Report for British Canoeing: Stand-up Paddleboard Leashes in Flowing and White-Water

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Executive Summary:

Stand Up Paddle Boarding has recently grown in popularity. Following a series of fatal accidents safety interest has focused on using leashes in flowing water. The project aims to improve British Canoeing's understanding of the use and limitations of leashes in flowing and white water. Thus, create findings that enable education of SUP padders to be evidence informed.

Initially, we applied an adapted method previously used to evaluate the performance of water rescue quick-release chest harnesses. We completed 130 tests with a randomised sample of waist-worn leashes in a calibrated channel that provided a range of laminar flow conditions from 1kph (0.7mph/ 0.54kn) to 5kph (3mph/2.7kn). We found that 42% of releases were rated as being compromised, firstly because of inherent problems associated with quick-release mechanisms, in common with earlier research and secondly, because the waist-worn systems had tendencies to move on the wearer and be associated with wearer instability in the water.

We completed a further 50 tests applying existing recommendations to improve the performance of similar devices. Results demonstrated that 10% of releases remained compromised, though these compromises are less significant than those reported from the original trial.

We tested a rescue manakin to examine the consequences of entrapment at river level and below river level (sub-surface) with an ankle leash and with and without PFDs. We found that below river-level entrapments, even at low flow rates 1kph (0.7mph/ 0.54kn), forced the manakin below the surface, this is only partially mitigated by a PFD. The PFD's effectiveness at higher flows reduced further. Waist-worn systems have two inherent instabilities that may impact the quick release of the leash should an entanglement or entrapment occur; these warrant further investigation.

As safety equipment, we expect it to operate perfectly 100% of the time. On the basis of severity of entrapment, the frequency of swimming while SUPing and the potential for extremely challenging rescue, we make interim recommendations that;

1. That leashes should not be used on white water until a suitably reliable method of quick release can be identified.

Because mature rivers and estuaries frequently include open water the wearing of a waist leash may have benefits that outweigh the risk of entrapment. The improved performance achieved in test 2 through the application of simple guidelines. We make interim recommendations that

2. There is a need for education and training that;

a. encourages the correct activation, sizing and fitting waist leashes. Such advice being actioned by BC via its education courses and in line with what should be currently taught for the use of quick release rescue harnesses and improved point of sale information.

b. develops greater understanding of the environment in which a SUP may be used, in particular how to recognise flowing water and its dangers.

3. That further research is required to identify further improvements to the performance of the waist leashes. Specifically, the two factors that appear to be at play- attachment point and belt movement.

4. Developing a data base of paddle sports near misses and accidents that can act as a resource in future research and decisions on safety.

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Acknowledgements

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We thank the manufactures for their on-going cooperation.

Conflicts of Interest

Collins declares a historical relationship with Palm Equipment UK.

Onions and Collins jointly declare a patent for a quick release harness developed from their earlier research (2013, 2014 & 2018). This forms part of an agreement between their former employer, University of Central Lancashire and Palm Equipment. Onions nor Collins benefit from that agreement.

1. Introduction

The origins of Stand-Up Paddle boarding (SUP) lie in surfing and the surf environment (Bassett, 2019), logically the use of ankle leashes has been encouraged as a safety measure in line with practice in many other surfing activities. The board acting as a buoyancy aid/ personal floatation device. However, the growth and expansion of SUP activities (British Canoeing) on other bodies of water has seen the use of waist and chest worn leashes also become common. Two such types of water are flowing and white water. Regrettably there have been a number of high-profile fatalities (Emma Powell on the Conwy estuary in July 2022; Simon Flynn on the Camel estuary in August 2020; Andrea Powell, Nicola Wheatley, Morgan Rogers, Paul O'Dwyer on the Cleddau River in October 2021) in these settings. In all these incidents the use of leashes is either a directly contributory factor (Gittin, 2022, both estuarine incidents) or as being worthy of note (Marine Accident Investigations Report, 2022, the Cleddau incident).

Following these fatalities British Canoeing (BC) have commissioned this piece of research (Appendix 1). The project aims to improve BCs understanding of the use and limitations of leashes when used in flowing and white-water contexts. The findings will enable BC coach and leader education to be evidence informed.

The objectives being to;

- provide the evidence informed basis for guidance to SUP users, BC leaders and coaches on the wearing, using and releasing of leashes in flowing and white-water environments.
- make recommendations on the desirable characteristics of, use and wearing of leashes on flowing and white-water.
- confidentially review a sample of commercially available leashes from a flowing and white-water safety perspective.

With these aims and objectives in mind we first present a short background to SUP, the use of leashes and their use on flowing and white water, before outlining our approach, our findings and presenting a set of evidence informed recommendations.

2. Background

2.2 Growth of SUP

SUP has a relatively recent but rapidly growing history in the United Kingdom, emerging as a popular water sport in the early 2000s. Originating from traditional surfing, SUP has its roots in Hawaii, where surf instructors used paddles to navigate their boards from a higher vantage point. The sport gained traction globally, reaching the shores of the UK as people embraced the versatility, accessibility and ease of SUP paddling. Initially, SUP found its niche among surfers seeking an alternative on calm days, but rapidly outgrew its coastal origins. As inflatable paddleboards became widely available and technology advanced, SUP became accessible to a broader audience, encouraging enthusiasts to explore rivers, lakes, and inland waterways. The UK's diverse water landscapes provided ideal settings for SUPs expansion. There has been a boom in SUP in the last three years, accelerated by the pandemic as people realised the value of outdoor space. SUPs are the most popular watercraft owned, due to their low cost, easy transportation, storage and low maintenance. Rushall market research data from June 2023 shows that in the two years from 2020 to 2022 SUP grew from 2 to 4.2 million participants (6.3% of the UK population).

Global SUP market will gain a market value of 165 billion U.S. dollars in 2023 and is expected to accumulate a market value of $4.3 billion over the next ten years. Global population growth, increases in water activities, rapid growth in the water sports sector, and increasing disposable income, have all contributed to the growth of the SUP market. A recent survey conducted by the outdoor industries association in the US reported over 3 million people will attend SUP events worldwide in the coming year. Increased recreational sport activities suggests SUP will continue to grow and with it an increased demand.

In the UK SUP is the fastest growing aspect to paddle sport and British Canoeing have recently become the governing body for SUP.

2.3 Uses of Leashes

As cited in our introduction the use of ankle, waist and chest worn leashes is established because of SUPs historic association with surfing. In this context the purpose of an ankle, waist and chest worn leash is to keep the paddler connected to the board. This has a clear logic on flat non flowing, open water and in surf as it ensures the paddler will always be able to recover themselves to the board. The board acts as a personal floatation device. In this respect any leash is a safety device. In particular Paddleboards are lite and generate some windage, meaning that they can be blown away from a paddler if they fall in and they are not attached by a leash, or can be washed away from the paddler in surf. Swimming after the board is difficult while retaining a paddle. The tendency not to wear personal floatation devices (a second safety measure linked to SUPs surfing antecedents) also supports a rational for wearing a leash on flat and open water as well as in surf. A leash can help save lives in these settings.

However, the use of leashes appears habitual. Indeed, boards are sold with leashes as a matter of course. Point of sale information, in the form of the BC infographic supplied with some boards, provides some advice on leash usage but does require the user to identify the characteristics of the water they intend to paddle on. Manufacture point of sale information on the use of leashes is of varying quality.

2.3.1 Types of Leashes

There are several categories of leashes; coiled/ elasticated and straight

Coiled/ elasticated leashes offer the benefit that they tend to sit on the board and therefore do not trail in the water, and so reduce the risk of entanglement. However, coiled leashes present a risk in surf as the tension between board and paddler causes the board to spring back towards the paddler once the wave has passed and has the potential to cause injury. In surf straight leashes, which have no elasticity, are preferred as these allow the board and paddler to be separated as the waves passes but reduce the potential for impact due to recoil between board and paddler. Typically, these leashes are, sized depending on the board, user and type of water being paddled. The leash is attached to the board, usually via a glued D ring on inflatable boards or via a string loop fixing point on composite boards, the position of these connections are typically towards the rear of the board, as typically seen in a surfboard leash configuration.

Leashes attach to the paddler in two ways at different locations. At the ankle or calf via a VELCRO® or similarly fastened cuff - common for general paddling, surf and non-moving waters, the system in non-releasable and is designed to sustain significant load. Or via a belt incorporating some form of quick release that is worn around the waist or in an improvised fashion over the buoyancy aid at chest level, akin to the QRH we outline later.

These ad-hoc adaptations appear to imply a risk of entrapment and entanglement that has been recognised within the SUP community. SUP paddlers report using a variety of different configurations to their leashes when used on flowing and white water. Adaptations include;

1. Positioning waist-worn leashes over the PFD, under the arms but high on the chest- akin to the quick release chest harnesses used in water rescue as cited above.
2. Velcro a release mechanism.
3. Integration of fail safes in the system, cable ties as replacement for components.

4. Integration of quick release shackles

Image 2.1: Straight ankle leash, suitable for surf

Image 2.2: Coiled ankle leash, suitable for open and standing water

Image 2.3: Waist leash,

Image 2.4: Cable tie improvisation, used to replace grub screw in connection

Image 2.5: Quick release shackle

2.5 SUP, Associated Research the New Environment: Flowing and White-water

At the time of publication there is no peer reviewed or published research that explores leash use. This report is in review for peer review with an international journal. There is peer reviewed published research, (Onions, 2013, Onions and Collins, 2014, Collins and Onions 2015) in related areas. There has been practitioner research reported on social media (https://www.facebook.com/groups/391546001013219/user/614142110/ and https://www.youtube.com/watch?v=-NJEYNWaD8Q) while possibly indicative this has not been peer reviewed. Like all research, but in particular non reviewed, the robustness and reporting of findings or opinions must be critically considered to establish its value to the debate at this point.

2.6 Safety Principles on Flowing and White Water.

British Canoeing and Rescue 3 Europe provide white-water safety and rescue training for paddlers and emergency responders in the UK. Both organisations courses are based on a set of key principles in relation to safety on flowing and white water. Understanding of flowing water and white water, the 'Clean Principle' and 'Releasability'.

The 'Clean Principle' attempts to reduce the risk posed of entanglement, being caught on ropes or items such as leashes, and entrapment, where that item also becomes entangled in the riverbed or other obstruction in the flowing water causing the person to be trapped, potentially under the water. This is the mechanism at play in the tragic accidents on the Conwy and Camel estuaries. Within the 'Clean principle' is an acceptance that the risk of entrapment and entanglement cannot be fully removed from the activity SO anything that presents such a risk that cannot be mitigated completely must have two features; a buoyancy, the ability to float so the item stays on the surface, reducing the risk of entrapment and a quick release capacity that can be operated by the paddler or fail safe should they become entangled or entrapped.

As a matter of practice, all paddlers on flowing or white-water are encouraged to wear Helmets and Personal floatation devices (PFD) and carry a knife.

2.6.1 Similar Equipment

Two items of equipment, typically used by paddlers are a QRH and body worn towlines, both have a relevance in this project. Both items have a long history of use in a range of environments, the ORH the subject of peer reviewed and published research, Onions and Collins (2014) and Collins and Onions (2015).

2.6.1.1 QRH: Is a quick release chest strap that is integrated to the PFD and provides a means of attaching, via a dorsal attachment, a rope to the wearer so they can perform a rescue. As the name implies, they have a quick release capacity via a chest mounted buckle and are designed to ensure a 'defensive' swimming position for the user- a measure that reduces the potential for a foot entrapment, wear the paddlers foot becomes trapped in the river bed and the force of water pins the paddler under water. Typically, users are trained in the QRH use via the British Canoeing or Rescue 3 systems and the effectiveness of these systems has been the subject of published research.

Image 2.6: Integral Quick Release Harness, front and rear images.

2.6.1.2 Body worn Tow lines: These are used on the sea and in flat / open water settings. British Canoeing do not advocate their use on flowing or white water. A body mounted towline involves a quick release waist belt, a length of webbing (that may be elasticated) and a clip to attach to the boat being towed. Body mounted towing systems fell out of favour in white water kayaking and canoeing following fatalities in which individuals became entrapped while attempting to tow swamped boats on flowing and white water.

Image 2.7: Simple waist mounted tow line

The similarities between body mounted towlines and the leashes provided in the sample for use on flowing and white-water is striking and so considerations have been informed by research into the performance of QRH and the historical lessons learned from towing on flowing and white-water.

3. Method

We adopted a 3-part pragmatic approach to our testing.

Part 1) A desk top review of the waist leashes using the safety principles advocated in the BC and Rescue 3 safety programmes.

Part 2) Test the remaining leashes in a series of simulated incidents and evaluate their performance

Part 3) Test the behaviour of leashes in a series of static in water and laboratory based tests as required.

As leashes are items of safety equipment our expectation was perfect performance in a range of conditions. We also decided that we may explore avenues of improving performance if required, with the agreement from BC.

3.1 Part 1: A desk top review of the leashes using the safety principles advocated in the BC and Rescue 3 safety programmes.

British Canoeing provided a commercially available sample of two examples of five different waist worn leashes (n=10). We initially reviewed the samples against the 'clean principles' outlined in our introduction. We familiarised ourselves with the leashes operation, manufacturer instructions, and satisfied ourselves that we could safely test each example provided. We completed 15min and 60 min float tests and elongation measurements on the elasticated parts of the leash (Table 1).

Table 3.1: Results Float test for waist belt

Float test for belt			
Code	**Initial**	**15mins**	**60mins**
1 & 10	Floating	Floating	Floating but becoming water logged
2 & 6	Non-floating	Non-floating	Non-floating
3 & 7	Floating	Floating	Floating but becoming water logged
4 & 8	Non-floating	Non-floating	Non-floating
5 & 9	Non-floating	Non-floating	Non-floating

Table 3.2: Results Float test for leash

Float Test for leash					
				Length (mm)	
	Initial	**15 mins**	**60 mins**	**Passive**	**Elongated**
4 & 8	Non-Floating	Non-floating	Non-floating	800	3300
2 & 6	Non-floating	Non-floating	Non-floating	1000	3300
5 & 9	Floating	Floating	Floating	1600	3100
1 & 10	Floating	Floating	floating	1500	2400
3 & 7	Floating	Floating	floating	1700	2600

We considered the float tests on the belts to be interesting but of limited value. All samples had an effective means of quick release and the belt, once released, would fall from the wearer and thus not present an entrapment or entanglement hazard. We considered that the leash sections mitigated the risk of entrapment by two ways, either by being highly elastic and this not trailing in the water when in use OR by being buoyant. We noted that no single leash combined the two.

We concluded that we could proceed to in water testing with all samples under stringent supervision based on a risk assessment (Appendix 1.) and ethical consent because each configuration had either buoyancy, an ability to be released or a combination of the two key features.

3.2 Part 2: Test the remaining leashes in a series of simulated incidents and evaluate their performance.

We split this test into two sections. The first a test of the release mechanism using the manufacturer advice, provided in the point-of-sale information. And the second, a smaller number of identical tests with the belts sized and adjusted in line with recommendation made by Collins and Onions (2015).

3.2.1 Procedure

3.2.1.1Test site

For the purposes of this test a calibrated channel was used 200m downstream of a British standard broad-crested weir (International Standards Organisation, 2008) and dam. The flow could be regulated and thus made consistent and measured accurately. A water velocity profile survey was conducted using an RDI stream pro acoustic Doppler current profiler and tagline. An accurate model of discharge on surface water velocity was calculated from the data collected using hydraulic software (WinRiver). Repeating the profile analysis for a range of discharges (1-12m^3/s) The cross referencing with the location and discharge, the water velocity for each of the test series events was calculated and recorded. The site comprised of gravel beds and earth embankments with some rock armouring at key locations. Due to the nature of the channel the flow type at the test site was turbulent slow flowing, being representative of the conditions in which SUP paddlers are likely to operate. The approach for determining the force induced by moving water on objects positioned by ropes has been established by Onions (2012); Onions and Collins, 2013; Collins and Onions, 2014; Onions and Collins, (2019). They present the case for capturing data under real world conditions using appropriate equipment in preference to mathematical modelling.

3.2.1.2 Data Collection

A rope was set up as a tensioned diagonal to the flow, upstream of the test calibration point (transit line, see Figure 5). The participant was position in the flow by means of reeving line and adjustable tether. A waterproof Rock Exotica Enforcer load cell was positioned in line with the tether at the tensioned diagonal line out of the water. The same tether was used for all tests and adjusted in length to ensure the participant was position on the calibrated transit line. The waist belt was selected at random by assigning each harness a number and then using a random number generator to select the harness to be used for each test.

The tests utilised four qualified swift water rescue technicians. To ensure consistency, we first trained the technicians in the use of the 0-7 rating scales highlighted in Table 3. This was an adapted version of the rating scale used by Onions and Collins, (2014) and Collins and Onions (2015). A zero rating was added in anticipation of waist belt movement.

Operating in rotation, each technician donned the randomly selected belt, and was then attached to the system via the tether and allowed to float onto the system, being position directly downstream of the attachment point on the tension diagonal and positioned on the transit line by adjusting the tether we could expose the technicians to different water speeds between (1 kph (0.7mph/ 0.54kn) and 5 kph (3 mph/2.7kn) by positioning them at different points on the transit line (see appendix 2). Once in position the system was allowed to settle, as indicated by a constant load on the load cell. Following visual confirmation from the technician that they were ready the belt was released. The maximum force from the release was recorded. The technicians recovered themselves to the bank and reported their views as to the quality of the release using the predetermined scale in Table 3.

3.2.3 Test 2 adaptation. The test procedure was identical for test 2 with the adaptation that the belts where sized and fitted in line with the recommendations on QRH use. Namely, release was activated using the toggle, in a punch away from the body and the webbing trimmed to ensure both buckle and tape separated in a trial, dry land release.

Figure 3.1: Plan of Testing site and Tensioned highline

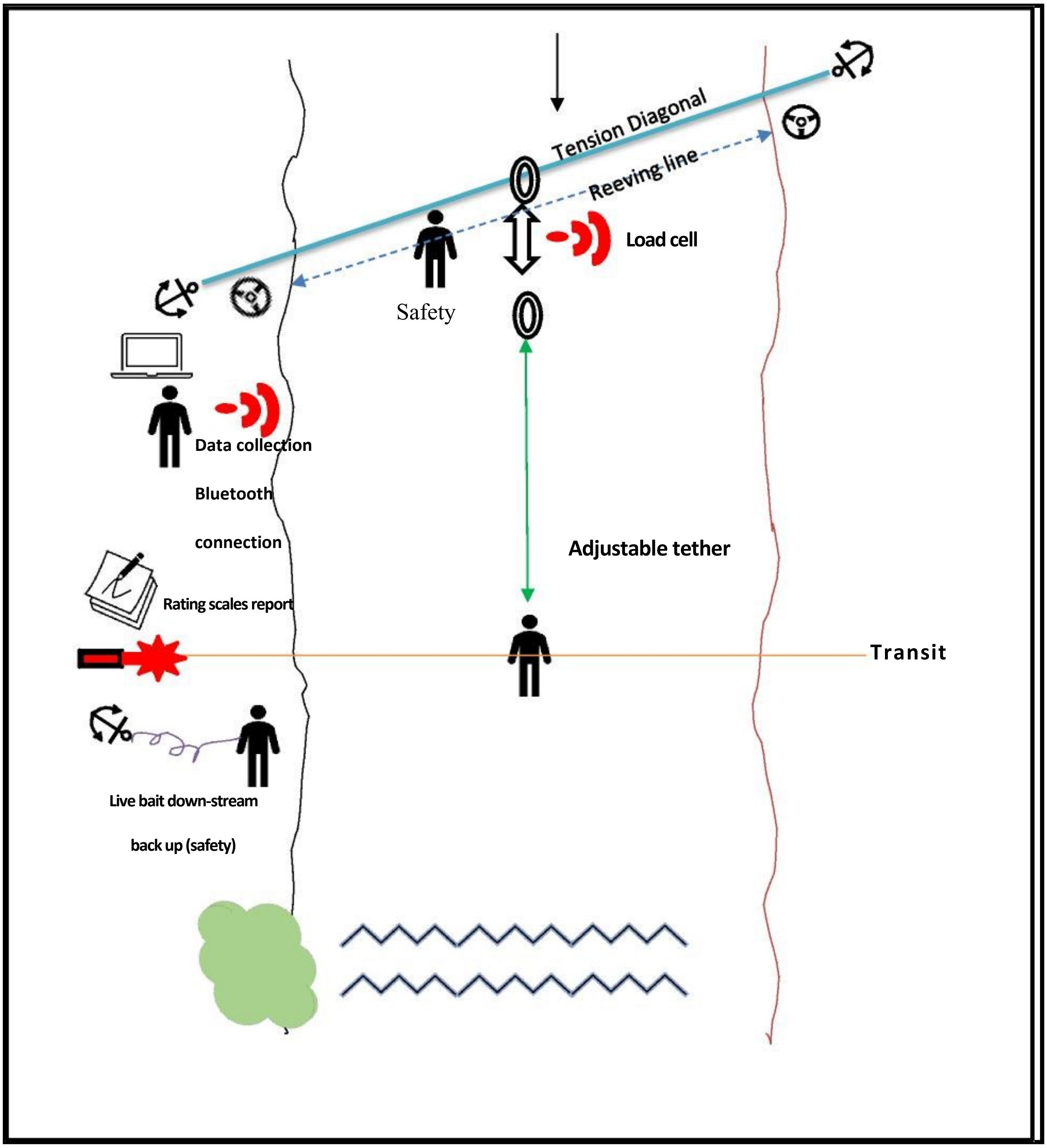


Table 3.3: Release rating scale adapted from Onions and Collins, 2014 and Collins and Onions 2015)

Rating	*Rating Descriptor*	*Example*
0	Participant is unable to locate or access the release mechanism for the belt: No activation possible	No release is possible, Assistance required recover participant to the bank.
1	From release to separation no notable friction or delay in the process	A smooth consistent and constant flow of the tape through the buckle.
2	From release to separation friction and load on the user is notable by the participant	Friction between the tape and buckle is noticeable by feeling rubbing or faltering as the tape pulls through the buckle.
3	From release to separation there is a momentary delay in the process that rectified without intervention	Friction between the tape and buckle is noticeable by feeling the force of water, on the participant, increased as movement is delayed as the tape pulled through the buckle.
4	From release to separation there is a momentary stop in the process that is rectified without intervention from the participant	The movement of the tape through the buckle is brought to a 'stop'. Without intervention the stop is rectified and the release continues.
5	From release to separation there is a momentary stop in the process that is rectified by an intervention from the participant	The movement of the tape through the buckle is brought to a stop the participant is required to take a single action to re-establish the movement of the tape through the buckle. For example, making a star shape to increase load as recommended by (Collins & Onions 2014)
6	From release to separation there is a clear stop in the process. That is rectified with repeated intervention from the participant.	A single intervention from the participant is insufficient to 'free the system' and the repeated actions are required to facilitate movement of the tape through the buckle.
7	From release to separation there is a clear stop in the process. That is rectified by intervention from the bank	Assistance required recover participant to the bank. or When loaded in the water the system fails, fail safe activated

4. Results, Parts 1 and 2

Reflecting the use of the waist leash as an item of safety we expected 100% of release to be rated as 1 across the conditions of the test.

Table 4.1 Results of Test 1 and 2

Rating	*Test 1 (%)*		*Test 2 (%)*	
0	0/130- (0)		0/50	
1	75/130 (58)	58	46/50(92)	92
2	41/130 (31)		3/50 (6)	
3	9/130 (7)		1/50 (2)	
4	2/130 (1.5)		0/50(0)	
5	1/130 (0.8)		0/50(0)	
6	1/130 (0.8)		0/50(0)	
7	1/130 (0.8)	41.9	0/50(0)	8

Test 1: We conducted 130 tests of which 58% rated 1, 42% had releases rated between 2-7. In addition, 15% of these tests also reported movement of the wait belts on the user during the test.

We concluded that the waist belts did not perform adequately as an item of safety equipment.

Test 2: We conducted 50 tests of which 92% rated 1, 8% had releases rated 2-3, 0% rated 4-7, 16% of the 50 releases reported movement of the waist belts on the user during the test.

We concluded that the recommendations had improved belt release performance, removing ratings, 4-7. Applying the same criteria as test 1 the performance was considered inadequate but improved. However, there remained 16% reported movement of the belt around the user's body.

Limitations: To ensure accuracy of rating on releases our participants where all trained rescue technicians, accustomed to being in flowing water and using quick release devices of this type and trained in the application of the rating scale. We conjectured that an untrained, inexperienced user would encounter great difficulty in activating the release.

We concluded that test 2 be best considered a ' proof of concept' at this point that strongly supported our earlier work with QRH.

We also note that there is no UK data base of accidents or near misses in SUP nor paddle sport that could support this or future research. Our judgements regarding levels of risk are based on the documented fatalities, research in directly related fields and our experience of paddle sport in flowing and white-water.

We conclude that such a data base is required, akin to those in aviation or medicine.

4.3. Part 3: Test the behaviour of leashes in a series of static in water and laboratory-based tests as required.
We opted to conduct further tests in five areas, three further tests in the calibrated channel using the test rig (figure 5), two further tests using a Dartec 100kN slow pull test machine.

.3.1 Ankle Releases*:* We wanted to examine *if* it was possible release an ankle leash under test conditions. We worked with one of the technicians to develop a way of releasing a coiled ankle leash. Initially on dry land, the technique was refined in standing water. Once confident in the technique, we moved the test onto the test rig (Figure 5) and positioned the technician on the transit line exposing them water speeds from 0.5kph increasing incrementally to 1.0kph. The technician decided not to exceed 1kph as they considered that would be impossible.
We concluded that ankle leashes can be released by well trained, very water confident individuals in very low flows if the entrapment point is above water level.

4.3.2.2 Entrapment Point: We then explored the impact of entrapment point on an entrapped leash user. This time using a ankle leash and a 65kg rescue manakin was position using the test Rig (figure 5) in a 1kph flow. We conducted 4 tests;

i. An entrapment point at river level *with* a PFD
ii. An entrapment point at river level *without* a PFD
iii. An entrapment point at riverbed level, 35cm sub-surface, *with* a PFD
iv. An entrapment point at riverbed level, 35cm sub-surface, *without* a PFD

The manakin was consistently washed directly downstream of the entanglement point. When the point was sub-surface the manakin was washed to the riverbed. A 'classic' entrapment that is nearly impossible to rescue. If the entrapment point was at river level the manakin was washed down stream at the surface. A PFD kept the manakin at the surface when the entrapment point was at the surface. If the entrapment was subsurface the PFD kept the manakin at the surface for longer, 'pourpoising' the manakin (oscillating between surface and sub surface, possibly maintainable by a wearer 'doggy paddling' in the early stages but limited by the user's fatigue) but did not overcome the entrapment when 35cm below the surface.

We concluded that in these low flows it was possible to be held under the water whilst wearing a PFD. The critical factor is the entrapment point.

4.3.2.4 Tensile Load Testing Slip Function: The waist leash samples were evaluated for their ability to slip and release when subjected to a tensile load. DMM International supported this phase of the project by supplying the services of their quality assurance technician and their Dartec 100kN slow pull test machine for evaluation of the leash samples.

Each leash sample was assembled as per the manufacturers' instructions and held in the machine with a 10mm pin as per the destructive testing of karabiners. The machine was set to pull each sample until either the sample broke, or slip was induced in the release mechanism. In the latter case the test was terminated when the ends of the leash parted from one another. The pull speed was set to 2.5mm per second for each test and each sample was subjected to three pulls in line with the DMM three sigma quality assurance methodology.

For each sample the peak force (kN), and a force against time profile was obtained. Each pull was observed, and the peak force recorded

Hook and loop fail safes

The screen shot is presented as a generic example of the mode of release for hook and loop design samples. There is an increase in force as tension is induced by the machine. Immediately after the peak there is a rapid decline as the hook and loop tape fails, but then partially re-grips. There follows a delayed progressive failure to full release that depends on surface area. Some manufactures incorporated a range of release thresholds within their designs. This consisted of markers on a hook and loop fastener tape with increments, for example 25, 50, 75 and 100mm of fastening in place.

Image 4.1: Screen shot of typical release

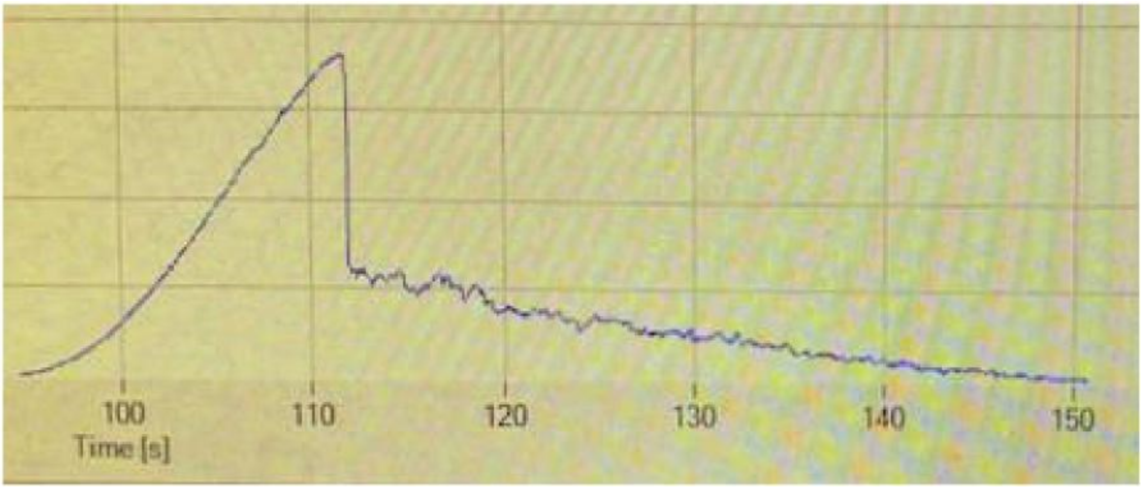


Table 4.2 Variable Hook and Loop results

Tape marker	Force (kN) average of three replicate pulls
25 mm	0.106
50mm	0.199
75 mm	0.317
100mm	0.337

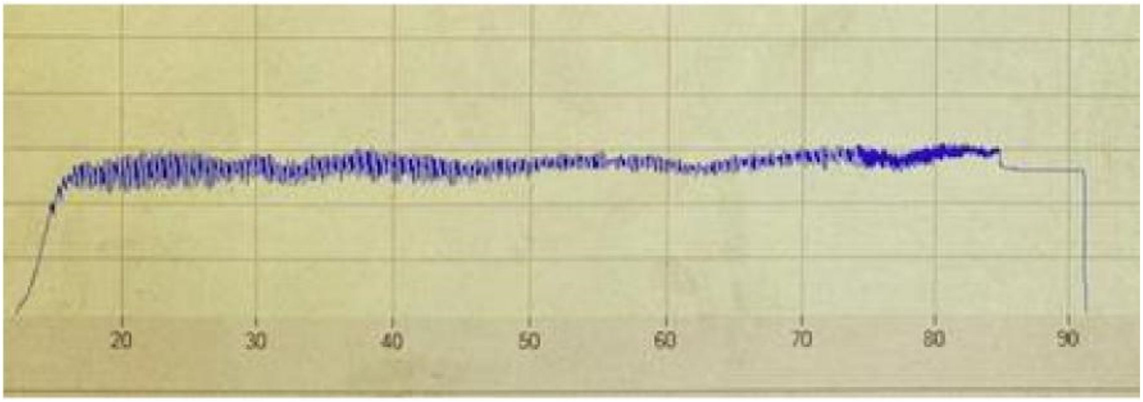
The release threshold increases with respect to the hook and loop fastener engagement (tape marker mm). There is a factor of greater than 3x the holding power prior to release between the 25mm marker and the 100mm marker. This is intuitive given that the holding power is a function of the cross-sectional area of the hook and loop fastener, but little can be determined in relation to the judgement that must be exercised by the user in relation to the desirable threshold of releasability. The smaller/ shorter contact area also saw a reduced progressive failure to full release.

We concluded that hook and loop fastening did not provide a failsafe release and that the judgement on the loads and releases required would be difficult for a typical user.

Cam Buckle slippage.

A second potential point of failsafe release could be the cam buckle.

Image 4.2: Screen shot of typical buckle slip



This screen shot is an example of a generic cam buckle type releasee. In contrast to the leashes incorporating a hook and loop design, the cam buckle reaches a threshold of grip and then releases under a constant tension until the end of the tape reaches the cam buckle.

The load required for the buckles to slip varied and was a function of the buckle and webbing combination.

We concluded that there was no consistency in the loads required to induce slippage, any assumption on loads would be dependant on the buckle webbing combination and specific to each leash.

A Failure to Release

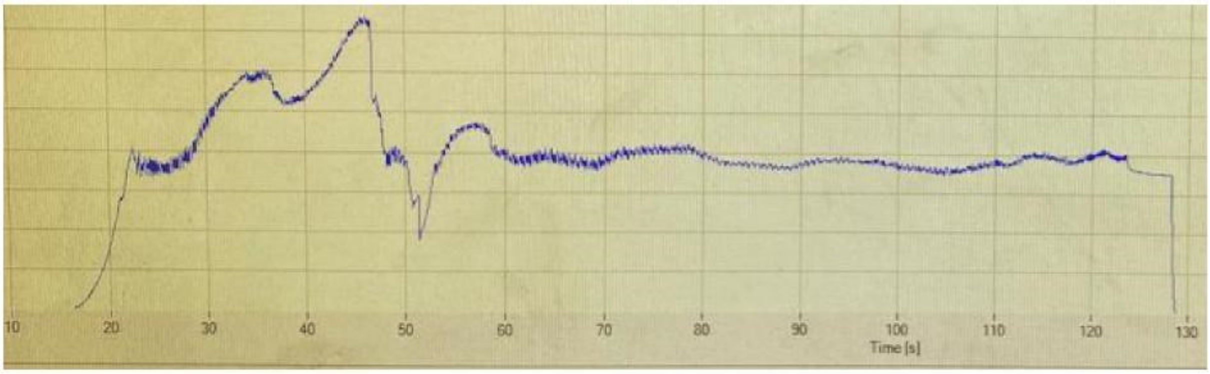
One can buckle design broke during the pull test. The mode of failure was attributed to a burr of melted nylon on the termination of the tape becoming trapped in the gap of the cam buckle. This resulted in a partial failure of the tape at a value at 2.6kN.

Tri-glide and cam buckle arrangement

One sample incorporated a plastic tri-glide rather than bar tacking the cam buckle in place. The tri-glide buckle formed part of the adjustments to ensure the cam buckle and leash attachment point stayed in position while the belt was worn, the cam buckle central at the front, the attachment point central at the rear.

In the screen grab there is an increase in load to a peak force of 3.7kN when the tri-glide and cam buckle are working together to provide a load bearing capacity. At approximately 45 seconds, the tri-glide relocates and jams against the cam buckle with a corresponding reduction in force. Thereafter the tri glide slips until the termination, the cam buckle shows no slippage. The belt fails once the webbing is pulled through the tri glide.

Image 4.3: Screen shot of tri glide buckle slippage



Recommendations

Whitewater

In the absence of a suitable UK based data base our initial recommendation is conservative. As safety equipment, we expect a leash to operate perfectly 100% of the time. On the basis of severity of entrapment, that frequency of swimming as an aspect of SUP and the extremely challenging rescue, we recommend that leashes should not be used on white water until a suitably reliable method of quick release can be identified. This brings SUP paddling, on white-water, in line with the long-standing practices advocated by British Canoeing and Rescue 3 in the UK.

Flowing water

Our investigation to date has not enabled us to make clear recommendation regarding the use of leashes on flowing water. Mature rivers and estuaries frequently include open water, the wearing of a waist leash may have benefits that outweigh the risk of entrapment when taken holistically. We note the improved performance achieved in test 2 through the application of simple existing guidelines and feel there is a possibility to further improve waist leash performance, ideally to a comparable level with that found in quick release harnesses. We make interim recommendations that there is a need for education and training that encourages the correct activation, sizing and fitting of waist leashes. Such advice being incorporated by British Canoeing via its education courses, in line with that currently taught for the use of quick release rescue harnesses, and improvements to point of sale information. In addition, point of sale information and training should also aim to develop greater understanding of the environment in which a SUP may be used, in particular how to recognise flowing water and its dangers.

Because test 1 and 2 identified movement of the belt and position of the attachment point as factors, further research is required to identify improvements to the performance of the waist leashes.

Wholistic Factors

To develop a data base of paddle sports near misses and accidents that can act as a resource in future research and decisions on safety. Such a data base could provide a better background to any recommendation in the future.

Key References

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Price, D. (2021).The paddle board Bible; the complete guide to stand up paddleboarding. Adlard Coles, London

Appendix1: Proposal

British Canoeing Research Proposal:

Stand-up Paddleboard Leashes in Flowing and White-water, 20-1-2023

Our understanding of your needs:

Following a series of fatalities and increased incidents involving Stand-up-Paddle boards (SUPs) British Canoeing (BC) are commissioning research into the use of leashes with SUPs in a variety of different environments, specifically:- (1) flowing and (2) white-water. Leashes have been cited as contributary or noteworthy factors on several of these accidents. The project aims to improve BCs understanding of the use and limitations of leashes when used in flowing and white-water contexts. The findings will enable BC coach and leader education to be evidence informed.

The objectives being to;

- provide the evidence informed basis for guidance to SUP users, BC leaders and coaches on the wearing, using and releasing of leashes in flowing and white-water environments.
- to make recommendations on the desirable characteristics of, use and wearing of leashes on flowing and white-water.
- to confidentially review a sample of commercially available leashes from a flowing and white-water safety perspective.

Core features of our proposal: A 6 month-3 Phase Approach

Phase 1: A systematic review of the research, reports and literature relating to leashes and their use on flowing and white-water by SUP paddlers. We will use an iterative approach drawing on what we know from related areas, such as quick release harnesses, body mounted tow lines, loads generated by flowing water on the body, characteristics of flowing water and accident/ coroners reports to identify areas of focus.

Phase 2: A three-part investigation.

2i) A desk top review of the leashes using the safety principles advocated in the BC and Rescue 3 safety programmes, remove any unsafe leashes from the sample.

2ii) Test the remaining leashes in a series of simulate incidents and evaluate their performance.

2iii) Tests the behaviour of all leashes in a series of static in water tests.

Phase 3: Preparation of a confidential report and presentation to BC that outlines our findings and makes specific recommendations on the use of leashes in flowing and white-water conditions.

Intellectual Property

Intellectual property will remain with BC with all resources, field notes and data returned, or destroyed on completion of the project. The research team may request permission to publish the findings in a peer reviewed journal.

Principle Outcomes

- A PDF report with executive summary with bulleted actionable recommendations by 1-10-2023.
- A presentation of the report to key stakeholders identified by BC, at an agreed time and place, tbc.

Staff

We anticipate a three-person team, led by Dr Loel Collins (LC) who will be your point of contact, with Chris Onions and Simon Alfree, supplemented by swiftwater rescue technicians as required.

Loel Collins DProf, FRGS, FHEA, PG Cert in HE. Loel is a swiftwater safety and research specialist. He completed his doctorate in 2014 and has been a white-water safety and rescue skills trainer for both BC and Rescue 3 International for over 20 years. Combined with his extensive experience Loel has published over 50 peer reviewed research papers, books, and contributed to many book chapters to work in this field.

Chris Onions (CO) MRes. Chris is a Rescue 3 Europe certified Instructor Trainer and has assisted in the development of many swiftwater and rope rescue Instructors based within the emergency services and the military. Chris has participated in research which has led to improvements in practice and influenced manufactures in the areas of load bearing and releasable systems in water rescue. Other research areas include the investigations of the behaviour of rescue craft when tethered in moving water and the implications for rescue responders.

Simon Allfree (SA) BEd, PG Cert. Simon has been working in and around water as a teacher, instructor and coach for over 25 years. He has worked in outdoor education, at the National Mountain Centre Plas y Brenin and in Higher Education, he is going through the Rescue 3 Instructor pathway and is currently the Centre Manager at the National White Water Centre, Canolfan Tryweryn.

Our team has a successful track record of peer reviewed research, conference presentation, research and development with manufactures and training in this field.

Appendix 2. Risk Assessment: Swiftwater Safety and Rescue Research: BC leash research 2023

RISK ASSESSMENT TO BE COMPLETED ON A 'PROJECT BY PROJECT' BASIS BY PRINCIPAL INVESTIGATOR

DATE: June- August 2023				
Completed by Loel Collins, Reviewed by Simon Allfree(June 2023)				
Venue: Top site at CT, calibrated channel and Irish Bridge				
Hazard	**Risk**	**Person at risk**	**Control Measure**	**Level of risk with mitigation *(prior level)***
Water	Drowning	Research Team	1. Within 3m of water edge PPE to be worn and rescue equipment carried, (PFD, Helmet, Knife, Throwline, boots) 2. PPE to be sized and fitted accordingly	

	Hypothermia River Levels		3. See above, plus suitable insulations (wet suit, dry suits + layers), warming facility available 4. Release times, volumes, Prior knowledge of site 5. Defensive swimming brief/qualified participants	Med/low *(high)* Med/low*(high)* Low (Med) Med/low(high)
Terrain	Trips, slips and falls		See 1 above	Low (med)

Weather	Heat (hyperthermia) Cold (hypothermia)		6. Knowledge of weather, for heat shade ad water available See 2 above	Low (med) Med/low(high)
Conditions	See Weather and water above Other users,		7. Manage use of site, coordination with other rescue providers 8. Sole user 9. Up-stream and down-stream spotters/ down stream live bait 10. Signage, notification at reception	Low(med/high) Low(med)
Entanglements/ entrapments	With equipment With riverbed/ banks		11. Multiple quick releases integrated into systems 12. Tensioned diagonals	Low (High) Med(high)

			13. Consideration of floating systems/ ropes 14. Management of banks 15. Agreed Comms 'Safe' words, signal 'HELP!' code and signal	
Human Factors	Operator error Fatigue Overload Communication		16. Research Briefing 17. Monitoring workload and conditions 18. Check and challenge culture and climate	Low (med)

	Un-expected/ diss-orientated swim		19. Radio's/ agreed signals 20. Briefing / white board. 21. Management of input and operational request, brief, re-brief 22. Down-stream live bait, single swimmer to fixed anchor on pre measured line See 1 & 2 above	Low(med)
Equipment failure	Failure due to damaged/ old equipment		23. Visual and manual checks i- PI pre session	Low (low/med)

			ii- by participant on issue iii- by participant on return	
	Edges or anchors		24. Edge protection on anticipated multi directional load, current load and future load, amount Multiple , self-equalising anchors if required 25. Quarantine mechanism	Low(med)
Manual Handling	Soft tissue		26. Identification of heavy loads, black and yellow hazard warning	Low (Med)

	Lower back		27. Good manual handling practice to be applied	Low (Med)
The hazard under test	Failure to release Diss-orientation		28. Dry land release test/ 29. Direct observation by dedicated spotter, 30. Deck top review of samples See 15 above	Med(high) Med(high)