AN ANALYSIS OF THE STRUCTURE OF 'BOWLINES'

Foreword

This technical paper examines why some knot structures are deserving of the title 'Bowline', and seeks to identify and explain the key components comprised in its structure.

Bowlines (in general) have received criticism within the climbing and rope rescue community – and some commentators have argued for their discontinuation. Part of the issue is that negative comments appear to be directed at only one type of Bowline (the Simple Bowline) – and ignore the fact that it was never intended for life critical applications. The *Simple Bowline* was more likely than not, invented by sailors for use on sailing vessels – a purpose for which it is perfectly adapted. This paper deals in facts – and presents another side of 'Bowline' knots, one that is positive and constructive.

If the *Simple Bowline* was employed in a role where it could remain in equilibrium with a steady/unchanging application of load, it would function perfectly – and there would be no security issues (and this paper would probably never have been written).

However, in climbing and rescue applications, a *Simple Bowline* would be employed in a dynamic environment with constantly changing (cycling) load, including slack-shaking. It is in this type of environment where the *Simple Bowline* can fail – and climbers and rope rescue technicians have long understood and tried to overcome this.

Simple Bowline
(#1010)

In life critical applications, "ABoK #1047" [1] (Figure 8 eye-knot) is widely used and is taught in virtually all entry-level roping courses. Its popularity is linked to the fact that it is easy to tie and *relatively* easy to learn (and remember) – and it is both *secure* and *stable* even under cyclic loading and slack shaking conditions.

However, the Figure 8 eye-knot can be somewhat difficult to untie after high loading events – and it is this point that makes it unpopular amongst some climbers and vertical rescue technicians. It is noteworthy that in order to tie a Figure 8 eye knot through a climbing harness or around a tree, a *two stage* tying process is required (that is, the Figure 8 eye-knot is not *Post Eye Tiable* – 'PET').

Ropes are also getting thinner…in the 1980's, 11mm was considered the gold standard. By 2015, 'single' category dynamic ropes had shrunk to 8.5mm.

1980's (11mm) 2015 (8.5mm) 2030 (sub 8.0mm) ?

Beal Apollo 11mm
Impact force: 7.7 kN
No. of UIAA falls: 16
Weight per metre: 75g
Sheath percentage: 35%

Climbing ropes are getting thinner!

BEAL OPERA 8.5mm

SPECS

WEIGHT: 48 g/m
SHEATH PROPORTION: 37 percent
UIAA FALLS (single, half, twin): 5/20/>25
IMPACT FORCE: 7.4/5.5/8.6 kN
DYNAMIC ELONGATION: 37/35/29 percent
DRY TREATMENT: Golden Dry, Dry Cover

6.0 – 7.0 mm ?

[1] ABoK numbers are a direct reference to each knot illustrated in the **Ashley Book of Knots** by Clifford Ashley, published in 1944 (ISBN 057109659X). Every knot is assigned its own unique ABoK number which enables it to be identified.

As climbing ropes become thinner, a tie-in knot becomes increasingly vulnerable to *jamming* after falls. Sport climbers will often take multiple falls in quick succession. In addition, as the MBS of the rope is reduced – the geometry/structure of a tie-in knot will become increasing important to raise its MBS yield.

Riggers, doggers (cranes/lifting/construction industry) and sailors have long known that the Simple (#1010) Bowline has the property of being easy to untie – even after high loading events. This is why it remains the knot of choice for their particular applications. All Bowlines are also 'PET'.

I originally embarked on a journey to find the 'ideal' knot that has the properties of a Bowline (easy to untie after loading events and is 'PET') plus the security and stability of a Figure 8 eye-knot (ABoK # 1047). This paper has evolved to much more than that – along with many new discoveries along with an expanding theory and deeper analysis.

A paradox for some of the Bowline creations is that in making the structure more secure, simplicity has been sacrificed. Recent efforts have tended to focus on finding simple ways to lock down the structure or to reduce the number of sharp turns within the knot core. Not all of the knots perform equally well with stiffer or slick/slippery ropes – and this needs to be carefully evaluated before entrusting a life to a particular knot. It is assumed that users will be using ropes that conform to EN 564, EN 892, and EN 1891 or an equivalent standard. Knots tied in 'dyneema' (made from UHMWPE) must be carefully evaluated to confirm security and stability *before* use.

Very little peer reviewed (reproducible) technical data is available for the properties of the various knots illustrated. Behaviour under static and dynamic loading including MBS for different geometries are generally poorly documented or of dubious origin.

With few exceptions, there appears to be a narrow focus placed on knot strength (ie MBS yield) and this is often cited as grounds for declaring one knot superior to another. Furthermore, many knot testers (measuring MBS yield of 'knot A' Vs 'knot B' mentality) rarely indicate which type of Bowline they are testing – often simply citing 'Bowline'. This immediately reveals a lack of attention to detail – since there are many *different* types of Bowlines – each with differing geometry and characteristics. Furthermore, knot testers often omit high quality photographic images of the particular knot specimens they were testing – leaving it to the imagination of readers to guess the precise geometry.

It is the view of this author that strength is not the most important characteristic of a knot. Of greater importance are the properties of ***security*** and ***stability***. The MBS yield of a particular Bowline (relative to an unknotted section of rope) is more than adequate for climbing and rescue applications. Indeed, there is no force that a falling climber can generate that will reach the MBS yield point of *any* knot.

The reality is that knots rarely fail in the field – eg harness tie-in knots used by climbers don't randomly fail on account of force generated by a fall. More likely causes of rope failure are contact with sharp edges and ropes sawing across another rope (direct nylon-to-nylon sawing action) as is thought to have been the causal factor in the 1998 Dan Osman tragedy. Reported cases where a particular knot has 'come undone' or 'slipped apart' – is invariably due to human error. That is, the climber made a mistake – and either tied the knot incorrectly or used a particular type of knot that was not 'fit for its intended purpose'.

Of greater interest to knotting experts is investigating the underlying *theory* behind knot rupture. We still cannot pinpoint with precision, the location from where rupture propagates. Dan Lehman posits that weaving small cotton color coded tracer threads in the knot test article will help to pinpoint the location of rupture. This author concurs, and this ought to be given greater priority in future knot break tests.

It has been theorized that the radius/curvature of the rope segments in a knot plays a key role in the knot MBS yield. In the case of 'Bowlines', there is both compression and tension forces occurring simultaneously within the structure – and rupture is thought to propagate from somewhere in the *nipping loop*. The *precise* location is unknown but, we do know that once rupture is initiated, it quickly propagates and leads to failure. Some papers have been written about the phenomena – and soft pasta noodles have been used as an analog to study knot failure.

Since this paper was originally published in Jan 2009, several new secure and stable Bowlines have been discovered – including several TIB (Tiable-In-the-Bight) methods for creating them.
A distinction is now made between those types of 'Bowlines' that are *inherently secure* versus those that aren't. An inherently secure Bowline is one that does not require any backup stopper knot to lock down the structure.

I am proud to have played a role in driving the development of our collective knowledge about 'Bowlines'.

Mark Gommers

February 2016

WARNING: LEGAL DISCLAIMER*:*

This paper does not constitute advice. All of the knots illustrated in this paper are loosely tied and oriented to give the best possible photographic appearance. Tails are deliberately tied short – so the entire knot structure would fit within the macro field-of-view of the camera lens. The appearance of a particular knot structure is not a warranty that it is safe to use in human life support applications (eg mountaineering). The concepts and theories advanced in this paper do not necessarily represent the views of the contributors – unless it is expressly stated as such. To the maximum extent permitted by law in your respective nation, the author and contributors to this paper will not be held responsible for any death, injury or loss arising from any use or reliance on the information published herein.

CONTRIBUTORS:

I would like to personally thank all the individuals who provided suggestions, comments, critique and support – without which, this paper would not exist. The theories and concepts advanced in this paper do not necessarily represent the views of the contributors unless it is expressly stated as such.

When I originally commenced this paper in 2009, I didn't realize the magnitude of the work involved. Producing work such as the subject material of this paper is time consuming and technically difficult. What was surprising to me, was the lack of any coherent body of universally agreed theory on knots. On the particular subject of Bowlines, there appeared to be much confusion, disinformation and inconsistencies.

I initially turned to the International Guild of Knot Tyers (IGKT) forum to spur interest in examining the theory of bowlines – "posting the topic:" 'What defines a Bowline?' That initial post sparked a surge of responses with at times heated debate. As of 12 February 2016, there are over 60,500 views of that thread with some 325 written replies. There is also a second thread which deals directly with this paper – and that has some 27,264 views with 374 written replies.

This paper was largely born out of that original Bowline post, in an effort to gather together all the information into one coherent body of theory. I am certain that there is still much work to be done to refine the theory – and this paper is therefore a 'living document' that can be updated over time.

I hope this will inspire others to write papers on interesting knot structures. For example, end-to-end joining knots (including why some are jam resistant) – has been a topic of interest – but one that has not been fully explored.

…

My sincerest thanks go to the following individuals:

Dan Lehman (USA)
Scott Safier (USA)
Constant Xarax (Greece)
Saverio Lentini (Italy)

…and all the individuals on the IGKT forum who provided comment.

Mark Gommers
February 2016

Historic photo showing Edmund Hillary and colleague on the summit of Mt Cook (NZ). The rope 'tie-in' knot is formed directly around their waist (note the long tail on Hillary). Note the hawser laid rope.

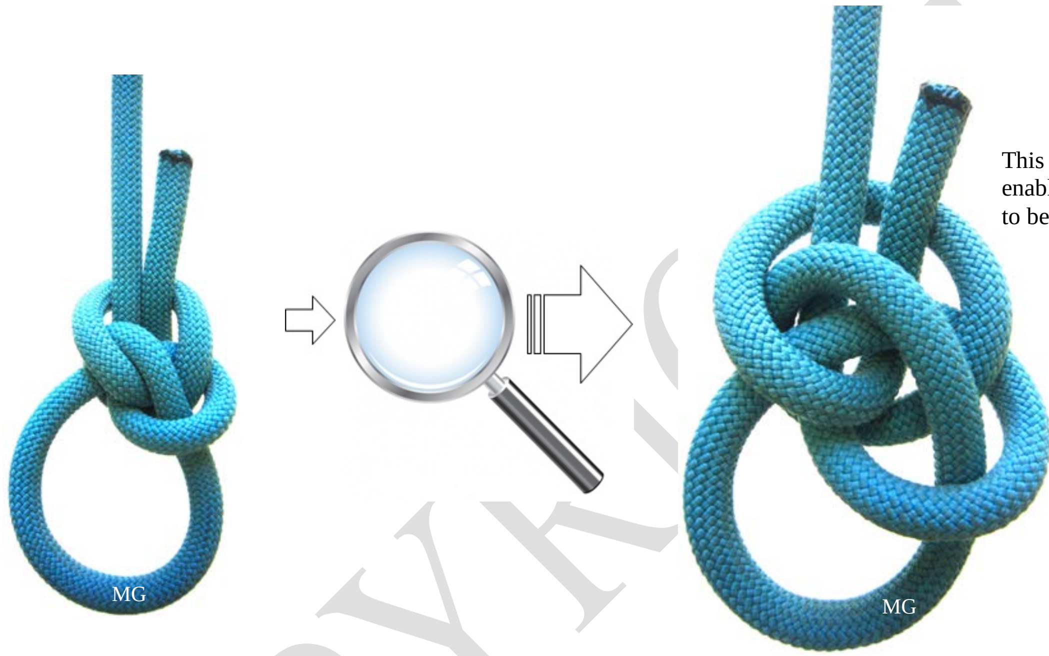
CONTENTS

Edmund Hillary getting ready for his historic 1953 ascent of Mt Everest at basecamp. Note the Bowline.

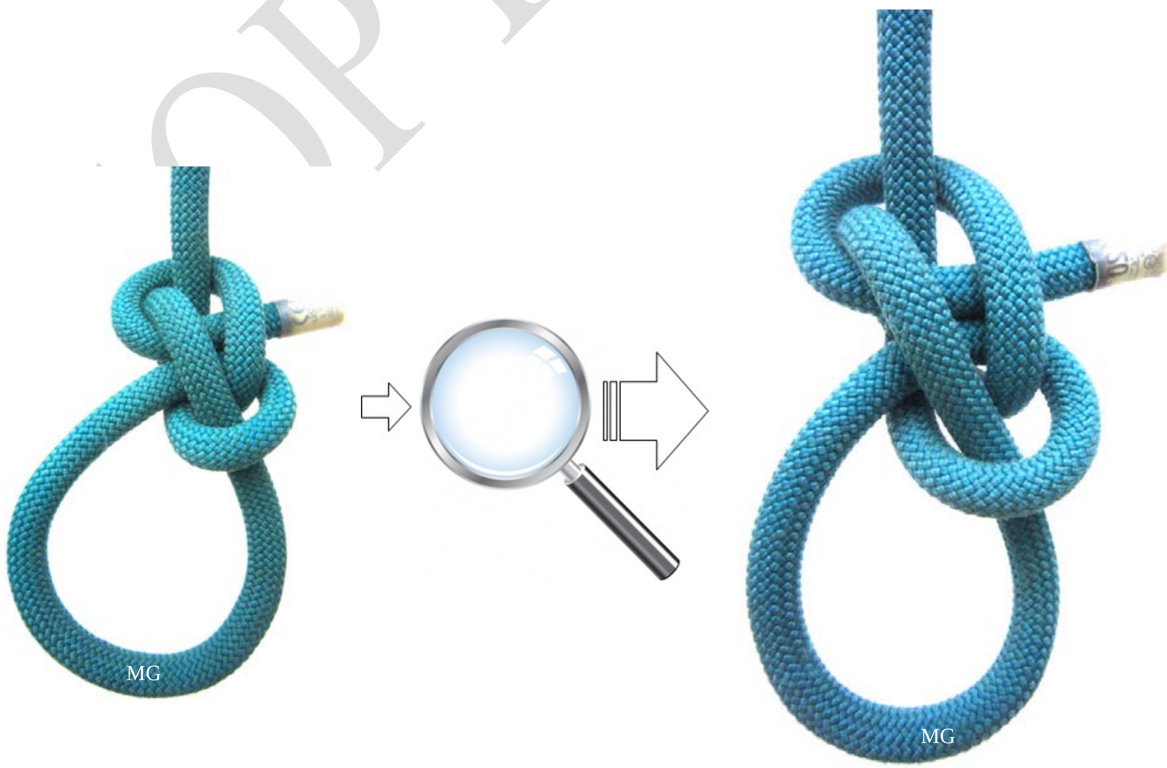
Knot structures are loosely tied to facilitate understanding

In this paper, a significant portion of the knots are deliberately tied loose. This is to facilitate easier observation of the knots core structure. Furthermore, tails are typically tied short – this was deliberately done so that the entire knot structure would fit within the narrow field-of-view of the macro camera lens.

WARNING! *Knots used in life critical applications must have tails of sufficient length to ensure security. Furthermore, the knot must be diligently dressed and cinched tight – attention to detail is crucial! Failure to do so could have catastrophic consequences.*



This loose dressing state enables structural detail to be viewed.



What is a Bowline?

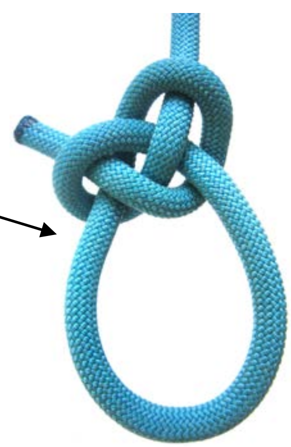
When I originally set out to write this paper (2009) – a precise definition of a 'Bowline' had eluded some great knotting minds. In Captain John Smith's 1627 work; '*A Seaman's Grammar'* – he wrote (chapter V at page 25):

"The Boling Knot is so firmely made and fastened by the bridles in the creengles of the sailes, they will breake, or the sail split before it will slip".

At #1010 (Ashley Book of Knots - page 186) Clifford Ashley commented that;
… the name is derived from bow line, a rope that holds the weather leech of a square sail forward and prevents the sail from being taken aback. As the line or rope that provided the knot is no longer in use, the Bowline knot is nowadays very apt to be termed merely the 'Bowline', the word 'knot' being dropped.

We do know for certain that the image at *below left* is – without doubt – a 'Simple Bowline'. This author is not aware of anyone who would disagree. But, what about the 2 knot structures at *below right*? Are they deserving of the title 'Bowline'? There are several more such knots – and there are more questions than there are answers. This paper attempts to classify Bowlines according to the structure of their 'nipping loop'– as an example; the Simple #1010 Bowline is based on a *single helical nipping loop*.

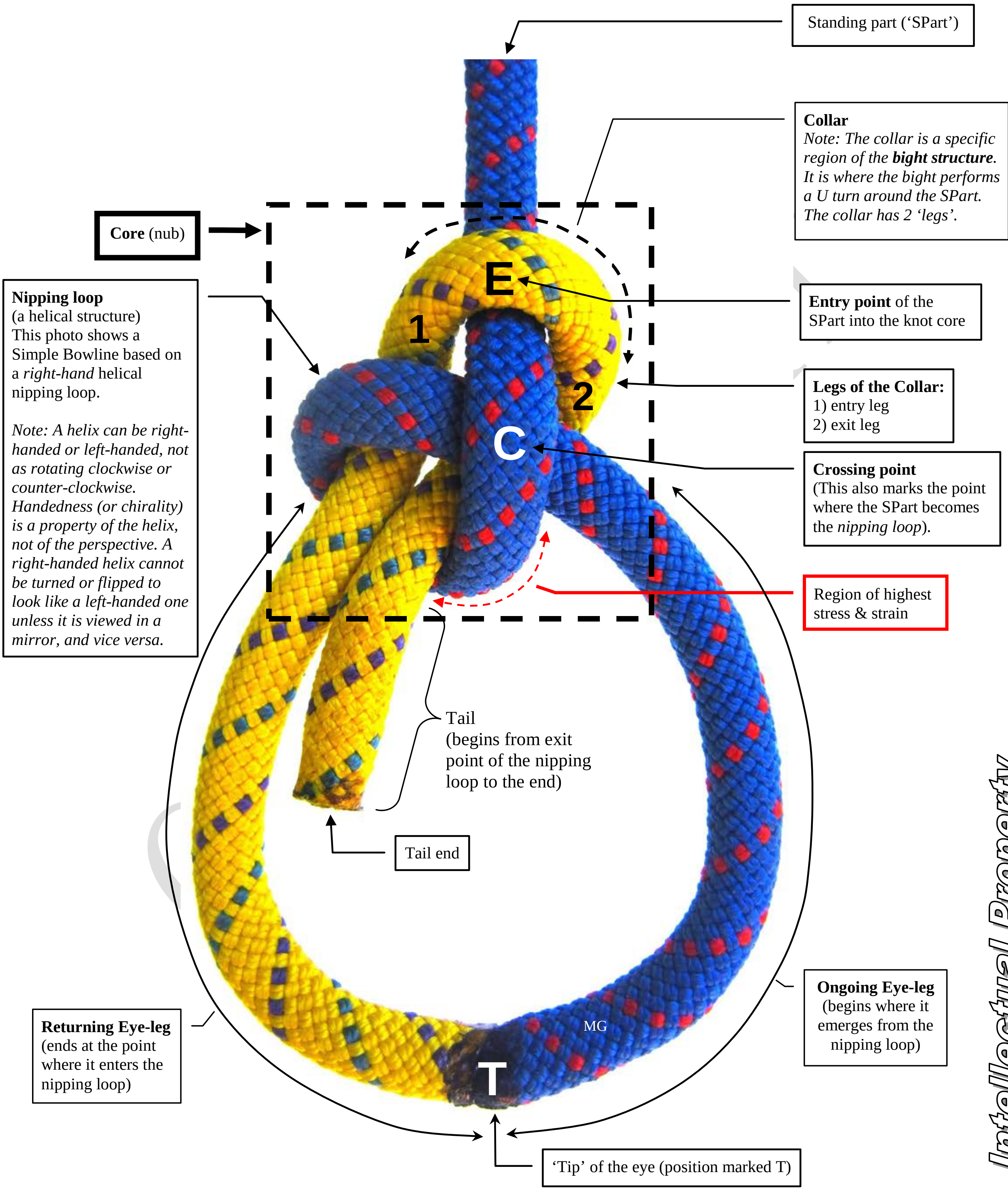
This is a Bowline!



#1010 Simple Bowline
(based on a single helical nipping loop)

And many people – including some great knotting minds – might scratch their heads when confronted with these knots!

The Anatomy of the Simple (#1010) Bowline

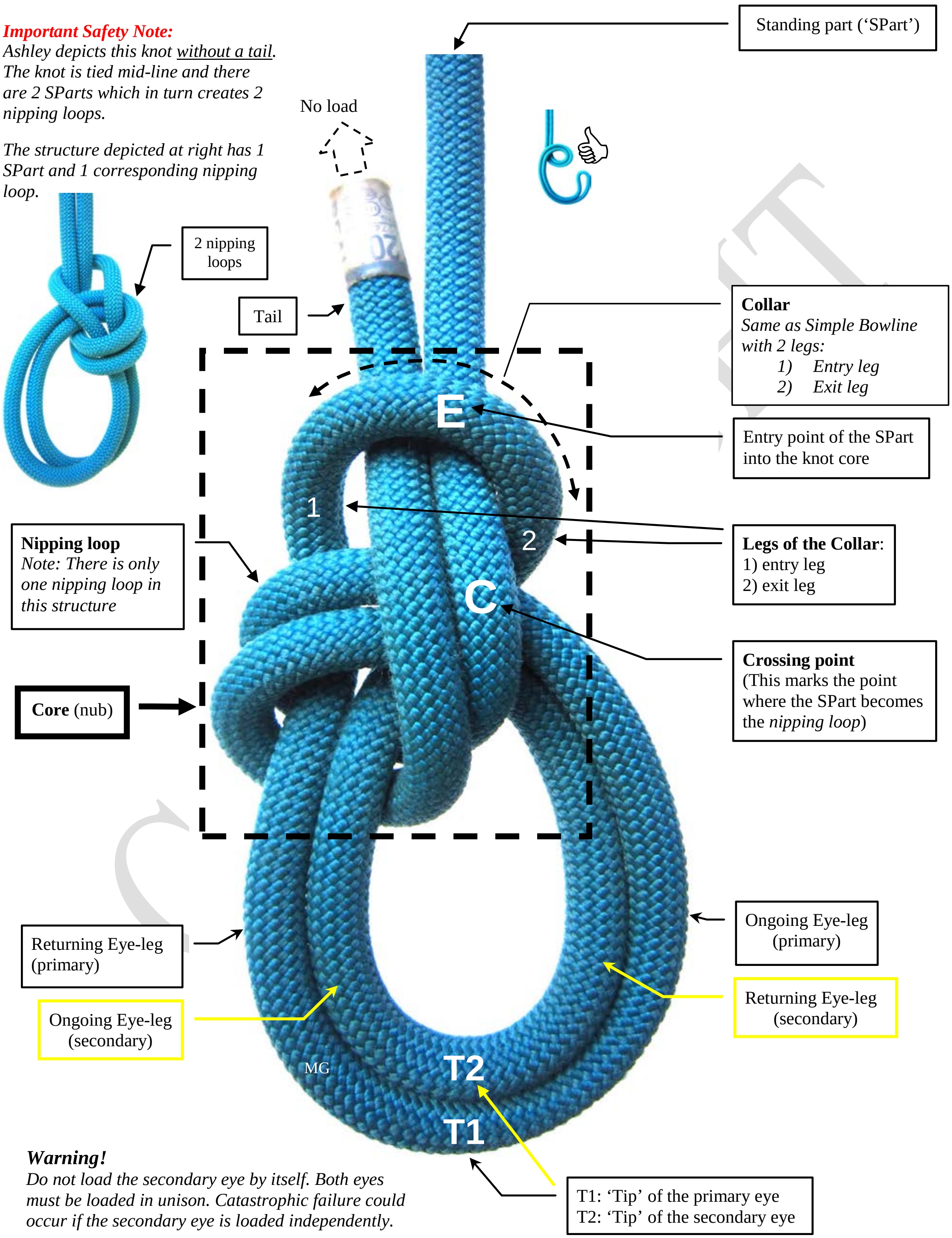


The Anatomy of a 'Bowline on the Bight' (#1080)

Compare with the Simple Bowline (#1010)… there are now 2 eyes – a primary eye and a secondary eye. This knot is also Tiable In the Bight (TIB).

Important Safety Note:
Ashley depicts this knot <u>without a tail</u>. The knot is tied mid-line and there are 2 SParts which in turn creates 2 nipping loops.

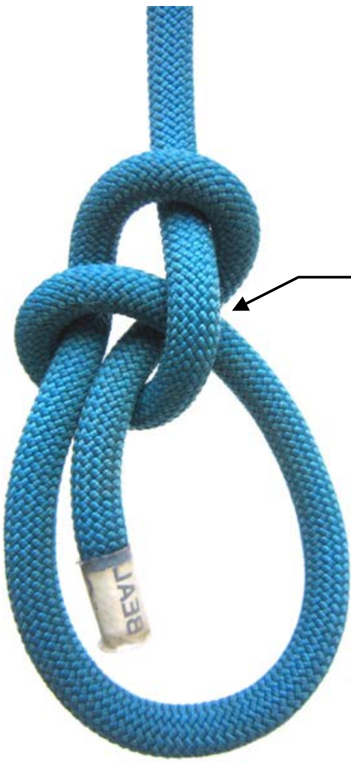
The structure depicted at right has 1 SPart and 1 corresponding nipping loop.



Warning!
Do not load the secondary eye by itself. Both eyes must be loaded in unison. Catastrophic failure could occur if the secondary eye is loaded independently.

Conventions used in this paper to illustrate knot structures

All knots can be identified by a universal 'ABoK' number. This number is derived from Clifford Ashley's masterwork – 'The Ashley Book of Knots' (abbreviated as ABoK). For example, the Simple Bowline can be found at illustration number *1010*. Therefore, the Simple Bowline is assigned the unique identifier number of "#1010". As another example, the Figure 8 eye-knot (F8 eye-knot) can be found at illustration number #1047.



This aspect clearly shows the *nipping loop* component of the Simple Bowline.

Many knot book authors only show the *conventional side* (ie most people would be familiar with the image at right).

This aspect more clearly shows the *collar* structure of the Simple Bowline.

DETAIL VIEW

CONVENTIONAL VIEW

Note: Dan Lehman is a strong advocate of the 'detail view' when showing Bowlines. This aspect properly illustrates the function of the *nipping loop* – which is a key component of all Bowlines. The author of this paper supports this view. This paper will show the detail view when it is important to examine technical detail and the action of the nipping loop. The 'conventional' view will also be shown since this has been commonly depicted in knot books and may aid readers in recognising some Bowlines. The conventional view may also aid in observing details of the *collar* – which plays an important role in the structure.

Denotes the knot is <u>inherently secure</u>.
Note: Strength is not an important consideration.

Denotes the knot is <u>insecure</u> and/or <u>unstable</u>.
Note: It should not be trusted for any life critical applications.

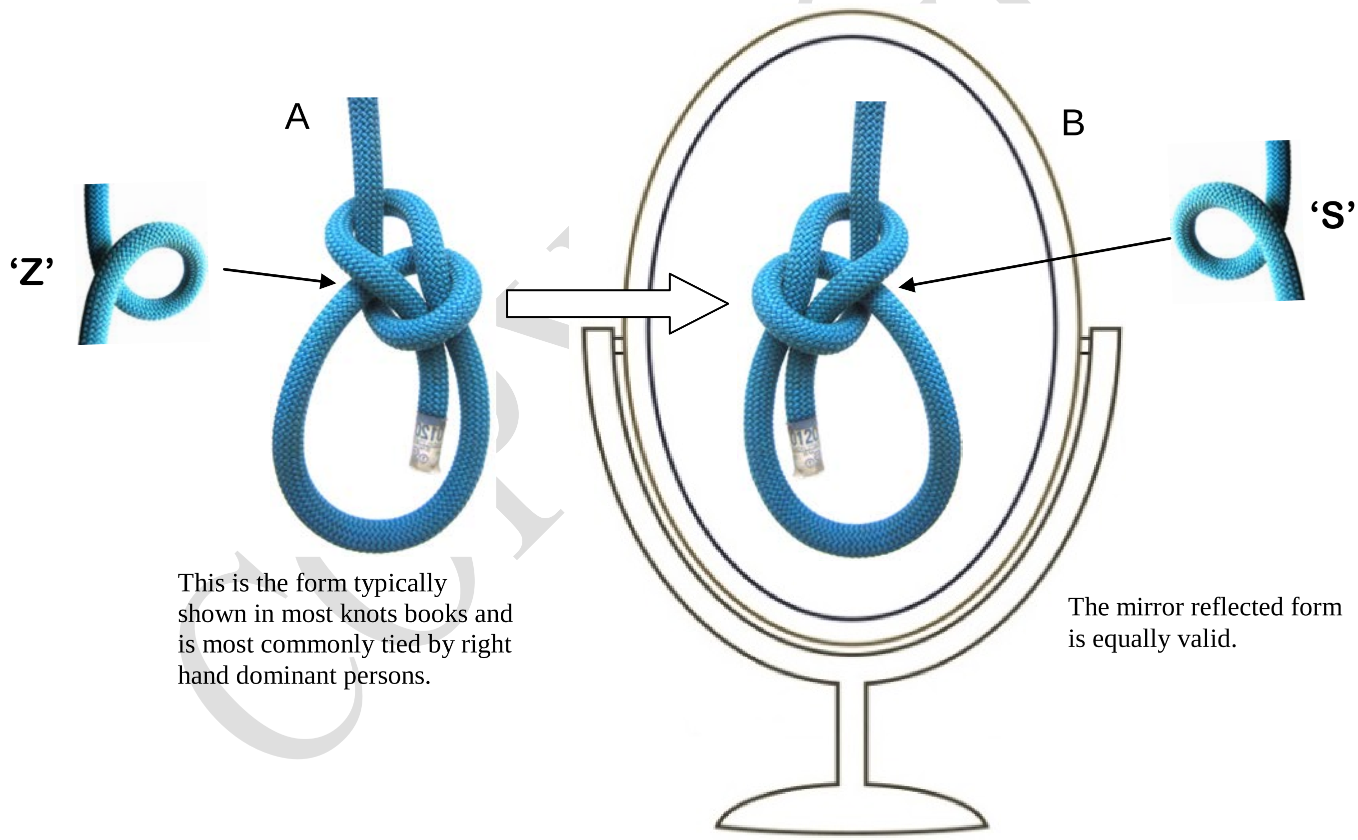
Denotes the knot is known to be TIB (Tiable In the Bight).

Perspective (Handedness / Chirality of knots)

All knots have a mirror image form.
In most knots books and other published articles, the author typically illustrates a knot in one particular geometry – most commonly tied from the perspective of a right hand dominant person.

Image A is the ‘Bowline’ form most commonly tied by right hand dominant persons. Image B is equally valid. Note that in image A, the *nipping loop* has right (Z) chirality and in image B, the *nipping loop* has left (S) chirality.

The concept of chirality (or handedness) was probably understood at some level by most knot tyers but it was Harry Asher who likely was first to publish and explore the concept in his book; “The Alternative Knot Book” in 1989.



This is the form typically shown in most knots books and is most commonly tied by right hand dominant persons.

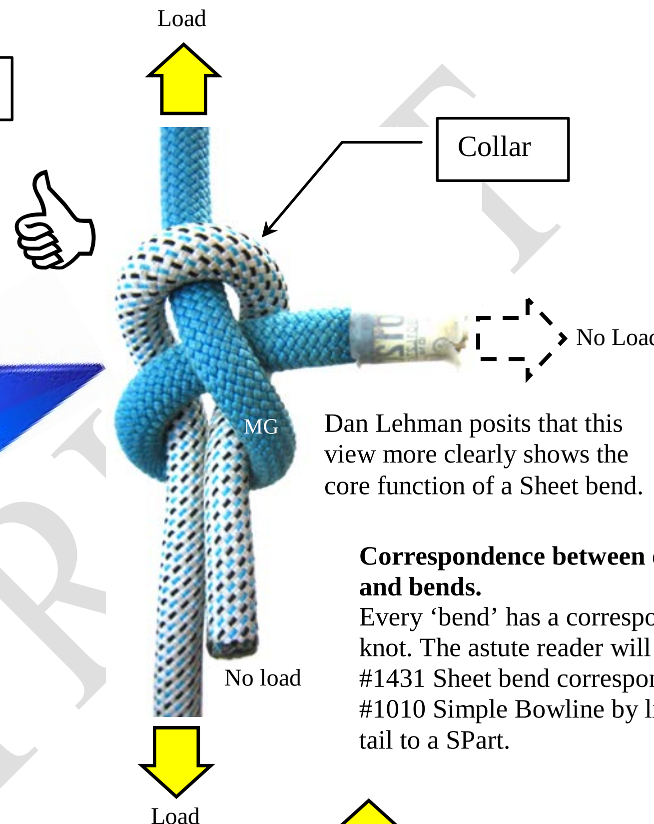
The mirror reflected form is equally valid.

In this technical paper, most knots will be shown tied in right hand dominant form but be aware that it is equally valid to tie the same knot in mirror image form. There is no difference in MBS yield or performance in one form or its mirror reflection.

A rationale for depicting 'detail view' versus the conventional view

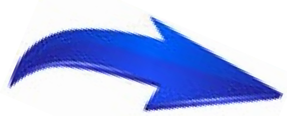
With few exceptions, #1431 (Sheet bend) is typically shown as per the photo below right. Why is this so? Dan Lehman (USA) posits that this particular aspect more clearly shows the core function of a Sheet bend – which is *similar* (but not identical) to the core function of a Bowline. This provides a strong case for showing the same view of a Bowline when we want to more clearly see the function of the 'nipping loop'.

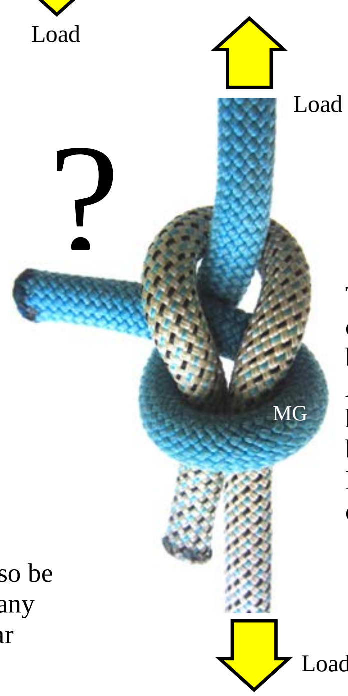
Detail view



Dan Lehman posits that this view more clearly shows the core function of a Sheet bend.

Correspondence between eye knots and bends.
Every 'bend' has a corresponding eye knot. The astute reader will notice that #1431 Sheet bend corresponds to #1010 Simple Bowline by linking a tail to a SPart.



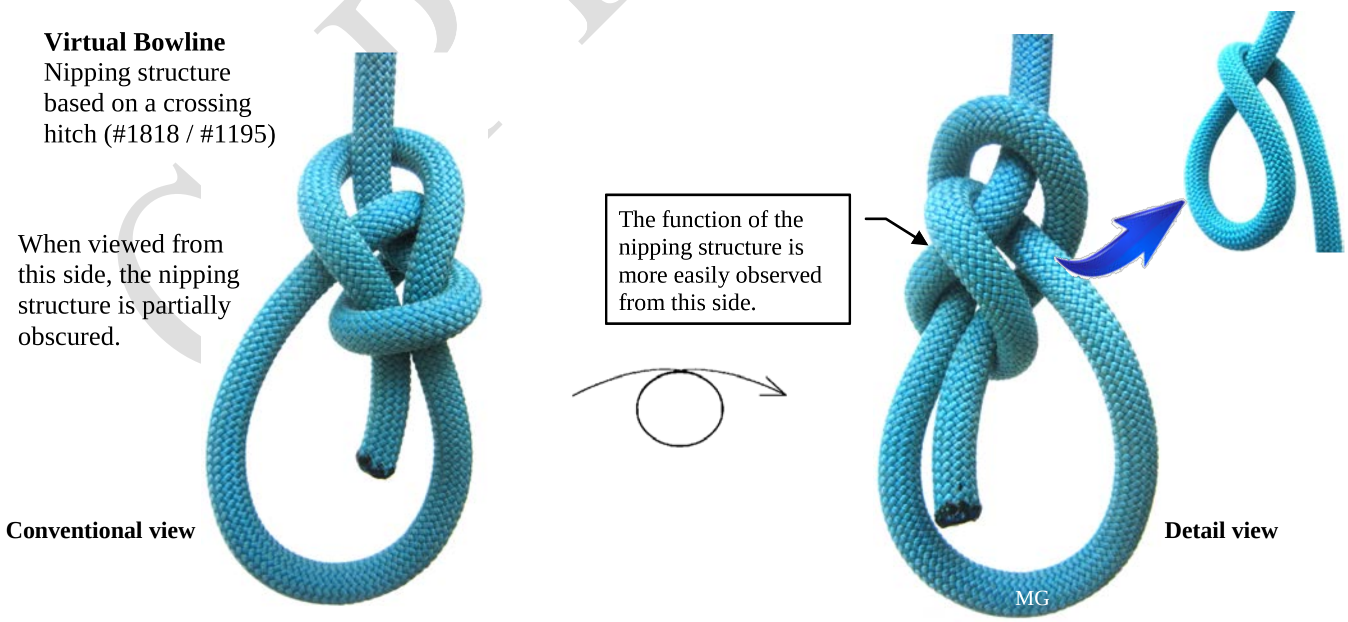


This view obscures the core function of the Sheet bend. Puzzlingly, Harry Asher shows this side in his otherwise excellent book 'The Alternative Knot Book' at image #74 on page 51.

The *conventional* view will also be shown in this paper – since many readers would be more familiar with this depiction.

Examples where the detail view is best for showing the nipping structure

Some Bowlines have more complex geometry and one side may show certain details that the opposite side obscures.



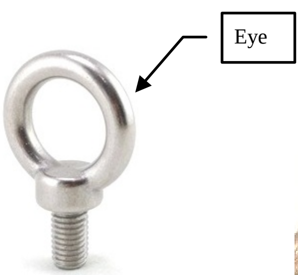
Definition of a fixed eye

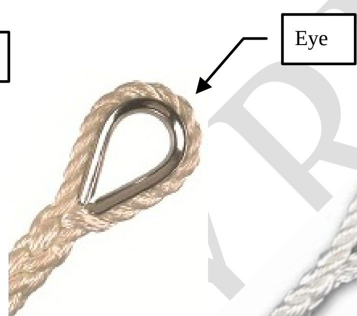
Traditionally, knots such as the Simple Bowline (#1010) and F8 eye-knot (#1047) have been referred to as ‘loop’ knots. This paper refers to these types of structures as ‘fixed eye-knots’. A distinction is also made between an ‘eye’ and a ‘loop’. An ‘eye’ has no chirality. Rationale for this can be found with well-known items such as ‘eye-bolts’ and ‘eye-splices’. Most people can readily identify with these items.

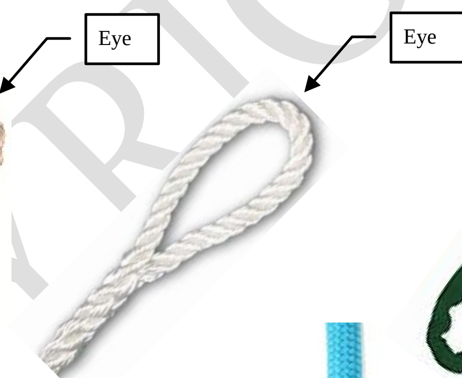
NOTE: Clifford Ashley did not use the term ‘eye’ – instead, he used the term ‘loop’. It is important to understand that Ashley did not publish the concept of loop *chirality* (ie S or Z form). Furthermore, the distinction between a ‘loop’ and a ‘turn’ was not fully explained.

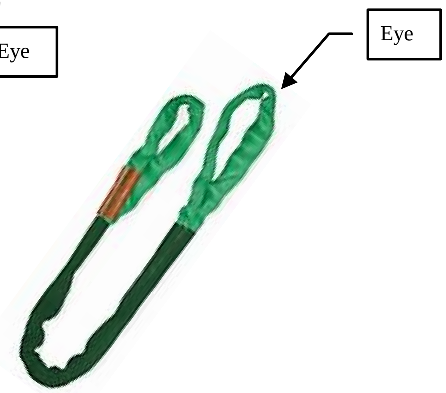
A fixed eye has the following properties:

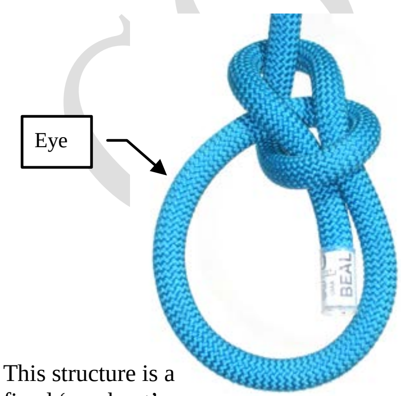
1. It is non-slipping while under load; and
2. It does not have any particular chirality (unlike a ‘loop’ which does have chirality; and
3. The eye permits attachments or links to be made (eg to a carabiner, a harness, a tree, etc).
4. An eye has two ‘legs’ – and load will be distributed 50% to each leg.



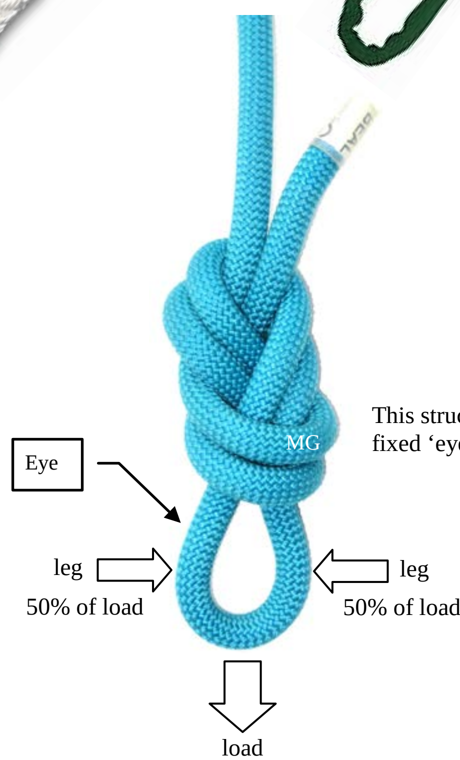








This structure is a fixed ‘eye-knot’



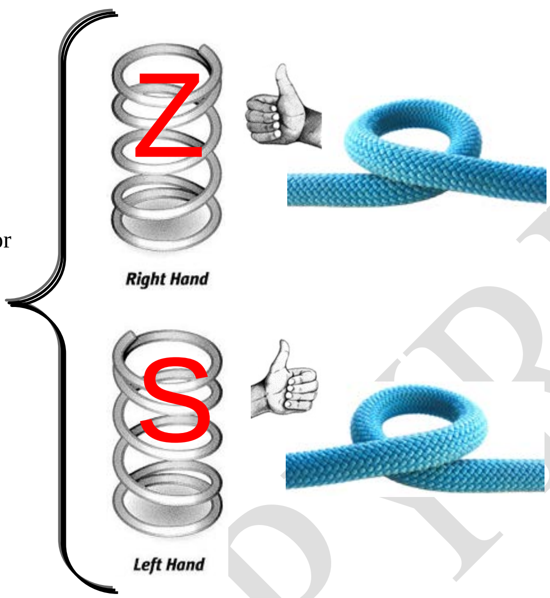
This structure is a fixed ‘eye-knot’

Definition of a loop

In this paper, a 'loop' is defined as a helical structure formed by the overlapping of one rope segment over the other in order to circularize – which creates a <u>defined chirality</u>.

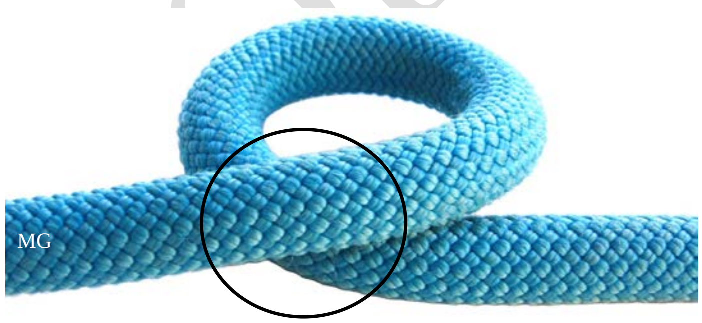
The subject of loops and turns receives limited attention by many knot book authors – and definitions are often loosely applied and/or derived from traditional concepts. Ashley deals with this topic at page 13 in 'ABoK' but, the differences between loops and turns is not fully explored. Dr Harry Asher's 'The Alternative Knot Book' is one of the few books that examines 'chirality' (or handedness) with loops at page 22. The chirality of a loop cannot be changed – even if it is flipped over. An example is a left and a right shoe. A left shoe cannot be flipped over or rotated to make it a 'right' shoe – it is *always* a left shoe.

A loop can have either right (Z) or left (S) chirality.



Single loop   Double loop

Right hand nipping loop



A loop is formed by the overlap of one rope segment over the other.
All loops will have a defined chirality (or 'handedness'). In this example, the loop has 'S' (left) chirality.

Left hand nipping loop

Definition of a turn

In this paper, a 'turn' is defined as a circular arc of a rope around an object – the number of degrees of arc scribed defines the type of turn.
A turn sets up a relationship with the *Capstan equation*.

U turn (180 degrees)

Turn (360 degrees)

Round Turn (540 degrees)

Note:
A turn is described by the number of degrees of arc scribed.

U turn = 180 degrees
Turn = 360 degrees
Round turn = 540 degrees

#1720 Round turn and 2 half hitches.

540 degrees

#1773 Clove hitch

Riding turn / Riding segment

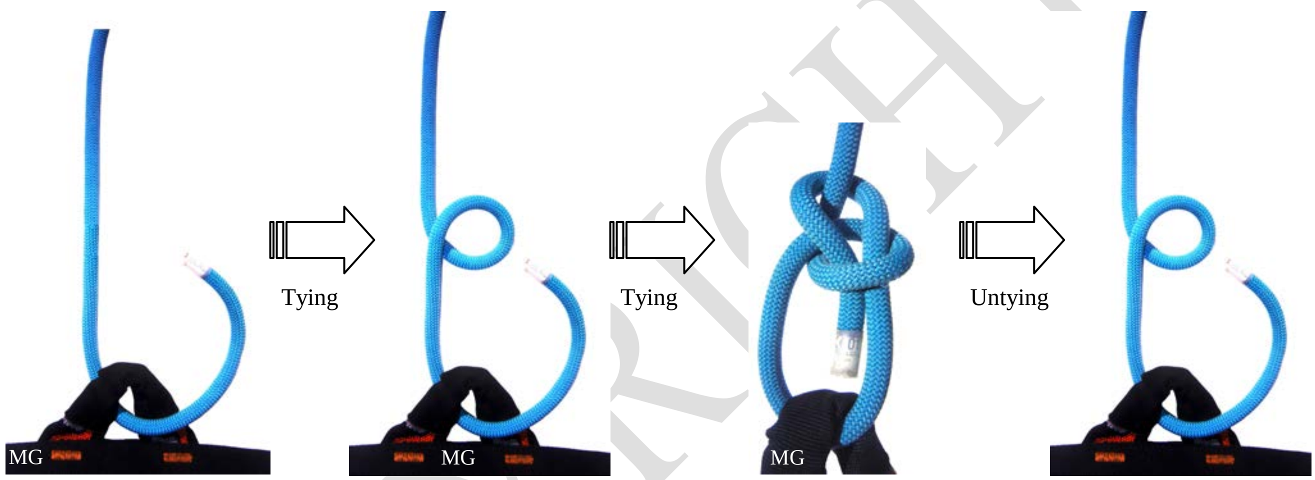
#2047 Tensionless hitch
Consists of a number of turns around an object (typically an object with a rounded profile). The holding power of the tensionless hitch is described by the capstan equation.

The Capstan equation

$$T_{load} = T_{hold}\, e^{\mu Ø}$$

The concept of 'Post Eye Tiable' (PET)

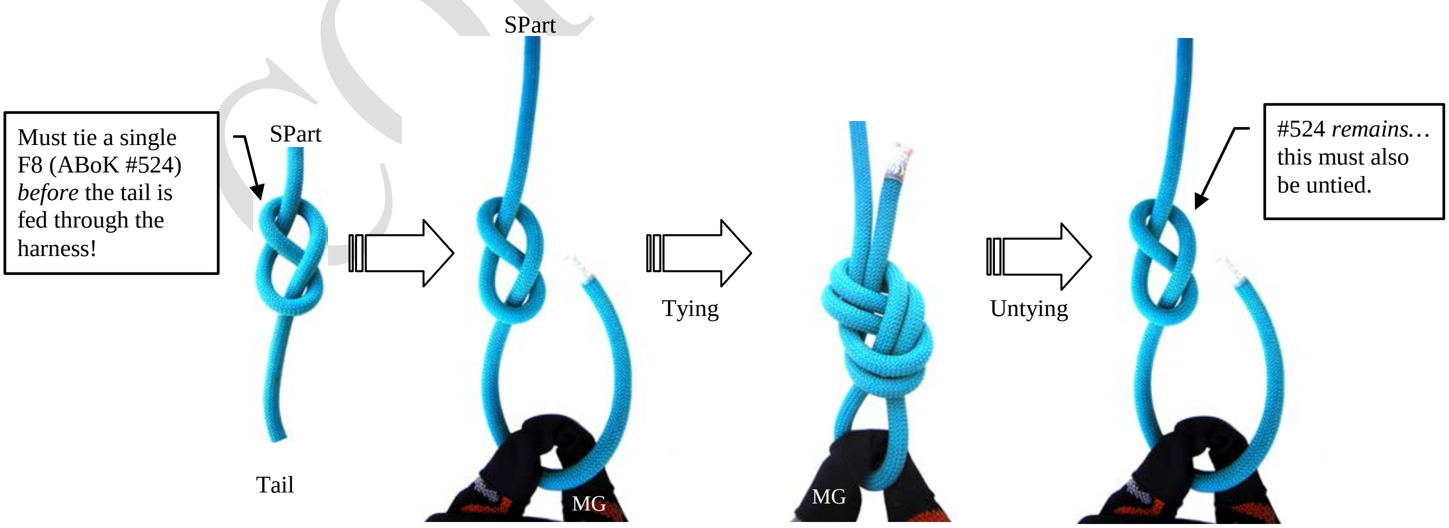
Further explorations by Dan Lehman and Constant Xarax include the concept of 'Post Eye Tiable' (PET). It is theorized that all Bowlines are PET. In contrast, #1047 (F8 eye-knot) is not PET. The benefit of a PET knot to a climber is that the rope can be fed through the harness to form the 'fixed eye' and then the knot can be completed in a one-stage tying process. In contrast, with #1047 F8, the climber must first tie a knot and carefully position it, *before* feeding the rope through the harness. Note that the *reverse* condition also applies – that is, when untying Bowlines, no knot is left in the rope. In contrast, when untying #1047 from a harness, a residual knot will be left in the rope (#524). This knot must also be untied.
Novice (new) climbers tying-in with #1047 F8 often struggle to correctly pre-position the #524 single F8 – and either run out of tail or overcompensate and leave too much tail.



Bowline is Post Eye Tiable (PET)
All knot tying maneuvers are performed <u>after</u> the tail has been fed through the harness to form the 'eye'.

ABoK #1010 completed

No remnant knot is left in the rope.



ABoK #1047 (F8 Eye-knot)
The F8 eye-knot is *not* PET. Meaning, you must tie a knot first – *before* forming the eye.

ABoK #1047 completed

Residual knot left in rope
When untying #1047, the final #524 F8 knot must also be untied.

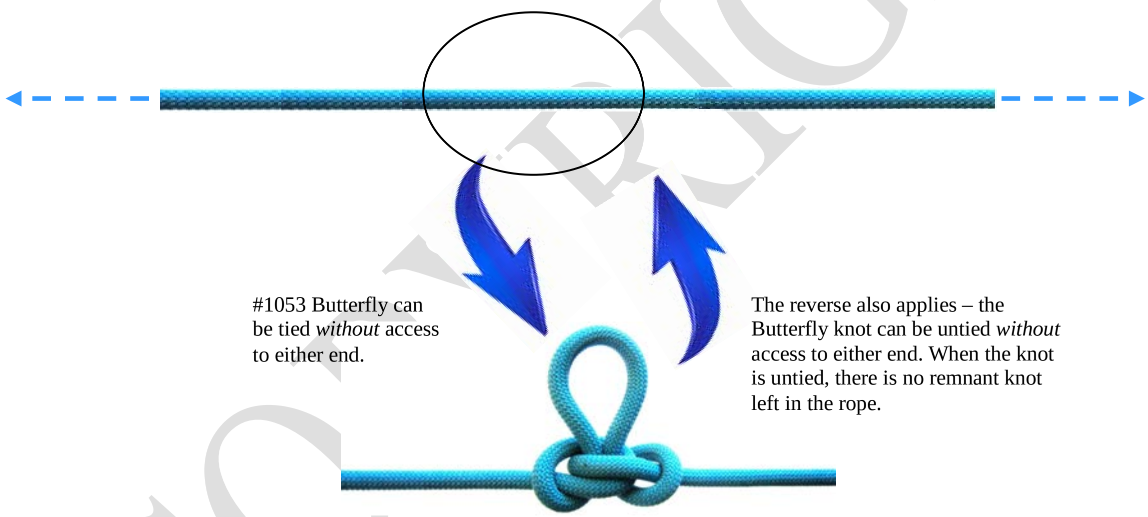
Definition of ‘Tiable In the Bight’ (TIB)

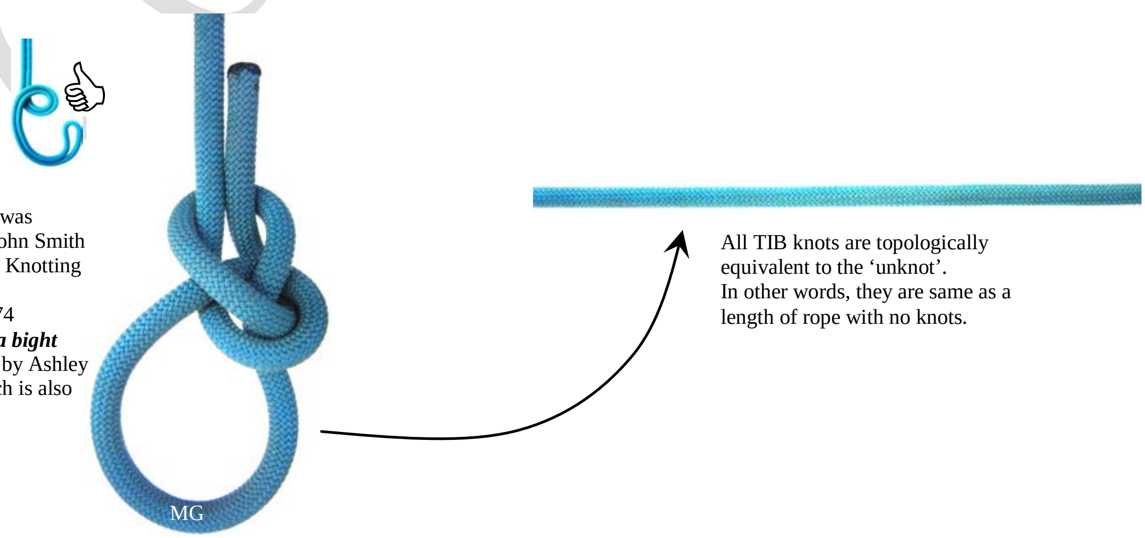
TIB means that the knot can be tied *without access to either end*. The reverse also applies – in that the knot can be *untied* without access to either end – leaving no remnant knot.

Dan Lehman reported that the TIB concept (re Bowlines) most likely had its roots circa 1987 through the work of two innovators – John Smith and Pieter van de Griend – via a variation of the Simple Bowline reported in ‘Knotting Matters’ issue #19, which also happened to be ‘TIB’.
Constant Xarax has posited that Bowlines with a *Jones polynomial* of 1 are TIB. In other words, they are equivalent to the ‘unknot’.

Knotting experts have been searching for ‘Bowlines’ which are also TIB. At the time this paper was written, there does not appear to be a solid theory explaining the underlying geometry which makes a particular Bowline TIB.

The #1053 Butterfly is a good knot to illustrate the concept of TIB. Most climbers would understand that a Butterfly can be tied without access to either end.

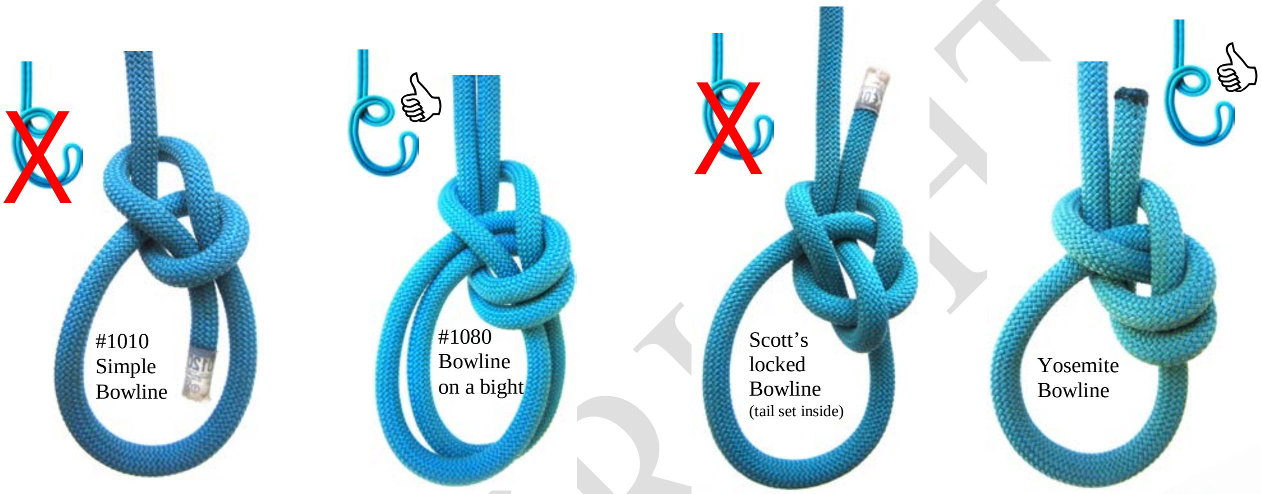




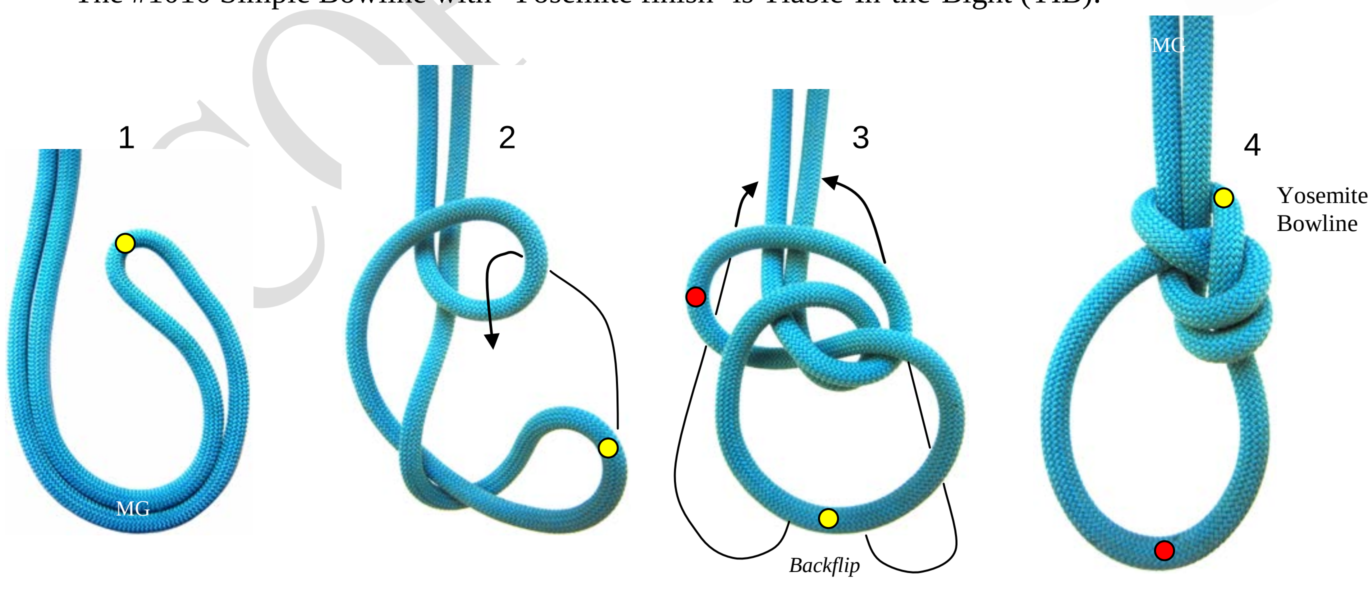
Tiable In the Bight (TIB)   Reverse engineering

One method of determining if a particular Bowline is TIB is to *reverse engineer* it. That is, attempt to untie the knot without accessing either end of the rope. If the knot can be untied without accessing either end – and there is no remnant knot left in the rope, this proves that the knot is TIB.

Constant Xarax also posited that a typical feature of TIB Bowlines is that the tail exits through the collar along a parallel pathway with the SPart. However not all Bowlines with the tail so arranged are TIB – there are exceptions…

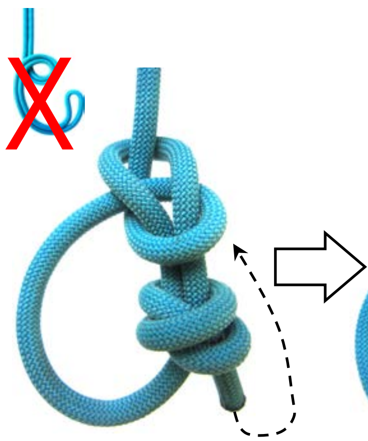


The #1010 Simple Bowline with 'Yosemite finish' is Tiable-In-the-Bight (TIB):



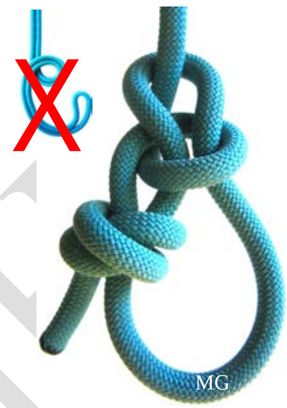
Tiable In the Bight (TIB) Further examples

Here is an example of a locked Bowline that can be made TIB by tucking the tail through the collar. Interestingly, if the ‘double overhand stopper knot’ is tied around the *ongoing eye leg*, the structure can no longer be made TIB with a tail tuck through the collar.

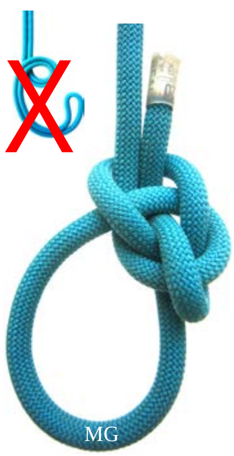


This structure can only be made TIB if the stopper knot is tied around the *returning eye leg*.

The tail is directed back through the collar.



Stopper tied on ongoing eye leg (not TIB).



Scotts locked Bowline can be made TIB if the tail is set outside of the eye and then the locking maneuver begins from inside the eye.

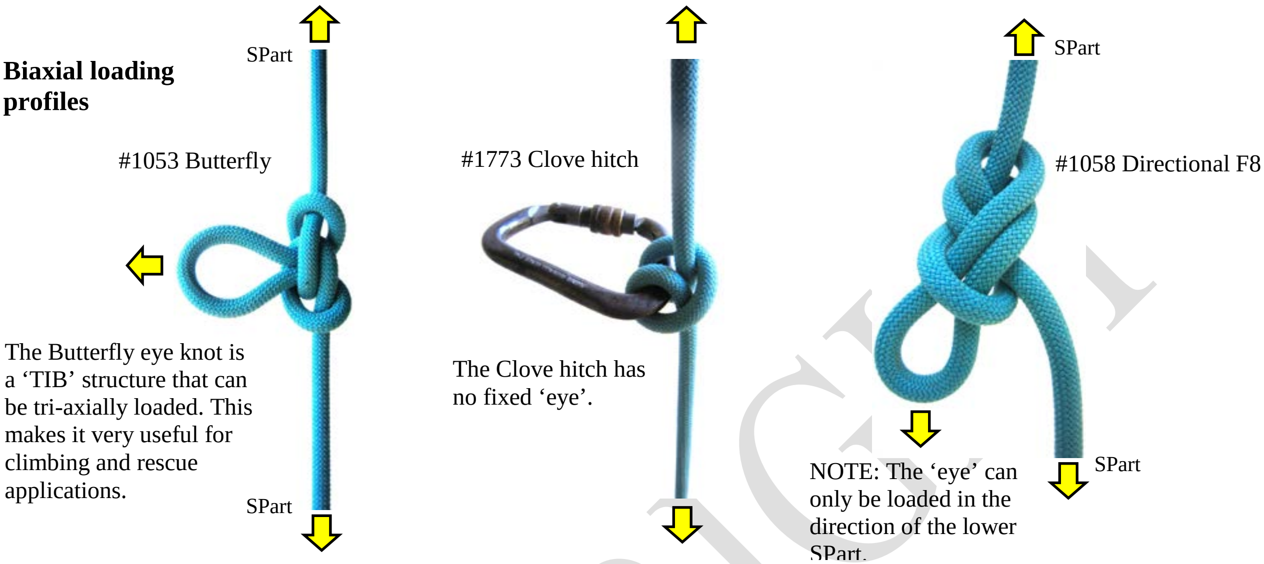
TIB version of Scott’s locked Bowline.

Lees link Bowline is known to be TIB.

Biaxially loadable   a definition

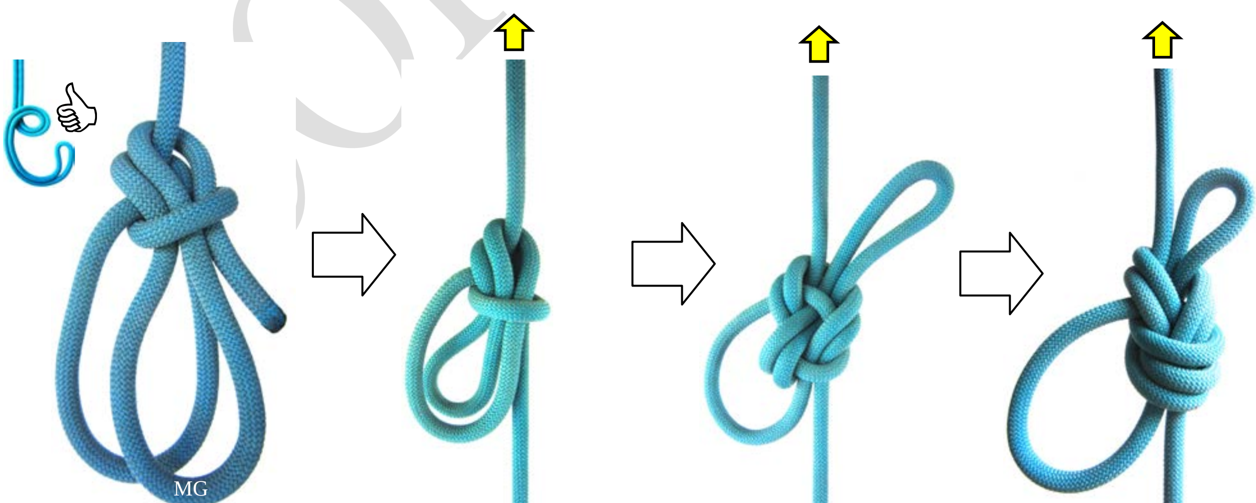
A knot that remains stable and secure when *through-loaded* (SPart-to-SPart) is defined as ‘biaxially loadable’. To illustrate the concept, the following knots are reasonably well-known. Most climbers would understand that the Butterfly knot can be tied mid-line and then biaxially loaded. Each of these knots is also TIB (Tiable In the Bight).

Biaxial loading profiles



Knots that are TIB are efficient because they can be tied in different ways and used in a variety of applications. Unfortunately, there are not so many ‘Bowlines’ that are *both* TIB and biaxially loadable. It seems that #1074 *Bowline with-a-bight* is one of the few ‘Bowlines’ that is both TIB *and* stable in a biaxial loading profile.

#1074 ‘Bowline with a bight’ may provide knotting enthusiasts with opportunities for new lines of research. Below left is the original #1074 structure as depicted by Ashley. The sequence of knots to the right are a progression of various enhancements to improve security.



#1074 Bowline with a bight

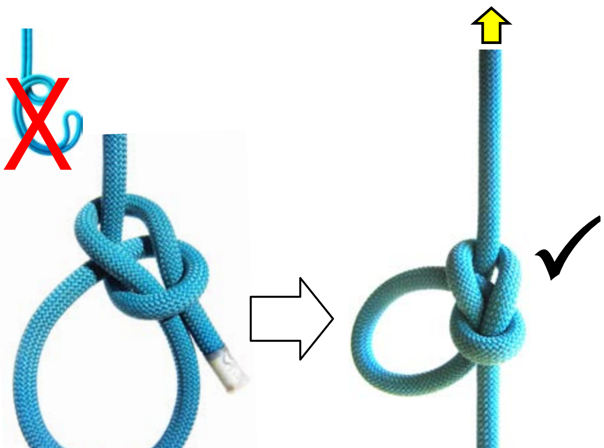
#1074 in a biaxial loading profile

#1074 with a Scotts lock enhancement

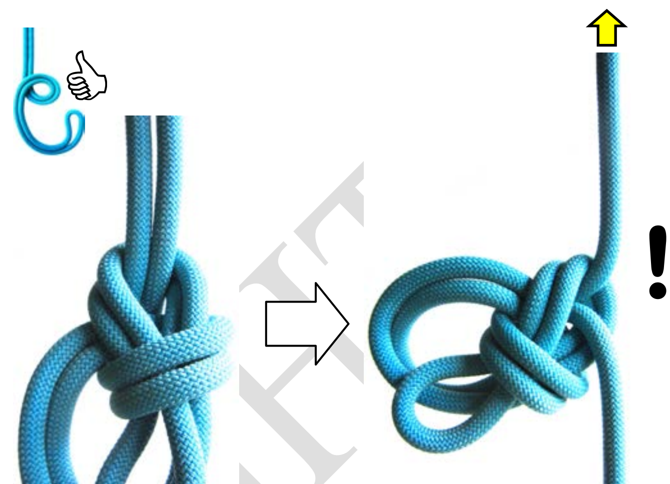
#1074 with a Yosemite finish enhancement

Biaxially loadable (examples)

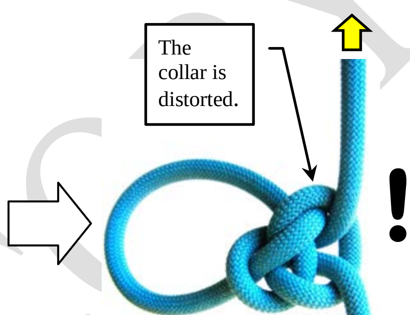
Bowlines which have the tail through the collar in a parallel pathway with the SPart will be vulnerable to instability when biaxially loaded. The legs of the collar will be forced apart with a consequence of vulnerability to inversion/spilling.



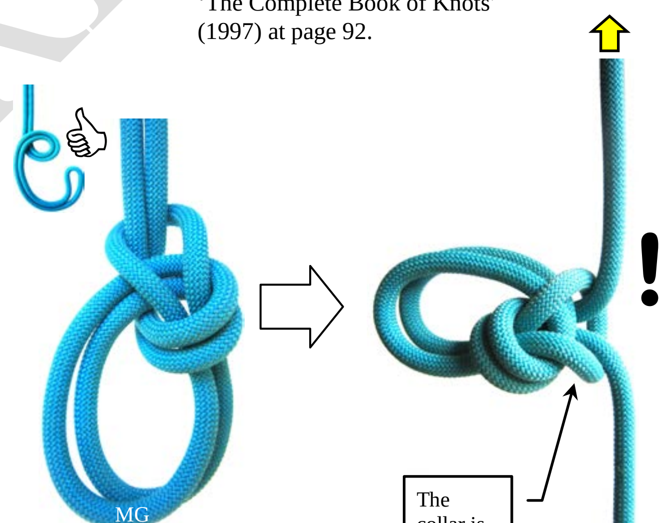

#1034 ½ Bowline can be biaxially loaded so it mimics the core function of a #1431 Sheet bend. When the 'eye' is loaded, it is exactly #1034 ½ Bowline. Unfortunately, it isn't TIB.

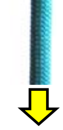



Triple Bowline is TIB but unfortunately cannot be biaxially loaded.
Budworth identified this knot as a *Triple Bowline* in his book; 'The Complete Book of Knots' (1997) at page 92.

Lee's Link Bowline is 'TIB'. However, it is *not* able to sustain a biaxial loading profile (the collar will distort and may invert / capsize).





#1080 Bowline on-a-bight is obviously 'TIB'. However, it is *not* able to sustain a biaxial loading profile.

Dual #1074 Bowlines with-a-bight is very useful for mid-rope tie-in.
No carabiners required!

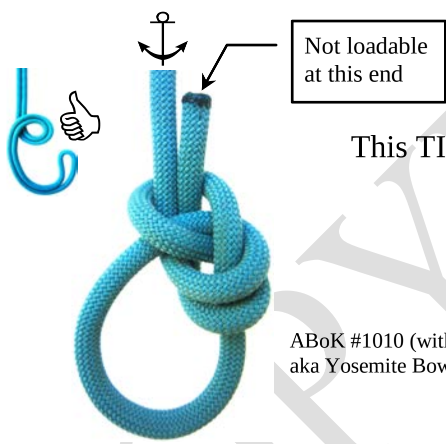
Either End Loadable (EEL)

Some Bowlines may be ‘either-end-loadable’ (EEL) – meaning that either end of the rope could function as the Standing Part (SPart). An example of a Bowline that is EEL is the #1080 Bowline on a bight.

ABoK #1080
Bowline on-a-bight

The structure at left is shown with a tail. Note that Ashley originally intended that there are 2 SParts – which also means 2 nipping loops – and no tail.

This TIB Bowline is ‘EEL’ (either end loadable).



ABoK #1010 (with ‘Yosemite tail finish’)
aka Yosemite Bowline

This TIB Bowline is <u>not</u> ‘EEL’.

This is a double eye version of an ‘anti Bowline’. Note: The anti-Bowline is sometimes referred to as an ‘Eskimo’ Bowline.

The structure is also ‘EEL’.

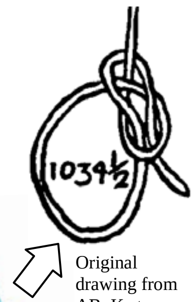
As an exercise, try discovering additional Bowlines that are TIB by reverse engineering.

Variations of the Simple Bowline

There are four possible variations of the Simple #1010 Bowline.

Confusingly, Ashley referred to the 2 structures at right as being 'left-hand Bowlines' (#1034 ½). This author finds that name unfortunate because it confuses the notion of 'left-hand' and 'right-hand' nipping loops. Evidently, Ashley did not have the concept of 'chirality' when he published his masterpiece.

Ashley referred to these structures as 'left-hand' Bowlines



Original drawing from ABoK at page 188.

Left handed nipping loop (tail inside eye) | Right handed nipping loop (tail inside eye) | Left handed nipping loop (tail outside eye) | Right handed nipping loop (tail outside eye)

It is therefore possible to see that there are 4 possible geometries of the simple (#1010) Bowline which are determined by tail position and chirality of the nipping loop ('S' or 'Z'). Note however that the tail position does influence how the structure behaves under certain loading profiles (refer to the section on 'circumferential/hoop stress loading').

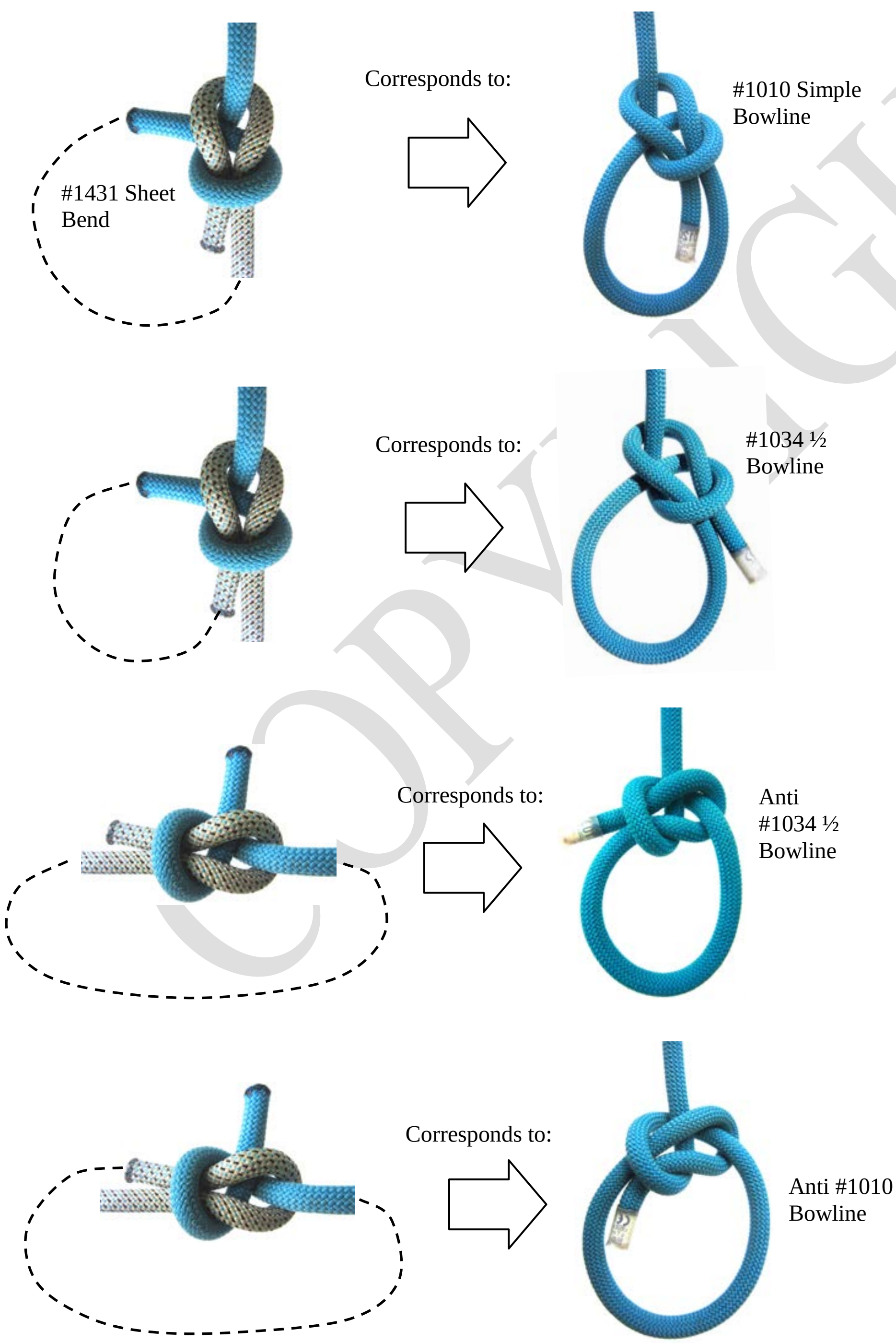
In the same way, there are four possible variations of the 'Anti-Bowline' (see also page 47) as follows:
(*Note: This structure has been identified as an 'Eskimo Bowline' by some authors which has attracted some criticism because it may be considered offensive to the Inuit people. This is another reason why the term 'Anti-Bowline' is preferred*).

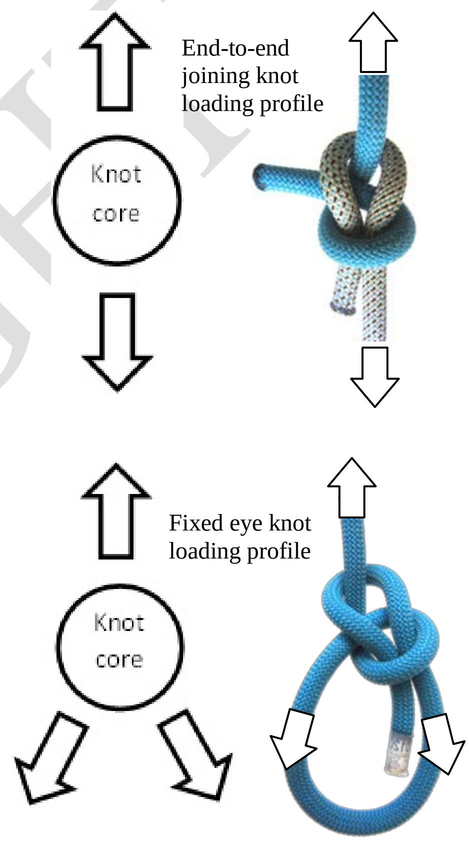
Left hand nipping loop (tail inside eye) | Right hand nipping loop (tail inside eye) | Left hand nipping loop (tail outside eye) | Right hand nipping loop (tail outside eye)

Correspondence between bends and eye knots

Every end-to-end joining knot (ie ‘bend’) has a corresponding fixed eye knot (theoretically 4). The Simple Bowline corresponds to #1431 Sheet bend. The idea of this correspondence was explored by Harry Asher in his book; ‘The Alternative Knot Book’.
In a ‘bend’, force enters the knot core from 2 *opposing* rope segments. In a fixed eye knot, force enters the knot core from 3 rope segments.

The following examples show 4 corresponding eye knots in relation to #1431 Sheet bend.





Loading profile
It may be tempting to think that a ‘Sheet bend’ is a ‘Bowline’ and vice versa.
However, the loading profile and resultant distribution of force within the knot core are completely different.
Furthermore, the Sheet bend has no functional ‘nipping loop’.

Definition of a Bowline

A precise definition has eluded some great knotting minds – evidence of this can be found on the IGKT forum website. From that website, and also from personal observations gleaned in experimentation and during the preparation of this research paper, I can posit that all Bowlines exhibit the following characteristics:

1. That all Bowlines fundamentally contain a ***nipping loop*** component that encircles and compresses all material within its helical structure. The loop is 'TIB' and will have a particular chirality (S or Z) and is topologically equivalent to the unknot. A nipping loop is loaded at *both* ends (ie both the SPart and the ongoing eye leg must be loaded).
   The nipping loop must be free to increase compression in direct proportion to the load applied. If the nipping loop is not freely acting (ie it is seized or occluded in some way) – it is non-functional – which in turn casts doubt on its claim to the title of 'nipping loop'. Not all knotting experts entirely agree on this salient point.

2. That all Bowlines have a ***collar*** component which has 2 legs. In the Simple #1010 Bowline, the collar is the point where the 'bight' makes a 180 degree U turn around the SPart. The SPart functions as a bracing post and this aids in stabilizing the bight structure *and* the nipping loop. Both legs of the collar must be fully encircled and clamped by the nipping loop.
   NOTE: The collar and its 2 legs, together with the returning eye leg and tail holistically constitute what is referred to as the '*bight*'. The bight is therefore a composite of five individual segments – with each segment playing a specific role.

3. That all Bowlines have a ***fixed eye***, and this eye does not slip (ie it is not a slip knot or a noose) under load which enables the knot to be linked to objects such as carabiners, trees, boulders & climbing harnesses.

4. That in Bowlines based on the Simple #1010 form – both legs of the collar feed into the nipping loop from the same direction along a parallel pathway. This is one of the classic recognizable features of the bight component. In some Bowline variations, the structure of the bight may not easily be identified or indeed even exist as a classic bight structure.

5. That all Bowlines are resistant to jamming. It is theorized that Bowlines remain jam resistant right up to their MBS yield point. In contrast, some eye knots are known to jam – for example #1047 F8 eye knot is known to jam after heavy loading (eg as would occur after a significant fall while lead climbing).

6. That all Bowlines can be tied in a one-stage tying process – a concept known as Post Eye Tiable (PET). For example, to tie "ABoK #1047" (Figure 8 eye-knot) into a climbers harness, a *two stage* tying process is required. Firstly, "ABoK #524" (Figure 8) must be tied and then secondly, the final structure is formed by a process of re-threading (or retracing) the tail back through the existing knot.

NOTE: The first 3 criteria are principal and intrinsic to a Bowline. The absence of any of these principal criteria *automatically* disqualifies a knot structure from being a 'Bowline'.

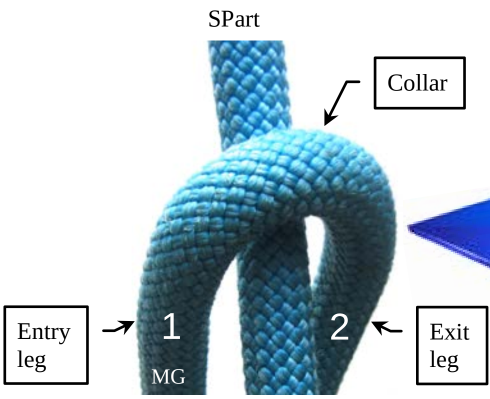
Components of a Simple Bowline

Here we examine the Simple #1010 Bowline:

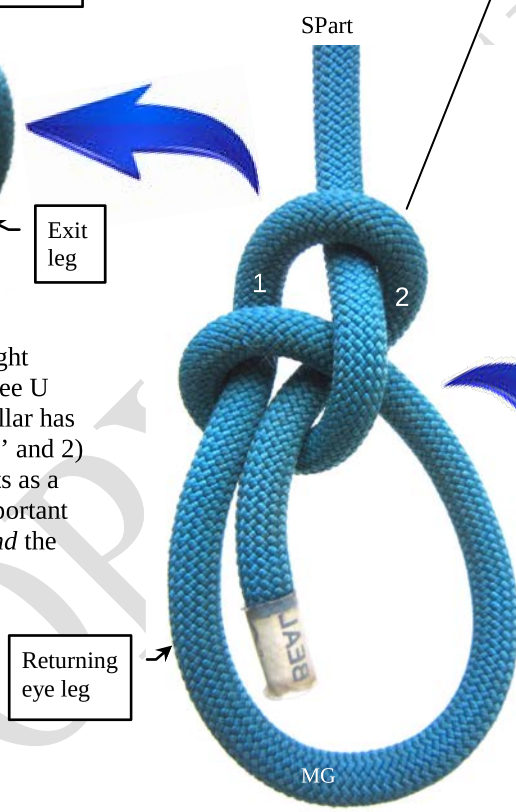
We can clearly see that the knot structure contains 3 key components:

1) Nipping loop – (in the #1010 Simple Bowline, it is a single helical form)
2) Collar (and its 2 legs)
3) Fixed eye (it is non-slipping… ie, not a slip knot or a noose).

All 3 components must be present, and they act in unison. The absence of any of these components automatically disqualifies a knot structure from being a 'Bowline'.

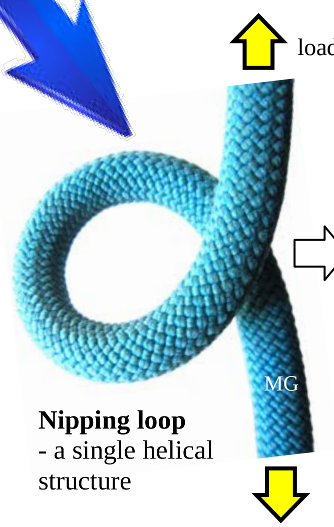


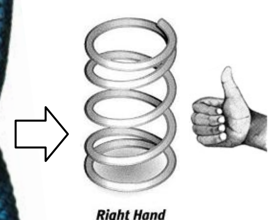
Collar
This is the point where the bight structure performs a 180 degree U turn around the SPart. The collar has two 'legs': 1) is the 'entry leg' and 2) is the 'exit leg'. The SPart acts as a *bracing post* and plays an important role in stabilizing the bight *and* the nipping loop.



Both legs of the collar 1) and 2) lie on the *same side* of the nipping loop – feeding from/to the nipping loop along a parallel pathway.

Note:
The nipping loop can be formed as either *left* hand or *right* hand chirality (or **S** twist versus **Z** twist). It does not affect the function of the nipping loop. The title of 'Bowline' is not affected by virtue of the nipping loop being *left-handed* or *right-handed* – it is still a Bowline.





Right hand (Z twist)

Nipping loop
- a single helical structure

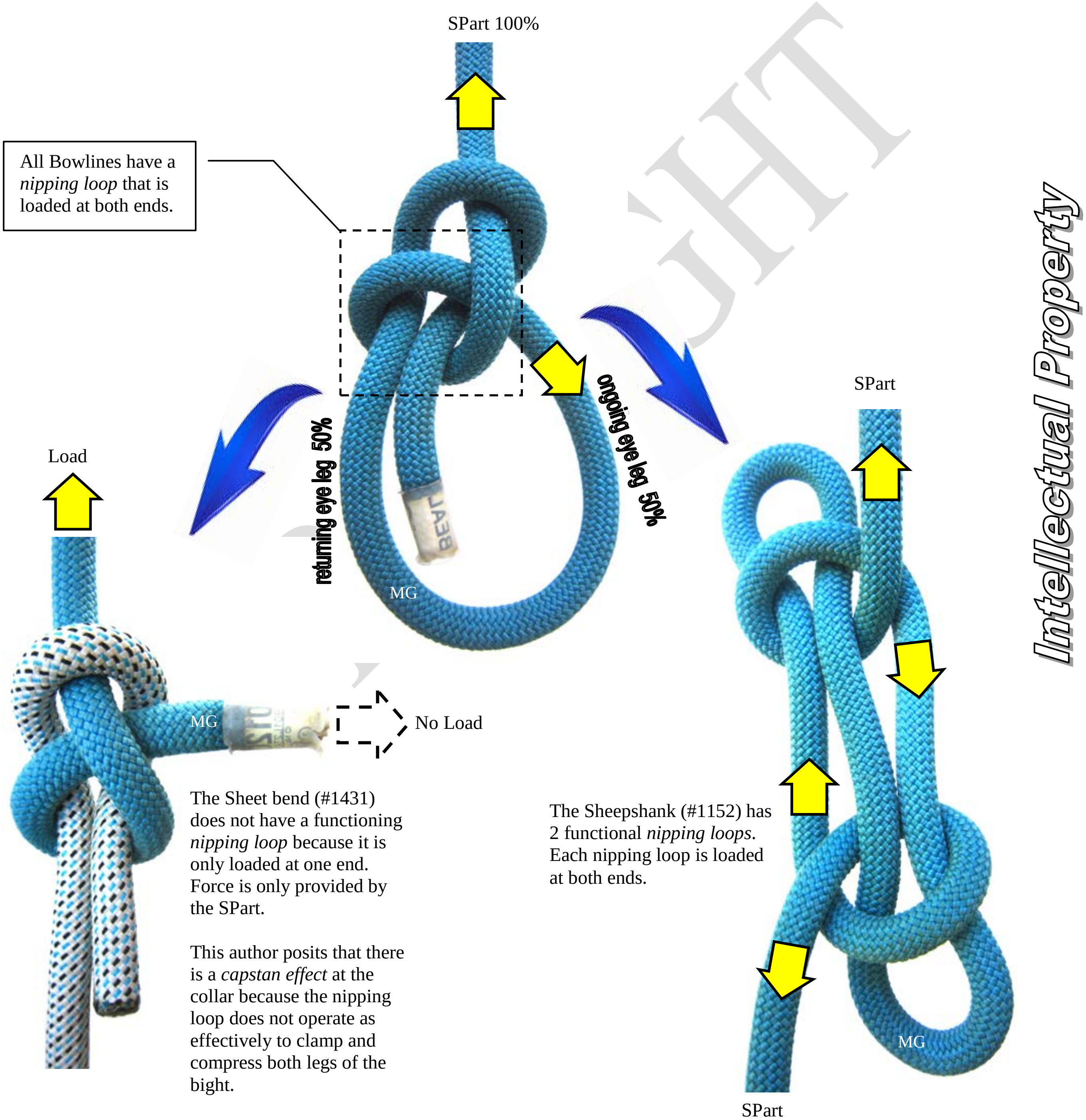
It is loaded at both ends and can freely operate to produce a compression force in direct proportion to the applied load.

Fixed eye
The eye is *not* a slip-knot or a noose…it retains its dimensions and allows connections. An eye has no particular *chirality*.

The Nipping Loop (an introduction)

A key component of all Bowlines is the *nipping loop*. Indeed, the nipping loop is the <u>defining component</u> – without which, there is no Bowline.

The nipping loop clamps and compresses all material inside of the loop – and this compressive force is generated by tension in both the SPart and the ongoing eye leg. However, the balancing force contributed by the ongoing eye leg is 50% of that on the SPart – with the remaining 50% provided by the returning eye leg.



The Sheet bend (#1431) does not have a functioning *nipping loop* because it is only loaded at one end. Force is only provided by the SPart.

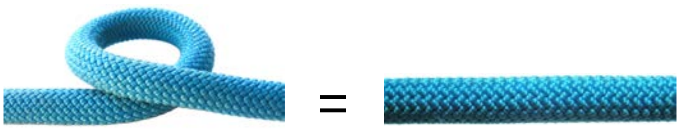
This author posits that there is a *capstan effect* at the collar because the nipping loop does not operate as effectively to clamp and compress both legs of the bight.

The Sheepshank (#1152) has 2 functional *nipping loops*. Each nipping loop is loaded at both ends.

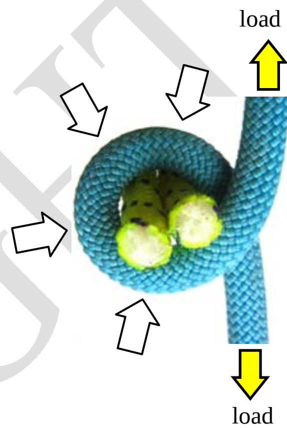
Defining the Nipping Loop

In order to qualify as a nipping loop, the following characteristics must be present:

1. That the nipping loop has a helical form and will have a particular chirality (either S or Z); and
2. That the nipping loop is TIB and therefore topologically equivalent to the unknot; and
3. That the nipping loop is loaded at *both* ends; and
4. That the nipping loop does not open or deform under load; and
5. That the nipping loop is freely able to clamp and compress material inside the loop.



A nipping loop is topologically equivalent to the 'unknot'.



The nipping loop is freely able to clamp and crush material within the loop.

Xarax devised this clever experiment to demonstrate the role of the nipping loop. Here we see that the nipping loop has been neutralized. When load is applied, the tail slips because it is no longer being clamped by the nipping loop.

#519 simple overhand knot is not TIB and it isn't a 'loop'.

#559 Marlinspike hitch is TIB but it is not a 'loop'. It is a nipping *structure.*

#206 Crossing hitch is TIB but it is not a 'loop'. It is a nipping *structure*.

Yes – this is a 'loop'!

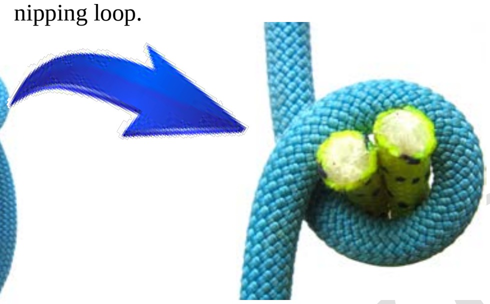
And this is a double loop!

Effect of stress and strain on the nipping loop

It is thought that the region where rupture propagates from is somewhere in the nipping loop – most likely near the region near where the SPart enters the nipping loop.

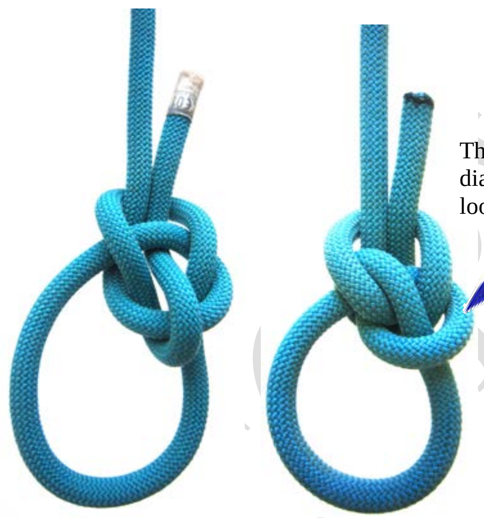
If this proves to be correct, then increasing the radius of the nipping loop should boost the threshold load at which rupture is triggered. To date, there is no peer reviewed test data to either prove or disprove this theory.

The Simple #1010 Bowline has 2 rope diameters within the nipping loop.

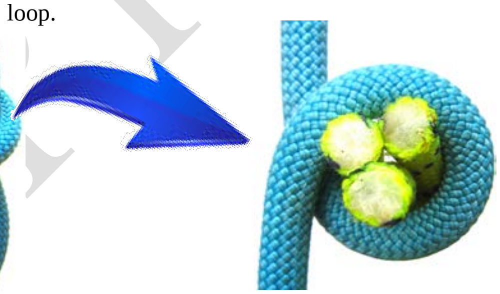


Why have a larger radius nipping loop?

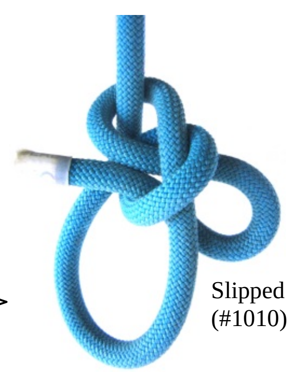
Another theorized benefit of having 3 rope diameters inside the nipping loop is that it provides ‘padding’.
In a dynamic (shock) loading event – such as a lead climbing fall – a padded out nipping loop will help to disperse energy over a larger surface area.



These Bowlines have 3 rope diameters within the nipping loop.



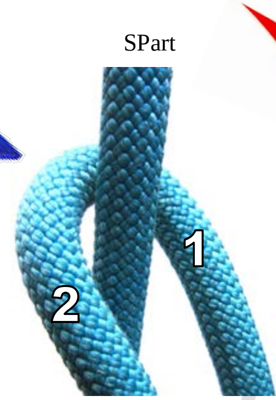
A simple method to test the effect of increasing the radius of the nipping loop.
(A ‘slipped Bowline’…insert the tail back through the nipping loop)



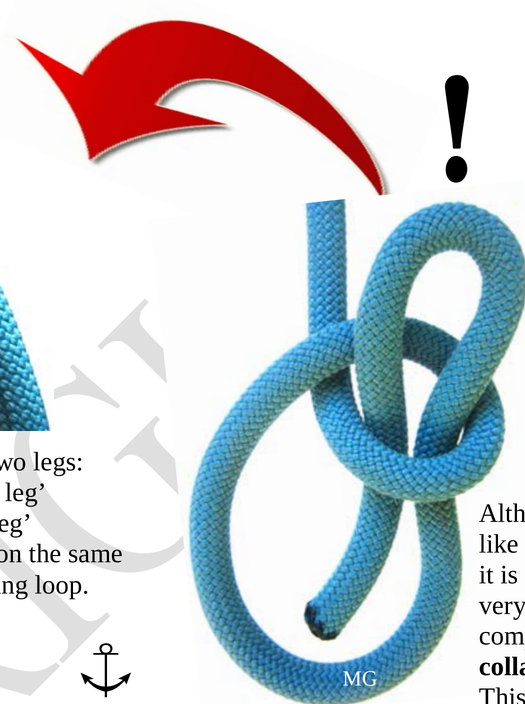
Slipped Simple Bowline (#1010)

The Collar (an introduction)

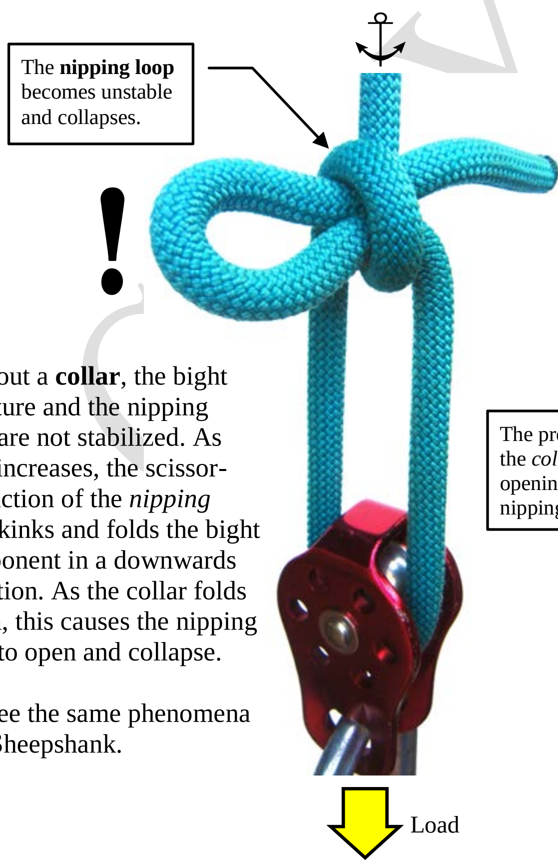
There has been some discussion on the role of the collar – and its significance has been the subject of debate. This author posits that the SPart acts as a *bracing post* for the collar – and this aids in stabilizing both the bight structure *and* the nipping loop.



The collar has two legs:
1) is the 'entry leg'
2) is the 'exit leg'
Each leg exists on the same side of the nipping loop.

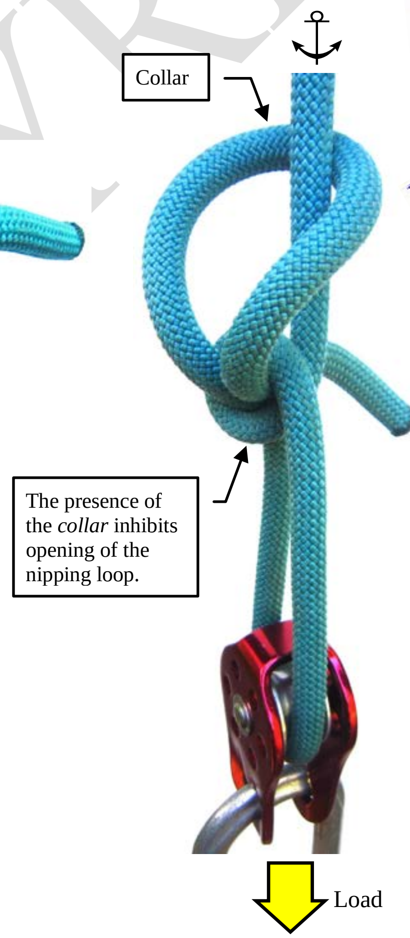


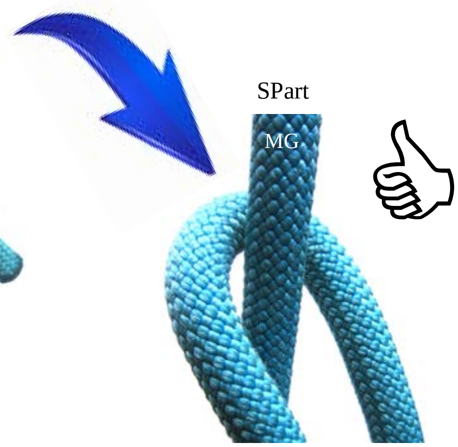
Although it looks like a Bowline – it is missing one very important component… the **collar**.
This structure is *unstable*.



Without a **collar**, the bight structure and the nipping loop are not stabilized. As load increases, the scissor-like action of the *nipping loop* kinks and folds the bight component in a downwards direction. As the collar folds down, this causes the nipping loop to open and collapse.

We see the same phenomena in a Sheepshank.



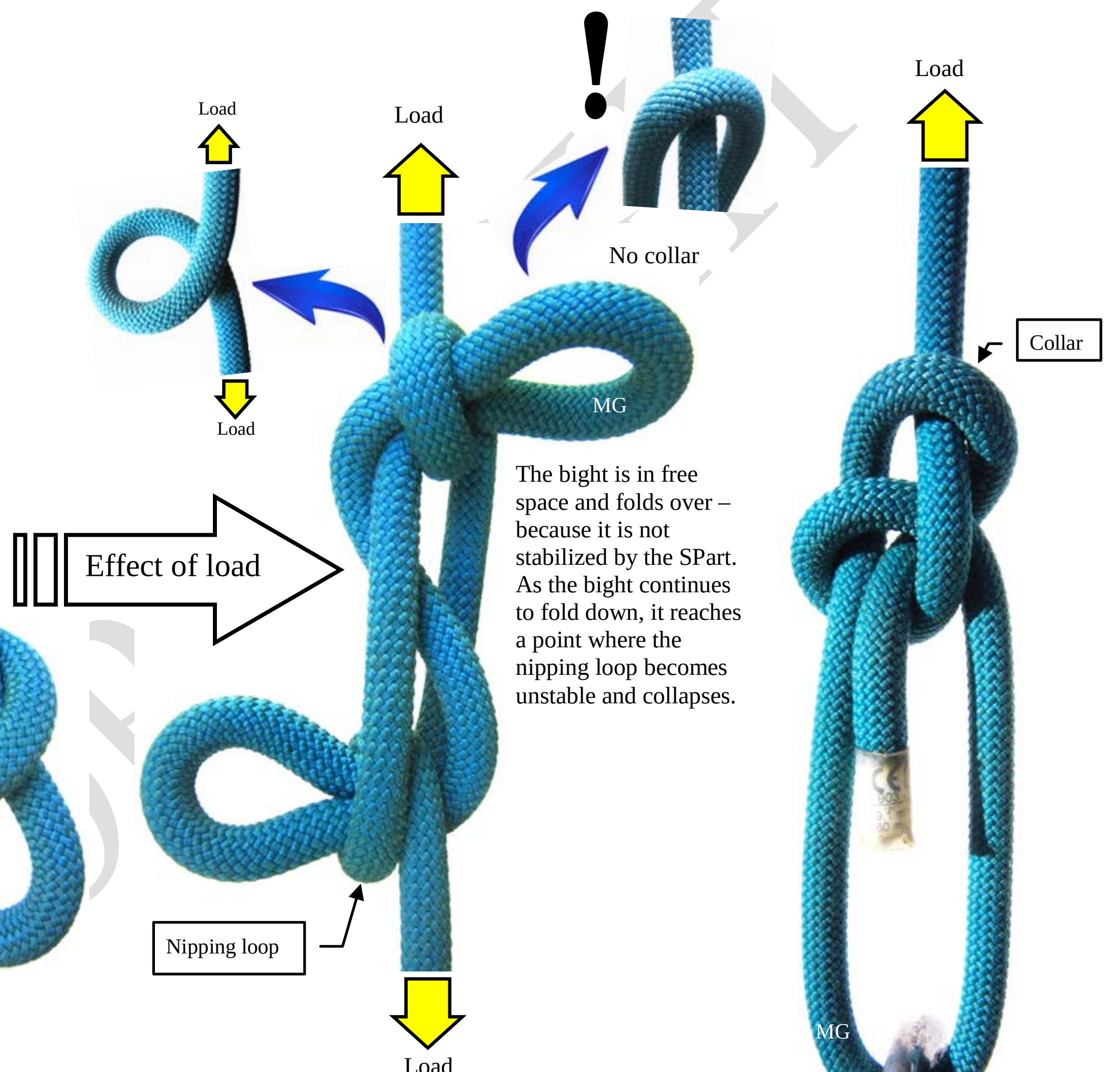


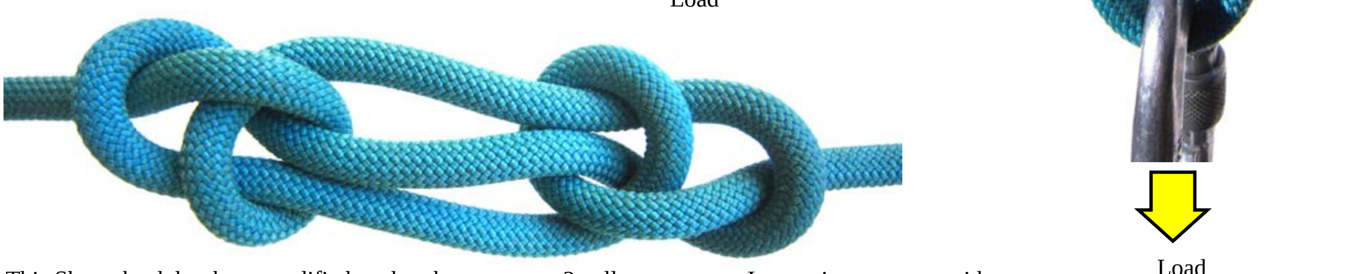
The SPart acts as a *bracing post* – which aids in stabilizing the bight structure and the nipping loop.

The Collar and the Sheepshank

#1152 Sheepshank is an interesting structure to examine because it has a ‘nipping loop’ (2 in fact) and somewhat resembles a Bowline. However, a crucial missing component is the ***collar*** – both bights are in free space and do not perform a U turn around their corresponding SPart’s. Under increasing load, both bights begin to kink and fold over – and it is theorized that at some point, the structure will eventually become unstable. This enables us to see the importance of the collar structure and the role the SPart plays as a <u>bracing post</u> for the bight. The scissor-like action of the nipping loop (a helix) is also observed.

Sheepshank (#1152)





This Sheepshank has been modified so that there are now 2 collar structures. In practice, access to either end is not generally possible – and so this structure is shown for theoretical analysis only. Under load, the structure would mimic a Bowline – since both bights *and* nipping loops are now stabilized.

The Capstan effect

The role of the collar is very important in a Bowline. The collar is the point where the bight performs a 180 degree U turn around the SPart.
Constant Xarax (Greece) posits that there is a ‘capstan effect’ created at the collar. Other knotting experts disagree. To date, nobody has devised a test method to reliably and consistently confirm (or deny) the existence of a capstan effect.

Constant Xarax proposed an experiment to demonstrate its effect – by installing a bearing on the SPart at the ‘collar’ position (the SPart is fed through the ‘inner race’ of the bearing). This author attempted to observe the capstan effect by rigging some simple experiments using pulleys in lieu of a bearing (refer to photos).

In each case, there was no observable capstan effect *after* initial loading once the compressive power of the nipping loop was in play. On intermittent occasions, during *initial* application of load – some slippage of the tail around the SPart was observed. However, the effect was *inconclusive* – because it was not possible to consistently replicate the slippage. Any experimenter will run into the same problem – trying to *consistently & reliably* induce tail slippage around the SPart is problematic. The images show that different configurations were rigged – including the use of 2 pulleys. None of the configurations produced consistent, reliable results. This author therefore declares the capstan effect to be *non-existent* once the compressive force of the nipping loop clamps and crushes both legs of the bight. However, in a Sheet bend (#1431) it may be possible to demonstrate a capstan effect since the nipping loop is not loaded at both ends.

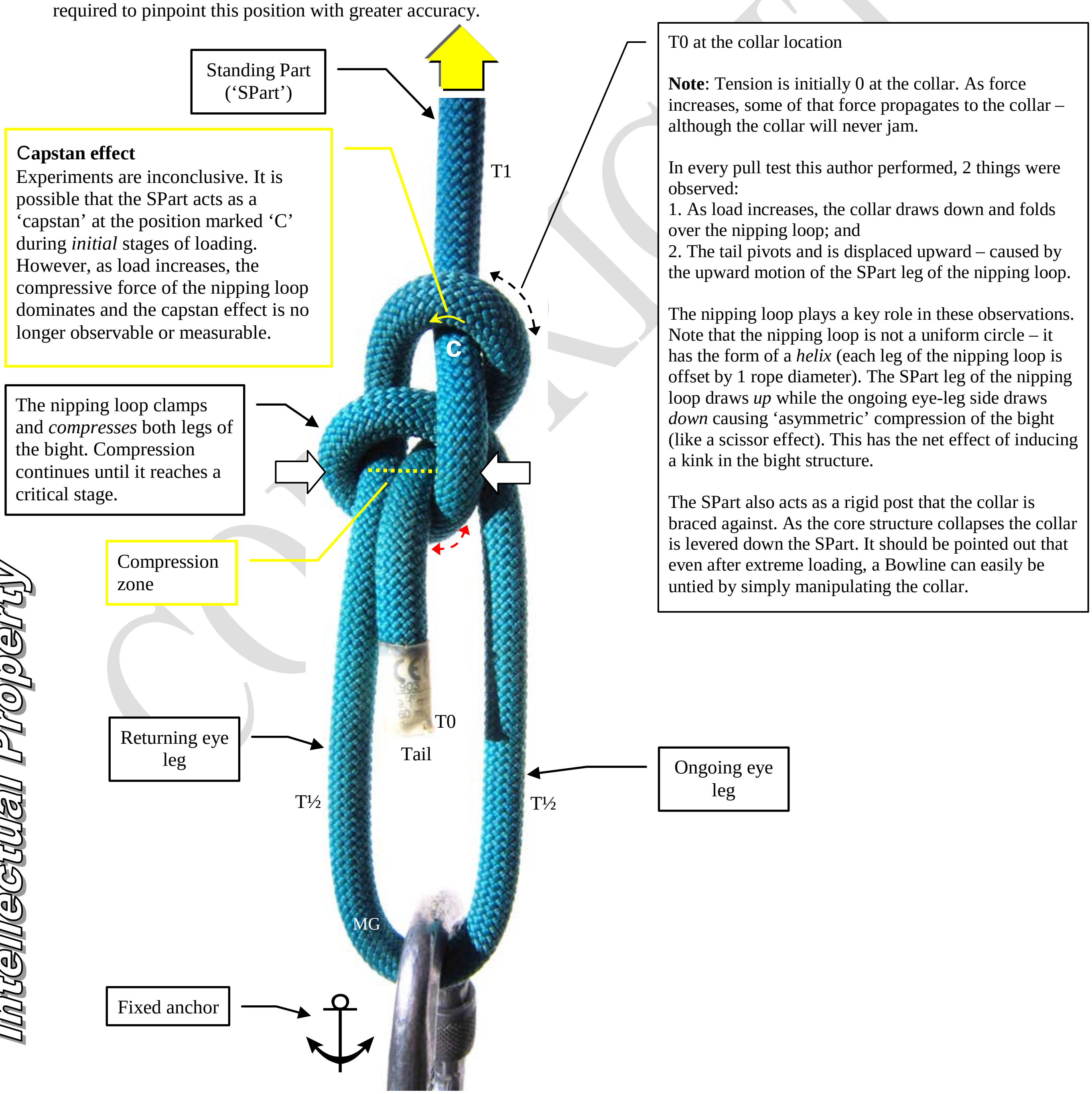
Experiments were inconclusive at *initial* stages of loading. There was no observable slippage of the tail around the SPart (at the collar position) *after* initial loading. The compressive force of the nipping loop clamps and crushes both legs of the bight – and is the dominant force – overriding any possible benefit of a capstan effect.

A theoretical analysis of force acting on a Simple (#1010) Bowline

Let's examine what happens as load is applied to a Simple Bowline structure…

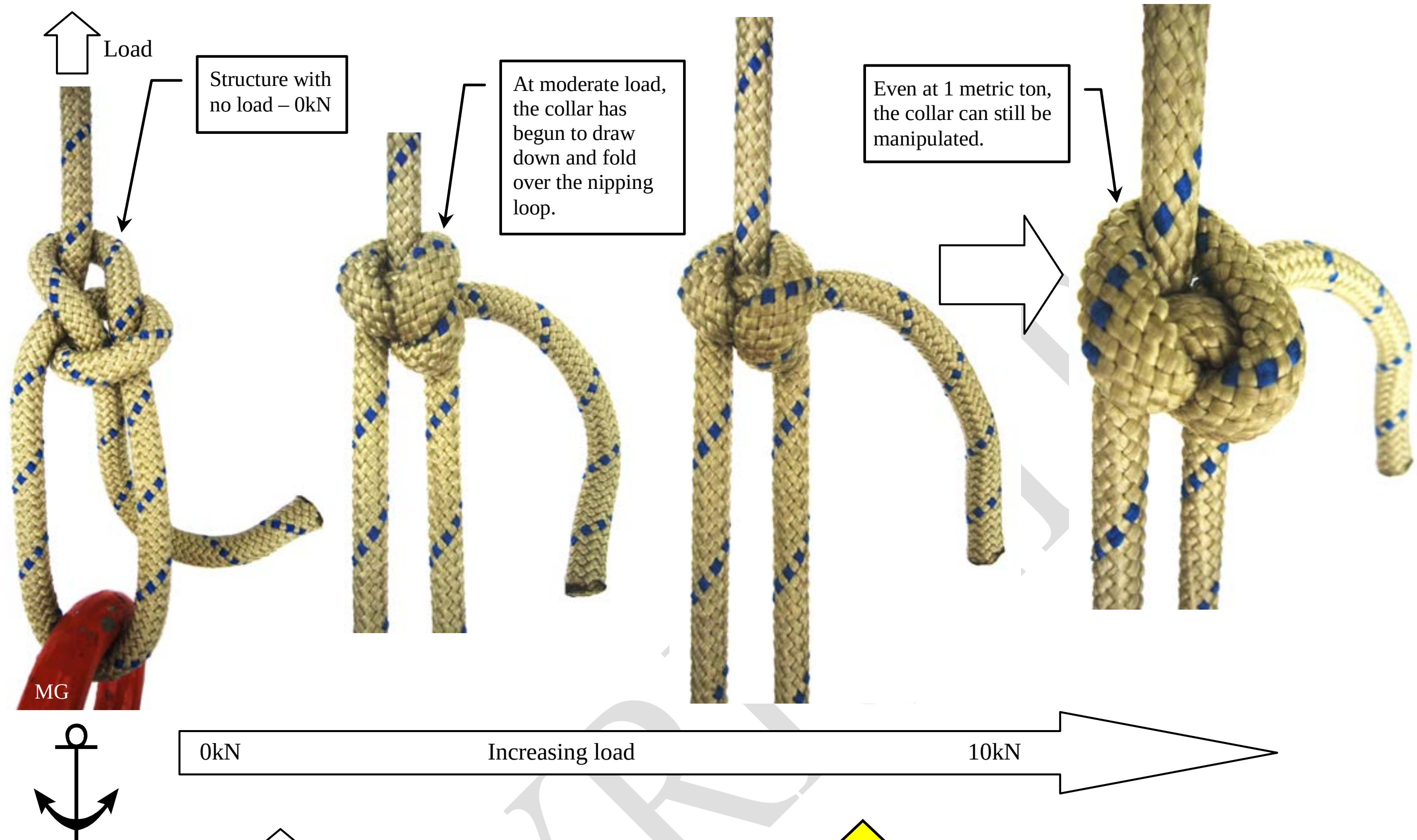
Force enters the core of the Bowline via the Standing part ('SPart'). At the opposite end, each leg of the eye sustains 50% (half) of the force. The nipping loop is loaded at both ends – 1) by the SPart and 2) the ongoing eye-leg. During initial uptake of strain, the greatest degree of rope movement within the core occurs with the *SPart*. Tension force causes the *nipping loop to* clamp and compress the bight. As load increases, compressive forces acting on the bight also increase. The radius of the nipping loop also plays a role – it is theorised that a smaller radius (sharp bends) induces higher stress and strain. Compression of the bight eventually reaches a critical stage – when the force required to further compress the bight *exceeds* the breaking load of the rope. At this point, rupture is triggered. It is thought that rupture propagates from a region somewhere in the nipping loop.

Note: This paper has not pinpointed the precise location of the point of rupture – measurements are only indicative of the *approximate* position (ie region). High speed camera equipment and carefully placed cotton thread 'markers' would be required to pinpoint this position with greater accuracy.

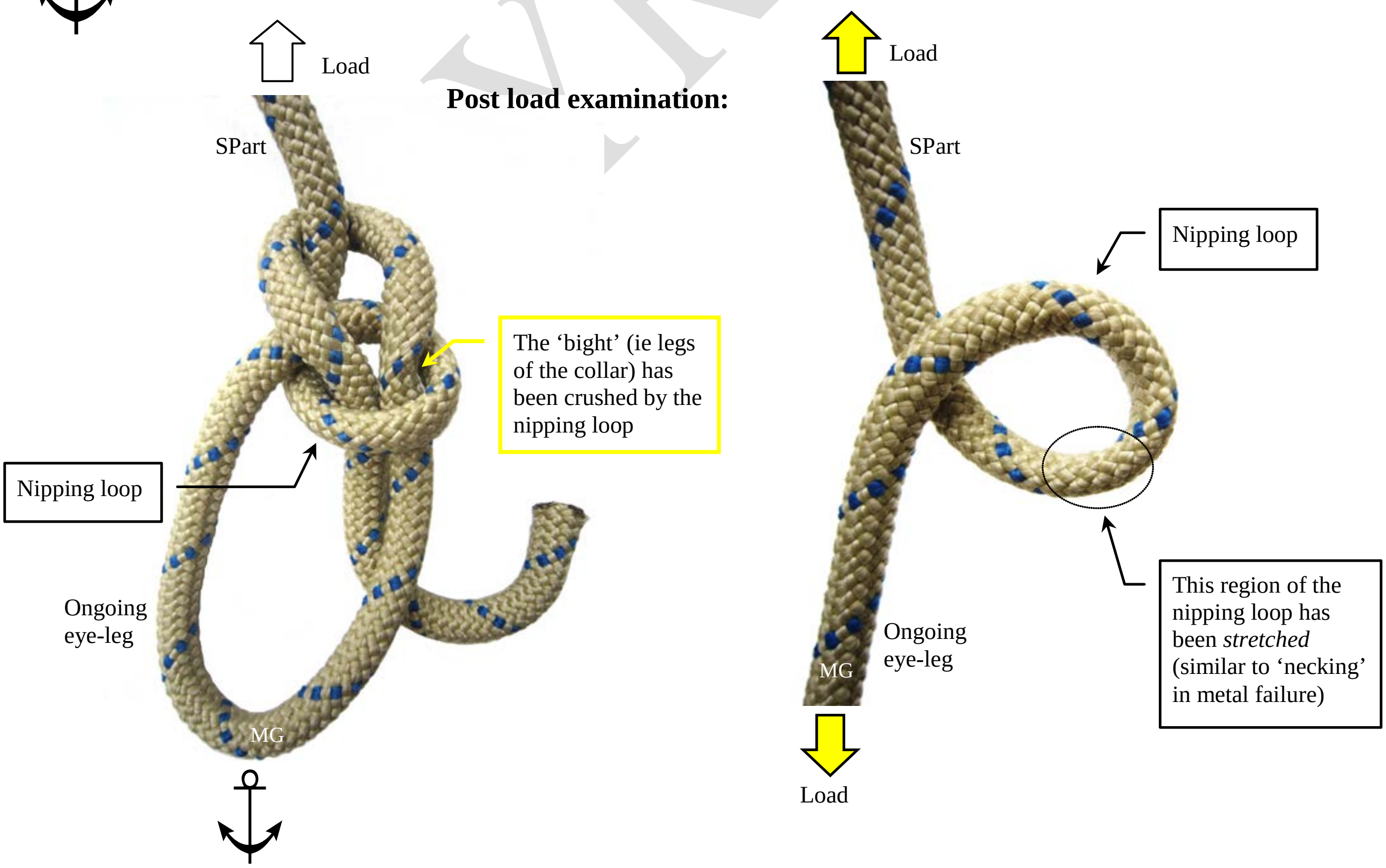


Load testing the Simple Bowline

The following images provide an opportunity to examine the response of the Simple Bowline to applied load.



Post load examination:

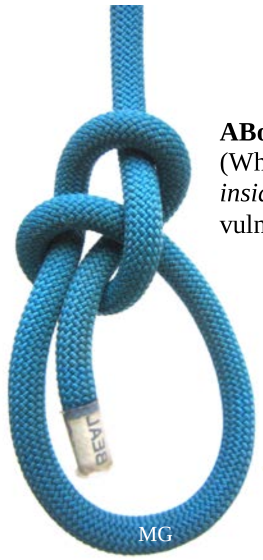


Circumferential (hoop stress) loading

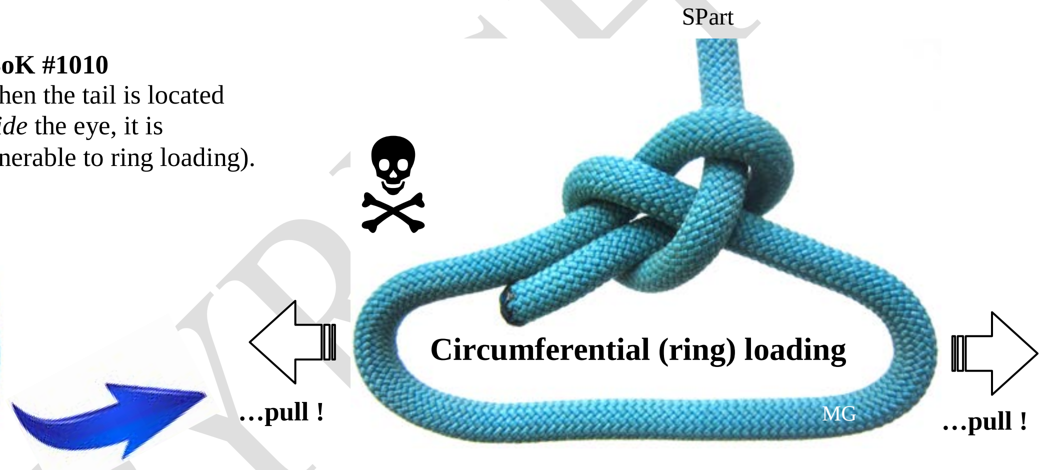
The structure shown at *bottom* (identified as “ABoK 1034½”) is sometimes referred to as a ‘Left hand Bowline’ or a ‘Cowboy Bowline’. Many authors wrongly condemn this version as being *inferior* to the Simple #1010 ‘Bowline’. In fact, it is *resistant* to a particular loading profile known as circumferential loading (also known as ring loading). In contrast, the Simple #1010 Bowline is vulnerable to circumferential loading and can fail. Test this for yourself…

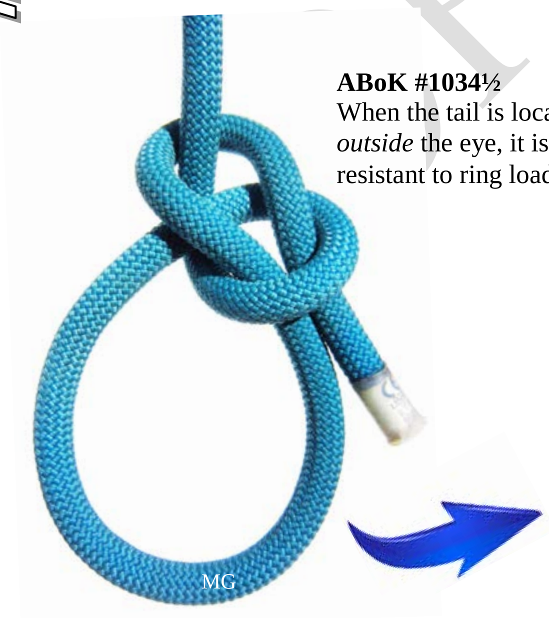
NOTE 1: Even though the “#1034 ½” bowline is resistant to ring loading, it is still not considered to be a secure and stable form.

NOTE 2: Confusingly, Ashley referred to the Simple #1010 Bowline as ‘right handed’ at entry #1034 ½ (page 188). This should not be confused with the ‘chirality’ of the nipping loop (which can be left or right – or, S twist versus Z twist).

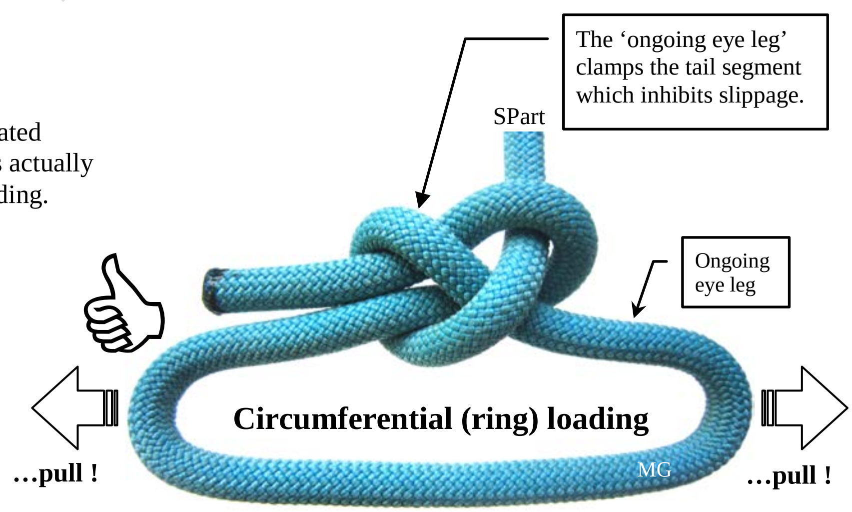


ABoK #1010
(When the tail is located *inside* the eye, it is vulnerable to ring loading).





ABoK #1034½
When the tail is located *outside* the eye, it is actually resistant to ring loading.

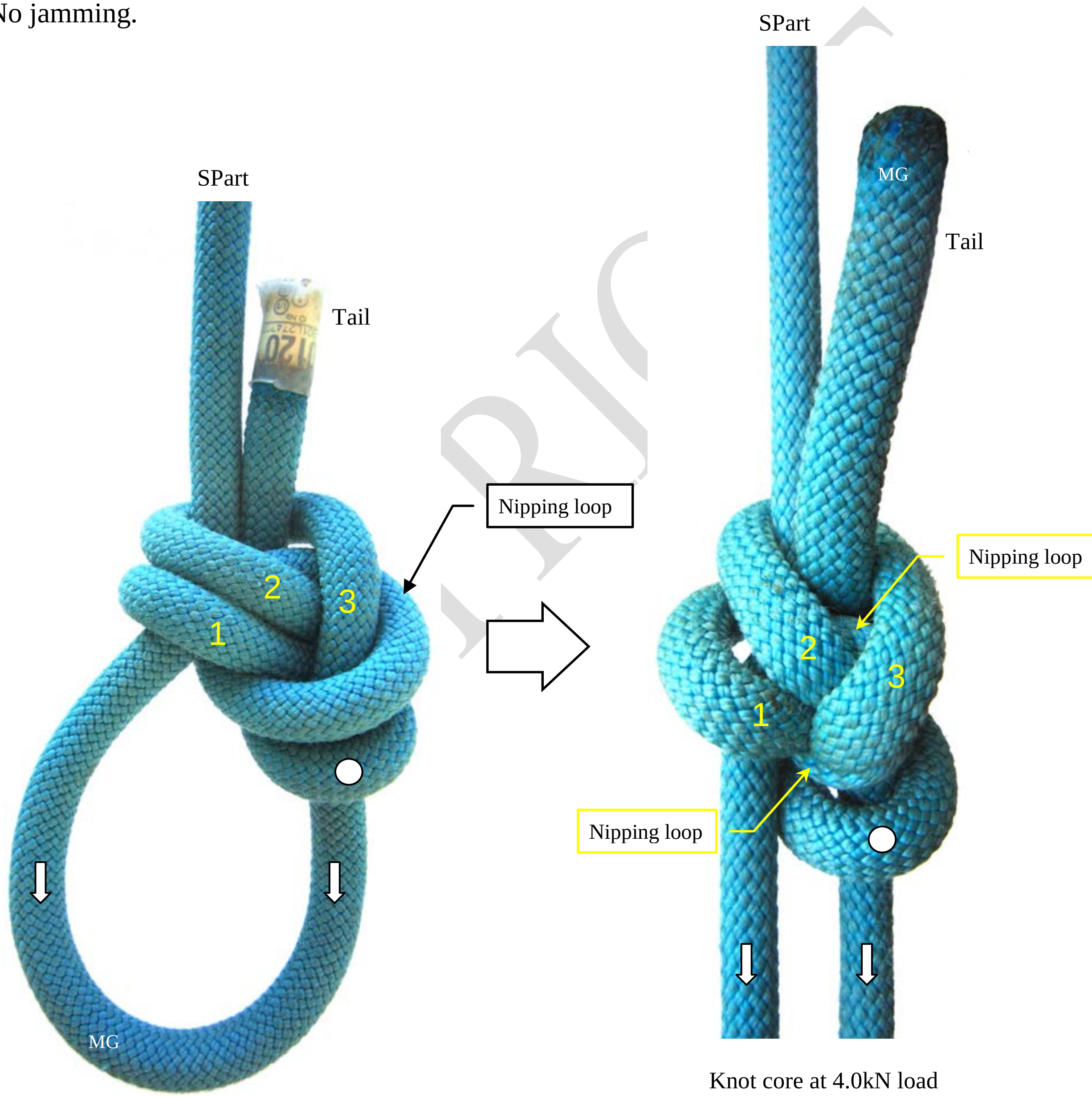


Point of interest:
Geoffrey Budworth, in his book ‘The Complete Book of Knots’ referred to this particular structure as a *Lapp knot* (at page 35). The history of the ‘Lapp knot’ was described in the April 1996 edition of ‘Knotting Matters’ where it was apparently used in Lapland for tasks such as hitching reindeer to sledges and suspending sheath knives. Budworth also comments that this knot was often called a ‘false sheet bend’.

EBSB Bowline response to slow pull test

Rope: EN892 Beal 9.1mm ‘Joker’
Method: Load was steadily increased to 4.0kN peak load

At 4.0kN load, we can see that the knot core undergoes significant compression. The nipping loop is a key component in all ‘Bowlines’.
The nipping loop has crushed all 3 rope segments.
No significant tail slippage occurred.
No jamming.



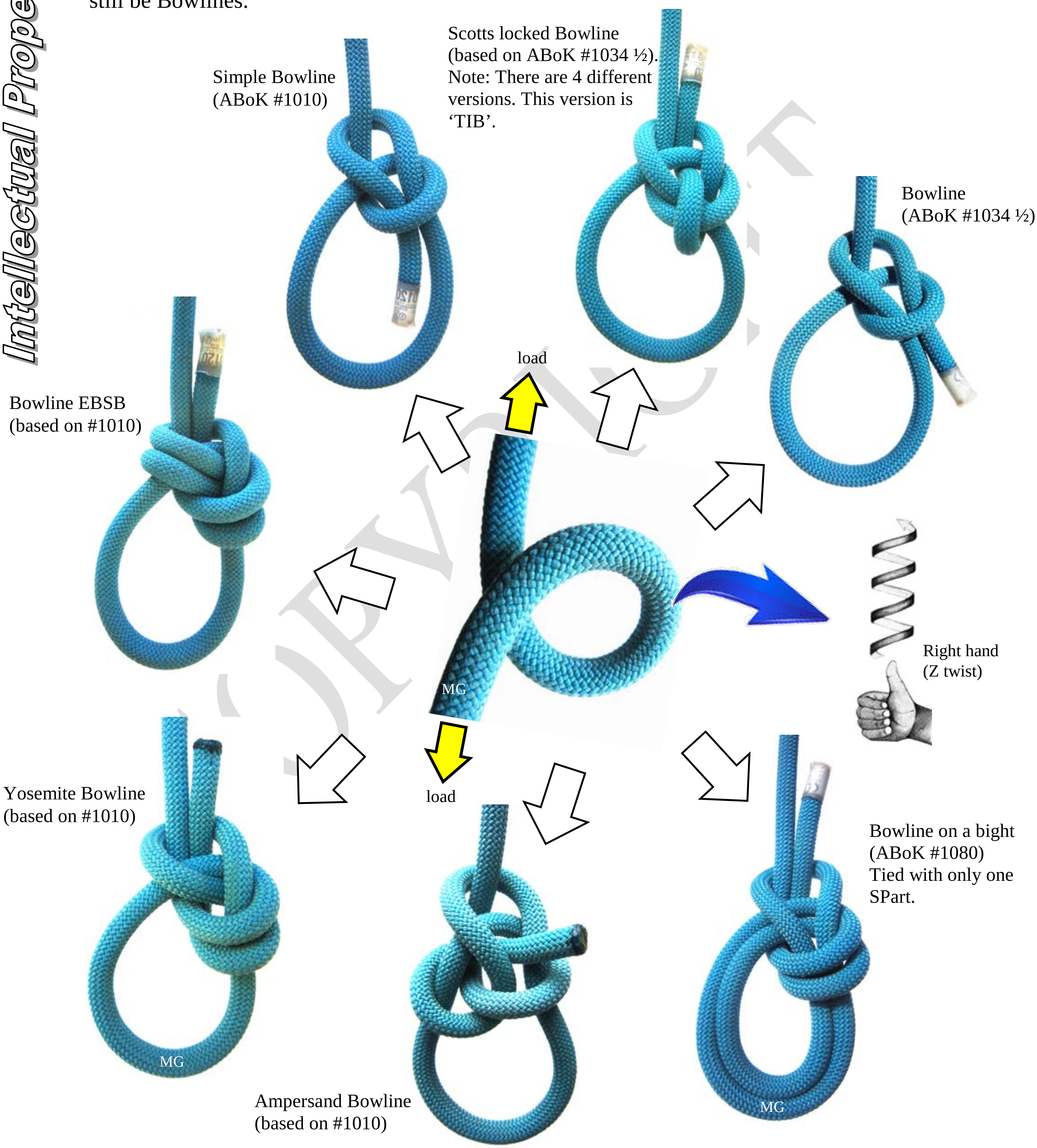
EBSB Bowline

Knot core at 4.0kN load

Note: Various symbols provide a frame of reference.

Bowlines based on a single nipping loop

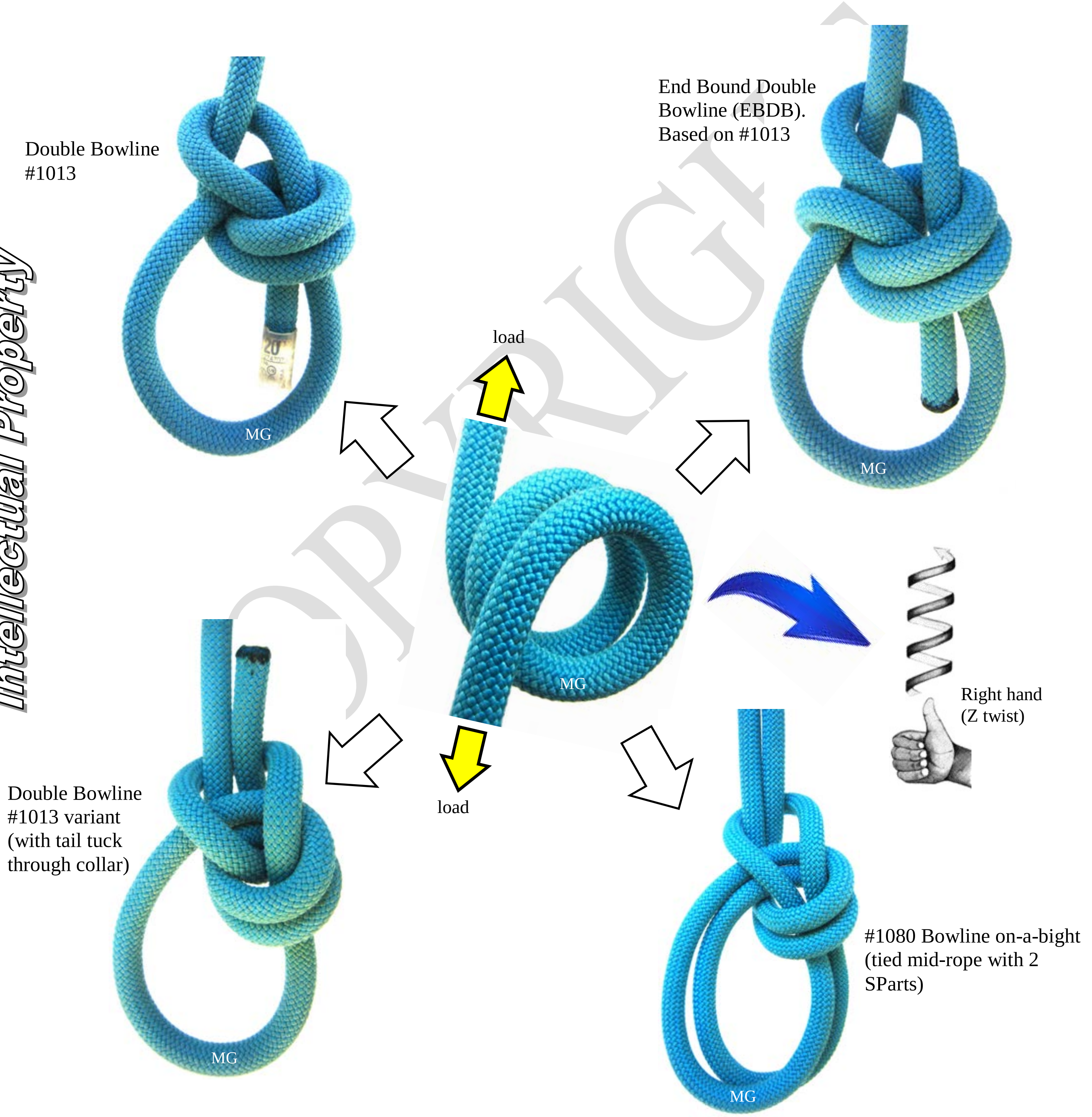
All of the following Bowlines are based on a single helical nipping loop.
Note: In this particular case, all of the Bowlines are shown with a ‘right-hand’ (**Z** twist) nipping loop. They could also have been tied with a ‘left-hand’ (**S** twist) nipping loop – and still be Bowlines.



Bowlines based on a double nipping loop

The following structures are based on a double nipping loop.

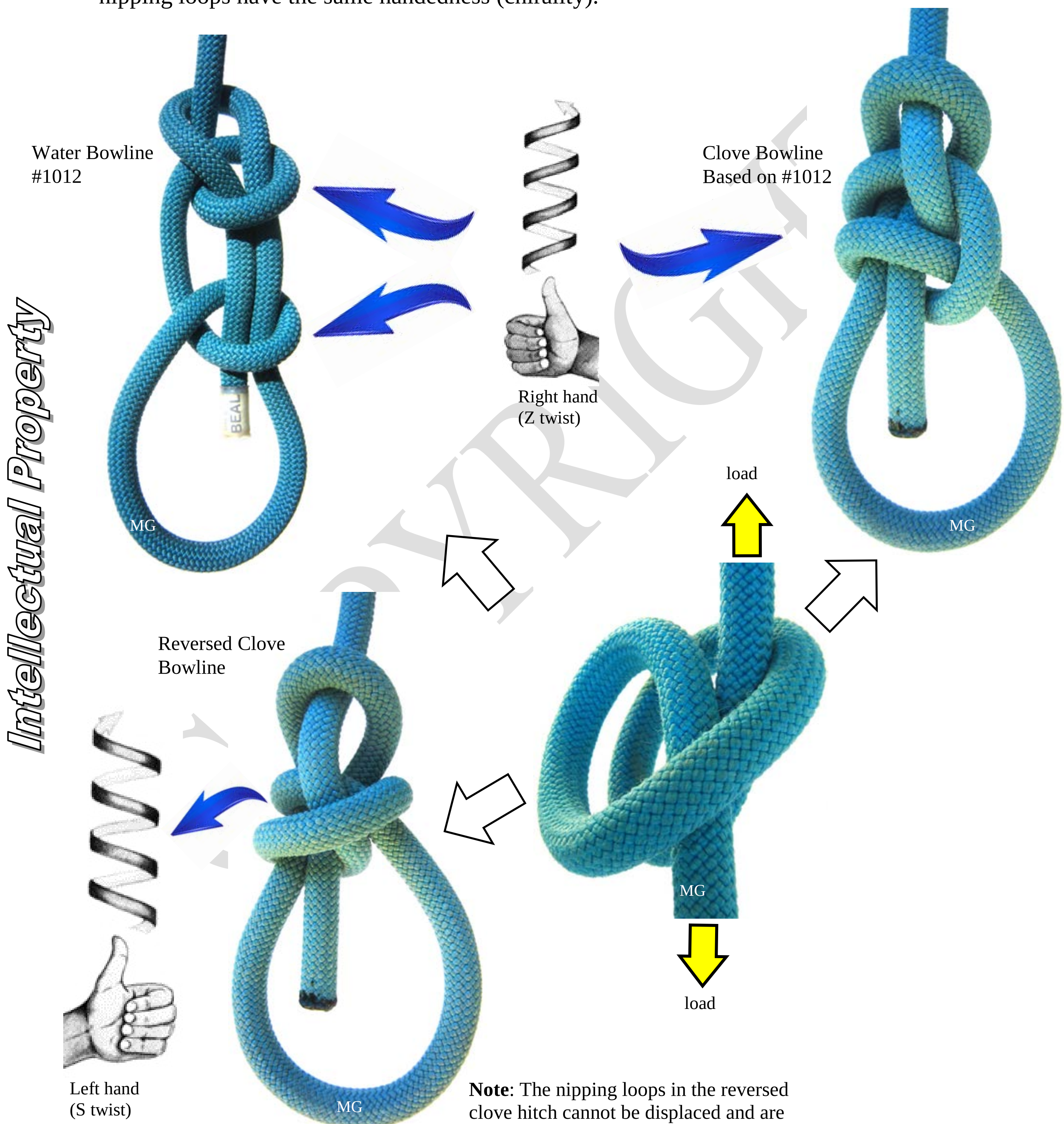
The addition of a second nipping loop was thought to improve security – but with modern climbing and abseiling ropes, this is not true. These structures are still vulnerable to cyclic loading and slack shaking. Dan Lehman’s ‘EBDB’ is an improvement on the original #1013 Double Bowline with the added benefit of 3 rope diameters within the nipping loop.



Bowlines based on a Clove Hitch nipping loop

The following structures are based on a nipping loop that takes the form of a clove hitch.

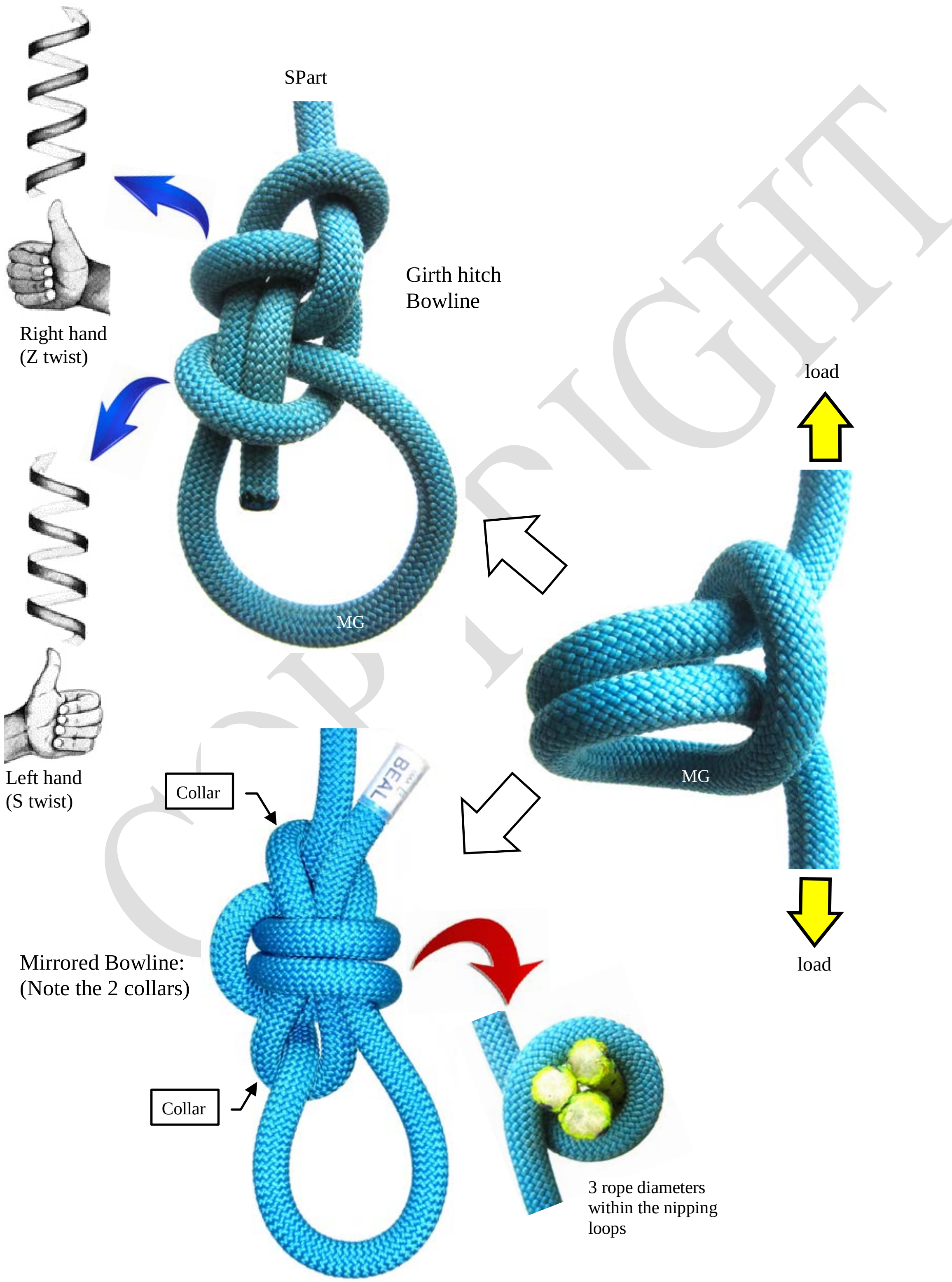
The image at left is shown at illustration #1012 in ABoK. Here we see the nipping loops are displaced. At right we see the nipping loops united to form a clove hitch (#1245). Both nipping loops have the same handedness (chirality).



Note: The nipping loops in the reversed clove hitch cannot be displaced and are therefore likely to jam.

Bowlines based on a Girth Hitch nipping loop

The following structures are based on a girth hitch (aka 'larks foot') nipping loop. This is an interesting nipping loop structure because each loop is of opposite handedness (ie chirality). It is also the foundation from which 'mirrored' Bowlines are built. Compare this structure to the 'Water Bowline' #1012.



Fixed eye knots – examining if they are in fact ‘Bowlines’ …

The following knot structures have been debated and argued about – and for some knotting experts, the jury is still out.

It is time to put the theory to the test… 5 knot structures for analysis. Do any of these structures fulfill the requirements to be deserving of the title ‘Bowline’?

#1033 Carrick loop

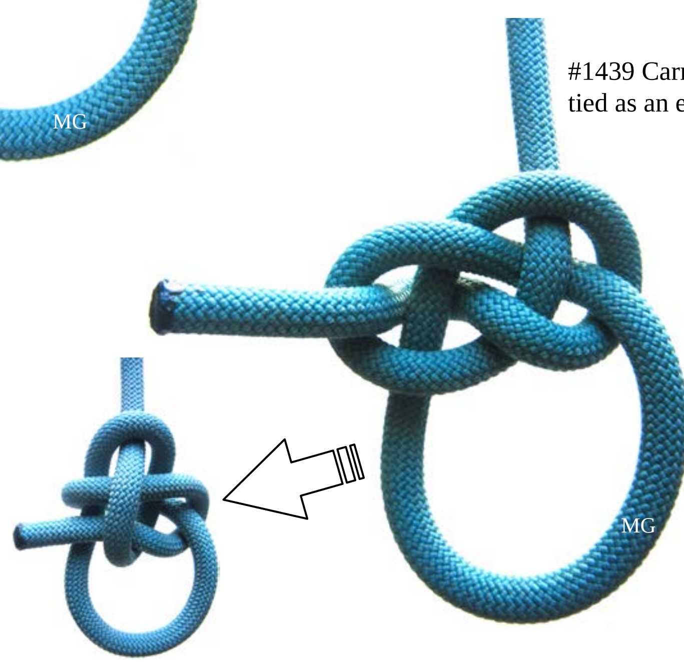
Karash eye knot - Single eye version (not identified in ABoK)

SPart

Anti Bowline (not identified in ABoK)

Lee-Zep Bowline (Alan Lee creation) Not identified in ABoK.

#1439 Carrick bend tied as an eye knot

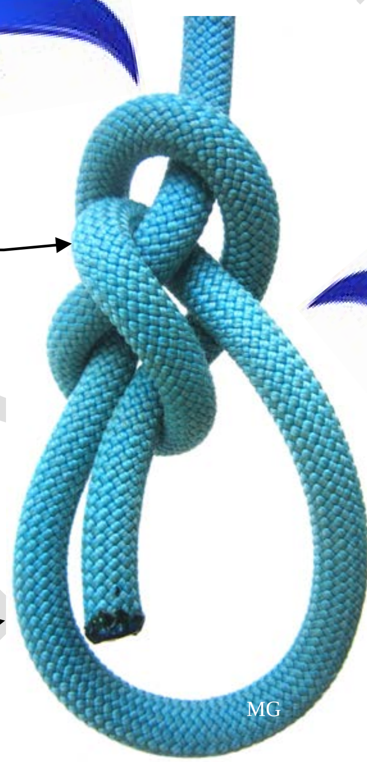


Transformed

Karash single Bowline

This single eye version of Mike Karash's 'double eye knot' was presented by Mark Gommers to the IGKT forum some years ago. At the time, it was unclear if the crossing knot / Munter hitch nipping structure would qualify as a 'nipping loop'. This author posits that it is a nipping 'structure' (not a loop) – and takes the form of a 'Crossing hitch' (#1195). The Crossing hitch is used extensively in mountaineering as a belay mechanism – and is more commonly known to climbers as a 'Munter hitch'. The holding power of a Munter hitch is provided courtesy of a 'capstan effect'.

SPart

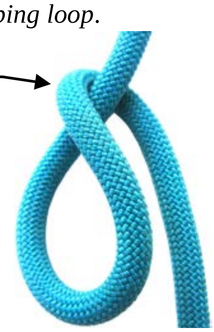


Nipping structure based on #1195 Crossing hitch
A *capstan effect* is created as the ongoing eye leg performs a U turn around the SPart. Friction at this point has the effect of reducing the compressive force of the nipping structure.
[Note that this is how the 'Munter Hitch' works – with the contact radius against its own SPart providing a Capstan effect].

Returning eye leg

The Crossing hitch clamps the bight and compresses material within its structure. The point where the ongoing eye leg performs a U turn around its own SPart induces a significant *capstan effect*. This has the effect of inhibiting the compressive force of the nipping structure – it does not function as effectively as a *nipping loop*.

Capstan effect



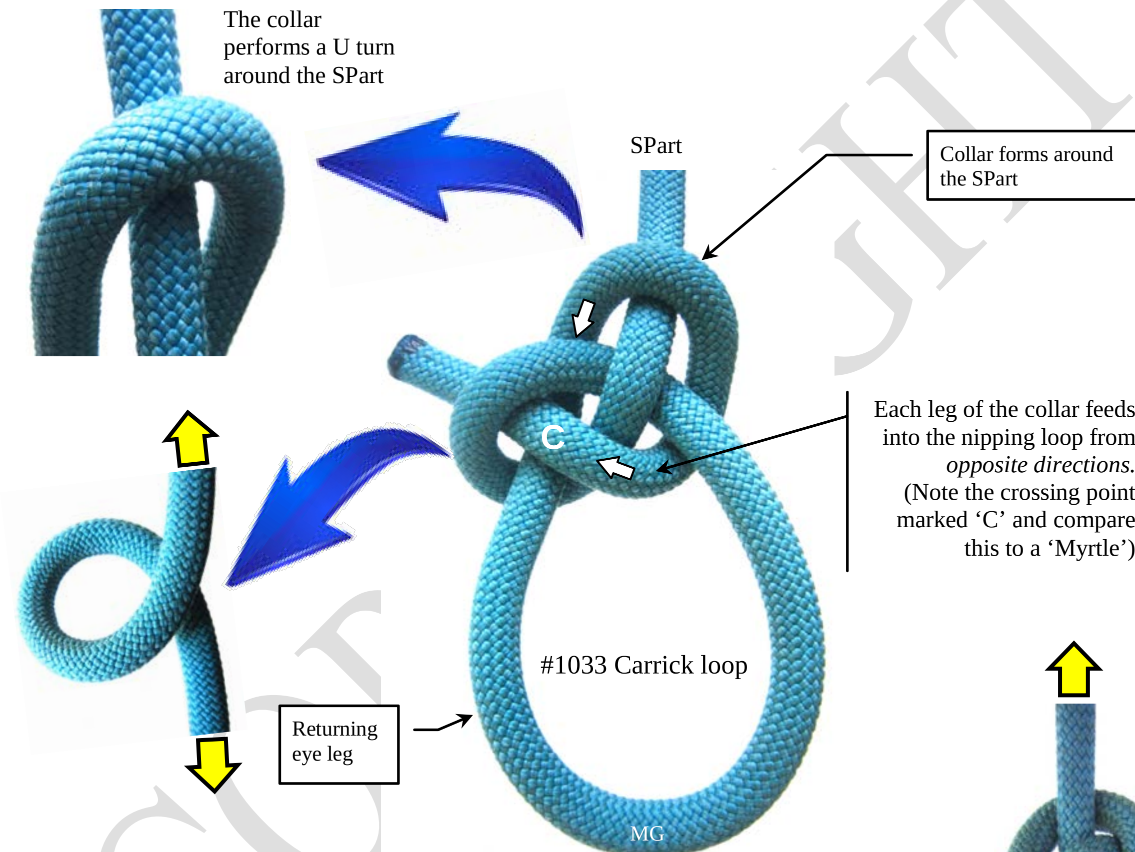
VIRTUAL BOWLINE

This knot has all of the characteristics of a Bowline with the one difference being the nipping structure.
In this case, the nipping structure does not take the form of helical loop.
However, the nipping structure is 'TIB' and loaded at both ends.

Carrick Loop ‘Bowline’ (#1033)

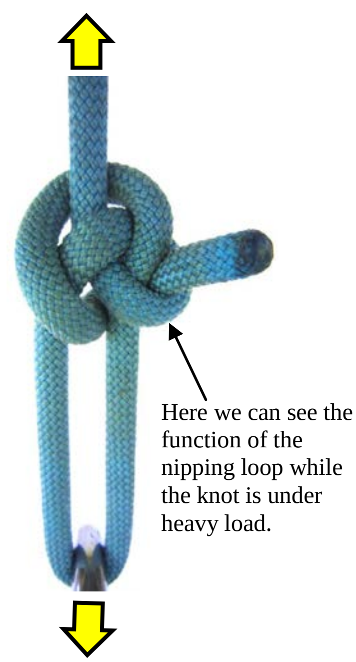
#1033 Carrick loop was not recognized by Clifford Ashley (in 1944) as a ‘Bowline’. However, this by itself is not absolute evidence to disqualify the structure. Some 70 years have passed since Ashley published his masterpiece – and new theories are emerging on the structure of Bowlines.

The issue for some is the fact that each leg of the collar feeds into the nipping loop from opposite directions – with the consequence that there is no prominent ‘bight’ structure. However, both legs of the collar are fully encircled and clamped by the nipping loop.



YES – IT IS A BOWLINE

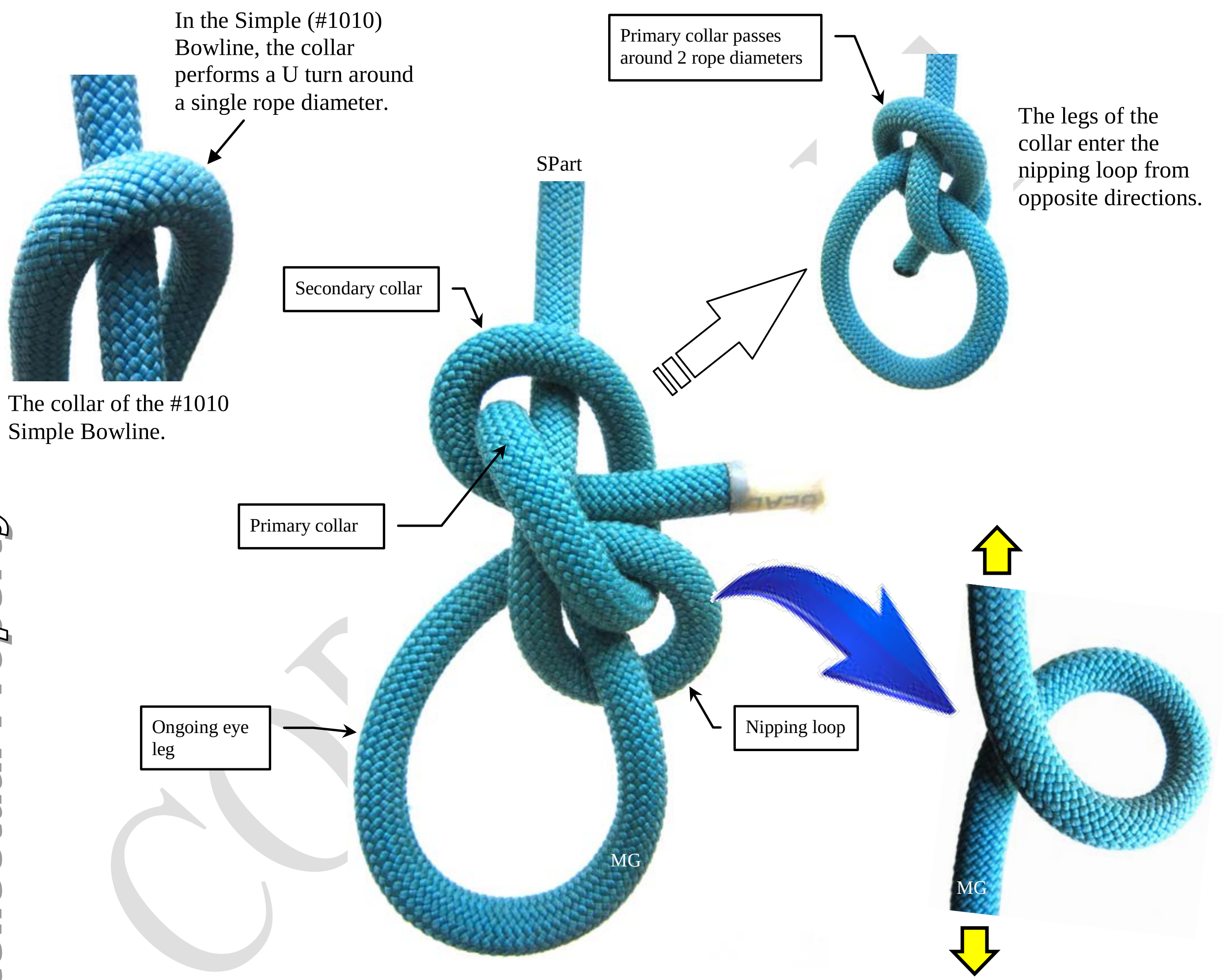
The ‘Carrick loop’ does in fact have all of the components to qualify as a ‘Bowline’.
Load testing has been conducted to determine if the structure jams. The knot was taken right up to its MBS yield point – and it did not jam. A property that is inherent to all Bowlines is that they are jam resistant on account of the function of the nipping loop. In this test, the nipping loop performed as expected.
The name ‘Carrick loop’ has stuck – but if there were future updates to the Ashley Book of Knots, this knot could be renamed as the *Carrick loop Bowline* (#1033).



Lee Zep Bowline – a strange looking collar

The Lee Zep Bowline was not known at the time of Ashley. The creative genius of Alan Lee brought this discovery to light in May 2012. It is based on a ‘Myrtle’.

The collar structure differs from the Simple #1010 Bowline. However, both legs of the collar are fully encircled and clamped by the nipping loop.



YES – IT IS A BOWLINE

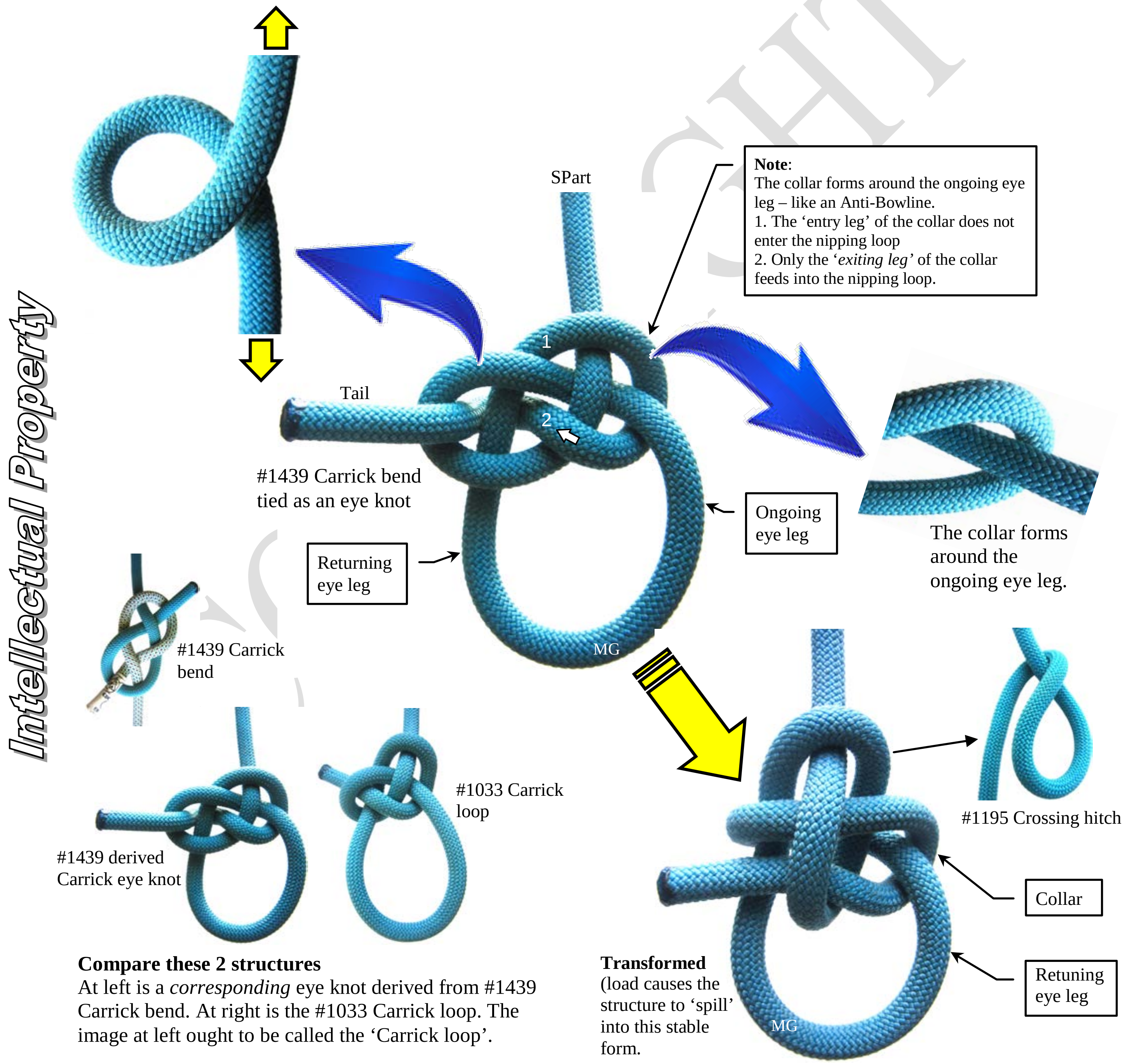
The ‘Lee Zep Bowline does in fact have all of the components to qualify as a ‘Bowline’.

Both legs of the collar are fully encircled and clamped by the nipping loop. The difference in appearance of the bight structure is because the legs of the collar enter the nipping loop from *opposite directions* – and the collar turns around the crossing point formed by the overlap of the SPart and ongoing eye leg. The collar in fact turns around 2 rope diameters.

Carrick eye knot

#1439 derived Carrick eye knot (derived from its corresponding #1439 Carrick bend) was not identified by Clifford Ashley. He only identified #1033 ‘Carrick loop’ - which has a different structure from the true Carrick lattice/mat.

This particular eye knot has a *transient dressing state*. When load is applied, it transforms into the inter-linked crossing hitches in the same way that #1439 Carrick bend transforms. The final stable structure is a **virtual anti-Bowline** based on the #1195 Crossing hitch. The collar is formed around the returning eye leg, and the legs of the collar are encircled and clamped by a Crossing hitch (which is loaded at both ends).



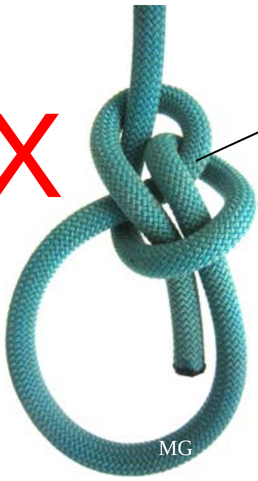
Compare these 2 structures
At left is a *corresponding* eye knot derived from #1439 Carrick bend. At right is the #1033 Carrick loop. The image at left ought to be called the ‘Carrick loop’.

Transformed
(load causes the structure to ‘spill’ into this stable form.

Eye knots that fail to meet the definition of a ‘Bowline’

The following knots provide an opportunity to examine the rules which apply to all ‘Bowlines’.

X



Only this leg is encircled and clamped by the nipping structure.

#206 / #1195 Crossing hitch

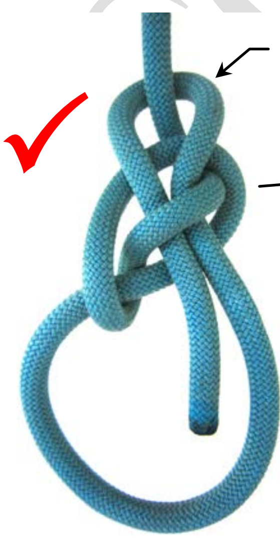
This eye knot fails to meet the criteria for title of ‘Bowline’.
There is a nipping structure and it is TIB.
However, both legs of the Collar must be fully encircled and clamped by the nipping structure. In this case, only one leg is inside the nipping structure (the ‘entry leg’).

X

#515 Single overhand knot

This eye knot fails to meet the criteria for title of ‘Bowline’.
There is no nipping loop – it is in fact a single overhand knot.
The #515 Single overhand knot isn’t TIB and it jams. If there is no TIB nipping structure, it is automatically disqualified.

✓



Collar

#559 Marlinspike hitch

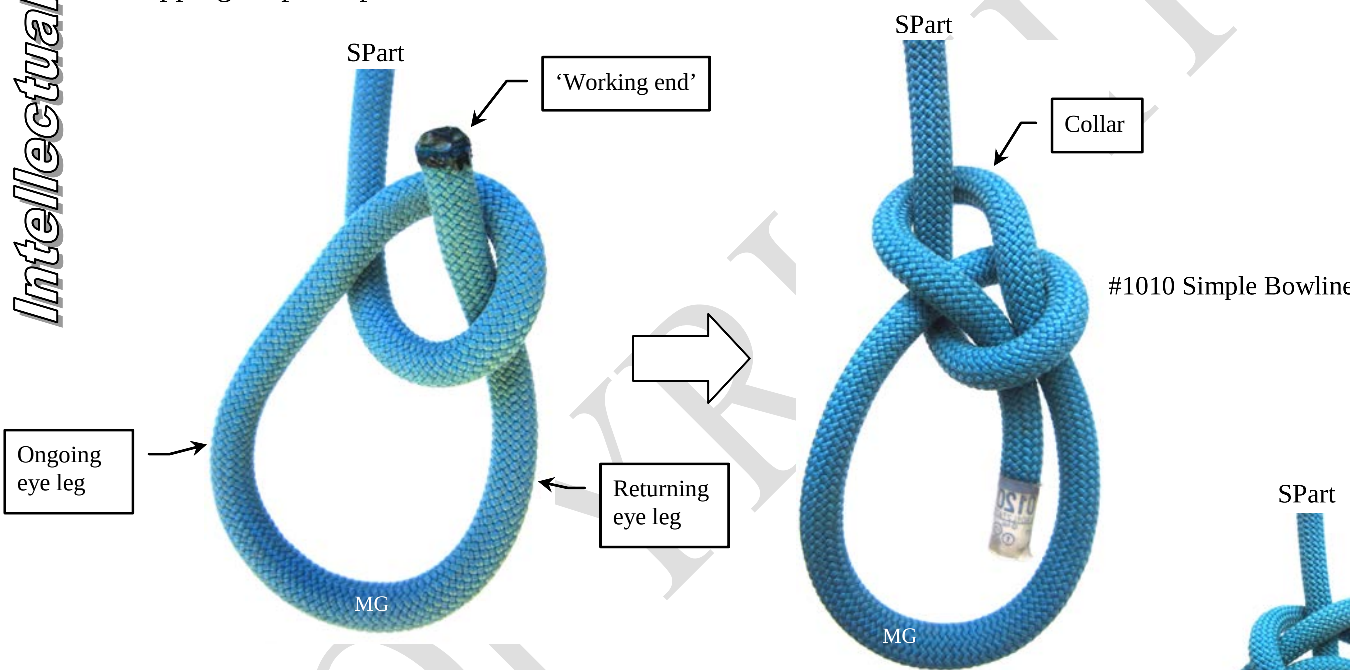
Virtual Bowline based on #559 Marlinspike hitch.
The title of ‘Virtual Bowline’ is assigned because the nipping structure is ‘TIB’ and non-jamming. Also, both legs of the Collar are encircled and clamped by the nipping structure.
However, the nipping structure is based on a Marlinspike hitch rather than a helical loop.

Anti Bowline

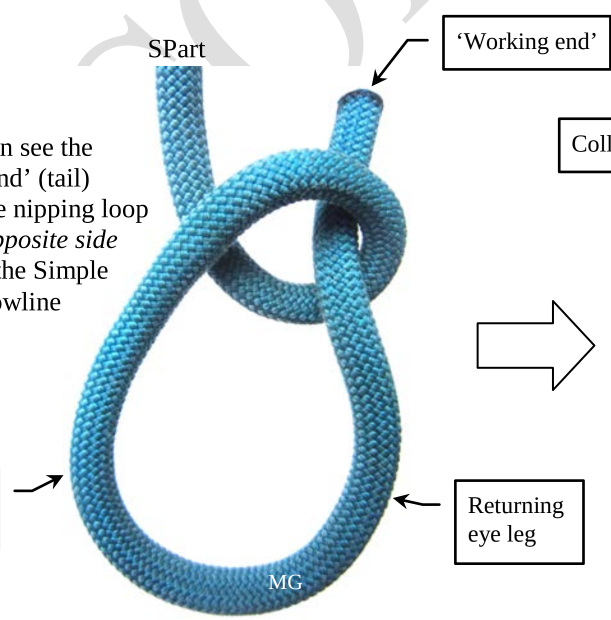
This interesting structure was not identified by Clifford Ashley (in 1944). Dan Lehman introduced the term ‘anti Bowline’ to describe a situation where the ‘working end’ (tail) enters the nipping loop from the *opposite* side relative to the Simple #1010 Bowline. This opposite tail maneuver was the inspiration for the term ‘Anti Bowline’.

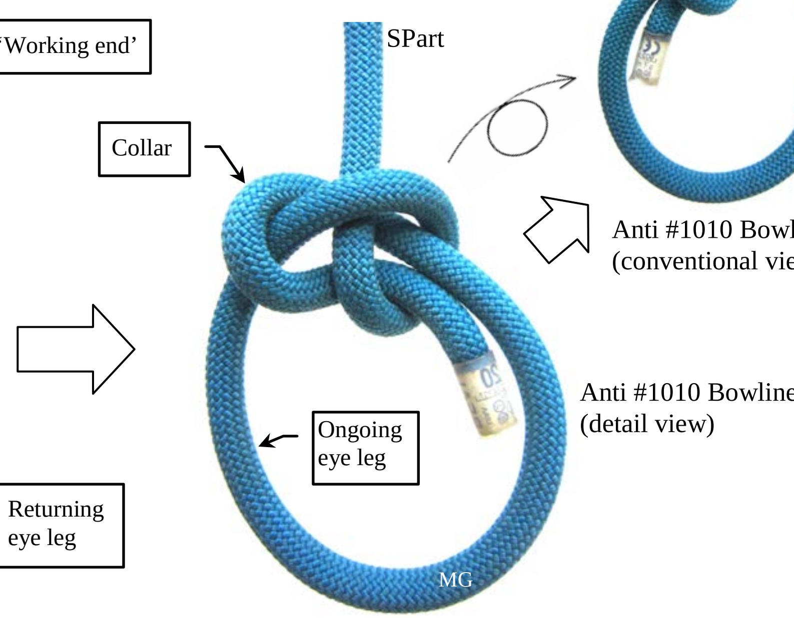
Note that the collar does not perform a U turn around the SPart – instead, it forms around the *ongoing eye leg*, and this is true for all Anti Bowlines. This structure has also been known as an ‘Eskimo Bowline’ and/or a ‘Cossack knot’.

Note that there are 4 variations of this particular anti-Bowline due to ‘chirality’ of the nipping loop and position of the tail.



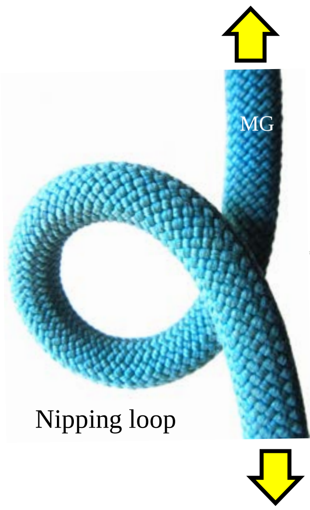
Here we can see the ‘working end’ (tail) entering the nipping loop from the *opposite side* relative to the Simple (#1010) Bowline



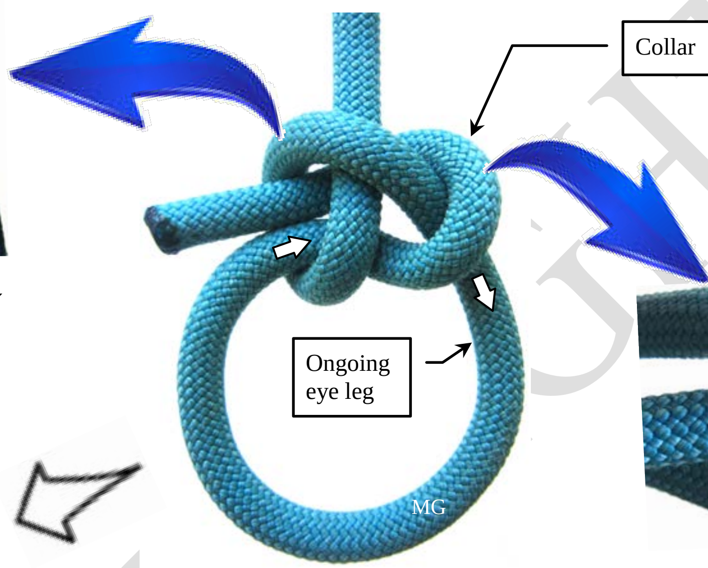


Anti Bowline relationship to #1431 Sheet bend

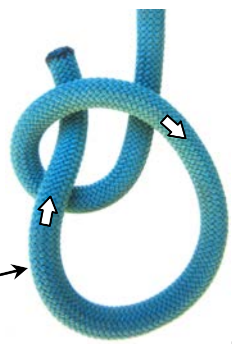
In the particular anti Bowline illustrated below (anti #1034 ½), when 'ring-loaded', the structure precisely mimics the function of a Sheet bend core.



Anti #1034 ½ Bowline (tail outside eye)

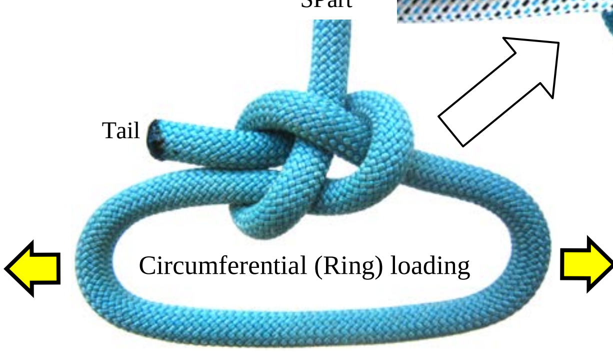


The collar is formed around the ***ongoing eye leg*** – and not the SPart. However, it still functions as a stabilizing element for the bight and the nipping loop.



Returning eye leg enters the nipping loop from the *same side* as the ongoing eye leg.

#1431 Sheet bend



When this *Anti #1034 ½ Bowline* is ring-loaded, due to the orientation of the tail, it mimics the core function of a Sheet bend.

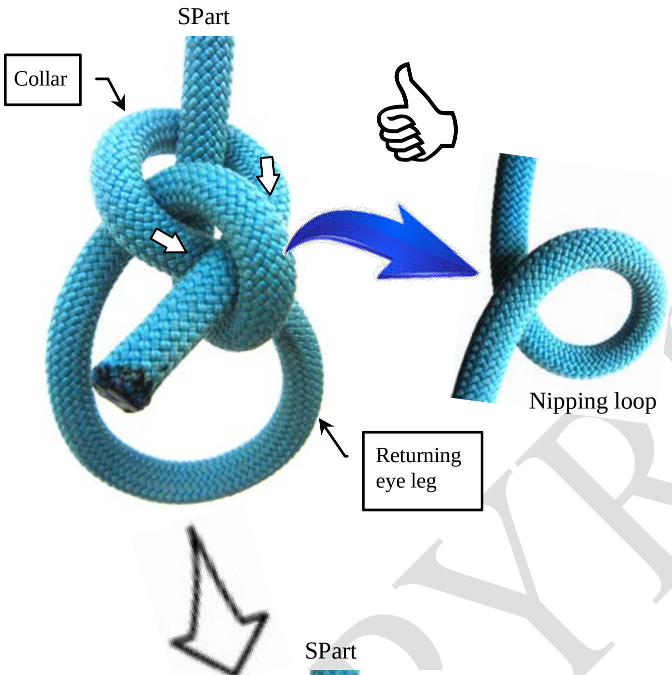
Anti Bowline examples

It appears that every Bowline has an anti-version of itself. Here are some examples to illustrate the concept. Note that the anti-Bowlines tend to be less stable than their principal forms due to the way load is distributed through the knot core.

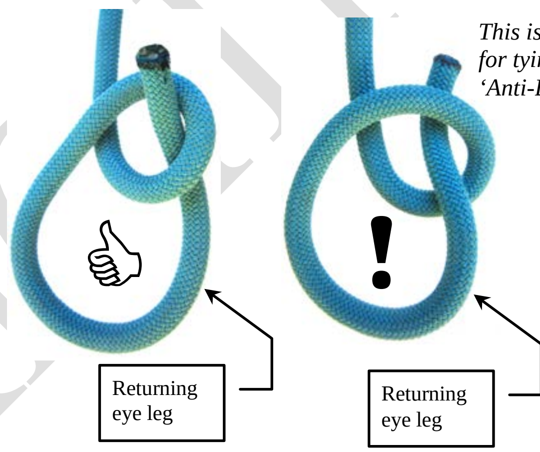
Collar structures based on a 'Myrtle'

Derek Smith advised that:
*Dave Root spotted this basic knot in the wild quite some time ago now, holding up a **Myrtle tree**, and after some discussion it was given the name of 'Myrtle Loop knot'.*

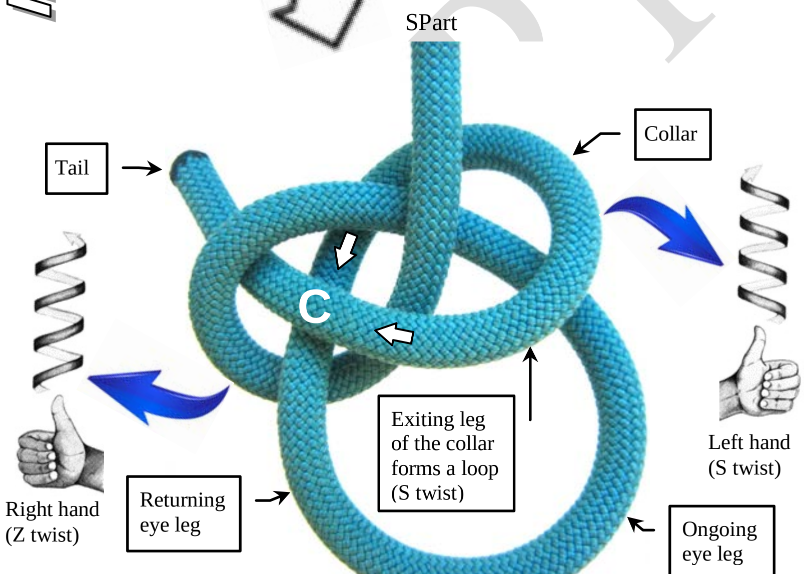
A defining characteristic of a Myrtle is that each leg of the collar feeds into the nipping loop from *opposite sides* – forming a *loop*. The collar makes a U turn around the crossing point of the nipping loop. The bight structure does not have the 'normal' appearance of a Simple #1010 Bowline.



Ensure that the returning eye leg enters the nipping loop from the *opposite side* relative to the ongoing eye leg.

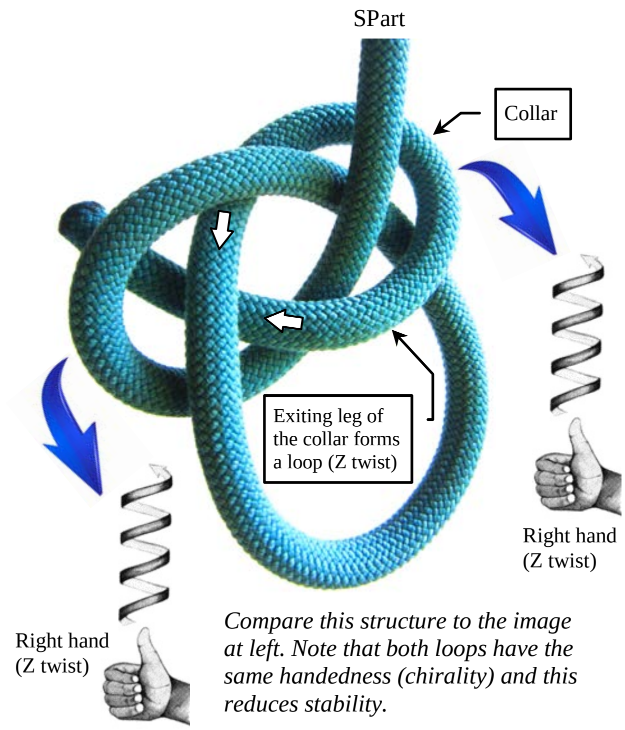


This is the basis for tying an 'Anti-Bowline'



This Myrtle structure is **stable**.

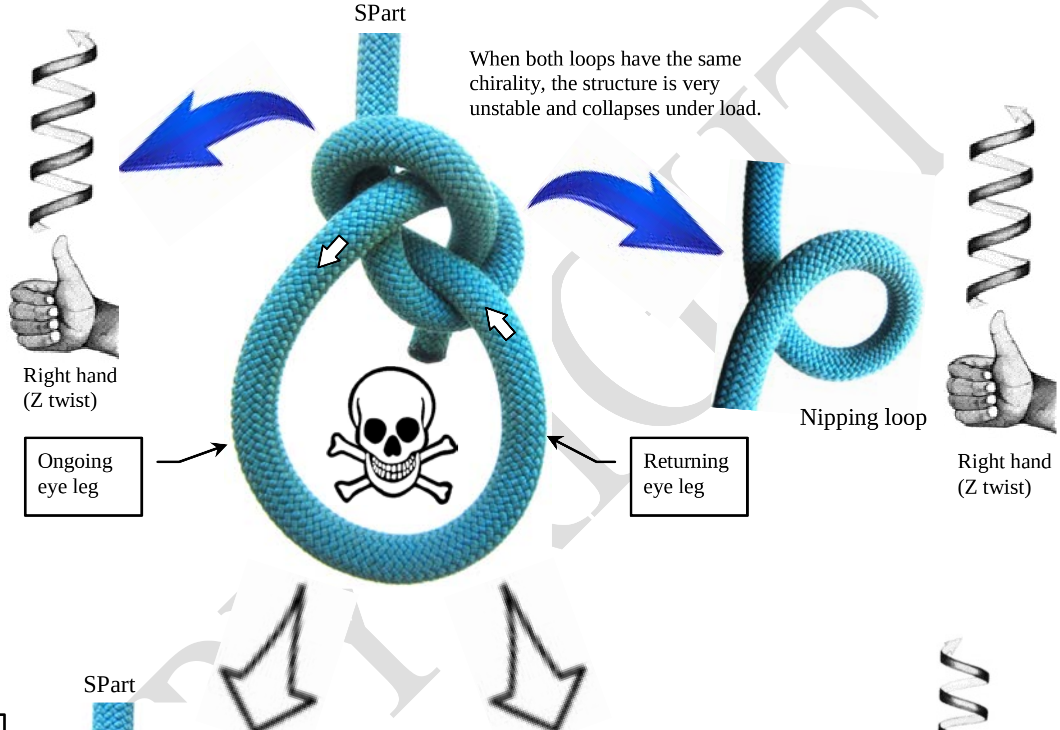
*<u>Key Concept:</u> A stable Myrtle is achieved when the returning eye leg enters the nipping loop from the **opposite side** relative to the ongoing eye leg. Stability is further enhanced by ensuring that the loop created by the exiting leg of the collar is of **opposite chirality** to the nipping loop.*



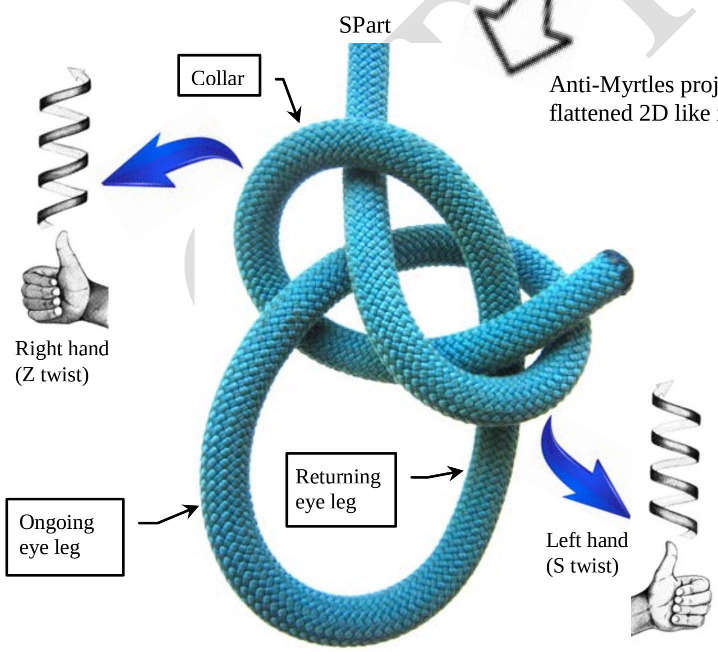
Compare this structure to the image at left. Note that both loops have the same handedness (chirality) and this reduces stability.

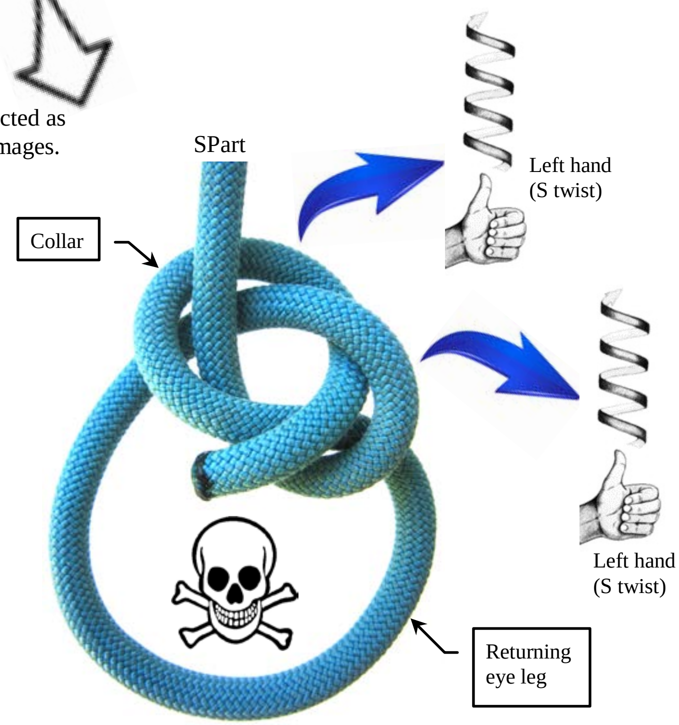
Anti-Myrtle

An 'Anti-Myrtle' will be created if the returning eye leg enters the nipping loop from the *same side* as the ongoing eye leg. That is, the *direction* from which the returning eye leg enters the nipping loop is what characterizes the structure as being 'Anti'. This form is less stable compared to the returning eye leg entering from the opposite side. This tendency toward instability can be countered by ensuring that both loops have opposite handedness (chirality).



Anti-Myrtles projected as flattened 2D like images.



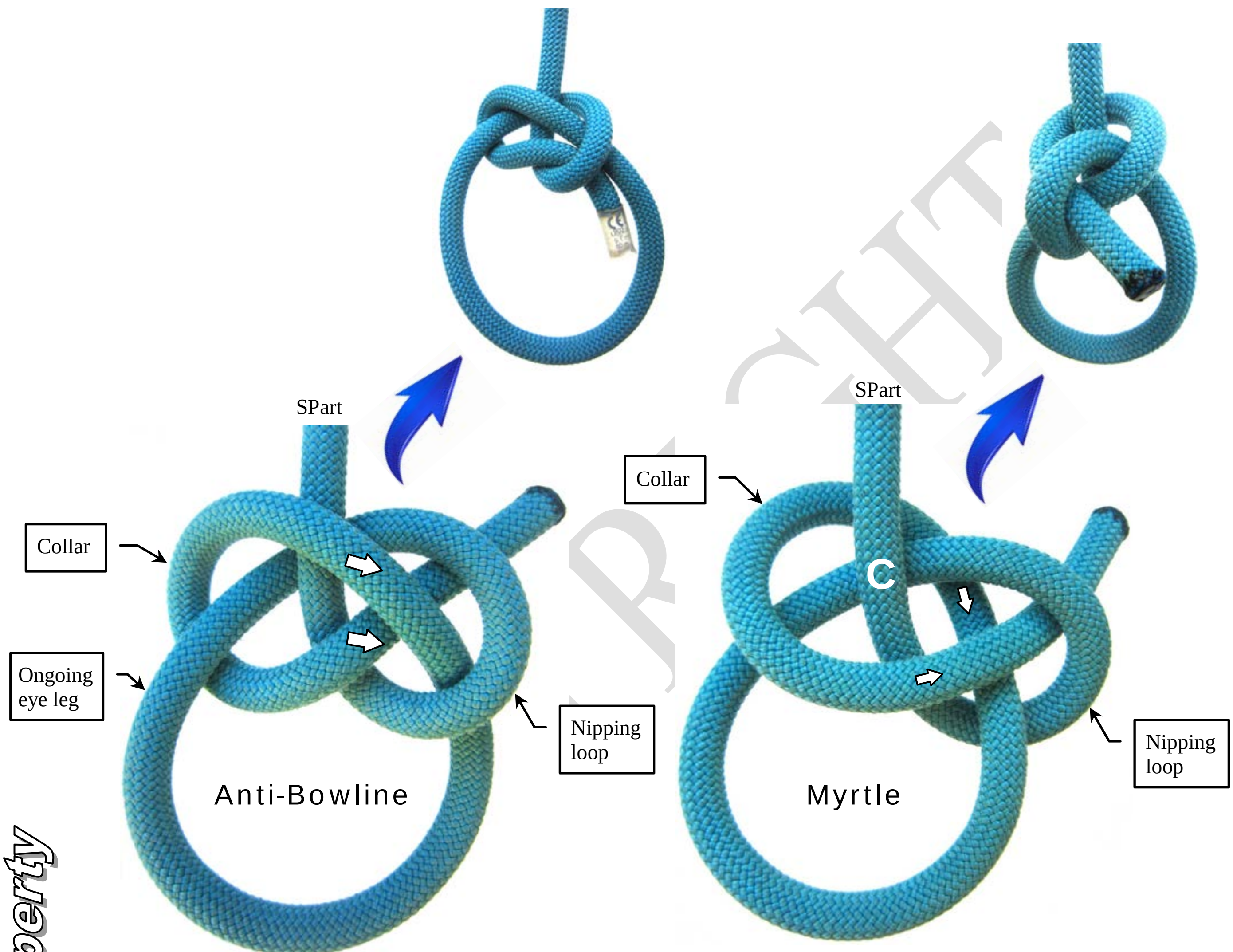


In this Anti-Myrtle, the loops are of opposite chirality. This has the effect of countering instability caused by the returning eye leg entering the nipping loop from the *same side* as the ongoing eye leg. However, this author posits that the Anti-Myrtle is inferior to the Myrtle.

This Anti-Myrtle is **very unstable** because both loops have the same 'handedness'. The nipping loop will open and collapse under load.

Myrtle compared to anti Bowline

A comparison of the Myrtle and the anti-Bowline projected in a flat 2D perspective.



Defining characteristics:
1. The collar forms around the ongoing eye leg
3. Both legs of the collar lie in parallel (once the knot is dressed)
3. Both legs of the collar feed into the nipping loop from the *same side*.

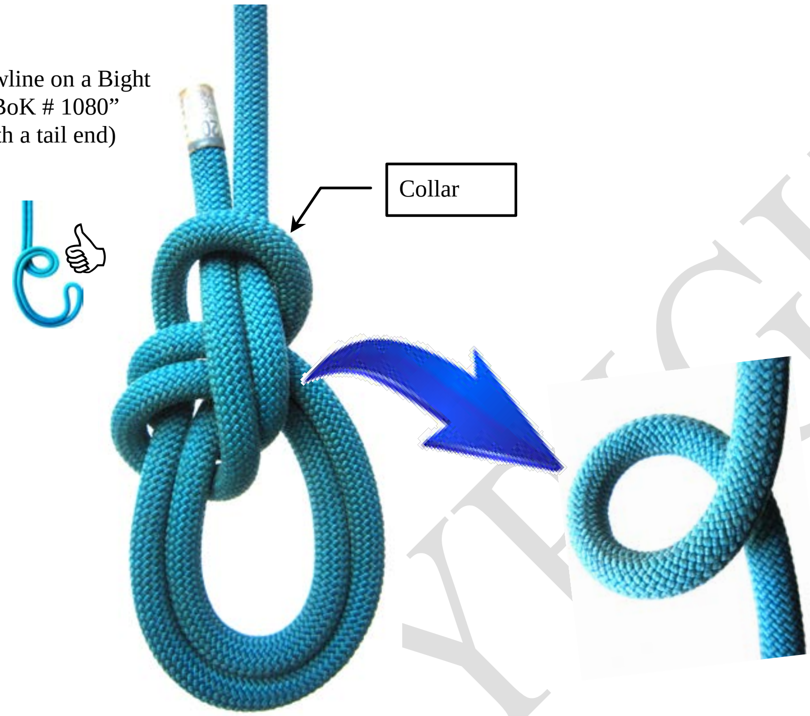
Defining characteristics:
1. The collar forms around the crossing point intersection of the nipping loop (marked 'C').
2. The exiting leg of the collar forms a loop - there is no defined bight structure.
3. The legs of the collar feed into the nipping loop from *opposite sides*.

The following pages showcase a variety of Bowline structures.

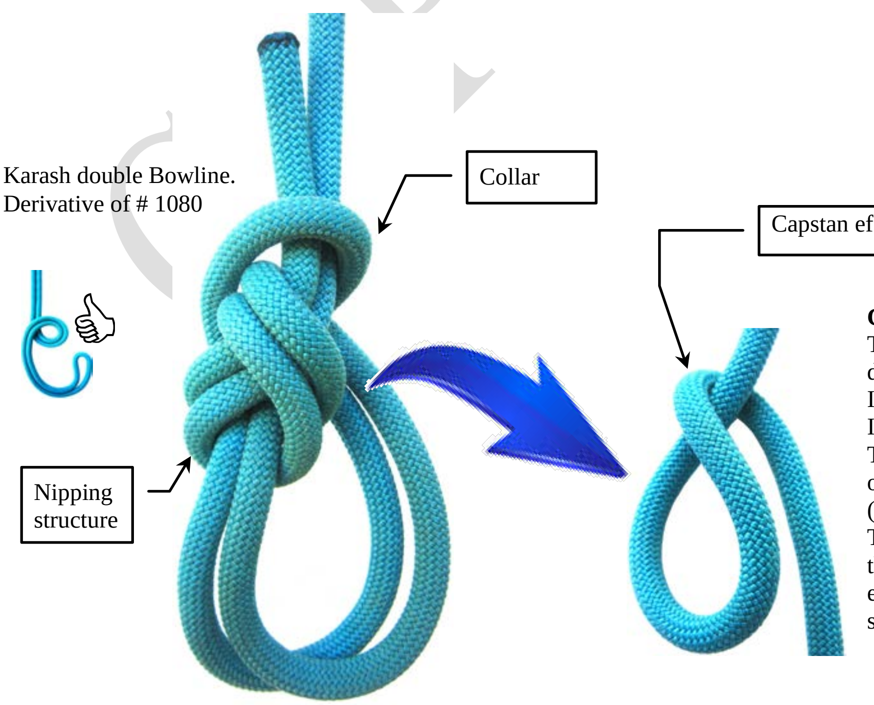
Karash double Bowline

A quick glance at this particular variant of #1080 may fool the casual reader into thinking there are 2 nipping loops. However, the Bowline on a Bight (#1080) only has 1 nipping loop (when tied as an end-of-line eye knot with a tail). When Mike Karash discovered his 'Karash double loop' – he didn't realize that it was in fact a Bowline derivative – and this explains why it is jam resistant. There is no nipping 'loop' – rather it is a nipping 'structure' because it does not take the form of a helical loop (it has the form of a 'Munter hitch' aka 'Crossing hitch').

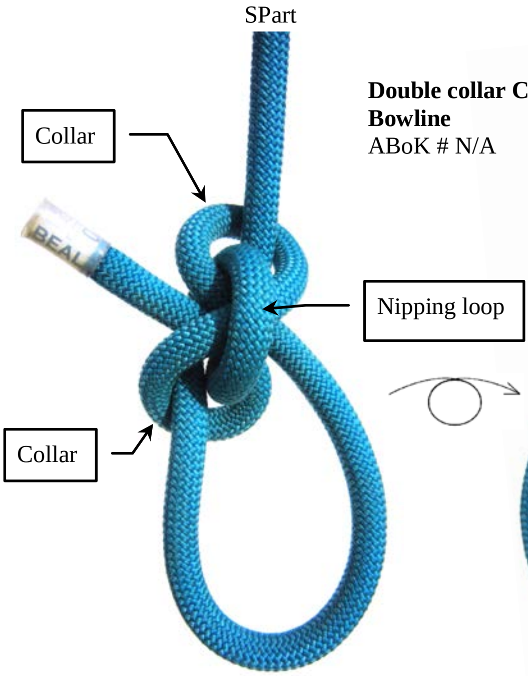
Bowline on a Bight
"ABoK # 1080"
(with a tail end)



Karash double Bowline.
Derivative of # 1080



Commentary:
The 'Karash double Bowline' (named after discoverer Mike Karash) is a **virtual Bowline**. It is derived from #1080 Bowline on-a-bight. It remains easy to untie after heavy loading. The nipping structure does not take the form of a helical loop – it is in fact a *Crossing hitch* (#206 / #1195 Munter hitch).
The nipping structure is TIB and equivalent to the unknot. Both legs of the collar are fully encircled and clamped by the nipping structure.



Double collar Clover Bowline
ABoK # N/A

Commentary:
The origin of the double collar Clover bowline can be traced to 'dfred' (IGKT forum) creation of a mid-line joining knot (April 2011). Dfred's structure employed a clove hitch and a nipping loop offset at 90 degrees.

Xarax took matters a step further and evolved the concept from a joining knot to an eye-knot around Sep 2011 basing his creation on a constrictor.

This structure contains a key component of the Bowline – the *nipping loop*. There are 2 collars; both in a 'myrtle' configuration. In fact, this structure is based around a 'Myrtle'. The double collar arrangement in effect creates a *clove hitch*. Variations can be tied with different chirality.

Double collar Clover Bowline
ABoK # N/A

Fasle Zeppelin eye knot
ABoK # N/A

Eye knot based on the ***false*** Zeppelin bend!

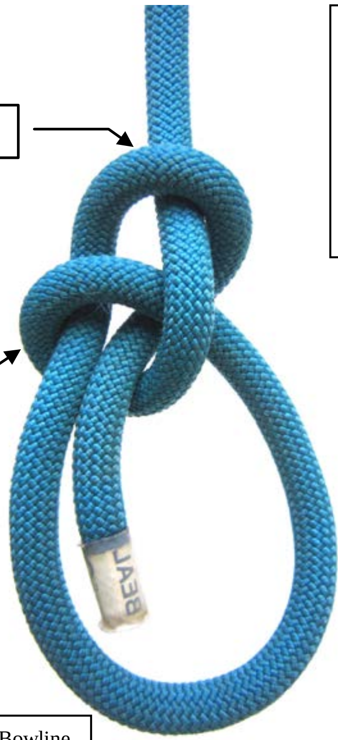
No nipping loop = No Bowline!

This structure is *not* a Bowline – because it has no *nipping loop*. It is in fact an eye-knot based on inter-locked overhand knots, and takes the form of a false Zeppelin bend.

Testing is required to verify if it jams. It is also *not* Post Eye Tiable (PET).

Collar

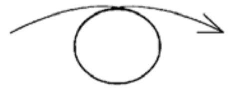
Nipping loop



Simple Bowline (Detail view)

The #1010 Simple Bowline
This Bowline is insecure and vulnerable to '*ring loading*'. It is the least secure form of all the Bowlines. However, it is perfectly adapted for use on sailing vessels (a purpose for which it was designed).

Do not use for life critical applications!



Simple Bowline (Conventional view)

Nipping loop

Note position of tail is *outside* of the *eye*

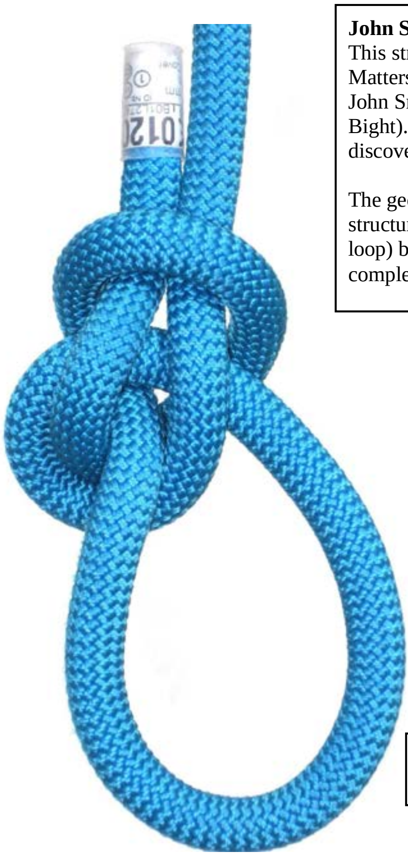
"ABoK #1034 ½" (Detail view)

#1034 ½ Bowline
This form of the Simple Bowline is resistant to ring loading but is still not suitable for mission critical applications. Ashley referred to this form as a '*Left Hand Bowline*.' Also referred to as a 'Cowboy Bowline'.

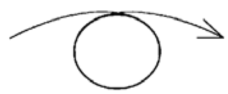
"ABoK #1034 ½ " (Conventional view)

John Smith Bowline
This structure was published in 'Knotting Matters' issue #19 (1987) at page 2 by John Smith. It is also 'TIB'(Tiable in the Bight). Dan Lehman appears to have discovered this variation independently.

The geometry of the core (nub) is structurally the same as #1017 (Anglers loop) but the loading profile is completely different.



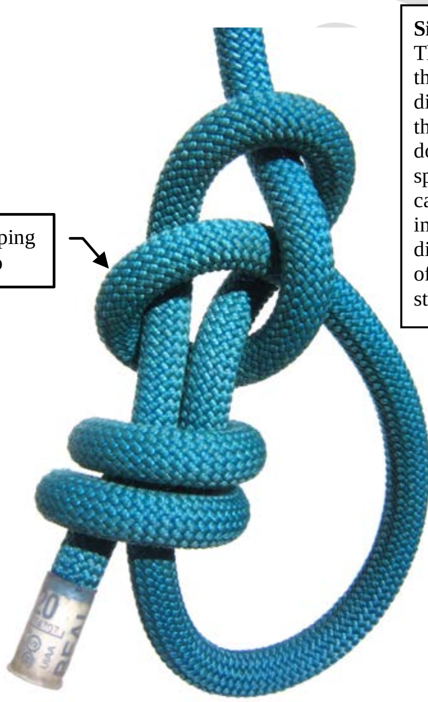
John Smith Bowline
Detail view



John Smith Bowline
Conventional view

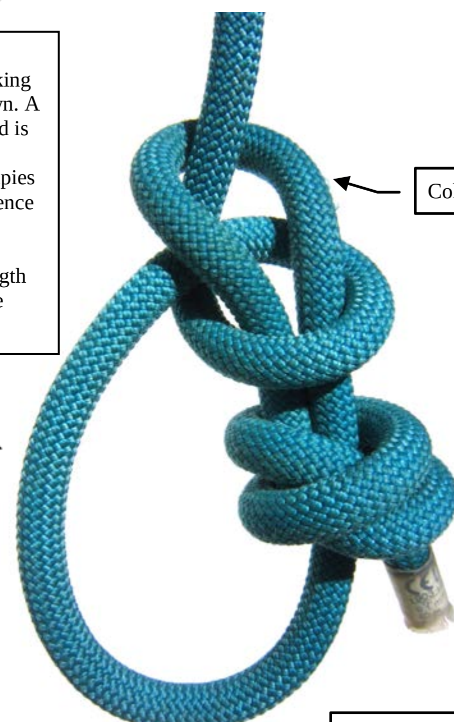
Simple locked Bowline
This simple method of locking the tail has long been known. A disadvantage of this method is the fact that the strangled double overhand knot occupies space within the eye and hence can cause unwanted interference. It can also be difficult to estimate the length of free tail needed to tie the strangle knot.

Nipping loop



Simple locked Bowline
(detail view)

Collar



Simple locked Bowline
(conventional view)

Strangled double overhand knot

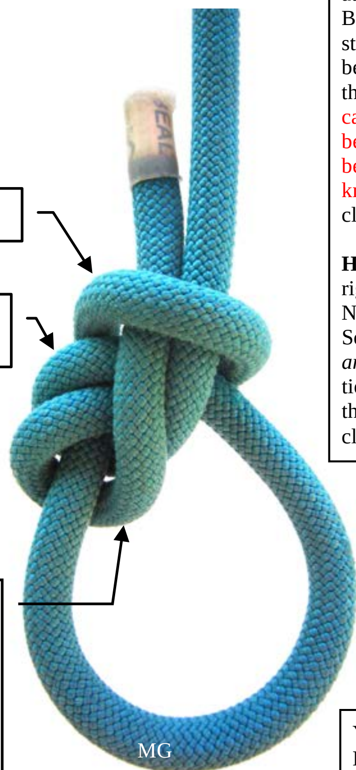
Yosemite Bowline
The so-called 'Yosemite Bowline' is an attempt to make the Simple (#1010) Bowline more secure. However, the structure is not as secure as is widely believed and may be compromised with the use of certain stiffer ropes. Also, care must be taken not to draw the tail up before setting the nipping loop or it may become displaced and compromise the knot. Nevertheless, it is widely used in climbing applications.

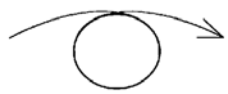
History: An IGKT member ('knot rigger') pointed out that Bruce Smith, in Nylon Highway no. 22 cites Tim Setnicka's 1980 book *Wilderness Search and Rescue* as a source for the "Yosemite tie-off". He asserts that Setnicka learned this tail securing finish in his "ranger classes" at Yosemite National Park.

Collar

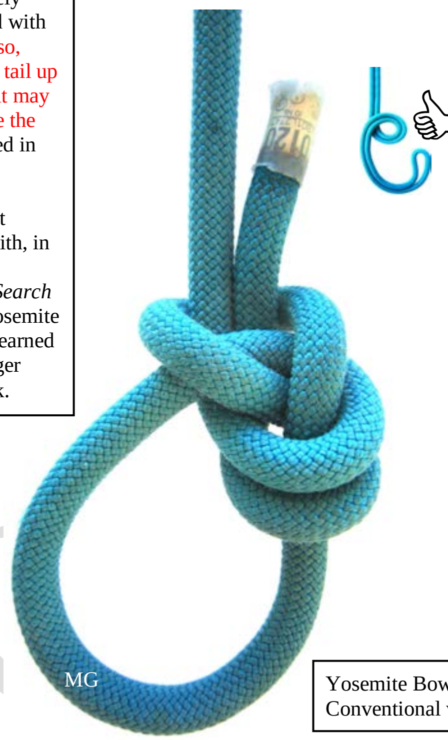
Nipping loop

Tail wraps around returning eye leg, then tucks through collar to finish.





Yosemite Bowline Detail view

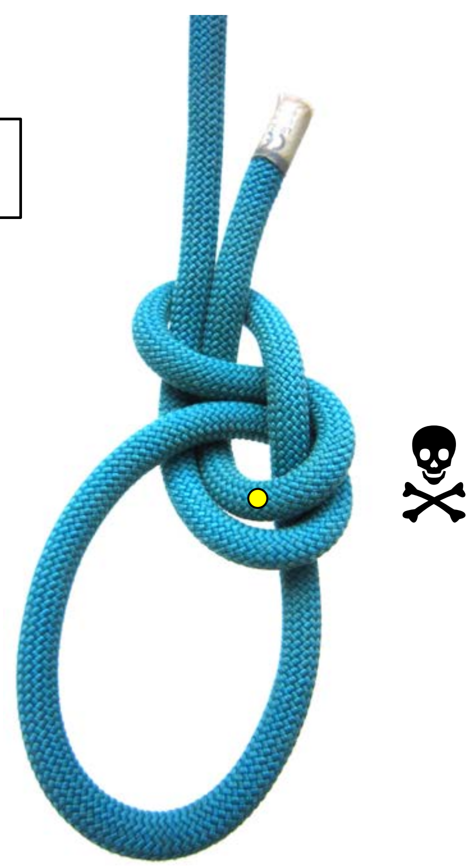


Yosemite Bowline Conventional view

SPart

Warning: Do not draw the tail up *before* properly tightening the nipping loop.

Nipping loop



The 'Yosemite' Bowline can easily be miss-tied. If the tail is drawn up before the SPart has been tightened (hence also tightening the nipping loop), the tail can be *displaced* to the extent that the entire Bowline structure is compromised.

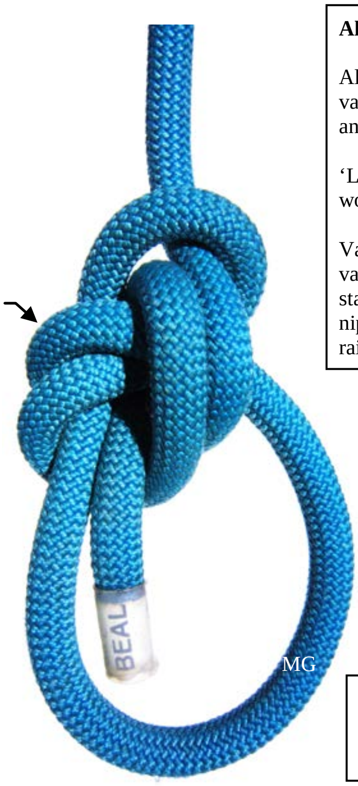
Alan Lee Yosemite Bowline

Alan Lee discovered this interesting variation of the Yosemite Bowline – and it is much improved.

'Lee's locked Yosemite Bowline' would appear to be a reasonable name.

Various trials of this Yosemite Bowline variant indicate it is both secure and stable. With 3 rope diameters inside the nipping loop, it should also have a raised MBS yield.

Nipping loop

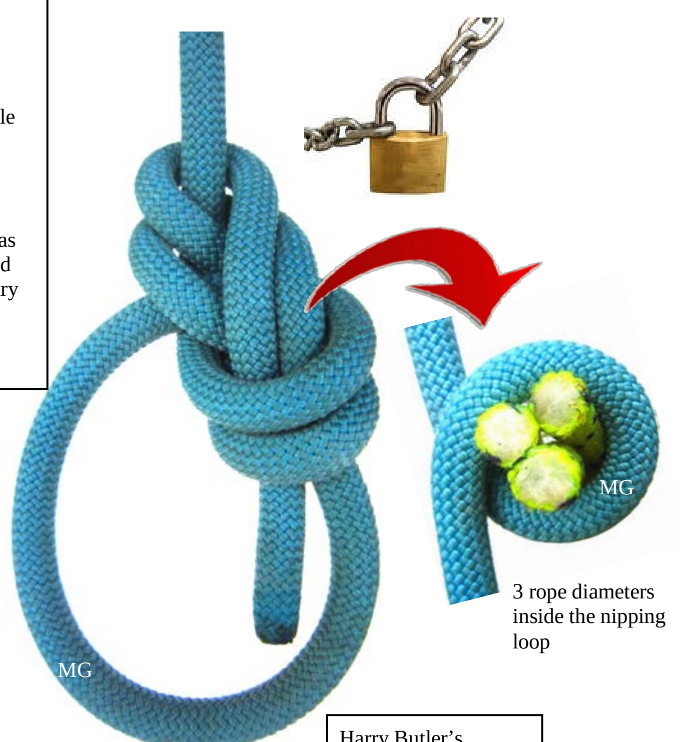


3 rope diameters inside the nipping loop

Alan Lee Yosemite Bowline (Detail view)

Alan Lee Yosemite Bowline (Conventional view)

Harry Butler's Yosemite Bowline
Discovered on or before 2015.
It's hard to believe that this variation went undiscovered for so long.
Harry Butler (Australia) discovered this Bowline while seeking a 'better' way to position the tail. He wanted the tail to exit inside the eye – so it wouldn't interfere while clipping rope to climbing protection.
It totally resolves security issues with the Yosemite Bowline and is also inherently secure.
<u>NOTE</u>: The so called 'Edwards Bowline' has been depicted with varying geometries – and there is some confusion as to which geometry is claimed to be correct. Unless definitive information is forthcoming, this knot will remain attributed to Harry Butler.



3 rope diameters inside the nipping loop

Harry Butler's Yosemite Bowline (Detail view)

Harry Butler's Yosemite Bowline (Conventional view)

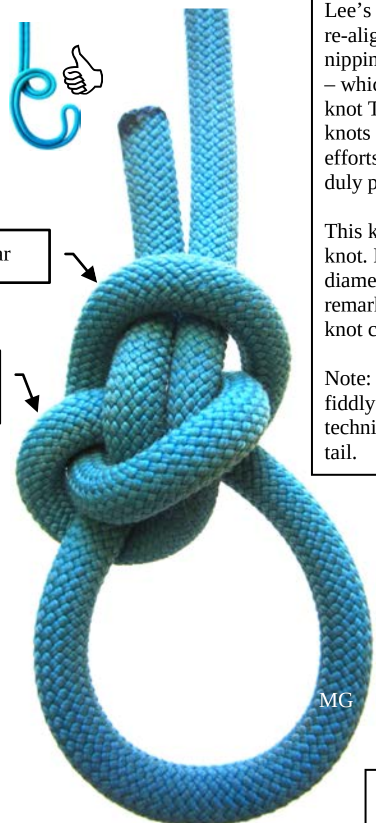
Lees link Bowline
Xarax had been on a mission to discover as many 'TIB' Bowlines as he could. Using Alan Lee's 'Lee Zep Bowline' as a starting base, he re-aligned the tail by feeding it through the nipping loop and exiting it through the collar – which was a known method of making a knot TIB. Xarax had also been searching for knots that had no sharp turns - the result of his efforts was 'Lees Link Bowline' – which he duly presented to the IGKT forum in 2013.

This knot is suitable as a lead climbing tie-in knot. It is *inherently secure* and, it has 3 rope diameters inside the nipping loop. It is also remarkable for having no sharp turns in the knot core.

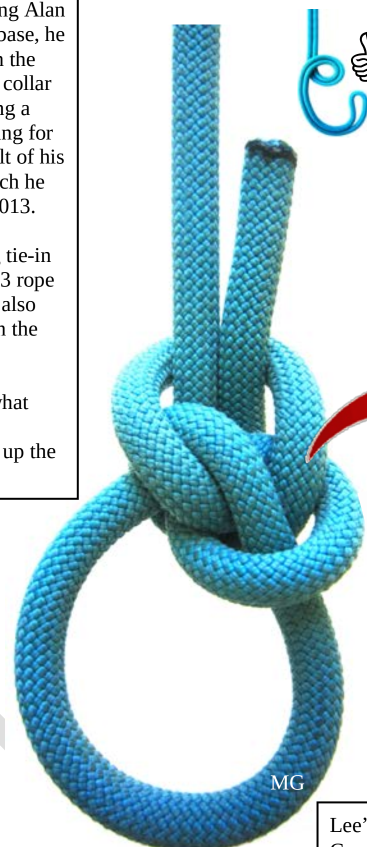
Note: Dressing this knot can be somewhat fiddly but, with practice you develop techniques to form the collar and draw up the tail.

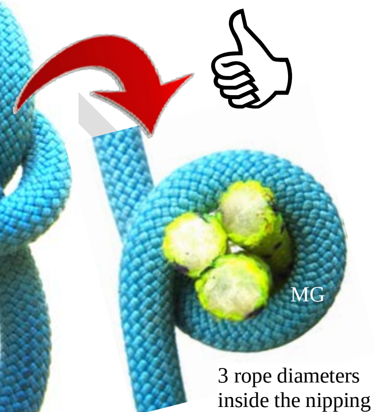
Collar

Nipping loop



Lee's Link Bowline
Detail view





3 rope diameters inside the nipping loop

Lee's Link Bowline
Conventional view

Scott's locked Bowline
A simple lock devised by Scott Safier (USA) from the IGKT forum website. A marvelous creation! There are in fact several variations of this knot.

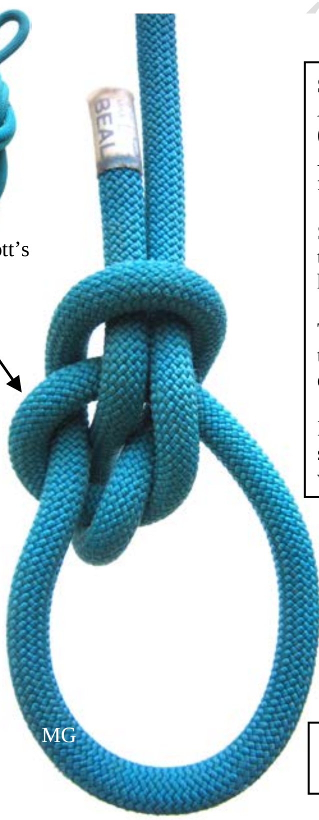
Scott has conducted personal field testing of this knot (climbing) and so has this author. It is *inherently secure*.

This is indeed quite a simple technique – and it also places 3 rope diameters inside the nipping turn.

If effectiveness is measured by simplicity, then perhaps this is a winner!

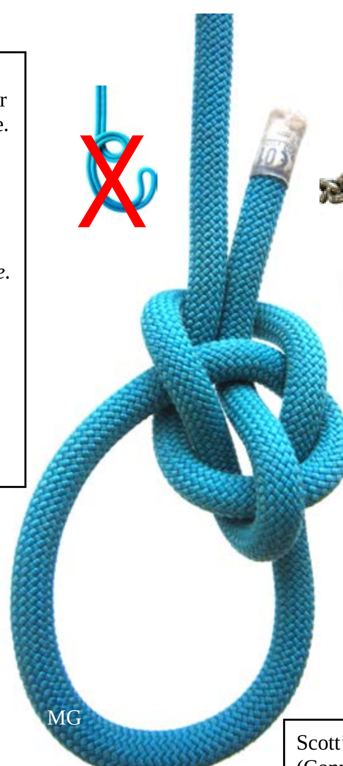
TIB version of Scott's locked Bowline.

Nipping loop



Scotts locked Bowline based on #1034 ½

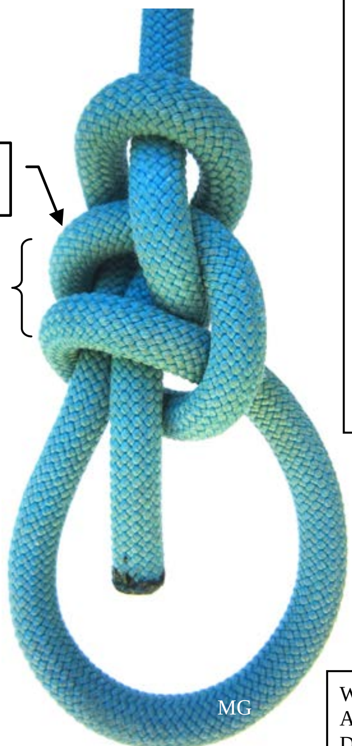
Scott's locked Bowline
(Detail view)



3 rope diameters inside the nipping loop

Scott's locked Bowline
(Conventional view)

SPart



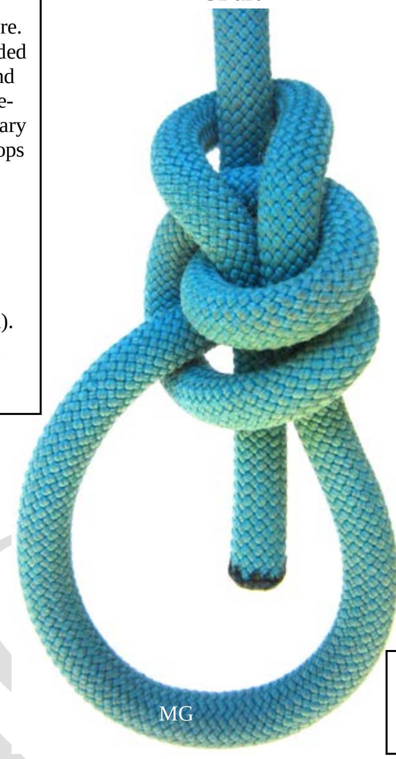
Nipping loops

Note the clove hitch structure

Water Bowline
This structure has 2 nipping loops (in the form of a clove hitch) which encircle and clamp the bight structure. These nipping loops could be regarded as 'the nipping loop of the SPart' and the 'nipping loop of the ongoing eye-leg' in a sort of primary and secondary effect. Under load, the 2 nipping loops tend to separate.

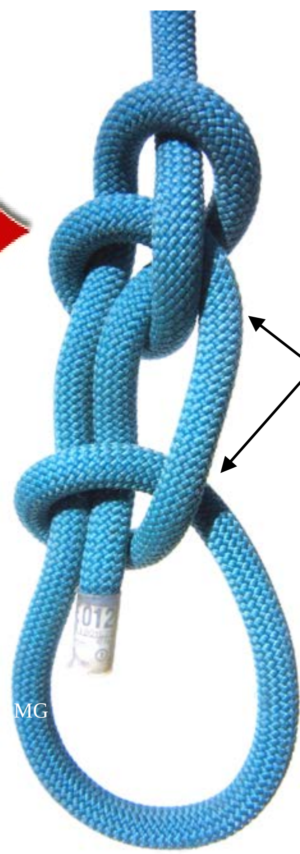
Note: Ashley did not specifically name this knot – he wrote; …*if a bowline is to be towed through the water, a second half-hitch may be added* (to lessen its tendency to jam). This has led to the knot being given the name *water bowline.*

SPart



Water Bowline
ABoK #1012
Detail view

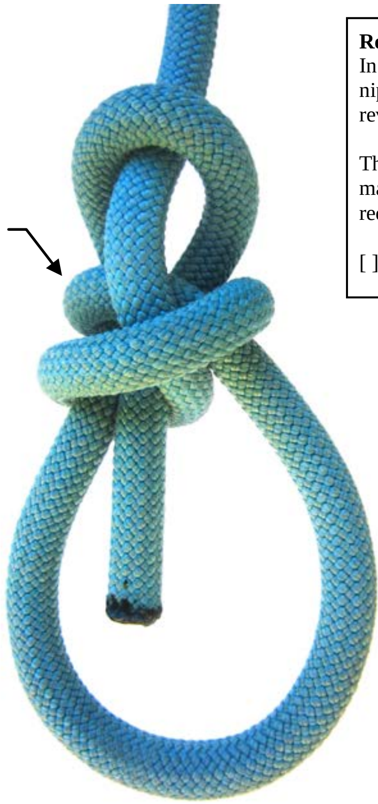
Water Bowline
ABoK #1012
Conventional view



Note the displaced *nipping loops*

This is how the 'Water' bowline is presented in Ashley Book of Knots (#1012)

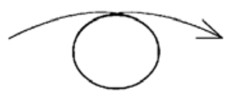
Nipping loops

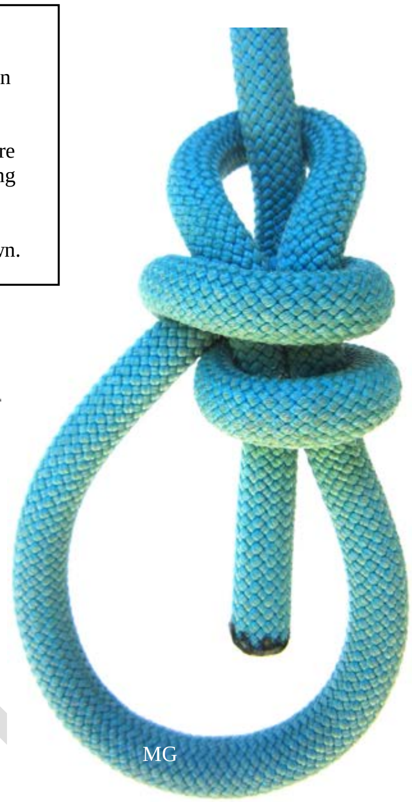


Reversed Water Bowline
In this variation, the clove hitch nipping structure has been tied in reverse.

This clove hitch nipping structure may be prone to jamming (testing required to confirm).

[ ] History/first use data unknown.





Reversed Water Bowline

[Detail view]

Reversed Water Bowline

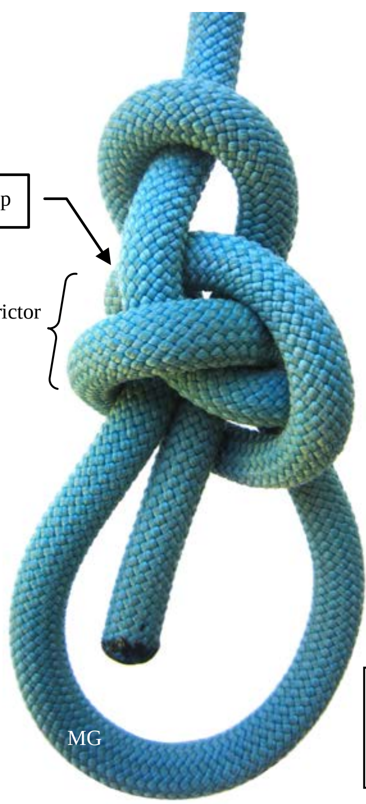
[Conventional view]

Constrictor Virtual Bowline
In this variation, a Constrictor hitch (ABoK #1249) is used as a *nipping structure*. The nipping structure is TIB.

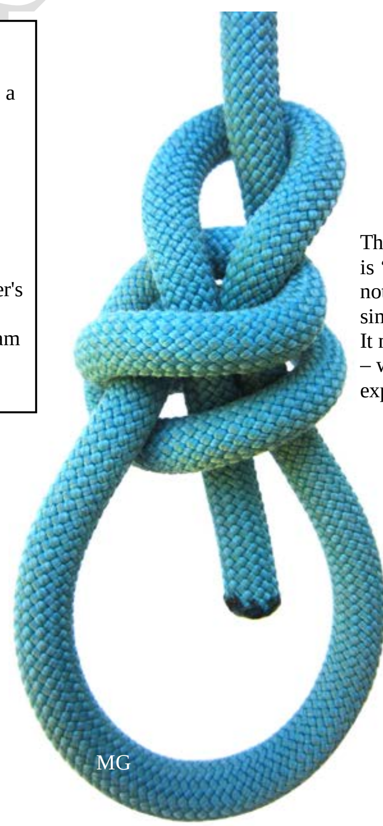
[ ] History: The first known description of the Constrictor hitch occurs in Tom Bowling's 1866 work, *The Book of Knots* where it was called the "Gunner's knot".
It is not known if this knot is jam resistant – testing needs to be carried out.

Nipping loop

Constrictor hitch



The Constrictor hitch is 'TIB' but it does not take the form of a simple helical loop.
It may cause jamming – which needs to be experimentally tested.



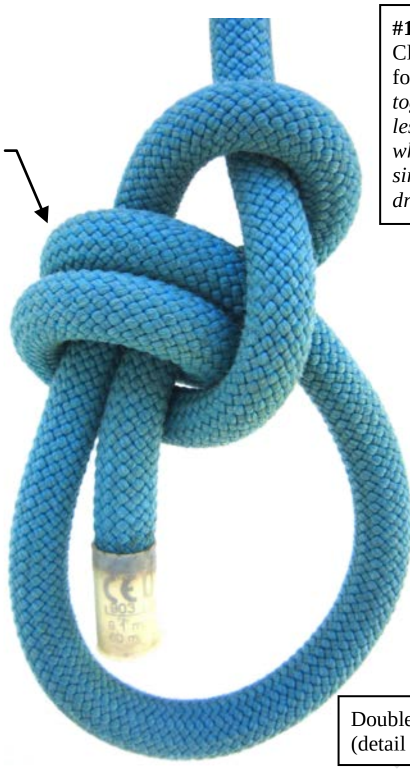
Constrictor virtual Bowline

[Detail view]

Constrictor virtual Bowline

[Conventional view]

Double nipping loops increase the overall surface area acting to grip and stabilize the bight. However, it is little improvement over the Simple Bowline.



Double Bowline (detail view)

#1013 Double Bowline
Clifford Ashley reported that this form "…*holds the bowline together in such a way as to lessen the danger of it capsizing, which is liable to occur when a single bowline is carelessly drawn up.*"

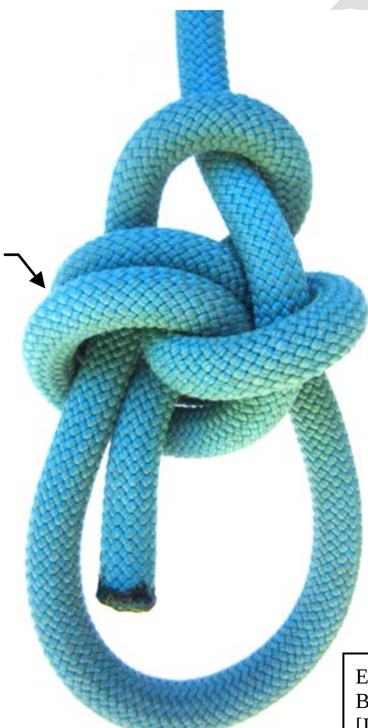
Double Bowline (conventional view)

End Bound Double Bowline
A clever improvement of "ABoK #1013" devised by Dan Lehman.

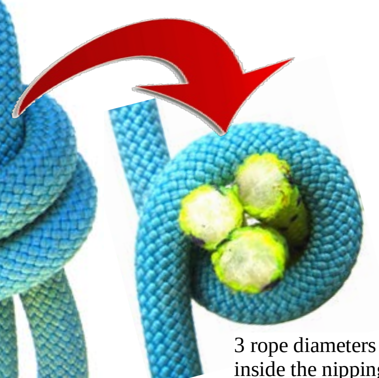
Discovery date: circa 2004

Double Nipping loops

Binding loop



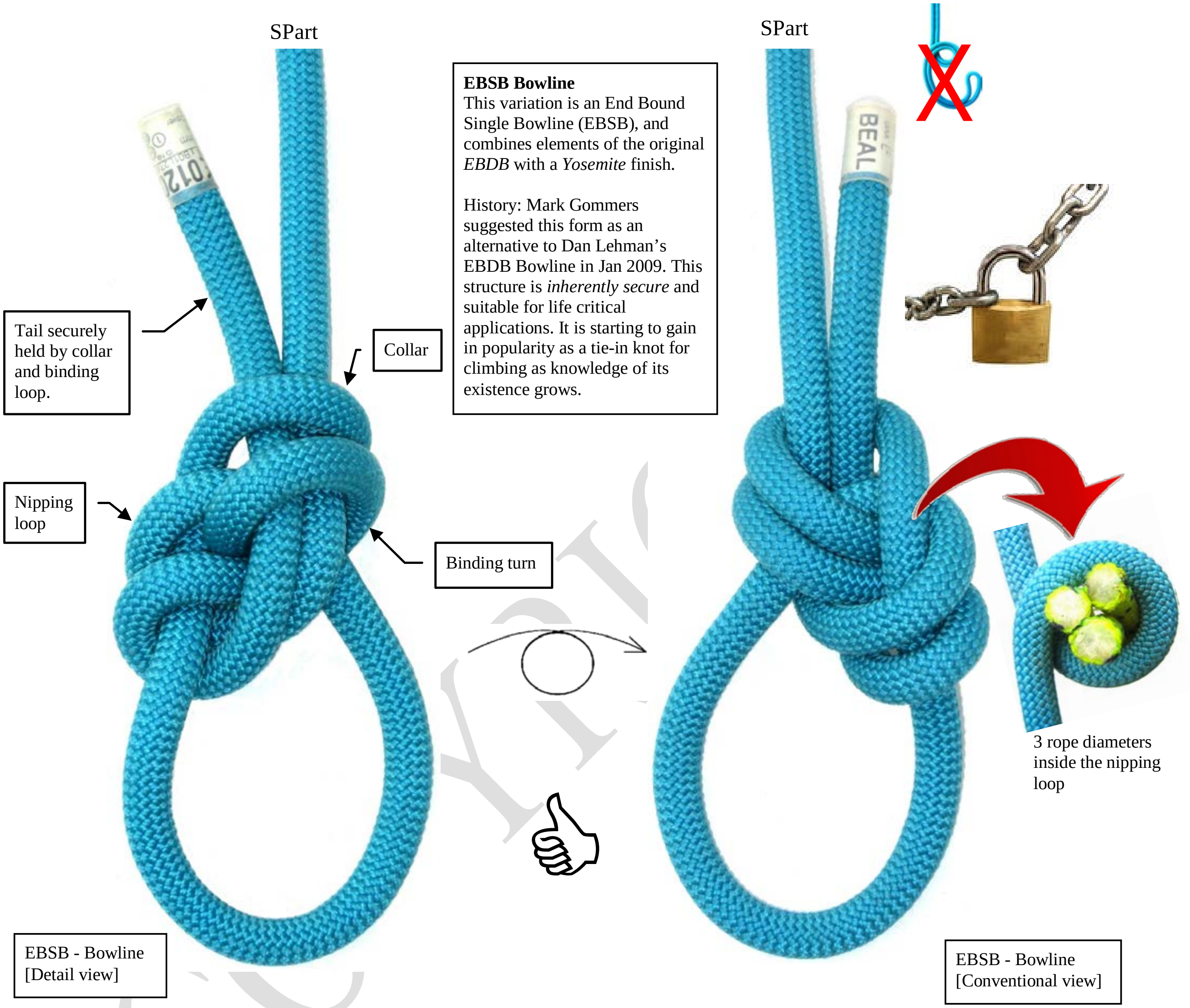
End Bound Double Bowline (EBDB). [Detail view]



3 rope diameters inside the nipping loop

End Bound Double Bowline (EBDB). [Conventional view]

EBSB Bowline



<u>Test data:</u> Tested by Mark Gommers

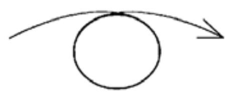
Cord batch coding: A050AS0100 Lot #R6-092507KT (purchased 02 Jan 2009).
Test method: Static load test using 5 Ton dynafor tension load cell. Slow pull using hand operated winch, peak load recorded at failure. Knots were cinched tight by hand strength – same degree of effort used to cinch all 3 knot specimens.

EBSB	Cord diameter	Cord material	Certification	Manufacturer	End fixing anchor pin diameters	Test date	Minimum Breaking Strength (Sterling)	Peak load at failure	% strength relative to MBS
Test 1	5.0mm	Nylon	EN 564	Sterling USA	10.0mm	14 Jan 2009	5.2 kN	3.84 kN	73%
Test 2	5.0mm	Nylon	EN 564	Sterling USA	10.0mm	14 Jan 2009	5.2 kN	4.02 kN	77%
Test 3	5.0mm	Nylon	EN 564	Sterling USA	10.0mm	14 Jan 2009	5.2 kN	3.96 kN	76%

Collar

Double Bight Bowline
The version of the Bowline is shown in Wright & Magowan's 1928 paper to the Alpine Club. Heinz Prohaska referred to it as a *'Double Bight Bowline'*. It also has 3 rope diameters which are encircled and clamped by the nipping loop. Of interest, Dan Lehman refers to this form as a *'Janus Bowline'*.

Collar



3 rope diameters within the nipping loop

Double Bight Bowline (Janus bowline) [Detail view]

Double Bight Bowline (Janus bowline) [Conventional view]

This variation of the 'Janus Bowline' was suggested by Dan Lehman. It also has 3 rope diameters which are encircled and gripped by the loop. This structure is vulnerable to ring loading.

Cowboy Janus Bowline variant [Detail view]

Cowboy Janus Bowline variant [Conventional view]

Girth hitch Bowline
The nipping structure is a girth hitch /larks head. Compare this structure to the water bowline.

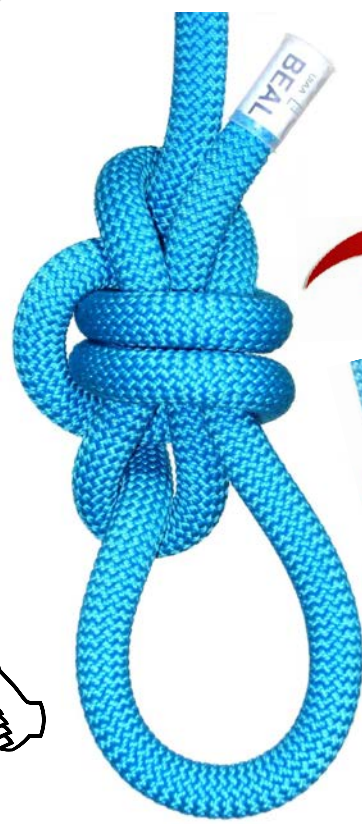
The girth hitch is also the base structure for tying *mirrored* Bowlines.

Girthed hitch Bowline [Detail view]

Girthed hitch Bowline [Conventional view]

Mirrored Bowline
Built from a girth hitch Bowline. There are 2 collars – similar in concept to the Janus Bowline. There are also 2 nipping loops.

The structure has 3 rope diameters inside each nipping loop. Although it is secure and stable – this author doubts that climbers and/or rescue teams would use it – simply because it is convoluted.



3 rope diameters within the nipping loop

Mirrored bowline [Detail view]

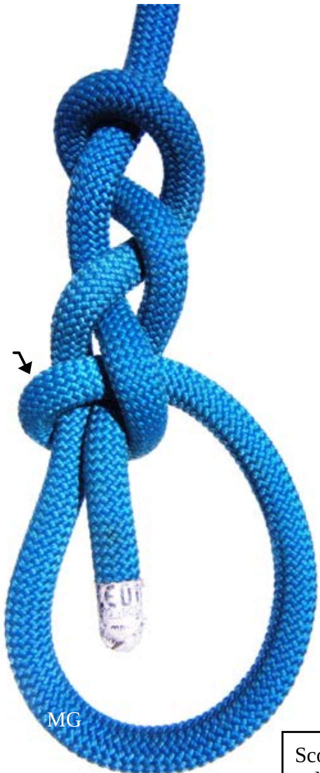
Mirrored bowline [Conventional view]

Scotts woven collar Bowline

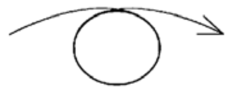
Scott Safier (USA) discovered this interesting lock for the bowline 02 Feb 2013. However, in Dr Harry Asher’s ‘The Alternative Knot Book’ a remarkably similar structure is shown at page 73 and is called the ‘Enhanced Bowline’.

The collar structure must be set and dressed for the lock to have maximum effect. This is an interesting structure because effort has been directed at securing the tail before it has been fed through the nipping loop. The weave appears to inhibit tail slippage pre-nipping loop. *Note: The weave can also be tied so that the tail ends up on the outside of the eye.*

Nipping turn



Scott’s woven collar Bowline Detail view

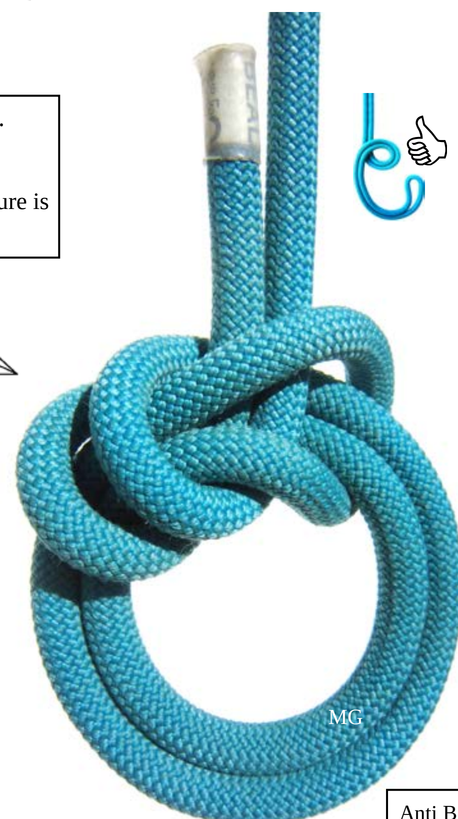


Collar

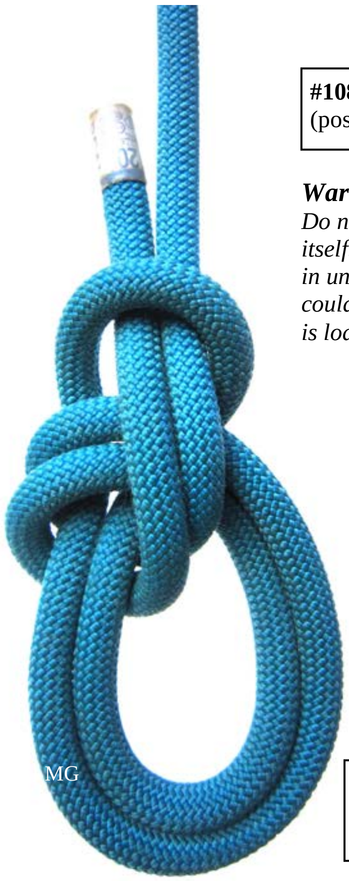
Scott’s woven collar Bowline Conventional view

Anti-Bowline on-a-bight.
ABoK N/A
‘IPatch’ (IGKT forum) discovered that this structure is TIB in Dec 2012.

Anti Bowline on-a-bight Detail view

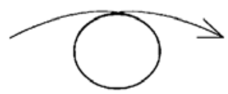


Anti Bowline on-a-bight Conventional view



#1080 Bowline on-a-bight
(positioned end-of-line with a tail)

Warning!
Do not load the secondary eye by itself. Both eyes must be loaded in unison. Catastrophic failure could occur if the secondary eye is loaded independently.



Secondary eye

Primary eye

ABoK #1080
Bowline on-a-bight
Detail view

ABoK #1080
Bowline on-a- bight
Conventional view

#1080 Bowline on-a-bight
(positioned mid-line with no tail)

As depicted in ABoK at illustration #1080 (both SParts are loaded.

No load

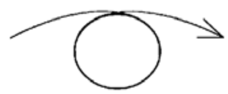
In this version, there is only one SPart.

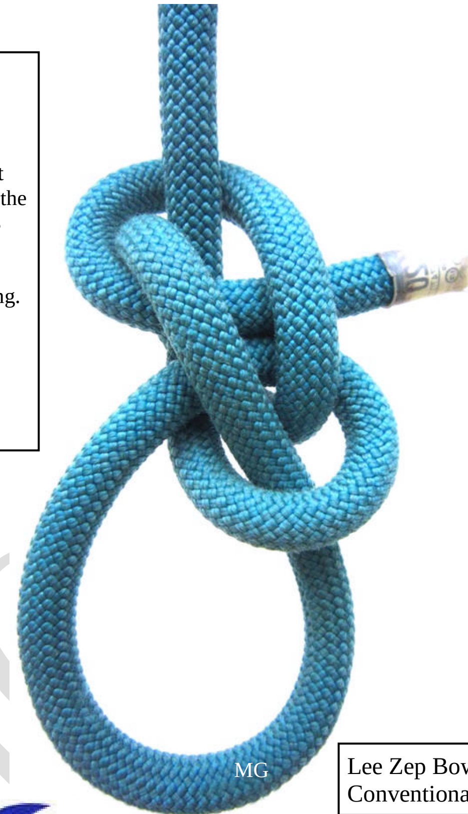
Lee Zep Bowline
An ingenious creation by knotting master Alan Lee (May 2012).

This structure is remarkable because it shares some structural similarity with the Zeppelin end-to-end joining knot. It is also based on a Bowline.

The structure is resistant to ring loading.

This knot is suitable as part of a ***dual clip-in*** system for indoor (artificial surfaces) top rope climbing and challenge ropes courses.





Lee Zep Bowline
Detail view

Lee Zep Bowline
Conventional view

Dual clip-in system

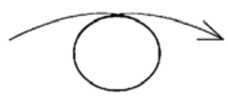
Zeppelin Bend
Compare this structure to Alan Lee's creation.

Zeppelin eye knot
Compare this structure to Alan Lee's creation.
Note the absence of a 'nipping loop' – which automatically disqualifies it from the title of Bowline

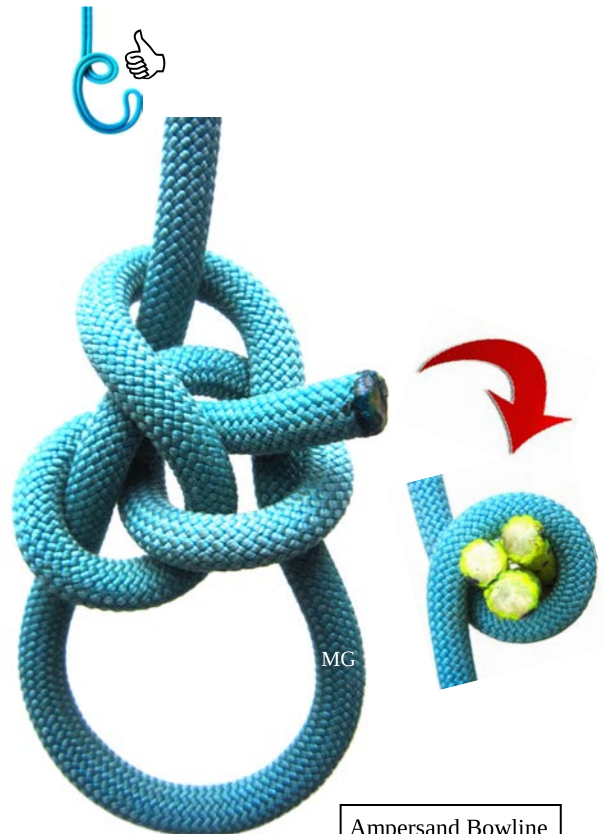
Ampersand Bowline
This structure was originally presented to the IGKT by **Alan Lee** on 01 April 2013. Constant Xarax independently tied this knot and presented it on 25 April 2014.

There are some interesting design elements that are worth noting:
1. It is TIB
2. There are 3 rope diameters within the nipping loop
3. There are no sharp bends in the tail securing maneuvers.
4. Under load, the tail is held captive between each leg of the collar due to a squeezing effect. This enhances security.

The structure seems to be secure and stable and also resistant to ring loading.



Ampersand Bowline
Detail view



Ampersand Bowline
Conventional view

Original text from Xarax's post on the IGKT forum 25 April 2014:
"The eye knot presented in this thread was known to me for some time now, but I had not noticed that it was TIB - probably because I was not searching for PET and *TIB eye knots when I had first tied it. You have to be lucky to tie a new knot, but* "Chance favors the prepared mind"*, and, at that time, it seems that my mind was not prepared yet for this...*
It is a very simple two-collar secure bowline, but it is somehow tricky, because the Tail End is not going through the nipping loop, as it happens in most similar eye knots - and that is what could had been, I think, the main reason it has not been tied already - if it has not been tied already, of course."

Note that Xarax had also submitted a *double nipping loop* version of the Ampersand Bowline on the same day.

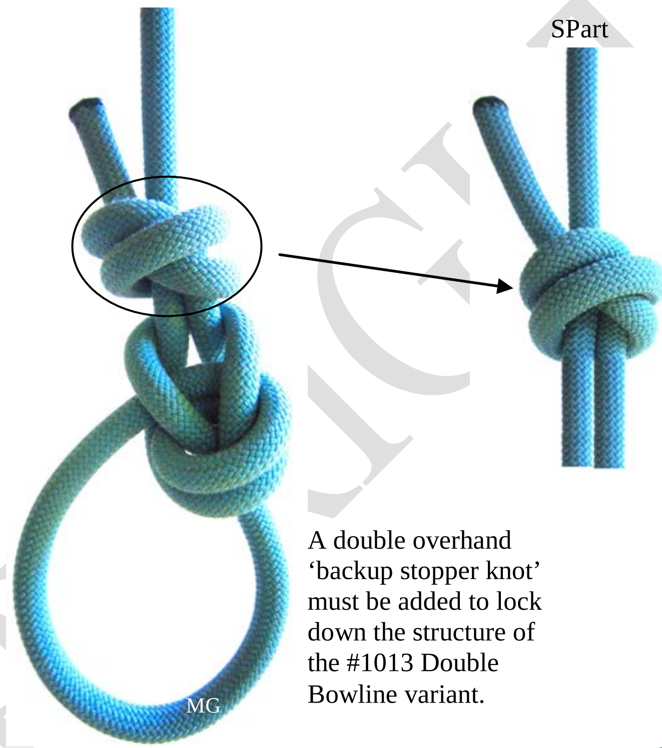
Another creation from Xarax.
Compare the position of the tail relative to the Ampersand Bowline.

INHERENTLY SECURE a definition

Some knots do not require any form of 'backup stopper knot' to achieve security. These types of knots are *inherently secure* – and are suitable for life critical applications. Inherently secure knots achieve sufficient internal friction and maintain core compression due to their geometry – such that failure mode by tail slippage does not occur. Cyclic loading and slack shaking does not disturb the security of these knots. By definition, if a knot requires a 'backup stopper knot' – it is not inherently secure.

***NOTE**: Due diligence is required. The knot must be firmly set and dressed by sequentially pulling on all rope segments. Sufficient tail must be left protruding from the knot core (minimum of 100mm with inherently secure knots). Knots may not be secure in UHMWPE material (eg 'dyneema').*

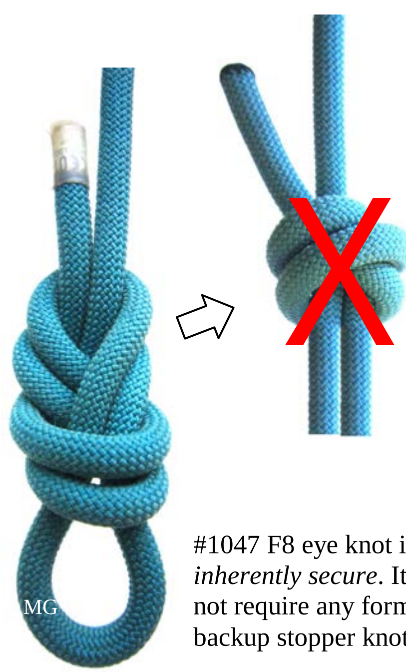
#1013 Double Bowline (with tail tuck through collar) is not secure.



A double overhand 'backup stopper knot' must be added to lock down the structure of the #1013 Double Bowline variant.

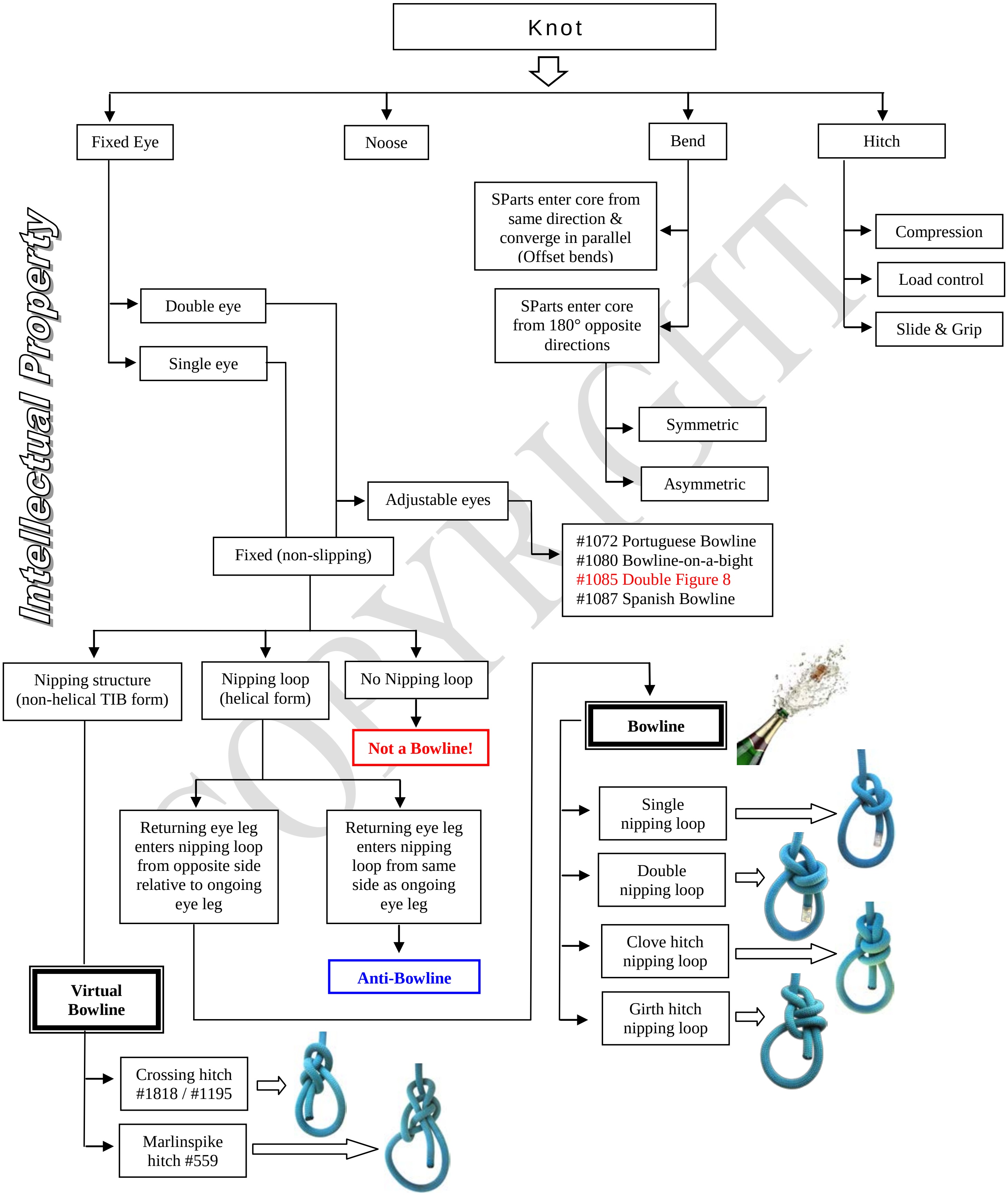
Backup stopper knot
This structure is a double overhand knot *strangled* around the standing part (SPart).

EBSB Bowline is *inherently secure*. It does not require any form of backup stopper knot.



#1047 F8 eye knot is *inherently secure*. It does not require any form of backup stopper knot.

Family Tree of Knots



CONCLUSION

All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident.

– attributed to Arthur Schopenhauer (1788 – 1860)

Historic photos of Sir Edmund Hillary and early mountaineers indicate that they used the Simple Bowline (#1010) – and also the Portuguese Bowline (#1072). However, it should be pointed out that ropes in the 1950's were made from hawser lay *vegetable fibre* and so were more frictive. Furthermore, climbers of that era were extremely cautious and did everything possible to avoid falling – because they knew that their rope likely would not sustain the force of a fall! With the introduction of modern synthetic kermantel ropes – the rope was no longer rough and frictive – it was now smooth and slick (slippery). Traditional tie-in methods using the Simple #1010 Bowline were no longer secure. This led to the widespread adoption of #1047 Figure 8 eye knot.

Modern climbers desire super lightweight and strong ropes. Rope manufacturers have responded by developing progressively thinner ropes. At the time of this writing, single EN892 dynamic ropes have reached 8.5mm diameter – which is almost a 25% reduction from the once standard 11.0mm ropes of the 1980's. However, a side-effect is that repeated falls leads to compression of the knot core with little relaxation of rope fibres. The nipping loop in all Bowlines acts to inhibit jamming – maintaining some resilience of the core – and this propensity to resist jamming is one of the cornerstones of knot efficiency (in conjunction with the amount of rope required to form the knot structure). With the reduction of rope diameters comes the corresponding resurgence of the Bowline (note that vertical rescue technicians also desire jam resistant knots and systems).

The journey to find a definition of a Bowline has led to several new and interesting discoveries. My research has allowed me to posit that Bowlines can be classified and described by the structure of their *nipping loop* – a key element common to all Bowlines.

Single *nipping loop* – a key component of the Simple (#1010) Bowline and its derivatives.

Double *nipping loop* – a key component of the Double Bowline (#1013) and its derivatives.

Within the general climbing community, advocates of #1047 Figure 8 eye knot often cite lack of familiarity and structural complexity as key elements in their argument against widespread uptake of inherently secure Bowlines. The familiarity argument is further expanded in terms of not being able to have a climbing partner check and verify the knot. Rope solo climbers are conveniently omitted from this tired argument (who checks a solo climber?) as are professional Guides working privately with a client. A professional Guide can't ask a total novice 'client' to check his/her tie-in knot. That would be a meaningless gesture! Bowlines are often cited as being a smoking gun in accidents where knot tying errors were made and that if #1047 (F8) were used instead, the accident would never have happened. At first instance, these arguments seem valid and are readily accepted by those who resist change or have a personal agenda.

It is typical to find comments on internet forums such as; *"The climber who fell or had an incident was using [the] Bowline"*. Note the use of the word 'the'. It implies that there is only one type of 'Bowline' – and 'it' is bad by default. To a layperson, it creates an impression that all 'Bowlines' must be unsafe – and the *word-of-mouth* rumor mill propagates. Very few people would stop and ask; - *"Hold on, exactly <u>which type</u> of Bowline are you referring to?"*

The concept of *inherently secure* is poorly understood. There are in fact several types of 'Bowlines' which are inherently secure – and don't require any form of backup stopper knot. This special class of knots is suitable for use in life critical applications – and indeed there are several types of 'Bowlines' which are deserving of this title.

To highlight this apparent paradox in implicating 'Bowlines' as the *usual suspect*, Robert Chisnall reported an accident involving a female climber on 17 September 2015 at Lac Larouche, Quebec Canada.
Link: http://publications.americanalpineclub.org/articles/13201213850/Fall-on-Rock-Incomplete-Tie-In-Knot

In this accident, the climber failed to properly tie a #1047 (Figure 8 eye knot) into her harness. It is very interesting that accidents involving F8 knots do not receive the same sensationalist press as 'Bowlines'. This of course leaves the impression that some commentators have their own agenda re Bowlines in general.

At the 'Mountain Project' internet forum, there is an interesting and somewhat heated discussion about the 'Bowline'. Reading through all of the posts was a painful yet enlightening experience… since it reveals the state-of-mind of some climbers and general prevailing social attitudes (and knowledge). The forum discussion refers to an incident where a harness tie-in knot came undone, leaving a female climber (Joanne Tuohy) high on a route with no rope.

Link (Original Post dated 04 Sep 2016):
https://www.mountainproject.com/forum/topic/112122298/incident-climbers-bowline-came-untied-while-climbing-at-rifle
Link to original source article authored by Alison Oslus (Rock and Ice Magazine) dated 11 May 2015: http://rockandice.com/climbing-news/tnb-when-your-rope-falls-off-and-5-ways-to-prevent-the-nightmare/

The alleged knot was a 'Double Bowline' (note that this description is rather *meaningless* since the exact structure of the knot Joanne Tuohy used is not revealed and detail about how it was secured or checked is left to the readers imagination). The author then proceeds to describe other incidents involving 'Bowlines' – presumably in an attempt to cast further doubt about using a 'Bowline' as a harness tie-in knot (again – no details are given about the precise structure of the knots used or any photo reconstructions to aid in post analysis). This type of reporting and commentary about 'Bowlines' is common – and contributes to widespread misinformation in the climbing community.

What can we glean from this? Do magazine editors / content writers sensationalize facts to draw in readers to boost hits to a website? Are magazine editors in a special position to influence others with content that reflects their own views/understanding of a perceived problem? Perhaps they feel duty-bound to point out *perceived* risks and change attitudes? Scientific rigor and detailed peer reviewed analysis seem to take a back-seat in the composition of content about 'Bowlines'.

Negative press about 'Bowlines' rarely cite exactly which *type* of 'Bowline' – simply citing the word 'Bowline' (or sometimes 'Double Bowline' in a vague attempt to make it sound like a more secure form of 'Bowline' that failed). Clear and unambiguous photos of implicated 'Bowlines' showing structural detail and dressing state is rarely supplied. This immediately reveals flawed knowledge and understanding since there are in fact many different types of 'Bowlines', some of which are inherently secure. A further complication is that readers will often assume that the authors of content are 'experts' – when in fact, they are not (what is an 'expert'?).

The layperson will often simply parrot what was taught or what was overheard at the crag or at the gym – with an often confusing array of common names assigned and no clear diagrams or photos to reference against. And many knot book authors are also guilty of parroting and reprinting concepts which may not have been verified as fact.

Concepts such as knot *familiarity* and *complexity* are entirely dependent on the training and experience of the individual. Training and practice is the key to developing new skills. What is 'complex' to one – may be simple to another. Furthermore, a person can make a mistake or have a lapse in concentration with *any* knot – it is just coincidence that a 'Bowline' might be involved (and since 'Bowlines' might be commonly used by those individuals who sport climb more often/frequently – it is automatically implicated by default).

Knot MBS yield (ie break) tests are also often cited as strong evidence to avoid 'Bowlines' since many authors report #1047 F8 eye knot as producing higher yields. Strength is often cited as an important factor – and in fact, many commentators appear to be single-mindedly obsessed with knot 'strength' – to the extent that, other more important factors such as *security* and *stability* are largely ignored or overlooked.

The reality is that harness tie-in knots simply don't fail simply because of a fall – there is no fall that can generate sufficient force to reach the MBS yield point of a tie-in knot. Even highlines / tyroleans which are significantly tensioned do not reach the MBS yield point of knots.

Resistance to jamming is of far greater importance in significantly loaded rope rigging systems, and indeed, this is one of the key criteria in measuring knot 'efficiency'. The amount of rope consumed in tying a knot is also a measure of efficiency and some recently discovered Bowlines employ *simple* yet *effective* tail maneuvers to lock-down the structure.

The Bowlines presented in this paper represents the creative work of many individuals and I thank them all for allowing me to publish their creations. Some immediately stand-out as worthy of use in not only climbing but, in vertical rescue and industrial rope access applications.

You are just as likely to miss-tie either of these knots. Some commentators have their own agenda against 'Bowlines' in general. The issue isn't a 'Bowline' – it is human error caused by factors such as; poor training, distractions, failure to check, and lack of due diligence. We don't ban cars or planes when people crash them!

Alan Lee continues his marvelous creative work – and has his own channel here…
Link: https://www.youtube.com/channel/UCkTiVp6Ks08FER-rFQdRyQQ
There seems to be no limit to his creative genius.

At the time of this writing, Alan had acquired a new knot test rig and it is hoped that some results of his testing can be published in a future update of this paper.

Richard Delaney from Rope Test Lab (Australia) is also doing great work testing knots and busting myths and urban legends. Richard has also started investigating the behavior of knots under cyclic loading and slack shaking – which is a refreshing change from the *pull-it-till-it-breaks* mindset.

There are other enthusiast knot tyers who routinely contribute information via the IGKT forum and 'Knotting Matters' (a publication from the IGKT) – and several have provided valuable assistance to me over the years.

All papers must have an ending… and this one has been many years in the making. Of course, I have had plenty of time to field test many different ‘Bowlines’ – and I would like to shine the spotlight on some now…

The five knots presented below have useful practical applications and I routinely use *and trust* them in various fall-protection (eg climbing and rescue) applications. Scott’s locked Bowline is perhaps the most simple and effective locking maneuver of all the different Bowlines presented in this paper.

Scott’s locked Bowline (ABoK #1034 ½ derivative that is ‘TIB’) Application: Anchor systems – end termination knot to anchor points. Can also be used as a tie-in knot for lead climbing. Elegantly simple, yet effective and adds a third rope diameter inside the nipping loop.	**EBSB Bowline** (ABoK #1010 derivative) Application: Tie-in knot for lead climbing. Totally secure. Inspired by Dan Lehman’s EBDB – with securely held tail. There are 3 rope diameters inside the nipping loop.	**Lees link Bowline** (Myrtle derivative) Application: Tie-in knot for lead climbing. Totally secure. This is a remarkable creation from Alan Lee. There are no sharp turns in this structure – the rope always feeds around at least 2 rope diameters. There are 3 rope diameters inside the nipping loop.	**Harry Butlers Yosemite Bowline** (ABoK #1010 derivative) Application: Tie-in knot for lead climbing. Totally secure. Although a variation of the original Yosemite Bowline – it resolves any issues with security. There are 3 rope diameters inside the nipping loop.	**Alan Lee’s Yosemite Bowline** (ABoK #1010 derivative) Application: Tie-in knot for lead climbing. Totally secure. Although a variation of the original Yosemite Bowline – it resolves any issues with security. There are 3 rope diameters inside the nipping loop.

Each of the above ‘Bowlines’ are ***inherently secure*** – and suitable for use in life critical applications (eg as a tie-in knot for rock climbing). All require a *minimum* of 100mm tail and must be dressed and cinched *tightly* (by sequentially pulling on all 4 rope segments).

A special mention goes to Alan Lee’s ‘Lee Zep Bowline’ – which is well suited as part of a dual clip-in system for indoor climbing gyms and challenge ropes courses (but not as a tie-in for outdoor lead climbing).

The journey for me is not over – it is a never ending work-in-progress.
This paper will be updated when new discoveries are made.

Mark Gommers
Australia