Asia-Pacific
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Compendium for the Marking of Fishing Gear in the APEC Region

APEC Oceans and Fisheries Working Group

August 2023

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Produced by

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Acronyms and abbreviations

aFAD ..... Anchored fish aggregating device
AIS..... Automatic Identification System
ALDFG ..... Abandoned, lost or otherwise discarded fishing gear
APEC ..... Asia-Pacific Economic Cooperation
COLREG..... International Regulations for Preventing Collisions at Sea
CWT ..... Coded wire tag
dFAD ..... Drift fish aggregating device
DFO..... Department of Fisheries and Oceans (Canada)
EEZ..... Exclusive Economic Zone
ETP..... Endangered, threatened or protected (species)
EC..... European Commission
EU ..... European Union
FAD ..... Fish aggregating device
FAO ..... Food and Agriculture Organization of the United Nations
GESAMP..... (United Nation's) Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GGGI ..... Global Ghost Gear Initiative
IMO..... International Maritime Organization
ISSCFG..... International Standard Statistical Classification of Fishing Gear
IUU..... Illegal, unreported and unregulated (fishing)
MARPOL..... International Convention for the Prevention of Pollution from Ships
MCS ..... Monitoring, control and surveillance
NFC ..... Near field communication
NM..... Nautical miles
NOAA ..... National Oceanic and Atmospheric Administration (US)
OFWG ..... (APEC) Ocean and Fisheries Working Group
RFID ..... Radio frequency identification
UN..... United Nations
UNGA..... United Nation's General Assembly
VGMFG ..... (FAO) Voluntary Guidelines on the Marking of Fishing Gear

Plastic materials

ABS ..... Acrylonitrile butadiene styrene
EPS..... Expanded polystyrene
EVA ..... Ethylene vinyl acetate
HDPE..... High density polyethylene
PA ..... Polyamide (Nylon)
PE..... Polyethylene

PES..... Polyester
PP ..... Polypropylene
PUR..... Polyurethane
PVA ..... Polyvinyl alcohol
PVC ..... Polyvinyl chloride

Preparation of the document

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1. Background and Purpose

1.1 Background

The Asia-Pacific Economic Cooperation (APEC) is a cross-continental economic forum established in 1989 to foster economic cooperation and development in the Asia-Pacific. APEC currently has twenty-one member economies from Asia, Oceania, North America and Latin America, with diverse levels of economic development, scales of economy, and a large disparity in population.

APEC economies have a total population of 2.92 billion, which 38% of world total. In 2019, APEC economies landed 44 million tons of fish from capture fisheries, 46% of world capture landing. APEC economies are thus important players in capture fisheries. Sustainable fisheries and ecosystems are thus vital to APEC economies.

APEC's Oceans and Fisheries Working Group (OFWG) was formed in 2011, with a mission to support APEC's goal of fostering sustainable economic growth, development and prosperity in the Asia-Pacific region with regard to ocean and fisheries resources.

The Global Ghost Gear Initiative (GGGI) is a cross-sectoral alliance committed to driving solutions to the problem of abandoned, lost or otherwise discarded fishing gear (ALDFG) worldwide. GGGI aims to improve the health of marine ecosystems, protect marine animals, and safeguard human health and livelihoods, through reduction and or elimination of ALDFG and its harmful impact.

Fishing gears are marked to establish their ownership and legality of their use, to indicate their position to aid for navigation and to reduce conflicts between gears. Fishing gears are also marked to inform the origin of the gear when entangled in marine animals or drifting at sea or beached as marine litter. Gear marking has been considered as an important tool to reduce ALDFG and to fight against illegal, unreported, and unregulated (IUU) fishing (FAO, 2016; 2018). The Food and Agriculture Organization of the United Nations (FAO) has been working on guidelines for the marking of fishing gears since early 1990s. The Voluntary Guidelines on the Marking of Fishing Gear (VGMFG) was adopted by FAO members at its 33rd Session of Committee on Fisheries in July 2018 (FAO, 2019).

Fishing gear marking intends to contribute to more sustainable fisheries through prompt reporting and facilitate retrieval of ALDFG to minimize their impact on the environment through the reduction of marine litter and on living marine resources of the ocean through the reduction of ghostfishing. A system of marking of fishing gear is also intended to provide means of identifying the ownership and position of fishing gears and should be considered in the context of broader fisheries management measures which support sustainable fisheries and healthy oceans, including reduction of plastic pollution, fishing effort control, legality of fishing, and measures against IUU fishing.

1.2 Purpose

The purpose of this report is to develop a compendium of fishing gear marking that is applicable to APEC region, including various gear marking methods and their application for different purposes and existing requirements and practices of gear marking in selected

jurisdictions and regions. The report will provide guidance for conducting risk assessment which is an integral part of developing a system of fishing gear marking, and means for designing a system of gear marking, including suggested minimum requirements for different fishing gears and fish aggregating devices. This report and the companion document "Managing Abandoned, Lost or Discarded Fishing Gear and Aquaculture Equipment in the APEC Region" (Huntington and Drinkwin, 2022) will provide framework for designing and implementing a system of fishing gear marking in the APEC region to combat ALDFG and its harmful impact, to aid in fisheries management for sustainable fisheries and ecosystems.

2. Major Fishing Gears in the APEC Region

The Asia-Pacific Economic Cooperation (APEC) region represents a large geographical area, a large population, and a high volume of fish production. Fishing gears used in the region are diverse, reflecting majority, if not all, of those used around the globe. All fishing gears listed in the sub-categories of the FAO's International Standard Statistical Classification of Fishing Gears (ISSCFG) as attached in Appendix 1 of this report are being used in the APEC region.

Unlike the standard classification in the ISSCFG and elaborated recently by He et al. (2021), in this document the gears are divided into two major groups: attended gear and unattended gear. The attended gears are fished when the gear is attached and/or actively operated by the vessel, while unattended gears are fishing without the active operation by the vessel. In general, attended gear are less likely to lose while unattended gears are more like to lose.

The following is a brief description of some important gears with regard to gear loss, plastic pollution, capacity control, and other related characteristics. This document has benefited from descriptions in the recent FAO's *Classification and Illustrated Definition of Fishing Gears* (He et al., 2021), *von Brandt's Fish Catching Methods of the World* (Gabriel *et al*., 2005), *China Atlas of Marine Fishing Gears* (Feng et al., 1987), and *Fishing Gear and Methods in Southeast Asia: II Malaysia* (Munprasit et al., 1989).

The description emphasizes on the scale and size of the gear, plastic materials used, and gear markings that have been used. Examples are given for the types of gears used in the APEC region if possible.

In this document, the definition of fishing gear as provided in Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL) is adopted:

> *A fishing gear is any physical device or part thereof, or combination of items that may be placed on or in the water or on the seabed with the intended purpose of capturing or controlling for subsequent capture or harvesting marine or freshwater organisms.*

While fish aggregating devices (FADs) are not strictly fishing gears, but an auxiliary gear that may increase fishing efficiency for the main gear they are associated with (He et al., 2021). Due to the importance and the quantity of FADs used in tuna purse seine and other fisheries, the description and marking of FADs and related measures are included in this report.

Fishing gears may be abandoned, lost or discarded due to a variety of reasons, which are collectively called abandoned, lost or otherwise discarded fishing gear (ALDFG). The Voluntary Guidelines on the Marking of Fishing Gear (FAO, 2019) authoritatively defined ALDFG as:

> *"Abandoned fishing gear" means fishing gear over which that operator/owner has control and that could be retrieved by owner/operator, but that is deliberately left at sea due to force majeure or other unforeseen reasons.*
>
> *"Lost fishing gear" means fishing gear over which the owner/operator has accidentally lost control and that cannot be located and/or retrieved by the owner/operator.*
>
> *"Discarded fishing gear" means fishing gear that is released at sea without any attempt for further control or recovery by the owner/operator.*

2.1 Attended gears

Attended gears include surrounding nets, seine nets, trawls, dredges, lift nets and falling nets. They also include handlines, and mechanical lines and pole-and-lines, trolling lines, encircling gillnets, and all gears listed as “miscellaneous gear” in the classification.

2.1.1 Surrounding nets

A surrounding net is a long piece of net that is constructed mostly from rectangular sections of netting framed by ropes and catches fish by surrounding a school of fish (He et al., 2021).

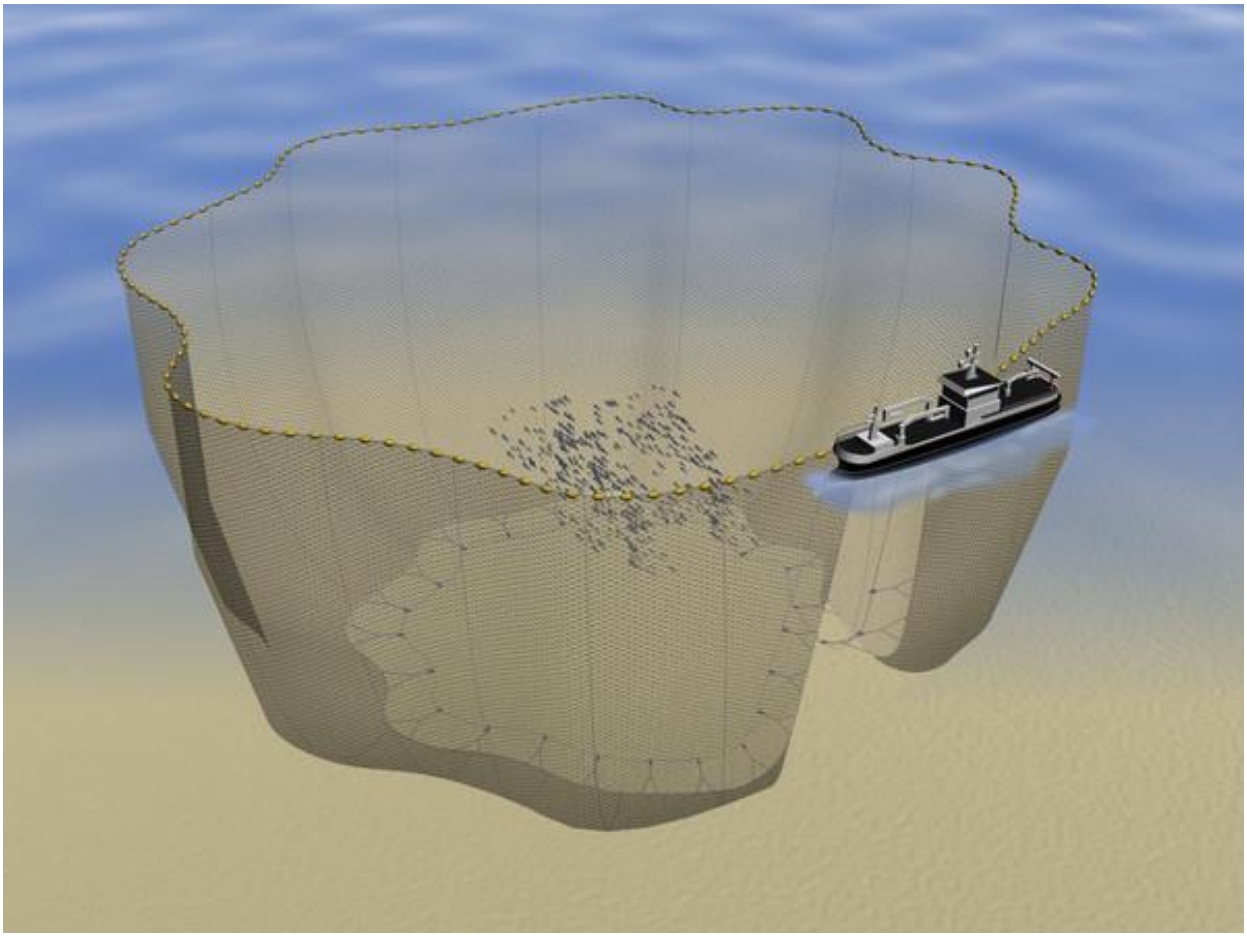
In a surrounding net, a headrope with numerous floats runs across the top of the net, while a weighted footrope runs along the lower edge. The ropes typically made of polyamide (PA), polypropylene (PP), or polyethylene (PE), and floats are typically made of polyvinyl chloride (PVC) or ethylene vinyl acetate (EVA). The netting is generally comprised of small mesh sizes to minimize fish becoming enmeshed. Netting materials are usually comprised of PA that have densities higher than that of seawater to increase the netting’s sink velocity. Sinkers are typically made of lead or metal chains. There are two types of surrounding nets: purse seines with a purse line, and other surrounding nets without a purse line.

A purse seine (standard alpha numerical codes: PS 01.1) is a wall of netting designed to encircle a school of pelagic fish near the surface and use a purse line to close the bottom of the net. The purse lines may be made of steel wire, but can also be PP or PE ropes, especially in small operations. Purse rings are made of iron, steel, or polyvinyl alcohol (PVA).

A modern tuna purse seine, as illustrated in Figure 1, can be very large, measuring 2000 m or more in length, and 250 m or more in depth. Purse seines can be operated by one vessel, one main vessel with the assistance of auxiliary vessels, or two main vessels. Purse seines are often operated with assistance of artificial lights at night to concentrate fish, around fish aggregating devices (FADs), or by targeting free-swimming fish schools. The purse seine is the most important fishing gear in marine capture fisheries in terms of the quantity of fish landed. According to recent FAO statistics, purse seines account for about a third of total marine landings. Technologies that enhance the catch efficiency of modern purse seines include solar-powered, satellite-linked buoys for drifting fish aggregating devices (dFADs) equipped with an echo-sounder, bird radar and spotter planes/helicopters for locating surface schools, high-speed boats for deflecting fast-moving schools towards the net, and high density purse seine netting to ensure the net sinks rapidly and prevents fish from escaping (Scott and Lopez, 2014; Lopez *et al*., 2014; Torres-Irineo *et al*., 2014).

A “surrounding net without a purse line” is a long wall of netting that is designed to surround fish at the surface or in shallow water, but without the use of a purse line. This is typically a small-scale fishing gear operating near the coasts or in lakes and rivers. An example of this type of net is the lampara net. A lampara net has a central bunt (with smaller mesh) and two long wings, making it possible to surround the fish when the wings are hauled simultaneously through attached ropes. The footrope of the net is much shorter than its headrope to form a dustpan-like shape when hauled. Lampara nets are often used at night with the assistance of light to attract and concentrate small pelagic fish so that they can be easily surrounded by the net.

Figure 1. Modern purse seine encircling a free-swimming fish school



Source: Seafish (www.seafish.org)

2.1.2 Seine nets

Seine nets may be cone-shaped nets with long wings and a codend, or a long piece of net without a codend, catching fish by encircling and herding.

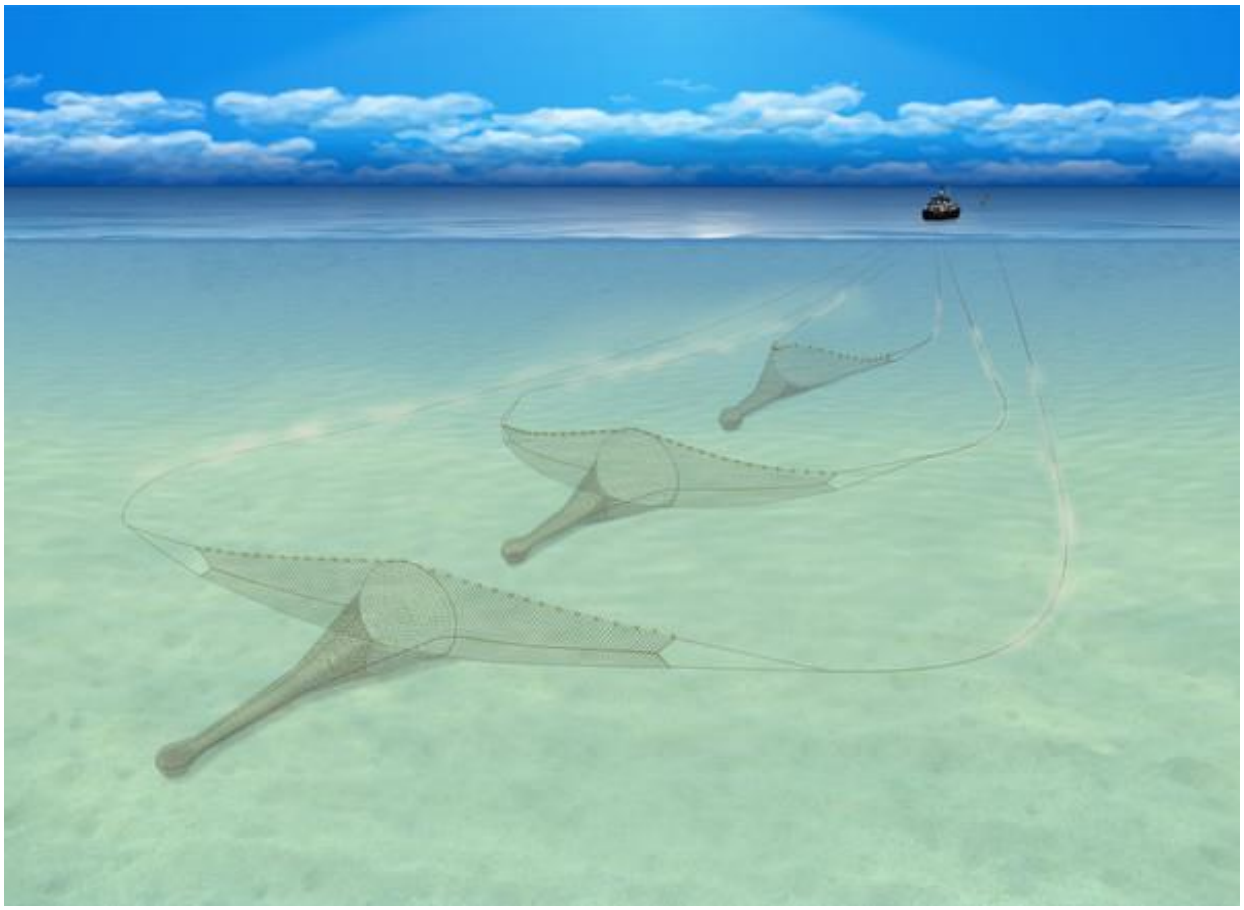
A seine net is usually framed by a headrope, with floats, along the upper edge and a footrope, with weights, along the lower edge of the net. The weighted footrope is used to maintain ground contract and reduce net abrasion. Framing ropes are typically made of PP and PA, and floats are made of PVC, EVA, and in shallow water, expanded polystyrene (EPS). Netting is typically made of PA or PE. Seine nets are divided into beach seines and boat seines.

A beach seine is a long-winged net with or without a codend that encircles fish in shallow waters, typically on a beach. The net usually extends from the surface to the bottom, both of which act as natural barriers, preventing the fish from escaping from the area enclosed by the net. Beach seines are widely used in small-scale and artisanal fisheries in the APEC region. A survey of beach seines in selected economies and an extensive review of beach seine fisheries has been published by FAO (Tietze *et al*., 2011).

A boat seine is a cone-shaped net with elongated wings, seine ropes and a codend, and operated by one or two boats, capturing fish by encircling and herding. Danish seines and

Scottish seines (Figure 2) are examples of one-boat seines (Walsh and Winger, 2011). *Due wang* (in Chinese) is a good example of pair seining using two boats.

Figure 2. Scottish seine, showing successive shapes during operation



Source: Seafish (www.seafish.org)

2.1.3 Trawls

The trawl is a cone-shaped body of netting, usually with one codend, towed behind one or two boats to catch fish through herding and sieving.

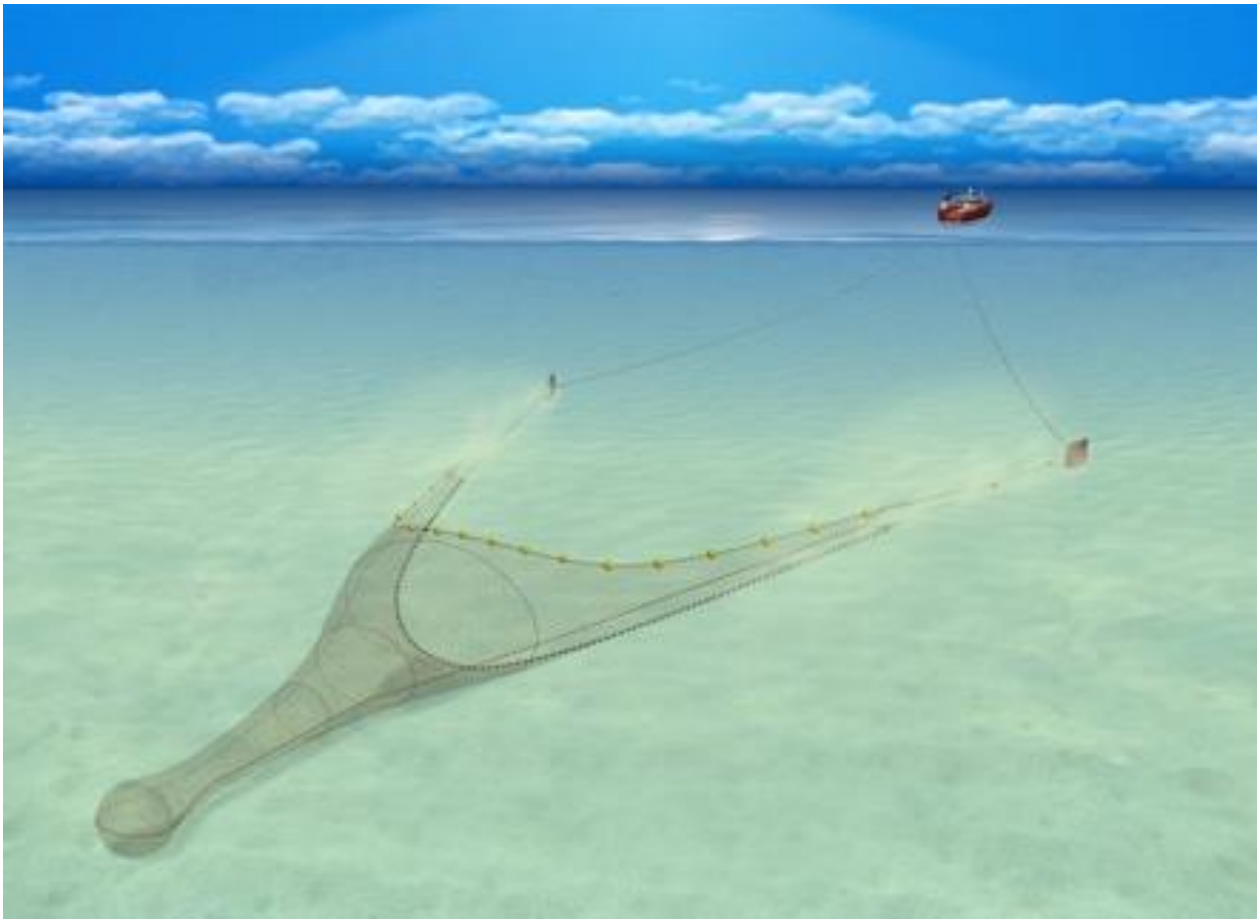
Trawls are designed to be towed across the seabed (bottom trawls) or in midwater (midwater trawls). A semipelagic trawl is a hybrid that can be set to fish on or off the seabed. A single boat can tow one trawl (most common), two trawls (twin trawl), or more than two trawls (multiple trawls). A single trawl can be towed by one boat (most common) or two boats (pair trawl).

A bottom trawl is towed on the seabed to catch fish living on or near the seabed. It includes beam trawl (TBB 03.11), single boat bottom otter trawl (OTB 03.12, Figure 3), twin bottom otter trawl (OTT 03.13), multiple bottom otter trawl (OTM 03.14), bottom pair trawl (PTB 03.15).

Bottom trawls are framed with a headrope, with floats (PVC; ABS in deep waters), and groundgear with weights to open the net vertically. Framing ropes are often made of PP or PA, or combination ropes with steel wrapped by PP, PA or other synthetic fibers. Nettings are

often made of PE or PA. The groundgears often consist of components such as heavy-duty ropes, chains, rubber spacers and discs, and metal bobbins to ensure that seabed contact is maintained during fishing while minimizing the risk of damage to the net. Otter boards (used in single boat otter trawls, and twin and multiple trawls) are typically made of steel, or steel/wood combination. For beam trawls, the horizontal opening of the net is maintained by a rigid beam which is typically made of steel or aluminum, and in smaller operations, maybe of wood, bamboo of PVC pipe.

Figure 3. A single boat otter trawl in operation

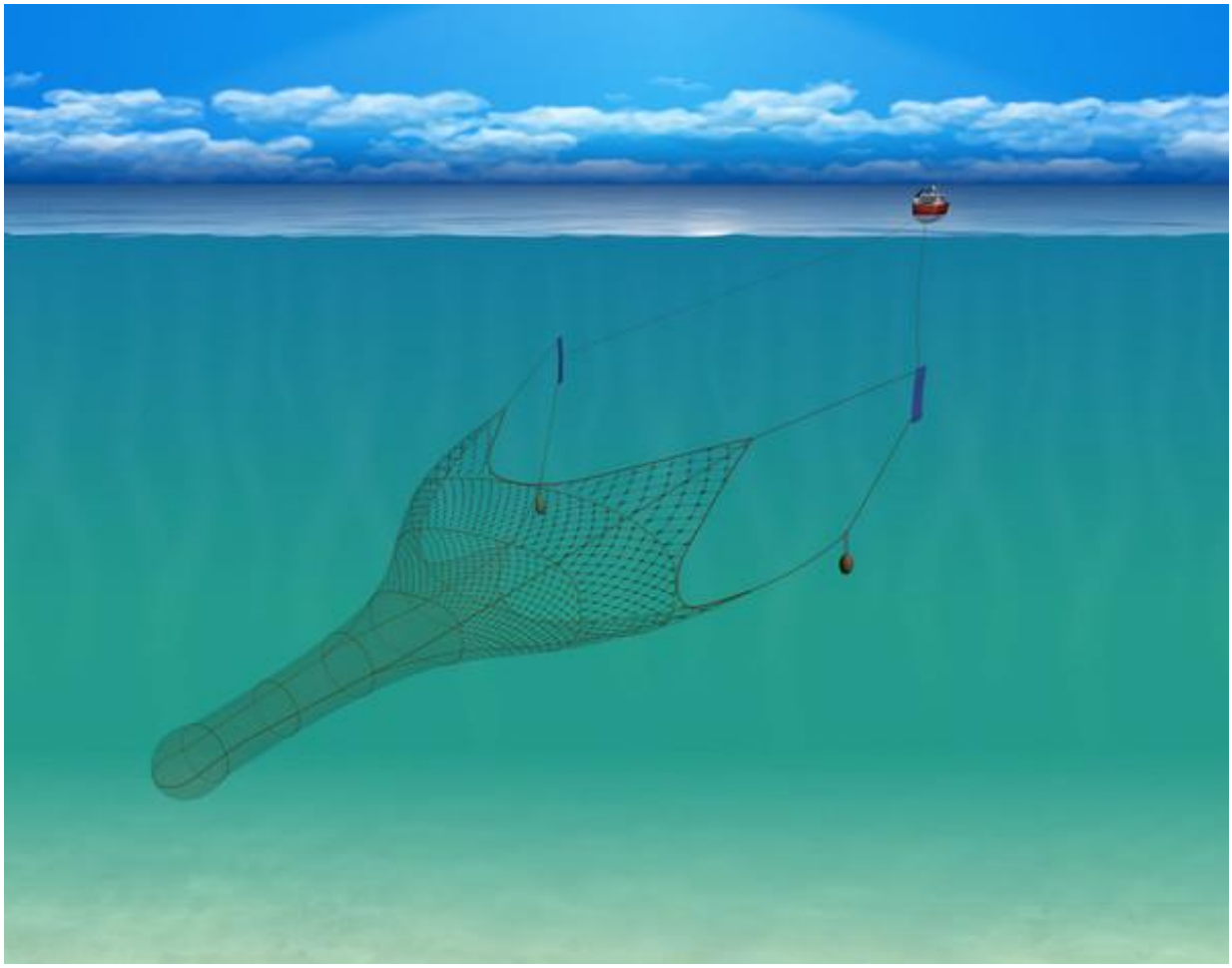


Source: Seafish (www.seafish.org)

A midwater trawl is a cone-shaped net towed in midwater by one or two boats to catch pelagic or semi-demersal fish in the water column. Midwater trawls are divided into single boat midwater trawl (OTM 03.21, Figure 4) and midwater pair trawl (PTM 03.22). The nets in both types of trawls are very similar in material and construction, except that in the midwater pair trawls, two boats and no otter boards are used. Midwater trawls are also called pelagic trawls whose components are not intended to have contacts with the seabed while fishing. Midwater trawl nets are usually much larger than bottom trawl nets. The front part of the net is usually made with very large meshes or ropes to reduce drag, but still herd the targeted fish. The vertical opening of a midwater trawl is often maintained with weights, typically chains or other heavy materials, attached to the lower wingends, while some have floats on their headline.

Similar to bottom trawls, ropes framing the nets are typically made of PP and PA, and nettings are typically made of PE and PA. Floats, if used, are typically made of PVC, and, if operated in deep waters, acrylonitrile butadiene styrene (ABS).

Figure 4. A single boat midwater otter trawl in operation



Source: Seafish (www.seafish.org)

A semipelagic trawl (TSP 03.3) is a trawl that has either the trawl net or the otter boards touching the seabed, but not both. The net is either similar to the bottom trawl or the midwater trawls depending on how they are operated. The trawl is not as popular as bottom trawl or midwater trawls.

2.1.4 Dredges

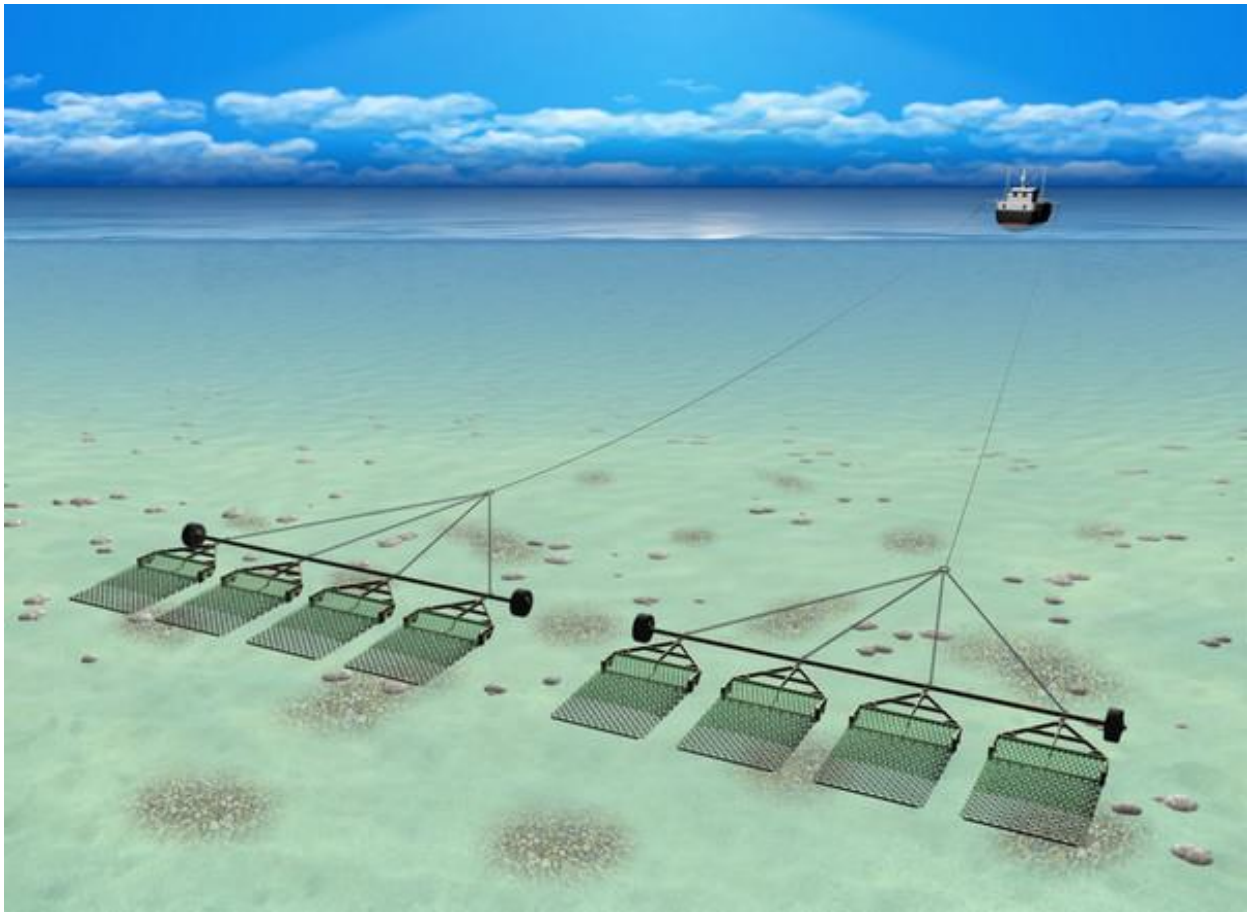
A dredge is a cage-like structure often equipped with a metal scraper blade or teeth on its lower part, either pulled or towed to dig animals out of substrate and lift them into the cage or bag.

As dredges are in heavy contacts with the substrate, the bottom part of the dredge, sometimes the entire cage, is made of metal rods or chain mesh to withstand chafing with the seabed; however, mesh bags made of synthetic materials are also used. Dredges may be operated either by hand, wading in the water or from a small boat in shallow waters (hand dredge, DRH

04.2), towing behind a boat (towed dredge, DRB 04.1, Figure 5), or using complex mechanized hydraulic systems (mechanized dredge, DRM 04.3). Common target species include molluscs such as mussels, oysters, scallops and clams.

Metal structure, chain mats or interlock metal rings are main materials for all dredges. Synthetic nettings may be used in the top of the towed dredges as required in US Georges Bank scallop dredge fishery; in this case, the netting is typically made of PE.

Figure 5. Eight dredges on two beams towed behind a boat



Source: Seafish (www.seafish.org)

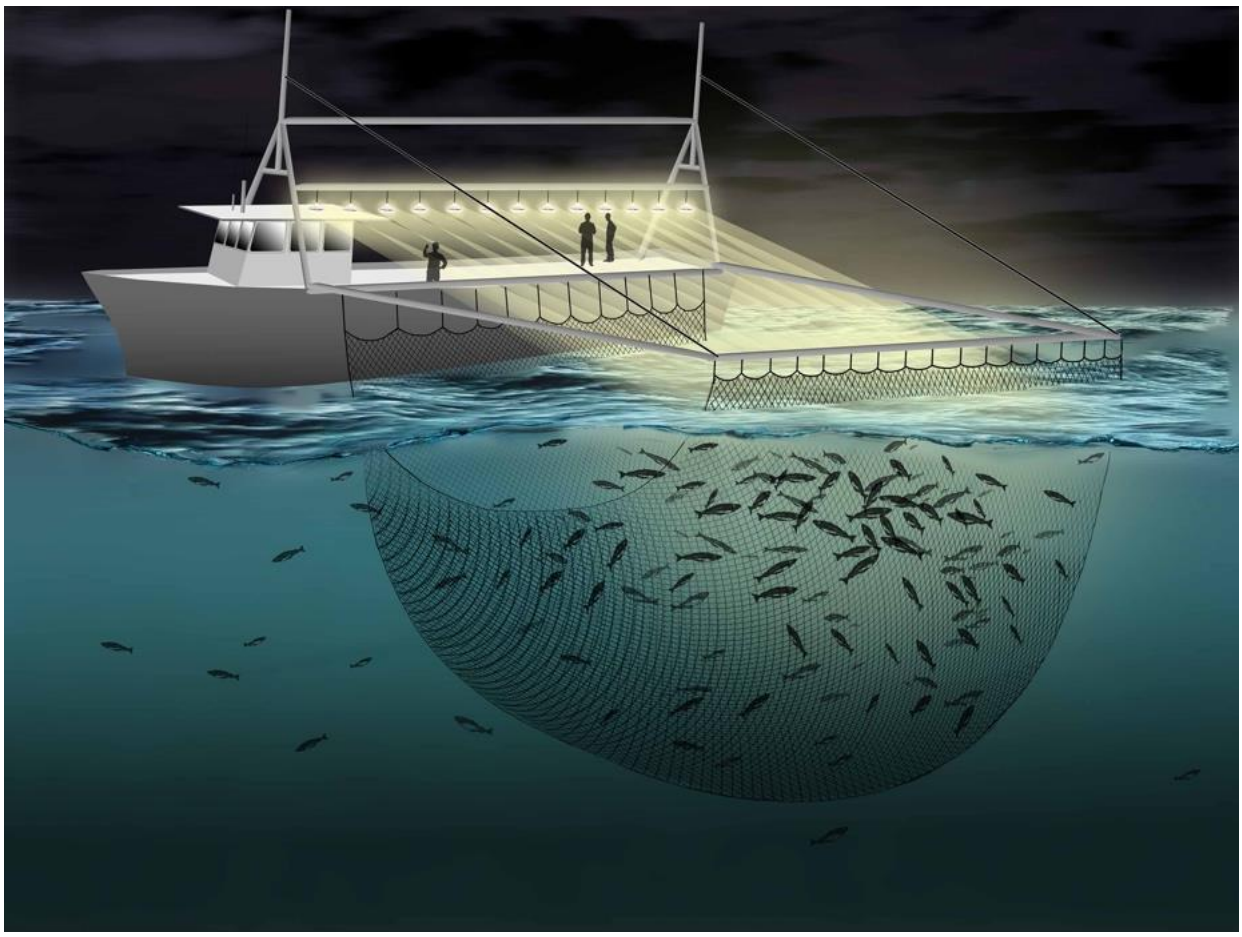
2.1.5 Lift nets

A lift net is a piece of netting mounted onto a frame that is lowered into the water to allow fish to enter the area above the net and is then lifted or hauled upward to collect the fish accumulated there. The fish are often attracted over the net by lights or bait, or drift over the net with the current. The netting (PE or PA) is often stretched over a frame of rods made of bamboo, wood, plastic or metal. These gears may be either small portable and operated by hand (portable lift net, LNP 05.1), large stationary on a pier or a cliff and assisted by a winch or other mechanical device (shore-operated stationary lift net, LHS 05.3), or operated from one or more boats (boat-operated lift net, LNB 05.2, Figure 6).

Shore-operated lift nets are widely used in many Asia-Pacific economies such as China; India; Indonesia; Malaysia; Philippines; Thailand; and Viet Nam. Krumme *et al.* (2013) described a large-scale lift net in detail in the Hainan Province of China in the north of the South China Sea. According to a field survey conducted by the authors, there were 293 lift nets in that area alone in 2009.

Boat-operated lift nets are usually large in size using beams extended from the boat. Lights are often used to attract and concentrate the fish at night (Figure 6). These gears include bagnets, blanket nets, and Japanese stick-held lift nets (Sudirman and Nessa, 1992). Boat-operated lift nets are primary fishing gears supplying live baitfish, mostly small clupeid and engraulid species, for tropical tuna pole-and-line fisheries (Blaber *et al*., 1990; Lewis, 1990).

Figure 6. A boat-operated lift net with light attraction



Source: FAO

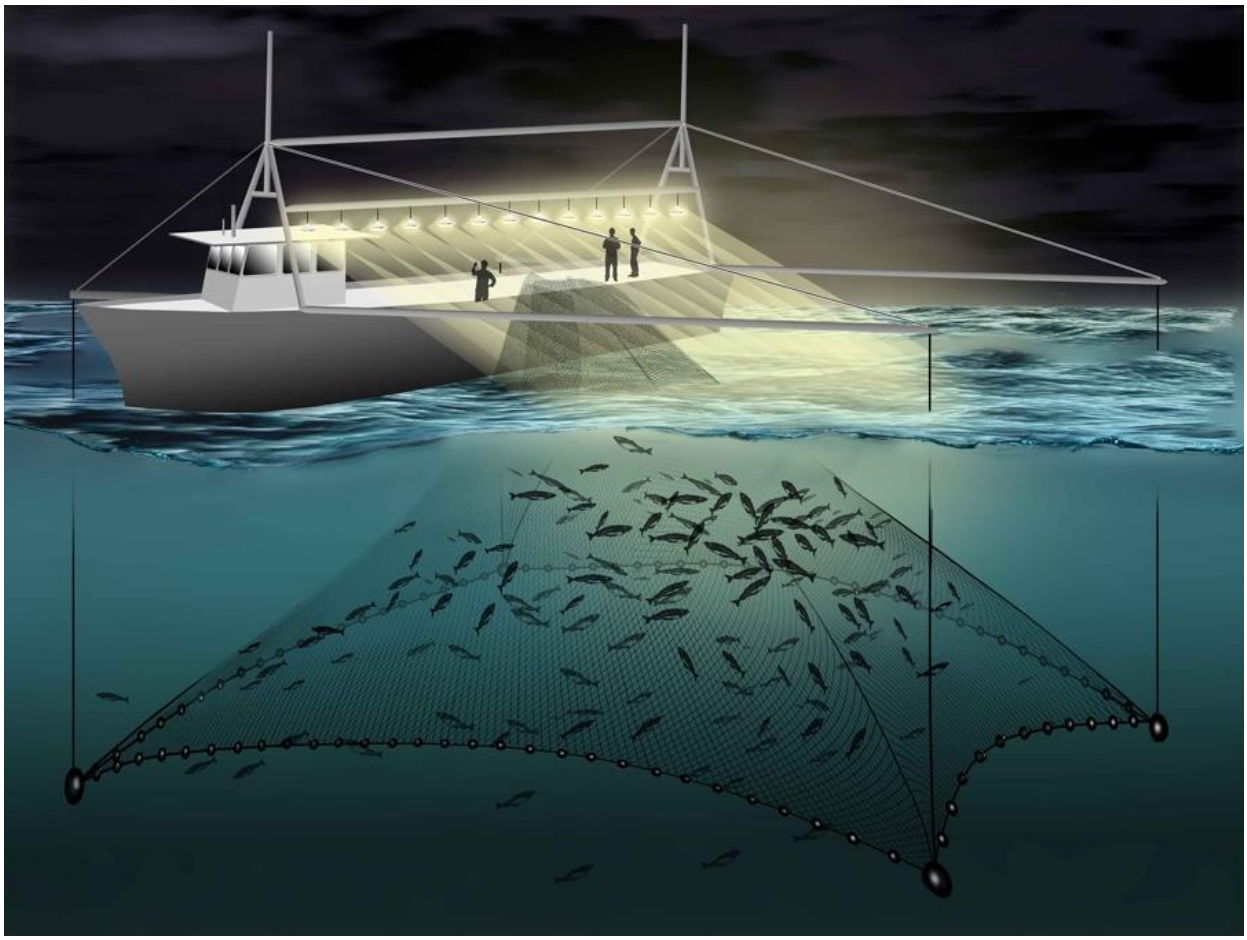
2.1.6 Falling gear

Falling gear is a net or a basket-like structure which is cast (cast net, GCN 06.1), pushed down or allowed to fall from above (covered pot/lantern net, FCO 06.2) to catch fish underneath it (He et al., 2021). Cast net is a very popular small-scale fishing gear in southeast Asia (Munprasit et al., 1989). Cast nets are typically made of PA, while lanterns may be constructed from bamboo or wood and covered with PE netting. Falling nets are usually used from

riverbanks or in shallow tidal waters, however, some large-scale falling nets can operate in deep waters from a boat with the use of lights to attract and concentrate fish.

A boat-operated falling net is usually operated at night with the use of lights to attract target species (Figure 7). Once fish are attracted to the area under the net, which has been prepared on the side of the vessel, the net is quickly released and sinks with heavy weights on its perimeter to entrap the fish. A drawstring closes the bottom of the net when the net reaches beyond the depth of the fish, and the net is brought to the deck. A large number of falling nets of this type have been used in China and other Asia-Pacific economies since the 1990s (Chen and Song, 2013; Zhao *et al*., 2017). These falling nets can have a perimeter of more than 300 m and operated by vessels of around 40–50 m long. The netting is typically made of PA, but can also of PE. This type of falling net is not in a specific classification in the current ISSCFG.

Figure 7. A boat-operated falling net with light attraction



Source: FAO

2.1.7 Other attended gears

Other attended gears include hand-operated and mechanized lines and pole-and-lines, trolling lines, encircling gillnets, and all gears listed in “miscellaneous gear” category in the ISSCFG (Appendix 1). Most of these gears are small-scale, recreational, or artisanal in nature.

Handlines, pole-and-lines and trolling lines typically use monofilament nylon (PA) or stainless steel wire as the mainline, metal hooks, and lead as weight. PVC or rubber lures may be used instead, or in addition to, natural bait in pole-and-line fishing. Poles are typically made of fiberglass or carbon fiber in high-quality rods, or PVC in cheap rods. While handlines and pole-and-lines are typically used in recreational and artisanal fisheries, the number of these gears in use may be very large. Pole-and-line is also an important gear for catching tuna, especially skipjack tuna, in commercial operations.

Encircling gillnets encircles a school of fish and make fish to swim into the net. Encircling gillnets have similar structure as the typical set gillnets, using PP or PE as framing ropes and monofilament PA or multifilament PA or PE as netting. The gear is not widely used and is typically operated in shallow waters.

Gears listed in “miscellaneous gear” category include harpoon, wrenching gear, clamps, tongs, rake, spear, pump and electric fishing gear, which seldom use any synthetic netting, but may use handles made of metal of PVC. Miscellaneous gears also include push net, scoopnet, and drive-in net, which primarily use PE netting. In drive-in nets, PP and PA ropes may be used for framing, and PVC or EVA floats may be used for floatation.

2.2 Unattended gears

Unattended gears include most of gillnets and entangling nets, hooks and lines, and all traps. These gears are set in place to catch fish that are attracted to, guided into, or accidentally swim into the gear.

2.2.1 Gillnets and entangling nets

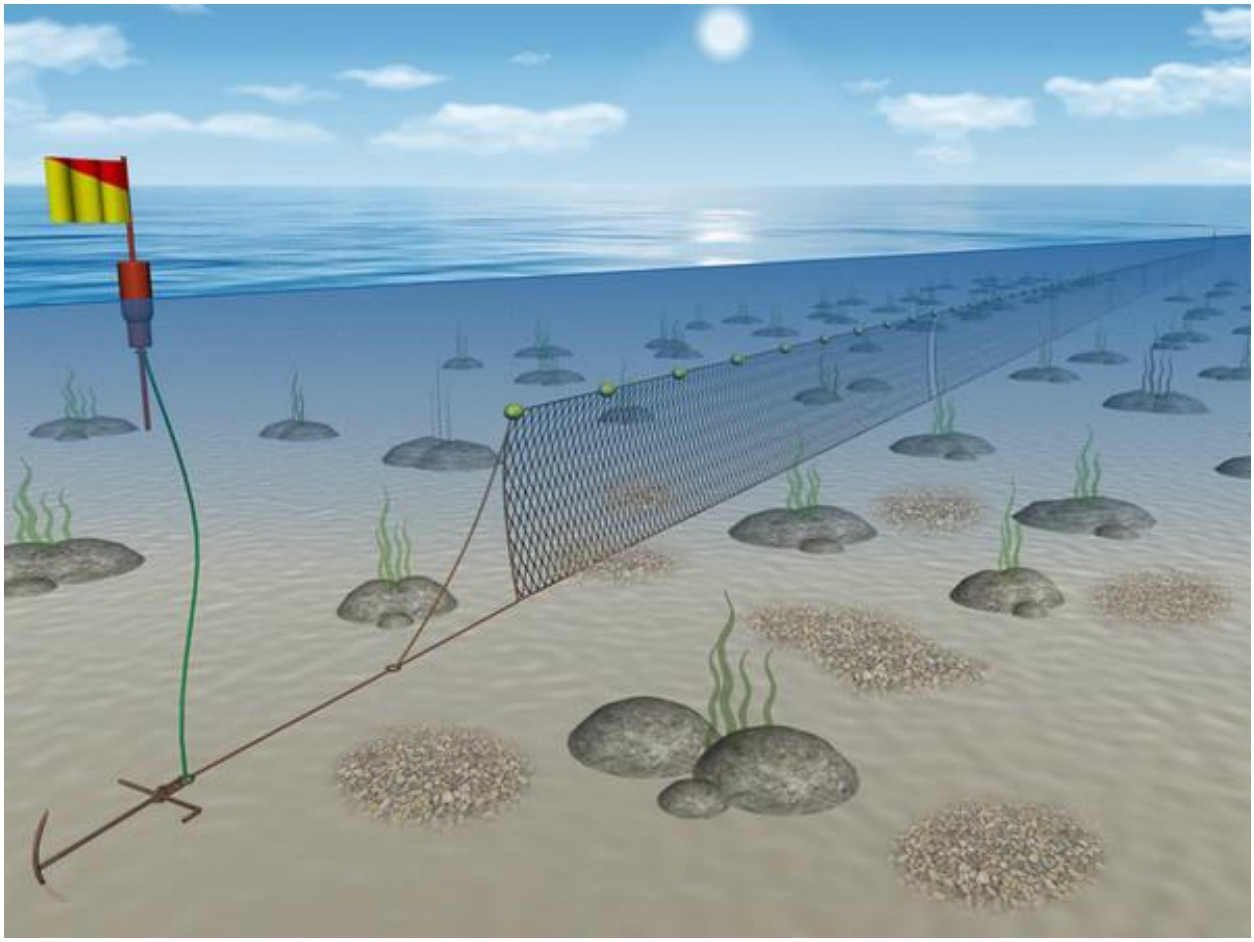
Gillnets and entangling nets are long rectangular walls of netting (PA or PE) that catch fish by gilling, wedging, snagging, entangling or entrapping them in net pockets. These nets are kept open vertically by floats (usually PVC or EVA; ABS in deep waters) attached to the headrope and by weights (lead) added to the footrope, but they can also be held open vertically by hanging the net onto stakes (wood, bamboo, or PVC). These nets are usually fished in long strings with a number of nets tied together (which may extend up to several kilometers), but they can also be used singly. Depending on their design, they may be used to fish at the surface, in midwater or near the seabed. They may be anchored to the seabed or allowed to drift freely with marker buoys or with the boat attached to it. Several types of net may be combined in one gear (for example, a trammel net combined with a gillnet).

Gillnets and entangling nets are an important and versatile gear type that contribute about 10% of global fish landings and widely used in the APEC region. In some APEC economies, this type of net may be the most important gear. Because abandoned, lost or otherwise discarded gillnets and entangling nets have the potential to continue catching fish and ETP species, more effective preventive and curative measures are needed to reduce their impact (Stelfox *et al*., 2016).

The set gillnet (GNS 07.1, Figure 8) is the most common type of gillnet and is often called “bottom gillnet” or simply “gillnet”. However, set gillnets can also fish in midwater or near the surface, especially in shallow waters. The most common type of netting material is monofilament nylon (PA), but multifilament PA or PE netting are also used in some fisheries.

Encircling gillnet (GNC 07.3), fixed gillnets (GNF 07.4), trammel nets (GTR 07.5), and combination gillnets (GTN 07.6) all have similar netting material. Framing ropes are typically made of PP or PE. Buoy ropes, typically made of PP lead to the surface where buoys made of PVC, EPS, EVA, or PUR are attached. A pole, flag and/or radar reflector may be used together with or instead of the buoy.

Figure 8. A fleet of set gillnets on the bottom

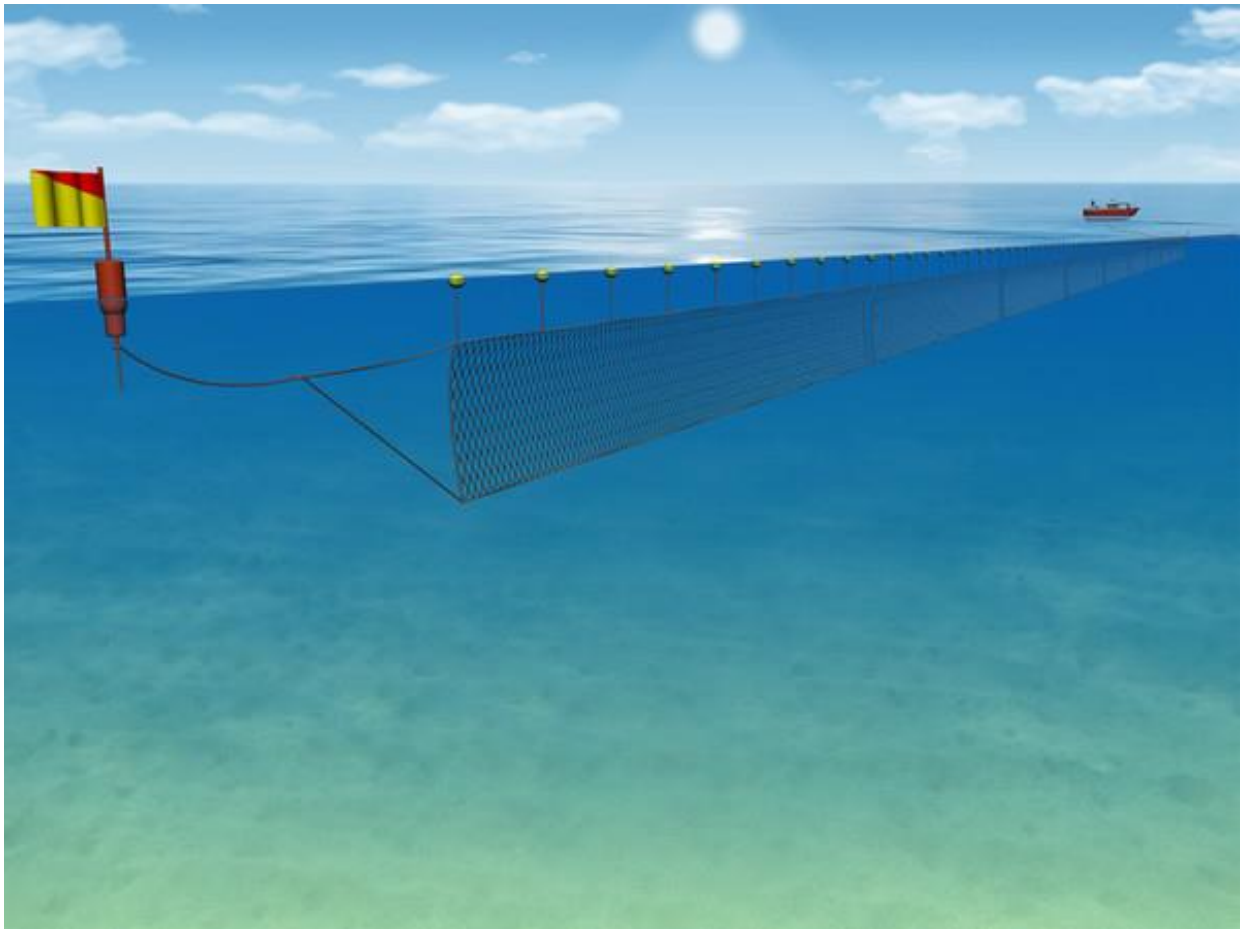


Source: Seafish (www.seafish.org)

Drift gillnet (or driftnet, Figure 9) is a type of gillnet that is not fixed to the seabed but allowed to drift with the current. Drift gillnets are usually fished in a fleet which can extend over a great distance in open waters. Drift gillnets use similar material for netting, rope and surface buoys as set gillnet described above. Drift gillnets usually fish on or near the surface but can be in midwater, with the length of buoy ropes controlling the depth of the net. The net is typically adrift with the vessel or markers (buoy and highflyer) attached to the end of the gear (Figure 9). In large operations, the marker may be equipped with radio or satellite transmitters for easy location. A fleet of drift gillnets can be over 10 km long and several fleets may be fished by a vessel; the total length of the net fished by one vessel may therefore stretch to tens of kilometers.

Drift gillnets have been reported as a concern for non-target species including ETP species such as marine mammals, seabirds and turtles (Northridge, 1991). As a consequence, the United Nations adopted a resolution banning the use of large-scale driftnets over 2.5 kilometers long in high seas in 1991 (UNGA RES 44/225; UN, 1989). Subsequently, some regional and domestic authorities have implemented similar bans in their jurisdictions, such as the European Union and various Regional Fisheries Management Organisations. However, the ban did not apply to drift gillnets of less than 2.5 km, which are commonly used in various small-scale fisheries in the APEC region.

Figure 9. A fleet of drift gillnet near the surface



Source: Seafish (www.seafish.org)

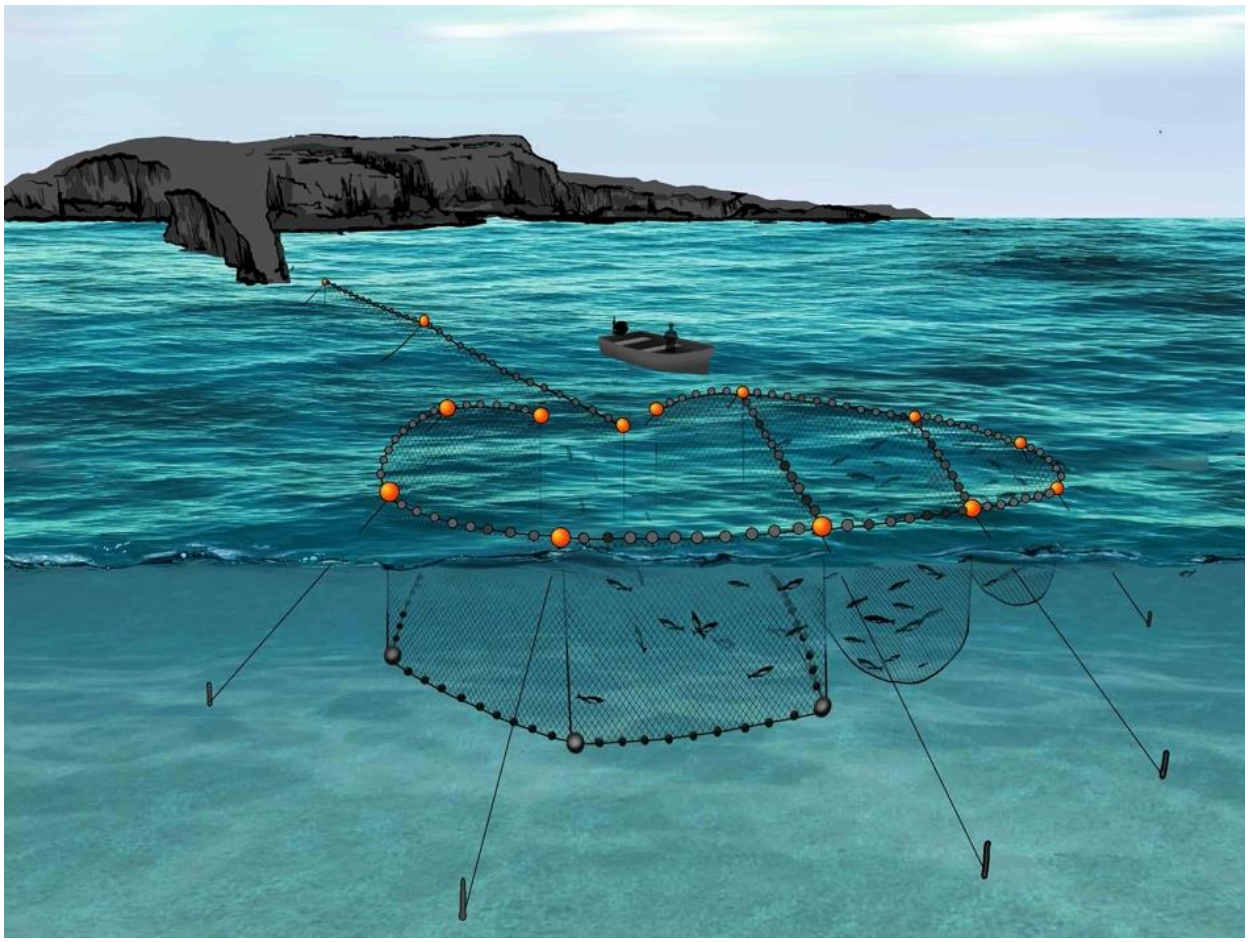
2.2.2 Traps

Traps are stationary structures of many shapes and sizes into which fish are guided, or pushed into by the current, or attracted into the gear by bait or other attractants (He et al., 2021). Traps include stationary uncovered pound nets (FPN 08.1), pots (FPO 08.2), fyke nets (FYK 08.3), stow nets (FSN 08.4), barriers, fences and weirs (FWR 08.5), and arial traps (FAR 08.6).

Stationary uncovered pound nets include large fish traps such as Japanese setnets (Figure 10), Chinese *jian wang*, Alaskan salmon traps and Newfoundland cod traps. These are permanent or semi-permanent large structures made of complex netting chambers, rope frames and mooring ropes, and leaders to guide the fish toward the trap. Nettings are usually

made from PA, PES or PE, and ropes mainly of PP or PE. Floats on the upper edge of the net are often made of PVC, EVA or EPS. Large buoys are strategically placed, and are made of PVC or PUR, but can also be EPS or EVA, especially in developing economies. Related to the uncovered pound net are barriers, fences and weirs, which are also large in size, and are usually permanently set in a location for many years. These gears were traditionally made of stone, and wood or bamboo piles, but now netting are often used together with the piles. If used, the netting and rope materials are often similar to those used in pound nets.

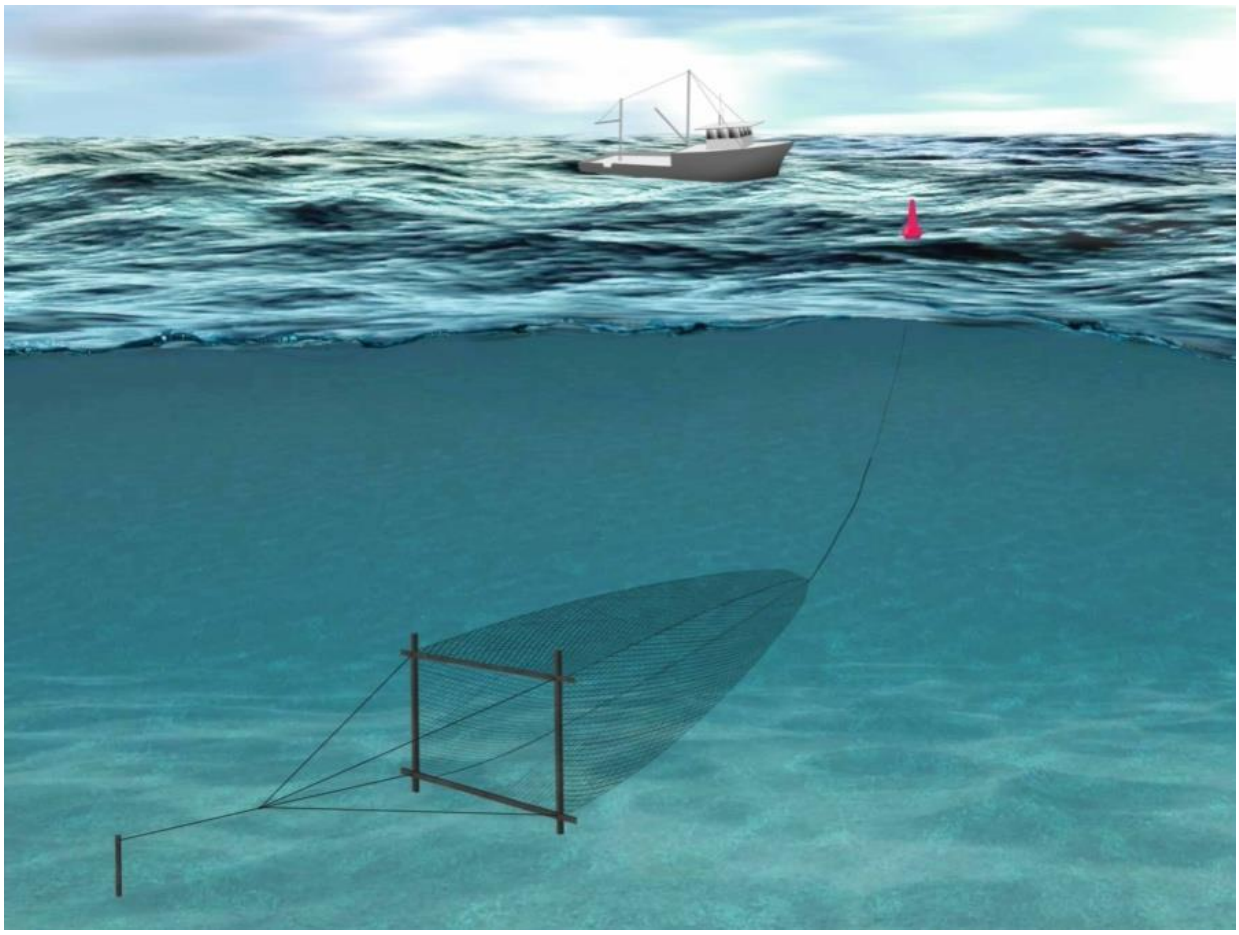
Figure 10. A Japanese set-net, a type of stationary uncovered pound net



Source: FAO

Stow nets are very popular in East and Southeast Asian economies. Stow nets, *zhang wang* in Chinese, are widely used along the entire coast of China (Figure 11). In *China Atlas of Marine Fishing Gears* (Feng *et al*., 1987), 39 types of stow nets were described in detail, illustrating the variety, extent and importance of the gear in China. Similar stow nets, but usually smaller in scale are fyke nets, which usually constructed of cylinders and cones with non-return devices, and fished in estuaries and coastal waters. The netting in stow nets and fyke nets are usually made of PE and framing and mooring ropes of PP. Rigid frames in stow nets, if used, were traditional made of bamboo or wood, but now metal or synthetic beams are often used.

Figure 11. A stow net with one anchoring point

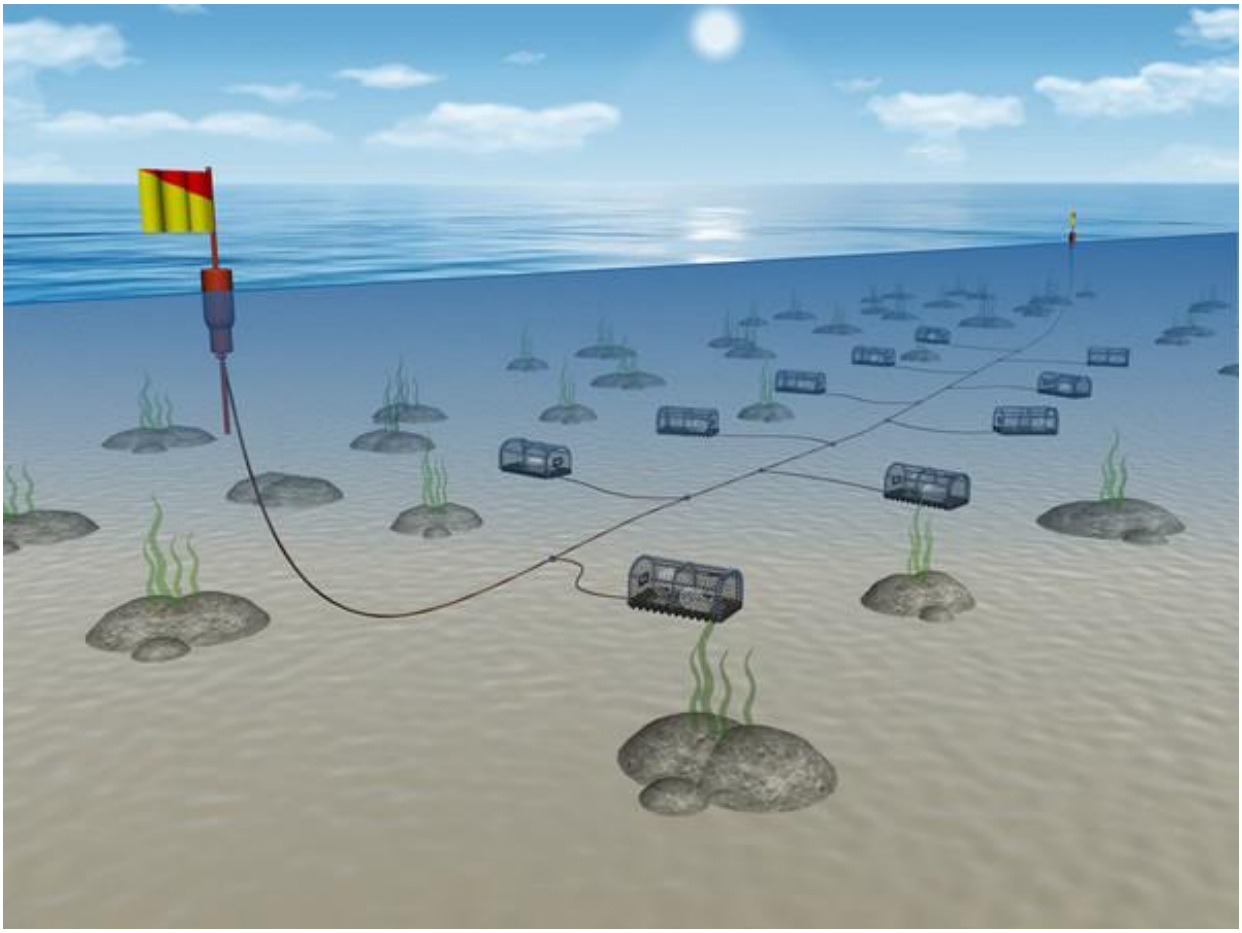


Source: FAO

A pot is a small enclosure that attracts fish or shellfish through one or more entrances that allow the entry but prevent or retard their escape. Pot is significantly different from other gears in the trap category described above. The term “trap” is often used interchangeably with “pot” in scientific and technical literature, management documents, and by the fishing industry in many fisheries and in many locations. Smaller pots are also called “creels”. In ISSCFG classification, pot is a sub-category of trap. Pots are widely used in the APEC region, especially for crabs, such as swimming crab pots in the East China Sea, king and tanner crab pots in Bering Sea, and lobster pots in Eastern Canada and Northern USA.

Traditionally, pots have been constructed of bamboo, rattan and wood, which is still widely practiced, especially in developing economies in the Southeast Asia region. Synthetic netting or wire mesh over rigid metal or plastic frames are now common. If used, netting is often made of PE. Wire mesh may be coated with PVC. Pots may be fished in singles or in a fleet of many pots (Figure 12). When fishing in fleets, the mainline connecting the pots may be made of PP or PES. Buoy ropes leading to the surface are usually made of PP, and buoy of PVC, EPS, EVA, or polyurethane (PUR). Some economies require mainlines and a portion of buoy ropes to be heavier than sea water (sinking rope) to reduce entanglement of marine mammals or vessel propellers.

Figure 12. A fleet of pots set on the seabed



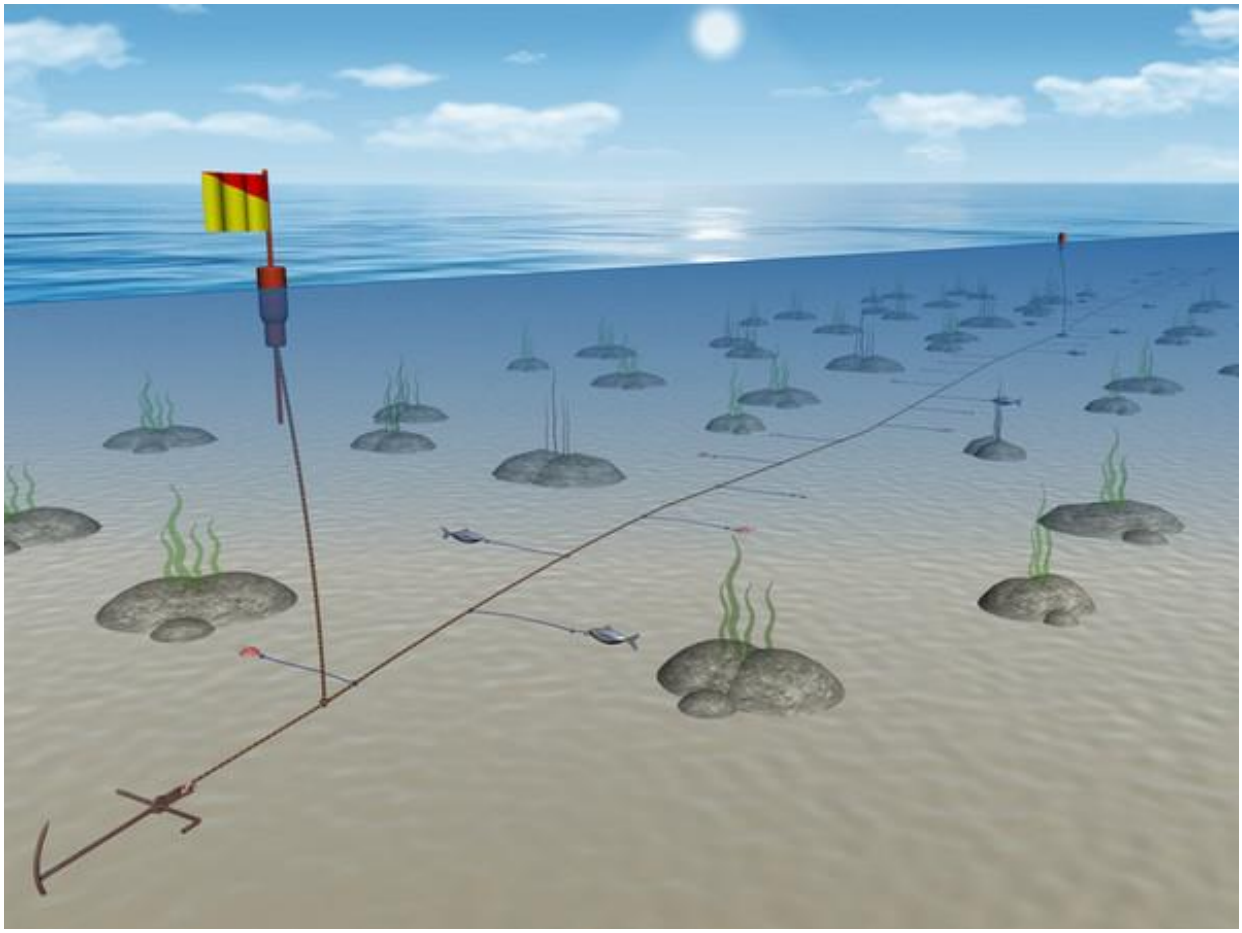
Source: Seafish (www.seafish.org)

2.2.3 Hooks and lines

Hook-and-line gears are those that use hooks and lines to catch fish. Hook-and-line gears may be fished with one hook tied to a line and a rod, or with many hooks tied to a line. They may be actively operated by a fisher or with a machine (handlines and pole-and-lines, and trolling lines) or may be left unattended (longlines and vertical lines). For unattended gears, they may be set on or near the bottom with anchors or weights (set longlines, LLS 09.31), near the surface or in midwater drifting with the currents (drift longlines, LLD 09.32), or vertically across water depths (vertical lines, LVT 09.4).

A set longline is a longline gear that is anchored or otherwise fixed to the seabed at either end of the mainline. Set longlines usually fish on or near the bottom; they are therefore also called bottom longlines or demersal longlines (Figure 13). However, set longlines can also have the mainline and hooks off bottom, or near the surface in shallow waters. A typical set longline includes a mainline either lying on the seabed (PES) or floating off the seabed (PP), snoods (PA) attached to the mainline at regular intervals (usually 1–2 m), an anchor or weight at either end of the string of the longline, and a buoy rope (PP) coming up to the surface with a buoy (PVC or PUR) and/or hyflyer to indicate location and to facilitate hauling.

Figure 13. A fleet of set longlines deployed on the bottom



Source: Seafish (www.seafish.org)

A drifting longline is a type of longline that is not fixed to the seabed and drifts passively with the current, or with the boat (also drifting) attached at one end of the longline. These longlines are often fish in open water or high seas targeting tuna or tuna-like species, and are often large in scale with mainline (PP, PA or PES) lengths up to 80 km. Snoods are, which hare often called branch lines in drifting longlines, often more than 10 m long, and may include a clip, one or more swivels and a weight. Monofilament PA is usually used in the terminal section of the branch line, but steel wires are sometimes used in shark longlines. In large-scale operations in open oceans and archipelagic seas, radio or satellite buoys are often attached to end buoys (PVC or PUR) or intermediate floats to monitor and locate the position of the gear.

A vertical line is a line set vertically with one or more baited hooks and are also called drop lines or buoy gears. A buoy is usually attached to the line at the surface to indicate position and a weight is attached to the bottom end of the line, which can be on the seabed to secure the position or off seabed to let adrift. Materials used for lines and surface assemblage are similar to set longlines.

2.3 Fish aggregating devices

A fish aggregating device (FAD) is a permanent, semi-permanent or temporary structure, which is deployed and/or tracked, and used to aggregate fish for subsequent capture (FAO, 2019). While fish aggregating devices (FADs) are not strictly fishing gears, but auxiliary gears that may increase fishing efficiency for the main gear they are associated with.

An FAD can be either anchored (aFAD) which is often deployed within an economy's EEZ, or drifting (dFAD), which is often deployed in the high seas. Both aFADs and dFADs are utilized by purse seine vessels, but large industrial tuna vessels use dFADs. Today, about half of tuna catches are from FAD-associated operations (Miyake et al., 2010). Anchored FADs are often set in coastal areas but can be set in archipelagic and/or offshore waters at depths greater than 2000 m. In addition to purse seines, aFADs are also often utilized by small-scale hook-and-line fishers.

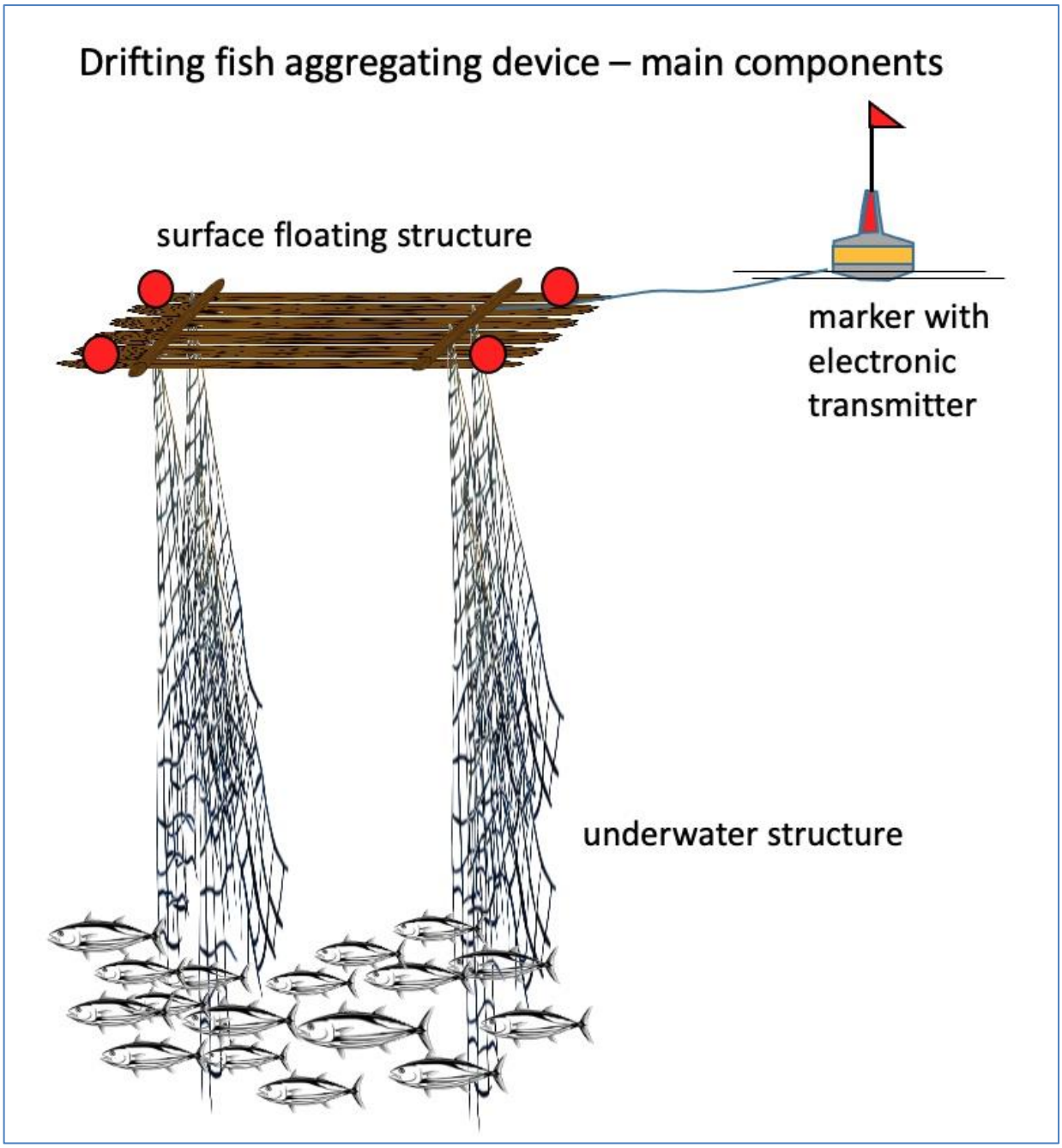
FADs typically consist of surface components (rafts), underwater components (appendages) and a marker to indicate or report its position (Figure 14). Drifting FADs often have a marker with an electronic transmitter, sometimes linked to satellite communication. Anchored FADs have a rope leading to an anchor or weight on the seabed. Both anchored and drifting FADs are marked for ownership, and position, and for dFADs for real-time tracking of position.

While earlier FADs were mostly made from natural degradable materials, such as bamboo, wood, tree branches, most FADs used today are primarily made of synthetic materials for both surface raft and appendage, with less than 2% made totally from natural materials in the western and central Pacific Ocean (Escalle et al., 2018; Hanich et al., 2019). The raft may be made from drums (metal or plastic), floats (PVC, EVA and EPS) and buoys (PVA, PUR), pipes (PVC) and netting (usually old netting from purse seines and nets, likely PA and PES). Some FADs bundle the netting so that they are less entangling to reduce unintentional meshing of fish and other animals. Electronic and/or satellite buoys used with dFADs contains metal and plastics (mostly PVC).

The large numbers of dFADs deployed by industrial purse seine vessels operating within EEZs and on the high seas have resulted in numerous FADs becoming abandoned, lost or otherwise discarded. Furthermore, without a clear requirement to identify the ownership of dFADs, it is not easy to ascertain the vessel to which responsibility and/or obligation for retrieval can be attributed (Gilman *et al*., 2018). Drift FADs deployed by purse seine vessels may drift for several years, raising concerns as to whether the boat operator has any intention of retrieving the gear. Moreover, concerns have also been expressed regarding the possibility that dFADs set by a vessel in one location may drift hundreds or thousands of kilometers, aggregating highly migratory tuna as they go, within and across multiple maritime boundaries (Hanich *et al*., 2019; Toonen and Bush, 2020).

Drift FADs are usually marked for real-time tracking of position (dFADs). The use of sophisticated satellite buoys significantly increased the number of FADs a vessel can handle, and speed of detection. While there is no reliable assessment, it is estimated that about 105,000 drifting FADs are in use by the world's tuna fisheries, primarily tuna purse seines (Baske et al., 2012). Commercial FAD manufacturers produce 47,500–70,000 FAD buoys per year, primarily for European Union purse seine fleets (Scott and Lopez, 2014), indicating that many FADs are not recovered, but left at sea.

Figure 14. A simplified drawing representing a drifting fish aggregating device (dFAD)



Source: FAO

2.4 Relative importance of the gear

The APEC region encompass a large area with its members of a diverse economic development status. The region includes the part of South America, the entire North America, and the majority of East and Southeast Asia, and Oceania. In 2019, landings from capture fisheries of APEC members were 44 million tons, which is about 46% the world's total capture production.

Fishing gears used in the APEC region largely reflect what are being used globally. Some gears may be more important in the APEC region than other part of the world in terms of usage

or landing, which may include stationary uncovered pound net (e.g., large-scale set nets used in Japan and China, cod traps in Newfoundland and Labrador (Canada), stow nets in China, and shore-based and boat-operated lift nets in the Southeast Asia.

Due to a lack of landing by specific gear types either from global or from economy levels, the relative importance of gear is broadly scaled from 1 (lowest) to 5 (highest), using data from Gilman et al. (2021) (Table 1). This ranking is largely supported by nine survey responses from APEC members, which also listed purse seines and bottom trawls as top two gear types by landing, followed by seine nets (including beach seines and boat seines), midwater trawls and set gillnet. Similarly, trawls, purse seines and gillnets are the highest landing gears in the Southeast Asia as reported by Amornpiyakrit (2019). The importance of gear may also be ranked by the number of vessels using the gear; in this case, set gillnets and pots were ranked as highest from the APEC member surveys.

Table 1. Relative importance of fishing gears in the world and in the APEC region according to landing

Importance of gear	Score	Gear types
Most important	5	Purse seine, bottom trawls, midwater trawls
Very important	4	bottom gillnet, bottom longlines
Medium important	3	Drift gillnet, drift longline
Somehow important	2	Boat seines, towed dredge, pots, stow nets, handline/pole-and-line,
least important	1	All other fishing gears

2.5 Plastic materials

A summary of relative scale of the amount of plastic material used and the types of plastic material for netting, rope and floatation and surface marking (buoys) for different gear types is provided in Table 2. While an FAD is technically not a fishing gear, it is also included in the table.

Plastic amount in the gear implies the relative size (and number of units) and plastic contents of the gear operated by a fishing unit (which can be a fisher/vessel, or more than one fisher/vessel) at a given time. When a fishing unit operates more than one unit of gear (e.g., one pot), the amount is multiplied. The values are given for larger operations. For example, small purse seines may have a few hundreds of kilograms of plastics, while large ones have tens of thousands of kilograms; the larger ones are noted here. For towed gears, towing ropes/cables are not included, which are usually made of steel wires, or for smaller operations, PP, PE, or PA.

It should be cautioned that different APEC members and different fisheries may use different sizes of gear, and different gear materials. While many more varieties of plastic may be used in different gears in different fisheries and different APEC economies, those listed represent

the common types for different components synthesizing information in Gabriel et al. (2005), Feng et al. (1989), Munprasit et al. (1989), Nedelec and Prado (1990), and GESAMP (2021).

Netting materials are typically made of PE for many gears, which is the least expensive and readily available. Gears that need to sink quickly use PA or PES netting, which is heavier than sea water. Gillnets and entangling nets typically use PA monofilament netting as it is less visible in water.

Ropes are typically made of PP, which is less expensive, strong and resistant to abrasion. Where there is a requirement to sink the rope to the seabed (sinking rope), PA or PES are used. Ropes for framing netting often use PP, PE or PA. It should be noted that some ropes (and netting) using mixed materials.

Floatation is provided by floats, which are often referred to those attached to the net, and buoys, which are often used as markers on the surface. When the gear is fished in shallow waters or set near or on the surface, EVA or PVC floats are often used. When the gear is fished in deep waters, such as deepwater trawls, floats are often made of pressure-resistant ABS material.

Table 2. Major fishing gear types (and standard codes), their relative importance, and common types of their plastic materials used for netting, framing ropes, floatation and surface marking. For hook-and-line gear, rope/line refers to mainlines, snoods and buoy ropes. Some gear subcategories are combined.

Category	Subcategory	Relative importance	Plastic amount*	Material types		
				Netting	Rope/line	Float/buoy
SURROUNDING NETS						
	Purse seines (01.1)	5	5	PA, PES	PA, PP	PVC, EVA
	Surrounding nets without purse lines (01.2)	1	3	PA, PES	PA, PP	PVC, EVA
SEINE NETS						
	Beach seines (02.1)	1	3	PE	PA, PP	PVC, EVA
	Boat seines (02.2)	2	4	PE, PA	PP	PVC, ABS
TRAWLS						
	Bottom trawls (03.11-3.15)	5	4	PE, PA	PP	PVC, ABS
	Midwater trawls (03.21, 03.22)	5	4	PE, PA	PP	PVC, ABS
	Semipelagic trawls (03.3)	1	4	PE, PA	PP	PVC, ABS
DREDGES						
	Towed dredges (04.1)	2	2	PE	-	-
	Hand dredges (04.2)	1	1	PE	-	-
	Mechanized dredges (04.3)	1	0	-	-	-
LIFT NETS						
	Portable lift nets (05.1)	1	1	PA, PE	PP	-
	Boat-operated lift nets (05.2)	1	3	PA, PE	PP	-
	Shore-operated stationary lift nets (05.3)	1	2	PA, PE	PP	-

FALLING GEAR					
Cast nets (06.1)	1	1	PA	PA, PP	-
Cover pots/Lantern nets (06.2)	1	1	PE	-	-
GILLNETS AND ENTANGLING NETS					
Bottom gillnets (07.1, 07.5, 0.7.6)	5	4	PA, PE	PP	PVC, PUR
Drift gillnets (07.2)	3	4	PA, PE	PP	PVC, EVA, PUR
Encircling gillnets (0.3)	1	3	PA, PE	PP	PVC, EVA
Fixed gillnets (07.4)	1	3	PA, PE	PP	PVC, EVA
TRAPS					
Stationary uncovered pound nets (08.1)	1	5	PA, PES, PE	PP, PA	PVC, EVA, PUR
Pots (08.2)	2	3	PE, PA	PP	PVC
Fyke nets (08.3)	1	2	PE	PP	PVC
stow nets (08.4)	2	3	PE	PP	PVC, PUR
Barriers, fences, weirs (08.5)	1	3	Pe	PP	PVC
Aerial traps (08.6)	1	2	PE	PP	PVC
HOOKS AND LINES					
Handlines and pole-and-lines (09.1, 09.2)	2	1	-	PA	PVC
Set longlines (09.31)	2	3	-	PA, PP	PVC, PUR
Drifting longlines (09.32)	2	4	-	PA, PP	PVC, PUR
Vertical lines (09.4)	1	3	-	PA, PP	PVC, PUR
Trolling lines (09.5)	1	2	-	PA	PVC
MISCELLANEOUS Gear					
Push nets (10.5)	1	2	PE, PA	PP	-
Scoopnets (10.6)	1	1	PE, PA	-	-
Drive-in nets (10.7)	1	3	PE	PP, PA	
All other misc. gears	1	0	-	-	-
Fish aggregating devices (FADs)					
Anchored FADs	-	3	PE, PA	PP	PVC, PUR
Drift FADs	-	4	PE, PA	PP	PVC, PUR

* 0 (no plastic material is usually used), 1 (0.1 to 10 kg), 2 (10.1 -100 kg), 3 (100.1 – 1000 kg), 4 (1,000.1 – 10,000 kg), 5 (>10,000 kg).

3. Gear Marking Technologies and Practices

There are varieties of fishing gear marking technologies and practices, from the earliest caving and paining on buoys to mark ownership, to flags for easy location, to modern electronic devices for real-time tracking. The VGMFG defined "mark" as:

i) an identifier, that allows the relevant authority to discern the person or entity ultimately responsible for the use of the fishing gear; and/or

ii) a means of providing an understanding of the presence, scale and nature of fishing gear in the water.

The types of fishing gear marking may include physical, chemical, electronic and virtual. The purposes of fishing gear marking may include ownership and legality, capacity control, position to aid navigation, identification of the origin of ALDFG, to track and locate the gear for easy recovery and prevention of loss. New technologies for subsea electronic and/or virtual gear will also be examined. Some of information described below are drawn from He and Suuronnen (2018) paper "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".

3.1 Types of Fishing Gear Marking

3.1.1 Physical marking

Traditionally physical marking, inscription, writing, color, shape, and tags have been used for ownership, legality and capacity control purposes, and buoys, lights, flags, and radar reflectors are used for marking of position and as an aid to navigation. Physical marking is still the primary fishing gear marking means today.

3.1.2 Chemical marking

Chemical elements that are embedded during the process of fishing gear material manufacturing may be used to identify the owner of the gear if loss and subsequently recovered, providing that a good book-keeping of sale and resale of the materials and gears are practiced. Chemical markings cannot be easily removed and provide a permanent "signature" of the material or the gear. The entire gear or some specific components of the gear may be identifiable through the analysis of chemical contents, which allow for retracing of the owner and the manufacturer of the material with good bookkeeping. Chemical content of material cannot be easily identified on site and need laboratory analysis to obtain information.

3.1.3 Electronic tags, marks and transmitters

Electronic tags may contain more information about the gear and its owner, and can be read by special devices, for example, through near-field communication (NFC) protocol. Electronic devices including radio and satellite transmitters have been uses in some fisheries, especially large industrial operations in open seas, for easier location from a distance or for real time tracking from the vessel and from the land. These electronic devices provide much more

temporal and spatial information of the gear, as well as biological and environmental information of the sea if additional sensors such as temperature, depth or other sensors are attached to the same buoy. Modern satellite buoys associated with dFADs are also equipped with echo sounders which provide information on the amount of fish density near a dFAD.

3.2 Gear Marking for Different Purposes

3.2.1 Gear marking to indicate position and for location tracking and surveillance

Gear marking for position aids in the quicker positioning of the gear by its owner, and also aids to navigation for other ocean users. Proper gear marking can reduce gear conflicts between fishers and between gear sectors (e.g., fixed and mobile gear sectors), thereby reducing the probability of gear loss. Gear marking for position also aids to navigation for other ocean users, thereby reducing gear damage and improving navigation safety.

3.2.1.1 Flags, lights, and radar reflectors

Flags, lights, and radar reflectors are the main position markers for coastal fisheries. Gear marking for location provides quicker retrieval of the gear, thereby reduces gear loss and gear conflicts, and improves safety at sea. Modern electronic devices allow accurate marking of set position of stationary gears on an electronic chart, allowing for quick and efficiency recovery of the gear. Specific requirements for surface marking of fixed gears are stipulated in IMO COLREG, which was further developed by FAO in 1996 (Appendix 2). FAO is currently developing a more comprehensive gear marking manual as required in the VGMFG.

3.2.1.2 Active RFID tags

Active radio frequency identification (RFID) tags are battery-powered radio transmitters. If they are attached to fishing gears such as buoys or hyflyers, they can be detected by the owner vessel from a distance even in poor weather and sea conditions. This device can also be detected by a low-flying airplane or a drone, greatly increase the area of monitoring and surveillance; providing enhanced means for enforcement and combating IUU fishing.

3.2.1.3 The Automatic Identification System

The Automatic Identification System (AIS) is primarily used by ocean-going shipping vessels, and increasingly used by fishing vessels. While AIS is primarily for safety at sea and for port security, there is a potential for use AIS as fisheries monitoring system for combating IUU fishing (Robards et al., 2016). Currently there is no known implementation or formal discussion of using AIS systems for the marking of fishing gear. However, there are advantages of using AIS-based transponders as fishing gear markers as many vessels already have AIS receivers, therefore, no additional onboard equipment is necessary. There are several versions of AIS buoys that are marketed as “fishing net tracking buoys” or other similar names. The potential use of AIS devices as fishing gear markers needs substantial domestic and regional elaborations and international agreements.

3.2.1.4 Radio and satellite buoys

Radio and satellite buoys are used by drift gillnetters, pelagic longliners and purse seiners (marking dFADs). As drift gillnets and pelagic longlines are not attached to the bottom, surface buoys and markers are thus very important for locating the “drifting” gear. Purse seiner fishing in offshore use FADs to congregate fish for subsequent capture. Anchored FADs are marked for ownership and position, while dFADs are marked for real-time tracking of position. The use of sophisticated marking systems significantly increases the number of dFADs a vessel can handle, and speed of detection.

3.2.1.5 Virtual marking

Due to increasing challenges of entanglement of megafauna species in vertical buoy lines of pots and other unattended gears, pot fishing without buoy ropes and surface marks are being developed and tested in several fisheries. “Ropeless” fishing intends to eliminate buoy ropes and surface markers when the gear is fishing. Virtual marking technology is being discussed and tested to reduce gear conflict and to facilitate enforcement. The technology requires virtual marking that can be “seen” by different levels of stakeholders, e.g., the gear owner, fishers in the same fishery, fishers and mariners passing by, and authorities including fishery managers and MCS entities). Virtual marks may be incorporated into electronic navigation charts. The technology is still under development and will require major technological advancement and legal and institutional approval (Baumgartner et al., 2018).

3.2.2 Gear marking for the identification of origin

There is a need to identify the origin of fishing gear or its components when they become lost and/or entangled with marine animals. Knowing the area, fishery and gear type that the gear was originally used provides valuable information for fishing gear modifications to reduce loss and entanglement, for area/season closure, and other management measures to reduce entanglement and potential mortality of vulnerable animals (Wilcox et al., 2015).

3.2.2.1 Colors and tracers

Colored ropes or tracers are being implemented in the north-eastern water of the United States (NOAA, 2015) and Eastern Canada (DFO, 2020) to aid tracing ropes that are entangled in endangered North Atlantic right whales. There are limited color shades that can easily be distinguished after rugged use in the sea. colors may fade under extended exposure under sun. Tracer yarns or strips may be woven into ropes or twines which would preserve the color for a long period. The tracer may have different colors, and information such as manufacturer, batch number, and/or material specification that can be printed on to the tracer before it is woven into the rope or twine. Fisheries and regions may require specific information to be printed and ordered specially.

3.2.2.2 Coded wire tags

Coded wire tags (CWT) have been tested for possible inclusion in fishing ropes to provide additional information. 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).

3.2.2.3 Radio frequency identification tags

Radio frequency identification tags (RFID) have been tested for possible inclusion in the components of fishing gear. One problem of using RFID tags is the readability, and ease of reading when ALDFG is recovered. RFID tags can potentially provide a large amount of information about the gear and the fishery that was used, and potentially the time of last deployment and environmental conditions. Applying RFID tags to some gear is less challenging than others. For example, incorporating RFID tags in fishing ropes still face great challenges in terms of durability of the tags and the ropes they imbedded, but attaching an RFID tag to a pot pose no technical issues.

3.2.3 Gear marking for ownership, capacity management and monitoring.

Gear marking for ownership, legality, and capacity management is especially important in capacity-controlled fisheries such pots, gillnet and longline fisheries. 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), or both. 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, etc.) as well as dynamic information (such as time in water, location deployed, etc.) 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.

3.2.3.1 Physical tags

Physical tags have traditionally been used, usually inscribed with the permit number or name of its owner. In some fisheries, the tags are fixed to the gear itself, while in others, the tags are attached to the surface buoys, and while still others, both underwater and surface components of the gear are tagged or marked. Printed tags with bar code or QR code can contain more information about the gear and other information.

RFID tags are being tested and used for ownership and capacity control. These systems not only serve as permit tags, but they are also designed to reduce the theft of gear and catch (NWIFC, 2015).

3.2.4 Gear marking to aid recovery of lost gear

Technologies that allow for relocating lost fishing gear will aid speedy recovery of lost gear and reduce ALDFG. Gear relocation devices typically use acoustic technology, taking advantage of superior sound transmission property in the sea water. There are two types of technologies: active pingers and transponders, and passive sonar reflectors. The first method is based on detecting specific frequencies of sound from the locator tag using a receiver hydrophone, and the second is based on enhanced target strength of the locator using an echo sounder or a sonar.

3.2.4.1 Pingers

Pingers (also called beacons) continuously emit acoustic signals at certain frequencies once in the water. A hydrophone is used to listen to the acoustic signals from the pinger to home in its position.

3.2.4.2 Transponders

Transponders listen to the acoustic signal from a commend unit via a hydrophone. Once it has detected a certain signal, the transponder sends an acoustic signal back to the hydrophone, so that the location of the transponder can be determined.

3.2.4.3 Passive sonar reflectors

Passive sonar reflectors enhance acoustic reflectivity of objects underwater so that they can be easily detected by echo sounders or other acoustic equipment. Measures to enhance reflectivity of objects include the size, shape, material, and other features (Islas-Cital et al., 2013).

A summary of different fishing gear marks and their application is provided in Table 3.

Table 3. Comparison of different marking technologies and their applications

Mark type	Detection distance	Usage and comments
Surface marking		Ownership, legality, positioning, navigation
Flags/floats/ reflective strips	Visual range	generally available; recognizable from distance; cheap; generally accepted; positioning; navigation
Lights	Visible range	Generally available; need battery; recognizable from distance at night; LED light long lasting; navigation
Radar reflector	Radar range	Need radar, generally accepted, positioning, navigation
RFID - active	100 m or more	More expensive; need battery; longer detection range, positioning; not yet being used
AIS transponder	Up to 25 NM	For satellite linked AIS, unlimited range; available existing infrastructure; navigation; not legally approved in many economies
Radio beacon	100-1000 NM	Large size, suitable for large buoys, e.g., pelagic longlines and FADs, positioning
Satellite buoy	unlimited	Unlimited distance, even from land; relatively expensive; high service/use costs (data subscription fee); dFADs in high seas; positioning
Underwater marking		Capacity control, component tracing, recovery of lost gear
Printable tracer	Visual range	Can be woven into ropes; cheap; tracing of origin if lost

Color marking	Visual range	Not unique but fishery-based identification; availability of colors limited; tracing of origin if lost
Physical tags	Visual range	Cheap; limited information on tags; good for individual gears; capacity control, tracing of origin if lost; bearing more information if using bar or QR coding
Chemical marking	Not visible	Cannot be removed; whole net is identifiable at manufacturer level; tracing of original owner
Coded wire tag	Under microscope	Small; need other marking to indicate the existence; tracing of origin of lost gear/component
RFID - passive	Within 3 m	Relatively cheap; can store extensive information; flexible use; suitable for pot fisheries; capacity control; ownership; tracing of origin if lost
Acoustic transponder	< 2 NM	Expensive; aid to recovery if lost
Passive acoustic reflector	Receiver dependent	Similar to the size of fishing floats; no need for battery; yet to demonstrate for fisheries use; aid to recovery if lost
Virtual marking		"Ropeless" fishing", "permanent" fishing gear
Virtual marking	unlimited	"Ropeless" fishing, need GPS coverage, electronic chart or App, shore-side database infrastructure. Can be used for "permanent" fishing gears, such as pound net, set net, traps, weirs, and barriers; electronic chart; navigation

Source: Modified from He and Suuronen (2018). NM – nautical miles

4. Gear Marking Requirements in Selected Jurisdictions

It has long been recognized that passive (unattended) fishing gears, such as set gillnets, drift gillnets, and longlines and pots, should be marked to facilitate retrieval, establish ownership and to reduce interactions with other vessels for safe navigation or avoiding gear conflicts. The need for a uniform marking scheme across management boundaries and in high seas resulted in the 1967 Convention on the Conduct of Fishing Operations in the North Atlantic. This Convention (Article 5) and its Annexes (Annex II and IV) have become the basis for many fishing gear marking legislations and recommendations for many economies and regions, including Annex IV "Proposal for the Application of Standard System of Lights and Shapes for the Identification and Location of Fishing Gear" of FAO Technical Guidelines for Responsible Fisheries 1. Fishing Operations (FAO, 1996), which is attached as Appendix 2.

The 1967 Convention and selected economy-level and regional fishing gear requirements are described below. APEC economies that are not included in the following examples may also have laws and regulations regarding gear marking. Examples given for the economy or region do not imply that there are no other gear marking-related laws and/or regulations in that economy, region or APEC member.

4.1 Convention on the Conduct of Fishing Operations in the North Atlantic (1967)

(1) General requirement

In Annex II, Item 1 (4) specifies that:

Small boats and, where practicable, all fishing implements shall be marked with the letter or letters and number of the fishing vessel to which they belong. The ownership of nets or other fishing implements may be distinguished by private marks.

(2) Specific requirements for surface marking

Annex IV specifies the following:

i. The ends of nets, lines and other gear anchored in the sea shall be fitted with flag or radar reflector buoys (hyflyer) by day and light buoys by night, sufficient to indicate their position and extent. Such lights should be visible at a distance of at least 2 NM (nautical miles) in good visibility.

ii. By day the westernmost hyflyer shall be fitted with two flags, one above the other or one flag and a radar reflector, and the easternmost hyflyer shall be fitted with one flag or a radar reflector. By night the westernmost hyflyer shall he fitted with two white lights and the easternmost hyflyer with one white light. The easternmost hyflyer may be set 70-100 m from the end buoy to indicate the direction of the gear.

iii. For gears extending more than 1 NM additional buoys shall he placed at distances of not more than 1 NM so that no part of the gear extending 1 NM or more shall be left unmarked. By day every buoy shall be fitted with a flag or a radar reflector and by night

as many buoys as possible with one white light. In no case shall the distance between two lights on the same gear exceed 2 NM.

iv. The flagpole of the hyflyer shall have a height of at least 2 m above the buoy.

v. Nets or lines which drift in the sea with no vessels attached shall be marked at each end and at distances of not more than 2 NM by a hyflyer. The hyflyer shall carry a flag or a radar reflector by day and a white light by night visible at a distance of at least 2 NM in good visibility.

vi. For driftnets where the gear is attached to a fishing vessel a buoy or hyflyer shall not be required at the end attached to the fishing vessel.

Many jurisdictions and Regional Fisheries Management Organization's/Arrangements (RFMO/As) have specific, and some are elaborative, requirements for gear marking.

4.2 Norway

There is a general requirement that fishing gear shall be marked in its fisheries law (FOR-2015-02-23-152. Chapter XVI. Marking of fishing gears). The requirements generally reflect those in the 1967 Convention with some additional requirements. Specific requirements are as follows.

(1) Marking requirements

i. All stationary or drifting fishing gear in use in the Norwegian EEZ must be clearly marked with vessel's district registration number. If vessel is not registered, then with the owner's name and address. At least one of the buoys attached to the gear must be marked.

ii. All aquaculture cages must be marked as in i, but at least two buoys must be correctly marked.

iii. Anchors and mooring ropes must be marked as described in i.

iv. Marking must be on the fishing gear if no buoys are used.

v. Pots used for snow crab fishery must be marked even used outside of the region mention in i. Pots fished in a fleet of more than one pots must be marked with vessel registration number, and on the float attached to the pot.

(2) Special marking rules outside 4 NM

Gillnets and longlines used in the Norwegian EEZ outside of 4 NM from shore baseline must be marked as follows:

i. At daytime the fishing gear must have both ends a hyflyer with a radar reflector or a flag. After sunset both ends must have a buoy with reflector (see section f) and with light (see section g) so that both end buoys show the location of the fishing gear and its extent.

ii. At daytime, the west end (accord to compass south through vest into and with north) buoy must have two flags, one over the other. Distance between those two flags must be at least 25 cm. Radar reflector can be replaced by the upper flag. After sunset the buoy must have two lights. Distance between the lights must be at least 50 cm.

iii. At daytime the east end (accord to compass north through east to and with south) buoy must have one flag. Radar reflector can be used instead of the flag. After sunset the buoy must have one light.

iv. Distance between buoy on anchored fishing gear may not be more than 1 nm. If fishing gear is longer than 1 nm, it must have one or more intermediate buoys between the end buoys. Intermediate buoys shall be marked as descripted in iii. After sunset those middle buoys can be without lights, but only if distance between light on the fishing gear is not more than 2 NM.

v. Distance between marking buoys on drifting fishing gear may not be more than 2 nm. Fishing gear with length over 2 nm, must have one or more intermediate buoys between the end buoys. The intermediate buoys must be marked as explained in iii.

vi. Driftnets in fleet of many connected nets with total length over 1 NM must have one or more buoys with light reflectors to assist in visual relocation.

vii. If the topography of the bottom and/or the current strength make it impossible to have buoy on both ends, the length of the fishing gear may not be longer than 1 NM.

viii. When one end of the drifting fishing gear is attached to the vessel, the marking is not needed at that end.

ix. The poles on hyflyer must be at least 2 m high above the surface. Marker, poles or the top marker must have a light reflector, capable to reflect light from all directions.

x. The light on the hyflyer must be yellow and visible from a distance of at least 2 NM in clear visibility in darkness. Constant lights which are on all the time or flashing lights may be used. However, it is not allowed to have both constant and flashing light on the same marker. Flashing lights must flash at a rate of 20 to 25 flash per minute. If two flashing lights are used on the same pole or marker, they must be synchronized, so that they blink in rhythm.

4.3 European Union and the United Kingdom

The European Union laid out detailed rules for the implementation of the Common Fisheries Policy (EC No. 1224/2009) with specific details on the marking of fishing gear and related reporting requirements that took effort in 2011. The United Kingdom has kept most of marking requirements after exiting the EU in early 2020. Below are some excerptions from EC No. 1224/2009:

(1) General rules for passive gear and beam trawls

i. The provisions contained in Articles 9 to 12 of this Regulation shall apply to EU fishing vessels fishing in all EU waters and the provisions contained in Articles 13 to

17 of this Regulation to EU waters outside 12 NM measured from the baselines of the coastal Member States.

ii. It shall be prohibited in EU waters as set down in paragraph 1 to carry out fishing activities with passive gear, buoys, and beam trawls, which are not marked and identifiable in accordance with the provisions of Articles 10 to 17 of this Regulation.

iii. It shall be prohibited in EU waters as set down in paragraph 1 to carry on board:

(a) beams of a beam trawl which do not display the external registration letters and numbers in accordance with Article 10 of this Regulation;

(b) passive gear which is not labelled in accordance with Article 11(2) of this Regulation;

(c) buoys which are not marked in accordance with Article 13(2) of this Regulation.

(2) Rules for beam trawls

The master of an EU fishing vessel or his representative shall ensure that each assembled beam trawl carried on board or used for fishing clearly displays the external registration letters and numbers of that fishing vessel on the beam of each beam trawl assembly.

(3) Rules for passive gear

i. The master of an EU fishing vessel or his representative shall ensure that each passive gear carried on board or used for fishing is clearly marked and identifiable in accordance with the provisions of this Article.

ii. Each passive gear used for fishing shall permanently display the external registration letters and numbers displayed on the hull of the fishing vessel to which it belongs:

(a) for nets, on a label attached to the upper first row;

(b) for lines and long lines, on a label at the point of contact with the mooring buoy;

(c) for pots and traps, on a label attached to the ground rope;

(d) for passive gear extending more than 1 nautical mile, on labels attached in accordance with (a), (b) and (c) at regular intervals not exceeding 1 nautical mile so that no part of the passive gear extending more than 1 nautical mile shall be left unmarked.

The same EU Regulation also specified in detail the “Rules for labels”, “Rules for buoys”, rule for intermediate and end marker buoys and how they should be fixed, “Rule for cords” which refer to buoy ropes, and reporting requirements. The regulation also has detailed requirements for marking of FADs, and electronic and satellite tracking devices.

4.4 Canada

(1) General provisions

Regulations for gear marking in Canada are contained in the Fisheries Act (SOR/93-53). The main provisions are as follows:

i. No person shall set, operate or leave unattended in the water any fishing gear other than mobile gear or handlines unless the gear is marked with the vessel registration number as set out in the license authorizing the use of that gear or in any other case, the name of the person who owns the gear.

ii. The vessel registration number or name shall be painted on or otherwise securely affixed to a tag, float or buoy attached to the gear and be legible and readily visible at all times without the necessity of raising the gear from the water or, where the water is ice covered, without the necessity of removing any snow or ice.

iii. The numerals in a vessel registration number shall be solid block Arabic numerals without ornamentation; not less than 75 mm in height; and in a color that contrasts with their background. In the case of an owner's name, block capital letters in Roman characters should be used.

iv. In tidal waters where one end of the fishing gear is fastened to the shore, a buoy shall be affixed to the end of the gear farthest from the shore; and in any other cases, be affixed to each end of the gear.

v. No person shall display any number, name or validation tab on fishing gear or on a tag, float or buoy attached to fishing gear that is so similar to a number or name required as to be capable of being mistaken for any such number, name or validation tab.

(2) Specific provisions for gillnets used to target Pacific salmon and roe herring

i. For Pacific salmon gillnets, buoys shall be orange in color and at least 125 cm in circumference. The end of the gillnet not attached to the vessel shall be marked with a light that gives a steady white light during night.

ii. For the roe herring gillnet fishery, buoys shall be at least 125 cm in circumference and of the same color. The validation tab issued with the licence under which the gillnet is being used shall be attached to a buoy that is attached at one end of the gillnet.

(3) Gear marking to trace origin in Eastern Canadian fixed gear fisheries

Canadian Fisheries and Oceans implemented mandatory gear marking to all unattended fixed gear fisheries in 2020 in Eastern Canada, including the Gulf, Maritimes, Newfoundland & Labrador, and Quebec Regions (DFO, 2020). The new requirements are part of the Canada's efforts to improve tracking of gear when lost, address ghost gear and further identify management measures to reduce threats to marine mammals, in particular North Atlantic Right Whales. They are implemented to trace gear origin, specifically economy, region, target species, as well as lobster and snow crab fishing areas. The gear marking requirements consists of interlacing different strands of colored twine within an existing rope.

i. Color combination using two different strands of twine interlaced on the same segment (Figure 15):

   (a) One color to identify specific Region – to be interlaced on the same segment of rope as the second color.

(b) A second color to identify target Species – to be interlaced on the same segment of rope as the first color. Each species will be attributed the same color across all Regions in Eastern Canada (i.e., yellow for lobster).

ii. For lobster and snow crab fisheries only, a third color is used to mark different fishing areas. The third color is added to a subsequent segment of rope immediately after the segment of rope with the first two colors.

iii. Gear marking is mandatory for ropes attaching the fishing gear to the primary buoy (vertical line). It could also be included on other rope segments when applicable, at the discretion of fish harvesters, such as on the rope from the primary buoy to the secondary buoy, and on the ground lines.

iv. At a minimum, gear marking is required at the top, middle and bottom of the vertical line or every 27.4 m throughout the length of the rope.

v. Use of a “tracer” as an alternative to color coding requirements is permitted (Figure 15). The tracer, a silver transparent tape inside the full length of the rope, must have a visible inscription identifying economy, regions, species and fishing area.

Figure 15. Color combination using two different strands of twine interlaced on the same segment to indicate the fishery and region (left), and tracer with visible inscription identifying economy, region, species and fishing area (right)

Source: Canada Department of Fisheries and Oceans

4.5 Chinese Taipei

Chinese Taipei recently implemented marking for gillnets, as published in "Gillnet Net Fisheries Fishing Gear Marking Measures" which took effect in 2018 (CoA, 2018).

Before a fishery person is authorized to engage in gillnet fisheries, his fishing gear shall be marked in accordance with the following prescribed methods, contents and locations (as shown in Figure 16) and shall maintain a clear and identifiable economy at any time:

(1) The manner and content of the marking:

i. to write, paint, engraving, tie label or other manners that are not easy to remove (or peel off).

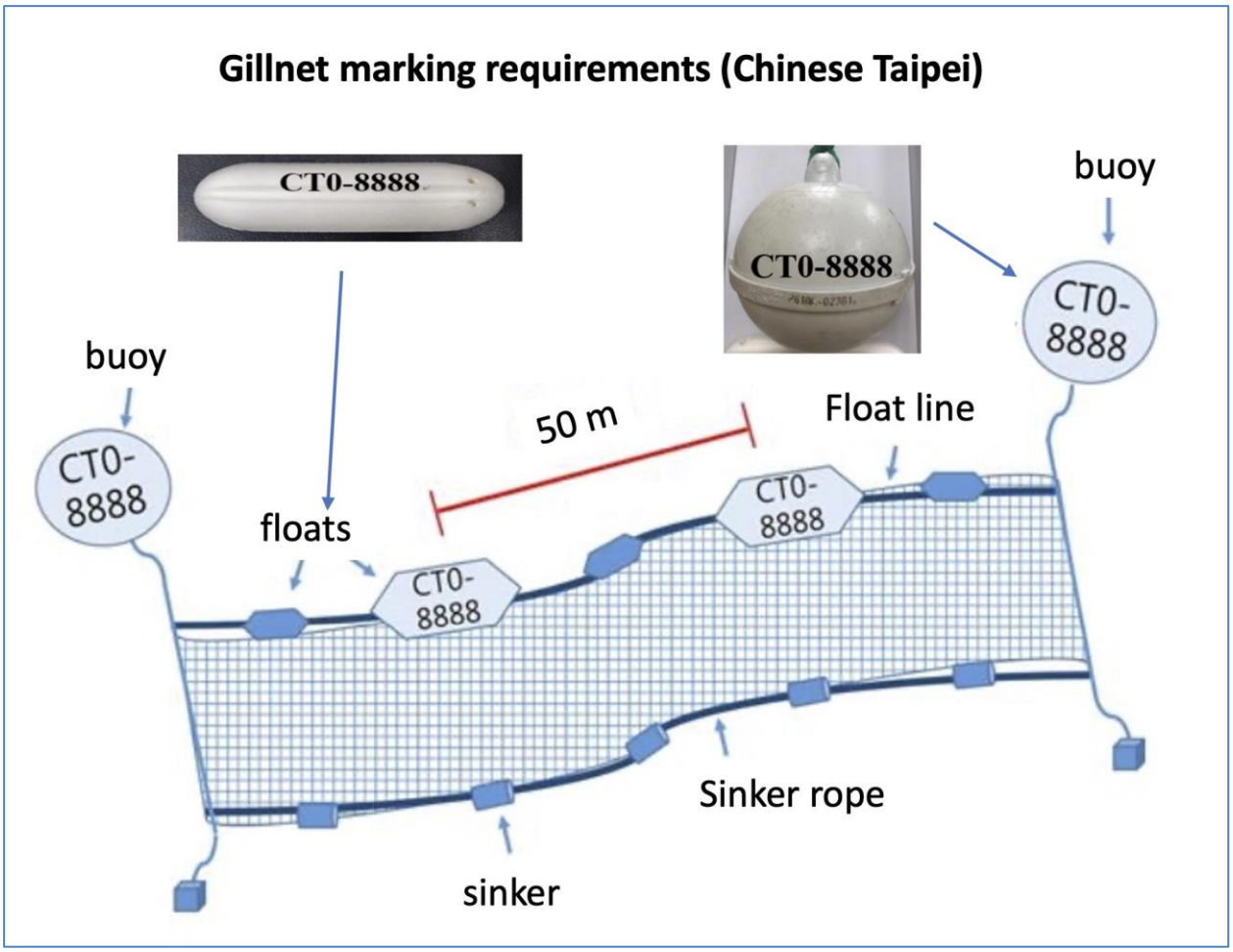
ii. should be marked with the vessel identification number, with legible font sizes.

(2) Location of marking:

i. on the buoys or flags at both ends of the float line of the gillnet.
ii. For floats longer than 8 cm, on floats at an interval of 50 m. For float shorter than 8 cm, or no floats on the float line, on the buoy at both ends of the gillnet.

When a fishing vessel is unable to bring back the gillnets due to adverse sea conditions, entanglement, navigation safety or other reasons, the fisher shall, orally or in writing, notify the Taiwan Fisheries Communication Radio, the county (city) municipalities, or local fisheries associations, who should in turn record the notification according to the format prescribed by the central government.

Figure 16. Gillnet marking requirements as stipulated by Chinese Taipei's Agriculture and Fisheries



Source: Council of Agriculture (Chinese Taipei) Executive Order 1091322238A (effective on 1 July 2018), with modifications.

4.6 Indonesia

From the questionnaires received, the Ministry of Marine Affairs and Fisheries regulation No. 71 (2016, as amended in 2021), there are some requirements for gear marking:

i. Use of radio buoy in every 2,500 meters of drifting gillnets for the fishing vessels that greater than 30 GT.
ii. Use of radio buoy also applied to the tuna longlines.

MMAF also in the process of drafting a new regulation about marine pollution which will contain few measures about gear marking.

4.7 The United States of America

Under the Magnusson-Stevens Fisheries Management and Conservation Act of 196, and subsequent renewals, the US marine fisheries are managed by NOAA Fisheries in cooperation with eight regional fishery management councils. Many specific management requirements, including fishing gear marking requirements, are region-specific. Some examples are given below.

(1) Surface marking requirements for Northeast multispecies and monkfish fisheries.

i. Bottom-tending fixed gear, including, but not limited to, gillnets and longlines designed for, capable of, or fishing for NE multispecies or monkfish, must have the name of the owner or vessel or the official number of that vessel permanently affixed to any buoys, gillnets, longlines, or other appropriate gear so that the name of the owner or vessel or the official number of the vessel is visible on the surface of the water.
ii. Bottom-tending fixed gear, including, but not limited to gillnets or longline gear, must be marked so that the westernmost end of the gear displays a standard 12-inch (30.5-cm) tetrahedral corner radar reflector and a pennant positioned on a staff at least 6 ft (1.8 m) above the buoy. The easternmost end of the gear need display only the standard 12-inch (30.5-cm) tetrahedral radar reflector positioned in the same way.
iii. In the Gulf of Maine and Georges Bank regulated mesh area specified, gillnet gear set in an irregular pattern or in any way that deviates more than 30° from the original course of the set must be marked at the extremity of the deviation with an additional marker, which must display two or more visible streamers and may either be attached to or independent of the gear.

(2) Tagging requirements

i. Roundfish gillnet. Roundfish nets must be tagged with two tags per net, with one tag secured to each bridle of every net, within a string of nets
ii. Flatfish gillnet. Flatfish nets must have one tag per net, with one tag secured to every other bridle of every net within a string of nets. Gillnet vessels must also abide by the tagging requirements in paragraph (a)(3)(iv)(C) of this section.
iii. Tags. Tags must be obtained as described in § 648.4(c)(2)(iii), and vessels must have on board written confirmation issued by the Regional Administrator, indicating that the vessel is a Day gillnet vessel or a Trip gillnet vessel. The vessel operator must produce all net tags upon request by an authorized officer. A vessel may have tags on board in excess of the number of tags corresponding to the allowable number of nets, provided such tags are onboard the vessel and can be made available for inspection.

iv. Lost tags. Vessel owners or operators are required to report lost, destroyed, and missing tag numbers as soon as feasible after tags have been discovered lost, destroyed or missing, by letter or fax to the Regional Administrator.

v. Replacement tags. Vessel owners or operators seeking replacement of lost, destroyed, or missing tags must request replacement of tags by letter or fax to the Regional Administrator. A check for the cost of the replacement tags must be received by the Regional Administrator before tags will be re- issued.

4.8 The South Indian Ocean Fisheries Agreement

The South Indian Ocean Fisheries Agreement's (SIOFA) Conservation and Management Measure for Control of Fishing Activities in the Agreement Area (CMM 2018/09) has gear marking, reporting and retrieval provisions. Below are some excerptions from CMM 2018/09:

(1) Marking of fixed gear

i. Fixed gear used by vessels flying its flag is marked as follows:

(a) the ends of nets, lines and gear anchored to the seabed shall be fitted with flag or radar reflector buoys by day, and light buoys by night, sufficient to indicate their position and extent. Such lights should be visible at a distance of at least 2 NM in good visibility.

(b) Marker buoys and similar objects floating on the surface and intended to indicate the location and/or origin of fixed fishing gear, and where possible, the gear itself shall be clearly marked with the vessel's name and International Radio Call Sign.

ii. notify without delay the Secretariat of the information regarding the marking of fixed gear used by vessels flying its flag. This notification does not need to be repeated unless there are changes to be reported.

5. Risk Assessment

The FAO Voluntary Guidelines on the Marking of Fishing Gear stipulates that implementation of fishing gear marking should be based on a risk assessment, which can also facilitate prioritization of actions regarding gear marking and other mitigation approaches based on the level of severity and likelihood of potential impacts on different fisheries. The VGMFG provided general guidelines for risk assessment in its annex (FAO, 2019) which is attached as Appendix 3.

5.1 Principles of risk assessment for gear marking

A risk assessment should be carried out to evaluate available data and information on both the fishing activity utilizing the gear type in question and the ecological and economic characteristics in which the fishery is prosecuted. Based on this information, an assessment is conducted to determine the risk of serious, unavoidable or irreversible ecological harm resulting from the current level of gear marking, or no marking in the fishery in question.

5.1.1 General consideration

The determination of risk levels involves four primary steps:

- Estimation of the consequence (impact) of the lack of a gear marking system (on an inadequate marking system) in the fishery under consideration
- Estimation of the likelihood of occurrence (probability) of the identified impacts, occurring as a result of the lack of a gear marking system (on an inadequate marking system) in the fishery under consideration
- Scoring of the risk
- Categorization of the risk

Consideration of risk assessment should be given to both actively fished gear as well as lost, abandoned or otherwise discarded fishing gear. The parameters that need to be considered for consequences and impacts should include, but not limit to:

- Ecological risks (plastic pollution; status of species impacted, e.g., ghosting fishing; impact on ETP species; habitats vulnerability and fragility)
- Economic risks (level of fishing effort; value of the fishery; economic nature of the fishery, e.g., subsistence, artisanal, small-scale, industrial; IUU fishing; and cost of implementation)
- Technological risks (Gear types; numbers of gear units; numbers of vessels; method of operation)
- Safety and navigational risks (risks to the vessel operating the gear, other fishing vessels, and non-fishing vessels)
- Implementation risks (different users, language, level of organization, availability of information and the quality of information, international, regional and local expert support).

Determining a risk level requires estimates of the consequences and likelihood based on best available science and local ecological knowledge and stakeholder input. To be able to defend estimates, a clear rationale should be provided on how estimated levels were chosen, so that the determination can be traced and verified. Regional standardization is desirable, but fishery- or location-specific criteria are possible if justifiable. Clear rationale also provides a basis from which future assessments can be made. The information, data and expert and fishers' opinion collected and consolidated through the initial scoping exercise form the basis for that rationale, with additional information being provided where appropriate and necessary.

5.1.2 Technology readiness

A risk assessment should include an assessment of the feasibility of implementing a system for the marking of gear. Accordingly, the risk assessment should address the following basic questions:

- Is the technology associated with the system feasible?
- Will the technology mature over time?
- Are there any technical barriers to integrating the capability within the system?

5.1.3 Economic consideration

For the economic consideration, the following questions may be asked:

- Is the technology fit for the required purpose?
- Do regions or economies in question have the administrative capacity to implement and monitor the system?
- What capacity building needs should be considered (both in terms of administrations and fishery operators)?

5.1.4 Transparency

Risk assessments and associated decision-making should be carried out in a transparent fashion and following written rules of procedure. Arrangements for conducting risk assessments and associated decisions should be carried out with balanced participation by independent technical experts and representatives of interested parties in system development, revision and approval processes. Development of gear marking systems should, wherever possible, include representatives of fisheries management authorities, the fishing industry, fisher organizations, scientific community, nongovernmental organizations, fish processors, traders and retailers as well as consumer associations. Once a risk assessment has been completed, it should be promptly published and accessible to a wide audience.

5.2 Categorization and scores of risks

Fishing gears and risks associated with not marking or not properly marking depending on types of gear, fisheries, fishery management regimes, and conditions and other usage of the sea. Scoring of risks for different gear types should be done with specific fishery and area in mind and involve stakeholders in question. The following are examples that only consider risks

from the intricate characteristics of gear design and their operation and should be varied for specific regions and fisheries. Both fishing gears in normal fishing conditions and those which have become ALDFG have risks as a result of not marking or improper marking.

5.2.1 Fishing gears in normal fishing conditions

One of the primary purposes of gear marking at surface is for positioning of the gear for subsequent retrieval by its owner and for guiding other fishers not to set or to tow their gears at the same location. Proper gear marking reduces gear loss due to the inability to find their gear and damage and entanglement caused by gear conflicts. Good gear marking also aid other marines to stay away from the gear for safe navigation, especially in areas with heavy vessel traffic.

5.2.1.1 Fishing gear loss and abandonment

Proper gear marking aids for easy location of previously deployed unattended fishing gear, thereby reducing probability of gear loss. Gear marking for capacity control also limit excessive amount of gear that leads to abandonment in incremental weather and sea conditions. Good gear marking also reduces gear conflicts between stationary and mobile fishing gears, and between stationary gears setting on top of each other, causing gear loss.

Generally speaking, unattended gears as described in Section 2.2 have higher risk of loss if not marked or not properly marked. This includes inability of the fisher to find the gear previously deployed, or due to gear conflicts and inability to avoid unmarked or improperly marked gear.

While gear marking may not directly affect abandonment of gear due to force majeure or other unforeseen reasons, marked gears may less likely be abandoned as the loss of marks, which, depending on management regime regarding replenishment of marks, may affect their subsequent ability to operate sufficient number of gears. Abandonment of gear with marks may also be perceived negatively on the fisher if the gear is subsequently recovered by others.

5.2.1.2 Ownership dispute and owner responsibility

Many unattended gears are marked on the surface and sometime also on the gear from the earliest times to ascertain ownership to deter theft and to avoid accidentally retrieving the gear not belonging to them. Surface buoys of pots, gillnets and longlines are often inscribed with names and/or unique numbers.

5.2.1.3 Overcapacity and effort control

One of the measures to control fishing effort, e.g., number of nets or pots that can be possessed or used by a fisher, is through the issuance and apply of marks or tags to the gear.

Many management regimes have limits on the number of gear units that can be used by fishers/vessels to limit fishing capacity and to avoid overcapacity to protect resources. A corresponding number of marks/tags, often issued by legal authority, are assigned to a fishing unit or a corporation, and are attached to each unit of gear.

5.2.1.4 Illegal fishing

While fishing gear marking cannot stop illegal fishing, a system of gear marking facilitates monitoring, control and surveillance (MCS) personnel for ascertaining legality of fishing operation and compliance of the fishing gear. For example, if a part of gear has specific requirements, e.g., the codend mesh size, or a turtle exclude device (TED), a government issued tag attached to the component or device may provide evidence of legality.

Unmarked or insufficiently marked fishing gear that cannot be linked to its ownership or permission to fish in a specific area may indicate IUU fishing operations (FAO, 2019). Gear marking should therefore be considered as an important mechanism for assisting in the prevention and deterring of IUU fishing.

5.2.1.5 Gear conflicts

Gear marking plays an essential role in reducing and preventing gear conflicts between stationary gears and between stationary and mobile gears. Properly marked gear indicates position, direction and extent of the gear.

5.2.1.6 Navigation hazards

One of the primary purposes of gear marking at surface is for positioning of the gear. Good gear marking also aid other marines to stay away from the gear for safe navigation, especially in areas with heavy vessel traffic. The hazards of not properly marking on the surface are therefore dependent on location, and sometimes, season.

Table 4. Score of risks (1 – lowest, 5 – highest) of fishing gears in normal fishing conditions if they are not marked or not adequately marked based on their characteristics of design, fishing mechanism, and operation

	Likelihood of loss	Ownership dispute	Over capacity	Illegal fishing	Gear conflict	Navigation[5]
Attended gear	LL	OW	OC	IF	GC	NV1
Purse seines	1	1	1	3	1	1
Boat seines	1	1	1	3	1	1
Beam trawl	1	1	1	3	1	1
Bottom trawls	1	1	1	3	1	1
Midwater trawl	1	1	1	3	1	1
Dredges	1	1	1	3	1	1
Lift nets	1	1	1	2	1	1
Falling nets	1	1	1	2	1	1
Handlines [1]	1	1	3	3	1	1
Unattended gear						
Gillnets (bottom) [2]	4	5	5	5	5	1
Gillnets (surface) [3]	4	5	5	5	5	5
Drift gillnets	5	5	5	5	5	5
Longlines (bottom)	4	5	5	5	5	1
Longlines (surface) [4]	4	5	5	5	5	5

Drift longlines	5	5	5	5	5	5
Vertical lines	5	5	5	5	5	1
Pots	4	5	5	5	5	4
Pound nets, barriers, fences and weirs	1	2	3	1	1	5
Stow nets	2	3	5	5	2	5
Fyke nets	3	3	5	5	2	5
FADS						
aFAD	1	3	5	3	1	5
dFAD	5	5	5	3	1	5

Note: 1. Include hand-operated and mechanized lines and pole-and-lines. 2. Include set gillnet, trammel net, and combination gillnets set on or near bottom. 3. Include set gillnet, trammel net, and combination gillnets set on or near surface. 4. Include set longlines on or near surface. 5. Navigation includes location of the gear by its owner, and other fishing vessel, and aid to navigation by other mariners.

5.2.2 Abandoned, lost or otherwise discarded gear

5.2.2.1 Marine plastic pollution

One of the most damaging outcome of gear loss, abandonment and discarding is marine plastic pollution. While there is no recent update on the relative contribution of ALDFG on marine plastics, or annual addition of marine plastic from fishing operations, an estimate of 10% or 640,000 tons has been reported and widely quoted (Macfadyen *et al.,* 2009). Due to a lack of reliable and more recent data that can be used for estimation of the amount of ALDFG, GESAMP urged “a more current and accurate estimate on the portion of marine litter that is ALDFG” (Gilardi et al., 2021).

While gear marking does not reduce marine pollution after the gears have become ALDFG, marking do provide information about the fishery and region that ALDFG had come from, helping prioritizing areas and gears that need to implement measures to reduce gear loss and abandonment, and prohibition of discarding.

The score for plastic pollution for each gear type is related to the amount of plastic materials in the gear that is operated by a fishing unit at any one time.

5.2.2.2 Ghost fishing

Another negative outcome of ALDFG is ghostfishing – the ability of fishing gear to continue fishing after all control of that gear is lost by the fisherman (Smolowitz, 1978). Some gears are more likely and last longer to ghostfish after becoming ALDFG, but most gears, especially netting gears, can ghostfish, damaging fishery resource and dependent species. Gillnets and entangling nets, and pots are of particular concern due to their gear composition and design.

Both actively fished gear and ALDFG can impact endangered, threatened and protected (ETP) species, but their degree of impact may be species and gear specific. The major differences between actively fished and ALDFG is that the former can be managed to reduce their impact through spatial and temporal closure, effort control, and gear modification, while the later cannot be controlled once they become ALDFG, unless some design features can be incorporated before they become ALDFG (de-hosting technology). A global review on ghost

gear interactions with wildlife revealed that more than 5,400 individuals representing 40 species were either entangled in or associated with ghost nets, compromising 3,834 marine mammals, 1,487 reptiles and 119 elasmobranchs (Stelfox et al., 2016), many of them are classified as ETP species.

5.2.2.3 Tracing of lost or entangled gear

Proper and effective marking of fishing gear is essential for tracing the region and fishery of the origin of the gear before they became ALDFG. This is especially important on gear that are entangled on large megafauna species, as identification of its origin can shed lights on measures to reduce entanglement and mortality of the animals. The score of traceability is related to mobility of ALDFG of specific gear types.

5.2.2.4 Navigation hazard

Navigational hazards of ALDFG largely dependent on the material of the gear. Floating gear materials such as PP and PE netting and ropes float on the surface when they become ALDFG. Netting and ropes with functional floats and buoys also pose greater hazards to navigation, thus have higher risk scores. Navigation risk scores are also related to their area of operation; higher risks when they are operated in coastal heavy vessel traffic areas and lower risk in the high seas.

Table 5. Score of risks (1 – lowest, 5 – highest) of ALDFG if they are not previously marked or not adequately marked based on their characteristics of gear design and amount of plastic material

	Plastic pollution	Ghostfishing	Gear origin	Navigation
Attended gear	PL	GF	OR	NV2
Purse seines	5	3	4	1
Boat seines	4	3	5	3
Beam trawl	3	3	1	3
Bottom trawls	4	3	5	3
Midwater trawl	4	3	5	3
Dredges	1	1	1	1
Lift nets	2	3	2	2
Falling nets	2	3	2	2
Handlines [1]	1	1	1	1
Unattended gear				
Gillnets (bottom) [2]	5	5	5	2
Gillnets (surface) [3]	5	5	5	5
Drift gillnets	5	5	5	4
Longlines (bottom)	3	1	5	2
Longlines (surface) [4]	3	1	5	5
Drift longlines	3	1	5	4
Vertical lines	2	1	5	2

Pots	3	5	5	3
Pound nets, barriers, fences and weirs	4	3	3	4
Stow nets	4	3	3	4
Fyke nets	3	4	4	4
FADS				
aFAD	2	2	4	5
dFAD	2	2	5	4

Note: 1. Include hand-operated and mechanized lines and pole-and-lines. 2. Include set gillnet, trammel net, and combination gillnets set on or near bottom. 3. Include set gillnet, trammel net, and combination gillnets set on or near surface. 4. Include set longlines on or near surface.

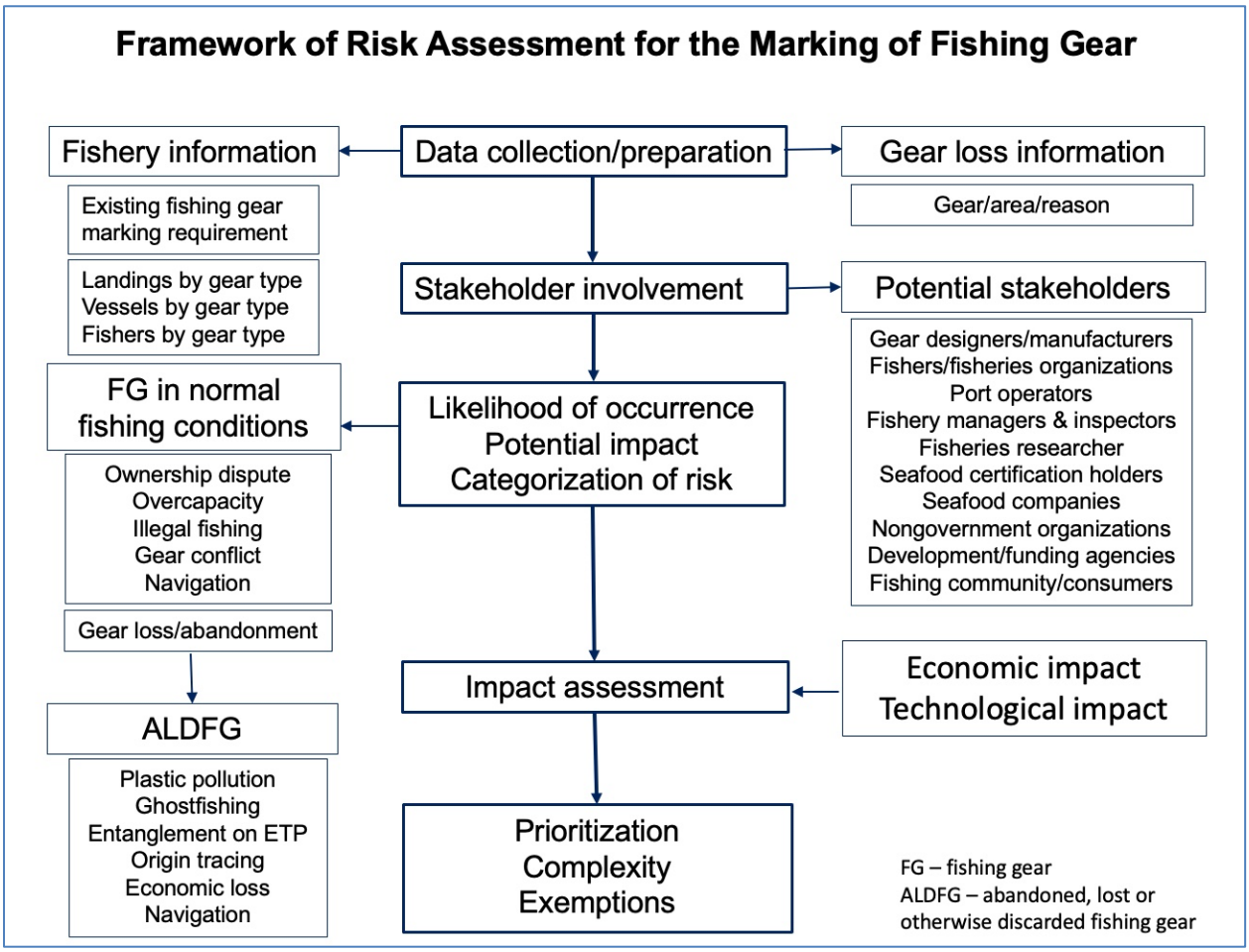
5.3 Value or importance of reducing or eliminating risks

Risks associated with not marking or not properly marking of fishing gear vary with fisheries, gears, regions, seasons, and other factors. The importance or the value of eliminating or reducing each of identified risks are varies among stakeholder groups and regions. For example, some stakeholders may be more concerned with loss of gear due to inadequate marking, while others may be more concerned with overcapacity. For gear loss, some may be more concerned with economic loss, others may be more concerned with marine plastic pollution. The relative value for each category of risks should be assigned through consensus and wide stakeholder input in a transparent manner.

5.4 Process for conducting a risk assessment

The process for conducting risk assessment for the marking of fishing gear should start with the Identification of scope, including area, fishery, and gear to be assessed. This should be followed by collection of gear and fishery data (importance of the gear, usage, number, landing by gear etc.), and, if available, gear loss data and where and when loss had often occurred (hot spot identification). As discussed above, the process should involve diverse stakeholders as identified in the previous section. Often through a workshop of other similar mechanism, stakeholders identify, using scientific, technical and fishers' knowledge, and through consensus to categorize risks and to score risks for not marking or not properly marking different fishing gears. One important aspect of stakeholder input and consensus is valuing the reduction of specific risks associated with specific gears – how important to reduce different types of risks. This is partly based on geographic location, ocean environment, economic condition, and personal or community perception. For example, what is more important between economic loss of gear and ghostfishing resulted from ALDFG? The process of risk assessment should result in Identifying priority for marking of certain types of fishing gear and level of complexity for marking. The assessment may also identify fishing gears that are exempt from marking. Figure 17 illustrates a process and components for conducting risk assessment for establishing a system of fishing gear marking based on the recommendation in Annex 1 of the VGMFG. A framework for risk assessment for the marking of fishing gear has been developed by FAO (He and Lansley, in press).

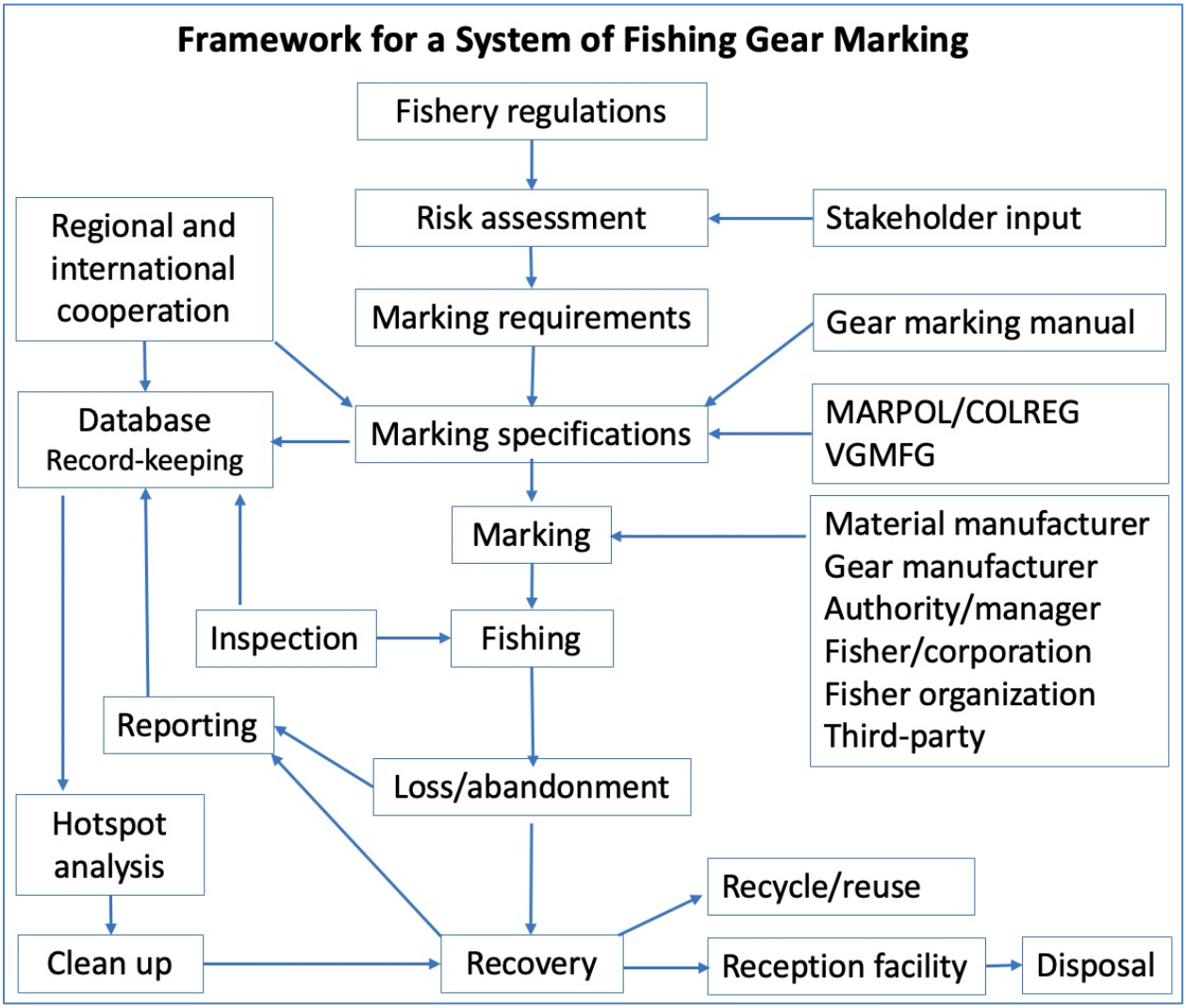
Figure 17. A framework for conducting risk assessment for the marking of fishing gear



6. Framework of a Gear Marking System for the APEC Region

As system of fishing gear marking should include risk assessment, gear specific marking requirements, reporting, recording and data management system, application of data for monitoring control and surveillance, and for mitigate ALDFG including retrieval ALDDFG, collection, reuse and recycle of end-of-life gear. A framework for a system of fishing gear marking synthesizing the VGMFG is shown in Figure 18.

Figure 18. Flowchart synthesizing a system of fishing gear marking, and its various components.



6.1 General principles

A system of fishing gear marking should be an integral component of and serves as an important tool for fisheries management. It should be compatible with existing international laws and rules, including, but not limited to MARPOL Annex V, and COLREG with special

reference to marking of fishing gear on the surface to prevent collision. The priority, complexity and level of gear marking should be based on the outcome of risk assessments as described in Chapter 5. In addition, a system of gear marking should have the following function and characteristics as suggested by the VGMFG:

- provide a simple, affordable and verifiable means of identifying the ownership and position of fishing gear,
- be compatible with related traceability and certification systems,
- be supported by a monitoring process for compliance,
- meet obligations in applicable international conventions and agreements,
- link with fishing authorization or license, and to vessel, its owner or operator engaged in fishing, and
- have minimal environmental risk, e.g., plastic pollution.

6.2 Framework for gear marking

6.2.1 Database

A system of gear marking should include a good book-keeping system on production, issuance, replacement, and termination of marking or markers, which usually involves a database linked to vessel records, fishing licenses and permits, gear regulations, as well as commercial tracing of manufacture, sale, resale and disposal of fishing gear or its major components. The database may have functionality for user input and query in controlled manners with different levels of user access based on authority, relevance and necessity.

6.2.2 Authorities and stakeholders

Fisheries management entities should be the principal bodies for designing, establishing, managing, and implementing a system of gear marking, in collaboration with a diverse stakeholder group. The Global Ghost Gear Initiative's Best Practice Framework for Managing Fishing Gear (GGGI, 2021) lists twelve entities that are considered as stakeholders:

- Gear designers and manufacturers
- Fishers
- Fleet operators and fisheries organizations
- Port operators
- Fisheries managers and regulators
- Fisheries control agencies
- Fisheries and aquatic environment research
- Seafood ecolabel standard and certificate holders
- Post-harvest seafood companies
- NGOs
- International development and funding agencies

- Municipality councils and authorities

6.3 Recommended gear marking in the APEC region

6.3.1 Attended gears

Generally speaking, attended gears have lower risks of loss and low risks to safe navigation. Marking on attended gear should focus on:

- legality of the gear or its components,
- capacity control, if multiple gear units are used, and
- ability to trace the origin of lost gear components

Some attended gears are large in scale and contain a large amount of plastic materials. components that prone to loss should be marked.

6.3.1.1 Surrounding nets, seines, trawls and dredges

While there are usually no ownership issues with these attended and actively operated gears, there are concerns on their legality of use, and/or confirming to management regulations, e.g., minimum mesh size.

Purse seines, boat seines and all trawls should have at least one mark on its headline (float line) to indicate legality for use in certain areas, seasons, and maybe target species, and linked to the vessel (e.g., IMO number if available), permit and/or license numbers. At least another mark should be attached to bunt of purse seines, and codends of boat seines and trawls. In cases of a vessel towing more than one gear, e.g., beam trawls, twin trawls or multi-rig trawls, each unit of gear should be marked with the same information, plus a sequential number or letter.

For legally required components, such as turtle excluder devices, a mark indicating that the device meets required specifications, may be attached, inscribed or printed.

For surrounding nets without a purse line, e.g., ring nets, and for beach seines, a mark indicating its owner and permit number (if required) should be fixed to its headline.

For all above gears, if feasible, floats on its headline should be printed with an identifying code that can be linked to the vessel or its permit/license.

For boat dredges and mechanical dredges, information on fishing permit should be welded or otherwise securely attached to their frame. For vessels towing more than one dredges, each dredge should be marked with the same information, plus a sequential number or letter.

6.3.1.2 Lift nets and falling nets

Portable lift nets, cast nets and cover pots/lantern nets are recreational or artisanal small-scale gears. They should be marked with their license or permit numbers, if their operation requires such license or permit. Otherwise, it is desirable to mark with owner's name.

Boat-operated lift net can be of large scale and should be marked with vessel and license/permit numbers, and any special restriction (season/area etc.). Mark should be fixed on its framing rope.

Shore-operation lift nets should also be marked similar to boat-operated lift net, except that vessel information should be replaced by operator information. If more than one lift nets are operated by one operator, a sequential number/letter should be added to its marking. Shore-based lift net should also be marked with a light or lights at night to aid to navigation, especially the net is set in an area of heavy vessel traffic.

6.3.1.3 Other attended gears

Other attended gears include hand-operated and mechanized lines and pole-and-lines, trolling lines, encircling gillnets, and all gears listed in “miscellaneous gear” category in the ISSCFG. Most of these gears are in recreational, artisanal or small-scale fisheries. If required, their marking may include the owner, and/or permit number, if such fishing operations require a permit or license.

6.3.2 Unattended gears

Unattended gears are left in the sea for a period of time before being hauled and are more likely to lose. They can also pose risks to navigation if not properly marked. Marking of unattended gears should focus on:

- Surface marking for locating the gear, for avoiding gear conflicts and as an aid to navigation
- capacity control as many of unattended gears contain multiple gear units, which often subject to limits
- Tracing of origin
- Ownership
- Legality

6.3.2.1 Gillnet and entangling nets

Set and drift gillnets, as well as trammel nets and combination gillnets, should be marked with tags with each unit of gillnet (typically 100 m or 50 fathoms (91 m)) attached at least one tag. If feasible, each float on its floatline should be marked with a number or a code that is linked to its owner or license number. Surface markers should bear similar numbers/codes, in addition to surface marker requirements as stipulated for navigation safety.

6.3.2.2 Hook and lines

Set and drift longlines should be marked with tags at certain length interval on the mainline. For drift longlines, each intermediate floats should be marked with a number or a code that is linked to its owner or license number. At least one mark should be applied to each vertical line. Surface markers for longlines and vertical lines should bear similar numbers/codes to their underwater marks/tags, in addition to surface marker requirements as stipulated for navigation safety.

6.3.2.3 Traps

Each pot should be marked with a tag or with written or inscribing information on the pot, whether the pot is fished in singles or in a fleet of multiples pots. Buoy ropes for pots should

be marked with suitable marking, e.g., color coding, if feasible and required. Surface marks of single or a fleet of pots should follow surface marking requirements for navigation, as well as for ownership and legality.

Pound net, including variations of large-scale set nets and trap nets, and barriers fences and weirs, should be marked at least with one mark or tag indicating its authorized use. All floats, if used, on its headline should be marked with corresponding codes, if practical. All buoys should be marked with similar codes. The gear should have at least one navigational mark to mark its extent, with a light or lights in the nighttime to aid to navigation. As these structures are set for at least a season, it may be feasible to establish a virtual mark that is enabled in an electronic chart.

6.3.3 FADs

6.3.3.1 Anchored FADs

Anchored FADs should be marked with ownership that is linked to license or permit to deploy the aFADs. The mark should also contain the date of deployment. The aFAD should be marked with surface marker for positioning and for aid to navigation.

6.3.3.2 Drift FADs

Drift FADs should be dual marked: one on the structure of the FAD, and an electronic or satellite buoy for positioning. The mark on FAD structure should bear information of the entity or vessel first deployed the FAD, and permanently attached to its raft. The marking on the raft should be readable at certain distances (e.g., 50 m) away from the raft.

The marking for position using electronic and/or satellite buoys should bear information/license number of the buoy owner both physically with inscription/print on the buoy, and electronically. Switching buoys should record and report information of the tag/marking of the raft.

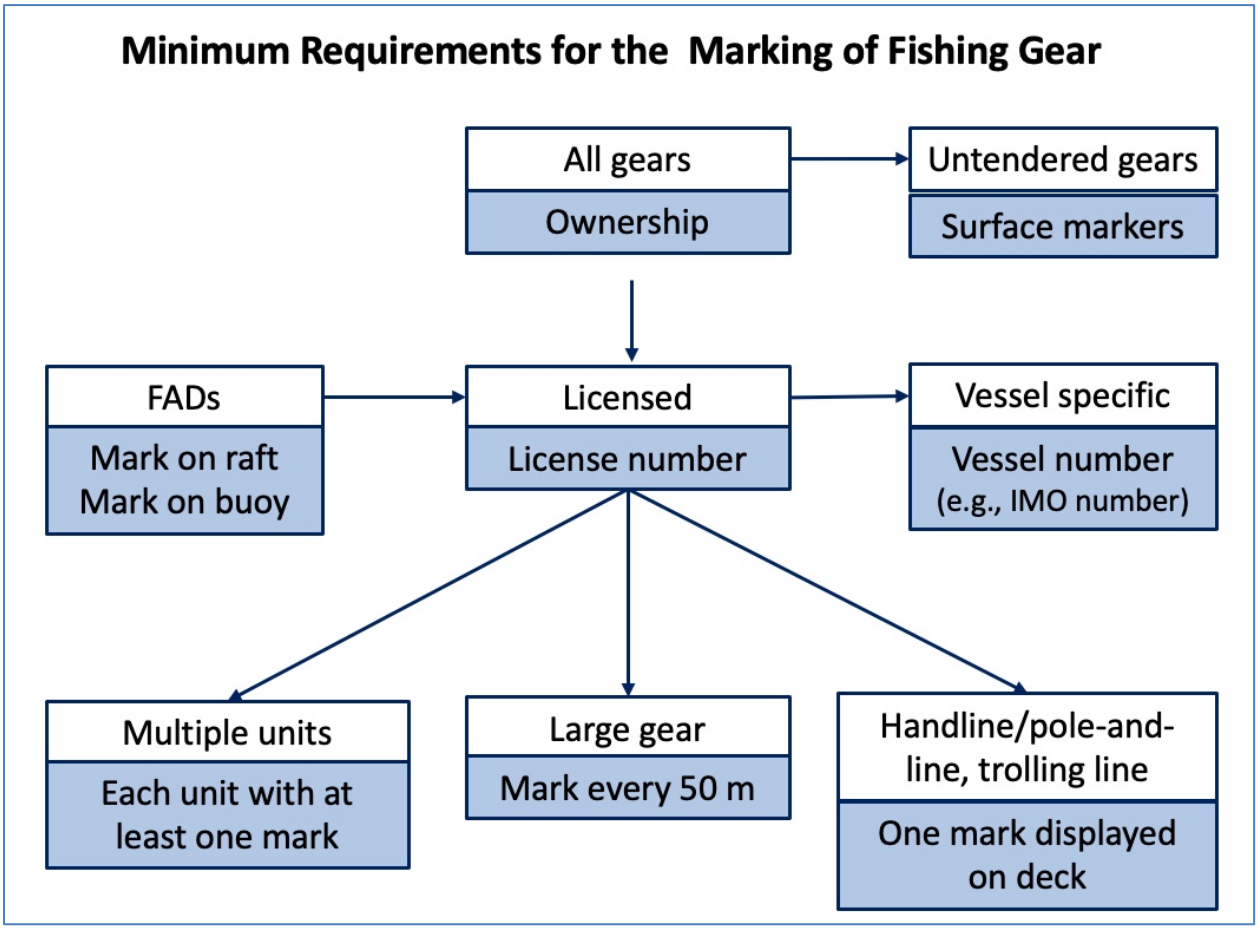
6.3.4 Marking for navigation and safety

The general requirement for surface marking of unattended gear should follow Annex 4 of the FAO Technical Guidelines for Responsible Fisheries, 1. Fishing Operations (FAO, 1996), which is being updated by FAO. The existing version of that annex is attached as Appendix 2 of this report.

6.3.5 Summary of the minimum requirements for the marking of fishing gear

The proposed minimum requirements for APEC region based on the level of fishery management and specific characteristics of gear is provided in
Figure 19. These recommendations are for information only and should be verified and confirmed through risk assessment and stakeholder input.

Figure 19. Minimum requirement for the marking of fishing gear



7. Summary

A system of fishing gear marking should be an integral component of and serves as an important tool for fisheries management. Gear marking is an important tool to reduce gear loss and aid recovery, as well as in determining ownership, assisting in fishing effort management and control, facilitating monitoring, control and surveillance, and deterring IUU fishing. Fishing gear marking is also an important means for safe navigation. Fishing gear marking can be physical, chemical, electronic, and virtual. They can bear various types of information, and often links to its owner or license and/or permit.

A risk assessment should be carried out to evaluate available data and information on both the fishery utilizing the gear and the ecological and economic characteristics of the fishery. The determination of risk levels involves the estimation of the consequence (impact) of the lack of a gear marking system in the fishery, an estimation of the likelihood of occurrence of the identified impacts, a score of the risk, and categorization of the risk, for both actively fished gear as well as ALDFG. The consequences and impacts may include ecological risks (plastic pollution; fishery resource and ETP species through ghosting fishing; and habitats), economic risks (including loss due to IUU fishing and cost of implementation), technological risks, safety and navigational risks, and implementation risks. Risk assessment should provide priority for gear marking, level of complexity, and any exemptions from gear marking requirements.

As system of fishing gear marking should include risk assessment, gear specific marking requirements, a reporting, recording and data management system, mechanism for the application of data for monitoring, control and surveillance, and for mitigate ALDFG including retrieval of ALDDFG, and reuse and recycle of end-of-life gear. A system of fishing gear marking should be compatible with existing international laws and rules, regional agreements and protocols. The priority, complexity and level of gear marking should be based on the outcome of risk assessments and stakeholder input. In addition, a system of gear marking should provide a simple, affordable and verifiable means of identifying the ownership and position of fishing gear, be compatible with related traceability and certification systems, be supported by a monitoring process for compliance, link with fishing authorization or license, and to vessel, its owner or operator engaged in fishing, and have minimal environmental risk.

Risk assessments and associated decision-making for designing and establishing a system of fishing gear marking should be carried out in a transparent fashion, with participation of a diverse stakeholder group including fisheries management authorities, the fishing industry, fisher organizations, scientific community, nongovernmental organizations, fish processors, traders and retailers as well as consumer associations.

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Appendix 1
International Standard Classification of Fishing Gears (ISSCFG), Rev.1 (2016)

Gear categories (First tier)	Subcategory (Second tier)	Standard abbreviations	ISSCFG code
SURROUNDING NETS			01
	Purse seines	PS	01.1
	Surrounding nets without purse lines	LA	01.2
	Surrounding nets (nei)	SUX	01.9
SEINE NETS			02
	Beach seines	SB	02.1
	Boat seines	SV	02.2
	Seine nets (nei)	SX	02.9
TRAWLS			03
	Beam trawls	TBB	03.11
	Single boat bottom otter trawls	OTB	03.12
	Twin bottom otter trawls	OTT	03.13
	Multiple bottom otter trawls	OTP	03.14
	Bottom pair trawls	PTB	03.15
	Bottom trawls (nei)	TB	03.19
	Single boat midwater otter trawls	OTM	03.21
	Midwater pair trawls	PTM	03.22
	Midwater trawls (nei)	TM	03.29
	Semipelagic trawls	TSP	03.3
	Trawls (nei)	TX	03.9
DREDGES			04
	Towed dredges	DRB	04.1
	Hand dredges	DRH	04.2
	Mechanized dredges	DRM	04.3
	Dredges (nei)	DRX	04.9
LIFT NETS			05
	Portable lift nets	LNP	05.1
	Boat-operated lift nets	LNB	05.2
	Shore-operated stationary lift nets	LNS	05.3
	Lift nets (nei)	LN	05.9
FALLING GEAR			06
	Cast nets	FCN	06.1
	Cover pots/Lantern nets	FCO	06.2
	Falling gear (nei)	FG	06.9
GILLNETS AND ENTANGLING NETS			07
	Set gillnets (anchored)	GNS	07.1
	Drift gillnets	GND	07.2
	Encircling gillnets	GNC	07.3
	Fixed gillnets (on stakes)	GNF	07.4
	Trammel nets	GTR	07.5
	Combined gillnets-trammel nets	GTN	07.6
	Gillnets and entangling nets (nei)	GEN	07.9

TRAPS			08
	Stationary uncovered pound nets	FPN	08.1
	Pots	FPO	08.2
	Fyke nets	FYK	08.3
	Stow nets	FSN	08.4
	Barriers, fences, weirs, etc.	FWR	08.5
	Aerial traps	FAR	08.6
	Traps (nei)	FIX	08.9
HOOKS AND LINES			09
	Handlines and hand-operated pole-and-lines	LHP	09.1
	Mechanized lines and pole-and-lines	LHM	09.2
	Set longlines	LLS	09.31
	Drifting longlines	LLD	09.32
	Longlines (nei)	LL	09.39
	Vertical lines	LVT	09.4
	Trolling lines	LTL	09.5
	Hooks and lines (nei)	LX	09.9
MISCELLANEOUS Gear			10
	Harpoons	HAR	10.1
	Hand implements (Wrenching gear, Clamps, Tongs, Rakes, Spears)	MHI	10.2
	Pumps	MPM	10.3
	Electric fishing	MEL	10.4
	Pushnets	MPN	10.5
	Scoopnets	MSP	10.6
	Drive-in nets	MDR	10.7
	Diving	MDV	10.8
	Gear nei	MIS	10.9
GEAR NOT KNOWN			99
	Gear not known	NK	99.9

Appendix 2
Guidance for the Marking of Fishing Gear to Indicate Position

Annex IV "Proposal for the Application of Standard System of Lights and Shapes for the Identification and Location of Fishing Gear" to FAO Technical Guidelines for Responsible Fisheries 1. Fishing Operations (FAO, 1996).

One of the key purposes of gear marking is to allow fishing vessels, control authorities and other maritime users to easily locate and therefore avoid fishing gear that has been deployed, especially where the responsible fishing vessel is absent. The key requirements for the marking of fishing gear are as follows:

i. Marking equipment (e.g. flags, lights, buoys, etc.) should be in a suitable size so as not to alter the fishing characteristics of the gear and affect handling on deck, with consequence for crew safety and vessel stability.
ii. Marking equipment should not be difficult and dangerous to deploy and retrieve.
iii. Radar reflectors should be designed without sharp edges. They should be effective and reliably detectable.
iv. Lighting should be powerful, robust, energy efficient and compact.
v. Marking need to be affordable in the context of the fishery involved.

Buoys, fitted with lights, radar reflectors and flags, increase the visibility of the spar buoy on the fishing gear to approaching vessels and assists them to navigate safely around the fishing gear. It also enables the owner to detect the marker at a greater distance. In addition, the cardinal system of shapes and lights would indicate the direction in which the passive gear is lying so that mobile gear vessel can fish in the vicinity without causing gear conflict which often cause loss of gear.

Nets and line that are set less than 2 m from the surface are considered to be a special navigational hazard to passing vessels, therefore they are subject to a more rigorous marking regime. For these fishing gears, spaces ("gates") should be left in the nets and line so that small vessels can pass safely through them particularly where there is high traffic density. These "gates" could be marked by two extremity markers, if practicable.

Buoys, lights, radar reflectors, flags and radio beacons used for marking fishing gear

Lights come in many shapes and sizes. For energy efficiency, the conventional lights should have a sensor which switches on the light automatically at dusk and then switches off at daylight, for example, using a Passive Infra-Red (PIR) sensor. High power strobe lights are commonly used but they are not readily available in all economies. The lights should be visible at a distance of two nautical miles and should not be confusable with lights specified for those required by vessels under the Collision Regulations or for navigational buoys, beacons or lighthouses.

LED lighting: light emitting diode (LED) lighting has been around for about 30 years, but major advances in brightness, power efficiency and form have been made over the last decade. LED lights are more energy efficient than conventional incandescent lights and very compact, making LEDs an obvious choice for marine lighting. Furthermore, they can be provided in a number of different colours (commonly red, green, white, yellow and blue), can be programmed to standard International Association of Marine Aids and Lighthouse Authorities (IALA) flash characters, as well as customized to new flash patterns. Depending upon their size, they can have a visible range of 1 nautical mile to over 12 nautical miles. They can be robust (e.g. rated as IP68 in terms of protection against water ingress) and

maintenance free with service lives in excess of ten years. Power can be provided by batteries and/or solar power. Battery lives are from 3 - 5 years, so the devices potentially require no maintenance or additional cost during this period, providing major advantages over the alkaline battery powered basic lights.

Radar reflectors can be a good aid to increase the detection range of the spar buoy for vessels fitted with radar. This helps the fishing vessel to locate the gear and the passing vessels to avoid the gear. The radar reflectors should be light in weight so that they can be carried high on the spar. Wire types are recommended over solid types to decrease wind resistance. The radar reflectors may be the traditional octahedral shape or in a round shape.

Flags should be displayed to increase the visibility of the marker, but should be placed in a position that does not interfere with the visibility of the light at night. They should be in suitable size so as not to affect the spar buoys' ability to stand erect in strong winds. Water resistant materials are recommended so that they are light even when wet and would not affect the flag's ability to stand upright. The dimensions of the flag should be at least 25 x 35 cm and the distance between two flags on the spar (if more than one) shall be at least 10 cm. The flag colour should be such as to be visible at considerable distances; fluorescent colours or black are recommended.

Radio beacons are used to mark fishing gear which can be subsequently recovered by using a radio direction finding system. They can emit a coded signal so that in areas of high fishing concentration each buoy is discernable by its owners. Many merchant and navy vessels are now fitted with scanning receivers which can detect the signals transmitted by these beacons, thus alerting these passing vessels to the presence of fishing activity in the area. Such markers are good technical options, though their cost- effectiveness should be considered in each fishery.

Spar buoys shapes are varied and are often constructed with a plastic or aluminum pole. The pole is inserted through the center hole of an inflatable spar buoy which is inflated and thus holds the pole securely. A weight is fastened on to the base of the pole so that the pole stands upright. The size of the weight is dependent on the wind resistance of the flags and/or the radar reflectors on the other end and on the prevailing weather conditions. This type of spar buoy can be visible for up to three nautical miles to the naked eye and can be detected even further by radar if fitted with a radar reflector. Gear marking details should be marked on the buoy and on the flags, if required, with indelible marking ink for the monitoring and control purposes (see also CIR 404/2011; Article 11). Supplementary buoys are normally used in conjunction with spar buoys as the spar buoy is to act as a marker and not to support the fishing gear, sometimes however in small scale fishing gear used inshore the functions are combined in one buoy.

Satellite beacons, with the use of FADs as a fishing aid, should have both a spar buoy with flag and lights and a radio or satellite beacon attached to the specifications in these guidelines.

APPENDIX MARKING THE POSITION OF A GEAR IN THE WATER COLUMN

The FAO 1996 Proposal for the Application of a Standard System of Lights and Shapes for the Identification and Location of Fishing Gear, was prepared on the basis of the Report of the 1991 Expert Consultation for the Marking of Fishing Gear (FAO Fisheries Report No. 485 and its Supplement) and the outcome of discussions at the International Maritime Organization (IMO). The content (without the gear drawings) of this 1996 Annex is the following:

1. General Provisions

1.1 In order to protect fishers and their gear and to warn other mariners of the presence of deployed fishing gear, economies should make provisions in domestic legislation for the adoption of a standard system of lights and shapes for the identification of fishing gear and for marking its position in the water.

1.2 Economies should make provisions for the inclusion of the details of the system in training programmes for fishers and mariners.

1.3 The need to comply with a system of lights and shapes related to fishing gear, fishing implements and fishing vessels should be in a condition of the authorization to fish.

2. Technical Provisions

2.1. The system should take into account:

a) the provisions of the International Regulations for the Prevention of Collisions at Sea (COLREGS);

b) any local rules, including rules of navigation governing river, lake or coastal fisheries;

c) regulations pertaining to offshore structures; and

d) systems for the marking of fishing gear for the identification of ownership.

2.2. Where practicable, all position indicators attached to fishing gear should:

a) be as conspicuous as possible in a clear daytime atmosphere from a distance of at least 2 nautical miles at sea level;

b) carry radar reflectors;

c) carry lights with characteristics which do not conflict with those of navigational marks and which would be visible on a clear night at a distance of at least 2 nautical miles; and

d) be fitted with a coloured flag or flags of fluorescent material, as an aid to daytime visibility.

2.3. Light and shapes should also indicate the direction and extent of set and drifting gear.

2.4. Electronic devices, such as transponders and radio beacons which automatically and continuously indicate their position by means of signals may be used in addition to the lights and shapes. Such devices, however, must not operate at frequencies that would conflict with other devices used for navigation and search and rescue purpose.

3. Application of a Standard System

3.1. An individual pot, trap, fyke net, stake net and other similar gear, should be marked with a buoy or other device at the surface to indicate its position. Gear set in series, such as a number of pots connected on line, should be marked at each end with a buoy.

3.2. Anchored or drifting fishing gear with the upper continuous edge of the gear at a depth of more than 2 metres below the surface should be marked in the following manner:

a) fishing gear set below the level of the sea and extending from an anchor or parent vessel, should be marked at both extremities by a spar buoy and at intermediate positions. The distance between the intermediate marks, and between the intermediate marks closest to the extremities and the extremity markers should not exceed one kilometre. In the case of fishing gear attached to a vessel, the extremity of the gear nearest to the vessel need not carry a marker;

b) for recognition in daytime, the westernmost end spar buoy of such gear extending horizontally in the sea should be fitted with two flags one above the other or one flag and a radar reflector. The end spar buoy at the most easterly extremity should be fitted with one flag or a radar reflector; and

c) for nighttime recognition, the most westerly end spar buoy should have two white lights one above the other, the most easterly end spar buoy to have one white light.

3.3. Fishing gear set within the upper two metres of the water column, and therefore a hazard to small transiting vessels, should be marked in the following manner:

a) for daytime recognition, the extremities of the gear should have spar buoys carrying top marks consisting of two spherical shapes, one above the other at no more than one metre apart; the diameter of the upper of the two spheres to be smaller but no less than one half diameter of the lower one;

b) for nighttime recognition, the spar buoys placed at the extremity of the gear should have two yellow lights, one above the other at no less than one metre apart and of different characteristics to lights fitted to intermediate buoys;

c) gear extending more than one kilometre should have intermediate buoys placed at distances of not more than one kilometre; intermediate spar buoys should have one spherical shape for daytime recognition and one yellow light for night time;

d) “gates” should be provided for the free passage of surface vessels. Each side of the gate should be marked by spar buoys; the closest intermediate float should not be more than 10 meters from these spar buoys; and

e) attended gear need not be marked at the extremity attached to a fishing vessel.

3.4. The dhan-buoy used with active gear, such as anchor seining, fly dragging and purse seining, should comply with the provisions as set out in paragraph 2.2.

3.5. Fish aggregating devices (FADs) should be marked in the same way as fishing gear and carry means to identify their position by day and night. As a minimum requirement, they should comply with the provisions set out in paragraph 2.2. The requirements of paragraph 2.4. should apply to the use of electronic devices fitted to FAD’s.

4. Technical Specifications

4.1. A spar buoy should meet the following requirements:

a) the pole of a spar buoy extending above the flotation buoy should have a height of at least 2 metres; the height of the spar buoy may be less than 2 metres if an administration is satisfied that the fishing gear so marked would not be a hazard to navigation;

b) where radar reflectors are required, they should be fitted at the top of the pole;

c) the size of flags should be less than 25 centimetres in height and 35 centimetres in width; when two flags are required, the distance between them should not be less than 10 centimetres; flags should be made of waterproof material in fluorescent colours;

d) lights should be attached to the pole in such a way that they will not be obscured by a flag;

e) for shapes that give the appearance of being spherical when viewed from a distance, provided for in paragraph 3.3 c) above, the lower of the spherical shapes and the shape, if only one is fitted, should have a diameter of not less than 30 centimetres, the upper shape should be smaller in diameter but not less than half that of the lower shape; and when two shapes are required, they should not be less than 10 centimetres apart; and

f) intermediate floats should have a diameter of not less than 50 centimetres.

4.2. Radar reflectors should be:

a) as light as possible;

b) octahedral in shape; and

c) of metal plate or wire mesh construction.

4.3. Lights should be visible at a distance of at least 2 nautical miles; and preferably of a type that are fitted with sensors that automatically switch the light on at dusk and off at daylight.

4.4. Radio Beacons may be of the type that can be attached to the pole of the spar buoy or FAD, if they are of the free-floating type, they should be linked to the spar buoy.

Appendix 3

RISK-BASED APPROACH TO ASSIST RELEVANT AUTHORITIES IN DETERMINING THE NEED FOR AND REQUIREMENTS OF A SYSTEM FOR MARKING OF FISHING GEAR

(FAO, 2019)

A risk-based approach to implementing gear marking systems to mitigate against ALDFG can reduce the likelihood of loss and the impact of the loss if it occurs.

Many factors contribute towards ALDFG, including but not limited to: the type of fishing gear, weather, sea and bottom conditions, equipment failure, the level of fishing effort in a particular area, human error and safety considerations.

Before a full risk assessment is undertaken, a simple yes/no assessment may be conducted based on the type of fishing gear, marking methods and techniques and the area of operation. This will allow simple small-scale methods, usually hand-held fishing gears, to be assessed without the need for a full risk assessment.

The assessment should be devised based upon the best available information to determine the risk associated with the current level of gear marking in the fishery in question concerning:

a) ecological harm;
b) economic harm due to ghost fishing or illegal, unreported, and unregulated fishing;
c) safety at sea; and
d) the impact on fishing operations.

The determination of risk levels involves four primary steps:

a) Estimation of the consequences (impact) of the lack of a gear marking system in the fishery under consideration;
b) Estimation of the likelihood of occurrence (probability) of the identified impacts occurring as a result of the lack of a gear marking system in the fishery under consideration;
c) Scoring of the risk; and
d) Categorization of the risk.

The specific criteria addressed in the risk assessment should be based on the specific fishery conditions under consideration. As general guidance, the scope of a risk assessment should include parameters influencing consequences and impacts including, *inter alia*:

a) Ecological risks: Status of species impacted, habitats fished, vulnerability and fragility of the species and habitats where the fishery takes place and taking into account that ALDFG may drift long distances and settle in areas outside the fishery of concern, in areas beyond domestic jurisdiction or in another domestic jurisdiction;
b) Economic risks: Level of effort, the value of the fishery, economic nature of the fishery (subsistence, industrial) and the potential for ghostfishing or IUU fishing;
c) Technological risks: Gear type, amount of gear, numbers of vessels, method of operation;
d) Safety and navigational risks;
e) Social and cultural risks: Different users, language competencies, level of organization;
f) Availability of information and the quality of information; and
g) The synergies to be derived from harmonizing gear marking systems.

Determining a risk level needs defensible estimates of the consequences and likelihood. A clear rationale should be provided on how estimated levels were chosen, so that the process can be traced and verified. A clear rationale also provides a basis from which future assessments can be measured. The information, data and expert opinion collected and consolidated through the initial scoping exercise form the basis for that rationale, with additional information being provided where appropriate and necessary.

Further information to consider in the risk assessment process

Feasibility and affordability

In addition to the risk assessment, decisions should also be informed by an assessment of the feasibility of implementing a system for the marking of fishing gear and of the related cost/benefit issues. Accordingly, the assessment could address the following basic questions:

a) Is the technology associated with the system feasible, cost-effective and fit for the required purpose?
b) Will the technology mature over time?
c) Are there any technical barriers to integrating the capability within the current fishery system?
d) How would the gear marking system affect the efficiency of the fishery (i.e., reduced CPUE, added down time, associated costs, etc.)?
e) What measures would be necessary to assist the fleet in the implementation of gear marking?
f) What resources would be available to ensure successful implementation?
g) Does the gear marking system add potential hazards or interference to regular fishing activities?
h) Do the economies in question have the administrative and economic capacity to implement and monitor the system?
i) What capacity building and/or funding needs should be considered (both in terms of administrations and fishery operators)?
j) Do language competencies, level of organization and different users have an impact on the implementation of gear marking systems?

Participation

Arrangements for conducting risk assessments and associated decisions should be carried out with balanced participation by independent technical experts and by representatives of interested parties in system development, revision and approval processes.

Transparency

Risk assessments and associated decision-making should be carried out in a transparent manner and follow written rules of procedure. Once a risk assessment has been completed, it should be published promptly and where possible be accessible electronically to the public.