Milwaukee Community Sailing Center
Sail Trim Theory 101 - Mains, Jibs and Rigs
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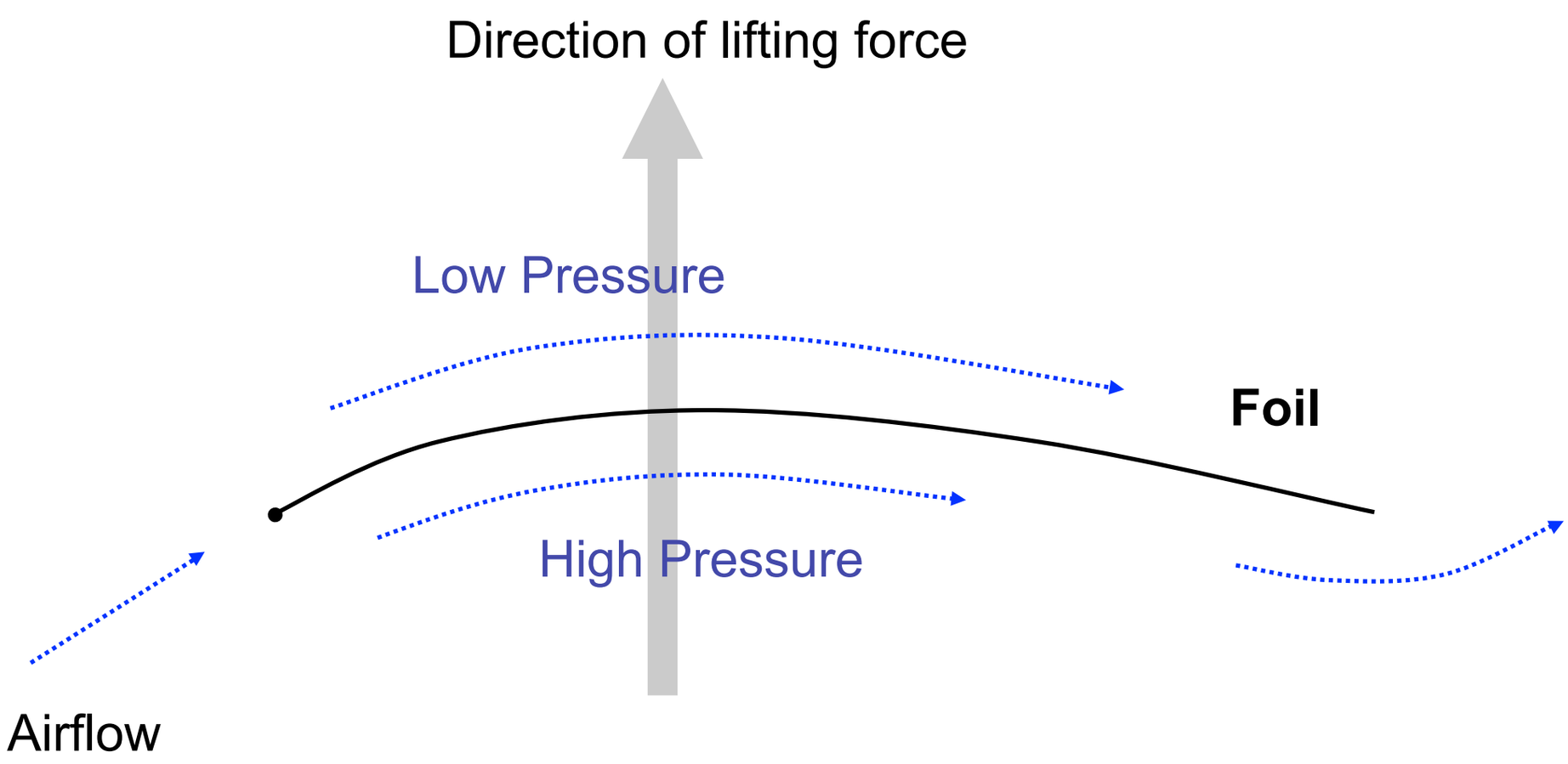
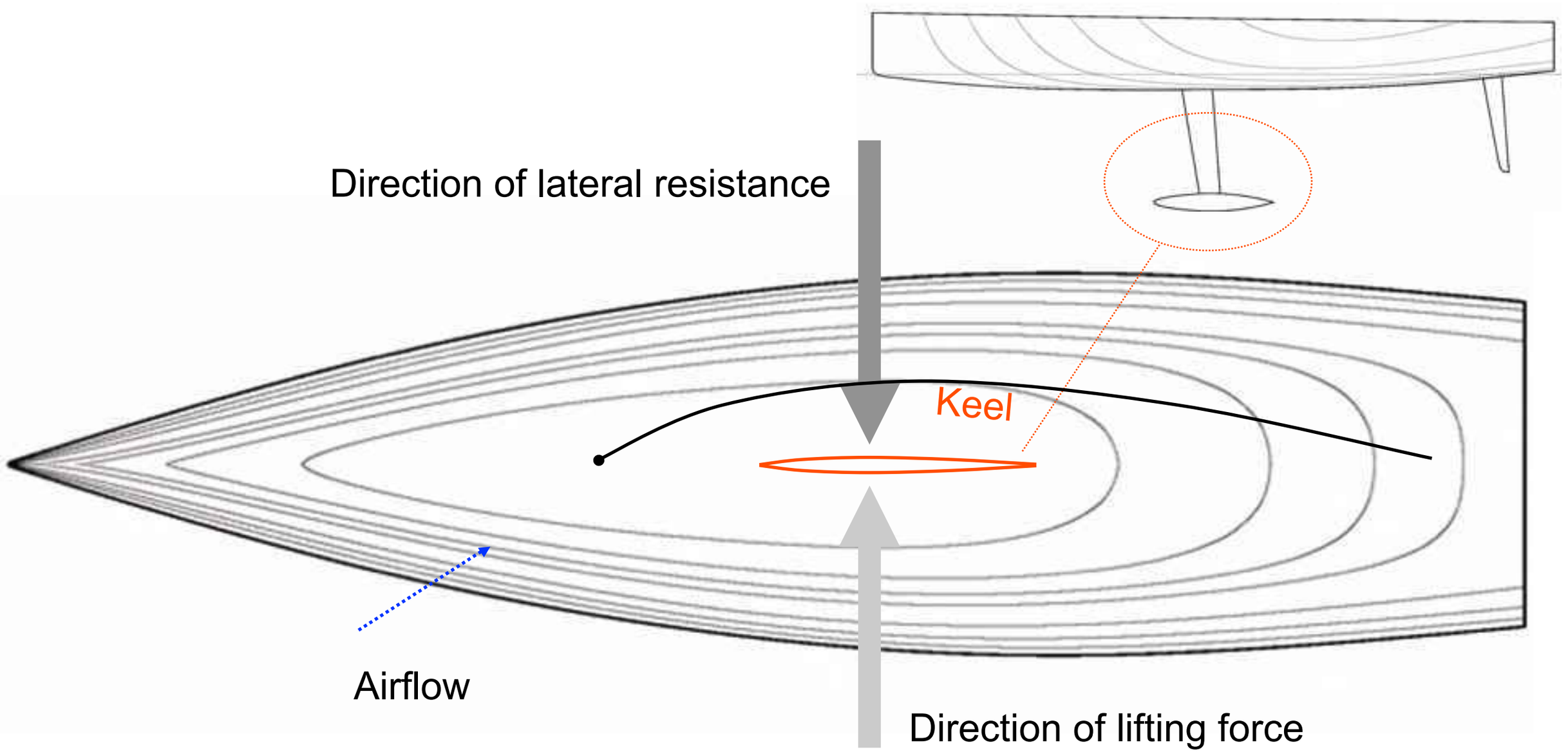
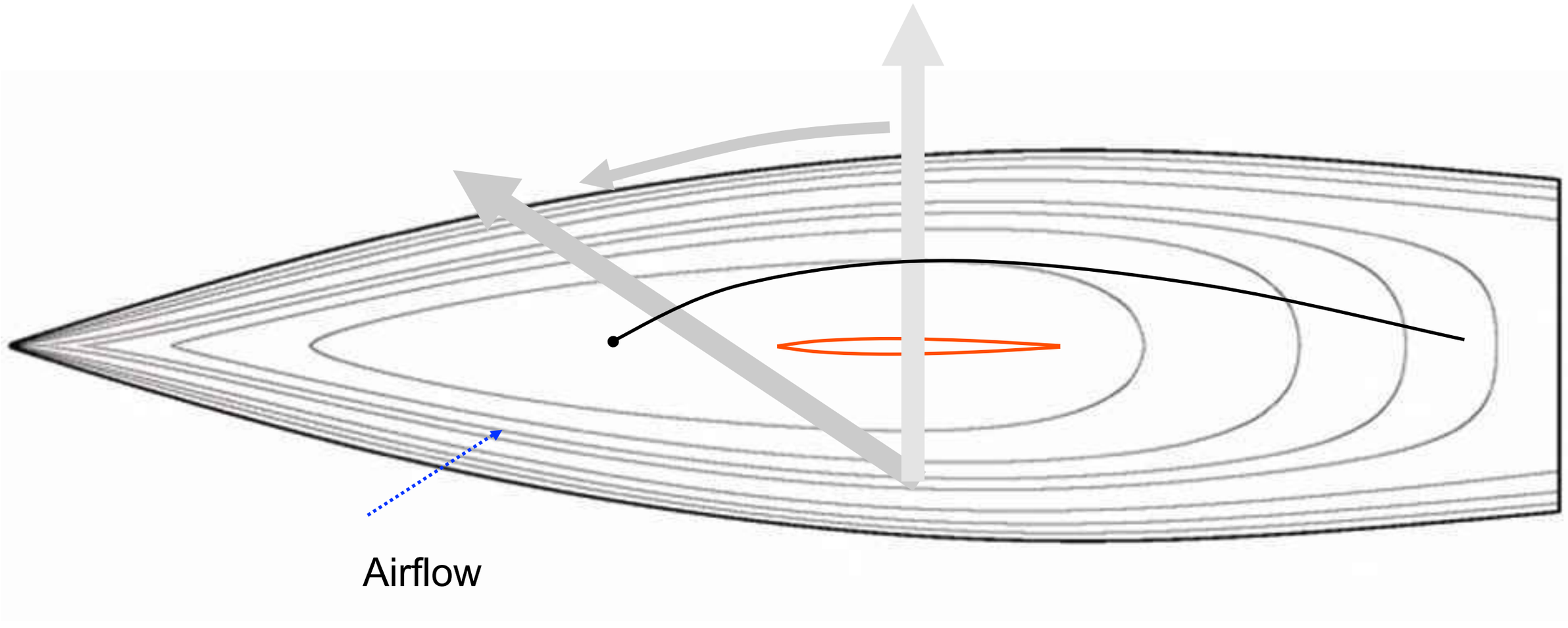
A foil (sail) creates lift by altering the flow of air, creating a difference in pressure between one side and the other



A boat's keel or centerboard cooperates with lift from sails…



…resulting in forward motion

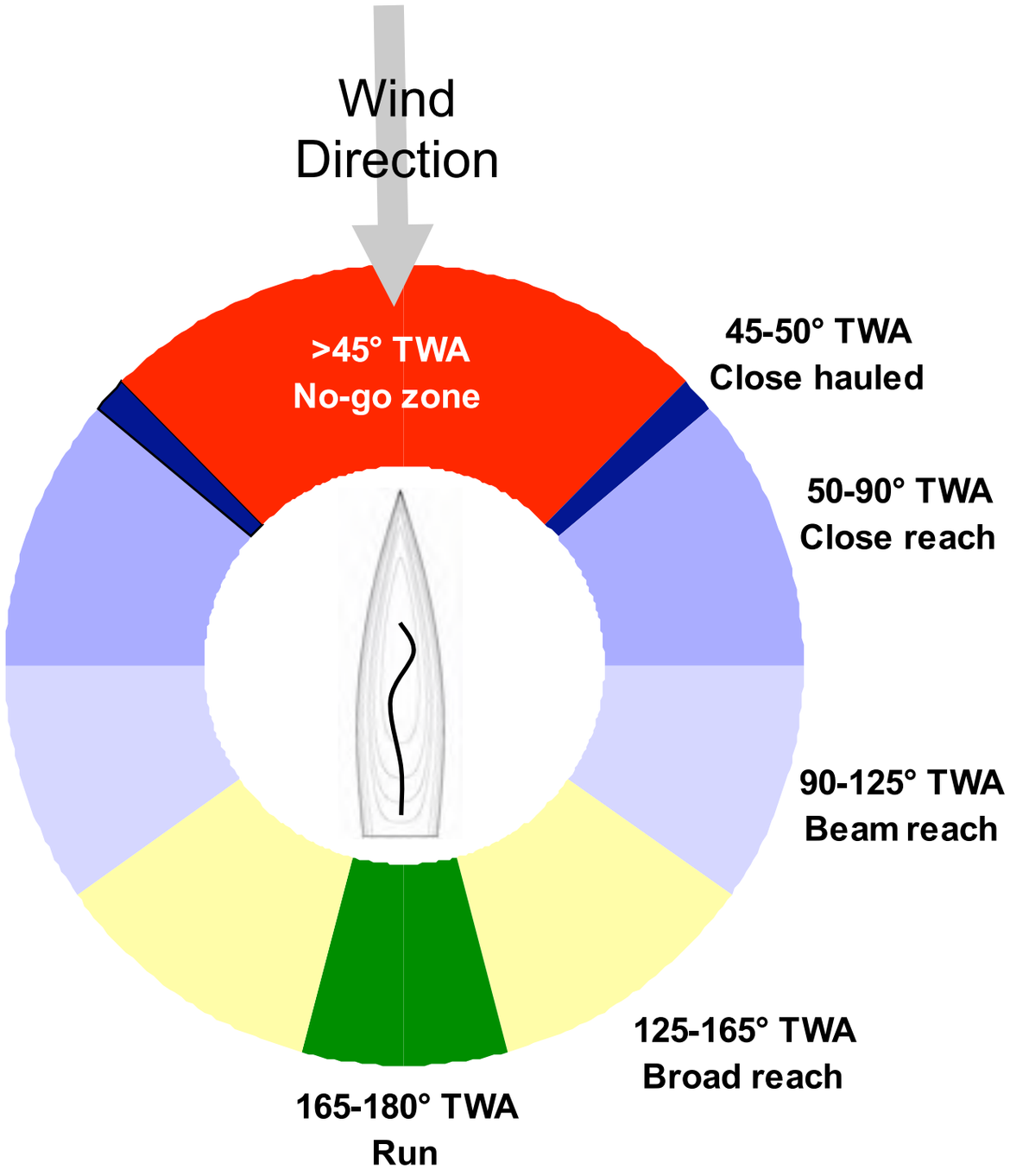


Sail trim is the act of controlling the shape of the foils on a sailboat to maximize its speed and efficiency

Course Agenda

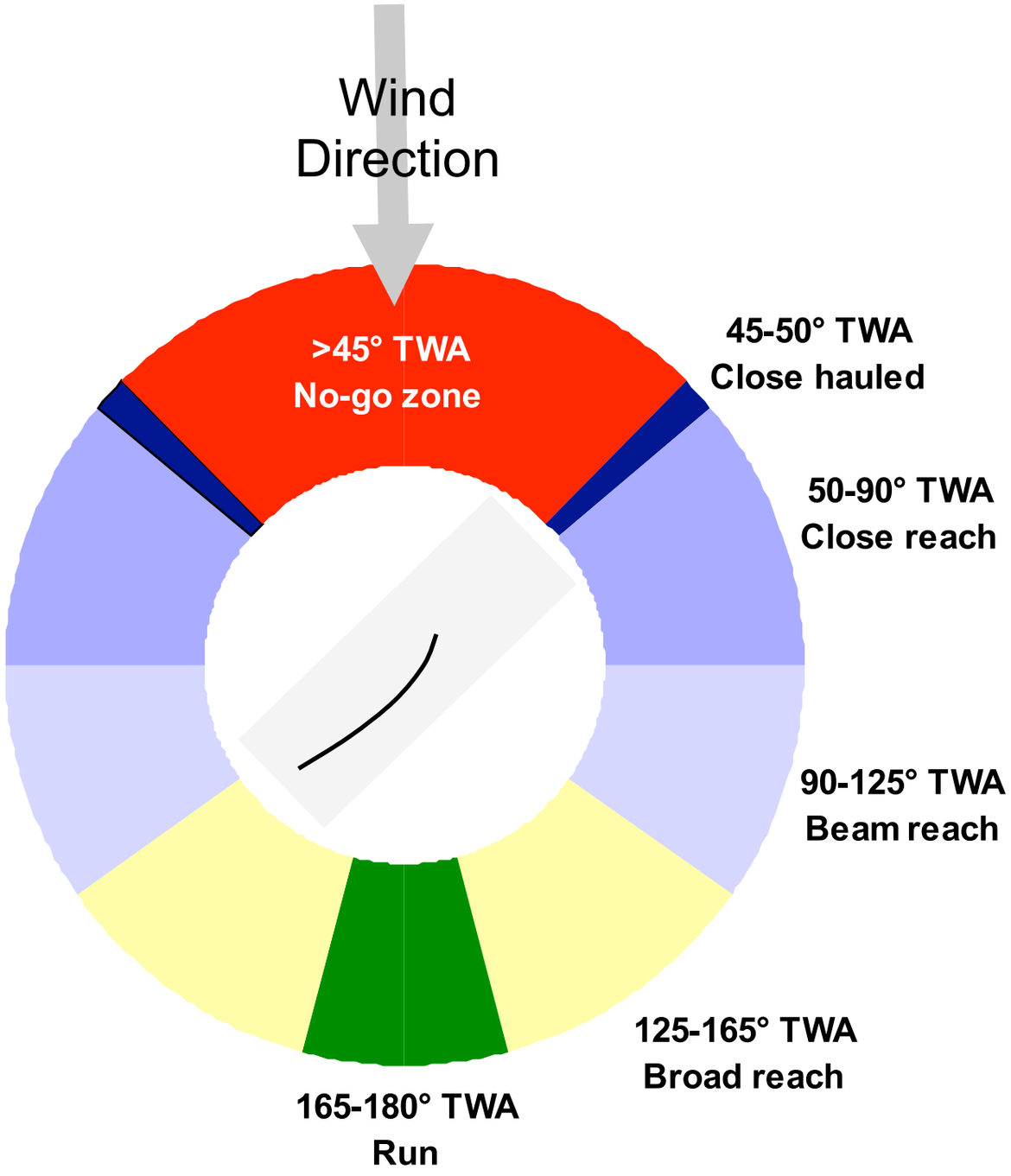
- Sailing basics
- Air and foils: attachment, lift, drag, stall
- Wind angles and velocity
- Tools of the sail trimmer: sensors, cues, controls
- Sail shape: angle, draft, twist, etc
- Mainsail trim
- Jib trim
- More than one sail
- Things to remember
- Q&A

A boat can’t sail directly into the wind



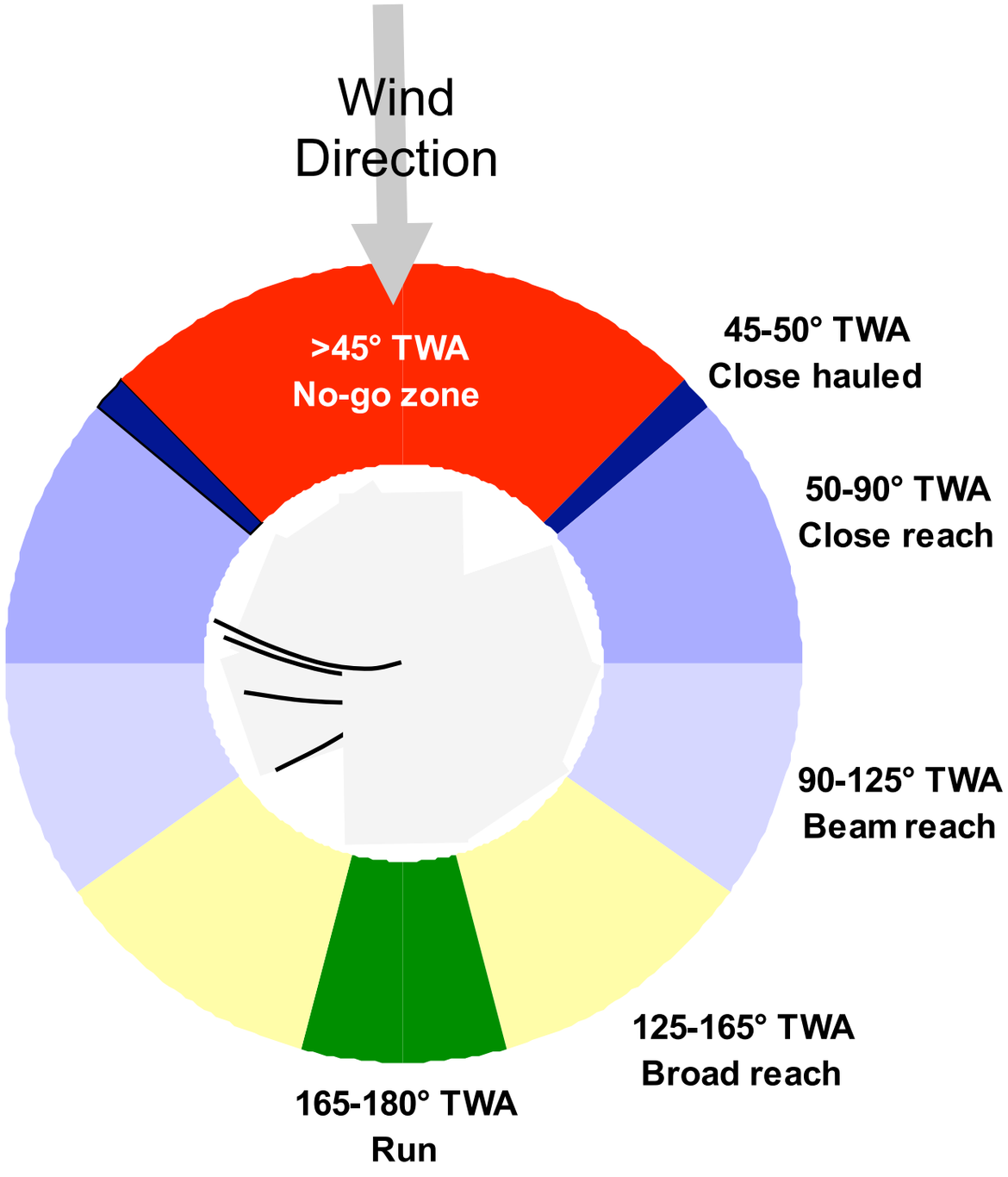
But it can generate forward motion from lifting forces at about a 45 degree true wind angle

Sailing “close hauled” a sail is sheeted in as far possible

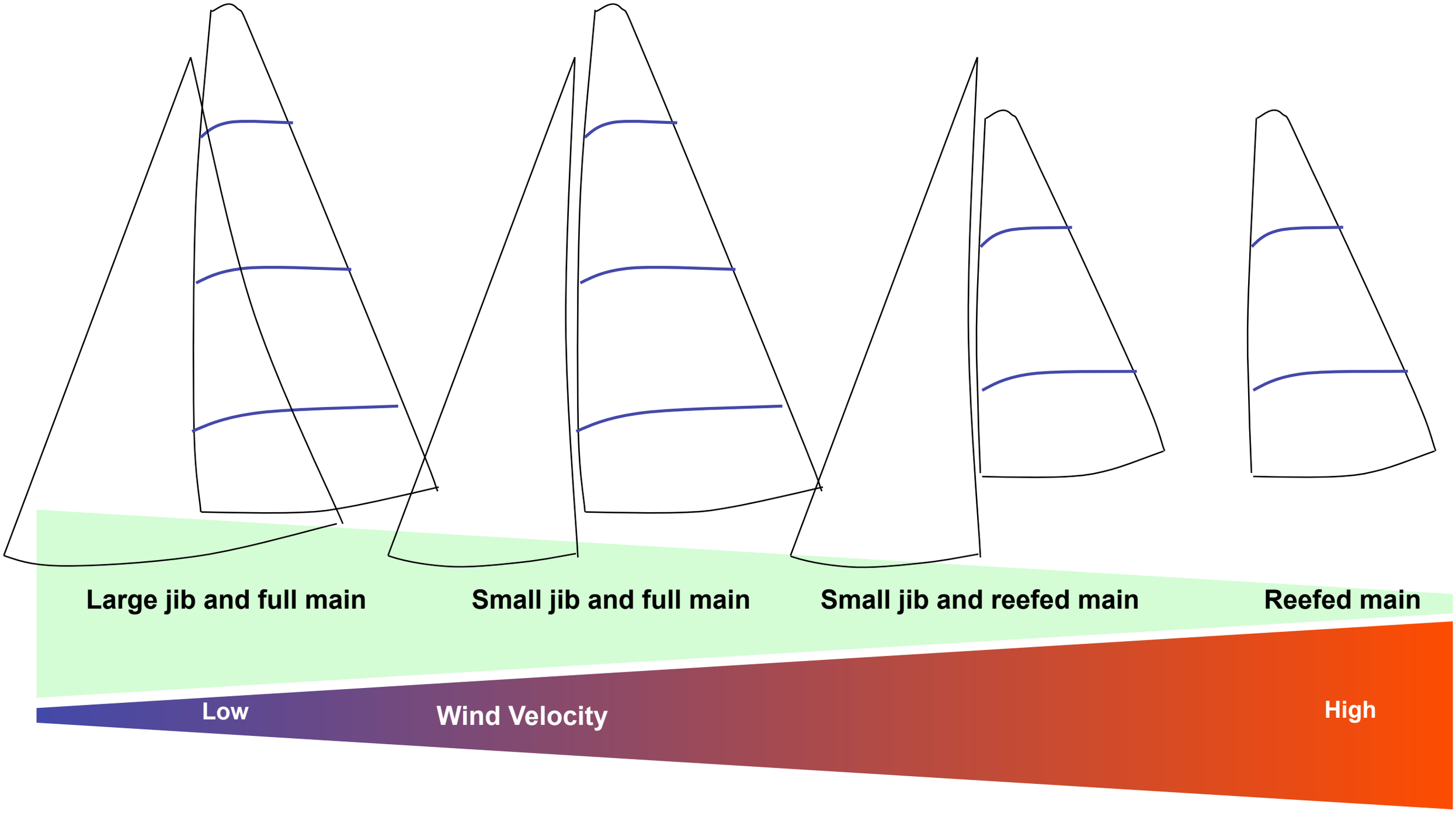


Given changes in the wind angle, a sail trimmer's first job is to set the right "angle of attack" for the sail

By "easing" the main sheet, (the control that sets angle of attack) while the driver turns downwind , the sail trimmer finds the optimum angle for the sail

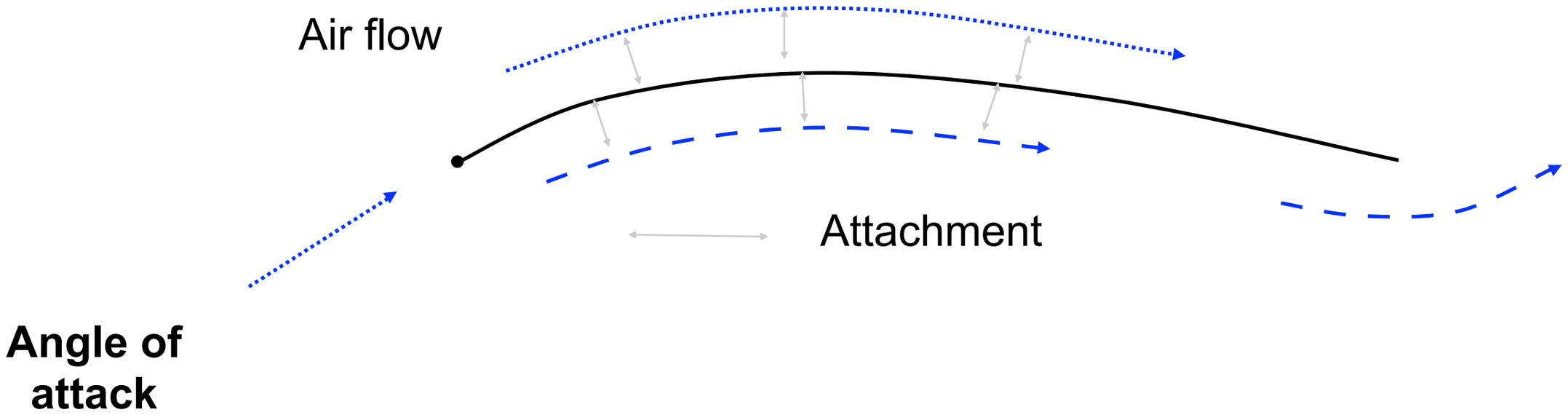


A wind increase calls for reduction in sail area, leaving the maximum power available for the conditions



But short of these major adjustments, most of the trimmer's attention is on keeping the sails "in trim"…

"In trim": the efficient state where air flow is undisrupted and remains attached to the foil



So this course will focus on “constant trim work,” when trimmers respond to change

Change	Symptoms	Degree	Potential Adjustments	Frequency
Decrease in wind velocity ↓	Underpowered, very slow, flat, “flogging”	Sustained	Add a sail (s)	Rarely
	Underpowered, slow, flat	Dropping	Remove reefs, power up	Sometimes
	Underpowered, difficult to steer (no “weather helm”)	**Lulls**	**Power up in lulls**	**Often**
Angle	**Boat turns, accelerates of decelerates, sails look or feel wrong**	**Any change**	**Reset angle of attack, shape**	**Constantly**
Increased wind velocity ↑	**Over-powered sometimes excessive heel**	**Puff**	**De-power sail(s) in puffs**	**Often**
	Over-powered: excessive heel	Building	De-power or reef a sail	Sometimes
	Over-powered: excessive heel, high loads	Sustained	Take down a sail (s)	Rarely

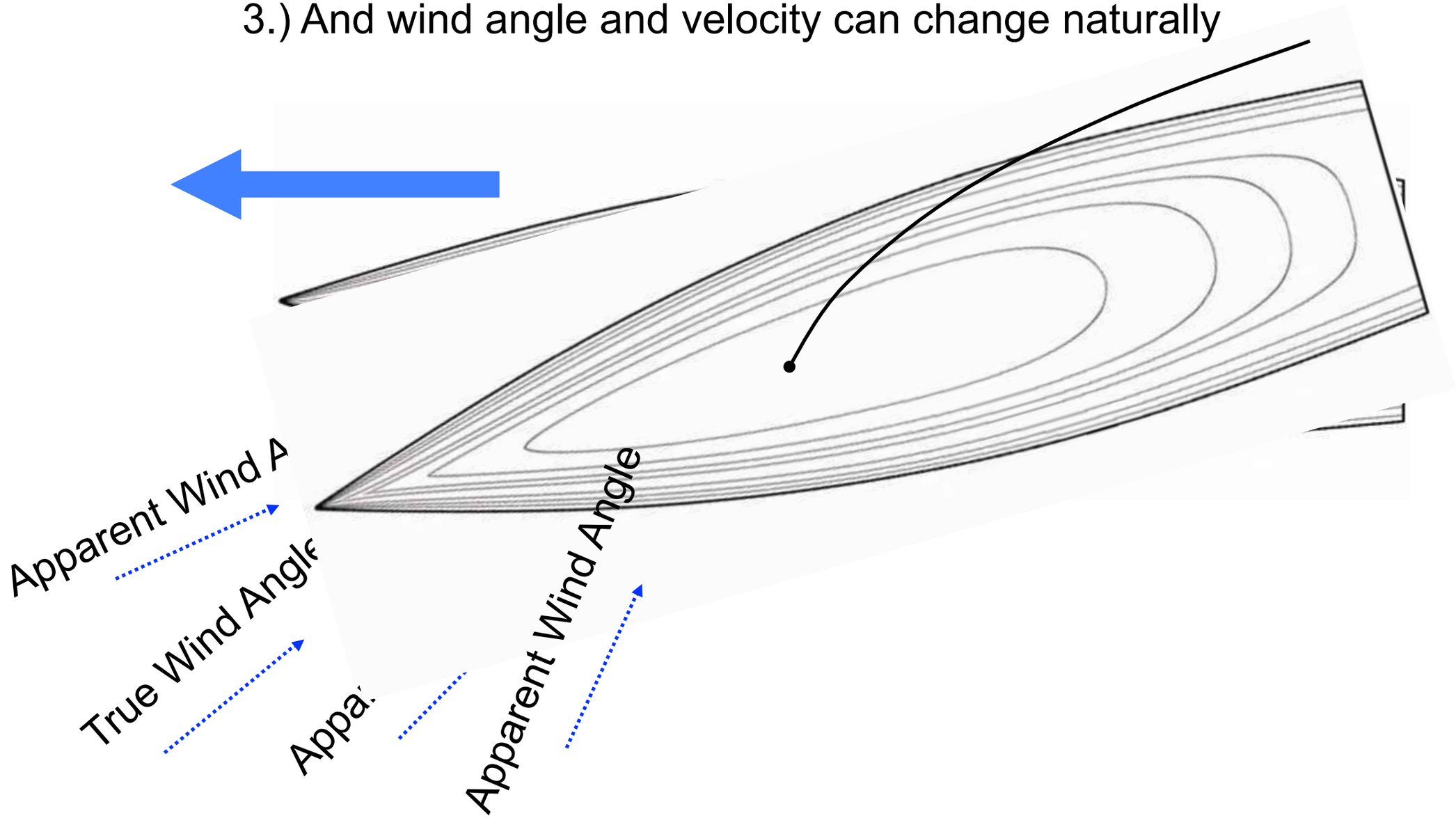
Course Focus

Angle changes come in many forms, and velocity changes often follow

1.) As a boat accelerates, wind angle and velocity increase

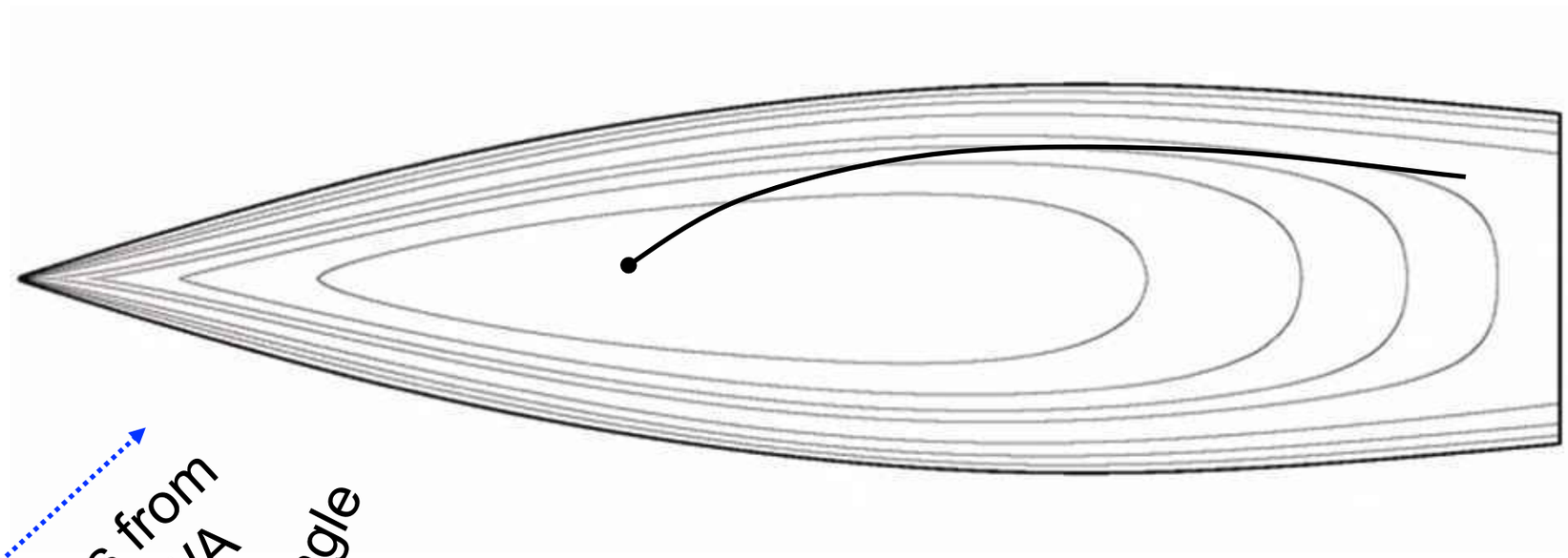
2.) As a boat turns, wind angle and velocity changes

3.) And wind angle and velocity can change naturally



And when velocity changes so does angle, so trimmers adjust to find the right “angle of attack” constantly

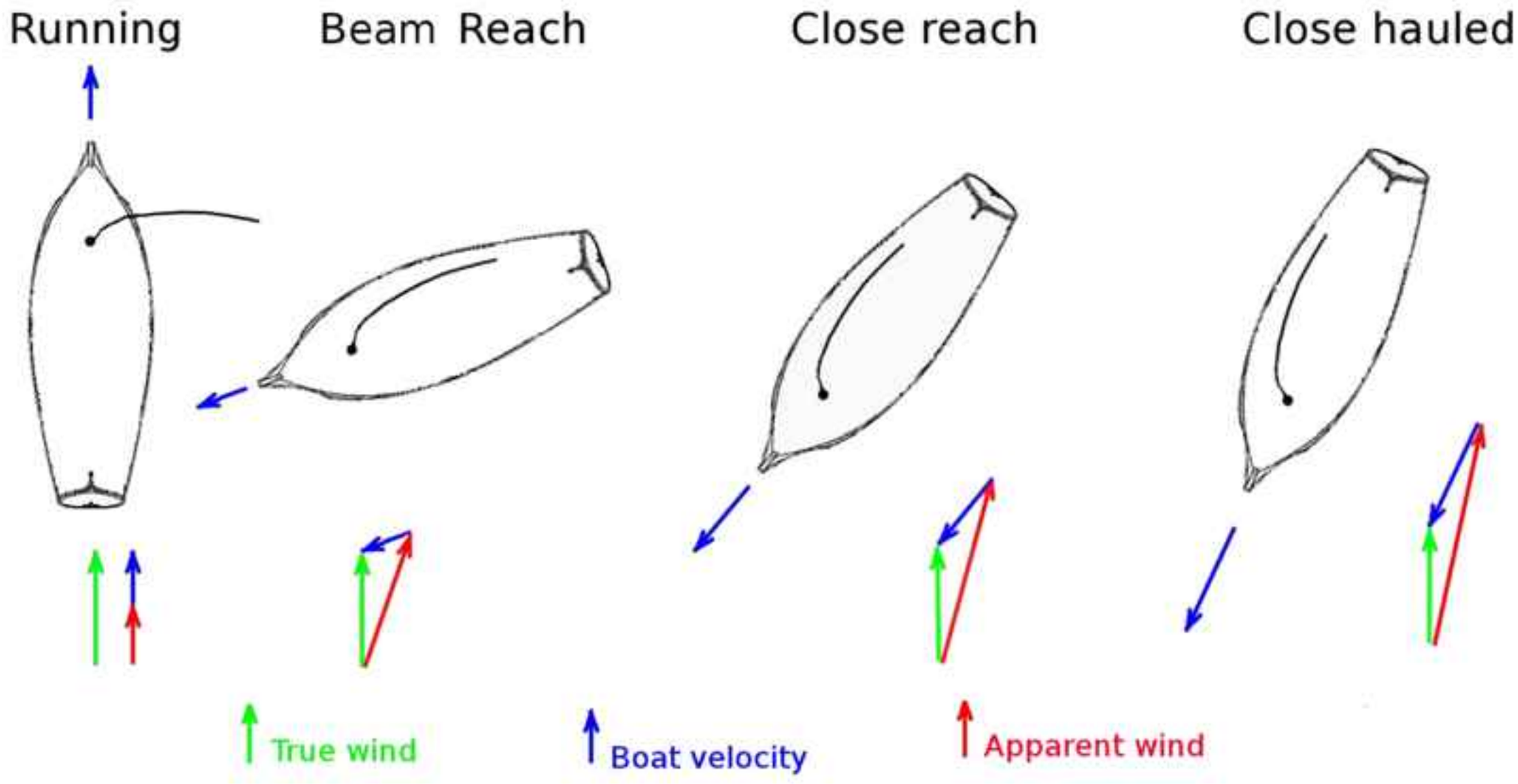
4.) As a wind velocity changes, wind angle changes too



A puff comes from a different AWA

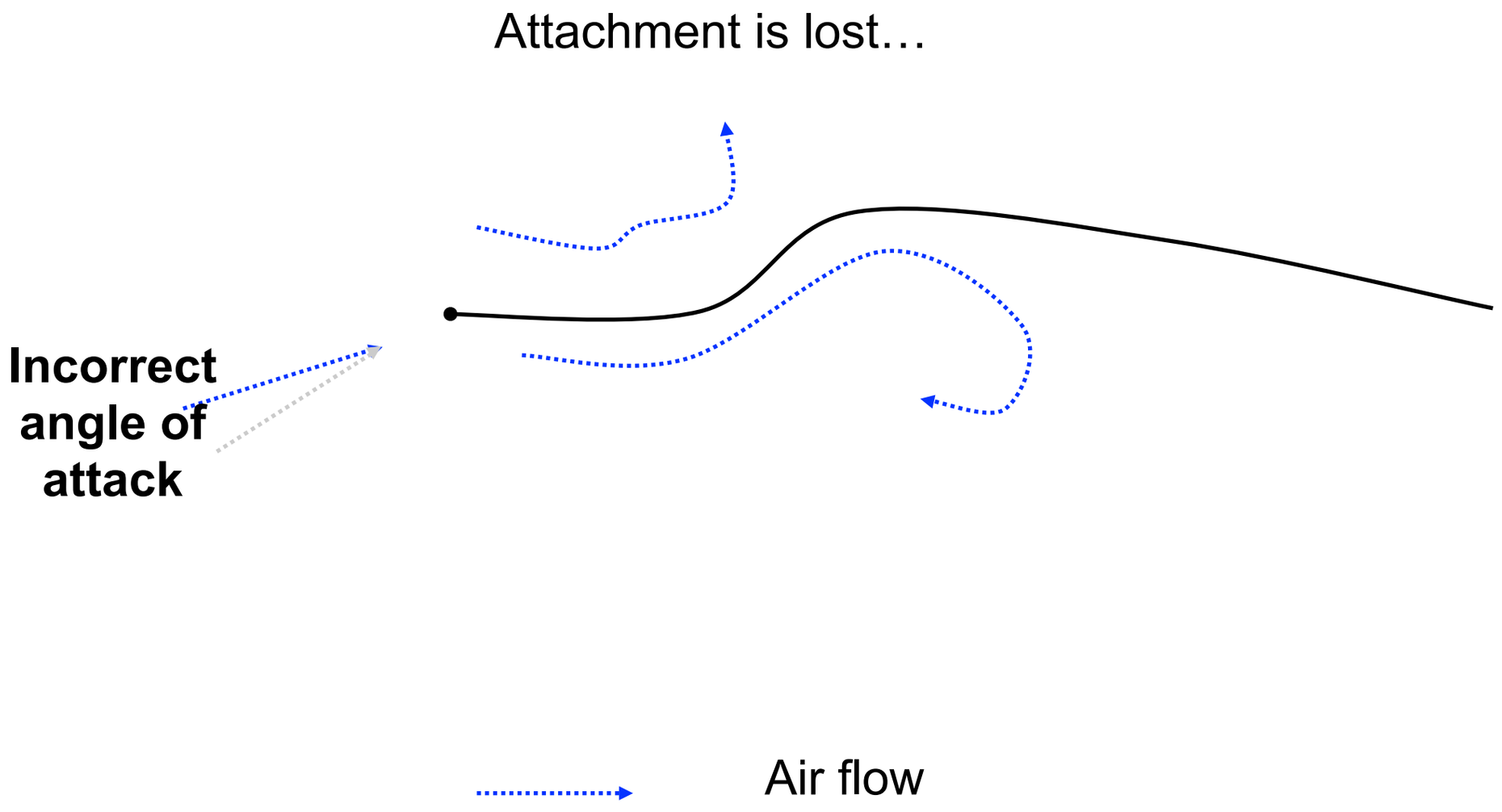
Apparent Wind Angle

Digging deeper into apparent wind



http://en.wikipedia.org/wiki/Forces_on_sails

If the angle of attack is too tight, flow is disrupted and the sail will “luff”, resulting in less lifting force and a slow boat



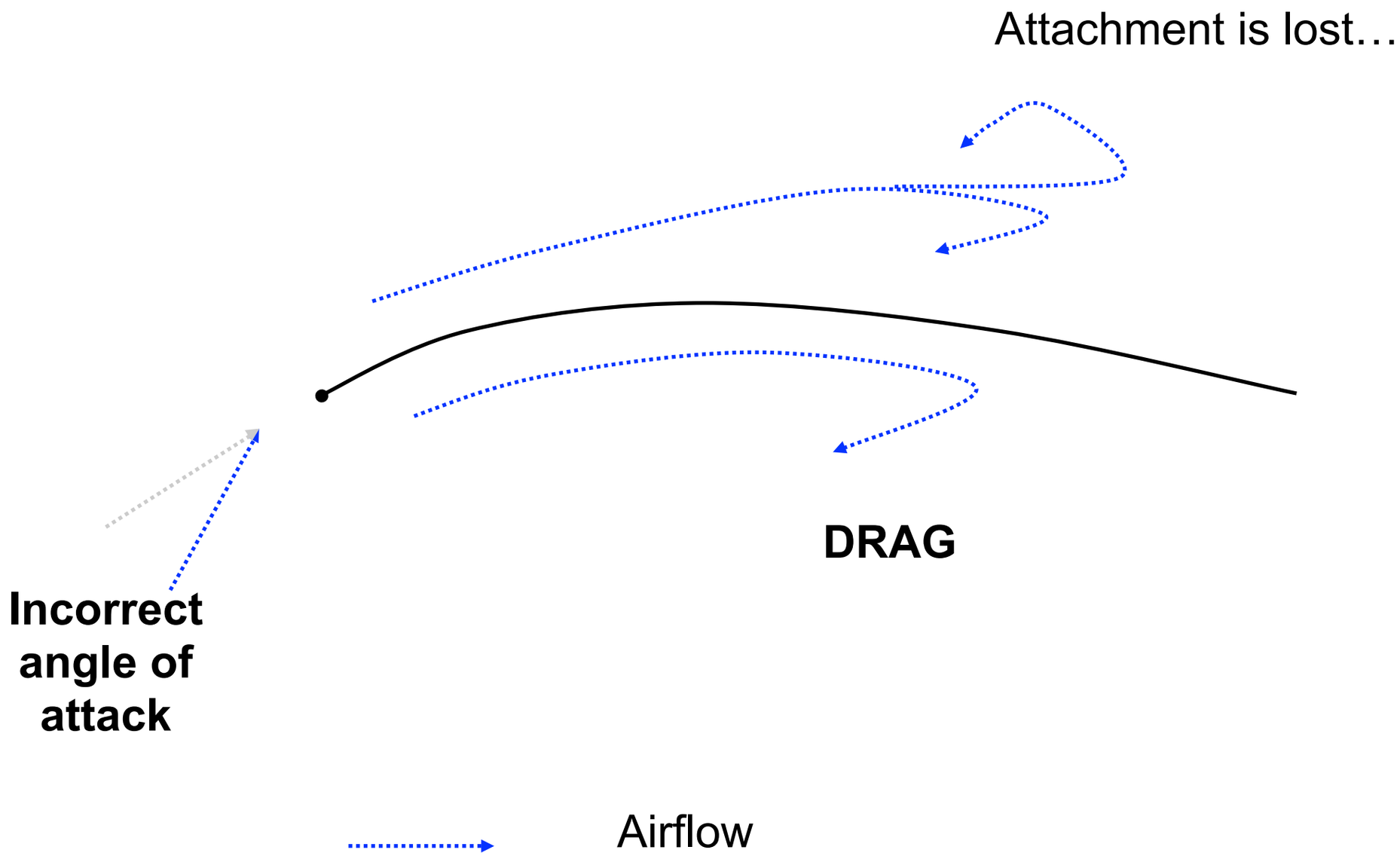
Luffing is easy to recognize – it looks, feels and sounds wrong

Source: Curtis Gruninger

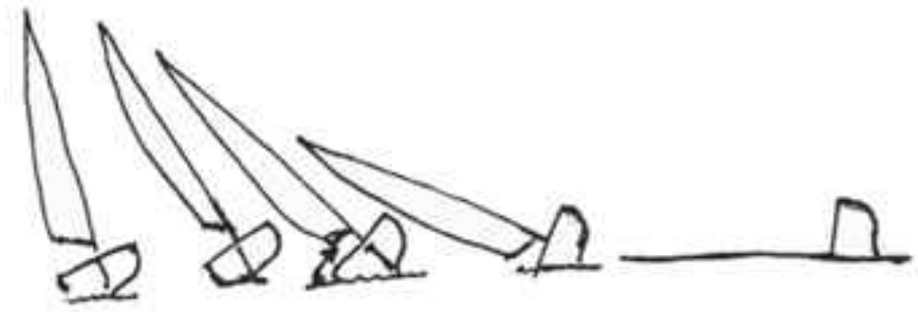
Symptoms of "luffing":

- Warped, twisted, inverted "speed strips"
- A slow boat
- The sound of flogging sails

If the angle of attack is too great, (the sail is trimmed to tightly) airflow is disturbed, stalling the foil



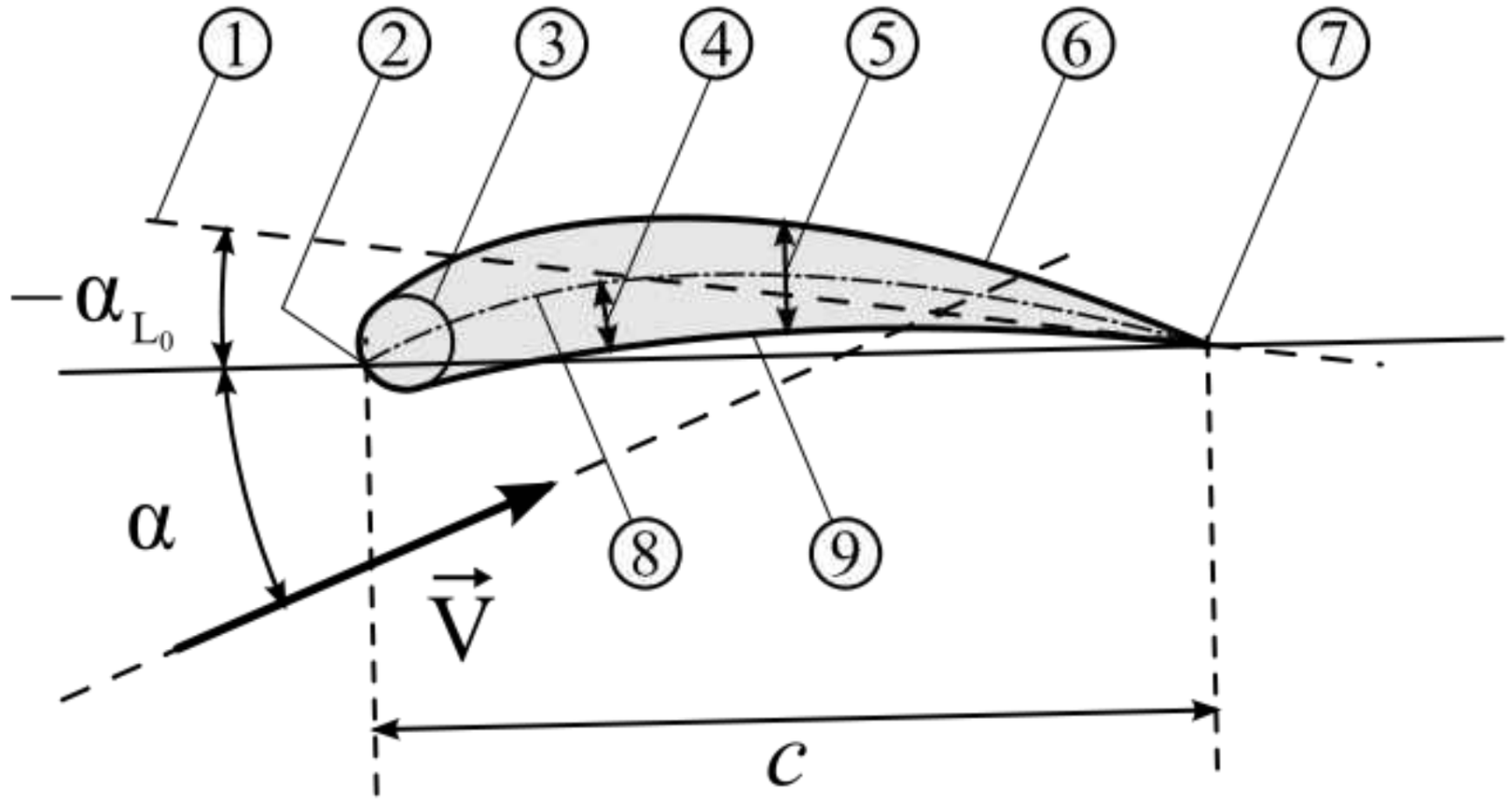
A stalled plane can’t fly, and a stalled sail can be equally unimpressive



“When in doubt, let it out.”
– unknown source

Sail (foil) geometry is well characterized by NACA

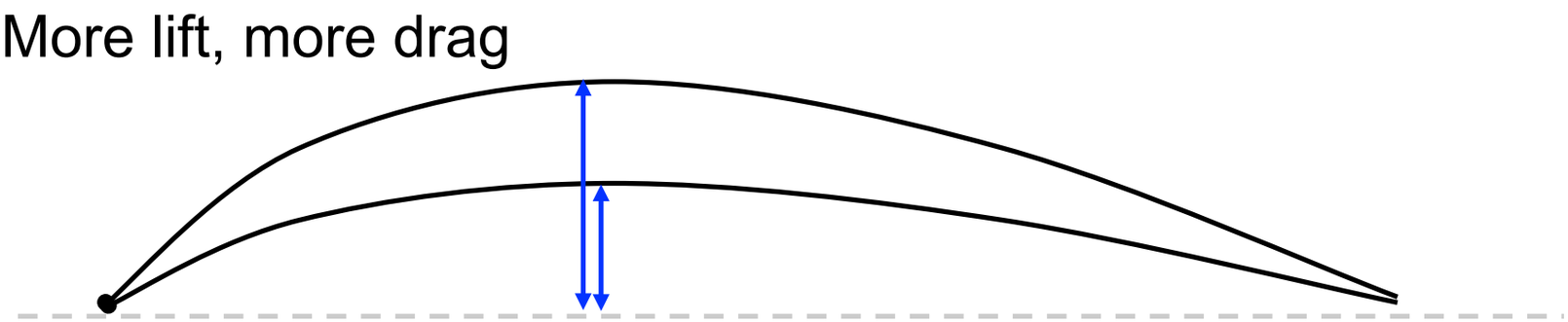
- Profile geometry – 1: Zero lift line; 2: Leading edge; 3: Nose circle; 4: Camber; 5: Max. thickness; 6: Upper surface; 7: Trailing edge; 8: Camber mean-line; 9: Lower surface



http://en.wikipedia.org/wiki/NACA_airfoil#mediaviewer/File:Airfoil_geometry.svg

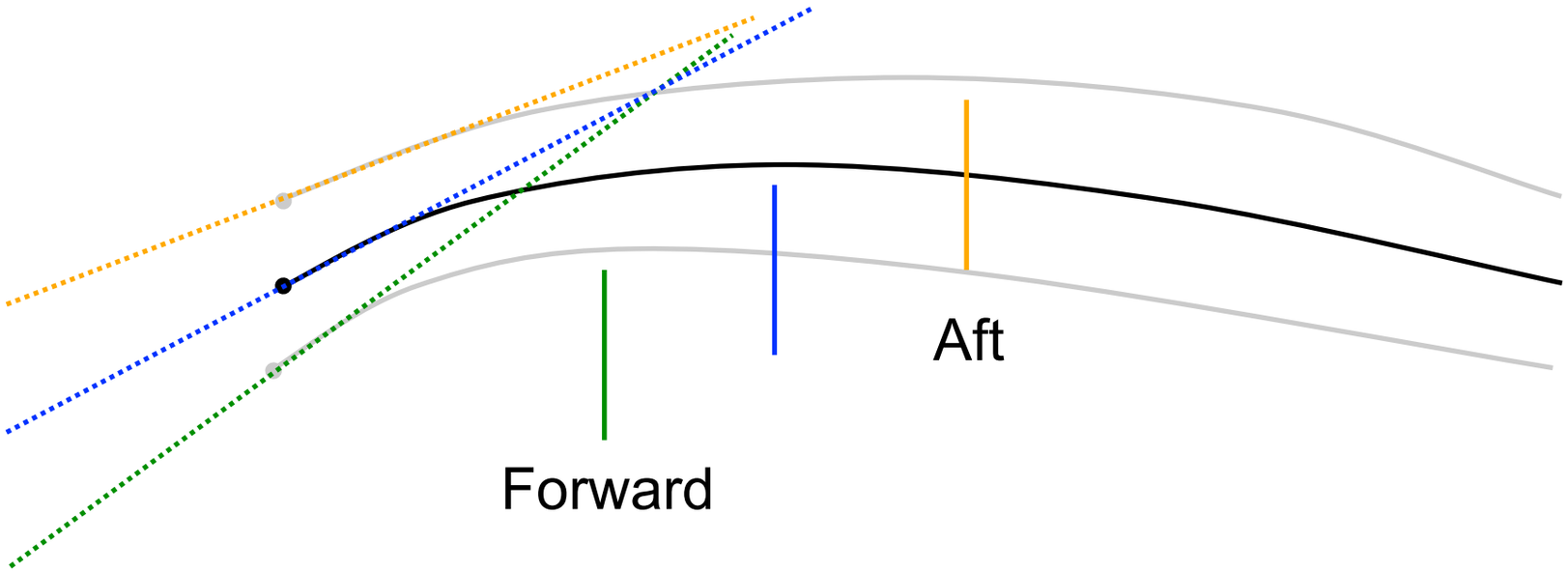
Camber is the maximum depth of the sail – a measure of how inherently powerful or efficient it will be

- New sails start flat, and typically deepen as they age
  - Trimmers adjust angle from base with controls and
  - …add or subtract depth for powering

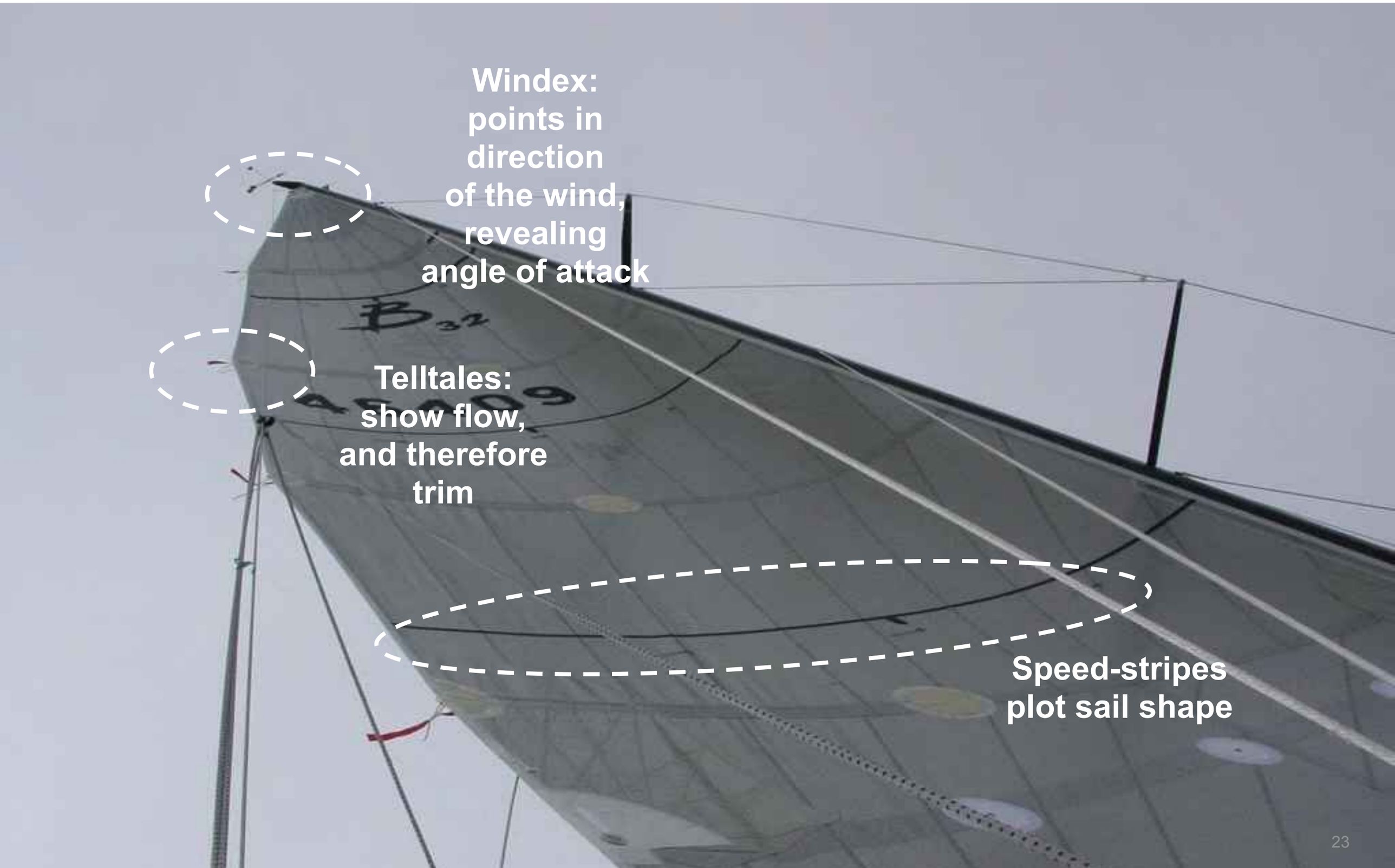


Draft is the point (fore and aft) where maximum camber appears – it effects angle, lift, power, center of effort and attachment

- Draft aft oftern results in the sailing acting as a brake
- Draft forward means center of effort is correct, but too far forward means the whole sail isn't optimized to lift



Trimmers can’t see air flow, but they can get information about it from sensors on and around the sail…



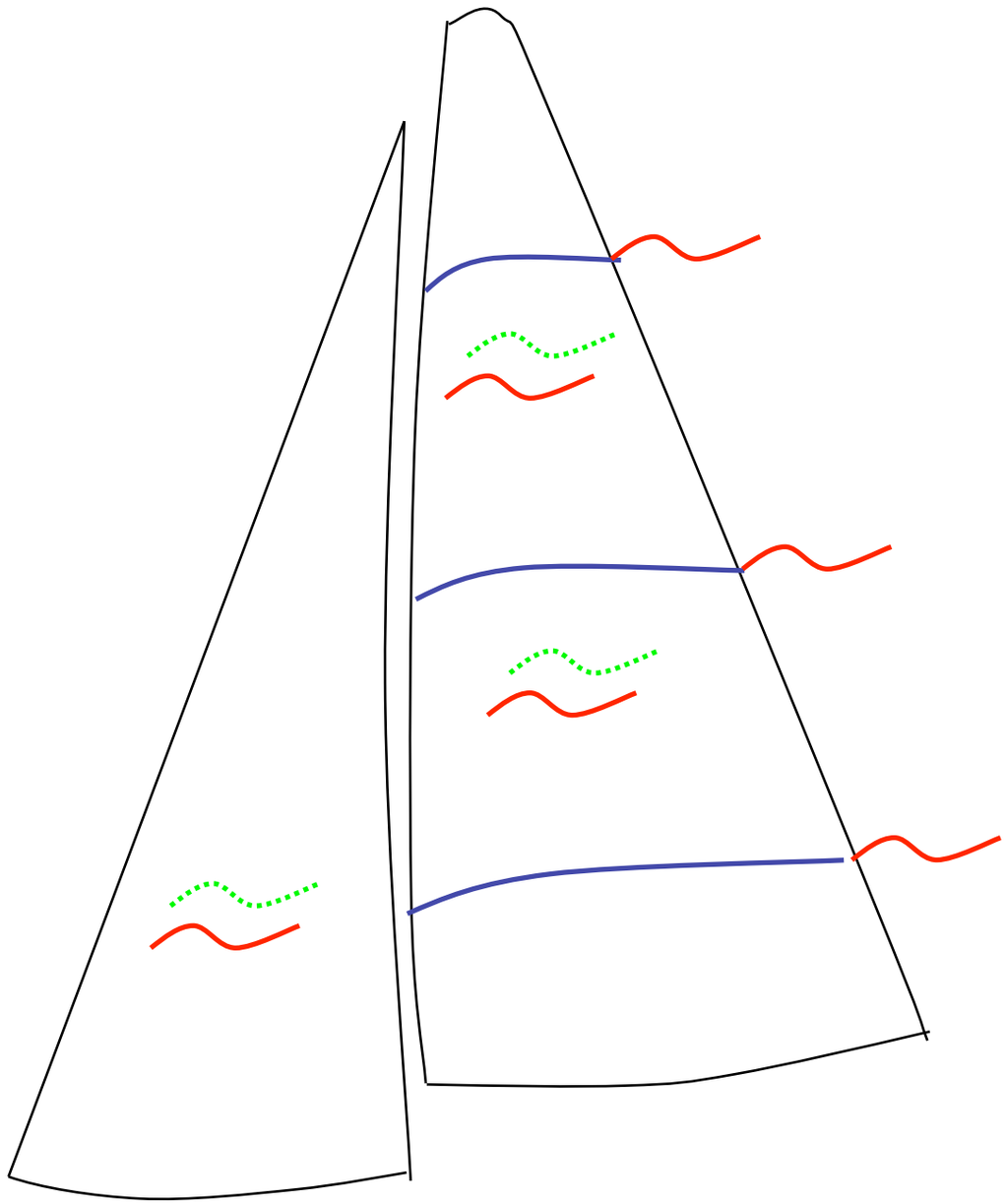
… and signals from elsewhere on the boat

- **Boat speed**
  Fast means trim is correct, slow means the opposite (Source: instruments or feel)

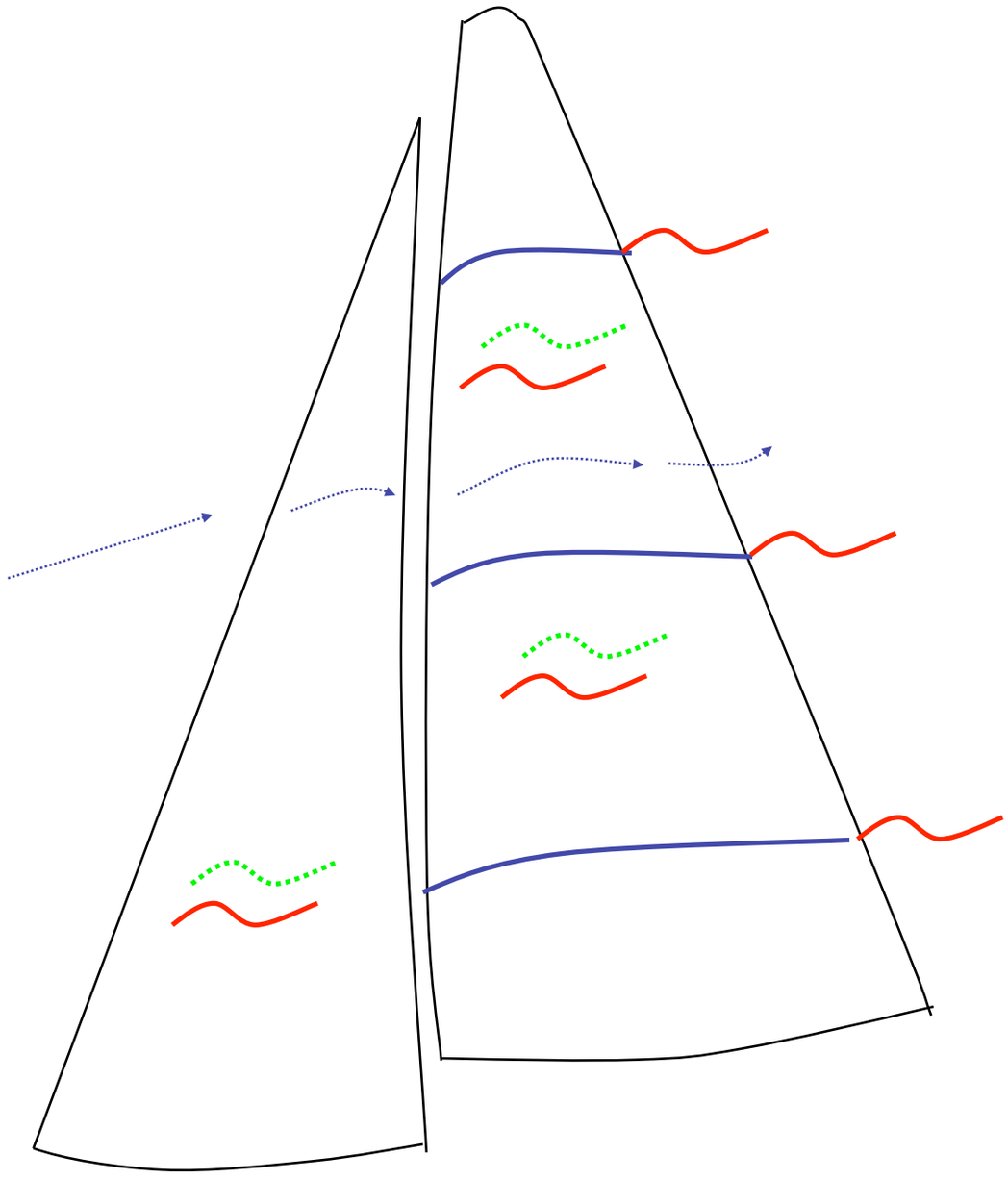
- **Helm**
  If it is hard to steer, it usually means that the sails are not trimmed correctly (Source: the helmsperson)

- **Heel**
  If there is too much of it, there is too much sail power (Source: feel, degree of crew panic)

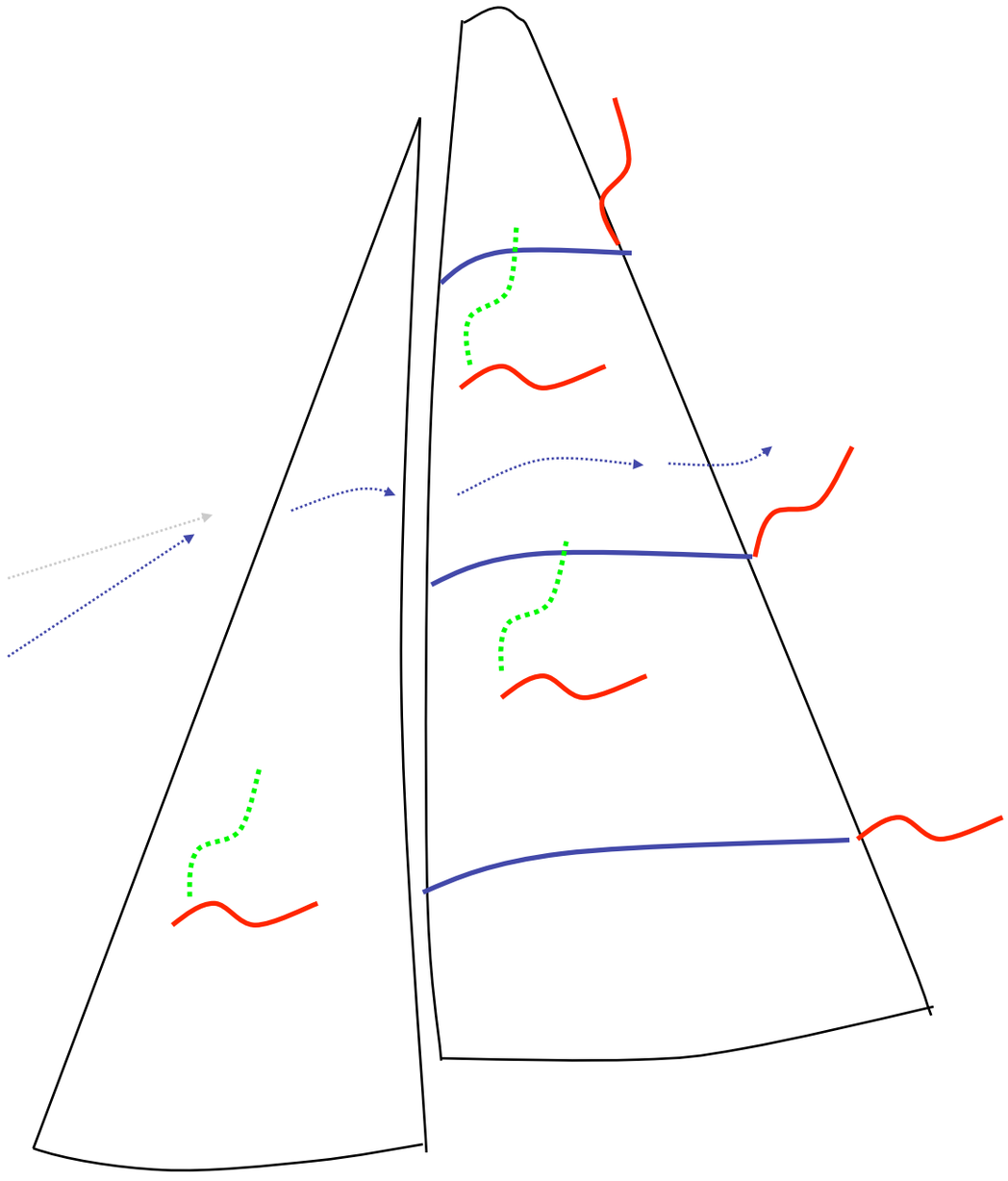
Of all the instruments at a trimmer's disposal, telltales are the most valuable



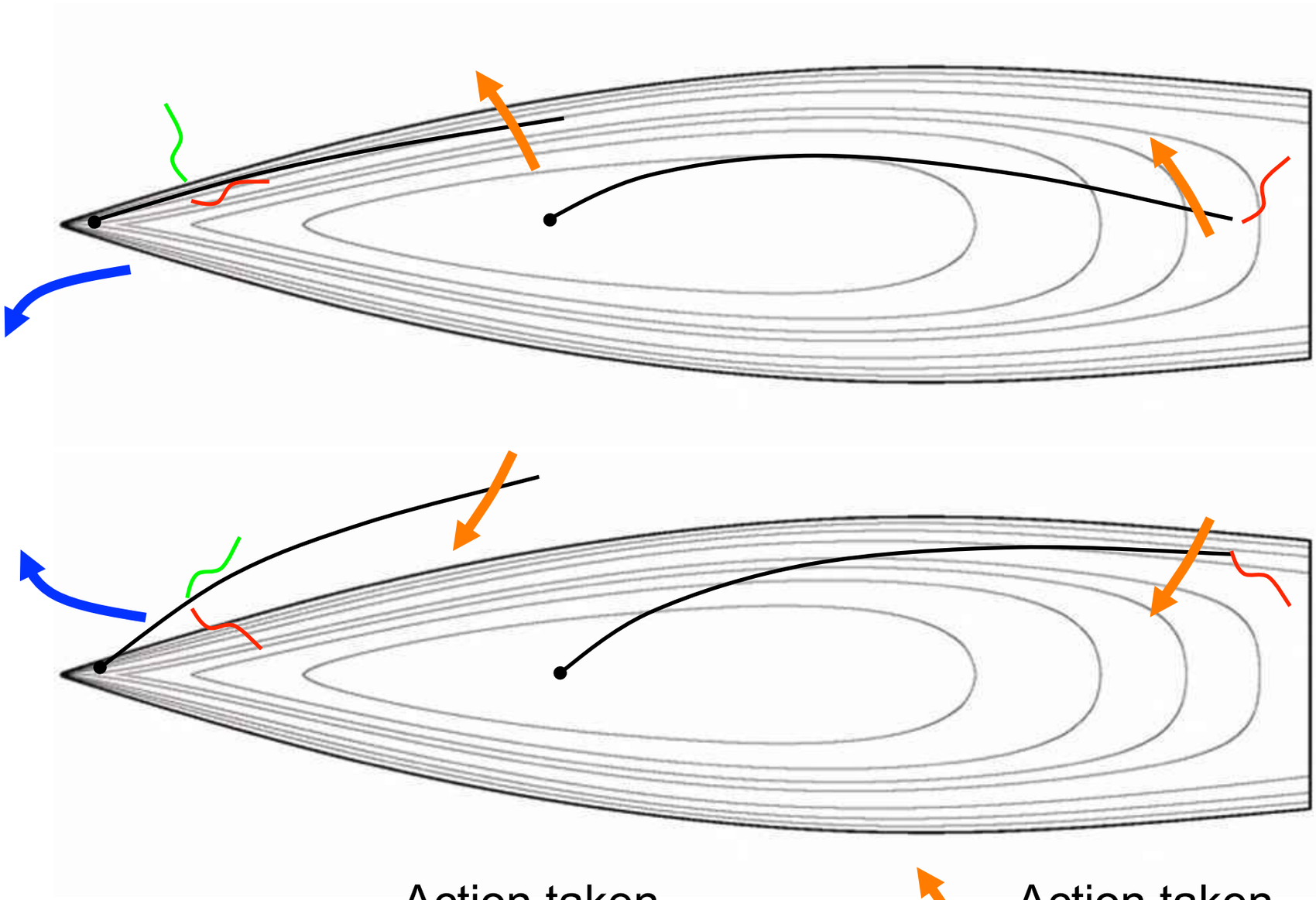
For example, on correctly trimmed sails, all telltales stream backwards consistently...



… whereas the telltales on sails that are out of trim signal inefficiency – calling for adjustment



The simple rules of telltales: if the outers luff, drive up *or* ease the sail, if the inners luff, drive down *or* trim the sail



Sailing to high, or sails trimmed too tight

Sailing to low, or sails not trimmed tight enough

Action taken by helmsperson

…and/or…

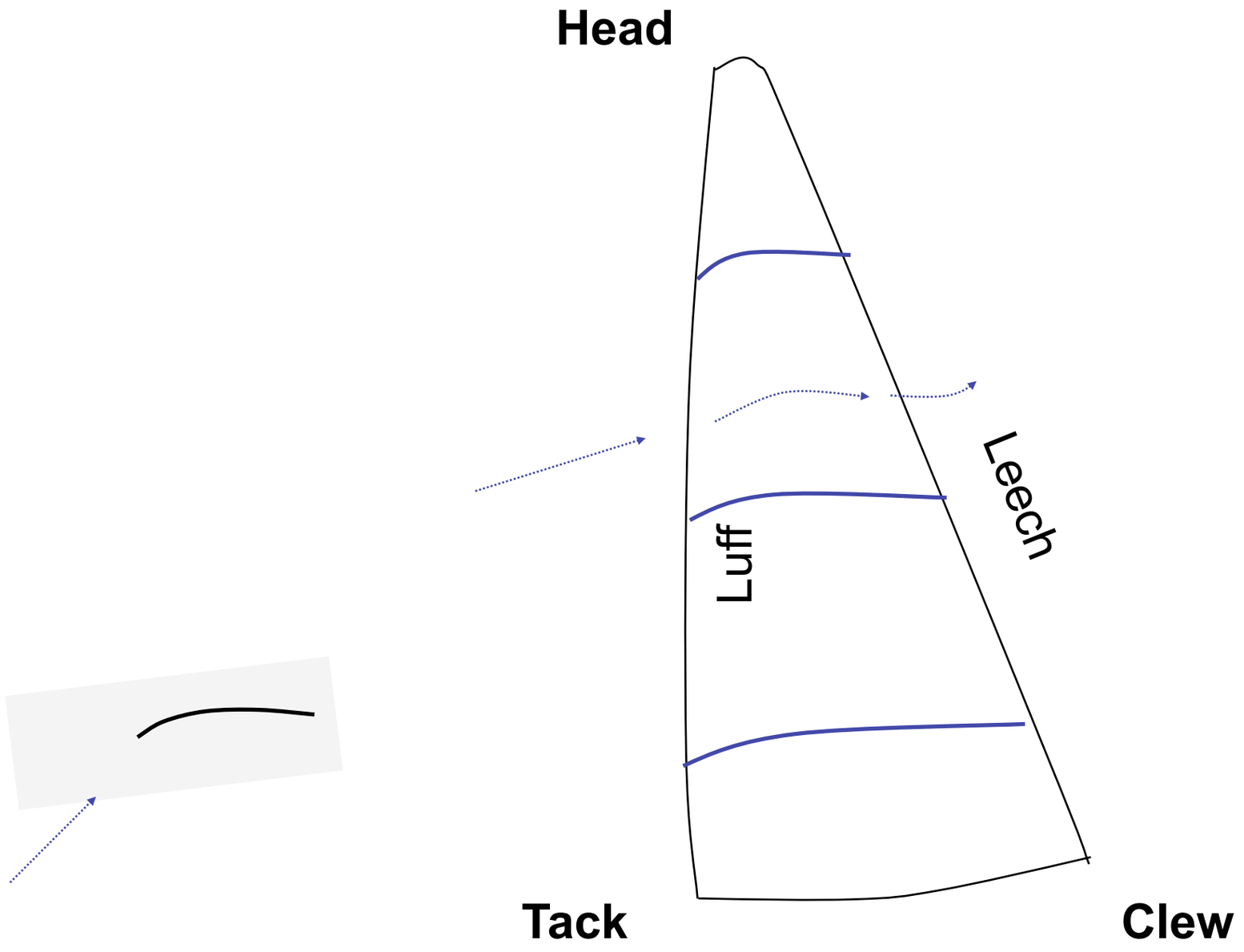
Action taken by sail-trimmer

A trimmer might first check the leach telltales, and then compare the Windex to the angle of attack

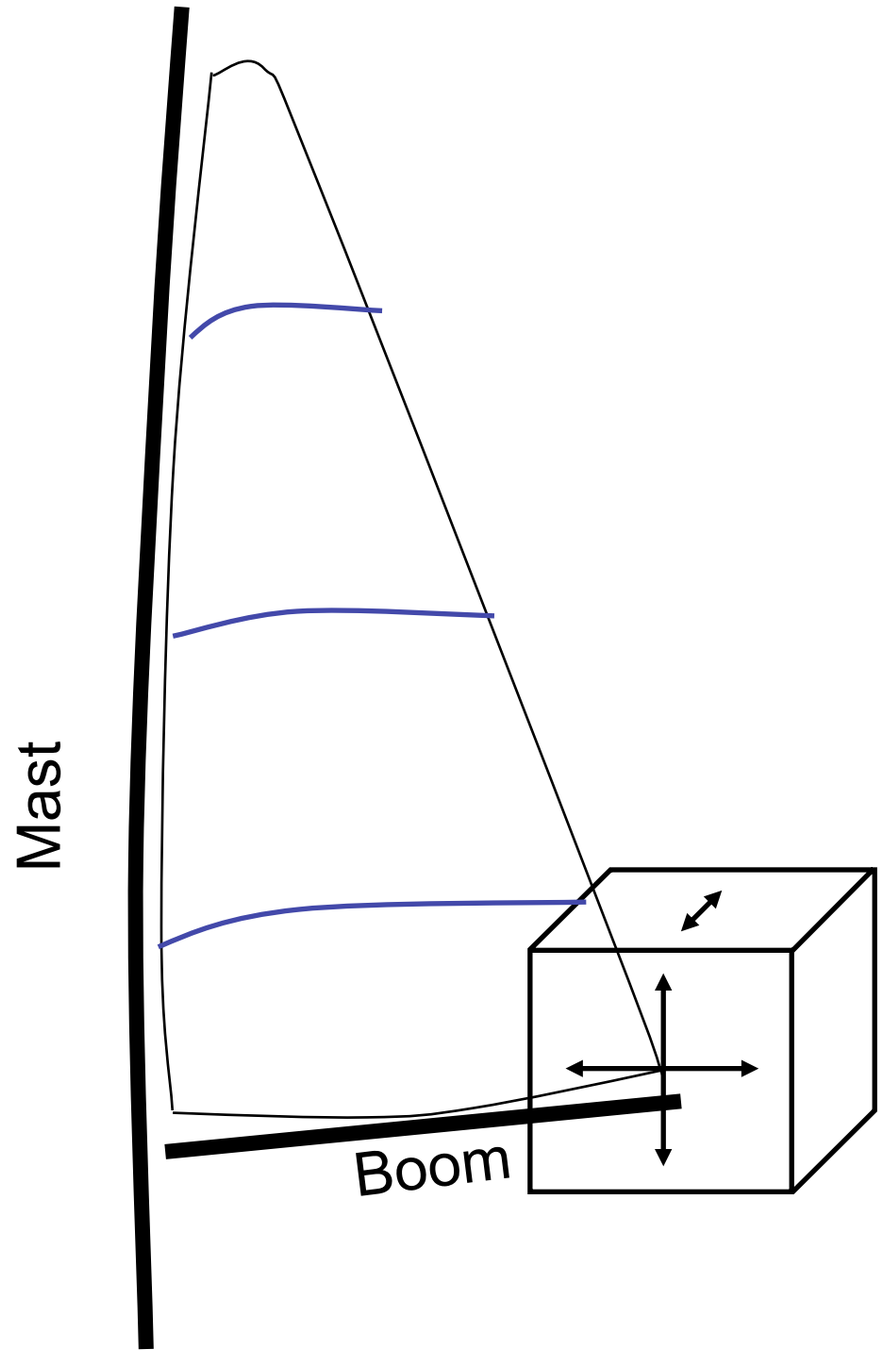
And what is wrong here?

This sail should be eased, or the driver should head up

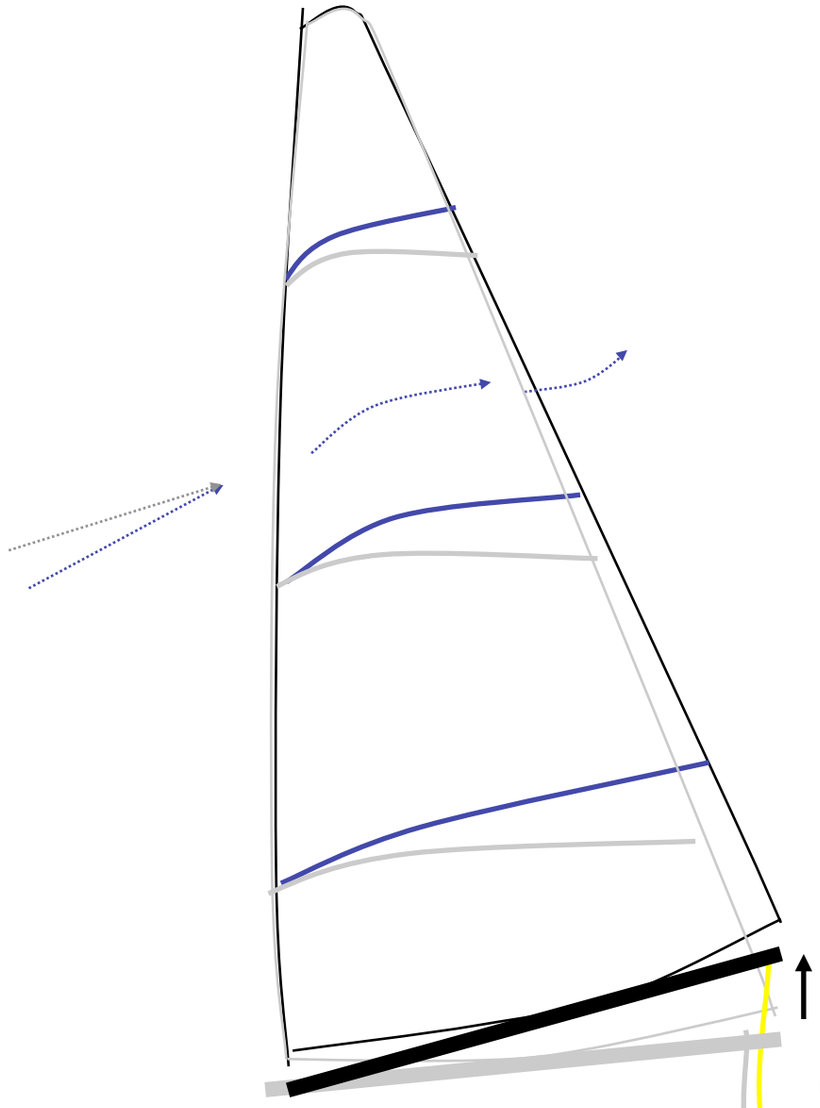
A sail is adjusted by moving the position of one of its corners, called the head, the tack and the clew



The vast majority of mainsail trim is accomplished by moving the position of the clew in a 3 dimensional space



For example, the clew is adjusted outward by easing the sheet, this sets angle of attack (and lowers power in a puff)

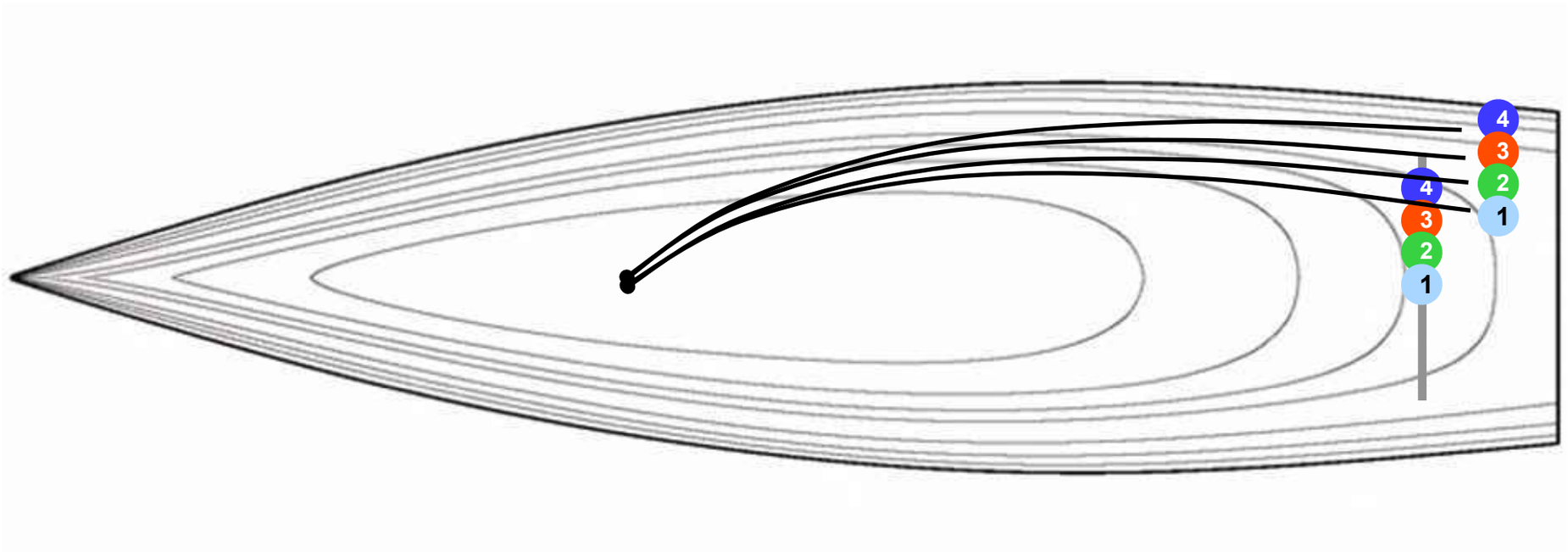


When to do this?

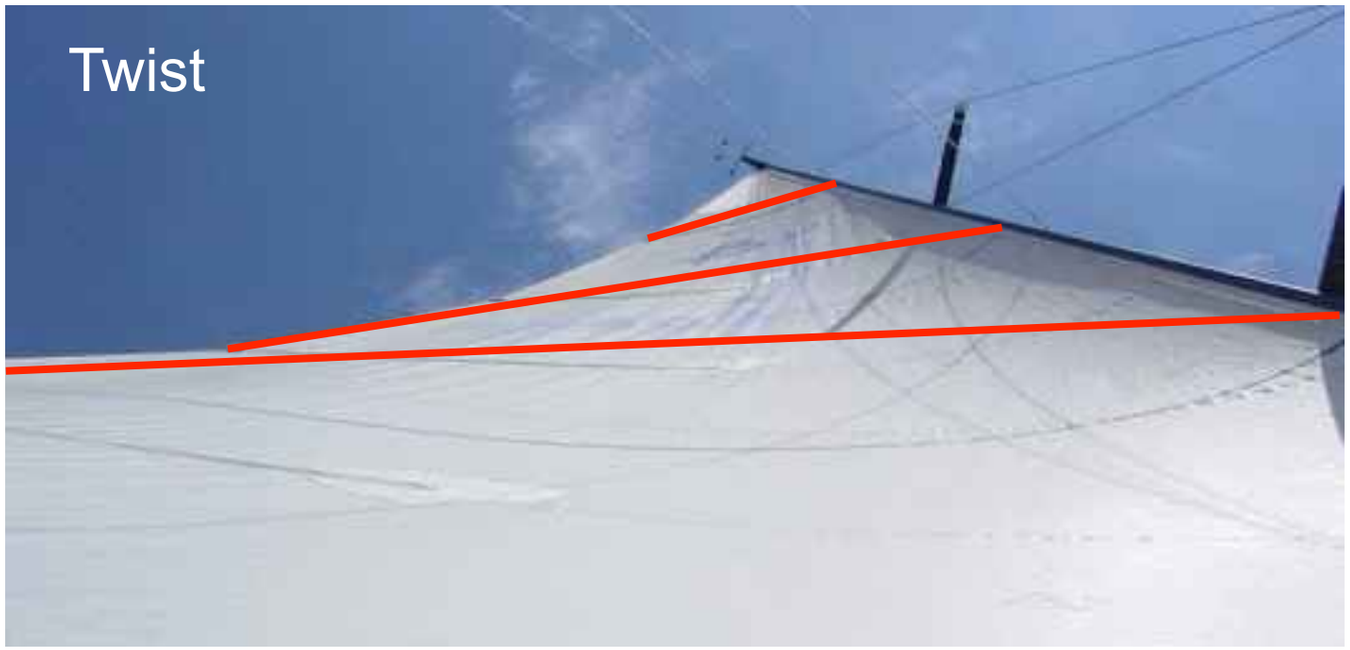
- The wind angle increases, like when the driver turns away from the wind
- To accelerate
- In a puff – to de-power temporarily

Source: Vendee Globe

Traveler position changes angle of attack without changing sail shape – so it is often done first

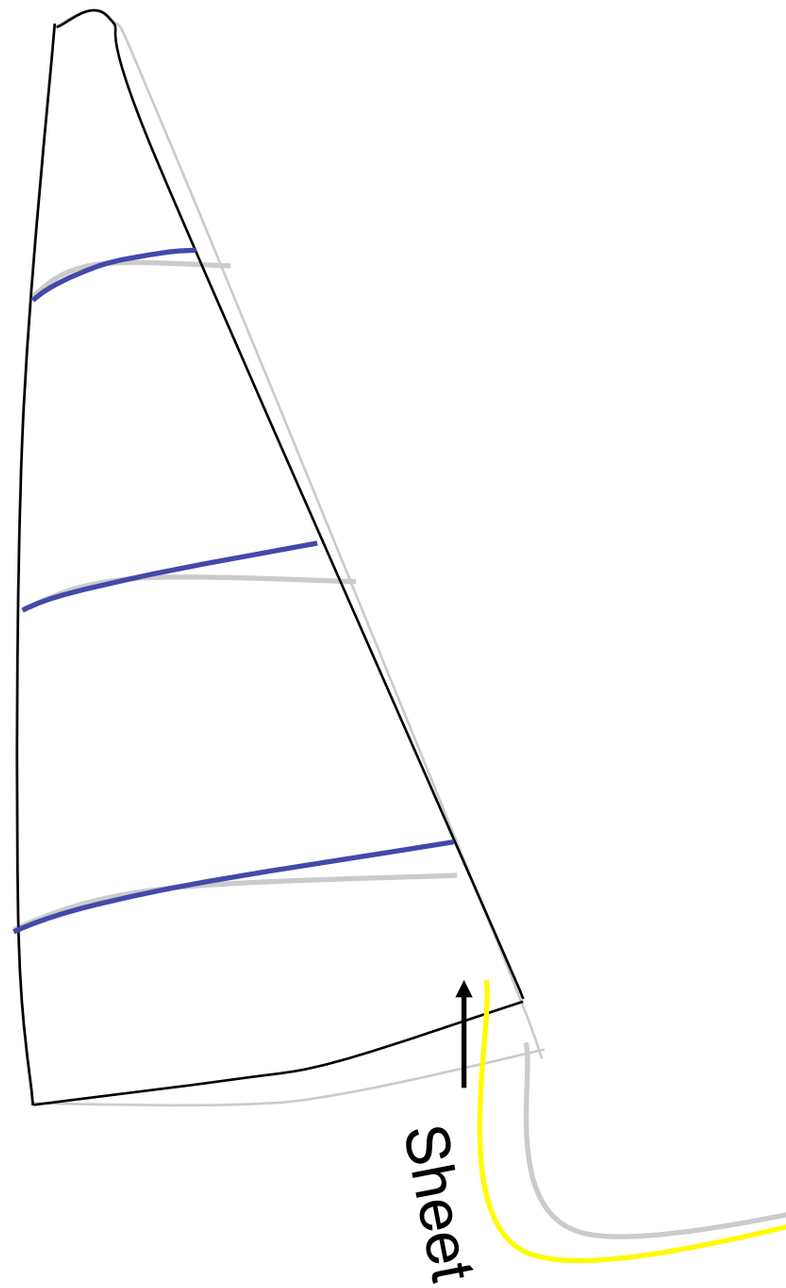


The sheet and traveller also control “twist” which has the effect of decreasing sail area – because the top “spills”



When to do this?

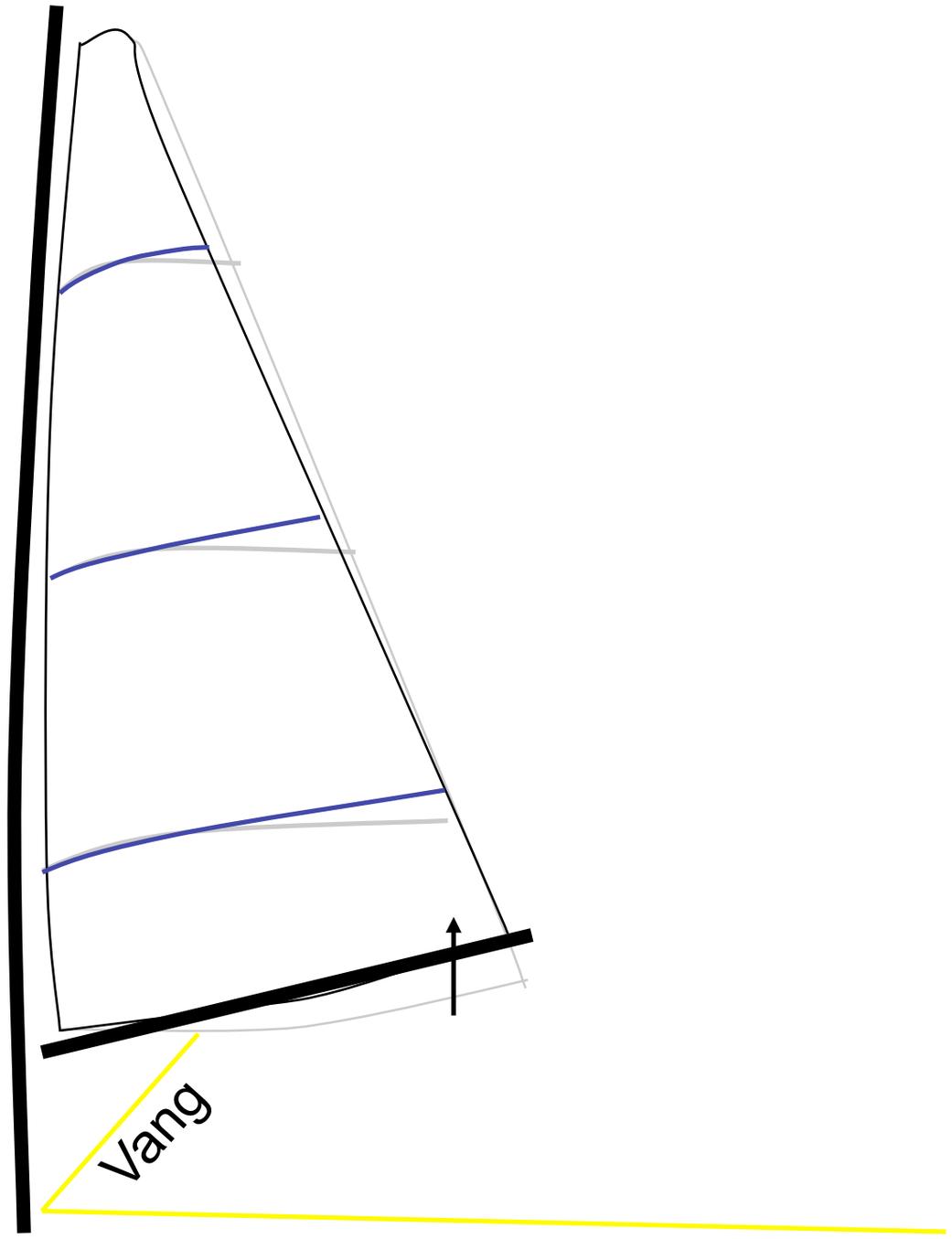
- The wind increases and the boat feels overpowered
- When the sail is in trim at the bottom, but not at the top (often called shear)



Twist can also be controlled with the vang, which is especially important when sailing downwind…

When to do this?

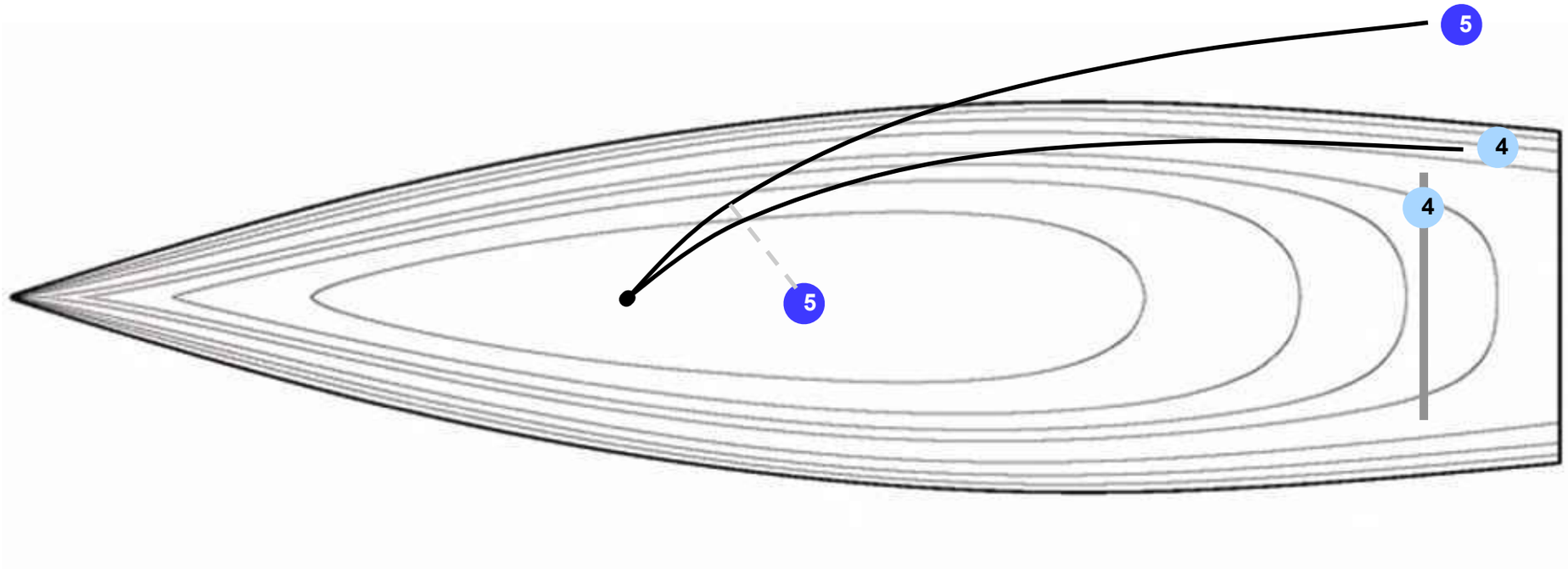
- The wind increases and the boat feels overpowered (ease)
- When the sail is in trim at the bottom, but not at the top (often called shear) (adjust)
- When sailing downwind the vang can increase effective sail area by closing the leach (trim)



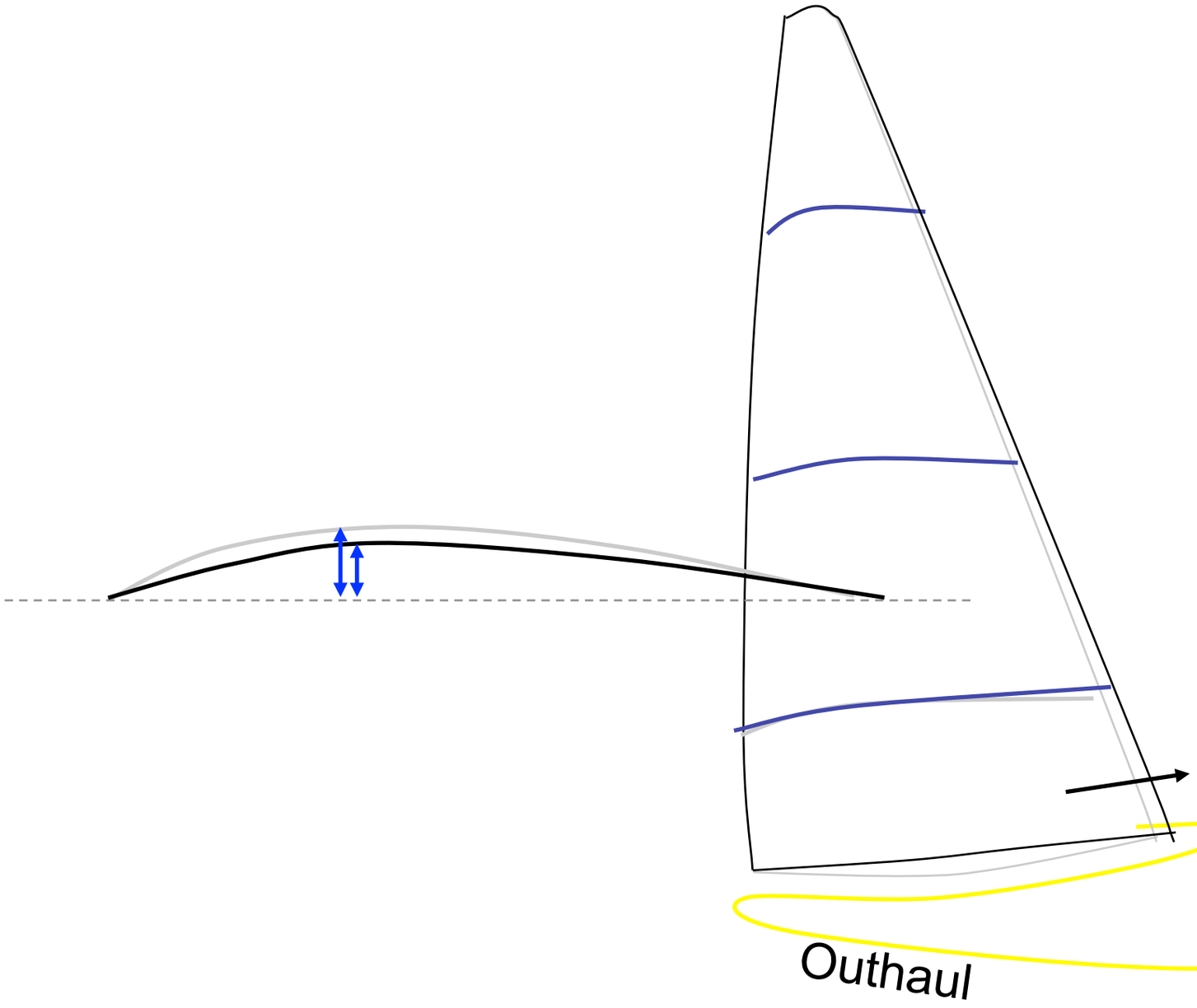
Note:

- *Different rigs respond to vang action differently – for example, on a Laser a tight vang depowers, whereas on larger boats the vane often powers*

The vang can also be used for direct sheeting, especially when you've run out of traveler



Outhaul tension has the effect of flattening (or de-powering) the lower half of the sail, as the clew is pulled back (reducing camber)

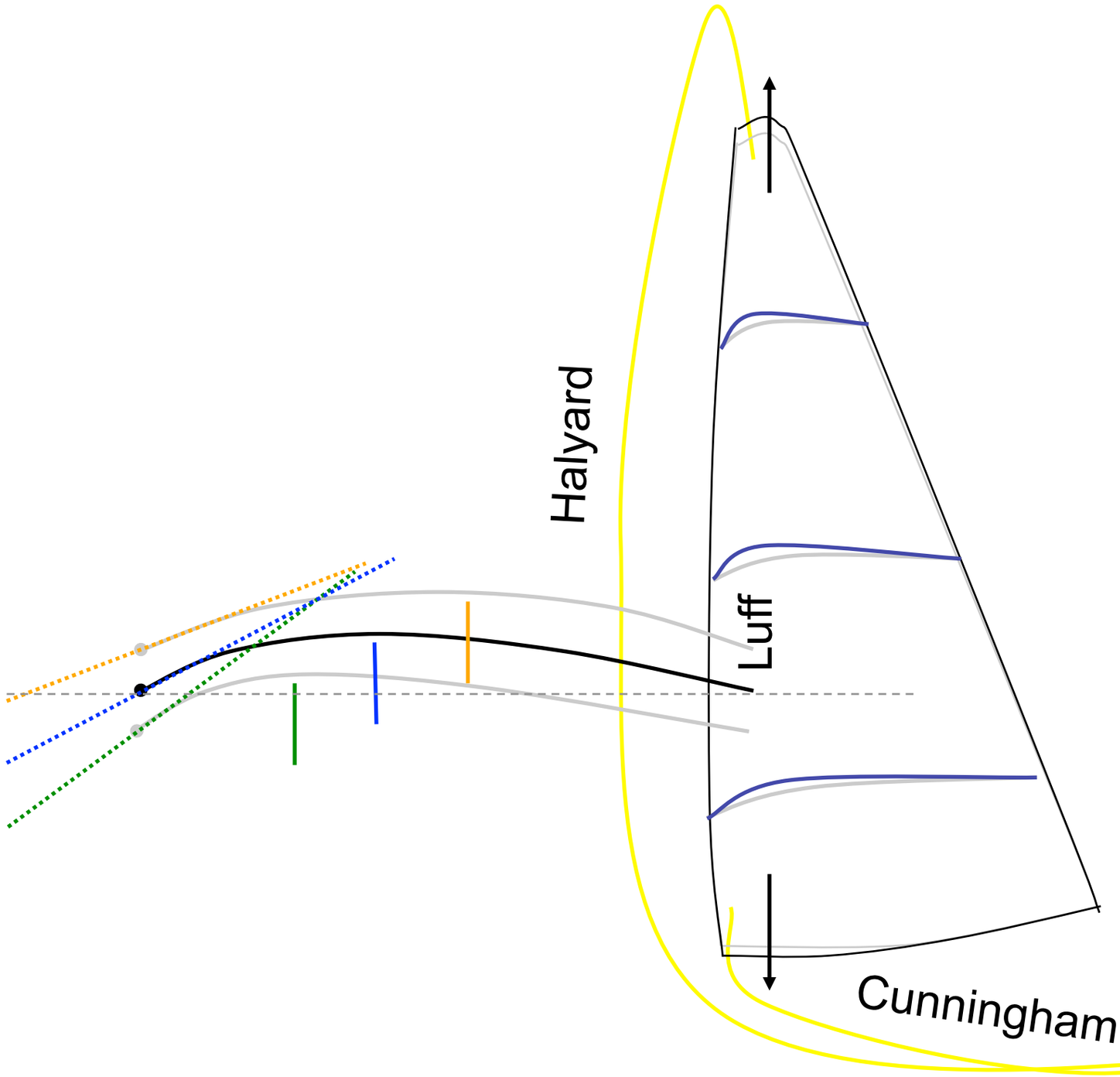


When to do this?

- When the boat turns upwind to sail close hauled for a time
- The wind increases and the boat feels overpowered
- In very light air

Source: Vendee Globe

The halyard and/or cunningham put tension on the luff by pulling on the head or the tack, changing draft (angle of entry)



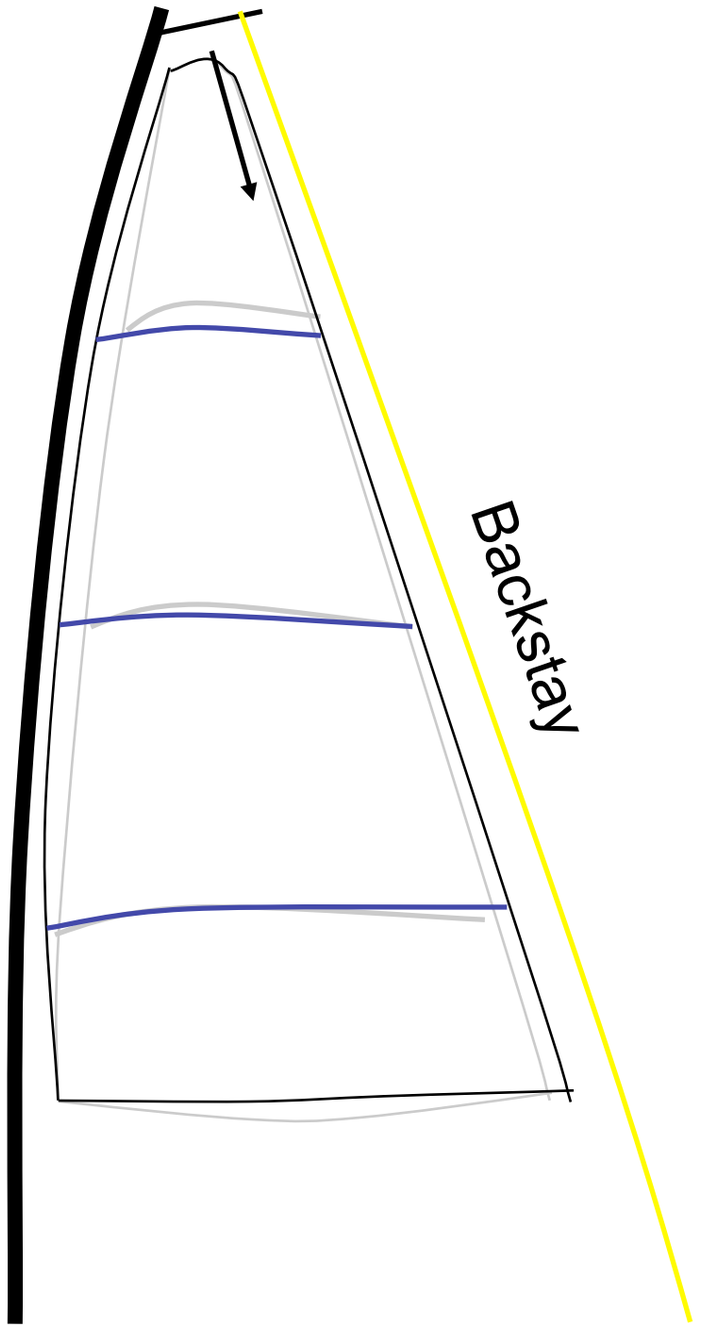
When to do this?

- When there is too little weather helm (opposing pressure on the tiller, expressed by the driver)
- Upwind in moderate and heavy air

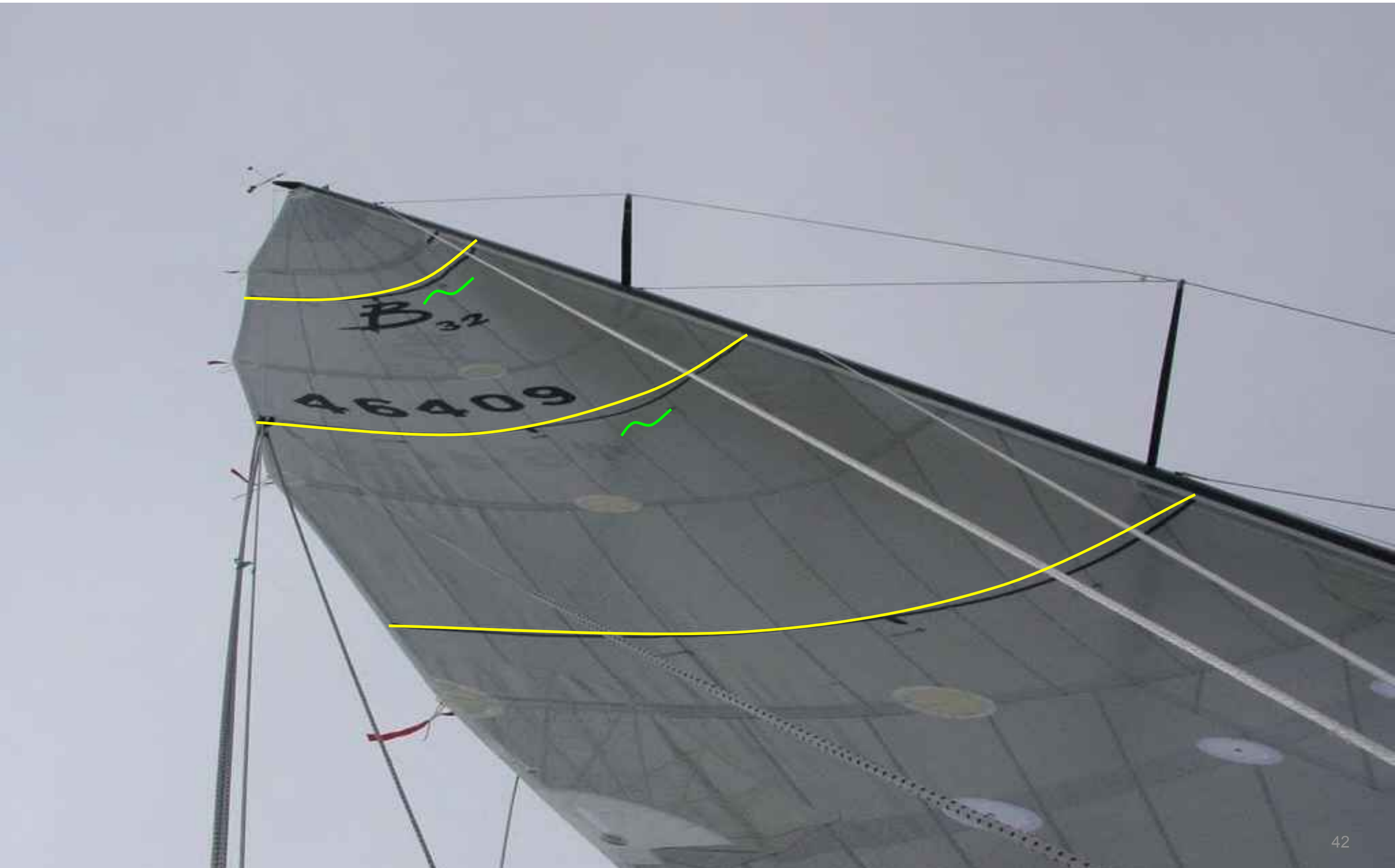
Source: Vendee Globe

While the outhaul flattens the lower half of a sail – mast-bend flattens the upper sections (reduced camber)

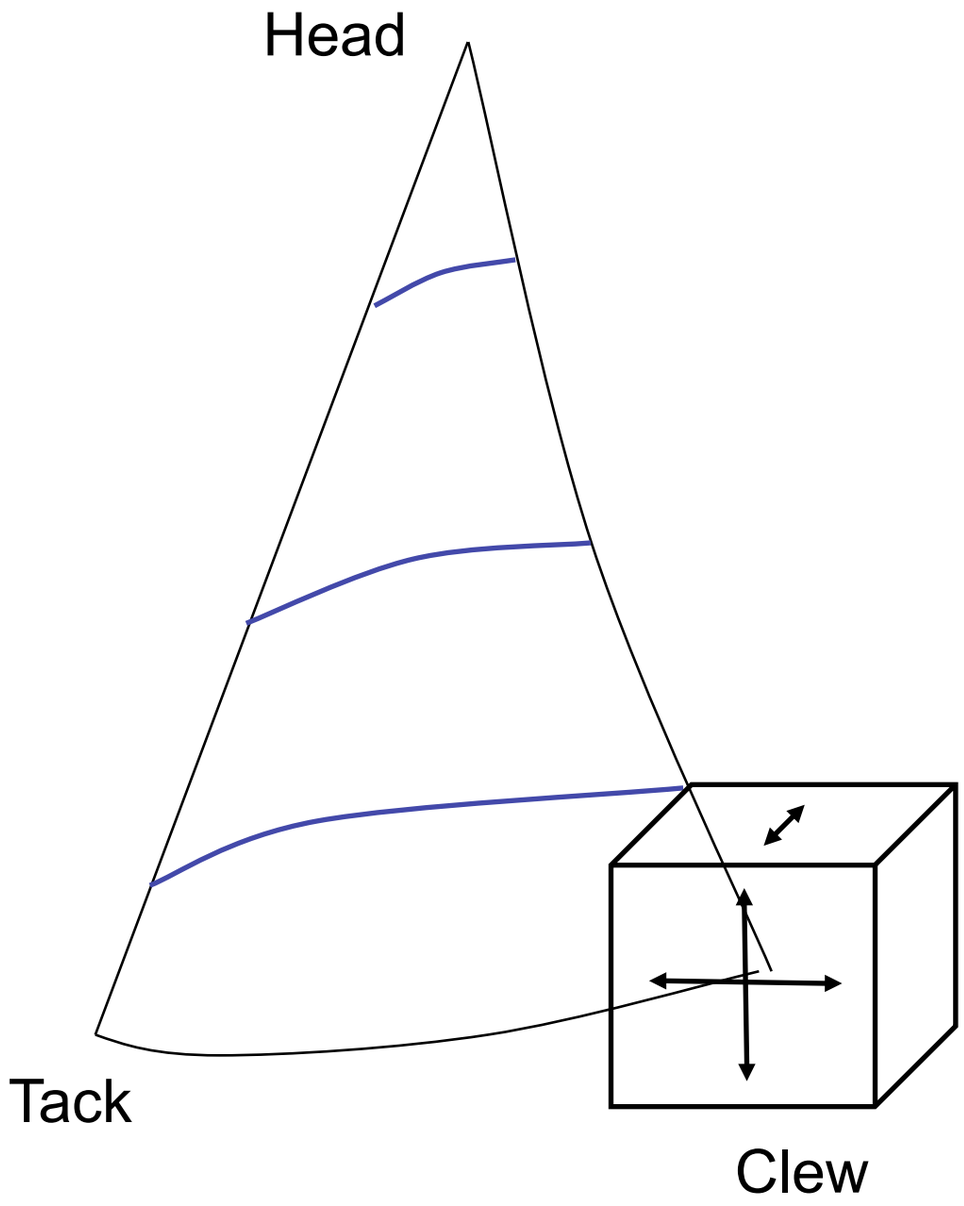
Control	Action	Effect
Outhaul	Tighter outhaul flattens sail	Reduces power
	Looser outhaul deepens sail	Increases power
Backstay (mainsail only)	Tighter backstay bends mast, which in turn flattens sail	Reduces power, increases angle of attack
	Looser backstay straightens mast, which deepens sail	Increases power, decreases angle of attack



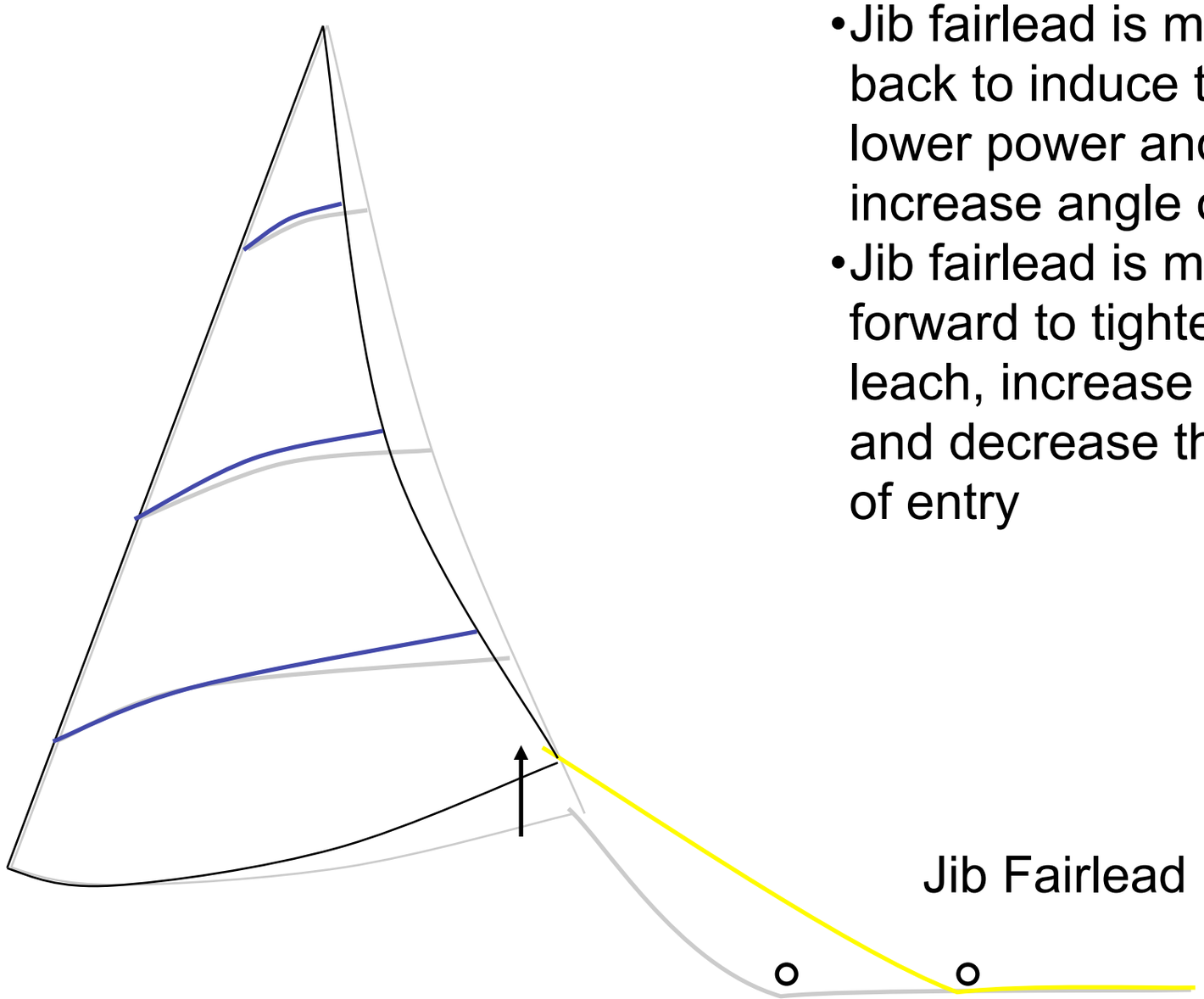
The solution to upper slack telltales is to tighten angle of attack up high – perhaps by adding some backstay



The same trim principals apply to jib trim…



The jib's clew floats freely so its position is determined by sheet tension, and sheeting angle (higher clew = twist)



When to do this?

- Jib fairlead is moved back to induce twist, lower power and increase angle of entry
- Jib fairlead is moved forward to tighten the leach, increase power and decrease the angle of entry

A jib trimmer depends on telltales too…

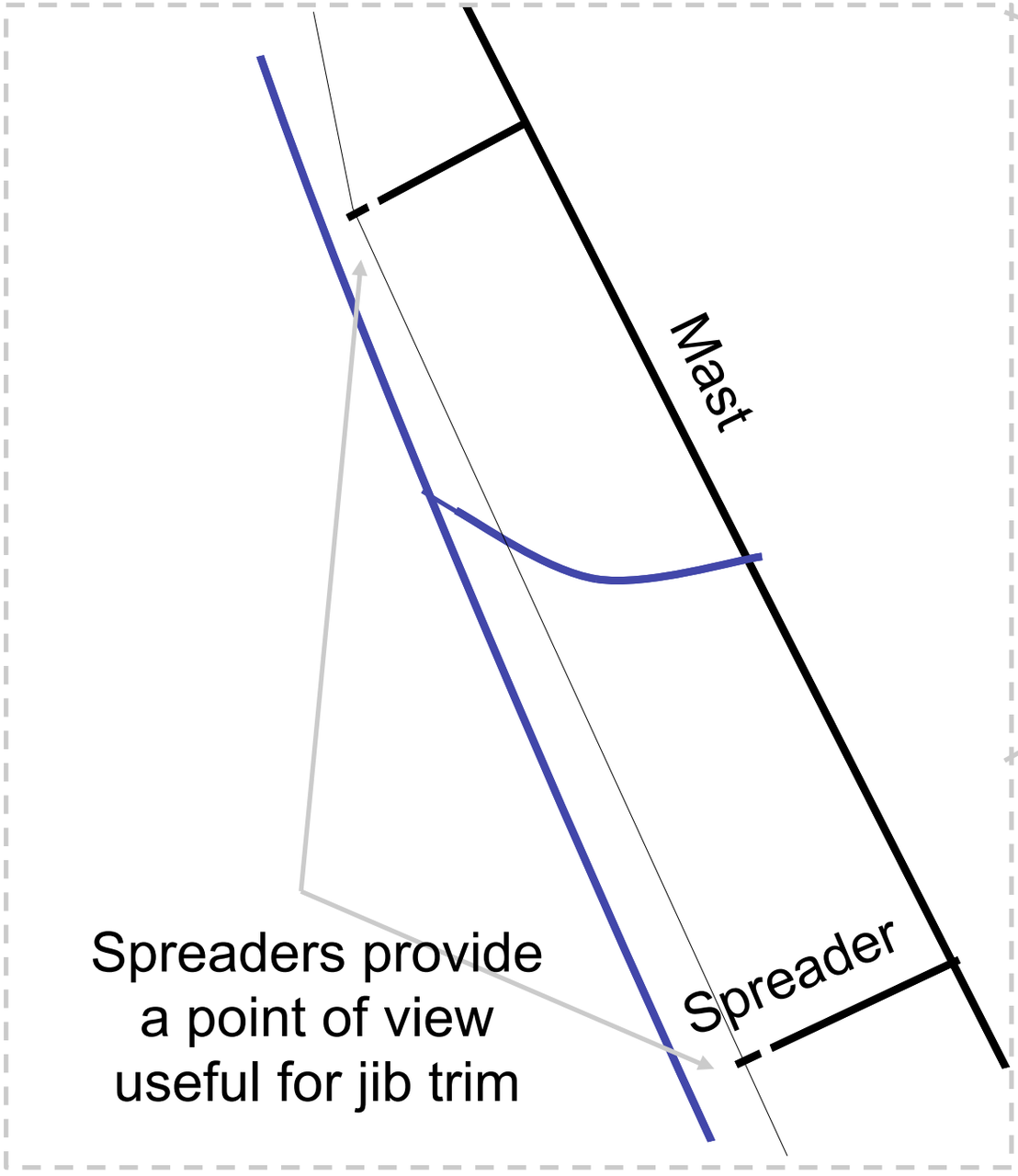
What should this jib trimmer do?

Source: Curtis Gruninger

What should this trimmer do?

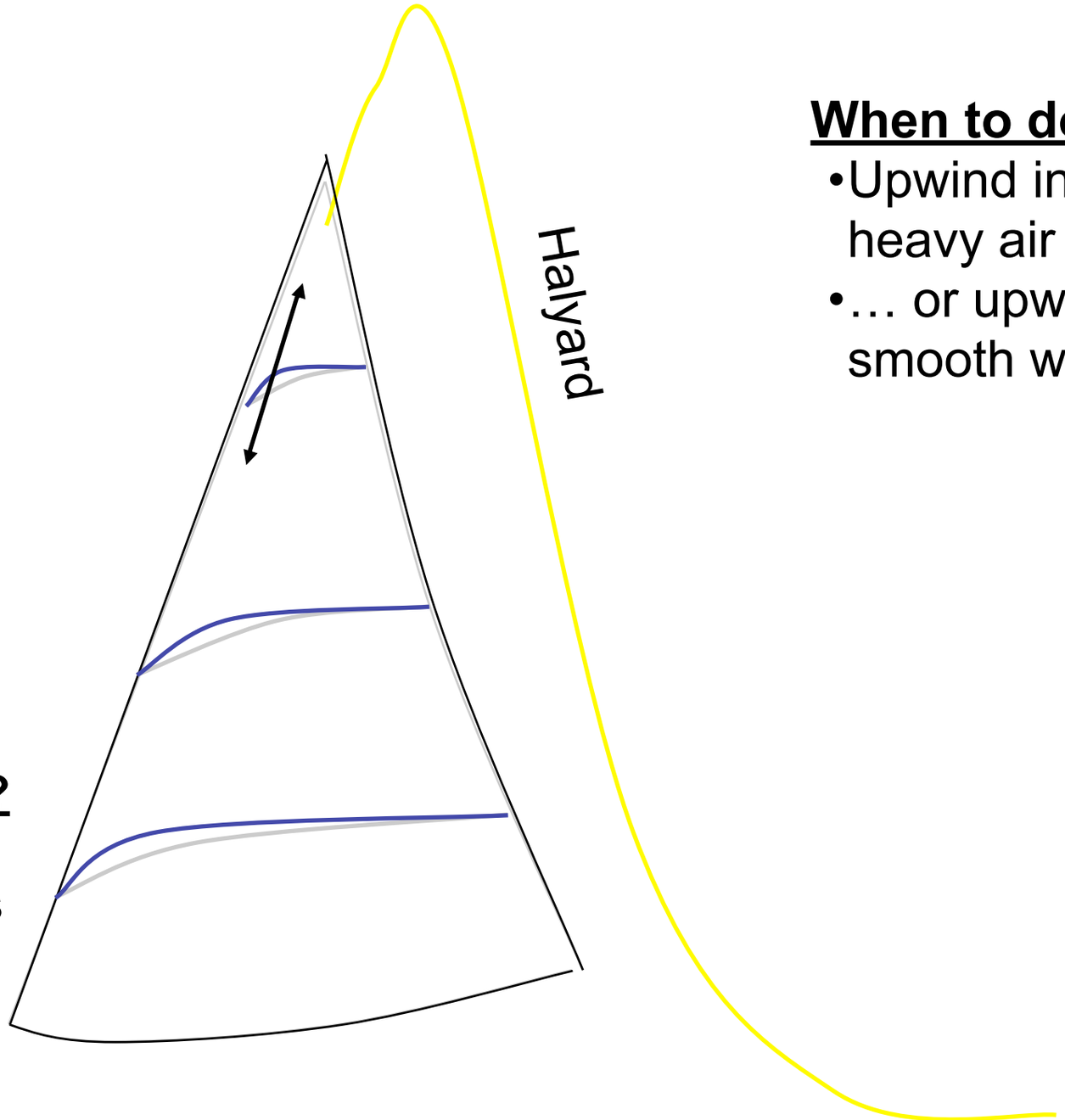
Source: Curtis Gruninger

…but when sailing close-hauled, has the additional perspective of leach position relative to the spreaders



Source: UK Sails

Jib halyard tension pulls draft forward, which effects angle of entry, and therefore efficiency



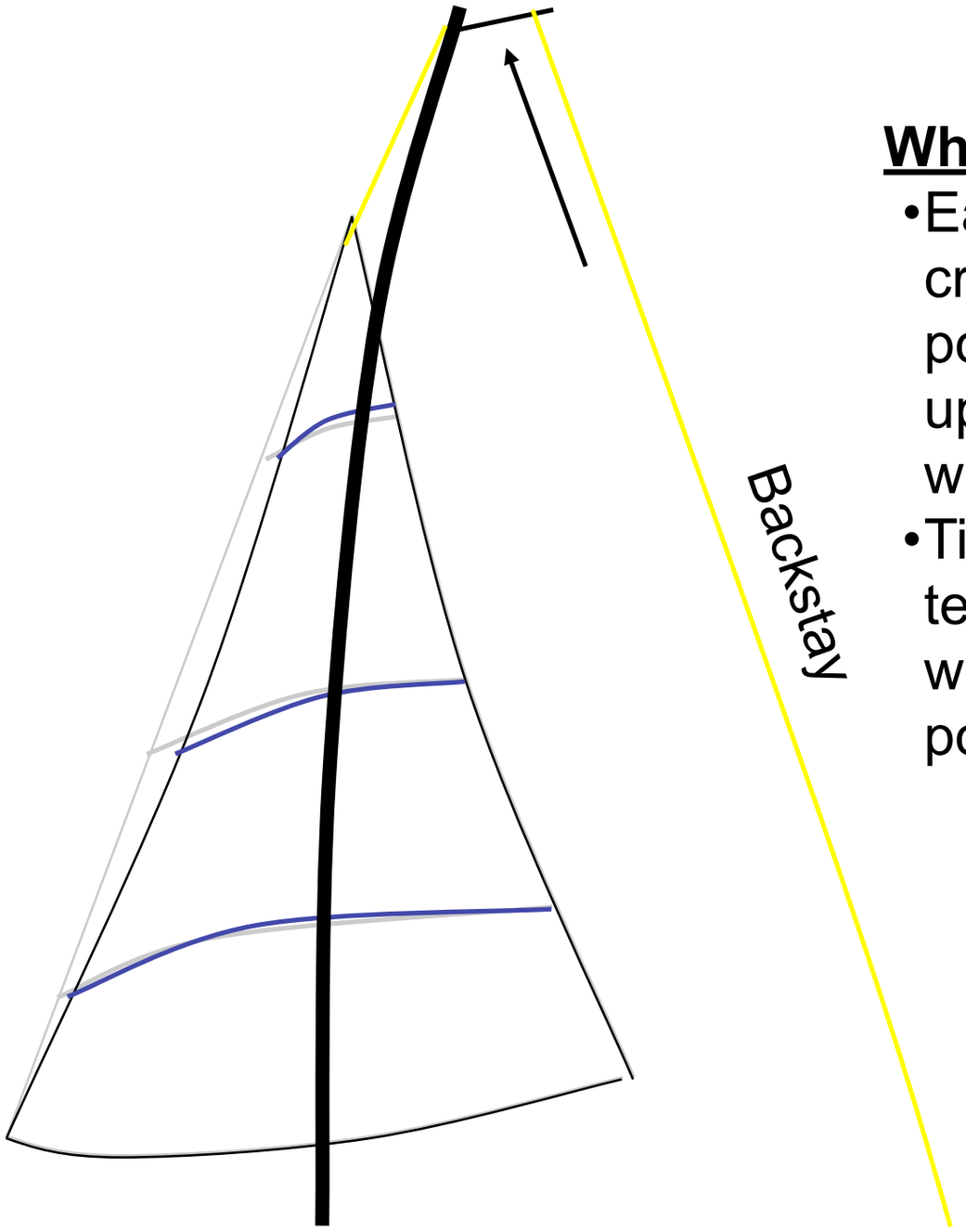
<u>When to do this?</u>

- Upwind in moderate and heavy air
- … or upwind in light air, smooth water

<u>Where is the cunningham?</u>

A jib's tack is usually permanent, so luff tension is controlled by the Jib halyard alone

Headstay tension (sag), controlled by the backstay, effects depth and angle, therefore, power and efficiency

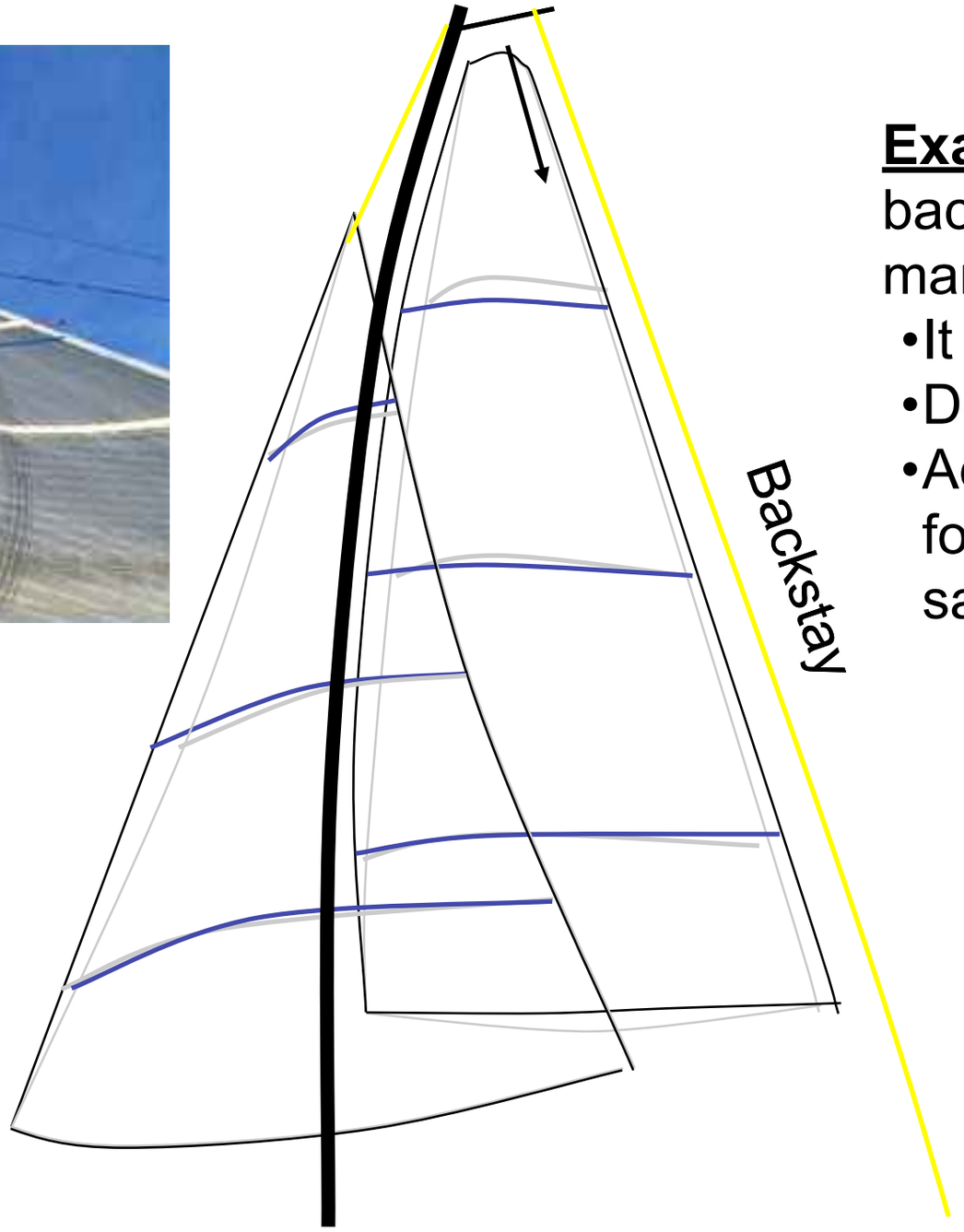


When to do this?

- Ease headstay tension, creating sag, when power is required – upwind in chop or light wind
- Tighten headstay tension, reducing sag, when the boat is over-powered

But wait – doesn't backstay also control mainsail shape?

Source: UK Sails



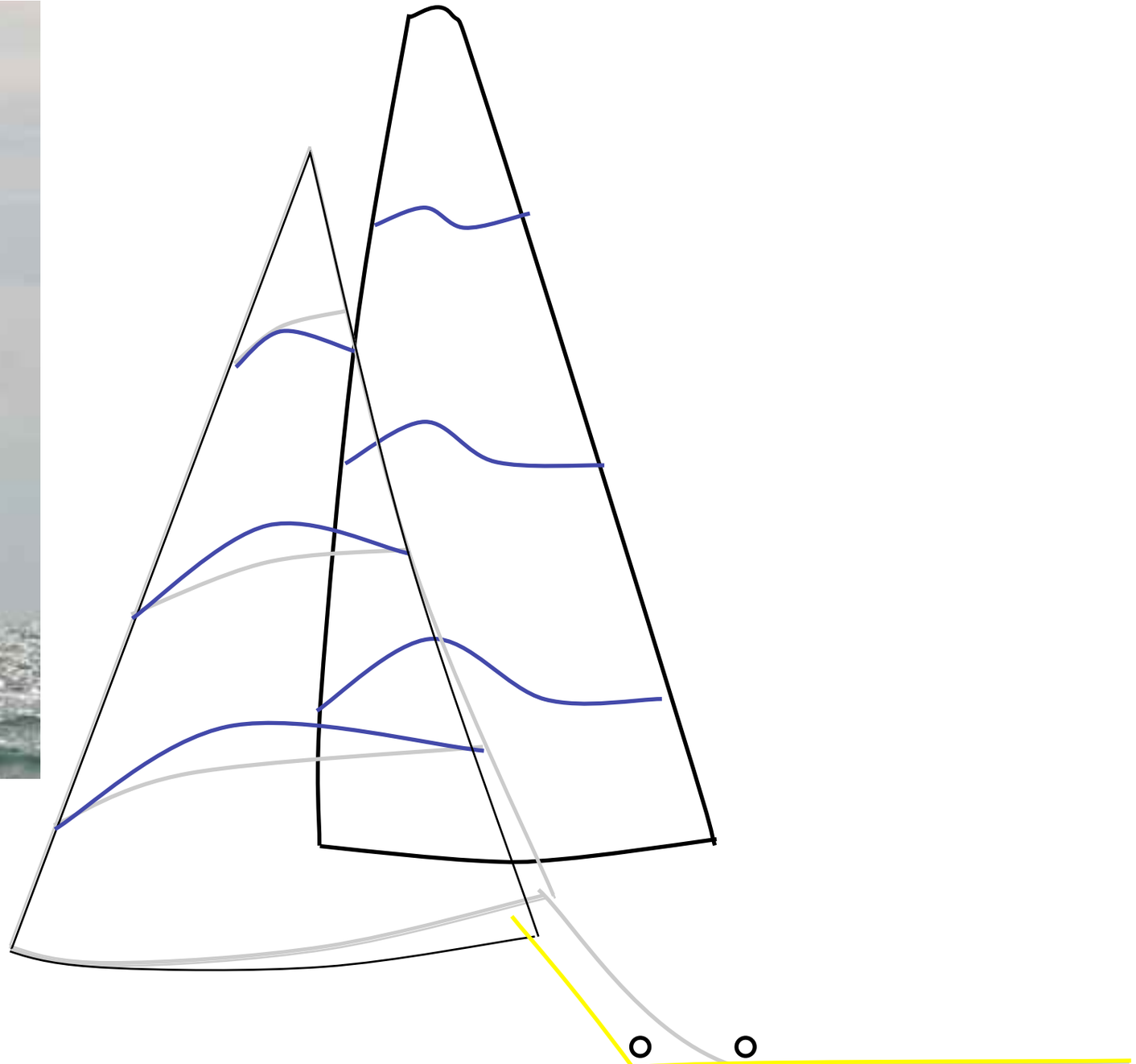
<u>Example</u>: In this drawing, backstay tension serves many functions:

- It de-powers to main
- De-powers the jib
- Adjusts angle of entry for higher close hauled sailing

In another example of the relationship between sails, a too-tightly sheeted jib will “backwind” the main

Source: Curtis Gruninger

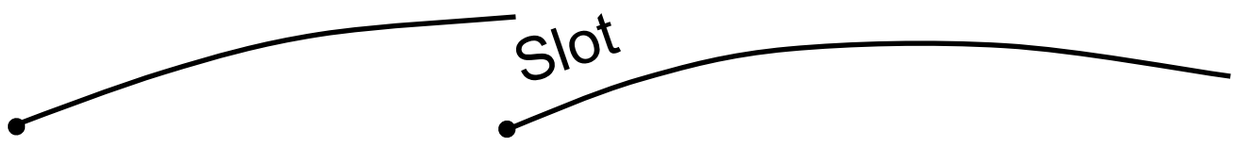
What should these trimmers do?



In fact, when sailing with both a jib and a main, a new trim advantage comes into play: the “slot effect”

- The jib adds sail area, therefore power
- But the jib also has the effect of helping to maintain attachment on the main through the slot effect, so the increased power potential is greater than with either sail alone

Source: Viper Productions



Review basic trim rules

- **Keep all the telltales flying** and the boat fast
  - Make small angle adjustment all the time
- **In heavy air, tighten everything** (except the vang)
  - Power down: flatter sails, less sail area
- **In light air ease everything** (except the vang)
  - Power up: deeper sails, more sail area
- **Talk and listen to the driver and other crew** about how the boat feels and try to find the speed solution
- **Don’t trim in a vacuum**: many controls change more than one sail or characteristic

… and then there is downwind sail trim, the topic of a Sail-trim 201

- Spinnaker trim is based on all the same principals, except
  - Both the clew and the tack are adjustable in the 3D box
  - The luff is free floating also!

Source: Viper Productions

Links and sources

- Get the iPad Wind Tunnel App!

- Upwind sail trim: http://sailingmagazine.net/article-1458-upwind-sail-trim.html
- More basics on foils: http://www.uiowa.edu/~sail/skills/racing_basics/chap2.shtml
- In depth shape analysis: http://www.onemetre.net/
- More on reading telltales: http://www.wb-sails.fi/news/95_11_Tellingtales/Tellingtales.html

- If you'd like to join Syrena for a race to **see these concepts in action**, or if you'd simple like to share ideas, contact me at ndhayes1@gmail.com.

- This presentation is be available for download at http://www.savingsailing.com.