Propellers Sea-Going

Propellers are a specialist subject and a full understanding needs a propeller specialist - whilst Beta Marine has many years of experience learning which propeller normally goes with which engine, please note that we are ***NOT*** propeller specialists.

A general guidance for propeller dimensions in inches – based upon 3 blade RH rotation and a 2:1 reduction ratio. For accurate guidance please provide us with full boat details.

Beta 10	Beta 14	Beta 16	Beta 20	Beta 25	Beta 30	Beta 35	Beta 38	Beta 43	Beta 50	Beta 60	Beta 75	Beta 90	Beta 150
12"x9"	12"x9"	13"x8"	13"x9"	14"x8"	15"x9"	16"x11"	16"x8"	18" x 12"	19" x 12"	Please ask	Please ask	Please ask	Please ask

Propeller Dimensions Propellers are normally measured in two dimensions: a) the actual diameter and b) the pitch – assuming the blade is set at an angle, then if you followed this angle through one revolution and measured the distance travelled between the starting and finishing point you will have moved forward the measurement called the pitch.

There are often physical limitations required of the propeller. This would frequently be the diameter due to the space limitations between the position of the propeller shaft and the underside of the hull. This can be compensated for by changing the pitch but again there are limitations.

This explanation that has been put together to provide some basic guidance to people who may be like myself and have a limited or minimum understanding of propellers. We apologise in advance if it is too simplistic.

Propeller Concept The concept of a propeller is to convert the power obtained from the engine – a torque on the rotating propeller shaft (power) – into forward (or backward) movement of the boat. This involves matching the propeller to suit the power and speed of the engine, to the size and displacement of the boat. Generally the propeller design must be as efficient as possible in converting the engine power into forward movement of the boat – this should keep the engine size and fuel consumption to a minimum; generally a large propeller rotating slowly is more efficient in converting hp into boat movement.

A propeller is 'sized' to absorb / transmit the full engine power at a specific engine speed. If you are looking for maximum power output from an engine, then this will always be at the maximum rated speed. In some cases where customers wish to limit engine speed and noise – propellers are sometimes sized to the normal engine cruising speeds, meaning that can be slightly 'over-propped' and the engines will never achieve their maximum rpm in gear.

Propeller sizing and selection involves different view points / criteria, and there is no single correct answer. Owners often want their boats to respond in different ways - a racing yachtsman will only be looking for the minimum engine weight, while a family cruising with small children will want a safety factor and reliability for stormy conditions or fast tides.

It should also be noted that all calculations are theoretical, and based upon sunny days with calm waters, with little account taken of 'windage' or heavy seas, there is no substitute for experience and you should be talking to propeller specialists.

Total Displacement Hulls and frictional resistance As you lower a boat into water you displace a volume of water. It is the surface area of the displaced water against the boat hull and corresponding frictional resistance that has to be overcome when propelling the boat forward and overcoming a certain amount of wave drag. However, as every yachtsman will know, if you have "loads of weed on the bottom" you will go a lot slower compared with the same boat that has just been anti-fouled. We are assuming in these notes that the bottom of the hull is clean! Drag due to hull form is also a major factor. The modern design of a 30 foot light displacement fin keeled racing yacht has much less drag than traditional bilge keel family cruiser or motor sailor of the same length. These factors are to some extent reflected in the displacement of a yacht, and this together with the waterline length are two key factors we use when considering the required engine size. As water is basically the same all over the world, your yacht will float at approximately the same displacement everywhere. The total sailing weight (displacement) to use in any calculation is the actual total laden displacement in the water, including all fuel, water, food and people – not just the weight of the bare hull.

A generally accepted rule of thumb for yachts up to 50 feet is 4 hp /ton - pleasure rating.

The maximum hull speed in Knots for displacement hulls is:

1.3 (or 1.4 for a sleek hull) x $\sqrt{\text{waterline length (measured in feet)}}$

Now, the above concept is relatively straight forward, however the power needed to push a boat hull through water is NOT a straight forward linear increase when measured against a simple speed increase of the hull. To complicate things there are also three basic hull designs/shapes: a) Displacement (yachts, fishing boats, narrowboats, Dutch barges, and work boats), b) Semi-Planing (fast cruising boats, power boats, and sailing dinghies), and c) Planing (power boats).

We are normally involved with 'displacement' hulls where the hull remains horizontal in the water. If you push a displacement hull with a larger amount of power there will be a point at which the stern of the boat descends slightly leaving the front up/out of the water; and it will consume more fuel without an increase in hull speed. The shape of the hull and the weight are critical factors and are very important. If you have a semi-planing or planing hull you need to contact the designer or a propeller specialist.

With displacement hulls we talk about the maximum hull speed through the water – this is the maximum hull speed that it can achieve. As the hull approaches this 'maximum hull speed' the power required to achieve the faster speed follows a law of diminishing returns (increases *'exponentially')* which I understand to mean that the required engine power must increase by larger and larger amounts to achieve a steady increase in hull speed – up to the maximum hull speed.

	Approximate boat speed for a 25 foot yacht	Approx hp
	4 knots	4.2
	5 knots	4.4
	6 knots	4.8
Max hull speed	6.5 knots	10.0

Generally yacht owners are looking to achieve something close to the maximum hull speed. This would normally mean that a 30 foot yacht with a total displacement of 5 tons (5,000kg) can achieve about 7 knots with an engine of 25hp, a 2:1 reduction gearbox and a suitable propeller. However if you were to sail your yacht with a slight reduction in hull speed of say about 10 percent you would normally reduce the power required to achieve this by about 40%, with a corresponding fuel saving.

Fuel Consumption

The fuel consumption of an engine will vary according to the engine speed, and the load applied to the engine. Engines will run between 'tickover' and the maximum rev/min; and at any stated speed the fuel consumption at that speed will be directly proportional to the load applied. Fuel consumption figures are normally given at maximum power and that is normally maximum engine speed. The load on the engine is created by the propeller, and this follows an 'exponential curve' as the speed increases. It is therefore important that the propeller is correctly sized to the engine power output and corresponding speed (rev/min).

We are now getting to the point where you need to discuss your requirements with a helpful propeller specialist who can explain propeller blade loading, cavitation, slip etc.. If you have any doubts about your propeller size you should consider a second (or third) opinion and this is where you should call someone like Paul Bell at First Marine Propulsion on Tel: 02380 225 944
email: paul@1stmarine.com

Calculations

To provide you with an accurate answer to the propeller sizing question we need to understand the size and weight of your boat. Obviously the more accurate the information you provide the more accurate the answer is:

Name:			
Address phone number and email			
Which Hull Type do you have?	Displacement	Semi-Planing	Planing
Overall length of vessel?			
Waterline length of vessel?			
Displacement Weight?			
Engine HP (horse power)?			
Single or Twin engines?			
Maximum rated rpm of engine?			
Gearbox reduction ratio required			
Maximum diameter of propeller			
Anticipated yacht speed?	knots		
Propeller shaft diameter and taper details.			
Do you want ?	A 2 or 3 or 4 fixed blade propeller		
	A 2 or 3 blade folding propeller		
	A feathering propeller or Autoprop or other design		