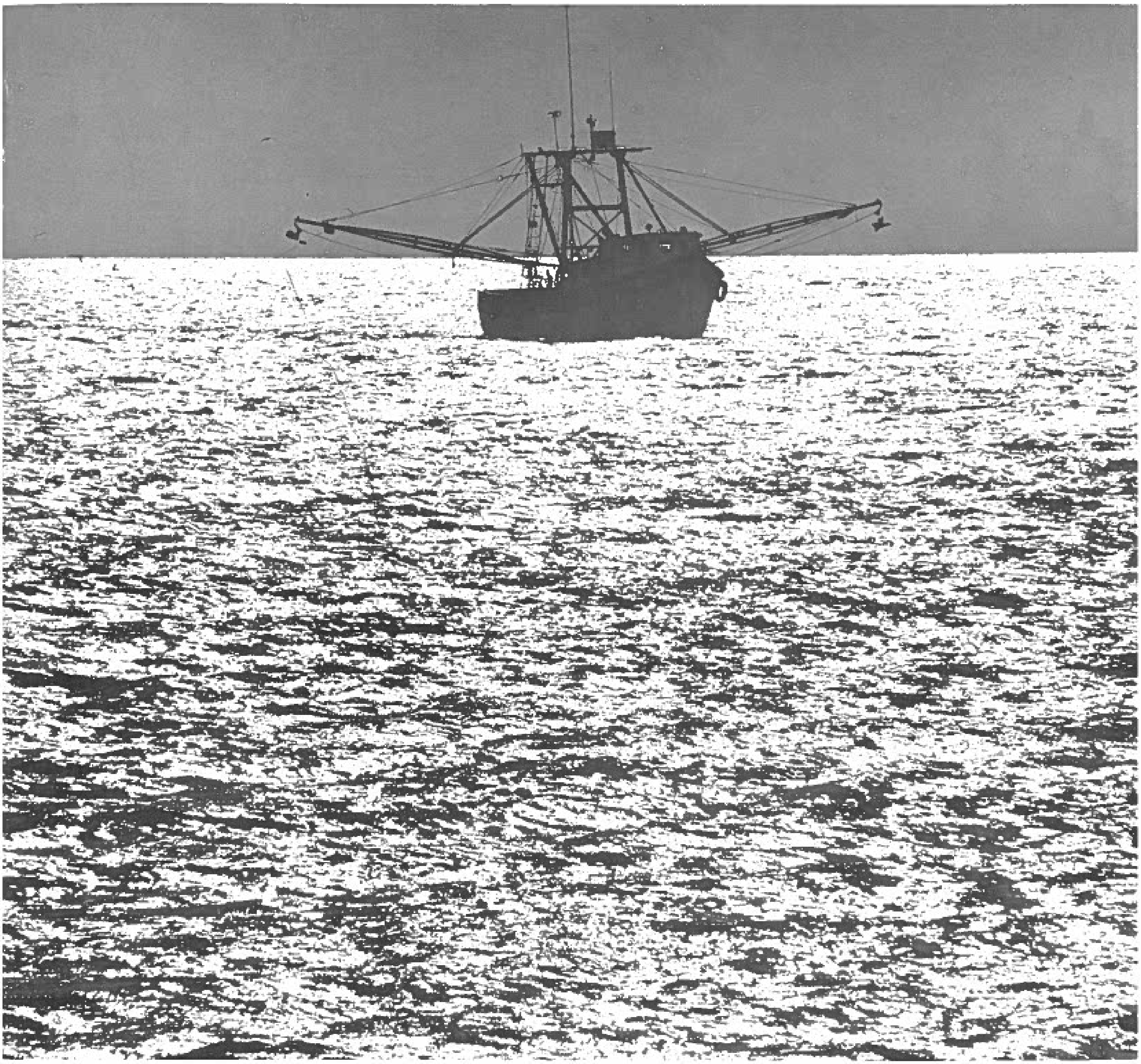
Cutting Fuel Costs

Alternatives for Commercial Fishermen

File Copy



Texas A&M University Sea Grant College Program

The shrimp industry, in conjunction with the National Marine Fisheries Service, initiated three energy-related studies in 1981 to help shrimpers adjust to high fuel costs.

One project, a joint effort of the Mississippi/Alabama Sea Grant Consortium and the Gulf and South Atlantic Fisheries Development Foundation, studied fuel use by shrimp vessels. Meant to provide information that could help suggest alternatives to decrease fuel consumption, the project looked at total fuel consumption; running, fishing and searching times; duration of average drag; and catch rate.

A second project, conducted by the Society of Naval Architects and Marine Engineers, looked at fishing vessel fuel use in the U.S. fleet compared to the state of the art of fuel efficiency.

The third study, funded through the National Shrimp Congress, was to gather energy conservation information that might help fishermen make decisions about ways to conserve fuel on both a short-term and long-term basis. This report is a summary of the findings of that study.

Cover Photo: Brazosport Facts

One to five copies of *Cutting Fuel Costs: Alternatives for Commercial Fishermen* is available without charge from the Marine Information Service, Sea Grant College Program, Texas A&M University, College Station, Texas 77843. Request publication TAMU-SG-84-504. For more than five copies, write for prices.

Cutting Fuel Costs

Alternatives for Commercial Fishermen

By Dewayne Hollin
Marine Business Management Specialist
Texas A&M University
Sea Grant College Program

and

Steven R. Windh
Graduate Student, Agricultural Economics
Texas A&M University

Special thanks to Thomas Lamb, naval architect, Seattle, Washington, for his contributions to this publication. Lamb has also published two related reports through Mississippi State University, the Mississippi Cooperative Extension Service and the Mississippi Sea Grant Advisory Service. They are: "Selecting and Improving Propulsion Systems" and "Improving Vessel Efficiency by Hull Design and Modifications."

Foreword

The past 10 years have been trying times for many shrimp fishermen. Dramatic changes in the United States' Gulf of Mexico shrimping industry have made fishermen increasingly vulnerable to today's highly uncertain economic situation. The 1970s witnessed increases in fuel prices, fishing gear and the general cost of shrimping. While the price shrimp fishermen get for their catch at the dock has risen, it often has not risen enough to make up for increasing shrimping costs.

The difference between prices received for the product and the increasing cost of production poses a serious challenge to the economic survival of commercial shrimp fisheries. One way to help alleviate this problem is to reduce shrimping costs. Although this is not easy, it can be done. Energy management — the application of energy saving technology and practices — can be highly effective in reducing a shrimp fisherman's fuel bills. This publication describes some of the alternatives available to shrimp fishermen to help conserve fuel and lower energy expenses.

The information provided here was derived from surveys, engineering references and conversations with boat owners, builders and engineers, and with the designers and manufacturers of proprietary devices. Costs are based on information furnished by those surveyed and available at the time of publication. Most figures given are estimates, and should be used as such when making decisions about energy saving alternatives. The authors of this publication do not endorse the estimates of cost savings and do not claim the estimates are totally accurate.

How to Use This Publication

Since this publication is designed as a guide for selecting fuel conservation alternatives, it should serve only as a starting point in the decision making process. As fuel conservation technology improves, the data in this publication will become obsolete. A fuel saving device that provides a 5 percent savings now may be improved in the future to provide a 10 percent savings. The cost of equipment, installation and the economic life of the alternative will also change. Fishermen should be very careful in selecting equipment that makes claims of high fuel conservation.

The alternatives are classified as short-term and long-term and the advantages and disadvantages of each alternative are listed, along with survey data on cost and economic benefits. These estimates were the best available at the time of the survey. Where estimates vary by a large margin an explanation is provided.

All alternatives should be weighed before making a selection. Charts for both short-term and long-term alternatives are provided as a summary for initial investigation. For quick review look over the summaries first, then look at specific descriptions of the alternatives. Once you have narrowed down your choice to a few alternatives that seem feasible, collect more information from manufacturers, distributors and designers on the selected alternatives and complete the payback formula worksheet for each choice. A comparison of the results of each worksheet tabulation should aid in your final choice.

Once a tentative selection has been made, a vessel owner would be wise to check with the distributor, manufacturer or boat builder to determine special financing available. This should also be a consideration in the final selection.

Fuel savings estimates provided in this publication cannot be verified in actual tests, and for this reason the authors do not accept responsibility for the accuracy of these claims. The reader should also be aware that fuel savings are not cumulative for two or more fuel conservation devices.

The most important element in fuel conservation is good management of your fishing vessel. No fuel savings device will help conserve energy unless it is installed, maintained and operated efficiently.

Future fuel costs will also control the amount of savings to be realized by installing fuel conservation equipment. If fuel prices rise, the efficiency of fuel conservation options will also increase.

Short-Term Alternatives

Short-term alternatives have an economic life of less than five years and are generally regarded as maintenance alternatives. Chart 1 summarizes various short-term fuel savings alternatives.

Speed Reduction

The easiest way to reduce fuel consumption is by pulling back on the throttle and reducing engine rpm. This can cut fuel costs by up to 25 percent with no initial costs or special equipment installation. On a 73-foot steel hull shrimp boat powered by a single 365-horsepower engine, reducing engine speed by 100 rpm reduced fuel consumption by 13 percent. Reducing engine speed by 200 rpm reduced fuel consumption by 25 percent while reducing the free running vessel speed by only 0.7 knot.

The horsepower required to propel a boat increases dramatically with vessel speed primarily due to hull resistance. The hull resistance curve below illustrates the relationship between required horsepower and vessel speed. Results of tests conducted by the boat builder are also shown to illustrate the savings.

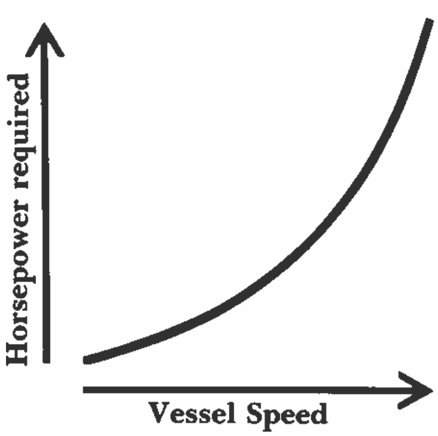
Speed reduction does have some hidden costs that need to be considered, particularly while towing nets or trawling. When trawling, pulling back on the throttle reduces thrust that is needed to tow nets and gear. A reduction in towing speed or the size of net may reduce the amount of the catch.

Boat Builder Tests
73 ft. Trawler
Light Ship Condition

Engine Speed RPM	1920	1820	1720
Boat Speed Knots	10.5	10.1	9.8
Fuel Rate Gal/HR	16.4	13.7	11.5
Savings		13%	25%

A boat builder ran tests on a 73-ft. steel hull shrimp boat powered by a single 365-horsepower engine. Reducing engine speed by 100 rpm reduced fuel consumption (as measured in gallons per mile) by 13 percent. Reducing engine speed by 200 rpm reduced fuel consumption by 25 percent. . . yet free-running vessel speed was reduced by only 0.7 knot.

Graphs from *Marine Fuel Management*, a 1981 bulletin from Cummins Engine Company, Inc., Columbus, Indiana 47201.



Hull resistance curve

Short-Term Alternatives

Hull Drag

A vessel moving through water at a given speed faces a certain degree of resistance that must be overcome by the propulsion system before any progress can be made. The total resistance a vessel faces is divided into two categories: frictional and residuary. Frictional resistance is simply the resistance between the hull and the water. For example, a hull with heavy marine growth has more frictional resistance than the same hull with no growth.

Residuary resistance includes all other resistance against a vessel. Although this is a rather broad definition, we can, for practical purposes consider residuary resistance as that resistance caused by the generation of waves by the hull. In short, it is the resistance caused by water being pushed out of the way of a moving boat.

Obviously, if either frictional or residuary resistance can be reduced, then the amount of energy (and fuel) needed to move the vessel at a given speed will be reduced.

A simple way to check the condition of the hull is to periodically perform a deceleration test to check how much the hull's frictional drag has increased since its last drydocking. A vessel should be at approximately the same draft condition each time this test is run. For example, the amount of fuel, water, ice, etc. should be about the same to keep the vessel's draft constant. In addition, each test should be done in similar sea and weather conditions, and the engine should be run at the same rpm. To perform the test, simply record the time needed to bring the vessel to a dead stop in the water once the gear is disengaged. By comparing the time needed to stop with previous times, the relative deterioration of the condition of the hull, and thus, the increase in drag, can be measured. Although this is an unsophisticated test, it does provide a valuable clue as to when cleaning is needed.

The following is an example of a form that can be used to record and analyze results from this test.

Date	*Time needed to stop (seconds)*	*Time difference*	*Percentage difference*

Chart to analyze hull resistance test.

Short-Term Alternatives

Hull Maintenance

The maintenance of the hull and propeller is of fundamental importance for saving fuel during the operation of a vessel. The total resistance of a vessel will increase gradually after drydocking, due to marine growth and surface deterioration. A program of bottom cleaning and surface maintenance at regularly scheduled intervals can reduce the vessel's total resistance.

Advantages.

1. A hull that is free of marine growth will have lower frictional drag, thus reducing fuel consumption.
2. Decreased hull drag may increase vessel speed for any given power setting.
3. A vessel does not have to be drydocked to be cleaned.

Disadvantages.

1. The boat must be taken out of service while being cleaned.

Cost and economic data.

Initial cost: Highly variable due to labor cost differences in different locations
Cleaning time: 8 to 20 hours
Haul-out necessary? No
Fuel savings: Up to 5 percent

Self-Polishing Paints

Self-polishing, anti-foulant paints are products that can cut hull friction. The paint is an acrylate-based, ablative type anti-foulant, paint. When the vessel is in the water, hydrolysis causes release of the paint's toxins. Toxin release is accompanied by a gradual wearing down and smoothing of the top layer of paint. The process is repeated until no hydrolyzable paint remains and the paint develops a very smooth outer surface. This "polishing" action takes a relatively long time depending on the condition of the hull and the number of coats of paint applied. Fuel savings occur while the paint is being polished and increase until all the paint is hydrolyzed.

Advantages.

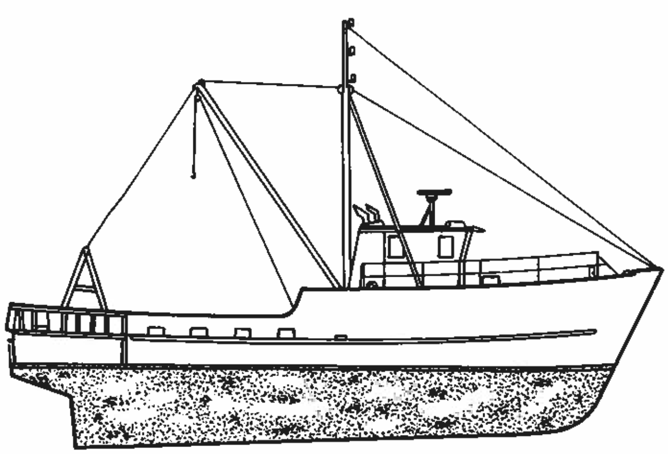
1. Self-polishing paints reduce frictional hull drag, thus reducing fuel consumption.
2. The hull (especially if wood) is additionally protected because the anti-foulant paint eliminates marine growth.
3. Decreased hull drag may increase vessel speed for any given power setting.

Disadvantages.

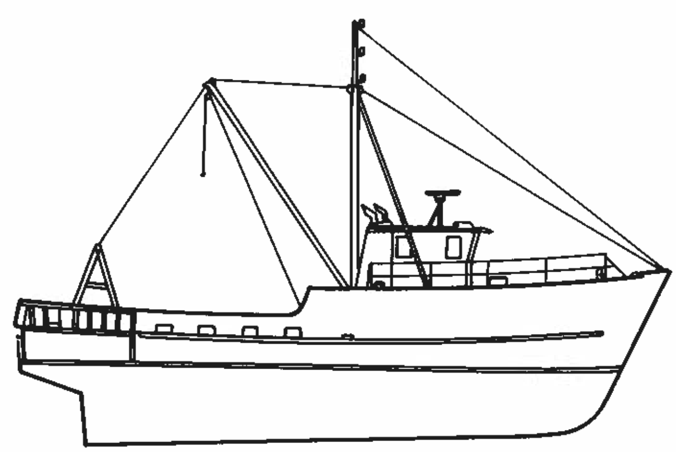
1. The hull must be completely stripped of old paint before self-polishing paint can be applied.

Cost and economic data.

Initial cost: Approximately 30 cents per square foot
Installation time: Three to five days
Haul-out necessary? Yes
Fuel savings: Up to 10 percent, but difficult to quantify
Economic life: One to two years



Dirty hull.



Clean hull.

Chart 1. Short-Term Alternatives

(Economic Life of Less Than Five Years)

Alternative	*Initial Cost*	*Cost of Installation*	*Haul Out*	*Fuel Savings*
Hull Maintenance	Variable due to labor cost	8-20 hours Rates vary	No	Up to 5%
Self-polishing Paints	30 cents/sq. ft.	3-5 days Rates vary	Yes	Up to 12%
Speed Reduction	None	Cost would be in possible reduction in amount of catch	No	Up to 25%

Short-Term Alternatives Cont.

Alternative	*Economic Life*	*Major Advantages*	*Major Disadvantages*
Hull Maintenance	Varies due to operation and workload	Lowers frictional drag and increases speed.	Boat must be taken out of service.
Self-polishing Paints	1-2 years	Reduces frictional drag and increases speed. Provides some protection for wood boats.	Hull must be stripped before application.
Speed Reduction	Unlimited	Save fuel and may reduce wear on engine and propulsion system.	Slow speeds reduce thrust needed in trawling. May have to reduce gear size.

Long-Term Alternatives

Long-term alternatives cover vessel alterations or additional equipment used to monitor or change the vessel performance in some way to reduce fuel consumption. Types of alternatives include fuel and vessel management aids, such as fuel flow meters, track plotters, and LORAN C and other alternatives to increase fuel efficiency such as ducted propellers, turbochargers and engine modifications.

Cost and economic data provided is based on estimates furnished by designers, boat owners and equipment manufacturers and in most instances could not be verified by the publication authors. Chart 2 provides a summary.

Management Aids

One possible way to save fuel is by managing vessels more efficiently. Although the alternatives given here will not save fuel directly, they can help the vessel operator determine the best course headings and power settings for lowest fuel consumption rates.

Fuel Flow Meters

With a fuel flow meter, a captain can keep a constant record of fuel use data, e.g., the rate at which fuel is being used and the amount of fuel remaining in the tank. Engine rpm and maximum time remaining at the current consumption rate can be determined also. Depending on the model, other functions are available.

While fuel meters do not directly save fuel, information provided by the readout can help an operator make more accurate decisions about optimal, fuel-efficient power settings.

Advantages.

1. Information concerning the engine's consumption of fuel is instantly obtainable through a digital readout.
2. By constantly monitoring fuel consumption, an engine's operating condition can be monitored. Engine tune-ups can be more accurately scheduled.

Disadvantages.

1. Takes up space in cabin area.
2. There can be a human interface problem: Someone must watch the meter and keep records for accurate monitoring of fuel use.
3. High initial cost.
4. High maintenance cost on some early models.
5. Must be calibrated for specific engine used.

Cost and economic data

Initial cost: $3,500 to $10,000 (Based on estimates by manufacturers and fuel management experts at the National Marine Fisheries Service)
*Installation cost:** $18 to $40 per hour
Installation time: Approximately three hours
Haul-out necessary? No
Fuel savings: Up to 10 percent normally, and under perfect operating conditions it could be higher.
Parts and service available? Yes
Economic life: Five years

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Long-Term Alternatives

Management Aids

Track Plotters

A video track plotter is an electronic navigation device used with a LORAN C receiver to provide the captain with basic navigational information such as position in latitude and longitude, range and bearing to destination, course waypoint coordinates, and location of underwater obstructions. It offers more precision in course-keeping.

Two types of plotters are on the market: paper plotters and video plotters. Each has its own advantages and disadvantages. A paper plotter enables an operator to keep a recorded plot for future reference. This procedure is more complex with a video plotter, which uses a video cassette to record the plot. A video plotter, however, offers a constantly visible plot on its video screen.

Advantages.

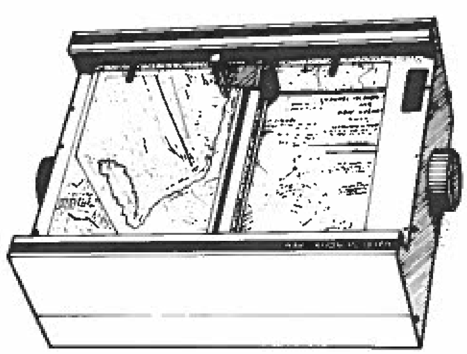
1. Increased navigational safety.
2. Areas already fished can be avoided; areas missed can be explored.
3. Plotters are used with LORAN C components.
4. The operator has the ability to plot a straight course to the destination and return over the same course. This minimizes wandering due to wave action and side drift.

Disadvantages.

1. High initial cost.
2. There can be a human interface problem: The operator must understand how to use the plotter.

Cost and economic data

Initial cost: $5,000 to $6,000
*Installation cost:** $23 to $30 per hour
Installation time: Two to three hours
Haul-out necessary? No
Efficiency increase: Operator-dependent
Fuel savings: Up to 10 percent normally, under perfect conditions it could be higher.
*Economic life:*** Five years



Typical track plotter printout unit.

LORAN C Equipment

The use of electronic navigation systems, such as LORAN C, can help keep a vessel from drifting off course while it is underway. Reduced course deviation means less travel time and less fuel consumed. Electronic navigation systems using LORAN C are preferred among commercial fishermen. LORAN C is relatively easy to use, very accurate, and offers a wide range of features.

LORAN C uses a network of crisscrossing radio waves which blanket the Gulf of Mexico as well as most other coastal regions. The on-board LORAN C unit receives these radio signals and then compares and measures them against the last radio signal it received. The difference in signals is then converted into latitude and longitude to define the vessel's present position.

Most LORAN C systems also calculate the distance between a vessel's current position and its final destination. This is done by entering the latitude and longitude of the destination into the system, or by using a memory system. The memory device allows the operator to record several locations without having to calculate current position, destination position, or the distance between the two.

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)
(**Economic life implies reasonable care, such as keeping the plotter away from salt air as much as possible.)

The unit's memory can calculate these positions automatically and give the operator course headings. Some LORAN C systems can calculate speed and time to destinations, while others offset any cross-track error, giving the unit accuracy to within 100 feet.

The LORAN C system may save a commercial fisherman up to 10 percent of his total fuel by eliminating drift and other problems associated with navigation, such as human error.

The LORAN C system can be improved by interfacing it with any one of several other support navigation aids such as track plotters or auto pilots. The interface between LORAN C and auto pilots offers many possibilities. One system frees two men from the bridge. The vessel operator enters his destination into the LORAN C unit, and the unit then plots a course and instructs the auto pilot. This frees the helmsmen to do other work. The operator, meanwhile, need only check to make sure the unit is working properly. Once at the destination, the memory function can be implemented to plot trawl patterns and the return to port.

Cost and economic data.

Initial cost: $2,000 to $9,000 (Based on manufacturer's estimates and the number of extra features on the unit)
*Installation cost:** $23 to $40 per hour
Installation time: Approximately six hours
Haul-out necessary? No
Fuel savings: Up to 10 percent
Economic life: Five to 10 years

Improving Engine Performance

The following long-term alternatives are primarily designed to improve the propulsion system and engine performance to reduce fuel consumption.

Turbochargers

A turbocharger is a turbine compressor driven by hot, exhaust gasses that provides additional air to the engine's cylinders. This action permits a larger fuel charge to be burned in the cylinder, allowing the engine to develop more horsepower. This additional power is added without increasing engine size. The result is a more efficient engine and a reduction in fuel consumption.

Advantages.

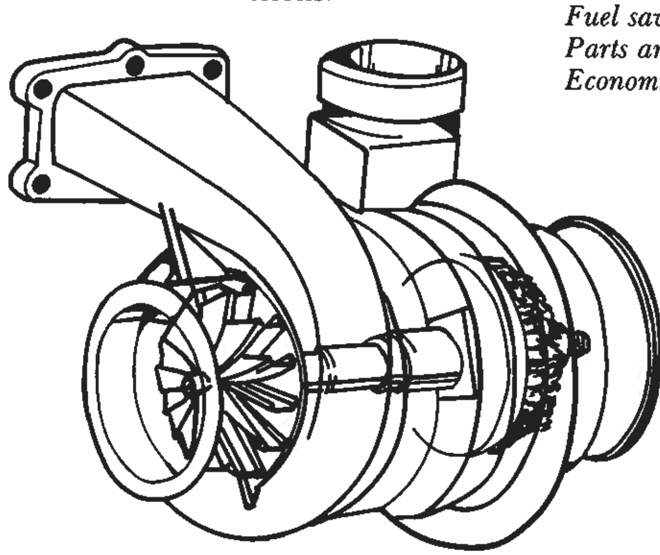
1. Longer piston, ring and valve life.
2. Reduced smoke and exhaust emissions.
3. Reduced mechanical noise from the engine.
4. Increased engine efficiency.
5. Increased fuel efficiency.
6. Cooler exhaust stack temperatures.

Disadvantages.

1. The pistons, rings, valves and cooling system may need to be modified or changed to properly match the turbocharger to the engine on which it is being installed.

Cost and economic data

Initial cost: $500 to $2,500 (Based on manufacturer's estimates)
*Installation cost:** $20 to $25 per hour
Installation time: 50 to 60 hours
Haul-out necessary? No
Fuel savings: Up to 10 percent
Parts and service available? Yes
Economic life: Five to 10 years



See-through diagram of turbocharger.

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Long-Term Alternatives

Improving Engine Performance

Engine Changeout

A four-cycle diesel engine operates more efficiently than a two-cycle engine because of its simplified piston operation. The piston goes through four cycles: intake, compression, power and exhaust strokes. This operation allows for maximum output from each cylinder.

Advantages.

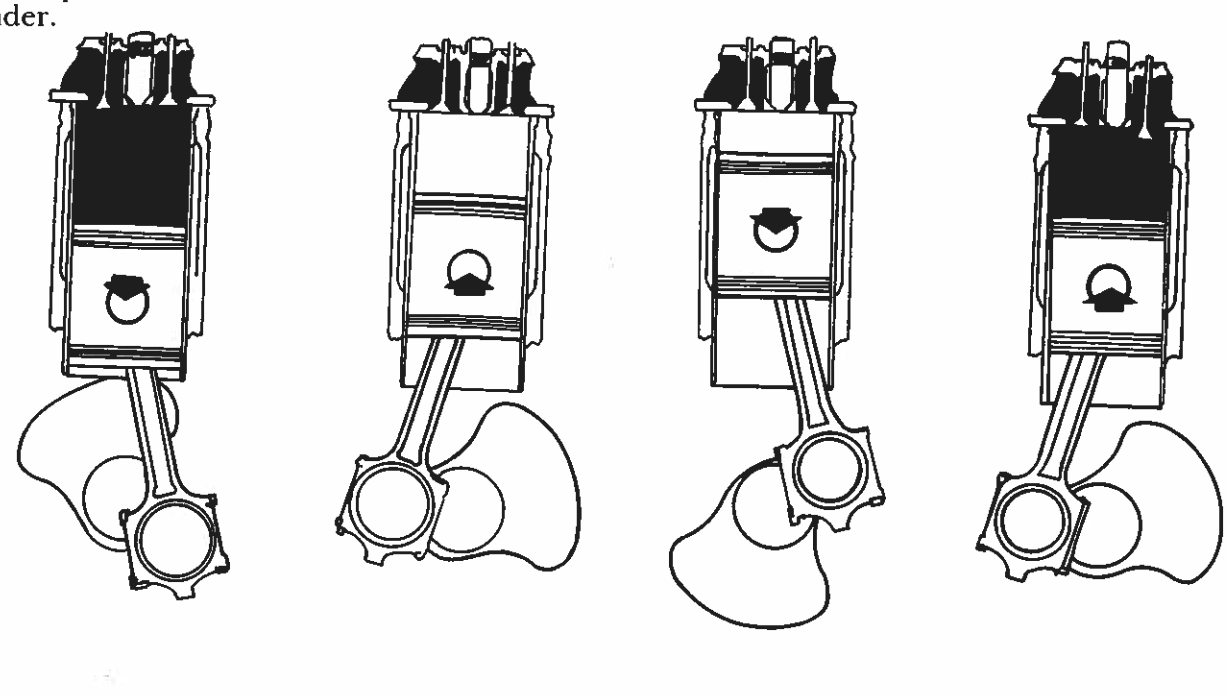
1. A full intake stroke allows more air to enter each piston chamber. The result is higher compression in each cylinder. In a two-stroke engine, the intake and exhaust strokes are combined, so less air enters the chamber and lower compression results. A full power stroke allows maximum output from each cylinder.
2. Less oil consumption. A two-stroke engine has intake ports on its cylinder walls. Oil is allowed to escape from the cylinder as the piston ring passes the port on its exhaust stroke. A four-stroke engine has no intake ports; therefore, no lubricating oil is lost.
3. The cylinder characteristics of the four-stroke engine result in longer piston and ring life, which can mean lower maintenance costs over the life of the engine.
4. Four-cycle engines are capable of using a wider range of fuel grades.

Disadvantages.

1. High initial cost.
2. Possibility of significant down-time for the changeout. The amount of time varies, depending on modifications necessary for engine installation.

Cost and economic data.

Initial cost: $22,000 to $42,000 (Based on engine size and manufacturer's estimates)
*Installation cost:** $3,200 to $7,500
Installation time: 70 to 80 hours
Haul-out necessary? No
Fuel savings: 1 to 2 gallons per hour or up to approximately 7 percent
Parts and service available? Yes, from major dealers
Economic life: 10 to 15 years



4-cycle engine *Stroke 1, compression* *Stroke 2, power* *Stroke 3, power* *Stroke 4, exhaust*

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Long-Term Alternatives

Improving Engine Performance

Diesel Fuel Preheater

The diesel fuel preheater works on the principle of fuel expansion by heating. Preheating also lowers the flashpoint of the fuel. Diesel fuel has a standard flashpoint of 150 degrees. Heating the fuel to 180 degrees pushes the fuel past its normal flashpoint for more efficient combustion.

Advantages.

1. The volume of fuel expands by approximately 8.6 percent. For example, 25 gallons of fuel will expand to 27.15 gallons after going through the preheater.
2. It is claimed the combustion is more efficient. Use of a preheater gives a 96 percent burn as opposed to an 88 percent burn for unheated fuel.

Disadvantages.

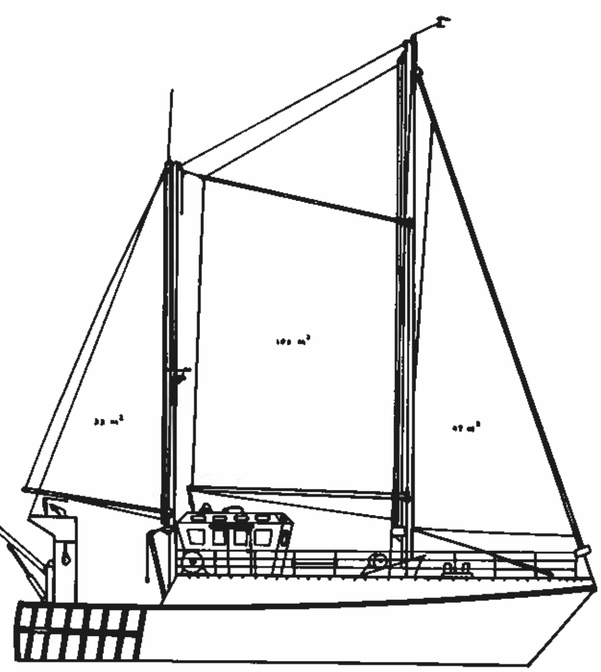
1. The preheater has not been tested extensively in the laboratory.
2. Diesel engines show an average 1 percent loss in power for every 10-degree increase in fuel temperature beyond the standard flashpoint.
3. Some engines use the fuel for injector cooling. Use of the preheater in these engines could cause heat damage to injectors.
4. If the preheater leaks water into the fuel system and the mixture is injected into the block, any resulting engine damage is not covered by the warranty.

Cost and economic data.

Initial cost: $400
*Installation cost:** $18 to $40 per hour
Installation time: 2 to 3 hours
Haul-out necessary? No
*Fuel savings:*** Up to 15 percent
Economic life: 10 to 15 years

Vessel Modifications — Propulsion

New ideas may be adopted and perhaps totally new types of vessels may be developed to meet the long-term, future needs of commercial fisheries. Currently, several firms are designing vessels that will use sail-assisted power in their fishing operations.



Vessel rigged with sails.

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)
(**Based solely on manufacturers' claims, since there is a lack of adequate independent testing.)

Long-Term Alternatives

Vessel Modifications — Propulsion

Sail-Assisted Power

The idea of using a sail to assist in powering fishing operations is being studied for application to U.S. commercial fisheries and several vessels are currently in operation in the New England fishery. These vessels do not use sail power exclusively, but use both a sail and an engine. The sailing rig employed has to be non-automated and as simple as possible to prevent excessive rigging from hindering the operation of fishing gear and interfering with crew mobility.

Advantages.

1. Increased security in the event of engine failure at sea.
2. Increased vessel stability in foul weather due to a heavily ballasted keel.
3. Potential for substantial fuel savings by effective use of sail-assisted power.

Disadvantages.

1. It is impractical to consider installing sails on most vessels presently in operation, because major hull modifications would be necessary to make the hull compatible with the sailing system.
2. Sails present an added maintenance item.
3. Crews must be taught the mechanics of sailing.
4. Information on costs, economic data and vessel operations with sail-assisted power in the Gulf of Mexico shrimp fishery is presently insufficient.

Two-Speed Gear Boxes

A two-speed gear box or two-speed propeller provides full power and maximum thrust during trawling operations. This improves propeller efficiency and thrust when trawling and also provides a more efficient free running operation. With a two-speed gear box, the fixed pitch propeller will probably still be designed to be at optimum performance in a free running condition or possibly at optimum performance somewhere between trawling and free running conditions.

A two-speed gear box with a lower free running speed will save fuel if it is used to obtain a given thrust at trawling equal to that provided by a single-speed gear box. A fuel savings of up to 10 percent is possible when the power required has been reduced.

Advantages.

1. Provides maximum thrust and full power during trawling operations.
2. Improves propeller efficiency.
3. Provides fuel savings by reducing power requirements for free running operation.
4. Provides variable engine speeds without loss of thrust and without the additional cost of completely variable propellers.
5. Reduces engine wear and lengthens engine life.
6. Improves vessel maneuverability and speed ranges of vessel.

Disadvantages.

1. Relatively high initial cost, but less than completely variable speed propellers.
2. Engine rpm and gear ratio adjustments must be controlled together for maximum efficiency.
3. Gear selection by operator is important to overall efficiency and full savings.

Cost and Economic Data.

Initial cost: $13,000 to $20,000 (based on vessel size and manufacturer's estimates)
*Installation costs:** $4,000 to $6,000
Installation time: One to two days
Haul-out necessary? Yes
Fuel savings: Up to 10 percent
Parts and service available? Yes, but may be limited in some areas.
Economic life: 15 to 20 years

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Long-Term Alternatives

Vessel Modifications — Propulsion

Ducted Propellers (Nozzles)

A nozzle increases a propeller's pulling power under heavy loads, for example, when trawling or coming into port fully loaded. By redirecting the natural flow of water through the nozzle, a force additional to the normal propeller thrust causes an increase in the velocity of water passing through the propeller's plane. The force of the water passing through the nozzle actually overrides the normal propeller thrust, reducing the propeller thrust itself, although increasing overall thrust.

Advantages.

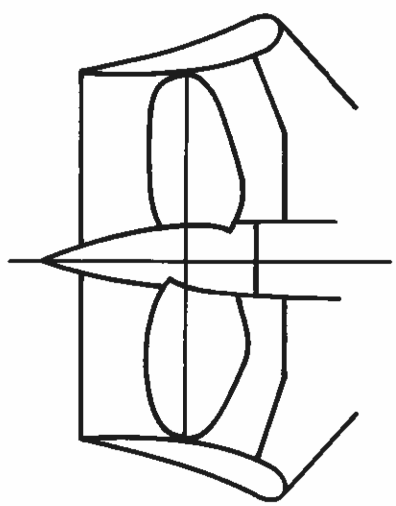
1. A relatively high fuel savings is possible using a nozzle/propeller combination.
2. The nozzle offers protection to the propeller. While some damage may be unavoidable in normal fishing operations, damage tends to occur less frequently with ducted propellers than with nonducted propellers used in similar conditions.
3. Less hull vibration. The velocity increase due to the shape of the nozzle tends to smooth out variations in hull wake.
4. Less risk of propeller cavitation.
5. Propeller noise is reduced.
6. The nozzle contains no moving parts, so routine painting and polishing are the only maintenance required.

Disadvantages.

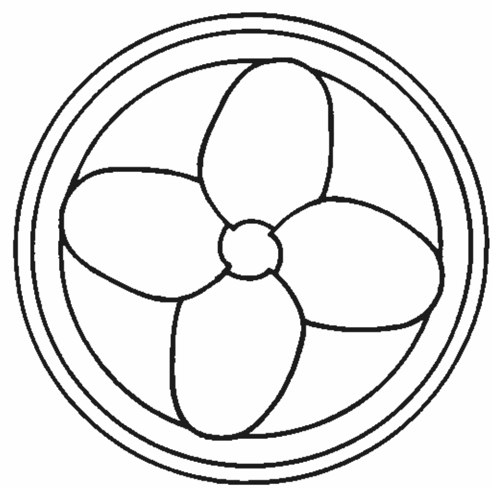
1. Older vessels may require major modifications to the hull to allow nozzle installation.
2. There is a possibility that increased drag will be greater than the increased thrust at speeds of more than 10 knots.
3. Maneuverability of the vessel may be lessened, especially at very low speeds.
4. Increased suction may pick up junk from shallow bottoms that may lodge between the nozzle and propeller. May also pick up sharks.

Cost and economic data.

Initial cost: $7,000 to $12,000 (Package price based on vessel size and manufacturer's estimates)
*Installation cost:** $2,000 to $3,000
Installation time: Approximately three days
Haul-out necessary? Yes
Fuel savings: 10 to 15 percent
Parts and service available? Yes
Economic life: 15 to 20 years



Cutaway side view of nozzle.



Rear view of propeller and nozzle mounted on fishing vessel.

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Long-Term Alternatives

Vessel Modifications — Propulsion

Controllable Pitch Propellers

A controllable pitch propeller allows adjustment of the pitch/diameter (P/D) ratio of a propeller, and allows the engine to be operated in the load and speed ranges which produce minimal fuel consumption. This is beneficial since the optimal P/D ratio for trawling is different than the optimal P/D ratio for free running conditions. Aside from fuel savings, the ability to adjust the throttling of the engine means a more efficient engine and longer engine-life potential.

Advantages.

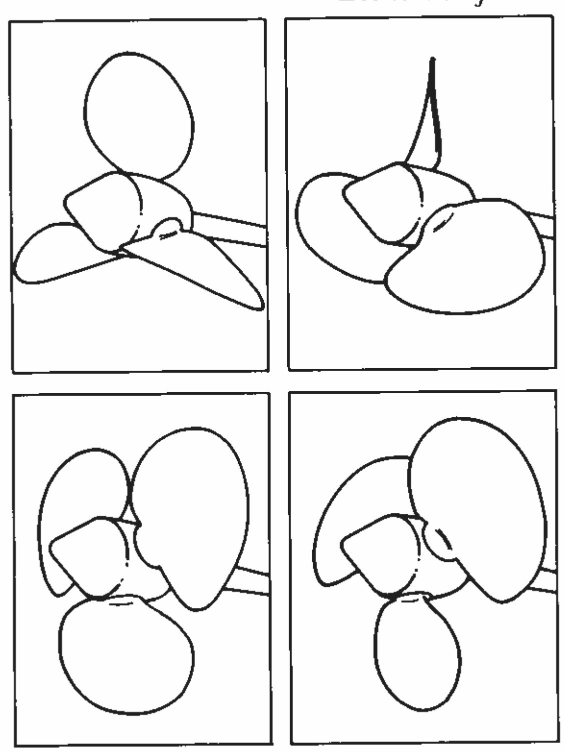
1. Longer engine life. The engine is allowed to run at an optimal load level.
2. Thrust is increased over that from a fixed pitch propeller by about 20 percent when trawling.
3. The vessel's maneuverability is better; low, creeping speeds are possible.
4. Reverse gear may be eliminated.
5. The operator has the ability to adjust for maximum pull or maximum speed.
6. There is potential for a longer propeller life. The blades run in one direction; consequently, the thin, trailing edges have less chance of being damaged.

Disadvantages.

1. The operator must know the proper operating procedures required by this system.
2. Initial cost is higher than for a fixed propeller system.
3. Poor propeller efficiency at low speeds.
4. Engine rpm and the pitch of the propeller must be controlled together for proper use.
5. A controllable pitch propeller is heavier than a fixed propeller; this adds weight to the vessel.
6. Additional hydraulics are normally needed to operate the unit.
7. Dealers are regional and limited in number.

Cost and economic data.

Initial cost: $40,000 to $60,000 (Based on vessel size and manufacturer's estimates)
*Installation cost:** 1/3 to 1/2 of initial cost
Installation time: Three to five days
Haul-out necessary? Yes
Fuel savings: Up to 15 percent normally and under ideal conditions the savings could go as high as 25 percent
Parts and service available? Yes, but limited
Economic life: 15 to 20 years



Propeller pitch adjustment on controllable pitch propeller.

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Long-Term Alternatives

Vessel Modifications — Hull

Bulbous Bows

There are ways to reduce the residuary drag on the hull. One way is to modify the hull to minimize the wave system generated by a vessel. A bulbous bow is an underwater extension, in the shape of a sphere or cylinder, built onto the bow of a vessel. Its purpose is to interfere with wave action. It acts as a wave resistor, canceling out waves generated by the movement of the boat. The net result is a reduction in residuary hull resistance.

Advantages.

1. It has the potential to reduce hull drag caused by a vessel's wave resistance. This is especially true on vessels whose designs cause excessive wave generation. The reduction of drag will increase fuel economy.

Disadvantages.

1. The services of a naval architect must be used to determine the proper dimensions and placement of the bulb.
2. The bulb may protrude beyond the bow overhang on some vessels, making it susceptible to damage.
3. A modified or controllable pitch propeller is needed with a bulbous bow, because the bow's presence can change the flow to the propeller.
4. The bulbous bow tends to reduce pitch in moderate waves, resulting in a "wetter" ride.

Cost and economic data.

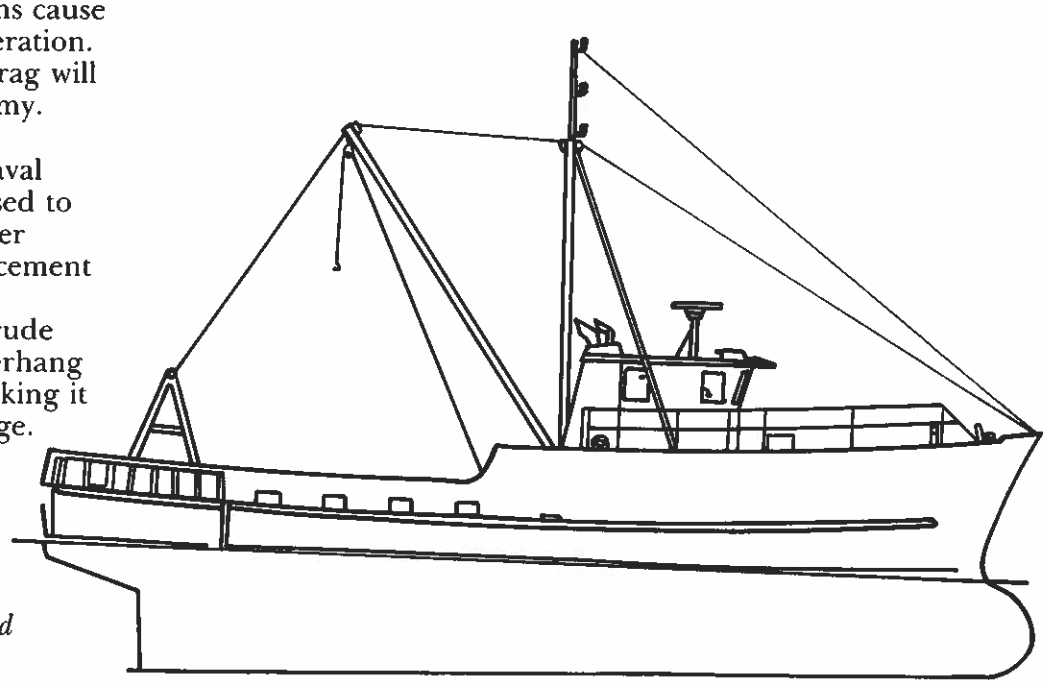
Design cost: $2,000 to $3,000. Design cost may vary depending on the naval architect consulted.

*Installation cost:** $5,000 to $11,000

Installation time: Variable, but at least one month

Haul-out necessary? Yes

Fuel savings: Up to 10 percent



Fishing vessel equipped with bulbous bow.

(*Cost of installation will vary depending on location and wage rates. For warranty purposes, it is recommended by manufacturers that installation be done by authorized dealers and representatives.)

Chart 2. Long-Term Alternatives

(Economic Life of Five Years or More)

Alternative	*Initial Cost*	*Cost of Installation*	*Haul Out*	*Fuel Savings*
Fuel Flow Meters	Varies greatly $3,500-$10,000	Varies by location and equipment $55-$120 or more	No	Varies greatly Up to 8-20% Operator efficiency & equipment accuracy
Track Plotters	$5,000-$6,000	Varies by location $50-$100	No	Varies by operator up to 15%
LORAN C System	Varies greatly $2,000-$9,000	Varies by location $140-$250	No	Varies by operator efficiency up to 10%
Turbochargers	Varies greatly $500-$2,500	Varies by location $1,000-$1,500	No	Varies by engine type up to 15%
Change from 2-cycle to 4-cycle diesel engine	Varies greatly by engine size & manufacturer	Varies by location and manufacturer $3,200-$7,500	No	Varies by engine size up to 7%
Diesel Fuel Preheater	$400	Varies by location $36-$120	No	Lack of adequate testing
Sail-Assisted Power	Varies greatly; presently inefficient information available for comparison.	Varies greatly; presently inefficient information available for comparison.	No	Varies greatly; presently inefficient information available for comparison.
Controllable Pitch Propeller	Varies greatly by manufacturer & size of propeller. $40,000-$60,000	Varies by location manufacturer & size of propeller. $14,000-$25,000	Yes	Varies by operator efficiency, size of propeller & type of operator. Up to 25%
Ducted Propeller	Varies greatly. $7,000-$12,000	$2,000-$3,000	Yes	Varies by operating speeds. Up to 15%
Bulbous Bow	Varies greatly due to design and installation costs. $7,000-$14,000	Varies greatly. $5,000-$11,000	Yes	Up to 10%

Long-Term Alternatives Cont.

Alternative	*Economic Life*	*Major Advantages*	*Major Disadvantages*
Fuel Flow Meters	5 years	Measures fuel consumption at different speeds to determine best operating speed.	Units vary greatly in efficiency and accuracy. High initial cost.
Track plotters	5 years	Reduces running time. Increases navigational safety.	High initial cost. Operator efficiency.
LORAN C System	5-10 years	Reduces running time by eliminating drift. Increases navigational safety.	High initial cost. Operator efficiency.
Turbochargers	5-10 years	Longer engine life. Improved engine efficiency & reduction in exhaust emissions.	May require modification to engine.
Change from 2-cycle to 4-cycle diesel engine	10-15 years	Longer engine life. More power per cylinder. Wider range of fuel grade.	High initial cost. 2-3 weeks down time for change over.
Diesel Fuel Preheater	10-15 years	Increases volume of fuel and provides more efficient combustion of fuel.	Loss of power can cause damage to fuel injector.
Sail-Assisted Power	Varies greatly; presently inefficient information available for comparison.	Security in event of engine failure. Potential for substantial fuel savings during running period.	Impractical on some vessels; added maintenance, crew training in sailing.
Controllable Pitch Propeller	15-20 years	Longer engine life. Increased thrust. Potentially longer propeller life and better maneuverability.	High initial cost. Operator efficiency. Poor propeller efficiency at low speeds.
Ducted Propeller	15-20 years	Less hull vibration & propeller noise. Low maintenance. Less risk of propeller cavitation.	Older vessels may require major modification. Maneuverability is lessened.
Bulbous Bow	15-20 years	Reduces vessel's wave resistance & hull drag.	Requires special design work. Bow may be susceptible to damage. May require some modification of propeller.

Payback Decision

One of the most important considerations in selecting a fuel saving alternative is to determine when the fuel saving device or vessel modification begins to contribute a profit to the operation of the vessel. Another way of looking at this is to determine how long will it take to "pay back" the cost of the equipment from vessel operations. The key to calculating payback is to have accurate cost estimates of purchase price, installation, maintenance and the value of funds to be invested for the equipment or the cost of borrowing funds for the purchase. You must also estimate the amount and cost of fuel you plan to use. With this information you can calculate the payback period. Most of this information will have to come from your own research. This publication provides general guidelines.

The payback formula worksheet (Fig. 2) will provide you with an approximate payback period. The steps are simple to follow and an example (Fig. 1) is provided to also serve as a guide. Several calculations might be useful using different alternatives and/or different cost estimates. You may want to make several copies of the worksheet for this purpose.

Figure 1. Example of Payback on a LORAN C System

You select a LORAN C system for your boat with a purchase price of $5,000. The installation cost on the system would be $35 per hour for six hours for a total cost of $210. The amount of lost revenue due to the vessel being out of service for six hours was estimated at $500. The annual maintenance cost was estimated at approximately $150 per year with an economic life for the system of about seven years. You estimate a value of your invested funds at 12 percent. The estimated fuel savings for the system is set at 7.5 percent. The annual fuel consumption on the vessel is approximately 40,000 gallons at an average price of 99 cents per gallon.

Enter the following values in lines noted.

Line 1. $ 5,000
Line 2. $ 210
Line 3. $ 500
Line 4. $ 150
Line 5. $ 1,050
Line 6. $ 6,760
Line 7. 12 percent
Line 8. 1.12
Line 9. 7,571.2
Line 10. .075
Line 11. 40,000 gallons
Line 12. 3,000
Line 13. $.99/gallon
Line 14. $ 2,970
Line 15. 2.549
Line 16. 30.6 months

Based on the figures given for the example it would take approximately 31 months for the LORAN C system to pay for itself and begin to show a profit from its operation.

Figure 2. Fuel Saving Equipment Payback Formula Worksheet

The following steps should be used in calculating the total payback for a fuel saving device purchase or vessel modification. When selecting cost data from this guide use the "most reasonable" estimate for your area and particular application since cost estimates vary so much nationwide.

Type of fuel saving device/vessel modification: ______________

______ 1. Enter total purchase price.
______ 2. Enter total installation costs.
______ 3. Enter amount of estimated revenue lost due to installation based on amount of time vessel is out of service and the net amount of revenue normally generated by the vessel for this period of time.
______ 4. Enter total annual maintenance costs.
______ 5. Multiply amount in line 4 by the estimated life of the equipment.
______ 6. Add value in lines 1, 2, 3, and 5.
______ 7. Estimate the value of your invested funds as a percentage based on what you feel would be a reasonable rate of return on your money if it were invested in some type of interest bearing account.
______ 8. Divide the percentage in line 7 by 100 and add a value of 1. (Example: 15% ÷ 100 = .15, + 1 = 1.15)
______ 9. Multiply value in line 6 by value in line 8.
______ 10. Take the expected fuel savings percentage to be generated by the fuel saving device and divide by 100. (Example: 15% ÷ 100 = .15)
______ 11. Annual fuel consumption in gallons for vessel.
______ 12. Multiply the value in line 10 by the value in line 11.
______ 13. Average expected fuel price per gallon in dollars and cents.
______ 14. Multiply value in line 12 by the value in line 13.
______ 15. Divide the value shown in line 9 by the value in line 14.
______ 16. Multiply the value in line 15 by 12.

The value in line 16 represents the number of months required to pay back the value of the fuel saving device or vessel modification. This represents the point that you begin to show a profit from the operation of the fuel saving device or vessel modification.

TAMU-SG-84-504
5M Jan. 84
NA83AA-D-00061
NA81AA-D-00007
A/F-4

The publication of this paper is a project of the Southeastern Region Marine Advisory Service Network (SEMAS), a cooperative activity of Sea Grant programs in Louisiana, Texas, Mississippi, Alabama, Florida, Georgia, South Carolina, North Carolina, and the NOAA Office of Sea Grant, U.S. Department of Commerce. Additional information may be obtained from local marine advisory agents.