6.0 general information for beginners

Which is the right boat for me?

Before you can answer this question, there are several things you need to ask yourself:

What is my budget and can I afford more than one boat?

The vast majority of kayakers start with one kayak but after becoming hooked, often end up with a collection of boats, each with a different design purpose and application. It is not uncommon for enthusiast kayakers to end up with 5 or more boats in their collection. It should be pointed out that the majority of kayaks hold their value extremely well. Unlike a high-end mountain bike that could be worth $000's less upon walking out of the showroom, and then require expensive regular maintenance and be worth a fraction of the original purchase price after 3 years, you could reasonably expect that a kayak will last for 10 years or more and require zero or very little maintenance, and still be worth a reasonably high percentage of the original purchase price when you do decide to upgrade.

Any enthusiast kayaker will tell you that "You can never have enough kayaks!"

What type of kayaking will I be doing? eg flat water marathon, flat water sprint, down-river/white water, multi-sport, ocean etc

Many craft these days are quite versatile and have multiple applications, so you need to consider whether you go for the highly specialised craft for one application, or compromise slightly on a craft that can be used for multiple applications.

What is my current skill level and how quickly do I expect my skill level to improve?

It is generally advisable to buy a craft that is marginally above your current skill level, so that you can "grow into it". On the other hand, you may be satisfied to always paddle a more stable, less racey craft.

One of the great advantages of a kayak club (at least in the bigger clubs), is that you will be able to try out a number of different styles of craft and use a boat that you're comfortable with. During your first 12 months of paddling, you may find that you progress rapidly through a range of craft, starting with a very stable TK1 and after 12 months perhaps being comfortable in a tippy K1. So if you have access to a kayak club that has a fleet of club boats, you would be well advised to spend the first few months using those club boats rather than investing in a new boat. After paddling two or three times per week for 3 months, you will have advanced to a level of ability where you may feel ready to buy your own boat. By that time you will also have worked out what type of paddling interests you most and therefore what type of craft to buy.

How much storage space do I have?

Before investing in a 7.3 metre double sea kayak, you'd be well advised to think about where the boat is going to be stored! The options for storage of boats include:

- slung from the beams of a carport/garage – tying rope loops from the beams will allow you to efficiently store your craft. Simply poke the nose of your kayak into the front loop, then hold up the rear of the kayak and use your hand to pull the rear loop over the rear end of the boat.
- stored at a kayak or surf club – close to the water and quite often the most hassle-free means of storing your boat securely and with trouble-free access to the water
- on wooden or metal racks attached to the side of your house or a fence – a quick visit to Bunnings and some basic handyman skills would enable you to construct a sturdy and space-efficient storage system for your kayak collection.

How long is the roof-line of my car?

Unless you have a Fiat Bambino or Smart car, you can more than likely carry a long kayak on your roof without a problem. It goes without saying that the longer the vehicle's roof-line, the more secure your craft will be at higher road speeds. Station wagons are of course perfect but craft of over 6 metres in length are also commonly carried on sedan roofs. A good kayak or outdoors store will carry a range of roof rack systems to suit your particular vehicle.

Where to buy?

Much like a new car, there's nothing quite like the feeling you'll get from taking a shiny new boat out on the water for its maiden voyage. There are many kayak retailers throughout Australia, some have a comprehensive range of new craft in stock, others will carry a small range and take orders. If you want a kayak manufactured in a custom colour or with custom specs, you may need to wait up to 3 months or more depending on the wait list.

If any of the craft reviewed in this document interest you, you can contact the manufacturer/distributor direct to find out the closest place where you can try and/or buy one of these kayaks. Contact details can be found in the table adjacent to the review results for each kayak.

If however you'd prefer to buy second-hand, here are some of the places you can check out:

http://www.rapidascent.com.au

Rapid Ascent has a Trading Post section on their website where you can often find kayaks and skis for sale.

www.ebay.com.au

Buying on e-bay is very simple and reliable, mostly people will allow you to inspect goods prior to bidding, so that you can make sure it's exactly what you want before you bid.

www.geartrade.com.au

Gear Trade is predominantly a surf kayak website with over 50 surf skis usually being advertised at any time, however K1 kayaks have become more common on this site in recent times.

http://members.iinet.com.au/~rokhor/canoe/newsfl.html

If you live in Western Australia, this is the place to look for a 2nd hand kayak or ski. Inter-staters contemplating the legendary Avon Descent white water race would be well advised to consider buying a 2nd hand ski from this site to use for the race. There aren't many people who'll loan you a craft to smash down the grade 3 rapids of the Avon!

http://www.canoe.org.au/classifieds/

Australian Canoeing has a Classifieds section that is split up by State.

Paddles

The key things that buyers should be aware of when buying a paddle are listed below. For competitive kayakers, a more scientific approach would be adopted in consultation with an accredited kayak coach. A more comprehensive review of paddles will be conducted during the next kayak test in 2008.

- For any competitive kayaker, a wing paddle is compulsory equipment. A wing paddle simply means that the blades have a curved lip on the top side to help catch the water during the stroke. Some old school paddlers still swear by flat-blade paddles, and flat-blade paddles are preferred by some top sea kayakers and white water paddlers. Bracing/rolling using a flat-blade paddle is easier than with a wing paddle.
- Construction materials for paddles can include:
  - Aluminium shafts – strong but not flexible, suitable for recreational purposes only
  - Fibreglass shafts
  - Fibreglass/carbon mix shafts
  - Plastic blades – the lightweight plastic blades found on cheap paddles have too much "bend" to be used for any serious racing application
  - Nylon blades – nylon injected blades are cheaper than carbon and far more durable (ie much more resistant to chipping if you hit a submerged object or rock), however the finish is not as smooth
  - Carbon-injected blades
  - Carbon laid-up blades
  - Aluminium tips for blades can help to prevent damage caused by hitting submerged objects or rocks, however they add weight to the paddle
- 2-piece paddles (ie split in the middle to enable portable transport) are becoming more popular, however expect to pay a 10%-20% price premium for this design feature. The added advantage of a split paddle is that you can experiment with different blade offset angles.
- The size of the blade will dictate how much water you are pulling with each stroke. Generally speaking, if you have biceps bigger than the average person's quadriceps, then you would probably favour big bucket-like blades that catch a very large amount of water with each stroke. For paddlers with a less muscular build, using a paddle with large blades could be counter-productive. Many competitive kayakers use smaller blades, the obvious advantages being that you can maintain a higher cadence (ie less drag) and suffer less fatigue.
- Trying to come up with a magic number that represents the shaft length that will be perfect for you is very difficult. The 2008 report will go into this subject in more detail, but in general if you paddle in both flat water and in the ocean and/or white water, you will either need 2 different paddles or a paddle with an adjustable split shaft. Shaft length for ocean/white water paddling will generally be about 5cm shorter than for flat water paddling.
- The offset angle of the blades is a subject that will be covered in more detail in the 2008 report.

If you are a beginner and need assistance in choosing a paddle, there will be

MAGELLAN 2XU ENERVIT ACTIVE NUTRITION KEEN ORIGINAL HYBRID FOOTWEAR AIS UNIVERSITY OF CANBERRA Australian Canoeing rapid ASCENT

someone at a kayak club near you who will be able to help you. A good kayak shop will also be able to assist you.

Australian Canoeing

Australian Canoeing (AC) is the National Organisation responsible for the management, coordination, development and promotion of paddle sports in Australia.

AC is committed to the provision of a high standard of competition, safety, and opportunity for participation in paddle sports in Australia. AC aims to provide all members with fair competition, access to high standard facilities and equity in participation at all levels.

To find out more about paddling and a list of clubs and events near you, go to Australian Canoeing's website:

http://www.canoe.org.au/

In addition, each State has a State kayaking association, you can find links to all the State websites here:

http://www.canoe.org.au/db/state_list.asp

You can search for a club near you by going here:

http://www.canoe.org.au/db/club_list.asp

7.0 speed analysis

by Margi Bohm & Adam Hunter

Introduction

In June 2005, a group of paddlers got together at Geelong Canoe Club on the Barwon River in Victoria to put together some useful information that paddlers can use when thinking about buying a boat (Kayak Test Results, Rapid Ascent at www.rapidascent.com.au) – and settle that long debated topic of which is the best boat! Seventeen boats were tested as to their suitability for long distance paddling that may include flat-water, white water or ocean paddling. The response to this report was enormous, with comments and suggestions from a range of people including paddlers, boat manufacturers and designers and even scientists. It was decided to repeat the experiment in July 2006, at the same location, using a more rigorous experimental method and a much wider range of boats. This report presents the findings from that test.

What did we do differently this time?

In June 2005, we assembled a bunch of paddlers, marked out a 1.4 km out and back course and each paddler paddled as many boats as they could at a "constant" effort, with the speed being recorded for each run. Paddlers used a combination of heart rate and "feel" to attempt to ensure a constant effort. Paddlers also assessed each boat in terms of seating, steering, handling, stability as well as what they did or didn't like about the boat. The June 2005 report presented detailed information on each boat together with a graph of boat speed and a table summarising how people assessed each boat.

In July 2006, we added more boats and paddlers. We also worked closely with University of Canberra, Australian Institute of Sport and ADI Ltd in an effort to improve the quality of the data collected and to address some of the questions raised from the first report. We measured the underwater characteristics of each boat, mounted GPS's (Magellan 400 series) onto each boat, based the testing around randomly selected blocks of random boats which were randomly assigned to paddlers, monitored weather conditions and instrumented two paddlers with sophisticated gear that measured boat performance as well as the forces applied to the paddle. We also tried to monitor if paddler fatigue was an issue.

The course that we used was similar to that used in 2005. GPS data show that the course was 1.239 m in length, including a 3-buoy turn. We measured the time it took for each paddler to complete the course and the time that it took them to paddle around the turn. Each paddler wore a heart rate monitor and was instructed to paddle at the same heart rate. Heart rates were chosen at around 65–75 % of maximum where maximum heart rate = 220 – age. Detailed experimental methods are described in Appendix 1.

We have compiled data for 41 boats (Table 1) and we are able to investigate a variety of interesting questions:

- Comparisons of boat speed on the straight portions of the course;
- Comparisons of turning boat speed;
- The effect of wind on boat speed;
- The effect of fatigue on boat speed;
- Perceptions of each boat;
- Underwater dimensions of each boat.

At a later date, scientists from the University of Canberra and the AIS will publish more detailed information on boat performance and links to paddle force.

Environmental conditions

Testing was conducted on 29th and 30th of July, 2006. We started at 10:20 am each morning and ended at 5:25 pm Saturday and 4:20 pm on Sunday. There was no significant current on the Barwon River during the testing period and temperatures were mild, ranging between 11 and 14 ºC. Both days were characterised by gusty winds; N–NW on Saturday and mainly N on Sunday (Figure 1). Paddlers started the course in generally calm conditions before paddling up the straight with a tail wind, taking the turn in an unprotected area and then paddling against the wind on the way back. Weather details are presented in Appendix 1.

The effect of wind on boat speed

The wind conditions on both Saturday and Sunday were gusty and it is likely that boats paddled during the windy times of the day recorded slower boat speeds than expected. We can investigate this using detailed data from the Magellan GPSs for two boats for Saturday (unfortunately the other GPSs were not set up to measure at a resolution required for this kind of analysis).

On Saturday, boat speeds (km hr-1) were significantly[1] slower on the return leg of the course, i.e., against the wind (Appendix 2.1), with the percent difference between upwind and downwind speeds ranging from 0 % to as much as 25 %. However, there is no apparent relationship between this and wind speed (Figure 2).

1. We use the word "significant" to refer to statistically significant outcomes.

BOAT NAME / MODEL	TYPE OF BOAT
BICSPORT TOBAGO	DOUBLE
CABO XT	DOUBLE
CAPRI	DOUBLE
DOUBLE SHOCK 6.55	DOUBLE
K2	DOUBLE
PRIJON EXCURSION	DOUBLE
SUPERSONIC	DOUBLE
TK2	DOUBLE
VULCAN 680	DOUBLE
NELO	K1
QUANTUM GT80	K1
QUANTUM TORNADO	K1
RAMPAGE TK1	K1
SPECTRUM	K1
COBRA VIPER	MULTISPORT
FINN MULTISPORT	MULTISPORT
RUAHINE FIREBOLT	MULTISPORT
THE FLASH	MULTISPORT
TIME BANDIT	MULTISPORT
COBRA SURF SKI	SURF SKI
DORADO	SURF SKI
ENDORFINN	SURF SKI
EPIC V10	SURF SKI
FENN MAKO 6	SURF SKI
FENN XT	SURF SKI
SPIRIT RACING SKI	SURF SKI
UNFAIR ADVANTAGE SURF SKI	SURF SKI
DAGGER CORTEZ 16.5	SEA KAYAK
GALASPORT METAX 525	SEA KAYAK
GREENLANDER PRO	SEA KAYAK
MARAUDER 550	SEA KAYAK
MERIDIAN - CYGNET	SEA KAYAK
PERCEPTION ECOBEZHIG	SEA KAYAK
POINT 65N XP	SEA KAYAK
PRIJON MILLENIUM	SEA KAYAK
PRIJON SEAYAK	SEA KAYAK
Q KAYAKS MAXIMUS	SEA KAYAK
BICSPORT SCAPA	SIT ON TOP
COBRA EXPEDITION	SIT ON TOP
Q KAYAKS SWIFT	SIT ON TOP
RTM DISCO	SIT ON TOP
SPRINTER	SIT ON TOP
COBRA ELIMINATOR	SIT ON TOP/ K1

Table 1.
List of boats in the Big Kayak Test of July 2006.

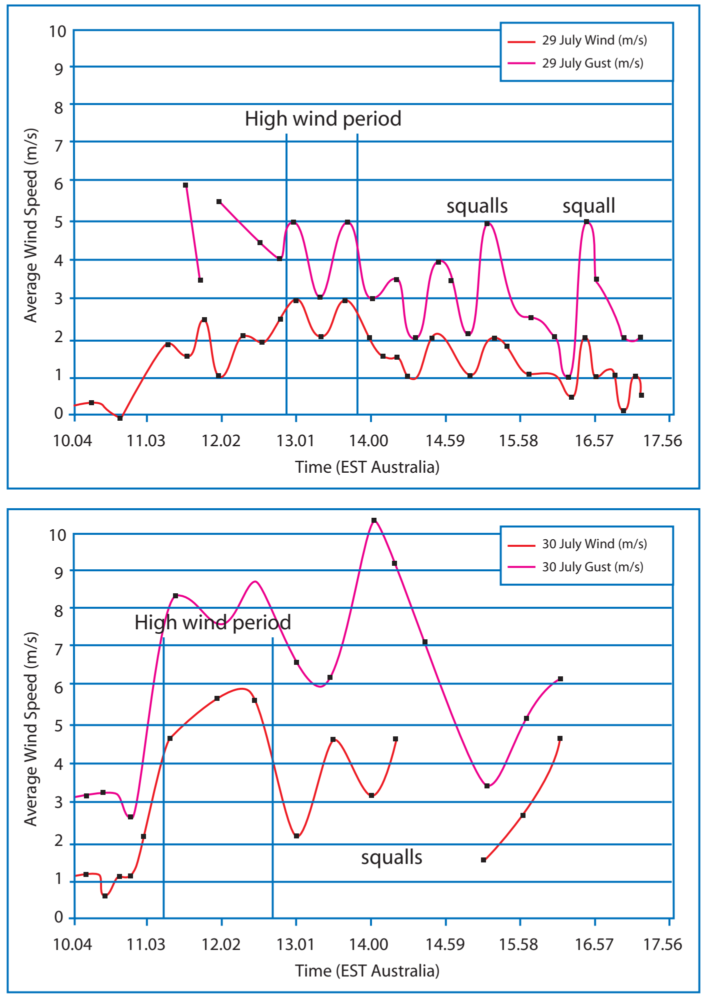


Figure 1.
Wind conditions during the Big Kayak Test. The first graph presents data for Saturday 29th July and the second for Sunday 30th July, 2006. The red lines provide information on the mean wind speed whereas the purple lines show the wind speeds for the highest gusts recorded during the sampling period.

This result is surprising and suggests that other factors were affecting boat speed on the upwind leg of the course. We looked at the possibility that different types of boats may respond differently to wind. The data suggest that the K1s are least likely to be affected, followed by the multisport boats, surf skis and sea kayaks. The only boat type that was significantly affected by wind on the Saturday was the Sit-on-Tops (Appendix 2.2).

Wind speeds on Sunday were gusting higher than those on Saturday (Figure 1), suggesting that boats tested on Sunday would probably return slower times to those tested on Saturday. Figure 3 shows that all types of boats, with the exception of the double kayaks, were tested across all sampling periods, with specific boat models tested almost exclusively within each sampling period. This kind of experimental design allows testing across variable conditions but may disadvantage particular boat models if within boat type comparisons are important.

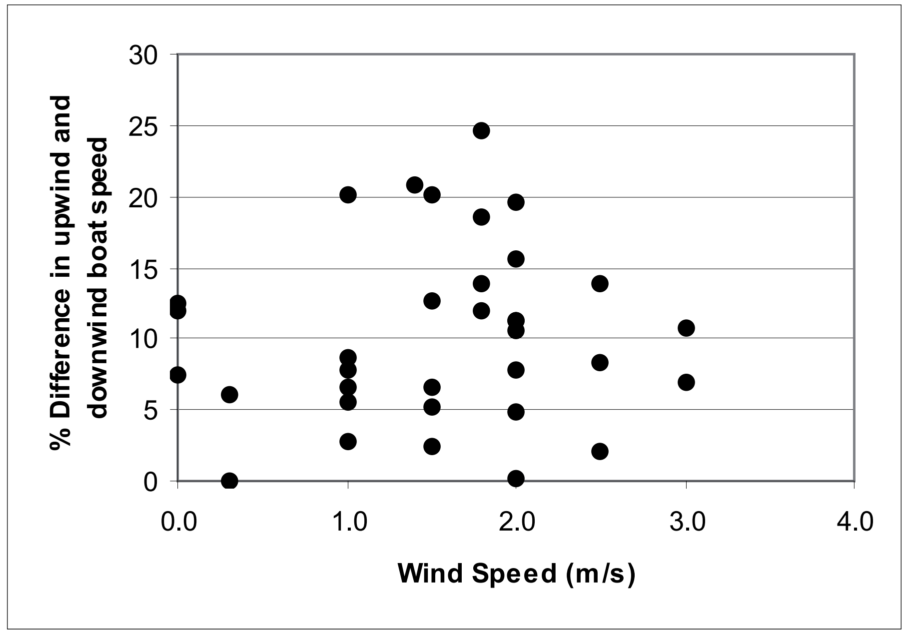


Figure 2.
Graph showing the relationship between wind speed (ms-1) and % difference between upwind and downwind boat speeds.

We compared the time taken to paddle the straight portions of the course by the single kayaks on Saturday and Sunday (Figure 4). There is no significant difference between the times recorded on the Saturday and the Sunday (Appendix 2.3). When we looked at the differences in times paddled by different boat models within a boat type (Figure 5), the K1 boats are the only boat type to show slower times on the Sunday compared with the Saturday, but none of the comparisons are statistically significant (Appendix 2.4).

When we investigated this further, we noticed that the boat models tested on Sunday in the K1 boat type are a TK1 and a sit-on-top Eliminator.

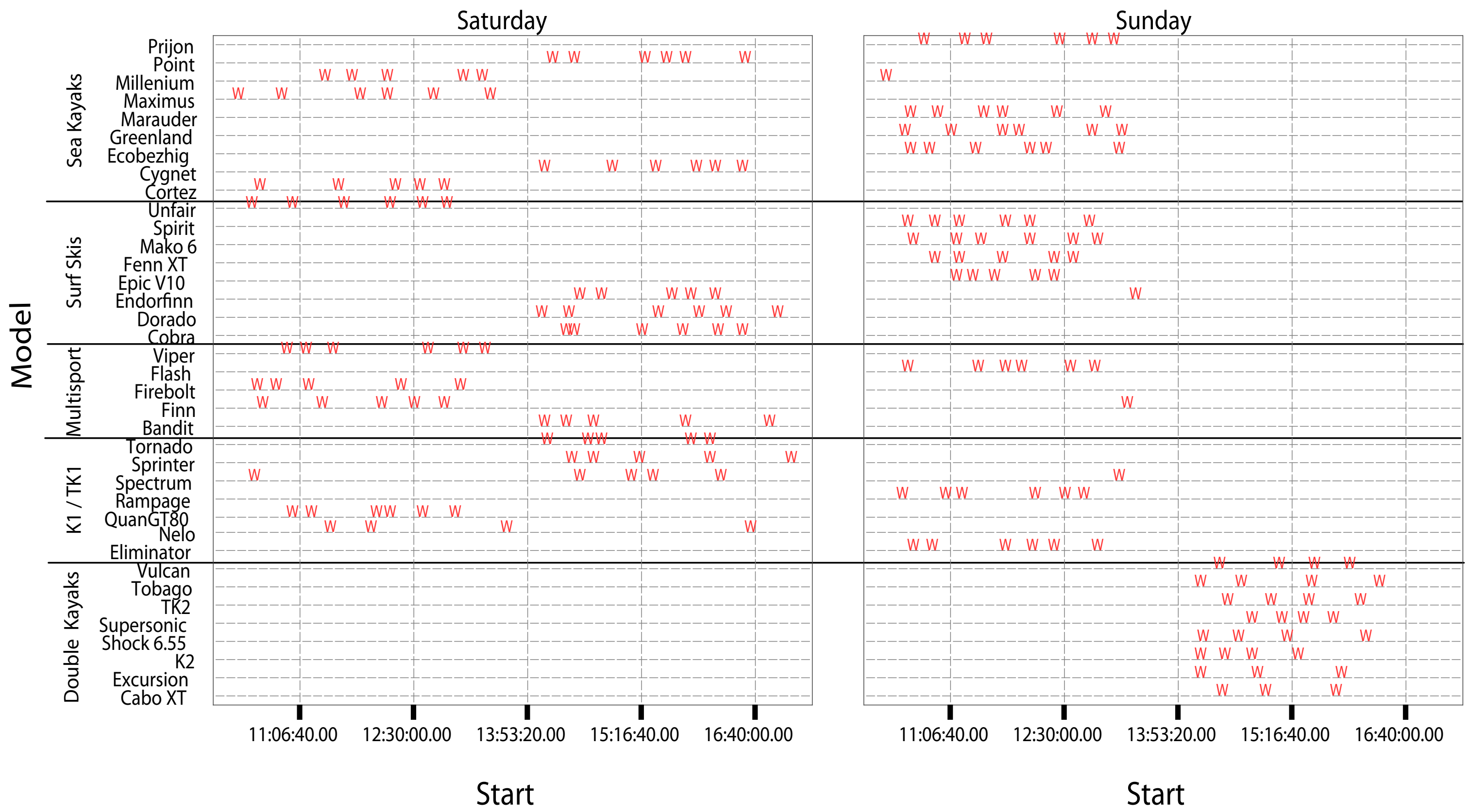


Figure 3.
Timelines of when different boat models were tested.

Finally, we compared the times paddled by the calibration boats (Table 2, see Appendix 1 for detailed description of the experimental method) on Saturday morning (during relatively calm conditions) and Sunday midday (during gusty conditions). The difference in times was consistently between -1 and 1 % with the exception of the Sit-on-Top (3.5 %). This aberration can be explained by the Sit-on-Top being the only boat type to show a significant response to windy conditions.

In conclusion, the times taken to paddle upwind are slower than those taken to paddle the downwind legs, but overall, there is no evidence to suggest that wind speed adversely affected any particular boat model or type in the racing categories. This outcome is fascinating and needs further investigation. Conventional wisdom suggests that kayaks are less vulnerable to wind than rowing shells because kayakers have greater flexibility in adjusting their stroke rate to counter headwind conditions. Experienced kayakers automatically paddle harder with a higher stroke rate when faced with a headwind. However, we all believe that we go slower when paddling against a headwind compared with the downwind leg and that this is compounded by a time effect because it takes us longer to paddle the upwind leg than the downwind leg. What is interesting about the data presented here is that the course we used (~600 m up, turn, and ~600 m back) may be too short for wind to play a significant role in overall paddle times. Our data suggest that over the course, paddlers were able to paddle under windy conditions to within 1 % of the times that they set during calm conditions. Consequently we did not correct the data for wind conditions.

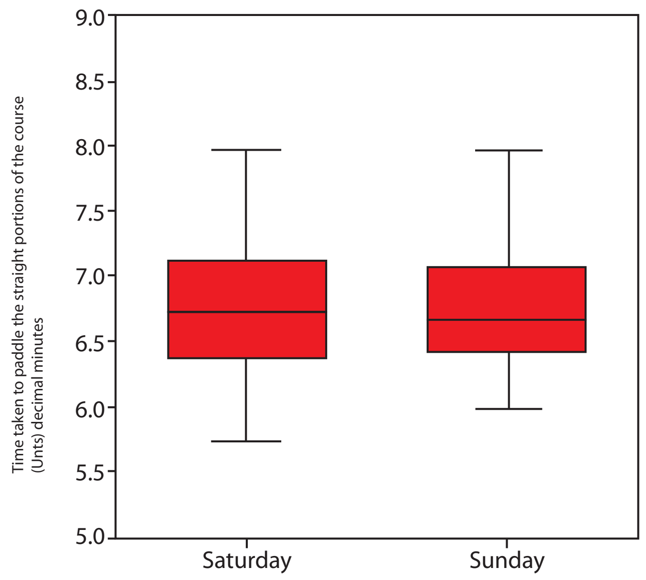


Figure 4.

Boxplots showing the times recorded on Saturday and Sunday. The whiskers demarcate the maximum (upper most horizontal line) and minimum (lower most horizontal line) times recorded. The coloured boxes are bounded by the 25th and 75th percentiles, which means that the middle 50 % of the data fall in the range represented by the coloured box. The horizontal line in the coloured box indicates the median of the data set. A median is the mid-point value for the data set. It is a better indicator of the average value than the well-know arithmetric mean when the data set is skewed as can happen with times generated by paddlers of greatly different ability.

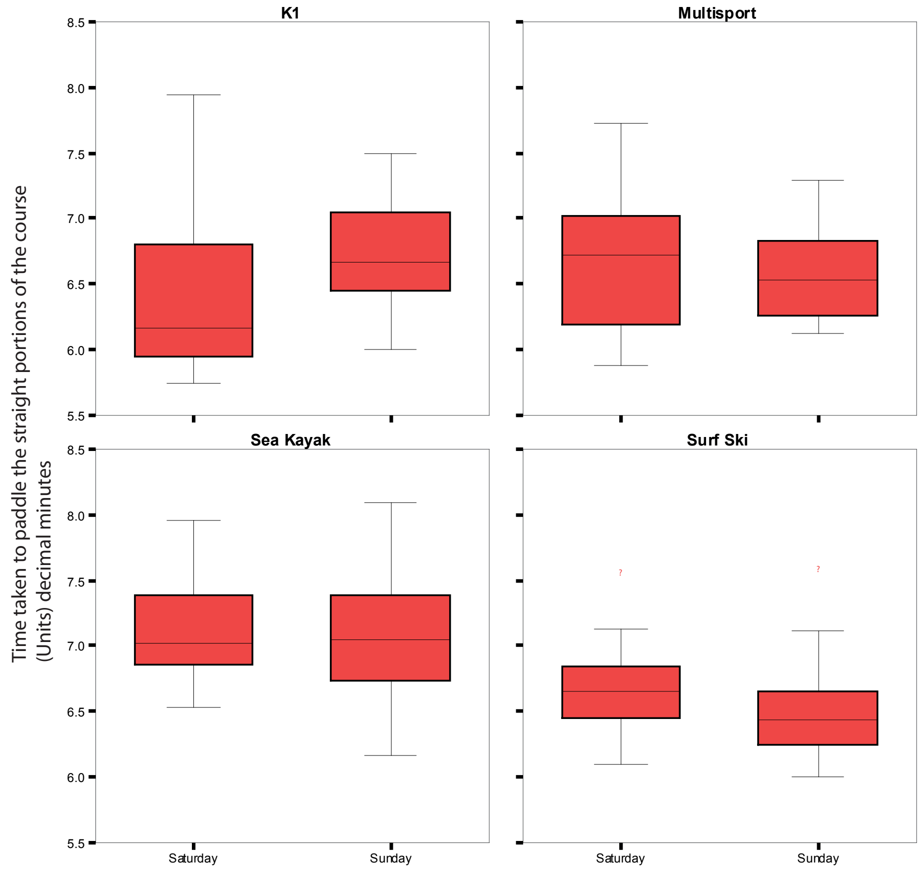


Figure 5.

Boxplots of times taken to paddle the course on Saturday and Sunday for K1s, multisport boats, surf skis and sea kayaks.

Paddler Fatigue

Some boats were paddled several times by the same paddler as a test of paddler fatigue. The data for Saturday show that the last run was between 0 and 5 % slower than the first run of the day and on Sunday, between -3 and 5 % (Table 2). The percent difference between the time taken on the first run on Saturday and the last run on Sunday is between -1 and 3.5 %. In contrast, the GPS data show that there is, on average, a 12 % difference in the time taken to paddle the upwind and downwind legs of the course that is not dependent on type of boat in the racing categories. This suggests that fatigue across the testing period contributed less to the decline in boat speed than did factors (possibly the combined effect of wind and fatigue) during each lap.

We compared the variability within one paddler's dataset, during the calibration runs, with the variability between paddlers for that boat. The results show that the range of times paddled by one paddler was well within that for all paddlers. This suggests that fatigue is not biasing one boat model against another (Appendix 2.5).

The outcome of the fatigue analysis is not unexpected given that each paddler chose a workload that they could maintain for an "all day" paddle. For most paddlers this was at a heart rate of 65-75% of maximum heart rate (as determined from 220 – age) with an average of 73 % of maximum.

Paddler	Boat	% difference between last run time and first run time of the day (SATURDAY)	% difference between last run time and first run time of the day (SUNDAY)
Bruce	Spectrum	1.8	2.9
Craig	Finn Multisport	2.4	2.6
Gill	Dagger Cortez	1.9	0.5
Jarad	Ruahine Firebolt	5.2	-3.9
John	Q Kayaks Maximus	4.7	1.7
Luke	Unfair Adv. Surf Ski	No data	-2.6
Mark	Bicsport Scapa	-0.5	5.3
Matt	Pijon Millenium	No data	2.7

Table 2

Percent difference between the last run of each day and the first run for boats used in the calibration study.

These data were collected to determine paddler fatigue.

Comparisons of Boat Speed (as measured by time) along the straight portions of the course.

This section compares the time taken to paddle the straight sections of the 1.235 km course as calculated by subtracting the turn times from the measured times for the entire distance. We will only consider those boat models used in racing, viz., double kayaks, single racing kayaks (K1s and TK1s), multisport boats, surf skis and sea kayaks. Several data points are not included in the analysis because they failed our quality checks on heart rate and paddling around all the buoys! We have also not included subsequent calibration runs as these observations are not independent statistically speaking.

We divided the dataset into two parts; (1) all data and (2) data only from those paddlers who paddled the Nelo. This is because the Nelo was only paddled by very experienced K1 paddlers and therefore its data are biased towards faster times. Also any comparison of boats should be made within one paddler and across the same paddlers. Given the outcomes of the wind and fatigue analyses, we have chosen not to correct the actual measured times. Consequently, we expect errors of around 1–5 %.

The data show that if we lump the boats by type (e.g., K1, surf ski etc.), there are no significant differences between performances of the double kayaks, racing singles (K1 and TK1), multisport boats and surf skis, but sea kayaks are significantly slower than these (Table 3; Figure 6; Appendix 2.6).

Different paddlers often prefer different boat models and will perform their best in different boats. Thus, any analysis of boat speed should be made in conjunction with paddler preference as this can dramatically influence statistical analyses in random tests like this one. In an effort to provide some idea of how boat models ranked by paddler, we compared the straight-line boat speeds of different boat models paddled by the same paddler (Table 4). Note that these data have not been corrected for wind or fatigue which may be a confounding factor in the following analysis. It is also unfortunate that not all paddlers paddled all boats; definitely something to improve on in 2007.

There is an interesting mix of how the boat models ranked by paddler. There appear to be three sets of paddlers. Paddlers 1, 2 and 3 appear to have different preferences to paddlers 6, 7, and 8 with paddlers 4 and 5 in between the two groups but tending towards

Boat Type	N	Minimum	25th Percentile	Mean	75th Percentile	Maximum	Standard Deviation
Double	30	5.5	5.8	6.5	7.1	8.5	0.9
K1	38	5.7	6.0	6.5	7.0	7.9	0.6
Multisport	28	5.9	6.2	6.7	7.0	7.7	0.5
Surf Ski	46	4.5	6.8	6.5	7.4	7.6	0.5
Sea Kayak	53	6.2	63	7.1	6.8	8.1	0.4

Table 3

The time taken to paddle the straight portions of the course in decimal minutes. We have used the full dataset for this analysis as all paddlers paddled all types of boat.

paddlers 6, 7 and 8. This may be based on experience. The first group of paddlers were less experienced in K1s than the third group. One of the paddlers in group 2 is a highly experienced K1 paddler, but quite a bit older than the young guns in group 3.

In the K1s, the fastest boats were the Nelo, the Quantum GT80, and the Spectrum. Generally it would appear that the Nelo and the Quantum GT80 provided the fastest times for most paddlers, followed by the Spectrum. In the multisport boats, most paddlers found the Flash to be the fastest boat. Interestingly, the Time Bandit ended up with the fastest average time because of the fast times posted by paddlers 4 and 8 relative to the times posted by the other paddlers for the Flash (Table 5). The surf ski data predictably showed that the Mako 6 was fastest, but at almost a half the weight of the next fastest boat the Epic V10, this is hardly surprising. In the sea kayaks, the Marauder 550, Q Kayaks Maximus and the Point 65N XP posted the fastest times for most paddlers.

We then undertook a statistical analysis of different models of boat within the boat type categories using the smaller dataset comprising only data for paddlers who paddled the Nelo. The Nelo Vanquish was the fastest of the racing singles (K1s and TK1s) with x = 5.89 minutes to complete the straight portions of the course. Of the multisport boats, the Time Bandit recorded the fastest mean time (x = 6.15 minutes ; Table 5). The Time Bandit and Ruahine Firebolt were faster than the Finn Multisport, but differences in the time taken to paddle the straight portions of the course between the remaining multisport boats were negligible. Of the surf skis, the Fenn Mako 6 was the fastest boat along the straight portions of the course (x = 6.14 minutes ; Table 5). The fastest sea kayak was the Marauder 550 (x = 6.56 minutes ; Table 5). It did not record significantly faster times to the Q Kayaks Maximus, Greenlander Pro or the Point 65N XP. Boxplots are shown in Appendix 3.

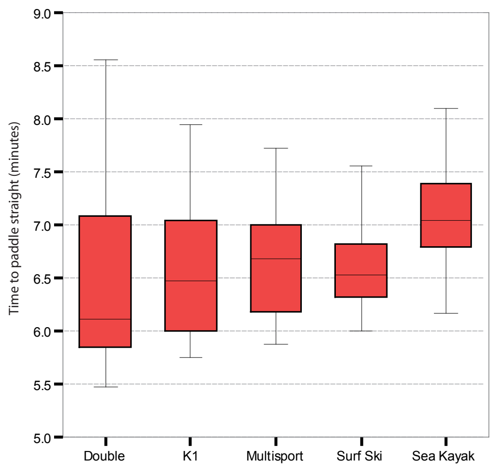


Figure 6.
Boxplots showing the range in times taken to paddle the straight legs of the course by boats groups.

We then compared boat models across boat types. This analysis has been done on a subset of the main database that has been drawn from the same paddlers as those who paddled the Nelo so that we can compare the Nelo with all the other boats. The data suggest that if you are in a team and doubles are allowed, the fastest boats are the K2 and the Supersonic (Figure 7). The TK2 and the Vulcan 650 scored very well, comparing well with the faster of the single kayak options. Of the single kayaks, the Nelo and Quantum GT80 are faster than multisport boats and surf skis tested.

		PADDLER							
Boat Model	**Boat Type**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Nelo Vanquish (medium)	K1					2	1	1	1
Quantum GT80	K1	1	3		1	1		4	2
Spectrum	K1	2	2	1		3	2	2	
Quantum Tornado	K1	3	1	2			3	3	
Rampage TK1	K1	5	4	3	2	4	5		
Cobra Eliminator	K1 /Sit on Top	4	5	4		5	4	5	
Time Bandit	Multisport		2	3	2	2			1
The Flash	Multisport	1	1	1		1		1	4
Ruahine Firebolt	Multisport		3	2	1	3			3
Cobra Viper	Multisport		4	4	3	4	1		2
Finn Multisport	Multisport	2	5	5	4			2	
Fenn Mako 6	Surf Ski			2	1		1	1	1
Unfair Advantage Ski	Surf Ski	2		3	2	3	2	4	
Fenn XT	Surf Ski				3	1	3	3	3
Epic V10	Surf Ski	1	1	1				2	2
Spirit Racing Ski	Surf Ski	3	3	5	4			6	6
Dorado	Surf Ski		2	4		2	4	5	5
Endorfinn	Surf Ski	5		6	6	5		8	4
Cobra Surf Ski	Surf Ski	4		7	5	4	5	7	
Marauder 550	Sea Kayak	1		1	1		1	1	1
Q Kayaks Maximus	Sea Kayak		1	2		1	2	2	2
Point 65N XP	Sea Kayak	3	2		2	2		3	4
Dagger Cortez 16.5	Sea Kayak	2		3	3	7			
Greenlander Pro	Sea Kayak	6	5		6	3	3		3
Meridian - Cygnet	Sea Kayak	4		6	7	6		6	6
Perception Ecobezhig	Sea Kayak		3		5	5	6	4	5
Prijon Millenium	Sea Kayak	5	4	5			4	5	7
Prijon Seayak	Sea Kayak	7	6	4	4	4	5		

Table 4.

Straight line speed rankings for each boat model within its boat type by paddler. 1 refers to the fastest time of the K1s paddled by that paddler.

The faster multisport boats and surf skis are of the same speed, albeit slightly slower than the K1s. The fastest sea kayaks are about the same speed as the slower multisport boats and surf skis, but generally the sea kayaks are the slowest option. These patterns are similar when we compared the times paddled by the same paddler in different boats.

In conclusion, sea kayaks are generally slower than K1s, multisport boats and surf skis as is expected. While patterns are evident in the graphical data, not many of the differences were statistically significant (at a confidence level of 0.05). No single multisport boat performed better than the others in terms of speed along the straight portions of the course, except for the Finn Multisport that was slower than the Time Bandit and Ruahine Firebolt. Of the surf skis, the Fenn Mako 6 and the Epic V10 posted faster times, although these were not significantly different from the other surf skis. The Marauder 550 was the fastest sea kayak.

Boat Model	Boat Type	N	Minimum	25th Percentile	Mean	Nelo Mean*	75th Percentile	Maximum	Standard Deviation
K2	Double	4	5.48	5.49	5.62	5.62	5.75	5.78	0.13
Supersonic	Double	4	5.56	5.60	5.74	5.74	5.86	5.90	0.14
Vulcan 680	Double	4	5.84	5.85	5.89	5.89	5.96	5.98	0.06
TK2	Double	4	6.00	6.01	6.10	6.10	6.25	6.30	0.14
Double Shock 6.55	Double	4	6.15	6.15	6.24	6.24	6.35	6.38	0.10
Prijon Excursion	Double	3	6.86	6.86	6.96	6.96		7.08	0.11
Cabo XT	Double	3	7.11	7.11	7.42	7.42		7.62	0.27
Bicsport Tobago	Double	4	8.06	8.10	8.31	8.31	8.51	8.55	0.21
Nelo Vanquish ** (medium)	K1	4	5.79	5.81	5.89	5.89	5.95	5.95	0.08
Quantum GT80	K1	6	5.74	5.82	6.18	6.03	6.43	7.39	0.61
Spectrum	K1	6	5.95	5.99	6.35	6.14	6.68	7.30	0.51
Quantum Tornado	K1	5	6.07	6.12	6.55	6.27	7.02	7.25	0.48
Rampage TK1	K1	6	6.45	6.45	6.80	6.78	7.16	7.42	0.40
Cobra Eliminator	Sit on K1	6	6.44	6.52	6.87	6.75	7.16	7.50	0.40
Time Bandit	Multisport	5	5.99	6.06	6.50	6.15	7.12	7.52	0.63
The Flash	Multisport	6	6.12	6.16	6.52	6.33	6.82	7.29	0.43
Ruahine Firebolt	Multisport	5	5.88	6.07	6.53	6.26	7.12	7.53	0.63
Cobra Viper	Multisport	6	6.07	6.16	6.67	6.51	7.06	7.54	0.55
Finn Multisport	Multisport	6	6.70	6.73	7.06	7.00	7.31	7.73	0.37
Fenn Mako 6	Surf Ski	5	6.07	6.07	6.24	6.14	6.45	6.65	0.24
Unfair Advantage Ski	Surf Ski	6	6.10	6.10	6.37	6.44	6.57	6.70	0.24
Fenn XT	Surf Ski	5	6.30	6.30	6.42	6.42	6.59	66.76	0.20
Epic V10	Surf Ski	5	6.00	6.12	6.43	6.26	6.82	7.06	0.41
Spirit Racing Ski	Surf Ski	6	6.44	6.45	6.74	6.52	7.12	7.56	0.45
Dorado	Surf Ski	6	6.31	6.42	6.77	6.56	7.12	7.53	0.45
Endorfinn	Surf Ski	6	6.44	6.60	6.79	6.71	6.95	7.11	0.23
Cobra Surf Ski	Surf Ski	6	6.61	6.63	6.80	6.80	7.04	7.13	0.22
Marauder 550	Sea Kayak	6	6.17	6.23	6.46	6.56	6.71	6.80	0.24
Q Kayaks Maximus	Sea Kayak	6	6.53	6.55	6.87	6.64	7.19	7.63	0.42
Point 65N XP	Sea Kayak	6	6.59	6.66	6.94	6.74	7.13	7.86	0.46
Dagger Cortez 16.5	Sea Kayak	5	6.83	6.86	7.09	7.17	7.29	7.37	0.22
Greenlander Pro	Sea Kayak	6	6.54	6.81	7.15	6.94	7.54	7.98	0.49
Meridian - Cygnet	Sea Kayak	6	6.94	6.98	7.20	7.19	7.47	7.53	0.24
Perception Ecobezhig	Sea Kayak	6	6.89	7.00	7.28	7.19	7.69	7.89	0.39
Prijon Millenium	Sea Kayak	6	6.73	6.94	7.30	7.11	7.62	7.96	0.43
Prijon Seayak	Sea Kayak	6	7.03	7.07	7.42	7.28	7.64	8.09	0.38

Table 5

Descriptive statistics for the time taken by each boat model to paddle the straight portions of the course (in decimal minutes) based on all valid data. N refers to the number of paddles in that boat, the 25th percentile is the value below which 25 % of the data lie, the mean is the arithmetic mean, 75th percentile is the value below which 75 % of the data lie and standard deviation is a measure of the variability in the data through an index whereby 68 % of the data lie in the interval defined by one standard deviation on either side of the mean. Two numbers are reported under the **Mean*** column. The first number refers to the mean for the full dataset and the second number is the mean for the dataset comprised of only those paddlers who paddled the Nelo. It is the latter figure that is used to calculate comparative speed for the purpose of this report.

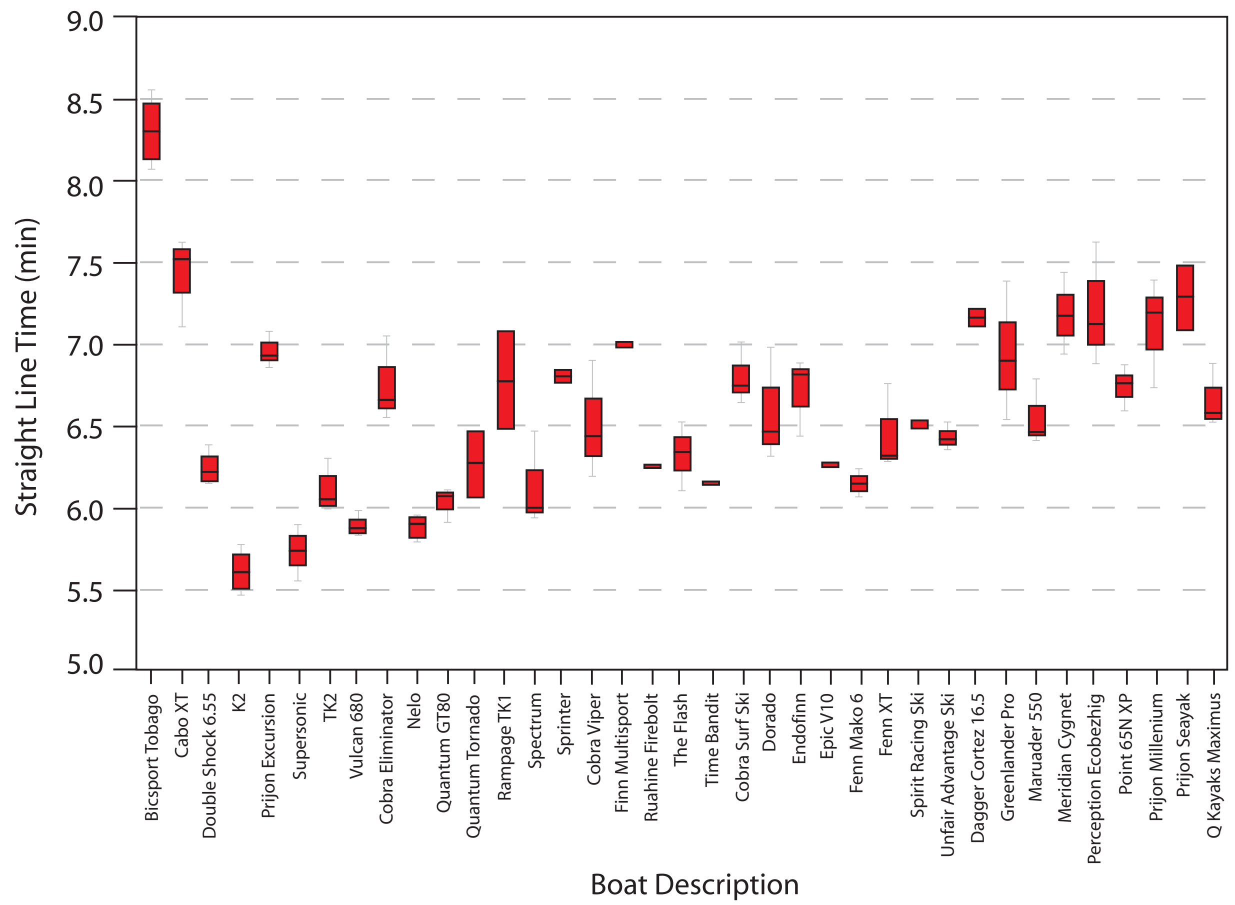


Figure 7.

Boxplots comparing the data for all racing boats that participated in the testing. The data are ordered by boat type.

Comparisons of Boat Speed (as measured by time) around the turns at the top of the course.

The time taken for each boat to paddle around the three-buoy turn at the top of the course was measured. When we look at the ability of a boat to turn by boat type, the K1s, multisport boats and surf skis are significantly faster than the sea kayaks (Appendix 2.8). This is most likely due to the fact that these boats are also faster on the straight. Looking at turn time as a percent of the time taken to paddle the straight portions of the course showed no differences between the different boat types (Appendix 2.9). Further analysis within boat type showed that the double kayaks and K1s had models that turned significantly faster than others, whereas all of the multisport boats, surf skis and sea kayaks turned at about the same speed (Appendix 2.10). The Nelo turned significantly faster than the Spectrum but all other K1s had a similar turn time. In the doubles boat type, the K2 turned faster than the Vulcan 680, but all other doubles had similar turn times.

These results are not unexpected. Firstly, the Spectrum K1 that was made available for the experiment is used exclusively in sprint so is not designed to turn whereas the Nelo used is the marathon model. Secondly, a three-buoy turn is the most common format for turns in kayak racing and is designed to allow boats to retain a fair bit of speed during the turn. Had we used a one-buoy turn, we may have found very different results.

Conclusions

1. there is inconclusive evidence to suggest that wind disadvantaged some boats against others, probably because the distance was too short, the wind conditions were gusty rather than continuous and paddler fatigue appeared to be a greater factor within a paddle than between paddles. Consequently we did not correct the data for wind speed or paddler fatigue.

2. the data suggest that the fastest boats are the doubles (K2, Supersonic and Vulcan 680), closely followed by the high performance K1s (Nelo, Quantum GT80 and the Spectrum). The faster multisport boats such as the Time Bandit and surf skis like the Fenn Mako 6 and Epic V10 were as fast as the middle-of-the-range K1s, the sea kayaks were in the next speed bracket after the multisport boats, and with a couple of exceptions, the sit-on-tops were the slowest of all the boat types. This is not a reflection on performance as these craft are mostly designed for a purpose other than flat-out racing. It is important to note that there was quite a range in the ability of the different speed testers, which when combined with the potential affects of wind and fatigue, resulted in a large range in paddle times which influenced the outcomes of the statistical tests and significant differences were hard to show. However, we still believe that the data are interesting and will provide you, the user, with information that will help you choose a boat best suited to your needs and ability.

3. the turn times were generally similar when normalised to the time taken to paddle along the straight portions of the course. This outcome is not unexpected given that we used a three-buoy turn typical of racing situations that allows minimal boat speed reduction during the turning process.

Appendix I. Experimental Methods

Single kayaks were randomly assigned into 3 blocks. The first of these blocks were paddled on Saturday morning, the second on Saturday afternoon and the third on Sunday morning. The sequence that boats were paddled was also randomly determined as was the assignment of a paddler to a sequence of boats. This experimental design reduces systematic errors that may result from time and boat preferences, but it assumes that environmental conditions are similar across the experiment. Boats were carefully marshaled on and off the water to ensure that the sequence was maintained throughout the experiment (Figure A1.1)

We mounted GPS units on each boat to record boat speed (Figure A1.2). Two of the units were set up to record boat speed at 10 m intervals so that we could look at the effect of wind on boat speed. This is an interesting question in itself, but is also important for assessing the quality of the data given that the wind tended to blow up the course. Paddlers tended to paddle the first leg of the course with the wind and the second part of the course against the wind.

Figure A1.1
Photograph showing Adam and Roger co-ordinating the marshalling of boats to ensure that the sequence of boats was maintained throughout the experiment.

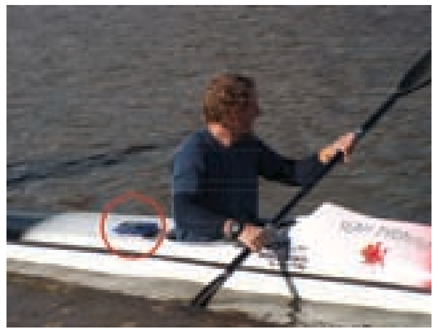


Figure A1.2
Photograph showing the location of the GPS on the kayak. Each paddler was issued with a GPS that they mounted on every boat paddled.

Paddlers were asked to choose a heart rate that they could comfortably maintain for a day of paddling. They were advised to choose heart rates between 60 – 75 % of their maximum heart rates, as determined from the generic equation:

maximum heart rate = 220 – age.

Each paddler wore his or her own heart rate monitor and they were instructed to maintain their chosen heart rate for the duration of each paddling leg.

We instrumented two of the paddlers with high-resolution GPS units. One of these paddlers also used a paddle that was instrumented with a paddle force unit that was synchronized to the high resolution GPS unit. These data are not reported here but will be published in the sports literature early next year, as they are part of a postgraduate research project.

We also monitored weather conditions throughout the experiment using a twin anenometer and windvane system. Locating a weather station to record wind conditions in the river channel is not without its problems, especially in terrain characteristic of the Barwon River. River channels that are surrounded by high banks tend to funnel the wind up and down the river, even when the upper wind direction is across the channel. These problems can be overcome by positioning the instruments in the middle of the channel used for the experiment, if there are suitable posts on which to mount the instruments. This was not the case with the Barwon River and we thus had to mount the instruments in a location on the bank that best provided information about wind conditions in the channel.

Given these constraints, the weather stations were located on the Geelong Canoe Club side of the bank, as far away from the human activity as possible. Two sets of sensors were mounted, one 5 cm above water level and one 50 cm above water level so that wind conditions relative to the paddlers could be measured ((Figure A1.3). Data were collected every 10 to 15 minutes. When winds became swirly in the sampling area, a hand held wind instrument was used to sample wind speed.

In order to better appreciate the conditions on the course, several paddlers were regularly asked as to the conditions "out there". The consensus was that the wind direction was clearly up-river on the course with swirly conditions around the first turn (near the start). Downstream of the start, the wind was blowing down-river, although gusts tended to move upstream as well in this region. These conditions are synonymous with the rotar effect seen by the fixed weather stations. Prior to 12:00 pm on Sunday, John Jacoby reckoned that conditions during singles testing (i.e., prior to 2:00 pm) were very similar to Saturday.

Saturday started off calm with air temperatures around 10–11 ºC. By 10:30 am, evidence of microgusts were being felt at the ground in the form of short bursts of cool air. At 11:00 am, it started to become windy. The winds were predominantly out of the N–NW in the river channel with mean speeds of between 1–2 ms-1, gusting to 4 ms-1. The highest wind period was between 1:00–1:30 pm. In the afternoon, a series of squalls came through with wind gusts up to 5 ms-1, followed by two brief showers. After 3:30 pm, winds started to decline with calm conditions prevailing after 4:00 pm. A quick squall passed through the area at 4:50 pm bringing brief gusts of 5 ms-1. Sunday dawned calm but the weather predictions were not good! By 10:15, conditions had become quite gusty and by 11:00 am, the wind had veered to the north, placing the weather stations in the lee of a rotar. The wind was blowing up the dominant straight of the course. To obtain information on wind speed, a comfort paddler, usually Ross Stevens, was asked to paddle into the main channel and measure wind speed using a hand held instrument. The wind data reported post 11:00 am come from this instrument and not the weather stations. Between 11:00 am and 12:45 pm, mean wind speeds on the course were between 4–5.5 ms-1 with gusts around 8 ms-1. Between 1:00 and 2:00 pm, the wind seemed to calm a bit with mean speeds of around 2–4.5 ms-1, gusting 6 ms-1. A squall at 2:00 pm yielded the highest gust of the day at 10 ms-1. The afternoon was characterized by mean wind speeds of around 2–4 ms-1 with some high gusts, usually in the vicinity of 5–6 ms-1.

Paddler fatigue was monitored by paddling the same boat at the start and end of each session.

Figure A1.3a
Photograph looking upstream and downwind from the start of the course. The weather station is located at the upstream tip of the jetty as marked by the red arrow.

Figure A1.3b
Photograph of the paired anemometers and wind direction sensors used to monitor weather conditions during the experiment.

We had four dedicated timekeepers, two at the start/finish and two at the turn. Each boat was numbered, allowing timekeepers to call the correct boat (as per the random sequence) to the start. At the start, boats were brought to a stop. The start/finish timekeepers called the start and recorded the boat number and time. Time of day was also recorded every so often to allow us to later link boat start time with wind conditions. The start/finish timekeepers monitored which boats were on the water and made sure that the sequence of boats was being maintained on the startline. Boats were started at least one minute apart to prevent racing. While this was generally successful, some paddlers did race. The start/finish timekeepers made a note of these boats and their data were removed from the database.

The two turn timekeepers recorded the time taken for each boat to complete the turn between two set markers positioned about 10 m downstream of the turn buoys. Time of day, boat number and turn time were recorded. Turn timekeepers also noted when a paddler missed buoys on a turn.

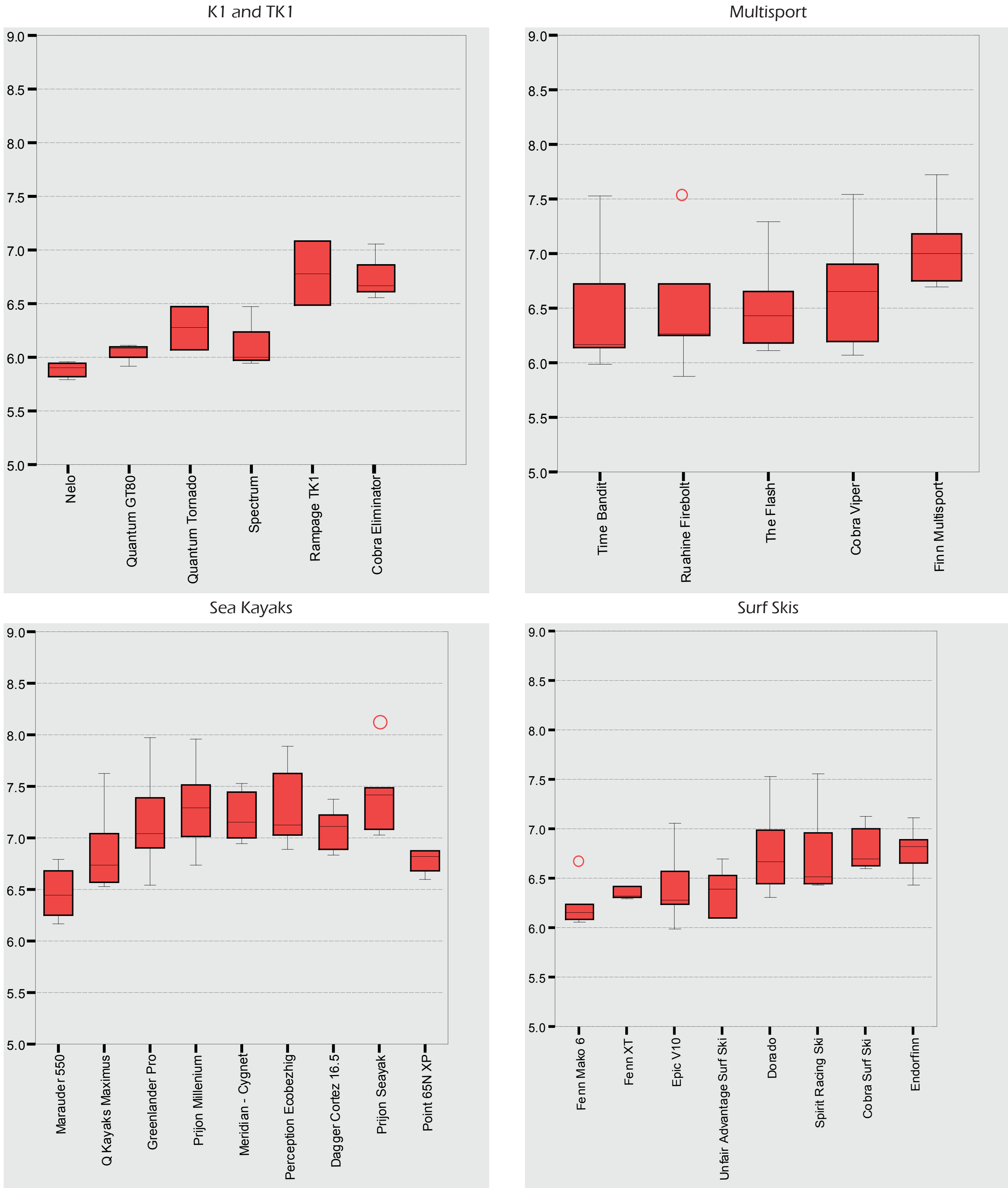
Appendix 2.
Statistical Tests

The data underwent data quality checks to ensure their integrity. We removed less than ten data points from the final data set because paddlers missed buoys on the turn or because of timing contradictions. The data were analysed in SPSS and Excel.

Comparison	Test used	Outcome
2.1 Upwind vs downwind boat speeds.	t-test: H0: Uupwind - Udownwind = 0 H1: Uupwind - Udownwind > 0	t = 3.2–10.7 df = 76–103 p = 0.000–0.001
2.2 Boat types and the effect of wind.	Linear regression: t-test : H0: slope = 0 H1: slope ≠ 0 If the slope cannot shown to be different from zero (i.e., p > 0.05), there is no relationship between the variables.	K1: r2 = 0.1081 (p = 0.671) Multisport: r2 = 0.2296 (p = 0. 277) Surf Ski: r2 = 0. 6448 (p = 0. 197) Sea Kayak: r2 = 0. 2995 (p = 0. 127) Siton: r2 = 0. 0464 (p = 0. 001)
2.3 Time to paddle straight portions of course on Saturday vs Sunday – all single kayaks compared.	ANOVA run on all valid data.	F = 0.210 p = 0.647
2.4 Time to paddle straight portions of course on Saturday vs Sunday by boat type.	ANOVA run on all valid data, by boat type.	K1 (F = 3.251, p = 0.080) Multisport (F = 0.205, p = 0.654) Surf Ski (F = 2.294, p = 0.137) Sea Kayak (F = 0.060, p = 0.807)
2.5 Comparison of calibration data with rest of the data by boat type.	t-test: H0: Ucalibration – Urest = 0 H1: Ucalibration – Urest ≠ 0	t = -1.9–2.2 df = 2–6 p = 0.158–0.464
2.6 Time taken to paddle straight portions of course by various boat types.	ANOVA run on all valid data.	F = 8.185 p = 0.000 Multiple comparisons (Dunnet with unequal variances) showed sea kayaks significantly slower than doubles, K1s, multisport boats and surf skis with p values between 0.000 and 0.021.
2.7 Time taken to paddle straight portions of the course by boat models within various boat types.	ANOVA run on all valid data, except for the racing singles where only data for Nelo paddlers were used.	K1s Sea Kayaks (F = 3.466, p = 0.004) with p values of between 0.009 and 0.046 for comparisons between the Marauder 550 and the Meridian Cygnet, Perception Ecobezhig, Dagger Cortez 16.5 and Prijon Seayak. A p value of 0.064 was recorded between the Marauder 550 and the Prijon Millenium.
2.8 Time taken to paddle the three-buoy turn at the top of course by various boat types.	ANOVA run on all valid data.	F = 11.633 p = 0.000 Multiple comparisons (Dunnet with unequal variances) showed sea kayaks significantly slower than doubles, K1s, multisport boats and surf skis with p values between 0.000 and 0.002.
2.9 % time taken to paddle the three-buoy turn at the top of the course by boat type	ANOVA run on all valid data. % turn time relative to time taken to paddle the straight.	F = 1.224 p = 0.305
2.10 % time taken to paddle the three-buoy turn at the top of the course by boat models within various boat types.	ANOVA run on all valid data, except for the racing singles where only data for Nelo paddlers were used.	Double kayaks (F = 4.997, p = 0.002) K1s (F = 7.557, p = 0.002) Sea Kayaks (F = 2.056, p = 0.097)

Appendix 3.

Boxplots comparing the range of times taken to paddle the straight portions of the course by the different boat models. We have clustered models by boat types. The circles represent outliers to the dataset as determined automatically by the statistical package used to generate these diagrams (SPSS).



8.0 hydrostatic data

Basic Hydrostatic Test 2006

Outline of Test by Craig Elliott

The kayak test included comprehensive measurements of each kayak's 'hydrostatics' to complement the time trials. These measurements of the kayak's hull shape tell us about the way the physical shape of the kayak is likely to interact with water. Some measurements are known to be linked to characteristics such as speed, stability and tracking/cornering of the craft. There are any number of complex coefficients and calculations that can be applied, but for the purpose of this report we have tried to keep it intelligible to the average kayaker. Some of the detail may be more relevant to readers with a knowledge of kayak design. If you are a kayak builder or have a special interest in hydrostatics, please feel free to contact Craig Elliott directly for a more detailed discussion (email: elliottkayaks@hotmail.com).

The objectives of the hydrostatic testing team were to:

- take detailed measurements of each craft, and calculate a number of key coefficients that are useful for comparing different craft
- test the idea that these measurements can be used to help people predict what subjective/speed characteristics a boat might have (what a boat might feel like to paddle). This could be useful for people who need to choose a boat without being able to paddle it beforehand, such as when competing overseas.

Method

A basic hydrostatics assessment of 19 kayaks was undertaken to complement the time trials. Not all kayaks where measured, due to time constraints.

The craft were held on a cradle whilst tape was placed along the length of the hull at 0.5m intervals (See Figure 1). The length and beam measurements were recorded. Measurement tolerance is +/-2mm.

Next, the waterline was measured. This is the level of the water up the hull of the boat when someone gets in it. Along with other measurements, the waterline height contributes to calculating how much of the hull is submerged (draft), and that relates to resistance and speed (wetted surface area). We used a paddler of 84kg who entered each craft, we used a jetty where the water level (displacement caused by the 84kg) was marked with a soft pencil on both sides.

Results

The results of these measurements are shown under the photos of the 19 individual craft for which measurements were taken. Table 2 opposite summarises several of these key hydrostatic terms and figures, and shows speed data for comparison.

Figure 1

Discussion

The results for each kayak are most useful when compared across all the different kayaks tested. The hydrostatic measurements are helpful in interpreting what to expect in terms of speed, stability and manoeuvrability of a craft, and provide additional quantitative support to the results found by the speed and stability testers.

We have not conducted any statistical comparisons to date, though this might be fruitful given more time and resources. An overview of our results suggest that:

- In general, the higher the length to beam ratio, the faster the craft. The range tested goes from 6.6 for very short recreational kayaks to 16.48 for high performance kayaks. (Figure of 12-16.5, seem to yield good results)
- Although longer boats may be heavier (due to more material) they also keep a good length to beam ratio and beam waterline. Time Bandit is a good example of this. These characteristics help stability for intermediate paddlers, while still being fast. (But if you are an advanced paddler, K1's at 5.2m still have the best acceleration & speed).
- Some of the longer craft (water line length 6.0+m) have a higher wetted surface area, hence increased resistance. For example, the Epic V10 (1.67m^2) was slower than the Spectrum K1 (1.21m^2), both had similar stability scores. The Epic is 6.4m long, where the Spectrum is only 5.18m long. Larger paddlers may find they can overcome this extra resistance because they have more power.
- Water plane coefficient figures of 0.60-0.68 were found for the fastest kayaks. E.g the Nelo K1 (0.67) compared to the Point 65 (0.58). This is because the Nelo has a fullness about the hull. The point 65 has a very narrow bow & stern.
- Hull mid section – The shape of the hull is known to be related to speed and stability. There was a range of hull shapes amongst the boats we tested. Semi elliptical to round sections are preferable in deep water such as the Nelo K1, while semi flat sections "mid to aft" such as the shape of the Cobra Viper help with floating in shallow water.
- Longer/wider craft usually have less 'draft' i.e. they sit higher in the water. This may be of importance to particularly heavy paddlers or multisport paddlers as the rivers are often shallow. In our selection the Quantum GT had the highest 'draft' whereas the Rauhine Firebolt had the smallest 'draft'.
- The cockpit size measured varied greatly. In general short cockpits (less then 700mm) are harder to enter/exist, but offer more protection from getting wet. Shorter cockpits can also create a lock in effect that some paddlers like/dislike. Large cockpits (750mm-850mm) can offer easy entry/exist while still having good bracing. Cockpits larger then (850mm+) offer little bracing usually very open K1 style. The cockpit size is important to consider when matching boats with size and style of paddler although all the craft tested were found to be versatile and were used by a wide range of paddlers on test day.

Thanks to Ian, Roger, Ron & the gang from the AIS for your help.

Table 1. Explanation of terms used (on this page and also in the hydrostatic measurements reported with each of the craft)

Length (LOA) and Length (WL)

The length overall (LOA) of the craft is taken from Bow to Stern at the longest point (Not including any rudder). The other measurement is length of the waterline (WL)

Beam (Max) and Beam (WL)

The beam is the width of the kayak. Comparing the beam at its widest point to the width (beam) of the kayak at its waterline is a measure of secondary stability. A larger difference between Beam (Max) and Beam (WL) may indicate greater resistance to capsize.

Length / Beam Ratio

This ratio is the length of the waterline divided by the beam water line, and is a generally good predictor of kayak speed.

Water plane Area and Water plane Coefficient(Cw)

Area of the kayak hull (inside the hull) at a certain waterline, on a horizontal plane. Coefficient of fineness = Area of water plan divided by area of the rectangle in grey

Draft

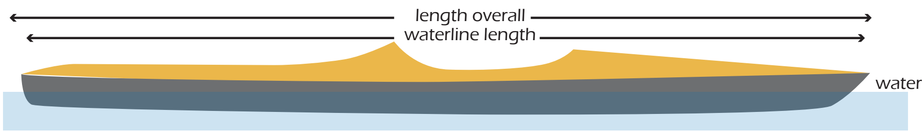
The draft is the amount of the kayak that is submerged in the water, measured from the bottom of the kayak up to the waterline. The draft tells us how deep in the water the kayak sits. Kayaks with small drafts are usually good in shallow waters.

Weight

Dry weight of the particular craft we tested. This might differ from the weight stated by the manufacturer depending on the features and options.

Cockpit size

We measured the cockpit size. Length by the width for kayaks. This may give an indication of how the kayak will suit different sized people (ease of entry/exit). For surf skis we took the difference between the seat height & the footwell height at the lowest point. It is often said the larger the difference (ie higher the seat), the more comfortable the ski.



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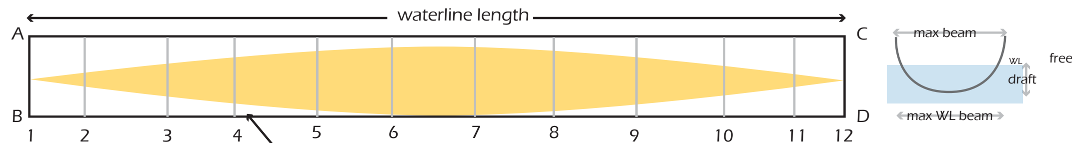
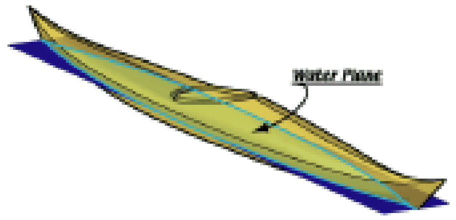


VIEW OF A KAYAK FROM TOP

stations at 0.5m



The water plane area: the area of the kayak hull inside the waterline. The water plane area is important for several reasons.It's size determines the "weight per mm immersion." The additional (paddler) weight required to sink the hull a certain distance. Secondly, the so-called moment of inertia around the longitudinal axis determines the stability at small angles of heel. Thirdly, the moment of inertia around a transverse axis through the centre of gravity yields the longitudinal stability (the moment to trim the hull a certain angle). The water plane area can also give an approximate resistance, or how much power is required for a given hull form. This is only rough as you need to work out the wetted surface area to give you viscous resistance & wave resistance, also wind resistance makes up a small part.

Table 2

Craft (& class)	Length / Beam Ratio (Approx indicator of speed)	Something (indicator of stability) Waterline width	Something else important from the discussion	Speed data (distance it would go in an hour)
Nelo K1 (K1-Sprint)	16.30	Prim=1, Sec=3 314mm WLW	Fast, Responsive. Alive	12.63km
Time Bandit (Multi-sport)	15.17	Prim=3. Sec=4 387mm WLW	Good speed. Vs stability.	12.09km
Marauder 550 (Sea kayak)	11.91	Prim=4, Sec=4 445mm WLW	Quite quick. Very stable.	11.34km
Fenn Mako 6 (Ski)	15.83	Prim=2, Sec=4 392mm WLW	Sustained speed. Good secondary stability	12.11km
Sprinter (Plastic sit on)	9.80	Prim=5,Sec=5	Very stable Good fitness craft	10.70km

9.0 paddling clothing

Paddling clothing

By Del Lloyd

There are as many options and differences in opinion on what to wear for kayaking as there are boats themselves! To a large extent, trial and error is required to learn what is most suitable for you as an individual. Requirements differ with weather and water conditions, experience, and of course personal preference. This section aims to highlight some of the pros and cons of paddling clothing options, and features a special report on using a dry-suit for kayaking by Heather Hadley-Powell.

The main things to consider when selecting suitable clothing are warmth and comfort. In particular, freedom of movement in the arms and torso, and balance of warmth and breathability are crucial. If the weather is inclement, water is cold, or you are likely to get particularly wet e.g. ocean paddling on a surf ski, then windproof and waterproof properties are also important.

Practical issues

Often with paddling, keeping the right temperature can be a problem. Even on the coldest of days, you will warm up with exertion. Clothing needs to be comfortable to move in, and breathable to allow perspiration to evaporate. During a paddle it may be possible to stop, in order to remove layers. Depending on the length of the paddle and conditions it may be feasible to attempt to stay dry with a spray jacket, cag, or a dry suit. The dry suit option was tested during this test. In Australia, it is a common belief that a dry suit for paddling is not warranted, but in special conditions our tester highly recommends the Kokatat Meridian suit. Beginners would be well advised to "dress for the swim, not for the weather"; even if you can't stay dry you should wear something that will keep you warm. As your skill levels increase, and your ability to cope with more adverse conditions improves, you may start to discard some clothing to give yourself more comfort or lightness.

Commonly used paddling clothing:

Thermals': Polypropylene, wool or mixed fibre?

Polypropylene is an artificial material made from plastic that does not absorb water. It is designed to carry water and perspiration through the fibres and away from the body. Polypropylene keeps you warm and dry by protecting against external temperature and reducing the dispersion of body heat, while channeling perspiration outwards, away from the skin. To maximise these features, they are designed to be a snug fit. Polypropylene is an extremely light fibre, which can create exceptional freedom of movement. Polypropylene absorbs almost no moisture, as the moisture is unable to attach itself to the fibres and is drawn away from the skin for ease of evaporation. If it gets wet it dries out quickly. Polypro is a must in your kayaking wardrobe. Wool thermals are also available. These are technically warmer but do not dry out as quickly, and many people find wet wool itchy and prone to chafing. Wool-polypro mix is a compromise; these come in different weights (proportions of wool/ artificial fibre), so shop around for the most suitable product for your needs.

Lycra knicks and paddling shorts

Whilst many people get away with wearing regular lycra shorts or even bike nicks they invariably have many seams which can cause chafing. There are some specific paddling knicks on the market which include suitable positioned chamois, no seams and technical fabrics. There are shorts and underpants that are made of material that wicks away any moisture, and these can be quite comfortable for paddling. Regular shorts are fine in warm weather, but for longer sessions or inclement conditions consider something more specialist.

Lycra knicks and paddling shorts

If you are worried about getting wet and cold then a wetsuit is not an uncommon option. Wetsuits are made from neoprene, which is a type of rubber.

Neoprene comes in various thicknesses, such as 3mm (1/8 inch) up to 9mm (11/32 inch), and in various styles or combinations. Kayaking wetsuit options include: shorts, long pants, 'farmer john' and 'farmer jane', long sleeved and short sleeved tops, and vests. The sleeveless "farmer john" style allows freedom of movement of you're arms. Full sleeve wetsuits used for ocean swimming/ and triathlon events often have good armpit flexibility too, though they are prone to damage. Diving wetsuits are much thicker, more restrictive and generally unsuitable for paddling.

One of the ways that body heat is lost to the environment is by conduction. This is where heat is lost with contact with something cold. That loss is 32 times faster when that 'something cold' is water. Wet suits are designed to keep the wearer wet and warm. Wet suits work best when they fit snugly over your body. With immersion, the small gap between you and the wet suit becomes filled with water. Your body heat then warms that water up, so that you keep warm. Unfortunately, if you are wearing a neoprene wet suit, you cannot lose your heat as effectively, so overheating is common. Only wear a wet-suit if you are likely to be continually wet, and if you are seriously worried about getting cold.

Many paddlers will wear a thermal top under their long john wet suit. The thermal clothing will help keep the paddler warm, as well as wick moisture away from their body. Having a shirt under the sleeveless wet suit top can also reduce chafing of that area between your chest and your arm.

Wet suits perform poorly in the air and wind. Wearing a windproof top such as a cag or spray jacket over the top of thermals or wet suit will help reduce heat loss through radiation and convection and protect you from wind chill.

Cags and Spray Jackets

A cagoule (also known as a 'cag'), or spray jacket can prevent heat loss in windy conditions. Another type of top is a dry top with seals around the arms, neck, and body which helps to prevent water entering through the sleeves, neck, and body openings. They should be breathable, to allow perspiration to escape, otherwise you will find you become wet from the inside, as well as from the elements outside the top.

Cags can be long sleeved, or short sleeved. Some people will have various cags, dry tops, and spray jackets to suit various conditions. Some paddlers may have one that is close fitting to their body, as well as another that can fit over all their outer clothing and their personal flotation device (PFD). This larger one will allow the cag to be donned or removed during a paddle trip without the need to also remove their PFD.

Gore-Tex combines waterproofness and breathability, and is an ideal fabric for sportswear such as cag's and dry suits. Unlike other fabrics it does not lose waterproofness after laundering, flexing, or abrasion. The Gore-Tex membrane is extremely thin and lightweight, yet strong and durable. It features an advanced composite made of two different polymers. It lets small droplets (such as water-vapour from perspiration) out, but water in its liquid form like rain or snow cannot get in. Salt water does not contaminate or clog the pores, but garments should be rinsed periodically to keep salt from accumulating. This fabric is generally more expensive than others on the market but it has excellent properties.

Dry Suits

A paddler's type of dry suit, is different from a scuba diver's dry suit. It is a complete waterproof body suit, sealed at the neck, wrists, and ankles with latex rubber seals. If the suit has built in socks or booties, they will not need to have seals around the ankles. As the name suggests, dry suits isolate your torso and limbs from direct contact with water, keeping you completely dry. They are made of a waterproof material, such as nylon, or a waterproof and breathable fabric, such as Gore-Tex. Suits have a waterproof zipper located either across the back, or up and across the chest. Remember to remove items, such as ear rings and watches, before putting on the suit so there are no sharp edges to catch the latex seals. Once the zip is closed, you need to 'burp' the suit. This is done by bending over in a crouching position, and then lifting up the neck seal slightly to let the air out.

Although dry suits isolate you from the water, they do not insulate you, so it is necessary to wear an insulating layer preferably a wicking material such as polypropylene or even fleece. The biggest problem with dry suits is that they keep water in, as well as out, so perspiration has no place to dissipate. Breathability is just as important to comfort as waterproofness as perspiration can cause dampness. Breathable Gore-Tex suits are more expensive and need a lot more care than other types of dry suits, but the benefits are clear. Kokatat is only one of two manufacturers in the world who have the license to manufacture breathable Gore-Tex dry suits.

After wear, a dry suit should be rinsed especially if used in salt water, cleaned, dried, and stored in an appropriate manner. Rubber seals can crack or become brittle without the appropriate care.

Dry suits are not commonly worn for paddling in Australia mainly due to concerns about overheating inside the suit. However, as found in Heather's report below, the breathable Kokatat suit can be a great option for prolonged exposure, extreme weather, or people especially vulnerable to the cold.

Special feature: The Kokatat Meridian Gore-Tex Dry Suit

By Heather Hadley-Powell

Background – Introducing the tester and aims

Refer to section 4.0 for a biography of Heather Hadley-Powell.

As a sea kayaker I was keen to test out the dry suit to see if it was a practical option for kayaking in the southern oceans around the coast of Australia. I was eager to test the comfort, fit, and heat regulation, as well as the quality and value.

Specifically I was concerned with:

- Fit - I can't stand tight fitting things, especially around my neck!
- Latex seals - the possibility of discomfort or leaking.
- Chafing - as with any tight fitting clothing.
- Flexibility - would the suit give me the freedom of movement required for kayaking?
- Overheating - I hate being too hot!

It was a pleasure to test out the Kokatat Meridian Gore-Tex Dry Suit which performed excellently throughout the test.

Kokatat Meridian Specifications

- Evolution 3.2 oz. nylon 3-layer Gore-Tex laminate, which is breathable and abrasion and puncture resistant fabric with Gore-Tex seam tape
- Completely waterproof and windproof from the outside
- Latex wrist and neck gaskets for the most watertight seal available
- Gore-Tex socks attached to legs eliminating the need to have gasket seals at ankles and helps to keep feet warm and dry
- Neoprene overcuffs and collar protect gaskets from abrasion and UV exposure
- Optiseal zipper, waterproof to 20 feet
- Adjustable bungee waistband and durable inseam gusset design
- Factory sealed seams and each suit 100% waterfill tested before leaving the factory
- Overskirt with cummerbund waist for an excellent fit over spray deck tunnel
- Chest pocket
- Uniquely patterned to comfortably move with kayaker's motions
- Added seat and knee protective covering to give extra protection against abrasion or puncture when sitting or kneeling
- Optional relief zipper at front for males, and drop seat zipper at rear for females
- Optional added reflective tape
- Optional added sleeve pocket

The suit comes in five men's sizes: small, medium, large, extra large, and extra extra large.

The suit comes in five women's sizes: small, medium, large, extra large, and extra large short. Kokatat has created the most extensive range of women's paddling gear in the industry. The women's sizes are not downsized men's patterns, but rather a large range of specially tailored features, including: narrower cuts in the shoulder to reduce bulk and enhance mobility; shorter sleeve and torso length meaning less bulk over the wrist and at the waist; narrower waists for less bulk; fuller hips with a longer rise to accommodate a woman's shape; special thigh gusset for a non-binding upper thigh fit; shorter inseam length meaning less fabic at the ankles to get in the way; and the special option of a drop seat relief zipper.

Paddlers can also request custom fitted suits, such as shorter or longer sleeves, and inseam length.

At the time of the testing, the recommended retail cost of the Meridian dry suit was AUS $1,618.00.

Kokatat dry suits are supplied by Paddle Sports Australia, (www.paddlesports.com.au) located in Richmond, Melbourne. Many thanks to Kokatat for supplying the suit for this test. (Bruce Baxter did not supply the suit, he put me in touch with the Kokatat sponsorship group who then dealt directly with me throughout the whole process.)

Testing the Suit

First impressions

I apprehensively ordered the suit by mail order. Luckily Kokatat have a good history and knowledge of dry suits and correct sizing of men, and women and it fitted perfectly. The Kokatat sizing charts are quite detailed with measurement ranges for: chest, waist, hips, inseam, height, weight, and sleeve length. Each of these measurements must be taken at the correct position on your body, under their expertise guidance. If the latex seals are too tight they can be stretched as per the instructions. I was not able to check out the quality of the material in advance of my mail order, but on opening the parcel all my worries were dispelled immediately. The Gore-Tex suit is extremely well made. The Gore-Tex material feels soft and supple, and does not make crinkling sounds which can be a real annoyance when paddling.

The test - 9 hours of paddling a day for three consecutive days!

After wearing the suit around the house to test the fit, I fine-tuned the fitting of the wrists and neck seals following the stretching instructions provided on the attached pamphlet. For testing I wore the suit for 9 hours a day, for three consecutive days!

The capsize testing of the sea kayaks was undertaken on a sunny day. I was not paddling and exerting energy, so I wore a pair of Mountain Designs branded thermal long pants, and their thermal singlet under the dry suit, as well as a pair of warm socks to keep my feet relatively warm inside the in-built Gore-Tex socks/booties. I was very comfortable. I did not get cold - although my fingers were becoming quite frozen in the cold water my body stayed dry and warm. While sitting on the river's edge, waiting in between kayaks I cooled down rapidly. I decided to reverse 'burp' the suit. I carefully slipped my fingers into the neck seal and gently pulled it out a bit. This allowed warm air to enter the suit. It was amazing how quickly I warmed up from this small amount of air that was acting as a layer between my thermal clothing and the dry suit.

On day two, testing started when it was 8 degrees Celcius (46o F), with a top temperature of 14o C (57o F). I would be padding for 20 minutes at a time intermittently all day so I decided to wear Mountain Designs branded thermal long pants, their 'evaporaide' t-shirt, their thermal long sleeved top, thermal vest, and their special x-Static mositure wicking underpants. I was extremely comfortable all day. I did not noticeably sweat at all in the suit, and at the end of the day was as dry as toast inside.

The relief zipper at the rear of the suit is an excellent feature for prolonged wear, allowing the wearer to go to the toilet with out taking the entire suit and all their clothes off!

I was thoroughly impressed by the quality and fit of the latex seals. They were snug without feeling restrictive or uncomfortable. People advised me to put on powder, petroleum jelly, or Vaseline to help reduce the chance of chafing, but I am glad that I didn't follow their suggestions. I had such faith in the Kokatat product, that I did not put anything on my skin to protect it from the seals and I had no problems whatsoever throughout the three days wear.

The suit was so comfortable that I had to keep looking at myself to know I was wearing a dry suit. There was absolutely no restriction to any movement whatsoever. I had no chafing at all. Getting in and out of the various kayak cockpits, I had no trouble with the leg material bunching up giving me a 'wedgie'. During the capsize testing I was fully submerged in the suit. During this time I had a strange feeling of being in the water but not getting wet. Due to a small amount of air still in the dry suit, it caused my shoulders to 'swell' with the air rising in the suit. With the rolling testing, this small amount of air could have been a bonus. I am still in the early phases of perfecting my rolls, and I wondered whether this small amount of internal air in the dry suit assisted me to execute each roll, by adding to my buoyancy at the appropriate part of the roll.

Reflection

The test involved paddling types of craft that I have not paddled before, especially those with less stability than I am used to in my sea kayak. Sitting in a wheelchair, does not give me great trunk muscles compared to an ambulant person. So I was a bit apprehensive about paddling those long skinny surf skis. But I am always willing to have a go and push myself. I was able to stay upright for a number of kayaks. I had no worry about capsizing and getting cold during the testing, as I was wearing the dry suit. Therefore, I was also able to try more kayaks without fear of getting too wet and cold, than if I had not been wearing the dry suit. Certainly when conducting scientific testing, you need as many variables removed as possible, so you can get as accurate a comparison as possible. This is not able to be done, if you are starting to get hypothermic.

I had a great time paddling the various craft. I certainly learnt a lot about dry suits, and am glad to dispel some of the pre-conceived ideas of paddlers concerning dry suits. Certainly I would recommend that any serious kayaker should get a dry suit, especially one made of Gore-Tex.

Me on the river bank, getting instructions from Brendon Grail, of Rapid Ascent Adventure Event Management, on what capsize tests I need to undertake.

As you can see above, I was totally submerged at times, during the test. Such as here, assessing the effort required, and time taken, to empty the cockpit of water after a capsize in the Point 65N XP, by lifting the bow up to let the water drain out of the cockpit.

10.0 subjective scoring

This is the 1-page "score sheet" that was used by testers to record their comments about each kayak. Testers paddled test craft for approximately 10 minutes each and then completed a score sheet immediately after testing each craft. Due to the randomised nature of the testing, testers did not paddle craft in their categories (ie all sit-on-tops in one block). It should also be noted that individual testers' attitudes towards particular test craft or styles of craft may be inherent in testers' scores and comments. All of the assessments made by testers are entirely subjective.

	Question	Score	Multiple Choice description
1	Primary stability		5 Extremely stable, could stand up and dance 3 Moderately stable, some tippiness there 1 Extremely unstable, capsize-inducer
2	Secondary stability		5 Excellent, can tip it a long way, edging easy to control 3 Average, a little tricky to control edging 1 Tip = Flip, goes from straight up to straight down with no stops
3	How easy is the boat to enter (and exit)		5 Very easy, a paddler of average skills could almost step onto/into and out of 3 Average, minimal manouevring required to position/extract bum comfortably 1 Difficult, significant manouevring required to position/extract bum comfortably
4	How comfortable is the seat? (imagine sitting in the seat for 1 hour)		5 Very comfortable, caresses my bottom 3 Average, may get a little uncomfortable after an hour in the seat 1 Poor, could feel "hot spots" needling my bum
5	How supportive is the seat position?		5 Excellent, moulds the bum beautifully, allowing good drive from the hips 3 Average, lack of bum-hugging mould that may prevent full drive from hips 1 Poor, very little support or shape to the seat position, bum-slide
6	How did the boat effect your body position?		5 Positive asset, it was easy to remain sitting tall 3 Neutral, no effect on my usual or preffered body position 1 Nightmare, made my back hurt or made my hips tip forwards
7	Is the footbar and steering/ pedal system effective?		5 Very effective, able to get good power through the legs, feels durable and easy to use 3 Average, not able to generate maximum power through legs, or pedals not super-durable or not that easy to use 1 Poor, unable to get much drive through the legs, not very durable or difficult to use
8	Is the steering effective? (as determined by effectiveness of rudder in turning the craft)		5 Very effective, precise & predictable steering 3 Average, takes a little while to respond/adjust and may take some getting used to 1 Poor, very non-responsive or sloppy/slow to react
9	How responsive did the kayak feel to your input?		5 Ferrari - agile and instantly responsive 3 Hyundai - eventually got going but needed some coaxing 1 Trabant - like swimming in mud, a one-speeder with no reward for effort
10	How much did you have to adjust your natural paddling technique in this boat?		5 Perfecto, no adjustment at all 3 Some adjustment required 1 Shocker, completely changed my normal paddle stroke
11	How wet did you get?		5 Not at all, dry as a chip 3 Bit wet 1 Soaking, might as well have went swimming
12	"Are there any design elements or features you particularly liked?		
13	"Do you have any suggestions for improving anything?		
14	"What did you most like about this boat?		
15	"What did you least like about this boat?		
16	"Anything that a beginner should be aware of in considering this boat?		
17	What type of paddler do you think this craft would be most suitable for?		
18	Rate the looks (ignoring colour) on a scale of 1 to 10, 10 being drop-dead gorgeous and 1 fugly		
19	If you had the choice of 6 boats you'd like to own, would this boat be in your top 6?