Fishing hooks are among the simplest and the oldest of fishing gears. Due attention has not been given in the study of hooks and whatever information that are made available on the properties and performance of hooks by a handful of workers have now become outdated due to emergence of new models, materials and technologies. This calls for a detailed study on the various properties of present day fishing hooks. As a first step, a detailed review of the studies carried out on fishing hooks was undertaken. The literatures have been sourced from different libraries, abstract databases like the Aquatic Sciences and Fisheries Abstracts (ASFA) database, Science direct, the internet etc. The literature search produced a few documents describing work in India and abroad, giving an overview or basic aspect of the study topic.

It was found that unlike the studies on netting materials, very little is done on fishing hooks. Baranov (1976) has reported on the scarcity of research work on the different properties and quality of fishing hooks. Kenchington and Halliday (1994) have also reported that most of the published research works on fishing hooks are concerned with the catch rates achieved by different hook designs (Bjordal, 1983, 1987). Only a few reports are available on the properties and standards of fishing hooks (Andreev, 1963; Baranov, 1976, 1977; Ko and Kim, 1981; Kitano et al., 1990; Varghese et al., 1997; Thomas et al., 2007; Edappazham et al., 2008). Most of the remaining studies are found limited to the catching efficiency or size selectivity aspects (Takeuchi and Koike, 1969; Despande et al., 1970; Kartha et al., 1973; Ralston, 1982; Huse and
Fernö, 1990; Lokkeborg and Bjordal, 1992; Durai, 2003; Kumar, 2006). Studies on the basic physical properties, mechanical strength properties, corrosion resistance and durability are not much looked into. In this context, a review on the information available on various aspects of fishing hooks is made for further study and development.

2.1. Physical and mechanical properties of hooks

Very few studies have been carried out on the physical and mechanical properties of fishing hooks. Ko and Kim (1981) evaluated six types of hooks for assessing the force required for breaking and unbending due to plastic deformation of the material using dynamometer. The tests were carried out at a speed of 290 mm/min and 780 mm/min respectively. They have also studied the dynamic forces acting on the fishing hook during hooking and hauling. Varghese et al. (1997) studied the physical properties, chemical composition and corrosion resistance of fishing hooks from five indigenous hook manufacturing firms and that of one imported brand (Mustad). They have carried out the unbending test of hooks by recording the load required for deformation equal to bite length. In their study they found that the indigenous hooks were poor in resisting deformation under load in contrast to imported brand and that the Indian hooks were more fragile compared to imported ones. According to Andreev (1963) the breaking load of the hook was independent of the shape and nature of hook. Practically hook failure occurs when the point move 60° from its original position. The load required to deform the hook bend equal to the bite length or that required to deform the bend by 60° from the original position or break occurring before attaining 60° is measured (Anon, 2002). Edappazham et al. (2008) observed that unbending test could be used as an effective tool in analysing the mechanical properties of fishing hooks. They compared the physical and mechanical properties of three imported brands of fishing hooks with two
indigenous brands. It was found that the indigenous brands of hooks were comparable with imported hooks in terms of physical and mechanical properties. This study also revealed that the wire diameter and the unbending force of fishing hooks are positively correlated.

2.2. Chemical composition

The chemical composition of the core material of the hook plays an important role in determining the mechanical strength of fishing hooks. Studies on the chemical composition of fishing hooks are found to be very limited. Chemical composition of Indian and imported hooks was evaluated by Varghese et al. (1997). The elemental make up of the core material of the hooks was analysed using Inductively Coupled Plasma Atomic Emission Spectrometer. They have reported that both types of hooks had almost similar chemical composition. Edappazham et al. (2008) compared the chemical composition of three imported brands of fishing hooks with two indigenous brands. They also did not find any significant difference in chemical constitution of Indian and imported hooks.

2.3. Corrosion resistance

Corrosion resistance, an important criterion in the quality evaluation of a hook, may vary depending on the type of the material, the type of the coating, fishing conditions, water temperature, pH value and type of bait. Only very few studies have been carried out on the corrosion resistance of fishing hooks (Thomas et al., 2007). Corrosion resistance is generally assessed using salt spray chamber test (ASTM B 117 - 03, 2003). Varghese et al. (1997) have opined that 98 hours of salt spray exposure of fishing hook is equivalent to 365 days in sea water. The corrosion resistance of different fishing hook has been studied by Kitano et al.
(1990) and Varghese et al. (1997). The Indian hooks compared very well with the imported hooks in their tolerance to slat spray in the salt spray experiments comparing Indian hooks with imported hooks carried out by Varghese et al. (1997). Wuertz (2002) has described about a ‘Modified ASTM B-117 Salt Spray Test’ in which the fishing hooks were exposed in a salt spray cabinet for 21 days (504 hours) to compare the performance of two different rust preventive coatings used for hooks manufactured by Mustad and Sons A.S., Norway (http://www.mustad.no), one of the major group engaged in hook manufacturing.

Kitano et al. (1990) studied the effect of attaching nylon monofilament on corrosion resistance of fishing hooks. In this study, seawater immersion test and electric potential measurements were conducted for tuna hooks, using various anti-corrosive materials to evaluate their corrosion mechanism and resistance to corrosion. The results showed that the method of attaching aluminum to the fishhook was found to be most effective and even low-priced aluminum proved to be effective. The study pointed out that adopting this method could greatly reduce labour and expenses required to exchange and re-plating of the corroded hooks. Edappazham, et al. (2007) studied the effect of attaching snood wire on corrosion rate of fishing hooks. In this study it was found that rigging of metallic hooks using stainless steel snood wires increased the corrosion of fishing hooks, especially at the eye portion where the snood wire was attached.

2.4. Fishing performance

Hameed (1982) carried out experimental fishing operations using vertical longlines at different water depths to find out the swimming layers of shark. Selectivity of hooks in *Lethrinid* longline fishery of Thoothukudi coast, Tamilnadu (India) was studied by Durai (2003). In a similar study,
the selectivity and efficiency of hooks in *Serranid* longline fishery of Thoothukudi coast was studied by Kumar (2006). In his study he has analysed the selectivity and fishing performance of six sizes of commonly used J-shaped (Round bent) fishing hooks with hook numbers 5 to 10. The hooking percentage observed for different species of *Serranid* fish ranged from 0.13 to 0.56%. He has reported that larger hook sizes had very good selectivity in capture of large sized *Serranids* while small sized hooks showed good selectivity in fishing small sized *Serranids*.

### 2.4.1. Hooking efficiency

The hooking efficiency is influenced by the size and species of the target fish. Hook efficiency can be expressed as the number of successful hooking divided by the number of attempts or number of fish caught divided by number of fish taking the bait (Number of bites). Hooking rate is generally expressed as the number of fish caught per hundred hooks (Gibson, 1979). Despande *et al.* (1970) studied the hooking rate and efficiency of 'Mustad' hook 4/0. Kartha *et al.* (1973) studied the effectiveness of round bent hooks (Mustad) of different denominations using different baits. The responses of cod (*Gadus morhua* L.) and haddock (*Melanogrammus aeglefinus* L.) to baited hooks were analysed by Huse and Fernö (1990) to determine their behaviour patterns, which could form the basis for improved longline hook design. The most important behaviour pattern observed for successful hooking of fish was when the fish swam away rapidly with the baited hook in its mouth, termed as the "rush" behaviour (Huse and Fernö, 1990). A hypothesis for hook design was formed, proposing that a longline hook with its point towards the line of pull would catch more fish than a typical Atlantic longline hook with its point parallel to the line of pull. Two experimental hooks conforming to this hypothesis were compared with a standard hook in fishing experiments. Sulochanan *et al.* (1989) have analysed the
hooking rate of tuna in the Arabian Sea with particular reference to yellow-fin tuna, *Thunnus albacares*. In this study, the catch index for all tuna and that separately for yellow-fin tuna was 1.54% and 1.43% respectively.

George *et al.* (1991) experimented 4/0 round bent indigenous hooks along with imported Mustad hooks. They have compared the hooking rate of sharks for the two types of hooks and found that both are comparable. The studies were conducted from M. V. Saraswathy of CIFE, Bombay in and around Angrea Bank and off southwest Bombay. Studies by Jorgensen (1995) shows that long lines were up to 30 times more effective in catching large fish when compared to the trawls. The study of Olsen (1995) also reveals efficiency of long lines for catching deep water fish. The fishes captured by hook and line fishing are relatively large in size and have better quality. Prince *et al.* (2002) have compared the performance of circle hook and "J" hook in recreational catch-and-release fisheries for billfish. They have reported that circle hooks used on sailfish had hooking percentages that were 1.83 times higher compared with "J" hooks. Bacheler and Buckel (2004) have studied the influence of hook type on the catch rate, size, and injury of grouper in a North Carolina commercial fishery. In a fishery resource survey of the Indian Exclusive Economic Zone (EEZ) around Andaman and Nicobar Islands conducted by Fishery Survey of India (FSI) during August 1989 to December 2002, the overall hooking rate recorded for tuna hook was 1.85% (John *et al.*, 2005).

2.4.2. Hooking Mortality and Survival

Korakandy (2000) reported India’s tremendous potential in recreational fisheries, especially in the state of Kerala as a result of the fast growing tourism industry. He pointed out the long tradition of recreational fishing in
India even before independence. There is a renewal of interest in recreational fishing due to the tourism development in the country. But recreation fishing needs to be introduced on a responsible manner as captured fishes are released subsequently in ‘catch and release’ type of recreation fishing. The survival of the released fish often depends on the severity of the wound and the handling of the catch. Fish caught by hooks are generally hooked in the mouth, particularly in the jaw or in the alimentary tract if the hooks are swallowed (Lokkeborg et al., 1989; Huse and Fernö, 1990; Lokkeberg and Bjordal, 1992). Hook shape can be designed to decide the depth of penetrating the inside of the mouth of a particular species of fish. Injuries to internal organs as a result of deep hooking or hooking in locations other than the mouth significantly increase release mortality (Anon, 2003). Appropriate hook types have to be used for minimum mortality and to conserve fish stocks for continued fishing activities. The design of the hook itself, when used properly, prevents fish from being hooked in the gut, which reduces the mortality.

Circle hooks seem to be a promising type of hook to reduce release mortality (Anon, 2003). They can keep the hooked fish alive, till they are taken out. These hooks are designed to move to the corner of the fish’s mouth and set themselves as the fish swims away. The more a fish is swimming away from the pull point, the more likely the hook will move to the rear corner of its mouth (Anon, 2005b). Significantly lower release mortality in striped bass when using non-offset circle hooks, as opposed to conventional “J” hooks is reported (Lukacovic, 1999, 2000, 2001, 2002; Lukacovic and Uphoff, 2002). Studies by Prince et al. (2002) on billfish, Skomal et al. (2002) on bluefin tuna, Falterman and Graves (2002) on yellowfin tuna, and Trumble et al. (2002) on Pacific halibut also showed significant decrease in release mortality while using circle hooks. Circle hooks can be used for reducing release mortality in rock bass (Cooke et
al., 2003). But the use of circle hooks on bluegill and pumpkinseed showed no significant benefit (Cooke et al., 2003).

A study by Ayvazian et al. (2002) with five hook types on the mortality rate, injury type and injury location for fish to find out the short term mortality following catch and release angling of tailor fish (Pomatomus saltatrix) showed that treble hooks produce significantly higher mortality rate than single barbed and barb less hooks. Treble hooks cause multiple injuries and require increased handling time to disengage hooks from the multiple penetrations, most of which are superficial. Single barbed and barb less hooks even though causes a single injury, significant mortality is caused due to penetration of internal organs such as oesophagus, gills and stomach. Ganged hooks with/without terminal trebles cause jaw injury while barbed and barb less single hooks cause gill injury. Muoneke and Childress (1994) reported that single hooks, especially when used in conjunction with natural baits, resulted in higher mortality than treble hooks.

A review of the studies carried out on different aspects of fishing hook reveals that only very limited studies have been carried out on hooks in the Indian context, with the exception of studies on hooking efficiency. Besides, no data are available on the availability as well as properties of many of the hook types currently used in the field.

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