<u>Some Thoughts on the Yuloh</u>

Introduction.

Shortly after I was pressed into the job of R & D Secretary of the JRA I received a number of mails which included references to using the yuloh on a cruising yacht instead of having an engine. These came from those who were using them on their own boats or from friends who were cruising in company with other who were using them. As I have always been interested in rowing dinghies and single oar sculling I also found the idea of using a yuloh fascinating but have never found evidence of satisfactory performance being achieved by westerners.

Every mention was followed up to see what could be learned about the various experiences. All involved seemed enthusiastic yet none seemed to be achieving the performance that was reputed to be achieved in China and Japan. All reported that they could move their boats, but that they could only move them slowly and that it was very tiring to do. It did not seem to be practical to use a yuloh over anything other than a fairly short distance. This did not tie up with the information form the eastern world.

A thorough web search did produce quite a few references to the western use of sculling oars, but the available information seemed to mix western ideas with eastern and none of them seemed to achieve the full potential performance. This led me into a more detailed analysis of the information and resulted in the writing of the article 'Some Thoughts on the Yuloh' which included a couple of 'recipes' on how to 'bake' a yuloh.

This article was passed to a few people who were known to be using yulohs to see how it compared with their experiences. Some of them experimented with some of the ideas and a couple actually used the recipes to make a new yuloh. In all cases they reported a gain in performance, and there were even reports that suggested that the performance was approaching that achieved in eastern countries. It appears that the suggestions in the article are going in the right direction and that a westerner can produce a practical yuloh as a replacement for an engine in a small to reasonable sized cruising boat.

Of all the people who have experimented with the yuloh, Robert (Bob) Groves has gone out of his way to report his progress, which is great benefit to all interested parties. Initially he reported, *"We have sailed Easy Go with only a sculling oar/yuloh as our secondary propulsion for more than two years now. With some modifications suggested by Slieve it has reached its maximum thrust which pushes our 10 ton junk rigged dory at about 2 knots.*" Later he reported, *"We are taking a break in Agadir, Morocco and I took the opportunity to change our oar to flat side up and make a handle about 8 in long perpendicular to the main shaft extending towards the deck.* (Which has the same effect as fitting a bend above the pivot). *In one word the change in power, WOW. At the dock the power transmitted via the blade is now exponentially more powerful. The blade is bending, large whirlpools are created and surface disturbance is two boat lengths from the stern."*

In a further report to me he said, *"I finally built the yuloh for Easy Go using your "Yuloh Recipe". It is very powerful and well balanced. It is built of Nova Scotia black spruce that I bought from a farmer. He had cut if for barn board siding but felt it was too good for that as it was virtually clear. This made the weight of a twenty foot oar manageable. I find that it floats a bit so will add some weight to the tip to get it too stay down.*

We have it all figured out now. It propels the boat very powerfully and one needs to resist the desire to push too hard as it only makes it expends more effort with little result. My standing position is under the arch and as it is mounted on the port side I am using the rope in my right hand with the left providing minimal assistance. Following the "recipe" has provided a unit that I don't think can be improved on.

The blade floats a bit as did our original sculling oar. When I start sculling I support the yuloh with my left hand and within two strokes of gradually increasing pressure the yuloh stays down and goes into propulsion mode. When one stops sculling it rises to the surface where it rides or can be lifted clear of the water and remain on the pin until one puts it back on deck."

Bob eventually wrote his own article on the yuloh he now uses on his boat Easy Go, and included details of the recipe he actually followed. It is well worth reading.

The pages that follow are my original article called "Some Thoughts on the Yuloh". It was originally published in the JRA Newsletter No. 54 and the AYRS magazine Catalyst. There has been some positive feedback in both cases.

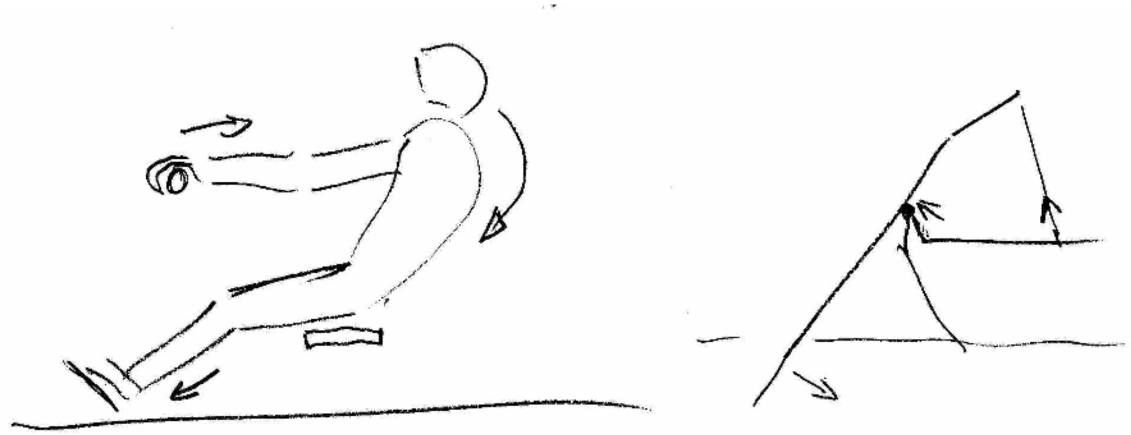
Some Thought on the Yuloh.

Get a group of technically minded sailing enthusiasts together for an evening and the probability is that the Chinese Yuloh will get a mention. Where they all will be interested, probably none will have practical experience but will have heard that a Chinese lady with child or grandchild slung on her back can propel a 2 to 3 tonne sampan at up to 3 knots for prolonged periods. A quick search of the web will show that a few westerners have tried to use home made yulohs but have not achieved such significant performance, and have found it very tiring to use. The question is – could the quoted performance be realistic and if so, is it possible for a westerner to build and use a Yuloh and achieves this performance?

Many are aware that the Yuloh from China and the similar Ro from Japan have been used through out the south and eastern coasts of Asia as the basic form of manual propulsion for small to medium sized vessels. In its basic form the yuloh is an oar used for sculling over the stern of a vessel. By making a bend in the loom and attaching it to the boat with a lanyard from the end of the loom it seems to have developed into a remarkably efficient device.

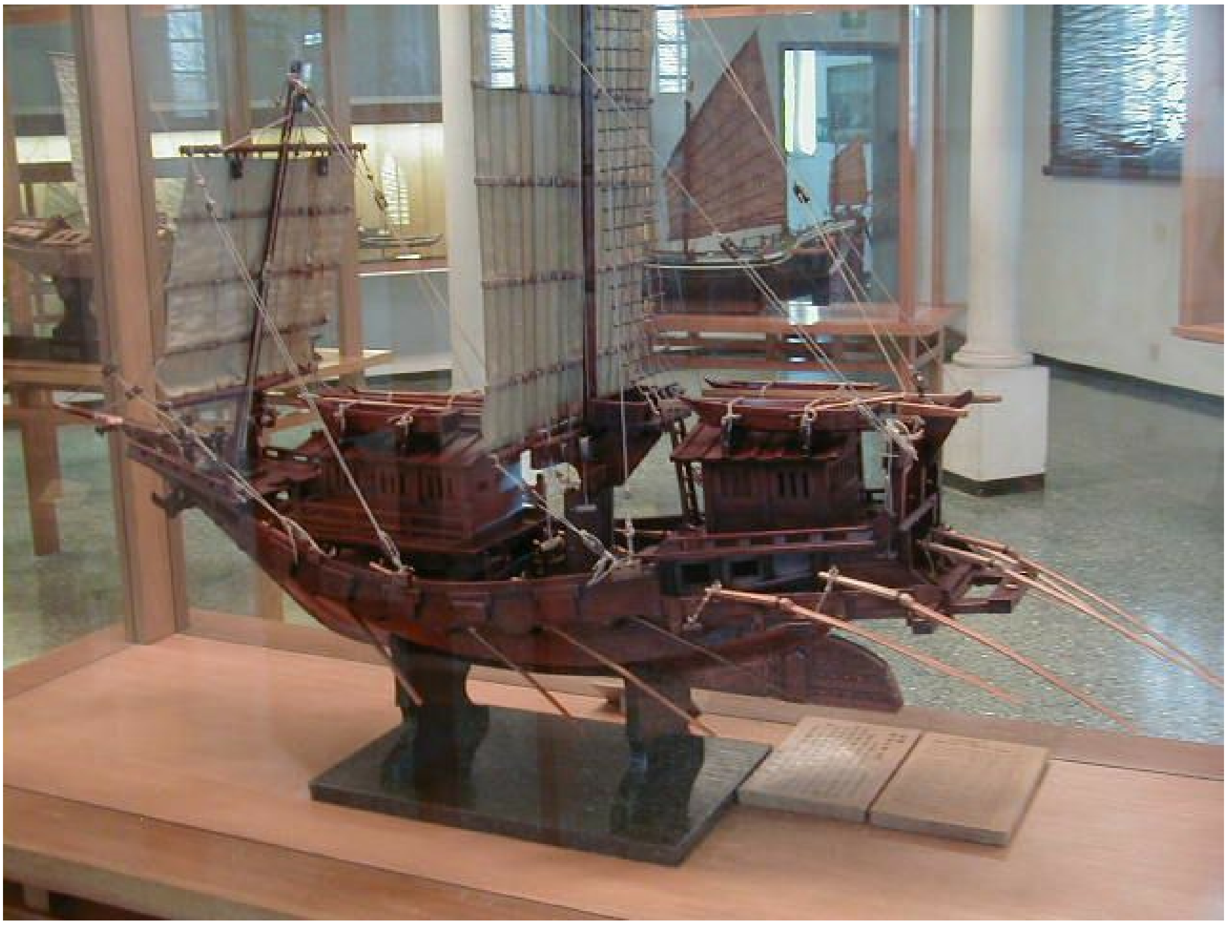
The yuloh generates forward thrust by slicing through the water from side to side, like an oscillating propeller which changes pitch as it rotates each way. The operator only providing the energy to overcome the drag of the foil, the inertia of the yuloh and the effort required to twist the blade to the required angle. The thrust or lift produced by the blade is transferred to the boat through the fulcrum and the lanyard and does not stress the operator. Each stroke, left to right and right to left is a power stroke and no energy is wasted on a recovery stroke, and therefore the thrust is effectively continuous.

On the other hand, in rowing the stroke is made by dragging the stalled blade through the water. The total force of the drag is supplied by the operator as he uses his lower arm muscles to grip the loom with his fingers, pulls with his arms, and using his back and legs the boat is propelled by the reaction at the rowlocks and the foot stretcher, with all the propulsive force going through the rower's body. The stroke is followed by lifting the blade out of the water for the recovery to the start position which although it requires less energy it imparts no drive to the boat, and may even suffer from air drag if the rower does not feather the blade.



Comparing the hydrodynamic performance of the oar to the yuloh is similar to comparing the paddle steamer to a propeller driven vessel, and it is well documented that the propeller is more efficient than the paddle wheel. This would suggest that the basic action of using the yuloh should require significantly less effort than using oars to produce the same work.

The yuloh seems to have other advantages, in that not only does the operator face forward but he can work in waters little wider than the beam of the vessel.



The picture is of a model displayed in the most interesting collection of 24 model junks in the Naval History Museum at the Arsenal in Venice. This would seem to be an extreme example of the use of the yuloh. The other photographs are also from the museum.

A search on the web on the subject shows one or two references to the writings of G.R.G. Worcester book, Junks and Sampans of the Yangtze, or drawings of the Japanese Ro, however the majority of the available information tends to be based on western sculling or attempts to make bent sculling oars which produce relatively low performance, and which tire the operator very quickly. None of the western experiments seem to be able to reproduce the performance reputed to be achieved in the eastern world.

So how can the mythical little old lady with the child on her back produce significant work output over long periods with a low calorie input? Having a child on her back may help with domestic responsibilities, but it may even be that the extra weight assists in the work of propelling the boat. It would seem that the yuloh is a very refined tool and the operating technique must make the most efficient use of its properties. It would seem that the reported western efforts have missed the finer points of design and operation.

Perhaps the best starting point to make an efficient yuloh would seem to be to go back to the original reports by G.R.G. Worcester. In his book he initially shows one yuloh in detail which has a downwards curve above the fulcrum and an upwards curve below. This is the only drawing showing the upwards curve and at a guess this could be to allow it to be used in shallow water. The other yulohs he draws are either straight or with a bend/ angle positioned above the fulcrum, and these latter would appear to be the most likely to produce the efficiency which it is desirable to achieve.

To aim for maximum efficiency it would seem reasonable to tailor the physical properties (length, balance, bend position and angle and blade profile) to suit the vessel and the operator, and even consider adapting the vessel to assist the operator perform the work with the minimum of effort.

The bend.

Although westerners have sculled with straight oars through out the ages, it is the bend that is unique to the eastern system. If there is no bend the operator will have to use his or her wrists to twist the blade to the desired angle for each stroke, reversing it at the end of each sweep. This will use the lower arm muscles which are not the most powerful in the body and which will tire the operator. By including a downwards bend the yuloh will automatically twist in the correct direction for the blade to produce drive. The position of the bend seems to have a big effect on the overall performance.

If the bend is centred on the fulcrum the tip of the loom will use a large proportion of the stroke while the blade swings round to change angle. This could waste up to half the stroke and produce negligible drive.

If the bend is placed just above the waterline less of the stroke will still be wasted in changing pitch. Although apparently more efficient than at the fulcrum, there is still waste effort, and the blade will always try to turn to the same angle on every stroke. The yuloher will have to use his grip and lower arm muscles to vary the pitch angle for differing conditions.

By placing the bend above the fulcrum and just below the hand on the loom the effort used to push the loom will all be used for drive, assuming the initial effort is with the hand on the lanyard is applied first to twist the blade. This position also allows the yuloher to control the pitch angle of the blade by varying the ratio and timing of effort with each arm. With a good technique and experience the yuloher can easily match the blade angle/ pitch to the requirements, eg. Light lanyard effort for fine pitch to acceleration from rest or into strong wind/ waves or by leading heavily with the lanyard, coarse pitch for cruise speed after the acceleration stage.

The actual position of the bend would seem to depend on the size of vessel and the size of the yuloher. For a large vessel is appears that the yuloher has the aft hand just above the bend about shoulder height and aft of his/ her body with the forward hand on the lanyard across the chest and forward of the body. The tip of the loom will probably be level with the top of the head or slightly higher. With the bend just aft of the aft hand then by only using the aft hand the blade would receive a slight twist and give the minimum drive liable to be required, and to keep the blade pressing down into the water and unto the fulcrum.

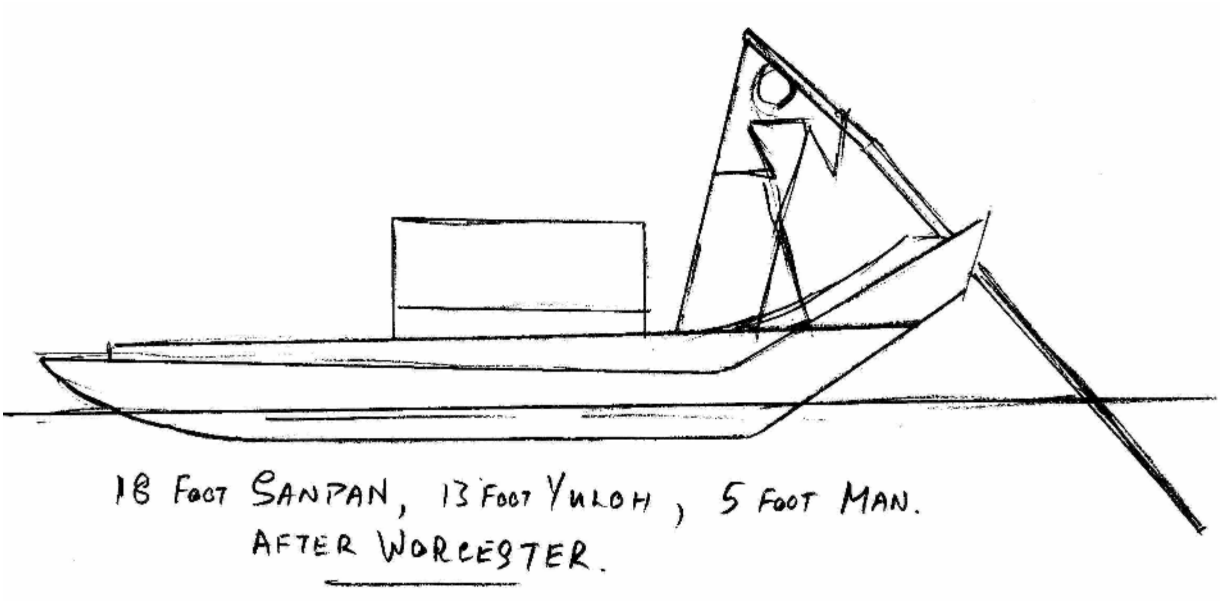
The angle of the bend will depend on two features. The maximum speed will dictate the maximum blade angel, and the way the lanyard is attached to the loom combined with the bend will dictate the amount of twist imparted. If the lanyard is tied round the loom then the bend angle will control the twist, but if the lanyard is tied to an eye which is screwed into the underside of the loom then the effective angle will be from the bend to the eye where the lanyard is tied. This would suggest that to use an adjustable length eye under the loom would be a good way to experiment with or tune the yuloh for efficiency. Could it be that by using 3 pieces of wood lashed together to form the angle that the Chinese did adjust each yuloh to the usual yuloher on each vessel?

The lanyard would seem to be attached close to the tip of the loom, and to slope forward at an angle of about 14º to the vertical from top to bottom. The lower end seems to be attached to the vessel at about the level of the yuloher's feet.

The photographs of the harbour sampans show the elevated position of the yuloher and the raised transom to support the fulcrum. It is not a large heavy vessel, so the yuloh does not extend to above head height.

Length.

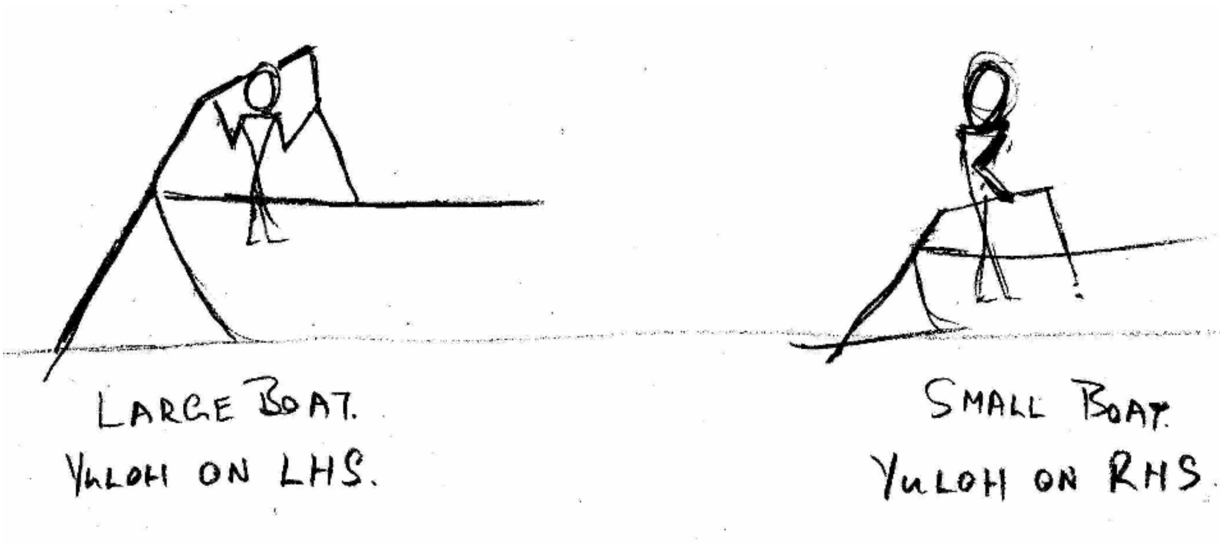
The overall length of each yuloh would seem to be tied to the length and design of the vessel. All indications seem to suggest the length of a traditional yuloh is normally <u>over</u> 50% of the length of the vessel, and as the vessel gets smaller the percentage increases to up to about 90% for vessels 3 metres long. Yuloh propelled harbour sampans seem to have a raised after deck for the yuloher to stand on and also a raised transom to mount the fulcrum on. Worcester suggests a stroke rate of about 41 per minute to be reasonable for a sampan, therefore to get effective drive the yuloh needs to be quite long with the yuloher raised above water level. We generally accept that a larger diameter slower revving propeller is more efficient than a smaller one.
This would suggest that for efficiency a westerner should raise the operator and fulcrum to accommodate the desired length of yuloh, and not just accept the low level cockpit sole.



Fulcrum.
As a fulcrum Worcester reported that the Chinese used an iron pin with a small ball end attached to the transom, and inlay a hardwood block with a cut out into the lower surface of the yuloh as a socket. When worn the hardwood block could be changed. On larger load carrying vessels the hardwood block can be quite long with a number of sockets distributed along the length. Worcester suggested that this would allow the yuloh to be adjusted for different heights of cargo and different waterline levels. This suggests that the trim of the vessel and the yuloh have to be right to gain best efficiency.

Many westerners seem to use a towing ball as a fulcrum, though the standard 25 mm ball is quite large and a hole of that size would weaken the shaft significantly. It may be possible to find an adequately strong towing ball from a bicycle shop nearer 15mm diameter.

From Worcester's diagrams it seem that on large heavy vessels the fulcrum is placed to the left of the centre line, and on small punts on the right hand side of the centreline. This may be that as the majority of Chinese are right handed they use the left hand on the loom and the right hand across the chest on the lanyard when propelling a heavy vessel, but for a small light one the yuloh is not high enough so they possibly only use one hand, the right hand, below waist level and move the hand fore or aft on the loom to vary the blade pitch from fine to coarse.



A couple of simple experiments to try now.
Stand up, and imagine a line on the floor to be the centre line of your vessel. Place your feet on either side of the line just over shoulder width apart and with the right foot forward such that the line joining the feet is at 45 degrees to the centre line. (If you are left handed reverse all lefts and rights). Imagine the yuloh to be on you left hand side and raise your left hand to hook it over the yuloh at shoulder level. Raise your right hand to a high waist level and grasp the imaginary lanyard in front of you. Remember that the lanyard is tensioned between a point at your foot level and the tip of the loom above your head. Using a relaxed upright stance, start to sway from side to side across the centre line at a stroke rate of about 40 per minute, which is a sway from left to right and back again in 1.5 seconds. Lead the change of direction with the lanyard hand.

If you imagine you are trying to propel a heavy vessel, but trying to use minimum effort you should realise that you can effectively lean on the yuloh and use it as a support. Adjust your stance to get the most relaxed position. You should notice that you will be using the larger muscle groups in a fairly relaxed way, and that the main effort going into the stroke will be coming from your weight swaying from side to side. It should become evident that, once you are used to the action that it should be possible to continue for long periods without getting overly tired. It would seem ideal to place the bend about 30 cm behind your left hand.

Now repeat the experiment, but with the yuloh much lower, so that the left hand is at waist level and the lanyard hand lower. By not standing upright the action will become tiring very quickly. This seems to be the situation with most of the existing western experiments where the yuloh is shorter and does not extend above the yuloher's head.

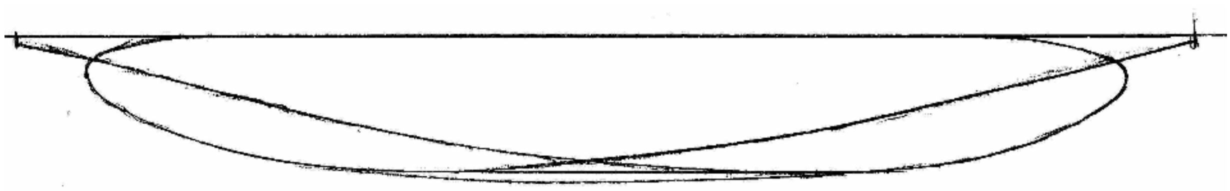
As a second experiment, imagine you are in a 3 metre light weight punt. Stand astride with you feet at right angles to the centre line. Let you right arm hang down by your side, and start to swing it out and in to the side as if you are 'swinging' the yuloh from side to side. This should be the 'fine pitch' position, with the bend just a short distance behind the hand. As speed increased and you want more twist, move your hand forward and upward on your imaginary yuloh and continue to stroke from side to side. Again you should see that this is a simple relaxed way to propel you vessel.

These simple experiments should help to give an idea of how to use a well proportioned yuloh with minimum exertion.

Blade profile.
As the yuloher is pushing the blade from side to side he is only overcoming the drag of the blade. The lift, or forward thrust is generated by the shape of the blade. Therefore it is important to use a blade shape to which gives the best lift/ drag ratio.

Western attempts to make sculling oars seem to be based on the oars used in the Bahamas, where the underside of the blade is generally flat and the top of the blade curved. With a straight oar this blade shape naturally wants to twist in the required direction for forward thrust, and reducing the wrist effort required from the oarsman. If cambered on the bottom and flat on top the blade will try to twist the wrong way, and will require additional effort from the oarsman.

As shown above, the bend in the yuloh takes care of the twisting of the blade for each stroke allowing the blade profile to be optimised for maximum forward thrust for minimum drag on the yuloher. For best lift/ drag an asymmetric cross section with the camber on the lower/ forward face would seem best. A Lift/Drag ratio of 6:1 should have 50% more drive force than a L/D of 4:1 for the same effort and although these figures are a pure guess they do show that getting the optimum section would seem to be the key to getting the remarkable performance mentioned earlier. The problem is that at the end of each stroke the trailing edge becomes the leading edge for the return stroke, so the section has to be symmetrical end to end.

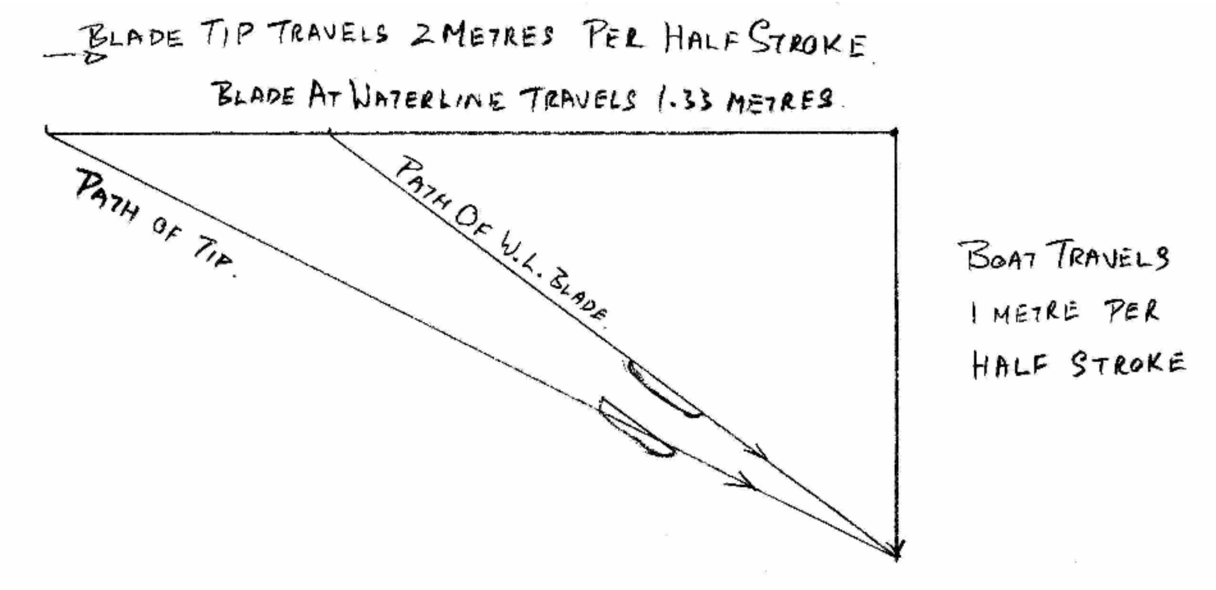


The diagram above is simply the Clark Y section and mirror image superimposed in an effort to draw a two way section to give a downward force. (The only lifting foil that requires a leading edge at both ends that easily comes to mind is the Frisbee, which might be a good starting point). A compromise would have to be reached to combine hydrodynamic efficiency and mechanical strength. Ease of manufacture must also be considered.

Clearly putting the camber on the top surface is similar to flying an aircraft with a Clark Y section inverted which is well known to be so inefficient that some such aircraft cannot maintain level flight when inverted.

As the blade is operating as a foil and not as a stalled surface, it would seem that the blade could be quite wide near the tip, possibly at about 4 – 5% of the length, but the following paragraph may suggest a rethink of these figures.

A further 'refinement' which may be worth considering, and possibly improve the performance would be to vary the section along the length of the immersed blade. A propeller blade has a twist built in along its length to optimise the pitch angle. As the yuloh sweeps in both directions the blade cannot be twisted, but it may be possible to adjust the cross section along the length in an effort to optimise the angle of attack of the leading edge. The diagram below is based on best guess for a 5 metre yuloh at 41 strokes per minute (82 half strokes / min) (Worcester) and a vessel speed of 2.5 kts.



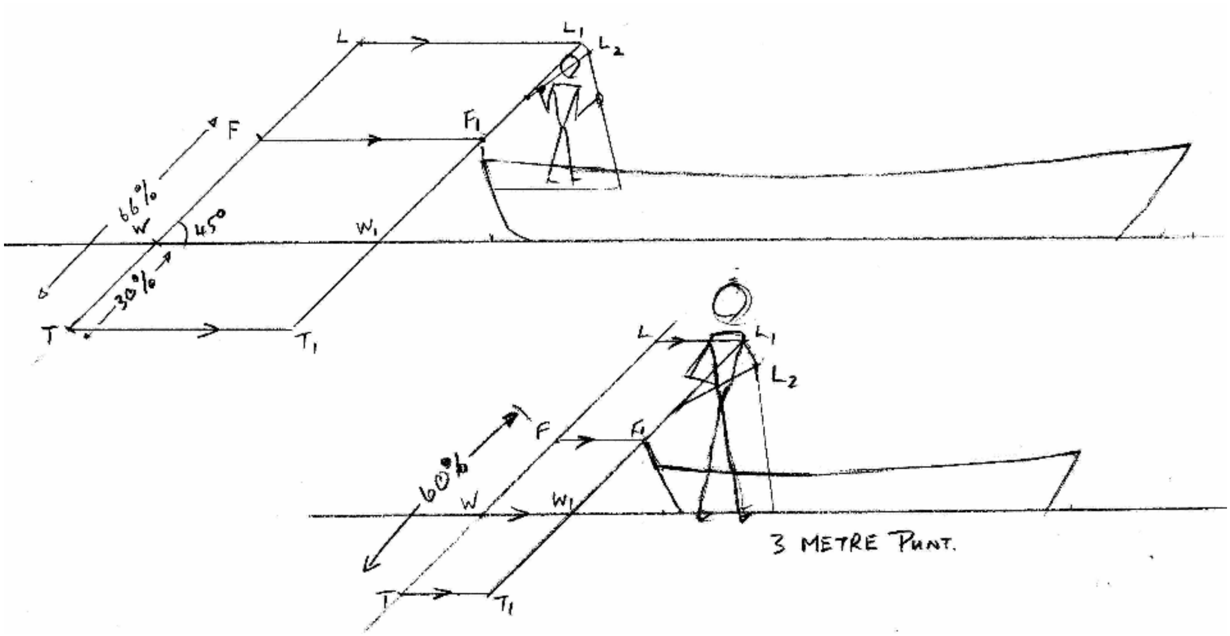
This would seem to suggest that the section near the tip could benefit from being flat closer to the leading edges (or even slightly under cambered on the top surface) than the section near the waterline. At the quoted speeds the angle of attack would seem to differ by about 12° over the length of the immersed blade. The section near the waterline would naturally tend to be thicker and possibly narrower for practical mechanical reasons. This is one area which would benefit from a more detailed study.

All the above would seem to suggest that with a well designed set up, as seems to have evolved in the eastern world, that the yuloh can be a very efficient device. The following is a suggested list of actions which should result in a well proportioned yuloh.

Recipe for a Yuloh for a large vessel.
The following is one suggested way to design a yuloh.

1. Make a scale drawing of the side elevation of the hull.
2. Draw a line at 45º clear astern of the hull. T – W – F – L.
3. Make the line 60% of the hull length, such that the bottom mark (T) is 30% of the length below the waterline, and L is 70% of the length above W.
4. Mark point F (fulcrum) 66% up from the bottom.
5. Transfer the line forward to the hull to position F_1 over the transom. This should be the desired position of the fulcrum.
6. Draw in the yuloher to scale, and adjust his/her position so that the tip of the loom (unbent) is above their head. This should indicate the level of the platform they should ideally stand on, and may be at cockpit seat level rather than at the cockpit sole level.
7. Mark the bend point a short distance below the yuloher's aft hand and just below the level of his shoulder, and draw in the upper section of the loom bent forward some 9 to 10º to get L_2.
8. Draw in the lanyard from the tip of the loom sloping forward some 14º to the level of the yuloher's feet.
9. You now have the general setup, and have to decide on the blade width and cross section which may vary from near the tip to near the waterline.

10. A reasonable starting width for the blade of a large vessel would be about 4% of the yuloh length at the tip, tapering in a straight line to 3% of the length at the waterline, and 0.4% of the length thick at the tip increasing to about 0.8%L thick at the waterline.
11. Make sure the blade is cambered with well rounded edges on the lower surface, and flat on the top surface if not slightly concaved near the tip.



Recipe of a Yuloh for a small vessel.
Similarly draw a diagram for short light weight dinghies or punts, but this time draw in the yuloher using an under arm action, and adjust the proportions to a length of about 90% of the boat length, and place the fulcrum about 60% up from the tip. As you will only be using one hand and not be working the lanyard with your other hand, then it would seem advisable to increase the bend angle to almost 20º when drawing L_1 to L_2, so that you can control the twist simply by moving the hand forward or aft on the loom. You may find it desirable to raise the fulcrum slightly above the edge of the transom on a normal western dinghy/ punt.

Worcester reports that the Chinese sometimes strengthen the tip with an iron band, which also helps to keep the tip under water when not in use.

Conclusion.
It would appear that western attempts at making yulohs with the bend designed to stow neatly around the gunwale and not designed for easiest use are not ideal, and by not placing the camber on the lower surface cannot achieve high efficiency. They do not encourage good use of the lanyard and good technique. It would appear to be pointless to make the shorter length yulohs used in most western attempts which do not encourage a relaxed stance. If the design can be optimised and the technique learnt then it may be possible for a westerner to compete with the little lady with the (grand) child slung on her back to produce good performance for long periods.

The author would like to receive constructive comments on the above, and any reports of recent experience on the use of yulohs at slieve@onetel.com (but he does not want to receive anymore 'junk mail').