Sea Blades: Fashion or Function?

Greenland narrow blades compared with European wide blades

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For hundreds of years serious sea kayakers of the Aleutian Islands and Greenland have used unfeathered narrow blades as tools upon which their livelihood depended. This article explains why.

Fig. 1 Conventional modern paddles and Greenland style narrow blades.

Narrow blade Greenland style paddles are very different from modern recreational kayak paddles (Fig. 1). Stated simply, wide blade paddles are *power* efficient with a single gear while narrow blade paddles are *energy* efficient with a variable gear and are less tiring on the muscles.

The Inuit designs show advantages in respect of ;

Windage,

Gearing,

Stroking,

Torsion,

Muscle fatigue, (& tendon strain reduction)

- and are possibly more

Energy efficient (more kilometres to the Mars bar !).

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History and purpose

In order to understand the reasoning for the design features of narrow blades it is important to realise the differences in requirements between modern recreational sea kayaking and the Inuit use of kayaks as hunting tools. Inuit paddles are the result of a continuous pressure over more than a millennium to evolve a tool most suited to long duration and bad weather paddling. Sea worthiness and survival were the paramount needs but speed was also important too, in hunting chases. Paddling each day for several days or weeks and for long distances created the need for an *energy efficient* design and one that would be less tiring on the muscles as well as being predictable in response when used in an emergency. These aims are achieved with a long narrow blade. Only in recent years has the sea worthiness of Greenland designs begun to be appreciated by the wider kayaking public particularly in the U.S.A.

In contrast modern (European) paddles evolved from English Victorian origins as wide blades at the ends of the loom or shaft used on inland waters and especially rivers. At first the blades were in the same plane, an orientation known as ‘unfeathered’. Probably the earliest in the U.K. the Clyde Canoe Club adopted feathered paddles in the 1870's (D.Winning O.B.E. pers. comm). This gives an advantage in a headwind and in racing, as the blade in the air is presented edge on to forward progress. Short duration racing and recreational touring constituted the modern use of kayaks. Only in racing and competition was there a pressure to evolve more efficient designs of paddle to produce more *power efficiency* from each stroke and in recent years the wing paddle is one design that has emerged to meet this need (Foster 1996).

There are a significant number of old Inuit paddles in museums around the world that exhibit a variety of blade shapes and lengths and many have been surveyed e.g. Brand 1984 & Ferris 2000. At first it was assumed by Europeans that the Inuit made long, thin–bladed paddles because of the shape of wood available i.e. driftwood logs. It is technically more difficult to make a wide blade from a single piece of wood but the Inuit had that capability and in a few cases made wide-blade paddles e.g. North Alaska Nunamiut kayak & Copper Eskimo kayak, (Zimmerly 1984). The majority of Inuit paddles are also made with both blades in the same plane while modern recreational paddles are ‘feathered’ and have one blade set at between 60° and 90° to the other.

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Windage

Wind more than sea state is the principal problem kayakers face at sea. Beam (side) winds and gusting winds are especially troublesome. In practice, European feathered paddles describe an arc through the air with each stroke. The blade rotates in the air during this arc to present a flat side at the apex of the stroke to any beam wind. This results in maximum pressure on the blade and leverage on the paddle from the beam wind as the blade is high and also at an acute angle, causing wind pressure to induce lifting forces. Consequently the kayaker using a European style paddle has to have a firm grip on the upside part of the shaft and have tensed arm muscles to control the blade in the air.

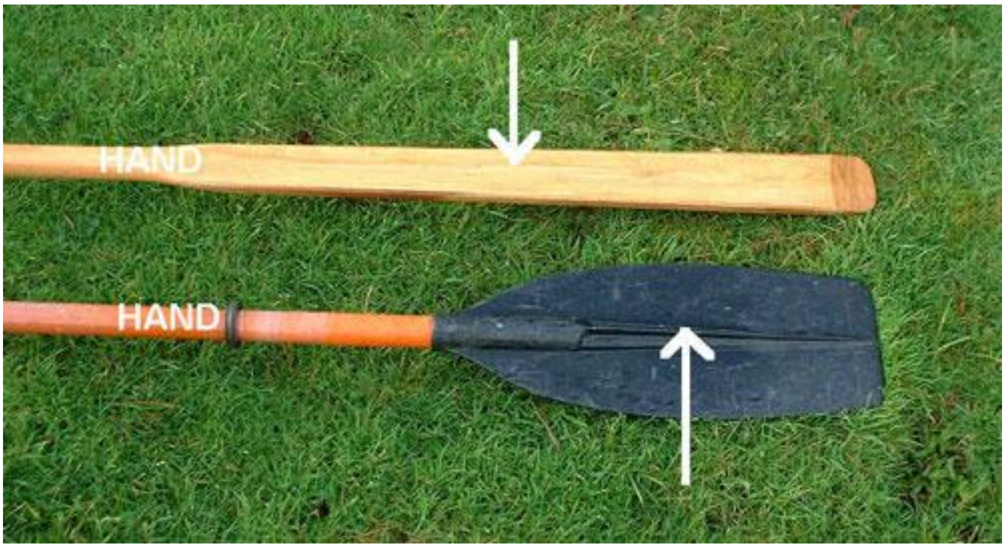

Fig. 2 Narrow blade and European flat blade. The centre of force of the wind on the wide, flat blade is farther from the paddler's hand grip creating more leverage.

In practice these wind effects start to become a problem for even experienced kayakers at Beaufort Force 5. At stronger wind speeds it can be a real fight in beam winds to maintain control of the blade in the air, especially on the upwind side. In contrast, the Inuit narrow blades are unfeathered (both parallel to each other) so that the blade in the air presents an edge to any beam wind. In practice these paddles are unaffected by strong beam winds. They are also not as affected by head winds as might be supposed because the centre of effort of the wind is several tens of centimetres closer to the paddler’s grip and there is less leverage compared to a European blade at the end of a shaft (Fig. 2) .

The absence of any significant wind effect on the unfeathered narrow blade in the air, is one of the principal advantages of Greenland style blades.

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Gearing

There is no uncertainty about the superior versatility of the narrow blade in that it provides the paddler with a variable gear. A low gear (with high stroke rate) is achieved by submerging only a part of the narrow blade in the water with each stroke. A ‘normal’ cruising gear results from submerging all of the blade and the ‘high’ gear from creating the maximum lever by using a full sliding stroke where the stroke rate may be as low as 40 per minute. The modern European paddle does not have a blade shape, weight distribution or loom, designed for a sliding stroke, and therefore can only be described as a power efficient paddle having a single gear.

Stroking

Vortex shedding; If a flat blade is held and drawn through the water with the blade face at 90° to the direction of pull, water flow is induced across the blade face splitting in the middle and spilling over to create a vortex behind each edge. In practice these vortices are not balanced and one comes to build and dominate. This induces a lower pressure on that side and causes the blade to slip sideways towards the larger vortex. As soon as this happens the relative speed of the water across each half of the blade face, reverses, so that the larger induced vortex declines while the smaller vortex at the other side increases, causing the blade to reverse and slip in the opposite direction

In practice, the effect is that the paddle "wiggles", "zig-zags" or "flutters" in the water during the stroke. This is especially noticeable when accelerating. Standing on solid ground and passing the paddle through a water trough can simulate the equivalent experience of accelerating the kayak (Heath 1986).

Forward stroke; Zig-zagging of the paddle can be greatly reduced and the ‘grip’ of the blade in the water noticeably improved if the blade is presented at an angle at the start of the stroke (Heath 2000).

The angle causes the blade to dive under the water surface, a phenomenon known to canoeists as "slicing". Water is flowing in only one direction across the entire face of the blade. Used in this style the blade is drawn back past the paddler as far as is comfortable, at which point it is at the correct angle for a smooth exit. The blade angle enables the paddle to leave the water quickly and easily, an aspect Heath reported was important to modern Greenlanders to help free the blade for the return phase (Heath 2000).

When used in a ‘power’ mode of stroking, the style becomes more of a vertical stroke close to the kayak. Brian Day provides an excellent description of the versatility of Greenland paddling and the variety of bracing and rolling strokes which are possible (Day, 2000).

Conventional, contemporary thinking for the European paddle is that little propulsion results from that part of the stroke aft of the paddler and modern teaching encourages paddlers to end the stroke when the paddle is level with the canoeist’s hip (Train 1990).

There are a number of possible effects that might operate in the aft part of a stroke to aid propulsion. The first is that the blade angle is such that applied pressure results in a force with a downward component depressing the kayak in the water (Stamer 2000). Once the blade exits, the kayak rises, returning the energy to forward motion, possibly by helping the bow rise over the bow-wave created by the first part of the stroke. The second effect may be that the water is compressed between the blade and the side of the kayak at the end of the stroke and thus forced aft in a weak propulsive jet. Published accounts of Greenland strokes suggest that propulsion also results from the active lift of the paddle at the end of a stroke when the top edge of the blade is angled forward. Any or all of these effects may operate but no detailed analyses have been published to date.

Smoothness of thrust; Another factor is the degree to which the kayak is accelerated with each stroke. Every kayak has an optimum cruising speed above which the energy required for faster travel increases exponentially as the craft builds up a bow wave. The European paddle causes a rapid acceleration and the kayak decelerates before the next stroke. It may be that the narrow blade supplies a smoother delivery of thrust thus conserving momentum by reducing the acceleration and deceleration and this could represent a substantial energy saving. There is an analogy here with carrying of loads on land. In a study of African women carrying 60 lb loads on their heads (c27.3 Kg) it was found they used 20% less energy compared with figures for European soldiers carrying the same weight as a backpack. The most likely explanation is that the women use the flexibility of their backs and legs to smooth out the rise and fall of the loads with each step. Loads carried as backpacks, because they rest on the shoulders and hips, rise and fall with each step, requiring energy each time, which can be considerable by the end of a day's walk.

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Torsion

Forward stroking with the paddle held at a shallow angle to the water surface is one of the versatile properties of Inuit narrow blades. However, with European wide blades this style of paddling is more difficult because as the blade enters the water, pressure is at first unequal on each side and torsional forces are induced which require a firm grip to control so that the style is uncomfortable.

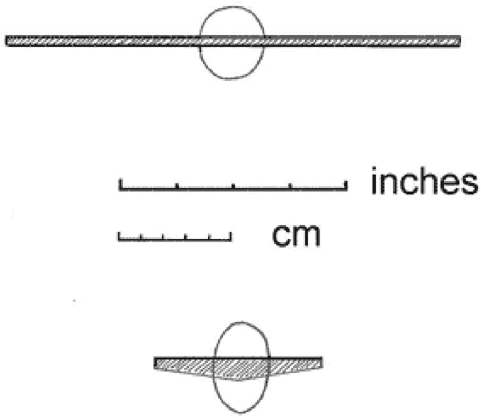

Fig. 3 Cross-section comparison between European flat blade and narrow blade showing round and oval looms respectively.

Being narrow (Fig. 3), torsional forces on the Inuit blade are slight and easily controlled as the ends of the blade are held with the last three fingers in the normal style of stroking. In the sliding stroke style, the hand in the air grips the top and bottom edges of the blade thus easily controlling any twisting For this reason also, bracing and rolling strokes are easier to perform with a narrow blade.

Tendon strains; These differences mean that narrow blades can be used with a much looser grip on the paddle than European blades. In windy conditions this difference in performance becomes more pronounced and the extra grip required to control European blades coupled with the need to twist the feathered paddle are the two main reasons why wrist tendon strains (tinosynovitis) are experienced (Lamont 1988a).

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Muscle fatigue

Acceleration of muscle fatigue occurs when micro-scale damage is caused to the muscle tissue. A modern, wide blade paddle causes an immediate pressure increase which is the aim of the design – the blade 'sticks' in the water while the kayak moves past it. In contrast when the long narrow blade enters the water at the start of a stroke the pressure increase on the blade is gradual.

When paddling, the muscles of the arms, shoulders and torso are tensed at the start of a stroke. In this condition the sudden increase in pressure from the European paddle creates a mechanical shock which causes micro-scale damage to the tensed muscles (Lamont 1988b). This micro-scale damage is cumulative and makes the muscles feel stiff after a long day's paddle.

The Inuit narrow blade avoids muscle shock because of the gradual pressure increase at the start of a stroke. Modern Inuit who have tried European paddles have been reported to remark that they are "too hard on the arms".

Energy efficiency and Power efficiency

Human muscular activity is similar to mechanical systems such as the internal combustion engine in that optimum power efficiency and optimum energy efficiency do not coincide at the same rate of work. To drive a car from one town to another as *power* efficiently as possible means as fast as possible. All the gears are used and maximum acceleration is employed to reduce the time taken. Fuel consumption is high. To drive the same car as *energy* efficiently as possible between the same two towns requires a different driving technique aimed at using as little fuel as possible. This distinction between power and energy efficiency also applies to human muscle but seems to have been ignored in discussions of paddling mechanics e.g. Edwards 1987, Sharp 1986, and the term 'efficiency' can thus sometimes be used ambiguously.

While it is easy to measure energy efficiency with accuracy in mechanical engines it is much more difficult in biological systems. One study in bicycle ergonomics concluded that human muscle operates at optimum ***energy*** efficiency over a broad range around 50 cycles (contraction/relaxation periods) per minute with a small drop in efficiency down to 33 or up to 70 cycles per minute (Whitt & Wilson 1988). In contrast, human muscle maximum ***power*** efficiency (easier to measure) was found to occur at around 80 to 90 cycles per minute. E Greenland Inuit kayakers using narrow blades have been observed to paddle at around 60 strokes per minute using a short sliding stroke. Holding the same short sliding stroke paddle without sliding it, would raise the stroke rate to the order of 80 to 90 strokes per minute or more. Thus, the short sliding stroke paddle is ideally suited to the dual needs of hunting, both when cruising to reach an area and also when sprinting in chasing game.

Wooden paddles are also buoyant, unlike many European blades, so that some or all of the weight of the paddle is supported by the water while stroking (Gronseth 1992).

Another feature, which reduces energy required, is the amount of water lifted by the blade when it exits the water at the end of a stroke. If even only a small amount of water is lifted – say 50 grammes – that has to be put in perspective when it is possible to accumulate twenty thousand strokes in a long day's journey. The 50 grammes adds up to100 kgs lifted perhaps 30 to 40 cm. Lifted water also falls back, making an unwanted splash that could alert game, an obvious disadvantage to Inuit hunters.

Muscle efficiency is only one component of the system involving the propulsion of a kayak. In still water, with no wind, the kayak itself (length and beam dimensions mainly), and the weight, muscular strength and fitness of the paddler are some of the variables which would make it very difficult to measure differences in energy efficiency between Inuit narrow blades and European wide blades.

Traditionally the Inuit paddle was made for each paddler and the width of the loom was adjusted to equal the distance between the bases of the thumbs when the hands are allowed to hang naturally at the sides. This is about the same as the width of the shoulders. A narrow distance between the hands means that each hand is lifted the minimum height when stroking. This represents a considerable energy saving compared to the contemporary European fashion for a wider than shoulder grip with wide-bladed paddles. Standard (British Canoe Union) teaching advocates a wide grip where the forearms are held vertical and the upper arms horizontal (Train, 1990). This is because the wider grip is required for power efficiency in stroking with European paddles, necessary in fast rivers and surf. If a touring kayaker paddles at 50 strokes per minute for a long day of, say, ten hours that represents lifting and lowering the arms perhaps 30,000 times. How much they are lifted by therefore becomes important if longer journeys are undertaken.

The narrow blade Inuit paddle, used in a low swinging style from the shoulder, represents an important saving in energy by avoiding the higher arm lift of the European style. This low angle stroking style is made easier since the Inuit blade is narrow and the torsion forces low.

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Size and length determination

Inuit kayakers made their own paddles and naturally adjusted the dimensions to fit themselves. The traditional Greenland touring length equalled the arm span (fingertip to fingertip with the arms outstretched) plus the distance from elbow to fingertip (Heath 1986&1987). Sometimes this is stated as the height plus elbow to fingertip (in humans, the arm span approximates the height). The short storm paddle developed in South Greenland equalled only the arm span in length. These specifications result in a paddle length which enables the typical Greenland kayak to be propelled at its touring speed with a stroke rate of around 50 to 60 strokes per minute, which is optimum for maximum muscle energy efficiency.

A touring length paddle is not so well suited to use in a fast (sprinting) mode and this could be a disadvantage when chasing game. The Inuit solved this conflict by making the length slightly shorter, an arm span plus elbow to wrist, and using the paddle in a short sliding stroke mode for normal cruising. In this mode the paddle is slid about 150 mm from side to side, making it the equivalent of the touring length. When required for sprinting the grip was held firm (the paddle was not slid from side to side) and a faster stroke rate could be achieved consistent with optimum *power* efficiency contraction rates for human muscle. Modern European recreational needs are not the same, but this is a solution to a design conflict which may have an application in some contemporary circumstances.

Blade width is limited, of course, to what can be comfortably held between the thumb and fingers in order to make a sliding stroke possible.

Measurements; Inuit paddlers made their own paddles to suit their personal measurements. Since Windslicer paddles are hand made it is possible to adjust the critical dimensions to suit each individual kayaker. The measurements required are:

1. the arm span,

2. elbow to wrist,

3. elbow to fingertip,

4. distance between thumb roots - when the hands are allowed to hang naturally at the sides while wearing canoeing clothing. This should be about the same as the width of the shoulders.

5. The final measurements are the height and length of the space encircled when the tips of the first finger and thumb are touching. Some people have significantly larger hands than others and some, especially women paddlers, have smaller hands. These measurements determine the shaft handgrip dimensions. The shaft or loom grip should ‘fill’ the hand.

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