# What's All This About Weather Helm?

Exploring One of Life's Great Mysteries.

## Part 1
## The Theory Stuff First

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***"Set up for slight weather helm"***
***"Lee helm is a dangerous way to balance your boat"***
Have you ever heard these statements? What do they mean? And is there anything that I need to do to my Hobie to fit into these requirements?

Here is the answer to these questions and more. More than you ever wanted to know about lee helm, weather helm, mast rake, rudder rake, tiller tug, rudder moment, and ruddertrack, and how they control your enjoyment and safety while sailing your Hobie Cat.

**Lee Helm or Weather Helm. - What is it Anyway?**

These terms relate to the sideways wind balance of your boat. Sideways balance? Yep. Sideways balance.

Go and get your bathtub boat and sit it on the table in front of you. You don't have a boat in the bathtub? Better use your computer mouse then, even something with wheels will do. Push the boat forward across the table with your right hand. The wind is in your left index finger.

As you sail the boat across the table, push your “wind finger” against the bow of the boat. It will turn away from the wind. Now push the stern of the boat with the wind finger. The boat will turn into the wind. You have demonstrated the effect of the sideways wind balance of the boat. When your Hobie is on the water the wind will tend to push it one way or the other in exactly the same manner.

*“What about the rudder?”* you say. Yes, the rudder does control steering, but this balance effect is measured when you let go of the tiller. When the boat is free to turn as the wind pushes it, then you see its natural balance.

Your boat is set up to turn away from the wind, or set up to turn into the wind, or it might just continue on the same course. This balance effect is called “helm”. You have either *lee helm*, or *weather helm*, or *neutral helm*. Neutral helm is when you are sailing along, let go of the tiller and just keep going in exactly the same direction.

This form of balance of your boat is controlled by the sail size, sail shape and fore/aft placement, and the shape of the boat under the waterline.

**Lee Helm or Weather Helm. - What Do I Need?**

You need to set your boat up for slight weather helm. This is for safety reasons as much as for sailing efficiency.

Imagine that you are in a heavy wind, you get into some trouble and fall overboard. If you have lee helm the boat's balance will take the boat away with the wind. You will be left in the water and the boat will be sailing away by itself.

Lee helm can also make the boat's steering “twitchy” and unpredictable. In a gust the balance of the boat will force it slightly to leeward and tends to push the bow into the water. If you are already running well off the wind this is when you can have a sudden jibe or pitchpole.

If you have weather helm and fall overboard the boat will turn up into the wind and stop and wait for you. This is the next best thing to having it circle around and pick you up.

A sudden gust with weather helm will turn the boat slightly towards the wind and tend to lift the bow (safer than nose-diving) with little effect on steering. You can continue without worry of the boat becoming upset.

### Balancing Your Boat

Balance is achieved by getting the right relationship between centre of effort and centre of lateral resistance.

**Centre of Effort - CE**

The centre of effort is the point on the sail plan which represents the centre of all the force of the wind. Think of it as being a point about 20% behind the mast and 30% up the mainsail. The point moves aft as the mast is raked.

**Centre of Lateral Resistance - CLR**

This is the point which represents the centre of the sideways resistance of the boat under the waterline. If your boat has a centreboard, the point will be there. If you don't have a centreboard the point will be somewhere along the hull and will move fore/aft as you move on the boat and push bow or stern into the water.

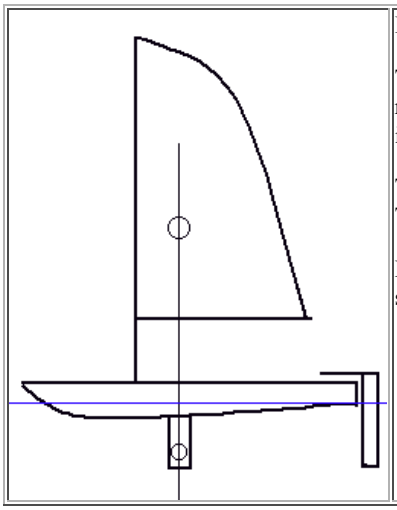

**Fig.1. Neutral Helm**

This boat has a centreboard, and that is where the centre of lateral resistance will be. If you were to push sideways at either end of the boat, it will pivot in the water around this point.

The centre of effort of the sail is directly above the centre of resistance. This boat has neutral helm.

Let go of the tiller and the wind will not tend to pivot the boat either way, so the boat will continue to sail its present course.

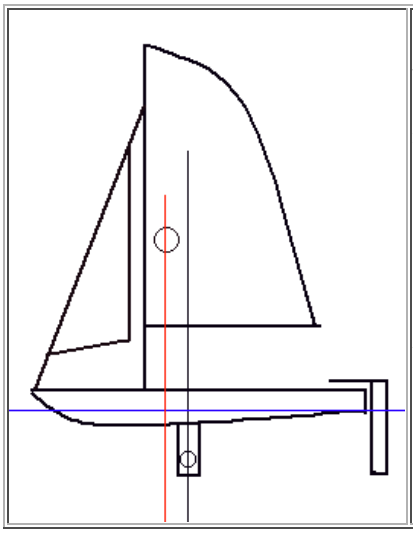

**Fig.2. Lee Helm**

Now we have added a jib. This puts more sail effort in front of the mast and so the centre of effort has moved forward. However, the centre of resistance is in the same place.

The wind will now tend to push the boat's nose away to leeward.

If you fell off this boat it would leave you in the water and sail away by itself.

Too much lee helm and the steering can also become twitchy and unpredictable in gusty weather and in certain angles of sail.

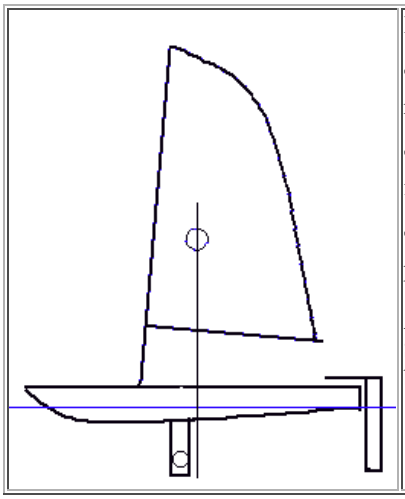

**Fig.3. Weather Helm**

The boat has some mast rake so the wind pushes behind the centre of resistance and turns the boat gently into the wind.

This is the preferred balance of most boats. It is also the safest. If you fell from this boat it would turn up into the wind and stop in irons.

The skipper corrects this tendency and sails a straight course by gently pulling on the tiller.

As mast rake increases the balance becomes increasingly weather helm. Sailors who prefer extra rake have to accept this eccentric balance of the boat.

**What Can We Learn From a Windsurfer?**

Have a close look at the next windsurfer you see. It has no rudder, just a centreboard around which it pivots, and a little skeg at the stern to keep it on track. So how does it steer? It steers by moving the sail backwards and forwards thereby moving between lee and weather helm. Tilt the sail forward and the windsurfer falls off the wind to leeward. Tilt the sail aft and it heads up into the wind.

Imagine surfing along with the wind coming from your port beam. Move the sail aft to increase weather helm and you turn into the wind to port. Move the sail forward to increase lee helm and you turn to the lee, to starboard.

## Now Let's Get Back to Your Hobie 14/16

You have no centerboard around which to pivot, and you have a lot of control over mast rake. So what does this mean for normal

sailing?

The centre of lateral resistance will not be located in a single place as with a centreboard boat. The CLR moves back and forth with the loading of the boat. Push the stern into the water so the bow comes out of the water, and the CLR moves aft. Just sitting over the rear corner casting will move the CLR aft. As you move forward, so will the CLR. There is a natural aft limit to which you can push the CLR like this. Because the hulls have less depth at the rear than in the front portion, the CLR will not move all the way aft. The deeper profile of the hulls in the front portion keeps the CLR further forward than we might sometimes like for good helm balance.

The centre of effort is controlled by sail configuration. If you have a jib it will be forward. If you rake your mast it will move aft. Balancing the CLR and CE is not difficult, as long as you know what you want to do with the boat.

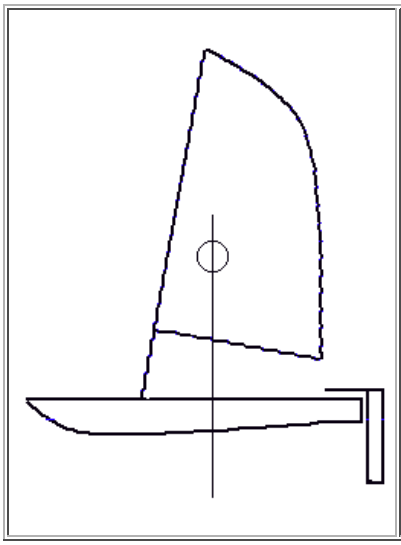

**Fig.4. Raked Mast, No Centreboard**

Remove the centreboard and increase mast rake. Without the centreboard the centre of resistance is mobile according to the movement of the crew.

As the crew moves aft the centre of resistance also moves aft. As the crew moves forward so will the centre of resistance. This movement gives Hobie 14/16 sailors another control, but it makes things rather indefinite to those unfamiliar with their boat's handling.

With more mast rake the centre of effort moves further aft. This means more effort from the wind pushing the boat from behind the centre of resistance. The boat's weather helm increases accordingly. As weather helm increases it puts more correction load on the tiller to keep running straight.

If you are a social sailor who does not need to get every ounce of speed out of the boat, you will not need extreme mast rake. If you race your Hobie, increasing mast rake will give you extra speed and more stability. However, you pay a price for this as the boat with extra mast rake has extra weather helm. To compensate for this extra weather helm and keep the boat running straight, the skipper has to supply extra tiller effort against the tendency to turn up into the wind. This effort comes from tugging on the tiller. It is easy for your arm to tire if your boat has excessive weather helm. The load that the skipper is supplying is what I call "tiller tug".

Another disadvantage with excessive weather helm is that the extra drag from turning the rudders to achieve a straight course slows your boat. Getting the maximum speed is a matter of balancing the extra power against the extra drag.

## Reducing Weather Helm When You Have Extreme Mast Rake.

### Tiller Tug

We now come to a very difficult subject to explain. Tiller tug is my own term to explain what is happening when you pull on the tiller to correct for excess weather helm. You can correct for tiller tug, but you can't fully correct for weather helm. This is an important concept to understand. You will probably need to read this portion several times before it starts to make sense to you. But the reading is worth it for the sake of understanding your boat.

| | |
|---|---|
| Miller's Rudder Rule 1. | If you have extreme mast rake you can't reduce weather helm with the rudders. |
| Miller's Rudder Rule 2. | Rudder rake reduces tiller tug, the effort of keeping weather helm under control. |

As you increase mast rake you increase weather helm. As weather helm increases, the boat increasingly wants to turn into the wind and the skipper has to compensate by pulling harder on the tiller to run a straight course. This becomes tiresome and people seek a way to ease the effort.

At this point it is easy to confuse weather helm with the effort required to keep your boat running straight. Many Hobie sailors confuse *weather helm* with *tiller tug*. These are different things and they are reduced by different adjustments.

**The only way to reduce weather helm is to more equally balance the CE with the CLR.**

If you have excess weather helm, you can reduce it by moving the CE forward, or moving the CLR aft. There is no other way to balance your boat. If you move the CE forward you lose the benefits of extreme mast rake. To move the CLR sufficiently aft both skipper and crew have to sit so far aft that they will fall off the boat. This is because the hull profile is not deep enough in the rear portion to balance the extra depth of the hull in the front portion.

The CLR is a function of the profile of the underwater hull shape. Your Hobie 14/16 does not have enough aft hull profile to move the CLR far enough aft to keep it under the CE with a raked mast. You are stuck with high weather helm.

Let me repeat, *"the only way to reduce weather helm is to more equally balance the CE with the CLR."*
***However, you can reduce tiller tug. This is a different dynamic from reducing weather helm.***

**Reducing Tiller Tug.**

Uh Oh... This is where we start talking about rudder rake and rudder moment. And later will come ruddertrack.

Rudder rake is where we adjust the rudders so that they point forward underneath the boat. We can adjust rudder rake to reduce the tiller tug, but this does not change the weather/lee helm balance of the boat. Welcome to confusion city.

Consider a normal Hobie 14/16 just out there sailing around. It has slight weather helm, the skipper does not have to apply much effort (tiller tug) to keep on track. It's just a good fun way to laze away a sunny afternoon. Now we will really mess up that fun loving skipper. Lift the tiller castings to unlock the rudders. The rudders are now pointing slightly backwards. The skipper continues, tiller in hand, but the tiller tug on his arm has increased to a point where he thinks he'd better start working out at the gym again.

What has changed with the balance of the boat? Nothing at all. The CE is still in the same place. The CLR is still in the same place. What we have done is to mess up the rudder configuration. The weather helm is still the same gentle balance, but the efficiency of the rudders in correcting it has been greatly reduced. With the reduced correction efficiency, the arm of the skipper is about to be pulled from his shoulder. We have increased his tiller tug without doing anything to his weather helm at all.

Push the rudders into locked position again, and their efficiency is restored. If we were to push the rudders further forward the skipper would have to put even less effort into his correction for the slight weather helm. But if we did too much of that his steering could become very erratic and dangerous.

And here is the irony. Moving the rudders like this is not balancing out weather helm. You can't balance excess weather helm by raking the rudders forward. Here's why. When you unlock your rudders they point further aft. Consider the underwater shape of the boat. Moving the rudder profile further aft moves the CLR further aft. And if you move the CLR further aft, it comes closer to being directly underneath the CE, which should give neutral helm, which should make the steering easier. But it doesn't make it easier, it makes it harder.

In the same way, raking the rudders forward moves the CLR forward, which should increase the weather helm, which should increase tiller tug. But it doesn't do that, it reduces tiller tug.

Remember these two rules:

| | |
|---|---|
| Miller's Rudder Rule 1. | If you have extreme mast rake you can't reduce weather helm with the rudders. |
| Miller's Rudder Rule 2. | Rudder rake reduces tiller tug, the effort of keeping weather helm under control. |

When you move your rudders forward or aft, the adjustment you are working with is not about weather helm. In fact, this rake effect works directly opposite to the weather/lee helm effect of moving your rudders. There are two effects working here. One is helm balance, the other is what I call *rudder moment*. The helm balance has only slight effect, the *rudder moment* has far greater effect in the opposite direction.

**Using Rudder Rake to Reduce Rudder Moment and Tiller Tug**

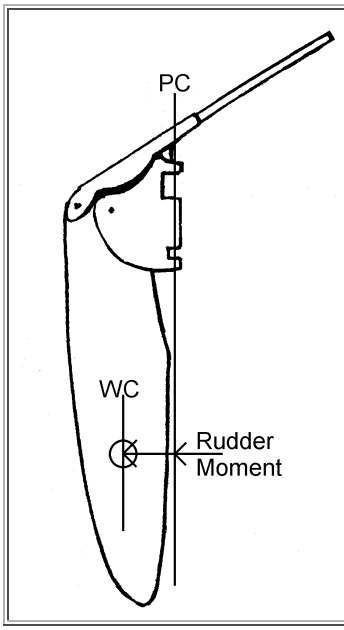


**Fig.5.**
Here is a Hobie rudder. You all recognise it.
It sits there doing its thing well enough in most cases. But it has some forces operating on it that we need to consider.

The rudder has a working centre (WC) and a pivot centre (PC). The pivot centre is the rudder pin. This does not change unless you do some radical reshaping of the rudder casting. The working centre is the point where underwater forces on the rudder can be considered to focus, like the centre of effort of the sail.

The rudder moment (RM) is the amount of force expressed by the horizontal distance between the WC and the PC. This is not an unusual concept, it is just a description of the leverage of the rudder around the pin. It is changing this leverage value that reduces tiller tug.

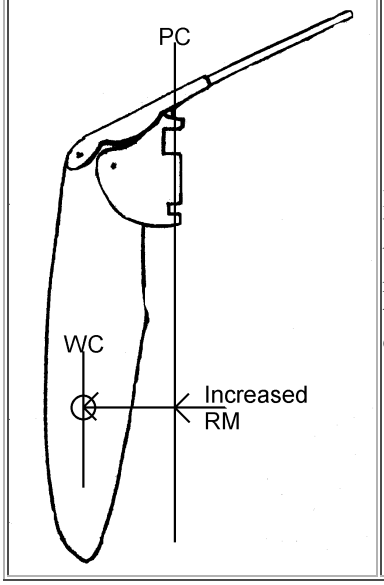


**Fig.6.**
When you unlock your rudders and let them drag behind the boat you have changed the position of the working centre in relation to the pivot centre. As the WC moves further behind the PC the rudder moment (RM) leverage increases and the effort to turn the rudder increases.

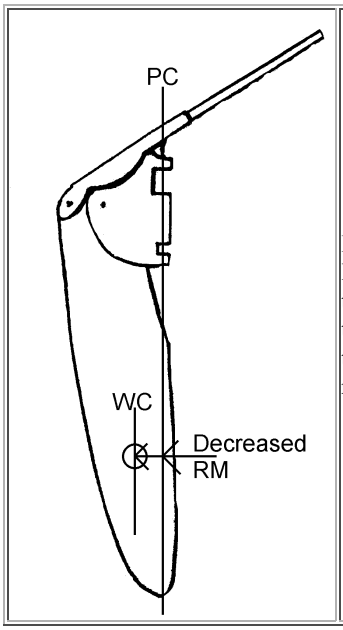


**Fig.7.**
If you move the WC towards the PC the RM leverage effort to turn the rudder decreases. So, to reduce tiller tug you can reduce the load required to turn the rudder by reducing the RM. You do this by moving the WC towards the PC. And you do this by raking the rudders forward underneath the boat.

When you rake the rudders forward does it mean that you have changed the balance of the boat? No. You have not moved the CLR of the underwater profile of the hulls, nor have you moved the CE of the sail.. You have just made the rudders easier to turn by reducing the working leverage.

**How Far Can You Rake the Rudders Under the Boat?**

Not very far. You can't take the working centre of the rudder too close to the pivot centre. To understand this we will go to an extreme position and work back from there.

When you rake the rudders forward you are moving the WC closer to the PC. If you were to increase this movement you would get to a place where the WC was directly in line with the PC, and as you passed this point the WC would be in front of the PC. Soon, the rudder blade would be totally in front of the rudder pin. The rudder would be hinged at the rear edge.

Why does the rudder hinge at the front? Why not hinge it at the rear? This is why not.

Imagine that your rudders were hinged at the rear edge. You are about to turn. As the rudder blade starts to swing the water pushes against it and swings it all the way to the side. And there it stays. There is no real control of the boat like this.

So we can't have the working centre too far in front of the pivot centre. In fact, we can't have it in front at all. Further, we can't even have it in line with the pivot centre. Its handling would become like a supermarket trolley and totally uncontrollable. So we need to have the rudder blade mostly behind the rudder pin. But if it is too far behind the pin, the rudder moment is too high and the tiller is hard to manage, such as when the rudders are unlocked.

Somewhere there is a balance point where the rudder is easy enough to handle, yet not twitchy or unstable. This is the point we need to find to reduce tiller tug without destroying boat handling. People who have made this modification tend to say that to have the leading edge of the rudder about one inch ahead of the pivot centre is sufficient.

## Ruddertrack

Rick White adds another element to this equation, what he calls *ruddertrack*. This is the angle at which the rudder must be held to compensate for weather helm. You are sailing along with slight weather helm and the rudder is out of line by about 2 degrees. Increase the weather helm and the rudder has to be held at 4 degrees. Increase weather helm further and this angle increases. The angle is called ruddertrack. You have 2 degrees of ruddertrack, or 4 degrees etc.

As ruddertrack increases, so does drag. But in the early stages of weather helm ruddertrack is actually good for your boat's steering as it decreases drag. It is when you move into higher levels of weather helm that ruddertrack has to be balanced off against any power advantage of extreme mast rake.

The drag free benefit of low ruddertrack is a byproduct of having asymmetrical hulls. Thinking time again, folks. Start your engines.

You are on a beam reach with the wind from port. You are on the port rear corner casting with your right hand on the tiller. The port hull is just kissing the water. Consider what is happening underneath the waterline of the starboard hull. This is what the water flow looks like from above.

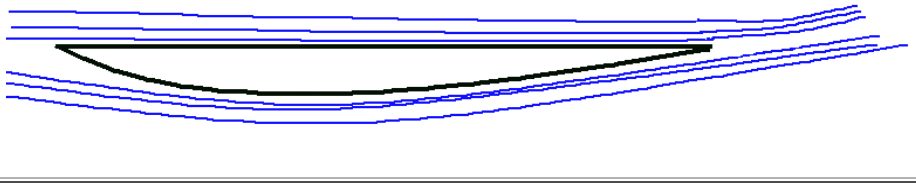

**Fig.8**. Top view of the water flow past the starboard hull, the boat is moving to the left of the page.

The water flows past the hull like air over a wing. The flat outer side of the hull cuts the water cleanly, the curved inner side of the hull pushes the water outwards along its foil shape. When the water joins up again at the rear of the hull, the tendency of the two streams is to flow outward from the boat.

This foil shape also gives the Hobie lift to windward, so the boat is moving forward as well as slightly to windward. This slight tendency adds to the tendency of the water streams to flow outward from the boat.

Now we will add the rudder.

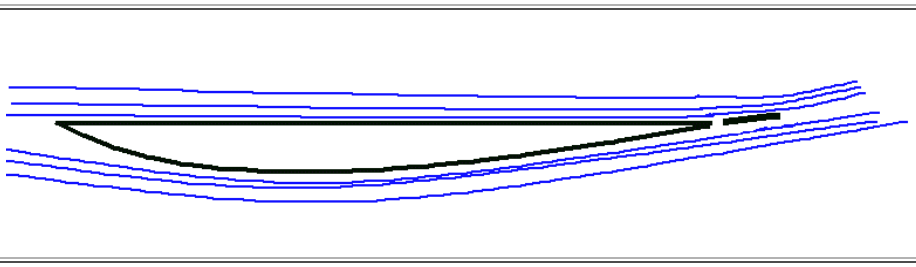

**Fig.9.** The rudder follows the outward flow of water away from the hull.

The water is flowing off the hull and outwards. The rudder wants to fit that water flow and it turns slightly outwards. This means that the natural tendency of the rudder will be to steer slightly to lee as if to compensate for weather helm. The rudder has a couple of degrees of ruddertrack but there is no force on the tiller as the ruddertrack is merely matching the water flow. This is why there is no drag at early values of ruddertrack, it is the way the boat's hull works the water. The flow of water off the hull has its own tendency to steer slightly to leeward, even when the hull is being pulled slightly to windward by the foil shape. This outward flow of the water from the hull is one reason why Hobie sailors often set their rudders up for slight toe-in. Each rudder then more easily matches the natural water flow.

When we have two hulls in the water, the windward hull is working in the opposite direction from the lee hull. If you are sailing flat with both hulls fairly equal in the water, then any effect of the foil shaped hulls is neutralised. You can see from this that if you are to get the benefit of drag free ruddertrack, you must have the windward hull out of the water where ever possible. When you are just starting to fly that windward hull, the underwater design of the Hobie is giving you its maximum efficiency. The angle of the rudder is smoothing the water flow, reducing drag, increasing speed, and increasing lift to windward. And it is doing it all for free. Try and get all that from KMart.

### Maximum Allowable Ruddertrack.

As weather helm increases, so must ruddertrack. This is independent of the effort to keep the rudder out there in the water flow. That particular effort, the tiller tug, is adjusted by reducing rudder moment with increased rudder rake. Even when there is very little effort required to keep weather helm under control, the drag associated with ruddertrack is an important factor to be considered.

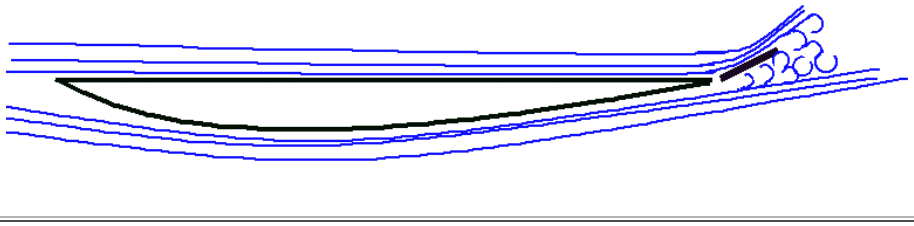

**Fig.10.** The turbulence of excess weather ruddertrack creates drag and loss of speed.

As the drag of having excess weather ruddertrack builds up, speed drops off. But how much does the drag reduce the added power of extreme mast rake? Where does the tradeoff between extreme mast rake and resultant drag become detrimental? This is a question that Hobie racers will debate over many kegs of beer. However, the boats which win the races have lots of mast rake, even to the point of the mast head overlapping the rear crossbeam.. If you want to join the debate, invite me to your party. (An airline ticket and a few days in a beach side hotel with a Hobie parked outside will also be appreciated.)

## Conclusions

There must be some conclusions out of all this. Here's a short list.

**1.** Mast rake gives more speed, more power, more efficiency at certain points of wind, and more stability under power.

**2.** Mast rake increases weather helm which increases tiller tug and resultant drag.

**3.** Weather helm can't be adjusted out by rudder rake, or by anything except decreasing the mast rake again.

**4.** Tiller tug can be adjusted out by rudder rake but ruddertrack remains.

**5.** Ruddertrack, and associated drag, can't be adjusted out with anything.

**6.** The power advantage of mast rake far exceeds the increased drag induced by extra ruddertrack. For this reason racing skippers set up for extreme mast rake and take the drag as part of the package.

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**Note about Rick White.**
Rick White is one of the catamaran world's highly respected sailing trainers. He runs sailing seminars all over the US and has written, with his wife Mary Wells, "Catamaran Racing for the 90s". This book is considered to be an essential resource for anyone who races their catamaran.
You can find Rick on the internet at http://www.catsailor.com/

# What's All This About Weather Helm?

Exploring One of Life's Great Mysteries.

# Part 2

# The How-To Guide

***Adjusting Mast Rake, Rudder Rake, and Toe-In***

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*This article follows on from Part 1 which deals with the theory behind the term* "Weather Helm"

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## Mast Rake

Mast Rake refers to the angle of attack of the mast. If it is upright it has no rake, if it slopes backwards so that the top of the mast is over or behind the rear cross beam is has extreme rake. If it points forward, well, it shouldn't point forward. One of the discoveries of the racing world is that having extreme mast rake makes the boat go faster. Extreme mast rake causes unwanted side effects, but the speed gain is worth it. Some of those side effects can be compensated for by adjusting other boat parts, particularly the rudders.

When your Hobie left the factory it was set with the mast at a pre-determined angle. As with many things, that angle might not be the most suitable for your kind of sailing. The angle of the mast is controlled by the length of the forestay. As the forestay is lengthened the mast tilts backwards. And as the mast tilts backwards the side stays become loose and have to be adjusted back to a suitable tension by shortening their effective length.

**How far should I rake my mast?**

If you want to get maximum speed from your Hobie the mast will want to be raked back as far as possible. This is not as radical as it sounds. There is a limit to how far you can rake it anyway. This limit is caused by the mainsheet blocks. As you rake the mast the outer end of the boom tilts towards the deck. This makes the mainsheet blocks come closer together. You can't rake the mast beyond that point of the blocks touching each other.

However, you still want some control over mast bend with the mainsheet, so you can only have the blocks touching after you have maximum operating tension on the mainsheet. This limits the mast rake again. If you have too much rake the blocks will touch before any mast bend is induced. This limit is measured when the boom is centred.

The most extreme rake you can put on the mast is when the blocks are just touching when you have pulled on the mainsheet as hard as you ever need to while sailing, generating maximum mast bend in the process.

**How do I rake my mast?**

You rake the mast by lengthening the forestay. The easiest way to do this is to add a short length of rigging cable called a strop at the top or bottom of the forestay. It is not a difficult process to get the length of the strop.

You will need two people. One stands on the trampoline and holds the mast from behind.
Rig the mast as normal.
Take some strong cord, like very heavy blind cord. Braided cord is better than twisted stuff.
One person holds the mast upright and the other person undoes the lower forestay shackle.
Tie the cord onto the bridle centre point and loop it through the lower forestay thimble.
Loop it around these two points three or four times. This makes it easier to manage the adjustment.
The mast-steady person then lets the mast lean backwards as the cord-tying person takes up the slack with the cord.
Rake the mast until the mainsheet blocks are about six inches apart.
Tie off the cord. It should be strong enough with 3 or 4 loops to take the load.
Centre the traveller. The mast-steady person has to hold the mast from swinging sideways.
Pull on the mainsheet and check how close the blocks come to each other when the mast begins to bend.
Adjust the cord length until you have good mast bend and the blocks are just starting to touch.
The cord now represents the length of the strop you need, less the shackles needed for attachment.

You have now reached the maximum mast rake point. There is no value in going further than this. However, you could easily decide in the future that you want to reduce the rake, so you can add adjustability by shortening the strop and added an adjusting plate while maintaining the overall length. Remember that the plate will have to begin life at maximum length so you can adjust it shorter if necessary. Instead of a cable strop you can add a stainless steel strip with adjusting holes in it.

Now you have to get the new length of the side stays. Your existing stays will have to be shortened, or you might like to have new ones made. The shortened length is easily worked out by measuring the amount of slack that has developed as the mast tilted back. Just cut that slack out of the stays and swage new thimbles onto the lower end. Remember that if you decide to reduce mast rake the side stays will lengthen, so cut the new length so that with full rake the adjuster plates are at their shortest. This way you can lengthen them as the mast moves forward if needed in the future. Keep both stays as equal as possible when measuring and cutting.

***If you are not familiar with how to cut the stays, or with how to swage new fittings, or you do not have the proper tools, (parrot beak cutters and a suitable sized swaging tool) do not do this work yourself. It is easy to measure it up, remove the stay, and have the sail shop do it for you. And it is a lot safer as well.***

**How long should my stays be?**

Unfortunately there is no real answer to this question. It will depend on your desired angle of mast rake, on the length of the bridle, on the length of the shackles you are using, on whether you have a jib furler or not, on the position of the mast tang. There are too many variables to give a set length. Two boats coming from the factory are the same, but in a year or two one of them could easily have had some modification that makes a difference. Even just replacing a lost shackle with a longer one floating around in the sail bag can make a difference.

## Adjusting rudder rake

Unfortunately, one of the side effects of extreme mast rake is that the rudders become harder to manage because of the extra weather helm and "tiller tug" induced by the new boat balance. You can make the boat easier to control by raking the rudders forward. There are several ways to do this.

**Rudder rake adjusting screws.**
If you have a newer model Hobie the adjusting equipment is built into the rudder castings. In the lower casting there is a grub screw which maintains the rudder position. On the top casting there is an adjuster to lock the rudder into the cam properly. To rake the rudders forward screw the grub screw into the casting and allow the rudder to move forward. You will need to experiment with the position, but with extreme rake you will probably have to screw that screw fully into the casting.
As the lower tip of the rudder blade moves forward the part that locks into the cam moves backward. You adjust that back into position with the top adjuster. With the rudder pushed forward against the lower casting, loosen the top bolt enough to that it slides back and forward. Push it as far forward as it will comfortable go and lock the bolt. Test that the rudder unlocks and locks without any slack in the cam. If there is slack, adjust the bold forward a little more.

**Re-drilling rudder positioning holes.**
If you do not have the adjusting system on your rudder castings you need to move the positioning holes in the rudder. You do this by filling one hole with resin and drilling it again in a slightly different position. This process has been dealt with in an earlier edition of On The Wire. It is not difficult, but you might get nervous drilling into the rudder blade.

**Taking up cam slack.**
Even if you do not have adjustable castings, and you have a certain amount of fore/aft slack in the rudder, you can rake the rudders forward as well as take up that slack. If your rudder moves more than a quarter or half inch at the lower tip it needs tightening. All you have to do is fill the space between the cam and the locking bar under the top casting. This space will be about the size of the head of a self-tapping screw. Just drill into the cam from behind the boat (lift the rudder cross bar) and screw in a short screw so the head rests on the cam material and when the rudder is locked the locking bar rests on the screw head.

## Adjusting rudder toe-in

The go-faster guys tell us that the boat works best with a slight amount of toe-in to the rudders. Here's how to measure it. With the boat on the trailer lock the rudders in the down position. Get a tape measure and a helper to steady the rudders. Tie the tiller cross bar so the rudders can't move sideways too much.

Measure the distance across the boat between the leading edges of the rudders. Now measure between the trailing edges The measure point is where the rudder has the widest fore/aft distance. The leading edge distance should be about a quarter inch shorter than the trailing edge distance.

The adjustment is made at one end of the tiller crossbar, where it fastens to the little casting joints. It is more likely that you do not have toe-in and the tiller crossbar has to be shortened. If you already have excess toe-in the crossbar has to be lengthened. This is a headache, but not impossible.

Once again, the newer boats have an adjustable system, and the older boats don't. If you have an adjustable tiller crossbar you can unlock one end and screw it in or out until the toe-is is set correctly. If you do not have an adjustable tiller crossbar you will need to drill out the pop rivets from one end of the crossbar, cut it to length, and replace the rivets.
Cutting the crossbar might make you nervous. That's OK, join the nervous club. Then do it.

If you you need to lengthen the crossbar you need a piece of tube that neatly fits inside the existing piece. Then you cut your crossbar, fit this new piece inside and pop rivet one end. Then measure again to locate where the other end should be pop riveted together. Doing things this way can leave edges that your hand will not like to run over when sailing, so put this extra piece as close to the center of the crossbar, not at the ends where you are more likely to hold on to it. Tape it over with duct tape when you are done.