This article was originally published on the Furnivall Sculling Club web site in 1996 (now www.furnivall.org). Furnivall SC is based near Hammersmith Bridge in London, so this document reflects GB practice and terminology. This 2013 version has been lightly revised and reformatted for PDF distribution. Same old graphics though...

BALANCE OF RACING ROWING BOATS

"Everything should be made as simple as possible, but not simpler."
Albert Einstein

Introduction

In this article the classic analysis of the static stability of ships is extended in a way that seems to offer some useful insights to rowers in racing rowing boats. It started out as simple curiosity to see what happened when I plugged some numbers for racing rowing boats into standard theory. The results were unexpected.

Balance does not get much of a mention in rowing literature. Generally textbooks seem to assume that if everything is kept symmetrical then balance will emerge naturally, and indeed this is how it generally works. The older texts seem to usually contain the unemphasised assumption that beginners will always start out in wide stable boats and graduate through a progression of finer craft. I suppose coaches did not need to worry about it much in those days as the boatman (remember them?) would normally issue the appropriate kit. This don’t think about it approach has continued, some modern texts, such as the GB ARA Instructors Handbook (1996), suggest starting off beginner scullers paddling square blades without really discussing what sort of boat is required to do it.

I suspect that it is relatively common in clubs today for beginners to be put into fine hand-me-down boats at a relatively early stage, which perhaps makes balance more of an issue than it used to be in the past.

The article is in two parts:

Part 1 - STABILITY ANALYSIS gives the investigation in detail.

Part 2 – SUMMARY / CONCLUSIONS also contains a Q&A section. The less technically minded might want to skip Part 1 and go straight to Part 2, but I would recommend that if you are going to use this material you should read Part 1 to understand the reasoning and its limits.

PART 1 - STABILITY ANALYSIS

Static Stability - Classic Ship Theory

Racing rowing boats are members of the common class of vessels where the centre of gravity (CoG) is some distance above the centre of buoyancy (CoB). This type of ship is stable provided that the CoB moves sideways faster than the CoG as the ship rolls, a condition that is satisfied if the CoG of the ship is below a geometric point known as the metacentre (MC). The MC is basically the point through which the buoyancy force effectively acts for small amounts of roll. If the CoG is higher than the MC then the ship will roll over at the slightest disturbance. See any textbook on basic fluid mechanics for a full explanation of these concepts, the derivation of the limiting equation and formal definitions of stability and balance (equilibrium).

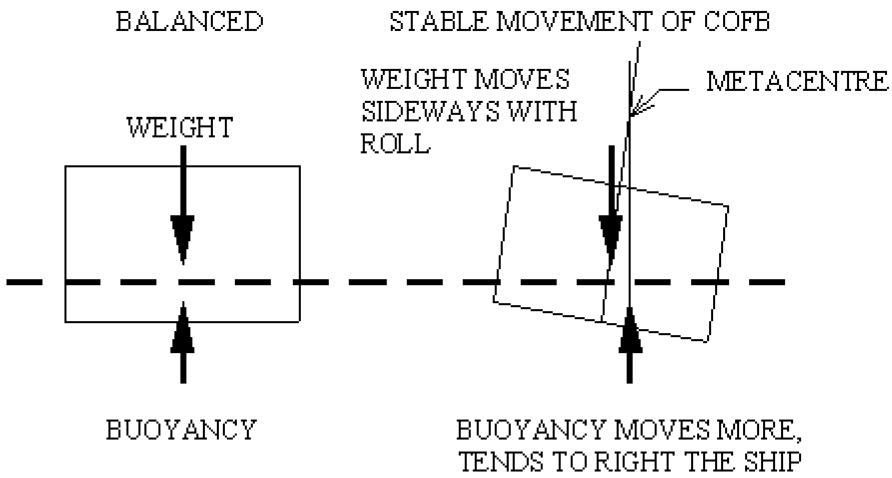

Figure 1. Metacentric stability.

The equation defining the limit of stability of ships is:

$$BG = I / V$$

Where:

BG = Metacentric height, the limiting distance of the CoG of the ship over its CoB.
I = 2nd moment of the horizontal waterline shape about the axis of rotation of the ship.
V = Volume of fluid displaced.

Points to note about "metacentric stability":

- The relationship depends on the horizontal shape of the hole the ship makes in the surface of the water at the waterline, not on the hull cross section as such (although for a given a carrying power there is a relationship between hull length, width and cross section, see below).
- The wider the waterline, the larger the I of the waterline area for any given length or load carrying capacity, i.e. short wide shallow draught boats are more stable than long thin deep boats. Sound familiar?
- The equation assumes a rigid system, i.e. the masses of the system can be considered to be one immovable mass. The standard textbook examples concern buoys, which are rigid, or ships, where the weight of the mobile stuff such as the crew can be neglected in comparison to the weight of the craft.

- In normal ships the CoG is placed a safe distance below the MC to ensure a margin of safety (for example icing of the superstructure will raise the CoG and at some point the ship can become unstable and capsize, a real danger in arctic conditions).
- A balanced stable ship is not necessarily one that is exactly level.
- A balanced unstable ship will always roll over, perfect balance does not last in the real world.

Measuring up some boats in the Furnivall Sculling Club boathouse and plugging in the numbers we get the table below. None of these numbers are very exact, but they serve their purpose (in particular the method used to approximate the MC is optimistic rather than pessimistic). All dimensions in cm. Crews on board unless stated otherwise. CoG etc. are referred to the waterline to allow easy comparison between different boats.

	Single scull	Eight	Mondego	Empty scull
Max. hull waterline width	27	57	74	18
Max. submerged cross sectional area (cm^2)	220	770	730	38
CoB below waterline	4.5	7.4	5.3	1.1
BG (MC over CoB)	7.7	20	47	13
Metacentre (MC) over waterline	3.2	13	42	12
CoG over waterline	30	28	26	9
Seat height over waterline	11	9	11	N/A

Table 1. Sample boat data.

Hum, not what was expected. Note that in both loaded racing boats the CoG is well over the MC, indicating that the boats are unstable. The Mondego on the other hand has the CoG well below the MC making it statically stable. Mondegos are easy to scull with the blades off the water, even by complete beginners. The eight measured is considered a straightforward boat to sit for normal club crews.

The case of the empty scull makes sense as a check on the method, given that the MC is likely to be an overestimate. This particular boat will sit flat when empty, but if I add a PaceCoach (look it up: bigger and heavier than the current NK StrokeCoach or SpeedCoach) to a bracket over the feet it will then fall over to either side, it has lost stability. The unloaded CoG is that close to the unloaded MC.

So where does that leave us?

- The classic ship theory covers the Mondego OK, and I suspect most traditional / trek / beginner type boats.
- The classic ship theory is accurate for racing boats without the crew on board.
- The classic ship theory is inadequate to explain how the racing eight or scull can be "sat" with the crew on board.

On The Stability Of Punts

Following the odd result for racing boats I plugged in some numbers for a punt as an example of a wide flat boat with an obviously high CoG. I found that the MC was still only 60cm or so above the waterline. The CoG of a human is about 100cm up from the feet. Even with a heavy punt that makes combined CoG of about 80cm+ above the waterline with the punter standing on the deck (Cambridge style). How is it possible to pole one of these things along without capsizing?

The answer seems to be that we are not dealing with a rigid system.

As I recollect when you first try to stand up in a punt you generally get a load of wild oscillations, which usually go away as you learn to relax and let the boat move freely under your feet. The boat hull now balances. What I think has happened from a mechanical point of view is that the boat sees your weight acting somewhere between your feet but exerting no turning moments, i.e. as far as the hull is concerned your weight is at deck level, which is well below the MC. So the hull is happy. You maintain your balance on top of the hull by VERY gentle differential pressure on your feet (there is some stability reserve) and by using the pressure of the pole against the water and river bottom, i.e. by using a load path external to the hull to help manipulate your mass.

The critical points about "punt stability" are:

- There is an active element to the system.
- The active mass may have reference to forces external to the hull.
- The hull is stable provided that the active mass exerts negligible turning moments on it.
- Looking again at Table 1 we see that the MC for the eight falls just above seat height. So if you can sit without disturbing the hull in any way, the hull might be stable (just!). Sharing your weight between your feet and your backside will lower your apparent weight in the boat which helps to improve things. More stable eight designs could well get the MC higher up.

Looking at some example cases for racing boats where the MC is just above the seat and ignoring the weight of the boat:

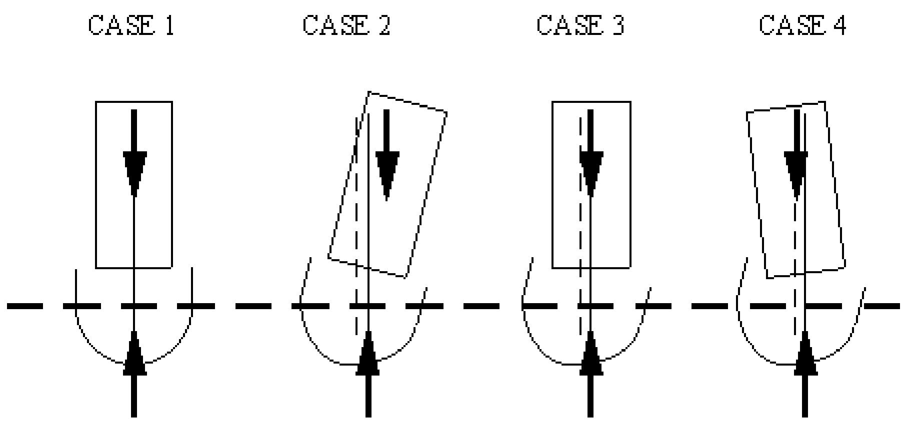

Figure 2. "Punt Stability", a system with one degree of freedom.

CASE 1. Everything is vertical. If the crew is rigid in the boat, the system is unstably balanced, i.e. it will fall over if disturbed in any way. If the crew is flexible, the hull has a chance to "sit" properly.

CASE 2. Rigid crew off vertical. CoG over MC, classic ship analysis, roll over time.

CASE 3. Boat tilted but crew CoG over CoB. From the crew's point of view they are leaning out of the boat. If the crew sits rigidly this is the same as case 1 with an unflat hull. If the crew is flexible the hull is stable, but will remain tilted over. Look or feel familiar? If the MC is lower in the boat the CoB will act along the dotted line and we still have case 2.

CASE 4. Boat tilted and crew leaning further over. With a high MC the boat will now tend to fall back if the crews sits rigidly (at last!). With a lower MC the CoB acts along the dotted line and we have case 3 again, the hull is not flat and the crew is hanging out, but the situation is in equilibrium.

Although crews go on about boats not being "balanced", in fact they usually do have the blades off the water most of the time. This implies that the combined CoG is roughly over the CoB, i.e. we have case 3. In other words the boat is balanced in the sense that forces are more or less in equilibrium, but it is not flat, one rigger is up and may stay up.

"Punt stability" seems to be an improved explanation in that it provides some insights that match common rowing experience:

- No racing rowing boat is statically stable if the crew sits rigidly in the boat. It will always tend to fall over.
- Large racing boats may just have static "punt stability" if the crew can "sit" the boat. It is probable that no fine scull can be "sat" statically.
- It is all a bit marginal. At best any static self-righting forces in racing boats will be small. The boat has no strong intrinsic tendency to sit flat. The forces the crew exert are large enough to "sit" it at any angle.
- The system is counter-intuitive. If a racing boat is more or less balanced and the crew or cox consistently lean slightly out of the boat, the "wrong" riggers will tend to come up and stay up.

Obviously from a static point of view if you hang out far enough you can force the hull down, but the transient forces required to get your body leant over and to recover it afterwards will cause further problems in turn. Such transient forces will tend to increase the tilt in the short term. Counter-intuitive again.

In practice there is no sudden loss of stability as the MC drops towards seat height. Boats get progressively harder to control, demanding more "feel" from their crews.

Hull Shapes

At this point a digression to see how various geometric shapes look in the light of static stability and punt stability. Considering various parallel sections corresponding to the middle of a four or eight:

- The sections have the same carrying power i.e. the same cross sectional area as the real eight.
- Realistic waterline width of about 50cm used to set geometric triangle.

- Seat height taken as 10cm over the water.

	Real Eight	Semi-circle	4:1 Rectangle	3:1 Rectangle	Triangle	Parabolic	Parabolic
Waterline/draught ratio	3.3:1	2:1	4:1	3:1	1.6:1	3:1	2:1
Waterline width	56.8	44.2	55.5	48.1	50	58.7	48.1
CoB below waterline	7.44	9.35	6.95	8	10.3	7.82	9.6
BG (MC over CoB)	19.8	9.35	18.5	12.1	13.5	21.9	12.1
Metacentre (MC) over waterline	12.4	0	11.6	4.1	3.2	14.1	2.5
Metacentre over seat	3.2	-10	1.6	-6	-7	4.1	-7.5
Surface area (cm^2)	9490	9026	10842	10400	10322	9558	9313
Surface area (% of semi-circle)	105	100	120	115	114	106	103

Table 2. Sample section data for sections of 770 sqcm

Notes on hull shapes:

- The semi-circle is the most unstable shape, but has the lowest wetted area.
- The flat bottomed rectangular shapes are both narrower than the real eight and have less stability for a greater surface area. A flat bottom as such is no indicator of stability.
- The pure triangle is quite unstable and has a large wetted area.
- The 3:1 flat parabolic shape, gives quite a flat curve and a wide waterline and is the most stable shape and at 106% has only slightly more wetted area than the real eight.
- The deep 2:1 parabolic shape, possibly similar to some coxless fours, is narrow with low stability and has low wetted area.
- The real eight appears to be a compromise to give a high water line width and hence some extra stability with modest extra wetted area (105%). See below for other reasons why there may be a trade-off in hull shape against wetted area.

Dynamic Stability

It is a common experience that moving boats are generally easier to sit flat than static ones. Think what happens when you easy at speed. This suggests that there can be significant dynamic self righting forces acting on the hull.

Such a consideration would not be meaningful in the case of most vessels as the relative size of dynamic forces to static forces are small and that adequate stability when stationary is absolutely vital (e.g. when loading cargo). This is perhaps why this type of analysis tends not to appear in the ship stability sections of fluid mechanics textbooks. In the case of racing boats the opposite is true: we do not really care if they are unstable at rest (as they can be satisfactorily controlled by the oars resting on the water), just so long as we can keep them near enough flat when in motion. Racing boats are sufficiently light and responsive that small dynamic forces can have an appreciable effect.

Consider the eight in Table 1 travelling at 5m/s (1:40 split). With a frontal area of 0.077sqm this gives approx. 400 kg of water displaced a second (or about a ton a stroke...). Admittedly most of the water flow is pulled out of the way by the standing wave system, but it will give rise to significant forces caused by momentum change of the order 100s of N normal to the skin of the hull. In particular the flat V shape of the bottom between the bows and the shoulders will produce righting moments in much the same way that they do in motor boats at speed. Note that a planing boat is not supporting its weight by sitting in solid water, so the normal buoyancy stuff does not act, it depends on manipulating the flow of moving water for stability. See figure 3. In the case of a non-planing boat such as a racing rowing boat these forces are in addition to the static buoyancy righting effects considered above.

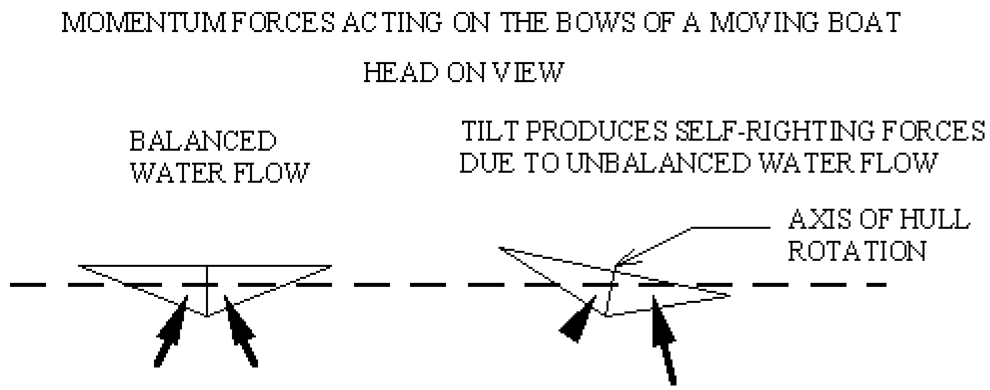

Figure 3. Self-righting forces on V section moving hull.

I suspect that other features of the hull shape such as camber and flat bottoms have similar effects, especially when the boat is at speed with the bows up and hull slightly inclined to the flow of water.

Points about dynamic stability:

- It depends on the boat moving. The forces involved are not massive and decrease with falling speed, vanishing when the boat is stopped.
- It is a property of the 3D hull shape and its interaction with the water flow. It may also depend on the attitude of the boat in the water (bows up or not). The closer the boat is to semi-circular form, the smaller these forces will be.
- It will tend to make the hull sit exactly flat.
- Not all boats have it. Try as I might I cannot detect it in my scull, however all eights I have rowed in have it.

Oars and Hand Heights

The oars in the gates are the other point of contact between the rower and the hull.

The weight of the oars is carried out on the riggers, which gives them a large lever to work on the hull. The oars are waggled up and down each stroke to get them in and out of the water which produces significant transient forces up and down on the riggers. Any out of balance motion between the actions of the oars on each side will tend to roll the hull.

There is a twist to do with changes in hand heights. If one side is up and the rowers on that side lift their hands, then they will temporarily reduce the vertical load down on the rigger and thus tend to make the hull roll up further. Similarly if the other side drop their hands, they will tend to push the riggers down. Even if the crew does not lift or drop their hands during the recovery when the boat is not flat, they will have to do so at the catch in order to reach the water, giving that nasty extra little lurch just before the catch. This is a positive feedback situation. Always unhelpful in dynamic systems.

The oars also allow the rower to exert vertical forces on the water independent of the hull, via blade and shaft buoyancy, the pitch in the blades and perhaps other factors. When the oars are in the water if you are gentle you can force the hull flat and correct your body position ready for the next stroke.

Points about oars and hand heights:

- Significant transient rolling forces can be exerted by the oars on the hull. Symmetry is the only way to reduce the disturbance. Lighter oars or sculls help too.
- Adjusting oars via hand heights can only produce transient forces, they cannot fix a permanent loss of flatness, although obviously they can be used to counteract it temporarily each stroke.
- Hand motion in response to roll of the hull can produce positive feedback, the hull tends to roll more if you try and keep the blades at the same height off the water.
- The oars can be used to force the hull flat during the drive.

Skimming Blades Along The Water

The practice of recovering your blades by dragging them lightly along the water surface is known by various names. It is mainly associated with singles and pairs, especially in the early stages of learning to scull. It is obvious that if you drag one blade along the water lightly some of the weight is taken by the spoon and it will reduce the weight acting down on the rigger. Hence that side of the hull will tend to come up. If you lift your hand further you can actively push down on the water. By exact hand control you can scull a boat dead flat this way.

During the recovery if the blades are off the water you will get a small aerodynamic lift force acting on the spoon due to the angle of attack of the spoon on the feather. If the spoon is very close to the water you seem to get a "ground effect" enhanced lift similar to that experienced by aircraft operating very close to the ground. This has been measured, it is not much, but it is there. The closer you get to the water the greater the lift and that side of the boat tends to rise, a nice negative feedback system that gives a reduced version of skimming along the water without actually having to touch the surface.

I think that this is why it is easier to scull neatly on dead flat water with a light head breeze. You can keep the blades off the water, or touch only briefly occasionally, and still get assistance from the unweighting of the riggers to make the boat conform to your hand heights. I suspect that waves break up the "ground effect" and force you to recover higher anyway. Paddling with square blades cuts off this assistance completely which I think is why it is such a pain in singles. It may also explain why scullers are reluctant to square very early.

Is seems to me as a general observation that the smaller the boat, the closer to the water the rowers recover their blades. This seems to me to be evidence that this is a significant effect. I don't think that it is just nervousness or laziness, I think it is done unconsciously because it makes the boat easier to control.

Note that crew boats require you to get the spoons right off the water to clear the puddles coming down from rowers behind you, hence this strategy is not available. Which may be why crew boats tend to be built with more basic stability to compensate.

Points about skimming the water on the recovery:

- It is a very powerful effect due to the leverage of the oars.
- It can be done by touching the water or by flying very close to it.
- The bad news is that in poor water conditions you have to manage without it.
- Crews have to get over puddles during the recovery and cannot use it. Skimming may only be of use to singles and pairs.

Body Inertia

OK, so how can you balance a single in choppy water if you can't skim the water, the boat has no static stability at all and there does not appear to be any dynamic self-righting effects? The answer as I see it is that you don't balance it as such. What you do is hold it approximately flat during the recovery; that is all that is necessary. The more skilled you are the better the approximation.

Basically if you set the boat up at the finish and swing straight down the hull, your upper torso is not going anywhere very quickly and its inertia can be used as a reference point to sit the boat flat by controlling the hips, feet and hands. The low rolling resistance of sculls means that you do not have to do much to achieve flatness.

This is a bit like walking: the system is not truly balanced, it is a series of controlled falls. The key point is that the sculler has reference to the water during the drive to control the body in preparation for the next recovery.

Points about body inertia control:

- It does not require the rower to have any fancy reaction times. You assert what you consider to be level, you do not wait for the boat to flop then try and correct it.
- There is not necessarily any stable point for the hull to return to, the hull can be set at any angle arbitrarily.
- The hull of a single may have systematic wriggles during each stroke, usually at the cross-over in the power phase. Photos and video shows that even some world champions do this under race pressure.
- Symmetry and a good set at the finish help a lot.
- The higher the rate, the easier it is because there is less time for things to fall over.

Hierarchy Of Control

Summarising the above into a hierarchy we get Table 3. Depending on the level of stability offered by the boat, different control techniques can be used to keep the boat flat. I suspect that beginners in crew boats might tend to learn these skills more or less in the sequence shown in the table. Scullers would do it differently (don't they always?).

	Mondego	Eight	Single
Static stability	yes	no	no
Punt stability	yes	(yes)	no
Dynamic self-levelling	yes	yes	(yes)
Affected by oars	yes	yes	yes
Skimming recovery	yes	no	yes
Body inertia	yes	yes	yes

Table 3. Hierarchy of control techniques workable in different boat types.

Points to note:

- Not all boats will respond to all the skills. Beginners boats have more basic stability, finer boats demand more refined skills.
- Generally scullers require the more advanced skills, however they may not be able to co-operate to sit a big crew boat.
- A sculler that depends on skimming during the recovery may not be able to sit anything else.

PART 2 – SUMMARY / CONCLUSIONS

To summarise the main conclusions from Part 1 in no particular order:

- No racing rowing boat is statically stable with the crew rigid in the boat and the oars off the water. Not even close, stationary or moving. Unstable systems always fall over in the real world.
- If the crew know how to "sit" a boat, some of the large boats may just be stable when stationary via "punt stability". No small boats are.
- It is possible for a skilled crew to "sit" most running crew boats flat using dynamic self-righting forces if there is sufficient speed. As the speed drops off at some point the system becomes unstable.
- Small boats are never stable, they can at best be held flat by skimming the blades and/or body inertia.
- Flatness and balance are two slightly different issues. It is possible to have a balanced boat that is not flat. Likewise it is possible to have a flat boat that is not truly balanced in the sense of being in static equilibrium. Rowers care about flatness.
- You cannot correct a consistently off-flat racing boat by permanently leaning slightly sideways to the uphill side, it will tend to reinforce the tilt, not reduce it. The system is counter-intuitive. Note however that stable beginners boats will respond to this treatment.

- Lifting or dropping the hands during the recovery to keep the blades at a constant height off the water with a non-flat boat tends to make it even less flat. The system has positive feedback.
- Some racing boats will sit flat on the water when empty, some will not. I believe that it is of little relevance to the behaviour of the boat when loaded. A shell with a crew on board is a completely different animal to an empty one. Telling a crew that the boat sits flat when empty and that it will continue to be flat if they do not upset it is untrue, once the crew is on board the system is no longer stable.
- Not all boats work the same. See Table 3 above. Just because an exercise can be done in an eight does not automatically mean that it is a good idea for all other boats.
- There is a hierarchy of skills used to control different boats. Not all skills will work on all boats.

Some of the above may be news to some people, I make no apologies if they are all obvious. Checking around among members of Furnivall Sculling Club during the preparation of this article it became apparent that people have quite widely different ideas about whether boats are stable or not, what causes it, how to balance boats in practice and whether all boats work the same or not.

As far as I can see the classic coaching points that most people trot out are unchanged by this analysis, but the reasons behind them and how they might be presented to a crew may be affected.

Suggestions might include:

- Coaches and coxes should accept that loaded shells are generally unstable when stationary or moving slowly. There is little point in trying to make a crew sit an "easied" boat once it has stopped or flopped over. It teaches the wrong methods to control the boat (leaning over then jerking the hips sideways is the usual approach) and makes the crew anxious when they cannot achieve the (usually) impossible. To avoid abuse perhaps it might be best to make it a rule that the "drop" always follows the "easy" after 2-3 seconds. The marker of excellence is to see how cleanly and flat the boat runs away before the "drop", not how long before it falls over.
- On the whole once you are past the absolute beginner stage most moving boats are roughly balanced, what they are not is exactly flat. Recognise that the natural human reactions to loss of flatness (to lean sideways or to lift or lower the hands) will make the problem worse, not better, the system is counter-intuitive. Calls to "press the riggers down" I think have much the same effect. I don't think that suggesting that the crew lean downhill will work either! What the crew needs to learn is that in eights the moving hull will sort itself out and that to "sit" the boat they have to let it do it via "punt stability" and dynamic forces. Smaller boats require more advanced skills.
- "Sitting" a boat is a positive skill, not just an absence of objectionable stroke features. I believe that the ability to "sit" a boat may turn out to be actually harder to learn in fours and eights as the actions of other rowers will mask your own feedback. Perhaps the quickest way for rowers to learn the skill is to practice in a playboat, Mondego or similar and focus on the skill they are trying to achieve. Fine sculls and restricted sculls should be avoided for this exercise as they have their own problems.
- Coxes should be encouraged to wedge themselves firmly into the middle of the boat and to let the crew sit it. Leaning consistently to the uphill side has the same effects as rowers leaning out. It works against you. Note that a skilled crew should be able to cope with a slow lean made while the blades are in the water to be able to look ahead, with unskilled crews you still need to look ahead, so tough!

- Beginner boats have reserves of static stability that allow beginners to learn the stroke without having to be magically able to "sit" the boat first (a real catch 22 situation). As you move towards finer and smaller boats they are not just less stable, but the type of instability changes and new control methods need to be learnt. To tell a crew of beginners that they "ought" to be able to sit a stable clinker eight is one thing, to tell them the same thing about a fine hand-me-down plastic item is another.
- If you want beginner scullers to start off paddling square blades then you must give them a statically stable boat to do it in. In particular restricted sculls are not stable enough. While it may be ultimately possible to start this way for kids, hours of misery and frustration are more likely with adults.
- Do not tell beginner scullers in restricted or fine boats that skimming their blades along the water is "wrong" and that they will go to sculling hell forever if they do it. It is a natural learning step. I think that advanced scullers never really stop doing it, they just refine it and get their blades off the water most of the time. Likewise for pairs. Oddly enough doubles for some reason don't seem to need it so much.

Questions & (Possible) Answers

Why are racing boats so marginal for stability?

> They are the product of evolution. It was found that finer boats went faster. As they got thinner the best rowers or scullers could still learn to control them, just. The first formal analysis of ship stability was done in the 1870's by Mr Froude (he of the Froude number) for the Royal Navy after some new battleships capsized unexpectedly. The outrigged fine shell was developed in the 1840s and 1850s, they didn't know it couldn't be done, so they did it!
>
> (NB Of course people have known about ship stability for thousands of years, especially for sailing ships and how to correctly ballast them, the perils of shifting cargos, etc. They just did not have the formal predictive mathematical model.)

Why worry about balance and stability, surely the crew correct the balance all the time?

> If you consider that the reaction time to produce a large action in response to unexpected events is of the order of half a second to a second then it is hard to see how reactive type control alone looks after flatness during a recovery that lasts less than a second at racing speeds. I think that flatness needs to be asserted via some combination of hull stability and technique.
>
> Of course the crew have to (try and) fix any major disturbances in the boat as they arise.
>
> If you look at eights that flop over when going through launch washes, it seems to me that often it is more the crews reaction to the wash that causes the boat to flop, rather than the impact of the wash itself. The counter-intuitive nature of the beast bites back, which to me does not auger well for the idea of reactive control.

If both sides row exactly the same then surely the boat will sit in any case?

> Not so in racing boats. They are not stable. If the boat is exactly upright and the crew exactly symmetrical that is not enough to ensure that the situation continues. The slightest disturbance (the proverbial butterfly landing on a rigger) will cause the boat to inevitably fall

over. You then have to correct the imbalance and return it to the symmetrical position, in other words you still have to be able to "sit" the boat. On the other hand a basically symmetrical crew will do less to upset the boat, making the job much easier. In statically stable beginner boats simple symmetry is enough, the boat does the rest.

My coach says I should press my rigger down when it comes up, you say that it might be counter-productive, what gives?

To press hard on a rigger usually means that you lean slightly out to that side to apply the force. The static analysis above shows that for racing boats consistent leaning will simply exacerbate a consistent lack of flatness. If a boat has lurched over for some reason you can force it back towards flat by leaning over then tweaking your hips. If this lurch happens all the time then doing the tweak all the time is just papering over the problem, the problem is why it goes off flat in the first place.

Gentle pressure against the rigger does allow the rower to control their upper body laterally relative to the boat and stop the rower flopping around which can be a problem in itself. In particular lateral pressure does tend to reduce leaning away from the rigger at the finish. In either case suggesting pressure on the rigger may help a lack of flatness problem. Note also that stable training boats do respond as expected to leaning.

Confused?

Does a bigger fin help?

Bigger fins will damp the rolling of the hull slightly, but they will not correct any loss of balance or flatness. Likewise I don't think full length keels help balance as such, but they are associated with wider more stable (less unstable) boats.

Fins are there to keep the boat pointing straight. If you have problems with excessive steering corrections when going straight then that may tend to throw the balance off, so fitting a bigger fin may help indirectly by reducing steering inputs.

I know it can be done, so why all the analysis stuff?

Some rowers need some sort of reasonable explanation to help the learning process (or at least an absence of wrong explanations that get in the way). Too many engineers, accountants, medics and computer programmers I suppose. I know it helps me. If you find it useful, fine. If you "just do it", then I am surprised that you have read this far.

Balance seems to me to be one of the black magic areas, I have not come across any complete or compelling explanation either verbally or in the literature. I have heard explanations of balance and how to achieve it which are just plain wrong. I have also seen coaches and coxes asking crews to do what I now believe to be the impossible, this is likely to produce frustration and loss of confidence.

Perhaps this analysis may help.

So how do I know that you have a better theory?

You don't. Nor do I for that matter. Please take all the above with a pinch of salt. Test it to see if it seems right to you before taking it for granted. Time will tell.

(2013 – seems to have survived the test of time, not everyone agrees, but basically OK.)

So why are Furnivall Sculling Club boats not balanced any better than anyone else's?

Even if the above analysis turns out to be correct, there are no magic solutions. You still need to learn to "sit" the boat properly. At best I hope to make the learning process a little shorter and clearer.

My crew can sit a V hulled coxless four dead flat with the blades off the water for ten minutes every time when it is stopped in a heavy chop with a gusty cross wind. What are you on about?

Good for you.

What do you mean by "balance"?

To most people in normal life the term "balanced" means to be in stable equilibrium. This is the sense that I have generally used in this article. However it also has the sense of something being actively held in place, which is perhaps closer to the mark for rowing. I suspect that some rowers get confused a little by the terminology because they are expecting a balance (passive static equilibrium) that will never happen in most racing boats.

It also happens that a boat can look flat and steady enough from the outside but it feels twitchy and uncertain from the inside so the coach thinks it is balanced, but the crew do not.

Were club boats really more stable in the past?

I think so. Certainly the clinker eights I learnt to row in were more stable than current plastic boats. As far as fine shells go two tangible bits of evidence I have come across recently support this idea. The cross section for the winning Oxford blue boat of 1901 shown in G.C.Bourne's "A Textbook of Oarsmanship" looks very broad and flat bottomed by today's standards. Remember that this was not too far off the era when successful Oxbridge crews might go to the Olympics. Recently (1996) we had a clear out of old wooden shells from the rafters of the Furnivall Sculling Club boathouse. Many of these boats would again be considered quite flat bottomed and broad by modern standards.

It might be that in days when eights were made by local builders in practice the designs offered would tend to favour user-friendliness. Builders would not want to cultivate a reputation for making boats that were difficult to row. Nowadays boats are moulded rather than built in the round and there is the temptation is to buy boats that come from the same mould as world championship winners.

Obviously if you have no choice about your boat you can get beginners going by doing a lot of paddling bow four/stern four. However this does result in less effective use of water time and cold crews.

I was told that my oar was like a high-wire balancing pole, why do you suggest holding it still?

> As I see it the mechanisms for balance on a high wire are different to a racing boat so the analogy is suspect. High wire artists ultimately maintain balance by moving their feet from side to side. The pole simply slows up the counter rotation of the upper body. (High wire artists please feel free to correct me on this.) If you watch a wire walker without a pole there seems to be a lot of arm waggling to produce the same effect. Boats do not allow you to move your backside sideways. Oars do act as balance poles in that they have a lot of rotational inertia and can produce relatively large forces at the rigger for little motion, which may be the point of the analogy. As noted above waggling oars around is liable to produce positive feedback, which is not a good idea to encourage.

So are heavy or light oars better for balancing a fine shell?

> Pass. Personally I prefer ultra-lights for sculling, but I think that this is because my hand control is a bit erratic so lighter blades reduce the disturbing impulses on the hull as I thrash around. If you have good hand control, heavier blades will increase the resistance of the hull to rolling, which might help you in rougher water and make the hull feel firmer.

What happens to stability in rough water?

> In addition to the obvious wave impacts on the side of the hull, I think that the circular currents making up big waves will produce uneven self-righting forces on the hull. I suspect that in really poor conditions any dynamic self-righting properties of the hull can be swamped out altogether. Obviously the bigger the boat the worse things have to get to upset the hull.
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> Note also that twitches in the hull, especially in singles, can lead to over control by the rower introducing further problems. Personally I have trouble with this one: trying to relax helps, but I have found no simple answer.