.

Another marking system for fishing gear are Wet tags⁵. They use semi-active RFID and can store environmental data (water temperature, depth, etc.) during fishing. At lifting, each gear's ID can be read automatically and recorded together with other data (GPS position, catch/gear). This system should be attractive for both fishers and supervisory staff. The abovementioned marking methods reduce ghost fishery predominantly by being preventive, as the owner of the gear/the fisher can be identified with high certainty.

⁵ <http://www.zebra-tech.co.nz/wet-tag-data-collection-fisheries/>

Other marks/devices reduce ghost fishing more directly as they can be used for localization and recovery. One of these devices, acoustic transponder, is used in many contexts to mark positions or expensive equipment in lakes and seas. There is also a product intended for fishing gear⁶. This makes it possible to locate lost gears by means of a hydroacoustic beacon receiver. Acoustic transponders are generally relatively expensive but a smaller and simpler variant - "banana pingers"⁷ are less costly. It is a relatively newly developed device which is attached to gill nets (used also in Swedish waters) and continuously emit high frequency sound pulses in the water to reduce the risk of bycatch of porpoises.

There are also technical devices (release systems) that are designed to release a buoy to the surface on command. They have mostly been developed for purposes within the defence, offshore services and marine archaeology, but also for commercial deep sea fishing operations⁸. These systems are generally complicated with advanced transmitters and receivers and are very expensive. None of these systems are considered suitable for recreational fishery's needs today because of their high price.

In recent years, a very interesting and completely passive technique (hydroacoustic responder) has been developed⁹ and is now available as a commercial product (SonarBell®). The responder can be detected by common echo sounders and sonars and is available in several configurations depending on frequency range. This technique was originally developed for other purposes (UK Navy) and is currently too expensive to use in recreational fishing. It does also require that the fisher has access to an echo sounder. However, the product is mentioned here because it has very interesting features from a ghost fishing perspective, and products with similar performance but a lower price may be developed in the future.

Marking alternatives described in the table have all (except the banana pinger) an operating time of at least 2 years. Prices are given in a range (different variants). The most relevant variants for recreational fishing are located at the lower end of respective range. When implemented on a large scale, costs are somewhat lower, but not dramatically so, as the products are already manufactured on a relatively large scale.

The outlined proposals for marking technology should be useful (in applicable parts) in commercial fishing as well.

6. Administrative options

Motivation is the single most important factor to reduce ghost fishing and implementing fishing regulations - they must therefore be logic, reasonable and easy to follow. Information must be available, clear, relevant and preferably also engaging. Fees should be directly linked to objective factors (e.g. average cost for salvaging ghost gears of a specific type, area, etc.). It would be to substantial advantage if some kind of feedback/benefit for the fisher can be incorporated. Likewise, it is desirable that the fisher can choose level of commitment after, for example, the frequency/extent of his or her fishing and economy.

⁶ <http://www.notus.ca/gearfinder-700/>

⁷ <https://www.fishtekmarine.com/deterrent-pingers/>

⁸ <http://www.scatri.com/SMART-BUOY-DLS.56.html>

⁹ Islas-Cital et al. (2013)

The time factor is also important, the faster the reporting of a missing gear takes place, the greater is the chance to find them or to later recover them. However, for a successful outcome it is not sufficient with an enforcement to immediately report lost gear and measures that have been taken to find them. It is crucial to stimulate and promote a personal commitment.

There is a need for an organization (like Ghost Guard¹⁰), where you easily can report your own losses, salvage of ghost gears and relevant observations to (e.g. suspect echo sounder images, drifting gear etc.).

Generally, it is considered advantageous if a future fishing gear database would include ID for both the gear and for the accountable owner/fisher.

6.1 Motivational factors

The requirement to mark gears will incentivize using gear in safe areas, as well as to avoid putting them out in bad weather. This because the right to fish is linked to the ID tag and loss of tags reduces prospects to fish.

The incentive to report lost fishing gear quickly is likely to be stronger if a penalty is imposed when a lost gear is found without it being reported (exceeding a certain time span). This could be implemented through an elevated fee for renewing the ID tag. However, there should not be any consequences when a loss is reported correctly and on time (the fee you pay when obtaining the license should act as an insurance for salvaging).

It may be feasible to introduce some kind of reward for the person who salvages a ghost gear with an ID tag. The reward could be a discounted ID tag for your own use or other benefit. Cash compensation is probably less appropriate.

In connection with signing for the ID tag, detailed information on the problem with ghost fishing is provided and deterrent underwater images are displayed depicting ghost gears with dying and dead fish.

6.2 Fees

The fee for ID tags may preferably be coupled to the underlying problem. This means that the fee is based on known data of amount of lost gear in the current fishing operation and respective costs for salvaging. Information about the scheme and the calculations is provided together with the ID tag.

The fee for the ID tag can be lower or non-existent if the fisher agrees to use technologies that reduces the risk of ghost fishing and facilitates search and salvage. For example, doubled amount of buoys per gear, posted GPS positioning for each fleet of nets, time delayed pop-up buoys, transponders or other solutions that are considered relevant (this would also increase involvement and serve as an incentive for product development).

¹⁰ <https://www.trelleborg.se/sv/bygga-bo-miljo/klimatforandringar-och-miljo/miljoprojekt/ghostguard/>

7. Possible examples

A few examples are described below as a concretization of the ideas regarding a new marking system. They reflect an increasing ambition level regarding the fisher's commitment to reduce the risk of ghost gear in his or her own fishing. The idea is to promote greater commitment and that a higher level of ambition will bring clear benefits to the fisher.

Base

Every individual gear (net, pots etc.) has a tag with a barcode where the information (ID number, name) also is available in plain text. The tag has a reflex for faster detection in dim light. There is a similar tag as well as a passive RFID tag on surface markers (buoys, flags). If issued tags are to be renewed at certain intervals they may be color-coded in a corresponding time series.

Supervisory staff should be able to:

- (1) easily detect the surface marker for a gear, even under difficult conditions (using the reflective tag)
- (2) at a certain distance, be able to make a preliminary assessment (e.g. valid colour code)
- (3) at some meters' distance read the ID (barcode) and
- (4) when being next to the gear verify ID via RFID

Already during the approach to the gear, the supervisory staff have received information to make a decision whether a full inspection or single sampling is required, or if they can patrol on without further action. This should facilitate and streamline the work.

Different levels of ambition, applicable under different circumstances:

Level 1

There is a great need for data on fishing efforts and catches in recreational fishing within the Fisheries Management. One possibility may be that chosen fishers retrieves a more advanced ID tag with a Wet Tag that is activated (automatically) when the gear is set. Data (date, time, position, depth and temperature) are automatically logged for the occasions when the gear is set, without further work for the fisher. At emptying (e.g. when supervised, periodic exchange), data is obtained that is very valuable for resource management. The ID tag may have technology indicating (when it's time for renewal, certain time or amount of fishing effort). A fisher using such an ID should be able to do it with significantly reduced or (preferably) no cost at all. Other advantages can also be thought of but this needs to be investigated further.

Level 2

Reporting of fishing efforts according to the previous paragraph fills part of the data gap whereas specific catch data can be calculated in other ways. However, explicit catch data is still of great value to the Fisheries Administration, while demanding detailed catch data/records may encounter several problems (e.g. reliability). It is possible however that sought data can be obtained from highly motivated and interested fishers in a voluntary additional step. In return, these fishers receive for their catch data partly exemption from the costs of the ID tag. They also receive summaries of their fishing data, and useful/educational analyses of their results in relation to the total fishing in the current sector/area. As a model, it would be possible to use the highly appreciated system for feedback to reporting agents that is provided by scientists at the Department of Aquatic Resources' (SLU Aqua's) database for electrofishing in streams (SERS) and the National Register of Survey test-fishing (NORS). Here too, more in-depth studies and proposals are needed.

8. Technical needs and development opportunities

Recreational fishing in Swedish waters almost exclusively takes place in areas where 3G coverage is available. This means there are opportunities for real-time information transfer. For example, a device can be automatically released from the gear after a certain time period and rise to the surface. Then, after logging the GPS position, the device sends this (SMS) message to, for example, the "Ghost Guard" (conceivable coordinating body). It may be an advantage if the device is attached to a line on the gear, but the functionality will probably be better without. The device marked with an ID tag may be clearly coloured and marked with the address to the Ghost Guard and a written promise of reward.

A more low-tech solution can be a "ghost float" that is released after a certain time by a time-dependent mechanism so that it can float to the surface, connected to the gear with a thin line. The precise position of such a float facilitates the salvage. It may be feasible to use a thin but extremely strong hi-tech line (Dynema®) that can be used directly for the retrieval¹¹.

The hydroacoustic responder Sonar Bell has several attractive features in respect to present efforts to minimize ghost fishing (possible to detect with normal echo sounder/sonar, indefinite operation time) but as a product it is too expensive for Swedish recreational fishery. However, it demonstrates that hydroacoustic phenomena can be used in fishing gear markers. It is considered as fully possible that products with even more valuable features (an ID-tag, affordable price) may be developed.

Can a targeted contest on the subject be announced in collaboration between e.g. SwAM, a technical university and MARELITT¹²?

9. Comments

An important issue is how an ID tag is best designed in relation to its use. The simplest way is probably if the marks only contain basic information on the individual gear (ID number, owner's name, type of gear, expiring date) while other information that concern the fishing operation (permitted number of gear, fishing area etc.) are handled separately. When signing for ID tags for "fishing with passive gear", the fisher undertakes a responsibility to comply with applicable regulations and rules. The fisher then receives needed info/links (updated web page with fishing regulations and any changes in limitations regarding areas, species, gears, quotas, time etc.). It may be beneficial to start gently with a new marking system but then have a plan B and plan C ready to gradually tighten up the regulations/requirements if necessary.

A new system for fishing gear ID ought to be as simple as possible and should be built in positive cooperation between fishers and their organizations. The ultimate objective is to protect the fish resource for everyone's benefit and to remove ghost gears from lakes and the sea.

¹¹ The material was previously very expensive but costs today 4-8 SEK/m for a 2-3 mm line with a strength of 500-1000 kg.

¹² MARELITT is an EU-funded project, aiming at identifying good practices for the removal of litter and derelict fishing gear from the sea. See <https://www.marelitt.eu/>