Design: The Basic Principles and their Relationship to Sail Trim

You've probably read articles on trimming according to differing wind strengths. The objective e is always to make his sails work across the maximum wind range possible. For the designer of the sails, the task is to produce sails which will respond to the sailor's adjustments with an overall goal of versatility.

Sails are made up of flat panels of sail cloth. Their three-dimensional shape—the airfoil—is produced by cutting the panels narrower at each end than the middle. (see figure 7) In addition, the curve of the sail's leading edge (the luff curve) is cut to match the curve of either the forestay sag (for jibs) or mastbend (for mainsails). By carefully controlling these two variables it is possible to produce almost any shape in a sail.

Although each sail is a separate entity, when used together they are highly inter-related. They should be thought of this way both on the design computer and when considering sail rim.

At Neil Pryde, we make a full range of cruising and race sails. Each is meticulously developed using the CDT design system program. CDT allows us to describe sail shape in a numerical format so that sails, subject to size and aspect ratio, can be scaled up and down and transferred from one boat type to another with consistent results. The computer imagines the designed mould and literally drapes the panels (in the defined layout) over the mould. Those areas where the fabric overlaps are plotted and cut by a computer driven cutter. By literally cutting off the overlap from the cloth it is possible, after joining the panels, to re-create the defined shape. This cutting is known as "broad seaming", and is applied to both the cross-cut (horizontal panel) and radial-shaped sails.

Upwind Sail Trimming

Basic Principles

Most people assume that there is an ideal trim setting for every given sailing situation. This is theoretically true, but involves balancing many factors according to conditions and performance goals. The constant changes in wind and sea, the relative disturbance of the air, and even, the tactical position in a race can affect the sail trimmer's goal at any one time. We'll see later that ideal trimming can go beyond perfect-looking sails.

In order to simplify matters let's begin by generalizing that the majority of upwind trimming situations fall into one of two categories: power or pointing.

"Power" means trimming for acceleration, and generally involves fuller, more twisted, sails. "Pointing" is trimming to flatter, less twisted, sails once you have attained higher speed, and want to head closer to the wind.

The only time when these principles do not apply are in very light, almost drifting, conditions when acceleration is improved not through additional power from the sails but through reduction of drag. This is achieved by flattening the sail: the wind will flow more easily over the flattened surface (less drag) than over a rounded surface.

For the cruising sailor following the principles of full or flat sails, excellent performance can be achieved over a wide variety of conditions.

The following graph, which shows when to trim for wither power or pointing (and basic characteristics of each), can be used at any stage of a day's sailing, You might even find it useful to keep on deck.

UPWIND SAILING GUIDE

Wind Condition	Extremely light (drifting) 0-4	NORMAL CONDITIONS			Extremely Heavy 22-30
		Light 4-8	Moderate to Heavy 8-22		
Trim Goal	Keep moving by reducing drag	Accelerate	Head Closer to Wind		Foward motion through rough sea
Trim Style	Pointing	Power		Pointing	Power
Sail Shape		Smooth Water	Rough Water		
Overall	Flat	Medium	Full	Med. Flat	Medium
Entry	Flat	Flat	Full	Medium	Med. Full
Exit	Med. Full	Med. Flat	Med. Full	Medium	Flat
Twist	Maxium	Medium	Med. High	Min.	Med. Low
Bottom 1/3	Flat	Med. Flat	Med. Full	Medium	Flat

Graph 1

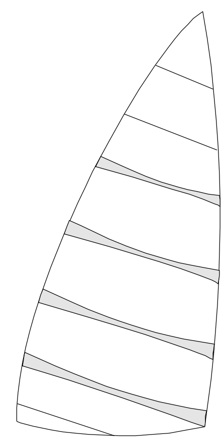
(Graph #1)

Special situations for each trim style:

Power	**Pointing**
·acceleration	·when at max speed upwind
·disturbed airflow	·clean air
·out of tacks	·during gusts
·rough water	·flat water
·after hitting waves	

This graph shows how the power/pointing relationship changes as the wind increases. The left hand side of the graph represents lightest wind. Moving across the pages show how trim should change as wind speed increases. Note how the trim in light air should be very different for smooth or rough water. Also note how, once you have heavy air (over 20 knots), the pure pointing mode must be modified slightly to power as the increasing windspeed will generate choppy seas.

Figure 7



Cross-cut panel layout. Panels are cut so that shaded area is removed (broadseaming), which gives depth to the sail.

Racing considerations

The racing sailor has to consider three other primary trim factors. They are : twist, angle of entry and vertical distribution of depth. They may sound complex, but they are in fact quite simple.

The Grand Prix racer will tell you that there is a fourth critical factor: exit angle. In this booklet we will avoid discussing exit angle because it's difficult to do anything about the shape of the back third of the sail using only the controls on the boat. That's really a question of entirely re-cutting the sail. The little that can be done to alter exit angle will be mentioned in the third point: vertical distirbution of depth.

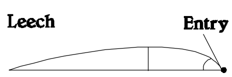
Twist is the amount the top third of the sail twists to leeward relative to the bottom. You want more twist in light air and less in heavy; more twist in a choppy sea and less in a smooth sea.

Angle of entry is term which describes the roundness of the front of the sail. A rounder entry—often referred to as a fuller entry—will create greater acceleration, speed and a more forgiving sailing “groove” at the expense of some pointing ability. (figure 8)

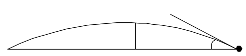
Vertical distribution of depth is carefully considered and manipulated at the design stage. On board, you really only have control over the bottom third of the sail. This is good if you want to point closer to the wind or if you are overpowered. The same effect is achieved in the mainsail by pulling on the outhaul or the flattening reef.

In order to simplify this matter we have created a reference table (below in graph 2). These additional factors must be considered together with either power or point condition, never separately.

Figure 8



Round entry (camber forward)



Straight (fine) entry. Entry gets finer as camber moves aft.

Now, let’s examine each of these extra factors.

SUMMARY OF SPECIFIC TRIM

POWER		POINTING	
REQUIREMENT	**TRIM RESPONSE**	**REQUIREMENT**	**TRIM RESPONSE**
Fuller Sails	1. Ease backstay	**Flatten Sails**	1. Tighten backstay
	2. Ease main outhaul		2. Outhaul on harder
	3. Ease genoa sheet		3. Sheets on harder
	4. Move jib fairlead fwd		4.Move jib fairlead aft
Increased Twist	1. Ease mainsheet	**Decreased Twist**	1.Tighten mainsheet
	2. Traveller up		2. Lower traveller down
			3.Tighten boom vang
Round Entry	1. Tighten halyard or cunningham	**Flatten Entry**	1. Ease halyard
	2. Ease backstay		2.Tighten backstay
Rounder Exit	1. Traveller up (main to centerline)	**Straighter Exit**	1. Traveller down
	2. Ease outhaul		2.Flattener on

Graph 2

Helm Balance

In a final consideration of sail trim, let us review the objective. Be it cruising or racing, the final aim of trimming is optimum performance.

But optimum performance is not necessarily the result of having what looks like perfectly trimmed sails. Rather, the sails are trimmed to complement a number of other factors which altogether produce optimum performance.

How do you gauge the level of your performance when under way? Downwind it is relatively easy because the shortest distance between two points is a straight line. Optimum performance is therefore the attainment of a maximum speed which can be measured by instruments.

When your destination is directly upwind, however, you are attempting to improve your VMG (Velocity Made Good). Although sophisticated electronic systems will give you some guides towards your VMG, the very best guide to over all performance is helm balance—the ability of your boat to maintain a smooth course on its own, without excessive load needed on the wheel to keep the boat from turning. This is optimum because it involves the lease amount of drag from the rudder.

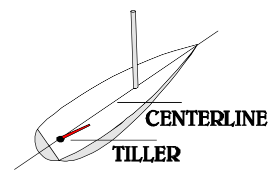
Sail trim must at all times take into consideration helm balance. In general the trim style we've referred to as "power" equates to increased weather helm (boat turning to windward); "pointing" produces less weather helm, and in light wind, can even produce lee helm (boat turning to leeward).

For really good performance on the race course, the trimmers—both main and genoa—must be constantly talking to the helmsman so that each is aware of the helm balance at any time. The helmsman should be aiming for a few degrees of weather helm, but not too much load (turning pressure) on the wheel. (figure 9) The trimmer, especially the mainsail trimmer, should be making sure that this load does not become excessive if there is a sudden gust or change in wind direction. The result could be a seriously over-balanced boat.

Don't forget, if everything looks perfect to you as a trimmer but the helmsman says the helm is unbalanced or you're going slow relative to your competitors, then your sail trim is definitely wrong.

The whole trimming sequence should start with an evaluation of the wind condition; more on to the function required (either pointing or power); then to achievement of sail trim through careful control; and then be completed with an analysis of the resulting balance and efficiency.

Figure 9



The angle of the rudder shuld be 3-4 degrees to windward of the centerline for best performance when sailing upwind.