Advancements in Active Fishing Methods

Madhu V.R.
Principal Scientist,
Fishing Technology Division, ICAR- CIFT, Cochin
Madhu.VR@icar.gov.in

1. Introduction

Fish harvesting technology has advanced dramatically over the last many decades. Among the most significant developments in the history of fishing gear and practices are the following:

(i) Technological advancements in craft design and mechanization of propulsion, gearing, (ii) adoption of synthetic gear materials (iii) changes in techniques for detecting fish using acoustics and satellite-based remote sensing (iv) technological advancements in electronic navigation and communication systems (v) awareness of the importance of responsible fishing in ensuring the long-term viability of resources, biodiversity protection, environmental safety, and energy efficiency.

Introduction of highly effective and powerful fish harvesting systems and fish detection techniques, as well as an unchecked expansion of fleet size, fueled by increased market demand for fish resulted in increased pressure on global fisheries resources. Signs unmistakable of overfishing and Negative effects on ecosystems have become more visible in recent years, emphasizing the importance of scientific fisheries management to ensure their long-term viability and future generations' accessibility.

Fishing vessels

Significant advancements in fishing vessel materials, hull optimization, engine performance, propulsion systems, gear and catch handling deck equipment, onboard preprocessing, processing, preservation, and packaging systems, and energy conservation have occurred. The navigation controls and displays are increasingly integrated into a single large display. Improvements in the devices like navigational instruments that are used to navigate the vessel at sea and in port, other instruments that are used to detect fish and aid in the fishing operation, such as sonar and electronic aids for the operation, and radio communications that are critical for safety and general communication.

Fishing gear materials

Significant advancements in fiber technology have occurred in recent decades, and so has the introduction of other modern materials. With the introduction of man-made synthetic fibers, natural fibers used in fishing gear were gradually phased out in favour of these synthetic materials due to their high breaking strength, resistance to weathering, low maintenance cost, long service life, and improved characteristic uniformity.

Polyamide (PA), polyester (PES), polyethylene (PE), and polypropylene (PP) are the most used synthetic fibers in fisheries. Other synthetic fibers include polyvinyl alcohol (PVAA), polyvinyl chloride (PVC), and polyvinylidene chloride (PVD), which are less widely used. The introduction of synthetic materials with high tensile strength properties like Ultra High Molecular Weight Polyethylene (UHMWPE) enabled the design and size of fishing nets to be reconfigured considering the available engine power of the vessels from which they are operated.

Fishing gears

There are a wide array of fishing gears that are being used, that typically suits the ecology and behaviour tendencies of the fishes that are being targeted and the fishing gears are classified based on the principle of capture, design and technical features and the operational methods.

Historically, technological advancements in fishing gear and methods were targeted at improving production through improved gear system efficiency.

However, in the current environment of overfishing and increased awareness of fishing's environmental and ecological impacts, fishing gear development efforts are concentrated on the development of responsible fishing gear systems with improved size- and species-selective properties, reduced impact on the environment and non-target resources, and increased fish stock sustainability.

2. What are active fishing methods?

Active fishing methods are fishing operations which involve some mechanical energy to be expended to capture fish, it differs from the passive methods of fishing, which predominantly lures the fish to a particular location/ area by different methods and then finally lifted out with very low energy requirement.

Depending on the type of operations and the amount of energy that is expended for the capture, wide variation exists in active fishing methods. For instance, the energy requirement of in case of hand dredge and double stick nets, are very low when compared to large mid water trawls, which spends large amounts of fuel for towing large net at speeds that outrun the speed of large pelagic fishes, that it intends to capture.

Most of the active fishing methods, particularly the dredges and trawls, are often implicated for collateral damages to biota and to affect the integrity of the ecosystems. Hence most of the recent advancements in the field of active fishing methods, has been to reduce the negative impacts and to improve the efficiency of the mechanical systems to conserve or optimize the energy use.

3. The classification of the most important active fishing methods

3.1. Dredges

The area of operation of this gear is along the inshore and offshore sea waters all along the world. Smaller boats are often employed for the inshore operations, with use a single dredge, whereas in offshore fisheries, particularly that target scallops along North America and Alaska, large vessels are often used, that employ two or three dredges.

Mechanization and large number of sophisticated methods are now employed, in dredges, particularly the offshore fisheries, which can dig and transport the catch to the vessel using mechanical conveyers, which can be considered as harvesting machines.

Direct and in-direct impacts of dredging operations

The impacts of dredging include, 1) damage to reef structures, 2) by-mortality, 3) sediment suspension and chemical changes, 4) reduce chemical exchange between water-soil interface etc. Though the physical changes diminish with time, but changes to ecosystems that are vulnerable, often take many years to revive. The effects are often a function of the type of dredge used, number of dredges operated by a vessel, use of rakes or deflectors etc.

Dredge selectivity is affected by several factors including the type of seabed, depth, tow duration and speed, the hanging coefficient of the net bag, the twine material and its diameter, tooth spacing and mesh size. The recent studies show that a hard collection system has better selectivity rather than the soft collecting system like webbing.

It has also been noticed that improving efficiency of the dredges, like in the Canadian waters, has significantly reduced the bottom contact time of the gear, thereby reducing the overall impacts. The different types of dredges and their classification is as follows:

3.1.1. Hand / Manual dredge – with handle, scratcher

3.1.2. Boat dredge/ mechanical dredges – mechanical power used, often to scrape the bottom up to a depth of 60 cm; but automation is not involved

3.1.3. Hydraulic dredge – lot of automation, with regard to harvesting, bringing onboard, sorting and packing. Mostly done using a water jet created by two pipes, one smaller in diameter and the other larger one, mostly by Venturi principle – venturi dredges.

3.1.3.1. Side rig dredges – depending on the deck arrangement and the operation of the dredge

3.1.3.2. Stern rig dredges – dredges that are operated from the stern of the vessel

3.2. Trawling

Trawling contributes significantly to the marine catches in the world and is one of the most efficient methods of fishing. The most significant improvements in the trawling sector, has been the introduction of mechanization, with large, powered engines, capable of fishing for long durations and facilities available onboard for preservation of the catches. However, it is often implicated with generation of large quantities of bycatch and significantly impacting the non-targets groups and the bottom integrity of the sea floor.

Based on the recent estimates of discards FAO (2020), the annual discard quantity in the world fisheries is about 9.1 million tonnes (10.1 percent of annual catches), of which 4.2 million tonnes is from bottom trawls, and 0.9 million tonnes from midwater trawls.

A large number of technologies and simple modifications were attempted in the world fisheries to address the issue of bycatch and also reduce the impacts to the sea bottom by trawlers. Common simple modifications like increasing the lateral mesh opening to match the morphology of the unwanted catches have been tried, so is the turning of mesh direction to allow the mesh to remain open and hence help in the release of unwanted catches from the trawl. In some fisheries, complex grids are often used, and in many temperate waters, this has been successfully implemented.

Bycatch Reduction Devices (BRDs) are a collective term for devices created to exclude endangered species such as turtles and to reduce non-targeted species in shrimp trawling (BRDs). These devices were built with the difference in size and behaviour patterns of shrimp and other animals inside the net in mind. BRDs can be categorized roughly into three types based on the materials used in their construction: soft BRDs, hard BRDs, and combination BRDs. Soft BRDs separate and exclude bycatch by utilizing soft materials such as netting and rope frames. Hard BRDs employ rigid or semi-rigid grids and structures to separate and exclude bycatch. Combination BRDs incorporate multiple BRDs, typically hard BRDs and soft BRDs, into a single system.

In addition to the modification in the size or shape of the codend, design modifications like semi-pelagic trawls, short body trawls, horizontally separated trawls, etc. have been tried with success experimentally, but their adoption have been equivocal, especially in locations where there are no strict legislations and effective monitoring, control, and surveillance mechanisms in place.

Despite many years of work related to making the trawls more selective, generation of bycatch is still a big issue is many trawl fisheries and this is particularly so in the multi-species fisheries around the globe. A recent global review of the studies carried out in bycatch reduction in trawls, point to the fact that despite many studies, about 203 in total, that has attempted many techniques, to reduce bycatch, no fishery has completely resolved all the bycatch problems while maintaining targeted catches at conventional levels.

The different trawling types and their classification is given below, which indicates the complex ways, in which trawling is being conducted and the difficulty in coming up with solutions to the myriad problems that it faces with respect to sustainability. Nevertheless, modifications to the codend are one of the most widely adopted technique and the recent developments in this gear, has been to improve the size selection in this part.

3.2.1. Bottom trawling

3.2.1.1. One boat – sailing broadside

3.2.1.2. Two boats -pair trawling

3.2.1.3. Beam trawls

3.2.1.4. Otter trawls

3.2.2. Mid-water trawling

3.2.2.1. One-boat otter trawls

3.2.2.2. Two-boat trawls

3.3. Seine nets

In its simplest form, a seine net is a net wall composed of two wings and a piece in the center to keep the catch (the bunt or bag). The wings are long, and each is lengthened by a long towing line or warp. The seines are basically divided into two major types, based on the presence of a bag or without a bag. Seining operations like beach seining can be thought of as one of the oldest methods of bulk fishing.

However, these techniques are frequently discovered to be fading with time, owing to the fact that seining was traditionally considered to be strenuous labour for a group of men. Now, with human labour wages at an all-time high, practically every seining fishery is slowly getting mechanized. Not only the towing ropes are wound on special winches, but entire wings are also being towed mechanically, mostly with the use of winches and tractors. This has helped in the modification of beach seines to boat seines, the main advantage being the increase in the operational area of the gear. There is however an increase in the size and engine power of the boats used for seining operations.

Nevertheless, with all the developments happening, seining operations remain traditional in most parts of the world, involving a large number of work force and the main investment is the large gear. Compared to trawling, the mechanization in the seine fisheries was late and little, and it remains a low energy operation, and comparatively more selective than trawling. Attempts have been made by use of inboard vessels fitted with winches, to pull the lines, but these have not been hugely successful in the long run. Floating otter boards like Hong kong diverter were also tried, which helps to maintain the webbing and the line in the water column for longer times, thus improving effective fishing times, but these would have increased the resistance and hence were not successful. Similarly, there had been attempts to electrify the head and foot ropes, with power coming from one of the boats used for towing. However, these were also not successful and not practiced now.

In comparison to bottom trawls, the advantages of seining include lower energy consumption and increased selectivity due to the bag's slower movement over the sea floor, which may mean that seining has a brighter future.

3.3.1. Double-stick nets – small nets, without bags held between two sticks

3.3.2. Genuine seine nets – without, and with one or more bags, equi or non-equi winged, with tow line of equal or non-equal length

3.3.3. Beach seines – with or without vessels onto beach

3.3.4. Boat seines – gear hauled in deep water from a boat - The boat seines consist basically of a conical netting body, two relatively long wings and a bag ahead of the wings, are long ropes which are used to encircle a large bottom area with the purpose of herding (catching) fish form that area.

3.4. Surrounding nets

The technique used to capture shoaling fishes in large quantities, by means of surrounding the shoal from the sides and may also from the bottom in case of gear with pursing mechanisms. There are wide variations in the designs and the most of them form either a dust pan shape while in operation or a closed purse, depending on the use of a pursing device.

These nets are widely used in the world fisheries and can be considered as an upgraded version of the seine nets, with a better efficiency compared to their predecessors. Among the mostly widely used surrounding net is the purse seine, which over the years has improved its efficiency in terms of the size of the gear and mechanization, like the use of puretic power block and Triplex. Studies using webbing with high sinking rates like Ultra High Molecular Weight Poly Ethylene (UHMWPE) have been tried and found to be successful experimentally. However, the adoption of these webbings in the fishery particularly in the south east Asian countries has been not so encouraging, mostly due to the high price of new generation webbing. Selective replacement of these high strength webbing in regions, where high damage is found to occur has also been tried experimentally along Indian waters.

Purse seines, like other surrounding nets, are not selective; nonetheless, schools are carefully selected based on the presence of bycatch species (operational selection). Bycatch species are a frequent occurrence during FAD assisted purse seining, with over 40 species of fish and

cetaceans reported from purse seine landings. To avoid dolphin capture in purse seines, special escape panels known as Medina panels have been introduced. Medina panels are sections of tiny mesh that prevent dolphins from being entangled in the gear. Purse seine selectivity can also be improved by selecting the suitable mesh size for the target species, as well as by selecting the appropriate fishing region, depth, and season.

Another equally important design that is the ring seines, which is hugely popular along the southern west coast of India. This has evolved from lampara type of nets and since then has seen major changes in the dimensions, which is now almost three or four times, bigger in proportion that it was originally envisaged to. This gear has now completely overtaken the purse seine operations along the south west coast of India and is seen to spread to other states of India. The technology creep has serious implications on stocks, since the increase in the size of the gear, coupled with high powered engines, has quadrupled the efficiency of these gears. It is also reported that this gear contributes significantly to juvenile catches of shoaling fishes like mackerel and sardines.

The major classification of the surrounding net are as follows:

3.4.1. Lampara-like nets – without pursing device, but with a shorter ground rope that helps in attaining a dustpan shape to the webbing during the operation.

3.4.2. Purse seines – with pursing device

3.4.2.1. One-boat system – with or without skiff

3.4.2.2. Two-boat system – without skiff

3.4.3. Ring nets – hybrid between lampara and purse seines, with pursing device

4. New technologies in fisheries

Apart from the technologies particular to each type of gear described, the future of fishing technology will be heavily reliant on the application of high data from satellites and big data from the various types of Vessel Monitoring Systems (VMS) currently in use worldwide. Numerous research articles utilizing AIS data from vessels worldwide have already demonstrated the application of bigdata and its utility. Fisheries management in the future will be dependent on the utilization of big data, sensors, robotics, and the internet of things.

Open sharing of VMS data can considerably aid in understanding fishing vessel movement and also in correlating these movements to ocean biogeochemical cycles, which can open up new paths for fisheries management and conservation.

5. Conclusion

Active fishing tactics account for a sizable portion of the world's total fish catch. While they add significantly to catch, the majority of these active methods of fishing are alleged to be non-selective and to have a detrimental effect on fisheries resources and the biological basis of production. Trawling is one of the most extensively practiced active fishing methods worldwide, and the process of mechanization began much earlier in this sector than in others. This led in design and mechanization advancements, which resulted in a large increase in fishing capacity. The growth in individual fishing capacity, along with the unfettered expansion of fleet size, has made it one of the most despised active fishing methods.

The generation of massive amounts of bycatch, often more than 50% of total catches in some fisheries, is the primary concern, as is the impact on the sea bottom, which has both short- and long-term effects on the ecology.

Making the trawls more selective both in terms of species and size, selection is one of the active areas of research. As a result, a large number of bycatch reduction devices, and also different designs have been developed in the world fisheries. Nevertheless, with all these developments, the issue of bycatch and the impacts of bottom still remain one of the main drawbacks in the case of trawling.

Though the developments have been late and little, the seine sector has also seen advancements, but most of these are often very minute, when compared to the sectors like trawling and purse seines.

Another active method of fishing, which has seen large scale advancements is the surrounding nets, like the purse seines and the ring seines. The advancements like power block, use of triplex etc. have significantly reduced the labour involved in these operations. However, there are issues with regard to capture of large quantities of juveniles of shoaling fishes. However, unlike towed gears, the fishers have the choice of selecting and surrounding the shoals due to the system's innate potential to choose.

While active fishing methods have a considerable negative impact on the environment and require a lot of energy, they are frequently quite efficient and are the most effective method of capturing some species. The primary impact is frequently due to the unchecked expansion of the capacity and fleet size of active fishing gears. Others, such as seining, are still used in their

most primitive forms, requiring minimal energy input and remaining among the most energy efficient ways of fish capture.

Effective management measures to rein in capacity expansion and also unfettered fleet expansion are critically needed in some active fishing methods.

6. References

Broadhurst M.K., Millar R.B., Wooden M.E.L.L. & Macbeth W.G. (2006). Optimising codend configuration in a multispecies demersal trawl fishery. *Fisheries Management and Ecology* **13**, 81–92. https://doi.org/10.1111/j.1365-2400.2006.00479.x

Donaldson A., Gabriel C., Harvey B.J. & Carolsfeld J. (2010). Impacts of Fishing Gears other than Bottom Trawls, Dredges, Gillnets and Longlines on Aquatic Biodiversity and Vulnerable Marine Ecosystems. *Canadian Science Advisory Secretariat Research Document*

Fok L., Lam T.W.L., Li H.-X., Xu X.-R., Virgili M., Vasapollo C., *et al.* (2019). Assessment of the stock status of small-scale and multi-gear fisheries resources in the tropical Eastern Pacific region. *Fisheries Research* **116**, 135371. https://doi.org/https://doi.org/10.1016/j.fishres.2019.05.015

Kennelly S.J. & Broadhurst M.K. (2002). By-catch begone: changes in the philosophy of fishing technology. *Fish and Fisheries* **3**, 340–355. https://doi.org/10.1046/j.1467-2979.2002.00090.x

Walsh S.J. & Winger P.D. (2011). Bottom seining in Canada, 1948-2010: its development, fisheries and ecosystem impacts.

Gabriel, O., Lange, K., E. Dahm, E. & Wendt, T. (Eds.) (2005) Fish catching methods of the world– 4th ed. 535 p.