

# **THE EVOLUTION OF THE KAYAK**

## **Raising the Bar in Kayak Design and Performance: New Standards in Kayak Design for the Third Millennium**

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### **Part 1 Traditional vs. Modern Kayaking - From Survival and Utilitarian Use to Recreational Applications**

#### **1. THE ORIGINS OF MODERN KAYAKS**

In the beginning of the twentieth century kayaks were practically unknown to the wide public. They were self designed, hand made personal paddling boats used by native people of the Arctic and Sub-Arctic regions, in Greenland, Canada, Alaska and Siberia, mainly for hunting marine and land animals.

These peoples seldom fished from their kayaks and hardly ever used them for recreation. They preferred to paddle their kayaks in protected waters such as rivers, estuaries and bays, and they neither surfed nor went in whitewater. They obviously didn't paddle standing in their kayaks - although they sometime did so in their Umiaks, which were bigger and wider, multi-passenger canoes.

Native kayaks were not uniform: some were narrow and some not, and while some were over 20 feet long others could be half that length. The common building technique used then is known as 'skin on frame': The builder covered an internal wooden skeleton-like structure with animal skins.

None of those traditional kayaks ever featured a rudder or a seat, or even a backrest, which are all modern additions aimed at solving problems that are characteristic to present days kayakers.

The native people who used narrow kayaks often relied on the 'Eskimo Roll' for recovery, but not always. Some researchers assume that rolling the kayak was practically the only means of survival available to these people who didn't have lightweight watertight suits, because swimming in extremely cold water while wearing heavy fur clothes is a recipe for disaster, and many native people didn't know how to swim.

The wider native kayaks were designed to offer more stability and thereby provide safety through capsizing prevention rather than recovery.

A much less known prehistoric personal paddle craft is the [Caballito de Totorá](#) ('Reed Pony' in Spanish) used by Pre-Columbian fishermen on the Pacific coast of South America. Like the Inuit kayak, this sit-on-top reed watercraft is paddled with a double blade paddle. Its paddleboard design is very much reminding of modern sit-on-top (SOT) kayaks, except for its higher bow designed to go over big waves.

There are similar designs in other ancient cultures around the world as well.

## **2. A BRIEF HISTORY OF KAYAKING AS A SET OF RECREATIONAL ACTIVITIES**

The first popular recreational human-powered boats in North America were round or flat bottomed canoes, skiffs and dinghies propelled by oars or by single-blade (I.E. 'canoe') paddles. As the twentieth century progressed people enjoyed more free time, canoe paddles gradually became more popular than oars, and canoeing became a widely practiced recreational activity.

Canoeing was practiced in combination with fishing, tripping and camping or by itself, and it was performed mostly inland - on fresh water.

After WWII the American public became gradually acquainted with kayaks, but kayaking as a popular set of recreational applications became commercially viable in the early seventies, after manufacturers found ways to use rotational molding for making low cost, durable Polyethylene kayaks.

Around that time some improvements introduced to paddleboards gave birth to the modern sit-on-top (SOT) kayak, which has gradually become very popular in a wide variety of kayaking applications performed mainly in warm climates.

During those decades American society's focus shifted towards the individual, and the kayak fitted the new trend better than the canoe since solo kayaking required less skill and experience than solo canoeing.

Today, in the beginning of the twenty first century, there are some three hundred thousand kayaks produced in North America annually, of which about one hundred thousand are SOTs. There are also one hundred thousand canoes produced every year.

Most contemporary kayaks are rotationally molded from Polyethylene, which is a durable, reliable and relatively inexpensive material compared to hand-laid fiber-reinforced plastics (FRP a.k.a. 'composites') used in smaller production series. Inflatable, canvas (folding) and wooden kayaks are made in limited numbers as well.

Modern kayakers use their kayaks in a much wider range of environments and applications than native kayakers did, and manufacturers offer an increasingly wider range of kayak designs and models.

Fishing from kayaks is becoming popular in recent years, mainly in the sunshine belt states where it is practical to use SOT kayaks. It is considerably less popular in colder climates.

## **Part 2 Design and Manufacturing**

### **1. DESIGN AND MANUFACTURING OF NATIVE KAYAKS**

In the old days, a native of the far North who wanted a kayak for himself would design it according to his personal liking and requirements while relying on his people's oral tradition and advice. He would use materials available locally such as driftwood to make a rigid frame on which he stretched a sealskin cover.

It was the job of the women in this kayaker's family to prepare the skins and sew the cover. The native kayak featured neither hatches nor seat, and it didn't offer support for the kayaker's ankles or feet. No native kayaker ever used a rudder or floatation, and bungee cords as well as Nylon pad eyes were unknown as well.

That is to say that many basic features in traditional-style modern kayaks are the product of the late twentieth century design, and have little to do with the way native kayaks were originally designed, built and used.

### **2. DESIGN AND MANUFACTURING IN THE 20th CENTURY AND BEYOND**

Nowadays, kayak design has become a profession, and kayak designers use Computer Aided Design (CAD) software, often in combination with special kayak design software. There are practically no kayaks today that are designed without a computer being part of the process.

A modern kayak is conceived as a commercial product, that is an object that should be reproduced many times and sold to various customers. As such it is not meant to fit a particular individual but rather a group of customers within a range of physical attributes, skills, requirements and purchasing power. Some manufacturers offer customization of certain features such as accessories and colors, but this service comes with a price.

### **3. DESIGN CONSIDERATIONS**

There is a major difference between native kayaks and modern kayaks in their basic built: Native kayaks had a rigid, internal wooden frame covered with a 'skin'. Such design is no longer in use except for folding kayaks, and nearly all other modern kayaks have an external, rigid skeleton ('shell') that serves a dual purpose and acts as the kayak's 'skin' as well. The introduction of this non-ribbed, simpler design was key in the proliferation of new, mass-produced, low cost and durable kayaks.

Customers' preferred kayaking activity is of critical importance for the designer since modern monohull kayak models are designed for one activity, or a narrow range of activities. The main activity categories are: Whitewater, Touring, 'Recreational' and lately Fishing too.

The whitewater kayak is very short and designed to offer maximum maneuverability. Similar designs are used for kayak surfing.

The Touring kayak design is usually narrow and long, and within this family of designs the sea kayak is longer and narrower. Touring kayaks are faster than other kayak categories. Recreational kayaks constitute the bulk of the market today, and they are characterized by

their higher stability due to their wider beam. These kayaks are seldom outfitted with a spray skirt because it is assumed that most paddlers can't roll their kayaks. Fishing kayaks are basically stabler recreational kayak designs accessorized for fishing that are sold within a higher price bracket. The reason this article mentions the fishing kayak as a separate category is that in recent years kayak fishing is growing in popularity, which reflects people's tendency to prefer stabler models. All monohull kayak designs except whitewater kayaks can be outfitted with a rudder system, and they often are since regardless of their type they all have tracking problems. Another factor that kayak designers bring into consideration is the customers' personal liking in terms of fashion. This goes to colors, materials, forms and accessories. And last but not least, designers and manufactures need to produce products that fit their customers' spending intentions and capabilities. There is no point in offering a cheap and durable Polyethylene kayak to a customer who has already decided to spend more on an expensive yet less durable kayak made from another plastic material reinforced with carbon-fiber or fiberglass (FRP, also called composite plastics)

#### **4. SIT-ON-TOP (SOT) KAYAKS**

Technically speaking, sit-on-top (SOT) kayaks further depart from native designs, as they can no longer be considered as vessels because they don't feature a hollow compartment for the passenger/s. These modern kayaks evolved from paddleboards in the past four decades, and their general form is that of a flat board equipped with a seat and small depressions for the passengers' heels. SOTs have become widely accepted as kayaks since they feature the essential characteristics of modern monohull kayaks (I.E. seat, feet support and double-blade paddle), and they are used for similar recreational activities. There are only few eccentrics left who still think of SOTs as being anything other than kayaks.

#### **5. 'RECREATIONAL VS. 'TOURING' KAYAKS**

The dictionary defines Recreation as "Refreshment of one's mind or body through activity that amuses or stimulates; play". The dictionary also defines Touring as "Travel, as on a bicycle or on skis, for pleasure rather than competition."

In this sense, all Touring kayak models are recreational in a broad sense since kayak touring itself is a recreational activity.

That is to say that the distinction between 'Recreational' and 'Touring' kayaks may be related to certain design characteristics such as width and length, but it is also related to marketing considerations - a process known as 'segmentation'.

## **Part 3 Ergonomics: From a Single, Uncomfortable Position to the Freedom to Choose From a Variety of Ergonomic Positions**

### **1. HOW THE TRADITIONAL, L KAYAKING POSITION CAME TO BE**

The native kayak was a 'man's boat' - that is a hunters' boat. What it practically meant was that the native hunter in his kayak had to approach prey such as swimming caribou, beached seals or certain bird species from the shortest possible range in order to effectively shoot a harpoon or an arrow at them. To remain unnoticed from the shortest range the Inuit kayaker needed to stay low above water. In fact, for whaling and long sea trips the Inuit preferred to use their bigger and stabler canoe-like Umiaks.

Since stealth was important for native kayak hunters they paddled in the low, traditional L kayaking position with their legs stretched forward. People around the world used to sit on the floor in similar postures before nearly everybody adopted special sitting furniture such as stools, benches, chairs, sofas, armchairs and other seats.

The kayak is rather unique boat in this sense since native canoes around the world usually offered additional, more comfortable and powerful positions such as sitting higher, kneeling and standing.

Interestingly, the L is not the only position that monohull kayakers offer: Some whitewater canoeists take kayaks and 'convert' them into 'canoes' just by adding a very low saddle inside their cockpit. This arrangement enables them to kneel inside on both knees in one of the traditional canoe kneeling positions, and paddle with a single-blade paddle (I.E. canoe paddle). The reason why only few paddlers 'convert' kayaks into 'canoes' is because that particular kneeling position is even less comfortable than the traditional L kayaking position, and this may be the reason why some of these canoeists call themselves 'pain boaters'... This leaves modern monohull kayakers with just one position to choose from, and it's not an ergonomic one. That's not much in terms of freedom of choice, especially when one considers the fact that in their everyday life modern kayakers are used to a variety of seats and sitting positions that do not include the L position.

### **2. THE MODERN L KAYAKING POSITION - TRYING TO SOLVE A PROBLEM BY CREATING ANOTHER**

Seats and foot rests (a.k.a. 'foot braces') have altered the L position without improving much: The backrest prevents the kayaker's torso from 'falling' backwards but it makes it slide down and forward. In order to counter affect this problem modern kayakers offer support for the kayaker's feet: By anchoring their feet in those small depressions or 'braces' kayakers can stop their bodies from sliding down and forward.

However, the combined backrest and footrest system created a new problem, which is constant pressure on the kayaker's lower back. This pressure is generated by the kayaker's own legs pushing against both footrests and backrest like a powerful spring. The negative physiological impact of this pressure is felt as fatigue, discomfort in the legs and back pain. The problem is amplified by the kayaker's inability to switch to other positions. Some kayak

seats offer a rigid support for the kayaker's back and other kayak seats offer heavily cushioned support, but four decades of experimentation proved the L position to be an ergonomic dead end.

### **3. BIOMECHANIC ISSUES WITH THE L POSITION**

Our legs have the most powerful muscles in our body and they are naturally best fit to do the hard work involved in locomotion and balance. The L kayaking position prevents paddlers from using their legs effectively for balancing, controlling and propelling their kayaks. Therefore, the kayaker's back, abdomen, shoulders and arms must do considerable extra work. This effort distribution is insensible from a biomechanic standpoint, which means you're spending energy for nothing and get tired more quickly while your kayak delivers less performance than you need.

## **4. VARIATIONS ON THE L POSITION - TRYING TO DEAL WITH A PROBLEM BY CREATING DIFFERENT ONES**

Manufacturers of monohull kayaks who tried to depart from the L position by offering higher seats found that they needed to increase their kayaks' width considerably in order to compensate for raising the paddlers' center of gravity (CG). This was done only to rediscover the fact that excessively wide kayaks track very poorly and are harder to paddle.

## **5. THE NATURAL SOLUTION: THE W KAYAK POSITIONS**

The W departed completely from both the monohull design and the L kayaking position. By offering much better lateral stability and a high saddle the W Kayak has enabled a new set of comfortable positions and a wide range of intermediary positions, as well as the possibility to alter your posture anytime you feel like it.

This is achieved without widening the kayak - In fact, the current W Kayak models are only 25" wide, which is as wide as some sea kayaks are.

The key to improving comfort and performance in paddling and fishing is the new, full role played by your legs: Instead of pushing horizontally against your lower back as they do in the L kayaking position, your legs support your torso vertically - from below, in the W Kayak riding (mounted) position. This is our legs' natural position for locomotion and other major physical efforts. For this reason the W Riding (mounted) position is not only ergonomically better (I.E. more comfortable) but it's also better biomechanically, that is more efficient in effort terms and more effective in performance terms of power output and control level.

The four basic W positions are: Standing, Riding (Mounted) with your legs on both sides of your body, Sitting with your legs forward (similar to sitting in a canoe), and Kneeling - a position preferred by some canoeists.

For more information visit Wavewalk's website [Ergonomics section](#).

## **Part 4 Increased Diversity: The Proliferation of New Kayak Designs**

### **MULTIHULL KAYAKS**

The kayak concept didn't stop broadening with the monohull sit-in and SOT designs: As soon as kayaks started gaining popularity people began experimenting and inventing new configurations and designs that included more than one hull (monohull).

The first multihull kayaks were ordinary monohull models equipped with a single outrigger (Proa style) or with two outriggers (trimaran style). Such outriggers were needed to compensate for the monohull's basic stability deficiency. Lately, outrigger kayaks are regaining popularity among kayak fishermen.

Later, catamaran style kayaks appeared in both sit-in and SOT versions. Inflatable sit-in catamaran kayaks are used for whitewater and fishing, and rigid polyethylene SOT catamaran kayaks were introduced as recreational and fishing kayaks.

The inflatable sit-in designs are not true catamarans but rather wide versions of tunnel-hull kayaks (monohull), and therefore slower than comparable monohulls.

The SOT catamaran kayaks are very wide and therefore harder to paddle than similar size monohull kayaks. They also place the paddlers in the L position much higher than the regular SOT kayak does, which results in increased instability without compensating for it by improving ergonomics or biomechanics.

One can no longer claim today that kayaks are monohull boats - The kayak has evolved into a class of small, personal watercrafts that seem to have two things in common: Paddlers propel them using double blade paddles a.k.a. 'kayak paddles', and more importantly: most people perceive them as kayaks and call them by this name.

And just to be realistic, these days a kayak doesn't necessarily have to be paddled since some kayaks are equipped with electric motors (mainly for trolling), and in some cases even with gas engines.

## **Part 5 Versatility: From Specialized Kayaks to Broad-Range, High Performance Kayaks**

### **1. THE ENVELOPE OF KAYAK DESIGN IN THE MICRONAUTICAL CONTEXT**

Ordinary multihull kayak designs offer increased stability but at a price of reducing speed and mobility, and without improving ergonomics. In this sense those designs didn't really expand the envelope of kayak performance, since the basic tradeoffs that characterized it remained the same.

This multi-dimensional performance envelope was limited by two basic factors: The L kayaking position and the monohull design, and liberating the kayak from the monohull constraint wasn't enough. This is because unlike bigger boats that greatly benefited by the introduction of multi hull designs, kayaks are personal micro-boats, which makes their design primarily a matter of ergonomics and biomechanics before hydrodynamic issues can be considered.

That is to say that kayak design falls under the definition of micronautics - the art and science of designing watercrafts that weigh less than their passengers, and are affected by their physical attributes, athletic skills, performance and behavior more than by anything else.

In this sense even traditional kayaks and canoes have more in common with surfboards, paddleboards and dinghies than they have with big monohull boats of similar hull shape.

### **2. TYPICAL TRADE-OFFS IN TRADITIONAL KAYAK DESIGN**

By 'envelope' we understand a boundary that limits what is possible to achieve. The kayak design envelope is multi dimensional, and each dimension (axis) is a continuum between two contradicting requirements.

The classic contradicting requirements in kayak design are Speed vs. Stability, and Tracking vs. Maneuverability. This double contradiction can be approached as a set of two broader requirements, which are Versatility vs. Performance.

There are other, less important pairs of contradicting requirements such as Durability vs. Weight, and Solo Performance vs. Load Capacity that define the kayak design envelope, but the first two ones are viewed to be the most important ones.

This classic envelope was imposed by the physical attributes of the monohull kayak. This is reflected in the kayak market by the fact that monohull kayak models are typically designed for narrow ranges of applications and users.

Versatility has hardly played a role as a feature because it was technically limited, and interpreted as lackluster performance in specific applications.

For example, a good fishing kayak had to be made as stable as possible, but because of this requirement it couldn't be fast or perform well in the surf.



### **3. VERSATILITY - THE NEW PARADIGM**

'Multi-purpose' kayaks aren't new: Long and slender kayaks known as surf-skis can be used for touring (sea kayaking) as well as for surfing, and wide recreational kayaks can be used for fishing.

The problem with multi-purpose monohull kayaks is that they don't offer high performance in either one or all the applications people use them for.

For example, recreational monohull kayaks and even those of them labeled 'fishing kayaks' are neither stable nor comfortable enough to offer the full range of performance that kayak fishermen can get from the W kayak. Similarly, being very long surf skis aren't well adapted for surf playing, and they certainly don't enable their users to paddle and surf standing.

Since the W kayak is not constrained by the monohull's narrow performance envelope it is the first truly and fully versatile kayak:

It is faster than any monohull kayak of similar size, yet it's stabler than any kayak. It's small and highly maneuverable yet offers more storage space than any kayak. The W is more comfortable than any kayak as well as more mobile than any kayak since you can launch, paddle and beach where other touring kayaks can't go. The W performs well both as a solo and tandem boat, and both double-blade and single-blade paddlers find it to be perfect for them. The W fits big and heavy users, yet it's friendly enough for small children to handle by themselves - even in the surf. And last but not least, the W offers four basic paddling positions including two new ones, plus many intermediary positions.

Interestingly, some people found it hard to believe that any kayak could be that versatile, and they doubted the W's capabilities. Other people who were used to highly specialized kayaks found it difficult to imagine a situation where they would be using the same boat for two different activities (E.G. fishing and touring).

These days more people are willing to question old conventions and accept the fact that paddling and fishing are subject to continuous and sometime substantial progress, like most other technical fields are. Many people now accept the W for what it is, which also means that they evaluate what the W offers relatively to their own, real needs, and even conceive new types of usage.