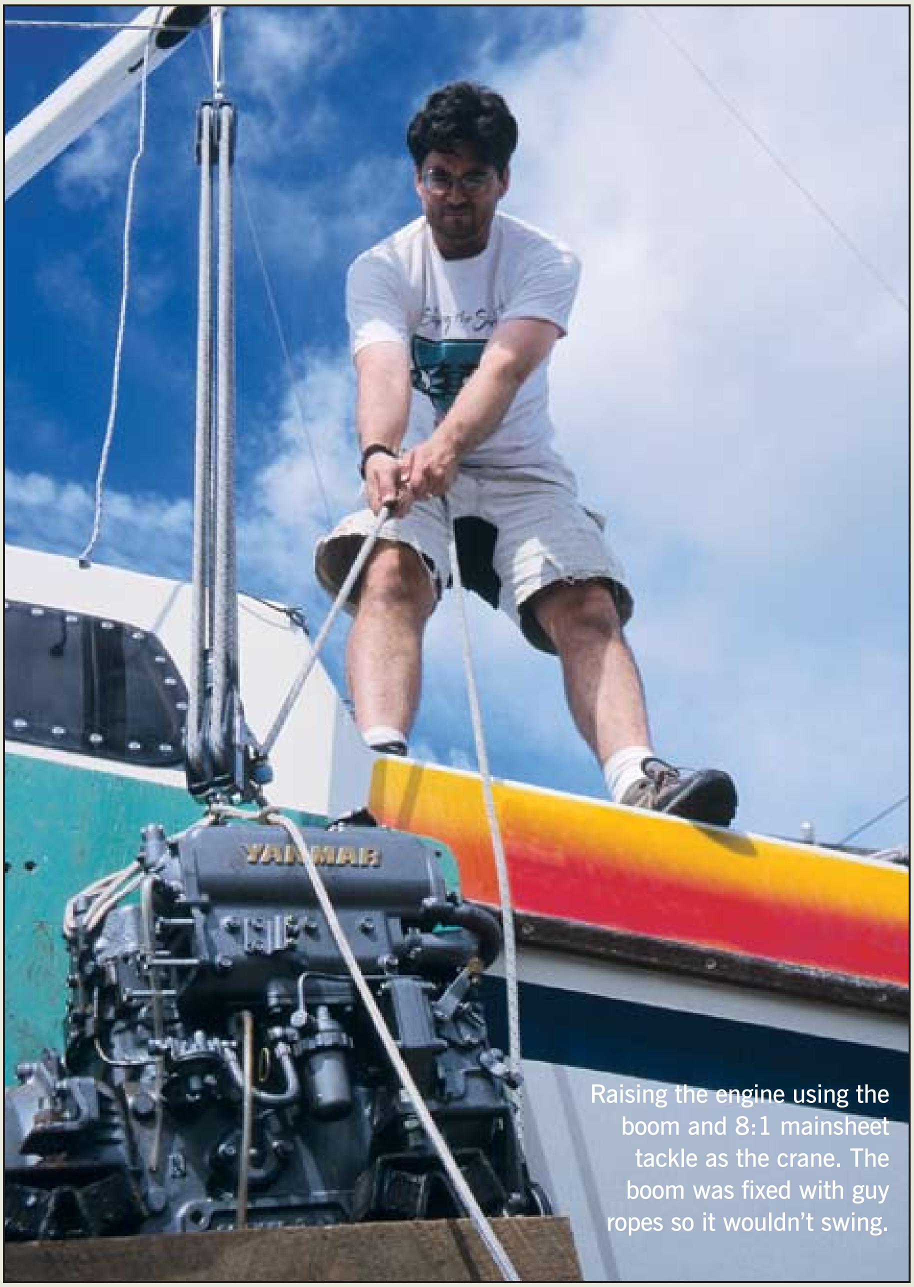
UPGRADE

Repowering with Diesel

Replacing two gasoline outboard engines with a single inboard diesel made cruising under power simpler and more enjoyable for this intrepid couple. In their experience, it all came down to "less is more."

Story and photos by Diane Selkirk and Evan Gatehouse



Raising the engine using the boom and 8:1 mainsheet tackle as the crane. The boom was fixed with guy ropes so it wouldn't swing.

Our 40' (12m) catamaran was originally equipped with twin 9.9 hp outboards. One engine died and the other spun its propeller hub during our first trip as new owners. A prop swap from the failed engine to the operational engine gave us enough power to limp home on one engine. The next sailing season began with both motors repaired, or so we thought, but one of them threw a rod putting us right back to motoring with one outboard. Clearly, outboards were not our preference for reliable power.

The planned conversion from twin outboards to a single inboard engine required us to discern the proper size engine and propeller to power our boat. For engine size, we looked at similar boats for comparison. We also used a 1.5- to 2-hp per 1,000lb (453kg) of boat displacement rule of thumb for boats in the 25' to 40' (7.5m to 12m) range. Propeller suppliers gave us recommendations for a range of propeller sizes that would suit the engine, gearbox ratio and the boat.

Since our boat moved at 7 knots with the two 9.9 hp outboards, we presumed that the lightly used Yanmar 3GM30, three-cylinder, 27-hp diesel we found would provide ample power. Our diesel technician gave the Yanmar a thumbs up and we bought it.

Prop Fitting

The next step was determining the optimum propeller location relative to the hull and the rudder. In general, for maximum thrust from input power, select the largest propeller diameter your installation will tolerate. We purchased a used, 17" (43cm), feathering, Autostream propeller. It's 1" (25mm) larger in diameter than our targeted size but the price was right and adjusting the pitch compensated for the increased diameter.

The desired blade tip clearance from the hull was 15% of the propeller diameter and the formula for positioning the prop (50% of its diameter) put this prop 8.5" (215mm) forward of the leading edge of the rudder blade with a tip clearance of 2.55" (64mm). Achieving adequate prop tip clearance can be challenging but, to minimize vibration, the right clearance factor is important.

Measuring the spot on the hull to locate the hole for the shaft reference wire.

Engine Placement

Unlike monohull sailboats, where the engine would probably be best located under the cockpit, our nearly new diesel engine fit under a berth in the port hull. We experimented with various shaft angles that would enable the desired propeller position and still keep the engine under the berth. The hull shape dictated a 5° shaft angle, which is well within the maximum 15° angle.

An installed engine requires at least 1" (25mm) clearance from its bearing surfaces to allow for its normal motion during engine operation. Also, we needed another drawing showing a sectional view of the hull where the engine would be located to confirm that the selected space was adequate.

We also considered the need for additional room inside the hull for a stern tube, stuffing box and shaft coupling aft of the gearbox and engine.

(left) Checking shaft position with laser level. (right) Engine mockup in position to locate engine beds. On this engine, the mid-point of the adjustable engine mounts lined up almost exactly with the gearbox output flange. If they were lower, we would have had to make a wooden support at each end of the plywood to position the reference wire.

Bearings and Shaft

On hulls with a long keel, the propeller shaft may exit the trailing edge of the keel. In this case, the cutless bearing is located in the trailing edge of the keel, affixed inside a fiberglass stern tube. For fin-keeled boats, a strut ("V" or upside down "P" shaped) is typically used to support a cutlass bearing. That strut should be no more than one shaft diameter's distance from the prop hub.

We fabricated a carbon fiber cutlass bearing strut to minimize weight and save some money. (A fiberglass strut would be too flexible; a cast bronze strut is much simpler and they are available to suit any shaft angle.) We found that you could easily drill and tap the carbon fiber laminate for setscrews to hold the cutlass bearing in position.

Shaft diameter is usually calculated using engine horsepower, gear ratio and shaft material properties. Dave Gerr's, "The Propeller Handbook," is the biblical reference for these calculations and rules of thumb. ABYC Standard P-6, Propeller Shafting Systems, is also an excellent reference on these matters. Suppliers of shafting often make recommendations based on these sources. You can also find aids to calculating prop size at websites like rbbi.com/folders/prop/propcalc.htm. Many engine manufacturer websites also offer shafting and propeller sizing formulas. Some post-installation tweaking of pitch and/or diameter might be necessary to get the optimum effect in actual performance.

Installation

With the boat out of the water, we located the approximate position where the shaft would pass through the hull. We drilled a small pilot hole for the reference wire that would establish the shaft line, ensuring that the hole was large enough that the wire did not touch the hull when it was pulled taut. With our shaft line drawing in hand, we positioned the wire to represent the proposed position of the shaft, using the center of the propeller and the forward end of the shaft at a convenient bulkhead as

Engine beds glued together and clamped in position while the epoxy putty sets.

reference locations, making sure the propeller tip clearance still matched the drawing.

(left) Measuring fiberglass to cover the engine beds. (right) Applying peel ply to the fiberglass to leave a smooth appearance.

To position the engine beds in reference to the shaft line, we made a wooden engine mock-up and marked the hull for the position of the beds. Following a final check inside the engine compartment to make sure we had enough room for the engine, both vertically and transversely, we measured the heights of the beds for shaping the timbers, taking care to shape the beds at the bottom so they fit against the hull.

After the bed timbers were shaped, we cleaned the hull with acetone then sanded with a coarse grinding disc. We used epoxy resin thickened with wood flour and colloidal silica to glue the wood beds to the hull and fill any gaps. We then formed large radius fillets between the wood and the hull and then glassed over the beds with several layers of biaxial fiberglass. Using many layers of fiberglass created a stiff engine foundation that would transmit less vibration to the hull when used with flexible engine mounts. The engine beds did not need to be exact in height to the last 1/8" (3mm) because the adjustable mounts allowed us to adjust the engine to its final position.

Stern Tube and Strut Bearing

The boom and mainsheet tackle was used to lift the engine from the ground onto the deck and down into the hull. With the engine in its approximate position on the engine beds, we adjusted the engine mounts so they were in the middle of their adjustment range.

Enlarging the pilot hole where the reference wire passed though to fit the stern tube enabled us to adjust the final position of the stern tube within the hole. With the prop shaft fit into the fiberglass stern tube, we slid this assembly into the hull, installed the shaft coupling on the front end of the shaft and bolted the coupling to the gearbox.



(left) There wasn't enough height over the engine for a block and tackle, so a lifting rope was lead through a block to a winch outside on deck. The overhead lifting beam was suitably braced. (right) Engine on the beds.

Using wood wedges, we adjusted the propeller shaft so that it was centered at both ends of the stern tube. We deferred installing the flexible coupling between the gearbox output flange and the propeller shaft flange because it would flex too much while we located the final shaft position.

Because the propeller shaft and stern tube were now rigidly connected to the engine, their installation position was correct. We could easily rotate the engine slightly on its beds by hand, so that the shaft and stern tube were lined up with the center of the hull.

Next, we fitted a cutlass bearing into the strut and slid the strut onto the outboard end of the shaft, sliding it into position just forward of the propeller hub and marking its location on the

Propeller shaft initial fitting and marking for strut.

Stern tube and strut in position.

hull bottom. We moved the strut out of the way and cut an oversize hole in the bottom of the hull as a pass-through for the strut.

The stern tube, propeller shaft and cutlass bearing strut were now all loosely fit in oversized holes in the hull but firmly connected to the engine in sequence and alignment. Gaps were packed with high-density foam to hold these parts into position and then thickened epoxy putty applied to fix them in place. Once the putty had hardened, we removed the propeller shaft and cut off the excess stern tube protruding though the outside of the hull. Any remaining gaps were filled with more thickened putty and the stern tube and strut were fiberglassed into position. An additional transverse gusset was mounted on the bracket inside the hull. With the propeller shaft in place, we bolted the engine to the engine beds.

Auxiliary Systems

The final aspect of installing an engine is connecting the engine's auxiliary systems, which included relatively uncomplicated plumbing, mechanical and electrical work.

We drilled a hole in the hull for a seacock to serve the seawater cooling intake. The foam core was removed from the perimeter of the hole, which was then filled with epoxy putty. We then glued a plywood backing pad in position, sealing it with two coats of resin before caulking and screwing the seacock in place on the backing pad. We bolted the sea strainer to a bulkhead and made the hose connections to the engine's saltwater pump. A vented loop, installed inline ahead of the connection to the exhaust outlet, prevents siphoning cooling water into the engine.

A waterlift muffler installed 6" (152mm) below the engine exhaust outlet and hose carries the exhaust discharge to its terminus in the hull side near the transom. We glassed a 2" (50mm) fiberglass tube into position for the outlet. At this point, we connected the components, looping the hose upward under the deck, where it was supported by a section of durable and non-chafing nylon webbing. The electrical system hookup was straightforward: connect the positive battery cable to the starter motor; the negative cable to a grounding bolt on the engine block; and plug the engine wiring harness into the engine control panel.

Ensuring the engine has an adequate supply of fresh air required the installation of a vent, designed to allow air flow but not admit water, in the side of the hull. A blower removes accumulated hot air from the engine compartment via a flexible hose.

The Yanmar and the control head directions guided our installa-




(left) Overlength stern tube ready for epoxy putty and fiberglassing. (right) Trimmed stern tube. (bottom) Stern tube fiberglassed in place on inside.

tion of the engine control cables to the engine and gearbox. A drop of Loctite on each clamp bolt ensured the cables wouldn't vibrate loose.

We then installed a new polyethylene fuel tank, a fuel filter and all U.S. Coast Guard-approved type A1 fuel hose.

DIY Bill of Materials

Cost totals, in U.S. funds, grouped by task, to repower a 40' (12m) catamaran with a 27-hp inboard diesel.

Engine	
Yanmar 3GM30, used	$4,132
Mechanic	$217
Engine beds: glass, foam, wood	$55
Stainless-steel lag bolts	$5
Fuel	
Fuel tank, Tempo 27 gal plastic	$213
Fuel filter, Racor 500 FG	$82
Miscellaneous fittings	$5
Deck fill cap	$11
Fuel fill hose 1' (12cm)	$7
Fuel vent hose 1' (12cm)	$2
Fuel vent fitting, Seadog	$6
Fuel supply and return hoses, 30' (9m)	$96
Shafting	
Shaft seal	$174
Shaft, 1-1/4"x72" (31mmx182m) stainless steel	$100
Machining prop shaft for coupling, custom coupling	$587
Shaft log 2" OD x 3" (50mm x 76mm)	$36
Flexible coupling, R & D Flexible Coupling	$165
Carbon fiber shaft strut	$25
Cutlass bearing, 1-1/4" x 1-3/4" x 5" (31mm x 44mm x 127mm)	$25
Folding prop, 17" (43cm) three-blade Autostream	$2,142
Cooling	
Hose clamps	$7
Miscellaneous fittings	$14
Cooling water hose	$15
Seacock, Marelon 1" (25mm)	$45
Sea strainer, Vetus 3/4" (19mm)	$34
Exhaust	
Exhaust hose, SAE J2006, 2" x 108" (50mm x 274cm)	$81
Exhaust outlet, 2" (50mm) fiberglass tube	$36
Waterlift muffler, Vetus NLP50	$94
Hose clamps	$10
Ventilation	
Sound insulation, Soundown, 54" x 72" (137cm x 182cm), 3 sheets	$150
Pins, clips, glue for installing insulation	$40
Blower	$10
Blower hose, 5' x 3" (1.5m x 76mm) diameter	$11
Vent intake air fitting	$7
Controls	
Control head, Morse SL-3	$134
Battery cables	$31
Engine stop cable (included with engine)	
Control cables, diesel throttle, Morse 33C, 14' (4.2m)	$70
Control cables, diesel gear Morse 33C, 14' (4.2m)	$70
Hour meter (included with engine)	
Total	**$8,944**

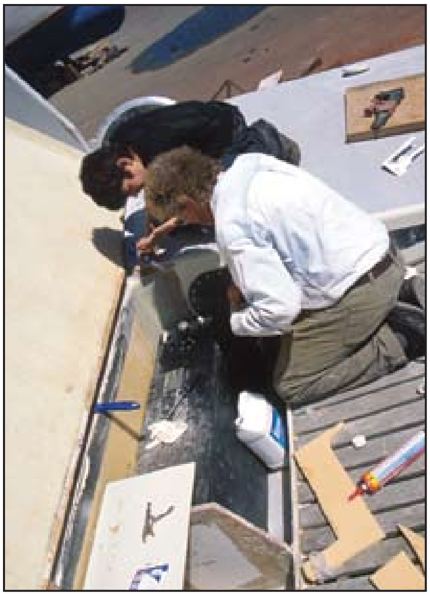
Post Launch

The final shaft alignment, adjusting the engine alignment by sliding feeler gauges between the shaft coupling and the gearbox, was done after the boat

Trimming excess foam shims at the carbon fiber cutlass bearing strut prior to shaping fairing compound.

Shaft seal with vent hose and exhaust hose outlet, which has to pass through a watertight bulkhead so the connection is made through a fiberglass pipe glassed to the bulkhead.

Vetus sea strainer on raw-water intake mounts to bulkhead.



Installing the fuel tank and fittings.

Material Sources

Stern Tube and Exhaust Outlet

Fiberglass tube and pipe for stern tubes and exhaust outlets can be purchased through many industrial suppliers of fiberglass pipe, such as Max-Gain Systems at 770/973-6251; mgs4u.com/fiberglass-tube-rod.htm

Shaft Seals

Duramax	440-834-5400; duramax-marine.com
Lasdrop	800/940-7325; lasdrop.com
PSS	800/523-7558; pyiinc.com
Sure Seal	800-420-0949; tidesmarine.com

Conventional Bronze Stuffing Boxes

Buck Algonquin	302/659-6900; buckalgonquin.com
Glen-L Marine Designs	562/630-6258; glenl.com

Cutlass Bearing Struts

Buck Algonquin (see above)
Marine Associates 800/544-1487; marineassociates.com

was launched. Once we were satisfied that the alignment was right, we installed the flexible coupling. Since we had a dripless shaft seal, we needed to "burp" the seal to make sure there was no trapped air. With a conventional stuffing box we would have had to adjust the tightness of the stuffing box. After a final check of fluid levels we happily motored back to our slip.

About the authors: Evan Gatehouse is a naval architect and mechanical engineer, with extensive experience in composite boat design and boat mechanical systems. Diane Selkirk is a freelance writer and sailor with stories and photos published in a variety of magazines. Together they are completing a total rebuild on "Ceilydh", a Wood's Meander 40' (12m) catamaran.