Operating techniques to maximize fuel efficiency
(and some thoughts on outfitting and maintenance)

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Savings may be realized through:

• New vessel design
• Alternative fuels
• Other emerging (and expensive) technologies

We’ll talk about:
• Operations
• Maintenance
• Equipment and outfitting
The bad news:
There's no silver bullet

Universities, governments, and industry are studying ways to improve vessel fuel efficiency.

Most results are not dramatic.

The good news:

Many individual decisions you can make will reduce fuel consumption.

Small, incremental improvements add up.
Six Unproductive Assumptions

1. The way it’s always been done is best.

2. The engine determines the power.

3. Bigger is better and over-sizing increases longevity and saves energy.

4. The prop the boat came with is the right one.

5. Heat, vibration and smoke are normal, don’t indicate a maintenance problem or wasted energy.

6. If it ain’t broke, don’t fix it.
To reduce fuel consumption:
Reduce *power* demand

Assess how power is being used, misused, and wasted.

An energy audit can help.
Operations
Slow down.

The enemy of vessel efficiency is wave resistance.

Typically, 10% speed decrease reduces fuel per mile 20-40%*

A rule of thumb – don’t exceed “hull speed”, which is $1.34 \text{kts} \times \text{square root of the waterline length in feet}$.

- 30’ - 7 kt
- 40’ - 8 kt
- 50’ - 9 kt

Below those speeds savings increase linearly. Above those speeds costs increase exponentially.

*Planing hulls are different but most efficient speed < top speed.
Engine Efficiency

Engine and vessel efficiency are not the same.

Best specific fuel consumption about 70-80% max rpm.

Over-sized, under-loaded engines are not efficient.

At 1.34:1 power demand is about 4.5 hp/ton or roughly 1 gph per 4 displacement tons.
Reduce distances traveled

• Adjust steering, tune autopilot.

• Avoid unnecessary trips. Anchor out.

• Fish cooperatively. Use code group, scout boats, combine deliveries, stack permits or quotas.

• Use electronic and on-line resources.

• Determine if it is cost effective to skip openings, quit early.
Work with the conditions

• Travel with the tides and currents.

• Avoid headwinds. Wind can reduce speed 30% at the same rpm.

• Use weather routing services, on-line weather and ocean current information.

• Use dynamic routing. The shortest distance isn’t always a straight line. Research on ships shows a 10% fuel saving.
Minimize parasitic loads

• De-clutch hydraulics, shut off lights when not needed.

• Minimize use of paravane stabilizers, which increase resistance 10%.

Don’t run pumps, crab lights “to keep a load on the generator.” Use inverter for “hotel” power.

• Don’t engage chiller until needed. Keep the chiller clean.

• Practice “cold ironing” at the dock where feasible.
Watch weight and trim

• Weight reduction can save up to 7%.

• If you don’t need it, leave it at home.

• If safe under stability letter, travel with RSW and crab tanks empty.

  (Each cubic yard of seawater weighs almost a ton, draws another 4.5 hp from the engine, a quart of fuel per hour.)

• Take only needed fuel and water, plus safety margin.

• Adjust load, tabs, to trim vessel trim, and save up to 5%.
Maintenance
Maintain the engine

Ensure engine room vents are adequately sized and kept clean.

A 30 degree temperature decrease improves engine efficiency >2%.

- Keep air filters clean. Belt dust, exhaust lagging clog them.
- Change oil religiously. Dirty oil increases internal friction.
- Maintain/replace turbo on schedule (2,000 – 4,000 hrs).
- Adjust valves, replace injectors, replace drive belts.
Check engine exhaust regularly
It should be invisible.

Black exhaust – overloading, over-fueling, worn injectors, inadequate combustion air supply.

Blue exhaust - burning oil from worn piston rings, valve guides, or leaking turbo seal.

White exhaust - leaking head gasket, overcooling, incorrect injection or valve timing, or burnt valves.

All indicate that the engine is operating inefficiently, most indicate problems that may cause failure.
Lube or grease the intermediate bearing.

- Check condition of the cutless bearing.

- Adjust the packing gland to reduce friction on the shaft. Replace with teflon packing or a drip-free shaft seal.

- Keep the prop free of nicks, dings, and marine growth to save 4%.

- Propeller polishing reduces ship fuel consumption 3-4%.

*Noise, vibration and heat waste fuel and cause damage.*
Maintain the hull and underwater appendages

Bottom growth can decrease propulsion efficiency by 15% over just a few months.

Rust pitting, rough paint also increase skin friction drag. Fair hull can save up to 3% in fuel.

Fair stern posts and rudders, fair or remove struts, bilge keels, sea chests, transducers.
Equipment and Outfitting
Electronics Are Your Friend

Fuel flow meter
Fuel/rpm/vessel speed/distance/mpg data logger and analyzer
Modern autopilot
Modern GPS/plotter
AIS
Satellite communications
Internet-based weather, traffic and charting
Engine electronic fault codes
As vessel weight, power and use changes the propeller should change too.

A fixed-blade prop is optimized for a single speed and load.

Many don’t properly fit the aperture or match available engine power.

Diameter, pitch, disc area ratio, number of blades, blade thickness, blade shape, rake, skew, material and other factors determine available power and efficiency.

In general, the bigger diameter, slower rotation, fewer blades, the more efficient. Preferably < 1,000 rpm shaft speed.
Most props 50-60% efficient. New designs are better.

New rudder designs increase efficiency 3-6%.

Consider also fairings, shrouds, ducted sterns, counter-rotating props, pods, stators, etc.

Kort and Rice nozzles can increase efficiency 15-30%.

Costa bulb – up to .5% gain
Half duct – 3%
Boss Cap Fins – 5%
Grim wheel – 5%
Electrical Systems

Right-size generator. Under-loading wasteful, damaging.

Use engine-driven alternator*, “smart” regulator, inverter.

NEMA premium efficiency electric motors use 1.5%-4.5% less energy. Motors sized to run at 75% of rated output.

Modern appliances are more efficient, consider DC.

LED lighting uses about 1/3 the energy of incandescent and 1/5 the energy of quartz halogen. Compact florescent – 1/4 the energy of incandescent.

*Standard alternators are sized to re-charge starting battery. Go to a large frame “Load Handler” alternator.
Refrigeration

Thoroughly insulate cargo holds, plumbing runs.

Use automatic regulating systems on RSW valves and frequency control on pumps.

Modern compressors are more efficient.

Over-sized systems are less efficient.

Systems that use waste engine heat can dramatically cut energy costs.
Bulbous bow reduces fuel consumption up to 15%.

A longer hull reduces the effect of wave resistance.

Variable displacement hydraulic pumps draw little power when not loaded. Size pumps to the job, and install so they can be isolated when not needed.

Anti-roll tanks, gyroscopic, other roll-reduction devices do not impose drag.

Capture engine heat for cabin heat or to power refrigeration.

Sail assist, or skysail.
Engine Replacement

Beware of new diesel efficiency claims. Typical is 5-10%.

Study power/torque/fuel curves, *specific fuel consumption*.

Correct application can save up to 10%.

“Right-size” based on propulsion requirement plus 15% “sea margin” X 125% plus machinery, parasitic loads.

Repowers involving hp increase ineffective without changes to prop, shaft, cooling, reduction, other systems.

Repowers of same or less hp are less costly, can save fuel.

(The European fisheries commission only finances repowers that reduce hp 20% or more.)
Fuel Conservation Habits

1. Promote an energy-conscious crew. Crew awareness can result in up to 10% fuel reduction.

2. Keep good records to know if changes are productive. Recording promotes energy consciousness.

3. Conduct an energy audit. For a template, see http://seagrant.uaf.edu/map/recreation/fuelefficiency/fuelaudit.pdf

4. Use an amortization table, calculate capital costs and repayment period for proposed improvements.

5. Do the math. Fuel is one of many costs, and fuel saving measures may counter other considerations.
Stay tuned for MAP/AFDF FV energy audit project.

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