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Waste Minimisation in Fishing Operations

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Abstract

Sources of wastes in fishing operations mainly include bycatch discards; processing wastes where catch is processed onboard; plastic wastes due to abandoned, lost and discarded fishing gear; bilges and other wastes from the vessel operations. Fishing systems in general have an associated catch of non-targeted organisms known as bycatch. Non-selective fishing gear that is not modified or equipped to exclude non-targeted organisms, may take a significant quantity of bycatch of non-targeted finfish, juvenile fish, benthic animals, marine mammals, marine birds and vulnerable or endangered species that are often discarded. Average annual global discards, has been estimated to be 7.3 million t, based on a weighted discard rate of 8%, during 1992-2001 period. Trawl fisheries for shrimp and demersal finfish account for over 50% of the total estimated global discards. Plastic materials are extensively used in fisheries, owing to their durability and other desirable properties, contributing to the efficiency and catchability of the fishing gear. However, plastics biodegrade at an extremely slow rate compared to other organic materials. Abandoned, lost or otherwise discarded fishing gear (ALDFG) and related marine debris have been recognized as a critical problem in the marine environment and for living marine resources. Prevention of excess fishing capacity by appropriate management measures could lead to enormous savings in terms of fuel consumption, emissions and bycatch discards from the excess fishing fleet, capital and operational investments and labour deployment in capture fisheries, with significant economic gains. In this paper, wastes originating from fishing operations are reviewed, along with their environmental impacts and possible mitigation measures.

Keywords: Capture fisheries, bycatch discards, bycatch reduction technologies, plastic wastes, garbage, engine emissions, waste minimization

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Introduction

Wastes are substances or objects that are disposed of or are intended to be disposed of or are required to be disposed (Anon, 1989; EC, 2008). Wastes generated in capture fisheries include bycatch discards; onboard processing wastes; plastic wastes due to abandoned, lost or discarded fishing gear; bilges and other wastes from vessel operations. Non-selective fishing gear that is not modified or equipped to exclude non-targeted organisms, may take a significant quantity of bycatch of non-targeted finfish, juvenile fish, benthic animals, marine mammals, marine birds and vulnerable or endangered species that are often discarded. The importance of reducing waste and minimizing ecological impacts of fishing operations has been emphasized by scientists and fishery managers (Laist, 1997; Kiessling, 2003; Brown et al., 2005; Harrington et al., 2005; Brown & Macfadyen, 2007; Boopendranath, 2007a; 2007b; 2008; NRC, 2008; Macfadyen et al., 2009; FAO 2010, Andrady, 2011; Thompson et al., 2011; Suuronen et al., 2012; Boopendranath, 2012). In this paper, an attempt is made to review the sources of wastes from fishing operations, their environmental impacts and possible mitigation measures.

Sources of wastes in fishing operations

Generation of wastes during fishing operations are represented in Fig. 1. Sources of wastes include bycatch discards; processing wastes where catch is processed onboard; plastic wastes due to abandoned, lost or discarded fishing gear; bilges, garbage and other wastes from the vessel operations.

Bycatch discards from harvesting systems

The term bycatch refers to non-targeted species retained, sold or discarded for any reason (Alverson et al., 1994). 'Target catch' is the species or species assemblage primarily sought in a fishery (e.g. shrimps and cephalopods), 'incidental catch' is the retained catch of non-targeted species and 'discarded catch' is that portion of catch returned to the

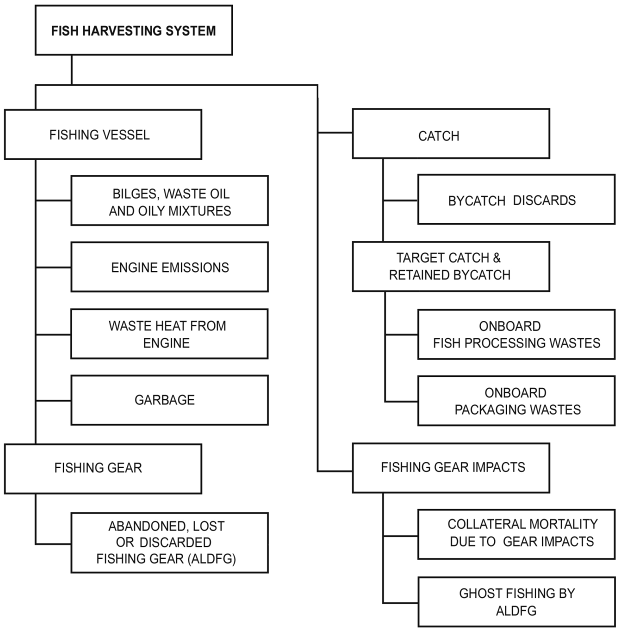

Fig. 1. Waste generation during fishing operations

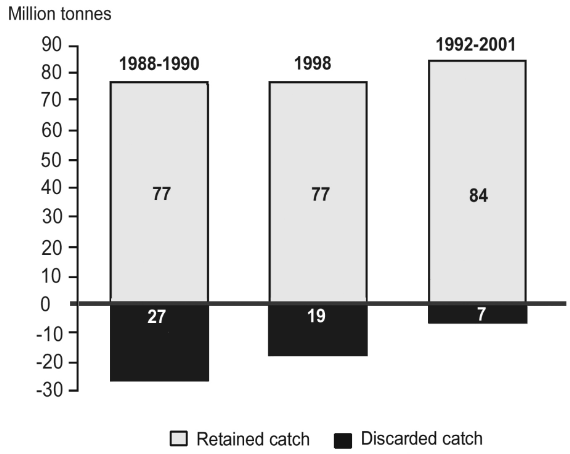

Fig. 2. Bycatch discards in world fisheries (Source: Alverson et al., 1994; FAO 1999a; Kelleher, 2004)

sea because of economic, legal or personal considerations. Bycatch includes both discarded and incidental catch. In addition to the non-targeted finfishes and invertebrates, bycatch also involve threatened and protected species like sea turtles.

Global bycatch by the world's marine fishing fleets was estimated at 28.7 million t in 1994, of which 27.0 million t (range: 17.9-39.5 million t) were discarded annually and shrimp trawling alone accounted for 9.5 million t (35%) of discards annually (Alverson et al., 1994). In 1998, FAO estimated a global discard level of 20 million t (FAO, 1999a). Average annual global discards, has been re-estimated to be 7.3 million t, based on a weighted discard rate of 8%, during 1992-2001 period (Kelleher, 2004) (Fig. 2). The reduction in bycatch discards in recent years could be attributed to (i) increased use of bycatch reduction technologies, (ii) anti-discard regulations and improved enforcement of regulatory measures, and (iii) increased bycatch utilization for human consumption or as animal feed, due to improved processing technologies and expanding market opportunities. Globally, shrimp trawling contributes to the highest level of discard/catch ratios of any fisheries, ranging from about 3:1 to 15:1, and the amount of bycatch varies in relation to target species, seasons and areas (EJF, 2003). Trawl fisheries for shrimp and demersal finfish account for over 50% of the total estimated global discards (Kelleher, 2004). Trawl bycatch in the tropics is known to be constituted by high proportion of juveniles and sub-adults, particularly of commercially important fishes, which needs serious attention in development and adoption of bycatch reduction technologies (Sivasubramaniam, 1990; Luther & Sastry, 1993; Rohit et al., 1993; Menon, 1996; Pillai, 1998; Pravin et al., 1998; Sujatha, 1995; 1996; 2005). Najmudeen & Sathiadhas (2008) have estimated the annual economic loss due to juvenile fishing by trawlers, purse seiners, ring seiners and mini-trawlers together, along the Indian coast at US$19 445 million yr^{-1}. Kelleher (2004) has estimated total bycatch discards in Indian fisheries at 57 917 t, which formed 2.03% of the total landings. Pramod (2010) has estimated the bycatch discards of Indian trawlers as 1.2 million t. FAO has recently brought out International guidelines on bycatch management and reduction of discards (FAO, 2011).

Bycatch reduction technologies

Different types of bycatch reduction technologies have been developed in the fishing industry around the world (Prado, 1993; Eayrs, 2005; Boopendranath et al., 2006; 2008; 2010; Boopendranath, 2007b; 2009; 2012; Kennelly, 2007; Boopendranath & Pravin, 2009; Pravin et al., 2011; Suuronen et al., 2012) (Table 1). Devices developed to exclude endangered species like turtle, and to reduce non-targeted species in shrimp trawling are collectively known as Bycatch Reduction Devices (BRDs). These devices have been developed taking into consideration (i) variation in the size and (ii) differential behaviour pattern of

Table 1. Approaches for bycatch reduction

Gear design related approaches

Trawls

- Trawl design improvements
- Mesh size optimisation
- Bycatch reduction devices and turtle excluder devices
- Juvenile and trash fish excluder devices

Purse seines

- Seine design and seine depth, appropriate for schools of target species
- Mesh size optimisation
- Use of aprons in the seine design

Gillnets

- Optimisation of gillnet dimensions
- Optimisation mesh size
- Choice of netting material
- Choice of colour of netting
- Optimisation of hanging ratio
- Use of biodegradable materials in rigging and construction to prevent ghost fishing

Hooks and lines

- Hook design optimisation
- Hook shape and size
- Hook spacing
- Use of circle hook to minimise sea turtle bycatch
- Use of rare earth magnets in the proximity of hooks to deter sharks
- Use of dyed baits, side sets, subsurface line setting chutes and bird scaring steamers to deter birds

***Trap*s**

- Trap design optimisation
- Optimised trap mouth
- Escape windows
- Use of biodegradable materials in rigging and construction to prevent ghost fishing

Operation related approaches

- Choice of bait type and bait size appropriate for the target species in hook and line operations; use of dyed baits, side sets, subsurface line setting chutes and bird scaring steamers to deter birds; and deep setting of line to minimize sea turtle bycatch
- Use of scaring devices and acoustic deterrents to prevent cetacean bycatch in gillnets
- Choice of fishing area
- Choice of fishing depth
- Choice of fishing time and season

shrimp and other animals inside the net. BRDs can be broadly classified into three categories based on the type of materials used for their construction, *viz.*, Soft BRDs, Hard BRDs and Combination BRDs. Soft BRDs make use of soft materials like netting and rope frames for separating and excluding bycatch. Hard BRDs are those, which use hard or semi-flexible grids and structures for separating and excluding bycatch. Combination BRDs use more than one BRD, usually hard BRD in combination with soft BRD, integrated into a single system. Juvenile mortality could be reduced by using specially designed BRDs for juvenile exclusion such as Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD) (Boopendranath et al., 2008; WWF, 2009) and Juvenile and Trash Excluder Device (JTED) (Chokesanguan et al., 2000).

Turtle Excluder Devices (TEDs) are recognized internationally as a convenient and effective measure for preventing trawling-related mortality and for reducing bycatches of sea turtles in shrimp landings (Mitchell et al., 1995). CIFT-TED is an efficient turtle excluder device developed at Central Institute of Fisheries Technology (Cochin, India) with focus on reducing catch losses, which is a cause of concern for trawler fishermen in adopting the device. Catch losses during the experimental operations due to installation of CIFT-TED were in the range of 0.52-0.97% for shrimp and 2.44-3.27% for non-shrimp catch components (Dawson and Boopendranath, 2001; CIFT, 2003; Boopendranath et al., 2003; CIFT, 2007). About 50 designs of BRDs and TEDs developed for different resource groups and fishing areas are in vogue either in experimental or commercial operations (Boopendranath et al., 2008).

Approaches for bycatch reduction in gillnets, purse seines, hooks and lines, and traps have been recently reviewed by Boopendranath (2009) (Table 1). Bycatch in drift gillnets may include marine mammals, sea turtles and seabirds, in addition to non-targeted fish species. Optimisation of gillnet mesh size and hanging coefficient according to the target species and size group and judicious deployment of gillnet in terms of fishing ground, fishing depth and season in order to minimise the gear interaction with the non-targeted species are important bycatch mitigation measures for gillnet fisheries. Recent innovations have attempted to make the gillnets detectable by marine mammals having echolocation abilities, using acoustic pingers and specially treated netting (Carretta et al., 2008). Acoustic reflective polyamide netting treated with barium sulphate has been reported to reduce bycatch of harbour porpoise in gillnets (Trippel et al. 2003; Larsen et al., 2007). Lost gillnets continue to gill and entangle fish and other marine organisms leading to unwanted mortality as gillnet material is non-biodegradable. This process known as ghost fishing is a negative characteristic of modern gillnets which is otherwise a simple, energy efficient method of fishing particularly suited for scattered populations, requiring low investment.

Selection of mesh size for the purse seine appropriate for the target species, proper choice of fishing area, depth and season could lead to better selectivity of purse seines. Special escape panels known as Medina panels, which are sections of fine mesh that prevent dolphins from becoming entangled in the gear, and back down manoeuvre have been deployed to prevent capture of dolphins in purse seines (Ben-Yami, 1994). Optimized hook design and size and selection of bait type and bait size appropriate for the target species and size class, proper choice of fishing ground, depth and time of fishing are approaches for mitigation of bycatch issues in hook and line fisheries and to minimise gear interaction with other species. Approaches to reduce bycatch in trap fishing include optimised trap design and trap mouth configuration according to the target species and provision of escape windows for juveniles and non-target species in the design side and appropriate choice of bait type, fishing area, fishing depth, fishing time and season in the operational side to minimise gear interaction with non-target species.

Minimizing wasteful destruction of benthic organisms during bottom trawling

Direct and indirect impacts of bottom trawling on marine environment and benthic communities are well known (Kaiser et al., 1998; Hall, 1999; Kaiser & de Groot, 2000; Barnes and Thomas, 2005; Meenakumari et al., 2008). Gear modifications to achieve the objective of reduced impact on environment include lighter gear construction, semi-pelagic trawling, benthic release panels and minimising contact area of the towed gear with seabed (Carr & Milliken, 1998; CEFAS, 2003; Valdemarsen & Suuronen, 2003; He, 2007; Valdemarsen et al., 2007; Suuronen et al., 2012; Boopendranath, 2012).

Onboard processing and packaging wastes

During onboard processing, wastes are generated due to (i) unwanted catch landed and discarded; (ii) high grading due to limited ice and storage capacity; (iii) processing wastes such as particles of flesh, skin, bones, entrails, shells or liquid stickwater; and (iv) packaging wastes which may include plastics. Processing wastes such as head, viscera, gonad, liver, skin, bones and cartilage from whole fresh fish may range from 30 to 73%, in the case of finfishes and from 22 to 73% in the case of shellfishes, depending on species (Chakraborti, 2006). Appropriate waste management and waste valorisation procedures should be put in place, in fishing vessels that have onboard processing facilities.

Abandoned, lost or otherwise discarded fishing gear (ALDFG) and other plastic wastes

Plastic materials are extensively used in fisheries, as they have very good strength, other desirable properties, and contribute to the high efficiency and catchability of the fishing gear (Ayyappan et al., 2005). Most important synthetic fibres used in fisheries are polyethylene (PE), polyamide (PA), polypropylene (PP) and polyester (PES) and other synthetic materials such as polyvinyl chloride (PVC), polyvinyl alcohol (PVAA) and polyvinylidene chloride (Saran) (PVD) are less widely used (Hameed & Boopendranath, 2000; Meenakumari & Radhalakshmi, 2003). Though valued for their extreme durability, plastics have been considered to be among the most non-biodegradable synthetic materials in existence (Sivan, 2011). The lifetime of a plastic material in the marine environment varies depending on environmental conditions, and may extend to hundreds of years for complete mineralization (Andrady, 2011). Although degradation rates of plastics are extremely low, they break down into less conspicuous microplastics (<5 mm in size) which may further degrade into nano-sizes. Microplastics are pervasive in seawater and marine sediments and are rapidly increasing, long-term threat to the fisheries environment (Moore, 2008; Andrady, 2011; Cole et al., 2011; Thompson et al, 2011).

Abandoned, lost or otherwise discarded fishing gear (ALDFG), popularly known as derelict fishing gear, cause ecological concerns such as ghost fishing. In 1975, the world's fishing fleets dumped approximately 135 400 t of plastic fishing gear and 23 600 t of synthetic packaging material into the sea (Cawthorn, 1989; DOC, 1990). A recent review of gear loss, abandonment and discard indicators from around the world has shown the ranges to be 0.02-3.2% per boat per year for gillnets, 20-30% for traps and 3% loss of hooks for tuna longline (FAO, 2010). ALDFG and related marine debris is recognized as a critical problem in the marine environment and for living marine resources in terms of the long-term sustainability of fish stocks, due to ghost fishing and habitat loss, safety of navigation, and impact on endangered species such as marine mammals and turtles (Laist, 1987; Jones, 1995; Ayyappan et al., 2005; Macfadyen et al., 2009; FAO, 2010). Approaches to minimize ghost fishing include (i) use of biodegradable twines to connect the netting to floats in gillnets whereby floats are separated after a fixed duration due to disintegration of the link and the gillnets loose the fishing attitude and hence the ability to fish and (ii) use of biodegradable netting panels in traps (Boopendranath, 2009; Macfadyen et al., 2009).

The deleterious effects of plastic debris on the marine environment have been reviewed by Derraik (2002) and others. A large number of marine species is known to be harmed or killed by plastic debris. Marine animals are mostly affected through entanglement in and ingestion of plastic litter (Laist, 1997; Kiessling, 2003; Brown et al., 2005; Brown & Macfadyen, 2007; NRC, 2008; Macfadyen et al., 2009; FAO 2010; Andrady, 2011; Thompson et al., 2011). A number of measures aimed at the prevention and mitigation of ALDFG and its impacts, such as gear recovery programmes and technological measures to prevent ghost fishing by ALDFG have been identified and many have been implemented in different countries (Macfadyen et al., 2009; FAO 2010). Measures such as effort restrictions which are implemented to tackle problems of excess capacity may have the additional benefit of reducing ALDFG.

Approaches to minimize plastic debris and measures aimed at the prevention and mitigation of ALDFG and its impacts include the following:

- Use twines, ropes, netting, connectors and shackles of correct specifications and breaking strength, in fishing gear fabrication.
- Introduce a system of marking fishing gears and procedures for reporting of lost fishing gears and their retrieval.
- Compliance of MARPOL regulations (IMO, 2010) that prohibit at sea disposal of plastics and other synthetic materials.

Garbage, waste oil and oily mixtures and emissions from the vessel operations

Garbage, waste oil and oily mixtures and emissions are generated during the vessel operations. Pollution of the marine environment by ships of all types, including fishing vessels, is strictly controlled by the MARPOL 73/78, the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. Different annexes of MARPOL deals with Oil (Annex-I), Noxious Liquid Substances carried in Bulk (Annex II), Harmful Substances carried in Packaged Form

(Annex III), Sewage (Annex IV), Garbage (Annex V) and Air Pollution (Annex VI) (IMO, 2010).

In accordance with regulation 9 of Annex V of the MARPOL 73/78, a record is to be kept of each discharge of garbage at sea, to reception facilities or to other ships. The garbage includes all kinds of food, domestic and operational wastes excluding fresh fish and parts thereof, generated during normal operation of the vessel and are liable to be disposed continuously or periodically except those substances which are defined or listed in other annexes to MARPOL 73/78 (Table 2). Every vessel of 12 m or more in length overall shall display placards which notify the crew and passengers of the disposal requirements. Fishing vessels of 400 gross tonnage and above need to carry a Garbage Management Plan providing procedures for collecting, storing, processing and disposing of garbage and maintain a Garbage Record Book giving details of discharge operations. The discharge of oily mixtures into the sea is prohibited. The only allowable discharge of an oily mixture is where a discharge rate of 15 ppm is achieved through oil filtering/separating equipment. All vessels over 400 tons are required to be fitted with this type of equipment.

World capture fisheries consumes about 50 billion litres of fuel annually (1.2% of the global fuel consumption) releasing an estimated 134 million t of CO_2 into the atmosphere at an average rate of 1.7 t of CO_2 per tonne of live-weight of landed product (Tyedmers et al., 2005). Annual fuel consumption by the mechanized and motorized fishing fleet of India has been estimated at 1220 million litres which formed about 1% of the total fossil fuel consumption in India in 2000 (122 billion litres) releasing an estimated 3.17 million t of CO_2 into the atmosphere at an average rate of 1.13 t of CO_2 per tonne of live-weight of marine fish landed (Boopendranath, 2008) (Fig. 3). CO_2 emission per kg of fish landed in India have been estimated to range from 0.3-1.02 kg in traditional motorised operations undertaking ring seining and mini-trawling, 0.17-0.99 kg in small-scale mechanised operations undertaking purse seining, gillnetting-cum-lining and bottom trawling, to 0.87-3.52 kg in large-scale mechanised operations undertaking aimed midwater trawling and bottom trawling (Boopendranath, 2008) (Fig. 4). Other pollutants from vessel operations include nitrogen oxides (NO_X) and sulphur oxides (SO_X) from engine emissions and ozone depleting substances from refrigeration plants and fire fighting systems. A typical fishing vessel utilizes only about 40% of the inherent energy of the fuel used onboard for propulsion and generation of energy and 60% is lost as waste heat. Technologies to convert the waste heat into electricity or cooling systems, if developed, could potentially lead to savings of 15-20% in fuel consumption of the vessel (Anon, 2006).

Approaches for energy conservation and minimization of GHG emissions from fishing fleet have been

Table 2: MARPOL 73/78 Garbage disposal regulations

Garbage type**	Disposal outside special areas*
Plastics including synthetic ropes, synthetic fishing nets and plastic garbage bags and incinerator waste from plastic products, which may contain toxic or heavy metal residues.	Disposal prohibited
Dunnage, lining and packing materials, etc, which will float	> 25 nm offshore
Paper products, rags, glass, metal, bottles, crockery and similar refuse	> 12 nm
All other garbage including paper products, rags, glass, metal, bottles, crockery and similar refuse comminuted or ground	> 3 nm
Food wastes not comminuted or ground	> 12 nm
Food wastes comminuted or ground	> 3 nm

* Special areas (MARPOL Annex V) include the Mediterranean Sea, the Baltic Sea, The Black Sea, the Red Sea, the Gulf Area I, the north Sea, the Antarctic Area and Wider Caribbean Sea, where it is illegal to discharge any garbage except food waste which may only be discharged beyond 12 nm offshore.

** Mixed refuse types: When garbage is mixed with other discharges having different disposal requirements, the more stringent disposal requirements shall apply.

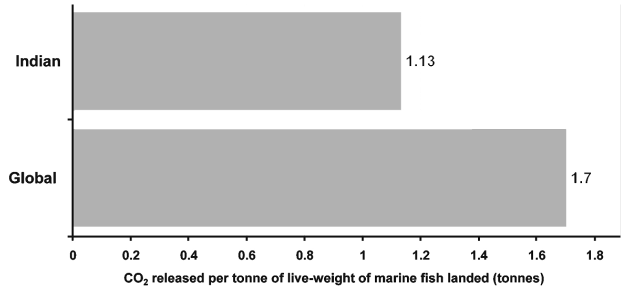

Fig. 3. GHG emissions from Indian and global fishing fleet (Source: Tyedmers et al., 2005; Boopendranath, 2008)

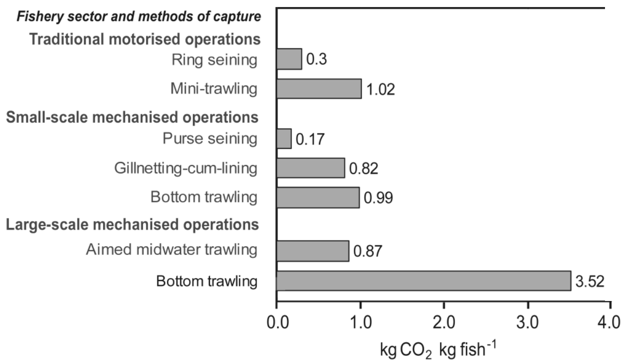

Fig. 4. GHG emissions according to fishery sector and methods of capture (Boopendranath, 2008)

reviewed by Gulbrandson (1986), Wileman (1984), Aegisson and Endal (1993), Boopendranath (1996; 2009) and Wilson (1999). The approaches include appropriate adoption of (i) low energy fishing techniques; (ii) low drag trawls; (iii) pair trawling; (iv) economic vessel speed; (v) hull design and displacement optimisation; (vi) effective anti-fouling measures; (vii) appropriate choice of engines; (viii) right sizing of engines; (ix) emission standards and fuel quality; (x) preventive maintenance of engines, (xi) appropriate reduction gear, propeller size and propeller nozzle; (xii) energy management system; (xiii) sail-assisted propulsion, where applicable; (xiv) use of advanced technology such as acoustic fish detection devices (echosounder, sonar and gear monitoring system), Global Positioning System (GPS), Potential Fishing Zone (PFZ) information based on remote sensing, and Geographical Information System (GIS); (xv) Fish Aggregating Devices (FADs); (xvi) effective fleet management and voyage optimisation; and (xvii) removal of excess fishing capacity.

Resource waste due to excess fishing capacity

Excess fishing capacity has been identified as a major problem affecting long-term sustainability and biodiversity of fishery resources and economic viability of fishing operations (FAO, 1995; 1999b; 2001; Boopendranath, 2007a; Arnason et al., 2008). In recent years, fishing capacity has significantly escalated both in terms of number of fishing units added to the fleet and in terms of increase in fishing power of individual fishing units due to increase in hp, vessel capacities, improved navigation and fish detection capabilities and improved efficiency of fishing gear systems. Significant economic gains could be achieved by eliminating excess fishing capacity, in addition to attaining objectives of resource sustainability and waste minimisation in capture fisheries. Estimates of optimum fleet size by Devaraj & Kurup (2000) for Indian shelf waters (excluding Islands) were 62748 consisting of 10998 mechanized trawlers, 784 mechanized purse seiners, 3694 mechanized gillnetters, 2014 mechanised bagnetters (*dol*-netters), 1558 other mechanised boats and 14862 motorized crafts. According to these estimates, the existing number (CMFRI, 2012) of mechanised trawlers were in excess by a factor of 3.2, mechanised purse seiners and ring seiners by 2.8, mechanised gillnetters by 5.5, mechanised bagnetters by 5.9, other mechanised boats by 2.0 and motorized vessels by 4.8 (Fig. 5). These estimates suggest that the present level of marine capture fish production could be maintained by deploying about one-fourth of the presently deployed fleet of mechanised and motorised vessels, saving enormous amount of wasted resources in terms of fuel

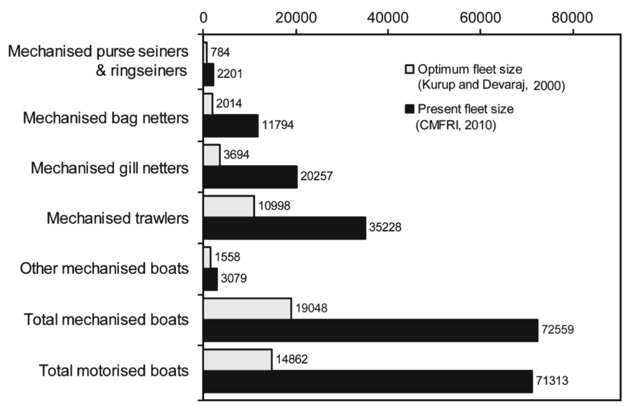

Fig. 5. Present (CMFRI, 2012) and estimated optimum fleet size (Kurup & Devaraj, 2000) for marine fisheries of India

consumption, emissions and bycatch discards from the excess fishing fleet, capital and operational investments and labour deployment in capture fisheries. A rights based regulated access system under a co-management regime based on a strong inclusive cooperative movement of stakeholders with built-in transferable quota system and buy-back or rotational right of entry schemes seems to hold potential for capacity management in the shelf fisheries of Indian states, which need to be implemented in collaboration with the Union Government and the neighbouring states with confluent ecosystems and shared fishing grounds (Boopendranath, 2007a; 2007b).

Conclusion

In capture fisheries, waste is generated mainly due to bycatch discards; onboard processing; abandoned, lost or otherwise discarded fishing gear (ALDFG); garbage; waste oil and oily mixtures and emissions from the vessel operations. A wide range of proven technologies and procedures are readily available for reduction of bycatch discards in harvesting operations. Adoption of such technologies may only be successful with the active involvement of stakeholders in the process, supported by a system of incentives and disincentives and training, under a participatory management regime. Procedures for minimization of plastic waste originating from abandoned, lost or discarded fishing gear need to be adopted. Fishing vessels must make every effort to retrieve all lost or damaged fishing gear. A system of marking of fishing gear and reporting of lost fishing gear facilitating its retrieval has to be in place. Technologies and procedures for minimization of GHG emissions from the fishing fleet need to be promoted through legislation, stakeholder education and training. Strict compliance of MARPOL regulations for safe disposal of garbage, oil, oily mixtures and other residues originating from fishing vessel operations need to be promoted and implemented. Appropriate processing waste management and waste utilisation procedures should be put in place, in fishing vessels with onboard processing facilities. Harbours and landing centres need to be provided with reception facilities for wastes from fishing vessels and procedures put in place for their safe disposal. Elimination of excess fishing capacity by appropriate management measures could entail in enormous savings in terms of fuel consumption, emissions and bycatch discards from the excess fishing fleet, capital and operational investments and labour deployment in capture fisheries.

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