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POPULAR ARTICLE

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Revolutionizing Fishing Gear for Sustainable Fisheries Management: Exploiting the Power of Selectivity

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Conflict of Interest

The authors assert that the manuscript was developed without any commercial or financial associations that could be interpreted as a potential conflict of interest.

Authors Contribution

All listed authors have contributed significantly, directly, and intellectually to the work and have endorsed it for publication.

Abstract

An overview of fishing gear selectivity and its impact on fisheries management is given in this review article. Although selectivity directly impacts the composition of the catch and non-target species and ecosystems, it is a vital aspect of sustainable fishing techniques. We talk about the benefits and drawbacks of using different fishing techniques, such as trawls, gillnets, long lines, traps, and hooks, to target particular species and size classes when addressing the selectivity of these techniques. We also look at the variables that affect selectivity, like fishing depth, mesh size, soak time, and gear design. We additionally look into the function of selectivity in fisheries management plans, including limits on size, gear, and marine protected zones. We can encourage by grasping the degree of selectivity exhibited by various fishing gears and putting in place suitable management strategies.

KEYWORDS

Selectivity, fishing gear, sustainability, non-target species, size classes, fisheries management.

INTRODUCTION

Specificity of a gill net is an important component in sustainable fisheries management as it directly affects catches, non-target species, and ecosystem composition. (Froese & Stern-Pilot, 2008). Different fishing techniques, such as trawls, gillnet, longlines, traps, and hooks, catch specific species and size classes. Factors such as fishing depth, mesh size, dive time, and gear design play an important role in determining the selectivity of these techniques. (Suuronen et al., 2012). Choice must be implemented in fisheries management plans through size limits, fishing gear regulations, and marine protected areas to promote sustainable fishing practices. Gear selectivity can reduce the loss of fish when the gear is recovered on board. Bottom trawls and purse seines are naturally selected due to their design and operational characteristics (Pitcher et al., 2002) Although selectivity is critical to sustainable fisheries, it alone cannot counter fishermen's tendencies to increase fishing inputs or avoid resource consumption (Sumaila et al., 2008). Understanding and selecting the nuances of different fishing gear is critical to effective fisheries management and conservation efforts. By balancing the advantages and disadvantages of different fishing techniques and implementing appropriate regulations, sustainable fishing practices can be promoted to ensure the long-term health of aquatic ecosystems (Pitcher et al., 2002).

ANALYSIS OF THE PRESENT SITUATION

Within most fisheries, there is an excess of fishing effort related to the stocks of available resources. This surplus can be further broken down into categories such as the number of fishing vessels, the size of these vessels, the level of engine power, and the amount of time spent at sea. Situations can differ seasonally and from location to place. Furthermore, it might apply to certain target species but not others (Sanchirico & Wilen, 1999). The issue of mixed fisheries frequently arises when mesh size must be compromised to meet the minimum landing sizes of various species (Kelleher, 2005). As technology advances, so does our capacity to catch more fish with each unit of effort. The current state of fishing gear selectivity is still a crucial component of global efforts to manage fisheries and maintain them. Even with advances in technology and gear adjustments to increase selectivity, problems still exist in some fisheries and areas.

Bell-shaped selection curve

For most fixed gears, the bell-shaped curve is crucial for the study of selectivity. The gear's selection range is indicated by the selection curve's width, and the optimum fish size that the gear can catch is shown by the curve's highest point.

Sigmoid-shaped selection curve

The fixed gear allows smaller fish relative to size to escape but prevents larger fish from entering. In contrast, larger fish become more susceptible to selection when moveable gears allow all the smaller fish to escape through meshes. As for size, the proportion of fish-maintained rises in tandem with the increase in fish population. A selectivity curve with a "S" shape is the result of the selection process (Pitcher & Kalikoski, 2012).

PRINCIPAL TYPES OF FISHERY GEAR

The different fishing methods or gears can be conveniently grouped according to the demands they place on the operating vessel

- Towed or dragged gear
- Encircling gear
- Static gear

Towed or dragged gear

These gears must be towed across the sea bed or through the water column and rely on their effectiveness in traversing considerable area of bottom or volume of water. the operating vessel sets out the gears and tows them for a set time to capture a particular group of fish and haul it back respectively all methods using towed or dragged gear energy requirements are high as considerable power is needed to tow the gear against the resistance of water and the seabed. These gears are the most energy-intensive fall fishing methods.

Encircling gear

A shoal of fish, an extensive mass of water, or the seafloor can be enclosed using encircling gear arranged in a circle. The circle is gradually closed up until the fish inside are caught. This comprises:

- Ring net: A net that is typically used by two boats to encircle a group of pelagic fish with a "wall" of netting.
- Purse seine: a huge net used to confine a school of pelagic fish by pulling its bottom together.
- Anchor seine: An encircling net shot in open water that is laid out on the seafloor by very long ropes before being hauled from a boat that is anchored. This is referred to as a Danish seine at times.
- Scottish seine: An encircling net shot in open waters with ropes on the seabed and very long ropes used to spread out the net.

Static gear

Static gear is designed to let fish swim into it or draw them in with bait so they get entangled in it. Several primary categories of static gear include:

- Lining: incredibly long lines with many baited hooks that can be left drifting or anchored.
- Pots and traps: Structures that fish are directed or lured into using funnels that promote entry but restrict escape are known as pots and traps.

Table 1: Comparative analysis of fishing method

Sr. No.	Fishing method	Depth	Principal directed fisheries	Areas fishes
1	Bottom otter trawling	Up to 1000m	Cod, Skates, Rays, Rockfish	On continental shelf worldwide
2	Bottom trawling	Up to 600m	Croakers, Shrimp, Prawns, Small pelagic fishes	Worldwide on shelf shallower waters in the temperate regions

Selectivity of Trawl Gear

Once fish become aware of the approaching vessel, the selection process for towed demersal fishing equipment starts. The approaching ship and its gear will then probably be audible to them as it crosses the seafloor. The gear will be visible as it approaches, as will the visual contrast it creates with its

surroundings and perhaps the pressure field connected to the gear. How fish respond to these stimuli will determine how selective the gear becomes: whether they move in the direction of the approaching gear, avoid getting within it, or manage to get out of it if they do

METHODS FOR MEASURING SELECTIVITY OF TRAWL

Covered cod-end

Place a small mesh cover over the cod end of the experimental net to measure the total fish population interacting with the gear within a specific fishing area. The small fish that manage to escape from the cod-end are captured by the small mesh cover, and the total population encountered can be determined by adding the fish that are caught in both the gear and the cod-end cover. This gear design will make it possible to estimate the selectivity of cod-ends with varying mesh sizes and shapes when conducting a series of distinct experimental cod-ends with the use of a small mesh cover.

Twin trawl

A single trawler drags two trawl nets at the same time. A small mesh cod-end, used to measure the overall population, makes up one trawl. The other trawl serves as an apparatus for research. The selectivity of the test cod-end is determined by analyzing the length frequency distribution of the catches from both the test cod-end and the small mesh cod-end. These methods have relatively minimal influence.

Trouser trawl

A vertical panel splits a typical trawl into two halves. There are two attached cod-endsone on each side of the panel. Codend selectivity can be computed by comparing the size distribution of the fish within each codend.

Alternate hauls

To employ this method, hauls must be alternately conducted using both an experimental trawl and a control trawl. Each set of hauls must be identical in every way, including the quantity of hauls made, to ensure the reliability and accuracy of the data.

Parallel hauls

Fishing on the same ground at the same time by two vessels is necessary for this strategy. One vessel hauls the experimental gear, while the other hauls the control gear.

Specificity of Gill Net

Gill nets exhibit selectivity based on size, typically capturing fish that are too large to pass through the mesh while allowing smaller fish to swim through. However, occasionally, larger fish may become entangled in the netting, although this is not consistently the case. Fishing selection, according to Parrish (1963), includes procedures that affect the probability of catching fish in a desired population. This idea encompasses the selection process that happens both among different species and within a species at different stages of catching. It takes into account the location and timing of fish, their interaction with fishing gear, and their susceptibility to capture. The initial two stages are heavily influenced by the distribution and behaviour of fish, whereas the third phase is determined by the properties of the gear. While within-species selection often referred to as length selection considers individual fish characteristics like age and size, between-species selection is based on how a species responds to fishing gear. This selection process is quantitatively expressed as selectivity, which is

usually assessed by comparison fishing using gillnets with different mesh sizes, based on hypotheses such as Baranov's "Principle of Geometric Similarity." In contrast to trawl cod end research, gill-net selection studies.

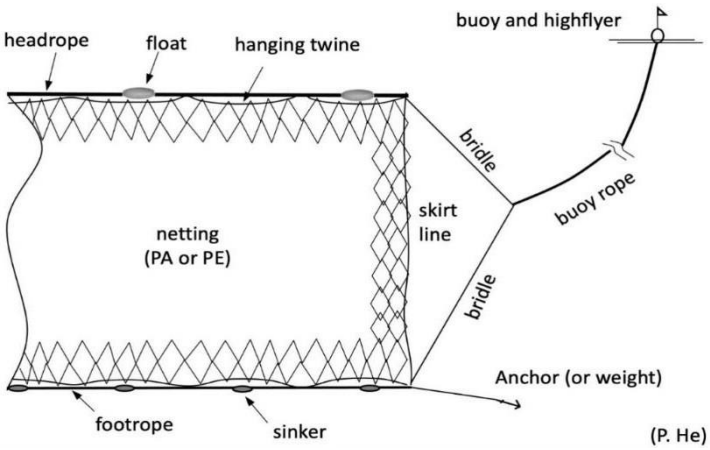

Fig. No. 1 showing the design of the gill net (FAO, 2021)

SELECTIVITY OF FISH ATTRACTION METHODS

Light attraction method

Throughout the tropics and subtropics, lights are employed to attract fish to purse seines, ring nets, or lift nets for capture. In temperate waters, light attraction is rarely used because fish react adversely or in an unpredictable way. Juveniles tend to gravitate to them while mature fish are either repulsed or unaffected. In the tropics, positive photo taxis is seen in the majority of tiny pelagic fish. Sardines, anchovies, saury, tiny mackerel, and bait fish are a few of these. Although they prefer to keep on the edges of the lighted area, squid also respond to light. Large fish are attracted by the concentration and movement of smaller fish, particularly when they are more active in the presence of light. Thus, mixed species fish are typically caught using light attraction and seines or lift nets. There are two exceptions to this rule: squid, which is caught using specialized jigs that won't capture other species, and saury, which swims at the surface and is caught in waters north of Japan using stick-held dip nets. Area-to-area variations in catch composition are possible. If the net and lights are used over deeper or shallower seas, various fish may be caught.

Bait attraction method

Probably the most traditional method of attracting fish, bait is still widely employed today, especially in traps and pots intended for rockfish, lobster, crabs, and prawns. In northern waters, there's a resurgence in longlining for species like cod, halibut, ling, or dogfish after experiencing a decline over the past few years. The Pacific and Indian Oceans are still used for tuna longlining operations. Long lines for swordfish are utilized off the eastern seaboard of the United States. Some regions of the world's small-scale fishermen employ lengthy, bottom-set lines. These techniques are largely species-selective. Sharks on tuna lines, skates on cod lines, and crabs in lobster pots are still common, but they are the exception rather than the rule. It is possible to argue that the baited lines and traps are selective in their

attraction and capture. Naturally, this is somewhat true, as they are situated in regions and at depths where the targeted fish are known to exist.

Innovations in Fisheries Management: Fish Aggregation Devices and Artificial Reefs

In tropical regions, structures known as fish aggregation devices (FADs) are deployed to lure pelagic fish. In the deep waters surrounding the Indo-Pacific islands, fishing methods such as pole-and-line fishing and tuna purse seining are commonly employed around these anchored FADs. In shallower waters near the coast, smaller purse seiners and lift-net boats target sardines and small mackerels near anchored FADs. The FAD is essentially A buoyant platform with strings made of palm leaves, old ropes, netting, or tires fastened to it. The reason why fish are drawn to these gadgets is not entirely clear. It might be used in part for orientation, in part for shelter or protection, and in part for feeding on the smaller fish or algae that gather there. A FAD attracts an integrated population of fish, just like light does. To increase the FAD's pulling power or to entice fish to approach closer before being caught, light or bait attraction is sometimes employed. Typically, the bigger fish swim farther away from the raft, while the smaller ones swim closest to it. Many fathoms below a FAD, big tuna can be caught manually with a line. As their name suggests, reef fish and crustaceans are the primary species drawn to artificial reefs. In areas of the sea bed with little natural habitat, they are placed naked. For many of these species, the artificial structure becomes a favorable home. Northern European fishermen have long engaged in close-in fishing, even though very few of them have been built.

Factors Affecting Gear Selectivity

It is essential to have a previous understanding of the elements that can impact gear selectivity while planning an experiment. The key components are listed in the list that follows. Many ones, such as those about the equipment, are simpler to manage than others that have to do with the fish or the surroundings. But it's important to consider how much of an impact these final components have on the final result. The main reasons vessel owners may seek to increase the selectivity of their fishing gears and reduce discards.

Table 2: Reasons of factors affecting gear selectivity

Reason	Description
Avoid choke points	Removing or limiting captures of specific stocks may assist fishermen in avoiding choke points, which may limit vessel activity and profitability.
Demonstrate fishing sustainability	Customers increasingly want proof that landed harvest is obtained by sustainable fishing methods. When products are successfully labelled as sustainable, eco-friendly, or favourable to the environment, market demand and value may rise.
Increase fishing efficiency	By increasing the amount of marketable catch, decreasing the amount of time spent sorting fish on board, or using less energy per unit of catch, changing the gear used to fish can improve fishing efficiency.
Increase catch quality	By minimizing damage to fish during capture, modified gear may raise the catch's market value.

Improve stock health	Reduce the amount of non-target and undersized fish that are caught in by catch to increase ecosystem output and restocking.

Gear Parameters

1. Floatation and weight
2. Mesh size
3. Hanging ratio
4. Net dimensions
5. Twine characteristics (material, colour, flexibility, etc.)

Parameters related to the fishing operation

1. Depth
2. Environmental factors
3. Sea currents
4. Sea bed
5. Net handling technique

CHALLENGES IN SELECTIVITY OF FISHING GEARS

Complexity of Gear Design: Developing fishing gear that efficiently targets particular species while reducing by catch is a difficult undertaking. To obtain the appropriate degree of selectivity, variables including mesh size, net configuration, and material composition must be considered carefully. Fisheries managers and gear designers are constantly faced with the difficulty of balancing the demands for selectivity and gear efficiency.

Environmental Complexity and Variability: The dynamic character of marine environments brings about uncertainty that can impact fishing gear performance. The efficiency of gear selectivity is impacted by environmental factors that affect fish behavior and distribution, including habitat features, water temperature, and ocean currents. Maintaining selectivity in the face of shifting conditions requires modifying fishing tactics and gear designs to consider environmental unpredictability.

Behavioural Responses of Target and Non-target Species: Achieving selectivity is complicated by the way that fishing gear affects the behavior of both target and non-target species. While some species may display erratic behavior that increases the chance of an unintentional catch, others may actively avoid or be drawn to particular types of gear. It is essential to comprehend and anticipate these behavioral reactions to develop gear that minimizes by catch and efficiently targets desirable species.

CONCLUSION

The crucial role that gears selectivity plays in sustainable fisheries management has been emphasized by this review. Selectivity is essential to sustainable fishing methods because it has a direct impact on the make-up of the catch, interactions with non-target species, and the health of the ecosystem as a whole. Through an analysis of several fishing methods like gillnets, longlines, hooks, trawls, and traps, as well as considerations like mesh size, fishing depth, and gear design, we have acquired important knowledge about the challenges associated with attaining selectivity in various fishing situations. Selective gear reduces by catch and promotes sustainable fishing, however, there are still several issues. Achieving effective selectivity is always hampered by the intricacy of gear design, environmental

unpredictability, and the behavioural reactions of target and non-target species. Additionally, efforts to implement are made more difficult by data restrictions, technology limits, and regulatory compliance.

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