Resource and Energy Conservation through Hook and Line Fishing

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Introduction

Hook and line gears consist of a minimum of two parts, a hook that is attached to a monofilament line and artificial or natural baits used to lure fish to the hook (FAO, 2001). This type of gear is one of the most common fishing gears used by both artisanal and mechanized sectors (Kurien and Willmann, 1982). Hook and line is one of the best methods of fishing with regards sustainability as this method has little impact on the surrounding environment and the catch can be selective (Rouxel, 2017). For example, any fish too small, or not the right species can be placed back into the water, without harm. These gears make it possible to operate in places with rocky or uneven bottom where it is impossible to deploy gears like ring seine or trawls (Mathai, 2009). Hook and line gear can be classified based on the method of operation. They are hand lines, troll lines, long line, jigging line, and pole and line fishing (Burdon, 1951; Gabriel, Lange, Dahm and Wendt, 2005; Pravin, 2008).

Hand lines

Hand line fishing, or hand lining, is a fishing technique where a single fishing line is held in the hands. One or more fishing lures or baited hooks are attached to the line. Hand lining is among the oldest forms of fishing and is commonly practised throughout the world today. This may be used to capture of all kinds of demersal fishes from motorized as well as mechanized vessels. The gear can be described as hook, fishing lure (or a fishing jig), sinker and float are generally attached to the line. Many hand lines use swivel to prevent excessive fouling and kinking of the line. Sometimes rollers are hauled over rollers on sides of vessel.

Generally the gear is made up of polyamide (PA) braided, twisted or monofilament line. Diameter of line used for fishing is varying highly from 0.2mm to 1cm. Srivastava et al. (2002) recorded 1 to 2 cm thick nylon rope in operation as a fishing line in streams of the Kumaon Himalayan Region of India. On the contrary, in Ratnagiri, hand line with hook made up of PA monofilament twine with diameter varying from 0.23 to 1 mm and length ranging from 5 to 16 m was operated. In Car Nicobar, 3 to 20 m long monofilament line was used for construction of hand line (Ahmed et al., 2013). Whereas in north east India, a rod can been seen tied with indigenous fibre or cotton thread or nylon twine and the end was fixed to a hook (Gurumayum and Choudhury, 2009).

Troll lines

These are lines with baited hooks that are dragged behind vessels called trollers. Trolling is primarily used for surface and subsurface fish. Splashing or rippling of water produced by an object has led to some improvement in the hook and line techniques. It is practised in Androth island of Lakshadweep (Pillai et al., 2006) for catching tuna (Vinay et al., 2017). Troll lines vary from region to region but use both natural and artificial baits. A trolling line consists of a line with natural or artificial baited hooks and is trailed by a vessel near the surface or at a certain depth. Several lines are often towed at the same time, by using outriggers to keep the lines away from the wake of the vessel. The lines are hauled by hand or with small winches. A piece of rubber is often included in each line as a shock absorber. Trolling speeds vary depending on the target species, but generally are between 2.3 and 7 knots. Troll lines may be set for fish close to the surface or the lines can be weighted for fish at selected depths. Lines may be hauled in by hand or by mechanical means (i.e. hydraulics). At the end of each line there are a variety of embellishments – spoons, spinners, and feathered jigs, in addition to baitfish (Gabriel et al., 2005).

Longlines

Long lining can be used to target both pelagic and demersal fish with the lines being rigged and set at a position in the water column to suit the particular species. A basic long line consists of a long length of line, light rope or more common now is heavy nylon monofilament, the 'main line', this can be many miles in length depending on the fishery. To this main line, multiple branch lines with baited hooks on (snoods) are attached at regular intervals. This rig is set either on the seabed (demersal) or in midwater (pelagic) with a 'dhan' bouy at either end, and allowed to fish for a period.

Longlines can be further classified as 1. Set longlines: These are stationary lines that are anchored to the vessel, the seafloor or to an anchored buoy. Setting can be practised either horizontally or vertically. 2. Drift longlines: these are attached to floats that drift freely with the ocean currents.

Jigger lines

These are a specialized type of vertical line, fitted with specialized ripped hooks, used primarily in the southern hemisphere Squid fisheries and some northern Cod fisheries. Multiple hooks are evenly spaced along the main line, which is hauled in using jerky vertical movements. This movement simulates the realistic movement of common prey species of the targeted species. In squid fishery, lights are used to attract the squid towards the surface. As the line is jerked vertically, the squid attack the hooks and are either caught by the mouth or the body. Jigger lines are typically used by specialized jigger vessels, but may also be operated from other types of boats. Jigger lines are generally of two types hand operated and automated jigging machines. Hand operated jigger line employs a reel or drum on which the jigging line is rolled over. Multiple jigs are attached to the jigging line and the reel is released by rotating the reel or drum. In automated jigging machine the machine has two drums and one drum is driven electrically. The machine lowers and retrieves the line in predetermined speed. A wire mesh frame is positioned in such a way to collect the squids falling off the jigs slides directly into boxes on deck.

Pole and line gear

The gear consists of a hook and line attached to a pole. Both artificial and natural fish are used to lure the prey. Poles are commonly made out of wood or fiberglass and can be operated by hand or mechanized. Albacore Tuna and other Tuna species are commonly caught by the pole and line method in commercial fisheries. Pole and line fishing can occur from the surface to great depths, the only limiting factor is the amount of line used. Pole and line fishing is extensively used in some areas such as Lakshadweep island of India, Japan, Maldives, Sri Lanka, California and Hawaii for catching skipjack and other species such as frigate mackerel, little tuna and bonitos. Bamboo poles are traditionally used of size ranging from 2.4 to 2.7m in length. A 75-90cm line is fastened to this pole. A 60cm wire leader bearing lure is attached to the end of this line to which a barbless hook is attached. Small fishes of weight 15-20kg are hauled by a single fisherman. In case of larger fish, a single leader is attached to two lines from two poles. The vessels use live bait and water shower to mimic shoal of small fishes to attract the tuna.

Targeted species in hook and line fishery

Hook and line fishing is highly targeted fishing practice which manages to land high value fishes. Though a high variability in value of fish is observed, Indian waters have shown less diversity in hook and line fishing. Out of five methodologies discussed here, four of them except jigging has targeted tunas invariably all around the coast. More details on targeted species are given gear wise as follows.

Long lining

In the Indian seas, longline fishery is mainly targeting yellowfin and bigeye tunas. As reported elsewhere (Shivasubramaniam, 1963; Pillai and Honma, 1978) the bycatches, especially sharks constitute a major portion of the longline catch in the Indian waters also. Mechanized sectors of Kerala, Tamil Nadu, and Andhra Pradesh rely on longlining for high value fishes like tuna, marlin, sail fish and sharks. In Kerala, landings from hooks and lines fishery contribute about 3.3% of the total fishery. Seerfish landings registered an upward trend with 83.3% increase from 2010 to 2011, out of which 54.7% was contributed by longline in Kerala (CMFRI, 2012). During 2011, 50.8% of elasmobranch catch was contributed by line fishing and grouper contributed about 15% by longline. In Tamil Nadu, 10.6% of seerfish, 1.2% of tuna and 4.2% of elasmobranchs were contributed by hook and line (CMFRI, 2012). In Visakhapatnam, annual catch of tuna recorded by hooks and lines was 2714 t during 2011 constituting dominant species, *Thunnus albacares* (53%), *Katsuwonus pelamis* (31%) and *Euthynnus affinis* (16%) (CMFRI, 2012). According to CMFRI (2012), a total of 29 longliners are operating in Kerala coast, 380 in Tamil Nadu and 21 in Andhra Pradesh during 2010 (Vipin et al., 2014).

Handlining

A very popular method for catching big demersal fishes like emperor fishes (Lethrinids) and snappers (Lutjanids) in the coastal areas of Indian waters. Bottom handlining was carried out with 'vallams' towed by mother ships to the fishing grounds close to the continental slope (Medcof, 1956). Recently handlines are found to be operated by Thoothoor fishermen all around Indian coast. Deep sea going fishermen of Toothoor operates handlining for Kalava fish

(*Epinephelus sp.*) from December to April from mechanized boats. Species like *Selar crumenophthalmus, Decapterus sp., Auxis rochei, Auxis thazard, Epinephelus areolatus E. bleekeri, E. cholorostigma E. tauvina, Thunnus albacares* contributes major catch from Indian coast (D'Cruz, 2000).

Pole and line fishing

The pole and line fishing technique supplies 11% of global tuna (ISSF, 2013) and is considered as a best practice due to its high selectivity and low environmental impact (Gillet, 2011). 10% of the Indian Ocean tuna catch comes from small-scale pole and line fisheries operating out of the Maldives and Lakshadweep islands (Gillett, 2013), landing a majority of skipjack tuna (Katsuwonus pelamis) amongst yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*), kawakawa (*Euthynnus affinis*) and *Auxis* spp. These fisheries utilize small planktivores from island lagoons and reefs as live-bait to target oceanic skipjack resources (Stone et al., 2009), thereby reducing the pressure on the sensitive coral reefs of their atoll ecosystems.

Troll lining

This method is prasticed to a lesser extent in India. An established fishery of pole and line is practiced at Androth island of Lakshadweep. Troll line contribute only 3.3% of tuna landing of Lakshadweep. The catch is dominated by yellow fin tuna, frigate tuna, little tuna, skipjack tuna and other species like shark, seer fish and sword fish (Vinay et al., 2017). Other than India, Maldives and Sri Lanka has troll line fisheries for tuna species (Sivasubramaniam, 1985).

Jigging

This methodology is solely aimed to catch cephalopods based on their feeding behavior all around the world. Countries like Japan, China Sea, New Zealand, Peru, Korea, Malaysia and Vietnam operate automated squid jigging for a wide range of cephalopods (*Todarodes pacificus, Ommastrephes bartramii, Loligo bleekeri, Photololigo edulis, Nototodarus sloanii, Dosidicus gigas, Uroteuthis duvauceli, Sepioteuthis lessoniana, Sepia aculeate, Sthenoteuthis oualaniensis*). Fish jigging is prasticed along North Pacific coast of Japan for Mackerel (Scombridae) and Hairtail (*Trichiurus lepturus*). Automated squid jigging is in experimental stage in India (Mohammed, 2016) whereas a few places like Ratnagiri, Vizhinjam, Kanyakumari, Palk Bay, Tuticorin and Gulf of Mannar- motorised crafts operates hand jigging seasonally. The catch mainly comprised of *Sepia pharaonis*, *Loligo duvauceli*, *Sepia aculiata* and *Sepioteuthis lessoniana* (Sujith and Desmukh, 2011).

Hook and line fishing: bycatch scenario

Since the numbers of species caught are less in a single operation, average mortality rate is assumed to be less than other fishing methods considering population parameters. Line fishing catches desired fishes during operation and unlike trawls, it avoids contact with the sea bottom hence it is assumed that very few species are affected other than targeted species. In a multispecies fishery like India, bycatch reduction has always been challenge (Lobo, 2012). Since the selectivity of line fishing is prominent, concern for bycatch is considerably less alarming.

The trolling method is used all around the world in fisheries targeting tuna, salmon (Salmo spp.), barracuda (*Sphyraena barracuda*) and others (Majkowski, 2003), with incidental capture of seabirds reported. In the Mediterranean, Cooper et al. (2003) reported that small Maltese vessels undertaking trolling for tuna, Bream (*Dentex dentex*) and other predatory fish killed 35 birds. Unpublished information in several countries reported captures of shearwaters (*Puffinus carneipes* and *P. pacificus*), Yellow-nosed albatrosses, Australian pelicans (*Pelecanus conspicillatus*) and boobies (*Sula* sp.) either by taking hooks or by colliding with gear and becoming entangled. Studies indicated minor implications when targeting Yellowfin tuna but major concerns (catch rate of 0.41 birds/day) when targeting Bigeye tuna. Many authors suggested that capture in this trolling occurs commonly and needs to be better studied, particularly when the vessels troll lines slowly (Bugoni et al., 2007).

Handlines are used to catch different species of tunas all around the Pacific Ocean, Indian Ocean, Red Sea, Mediterranean and Atlantic Ocean, frequently around FADs. Handlines are also reported to be a selective fishing method (Majkowski, 2003). But high levels of incidental capture mortality of birds (0.61 birds/day) were reported in Atlantic (Cuthbert et al., 2003; Ryan et al., 2006).

Surface long lines for dolphinfish practised in the Atlantic had a high bycatch of seabirds (0.147 birds/1000 hooks). However, the traditional pelagic longline captures seabirds during winter months (Neves et al., 2006), while the surface longline for Dolphinfish takes place during summer in the Atlantic (Swimmer et al., 2005). A range of characteristics including low depth, deployment during daylight hours, and use of small hooks make it particularly dangerous for seabirds by being available throughout fishing and not only during deployment as in the longline for Swordfish and tuna. Catch rate of sea turtles was also high in the surface longline for Dolphinfish (1.08 turtles/1000 hooks) comparable to rates reported in the pelagic longline fishery for Swordfish in the SW Atlantic of 0.68–2.85 turtles/1000 hooks (Domingo et al., 2006).

Sharks and cetaceans cause significant damage worldwide in pelagic longline fishery operations. Damages are in the form of bite-offs, loss of gear, catch displacement, reduced gear efficiency, and depredation of the catch (Yano & Dahlheim, 1994; Secchi and Vaske, 1998; Garrison, 2007). The experimental longlines operated in Indian waters showed a very high shark catch during the post-monsoon season in the Bay of Bengal (John and Neelakandan, 2004).

Conservation of non-targeted resources

Major bycatch in line fishing are turtles, seabirds, sharks and non-targeted fishes. The most discussed case is the incident of turtles in tuna long line. There are many methods adopted by sector all around the world for the conservation of these resources. Methodologies developed specifically for each organism. These methodologies are listed below:

Avoid hotspots: Hotspots are the location where the unwanted species are caught in large quantities. There is currently no quantification of what constitutes a hotspot. This would be left to the fishermen to determine if they are fishing in an area that is resulting in the incidental capture of sharks, sea turtles, sea birds, marine mammals or unwanted fishes.

Set operational depth to deeper or shallow waters: This may work in case of shark species which swim to the surface waters. Setting line deeper than 100m will avoid most of the species and only yellow fin tuna may come in contact.

Use circle hook with offset: Circle hooks have a rounded shape with a point oriented toward the shank, which is different than the J hook that has a point oriented parallel to the shaft. Circle hooks are wider and therefore more difficult for sea turtles to become hooked on. The offset creates a larger gap between the point and the shank hence the turtles can escape from accidental hooking. Similar to other species, circle hooks are wider and more difficult for some marine mammals to bite and become hooked on. Bill fishes are also known to escape from circle hooks without incidents of hooking. Use of wider circle hooks in place of narrower J and tuna hooks to reduce turtle bycatch rates and mortality in longline fisheries has also been found to reduce seabird bycatch rates by about 80% (Gilman, 2011)

Line weighting: Weights are added to the branch line so hooks are quickly deployed to the target fishing depths. This reduces bycatch of seabirds by moving the baited hooks out of the diving range of seabirds. The effectiveness of line weighting depends on the distance between the weight and the hook (a short distance accelerates the initial sink rate) and the amount of weight added (greater weight accelerates the subsequent sink rate). This mitigation measure must be used in conjunction with properly deployed streamer lines or night setting in case of seabird interaction. Using weight or lead swivels of minimum weight 45g within 1m of the hook may reduce sea turtle interaction also.

Use of finfish bait: Using finfish instead of squid for bait has been shown to reduce sea turtle interactions. This may be more effective for leatherback sea turtles compared to other species. Using finfish instead of squid for bait has been shown to reduce interactions with some but not all shark species

Night setting: Night setting is the practice of setting and hauling fishing gear between dusk and dawn. No modifications to fishing gear are needed and this has been proved to avoid sea bird interaction to logline.

Shorter soak time: This reduces the amount of time the gear is in the water, reducing potential interactions. It also may reduce mortality in incidentally captured turtles because they remain hooked for a shorter period of time Adequate soak time reductions would be species/fishery specific. The challenging part is to determine soaking time for specific species with experimental fishing.

Streamer line (tori or bird scaring line): This is a line with streamers that is towed from a high point as the baited hooks are deployed (usually near the stern). An aerial segment with streamers suspended at regular intervals is formed as the vessel moves forward, creating drag on the streamer line. The mitigation measure works by maintaining the streamer line over the sinking baited hooks, therefore preventing seabirds from attacking the bait and becoming hooked.

Conduct fleet communications: This will allow fishermen and policy makers to determine where marine mammal sightings may have occurred and move fishing locations when interactions occur

Prohibit the use of wire leaders and shark lines: Shark lines are attached to the floats and stay above mainline of logline. Wire leaders prevent sharks from being able to bite through and escape after accidental capture. Shark lines may attract more sharks to the fishing gear.

Removing the first and/or second hooks closest to the float in each basket: The hooks closest to the float fish in shallower water and therefore have a higher likelihood of incidentally capturing sea turtles.

Hook-shielding devices: These are devices that encase the point and barb of baited hooks. This prevents seabird attacks during the setting process. Hooks are released after the hook has reached a minimum of 10m depth or has been in the water for a minimum of 10 minutes. The Hook Pod and Smart Tuna Hook are two devices assessed as having met ACAP (Agreement on the Conservation of Albatrosses and Petrels) performance requirements.

Use 'weak' hooks: These are specially designed hooks that break or bend when certain amount of pressure is applied, allowing incidentally captured species the ability to escape. Mostly used in case of marine mammal incidents as they are stronger than fishes.

Restrict the use of light sticks: This may reduce billfish interactions by lessening the ability to see baited hooks. Turtles are also found attracted to light sticks.

Use of monofilament for the mainline and branch line: Monofilament line reduces the risk of entanglement compared to multifilament lines. Monofilament is less flexible, making it easier to release entangled sea turtles (i.e. reduces knotting of the line).

Time/area closures: Time-area closures and restrictions on the timing of setting could further reduce seabird bycatch as these factors have been observed to have significant effects on seabird catch rates

Cover the point of the hook: This will reduce the ability of sea turtles to bite and become hooked.

Avoid using light sources: This may reduce sea turtle interactions by lessening the ability of turtle to see baited hooks.

Fisheries certification: It is important to recognise and reward good fishing practices in the market place. Among the most popular seafood certification organisations is the Marine Stewardship Council. The Council certifies fisheries based on the sustainability of fish stocks, the level of environmental impact (one of the parameters is that the fisheries should have negligible/low levels of bycatch), and whether the fishery is being effectively managed. A fishery that comes close to meeting these criteria of sustainability is the pole and line skipjack tuna fishery in the Lakshadweep. However, it is important to recognize the dynamic nature of what constitutes bycatch and evolve incentive systems which recognise the moral, social, and economic implications of bycatch along with its ecological impacts. It is equally important to understand that certification alone is not likely to bring about major improvements in the conservation of bycatch species. So far certification has primarily been effective in raising awareness among consumers (Ward, 2008). Its shortcomings are that it is seen primarily to market opportunities, and has rarely, if ever, helped the recovery of depleted species (Jacquet et al. 2009; Jacquet et al. 2010).

Hook and line fishing: insight into advantages

Hook and line fishing is more selective than other types of fishing in terms of species and size, and provides high quality fish (Erzini et al., 1996). The method can be used in spawning fish as they normally only bite after completion of spawning (Farmer et al., 2017). Lines are set for a relatively short time so that any unwanted species can often be returned live to the sea. Advantages of hook and line fishing are listed below.

Quality of end product: while comparing meat quality from hook and line fishing and trawl caught fishes, line caught fishes exhibit firmer as well as whiter meat. The better quality may be due to better bleeding and less compression damage. Both the compression damage and the poor bleeding out are caused because trawling brings up from five to twenty tons of fish onto the deck each time, while with long-lining the fish are brought on board one by one.

Lower fuel consumption: A significant advantage that longliners have over trawlers is the relatively low fuel consumption per unit of catch. For example, it was established that a trawler expends 0.6-1.5 tonnes of fuel per tonne of raw fish caught, while a longliner expends 0.1-0.3 tonnes (Karpenko, 1997; Makeev and Shentyakov, 1981; Pavlov and Makeev, 1987; Glukhov, 1994; Chumakov and Glukhov, 1994a, 1994b; Sorokin and Chumakov, 1995). With regards the amount of fuel used over time, the longliner spends 2.7 times less fuel every hour than a trawler (Zherebenkova and Makarova, 1990). The results of modern-day research in the Barents Sea show that a longliner spends 0.3-0.6 tonnes of fuel per tonne of raw fish caught (Grekov, 2007a). This is approximately 20-40 % of the fuel consumption of a similar type trawler (Bjordal and Lokkeborg, 1996).

Species selectivity: In general, neither the trawl nor the longline can be considered as fishing gears that have a high selectivity towards some species of fish. Trawl can hardly be called a selective fishing gear as it takes almost everything that comes into a forenet (Bjordal and Løkkeborg, 1996). As for the longline, it is more selective because of its passivity. The catch depends mostly on the behaviour, biology and physiology of the fish. In particular, most fish cannot be caught by a longline as they are simply unable to swallow a hook (Lokkeborg, 2000). According to the work carried out at Barrent Sea, twenty-nine species of fish are harvested by longline. When carrying out trawler-acoustic counting of ground fish stocks, up to 70 types of fish were recorded in trawls (Grekov, 2007).

Size selectivity: As the number of hooks on a longline is limited, the hooking of a large fish reduces the number of free hooks and so lowers the chances of catching juveniles. Furthermore, the hook itself is selective regarding fish size as small-sized fish can swallow a baited hook of no larger than a certain size. By changing the size of the hook and bait, therefore, one can satisfactorily control the volume of by-catch of small-sized fish (Grekov, 2007).

Value of fish products: In general, the larger the fish, the higher its value. There are more large fish in logline catches and longliners tend to catch more products of large size. Consequently, more income is generated. According to verbal information provided by ship owners, the market value of fish produced by longliners is 15-20 % higher than for trawlers, largely because of the higher quality of product harvested by longliners.

Energy efficiency in hook and line fisheries: key areas to aim: The significance of energy and fuel in the fisheries sector and its vulnerability to changing energy supplies and prices have highlighted the need to review the sector's energy and fuel needs and interactions, and their future trends. This needs to consider different areas and parts of the sector to and mitigating the effects of increased energy and fuel costs.

Data acquisition, energy management and control systems and energy audits

With the aid of proper tools like sensors and data loggers, energy consumption can be measured. The integration of data collection with criteria settings may allow estimation of relationship between speed and fuel consumption for vessel. A more complex system should be able to optimize aspects as the electricity consumption also. An energy audit, which requires extensive expertise and a good data acquisition, may propose solutions for each vessel. It is a necessary step to reduce energy consumption of existing vessels. Transparent energy audits should be promoted, defining the existing "base line" in terms of energy efficiency and advising about how to improve.

Propeller optimization

Fishing boats are often equipped with propellers not matching correctly their needs, despite this is a critical aspect in fuel consumption control. Interventions frequently focus on engines, but some experts consider this is probably not the best factor to influence on. However, it appears to be no awareness about the importance of a correct propeller selection, and propeller for specific fishing practices need to be developed. The correct choice of the engine is critical for fuel consumption. In particular, engines have poor performance when working under low load. A configuration to consider is the use of two different engines when two different regimes are frequently used. In addition to possible improvements in design and maintenance, proper selection and modification when necessary are important. In some vessels, the choice of two gear ratios could be a good option.

Alternative fuels and complementary energies

It is necessary to study the economic and energetic feasibility in order to obtain complete information and offering energy-efficient solutions to the energy consumption of the fishing vessels. In this context, the principal aims are to analyse and assess, through feasibility and techno-economic studies, the potential use of other fuels, and/or alternative energy for fishing vessels. Main fuels to consider are: LNG, CNG, LPG, hydrogen, biofuels, and syngas. Main alternative energies to consider, usually as auxiliary energy, are: wind turbines, sails and solar energy sources.

Modifications in the vessels

Design technologies must optimize energy consumption. Computer simulation methods and testing of models can be improved, but especially should be more widely used in fishing boats. Maintenance of the ship painting in contact with water can help reducing friction and therefore reducing fuel consumption. The design of bulbs may be an option on ships already constructed, but changing hull configuration could be the most expensive action, and current regulation is a barrier. In any case, correct data acquisition would be crucial in order to suggest and assess hull modifications.

Energy for uses other than propulsion

Improvements in electricity consumption management would allow using engines of lower power, at higher load. This greatly reduces consumption. Generating electricity with a part of the propulsion engine reduces consumption as well. The residual heat from the propulsion engines contains more than 60% of the energy of the fuel. This energy is in the exhaust gases, and in the water used for cooling the engines. Some of this energy can be recovered for heating water (boiler), cooling in refrigeration room and desalination of seawater to obtain potable water. The use of electric consumers (such as kitchens, heating and/or cooling systems, desalination systems, lights, deck machinery (hydraulic, electric), pumps, etc.) must be minimised and correctly regulated. It is recommended to explore possible advantages derived from converting hydraulic actuators, or other systems, into electric ones (example: an electric rudder system works just when the movement is needed, whilst hydraulic systems include a pump working consistently).

Efficient steering and navigation

Through efficient steering and navigation, a fishing operation can achieve lower fuel consumption by introducing variations on the way of storing, way of processing and of transporting fishes. It is necessary to study the economic cost of implementing the different proposed models to assess their actual implementation capacity

Conclusion

Line fishing methods especially longline and pole and line widely used in Indian waters has advantages in biological and economical aspects as discussed earlier. Considering the current production from line fishing where tuna is targeted, production level has to fill in the huge gap with estimated potential of tuna from coastal fishing and island fishing. However, it is also to be noted that line fishing has the clear drawback of needing to use additional biological resources in the form of bait especially live bait for pole and line fishing. The large scale development of the line fishery is one of the means of optimizing exploitation of resources from Indian waters. At the same time, it is necessary to understand that development of the fleet must not only be aimed at increasing size but also at increasing efficiency.

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