

ADVANCED CREATIVE ENQUIRY

M6X01787

2021-2022

**BETHAN ROSE LLEWELLYN
JOHNSON**

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IDENTIFIED PROBLEM

From personal and mutual experiences of training as a lifeguard, I have noticed an issue within the 'vice grip' manoeuvre which is used when a casualty with a suspected spinal injury is unconscious or unable to move facing downwards in the water.

The manoeuvre enables the casualty to experience as little movement to the spine as possible which could cause further detrimental spinal damage. The manoeuvre enables the casualty to move from their head and body facing downwards in the water to facing upwards above the water allowing them to breathe. The 'vice grip' remains firmly in position whilst the lifeguard treads them over to shallow water where a PXB board waits along with other lifeguards. The lifeguard then transfers the casualty onto the PXB board but the 'vice grip' is not removed or loosened until the casualty is in the centre of the PXB board and the two head blocks and straps are in place. The casualty is strapped onto the board across their body and lifted from the pool where further lifeguard and health and safety practices occur.

FIRST-HAND EVIDENCE

I have personal experience from training this manoeuvre repeatedly and under examination which led me to find personal difficulties. I trained for my National Pool Lifeguard Qualification in Pontypridd Lido, and I have experience training as a lifeguard in the LC2 swimming pool in Swansea. I was able to analyse myself performing the process as well as observing peer lifeguards practice it repeatedly.

When this maneuverer is learnt and continuously practiced by lifeguards, one lifeguard plays the role of the casualty and the other performs the manoeuvre then swaps once perfected. By both experiencing this manoeuvre as a lifeguard and role of a casualty, I was able to gain great insight into problems that arose. By observing numerous lifeguards performing the manoeuvre, I was able to confirm problems that occurred to myself and identify key problem areas.

The 'Vice Grip' Manoeuvre Observed

1. The casualty is facing downwards in the water and seemingly unconscious with a suspected spinal injury.
2. The lifeguard blows the whistle three times and shouts "lifeguard going in", taps the back of their head and shouts "suspected spinal injury".
3. The lifeguard enters the water whilst creating as little ripples and movement in the water as possible.
4. The lifeguard swims to the casualty as swiftly as possible whilst minimising movement to the water and casualty.
5. As the lifeguard approaches the casualty, they move the casualty's two arms from in front of them to their sides.
6. The lifeguard places their outside arm firmly on the back of the casualty, following the direction of their spine, with the palm of the lifeguard's hand cupping the back of the casualty's head.
7. The lifeguard places their inside arm firmly on the front of the casualty underneath the water, aligning with their spine. The lifeguard makes a 'v' shape with their hands which fits onto the casualty's chin and jawline avoiding covering the mouth.
8. With the lifeguard's arms in place, the lifeguard then proceeds to move themselves underwater with the casualty by kicking their legs. This results in turning the casualty 180 degrees so that they are facing upwards and able to breathe. The 'vice grip' is held in place securely the whole time.
9. The lifeguard treads the casualty, whilst maintaining a secure 'vice grip', to the pool edge. The lifeguard kicks their legs only whilst treading them as their arms are firmly held in place around the casualty.
10. At the pool edge are additional lifeguards waiting to perform and partake with following procedures involving the PXB board.

Personal Issues Identified as a Lifeguard

Personal problems I faced whilst being of a smaller height and build, was performing the manoeuvre on a larger height and build casualty and continuing to tread them across deep water of the pool to the shallow edge of the pool. I am 5 foot 2 inches and 8 stone 6 pounds. I managed to perform the 'vice grip' manoeuvre correctly and up to the qualified standard but struggled at the start of practising this manoeuvre and would continue to do so for an individual of a much larger build/height. Due to the difficulty in keeping an individual of larger height afloat on the surface of the water, I found it increasingly difficult to swim them.

I found difficulties arose with my swimming form when treading an additional other of a large build. As I was struggling to keep them afloat, I began to struggle to keep myself afloat above the water also. As I was unable to keep close to the surface of the water, this resulted in not being able to see, struggling to breathe or maintain a steady breathing pattern as water went into my mouth and difficulty in pulling and treading the individual by only using my legs.

Mutual Issues Identified (Lifeguards)

I have watched peer lifeguards train this manoeuvre repeatedly over multiple sessions which enabled me to discover common issues and difficulties I witnessed and determine whether issues I faced were personal or mutual.

Mutual problems peer lifeguards and I faced were keeping the tight pressure of the grip on the casualty when performing the manoeuvre especially whilst going underwater. This is evidently a big problem as the tight grip minimises harmful movement to the spine.

Furthermore, a tight and firm 'vice grip' around the casualty wasn't maintained and a loose grip was performed numerous times when the lifeguard was pulling the casualty onto the PXB board.

Lifeguards of both genders with a smaller physique including myself, found swimming alongside a static larger build of individual in deep water especially difficult due to a difference in weight ratio between lifeguard and larger individual which resulted in difficulty keeping them afloat. This

difficulty in keeping them afloat on the surface of the water led to them being deeper in the water closer to a 45-degree angle. This meant it was harder to tread them to the pool edge as drag is decreased at this form which results in more energy required from the lifeguard.

Key Problem Areas

1. Keeping the casualty of a large build afloat.
2. Keeping the lifeguard afloat while holding a large build casualty.
3. Water in eyes and unable to see when not afloat to surface of water. (Lifeguard and casualty).
4. Streams of water in mouth when opening to breathe when not afloat to surface of water. (Lifeguard and casualty).
5. Difficulty in transporting casualty underwater with lifeguard's legs only at use. Tiresome on legs of lifeguard.
6. Loose and inappropriate 'vice grip' whilst under water and turning the casualty 180 degrees.
7. Loose and inappropriate 'vice grip' whilst moving the casualty onto the PXB board.
8. Casualty of larger size experiencing urges to kick legs to push themselves closer to surface of water if lifeguard is struggling to tread them.

Issues Identified from Perspective of the Casualty

I asked lifeguards of a larger build and height, which played the role of casualty, what they experienced. I also observed a lifeguard perform the manoeuvre on a larger individual which meant I could view further issues from the casualty's perspective.

Lifeguard's which played the role of the casualty, explained to me that when the lifeguard struggled to turn them, they "became very desperate for air to breathe." I also viewed that as the lifeguard of a bigger build was more difficult to turn it took longer for them to do so and therefore left them sometimes gasping for breath once turned.

Further feedback was that they would have streams of water over their face which made it "difficult to see and give a feeling of slight panic at times." I also noticed this when observing as streams of water would flow

over the casualty's face in waves as the lifeguard treaded them to the pool edge.

Additionally, criticism was received as the casualty felt that if the lifeguard was severely struggling to tread them and keep them afloat, that they had "urges to kick and keep themselves afloat." This was seen on one occasion as the lifeguard was failing on their first attempt at practising the manoeuvre, the casualty became close to 90 degrees in the water alongside the lifeguard and just before the lifeguard restarted the procedure, the pretend casualty kicked their legs to bring themselves higher to the surface of the water to aid the lifeguard and themselves.

This problem would be extremely dangerous if it occurred to a conscious suspected spinal injured casualty, as kicking their legs would cause additional damage to the spine.

SECOND-HAND EVIDENCE

Videos

I have also studied videos of the manoeuvre being performed enabling me to study the manoeuvre further as I was prohibited from taking images/videoing when observing and partaking with peer lifeguard's NPLQ training.

I did not find any further issues from the videos. However, it enabled me to confirm my views and my peer lifeguard's feedback against another lifeguard academy's.

Below are the hyperlinks and some images, from the manoeuvre performed in the videos, which show the problems other experienced lifeguards and I explained previously.

<https://www.youtube.com/watch?v=wZbmTHjiUgQ>

<https://www.youtube.com/watch?v=WSVKxD7y5RI>

https://www.youtube.com/watch?v=cDj_TDQ8NbE

Images demonstrating a loose 'vice grip' resulting in movement of casualty



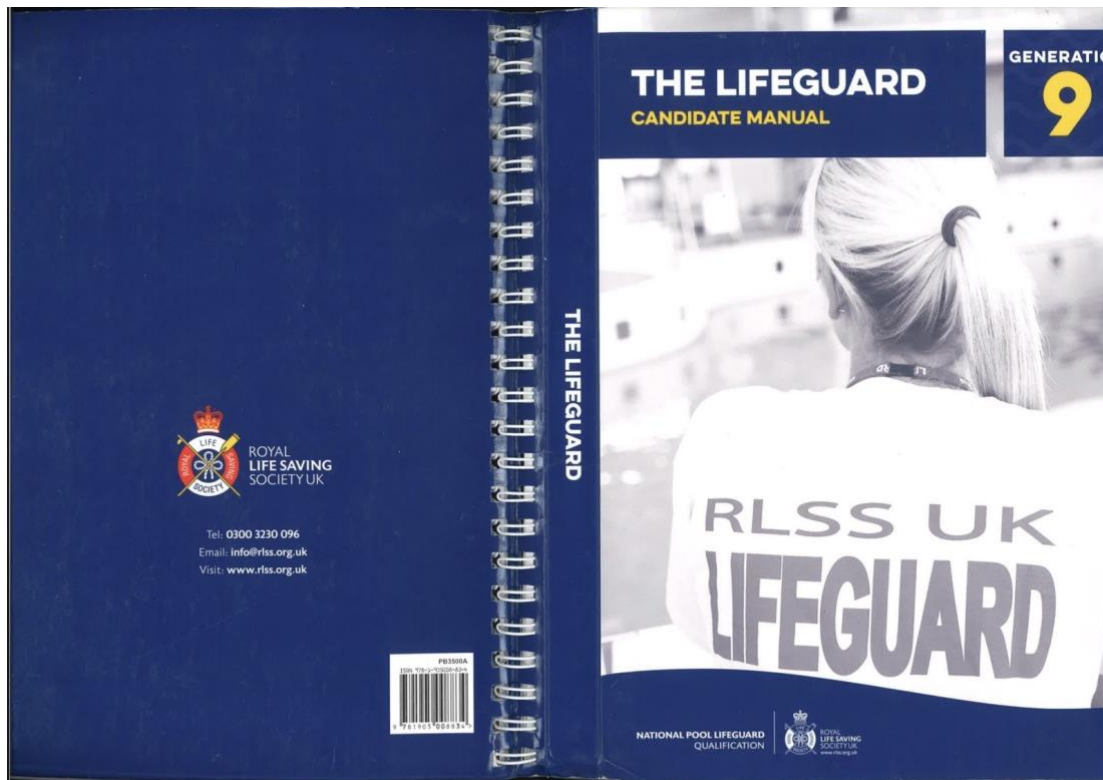
Images demonstrating a correct 'vice grip' hold



ROYAL LIFE SAVING SOCIETY CURRENT CANDIDATE MANUAL

2018 - currently the most recent and up to date manual published by the RLSS.

A new manual is published every two years. These are published and used to both train and ensure lifeguards stay competent with correct procedures.



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NATIONAL POOL LIFEGUARD QUALIFICATION

the lifeguard

FOREWORD

The National Pool Lifeguard Qualification (NPLQ) was first developed by the Royal Life Saving Society UK in 1990 to address the future role of the lifeguard and the needs of swimming pool operators. As the pool industry continues to change, and the legal obligations for operators have continued to increase, the RLSS UK and IQL UK have endeavoured to respond to change through the ongoing development of this qualification.

In 2012 the NPLQ was developed in direct response to comprehensive industry consultation. The consultation process has continued for the latest revision, whilst also recognising some of the developments in aquatic safety and changes to the industry guidance contained in the Health and Safety Executive publication, Managing Health and Safety in Swimming Pools (HSG 179/2018).

Careful supervision by qualified and competent lifeguards and early intervention is the best way to prevent incidents and accidents in swimming pools. This qualification serves to constantly improve standards of lifeguarding in pools thus ensuring that public safety remains at the forefront of everything we do. The NPLQ will fully prepare future lifeguards for the essential role they will undertake in safeguarding lives.

We would like to acknowledge the incredible contribution from the leisure industry in the development of this new qualification and is proud to continue to partner the swimming pool industry.

Ian Hutchings
President
Royal Life Saving Society United Kingdom

NATIONAL POOL LIFEGUARD
QUALIFICATION



NATIONAL POOL LIFEGUARD
QUALIFICATION



CANDIDATE MANUAL



Sixth Edition published in 2018 by

Royal Life Saving Society UK (RLSS UK)

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Acknowledgements

We gratefully acknowledge the help of all those who contributed to the development of the National Pool Lifeguard Qualification.

First Edition 2001

Second Edition 2003

Third Edition 2006

Fourth Edition 2012

Fifth Edition 2016

Sixth Edition 2018

Throughout the text the masculine includes the feminine (unless the context dictates otherwise) and vice versa.

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Published by RLSS UK

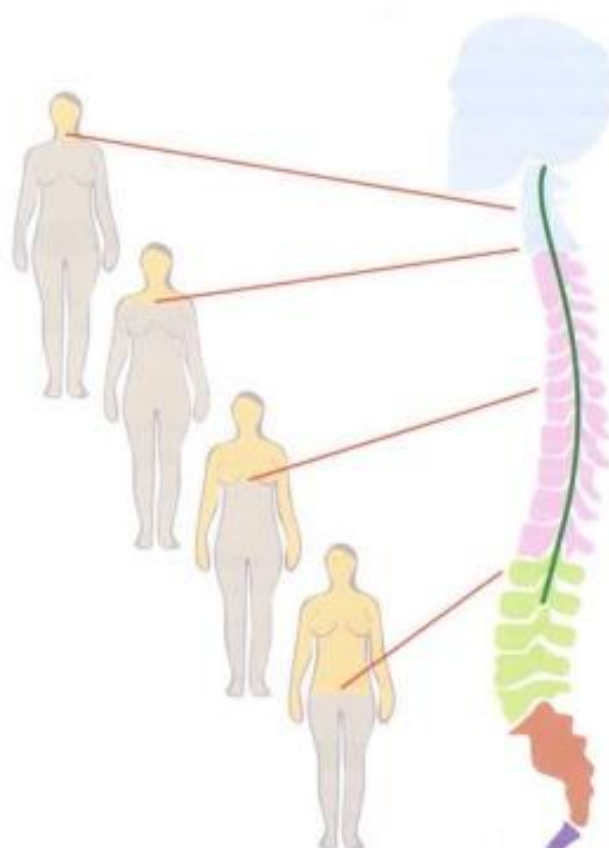
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2.0.2 The Spinal Cord and the Nervous System

The spinal cord runs down the centre of the spinal column. It links the brain and the nerves supplying the trunk and the limbs. It is through the cord that the brain sends signals to control movement throughout the body, from the simple action of breathing in and out to controlling all major muscles and moving limbs.

When the spine is injured, depending on the severity, some of these functions are affected and often result in the casualty suffering paralysis.

The higher the spinal injury, the more muscles become paralysed



**SECTION 2: INTERVENTION,
RESCUE & EMERGENCY ACTION PLAN**

2.1 RECOGNISING A POTENTIAL SPINAL INJURY

History

As a lifeguard you may witness an accident where a casualty has sustained an injury from severe force or blow to their spine, examples of either, within a swimming pool environment, are detailed below:

Severe impact:

- Diving and hitting the pool bottom, side of pool or swimmer
- Collision with other swimmer e.g. acrobatics, equipment use
- Some equipment may increase the likelihood of a spinal injury due to the potential increase of the forces involved with each piece of specific equipment:
 - Diving boards or platform

ELEMENT 2 – RESCUE OF A CASUALTY WITH A SUSPECTED SPINAL INJURY

What we will cover

- Basic anatomy of the spine
- Identifying a casualty
- Managing the casualty in the water
- Casualty recovery
- Using specialist rescue equipment

The EAP must identify the arrangements for the management of this type of injury at each individual pool facility and the use of a rescue board or PXB.



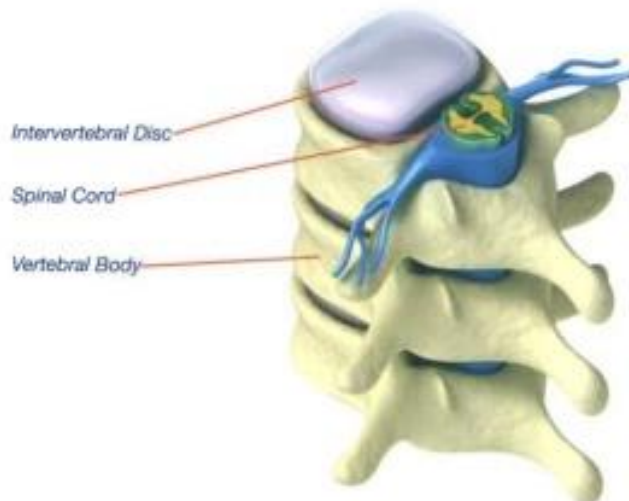
2.0 THE SPINE AND SPINAL CORD

Before we start, you need to have a basic understanding of the anatomy of the spine as this will help you to understand how to identify a possible injury, the importance of immobilisation, team work and careful casualty handling in the event of an accident.

2.0.1 The Spine

The spine is a column of 33 irregular shaped bones called vertebrae. It supports the skull and the ribs are attached to it. In between the vertebrae are cartilage discs which:

- Allow limited movement
- Prevent friction
- Act as shock absorbers



2.4 RESCUE TECHNIQUES

Rescue under such circumstances is based on the principle of keeping the casualty's head in a stable position and the stabilisation of the whole spine.

Two techniques can be used depending on the circumstances these are called:

- Vice grip
- Head splint

It is unusual for a casualty to be discovered floating face up. The body's natural centre of gravity normally turns a casualty into a face down position.

As always, your first priority is to turn them face up so they can breathe; your second and third priorities can be met by using one of the two approved rescue techniques. The descriptions refer to face down casualties, however it would be possible to apply the vice grip or head splint with the casualty in the face up position if required.

As with all rescues, as soon as spinal injury is suspected, the EAP should be implemented. At the very least, this should make sure the surrounding water area is cleared, waves and other features are stopped, and support lifeguards and other staff report to the poolside.

2.4.1 Vice Grip - Rescue from water, out of a comfortable standing depth

This technique is used to secure the head, neck and upper spine of the casualty between a lifeguard's hands and forearms, as if in the jaws of a vice.

Approach

1. Enter the water carefully minimising as far as possible any further movement
2. Approach the casualty from one side
3. Approach by swimming head up and as you get closer to the casualty, minimise splashing and water disturbance

Once you have reached the casualty you must stabilise the head and neck

- Gently reach under the casualty, ensuring your arm goes around their near arm
- Place your forearm along the line of their breastbone, supporting the casualty's face just above the chin, securely placing your thumb and fingers in a Y-shape either side of their jaw
- Place your other forearm in the same position along their spine. Your fingers should be outstretched on the back of their head, clamping it securely from behind
- Keep your fingers, hands, wrists and elbows rigid; your elbows and forearms should be gently but firmly pressed together
- Keep the casualty close to your body



ELEMENT 2 – RESCUE OF A CASUALTY WITH A SUSPECTED SPINAL INJURY

History is key when identifying a casualty with a suspected spinal injury, as the cause of the accident may indicate the likelihood of a spinal injury particularly where large forces are involved as indicated above.

Whether you have an understanding of the casualty history or not, look for symptoms and signs.

Symptoms

- Lack of movement/power in one or more limbs
- Disorientation or bewilderment
- Numbness or tingling in the limbs
- Pain in the neck or back

Signs

- Casualty floating face down in the water, unable to turn over (not necessarily unconscious)
- Bruising or swelling at impact area of head, neck or spine
- Deformity or irregularity of the spine
- Loss of muscle control
- Unconsciousness

2.2 PRINCIPLES OF CASUALTY MANAGEMENT

Because most accidents happen unexpectedly, it is often impossible to know exactly what happened, the nature of the injury and any subsequent damage to the spine. It is important to treat and follow the basic principles below:

Stabilising the head, neck and upper spine

As mentioned before, the higher the spinal injury the more of the body can potentially be paralysed. Therefore the first action must be to stabilise the head in a neutral position, keep the neck and upper spine supported and in line, this is called in-line stabilisation.

Maintaining a horizontal position

When rescuing and recovering a casualty with a suspected spinal injury from the water, you must make sure the casualty is kept in a horizontal position and all movement is minimised and carried out with great care.

Due to the above, an assisted lift would not be appropriate and could cause further damage to the spine as it is difficult to keep the spine straight and the head immobilised. Due to this, a horizontal lifting technique is recommended with or without the use of a rescue board or PXB.

2.3 INCIDENT MANAGEMENT PRIORITIES

The first priority of the lifeguard is to save life. If face down, clearly the casualty needs to be turned face up so they can breathe; where the casualty is deemed unconscious by not responding to "Are you alright?" you would need to remove the casualty from the water immediately so the primary survey can be completed on poolside.

It is important to remember that the casualty's airway takes priority over injury. Ultimately your decision must be based on the priority of saving life. There are three key priorities for lifeguards to follow:

- Save life
- Stabilise the casualty's head, neck and upper spine
- Maintain their horizontal position

2.4.2 Head Splint - Rescue from shallow water

The head splint can be used in a range of water depths up to about lifeguard's chest depth and is simple to apply.

Approach

- Slide into the water
- Approach the casualty from the side, and stop when in a position next to their shoulders

Stabilise the head and neck

- Gently grasp the casualty's arms
- Placing your hands midway between the casualty's elbows and shoulders
- Gently move their arms in a smooth sweeping action to a position next to the ears
- Carefully squeeze their arms against their head to splint the head between both arms to prevent any movement
- Position your thumbs on the back of their head, maintaining the pressure on the arms



Turning the casualty face up

- Gently roll the casualty towards you by pushing the arm nearest to you downwards and pulling on the arm furthest away from you towards you (avoid twisting the casualty)
- Continue to roll the casualty in one smooth action until they are face up

A forward motion during the turn may help to move the casualty's body into a horizontal position.



- Once the casualty is face up, lifeguard 1 maintains the pressure on their arms and support the back of their head on their submerged forearm. Do not release the pressure on their arms until you get extra help

- once the casualty is face up you should check the response of the casualty by asking "Are you alright?"

* If the casualty is not responsive when the lifeguard asks "Are you alright?" they should be removed quickly from the water, taking care to limit movement of the head and neck as much as possible. The priority, however, is to get the casualty to a position where breathing can be assessed fully and CPR started if required.

The 'vice grip' Procedure Explained by the RLSS.

1 of 1

ELEMENT 2 – RESCUE OF A CASUALTY WITH A SUSPECTED SPINAL INJURY



Turning the casualty face up

- Once secured in the vice grip, begin to gently roll the casualty by sliding under the water.
- Continue to roll the casualty until they are face up on the surface of the water
- When turning someone in water out of standing depth, kick hard to make sure they are not pulled under the water, whilst minimising water turbulence



If you are able to, a forward motion during the turn may help to make the turn smooth and move the casualty's body into a horizontal position earlier.

Turning is made very much easier if the casualty is rolled at the surface of the water; lifting the casualty during the turn increases the potential for further injury.

Are you alright?

Once the casualty is face up you should check the response of the casualty by asking "Are you alright?".

***If the casualty is not responsive when the lifeguard asks "Are you alright?" they should be removed quickly from the water, taking care to limit movement of the head and neck as much as possible. The priority, however, is to get the casualty to a position where breathing can be assessed fully and CPR started if required.**

Returning to shallow water

When the casualty is face up, maintain the vice grip while you tow them back to a point of support in shallow water. Lifeguards may use side stroke leg kick, breast stroke, flutter kick or egg beater leg kick (the latter is most effective), to trawl the casualty horizontally through the water.

Remember that the casualty could be facing in any direction, meaning that once you have turned the casualty face up you may need to trawl them towards the shallow end, in an arc (where possible) to help maintain the head, neck and spine in a straight line.

As you approach a point where standing is easier, it is essential that the vice grip and horizontal position are maintained, no matter how uncomfortable this may be for you.

ELEMENT 2 – RESCUE OF A CASUALTY WITH A SUSPECTED SPINAL INJURY**Secure the casualty**

- Lifeguard 1 Applies the head splint turn then supports near the shoulders and the upper part of the back after lifeguard 2 supports the head and reassures the casualty
- Lifeguard 2 Supports head, thumb above ears, fingers below
- Lifeguard 3 Supports the lower back and upper thigh on their arms palms down
- Lifeguard 4 Carefully and gently moves the casualty's arms to the side of their body when lifeguards 2 and 3 are in position then moves to support the lower legs palms down or prepares and applies the rescue board if available

Additional support can be applied in exactly the same way as for the vice grip, by lifeguard 2 at the head sliding hands between the casualty's raised arms and head.

Lifeguard 2 supports head, thumb above ears, fingers below.



The arms may be carefully and gently moved to the side of the casualty's body by lifeguard 4 once the body is supported by lifeguards 1, 2 and 3. Lifeguard 1 can continue to reassure the casualty.



2.4.3 Stabilisation in Shallow Water



Once stabilised in this position, the casualty is ready to be removed from the water. This must be done as quickly as possible to prevent the onset of hypothermia and enable further treatment of their condition.

AquaBoard Procedure Explained by the RLSS

1 of 1

ELEMENT 2 – RESCUE OF A CASUALTY WITH A SUSPECTED SPINAL INJURY

2.5 REMOVAL OF A CASUALTY WITH A SUSPECTED SPINAL INJURY FROM THE WATER

2.5.1 Removal of a Casualty using a Rescue Board

A rescue board provides quick, safe and easy means of recovering a casualty with suspected spinal injuries from the swimming pool to poolside. The rescue board serves to immobilise a casualty within the water, helping to prevent secondary injury to the spinal cord prior to recovery on the poolside.

The Ferno AquaBoard is a rigid, buoyant rescue board designed in collaboration with RLSS UK to recover a casualty from a pool.



The rescue board includes the following unique features:

- Five body and Leg Straps to hold a casualty to the board, with colour coded buckles for ease of identification and accurate application. The strapping system should allow sufficient adjustment for a wide range of sizes of casualty.
- Lightweight Head Restraint with three retaining straps, to secure a casualty's head in a stable, neutral position.
- As the board is X-Ray Translucent, the patient can remain on the board throughout X-Ray procedures

The rescue board can be used to rescue casualties with spinal injuries or other conditions which prevent them being assisted from the water using the other techniques identified throughout this qualification.

The practicalities of using a rescue board should be risk assessed by the pool operator to ensure the pool dimensions and environments are suitable.

It is essential that pool operators have at least two of the rescue team trained in the RLSS UK National Pool Lifeguard Qualification with rescue board, and two additional people must be trained to support the lifeguards to use the rescue board.

Rescue board storage

The rescue board will be stored at a point specified within the centre's NOP. The rescue board must be easily accessible. Some pools will specify where the rescue board can be extracted from the water.

ROYAL LIFE SAVING SOCIETY

PREVIOUS MANUAL

2011 – A previous manual published by the RLSS.

A previous candidate Emanual from 2011 is demonstrated below. I found it interesting to analyse as it holds the previous method of spinal injury management.

This means I can see the evolution of the manoeuvre and identify where the key problems used to be as they would have changed and identify possible remaining problems.

Comparison

As I compared the RLSS candidate manuals from 2011 and 2018, I noticed that the 2011 version did not include the 'Vice Grip' manoeuvre. It only included the shallow water 'Head Splint' manoeuvre. This means that the manoeuvre was recently developed, and it wasn't taught or used previously in 2011.

Also, the older manual only contains one double sided page on spinal injuries which I do not find sufficient and suggests it was previously not thought of as very important as it is developed and evolved to 9 pages in the recent manual.

I find it an interesting observation that the 'vice grip' wasn't invented and practiced in 2011 as it means the RLSS is always updating and evolving their procedures to the best of their capabilities.

1 of 1



**ROYAL
LIFE SAVING
SOCIETY UK**

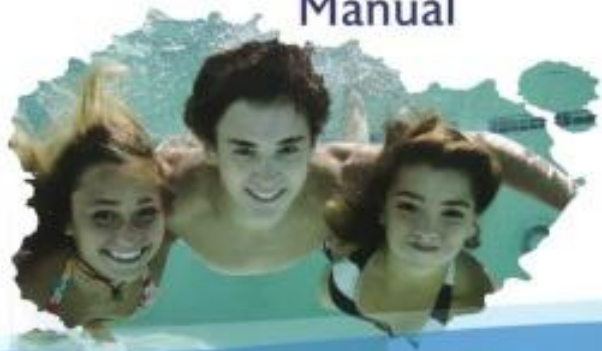
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THE NATIONAL LIFESAVING AWARDS
survive&save
programme

Candidate Manual



**Safeguarding lives in,
on and near water**

This Candidate Manual is the core resource for the RLSS UK Survive & Save Programme (previously and two level) specifically designed to deliver the information to support your training and ensure you deliver the programme.



**Safeguarding lives in,
on and near water**

Lifesaving Rescue Skills



Aquatic Spinal Injuries



Basic Principles of Aquatic Spinal Injury Management

Management of aquatic spinal injuries requires specialist skills. These skills are trained through the vocational awards of RLSS UK. However, in cases where specialist rescuers (such as lifeguards) are not available and the casualty's life is at risk, other rescuers may have to act to stabilise the casualty whilst awaiting the emergency services.

Rescuers should have a basic understanding of spinal injury, and be able to recognise and stabilise a spinal casualty in the water whilst awaiting specialist assistance.

Rescuers should treat a casualty as a suspected spinal casualty if:

- Abnormal or severe forces have been applied to the casualty's back or neck (often as a result of slipping or diving into the water).
- The casualty complains about unusual sensations or paralysis anywhere in their body.

The basic principles of spinal injury management are:

- The head and body must be kept in neutral alignment (as if the casualty is looking straight forward).
- The arms should be moved slowly and within the natural movement range of the shoulders.
- The casualty should not be removed from the water unless their life is at risk by staying in the water (see below).
- The casualty will require constant reassurance.

In extreme circumstances, a spinal casualty may need to be removed from the water before the emergency services arrive on the scene. Reasons for landing a spinal casualty without professional support include:

- If the casualty is not breathing normally (as defined in Life Support).
- If the casualty is suffering from other life-threatening conditions.
- If it is not safe to remain in the water.

In situations where a spinal casualty does have to be removed from the water, the horizontal lift should be used. Additional care and attention must be given to the head and spinal alignment during the lift.

Head Splint



Definition of the Skill

A water-based, temporary immobilisation and stabilisation of the head and spine, to preserve the condition, and reduce further injury to a spinal casualty.

Technique

- Approach the side of the casualty, creating as little water disturbance as possible.
- Grasp the casualty's arms between the elbow and shoulder.
- Slowly move the casualty's arms to the side of their head.
- Apply firm pressure through the casualty's upper arms, clamping their head in the neutral position (as if the casualty is looking straight forward).

Turning a Suspected Spinal Injury Casualty



Notes

Rescuers should only turn a suspected spinal injury casualty when specialist support is unavailable.

Technique

- Approach the side of the casualty, creating as little water disturbance as possible.
- Grasp the casualty's arms between the elbow and shoulder.
- Slowly move the casualty's arms to the side of their head.
- Apply firm pressure through the casualty's upper arms, clamping the head in the neutral position (as if the casualty is looking straight forward).
- If you can't reach, support the back of the casualty's head with your thumb.
- Lower your body so that your chest is level with the casualty.
- Move slowly forward with the casualty to encourage their legs to rise towards the surface.
- As the casualty's body becomes horizontal in the water, begin to rotate the casualty by pushing down on the side that is closest to you, as you continue moving slowly forward.
- When the casualty is face up, slowly stop the forward movement and continue to hold the casualty securely until specialist assistance arrives.
- If another person is able to assist, they can gently support the lower body by placing their arms under the casualty's hips with their palms facing down.

Definition of the Skill

A method of turning a suspected spinal injury casualty from a face down to a face up position, whilst immobilising and stabilising the head and spine using the head splint technique.

USER PROFILE ANALYSIS

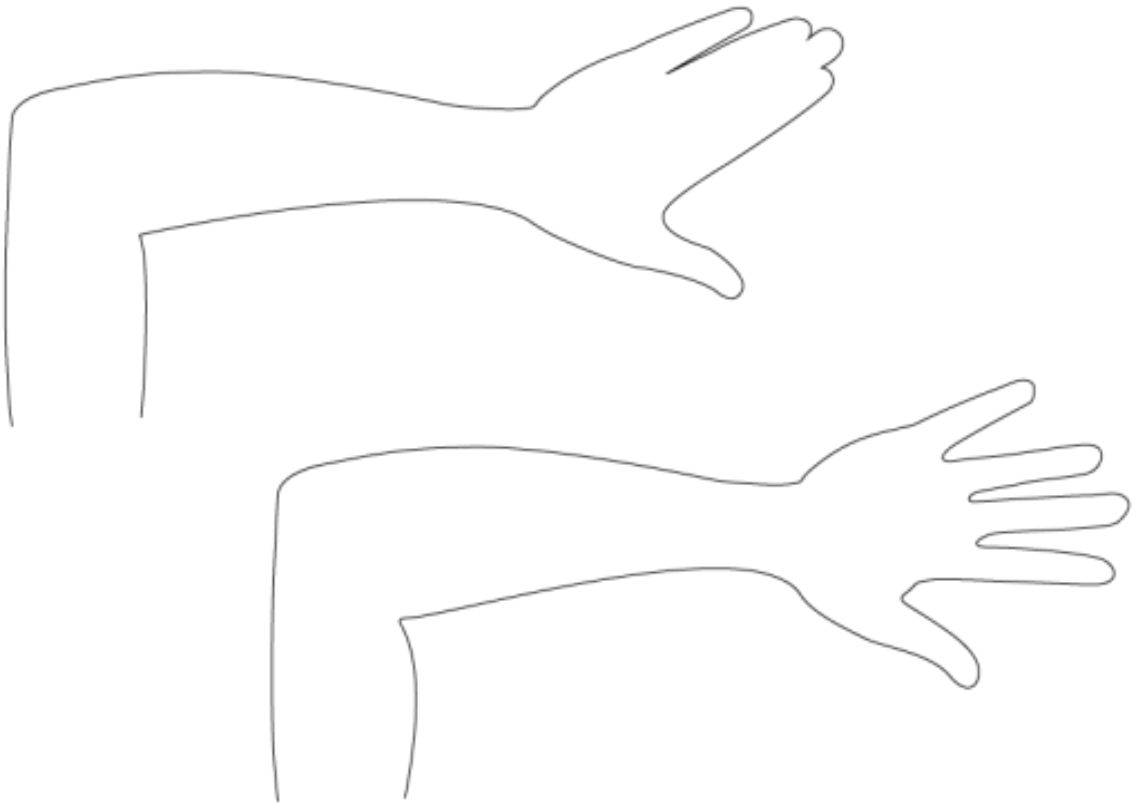
LIFEGUARD'S ARMS

1st image represents the palm of the lifeguard's hand covers the back of the casualty's head aligning the lifeguard's arm down the casualty's spine.

2nd image represents the lifeguard's 'V' shape between index finger and thumb is placed upon and around the casualty's chin with the lifeguard's arm following the alignment down the casualty's spine.

Both lifeguard's hands and arms are then 'clamped' together to the casualty, once correctly positioned, then the lifeguard submerges underwater to rotate the casualty 180 degrees from face down in the water to face above the water.

The position must remain being held tightly and securely whilst treading them to shallow water where safety of continuous procedures then take place with the aid of additional lifeguards.



THE SPINAL CORD

The spinal cord is a collection of nerves that travels from the bottom of the brain down your back. There are 31 pairs of nerves that leave the spinal cord and go to your arms, legs, chest, and abdomen. These nerves allow your brain to give commands to your muscles and cause movements of your arms and legs. The nerves that control your arms exit from the upper portion of the spinal cord, while the nerves to your legs exit from the lower portion of the spinal cord. The nerves also control the function of your organs including your heart, lungs, bowels, and bladder. For example, signals from the spinal cord control how fast your heart beats and your rate of breathing.

Other nerves travel from your arms and legs back to the spinal cord. These nerves bring back information from your body to your brain including the senses of touch, pain, temperature, and position.

Eck, J. (2021) *Spinal Cord Injury*, MedicineNet. Available at : <https://medicinenet.com>

THE SPINAL CANAL

The spinal cord runs through the spinal canal. This canal is surrounded by the bones in your neck and back called vertebrae which make up your backbone. The vertebrae are divided into 7 neck (cervical) vertebrae, 12 chest (thoracic) vertebrae and 5 lower back (lumbar) vertebrae. The vertebrae help protect the spinal cord from injury.

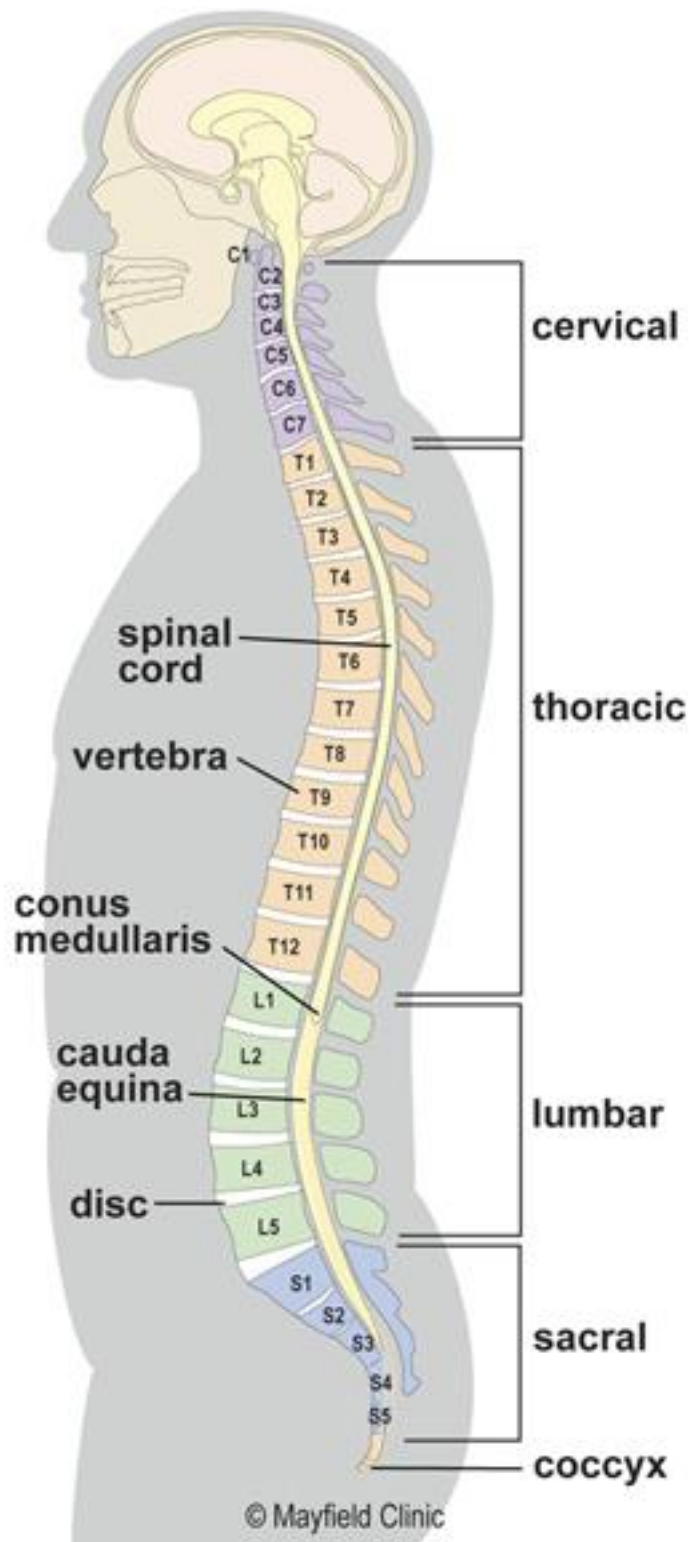
Eck, J. (2021) *Spinal Cord Injury*, MedicineNet. Available at : <https://medicinenet.com>

SPINAL CURVES

When viewed from the side, an adult spine has a natural S-shaped curve. The neck (cervical) and low back (lumbar) regions have a slight concave curve, and the thoracic and sacral regions have a gentle convex curve. The

curves work like a coiled spring to absorb shock, maintain balance, and allow range of motion throughout the spinal column.

Hines, T. (2018) *Autonomy of the Spine*, Ohio: Mayfield Clinic. Available at: <https://mayfieldclinic.com>



(Hines,
2018)

Map Showing the Pressure Areas of an Individual Lying down

I gathered this chart from a mattress company as they researched into the pressure areas a lying down individual has. It shows the pressure distribution as red indicates peak pressure points and blue indicating lower pressure points.

This is relevant as I can clearly see where my design may or may not need more support to support the casualty correctly. Furthermore, it enables me to see the spinal curve as the middle of the back is low pressure and the top and bottom and head is high pressure, indicating the curve is still there when an individual lies down.

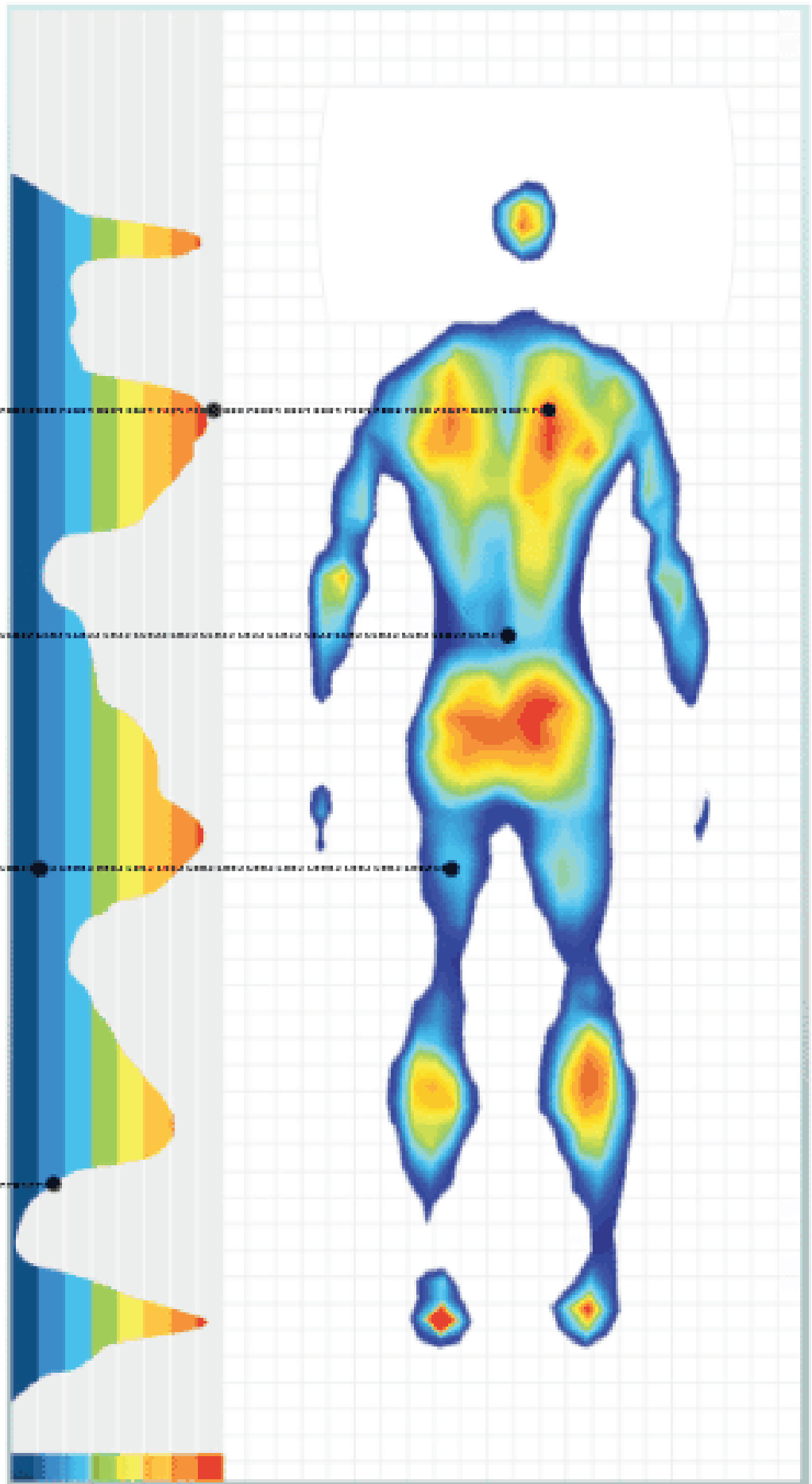
Furthermore, the calves and heels being high pressure peak points was a surprise to myself as I didn't expect the heels to be such a high pressure with such a small surface area. This will be considered when designing. Added supportive material to where the heels would be placed on the project could be integrated to support this aspect.

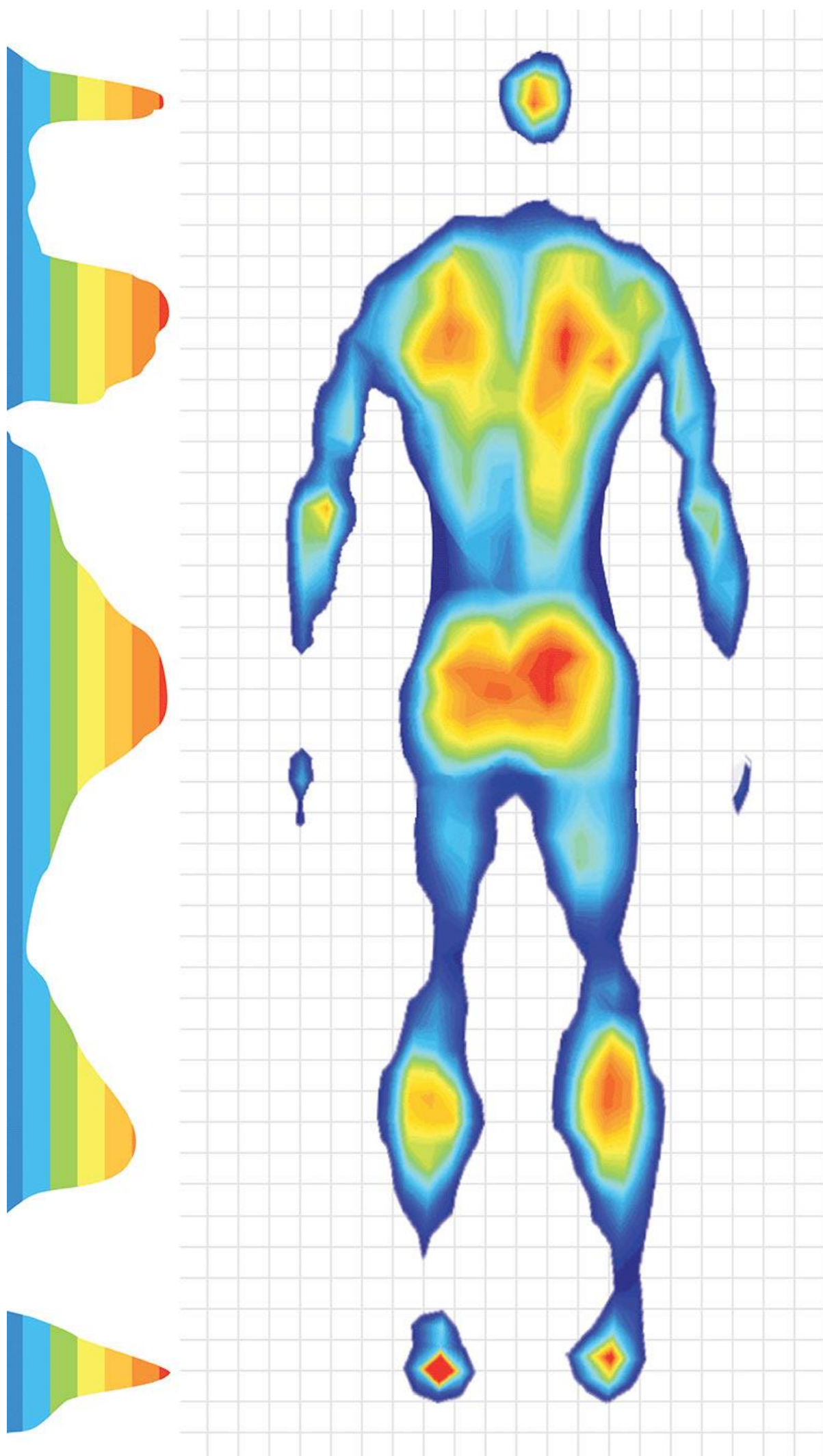
Red indicates peak pressure points.

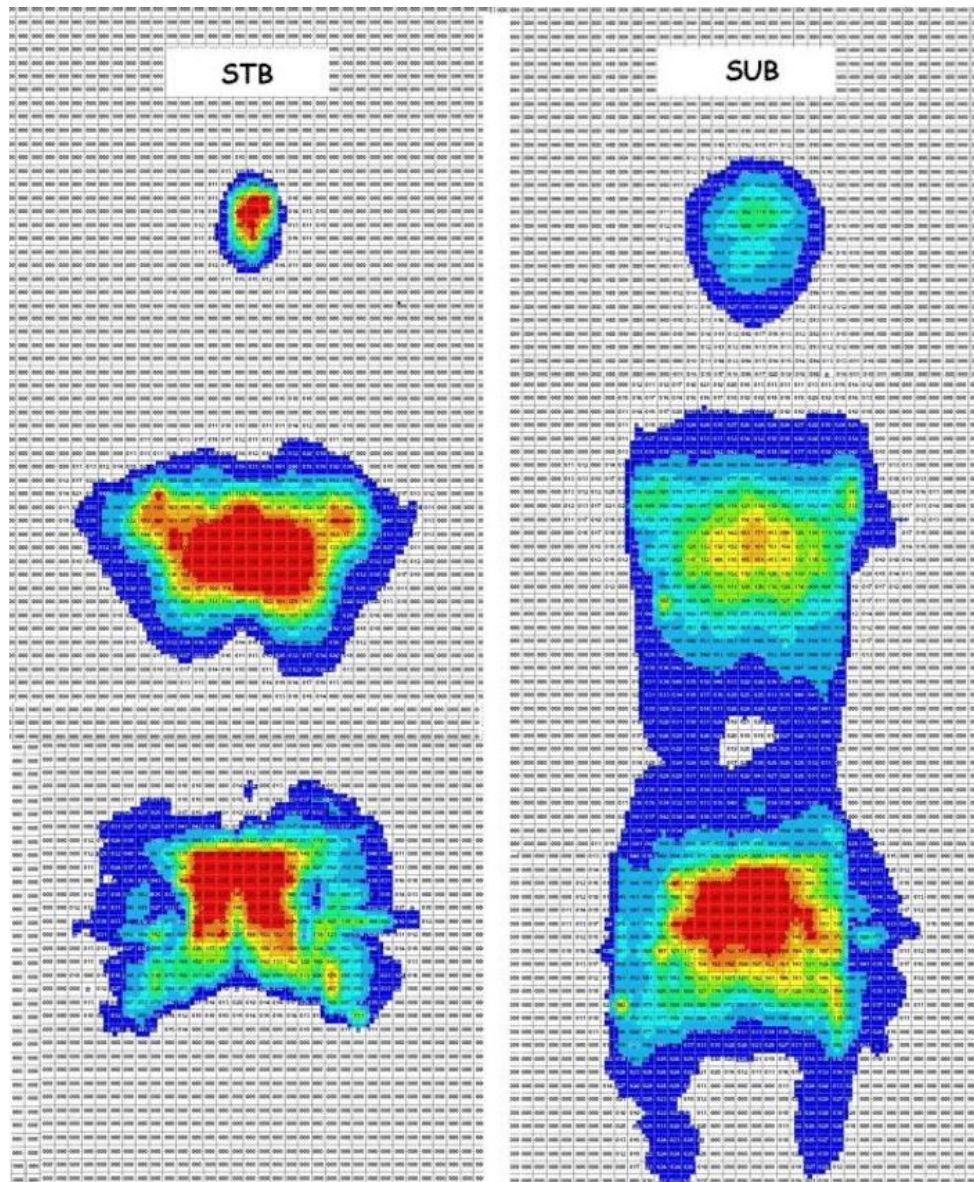
Body form shows lower back support.

Blue indicates areas of lower pressure.

Flatter curve indicates better conformity.







ARTHROMETRIC OF CASUALTY'S BODY

Biacromial width (shoulder to shoulder)

Europe and UK: average shoulder width calculated for 105 men over 18 was 15.5 inches (39cm). Out of 262 women measured, the average shoulder breadth was 14 inches (36).

United States: average shoulder width is at least 16 inches (41 cm) for men and 14 inches (36 cm) for women.

The largest average measurement is what I will base the products measurements off. This would be 435mm.

Bdelloid (shoulder to shoulder) average measurements

Maximum horizontal breadth across the shoulders, measured to the protrusions of the deltoid muscles.

The largest measurement listed in the table below of results is 515mm which is what I will base my products sizes off.

Sitting shoulder length (back length)

Vertical distance from the seat surface to the acromion (i.e., the bony point of the shoulder).

655mm is the largest measurement.

Sitting eye height

Vertical distance from the sitting surface to the vertex (i.e., the crown of the head).

975mm is the largest measurement in the table.

Chest bust depth

Maximum horizontal distance from the vertical reference plane to the front of the chest in men or breast in women.

295mm is the largest measurement in the table.

Head length

Distance between the glabella (the most anterior point on the forehead between the brow ridges) and the occiput (back of the head) in the midline.

210mm is the largest measurement.

Head breadth

Maximum breadth of the head above the level of the ears.

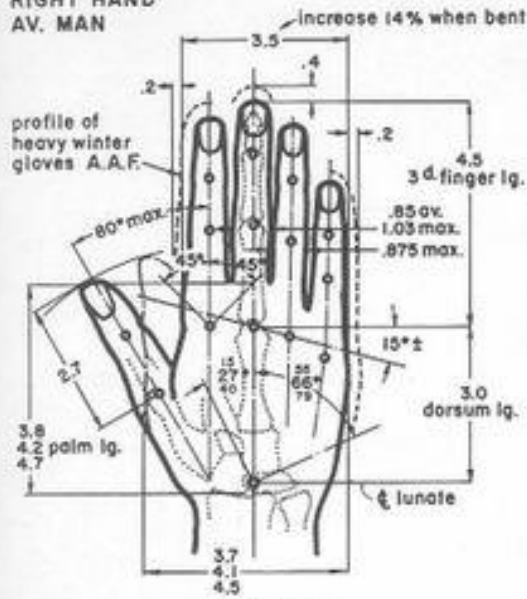
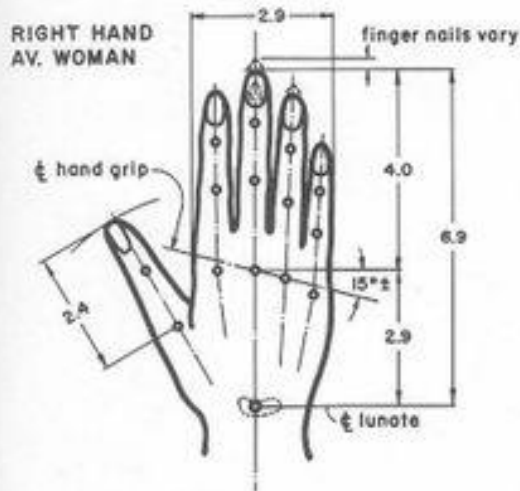
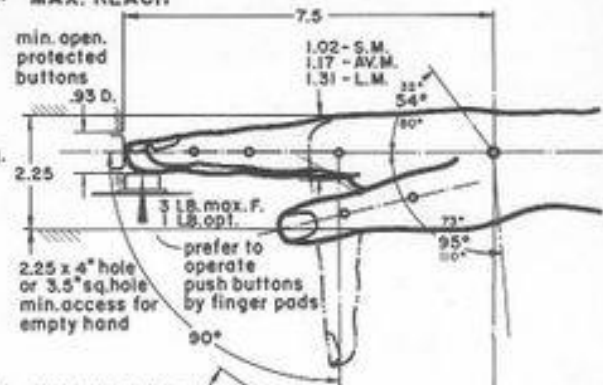
165mm is the largest measurement.

WEIGHT

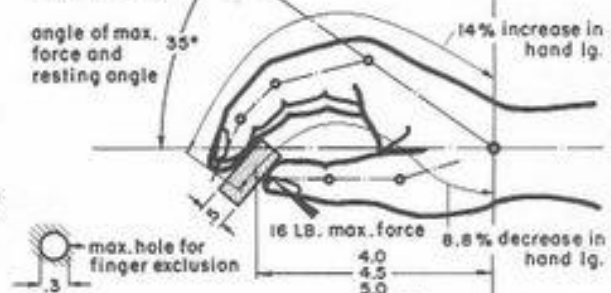
The highest average weight is 102kg. However, I need to know the maximum weight of an average larger individual. I investigated what weight paddleboards and rescue boards support as they are proving to do so efficiently, it makes sense to keep that data the same.

The RLSS PXB can hold a maximum weight of 182kg which is the weight I need to account for also.

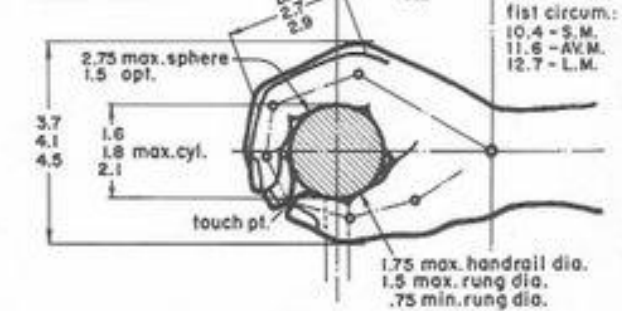
HAND MEASUREMENTS OF MEN, WOMEN AND CHILDREN

RIGHT HAND
AV. MANRIGHT HAND
AV. WOMANHAND POSITIONS - AVERAGE MAN
MAX. REACH

FINGER GRIP

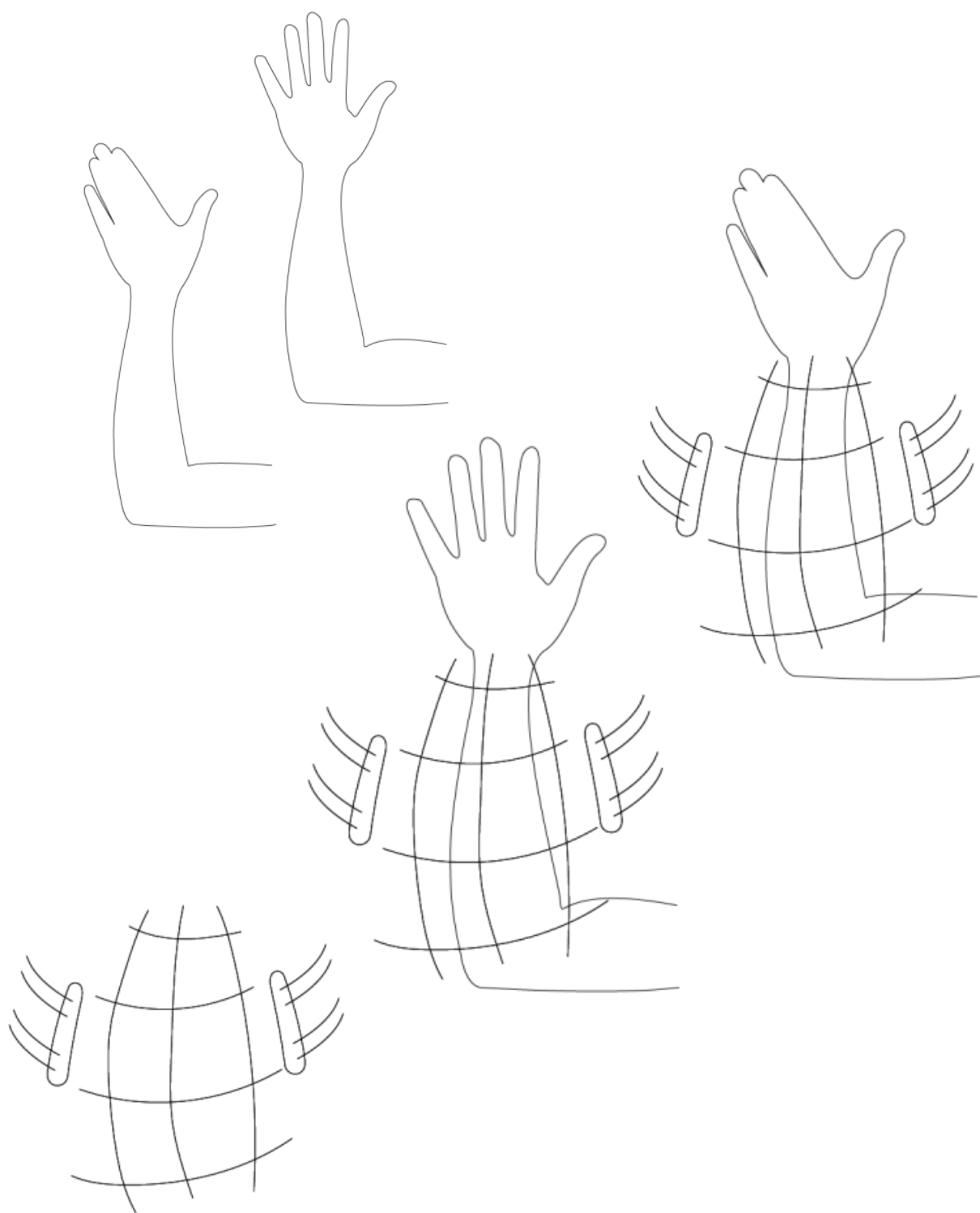


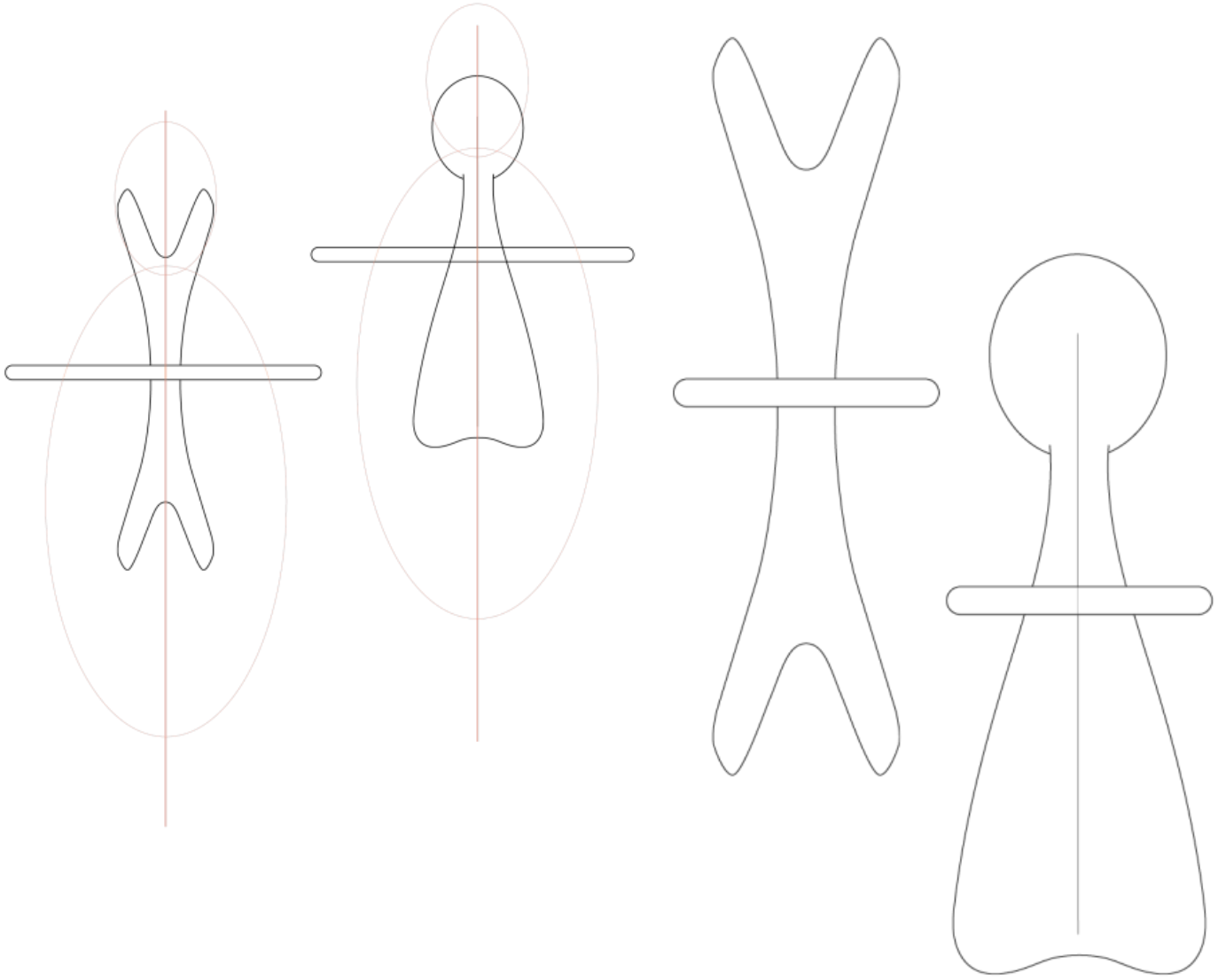
HAND GRASP

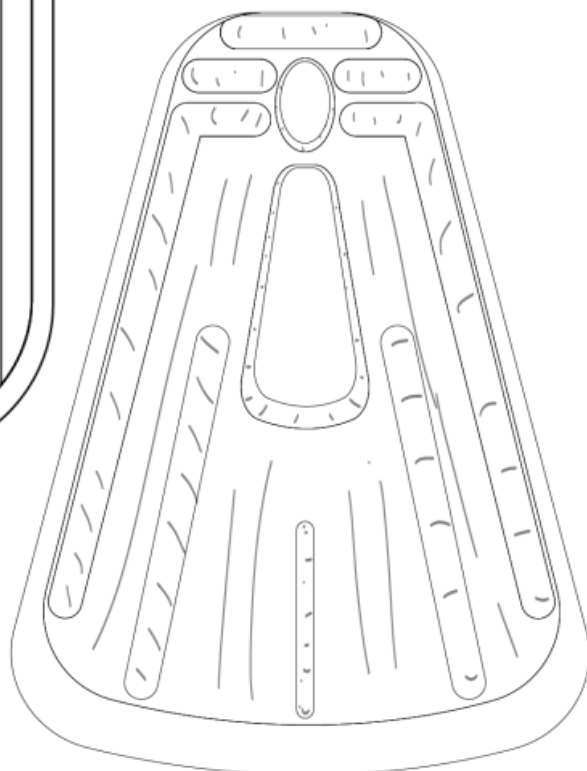
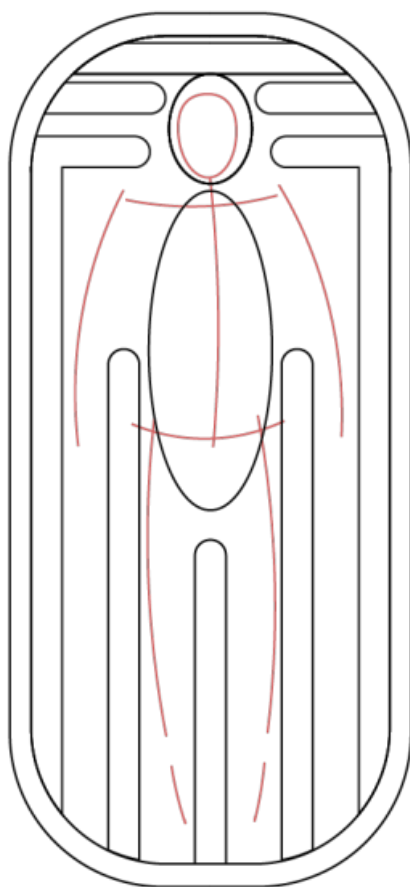
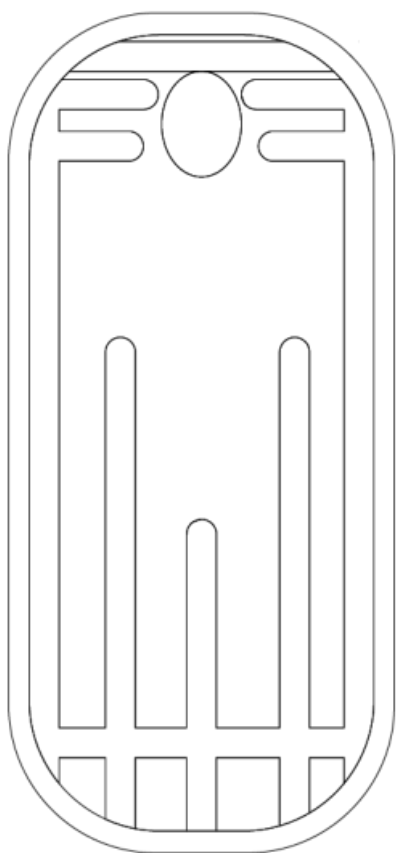
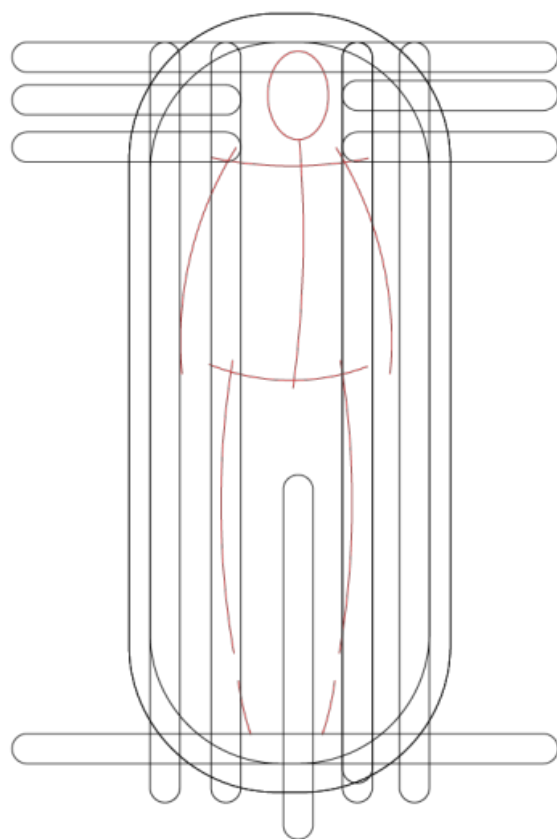
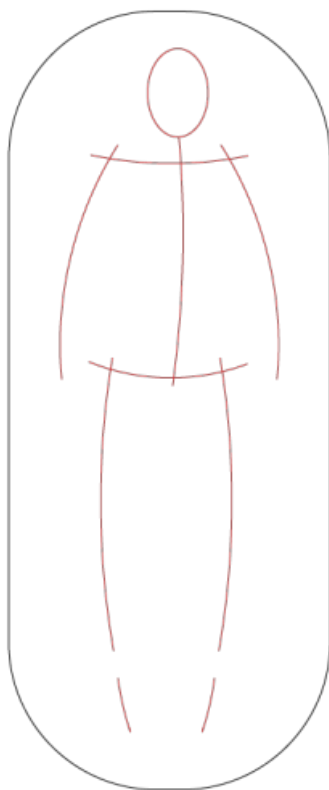


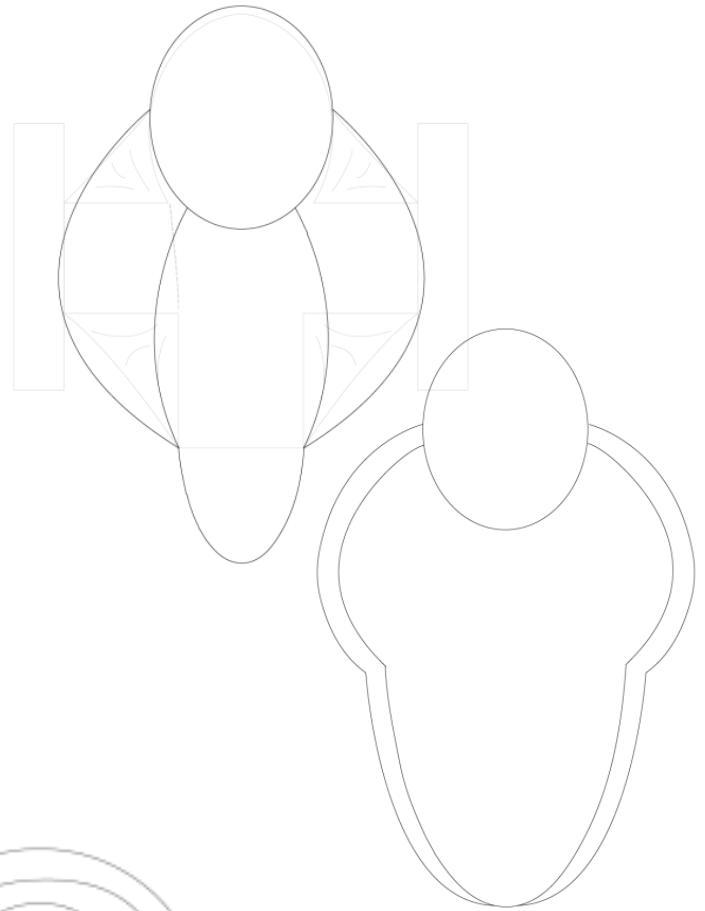
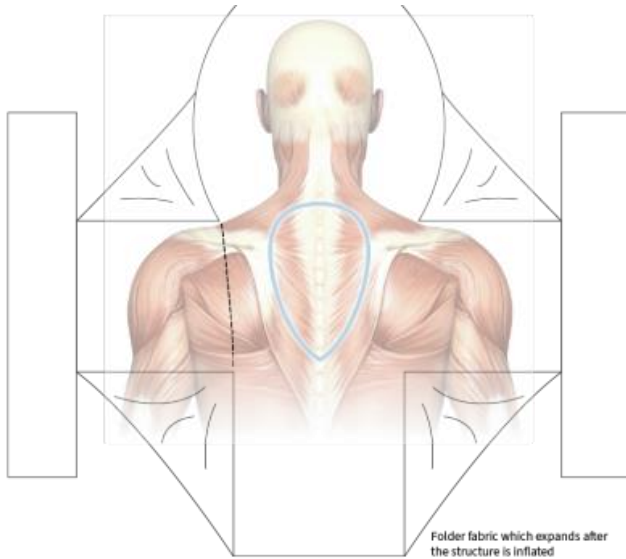
HAND DATA	MEN			WOMEN			CHILDREN			
	2.5% tile	50.% tile	97.5% tile	2.5% tile	50.% tile	97.5% tile	6 yr.	8 yr.	11 yr.	14 yr.
hand length	6.8	7.5	8.2	6.2	6.9	7.5	5.1	5.6	6.3	7.0
hand breadth	3.2	3.5	3.8	2.6	2.9	3.1	2.3	2.5	2.8	—
3 ^d . finger lg.	4.0	4.5	5.0	3.6	4.0	4.4	2.9	3.2	3.5	4.0
dorsum lg.	2.8	3.0	3.2	2.6	2.9	3.1	2.2	2.4	2.8	3.0
thumb length	2.4	2.7	3.0	2.2	2.4	2.6	1.8	2.0	2.2	2.4

CONCEPT INITIAL IDEAS

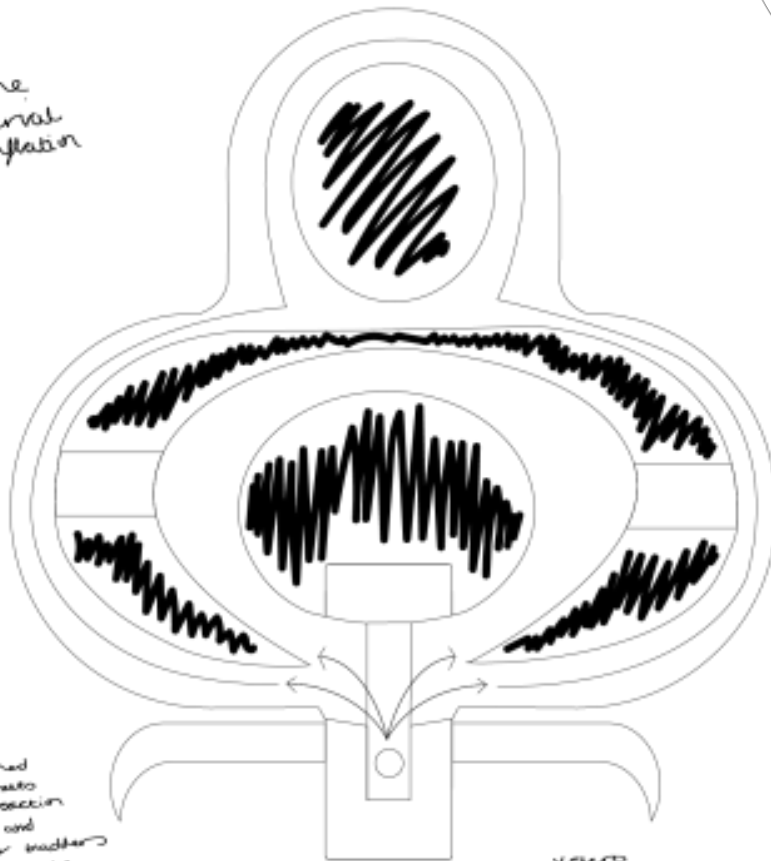






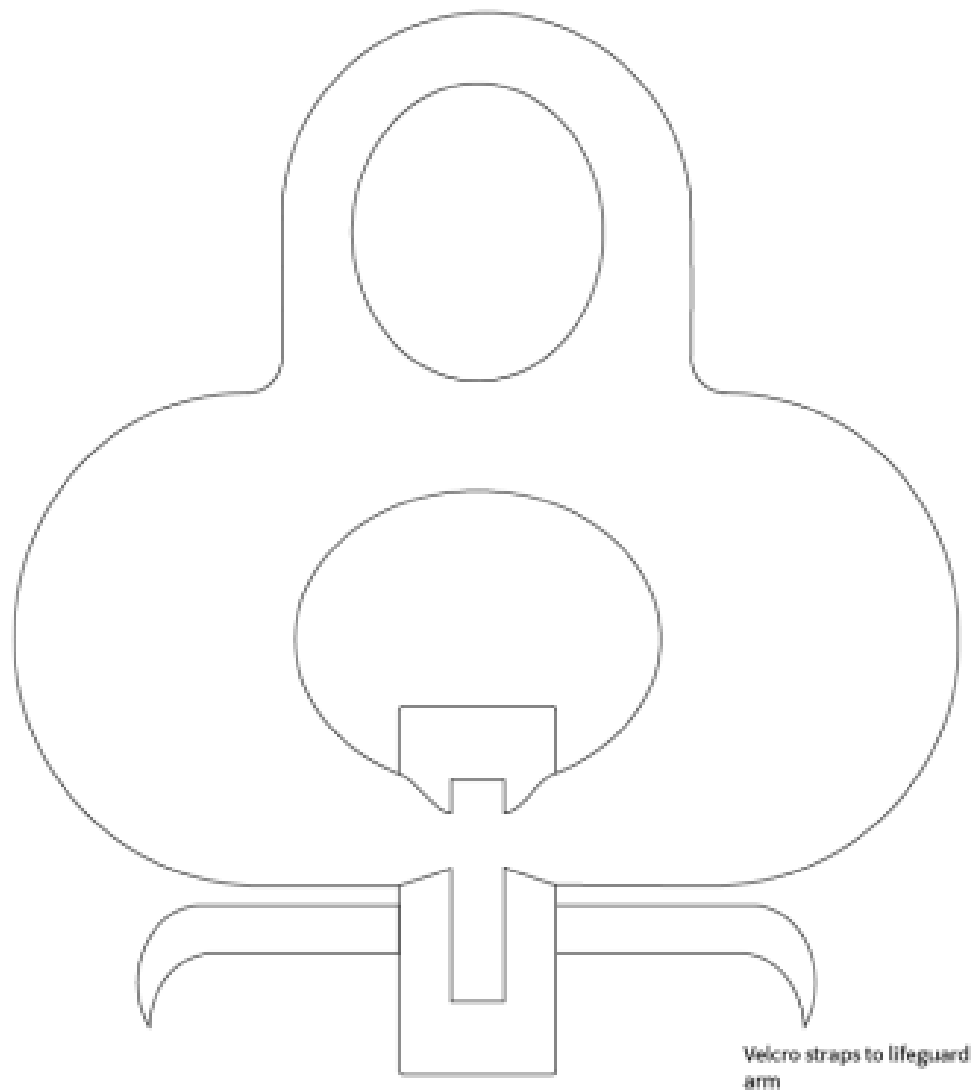



 = same material no inflation



Small portion of stomachs which when broken and pushed by upward, acts of stomach reaction emitting CO₂ and filling the air bladder and supporting the carotid vessels and weight

Vagus nerve to stomach



All in one inflate on back of head and neck structure. Lifeguard position hand of back of head as they would when performing the vice grip manoeuvre, then press the chemical pouch to inflate the product which inflates while turning the casualty. Once the casualty is turned the product will continue to inflate to full capacity within seconds. The casualty will then be supported fully, taking the ease of the lifeguard to fully hold the clamp position and making it easier to tread them to shallow water and safety.

EXISTING PRODUCTS

EXISTING RESCUE PRODUCTS

	Teqler Head Immobilisation Set	• Teqler head immobilisation set • With wide openings for ears • The head strap can be adjusted to the patient's forehead • Only small interference with CT, MRT and X-rays • With straps to attach the set to the spinal board • Waterproof plastic for a high level of hygiene • Easy to clean • Durable • Needed straps included • Measurements: 40 x 25.5cm (W x D)
	Head Immobilisation Set	• Foam padded sides covered with an orange bag that can be taken off and washed • Padded forehead strap • All straps can be length adjusted with Velcro fasteners

	Headlock Head Immobiliser	• Fits easily on to any spinal board • Made from MicrAgard anti-microbial materials • Yellow for high visibility and X-ray translucent • Fluid repellent and impact resistant • No Velcro is used and can be easily assembled or folded flat for easy storage.
	Ferno Combi Head Immobiliser	• Uniquely designed base pad and strapping system providing optimum fitting in all cases. • Latex-free Polyurethane moulded head-blocks, which are impervious to liquids and contain anti-bacterial additives. • Accidental surface damage will not affect the integrity of the product, which means enhanced durability and many years of effective use. • Compatible with all versions of Scoops and Spine boards, by altering orientation of head-blocks and using a specially designed strapping system. • Compact in design, can be stored whilst located on a spine board or separately in a cupboard. • Allows replacement of individual parts, not the complete product. • For immobilising the head when using a Scoop® Stretcher or spine board to transport a patient

		• Provides secure immobilisation preventing further injury to the head and neck • Can be used on Ferno® spine boards, Scoop® or breakaway stretchers • X-ray and MRI compatible • Highly visible, reusable, and easy to store.
	Laerdal Speedbloacks Head Immobiliser	• Easy, 4-step process for application - blocks provide a contoured fit for any patient aged 2 and upwards • Multi-axis blocks system to accommodate all head shapes and injury positions • Gives direct access to patient's ears for better communication • Handle-locking mechanism with quick-release locks give confidence to the user and patient • Radiolucent, MRI and CT scan compatible.
	Compact Universal Head Immobiliser	• For immobilising the patient's head • Can be used with a spinal board or scoop stretcher • The head position can be easily adjusted using the Velcro® straps to keep the patient's head stable • The base is reinforced in areas that are more exposed when in use • Made of high-density foam, covered with water repellent material.

	Aqua board head restraint	• Head restraint for use with the Aquaboard • For rescue of casualties with suspected spinal injuries from swimming pools and leisure centres • Use to immobilise and carry a casualty in water to the poolside.
	RLSS UK PXB (pool extraction board)	• Designed specifically for lifeguards and operators, it provides significantly faster rescue times, improved safety, and reduces demands on staff. • The innovation requires just two trained users to carry out a pool rescue for deck-level pools, and three trained users for freeboard pools (max freeboard depth 30cms) as opposed to the traditional four users. • This means fewer lifeguards are drawn into a rescue, enabling them to continue to monitor other swimmers and perform key roles in a rescue situation. • The versatile board can be used with or without a freeboard and at any depth. • A rescue using the new Pool Extraction Board can be accomplished in as little as 90 seconds. • Size:- 200 x 40cm • Weight:- 10kg • Maximum Load Capacity:- 182kg

	Aquaboard	• The Aquaboard serves to immobilise a casualty within the water, helping to prevent secondary injury to the spinal cord prior to recovery on the poolside. • Incorporating several innovative features, the Aquaboard is quick and simple to apply and is effective for aquatic rescue. • The durable back support, manufactured from hard wearing neoprene material, easily attaches to the board by means of Velcro strapping. • The non-slip base of the back support helps prevent the casualty from moving once strapped to the board. • For ease of use, four basic stages of application are clearly illustrated on this support which allows the patient to be accurately positioned for optimum stability • 5 Body and Leg Straps with colour coded buckles for ease of identification and accurate application • Lightweight Head Restraint with three retaining straps • Fully Adjustable to accommodate various casualty sizes from child through to adult • A concave design for easy positioning under the supported casualty • A convex underside with protected straps and built-in runners to facilitate a smooth manoeuvre • Multiple hand holds enable easy carrying without jeopardising the rigidity of the board
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		• A special design feature helps the board float up and under the casualty • As the board is X-Ray Translucent, the patient can remain on the board throughout X-Ray procedures • Size:- 183 x 43cm • Weight:- 8kg • Maximum Load Capacity:- 182kg
	Rescue Can	• Flootation device (Baywatch buoy) • For saving drowning victims • Buoyancy supports people weighing up to 150 kg • Made of robust HDPE • Multiple handles allow one to hold onto the can from 3 sides (can also be held by multiple people simultaneously) • Unbreakable from impacts deriving from up to 4 meters in height • Dimensions: 68 x 24.4 x 14 cm • Weight: approx. 1.5 kg
	Leardal Stifneck Select® Neck Collar	• Adjustable sizes: tall, regular, short, no-neck • The adjusted size is securely maintained • Adjustment tracks ensure symmetrical size adjustment • Uses the same size and application method as the original Stifneck collar • Easy access for pulse checks, airway management and a clear view of the larynx through oversized trachea hole • Room for large fingers to slide through the rear panel for cervical palpation • User instructions stamped onto the collar • Economical und space-saving

		• Radiolucent, MRI and CT scan compatible
 	Adjustable Cervical Collar	• Variable, adjustable cervical collar • To immobilise and stabilise the cervical spine • Holds the cervical spine in a straight position • Ideally suited for use during patient transport inside and outside the clinic • For single use - particularly hygienic • Width adjustable with Velcro • Height adjustable with ratchet mechanism (16 settings for the adult and 12 for the paediatric collar) • Quick and easy to fasten to the patient in only a few simple steps • Made of strong plastic with soft foam cushioning • Space saving storage • Radiolucent, CT and MRI compatible • Generous apertures in the front and back of the neck allow for pulse monitoring and respiratory management • Latex-free, non-toxic, and hypoallergenic • Adult collar colour: blue green paediatric collar: yellow
	Cervical Collar for Children	• Laerdal Stifneck Select Neck Collar, children • Securely holds adjusted size • Guide grooves guarantee symmetrical size adjustment • Same size selection and adjustment as with original Stifneck collars • Oversized tracheal opening provides easy access for pulse-

		taking, respiration management and unobstructed view of the larynx • Room for large finger palpation at back side • Instructions stamped inside collar • Economical, space-saving • X-ray permeable, MRT- and CT compatible
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I used 3 UK based sites including St John Ambulance, www.sja.org.uk, Royal Life Saving Society, www.rlssdirect.co.uk, and Ferno, www.ferno.co.uk, to source these existing products which are all used with suspected spinal injuries. I also used to worldwide site Amazon, www.amazon.co.uk.



REVERSE ENGINEERING OF THE PXB BOARD

POOL EXTRACTION BOARD (PXB)

Pool Extraction Board (PXB) was created in partnership with the RLSS UK and Ferno UK.

Compared to the previous Aqua board, the new design creates faster rescue times, offers improved safety, and has the potential to reduce demands placed on staff whilst ensuring the casualty is extracted from the pool with the correct care and attention for £955.97 each.

Ferno have developed the PXB in conjunction with the Royal Life Saving Society to make safe patient extraction from pools as simple as possible.

Benefits

- Fewer lifeguards required
- Faster and easier extraction compared to other systems
- Full C-spine immobilisation
- Ease of deployment due to colour-coded restraints
- A reduction in manual handling risks
- Less training required

Dimensions

Board length minimum – 2000mm

Board width overall – 400mm

Board thickness body – 40mm

Board thickness overall – 70mm

Overall depth with head blocks attached – 200mm

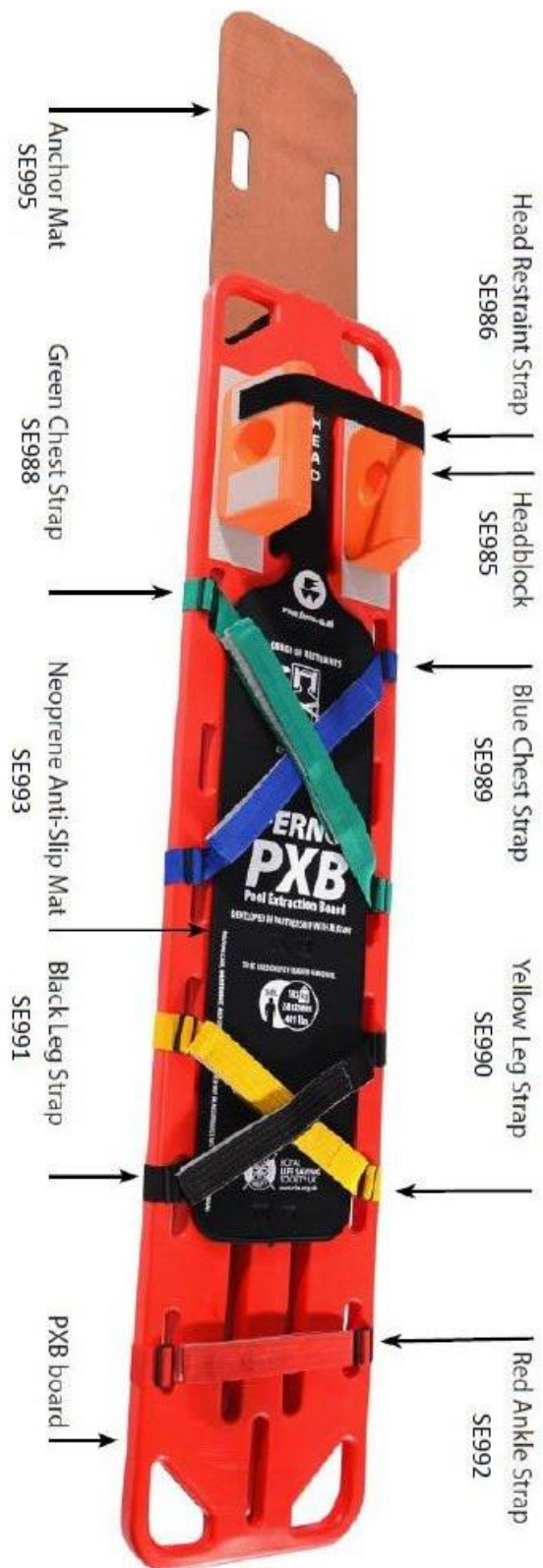
Maximum Load Capacity – 182kg

Nett Weight – 10kg

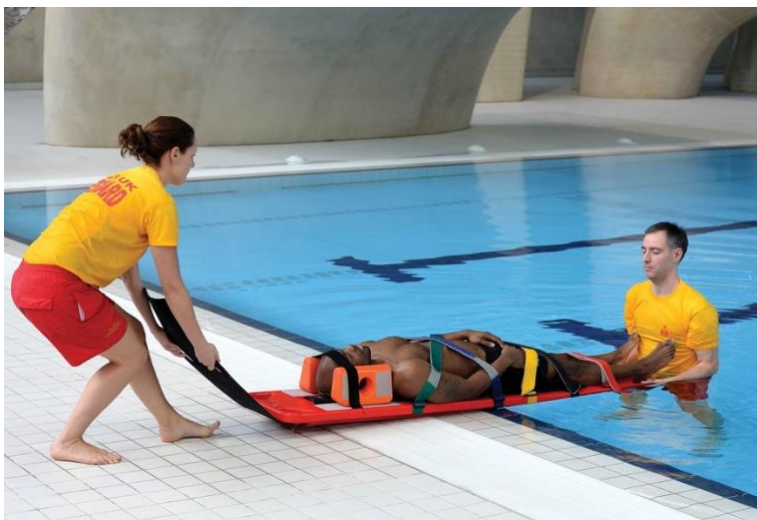
Materials

Board Construction – Cross-linked Polyethylene

Base Mat – Anti-slip neoprene







Set of 2 head blocks and x1 head strap



X1 head strap





X1 Chest/Waist Strap (Green)



X1 Chest/Waist Strap (Blue)



X1 Leg Strap (Yellow)



X1 Leg Strap (Black)



X1 neoprene anti-slip mat - £135.67



X1 Wall mount bracket

X1 Anchor mat - £120.42



AQUABOARD IMMOBOLISATION SYSTEM

X5 AQUABOARD straps and x1 anti-slip mat

SE1411 Body Strap Green

SE1412 Body Strap Blue

SE1413 Body Strap Orange

SE1414 Leg Strap Black

SE1415 Leg Strap White

£215.82



X5 AQUABOARD straps

SE1411 Body Strap Green

SE1412 Body Strap Blue

Se1413 Body Strap Orange

SE1414 Leg Strap Black

SE1415 Leg Strap White

£215.82

**X1 AQUABOARD Head Restraint**

£48.50 each



AQUATIC THERAPY FOR SPINAL CORD INJURIES

I found these aquatic therapy products interesting as they allow the individual to float with spinal injuries. They show me different ways of supporting the body in water.



STRUCTURAL RESEARCH

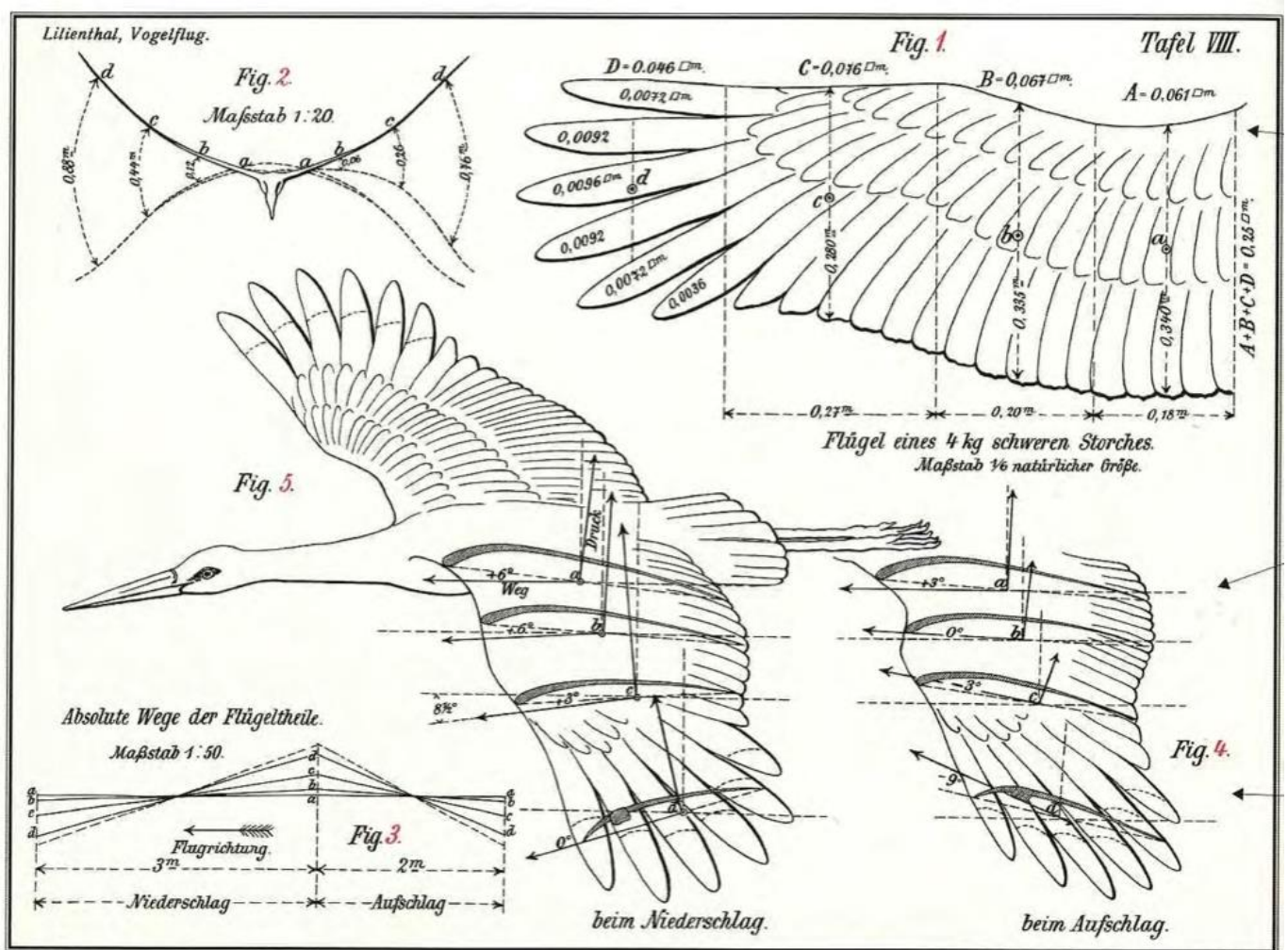
BIOLOGICAL INSPIRATION – BIRD FLIGHT

Bird Flight

Otto Lilienthal (German civil engineer) conducted the first studies of bird wing shapes around 1890. He was convinced wing curvature was key to gliding behaviour.

Findings

Curved cross sections (aerofoils) was found and then used for his gliders which resulted in the invention of the first safe hang-gliders capable of multiple journeys.



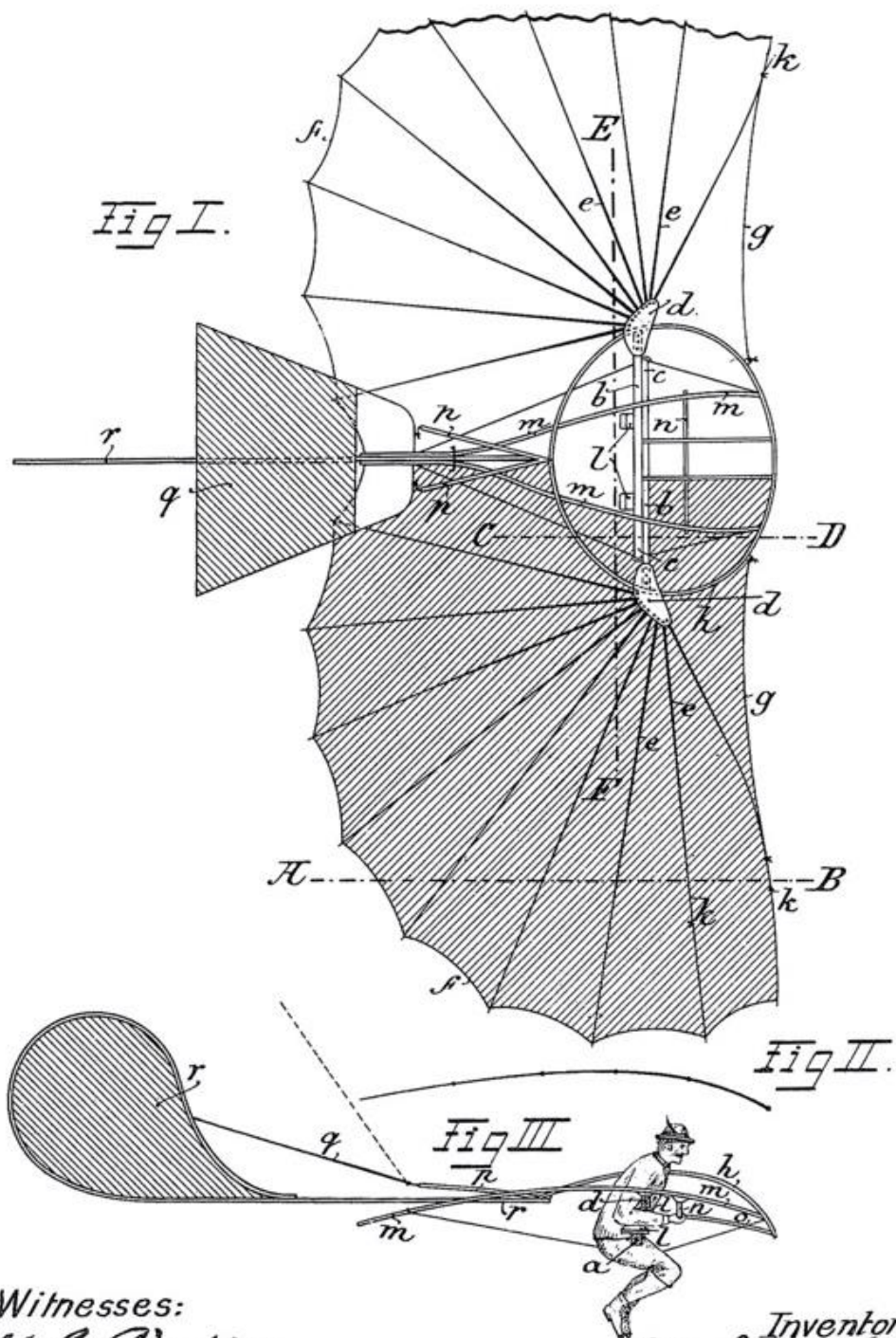
(No Model.)

2 Sheets—Sheet 1

O. LILIENTHAL.
FLYING MACHINE.

No. 544,816

Patented Aug. 20, 1895.



Witnesses:
 W. C. Pinckney
 N. E. Bowen

Inventor:
 Otto Lilienthal
 By Attorney:
 J. M. Dwyer

Biomimetic Product – Otto Lilienthal

Lilienthal's concept relied on shifting body weight to manage the direction of travel.

How the Concept Could Potentially be Applied to my Project

The shape of the aerofoils in this product is mimicked from birds.

Aerofoils are a 'structure with curved surfaces designed to give the most favourable ratio of lift to drag in flight' (OxfordDictionaries, 2021).

Although the product is designed for air, a similar shape may work well in water also. However, as Lilienthal's concept was controlled by the direction of the wind and not user, this would suggest the water would have a lot of control over the direction of travel also instead of the lifeguard.



Biomimetic Product – Wright Brothers

Orville Wright and Wilbur Wright (brothers) developed the design to achieve control over direction of movement with greater accuracy.

Studies on the way bird's maneuverer during flight discovered they manage movement of flight by altering the angle of their wings.

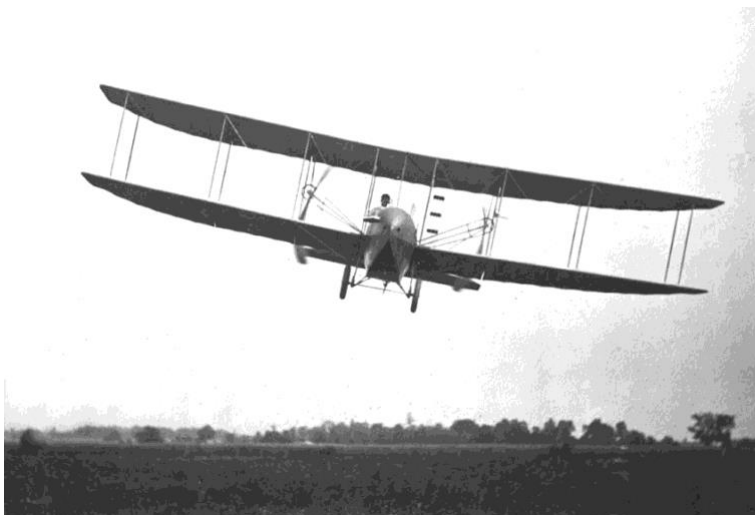
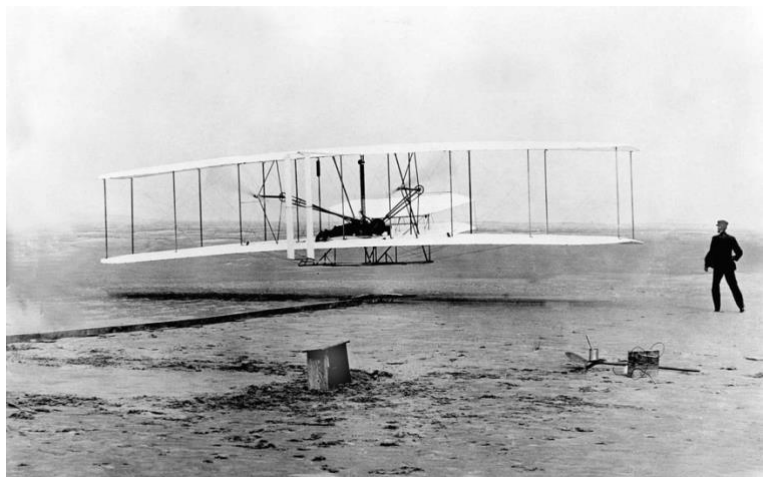
Wright's wing warping technology – a mechanism consisted of rudder-controlled system. Once applied to the design of gliders, they were able to alter direction by warping or twisting wings just as birds do.

Wings create 'covert' feathers which help create smooth airflow over the wind

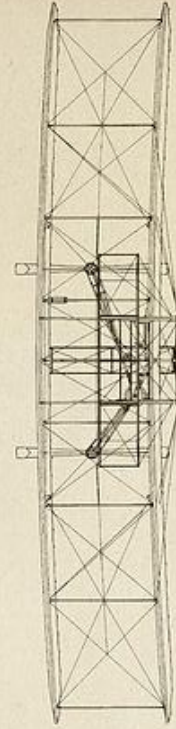
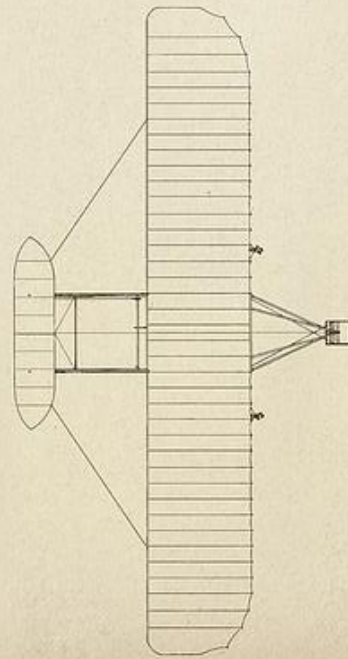
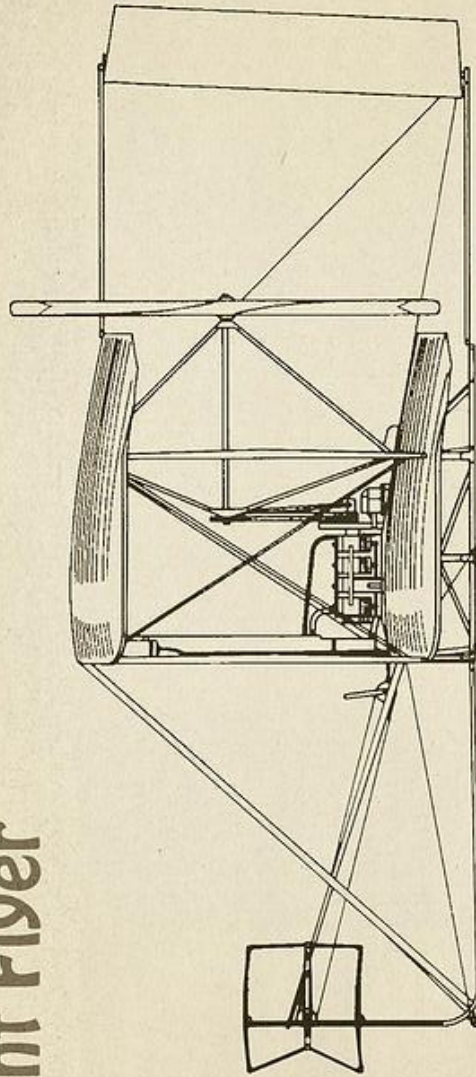
Plane wings currently have same concept. Three-axis controlled system invented by the Wright's brothers that allows the pilot to steer the aircraft effectively.

How the Concept Could Potentially be Applied to my Project

Features which separate Lilienthal's concept from the Wright brothers' concept, such as the 'wing warping technology' consisting of a rudder-controlled system, could be mimicked to add control over direction for the lifeguard's benefit.



Wright Flyer



Name: Wright Flyer
 Role: First airplane
 National origin: United States
 Designer: Orville and Wilbur Wright
 Manufacturer: Wright Cycle Company
 Owners and operators: Wright Brothers

First flight: December 17, 1903
 Last flight: December 17, 1903
 Flights: 4
 Fate: On display (National Air & Space Museum)
 Type: Experimental canard biplane

Crew: One
 Length: 21 ft 1 in (6.43 m)
 Wingspan: 40 ft 4 in (12.31 m)
 Height: 9 ft (2.74 m)
 Wing area: 510 ft² (47 m²)
 Max. takeoff weight: 745 lb (338 kg)

Powerplant:
 4 cylinder engine, 12 hp at 1150 rpm
 Two contra-rotating propellers
 Maximum speed: 30 mph (48 km/h)
 Total distance: 1,500 feet (0.45 km)
 Service ceiling: 30 ft (9 m)

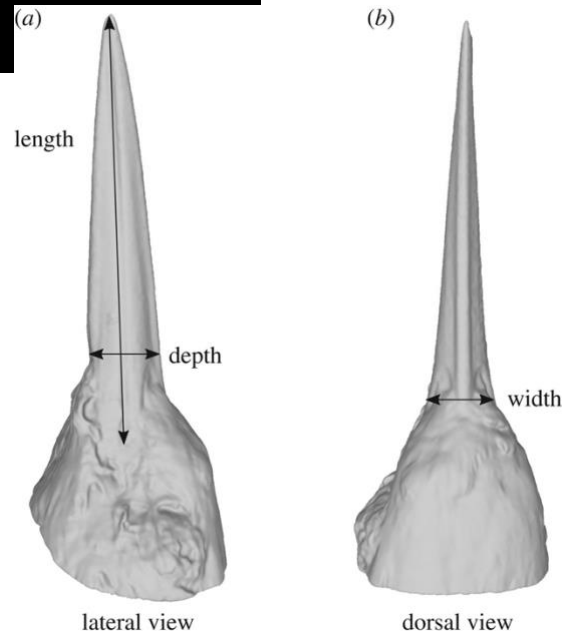
BIOLOGICAL INSPIRATION – KINGFISHER BEAK

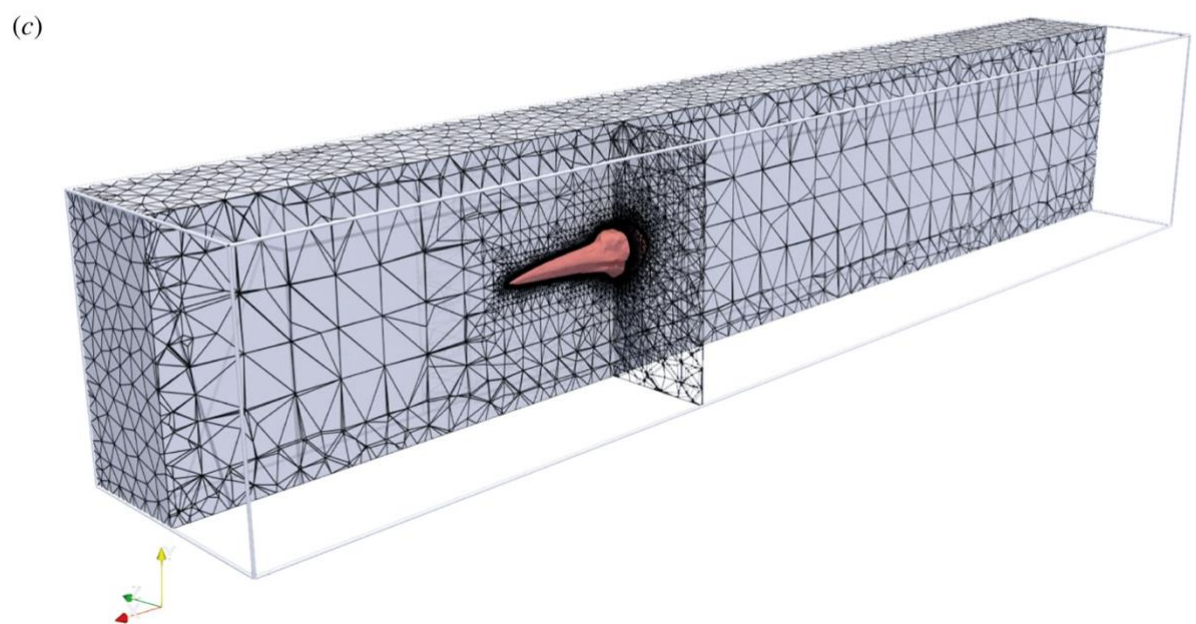
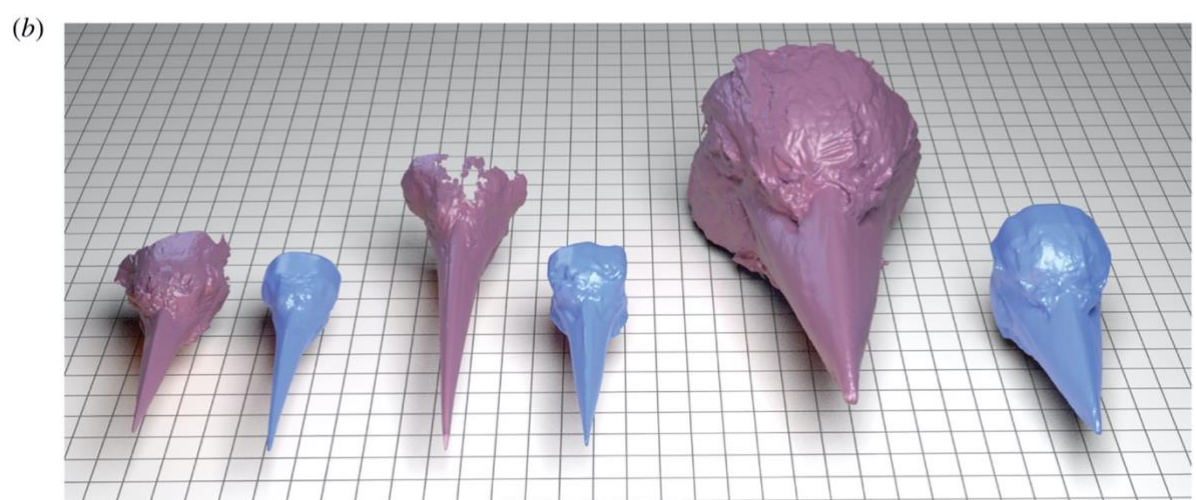
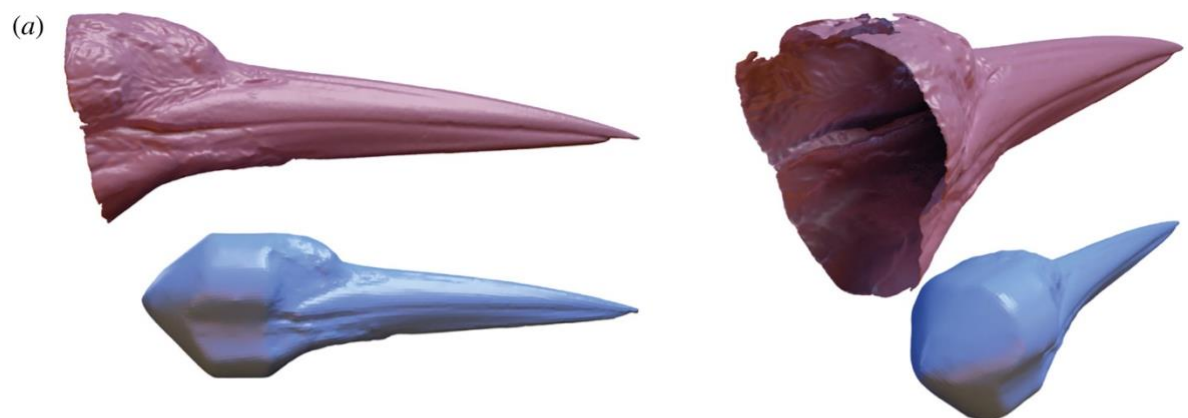
Kingfisher Beak

The Kingfisher has a long, streamlined beak which forms a wedge with its head that is round in cross-section and has a pointed tip with grooves along each side.

Findings

The unique form allows it to dive into the water without making a splash. The bird dives from air (area of low resistance) into water (higher resistance) without splash due to unique beak.





Biomimetic Product - Shinkansen Bullet Train

The form of the beak was mimicked exactly to create the Shinkansen series 500 train. It has the benefits of reduced noise and efficient energy consumption. It is the fastest train in the world reaching speeds of 200mph.



How the Concept Could Potentially be Applied to my Project

As the bird travels from air (area of low resistance) into water (higher resistance) without splash due to unique beak, the lifeguard needs to enter the water and approach the casualty causing minimal splash and water movement as possible. The beak could offer some insight into how to achieve the most minimal splash for the lifeguard's aid as possible.

BIOLOGICAL INSPIRATION – DOLPHIN FUSIFORM SHAPE

Dolphin body shape

Dolphins have highly streamlined shapes as they're able to leap out of water. Dolphins have fusiform body and the characteristics elongated droplet shape. Marine mammals such as dolphins and whales migrate long distances and are apex predators. Due to their fusiform body and highly streamlined shape, they can swim energy efficiently.

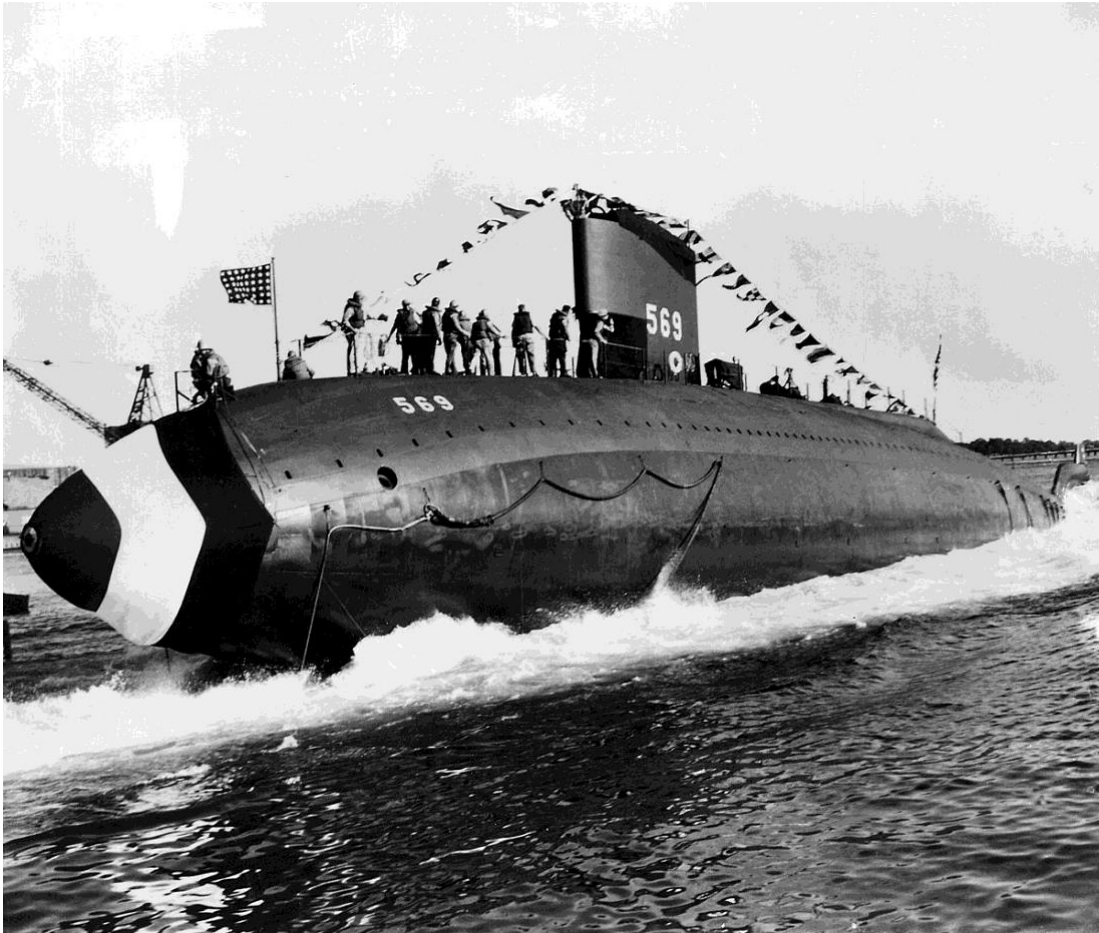


Findings

Sir George Cayley aerodynamic pioneer studied the dolphin and aquatic mammals and mimicked it within his design in the 1800's. He studied the body shape of a dolphin and concluded that fusiform design (resembling an elongated droplet with a rounded leading tip and a thick middle tapering gradually to the tail) delivered the least resistance among solid shapes. Aquatic animal body parts such as fins, flippers and tails similarly echo this design principle.

Biomimetic Product - Streamlined hulls

These findings inspired the modern submarine hulls including the USS Albacore (AGSS-569) 1953.



How the Concept Could Potentially be Applied to my Project

The primary strategy for drag reduction in aquatic mammals is streamlines profile of their bodies and appendages and Sir George Cayley found that the fusiform shape delivered the least resistance among other solid shapes. Therefore, the fusiform shape can be applied to the shape of my project as it would deliver the least amount of resistance than any other shape and therefore give a lot more ease with the lifeguard pulling and treading with the casualty.

The shape would mean the lifeguard would require less energy to tread and move the casualty as the shape would overcome drag forces.

MOVEMENT THROUGH WATER

Drag

Water is dense compared to air and viscous medium. Resistant forces such as drag occur.

The friction between the surface of a moving body and the contacting layer of water causes a reduction in the speed of flow.

As water flows over a surface, it slows down, and drag is created by the difference in speed between the sheet of water that meets the water flowing away.

THRUST

To move forward and overcome drag forces, speed, acceleration, and manoeuvrability is required.

Strategies which maximise the control of water flow are to optimise energy use by managing water flow, reducing resistant forces, and increasing propulsive forces.

BIOLOGICAL INSPIRATION – HUNPBACK WHALE PECTORAL FIN

Humpback Whale Pectoral Fin

The Humpback whale has amazing precision manoeuvrability in water.

A side view of the pectoral fin from a humpback whale shows the bumps/tubercles along with edge of fin.

Adult humpback whales can grow to 15metres long and weigh 40 tonnes yet capable of precise and agile manoeuvres.

They can swim in tight circles as narrow as 1.5metres in diameter which generates vortices filled with bubbles that trap large quantities of krill in a single session.

This level of agility demonstrated by such a large mammal suggests a highly sophisticated method of controlling and manipulating drag forces.





Findings

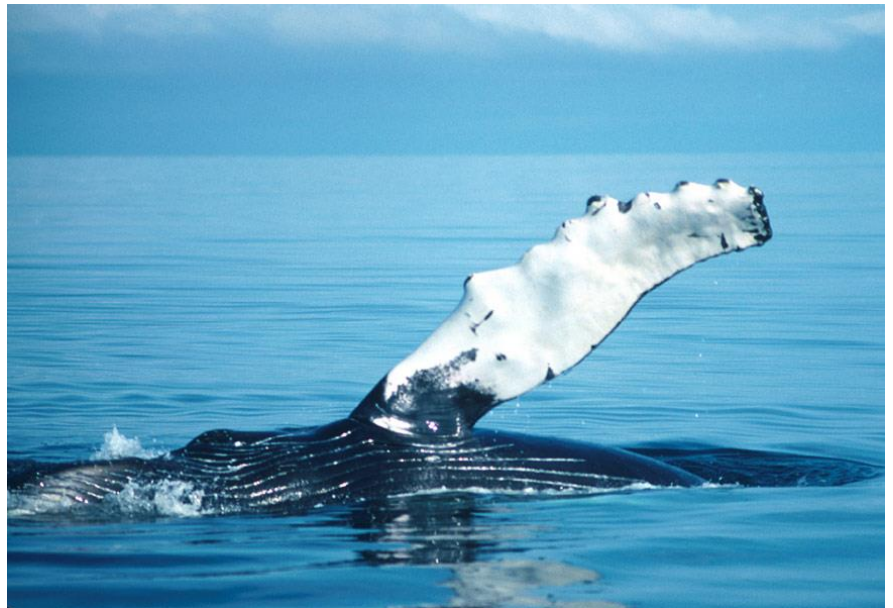
Dr Phil Watts and Dr Frank Fish in 2004, discovered that this was due to design of the pectoral flipper.

The flipper is long with a high aspect-ratio – there is a large difference between the length and the width of the structure – like a bird's wing.

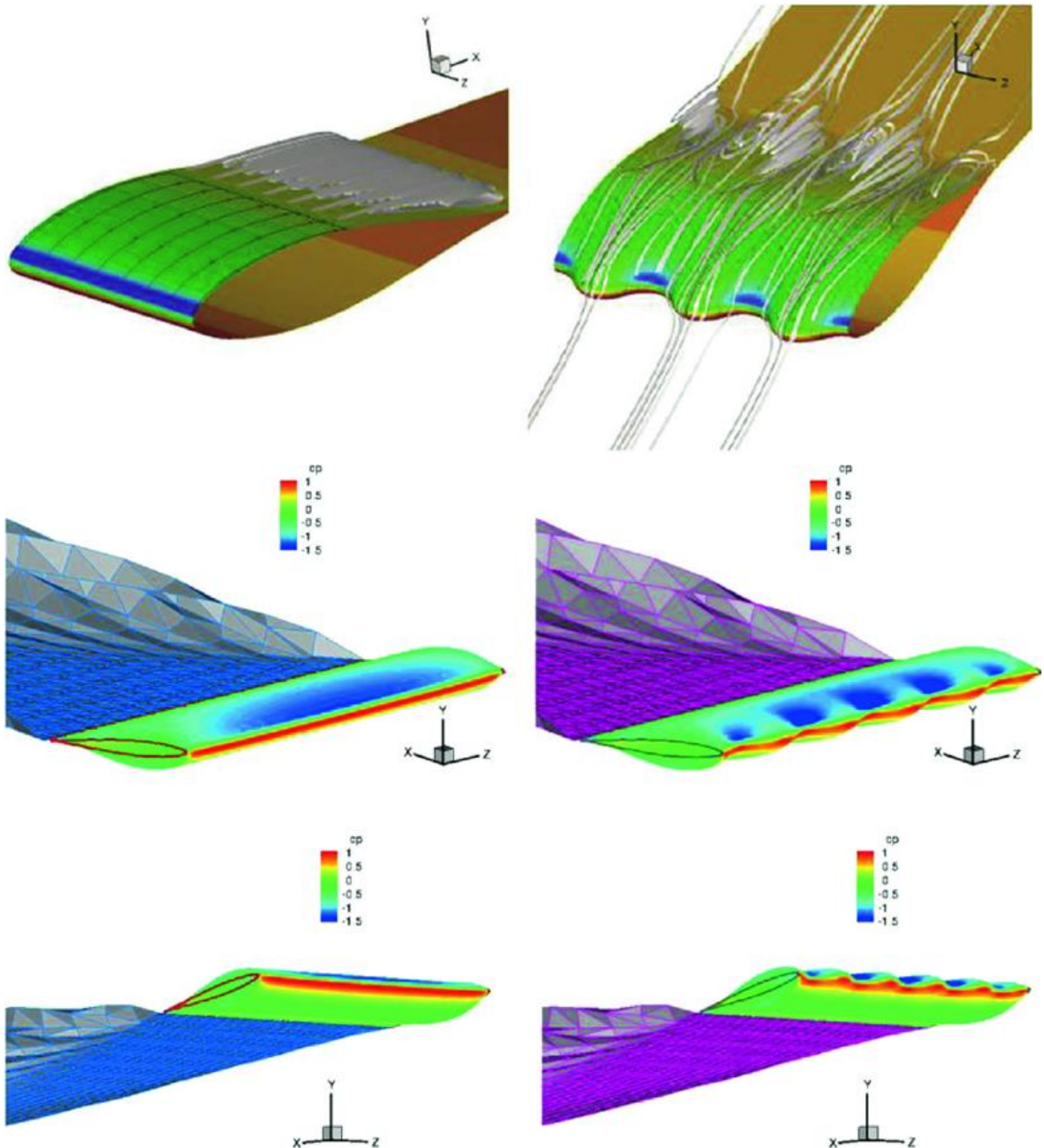
Characteristic large irregular bumps called tubercles line the flippers leading edge

As the flipper moves, the tubercles manage the flow of water by splitting the contact sheet of water into even channels. This simple design feature is estimated to improve lift by 8% and reduce drag by 32% compared to a smooth flipper.

Large sheet of water flowing over the smooth surface of a fin creates a strong drag force. Water flowing over a bumpy fin is divided into smaller streams, minimising the creation of drag forces.



Graphs represent drag on a smooth surface compared to a rigid edge



Biomimetic Product - Tubercle technology

Specialised wind turbine blades which mimic the whale fin can generate more energy at moderate wind speeds than a conventional blade.

Large sheet of water flowing over the smooth surface of a fin creates a strong drag force. Water flowing over a bumpy fin is divided into smaller streams, minimising the creation of drag forces.

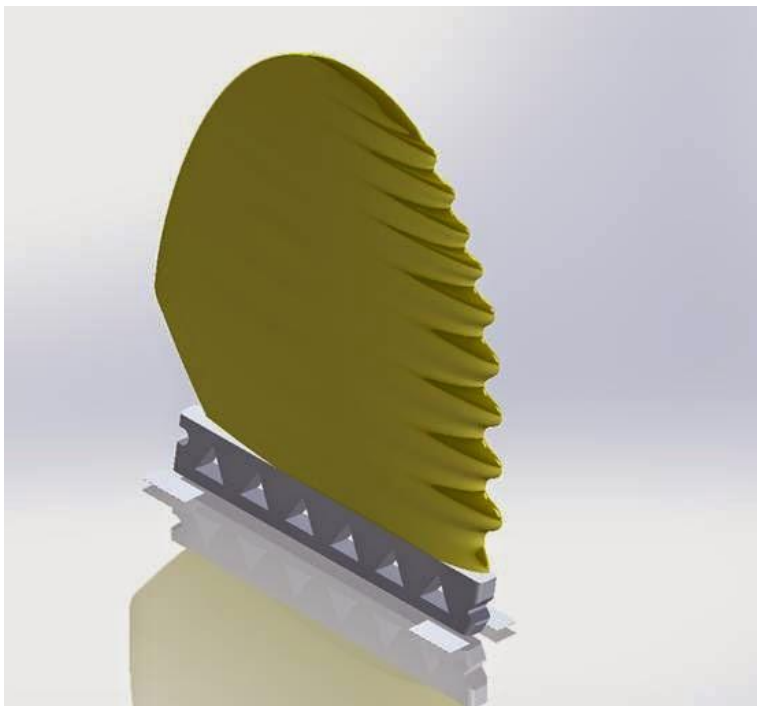
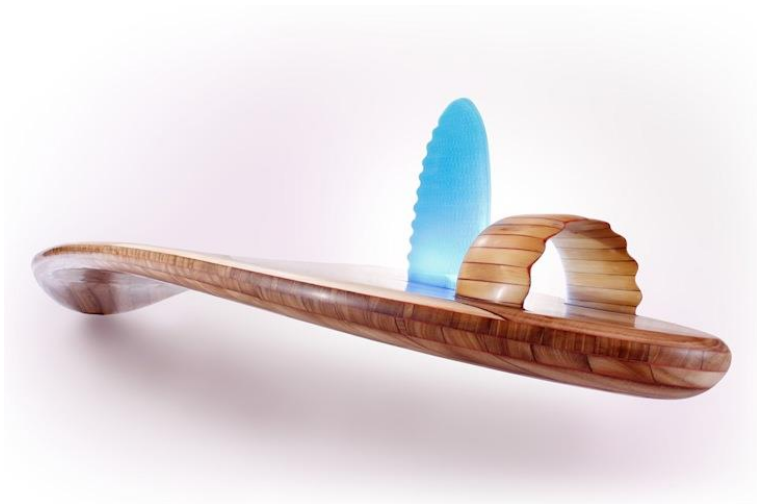
Roy Stuart

The New Zealand surfboard shaper handcrafted the most expensive surfboard from wood named the 'Rampant'. Applied principles of



Tubercle technology to the design of the surfboard fin improves the performance of large-wave surfboards during contact with water.

'Warp Drive Bumpy Leading-Edge Fin' provides great impact of manoeuvrability, great control and lift when compared to conventional designs.



BIOLOGICAL INSPIRATION - BOXFISH (TELEOSTRI OTARIIDAE)

Boxfish are rigid creatures due to a bony external structure of thin hexagonal plates that cover majority of body. This exoskeleton protects from impact.

The fish moves using a mechanism that involves complex motions of its five fins rather than body bending soft bodied fish.

The shape of the fish combined with the rigid structure of its exoskeleton and powerful fin muscles delivers a unique system that enables movement using a minimal amount of energy.

The shape is trapezoidal in shape, flat back (keel) structure, concave sides, and bumpy texture.



Findings

The specialised exterior enables fish to passively resist forces of turbulent water by transforming the turbulence into self-stabilising vortices, a mechanism which allows the fish to move through water in a smooth, energy-efficient trajectory with minimal engagement of its fin muscles thus conserving considerable amounts of energy.

The carapace or exoskeleton of boxfish is made of stiff hexagonal scales fused together.

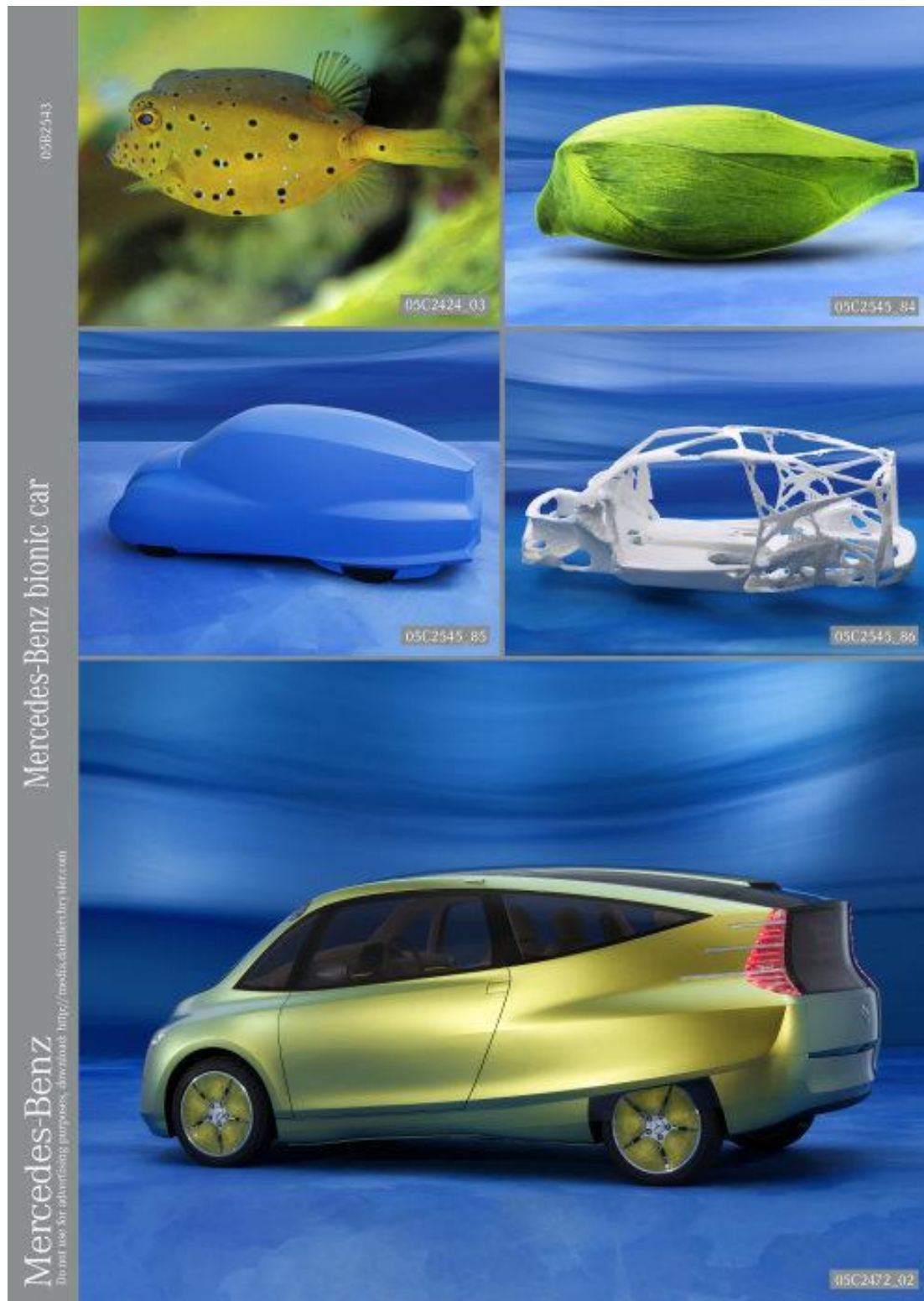


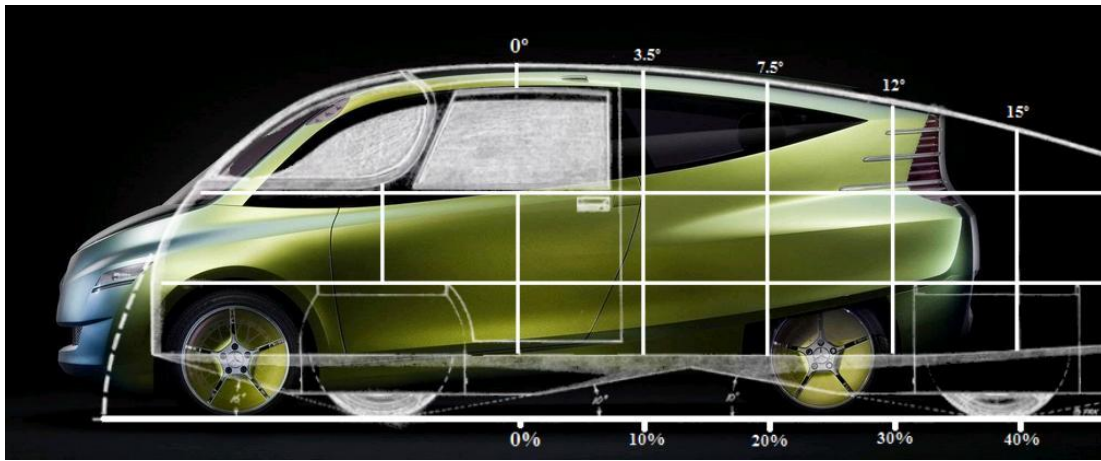
How the Concept Could Potentially be Applied to my Project

As the shape of a boxfish helps to remain stable in turbulent water. This shape could be repeated within my design potentially which would provide the same stability. This stability would be very useful for the lifeguard in trying to maintain the casualty's spine remains stable whilst being treaded in water.

Biomimetic Product - Daimler Chrysler and Mercedes-Benzes

Bionic concept car based on aspects of boxfish. It uses a combination of simple structural and textural design to deliver strength, stability, and agility passively.





BIOLOGICAL INSPIRATION – SHARK DERMA DENTICLES

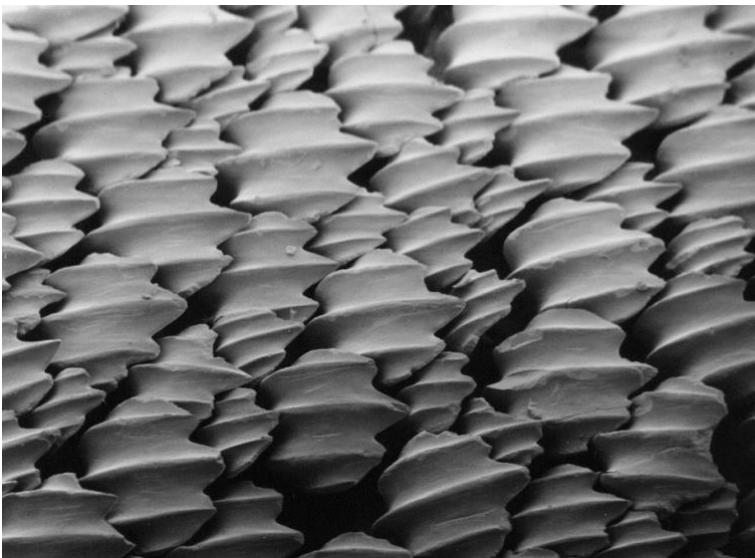
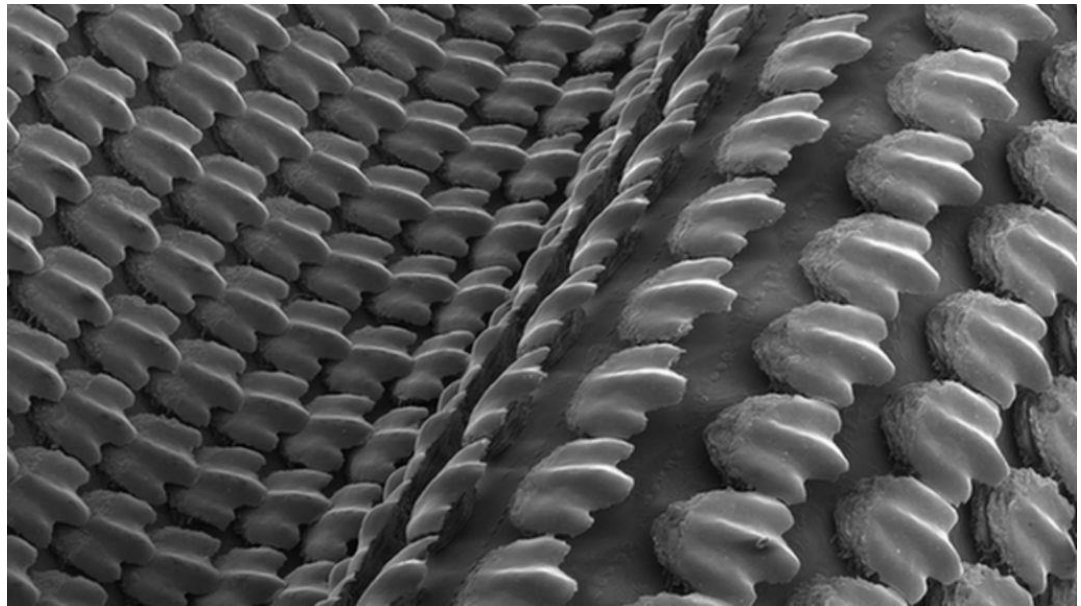
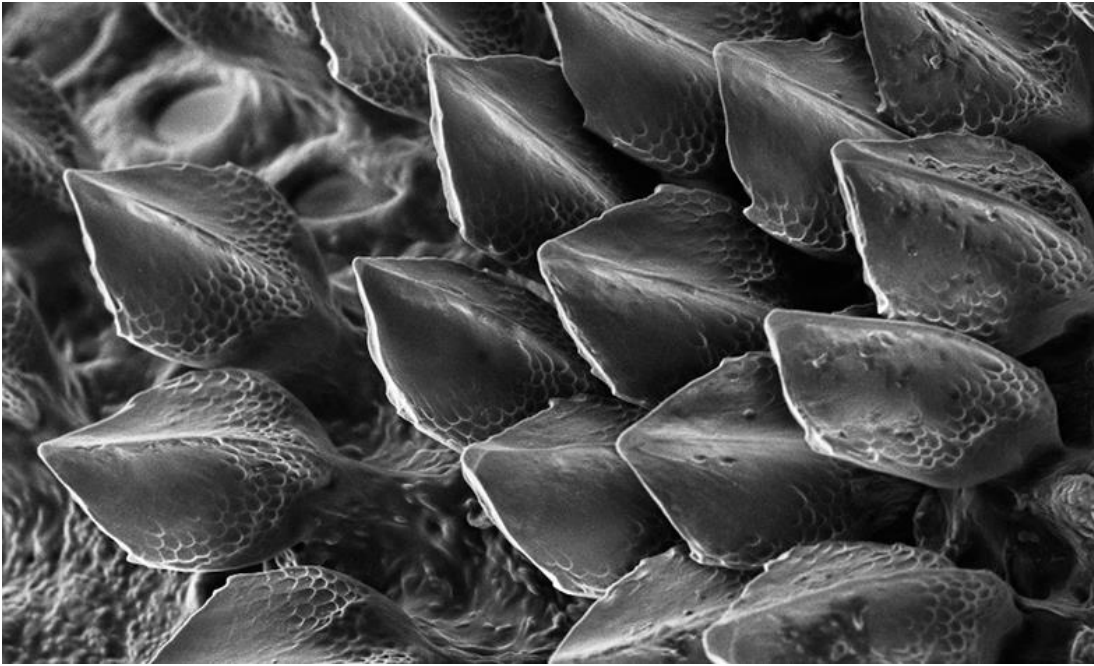
Shark Skin Derma Denticles

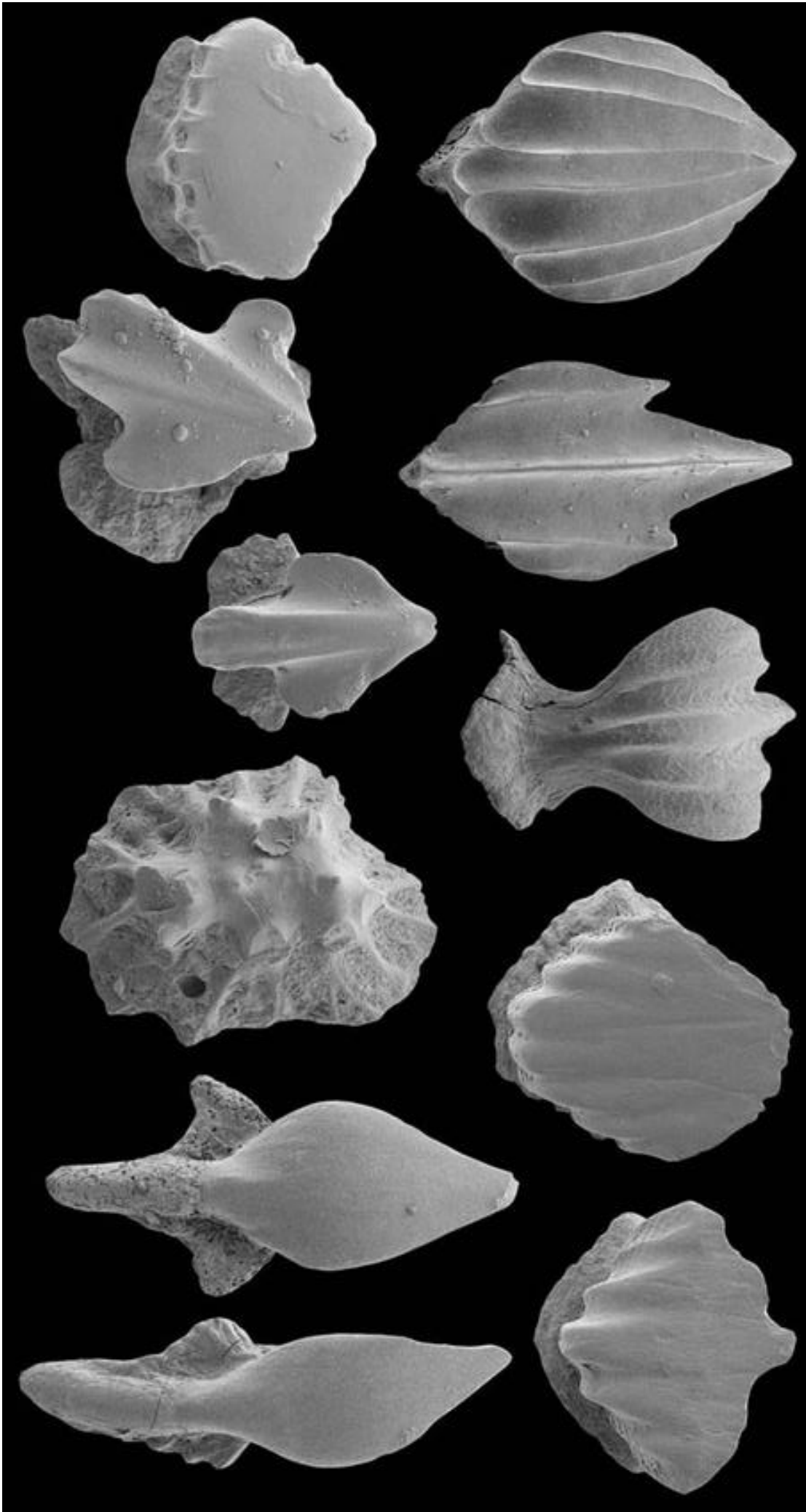
A shark's skin is covered by tiny flat V-shaped scales, derma denticles, that are more likened to teeth properties than fish scales. These denticles decrease drag and turbulence, allowing the shark to swim faster and more quietly due to less water disturbance.

A study published by Okinawa Churashima, Japanese marine biologist, has found that a whale shark's eyeballs are covered in hundreds of 'dermal denticles'. They are tiny teeth-like structures that coat their body also. The denticles reduce drag and help aid the shark glide through the water. It is suggested these denticles also offer protection to the eyes.

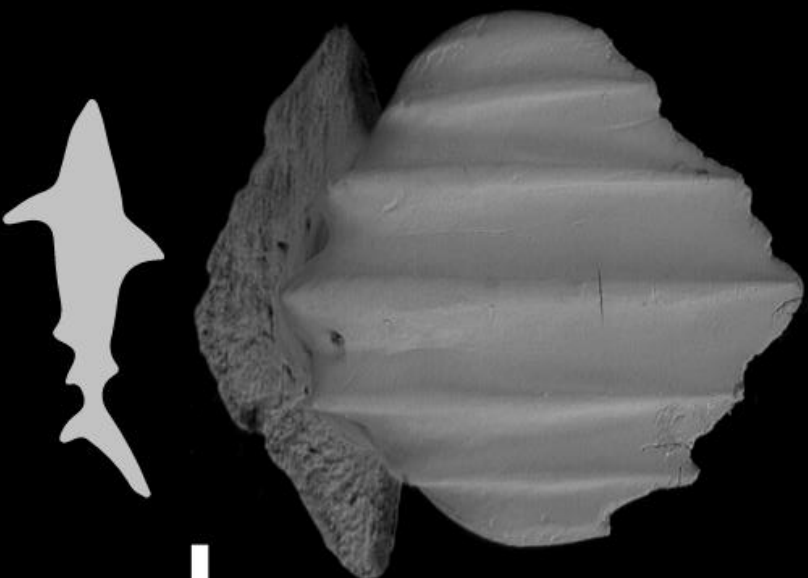
Findings

These microscopic size denticles work by channelling the water as it travels over the body. They are aligned to the direction of water flow. By channelling the water, they manage the speed and direction of water flow. If the shark's body was smooth and it's denticles were flat, the difference in water speed would create large turbulent vortices around the mammal which would resist motion and therefore making it harder to swim at speed.

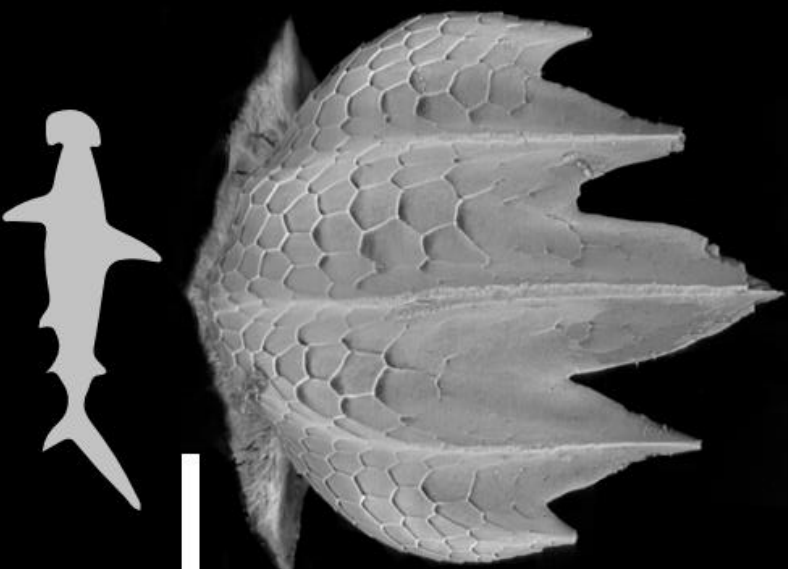




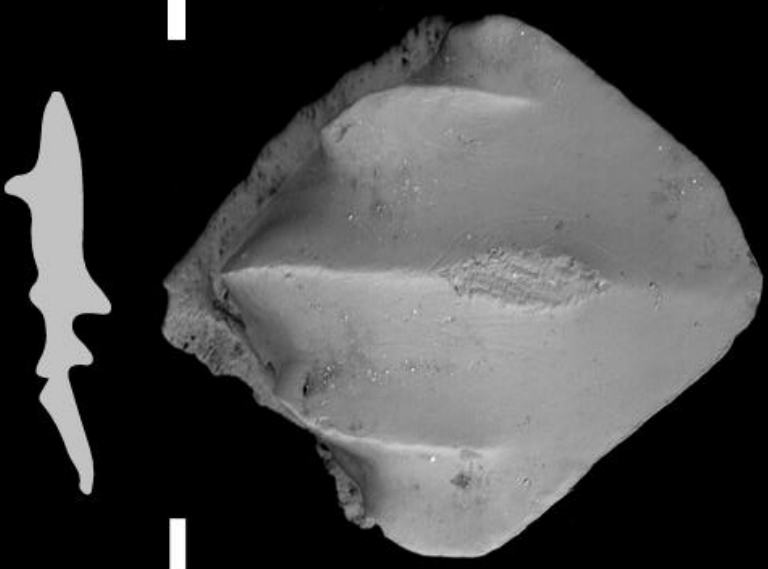
Family Carcharhinidae
Requiem sharks



Family Sphyrnidae
Hammerhead sharks



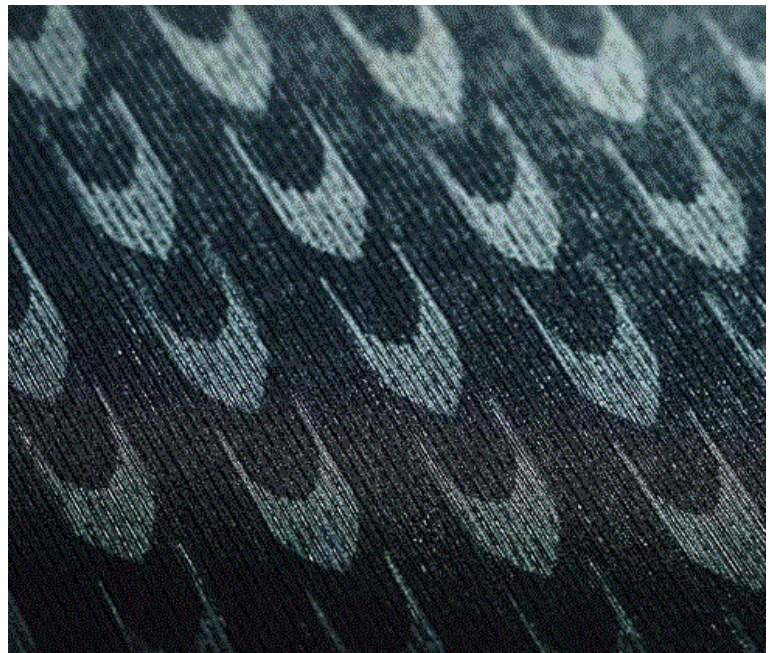
Family Ginglymostomatidae
Nurse sharks



Biomimetic Product - Speedo' FastSkin'

Speedo mimicked the shark denticle structure onto swimwear named 'FastSkin'. This swimwear was used in the 2000 Sydney Olympics where 13/15 records were broken and 83% of medals won which is evidence on how the structure works to purpose. The swimwear was later banned for competition use as it set a further 300 new records.

16.6% passive drag reduction, 11% improvement in oxygen economy, 5.2% reduction in full body drag.



BIOMIMETICS: DESIGNED BY NATURE, PERFECTED BY SPEEDO

SPEEDO FASTSKIN has been developed using biomimetics: the extraction of good design from nature. This means its features are based on those that make the shark an extremely fast mover in water. The fabric mimics the v-shaped ridges, called dermal denticles. These make the shark cut through water by sucking it closer to the body and so reducing drag.

SPEEDO FASTSKIN
The ultimate swimsuit. For the ultimate swim.

Water velocity 2m/s

Combination of fabric panels and unique seaming increases the co-ordination of muscles.

Maximum body coverage giving the optimum silhouette. Designed and cut using exact measurements taken from the world's elite swimmers in the racing position.

V-shaped ridges create small vortices. The denticle-shaped knit creates large vortices. These two currents work together to control the flow of water and reduce drag.

Inner arms incorporate gripper fabric that maintains the swimmer's grip and feel in the water.

SPEEDO **fast·skin™**

A graph showing the drag on different shark's denticles of different shapes

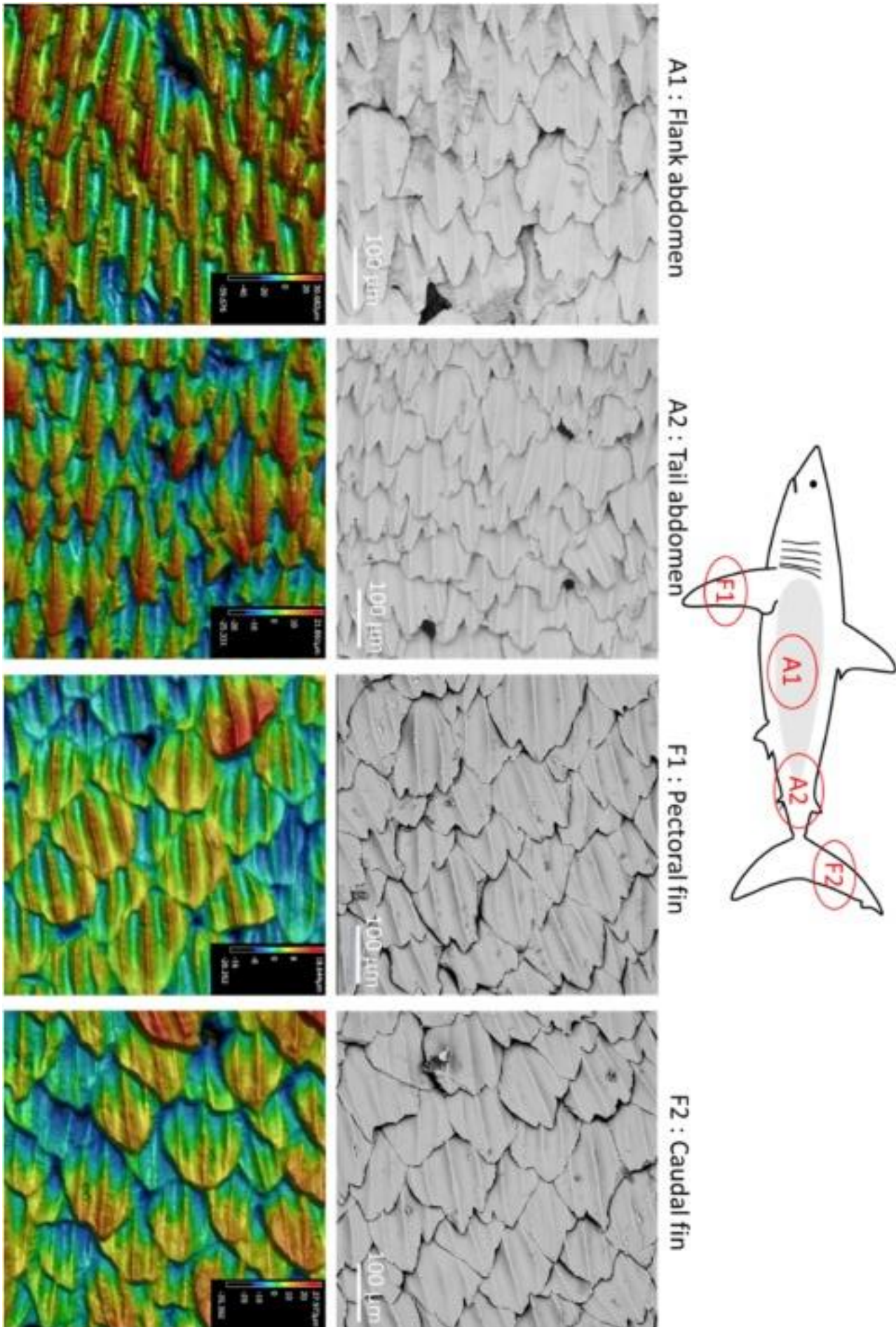
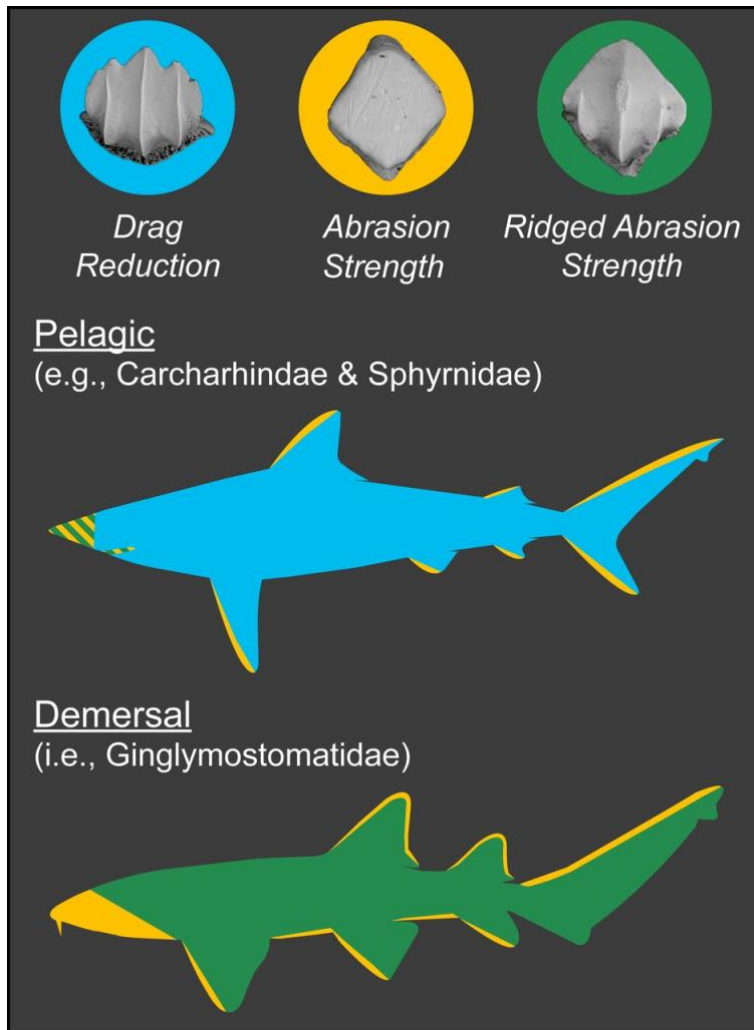


Diagram Explaining what properties apply to each denticle shape



How the Concept Could Potentially be Applied to my Project

This concept of shark denticles could be repeated within my design to minimise drag and improve the moveability for the lifeguard when transporting the casualty through water.

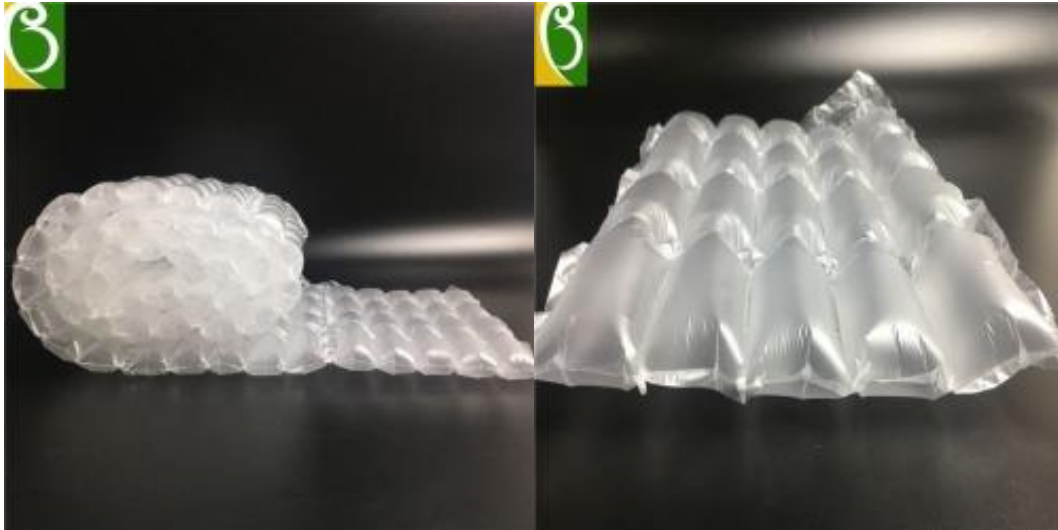
The structure and shape of them could be repeated on a larger scale for the air chambers in the product which would provide buoyancy so the casualty is closer to the surface of the water and the shape of the chambers would channel the water through them as opposed to a flat surface which would reduce drag. This would give more ease to the lifeguard and solve a common issue identified of a tired lifeguard due to them only being able to use their legs.

FUNCTIONALITY

POTENTIAL AIR CHAMBERS

AirPacks are inflated via a single nozzle which passes air through a series of patented one-way valves into independent air chambers that then inflate

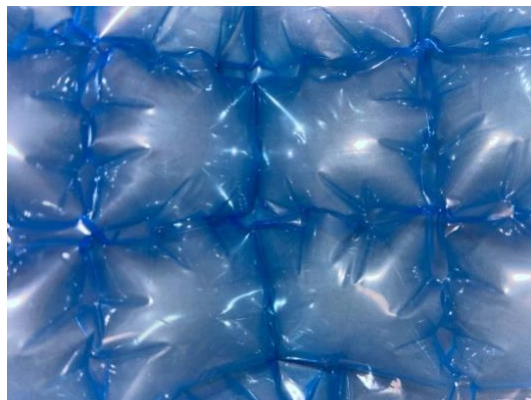
If one of the independent air chambers punctures during transit the remaining chambers remain inflated.

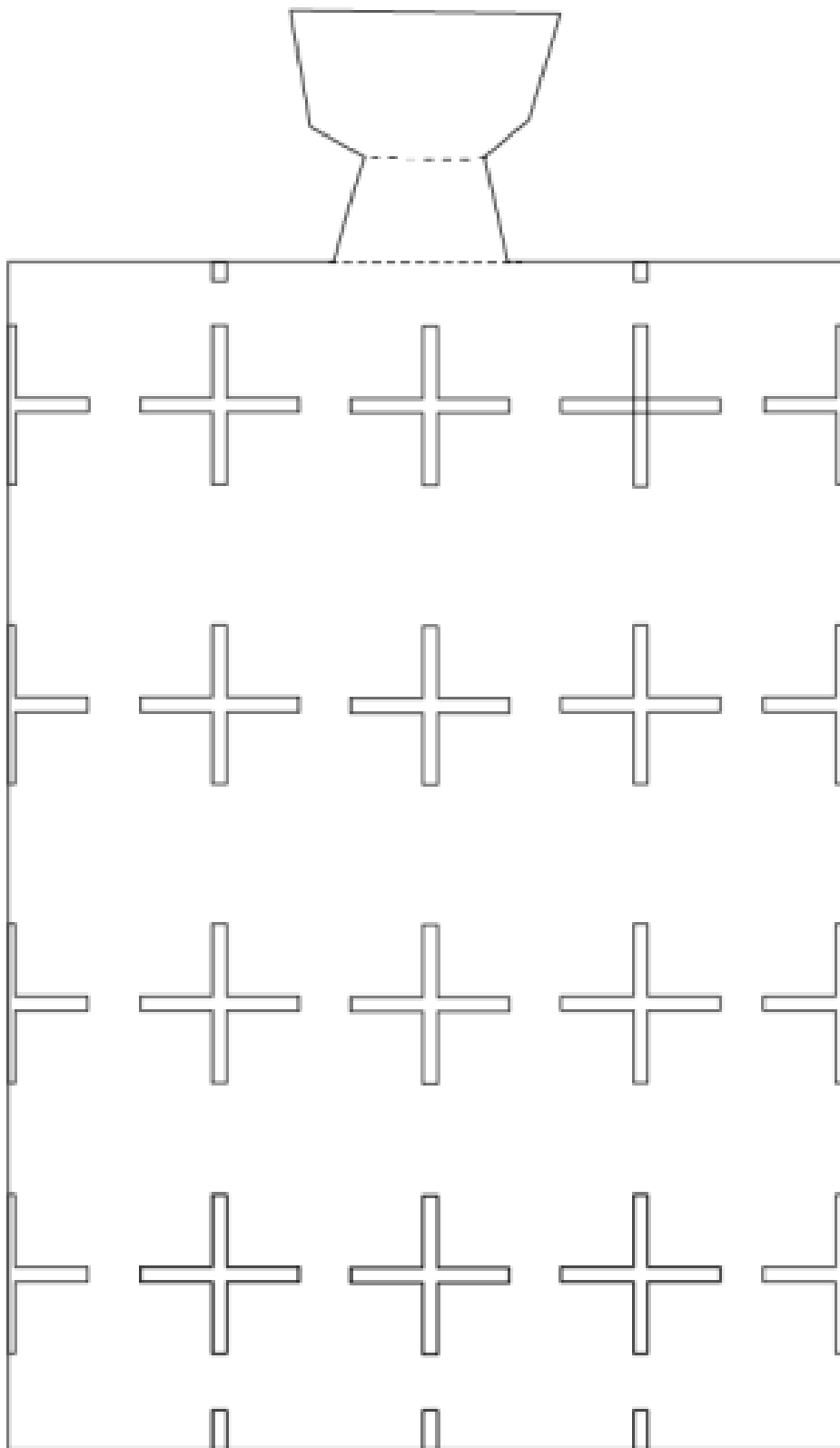


EXISTING PRODUCTS WITH AIR CHAMBERS

I have gathered many products with air chambers to view different ways of creating different structures. One product that stood out to look rigid yet flexible was the product with the structure that is like the lotus leaf structure which can be found through the contents page. This would provide good water resistance and stable support to the casualty as the lotus leaf structure does the same.







CHEMICAL INFLATION

At MIT, scientists and designers have developed technology, which is a chemical mixture in small, heat-sealed bags which when popped will create a chemical reaction which emits CO₂. This gas then inflated the surrounding space instantly.

Sodium Bicarbonate (NaHCO₃) and Citric Acid (C₆H₈O₇) emits CO₂.

Benefits

- Changes of the shape, volume, texture, temperature, colour, and movement can be achieved with this technology.
- Small to large shape change
- Soft and Rigid Structures for control of dynamic movement
- Surface Pattern can be applied to create texture through repeated patterning, adding shapes and movement

Below is a video demonstrating the technology and images showing the possible outcomes.

<https://spinalinjuryproject.tumblr.com/post/636541770414555136/self-inflation-technology>







CO2 CANISTER

Each canister is connected to a separate pull tab located on the front of the vest. When you pull on a tab, a nail punctures the lid of the compressed CO2 cartridge which allows the gas to expand and fill the bladder.

At this stage of the project, I am unable to determine whether a CO2 canister will be large enough to fill the design as I haven't got a final design. However, I could use multiple CO2 canisters within the design, but this would mean the lifeguard would have to pull more than one tab and therefore resulting in more time lost.

THE TESTING OF LIFE-JACKETS

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FIG. 25.—As (24), underwater view.



FIG. 26.—Vertical jacket, "self-righting" first stage.



FIG. 27.—As (26), further stage.

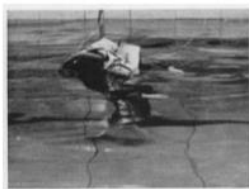


FIG. 28.—Head support incomplete.



FIG. 29.—Good head support.

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FIG. 7.—Buoyant overall, rough water, stable when prone.



FIG. 8.—Life-jacket, supine 45° position.



FIG. 9.—As (8), underwater view.



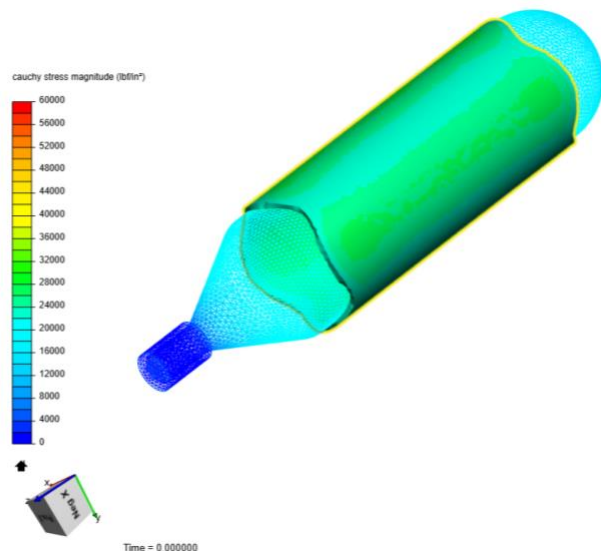
FIG. 10.—Supine, 45° jacket, start of "self-righting".



FIG. 11.—As (10), further stage.



FIG. 12.—As (10), "self-righting" almost complete.



COMPARISON

	CO2 Canister	Chemical Inflation
Method	Pull tab – nail punctures lid of cartridge	Heat sealed bag of sodium bicarbonate and citric acid mixed to emit CO2
Gas emitted	CO2	CO2
Capacity	10g 16g, 20g, 24g, 33g, 38g and 60g	Contact MIT for specifics of ratio
Size	33g = length 13.5cm	Contact MIT for specifics of ratio
Aesthetics	Tab visible	Not visible to outside
Functionality	Rapid air to fill air chamber	Rapid air to fill air chamber
Speed	Testing required	Testing required

EVALUATION OF MATERIALS FOR CONTROLLED AIR REACTION CHAMBERS

K. W. Wilson and H. Buchberg

K. W. WILSON and H. BUCHBERG

Department of Engineering, University of California, Los Angeles, Calif.

Evaluation of Materials for Controlled Air Reaction Chambers

CHEMICAL reactions involving minute traces of pollutants continuously occur in the natural air environment. A transparent air reaction chamber used to study these reactions must be made of materials which fulfill five major requirements—they must transmit all short-wave-length solar radiation and not remove nitrogen dioxide, ozone, or any material from the polluted air. Air components must not diffuse through the chamber walls. The materials must not introduce pollutants into the enclosed air, must withstand the necessary structural loads, and must have a reasonably useful life.

Experimental Investigation

Transmission of Solar Radiation. Figure 1 shows the transmissivities of various plastic films as obtained with a Beckman DU spectrophotometer. The values for glass were taken from manufacturer's literature. No attempt was made to obtain highly accurate data for a single specimen of film, because the variation in properties between batches makes this impractical. A satisfactory wall material must transmit a high percentage of radiation down to 300 mμ (5, 70). Saran, Mylar, and window glass are clearly unsuitable. Borecillate glass might be acceptable but is less satisfactory than Flex-O-Glas, Teflon, polyethylene, Kel-F, and cellophane. Cellothene (polyethylene sandwiched between cellophane) became yellow after several days' exposure to sunlight and is unsuitable.

Pollutant Removal at Walls. Any material that removes pollutants by adsorption or chemical reaction is unsuitable for use in an air reaction chamber. Obtaining this kind of information for each pollutant is obviously impossible, as so many are not yet identified. Nitrogen dioxide, ozone, acetone, methanol, pentane, and cyclohexene were chosen as representative pollutants and investigated without attempting to distinguish between adsorption or chemical reaction with test materials. Two identical glass flasks, one with and one without plastic film, were filled with blends of pollutant and oxygen, nitrogen, or air, and pollutant concentrations in the two flasks were compared at appropriate time intervals (3). Ozone was determined colorimetrically by measuring the amount of iodine produced when a measured volume of gas was shaken with neutral 20% potassium iodide solution.

Nitrogen dioxide analyses were made by the Saltzman method (6). Organic vapors were determined by passing a measured volume of gas through a trap cooled in liquid oxygen, evacuating the trap, warming it, and introducing the contents into a mass spectrometer.

Figure 2 summarizes studies with ozone and various structural materials. The precision is not high, but the results are sufficiently meaningful to permit conclusions. All glass flasks were filled with oxygen containing 100 to 500 p.p.m. of ozone and allowed to stand overnight before use. The number of joints and stopcocks in the apparatus was kept low and a minimum amount of fluorocarbon grease was used. Ozone decomposes slowly in a 12-liter flask (Figure 2A) and the effect of the glass container can be neglected for most experiments; the decomposition rate is appreciable in 250-ml. flasks. Poly(vinyl chloride), unpainted maple, and painted surfaces react with ozone much too rapidly to be incorporated in any air reaction chamber (Figure 2B and C). Silicone-coated wood or metal reacts rapidly and should be avoided (Figure 2C). Saran, Mylar, cellophane, polyethylene, stainless steel, and aluminum react slowly enough to be useful in large chambers. Figure 2D, shows that the rate of ozone disappearance is roughly proportional to the amount of polyethylene present. Results with Kel-F and Teflon are omitted because the reaction rate is of the same order of magni-

tude as that for ozone disappearance in an empty glass flask.

Figure 2E, shows ozone decomposition rates in two containers constructed entirely of Kel-F. The 16 × 34 inch bag consisted of two flat pieces of 0.005-inch film heat-sealed together; it contained 9 liters of ozonized oxygen. For the 27 × 30 inch chamber, 0.005-inch film was sealed with Scotch tape having adhesive on both sides; care was taken not to expose any tape inside the chamber. In these containers ozone decomposes at a slow but measurable rate which may be due to traces of foreign materials on the plastic surfaces. No attempts were made to remove minute traces of foreign matter from the glass or plastic surfaces and subsequently to determine relative ozone decomposition rates on glass, Kel-F, and Teflon surfaces.

Experiments with a 27 × 30 × 30 inch polyethylene chamber of 0.005-inch film (similar to the Kel-F chamber) showed that the ozone decomposition rate agreed with that predicted from the surface volume ratio of the chamber and the data of Figure 2D. This rate was essentially unchanged by flexing the chamber walls to produce turbulence, or by previous contact of the polyethylene with acetone or nitrogen dioxide.

Table I summarizes the results of experiments with nitrogen dioxide and various films. Preliminary experiments indicated that only small changes in concentration occurred, which were due to a

Table I. Action of Nitrogen Dioxide on Plastic Films

Plastic	Plastic Surface/ Gas Vol., Ft. ² /l.	Standing Time, Hr.	NO ₂ in Flask, P.P.M.		P.P.M. Adsorbed $\left[\frac{\text{Final}}{\text{Concn.}} \right] \left(\frac{\text{Sur.}}{\text{Vol.}} \right)$
			Empty	With plastic	
Kel-F	19	3	0.78	0.78	0.000
	19	3	0.88	0.88	0.000
Kel-F bag (no glass surface)	30	24	1.29*	1.55	-0.005
	30	120	1.29*	1.19	0.003
Polyethylene	33	5	0.56	0.27	0.032
	20	5	1.66	1.11	0.025
Saran	23	4	1.84	1.32	0.017
	23	18	2.52	1.63	0.024
	23	16	2.28	1.60	0.019
Poly(vinyl chloride) (Flex-O-Glas)	19	4	13.8	2.6	0.23
	19	17	4.0	0.70	0.25
Aluminum	1.0	70	3.4	2.1	0.62
Stainless steel	1.3	24	5.5	4.7	0.13

* Initial concn. in bag.

DEFLATION

I have investigated deflation processes. I want to include a sustainable, secure, and reliable method of deflating the project. My paddleboard took my attention as the deflation was rapid, secure, and reliable. It is cost effective as well. It is watertight and will not allow water within in but allows air to escape. The valve is called the Halkey-Roberts Valve

Halkey-Roberts Valve

The Halkey Roberts valve has a special pushpin inside. This pushpin has two positions, both up and down. When it is pressed into the down position, air will escape. Once the pin is in the 'popped up' position, air can be inserted but no air will escape from the valve.



ARCHIMEDES' PRINCIPLE - PHYSICAL LAW OF BUOYANCY

This principle states that the buoyant force applied to an object is equal to the weight of the fluid displaced by the object

The depth of a liquid (or pool) does not affect the buoyant force.

My product will remain buoyant in all sizes of pools in both the deep and shallow end.

Weight is a downward force

Buoyant force is an upward force.

The force applied upward on an object by any fluid.

Objects that are less dense are more buoyant

Bubbles rise in a fizzy drink as the air is less dense than the liquid they are in

Displacement is the context in which an object moves a fluid so it can occupy the volume the fluid originally occupied. (When getting in a bath

BERNOULLI'S PRINCIPLE

This principle states that as the speed of a fluid increases, its pressure decreases

Lift is the upward force created by the difference in pressure above and below a wing

PASCAL'S PRINCIPLE

This principle states that a fluid in a closed system increases the pressure throughout the fluid equally and in all directions

Findings

Drag gets bigger as fall into water and buoyancy decreases. This explains why when the large casualty dips i the water, the lifeguard struggled more to tread with them. Floatation and buoyancy need to be increased to receive less drag.

Equation

Buoyancy = Volume x Gravity x Fluid Density

Gravity = 9.81

Fluid Density = 1000kg/m³

Volume = 62000cm³/62,000,000 litres (average human volume) + 20litres – taken from Swim Buoy documented later in document (predicted product volume)

GILISPORT PADDLEBOARD

<https://www.gilisports.com/blogs/sup-expert-advice/paddle-board-size-and-weight-chart>

Made from Military Grade PVC

More durable their epoxy paddle boards, iSUPs are made from high strength PVC material for a board that easily lasts years of fun and sun.

Strong & Rigid

The cross-stitched construction and high-pressure valves give our paddle boards superior rigidity - they feel like a hard board under your feet!

PADDLE BOARD SIZE & WEIGHT CHART

	10'6 AIR	11' / 12' ADVENTURE
LENGTH	10'6	11 12'
WIDTH	31"	32"
THICKNESS	6"	6"
VOLUME	225 L	238 L
CAPACITY	275 LBS	290 LBS
WEIGHT	19 LBS	19 LBS
BOARD TYPE	All Around	Touring
PET FRIENDLY	✓	✓
CARRY HANDLES	1 Centre, 1 Front	1 Centre, 1 Front, 1 Rear
FRONT BUNGEE	✓	✓
REAR BUNGEE		✓

FIN SYSTEM	1 Snap In + Side Bites	2+1 Snap In
PADDLE	Aluminium	Aluminium or Carbon
BACKPACK	Standard Backpack	Standard Backpack
PUMP	2 Stage	2 Stage
ACCESSORIES	Leash, Repair Kit	Leash, Repair Kit
OTHER	Kayak Kit Compatible	Kayak Kit Compatible
RIFER SKILL LEVEL	Beginner / Intermediate	Beginner / Intermediate

Paddle Board Dimensions

Paddle boards come in a range of sizes: from 9 feet to over 12 feet long and from 30 inches to 35 inches wide. The wider your board, the more stable it will be.

However, the wider your board is the harder it is to paddle. Under 36" doesn't compromise manoeuvrability.

Paddle Board Volume

The volume of a paddle board determines its buoyancy. The more volume a board has, the greater the weight capacity. If the board does not have enough volume to float an individual, the board will drag and be hard to

paddle. Volume is calculated by the paddle board's length, width, and thickness.

Stability

Generally, the more volume a board has the more stable it will be on the water. This is true to be seen with whales. As their volume increases as does their stability within the water.

Weight Capacity

A paddle board's weight capacity is determined by its volume, shape, and dimensions. When a paddler is heavier than the SUP's weight capacity, the board will sink in the water and drag. You cannot be too light for a board as it will always sit on the surface of the water providing the most ease.

Paddle Board Volume Calculation

The formulas below are to calculate the ideal volume measured in litres.

Multiply body weight (in pounds) by 1.1 to 1.4 to find the perfect volume range for your first board.

For example:

If you weigh 175 lbs and you plan on carrying 10 lbs of gear, your total weight is 185 lbs.

185 lbs multiplied by 1.0 equals 203.5L

185 lbs multiplied by 1.4 = 259L

The ideal paddle board would have a volume of at least 185L to 258L.

MATERIAL RESEARCH

MATERIAL INSPIRATION

I have found that inflatable fabrics are typically coated or laminated with synthetic materials to increase their strength and durability. I have investigated the materials used in products which have similar functionality or properties such as inflatable products and inflated products in water.

Swim Buoy - New Wave Swim Buoy



Large

Capacity - 20litre

Dimensions – 25inches x
12inches

Swimmers – 190lbs or more

Buoyant Force – 15kg/33lbs

Material - TPU-coated Nylon

Out cover material - Polyamide

Inner material - Polyvinyl Chloride - Phthalate Free

Arm Bands

Material - Soft polyester

Material - durable Vylux which is not easily torn or punctured

Air Mattress

Material – Polyvinyl Chloride

Medium

Capacity – 15litres

Dimensions – 23inches x
10inches

Swimmers – 190lbs or less

Buoyant force – 9kg/20lbs

Life Jacket

Material – Polyvinyl Chloride

Other Buoyant Materials

Foam (Styrofoam)

Cork

POTENTIAL MATERILA LIST

1. Cork
2. Thermoplastic polyurethane
3. Polyvinyl Chloride
4. Nylon
5. Polyester

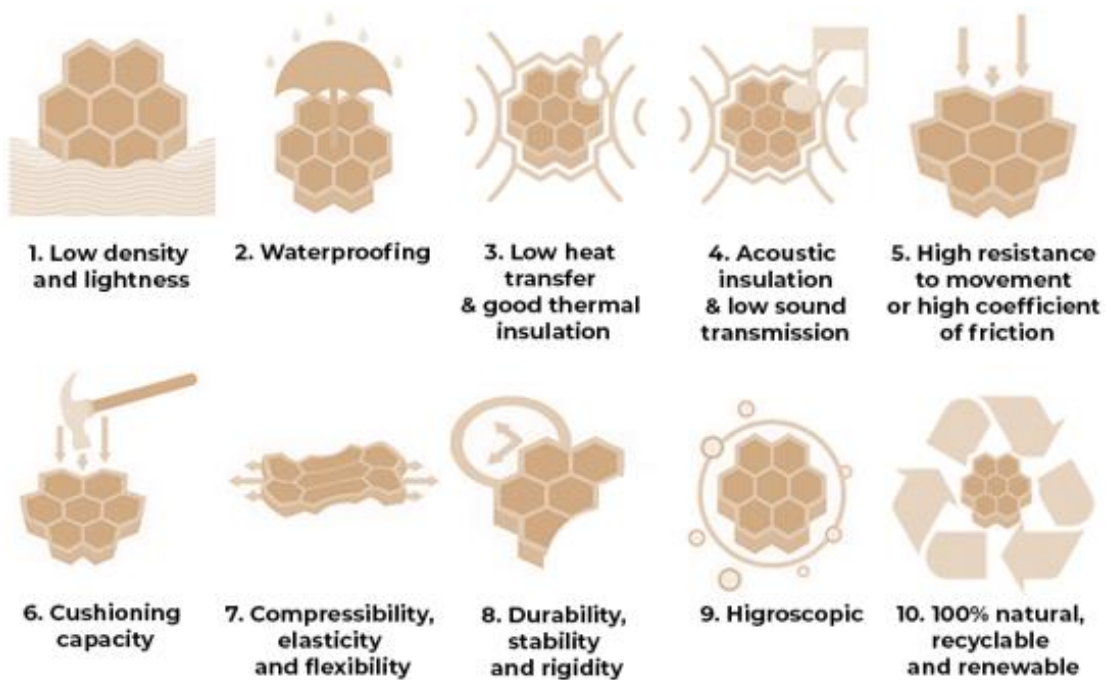
CORK

Relevant Properties

- Waterproof - due to cellulose structure
- Lightweight
- Buoyant

Sustainability:

- Cork is harvested from trees and not cut down.
- Harvested cork trees absorb 3-5 times more CO₂ than non-harvested trees.
- Each time the cork is harvested it regenerates itself
- Cork trees live between 100-300 years.
- The material itself is 100% biodegradable and 100% recyclable



TPU (THERMOPLSTIC POLYURETHENE)

- Biodegradable, non-toxic, and non-plasticizer.
- Eco-Friendly Process and High Yield Rate

- No DMF residue in the final products. As a result, the products can solve VOC emission problem effectively.
- Durable
- Recyclable
- Biodegradable 3-5years
- During the lamination process to material, solvents are not used
- Chemical resistant

TPU TEXTILE IMPROOTNAT PROPERTIES

Thermoplastic polyurethane membrane bonded to a base textile is how a TPU fabric is made.

It is resistant to chemicals, ozone, oxygen, oil, and fuel which is extremely important within my design as the self-inflation system will be activated by a chemical reaction within the product which will emit CO₂ and inflate the bag. In addition, the environment this product will be in is a chlorine pool.

It upholds flexibility and softness which are important in keeping the correct form when inflated and not being rough on human contact.

UV resistant is an important feature as it won't damage the casualty or users' eyes or distract by reflecting sunlight.

It resists abrasions and punctures and stands up to extreme weather and environmental conditions which is highly important as it will remain the correct durability needed.

It can have glued or welded seals. These fabrics have excellent air and liquid holding capability which is a very important feature as it will need to hold air and keep out liquid.

TPU TEXTILE REUSE

A company 'Erez' partners with manufacturers globally who specialize in coated textile reuse, and who take coated textiles at the end of their product life cycle and repurpose them into a wide range of second-life products – from woven mattresses to water containment for livestock, the possibilities are endless.

This is a good option for me as sustainability is very important within my design and although the material, I have chosen is more environmentally friendly than any other on the market, it is even more sustainable to reuse off-cuts of the same material from previous products which otherwise would go to waste. As the material is so durable and resistant to scratches etc the material used won't have any imperfections. This also saves major costs.

PVC (POLYVINYL CHLORIDE)

I have noticed that PVC is widely used in most products, which require similar properties to my design, from children's arm bands, air mattresses, life jackets and more. However, I have found how damaging this material is to the environment and therefore decided against using it. Below are some points as to why it is so damaging to the environment.

- PVC contaminates humans and the environment throughout its lifecycle during its production, use and disposal
- PVC is the single most environmentally damaging of all plastics
- PVC production has the largest and fastest-growing use of chlorine
- Chlorine is the basic building block of our most infamous toxic problems: CFCs which destroyed the ozone layer, the dioxin contamination at Love Canal and Times Beach, Agent Orange, PCBs, and DDT pesticides
- Hundreds of chlorine-based toxins are building up in the air, water, and food chain

- It is one of the least recyclable materials of all plastics
- PVC items contain so many additives that recycling would be impractical and expensive

TPU (THERMOPLASTIC POLYURETHANE) AVANTAGES VS PVC (POLYVINYL CHLORIDE)

- Greater flexibility and excellent strength
- Lighter weight
- Abrasion resistant
- Resistance to oil and solvents
- Resistant to ageing and cracking
- UV resistant
- A LOT more sustainable

Thermoplastic Polyurethane (TPU) Material: Properties & Applications

<https://OMNEXUS.SPECIALCHEM.COM>

ENVIRONMETNLLY FRIENDLY SUBSTITUTES TO PVC

ECOSTORM

- Recyclable
- Made from recycled microfibres
- Solvents are not used in the production of the film
- Few toxic gases are released when burned
- Waterproof & Breathable
- 100% polyester

- Thin and highly durable
- Lightweight

Hydrostatic resistance

20,000mmH₂O or greater (JIS L1092 B)

Moisture permeability

5,000g/m² • 24hrs(JIS L1099 A-1)

15,000g/m² • 24hrs(JIS L1099 B-1)

ECO STORM® | Materials | TEIJIN FRONTIER CO., LTD.

TEIJIN FRONTIER CO., LTD. Materials (Comfortable materials)

WWW2.TEIJIN-FRONTIER.COM

XPLORE TECHNOLOGY MEMBRANE

Layer of unique ultra-thin membrane with 10 billion nanopores in every square inch

- The pores are 20,000 times smaller than water droplets
- large enough for perspiration vapor and airflow to pass through
- durable waterproofing
- bacteria and mite blocking
- Lightweight
- PFCs Free
- Solvent Free
- Hydrophobic Porous Membrane

Technology-Xpore-Eco-Sustainable Waterproof-Breathable Textile Technology

Created with specially designed breathing pores, Xpore is the best-in-class waterproof-breathable textile technology that provides the susta

POLYESTER VS NYLON

POLYESTER ENVIRONMENTAL IMPACT

Polyester production has a lower environmental impact than natural fibres production in terms of water usage and wastewater. However, the energy required to produce polyester (125 MJ of energy per kilogram produced) and the greenhouse gas emitted (14.2 kg of CO₂ per kilogram produced) make it a high-impact process.

NYLON ENVIRONMENTAL IMPACT

Producing nylon creates nitrous oxide, a greenhouse gas that is 300 times more potent than carbon dioxide. Manufacturing nylon is a very thirsty process; large amounts of water are used for cooling the fibres, which can be a source of environmental contamination and pollution.

	Nylon	Polyester
Chemical Name	Polyamide	Polyethylene Naphthalate
Manufacture	Created as a liquid, mechanically spun and dried into individual fibers.	Spun into thread from chemical solution.
Uses	More common to certain kinds of apparel, including lingerie, <u>tights</u> , raincoats, and swimwear. Carpets, drapes, and bedding. More wide range of industrial uses.	More widely used in all kinds of apparel. Carpets, drapes, and <u>bedding</u> . Some industrial use.
Wearability	Low moisture absorbency	Wrinkle resistant
Durability	Exceptionally strong, abrasion resistant, resistant to damage from oil and many chemicals.	Strong, resistant to stretching and shrinking, resistant to most chemicals, crisp and resilient wet or dry, abrasion resistant.
Flammability	Melts then burns rapidly	Melts and burns at same time
Environmental impact	Most nylon made from unavoidable oil refinery byproducts	Non-biodegradable, but can be recycled - possible to purchase 100% recycled polyester
Comfort	Light-weight, warm, smooth, soft, quick drying.	Quick drying, light-weight, smooth.
Styles	Blouses, dresses, foundation garments, hosiery, lingerie, underwear, raincoats, ski apparel, windbreakers, swimwear, cycle wear.	Every form of clothing
Appearance	Lustrous, wide range of colors.	Wide range of colors, slightly slick.
Allergic reactions	Possible, more likely caused by finishing resins, fibers repel typical allergens.	Possible, more likely caused by finishing resins, fibers repel typical allergens.

Maintenance	Easy to wash, mildew resistant.	Easily washed, mildew resistant.
Cleaning	Easy to wash, mildew-resistant. Can be dried on low heat cycle, but must be removed as soon as finished. Can be ironed. Cannot be dry-cleaned.	Easy to wash, mildew-resistant. Can be dried on low heat cycle, but must be removed as soon as finished. Can be ironed. Can usually be dry-cleaned.
Materials	Polyamide made from petroleum.	Polymer production of coal, air, water, petroleum products.
UV Resistance	Somewhat	Very
First Made	First U.S. Commercial Nylon Fiber Production - 1939, DuPont Company	First U.S. Commercial Nylon Fiber Production - 1953, DuPont Company
Worldwide Production	Around 3.9 million metric tons, 11% of synthetic fiber production	Around 21 million metric tons, 5

POTENTIAL MATERIAL

Erez as a company offer recycled off cuts of the material from previous product which would otherwise go to waste which saves the process of adding the material and manufacturing process to the world. Despite the fact I will not be impacting to the world, I have researched and chosen the most sustainable material possible with the properties I require for a good design.

I have listed the importance of the properties of both Nylon and TPU previously and mainly chosen TPU coated Polyester due to the major environmental issues Nylon causes. Polyester uses small amounts of water compared to Nylon. Polyester emits CO₂ when being produced, but Nylon produces Nitrous oxide which is 300 times more potent than CO₂.

However, TPU-coated Nylon has enhanced tear and abrasion strength and is unaffected by chemicals such as chlorine or oils such as sun cream or outdoor exposure to bacteria and UV solar radiation.

REZCOAT™

REZcoat™ (TPU coated fabric) is a family of Erez textiles utilizing breakthrough polymer blending to create a uniquely strong thermoplastic polyurethane (TPU) coating, which is then applied to a variety of high quality polyester and nylon base fabrics using hot melt or spread coating on complementary production lines. The resulting REZcoat™ technical textiles offer excellent resistance to extreme weather conditions, chemicals, abrasion and punctures, as well as high UV stability. REZcoat™ textiles are available in a wide range of fabric weights and are utilized across a diverse range of industries and end product applications.



BENEFITS

- Excellent chemical and abrasion resistance
- High UV stability
- Resistant to extreme weather conditions
- Excellent mechanical properties

RECOMMENDED APPLICATIONS

- Medical
- Industrial
- Flexible Storage Tanks
- Environmental Control
- Marine Safety
- Boats
- Architecture

REZCOAT™ SERIES		READ MORE
NAME	TPU 2012	
APPLICATIONS		
FABRIC TYPES	Nylon 23S Drex/ 210 Den	
COATINGS	TPU	
WEIGHT (GR/M ²)	400	
WEIGHT (OZ/YD ²)	12.5	
MORE INFO	 Download	
NAME	TPU 2009	
APPLICATIONS		
FABRIC TYPES	Polyester 1100 Drex/ 1000 Den	
COATINGS	TPU	
WEIGHT (GR/M ²)	630	
WEIGHT (OZ/YD ²)	18.6	
MORE INFO	 Download	
NAME	TPU 2007	
APPLICATIONS		
FABRIC TYPES	Nylon 940 Drex/ 840 Den	
COATINGS	TPU	
WEIGHT (GR/M ²)	600	
WEIGHT (OZ/YD ²)	17.6	
MORE INFO	 Download	

NAME	TPU 1101	
APPLICATIONS		
FABRIC TYPES	Nylon 78 Drex/ 70 Den	
COATINGS	TPU	
WEIGHT (GR/M ²)	215	
WEIGHT (OZ/YD ²)	6.3	
MORE INFO	 Download	

NAME	TPU 1009	
APPLICATIONS		
FABRIC TYPES	Nylon 2x235/940 Drex / 2x210/840 Den	
COATINGS	TPU	
WEIGHT (GR/M ²)	330	
WEIGHT (OZ/YD ²)	9.7	
MORE INFO	 Download	

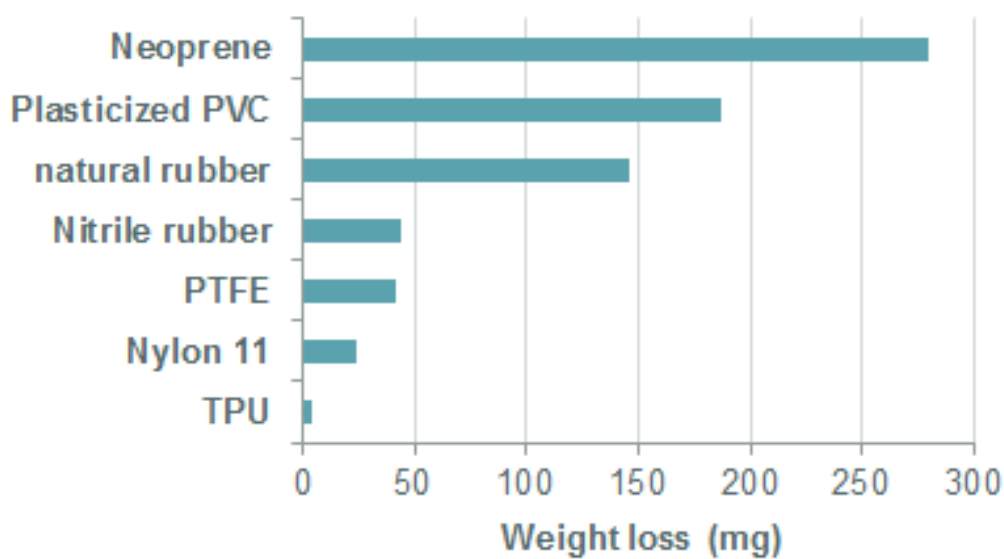
NAME	TPU 1001 L	
APPLICATIONS		
FABRIC TYPES	Nylon 23S Drex/ 210 Den	
COATINGS	TPU	
WEIGHT (GR/M ²)	273	
WEIGHT (OZ/YD ²)	8	
MORE INFO	 Download	

KEY PROPERTIES OF THERMOPLASTIC POLYURETHANE

Abrasion/Scratch Resistance

High abrasion and scratch resistance ensure durability and aesthetic value

The abrasion resistance of materials is usually determined by measuring the weight loss of a specimen in a standardized wear test as shown in the chart below:



Soft Touch/High Comfort of Use for Ergonomic Applications

Recent developments have made it possible to produce plasticizer-free TPU in the hardness range of 55 to 80 Shore A.

These solutions offer a high quality surface finish, excellent adhesion to engineering plastics such as [ABS](#) and [Nylon](#), as well as unequalled scratch and abrasion resistance.

UV Resistance

Aliphatic TPUs ensure color fastness to your aesthetic parts. They show a

superior stability to ultraviolet radiation and thus superior color stability, while maintaining good mechanical properties.

Combination of High Transparency with Abrasion Resistance

Crystal-clear TPU are available with very good hardness. This characteristic allows the use of TPU in the extrusion of transparency films & tubes and hoses, or in the injection molding of technical, aesthetic parts, where transparency at a thickness as high as 6mm can be achieved.

Other Benefits of TPU

High elasticity across the entire hardness range

Excellent low-temperature and impact strength

Resilience to oils, greases, and numerous solvents

Good flexibility over a wide temperature range

Robust weather and high-energy radiation resistance.

HOT AIR WELDING

All Erez products are glue able and weldable by HF and Hot Air.

Benefits

- Hot air welding speeds up production time and costs.
- Constructing a product with different shapes and curves
- Producing a versatile range of products
- Create seams that are stronger than the material itself for diverse manufacturing jobs
- Create airtight and waterproof seams unlike when you sew and are poking holes in the fabric
- Changing the weld width often throughout the manufacturing process

Hot Air Welding Machines | Industrial Hot Air Welders

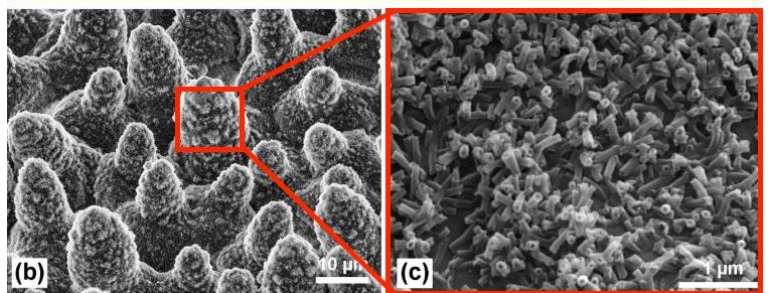
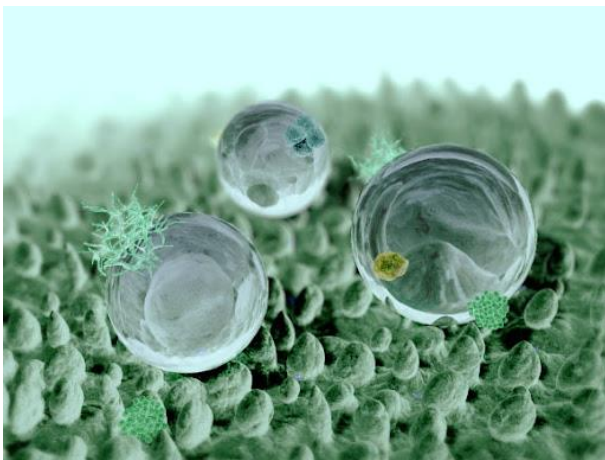
WELDMASTER.COM

BIOLOGICAL INSPIRATION – LOTUS LEAF

Lotus Leaf Super Functional Texture – Antibacterial and Anti-adhesion surfaces

The lotus leaf provides an anti-adhesion surface which I found interesting to view. The plant is water-repellent due to its cellulose structure exemplified below.

The positioning of the papillae and wax structures is responsible for the superhydrophobic self-cleaning function. The design texture combines with air to repel water as the water droplets is prevented from spreading and instead rolled to balls off the leaf. The distance between the wax crystalloids is smaller than the surface of dirt particles, pathogens or other contaminants which means foreign particles cannot enter the leaf and it remains clean.



Biomimetic Product - Self-cleaning Paint and Textiles

The lotus leaf properties have been mimicked in the form of a paint. It is a self-cleaning masonry paint called 'Lotusan.' The paint creates a surface microstructure that resembles the wax-tipped papillae of the lotus leaf both form and scale. Objects coated in the Lotusan take on superhydrophobic characteristics and therefore allow the object to also self-clean itself as dirt particles are too large to get to the surface. This provides low maintenance.

How the Concept Could Potentially be Applied to my Project

The lotusan paint could be applied to my chosen material, waterproof or not, and it would provide superhydrophobic and self-cleaning properties. This would increase the longevity of my product as it wouldn't need to be cleaned as often. With Coronavirus present currently, this aspect is very important. It would provide a natural and very efficient way of keeping the material hydrophobic.

REFERENCES

2021. *BILLY ECO15 RECYCLED DRYBAG FLOAT*. [online] Available at: <<https://www.puffinswim.co.uk/product/billy-eco15-drybag-float/>> [Accessed 11 October 2021].

Biggers, M.D, MPH, A. and Watson, K., 2018. *Average Shoulder Width*. [online] Healthline. Available at: <<https://www.healthline.com/health/average-shoulder-width#1988-to-1994>> [Accessed 11 October 2021].

C. Eck, J., 2019. *Spinal Cord Injury: Treatment, Symptoms, Recovery*. [online] Medicinenet.com. Available at: <https://www.medicinenet.com/spinal_cord_injury_treatments_and_rehabilitation/article.htm> [Accessed 11 October 2021].

Corporation, M., 2021. *Hot Air Welding Machines | Industrial Hot Air Welders*. [online] Weldmaster.com. Available at: <<https://www.weldmaster.com/technology/hot-air-welding>> [Accessed 11 October 2021].

Greenpeace.org. 2021. *PVC: The Poison Plastic*. [online] Available at: <<https://www.greenpeace.org/usa/wp-content/uploads/legacy/Global/usa/report/2009/4/pvc-the-poison-plastic.html>> [Accessed 11 October 2021].

Greenpeace Organisation, (2018). *PVC: The Poison Plastic*, United States: Greenpeace Organisation. Available at: <https://greenpeace.org>

Miller Weldmaster, 2018. *How to make an Inflatable Product - T300 Extreme*. [video] Available at: <<https://www.youtube.com/watch?v=fVKEU1aI7Bk>> [Accessed 11 October 2021].

Omnexus.specialchem.com. 2021. *Thermoplastic Polyurethane (TPU) Material: Properties & Applications*. [online] Available at: <<https://omnexus.specialchem.com/selection-guide/thermoplastic-polyurethanes-tpu>> [Accessed 11 October 2021].

Personal.cityu.edu.hk. 2021. *Anthropometry*. [online] Available at: <<http://personal.cityu.edu.hk/meachan/Online%20Anthropometry/Chapter3/Ch3.htm>> [Accessed 11 October 2021].

Quartz, 2017. *MIT's new self-inflation technology*. [video] Available at: <<https://www.youtube.com/watch?v=YBi9GQN1boM>> [Accessed 11 October 2021].

Royal Life Saving Society WA, 2016. *Spinal Injury Management Deep Water*. [video] Available at: <<https://www.youtube.com/watch?v=wZbmTHJiUgQ&t=22s>> [Accessed 11 October 2021].

Royal Life Saving Society WA, 2016. *Spinal Injury Management Shallow Water*. [video] Available at: <https://www.youtube.com/watch?v=cDj_TDQ8NbE> [Accessed 11 October 2021].

Sew Guide. 2021. *10 Best Waterproof fabric {& water resistant} for sewing - Sew Guide*. [online] Available at: <<https://sewguide.com/waterproof-water-resistant-fabric/>> [Accessed 11 October 2021].

TEIJIN FRONTIER CO., LTD. 2021. *TEIJIN FRONTIER CO., LTD*. [online] Available at: <<https://www2.teijin-frontier.com/english/>> [Accessed 11 October 2021].

Wilson, K. and Buchberg, H., 1958. Evaluation of Materials for Controlled Air Reaction Chambers. *Department of Engineering, University of California, Los Angeles.*, 50(11), p.1705.

Xpore-global.com. 2021. *Technology-Xpore-Eco-Sustainable Waterproof-Breathable Textile Technology*. [online] Available at: <<https://www.xpore-global.com/en/technology>> [Accessed 11 October 2021].