

Energy Optimization in Fisheries

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Efficient fishing practices can reduce fuel use, operating costs and environmental pressure while maintaining productive fisheries

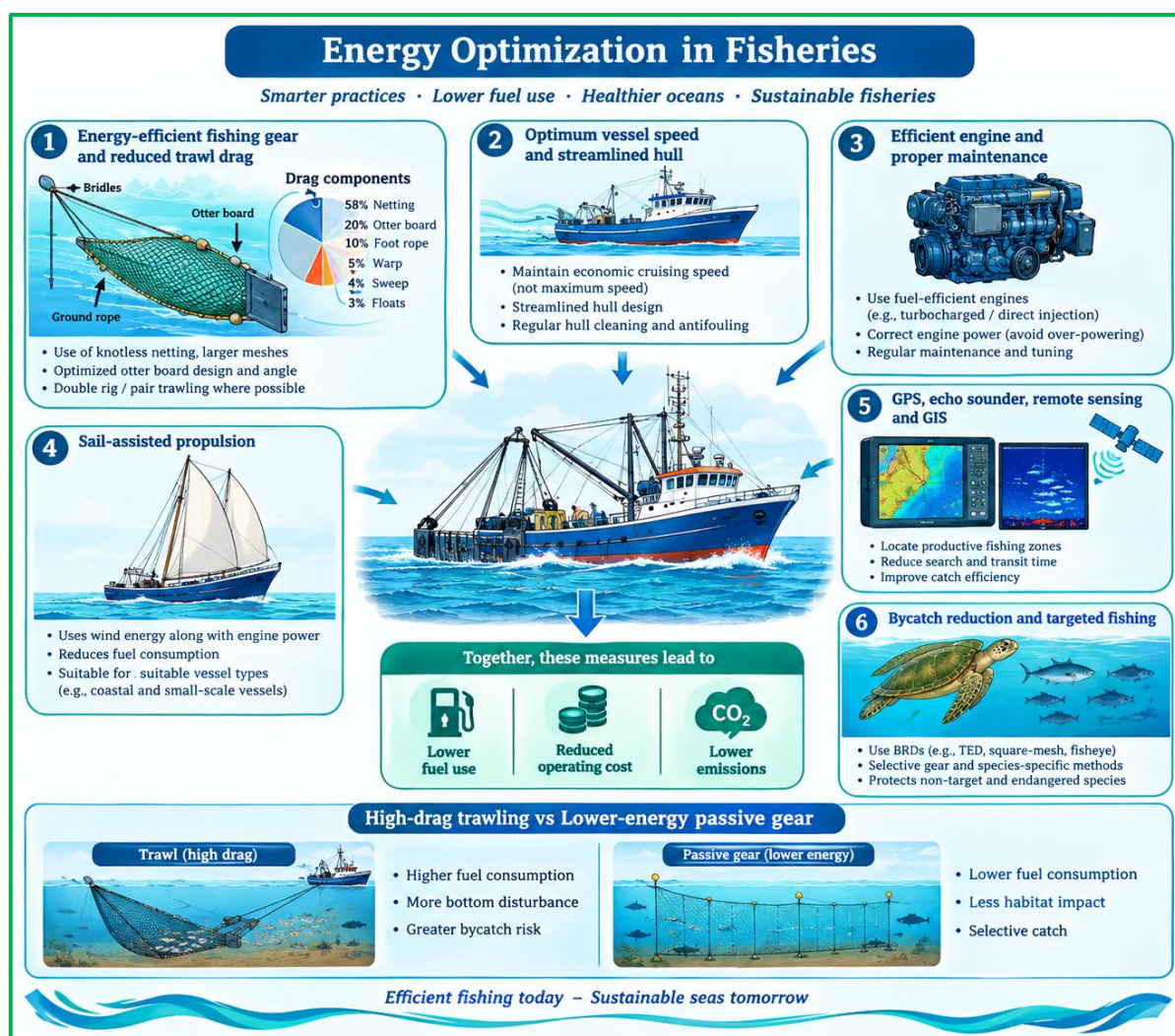


Figure 1. Major approaches for energy optimization in fishing operations

Abstract

Energy is a major operational requirement in capture fisheries, particularly in motorised and mechanised fishing. The dependence of fishing vessels on fossil fuels links fishing costs with fuel prices and also contributes to carbon dioxide and other emissions. Energy optimization therefore involves more than choosing an efficient engine: it includes selecting appropriate

fishing methods, reducing gear drag, operating vessels at economical speeds, improving hull condition, maintaining engines, using sail assistance where suitable, and applying technologies that reduce search and fishing time. The source material for this article identifies fishing gear and methods, vessel technology, engines, sail-assisted propulsion, advanced technology, bycatch reduction, and conservation of fishery resources as major routes for energy conservation. Among fishing methods, trawling is described as particularly energy intensive because the vessel must continuously tow gear through water. Energy-efficient gear design, correct rigging, targeted fishing and responsible resource management can therefore contribute to better fuel efficiency and improved economic and environmental performance.

Introduction

Modern fishing is one of the more energy-intensive forms of food production when motorised vessels and active fishing gears are used. Fishing vessels depend largely on fuel for propulsion, towing gear, searching for fishing grounds and supporting onboard operations. The uploaded source notes that fossil fuels are non-renewable and that their combustion produces carbon dioxide and other pollutants. At the same time, increasing fuel prices can affect the economic viability of fishing operations. For a fishing enterprise, the amount of fish landed per unit of fuel is therefore an important practical measure of operational efficiency. Fuel demand is not identical among fisheries. It varies with fishing gear, vessel size and design, engine condition, operating speed, distance to the fishing ground, trip pattern and environmental conditions. FAO guidance similarly emphasizes that fuel-saving measures need to be matched to the fishing method and vessel rather than treated as a single universal solution. Energy optimization is consequently a combination of technical improvement and better operational decision-making.

Why Energy Optimization Matters in Fisheries

Energy optimization has three closely connected dimensions. First, lower fuel consumption can reduce the operating cost of a fishing trip. Second, using less fuel reduces the amount of fuel-derived emissions associated with fishing activity. Third, efficient fishing can improve the amount of marketable catch obtained for a given amount of energy input. These benefits are particularly important for active gears that require continuous towing or high propulsion power. The source material reports that fuel costs can form a substantial share of trawler operating expenditure and describes trawling as the most energy-intensive fishing activity among the methods discussed. It also notes that trawling can require substantially more fuel than passive gears and purse seining for comparable fish production. The exact fuel requirement, however, is fishery-specific and should be assessed using actual vessel and trip data.

1. Energy-Efficient Fishing Gear and Methods

The selection of fishing gear is one of the first opportunities for reducing energy demand. The most suitable approach is to select and deploy an energy-efficient combination of fishing technology appropriate to the target resource and local fishing conditions. Passive gears such as gillnets and longlines generally do not require continuous towing, whereas trawls require propulsion power to overcome the resistance of the gear. Trawl energy demand is strongly influenced by drag. Drag depends on gear design, rigging, towing speed, netting characteristics, otterboard performance and operating conditions. The source material recommends several practical approaches for reducing drag, including knotless netting, thinner twine, larger meshes, cambered otterboards, optimized otterboard angle of attack, slotted otterboards and multi-rig or pair-trawling arrangements where appropriate.

Understanding Trawl Drag

The supplied material illustrates the components contributing to trawl drag and identifies netting as the largest component in the example distribution, followed by the otterboard, foot rope, warp, sweep and floats. This demonstrates why even apparently small modifications to netting or rigging can influence the power required to tow a trawl. Reducing drag does not mean simply making every component smaller. The gear must still retain the geometry and fishing characteristics required to capture the target species. Energy-efficient gear design therefore aims to achieve the required fishing performance with the lowest practical resistance.

Practical Methods for Saving Fuel in Trawl Fishing

Approach	Energy-saving principle
Knotless netting	Can reduce resistance associated with the netting structure and may contribute to lower towing requirements.
Thinner twine	Reduces the amount of material presented to water flow and can reduce resistance when appropriate for gear strength.
Larger meshes	Can reduce the netting area resisting water flow while also supporting selective fishing when designed correctly.
Cambered otterboards	Improved hydrodynamic design can reduce resistance for the required spreading force.
Optimal angle of attack	Correct otterboard setting helps obtain the necessary spreading performance without unnecessary drag.
Slotted otterboards	Hydrodynamic modifications can improve board efficiency and reduce resistance in suitable trawl systems.
Multi-rig and pair trawling	In fisheries where operationally appropriate, alternative rigging arrangements can reduce energy required per unit of catch.

2. Vessel Technology: Speed, Hull and Maintenance

Vessel operation has a major influence on fuel consumption. The source material emphasizes that fuel consumption increases sharply as a vessel approaches its maximum speed because wave-breaking resistance increases rapidly. Consequently, maintaining an economical operating speed is one of the most practical fuel-saving measures. Hull design and condition also influence resistance. The source notes that increasing the length of the waterline while keeping other dimensions constant can reduce hull resistance, while reducing vessel displacement can lower fuel requirements. Lightweight construction materials such as aluminium and fibre-reinforced plastic can reduce displacement compared with heavier construction materials, depending on the vessel design. Hull maintenance is equally important. Periodic cleaning and antifouling treatment help control marine growth and surface roughness, both of which can increase resistance. Good maintenance should therefore be regarded as an energy-saving practice rather than merely a repair activity.

3. Engine Selection, Operating RPM and Maintenance

Engine efficiency directly affects the amount of fuel required to produce useful propulsion power. The source discusses outboard petrol or kerosene engines and inboard diesel engines, noting that two-stroke outboard engines can have relatively high fuel consumption. It also identifies turbocharged diesel engines as more fuel efficient than normally aspirated engines in the context presented. Correct engine sizing is important. Installing substantially more power than a vessel can effectively use may increase fuel consumption without providing a corresponding operational benefit. The source material also states that modern marine diesel engines can operate most economically around 80% of maximum continuous rating under suitable conditions, and it gives reported fuel-saving effects from modest reductions in engine RPM. Preventive maintenance is another simple but important measure. Cleaning or replacing injectors, changing lubricating oil and maintaining the engine in good operating condition help prevent loss of efficiency. The supplied material reports that efficiency losses from a badly maintained engine can be substantial.

4. Sail-Assisted Propulsion

Wind-assisted propulsion has a long history in small-scale fisheries. The source identifies India, Sri Lanka and Indonesia as countries with traditions of sail use in small fishing vessels and catamarans. Where wind conditions, vessel design and fishing method are suitable, sails can provide part of the propulsion requirement and allow a smaller engine to be installed. Sail assistance is particularly relevant to lower-energy fishing methods such as coastal gillnetting and longlining. Traditional sail systems mentioned in the source include sprit, lateen, Chinese lug and Bermuda sails. Fixed aerofoils and Magnus-rotor systems are also described as proposed wind-driven technologies, although the source identifies these as experimental.

5. Advanced Technology for Energy Optimization

Modern navigation and fish-finding technologies can reduce the time and distance spent searching for fish. The source identifies GPS for accurately reaching potential fishing grounds, echo sounders and sonar for fish detection, gear monitoring systems, satellite remote sensing based on sea-surface temperature and ocean colour, and fisheries GIS for decision support. These technologies do not automatically reduce fuel use; their benefit depends on correct interpretation and operational use. When they help a vessel avoid unproductive searching and reach suitable fishing grounds more efficiently, they can reduce unnecessary steaming and fishing time. Fish aggregating devices have also shown potential for reducing search requirements in fisheries using purse seines, handlines and gillnets. Fuel-flow monitors and onboard vessel-analysis systems can provide quantitative information about how much fuel is being used during different activities, helping operators identify inefficient operating conditions.

6. Bycatch Reduction and Targeted Fishing

Bycatch reduction devices (BRDs) are primarily designed to reduce unintended capture, but the supplied source also highlights their energy-related value. In trawling, a suitable BRD can alter water flow and catch composition and may reduce drag under appropriate conditions. The source lists turtle-excluding devices, fisheye devices, juvenile and trash excluding devices, square-mesh codends, radial escape sections, square-mesh windows and fish boxes among BRD-related technologies. Targeted fishing is another route to energy optimization. A gear that is well matched to the target species can reduce effort spent handling unwanted catch and can improve the proportion of useful catch obtained from each unit of fishing effort. Energy optimization should therefore be considered together with selectivity and responsible fishing rather than as fuel saving alone.

7. Conservation and Enhancement of Fishery Resources

The source identifies conservation and enhancement of fishery resources as a long-term solution to fuel conservation. The basic relationship is straightforward: when target resources are abundant and fishing is well managed, less searching and fishing effort may be required to obtain a given catch. When resources decline, vessels may need to travel farther, search longer or fish more intensively, increasing energy use. Three strategies highlighted in the source are restoration and enhancement of coastal fishery resources through responsible fishing practices, removal of excess fishing capacity, and implementation of resource-conservation and enhancement strategies. Energy efficiency therefore cannot be separated completely from fisheries management.

Integrated Energy Optimization: A Practical Framework

Energy optimization is most effective when several measures are applied together. A vessel operator can begin by recording fuel consumption for each trip and separating steaming, searching, fishing and return-to-port phases. The next step is to identify the largest energy-consuming activity. Depending on the fishery, the priority may be towing drag, excessive cruising speed, long search time, poor engine condition, hull fouling or inefficient gear configuration. A practical sequence is: select an appropriate fishing method; optimize gear design and rigging; maintain an economical vessel speed; keep the hull clean; select and correctly size the engine; operate the engine within an efficient range; maintain the engine regularly; use navigation and fish-finding technologies effectively; and evaluate selective or targeted fishing options. Fuel-flow monitoring can then be used to compare performance before and after changes.

Economic and Environmental Benefits

The immediate economic benefit of energy optimization is reduced fuel expenditure. Because fuel is a recurring trip-level cost, even modest improvements can become significant over a fishing season. Better fuel efficiency can also increase the quantity of fish landed per unit of fuel and improve the resilience of fishing operations when fuel prices rise. The environmental benefit comes mainly from reducing fuel use and the associated emissions. FAO guidance also

recognizes energy efficiency in fisheries as an important component of responsible and lower-impact fishing. However, energy efficiency should not be evaluated only through fuel consumption: gear impacts, bycatch, habitat interaction and stock condition also need to be considered.

Challenges and Considerations

No single energy-saving technology is appropriate for every fishery. A modification that works well for one vessel may not provide the same result for another because vessel dimensions, engine power, gear type, target species, fishing ground and operating conditions differ. Changes in gear design must also be tested to ensure that fuel savings do not compromise target catch, safety or gear durability. Energy optimization should therefore be based on measurement rather than assumptions. Fuel consumption per trip, fuel per hour, fuel per kilogram of landed catch, towing speed, engine RPM and fishing time are useful operational indicators. Site-specific energy audits can help identify the most effective interventions.

Conclusion

Energy optimization in fisheries is a combination of efficient gear, efficient vessels, efficient engines, appropriate technology and responsible resource management. The supplied material emphasizes that trawling is particularly important because towing resistance can create high energy demand. Reducing trawl drag, selecting suitable gear, maintaining economical vessel speed, improving hull condition, choosing and maintaining efficient engines, using sail assistance where appropriate, and applying GPS, sonar, remote sensing and GIS can all contribute to lower energy use. The broader objective is not simply to save fuel. Efficient fishing should produce useful catch with less unnecessary energy expenditure while supporting economic viability and responsible use of aquatic resources. When technical efficiency is combined with selective fishing and conservation of fishery resources, energy optimization becomes an important component of sustainable fisheries.

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