

Agency: Commerce, Community and Economic Development**Grants to Named Recipients (AS 37.05.316)****Grant Recipient: Alaska Fisheries Development Foundation****Federal Tax ID: 92-0068881****Project Title:****Project Type: Planning and Research**

Alaska Fisheries Development Foundation - Fishing Vessel Energy Audit Pilot Project

State Funding Requested: \$500,000**House District: Statewide (1-40)**

One-Time Need

Brief Project Description:

This project will conduct energy audits of commercial fishing vessels. The results of this 3-year pilot program are intended to inform the design of a larger-scale 5-year program with the goal of a total energy savings for fishing vessels of 15% of 2010 levels by 2020. This goal is consistent with the three energy efficiency goals identified in the 2010 "Alaska Energy Pathway".

Funding Plan:

Total Project Cost:	\$500,000
Funding Already Secured:	(\$0)
FY2013 State Funding Request:	<u>(\$500,000)</u>
Project Deficit:	\$0

Funding Details:

AFDF and the University of Alaska Marine Advisory Program (MAP) sponsored previous work in energy efficiency for fishing vessels in 2011. This pilot program will be a new project, and will be conducted in collaboration with industry, the MAP, and the Alaska Energy Authority.

Detailed Project Description and Justification:

In 2010, AFDF and the University of Alaska Marine Advisory Program (MAP) sponsored an international symposium on "Energy Use in Fisheries" (see attached agenda). In 2011, AFDF and MAP sponsored a workshop at the Pacific Marine Expo regarding improving energy efficiency of fishing vessels through the use of an energy self-audit workbook (see attached documents). Recently, AFDF and MAP submitted a grant application to the North Pacific Research Board (NPRB) to conduct scientific testing of various fuel saving technologies compatible with Alaska fishing vessels which have the potential to reduce energy consumption and decrease emissions.

Based on the research from this previous work, implementing combinations of energy efficiency operating techniques and technologies on fishing vessels could reduce energy consumption by 15-30%. However, initial feedback from fishermen related that the self-audit workbook was somewhat complicated and it would not replace an energy audit by an expert. Therefore, AFDF is collaborating with both the MAP and the Alaska Energy Authority to design a Fishing Vessel Energy Audit Pilot Project. The Fishing Vessel Energy Audit Pilot Project will complete the following objectives: 1) conduct 50-100 audits per year for three years, 2) conduct a survey in order to determine baseline end-use energy consumption data, and 3) provide outreach to the industry in order to disseminate results.

Results: The results of this 3-year pilot project are intended to inform the design of a larger-scale 5-year program with the goal of a total energy savings for commercial fishing vessels of 15% of 2010 levels by 2020. This goal is consistent with and complimentary to the three energy efficiency goals identified in the 2010 "Alaska Energy Pathway":

- 1) A total electricity savings of 15% of 2010 use levels by 2020
- 2) A total heat savings of 15% of 2010 use levels by 2020
- 3) The promotion of modern, efficient, and sustainable transportation options

Project Timeline:

This is a 3-year pilot program. Planning will occur during the first half of year one. Energy audits will be conducted each of the three years. Outreach to the fishing fleets will also occur (twice events per year) throughout the project. All activities and expenditures will be concluded by June 30, 2015.

Entity Responsible for the Ongoing Operation and Maintenance of this Project:

Alaska Fisheries Development Foundation

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Has this project been through a public review process at the local level and is it a community priority? Yes No

Fuel-Saving Measures for Fishing Industry Vessels



When gasoline and diesel fuel prices hit record high levels in 2008, vessel operators looked for new ways to reduce fuel consumption and costs. Prices retreated the following year and the concern about fuel efficiency diminished. In 2011 prices began climbing again, and analysts say that the supply and demand factors point to a coming era of fuel prices substantially higher than previously experienced in the United States.

Research organizations in the United States and abroad conduct studies on ways to cut fuel costs. Formal research and operational experience point to technological and operational measures that can help vessel owners save fuel.

This report summarizes results from published studies and experiences reported by commercial vessel operators on ways to reduce fuel consumption and save money. It is intended to do the following:

1. Briefly outline how fuel energy is consumed in a fishing vessel and the implications for finding fuel savings.
2. Describe results of research into vessel energy efficiency.
3. List some emerging technologies, existing technologies currently in application outside of the fishing industry, and technologies and classes of products that are being touted as helpful in saving fuel but are impractical, unproven, or proven to be ineffective.
4. Describe some proven methods for achieving improved efficiency that are realistic for fishing operations.
5. Summarize the concept of a fishing vessel energy audit.

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Apart from the methods and technologies mentioned in no. 3 above, this publication addresses only methods that are **currently available, relevant, proven**, and at least potentially **financially viable**. Most can be applied to existing vessels at modest or no cost. Some are appropriate only at the time of re-power or refit of an existing vessel, or new construction.

To document fuel savings it is necessary to **keep consistent and detailed performance and cost records**. Any modifications that impose additional cost on the operation should be undertaken only if financial analysis projects a **positive return on investment (ROI)** over a reasonable period of time (“payback period”). An improvement that pays for itself in a couple of years through fuel cost savings probably is a good move—one for which payback is projected to take decades may not be. Most of the measures discussed here will produce only modest reductions in fuel consumption, so careful calculations are in order to make the best decisions.

Approaches to potential fuel savings that are **not discussed in this publication**:

- ◆ Fish harvesting gear and methods, and improvements to gear design and construction.
- ◆ Seafood handling, storage, processing, and distribution.
- ◆ Fisheries management for fuel savings.

Fishing Vessel Efficiency Research

Around the world navies, shipping companies, and fleet owners of large workboats are studying ways to reduce vessel fuel consumption. Most of this work is focused on size classes of vessels too large for results to transfer readily to small fishing industry vessels. At the same time, a few universities and government and intergovernmental agencies are conducting efficiency research specifically on fishing vessels. This research includes:

- ◆ Naval architecture and marine engineering approaches to more efficient hull shapes, better propellers, more efficient roll attenuation devices, and similar technical approaches.
- ◆ Gear design improvements, particularly improved design and construction materials of trawl nets, and comparative studies of fish harvesting methods.
- ◆ Advances in electronics for navigation and fish finding.
- ◆ Improving efficiencies in fish product handling, storage, shipping, distribution, and marketing.
- ◆ Changes in fisheries management strategies, fishing access allocation, scale of operations, and other economic approaches.

In 2010, two international conferences on energy efficiency in the fishing industry were held: The First International Symposium on Fishing Vessel Energy Efficiency: E-Fishing in Vigo, Spain; and the International Energy and Fisheries Symposium in Seattle, USA. Each featured reports on the research of dozens of experts in vessel design, fisheries engineering, economics, and other fields. Proceedings (the collected papers and presentations) of both conferences are posted on the Internet: www.e-fishing.eu/papers.htm for the conference in Vigo, and <http://energyefficientfisheries.ning.com/page/energy-use-in-fisheries> for the Seattle symposium (requires login).

How Vessels Consume Energy

The diesel engine is a marvel of efficiency compared to any currently available alternative. However, about **two-thirds** of the energy in the fuel that is burned in a diesel engine is **lost as heat** mainly through the exhaust, water jacket cooling system, and radiation from the block. Additionally, energy that reaches the drive train is lost in reduction gear (1-3%) and shaft friction (1-2%) and propeller slip.

Only 10 to 15% of the energy contained in the fuel actually moves the boat. Of the fuel energy that reaches the prop, more is lost to other inefficiencies:

- ◆ 27% is used to overcome wave resistance (surface waves made by the vessel).
- ◆ 18% is used to overcome skin friction.
- ◆ 17% is used to overcome wake and prop wash at the transom.
- ◆ 3% is used to overcome air resistance.

Six Approaches to Saving Fuel

It is helpful to think of a fishing vessel, including propulsion, hull, operator, and operating strategies, as an integrated whole. The information in the preceding section, derived from published sources on marine engineering, points to places within that system to search for energy savings. Following are six general approaches to fishing vessel energy conservation.

1. Improve engine efficiency.
2. Reduce drive train (reduction gear, propeller, or jet) losses.
3. Reduce wave resistance. This normally is achieved by reducing boat speed.
4. Minimize skin friction, and hull and appendage drag.
5. Reduce non-propulsion-related energy demands and parasitic loads such as pumps, motors and lights that are on when not needed.
6. Reduce total distance traveled through the water.

Emerging Technologies

Many new technologies are being applied to vessels, including commercial fishing vessels—some totally experimental, and some already in application on other kinds of vessels. Following is a brief summary of these emerging technologies. **Most are not in use or are in very limited use on working fishing vessels**, and some never will be used. They are listed here not to dismiss them as unworkable, but to set them apart from approaches that are being applied on working fish-boats, discussed in later sections of this publication. These emerging technologies fit into four broad categories: hulls, propulsion, alternative fuels, and fuel combustion efficiency products.



This vessel has space for a larger diameter propeller, which would improve propulsion efficiency. Note also two sets of V-struts, appendages that create fuel-robbing drag. Though less than optimally efficient, the boat was configured this way to meet other operational criteria. Sometimes the pursuit of fuel efficiency can compromise other objectives.

HULLS

Catamarans, small-waterplane-area twin hulls (**SWATH**), **hydrofoils**, **low-block-coefficient (ultra-slim) hulls**, and **ultra-lightweight construction** materials are hull types used by the military and in the commercial passenger industry, but have not been proven efficient for commercial fisheries with very few exceptions. Note that what may now be considered an ultra-slim hull was at one time standard in many fisheries. Length-to-beam ratios of 4:1, 5:1, and even 7:1 still can be found on some working boats built a half-century ago or more.

PROPULSION

Electric, Solar-Electric, Diesel-Electric Hybrid

Various forms of electric drives are currently in use in commercial and recreational vessels. Diesel-electric propulsion has long been used in ships and large workboats. **Hybrid diesel-electric**, where a small diesel-powered generator maintains a battery bank that supplies current to an electric motor turning the propeller shaft, is the technology being adapted to some pleasure boats and a few commercial passenger boats. It offers significant efficiency improvement because the diesel generator operates at optimum output and load—the slow-turning high-torque characteristics of the electric motor allow use of an efficient large-diameter, slow-turning propeller. Diesel-electric allows for use of a smaller diesel engine and more flexibility in its location. The electric motor can run on batteries alone for hours at a time to reduce noise and pollution. Batteries also can be charged from solar panels, shore power, or wind. Continuing improvements in battery technology may soon make hybrid diesel-electric viable for commercial fisheries.

Drive System Innovations

Many innovations in drive systems are in use. **Jet** drives and **surface piercing** drives are used in some fisheries and are being refined with an eye toward improved fuel efficiency. Workboats and recreational boats are seeing applications of **pod drives**, **Z-drives**, and other variations on the screw propeller. Particularly in planing hull configurations, pod drives—either forward- or aft-facing—are claimed to produce as much as a 30% reduction in fuel consumption due to their zero shaft angle, the efficiency of dual props, and the reduction in underwater appendages.

ALTERNATIVE FUELS

Fuel with characteristics similar to diesel oil can be made with fryer grease, soybeans, algae, fish oil, and other materials, and **bio-diesel** can be made as a blend of petroleum and biological sources. Typically bio-diesel is a blend of 10% or 20% bio-fuel with petroleum diesel oil, but diesel engines also will run on straight vegetable oil (SVO). Ethanol, made from corn, grains, and agriculture waste, has long been blended with gasoline. Bio-diesel is less energy-dense than petroleum diesel fuel and has a gelling problem at low temperatures. It is unclear what effect long-term use will have on engines in prolonged service. Where commercially available, bio-diesel also has been more expensive than diesel oil, although this may change as the diesel price increases.

Work continues on **hydrogen fuel cell** technology, which someday could be used to power vessels. Hydrogen is not a fuel—it is a way of holding and transporting energy produced in some other manner (such as hydro, coal, or nuclear electricity generation) in a manner analogous to a battery. Therefore the cost of the fuel would be tied to the cost of generating the electricity needed to produce it.

The shipping industry currently is developing vessels fueled by **liquid natural gas (LNG)**, and other forms of propane and natural gas are used in shore-based engines. Natural gas is abundant, inexpensive, and cleaner burning than diesel, but is less energy dense and requires large and expensive tankage. Propane and compressed natural gas (**CNG**) already fuel many vehicles, generators, and industrial machines like forklifts.

Wind also may be termed an “alternative fuel” simply because it has fallen so far out of favor with the fishing industries of industrialized nations. But sails still power many of the world’s fishing boats in developing countries, and new technologies such as kite sails and axial sails may bring a resurgence of interest in sails in developed economies.

FUEL ADDITIVES, FUEL CATALYSTS, MAGNETIC FUEL POLISHING, HYDROGEN INJECTION, ETC.

Many companies offer products claimed to improve fuel combustion efficiency, reduce engine internal friction, remove fuel contaminants, or in other ways improve fuel economy. These claims should be examined closely—most of the products have not been proven effective in controlled testing, and are not endorsed by engine manufacturers. The U.K.’s Seafish Authority tested several products on the market in that country and found that they produce only insignificant improvement, if any.

Some fishermen are experimenting with variations on the concept of “Brown’s gas” or **hydrogen injection**. They use onboard electrical power to produce hydrogen gas from purified water and inject the hydrogen into the fuel line or engine air intake where it is said to make the diesel fuel burn more cleanly and completely. A California fisherman who built his own system reports cleaner exhaust and 15% less fuel consumption. A commercially manufactured system is used in trucks and stationary power plants. More will be known when detailed performance data are published.

Approaches to Improving Engine Efficiency

BUY A NEW ENGINE

Sometimes an effective way to improve vessel efficiency is to replace an aging diesel main engine with a turbocharged “common rail” electronically controlled four-cycle model diesel. Manufacturers claim that their new engines are significantly more fuel-efficient than predecessors, particularly when compared to the popular and durable two-stroke diesels of a design going back to the 1930s. The State of Alaska offers a low-interest loan program for engine upgrades through the Division of Investments. An operator whose engine is old, in need of major repair, or approaching replacement time might do well to consider such an upgrade.

However, actual fuel savings may be difficult to quantify and it is questionable whether a healthy running engine should be replaced on the basis of fuel savings alone. Some anecdotal accounts put savings at as much as 20% or more, and others found no savings at all. When considering an engine replacement it is helpful to obtain factory spec sheets that include power, torque, and fuel curves for the models being considered, and compare with performance curves for the current engine. Compare the **specific fuel consumption** (amount of fuel per horsepower [hp] or amount of horsepower per unit of fuel at specific rpm or outputs) among different engines. Unfortunately, not all engine manufacturers publish these data. Consider that company-published performance data are derived from engines in test bed configurations under optimal conditions that may produce results 2-8% better than real world conditions, and further that manufacturers commonly exaggerate results by 5% for competitive reasons.

Most diesel engines at maximum rated output produce 17-20 hp per gallon of fuel burned per hour. Specific fuel consumption is slightly better at around 70-85% of rated output, which is usually near the engine speed where torque is greatest. Fuel efficiency gradually diminishes as output decreases below 70%, even though total fuel consumption decreases even more. Two-stroke diesels tend to be more inefficient at low rpm than four-strokes, although both types are less efficient at the low and top ends of their power curve than at the 70-85% range.

Four-stroke gasoline engines and direct injection two-strokes at maximum rated output develop about 11 hp per gallon per hour. Carbureted two-strokes produce around 9-10 hp. Fuel efficiency in carbureted two-stroke gas engines drops off significantly at

lower engine speeds because irregular firing causes much of the fuel mix to be pumped out the exhaust unburned.

Typically there are only modest differences in specific fuel consumption among makes and models of diesel engines. Replacing an engine with a more fuel-efficient model based only on estimated fuel savings is recommended only if the current engine is a very old design and/or is due for overhaul/replacement anyway.

It is important to remember the distinction between **engine** efficiency and **vessel** efficiency. Even as an engine's efficiency decreases, expressed by the amount of fuel consumed per unit of horsepower produced or specific fuel consumption, the vessel's efficiency, expressed as fuel consumed per nautical mile traveled, may increase. This usually occurs when a displacement hull vessel slows, resulting in less wave energy loss.

Note that purchase of a new engine can impose other significant costs, including installation, replacement reduction gear, shaft, bearings, prop, exhaust, engine beds, and cooling system. Engine replacements tend to be most economical when the replacement engine is nearly the same size, shape, and output as its predecessor since it usually requires fewer alterations to the boat than would a more powerful engine. There has been a tendency in engine replacements to select a new engine that is bigger and more powerful than its predecessor. But anecdotal accounts suggest that some of the most successful swaps in terms of fuel efficiency involved purchase of a smaller engine. See How to "Right Size" the Engine below.

How to "Right Size" the Engine

Most displacement-hull commercial fishing vessels in Alaska are overpowered; that is, their engines can produce more power than is needed to propel the boat at its "**hull speed**" and do the required work.

Hull speed is the rate through the water at which a displacement hull vessel starts to encounter excessive wave resistance forces and requires disproportionately more power. Hull speed (in knots) is calculated as 1.34 times the square root of the waterline length in feet. (The 1.34 multiplier applies to a typical hull with a length to beam ratio of approximately 3:1. A lower multiplier would apply to a beamier hull, whereas a slimmer hull would have a larger multiplier.)



A seiner is steaming at about hull speed. The "bone in its teeth" shows that it is using more fuel than necessary.

For example the hull speed of a boat with a waterline length of 36 feet would be calculated as follows: the square root of 36 is 6. Multiply 6 x 1.34 and the result is a hull speed of about 8 knots. Hull speed for an 80 foot hull would be 12 knots based on the following calculation: 80 has a square root of approximately 9. Multiply 9 x 1.34 and the product is about 12 knots.

Hull speed for a typical boat in calm sea conditions (that is, steaming power demand only) requires about 4.5 hp per displacement ton. Increasing speed by one knot increases horsepower and fuel requirements by about 50%, and at speeds above hull speed the increase is even steeper. At a speed:length ratio of 1:1 only about 1 hp per displacement ton is required.

Add a 15% horsepower "sea margin" to overcome adverse wave conditions, and a 36-footer that displaces 12 tons needs only 62 hp to achieve an economical 8 knots. Since a diesel engine is most efficient running at about 80% of its rated horsepower, the

nominally correct size of engine for this vessel would be 77.5 hp.

Most Alaska fishermen are unwilling to settle for such a small engine—they like the feel of additional power, they believe that it's easier on the engine to run it well below its 80% output rate,¹ or they simply feel they need to go faster. But additional power comes at the cost of **greater fuel consumption**.

Right-sizing an engine at replacement time or during new construction can save in both capital and operating costs.

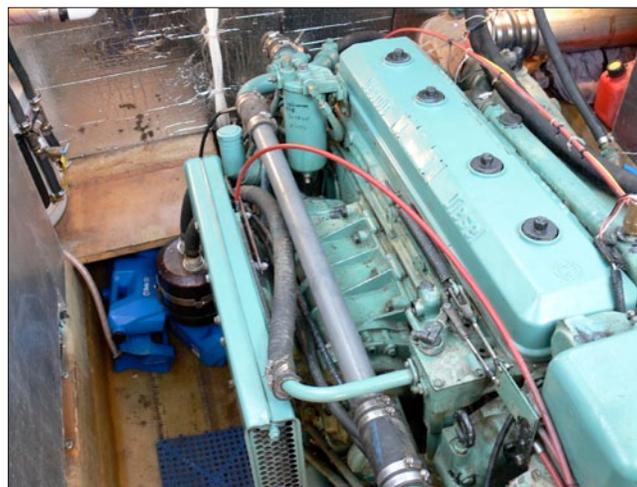
Inspect and Maintain the Current Engine to Obtain Greatest Efficiency

1. Be sure the engine is properly “tuned.” Keep valves adjusted, keep pump and injectors serviced, and stay current on other recommended maintenance to ensure that the engine is converting all the fuel energy possible into useful work.
2. Ensure adequate engine room **ventilation** (try to achieve neutral or slightly positive engine room air temperature), and keep engine **air filters** clean. Cool air contains more oxygen than hot; therefore adequate ventilation can reduce fuel consumption by improving combustion efficiency. A 30°F reduction in intake air results in a 2-3% decrease in fuel consumption with the same performance. If you have stove stack downdraft, suction holding engine room access hatches closed, or heat buildup in the engine room, ventilation is inadequate.
3. Periodically inspect and replace primary and secondary **fuel filters** to ensure a free flow of fuel to the engine. Check **fuel feed and return lines** for leaks or restrictions. Use biocide in the fuel to reduce injector damage. Bacterial fuel contamination can foul injector tips, causing poor fuel spay pattern inside the cylinder and wasted fuel.
4. Check your engine **exhaust** frequently. Exhaust from a properly functioning engine should be virtually invisible. Soot or visible exhaust indicates engine problems that reduce efficiency. **Black exhaust** indicates an overloading or over-fueling condition, worn injectors, or inadequate air supply to the engine. **Blue exhaust** usually indicates burning oil from worn piston rings or valve guides, or from a leaking turbo seal.

¹ Operating for long periods in an underloaded condition can cause harmful carbon deposits on pistons, valves, and cylinder glazing due to the presence of unburned fuel, a condition known as “wetstacking.” Generators that are not kept under constant load are also prone to this problem. Conventional wisdom is that if a propulsion engine is run in an underloaded condition for a period of time, such as when trolling, picking up strings of longline gear, or drifting on the end of a gillnet, the operator should periodically run the engine up to full operating speed for 15 minutes to raise internal temperatures. Fishermen call this “blowing out the carbon” and in fact sparks, black smoke, and soot often are visible.



A halibut schooner slices through the waves at an efficient travel speed, as evidenced by the small bow and stern waves.



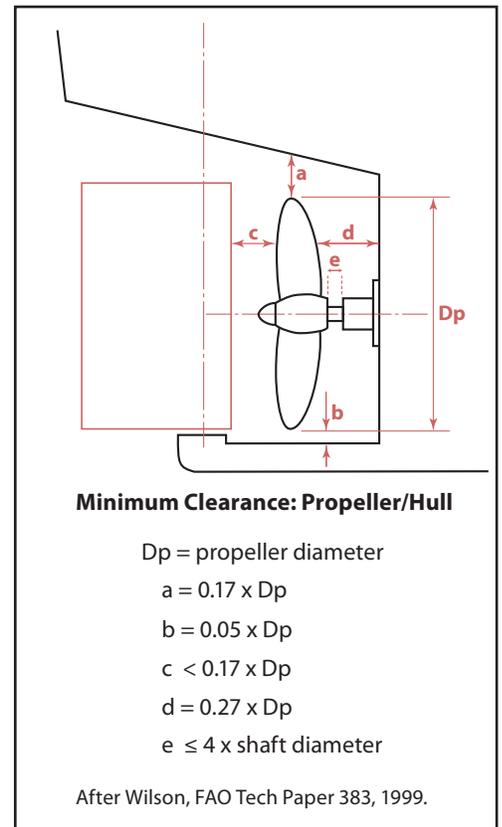
A modern, electronically controlled engine may produce measurable improvement in fuel efficiency over an older model like this two-stroke Detroit. However, before buying a new engine based on fuel consumption alone, get the data needed to ensure that the additional efficiency will actually materialize, and calculate in all the costs involved in an engine replacement.



Two photos illustrate the difference in stern wave of a 40 foot boat between 7 knots (left) and 8 knots. The bigger the stern wave the more power and fuel it takes.

White exhaust is either steam from an overheated engine (in a wet exhaust) or a leaking head gasket, or is unburned atomized fuel from overcooling, incorrect injection or valve timing, or burnt valves.

5. Ensure you are using the right **propeller**. Correct diameter and pitch are essential for optimal efficiency, as well as performance. In general, the larger the diameter (while allowing adequate hull clearance), the fewer the blades, and the lower the blade area ratio—the more energy efficient the propeller. Of course noise, vibration, and the need to absorb available horsepower may require a propeller configuration that is less efficient. Pitch, rake, blade shape, aperture clearance, and blade material also influence propulsion efficiency. A correctly pitched propeller absorbs all available engine horsepower by allowing the engine to turn up to its rated rpm but not exceed it. As a boat gains weight with additional structures or equipment, the engine loading changes and the prop should be adjusted or replaced.
6. Prop matching is best done by a combination of computer program and trial-and-error. A simple test of proper propeller match can be done with the boat's **tachometer** and **pyrometer** to ensure that proper engine speed is achieved without causing excessive stack temperature.
7. **Variable pitch propellers** and some new propeller designs can be more efficient over a broader range of shaft RPMs than traditional fixed-blade props. In some cases modifications such as a propeller **nozzle**, **duct**, or **shroud** can improve efficiency further. Newer rudder designs also improve propulsion efficiency. A prop is less efficient if bent, dinged, or eroded by cavitation or galvanic corrosion, or if fouled by marine growth.
8. Minimize **parasitic loads** on the engine. Declutch hydraulics and engine-driven pumps when they are not needed. Turn off extraneous electrical devices (e.g., unnecessary lights) that are powered by the engine's alternator, when they are not required.



9. Use a **fuel flow meter**. It helps the skipper find the most efficient running speed. Furthermore, if fuel consumption starts increasing as speed remains constant, it can indicate problems with the engine, drive train, or hull. Fuel metering is a standard feature of electronic engines, and aftermarket meters can be retrofitted on almost any engine.

Reducing Hull Resistance

SLOWING DOWN, DISPLACEMENT HULLS

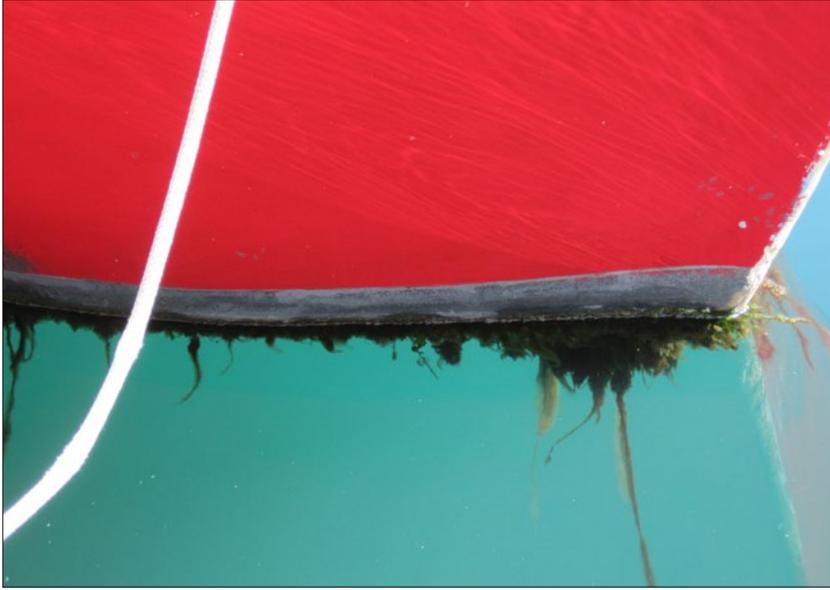
In a displacement-hull vessel (one that travels slowly through the water rather than rapidly on top), running at a slower speed does more to reduce fuel consumption than any other single measure. Even at or below hull speed (see calculation above), speed reduction pays dividends by reducing wave-making resistance. For each 1% reduction in vessel speed (below hull speed) fuel consumption drops 2-4%, and in the range above hull speed the difference is greater. In one test a 40 foot displacement hull boat with a 250 hp diesel went from using 4 gallons per hour at 8 knots (2 nautical miles per gallon) to 2.3 gallons per hour at 7 knots (3 nautical miles per gallon), a 50% increase in mileage for a 13% decrease in speed. Other tests with various sizes of boats produce similar results.

SLOWING DOWN, PLANING HULLS

Planing boats are much more efficient once they are “on step” (planing) than when they are plowing along at just below planing speed. Furthermore, a planing boat actually may be most efficient at some point above minimum planing speed as more of the hull lifts from the water and friction is reduced. Still, in general the faster a planing boat goes (once on step) the more fuel it will use per mile traveled. This is clearly illustrated in performance data recorded in sea tests done on various hulls. Optimum planing speed is heavily influenced by engine type and power, hull shape, weight, and trim. It is impossible to calculate the most efficient speed, although tach and speed readings give some indication of the boat’s “sweet spot.” A fuel flow meter (no. 9 above) is useful for achieving optimum planing speed.



This planing gillnetter uses a lot of fuel per mile traveled, but its efficiency may actually be better at this speed than a few knots slower.



The hull needs scraping and a new coat of bottom paint. Marine growth imparts drag and wastes fuel.

KEEPING THE BOTTOM CLEAN AND SMOOTH

A rough bottom due to marine growth or poor paint condition has greater skin friction, which increases drag. Boats kept in saltwater for more than two weeks at a time should be painted with appropriate antifouling paint. Otherwise they need to be trailered, hauled, or put on a grid frequently for scrubbing and scraping off barnacles. Fairing (clearing) the hull and maintaining smooth bottom paint coverage are useful. Fairing the deadwood, stern tube, rudder guard, and other underwater parts reduces drag.

MINIMIZING UNDERWATER APPENDAGES

Struts, keel cooler tubes, rolling chocks, transducers, batwings, and other

appendages impart drag. Removing any appendages that are not needed will reduce hull resistance, as will adding fairing where possible to those that remain. For example, a grid cooler imparts less drag than an external tube keel cooler.

REDUCING WEIGHT AND MAINTAINING TRIM

Energy demand is a function of the weight being pushed through (or on) the water: the lower the weight, the less fuel required. As noted above, each ton requires about 4.5 hp (1 quart of diesel fuel per hour) at hull speed and exponentially more at higher speeds. A ton is 300 gallons of diesel fuel or 250 gallons of water, or a few lockers full of chain, anchors, paint, tools, and spare parts. If the gear and supplies are not needed on the next voyage, save money by leaving them at home. The same is true if trip duration doesn't require full fuel and water tanks, as long as tank-free surface doesn't create a stability problem.



Tabs (far left, midway) outboard of twin outdrives help the boat maintain proper trim.

Vessel trim also affects hull resistance. An out-of-trim hull cuts an irregular and asymmetrical path through the water and drags a bigger wake, which wastes energy. Shifting ballast, pumping fuel between tanks, and moving above-deck weight can improve trim, as can use of trim tabs, where fitted. Trim is even more important on planing vessels.

INSTALLING A BULBOUS BOW

Extensive research has shown that a properly designed bulbous bow significantly reduces fuel consumption, and at the same time improves seakeeping and provides a more comfortable ride. Data collected on retrofitted fishing vessels in the 60-80 ft range show a 15% decrease in fuel consumption at the same cruising speeds.

ROLL STABILIZATION

Reducing roll helps minimize **yaw** (zigzagging) while keeping the crew more comfortable, but both paravane and active fin stabilizers impart considerable drag. Testing of vessels equipped with **anti-roll tanks** (ARTs) has shown significant roll reduction without additional drag. **Gyro stabilizers** and **steadying sails** also provide roll reduction without pulling bulky devices through the water. If paravanes are the preferred device for roll attenuation, outfitting a boat with two sets can save fuel—smaller “fish” for running and a larger set for use at anchor, drifting, or pulling gear.

HULL LENGTHENING

A longer, relatively narrower hull is more efficient for comparable displacement. The decision on hull shape is normally made at the time of the vessel’s design, but a hull can be lengthened later. Adding a transom deflector or other extension device, to minimize transom suction and reduce squatting, can induce a wave energy pattern that mimics the pattern produced by a longer hull. Adding sponsons or in other ways making the boat beamier has a negative effect on propulsion efficiency, although it may produce advantages in capacity, comfort, and seakeeping. In some cases additional packing capacity and seakeeping can allow the vessel to make fewer trips, which saves fuel.

Reducing Non-propulsion Energy Demands

RETHINKING AUXILIARY POWER

In addition to the main propulsion engine many vessels run auxiliary engines to provide electricity, hydraulic power, or refrigeration, or to run pumps and other machinery. In some cases, it may not be necessary to run a separate power plant, probably underloaded most of the time, when the same **power could be taken off the main engine** more efficiently.

This is especially true for generating electricity. For example, an **inverter** fed by a battery bank maintained by an oversized alternator, or an AC cruise generator on the main engine or a shaft generator, may be a more efficient source of intermittent “hotel” power. An underloaded genset not only wastes energy but also tends to have a shorter life due to cylinder glazing. Where a stand-alone genset is warranted, a variable speed generator that can operate at different speeds and output ratings in response to electrical demand may use less fuel overall than a constant-speed genset.

Cooking with propane and heating with oil are more efficient than using onboard-generated electricity to produce heat.

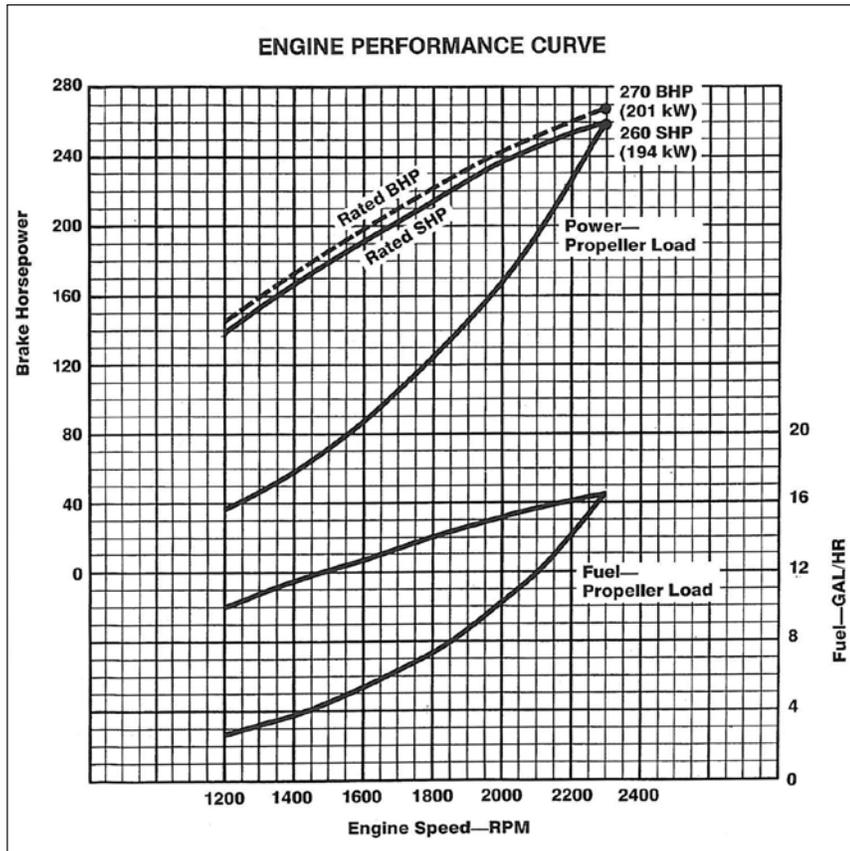
If AC power is required at dockside to maintain refrigeration or cabin appliances, use **shore power** wherever possible. Electricity produced by even the most efficient diesel generator is more expensive than electricity from municipal power systems.

Consider also the devices being powered: compact fluorescent and LED lights, more efficient appliances, and solid-state electronics all demand less energy from the auxiliary power system.

Reducing Distances Traveled

A 2008 survey of Alaska fishermen, who had just experienced the highest fuel prices in history to that point, found that 88% had changed their behaviors in some way in response to high fuel prices.

The most common changes fishermen made to save fuel were a **decrease in prospecting or exploration, fishing closer to home, and/or reducing the frequency of returning home**. Other responses were **skipping openings, using tenders** more often, **quitting fishing earlier** each day or earlier in the season, and **joining other quota holders** to fish off a single boat. Each of these changes resulted in vessels traveling less total distance.



This set of performance curves illustrates that specific fuel consumption and engine horsepower output do not parallel one another. At 1200 rpm the propeller is drawing about 38 hp at 2.6 gph, or 14.6 hp/gal/hr. At 1800 rpm it's getting 125 hp @ 7.2 gph or 17.4 hp/gal/hr, and wide open it gets 260 hp at 16.5 gph or just about 16 hp/gal/hr. One step toward deciding whether to buy a new engine to replace this older two-stroke Detroit would be to compare fuel and propeller load curves with the new engine.

(HF-SSB and satellite phone) allows them to contact other vessels for information that directs them to productive spots or away from unproductive ones, and helps them avoid bad weather and sea conditions. Newer satellite-supported technologies such as electronic catch reporting and bycatch monitoring also can help fishermen target areas to fish or avoid. The Automatic Identification System (AIS) allows vessels to keep track of others and to avoid ships or congested areas.

Internet-based information systems, such as the national Integrated Ocean Observing System (IOOS, and in Alaska, AOOS, <http://www.aos.org>), provide information such as sea surface temperatures, ocean primary productivity, wave heights, sea ice, and other data that can help skippers save fuel by targeting or avoiding certain ocean conditions.

STEERING

No helmsman can steer as straight as an autopilot. New-generation electronic autopilots steer straighter than their predecessors. They can be fine-tuned to minimize yaw in varying sea and load conditions. If a glance at the wake reveals a curvy or zigzag pattern, it may be time to get out the owner's manual and retune the pilot.

Steering gear develops slack with use and may need to be tightened, adjusted, or replaced. Hydraulic steering is least prone to becoming slack, but the fluid reservoir needs to be kept topped up with clean oil, and all air must be purged from the system. Eventually rams wear, fittings leak, connecting bolts loosen, and the whole steering system needs to be tuned up. Maintaining the steering system not only saves fuel—a steering gear breakdown would be a serious safety threat.

COOPERATIVE FISHING

Most fisheries in the world work on a cooperative basis, and Alaska fishermen can find models among some of the most sophisticated and prosperous fleets on the sea.

Cooperative fishing has a mixed history in Alaska. Some harvesting co-ops have been short-lived while others continue to thrive. With or without formal organization, any two or more boat operators may decide simply to share catch information, combine quotas

ROUTING IN RESPONSE TO CONDITIONS

Vessels used to depart "on the tide." Today powerful engines make it less essential for skippers to use tidal currents, but bucking tides consumes more fuel. Smart operators know and use the **prevailing currents** to their advantage. They also study weather patterns and whenever possible work with the weather to minimize pounding into head seas. On the water the shortest distance between two points is not necessarily a straight line—currents and weather can add or subtract effective distance.

Information available through ocean observing systems, government weather services, and commercial weather routing services can help operators make the most and avoid the worst of currents and weather.

ROUTING BASED ON ELECTRONIC COMMUNICATION AND POSITION FIXING

Skippers long ago learned the advantages of using the available technology for fixing position and plotting the safest and most direct courses. Long-range communication

on a single boat, take turns at scratch fishing, haul catches to the processor for one another, and in many other ways work cooperatively to reduce running time, distance, horsepower, and fuel consumption.

Incremental Improvements

“There is no silver bullet, but there are silver BBs.”

Except for slowing down, few if any of the methods and technologies outlined above will dramatically improve a boat’s fuel efficiency. Others offer the hope of incremental improvements. However, combining small changes can result in significant improvement. Keeping detailed records and applying some of these suggestions are sure to produce measurable improvement in any boat’s fuel efficiency.

See the following examples of incremental improvements in fuel efficiency in ships, courtesy of the heavy engine manufacturer Wartsila:

Clean hull	<3%
Engine optimization	<4%
Trim correction	<5%
Excess weight reduction	<7%
Dynamic routing	<10%
Energy-saving operational awareness	<10%
Speed reduction	<23%

Fishing Vessel Energy Audits

A vessel energy audit is a procedure for determining how much energy is used in each of a vessel’s systems so that the owner can identify places where energy is wasted and make energy-saving improvements.

Energy audits can consist of a walk-through (Level I), a walk-through followed by a vessel energy survey that includes operational profile and system-by-system observation (Level II), or an audit with an in-depth analysis of overall energy use plus detailed recommendations for improvements (Level III). Some marine engineering firms conduct Level III audits, but the cost is substantial. Even a Level I walk-through can provide a useful perspective on potential improvements.

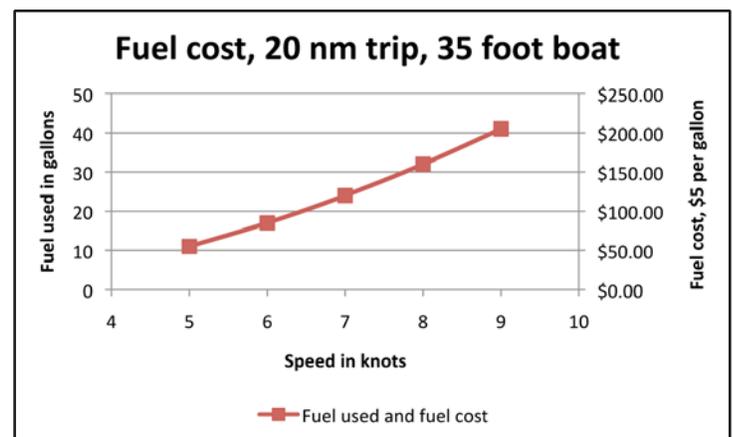
The Alaska Sea Grant Marine Advisory Program, University of Alaska Fairbanks, is working with partners to develop do-it-yourself templates for vessel energy audits that will be cost-effective for small boat owners. Periodically check <http://www.alaskaseagrant.org/fuel> for an announcement of template availability.

Fuel Saving Checklist

1. **Slow down.** In a displacement-hull vessel, every knot increase in speed requires about a 50% increase in fuel, and above hull speed the increase in consumption is even steeper. The relationship between speed and fuel consumption is more complicated in a planing boat but in general more speed requires more fuel for the distance traveled.

Fuel savings

Speed (knots)	Total gallons used	Total cost	Savings under 9 knots
9	41	\$205	—
8	32	\$160	\$45
7	24	\$120	\$85
6	17	\$85	\$120
5	11	\$55	\$150



Source: Department of Fisheries and Aquaculture, Newfoundland and Labrador, Canada.



Renewing bottom paint on this classic troller prevents fuel-robbing bottom growth from taking hold.

2. Keep the boat's **bottom smooth and clean**. Maintain a coating of appropriate antifouling bottom paint. Marine growth (barnacles, weeds) and rough paint increase hull drag. Eliminate unnecessary underwater appendages such as struts and exterior transducers, if possible, and apply fairing to remaining appendages.

3. Reduce unnecessary **weight**, and maintain optimum vessel **trim**. Seawater or ice ballast makes a more comfortable ride but there is a fuel penalty. If full fuel and water tanks aren't needed for the voyage, consider leaving them partly empty.

4. Check your engine **exhaust**, which can reveal important information about the condition of your engine. Diesel exhaust should be invisible. Black exhaust indicates overloading, air starvation, or worn injectors. White may indicate injector or valve timing problems, burnt valves, or bad gaskets that allow coolant into the cylinders. If exhaust is blue there is oil in the combustion chambers from worn rings or valve guides or from turbo seal failure. Keep engine injectors, valves, and filters serviced. Ensure adequate engine ventilation and free flow of fuel.

5. Check **propeller, shaft, bearings, and rudder** for wear, damage, or corrosion. Ensure that the prop size and pitch are correct for current load conditions. Consider re-propping, replacing the rudder with a more efficient design, or adding a **nozzle, duct, or shroud**.
6. Consider replacing paravane stabilizers with **anti-roll tanks, a gyro stabilizer or steadying sail**, or switch out large paravanes for smaller ones when traveling.
7. Check the **steering** for play. Tune the autopilot for minimal overcorrection.
8. Review your **electrical system**, looking for inefficiencies. Consider replacing a generator with a bigger alternator, more storage batteries, and an **inverter**. Experiment with solar panels and a wind generator. Replace the electric range with a propane or diesel stove.
9. Work with the **wind, tides, and ocean currents** where possible.
10. Use **electronics** such as AIS and Internet resources to monitor sea and weather conditions, vessel traffic, and fishing conditions.
11. **Minimize travel**. Make fewer trips to town, do less scratch fishing, and cooperate with other vessel operators to do less prospecting.
12. Keep **detailed records** of engine hours, distances traveled, speeds, and fuel consumed. Look for trends. Calculate costs of improvements, return on investment, and payback time.

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For more resources on Alaska boating fuel efficiency, see
<http://www.alaskaseagrant.org/fuel>

Terry Johnson is a fisheries extension agent with the Alaska Sea Grant Marine Advisory Program, University of Alaska Fairbanks. For 30 years he owned and operated small commercial fishing and charter vessels on the coast of Alaska. From 1998 to 2003, Johnson wrote the Boatkeeper column for *Pacific Fishing* magazine, on fishing vessel maintenance and operation. Download the free articles at <http://seagrant.uaf.edu/bookstore/boatkeeper/index.html>.

Alaska Sea Grant is a marine research, education, and extension service headquartered at the University of Alaska Fairbanks School of Fisheries and Ocean Sciences. Alaska Sea Grant is supported by the National Oceanic and Atmospheric Administration Office of Sea Grant, Department of Commerce, under grant no. NA06OAR4170097 (projects A/161-02 and A/151-01), and by the University of Alaska with funds appropriated by the state.

For information on undergraduate and graduate opportunities in marine biology, fisheries, oceanography, and other marine-related fields at the University of Alaska Fairbanks School of Fisheries and Ocean Sciences, visit <http://www.sfos.uaf.edu/>.



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 Anchorage, AK 99501
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Alaska Sea Grant
 University of Alaska Fairbanks
 PO Box 755040
 Fairbanks, AK 99775
 (888) 789-0090
fypubs@uaf.edu
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Project Title: *Fishing Vessel Energy Audit Pilot Project*

Amount Requested from State of Alaska: *\$500,000*

Organization: *Alaska Fisheries Development Foundation (AFDF)* – a statewide non-profit created in 1978 with the mission of creating opportunities out of challenges for the Alaska seafood industry. The AFDF Board of Directors is made of fishermen, processor and support sector representatives.

Description: In 2010, AFDF and the University of Alaska Marine Advisory Program (MAP) sponsored an international symposium on “Energy Use in Fisheries” (see attached agenda). In 2011, AFDF and MAP sponsored a workshop at the Pacific Marine Expo regarding improving energy efficiency of fishing vessels through the use of an energy self-audit workbook (see attached documents). Recently, AFDF and MAP submitted a grant application to the North Pacific Research Board (NPRB) to conduct scientific testing of various fuel saving technologies compatible with Alaska fishing vessels which have the potential to reduce energy consumption and decrease emissions.

Based on the research from this previous work, implementing combinations of energy efficiency operating techniques and technologies on fishing vessels could reduce energy consumption by 15-30%. However, initial feedback from fishermen related that the self-audit workbook was somewhat complicated and it would not replace an energy audit by an expert. Therefore, AFDF is collaborating with both the MAP and the Alaska Energy Authority to design a ***Fishing Vessel Energy Audit Pilot Project***. The ***Fishing Vessel Energy Audit Pilot Project*** will complete the following objectives: 1) conduct 50-100 audits per year for three years, 2) conduct a survey in order to determine baseline end-use energy consumption data, and 3) provide outreach to the industry in order to disseminate results.

Results: ***The results of this 3-year pilot project are intended to inform the design of a larger-scale 5-year program with the goal of a total energy savings for commercial fishing vessels of 15% of 2010 levels by 2020.*** This goal is consistent with and complimentary to the three energy efficiency goals identified in the 2010 “*Alaska Energy Pathway*”:

- 1) A total electricity savings of 15% of 2010 use levels by 2020
- 2) A total heat savings of 15% of 2010 use levels by 2020
- 3) The promotion of modern, efficient, and sustainable transportation options

Budget	Year 1	Year 2	Year 3	Subtotal
AFDF Project Manager	\$ 20,000	\$ 20,000	\$ 20,000	\$ 60,000
AFDF Administrator	\$ 15,000	\$ 15,000	\$ 15,000	\$ 45,000
University	\$ 20,000	\$ 20,000	\$ 20,000	\$ 60,000
Auditor (contractor)	\$ 60,000	\$ 60,000	\$ 60,000	\$ 180,000
Travel (audits)	\$ 25,000	\$ 25,000	\$ 25,000	\$ 75,000
Outreach - materials	\$ 5,000	\$ 5,000	\$ 5,000	\$ 15,000
Outreach - travel	\$ 5,000	\$ 5,000	\$ 5,000	\$ 15,000
Survey - baseline data	\$ 50,000	\$ -	\$ -	\$ 50,000
Total	\$ 200,000	\$ 150,000	\$ 150,000	\$ 500,000



North Pacific Research Board
1007 West 3rd Avenue, Suite 100
Anchorage, AK 99501
Ph: (907) 644-6700
www.nprb.org

December 7, 2011

RE: Support for the grant titled, "A project to increase energy efficiency on fishing vessels"

To the North Pacific Research Board:

On behalf of the Anchorage Economic Development Corporation, I would like to offer support for the grant proposal titled, "A Project to Increase Energy Efficiency on Fishing Vessels", submitted by the Alaska Fisheries Development Foundation (AFDF) and the University of Alaska Sea Grant Marine Advisory Program (MAP) in collaboration with the Alaska Marine Conservation Council (AMCC), the Juneau Economic Development Council (JEDC) and the fishing industry. The project's objectives include the following, followed by substantial outreach to the commercial fishing industry with the results of the project:

- **Develop accurate measurement techniques for fuel usage on vessels:** Test appropriate fuel monitoring technology, compatible with commercial fishing vessels and capable of accurate enough measurement to quantitatively evaluate fuel savings from structural, operational or technological changes to the vessels.
- **Evaluate new fuel saving technologies:** Identify, acquire, install, test and evaluate specific fuel saving technologies on commercial fishing vessels.
- **Create an interactive web portal:** Create and host a web site to serve as a platform for synthesizing current knowledge on *best practices*, an *"energy calculator"* to help fishermen evaluate potential energy savings, and a *discussion forum* for stakeholders to evaluate the potential implications of technology changes.

As the trend of increasing fuel prices continue, fishermen are beginning to make changes in their fishing behaviors to adopt fuel saving measures, however, progress has been slow due limited, accurate information applicable to commercial fishing vessels. This project will provide this information and a forum for its distribution and discussion which will enable fishermen to more readily take action to insure the long-term viability of their industry.

Sincerely,

A handwritten signature in blue ink, appearing to read "Bill Popp", is written over the word "Sincerely,".

Bill Popp,
President & CEO

Alaska Crab Coalition
3901 Leary Way N.W. Ste. #6
Seattle, Washington 98107
206.547.7560
Fax 206.547.0130
accrabak@earthlink.net

December 8, 2011

Cynthia Suchman
Executive Director
North Pacific Research Board
1007 West 3rd Avenue, Suite 100
Anchorage, AK 99501
www.nprb.org

December 7, 2011

RE: Support for the grant titled, "A project to increase energy efficiency on fishing vessels"

To the North Pacific Research Board:

On behalf of our organization, the Alaska Crab Coalition, whose representatives have reviewed the proposal, I would like to offer support for the grant proposal titled, "A Project to Increase Energy Efficiency on Fishing Vessels", submitted by the Alaska Fisheries Development Foundation (AFDF) and the University of Alaska Sea Grant Marine Advisory Program (MAP) in collaboration with the Alaska Marine Conservation Council (AMCC), the Juneau Economic Development Council (JEDC) and the fishing industry. The project's objectives include the following, followed by substantial outreach to the commercial fishing industry with the results of the project:

- **Develop accurate measurement techniques for fuel usage on vessels:** Test appropriate fuel monitoring technology, compatible with commercial fishing vessels and capable of accurate enough measurement to quantitatively evaluate fuel savings from structural, operational or technological changes to the vessels.
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Sincerely,



Arni Thomson
Executive Director



UNITED FISHERMEN OF ALASKA

211 Fourth Street, Suite 110
Juneau, Alaska 99801-1172
(907) 586-2820
(907) 463-2545 Fax
E-Mail: ufa@ufa-fish.org
www.ufa-fish.org

December 12, 2011

North Pacific Research Board
1007 West 3rd Avenue, Suite 100
Anchorage, AK 99501

RE: Support for the grant titled, “A project to increase energy efficiency on fishing vessels”

To the North Pacific Research Board:

On behalf of United Fishermen of Alaska, I would like to offer support for the grant proposal titled, “A Project to Increase Energy Efficiency on Fishing Vessels”, submitted by the Alaska Fisheries Development Foundation (AFDF) and the University of Alaska Sea Grant Marine Advisory Program (MAP) in collaboration with the Alaska Marine Conservation Council (AMCC), the Juneau Economic Development Council (JEDC) and the fishing industry. The project’s objectives include the following, followed by substantial outreach to the commercial fishing industry with the results of the project:

- Develop accurate measurement techniques for fuel usage on vessels: Test appropriate fuel monitoring technology, compatible with commercial fishing vessels and capable of accurate enough measurement to quantitatively evaluate fuel savings from structural, operational or technological changes to the vessels.
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- Create an interactive web portal: Create and host a web site to serve as a platform for synthesizing current knowledge on best practices, an “energy calculator” to help fishermen evaluate potential energy savings, and a discussion forum for stakeholders to evaluate the potential implications of technology changes.

As the trend of increasing fuel prices continue, fishermen are beginning to make changes in their fishing behaviors to adopt fuel saving measures, however, progress has been slow due limited, accurate information applicable to commercial fishing vessels. This project will provide this information and a forum for its distribution and discussion which will enable fishermen to more readily take action to insure the long-term viability of their industry.

United Fishermen of Alaska is the largest statewide commercial fishing trade association, representing 37 commercial fishing organizations participating in fisheries throughout the state and its offshore federal waters.

Sincerely,

Mark Vinsel
Executive Director



Andrew Gray, CRA
Director
Tel (907) 474-1851
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amgray@alaska.edu
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Center for Research Services - Office of Sponsored Programs
University of Alaska Fairbanks, P.O. Box 757270, Fairbanks, Alaska 99775-7270

7 December 2011

Julie Decker
Development Director
Alaska Fisheries Development Foundation
431 W. Seventh Avenue, Suite 106
Anchorage, AK 99501

Re: Letter of Support for Proposal to the North Pacific Research Board

The University of Alaska Fairbanks is pleased to collaborate with the Alaska Fisheries Development Foundation on the proposal to increase energy efficiency on fishing vessels, which is being submitted to the North Pacific Research Board. The Principal Investigator from UAF is Terry Johnson, Marine Recreation and Tourism Specialist for the Alaska Sea Grant Marine Advisory Program.

The appropriate administrative and programmatic personnel at UAF are aware of the pertinent federal regulations and policies, and we are prepared to collaborate with the Alaska Fisheries Development Foundation in such a way that ensures compliance with all such policies, should this proposal be funded.

If you need additional information, please feel free to call my office at (907) 474-1851.

Sincerely,

A handwritten signature in blue ink, appearing to read 'AMG', is written over a light blue horizontal line.

Andrew M. Gray



North Pacific Research Board
1007 West 3rd Avenue, Suite 100
Anchorage, AK 99501

December 10, 2011

RE: Support for the grant titled, "A project to increase energy efficiency on fishing vessels"

The Bristol Bay Regional Seafood Development Association supports the grant proposal titled, "A Project to Increase Energy Efficiency on Fishing Vessels", submitted by the Alaska Fisheries Development Foundation (AFDF) and the University of Alaska Sea Grant Marine Advisory Program (MAP) in collaboration with the Alaska Marine Conservation Council (AMCC), the Juneau Economic Development Council (JEDC) and the fishing industry. The project's objectives include the following, followed by substantial outreach to the commercial fishing industry with the results of the project:

- **Develop accurate measurement techniques for fuel usage on vessels:** Test appropriate fuel monitoring technology, compatible with commercial fishing vessels and capable of accurate enough measurement to quantitatively evaluate fuel savings from structural, operational or technological changes to the vessels.
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As the trend of increasing fuel prices continue, fishermen are beginning to make changes in their fishing behaviors to adopt fuel saving measures. But progress has been slow due limited, accurate information applicable to commercial fishing vessels. This project will provide this information and a forum for its distribution and discussion which will enable fishermen to more readily take action to insure the long-term viability of their industry.

Sincerely,

A handwritten signature in black ink, appearing to read "Bob Waldrop".

Bob Waldrop
Executive Director

Alaska Whitefish Trawlers Association

P.O. Box 991
Kodiak, AK
99615
(907) 486-3910
aktrawlers@gmail.com

North Pacific Research Board
1007 West 3rd Avenue, Suite 100
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December 8, 2011

RE: Support for the grant titled, "A project to increase energy efficiency on fishing vessels"

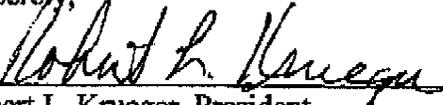
To the North Pacific Research Board:

On behalf of our organization, the Alaska Whitefish Trawlers Association, I would like to offer support for the grant proposal titled, "A Project to Increase Energy Efficiency on Fishing Vessels", submitted by the Alaska Fisheries Development Foundation (AFDF) and the University of Alaska Sea Grant Marine Advisory Program (MAP) in collaboration with the Alaska Marine Conservation Council (AMCC), the Juneau Economic Development Council (JEDC) and the fishing industry. The project's objectives include the following, followed by substantial outreach to the commercial fishing industry with the results of the project:

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As the trend of increasing fuel prices continue, fishermen are beginning to make changes in their fishing behaviors to adopt fuel saving measures, however, progress has been slow due limited, accurate information applicable to commercial fishing vessels. This project will provide this information and a forum for its distribution and discussion which will enable fishermen to more readily take action to insure the long-term viability of their industry.

Sincerely,


Robert L. Krueger, President
Alaska Whitefish Trawlers Association

Savage Inc.
2417 Tongass Ave Suite 111-176
Ketchikan, AK 99901

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1007 West 3rd Avenue, Suite 100
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Ph: (907) 644-6700
www.nprb.org

December 7, 2011

RE: Support for the grant titled, "A project to increase energy efficiency on fishing vessels"

To the North Pacific Research Board:

On behalf of our organization, F/V Savage, I would like to offer support for the grant proposal titled, "A Project to Increase Energy Efficiency on Fishing Vessels", submitted by the Alaska Fisheries Development Foundation (AFDF) and the University of Alaska Sea Grant Marine Advisory Program (MAP) in collaboration with the Alaska Marine Conservation Council (AMCC), the Juneau Economic Development Council (JEDC) and the fishing industry. The project's objectives include the following, followed by substantial outreach to the commercial fishing industry with the results of the project:

- **Develop accurate measurement techniques for fuel usage on vessels:** Test appropriate fuel monitoring technology, compatible with commercial fishing vessels and capable of accurate enough measurement to quantitatively evaluate fuel savings from structural, operational or technological changes to the vessels.
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Sincerely,
Tomi Marsh



February 6, 2012

RE: Support for Fishing Vessel Energy Audit Pilot Project

Dear Members of the Alaska Legislature,

I am eager to support the proposal being forwarded to you by the Alaska Fisheries Development Foundation (AFDF) which is seeking state funding to conduct research and information dissemination on approaches to improving fishing vessel energy efficiency.

The cost of fuel is a critical factor influencing profitability in many of Alaska's commercial fisheries, and as independent businessmen fishing vessel owners have no control over that cost. Their only hope for continuing to remain profitable in the coming days of significantly increased fuel prices is to develop strategies for reducing fuel consumption. Neither increasing catches nor charging more for what they catch is a realistic option; biology limits the first to current levels of harvest in most cases, and international market forces limit the second.

Fortunately, AFDF is ahead of the curve and is developing projects to do the research and compile the information that those independent businesses can use. As part of the University of Alaska's Sea Grant Marine Advisory Program I have been honored to be asked to participate in some of the earlier AFDF work and I hope to continue that work, bringing a sharper focus and greater outside technical and engineering expertise to bear on the problem. We have been engaged with AFDF on this effort for five years with minimal funding and have already produced some results in terms of publications, workshops, and a fishing vessel energy self-audit template. However, for many potential users, a professionally-conducted energy audit will produce more detailed and technically specific solutions. We can make that happen. Fishing vessel energy audits are an effective way to reduce energy consumption, and no other organization has undertaken to do them.

The project will cut owner costs, reduce emissions, and strengthen industry resilience to a suite of future changes that we know will confront it.

I hope that the Legislature gives the AFDF proposal, ***Fishing Vessel Energy Audit Pilot Project***, its full support.

Yours respectfully,

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Fishing Vessel Energy Efficiency Self-Audit Workbook

Introduction

As rising fuel costs take a bigger share of operating incomes, commercial fishermen are looking for ways to reduce the amount of diesel fuel their vessels consume during operations. Energy conservation measures can involve **vessel and systems modifications**, such as replacing older machinery with more efficient modern models, and **operational changes**, such as changing speed or modifying fishing patterns to reduce fuel consumption.

To plan conservation measures the owner must identify where the vessel's fuel energy is being consumed, recognize inefficiencies and identify improvements that can be made, and do financial calculations to determine which measures would be cost-effective.

Owners of ships and large workboats may accomplish these steps by commissioning a formal **vessel energy audit**, which normally is done by team of specialists from a naval architecture/marine engineering firm. A full energy audit has three levels:

1. A walk-through vessel survey to record details, equipment, and systems as well as an operational profile that points to energy saving opportunities.
2. A technical analysis of data gathered, and development of a report on energy reduction potential.
3. A more detailed technical study usually focusing on electrical and HVAC systems.

A full energy audit takes weeks and costs tens of thousands of dollars, and is cost-effective for a fishing vessel. However, any owner can do his own **Level 1 walk-through energy audit** of the vessel and apply the same principles to find ways of reducing fuel consumption. A Level 1 walk-through gathers useful energy use data and identifies energy consumption measures that can be readily adopted aboard the vessel. **This workbook is a tool to assist in that process.**

The goal is that the vessel owner identifies realistic measures that result in fuel savings. The measures **should produce a positive return on investment (ROI) and an appropriate payback period**, shorter than the anticipated service life of equipment purchased to enhance efficiency or service life of the vessel itself.

This evaluation tool considers both technology and operations to help the owner identify **energy conservation opportunities (ECOs)**—measures that are technically feasible for an existing vessel and cost-effective based on fuel savings. Emphasis is on the “low-hanging fruit”—measures that are easy and **can be implemented at little or no cost and that can produce savings quickly**. Most individual measures will yield relatively small savings but they can be used in combination and may add up to a significant amount of money over time.

In addition the workbook will help the owner consider **energy conservation ideas (ECIs)**. ECIs are measures that have potential for saving fuel for the vessel but would be more expensive, or for which there is insufficient information to judge whether they would be cost effective.

Instructions

1. Provide specifications and operating data on the systems requested in the “Vessel Details”; “Systems in Place”; “Operational Profiles”; and “Energy Financial Profiles” inventory forms below. When possible include measured or calculated fuel or energy consumption.
2. Separate out how much energy is used by each of those systems, wherever possible.
3. Consult the “rules of thumb” provided below, or data available from other sources, to determine whether systems and operations on this vessel could be more efficient.
4. Where inefficiencies are identified, consult the Energy Conservation Ideas below to find suggestions on ways to improve efficiency. Most will be impractical but a few may be helpful.
5. Draft a short list of Energy Conservation Opportunities that appear to be practical for this vessel. Jot down the costs. Some examples of no-cost or low-cost ECOs are in section VII.
6. Calculate the potential fuel savings that would result from adopting those measures. Use the savings calculator to estimate the potential savings, return on investment, and payback period. The economic analysis will determine priorities, modified by any non-monetary considerations resulting from #7 below.
7. Consider other financial or non-monetary costs to determine whether adopting the measure is justified.

Principles to Apply in ECO Analysis

- Best results come with measuring rather than estimating systems energy use. Relatively inexpensive fuel and electrical monitoring devices are available for owner use.
- Convert energy use to kWh, gph, or other standard measures. Compare how much it costs to operate the old system, and how much to operate the new system. The difference is the savings.
- The financial analysis consists of developing a series of cash flows over time.
- Net present value may be useful for making comparisons between options but is not essential for using this tool.
- When considering measures to adopt, give top priority to measures that cost nothing, and second to measures that cost very little.
- Where expenditures are required, favor those that produce the best return on investment and the shortest payback period.

1. Vessel Details

Vessel name _____ Type/fishery _____ Owner _____ Home Port _____

Description (deck layout, hull bottom shape, transom shape, construction material) _____

Displacement: _____ lbs or tons

Dimensions: waterline length _____ beam _____ operational drafts _____ light _____ loaded molded depth _____

Fuel capacity: _____ gallons. Fresh water capacity _____ gallons.

Bottom type, shape and condition; antifouling type, age and condition _____

Appendages (struts, chocks, stern wedges, cooling pipes, transducers): _____

Bulbous bow: yes ___ no ___

Stabilizers or roll stabilization attachments or devices (paravanes, active fins; type and size) _____

2. Systems in Place**Power and Drive Systems**

Main engine(s): make _____ model _____ aspiration _____ age _____ yr. Rated output _____ hp at _____ rpm

Fuel flow meter(s)? yes ___ no ___ If so, on what fuel lines? _____

Power takeoffs: electrical _____ hydraulic _____ mechanical _____ type _____ use _____ hp. Draw _____ hp

Engine room air supply: opening area _____ sq in. Flow capacity _____ cfm

Reduction gear(s): make _____ model _____ reduction ratio _____:_____ age _____ yr

Propeller(s): number _____ type (fixed vs. controllable pitch) _____ d _____ x p _____ material _____ # of blades _____

blade shape _____ shroud/nozzle _____ aperture clearance _____ in. top _____ in. bottom

Auxiliary electrical generator(s): make _____ model _____ age _____ yr. Rated output _____ kW. Normal load factor _____ %

Auxiliary hydraulic power generator(s): type _____ make _____ model _____ age _____ yr. Rated output _____ gpm at _____ psi

Fish hold refrigeration power source type (elect, hyd, mech): _____ make _____ model _____ age _____ yr. Capacity _____

Electrical

Electrical system plan (12V, 24V, 120VAC, 240VAC): describe _____

DC to AC inverter(s): make _____ model _____ capacity _____ watts

“Hotel” power demands (elect. stoves, heaters, coffee makers, AC, refrigerators, etc.). Amps/watts draw _____

Lights: number _____ type _____ wattage _____ service cycle (hours per day or year) _____

Elect. pumps: number _____ make and model _____ rating _____ service cycles _____

Other electrical demands: power demand _____ kWh

Fish Hold Refrigeration

Compressors (type, make, model, capacity, age, duty cycle): _____

Fans (number, locations, nameplate data, duty cycle): _____

Other product freezing or chilling equipment and energy type: power draw _____ duty cycle _____

3. Operation Profiles

Normal cruising engine speed rpm divided by max rated output rpm: _____%. Fuel gph at cruising speed: _____

Normal vessel cruising speed: _____ kt. Speed during other operational modes: _____ kt

Speed to length ratio: S (kt) divided by sq rt of waterline length (ft): _____

Percent of operating time at cruising speed: _____%. Number of hours/yr at cruising speed: _____ hr

Normal engine speed during fishing operations: _____ rpm. Fuel gph at fishing speed (if available): _____ gph

Number of hours/yr at fishing speed: _____ hr. Idling time/yr: _____ hr

Total hours/yr of main engine operation: _____ hr. Total gal/yr main engine fuel consumption: _____ gal

Generator/auxiliary fuel consumption at rated output: _____ gph. Consumption at actual output: _____ gph

Generator/auxiliary hours/yr at rated output: _____ hr. Normal operational load factor: _____ %

Generator/auxiliary hours/yr at reduced output: _____ hr. Hours/yr operating at standby output: _____ hr

Gallons per year generator/auxiliary power fuel consumption: _____ gal. Heating, other fuel consumption: _____ gpy

Operational pattern (# trips, nm per trip, time underway, time on gear, time at dock etc.): _____

4. Energy Financial Profiles

Current fuel price per gallon: \$ _____ /gal. Projected (3-5 yr) fuel price: \$ _____ /gal

Total fuel bill per year: \$ _____ Price/kW of shore power at ports of delivery or home port: \$ _____

5. Useful Principles, Equations, and “Rules of Thumb”

Hull and Appendages

1. Speed to length ratio (S/L) = speed in knots divided by square root in feet of waterline length. “Hull speed” of conventional fishing vessel with 3:1 length to beam ratio is $S/L = 1.34$.
2. Power demand for a displacement hull vessel: 1 hp/ton at $S/L = 1:1$. 4.5 hp/ton at $S/L = 1.34$.
3. Power required for planing hull to reach and maintain on-step speed is 2.5 shaft hp/100 lbs wt.
4. Appendage resistance increases as the square of the speed (e.g., double speed = 4 x drag).

Propulsion

1. Optimum propulsion diesel engine rating is 5-6 hp per displacement ton.
2. Optimum (efficiency, longevity) load factor diesel engine is 70-85% rated continuous output.
3. At speeds below S/L 1.3 each 10% speed increase requires 23-30% more power; at S/L greater than 1.3 the power required for each 10% speed increase is 30-40%.
4. Approximate specific fuel consumption for diesel at rated output is 1 gal/18 hp/hr. Actual produced hp x 0.055 = gph.
5. The larger the propeller diameter the more efficient, if other parameters such as pitch blade area and aperture clearance are correct. Allow 12% of prop diameter for hull clearance and 4% of prop diameter for rudder shoe clearance.
6. One indication of correct propeller pitch can be obtained by using the pyrometer to check that exhaust temperature achieves but does not exceed recommended range. The tachometer indicates whether the engine comes up to full rated rpm quickly but not instantly and does not exceed it.
7. One inch of additional prop diameter absorbs about the same power/torque as 2-3 inches pitch.
8. Engine condition and loading can be evaluated based on exhaust visibility and color. Exhaust of a properly maintained, warm diesel engine, under design load conditions (70-85% max specific continuous rate) should be virtually invisible. Black smoke indicates over-loading, worn or damaged injectors, or insufficient combustion air; blue indicates lube oil burning from worn rings or valve stem/seats or turbo gaskets; white indicates coolant in combustion chamber (head gasket), under-loading, running too cool or—in a water-cooled exhaust system—inadequate cooling water.

9. Engine room natural ventilation air vent minimum opening size in square inches = hp x 3.3. Area of a circular vent opening is calculated as pi (3.1416) times the radius squared (takes into account screens and louvers). Inadequate air can reduce fuel efficiency by as much as 20% by causing incomplete fuel combustion.
10. Engine room air supply should be at least 1.5 x total combustion air requirements of main engines, and ventilation air should be at least 1.75 x total requirements of all engines, compressors, and boilers; 2 x is preferable. Combustion air requirements are provided by the equipment manufacturer.
11. Engine room natural ventilation minimum passage rate in cu ft/min = (2.75 x hp) – 90. This should be increased by 20% where extensive flow distance or baffles are involved.
12. Engine efficiency loss is approximately 0.7% for each 10 degree F increase in engine room temperature, within normal engine room temperature range.
13. Twin engines use about 20% more power/fuel to achieve same speed as a single.
14. Power per sq ft of sail area: 10 kt wind = 0.015 hp; 20 kt wind = 0.040 hp; 26 kt wind = 0.070 hp.

Auxiliary Generators and Electrical

1. Approximate specific fuel consumption diesel generator electricity is 1 gal/12.5 kW/hr. 1 hp = 0.7457 kW but one horsepower of input produces only about 0.69 kW of electrical output.
2. Horsepower drain of engine-mounted alternator is approximately 2 x kW produced. Example: 100 amp 14-volt alternator at full output draws 2.8 hp., or about ¼ gph additional fuel consumption.
3. Alternator recharging amps should equal 24-40% of amp-hr capacity of batteries, via a multistage regulator. Otherwise, limit charging capacity to 10% of battery amp-hr capacity.
4. Electric motors are most efficient at about 75% of rated load. NEMA premium efficiency motors use 1.5% to 4.5% less electricity than standard motors.
5. Shore power is two-thirds or more less expensive than running a diesel generator while at dock.
6. One ton (12,000 btu) of typical commercial refrigeration requires about 1 kW (1.341 hp).
7. Compact fluorescent light bulbs use 1/3 to 1/4 as many watts of power to generate the same intensity of light as incandescent bulbs and their service life is 10 times as long.
8. LED light bulbs use slightly more than 1/10 as many watts of power to generate the same intensity of light as incandescent bulbs, and their service life is 30 times as long. Furthermore, there is no filament and the tiny LEDs are more resistant to physical damage.
9. Hydraulic power rule of thumb: 1 horsepower can produce the equivalent of 1 gpm at 1500 psi.
10. Weights in pounds of fluids per gallon: Diesel fuel is 7.2. Gasoline is 6.1. Fresh water is 8.4. Saltwater is 8.556. Approximately 31 cu ft of water or 37 cu ft of diesel fuel weigh one ton.

6. Energy Conservation Ideas (ECIs)

Note: all savings are informed estimates, and results vary widely with operational profile.

Hull

- Maintain vessel bottom and renew antifoulant paint. Cleaning bottom **can save up to 3%**.
- Install a bulbous bow, which has been shown to **save as much as 15%**.
- Lengthen the hull. **An increase in waterline length of 25% may improve efficiency up to 20%**.
- Downsize paravane stabilizers, switch to smaller paravanes during running, or replace with anti-roll tanks or gyro-stabilization. Elimination of paravanes **can save up to 10%**.

Propulsion

- Replace older main engine with modern electronic model. **Modern design engine of same output can save 5-20%** depending on operational profile. If current engine is running well below its maximum rated output, **downsizing engine can save even more.**
- Install fuel flow meter on main engine, which can produce **savings estimated as much as 10%**.
- Ensure adequate engine room air supply. Poor ventilation **can add up to 3% in fuel consumption.**
- For optimal propeller, ensure engine speed and exhaust temperatures are correct, engine achieves rated rpm, and prop wash is free of excess turbulence. If prop is not optimal, replace reduction gear with higher ratio to allow swinging of largest wheel for available aperture. If not optimum, re-size or replace wheel.
- Ensure engine exhaust is virtually transparent. If colored smoke indicates engine problems, do engine maintenance, repair.
- Fit auxiliary sail. A 300 sq ft sail **can save 1 gph of fuel in 26 kt wind.**

Electrical and Auxiliary Power

- If genset is not operating at high load factor, replace with correct size unit. If full load is only for a few hours/day, run it only those hours and supply other electrical with inverter powered by alternator on the main engine. The key is to match electrical load with capacity.
- Install a waste heat recovery system to use jacket water heat for cabin heat, hot water, etc.
- Switch off electrical items when not in use.
- Replace electric heaters and galley ranges with oil or propane.
- Use ice from the processor to chill product on short trips, or to pre-chill RSW holds to reduce refrigeration demand. Increase insulation around fish holds and RSW tanks.

Operations

- Make full use of navigation electronics, including autopilot, to minimize travel distances. Include web-based information sources, such as AIS or Alaska Ocean Observing System buoy reports.
- Do an analysis to determine if any fisheries, areas, or openings produce negative or minimal financial returns relative to fuel costs. Consider minimizing unproductive operations.
- Discuss the potential for cooperative fishing, using a “scout” boat to prospect, pooling deliveries, or other ways of minimizing fuel consumed in running and active fishing.

7. No-Cost and Low-Cost Energy Conservation Opportunities (ECOs)

- Reduce free running speed to minimum needed to meet operational objectives. Example: For a 50 ft boat, reduction from $S/L = 1.4$ to $S/L = 1.2$ is a 14% (1.4 knot) decrease, **saves 53% fuel.**
- Turn off lights where not needed and at dockside. Replace dead bulbs with energy-efficient CFLs or LEDs. **Replacing incandescent bulbs with CFL can save 75% of lighting costs, and with LED can save 80-85%. CFL bulbs and LEDs cost more but last 10 times as long.**
- Repair leaks in compressed air systems and increase distance between cut-in and cut-out on large compressors.
- When they need replacement, swap out old electric motors for NEMA premium efficiency motors. **Power savings can be 3-5% on each unit.**
- Tighten, adjust, or repair steering gear if vessel does not track straight.
- Remove any unneeded appendages.
- Carry only enough fuel and water to meet operational requirements. **Each 235-285 gallons reduces vessel weight by one ton, which saves 0.25 gph at hull speed.**
- Base trip departure times and courses on tide, currents, wind direction, and sea state.
- Ensure insulated hatch covers are kept in place at all times except when loading or unloading.
- Disengage clutches when hydraulics are not in use.
- Run electrical systems including refrigeration on shore power when dockside (“cold ironing”). Use electrical power-analyzing data logger to determine current demand, hourly use. Multiply kW by the difference in price between shore power kWh cost and diesel generator kWh cost.

8. Selecting Energy Saving Measures

ECO # 1 (Energy Conservation Opportunity #1)

Current situation (describe one inefficiency in the vessel or operation): _____

Proposed improvement: _____

Cost of implementing measure, including purchase, installation, downtime if any: \$ _____

Anticipated fuel savings per year at current fuel price: \$ _____ At projected fuel price: \$ _____

Return on investment (estimated cost savings divided by estimated cost to implement) over 20 years or the remaining service life of the vessel: \$ _____

Payback period: _____ years

Net present value (the value or amount of money in today's dollars that the ECO will result in over the course of its life): \$ _____. (Use a software package or business calculator to calculate NPV.)

Non-monetary considerations: _____

ECO # 2

Current situation (describe one inefficiency in the vessel or operation): _____

Proposed improvement: _____

Cost of implementing measure, including purchase, installation, downtime if any: \$ _____

Anticipated fuel savings per year at current fuel price: \$ _____ At projected fuel price: \$ _____

Return on investment (estimated cost savings divided by estimated cost to implement) over 20 years or the remaining service life of the vessel: \$ _____

Payback period: _____ years

Net present value (the value or amount of money in today's dollars that the ECO will result in over the course of its life): \$ _____. (Use a software package or business calculator to calculate NPV.)

ECO # 3

Current situation (describe one inefficiency in the vessel or operation): _____

Proposed improvement: _____

Cost of implementing measure, including purchase, installation, downtime if any: \$ _____

Anticipated fuel savings per year at current fuel price: \$ _____ At projected fuel price: \$ _____

Return on investment (estimated cost savings divided by estimated cost to implement) over 20 years or the remaining service life of the vessel: \$ _____

Payback period: _____ years

Net present value (the value or amount of money in today's dollars that the ECO will result in over the course of its life): \$ _____. (Use a software package or business calculator to calculate NPV.)

ECO # 4

Current situation (describe one inefficiency in the vessel or operation): _____

Proposed improvement: _____

Cost of implementing measure, including purchase, installation, downtime if any: \$ _____

Anticipated fuel savings per year at current fuel price: \$ _____ At projected fuel price: \$ _____

Return on investment (estimated cost savings divided by estimated cost to implement) over 20 years or the remaining service life of the vessel: \$ _____

Payback period: _____ years

Net present value (the value or amount of money in today's dollars that the ECO will result in over the course of its life): \$ _____. (Use a software package or business calculator to calculate NPV.)

Energy Audits for Fishing Vessels*

Acronyms & Definitions

BHP	=	Brake Horse Power
Btu	=	British thermal unit (↑ temp. 1 lb. water, 1°F)
Btuh	=	British thermal unit per hour
ECO	=	Energy Conservation Opportunities
FO	=	Fuel Oil (Used interchangeably as #2 Diesel Fuel)
hph	=	Horse Power per hour
kW	=	kilo Watt (1000 watts)
kWh	=	kilo Watts per hour
ULSDO	=	Ultra Low Sulfur Diesel Oil
NEMA	=	National Electrical Manufacturers Association
ROI	=	Return on Investment
SMCR	=	Specified (Specific) Maximum Continuous Rating (80%-85%, typ.)
~	=	Approximately
≡	=	Equivalent to

Conversions - (Typical values, and general rules of thumb.....)

- 1 gallon #2 MDO = 137k to 142k Btu
- 1 gallon #2 ULSDO = 1.2% less than #2 MDO
- 1kW = 1.341 hp
- 1kWh = 3,413 Btu
- 1 hph = 2,545 Btu
- 1 ton (refrigeration) = 12,000 Btuh
- 1 ton refrigeration requires ~ 1 kW (1.341 hp) in commercial AC systems.

Common Mechanical and Electrical Efficiencies

Electrical:

Generators / Large Alternators	-	95%
Small Engine Alternators	-	40% to 85% (Speed dependent)
Small Engine Alternators	-	55% to 85% (Full speed output)
Lead Acid Batteries	-	85% to 95% (Discharge rate dependent)
Rectifiers & Inverters	-	85% to 90%
Standard Electric Motors	-	80% to 90% (1 hp to 50 hp)
Premium Efficiency Motors	-	82% to 95%

*All information contained herein is to be used at you own peril and risk. No warranties are expressed or implied w/regard to its use, applicability, or accuracy.

Common Mechanical and Electrical Efficiencies, cont.

Mechanical:

Drive Belts	-	(Discussed below)
Centrifugal Pumps	-	40% to 70% (<200 gpm)
Hydraulic Pumps/Motors	-	85%
Diesel Engines	-	40%

Note: Electrical power derived through an engine driven alternator is not free. It comes as a direct result of consuming fuel within the engine to drive the alternator. With a typical engine efficiency of 40%, a belt efficiency of 98% and an alternator efficiency of 55%, this leads to an overall energy conversion efficiency of only 21%. Assuming a fuel cost of \$4.00/gal, this leads to an on-board electrical power cost of \$0.51/kWh, or roughly 6 times a typical household utility rate in Seattle WA, in 2011.

General Energy Equations

- Energy Cost per Year (calculated) = Energy Price (\$/kWh) x Weighted average power consumed (kWh) x Average Operating Hours per year
- Input Power Measurements: (3-phase, AC Power)

$$P_i = (V \times I \times PF \times \sqrt{3}) / 1000$$

Where:

P _i	=	Three Phase power in kW
V	=	RMS voltage, mean line to line of 3-phases
I	=	RMS current, mean of 3-phases
PF	=	Power factor as a decimal

- For DC:
 - Power (watts) = Amps x Voltage (x efficiency as applicable)

A motor's Power Factor is a function of both motor size and most importantly, a function of percentage of full load amperage. PF's are maximum at and above 75% full load amperage. At 75% full load amperage, the following are good estimates for motor PF's:

Motor Size (hp)	PF
5-10	70
15-30	75
40-75	80
100-125	84

Hydraulic System Rules of Thumb

- Hydraulic (fluid power) hp = (psi x gpm)/1714
- 1 hp of drive (for a hydraulic pump) produces ~ 1 gpm at 1500 psi

- Heat generated by flowing oil across a valve:
 - 1 hp = 2,545 btu / hr
 - 1 btuh = 1.5 x psi x gpm

General Lighting System Equations and Rules of Thumb

- Lighting Efficacy: Light Energy Intensity (Lumens) / Power In (Watts)
- Lighting Costs = (Total watts x # of hours x energy cost)
 - Total watts = (bulb wattage x # of bulbs)
 - # of hours = # of hours each bulb is on
 - Energy Cost =
 - Rate per kWh local utility charges (~ \$0.083 kWh - Seattle; ~ \$0.094 - Sitka)
 - Rate determined using is either determined fixtures x \$ per /kW #of bulbs x bulb wattage(s) x total wattage
- Incandescent vs. Florescent vs. Compact Florescent (CFL) vs. Light Emitting Diode (LED)
- 60 w IC bulb \equiv 900 lumens ; 75 w IC bulb \equiv 1200 lumens ; 100 w IC bulb \equiv 1750 lumens
- 20 w CFL bulb \equiv 1200 lumens
- IC bulbs require 3-4 times the amount of watts, to produce the same amount of lumens as a CFL bulb.
- LED's are more efficient than CFL and extremely long lived; technology is coming along rapidly.
- Relative bulb energy costs and (commercially rated) lives: (Standard Florescent bulbs = a score of 100, and is the benchmark against which others are compared; i.e. a smaller number is better.....)
 - IC bulbs = 412
 - SFL = 100 (10 x life of IC)
 - CFL = 102 (10 x life of IC)
 - T8 FL = 74 (10 x life of IC)
 - Mercury Vapor = 149 (24k hours)
 - Metal Halide = 90 (10k to 20k hours)
 - High Pressure Sodium = 65 (24k hours)
 - Low Pressure Sodium = 44 (18k hours)

Electrical Costs to Generate Power w/onboard Generators

- Establish the price of fuel (\$/gallon) delivered to the vessel.
- Establish Generator Load Profile and FO Costs/kW generated. (Example below is for a 10 kW Generator, \$4/gal FO, and \$.)

Cost of Energy Aboard					
Price of fuel (\$/gallon)		\$	4.00		
Rated size of generator (kW)			10		
Hour load profile			24	kW	gal/hr
Time generator is off (hrs)			6	0	0.00
Time at 0% of rated load (hrs)			0.25	0	0.18
Time at 25% of rated load (hrs)			1	2.5	0.45
Time at 50% of rated load (hrs)			10	5	0.63
Time at 75% of rated load (hrs)			1	7.5	0.80
Time at 100% of rated load (hrs)			5.75	10	1.00
					\$/kW-hr

- Note that gal/hr in the Load Profile chart above is based on the values provided in the next chart (FO consumed vs. load percentage, based on generator size).
- \$/kW-hr values above are determined with the following equation:

$$\frac{FO \text{ Cost} \left(\frac{\$}{gal} \right) \times \frac{gal}{hr} \times \text{time at rated load (hrs)}}{kW \text{ (at each load level)} \times \text{time at rated load (hrs)}}$$

- Chart below provides estimates for FO consumption of various generator sizes, at partial loads. When possible, actual measurements (fuel consumed vs. power produced) should be used for these values. Alternatively, use manufacturers' curves.

Generator Size (kW)	1/4 Load (gal/hr)	1/2 Load (gal/hr)	3/4 Load (gal/hr)	Full Load (gal/hr)
10	0.45	0.63	0.8	1
20	0.6	0.9	1.3	1.6
30	1.3	1.8	2.4	2.9
40	1.6	2.3	3.2	4
60	1.8	2.9	3.8	4.8
75	2.4	3.4	4.6	6.1
100	2.6	4.1	5.8	7.4
125	3.1	5	7.1	9.1
135	3.3	5.4	7.6	9.8
150	3.6	5.9	8.4	10.9

- Estimate or otherwise establish a generator maintenance cost per kWh produced. EBDG uses between \$0.01 and \$0.035 per kWh produced. This example uses **\$0.02 / kWh**.
- The next chart provides tabulated calculated values based on the information contained above.

Average load		5	kW
Fuel consumed per 24 hours (gallons)		13.345	gallons
Cost of fuel per 24 hours		\$ 58.72	
kW-hr in 24 hours		118	
Cost of maintenance per 24 hours		\$ 2.35	
Cost to operate per day		\$ 61.07	
Cost per kW-hr		\$ 0.52	

- Average Load is determined by multiplying each of the six load point times by its respective kW produced (for example 11.66 hrs. x 0 kW produced), summing all six of those values, and then dividing that total the total number of hours (24 in this example).
- FO consumed in 24 hours is determined similarly by multiplying each of the six load point times by its respective gal/hour value, and adding up those six numbers.
- Cost of fuel consumed in 24 hours = Cost of FO (\$/gal) x FO consumed in 24 hrs (determined above) x an added "fudge factor" to account for FO leaks, evaporation, fuel degradation through various means, filters, hoses, and other materials and handling costs, etc. This example uses a 10% "fudge factor."
- kW-hr in 24 hours is the numerator of the Average Load calculation. It represents the sum total of the kWh produced by the gen set in 24 hours.
- Cost of Maintenance per 24 hours is the total kWh produced in 24 hours (determined immediately above) x the measured or assumed hourly cost to maintain the gen set.
- Cost to operate per day (24 hrs) is the cost of FO + the cost of maintenance.
- Cost per kWh (or kW-hr) is the cost to operate per day divided by the total kWh generated in 24 hours.

Determine FO costs per kW generated, based off actual measurements (fuel consumed vs. power produced) or Mfgs. Curves.

Electric Motors

- Maximum efficiency for electric motors is ~ 75% of rated load. Operating motors above or below this maximum efficiency point wastes energy.
- Operating motors below 50% rated load dramatically decreases motor efficiency.
- NEMA premium efficiency motors use 1.5% to 4.5% less electricity for the same output, compared to "old style" standard efficiency motors.

General Ventilation Equations and Rules of Thumb

- Minimum engine room air supply should be at least 1.5 x total air consumption of main engines, auxiliary engines, boiler, etc. at all maximum SMCRs.
- Minimum engine room ventilation air should be 1.75 x SMCR; 2.0 x SMCR is preferred.
- Roughly 50% of required engine room ventilation air should be directed at the engine intakes.
- For every 10° increase / decrease in engine room temperature, fuel consumption will increase / decrease by ~ 0.7%. (Note: Operating in Arctic conditions typically requires pre-heating combustion air to avoid excessive firing pressures and potentially damaging the engine.)

Financial Analysis of Energy Conservation Opportunities

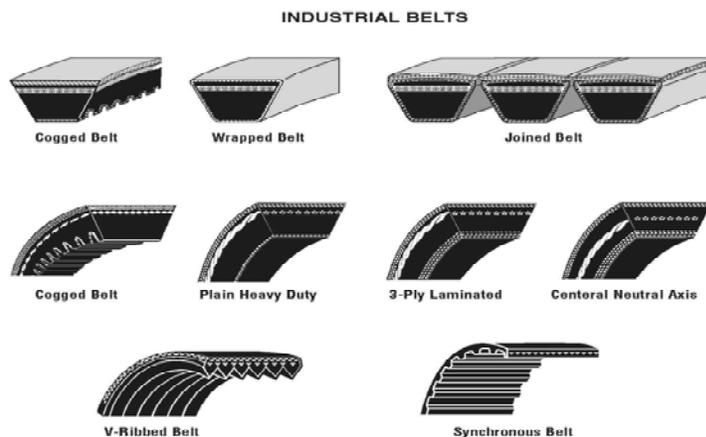
- Basic /Fundamental approach is identical to how a businessperson's banker looks at the "numbers" when asked for a capital loan. It boils down to analysis of a discounted series cash flows.

- What is the ECO going to cost you initially to implement?
- What are your anticipated annual "net returns" from that investment?
- What is your "cost of money"?
 - Include FO cost escalation factor
 - General inflation factor
 - Risk
 - History
- What is the time frame over which we are evaluating this?
- From this analysis, ROI, Pay Back Period – and if deciding between two different ECOs – possibly the NPV of the investment is determined.
- These three (3) financial metrics are weighed and compared against the alternative costs of making no changes (leaving the status quo), and other operational and business considerations, to arrive at an action decision.

General ECO Equations and Rules of Thumb

Drive Belts:

- Typical Efficiencies:
 - V-Belt Drives - 95%
 - PolyV or Cogged Belt Drives - 97%
 - Timing Belt Drives - 98%
 - Flat Belt Drives - 98% - 99%
- Losses are affected by entering and leaving losses of the belt with the pulley, hysteresis energy dissipation from straight to curved spans in the belt path, slippage, and heat generation.
- Cog belts can improve transmission efficiency by as much as 2.5% over a v-belt or joined v-belt and are comparably priced with high quality v-belts.
- Synchronous belt drives require special sheaves, which increase the cost of the belt drive; however, efficiency is improved by as much as 6% as the result of less slippage and cooler operating temperature.



Preliminary Report

Fall 2008 Alaska Commercial Fishermen and Tender Fuel Survey

By -

The Marine Advisory Program's

Allison "Sunny" Rice, Agent, Petersburg

Torie Baker, Agent, Cordova

Glenn Haight, Fisheries Business Specialist, Juneau

November 2008

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The fuel survey and subsequent reports was led by Sunny Rice with contributions by Paula Cullenberg, Torie Baker, and Glenn Haight of the Alaska Sea Grant Marine Advisory Program; Carol Kaynor, Doug Schneider and Dave Partee of the Alaska Sea Grant Program; Greg Fisk with SeaFisk Consulting; and Mark Vinsel of United Fishermen of Alaska. The survey was a product of the Alaska Sea Grant Marine Advisory Program’s fuel and energy committee, under the Alaska Fisheries Business Assistance Program (FishBiz).

Introduction

In fall 2008, the Alaska Sea Grant Marine Advisory Program (MAP), in partnership with the United Fishermen of Alaska, conducted a web-based survey of Alaska's commercial fishermen and tender operators. The survey asked respondents how increased fuel prices impacted their fishing businesses, what steps they took in response, and what further technical assistance would help them adapt to increasing costs. Following a strong response of 126 completed surveys, representing a broad cross-section of gear types and fishing locations in the state, MAP identified several technical issues that require further research and support.

Background

The Alaska seafood industry is the state's largest private sector employer and its main economic engine along Alaska's vast coastline. In the spring of 2008, the Alaska seafood industry braced for the highest fuel prices ever. Diesel-dependent seafood processors and commercial fishermen, sometimes operating in highly remote areas of the state, faced per gallon prices in excess of \$5 to \$6. Some areas reported prices in excess of \$7 per /gallon. In some cases, this increase represented a doubling of fuel costs.

The resulting huge production costs likely offset many of the gains the sector had made on improved seafood prices, and any future increases in fuel costs will continue to cast a pall over the fishing sector. This prospect, combined with growing consumer trends favoring food sources that use less fossil fuel to produce, serve as compelling reasons to reduce and/or eliminate fossil fuel use.

As first responders to the Alaska commercial fishing industry, MAP developed a detailed survey for the fleet to gather baseline information and determine initial impacts. This information serves to identify areas for further research, outline long-term alternative energy needs and prompt policy makers to address this crucial issue for coastal Alaska's main economic engine.

Summary Findings

This section summarizes significant survey findings listed throughout the report.

Changing Behaviors

- On average, fishermen attempted to lower their fuel costs through several changes in their fishing practices.
- The most common method of reducing fuel usage was less prospecting for fish.
- Other common methods include staying closer to home or staying out on the grounds longer.
- These top techniques for reducing fuel during fishing appear to indicate less overall effort.
- The most common fuel saving techniques in the fishing operations were throttling back and maintaining engine and fuel systems.
- The next most common fuel saving techniques were more careful planning of routes and timing, keeping the vessel bottom clean and propeller tuned, and monitoring vessel trim.
- Respondents indicating they owned a Bristol Bay gillnet permit were the least likely to change their operation to reduce fuel consumption.

Impact on Income

- Forty-three percent of the survey respondents projected fuel expenses between 10-20% of their total gross income. Expanding that range to 10 - 30% of total gross income expands the percentage of respondents to 70%.
- Almost 90% of the survey respondents indicated their fuel cost as a percentage of income increased “somewhat more” or “more than doubled” over the past five years.
- Eighty percent of the respondents with crew reported higher fuel costs negatively impacted income to crew members.
- Twenty-four percent of survey respondents received some form of fuel assistance from their processor.

Fisheries Management Impacts

- A majority of the respondents (64%) believe fisheries management decisions may affect their fuel costs. Conversely, only 40% believe fisheries managers should consider the impacts on fuel usage when managing fisheries.

Survey Limitations

- Underreporting of conditions for fishermen in the AYK region requires additional review. These regions sustain high fuel costs, and with gas powered engines, employ some of the more inefficient engines in the fishery.

Survey Parameters

The fuel survey ran on Survey Monkey©, an online survey tool, from late September until mid October.

Results of this survey are unscientific. Respondents were self-selected members of the Alaska commercial fishing industry, referred to the survey website by radio or newspaper stories, fishing-related listserves, or by direct referral from MAP faculty or others. As the survey was conducted using a web-based survey-hosting site, respondents were limited to those with internet access. Neither names nor computer IP addresses were collected with responses and no attempt was made to verify that respondents had identified themselves accurately.

Respondents were asked 17 questions on topics ranging from energy saving techniques to fisheries management impacts and possible research areas. Appendix I provides the survey tool.

While we were pleased with the response rate (126 total responses) and the information provided, there are over 10,000 permit holders in the Alaska state fisheries alone. Furthermore, the number of respondents per gear type in some cases was very small.

Despite these limitations, we feel these results provide a relevant snapshot of the impacts of, and fishermen's responses to, increased fuel prices.

Survey Respondent Information

Make up of Survey Responders

126 Alaska commercial seafood harvesters and tender operators responded to the survey. Table 1 provides the gear type and, in some cases, the region of each responder.

124 survey respondents indicated participating in 199 separate fisheries. This indicates several fished in more than one fishery. Two skipped the question. Almost 50% of the responders were gillnetters.

Several areas in this report provide gear-specific results where notable differences occurred between gear types.

Answer Options	Response Count	Response %
Gillnetting - Bristol Bay	12	9.7%
Gillnetting – Arctic, Yukon, Kuskokwim (AYK)	2	1.6%
Gillnetting – other locations	46	37.1%
Setnetting	9	7.3%
Trolling	15	12.1%
Seining	24	19.4%
Longlining	37	29.8%
Trawling	14	11.3%
Diving	3	2.4%
Jigging	7	5.6%
Pot fishing	19	15.3%
Tendering	7	5.6%
Other	4	3.2%
Comments	11	
Total Responses	199	
Total Respondents	124	
Skipped questions	2	

Current fuel usage

A large majority, 78%, of the respondents had diesel engines. This result may overestimate the percentage of diesel vessels in the fleet because of the low number of AYK responses (only 2 out of 126). Small boat fishermen in the Arctic, Yukon, Kuskokwim (AYK) region tend to employ gas powered engines.

Changing Behaviors

Fishing Practices

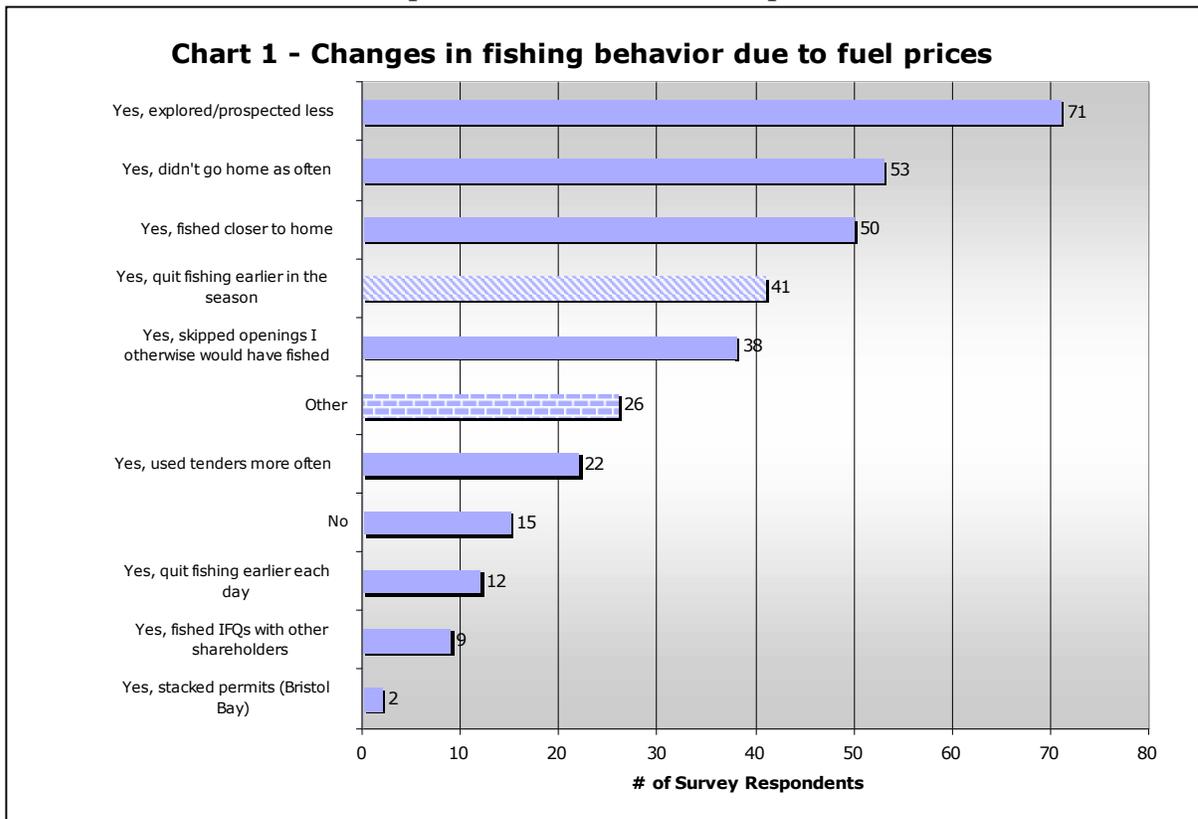
The high cost of fuel dramatically changed the fishing activity of the survey responders. While survey results revealed 15 individuals (12% of total respondents) that did not change the way they fished because of the increasing cost of fuel, the vast majority of the respondents did change the way they fished.

An examination of respondents indicating no change in fishing activity by gear type reveals over half were Bristol Bay gillnetters.

After removing these respondents, there were a total of 324 responses on types of changes made. This equates to an average of three changes per respondent. This indicates fishermen changed fishing practices in several ways to mitigate the high cost of fuel.

The most common response was that fishermen prospected less. This may have caused lower harvests as fishermen targeted areas known for large harvests, missing altogether areas that produced less fish historically.

Other top answers included, not going home as often and, conversely, fishing closer to home. The other top answer was fishermen quit earlier in the season.



Most responses would seem to indicate less total harvesting activity. Chart 1 provides a summary of changes in fishing practices.

Fuel Saving Techniques

The survey sought information on what fuel saving techniques fishermen employed in the operation and maintenance of their vessels. Over 70% of

respondents indicated that they “paid lots of attention” to maintaining their engine and fuel systems, and throttling back. Over 60% paid attention to planning their routes and timing.

General maintenance of the vessel proved very important with fishermen. This included carefully cleaning their boat, maintaining the propeller, and monitoring vessel trim.

Table 2 summarizes all responses to Question 9, *“How much attention do you pay to the following techniques for decreasing fuel consumption?”*

Answer Options	Lots of attention	Some attention	Very little attention	Response Count
Throttling back	90	23	5	118
Maintaining engine and fuel systems	89	23	4	116
Planning your route and timing	78	25	11	114
Keeping bottom clean	61	39	10	110
Keeping propeller tuned	58	36	15	109
Monitoring vessel trim	54	31	25	110
Maintaining fuel consumption records	46	33	27	106
Adjusting autopilot to improve tracking	43	23	26	92
Reducing vessel weight	33	44	37	114
Cutting back on diesel genset use	28	20	29	77
Other	14	2	6	22
Comments				19
			Total answered	119
			Total skipped	7

Investment Into Fuel Saving Devices

The survey attempted to learn what kinds of investments fishermen were considering making into fuel saving equipment. Adding a new engine drew the most positive response, while adding a flow meter was a close second. Items like bulbous bows, aerofoil-shaped rudders and kort nozzles were not as highly considered.

Table 3 summarizes all responses to Question 10, *“What new DEVICES have you used or considered using to decrease your fuel consumption?”* Not counting the “Other” category, the answers are sorted by those that drew the most favorable responses (measured as the “Added this year”, “Added prior year”, or “Considering adding”).

Table 3

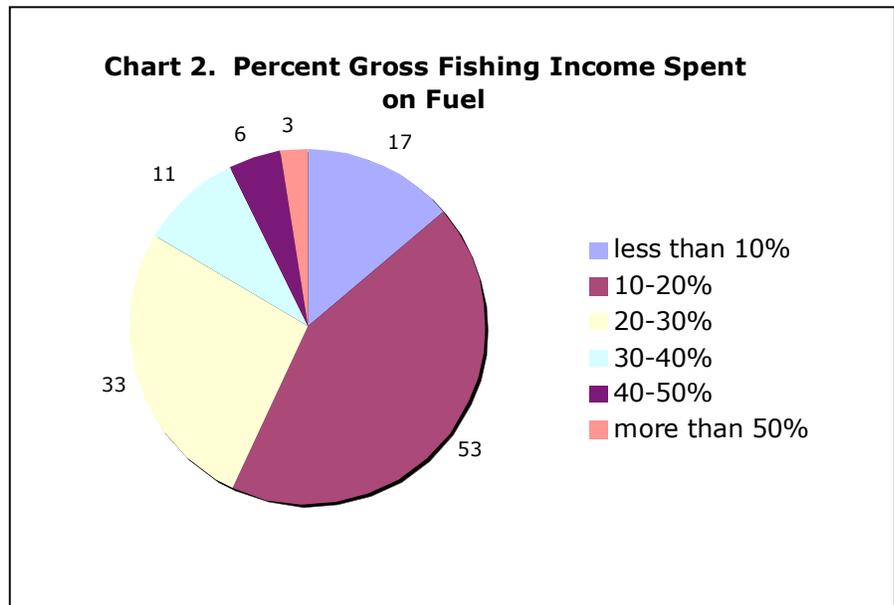
Answer Options	Added this year	Added prior to this year	Considering adding	Not interested	Response Count	Positive Response Count
New engine	12	21	42	19	94	75
Flow meter	3	17	44	22	86	64
Bulbous bow	2	5	22	44	73	29
Aerofoil-shaped rudder	0	8	17	44	69	25
Kort nozzle	0	5	15	48	68	20
Other	9	1	6	8	24	16
Comments					25	
				Total answered	109	
				Total skipped	17	

Income Impacts

Current Cost of Fuel

Survey respondents were asked what percentage of their income was spent on fuel. Forty-three percent of fishermen surveyed said they spent between 10 to 20% of their gross fishing income on fuel. Seventy percent (n=86) fell in the 10 to 30% range.

Chart 2 highlights the survey results for Question 4, *“Over the past year, what percentage of your gross fishing income has been spent on fuel?”*

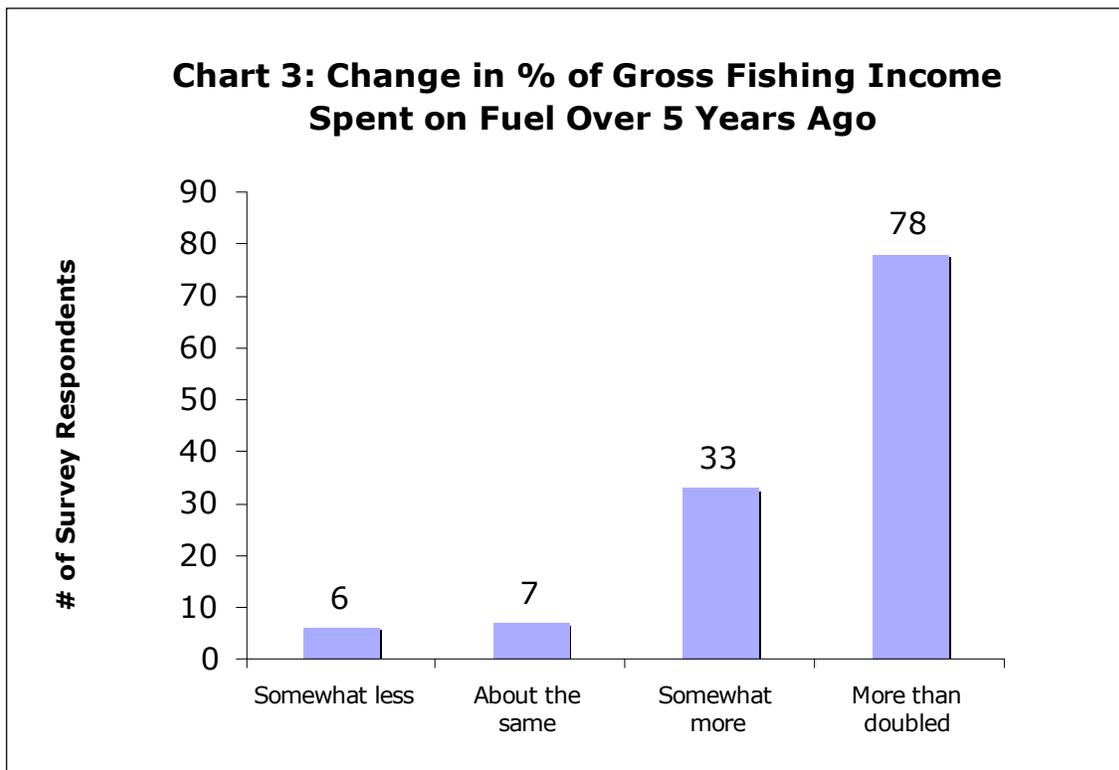


Increase in Fuel as a Production Cost

Respondents were then asked how much the cost of fuel increased as a percentage of income over the last five years. Sixty-three percent offered it more

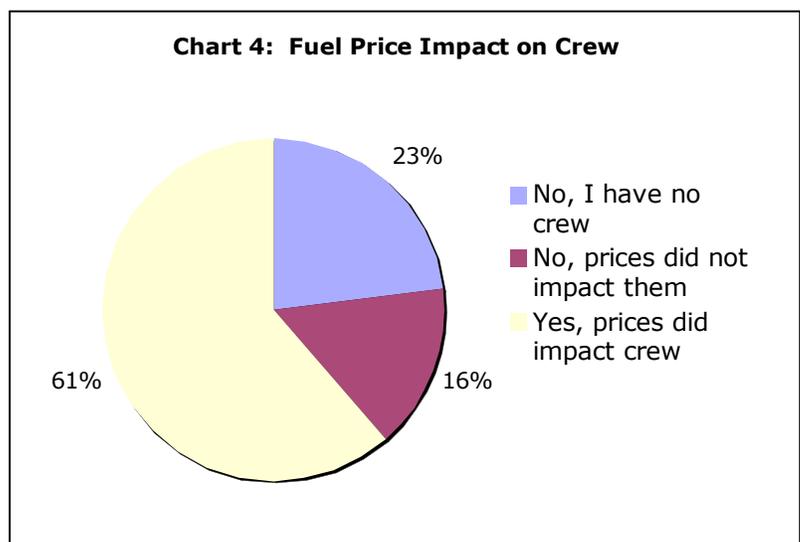
than doubled over that time. Very few indicated no real change at all. In total, 89.5% of the survey respondents indicated their fuel cost as a percentage of income increased at least "somewhat more". This is a disturbing trend considering that increased market prices in most salmon fisheries should have increased their income over that period of time.

In reviewing gear specific responses to this question, it appears this doubling of fuel costs occurred consistently across all fisheries. Chart 3.



Impacts to Crew Income

Permit holders were not the only ones impacted. A majority (61%) of respondents



said their crew also felt the pinch of high fuel prices. A large portion, 23%, offered they had no crew. Of the remaining respondents, 80% indicated the price of fuel impacted how much income the crew made.

When asked how crew were impacted, most said that crew shares were reduced because the cost of fuel was taken off the top before shares were calculated. In many cases, this was the first year permit holders considered fuel costs in the crew share calculation. Others indicated that they fished short-handed or didn't hire crew at all. Others said they quit fishing or laid crew off sooner.

Help from Processors

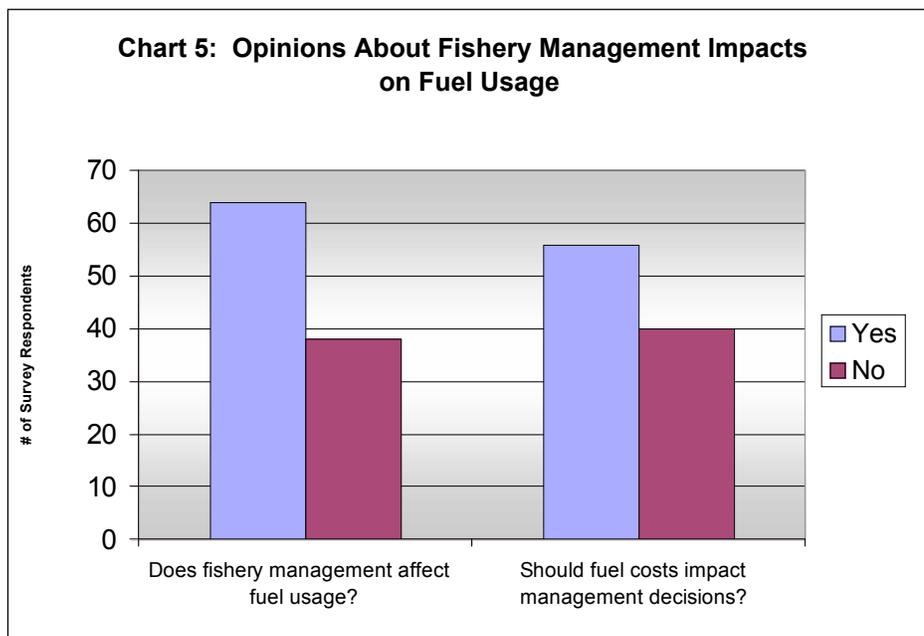
Finally, survey respondents were asked to detail whether they received fuel cost assistance from their processor. Comments provided under this question indicate that processors assisted primarily through selling fuel to them at a bulk fuel price or providing fuel bonuses. Twenty eight percent of fishermen said that their processors provided assistance with their fuel costs. Table 4 summarizes the answers.

Answer Options	Response Count	Response Percent
Yes	34	27.6%
No	89	72.4%
Comments	29	
Total answered	123	
Total skipped	3	

Fisheries Management Impacts

Finally, respondents were asked about fisheries management's impact on fuel consumption. While 64 respondents said that management did affect fuel consumption rates in their fisheries, only 40 felt that "fuel costs are a valid concern and should be integrated into the fishery management process," with 56 indicating that "management should be strictly biological."

When these responses are examined by gear group, however, only one gear group indicated a contrary opinion. 53% of trollers responding felt that fuel costs should be integrated into fishery management decisions, while 33% felt that management should be strictly biological.



Further Technical Assistance

As a final question, the survey asked respondents to identify how else the Marine Advisory Program could help adapt to rising fuel prices and if they had any particular questions or comments. The survey received a number of responses which may or may not fall within the purview of the Marine Advisory Program. In any event, they are informative for the general discussion.

Selected comments, including those of great frequency, are provided here.

- Clear technical advice from engine and fuel industry.
- Funding options for new engine or engine rebuilds.
- Promote energy independence for country and Alaska.
- Alternative assistance from processors.
- Develop harvesting privileges for dive fishery.
- Subsidies for food suppliers.
- Improved technology for alternative fuels and energy.
- Pre-season lectures/workshops on energy use.
- More coordination with the Alaska Department of Fish & Game.
- Research into green technologies adapted for the fishing industry.
- Fuel consumption comparisons between engines.
- Investment cost recoupment calculator for engine overhauls.

- Low interest loan/tax relief for engine upgrades. (*Author's Note: Please check with the Alaska Division of Investments for their new program for energy efficiency improvements.*)
- Constant and current information for industry.
- Literature/project review to determine successful programs in other areas of the world.
- Lower other government costs like taxes and permit fees.
- Seek cooperation from Alaska fuel refineries to sell to Alaska producers, like truckers, farmers, fishermen, at a point a slight profit margin.
- Continue focus on other profit points like improving ex-vessel value of fish.
- Seek removal of fuel tax on fishing boats during the season. (*Author's Note: commercial fishing activity is exempt from paying federal fuel excise tax. Most fuel suppliers have fishermen fill out appropriate paperwork and handle the exemption. If you fuel at the regular gas station or aren't getting the exemption, keep track of your fuel costs and write it off on your income tax.*)
- More information on pyrometers – specs, efficiencies, etc.
- Workshops for outboard and boat engine maintenance.
- Weekly price reports on different port fuel charges.

And finally....

- “Give me the winning Power Ball #'s so I can keep fishing until the money is gone.” (*Author's Note: It is good to see a sense of humor even as we deal with our most trying issues. Thanks to all who assisted with the survey. It does make a difference.*)

Appendix I – Survey Tool

The following is the survey tool used to develop the information for this report.

Q1. Did the price of fuel cause you to change how you fished this year (check all that apply)?

Answer Options

- Yes, stacked permits (Bristol Bay)
- Yes, fished IFQs with other shareholders
- Yes, quit fishing earlier each day
- No
- Yes, used tenders more often
- Other
- Yes, skipped openings I otherwise would have fished
- Yes, quit fishing earlier in the season
- Yes, fished closer to home
- Yes, didn't go home as often
- Yes, explored/prospected less
- Comments

Q2. Which types of commercial fishing operations do you run (check all that apply)?

Answer Options

- Gillnetting - Bristol Bay
- Gillnetting - AYK
- Gillnetting - other locations
- Setnetting
- Trolling
- Seining
- Longlining
- Trawling
- Diving
- Jigging
- Pot fishing
- Tendering
- Other
- Comments

Q3. Which type of engine do you run on your primary fishing vessel?

Answer Options

- Gas
- Diesel

Q4. Over the past year, what percentage of your gross fishing income has been spent on fuel?

Answer Options

- less than 10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- more than 50%

Q5. How does this percentage compare to 5 years ago?

Answer Options

- Somewhat less
- About the same
- Somewhat more
- More than doubled
- Comments

Q6. Did your buyer or processor assist you with your fuel costs?

Answer Options

- Yes
- No
- Comments

Q7. Did increased fuel prices impact your crew?

Answer Options

- No, I have no crew
- No, prices did not impact them
- Yes, prices did impact crew
- Comments

Q8. How else have fuel prices impacted your fishing business this year?

Q9. How much attention do you pay to the following techniques for decreasing fuel consumption?

Answer Options

- Throttling back
- Reducing vessel weight
- Cutting back on diesel genset use
- Keeping bottom clean
- Keeping propeller tuned
- Maintaining engine and fuel systems
- Adjusting autopilot to improve tracking
- Monitoring vessel trim
- Planning your route and timing
- Maintaining fuel consumption records
- Other
- Comments

Q10. What new DEVICES have you used or considered using to decrease your fuel consumption?

Answer Options

- New engine
- Flow meter
- Bulbous bow
- Aerofoil-shaped rudder
- Kort nozzle
- Other
- Comments

Q11. If you have repowered or are planning to repower your vessel for greater fuel efficiency, what are your estimated costs?

Q12. Can you share any specific websites, periodicals or other sources that you use for information on fuel efficiency?

Q13. Do you feel that management decisions affect fuel consumption rates in your fishery (fisheries)?

Answer Options

- Yes
- No
- Comments

Q14. Should managers (Board of Fish, ADF&G, NPFMC, IPHC) take fuel cost issues into account when making management decisions?

Answer Options

- Yes, fuel costs are a valid concern and should be integrated into the fishery management process
- No, management should be strictly biological
- Don't know
- Other
- Comments

Q15. What kinds of management changes do you think could be made in your fisheries to reduce fuel consumption?

Q16. In addition to our fuel efficiency webpage, which you will be redirected to when you finish this survey, how else can the Marine Advisory Program help you adapt to rising fuel prices?

Q17. Comments or questions for the Alaska Sea Grant Marine Advisory Program or United Fishermen of Alaska?

About MAP

The Marine Advisory Program (MAP) is a university-based, statewide, outreach and technical assistance program designed to help Alaskans wisely develop, use, conserve, and enjoy Alaska's marine and coastal resources. MAP faculty members and staff provide informal marine education, offer technical assistance to coastal communities related to economic development, conduct applied research, and serve as a link between the University of Alaska and Alaska Sea Grant, and marine and freshwater resource users in many areas of the state not served by traditional faculty.



The Marine Advisory Program works to:

- Broaden the opportunities of coastal residents through involvement in activities that diversify the community economic base such as marine recreation and tourism, shellfish mariculture, and direct marketing of seafood;
- Enhance the value of the commercial fishing, shellfish mariculture, and seafood industries in Alaska through training and technical assistance; and
- Contribute to the information base of Alaskans who are making decisions affecting the conservation of our marine resources, or who are dependent on them for traditional, cultural, recreational, or nutritional sustenance.

In a state as big as Alaska that is so dependent on the health of marine resources, it's critical that people can readily get information and technical assistance. MAP agents and specialists live and work in the communities they serve. The integration of MAP personnel with local communities provides for the efficient flow of information between the University of Alaska and the people.

Preliminary Report

Fall 2008 Alaska Commercial Fishermen and Tender Fuel Survey



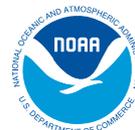


Why this Symposium?

Seafood producers around the world are faced with volatile fuel prices as they attempt to harvest, process, and grow seafood. At the same time, their marine environment is threatened by climate change and ocean acidification resulting from ever increasing greenhouse gas emissions. Although the carbon output from fisheries production is small relative to other industries, it is important that those who depend on the sea find ways to reduce their dependence on fossil fuels. By becoming more energy efficient, seafood producers can increase their profits, demonstrate their commitment to the environment, and help reduce greenhouse gas emissions.

The “Energy Use in Fisheries Symposium” will provide a forum for fishermen, environmental experts, fisheries managers and scientists from around the world to meet and address these direct and indirect effects of energy costs and identify possible solutions. Over 90 presentations over three days will allow participants to discuss fishery management strategies, alternate gear and vessel designs, alternate fuels, vessel operation and maintenance strategies, and possible metrics to measure energy efficiency in seafood production. Our goal is to have these discussions not only identify unique and innovative solutions but also start a global dialogue that will continue well into the future.

Sponsors



National Fisherman

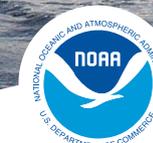


ENERGY use in
FISHERIES:

Improving Efficiency and Technological Innovations from a Global Perspective

Agenda

November 14-17, 2010 | Seattle Sheraton Hotel | Seattle, WA



www.energyfish.nmfs.noaa.gov

Sunday, November 14, 2010

8:00 am - 5:00 pm **FAO Workshop** (by invitation only)
Energy Use in Capture Fisheries

3:00 pm - 7:00 pm **Registration**

Monday, November 15, 2010

7:00 am - 4:00 pm **Registration**

7:00 am - 8:00 am **Continental Breakfast**

8:00 am - 9:00 am **Welcome and Opening Remarks**
Metropolitan Ballroom

Chris Moore, Mid-Atlantic Fishery Management Council,
Symposium Chair

Will Stelle, NOAA Northwest Regional Administrator

His Excellency Dr. Ibrahim Didi, Minister of Fisheries
and Agriculture, Maldives

9:00 am - 9:40 am **Plenary Session**
Metropolitan Ballroom

Dr. Peter H. Tyedmers, School for Resource and Environmental
Studies, Dalhousie University

9:40 am - 10:00 am **Morning Break**

10:00 am - 12:00 pm **Concurrent Sessions**

**Designs I: Alternative Boat and Power Plant Designs to Increase
Fuel Efficiencies**
Room: Metropolitan A

Energy Efficiency in Aquaculture
Room: Metropolitan B

**Uncertain and Rising Energy Costs: The Impacts on Fishing
Communities and Possible Adaptive Responses**
Room: Issaquah

12:00 pm - 1:30 pm **Lunch**

1:30 pm - 3:15 pm **Concurrent Sessions**

**Designs II: Alternative Boat and Power Plant Designs to Increase
Fuel Efficiencies**
Room: Metropolitan A

Fisheries Extension Meeting I: Catch Shares Workshop
Room: Metropolitan B

**Sustainable Fisheries I: Reducing Energy Use, Carbon Emissions,
and Ocean Acidification**
Room: Issaquah

3:15 pm - 3:45 pm **Afternoon Break**

3:45 pm - 5:30 pm **Concurrent Sessions**

Gear I: Gear Designs and Fishing Strategies that Reduce Energy Costs
Room: Metropolitan A

Fisheries Extension Meeting II: Catch Shares
Room: Metropolitan B

**Sustainable Fisheries II: Reducing Energy Use, Carbon Emissions,
and Ocean Acidification**
Room: Issaquah

6:30 pm - 7:30 pm **Social**

7:30 pm - 10:00 pm **Dinner with Keynote Speaker**

Jeff Steele, SeaLand Environmental — A green re-fit of the F/V Time
Bandit

Tuesday, November 16, 2010

7:30 am - 12:00 pm **Registration**

7:30 am - 8:30 am **Continental Breakfast**

8:30 am - 9:00 am **Opening Remarks**
Metropolitan Ballroom

U.S. Congressman Jay Inslee (Invited)

U.S. Congressman Jim McDermott (Invited)

9:00 am - 9:40 am **Plenary Session**
Metropolitan Ballroom

Dr. Ragnar Arnason, Department of Economics, University of Iceland

9:40 am - 10:00 am **Morning Break**

10:00 am - 12:00 pm **Concurrent Sessions**

Gear II: Gear Designs and Fishing Strategies that Reduce Energy Costs
Room: Metropolitan A

**Reducing Food Miles and Increasing Profits through Direct-Sale
Marketing of Locally Caught and Grown Seafood**
Room: Metropolitan B

**Metrics I: Metrics to Measure the Carbon Footprint of Fisheries and
Aquaculture Production on the Environment**
Room: Issaquah

12:00 pm - 1:30 pm **Lunch**

1:30 pm - 3:15 pm **Concurrent Sessions**

Gear III: Gear Designs and Fishing Strategies that Reduce Energy Costs
Room: Metropolitan A

**Special Session: Energy Consumption and Beyond: Application
of Holistic Approaches to Energy Conservation and Innovation
in Fishing Operations and Gear Design**

Port of Seattle and U.S. Navy Case Studies of Energy Efficiency
Room: Metropolitan B

**Metrics II: Metrics to Measure the Carbon Footprint of Fisheries and
Aquaculture Production on the Environment**
Room: Issaquah

3:15 pm - 3:45 pm **Afternoon Break**

3:45 pm - 5:30 pm **Concurrent Sessions**

Gear IV: Gear Designs and Fishing Strategies that Reduce Energy Costs
Room: Metropolitan A

**Special Session: Energy Consumption and Beyond: Application
of Holistic Approaches to Energy Conservation and Innovation
in Fishing Operations and Gear Design**

**Alternate Fuels: Alternative Fuels and Distribution Systems to Reduce
Petroleum Based Energy Demands**
Room: Metropolitan B

**Management I: Fishery Management Regulatory Changes to Reduce
Energy Costs and Greenhouse Gas Emissions**
Room: Issaquah

5:30 pm - 7:30 pm **Planning Meeting**
Metropolitan A

Meeting of rapporteurs, session moderators, and facilitated panel
discussion participants

Wednesday, November 17, 2010

8:00 am - 9:00 am **Continental Breakfast**

9:00 am – 9:40 am **Plenary Session**
Metropolitan Ballroom

Angus Garret, Senior Economist, SeaFish Industry Authority

9:40 am - 10:00 am **Morning Break**

10:00 am - 12:00 pm **Concurrent Sessions**

**Gear V: Gear Designs and Fishing Strategies that Reduce
Energy Costs**
Room: Metropolitan A

Operating Strategies and Vessel Maintenance Workshop
Room: Metropolitan B

**Management II: Fishery Management Regulatory Changes to
Reduce Energy Costs and Greenhouse Gas Emissions**
Room: Issaquah

12:00 pm - 1:30 pm **Lunch**

1:30 pm – 3:30 pm **Facilitated Panel Discussion**
Metropolitan Ballroom

The Future of Energy Use in Fisheries

Dr. Peter Tyedmers, School for Resource and Environmental Studies,
Dalhousie University

Dr. Ragnar Arnason, Department of Economics, University of Iceland

Angus Garret, Senior Economist, SeaFish Industry Authority

Bob van Marlen, Wageningen Institute for Marine Resources and
Ecosystem Studies

Frank Chopin, UN Food and Agriculture Organization

Clifford Goudey, Marine Industry Consultant

Energy Use in Fisheries Symposium

AGENDA UPDATES

14-17 November 2010 | Seattle Sheraton Hotel | Seattle, WA

MONDAY, 15 NOVEMBER 2010

<p>8:00 am - 9:00 am <i>Metropolitan Ballroom</i></p>	<p>Welcome and Opening Remarks Chris Moore, Mid-Atlantic Fishery Management Council, Symposium Chair U.S. Congressman Jim McDermott U. S. Congressman Jay Inslee Will Stelle, NOAA Northwest Regional Administrator Frank Chopin, UN FAO</p>
<p>10:00 am - 12:00 pm</p> <p>1:30 pm - 3:15 pm 3:45 pm - 5:30 pm</p>	<ul style="list-style-type: none"> • <u>Energy efficiency in aquaculture</u> Room: Metropolitan B Session Moderator: Pete Granger, Washington Sea Grant <ol style="list-style-type: none"> 1. "Trends in energy use in aquaculture: ancient Chinese fish ponds to modern integrated multi trophic aquaculture systems...and beyond" – Peter Becker, Olympic Aquafarms-BP/S Industries Inc. 2. "Pneumatic pump as an approach to improve the pump efficiency and to ease maintenance burden" - Kondo, Sam; Gao, Ming Wu, Geysler Pump Tech. Co.; Chuck Thompson, Nittany Engineering 3. "Energy and resource consumption of land-based Atlantic salmon smolt hatcheries in the Pacific Northwest (USA)" - John Colt, NOAA Fisheries; Steve Summerfelt; Tim Pfeiffer; Sveinung Fivelstad; Michael Rust 4. "Comparison of near shore and offshore netpen culture of Atlantic salmon in the Pacific Northwest Using LCA" – John Colt, NOAA Fisheries; Joyce Cooper, University of Washington <p>Room Change: Fisheries Extension Meeting I & II is in Issaquah Sustainable Fisheries I & II is in Metropolitan B</p>

TUESDAY, 16 NOVEMBER 2010

<p>8:30 am - 9:00 am <i>Metropolitan Ballroom</i></p>	<p>Opening Remarks Canceled</p>
<p>3:45 pm – 5:30 pm</p>	<ul style="list-style-type: none"> • <u>Management I: Fishery management regulatory changes to reduce energy costs and greenhouse gas emissions</u> Room: Issaquah Session Moderators: Gil Sylvia, Oregon State University; Rolf Willman, UN Food and Agriculture Organization (FAO); Frank Chopin, UN FAO; John Ward, NOAA Fisheries <ol style="list-style-type: none"> 1. "FAO Expert Workshop on energy use in capture fisheries synopsis" – Frank Chopin, UN FAO 2. "Modeling the influence of management on fuel use and emissions associated with the U.S. Atlantic herring fishery" – John Driscoll, Dalhousie University; Peter Tyedmers, Dalhousie University 3. "Modeling the influence of management on fuel use and emissions associated with the U.S. American lobster fishery" – John Driscoll, Dalhousie University; Peter Tyedmers, Dalhousie University 4. "There is more to greenhouse gas emissions of fisheries than carbon dioxide from fuel combustion" – Friederike Ziegler, The Swedish Institute for Food and Biotechnology; E. Skontorp Hognes, SINTEF Fisheries and Aquaculture; Andreas Emanuelsson, The Swedish Institute for Food and Biotechnology; U. Winther, SINTEF Fisheries and Aquaculture; H. Ellingsen, SINTEF Fisheries and Aquaculture; V. Sund, The Swedish Institute for Food and Biotechnology 5. "Effects of fishing effort allocation scenarios on energy efficiency and profitability: an individual-based model applied to Danish fisheries" - Francois Bastardie; J. Rasmus

- Nielsen; Bo Sølgaard Andersen; Ole Ritzau Eigaard, Technical University of Denmark
6. "A managerial solution to reduce fuel cost for small-scale fisheries: Case from walleye pollack fishery in Japan" - Hirotugu Uchida, University of Rhode Island; Masamichi Watanobe, Hokkaido Hakodate Fisheries Experimental Station, Japan

WEDNESDAY, 17 NOVEMBER 2010

10:00 am - 12:00 pm

- **Gear V: Gear designs and fishing strategies that reduce energy costs**
 Room: Metropolitan A
 Session Moderators: Clifford Goudey, Marine Industry Consultant; Dana Morse, Maine Sea Grant
 1. "Trawl gear design to improve the energy efficiency using computer aided method" - Chun-Woo Lee; Jihoon Lee; Moo-Yeol Choe, Pukyong National University
 2. "DSM Dyneema in commercial fishing: win-win-win for people, planet as well as profit" - André van Wageningen, Jeff Turner, DSM Dyneema
 3. "The CP2 Batwing otter board: an energy efficient, low impact, and economic trawl door for prawn trawling" - David Sterling, John Payne, David O'Neill, Sterling Trawl Gear Services
 4. "Practicable LED fishing light for saury lift-net" - Hirotugu Toeda, Hiroshi Inada, Kanau Ozawa, Tokyo University of Marine Science and Technology; Eisaku Sano, Towa Electric Machinery Co.; Toshio Watanabe, Yamatsu Yachi Com. Co.
 5. "Application of an Environmental Management System to reduce energy consumption and environmental impacts: A win-win for fishermen and the environment" – Steve Eayrs, Gulf of Maine Research Institute

- **Management II: Fishery management regulatory changes to reduce energy costs and greenhouse gas emissions**
 Room: Issaquah
Cancelled