Trawl fisheries and greenhouse gas emission: environmental impact and mitigation measures

The following article is a part of FIFP webinars on the topic "Earth Tomorrow: Environment, You and Seafood -Part 1I" held on 25th September, 2021.

Note from the Chief Editor:

The main theme of FIFP webinar conducted on 25th September, 2021 was 'Earth Tomorrow: Environment, You and Seafood -Part 1I". Two presentations were made that covered Trawl fisheries and greenhouse gas emission: environmental impact and mitigation measures; and Organic farming: concepts and environmental benefits. Dr Latha Shenoy gave valuable insights into the role of trawl fisheries in increasing greenhouse gas emission and its impact on the environment. GHG emission from human activities is the major cause of global warming and climate change. Considering growth of 28% emissions from the global fishing industry between 1990 and 2011, it is imperative to keep emission in check. Trawling is an energy intensive fishing method dependent on non-renewable fossil fuel, burning of which results in CO_2 emission. The article provides details of global and Indian fisheries emissions, impact of GHGs on the environment and mitigation measures to reduce carbon emissions and improve fuel use efficiency. The environmental impact is understood by assessing the carbon footprint of trawlers expressed as 'kg CO_2e kg^{-1} fish' produced. Data requirements for assessment of carbon footprints by trawlers, concepts of fuel-use intensity, energy intensity and carbon emission are described. The article spelt out mitigation strategies to reduce energy use and greenhouse gas emission in capture fisheries. She emphasized the need for regulation of fishing capacity considering the environmental impact of trawl fishing and highlighted the importance of adoption of mitigation strategies. The fossil-fuel consumption and CO_2 emission data can be interpreted to gain an insight into the increasing fishing cost and fish price, to evolve policies on regulating fishing effort and fuel subsidies, and to suggest climate change mitigation measures.

Introduction

Fishing, dependent on fossil fuels is considered as one of the most energy-intensive food production methods. However, emissions due to fishing received less attention compared to the direct impact that fishing had on stocks and associated marine ecosystems. While the use of fossil fuels has increased the availability of fish to fisheries, the dependence of the fishing sector on fossil fuels raises concerns related to climate change, ocean acidification and economic vulnerability. Carbon dioxide is a major component of the Greenhouse gases and is responsible for about three-quarters of emissions warming our planet. Methane, nitrous oxide and hydrofluorocarbons are among other GHGs.

Trawling is an active energy-intensive fishing method, diesel being the major fuel used. The ever-growing demand for fish and fisheries products in domestic and international market led to more investment in mechanized sector particularly trawl fisheries. The outcome of high capital investment and advanced fishing technologies were overcapacity and overfishing that affected biological and economic sustainability. Trawl nets are known for their destructive nature- Juvenile fishing, bycatch, discards and destruction of ocean floor. Trawling has contributed to increased marine fish production and has led to its widespread adoption by many countries. In India, trawlers have contributed major part (>50%) of the total marine fish production. As per the Sector-wise landings, the mechanized sector contributes about 83% towards the total landings, motorized (16%) and nonmotorized sector (1%).

Greenhouse Gases (GHG) emissions

Burning of fuel (diesel in trawlers) leads to emission of GHGs. GHG emission is the major cause of global warming and climate change. Trawler's emission rate is higher than other fishing methods. Carbon dioxide (CO_2) is the main GHG emitted through human activities. Carbon dioxide (CO_2) was chosen by the Intergovernmental Panel for Climate Change (IPCC) as the reference gas and its GWP is set equal to one (1). Global Warming Potentials (GWPs) are a quantified measure of the impacts of a particular greenhouse gas as given by IPCC. GWP is expressed as carbon dioxide equivalent (CO_2e).

Carbon footprints

The carbon footprint is a measure of the total amount of carbon dioxide emission that is directly and indirectly caused by an activity or is accumulated over the life stages of a product. Carbon footprints are measured in terms of kilos or tonnes of Carbon dioxide (CO_2). The environmental impact is understood by assessing the carbon footprint of trawlers expressed as 'kg CO_2e kg^{-1} fish' produced. LCA is an environmental assessment tool to quantify environmental impact throughout the entire life cycle of a product or process.

Global fisheries emissions

Global fisheries generated a total of 179 million tonnes of CO_2-e in 2011 (4% of global food production) or 2.2 kg CO_2-e per kg of landed fish. Emissions from the global fishing industry grew by 28% between 1990 and 2011. Growth in emissions was driven primarily by increased harvests from fuel-intensive crustacean fisheries. Fishing fleets based in China alone emitted 50 million tonnes CO_2-e, approximately one quarter of total global emissions from fisheries. Global fisheries account for about 1.2% of the global oil consumption. The top 5 countries with the most carbon emissions from bottom trawling are China, Russia, Italy, UK and Denmark.

Emissions from Indian marine fisheries

Emissions from the fisheries sector started with the introduction of mechanised and motorised boats in India during 1960s and 1980s respectively. The CO_2 emissions in marine fishing rose from 0.30 mt CO_2 e in 1961– 3.60 mt CO_2 e in 2010. Carbon dioxide emission per tonne of fish caught by Indian capture fisheries doubled from 0.50 t in 1961 and 1.02 t. in 2010. Fuel cost accounts for 50-55% of the operating cost of mechanized boats. The diesel usage in the motorised and mechanised marine fishing fleets contributed 80–90% of the total emissions in the industry. The consumption of diesel fuel increased by about 6% annually due to a switch to energy-efficient fuels in fishing fleets. The emissions from the fisheries sector increased from 3.2 mt CO_2 e to 5.1 mt CO_2 e from 2005 to 2014 due to Increase in efficiency (number & size of fishing vessels, engine power, sea endurance etc.) and shift from single-day to multi-day trawling operations. Fishery is a minor contributor to GHG energy emissions, contributing < 1% to the global GHG emissions. India contributed < 3% to the global marine fisheries CO_2 emission.

Environmental impact of trawl fishing

Besides carbon emission from burning of fossil fuels, the carbon gets released from the seabed sediments into the water due to bottom trawling that increases ocean acidification, adversely affecting productivity and biodiversity. Fuel efficiency is an indicator for environmental effects of fishing and fuel-use efficiency of a vessel. Assessment of carbon footprints by trawlers is based on input data gathered such as size of trawlers, fuel consumption, catch per unit effort etc.

Data requirements

Pre-harvest, harvest, post-harvest and transportation comprise the 4 phases of Life Cycle Assessment of marine fisheries. The system input data such as craft and gear construction materials and fuel used for fishing, ice used for onboard storage are converted to environmental indicator i.e., 'CO_2 equivalent' using standard conversion factors. To determine the environmental impact, the indicator is divided by the system output i.e., total fish catch (kg) and is expressed as 'kg CO_2e kg^{-1} fish' produced.

The carbon footprint is generally evaluated only for the harvest phase as contribution of this phase was the major component of carbon emissions in marine fisheries. Trawler data required include type and size of trawlers, average duration of fishing in a day (h), average number of days in a trip, average number of trips in a year, average number of fishing days in a year, fuel consumption/hr. (L), fuel consumption/ day (L), fuel consumption/ trip (L)and average catch per trip (kg).

Synthesis of data

Fuel-use intensity

Fuel consumption varies according to the size of trawlers, engine horsepower and duration of fishing. Fuel efficiency or fuel use intensity is the amount of fuel consumed to land unit weight of fish. It is expressed in terms of litres of diesel per tonne of fish landed and kg of fuel per kg of fish landed. The amount of fuel in litre is converted to kilogram as 0.86 kg per litre of diesel.

Fuel-use intensity = Fuel consumed (in tonnes)/ Catch landed (in tonnes)

Energy intensity

Energy utilization per litre of diesel is taken as 38.31 MJ (megajoules) (United States Environment Information Administration- USEIA).

1000 MJ = 1GJ (giga − joules)

1 litre diesel = 38.31MJ

Energy intensity = Energy consumed (in giga − joules)/Catch landed (in tonnes)

Carbon emission intensity

Carbon emission intensity is estimated as the amount of carbon in kg per kg of fish landed. Carbon emission is estimated using the conversion factor, 2.7 kg of CO_2 is released per litre of diesel consumed.
1 litre diesel = 2.7 kg of CO_2 (United States Environment Protection Agency-USEPA)

Carbon emission (in kg) = 2.7 × Diesel consumed (in litres)

Carbon emission intensity = Total carbon emission (in kg)/ Catch landed (in kg)

Mitigation strategies to reduce energy use and greenhouse gas emission in capture fisheries

Optimizing fishing vessel design

In capture fisheries, vessel and gear are the two main sources of energy consumption. The choice of vessel design, size of engine and type of propeller determines fuel efficiency. Proper vessel length to width ratio, smooth hull painting and fairing, bulbous bows, high efficiency internal combustion engines, and larger diameter propellers with nozzles are some of the important features for a highly fuel-efficient vessel. For new fishing vessels, optimizing design and propulsion would reduce energy consumption. Optimize hull size and shape to provide safety, speed, hold capacity and weight. For existing fishing vessels, refitting and replacing an old and inefficient engine with a modern design can reduce fuel consumption by taking advantage of technology developments such as turbocharging. A propeller installed with a nozzle can result in fuel savings of up to 20 %. Replacing a petrol outboard with a diesel inboard engine can significantly save fuel by 30 to 40 %.

Fishing vessel maintenance and operation

Undertaking regular maintenance of engines and other machinery is a simple low-cost action that can improve fuel efficiency. Marine growth, including micro-organisms, can accumulate rapidly on a hull, increasing roughness and resistance. Ensuring that the hull and propeller are cleaned regularly can improve vessel efficiency by up to 30 %.

Adoption of advanced technology, choice of appropriate engine, improved fuel efficiency of fishing craft, reduction of speed, large propeller with low rpm are options for reducing fuel consumption. A small reduction in speed can dramatically reduce fuel consumption, fuel savings of 5 to 30 % can be expected.

Optimizing fishing gear design and operation

Within the trawl system, the trawl net is responsible for 60 % of energy use, with otter boards at 30 %, and warps and other cables at 10 %. As the trawl system is the major component of the resistance responsible for fuel use, improving design, construction and operation of trawls to reduce fuel use has great potential. For trawls, the use of efficient otter boards, off-bottom fishing, high-strength materials, large mesh sizes, and smaller diameter twines are some of the measures that reduce fuel consumption. Strong synthetic warp, use of cambered otter boards, Smart trawl design & operation, use of advanced materials like Ultra high molecular weight Polyethylene - UHMWPE (Dyneema, Dynex, Spectra) that reduce twine surface area can reduce trawl resistance by about 20 %. Knotless netting can further reduce resistance. Alternative fishing gears (Semi-pelagic trawl) can be adopted.

Technologies for energy conservation in fishing

Adoption of advanced technologies such as Global Positioning System (GPS), Use of acoustic instruments (echo sounder, SONAR, gear monitoring system), Use of remote sensing technology and Geographical Information System (GIS), and Fish Aggregating Devices/ Artificial Reefs (FADs/ARs) can improve fuel efficiency. Opportunities for reducing dependence on fossil fuel exist in usage of renewable energy systems such as wind and solar-powered generation of electricity.

Selection of energy-efficient harvesting method

Fishing gears have varying degrees of impact on marine ecosystems as well as fuel-use intensity, and energy intensity. Towed gears like otter board trawls affect the bottom where a contact with the fishing gear components and the bottom occurs. Stationary fishing gears have minor effect on the bottom habitats. Off-bottom fishing gears like pelagic trawls and purse seines have little or no bottom impact. Gill nets, long lines, pots and traps comprise fishing gears with low energy use or low impact fuel efficient fishing methods.

International treaties dealing with climate change

India is committed to compliance with international treaties dealing with climate change such as the United Nations Framework Convention on Climate Change (UNFCCC, 1992) the Kyoto protocol (1997) and Paris climate agreement pledge to reduce its carbon footprint by 33-35% from 2005 levels by 2030. Conference of parties (COP21) held in Paris in 2015, of the UNFCCC aims at reduction of increase in global average temperature & highlights the vital need to reverse the current trend of overexploitation and pollution to restore aquatic ecosystem services and the productive capacity of the oceans. The Kyoto protocol operationalizes the UNFCCC and aims at reduction of emissions of greenhouse gases to achieve sustainable management.

Conclusion

Estimation of carbon footprint of different phases of fish production is very essential to understand the global warming potential of different methods of exploitation in capture fisheries for assessment of possible environmental impact. With the rising concern and awareness of climate change and environmental impact of fishing, the information on fuel-use intensity, energy intensity and carbon emission from trawl fisheries would help in decision making of fish harvesting. Considering the impacts of trawlers on environment, phasing out trawlers with high installed engine horsepower is desirable. Regulation of fishing capacity is necessary to reduce the overall carbon emissions due to large trawlers as a measure to support the climate change strategies. Fuel consumption, energy intensity and GHG emissions in trawl fisheries can be reduced through optimization of fishing vessel and gear design and operation; enhancing fuel efficiency of fishing operations; use of low impact fuel efficient fishing methods & gears; adoption of advanced technologies for energy conservation in fishing; and fisheries management that reduces fishing effort and enhances fish stocks. There is possibility of improving energy efficiency in trawling by adopting energy audit system. Inclusion of emission in fish product ecolabeling in future would help awareness at consumer level.

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Dr. Latha Shenoy has more than 36 years' experience in Fisheries education, training and research. She retired as Principal Scientist from the Central Institute of Fisheries Education, Mumbai in 2019. After completing M.Sc with first rank in Industrial Fisheries, she joined as Scientist through Agricultural Research Service at CIFE, Mumbai. She was involved in the design of course curriculum, teaching, guiding students, training and research. Her areas of expertise include Craft and gear technologies, Responsible fisheries, Fisheries resource management and Marine regulatory / policy issues. She has guided 25 PG and 10 PhD students. She completed 3 externally funded and 3 institute funded research projects as Principal Investigator besides 4 Institute funded projects as Co-Principal Investigator. She has more than 60 scientific publications to her credit in national and international journals. She has authored 6 text books, co-authored 4 and edited 3 books in addition to 5 book chapters and 5 popular articles. As Coordinator, she conducted 3 International Training Courses on Code of Conduct for Responsible Fisheries (CCRF) from 2008 to 2010 for participants of the neighbouring countries in collaboration with the Bay of Bengal Program (BoBP)Intergovernmental Organization. She was awarded Diploma in Marine Management-Good governance in practice by Swedish International Development Co-operation Agency (SIDA) on successful completion of one-month international training program at Sweden (2009). She was the Regional Coordinator (Western region) of the National Agricultural Higher Education Accreditation Board (NAHEAB) for accreditation of

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