01 PRODUCT

Master Thesis - Industrial Design
Aalborg University
May 2016

Anders Poulsen

Anne Hjortflod Nielsen

Peter Vestergaard Sørensen

TITLE PAGE

Title:	Ardea
Theme:	Spearfishing Equipment
Period:	01.02.2016 - 25.05.2016
Team:	MSc04 ID Aalborg University - Team 04
Students:	Anders Poulsen, Anne Hjortflod Nielsen & Peter Vestergaard Sørensen
Supervisor:	Finn Schou
Co-Supervisor:	Raino Mikael Larsen
Issue:	7
Pages:	20

Anders Poulsen

Anne Hjortflod Nielsen

Peter Vestergaard Sørensen

ABSTRACT

This project focuses on designing a speargun for the Danish ocean conditions. Today spearfishing sees an increasing interest around the World and also in Denmark, but the current spearguns are not suitable for the ocean conditions spearfishers experience in Denmark. Low, changing visibility and high current are typically what you meet in the Danish oceans, while in more tropical places it is high visibility and low current. This means, that spearfishers have to bring several spearguns in different lengths to the ocean in Denmark, because they do not know how much visibility they can expect and a spearfisher should never use a longer speargun than he can see the tip of in the ocean. The new speargun, Ardea, is able to adjust in length at and in the ocean, so it fits the specific visibility and current. Furthermore Ardea uses a new way of loading the rubber band, which gives the spear its power. Now the spearfisher will use his legs for loading the speargun, which will make it easier than the way it is done with spearguns today; by arm strength.
Ardea is sold in a standard length of 50 cm and can be bought with a module, which makes it possible to adjust the length between 50 and 90 cm. This gives the user the opportunity to try the standard speargun out before adding the adjustable module. The final product can be seen in the product report, while the development process of Ardea can be seen in the process report.

INTRODUCTION

Denmark is one of the countries with most coastline per citizens and has an old history of fishing both in terms of commercial and leisure-related interests. The recent years a new sport and fishing method has been fast expanding in Denmark - this sport is spearfishing. The sport is about fishing with a speargun while being in the water and getting the nature experience while fishing. The sport is rapidly expanding in interest and market within Denmark. Just 5-7 years ago it was almost unknown in Denmark whereas today there is more than 5.000 performers of the sport and the number is still increasing. The combination of exercise, hunting by free-diving and catching your own food makes spearfishing appealing to a broad range of people. The thrill of the hunt and the fight with the fish gives an special type of adrenalin rush rarely seen in other sports. The growing trend of being self-supplying can also be a reason for the fast expanding interest.

TARGET AUDIENCE

With spearfishing becoming more common to practice in Denmark, the team sees an opportunity to design a product more directed towards the Danish market. Many brands are located in countries with more tradition for spearfishing than Denmark, which have made the equipment specifically designed for the regional ocean conditions. Denmark is generally known for rough oceans with low visibility, high current and cold water. Therefore a potential in designing a product more adaptable to the aforementioned ocean conditions is identified. These conditions can also be found in a lot of other places around the World, which means the new speargun is not only targeting spearfishers in Denmark, though it is designed based on the exact conditions a spearfisher will experience in Danish oceans.
More specifically the target audience is spearfishers in all experience levels, who are spearfishing in Danish ocean conditions or similar conditions outside of Denmark. The speargun is designed to some of the worst and roughest ocean conditions spearfishers can meet, which means it will also be suitable for better ocean conditions.


ARDEA

ARDEA

Ardea is a new speargun capable of adjusting its length to optimize the shooting range according to the visibility in the ocean. A simple locking mechanism between the two barrels makes it easy and quick to adjust the length both before going into the ocean and when being in the ocean.
Ardea uses a roller system, which makes it possible to only use one set of rubber bands and remain the high power. The locking mechanism adjusting the length of the speargun will at the same time change the position of the rubber band in order to regulate the force by which it will fire the spear. The spear is a modular system, so the length always is optimized for the length of the speargun. The modular parts can be stored in a rail on the bottom of the barrel, so they always are available when needed.

Ardea changes the way of loading a speargun. Now the speargun will be loaded by a simple and easy motion, where the spearfisher places the feet on a loading pad and then stretches out the legs. This motion will stretch the rubber band, which is attached to the spear.

Ardea is the optimal choice of speargun for ocean conditions, where the visibility is low and changing. Ardea is also a speargun perfect for the spearfisher, who wants to hunt fish in different surroundings, where Ardea's ability to change and adapt will be indispensable.

WHAT YOU GET

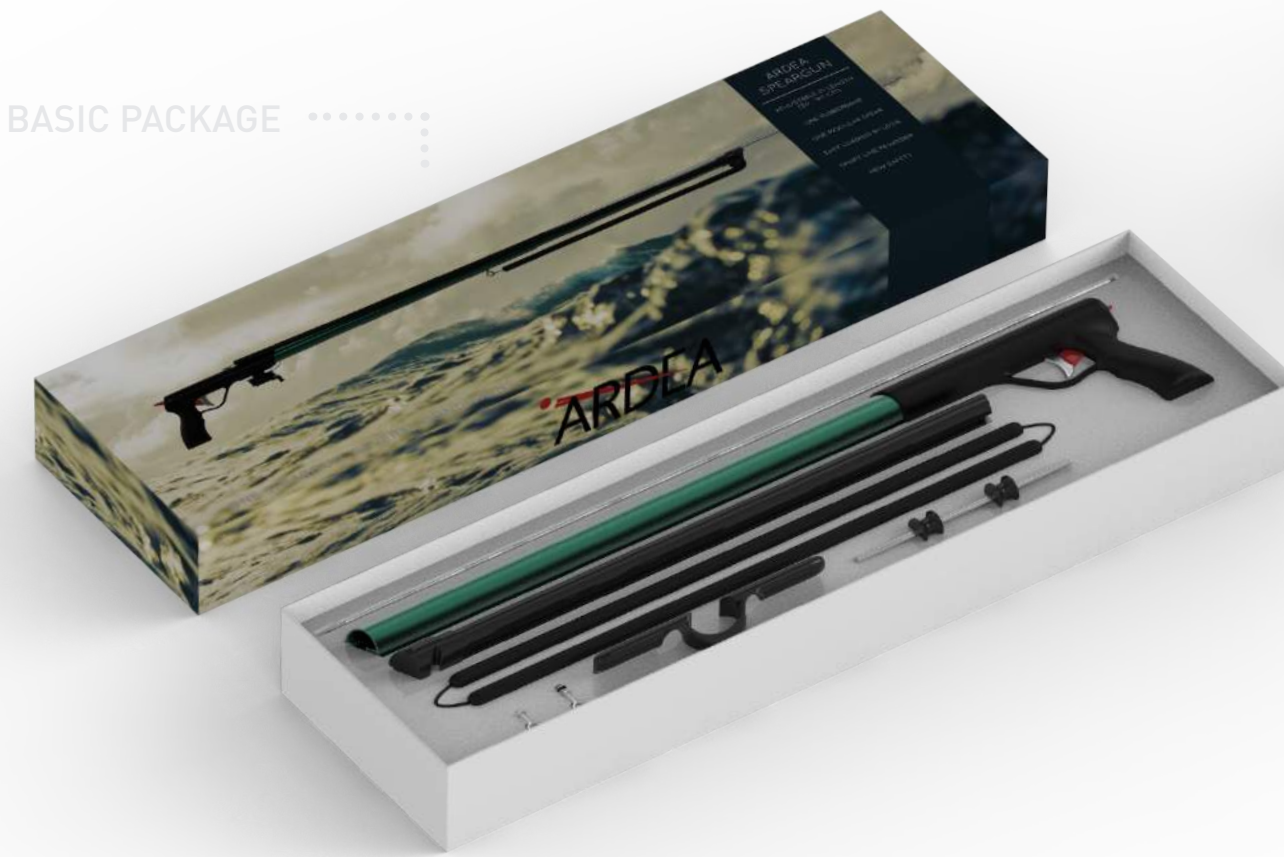
When purchasing Ardea you can choose between two packages;

BASIC PACKAGE

- 50 cm Ardea speargun incl. Ardea loading pads
- 80 cm Ardea stainless steel spear

The basic package is composed specially for new spearfishers, who will be introduced to the world of spearfishing with the best product in hand, Ardea. With Ardea Basic, you will get to learn the sport and its techniques with a speargun fitted for short range and easier targets.
The benefits of purchasing Ardea as a new spearfisher is that you can learn the foundations of spearfishing with an easy to handle product in hand and become comfortable with the gun.

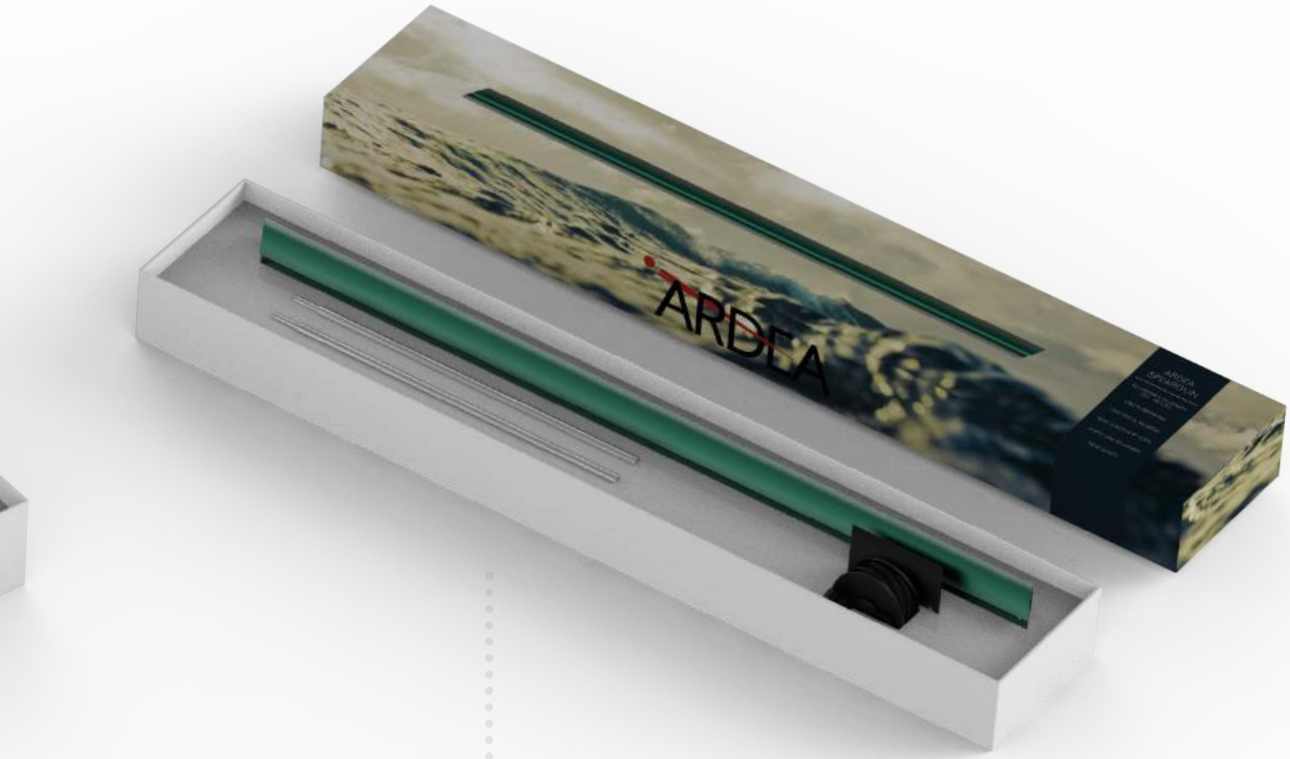
When getting more experienced, you can purchase an extension package for your Ardea speargun to upgrade to features within Ardea. The extension package will allow you to adjust the speargun from 50-90 cm, and the techniques gained from Ardea will follow with the extension package.



EXTENDED PACKAGE

- 50 cm Ardea speargun incl. Ardea loading pads
- Adjustment module
- 80 cm Ardea stainless steel spear
- 2 extra spear adjustment modules
- 1 line winder wheel
- Tools for assembling and maintenance

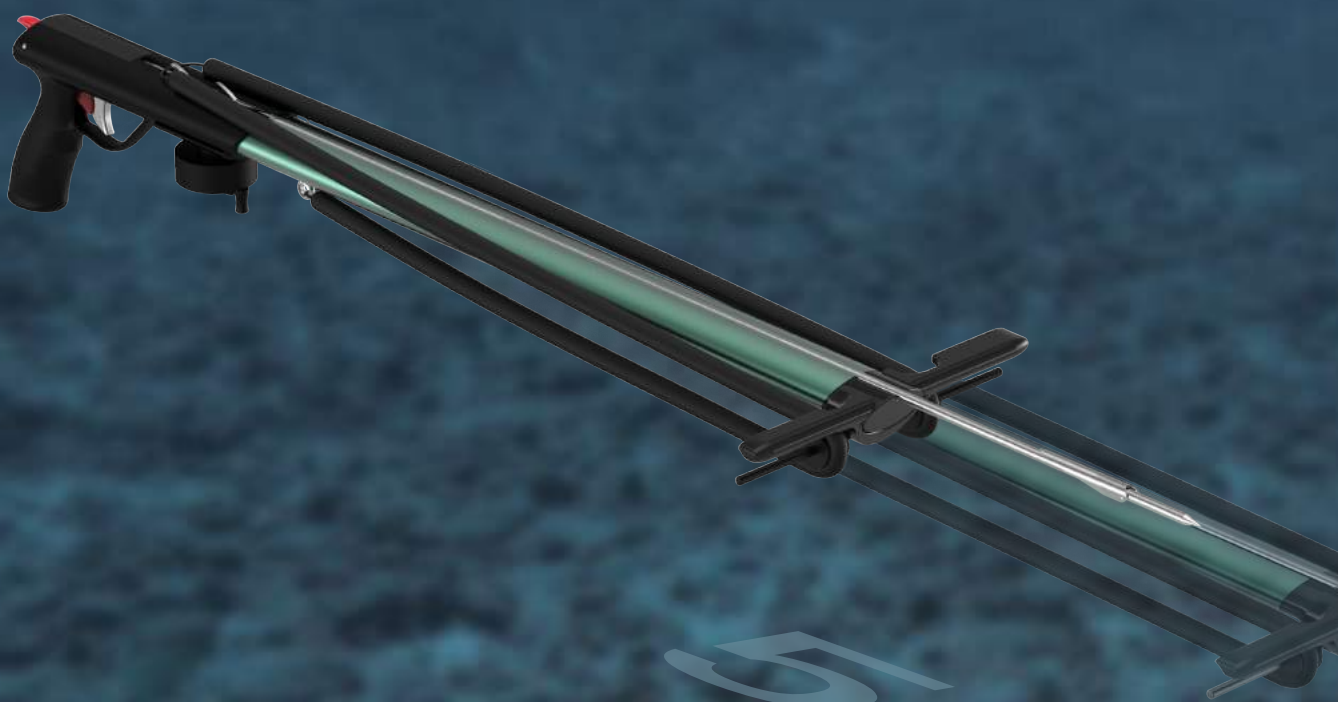
The extended package is composed for experienced spearfishers, who already is familiar with the sport of spearfishing and wants to purchase a speargun, which can reduce the need for several spearguns. The benefits of purchasing Ardea Extended is that



EXTENSION PACKAGE

ADJUST YOUR SPEARGUN

Ardea can change its length from 50 to 90 cm by pulling the hook underneath the barrel out and slide it towards the next hole in the rail of the standard barrel. When the hook is in the desired position the inner barrel will be moved and slided until it locks with the hook, which is functioning by a spring, and now you have a speargun adjusted to your specific needs.



PULL

MOVE

READY

EASILY LOADED

Ardea is loaded in a revolutionary new way, which makes it easier to load the speargun even to the longer lengths.

The loading position is changed from using the limited strength in the arms to using the bigger and stronger muscles in the legs. This will make the loading much easier and the speargun able to gain more power.

To load Ardea you attach the wishbone in the end of the rubber band to the spear, step onto the loading pads and stretch out your legs - all while being almost weightless in the water. When the loading pads are pushed to the tip of Ardea, the pads will lock in the muzzle. Now Ardea is loaded and ready to shoot fish.

KNOW WHEN IT IS SAFE

Safety is an important part of a responsible performance of spearfishing. Ardea is therefore equipped with a new safety mechanism with two functions.
The switch for the safety mechanism is placed on the back of the handle, so it is easy to handle while holding the speargun and potentially aiming at a fish.

Opposite other spearguns, the safety mechanism on Ardea visually blocks the trigger mechanism so it is obvious for both the user and people around, that it is secure and safe.

To emphasize the speargun is ready to shoot, and the safety is off, the safety switch is pushed upwards and turns into a crosshairs visible when aiming at a fish. This ensures you will never again be in doubt whether or not the safety mechanism is off, and you will never loose another fish due to a tricky safety mechanism.

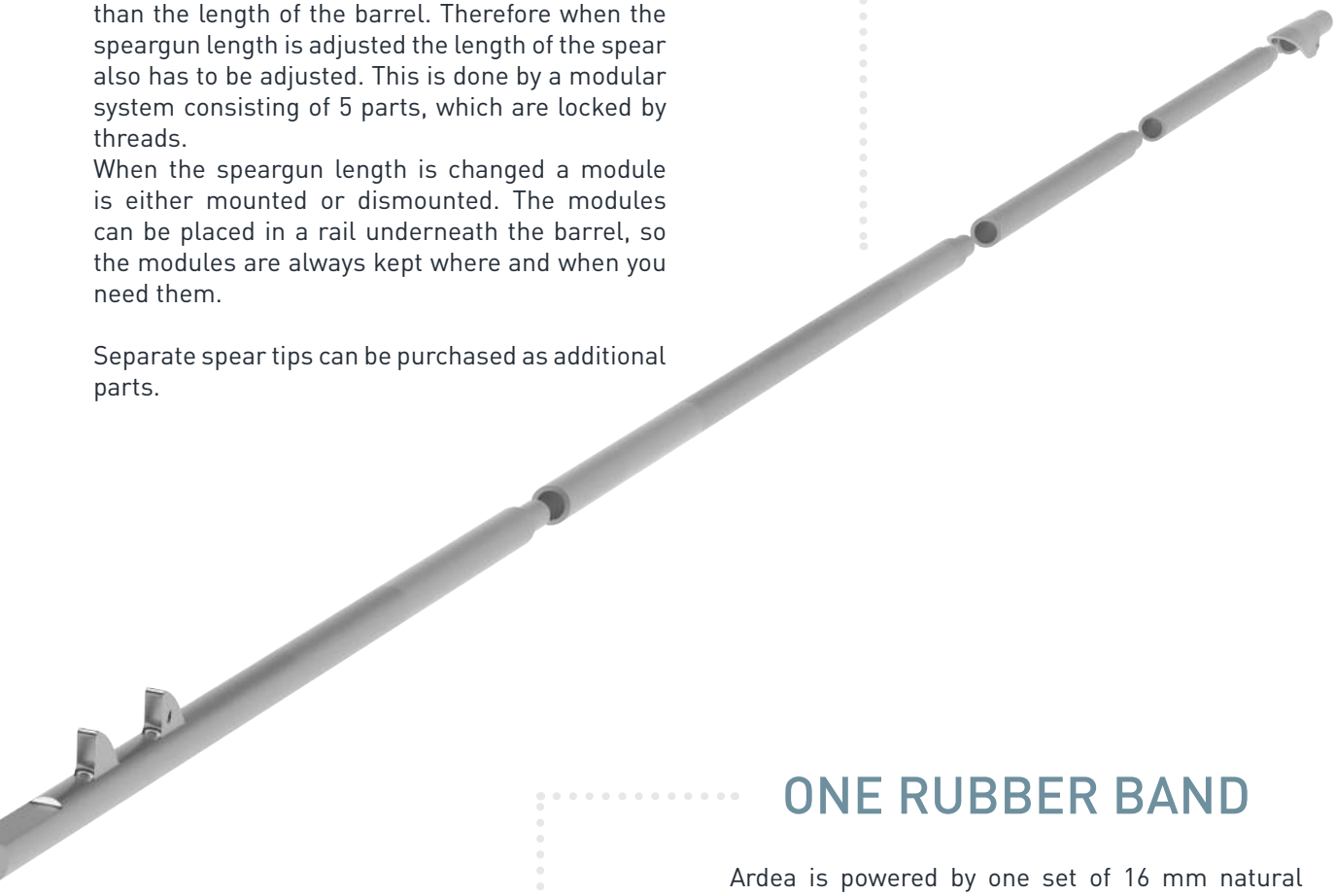
CONTROL THE LINE

The line between the speargun and the spear is necessary in order to not loose the spear in the ocean when you shoot at a fish. The line will normally get tangled into everything, but Ardea offers a solution, where a wheel is used to always keep track of the line. It can easily be rolled back and will not be tangled into the speargun or the spearfisher.

MODULAR SPEAR

The optimal length of the spear is 40 cm longer than the length of the barrel. Therefore when the speargun length is adjusted the length of the spear also has to be adjusted. This is done by a modular system consisting of 5 parts, which are locked by threads.
When the speargun length is changed a module is either mounted or dismounted. The modules can be placed in a rail underneath the barrel, so the modules are always kept where and when you need them.

Separate spear tips can be purchased as additional parts.



ONE RUBBER BAND

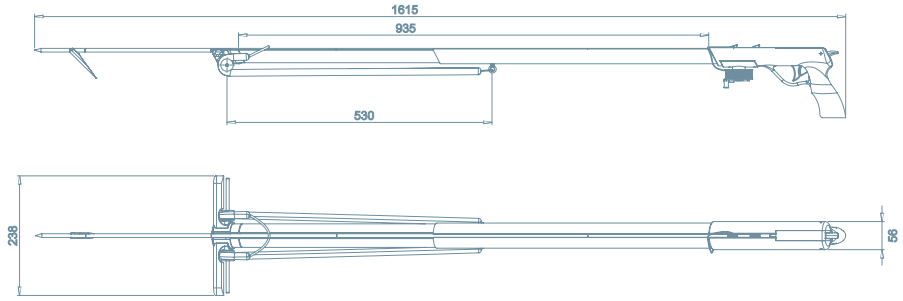
Ardea is powered by one set of 16 mm natural rubber bands which is mounted in a roller system connected to the loading pads. The roller system exploits the whole length of the speargun and thereby adds more power to the shot.
Ardea is designed to only use one set of rubber bands despite the ability of adjusting to different lengths.

AESTHETICS AND EXPRESSION

Ardea is inspired by predators of the ocean - sharks and marlins. The head on the hammerhead shark and the fins are both represented in features and functions in Ardea. The angle of the cuts on Ardea are imitated from the sea creatures streamlined bodies and gives Ardea the expression of being a weapon in a forward moving direction.

TECHNICAL SPECIFICATIONS

MEASUREMENTS



FEATURES

Adjustable length | Loading with the legs | Handle dimensioned for gloves | Safety combined with aim
Product platform with upgrades | Easy interaction with and without gloves

SIZE ADJUSTMENT
50 - 90 cm

LOADING
With the legs

LOAD FORCE
500 - 900 N

WEIGHT
2100 grams

WEIGHT IN WATER
250 grams

BARREL SIZE
Oval 30x50 / 27x47

MATERIALS
Aluminum, glass reinforced nylon, natural rubber, stainless steel

UPGRADES
Adjustment barrel
Spear modules
Line Wheel

COMPONENTS

OUTER BARREL

INNER BARREL

MUZZLE

HANDLE

LINE WHEEL

TRIGGER

SAFETY

LOADING PAD

HOOK

SPEAR

RUBBER BAND

BUSINESS AND COSTS

Ardea can potentially be produced and become a reality in collaboration with the right business partner. Through the development of Ardea a collaboration with the South African spearfishing company, Rob Allen, has been considered strongly.

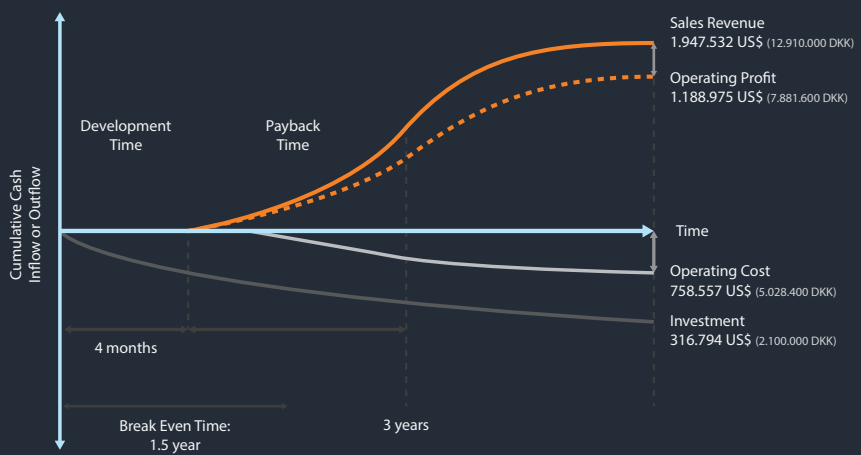
For Ardea to come in production, the project will need an investment of $317.000 (2.100.000 DKK). Through a development time of 4 month the Ardea team will in collaboration with a Rob Allen employee further develop the speargun, and optimize it for production. After the period of four months the product will at best be launched on the market.

The production is estimated to $60 (395 DKK) for one complete Ardea Extended including production, finishing and assembling of all components. Production estimation of Ardea Basic is $47 (310 DKK) for the speargun and $14 (90 DKK) for the Extension package.

The sales price for the complete Ardea package is $270 (1800 DKK).

It is estimated that 3700 Ardea spearguns will be sold throughout the first year on the market. The second year the number is estimated to increase to 6300 spearguns and in the third year 10.000 spearguns.

Based on the production costs and the estimated number of sales it is estimated that the break even time for the product will occur after 1,5 years. After three years the profit, when all expenses have been payed out, will approximately be $1.190.000 (7.900.000 DKK).



SALES REVENUE **$1.950.000 12.910.000 DKK**

SALES PRICE **$270 1800 DKK**

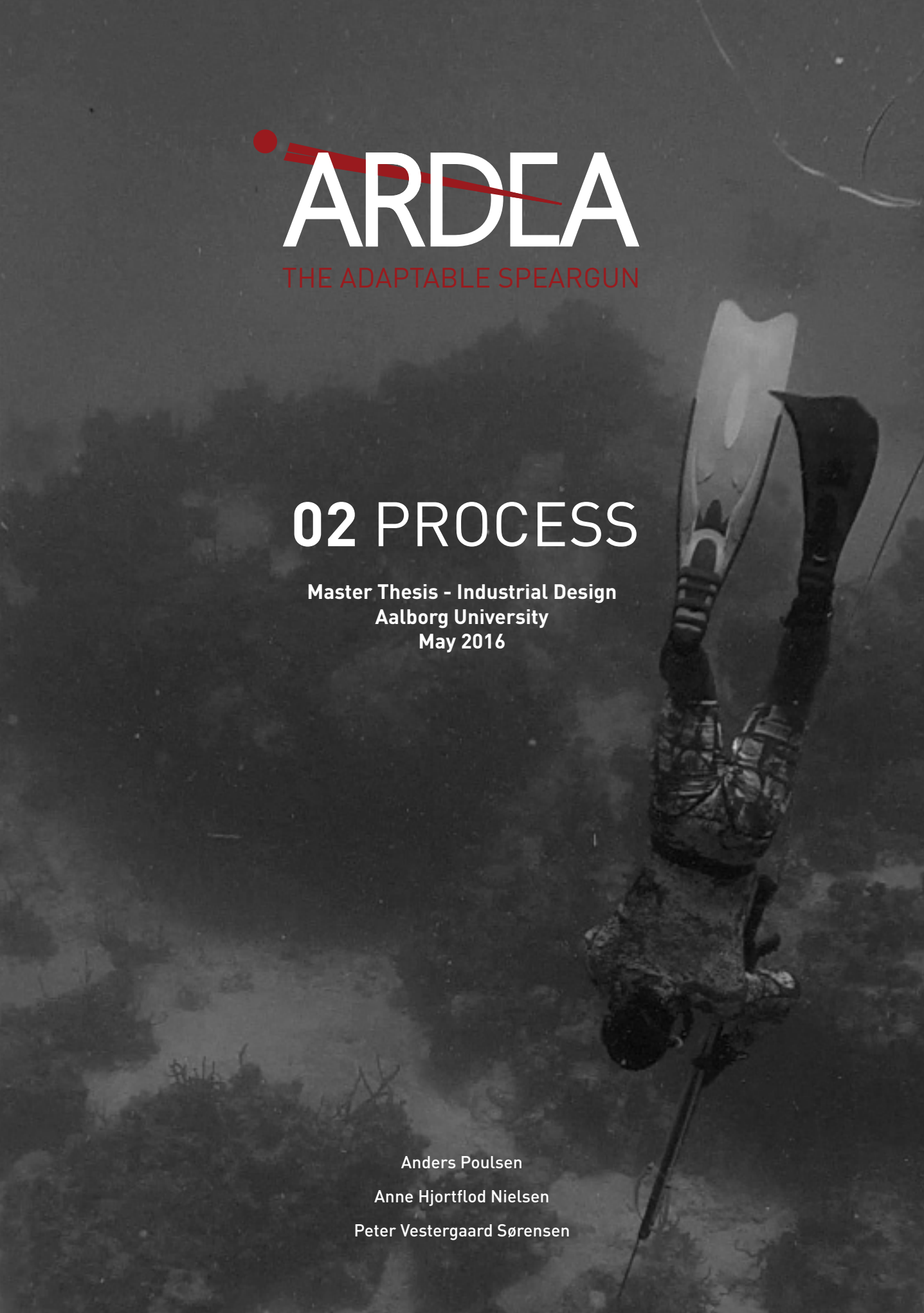
SALES IN THREE YEARS **15.000 SPEARGUNS**

BREAK EVEN TIME **1.5 YEARS**

ARDEA

THE ADAPTABLE SPEARGUN

AALBORG UNIVERSITET



ARDEA

THE ADAPTABLE SPEARGUN

02 PROCESS

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Keystrokes:	129.789 (54 standard pages)

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ACKNOWLEDGMENTS

A special thanks to Finn Schou and Mikael Larsen for valuable supervision and feedback during the whole process.

A lot of people have been involved in the project during the process, and we want to thank all these people.

Rob Allen for the interest in the project, the collaboration during the project and for answering all our questions and helping us clarifying the market.

Morten Rosenvold Villadsen for helping us by answering all our questions and giving us valuable knowledge from the inside of spearfishing in Denmark.

Lamberto Azzi for giving us an introduction into the world of spearfishing in Denmark and all over the World, the equipment and the trends.

Hans-Henrik Carlsen for lending us equipment and for clarifying the topic.

Guy Skinner for answering our questions and helping us getting an understanding of the specific markets around the World.

We also want to thank all the persons involved in our gathering of inputs and thoughts through mails, interviews and tests.

Thank you!

SYNOPSIS

The purpose of this thesis is to design a speargun for the Danish ocean conditions. It seems like spearfishing has become increasingly popular and widespread around the World - also in Denmark. Apparently the current spearguns are not suitable for the ocean conditions spearfishers experience in Denmark, where low changing visibility and high current are typically unlike tropical places where there is high visibility and low current. In Denmark spearfishers therefore need to bring several spearguns in different lengths because they do not know how much visibility they can expect. The inspiration and motivation for this thesis is to design a speargun that better suits the Danish ocean condition. It is proposed that the speargun "Ardea" is suitable for Danish ocean conditions. The final product can be seen in the product report, while the process can be seen in the process report.

Ardea is sold in a standard length of 50 cm and can be bought with a module, which makes it possible to adjust the length between 50 and 90 cm. This gives the user the opportunity to try the standard speargun out before adding the adjustable module. The final product can be seen in the product report, while the process can be seen in the process report.

Phase **0.0**

PREFACE

In the preface it is described what the reader should be aware of when reading the reports and worksheets. Then a table of content will give an overview of the whole process report to easily find back to a specific chapter. Finally an introduction and initial thoughts are explained, a short description of the topic and why it has been chosen.

0.1 READING GUIDE

During the project worksheets has been the way of documenting the process. Every investigation, test, analysis, interview, mail correspondence and research in general are described in individual worksheets. In the process report the purpose and conclusion of every test, analysis etc. are mentioned, and for a deeper understanding the reader can look up the execution and data in the worksheets. Worksheets are referred to as (Worksheet no. XX). Videos documenting the process are attached on the USB-stick and are referred to as [Appendix no XX].

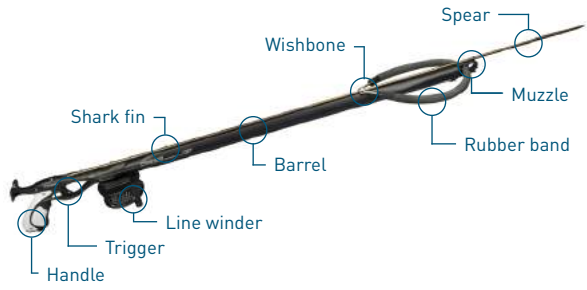
Through the process report the conclusion of each chapter is written and highlighted in an orange frame. Blue frames highlight if a requirement for the product design has been determined.

Tests and experiments will be presented in blue boxes, where purpose, explanation and conclusion of the tests will be stated.

Through the process report there will be presented two requirement specifications. The first one presented is based entirely on the research gained and the preface of the project. As the process proceed there will be added more requirements and some of the originals will be eliminated which all will be summed up in a final requirement specification on page 46.

For giving the reader an immediate understanding of a speargun and the terms used during the report, the terminology is described below and highlighted on a picture of a speargun.

It should be noted that all measurements of lengths are written in cm because in the world of spearfishing everything is measured in cm.



The name Ardea is used both as the name of the team and of the product which they have designed.

Enjoy!

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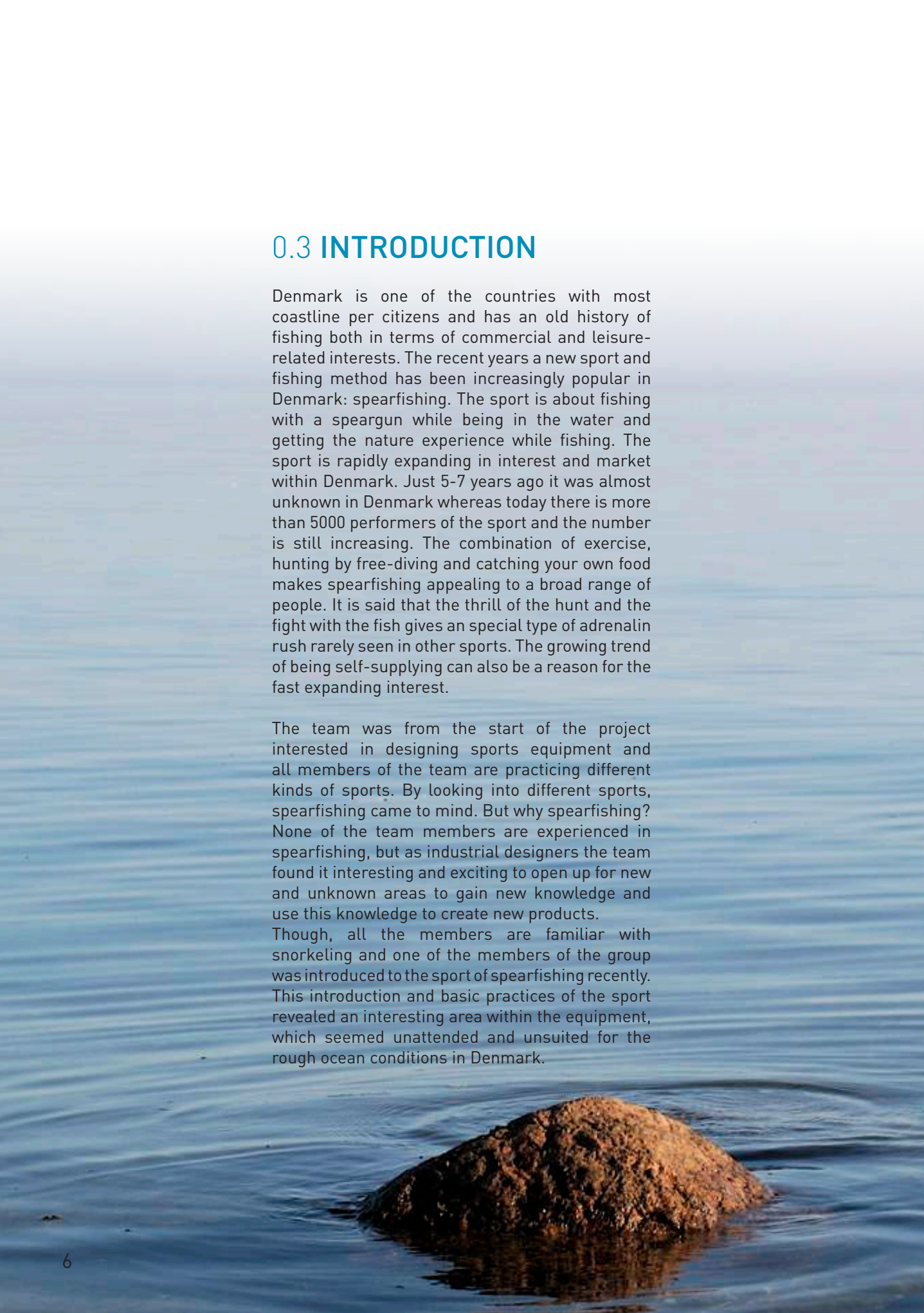
0.3 INTRODUCTION

Denmark is one of the countries with most coastline per citizens and has an old history of fishing both in terms of commercial and leisure-related interests. The recent years a new sport and fishing method has been increasingly popular in Denmark: spearfishing. The sport is about fishing with a speargun while being in the water and getting the nature experience while fishing. The sport is rapidly expanding in interest and market within Denmark. Just 5-7 years ago it was almost unknown in Denmark whereas today there is more than 5000 performers of the sport and the number is still increasing. The combination of exercise, hunting by free-diving and catching your own food makes spearfishing appealing to a broad range of people. It is said that the thrill of the hunt and the fight with the fish gives an special type of adrenalin rush rarely seen in other sports. The growing trend of being self-supplying can also be a reason for the fast expanding interest.

The team was from the start of the project interested in designing sports equipment and all members of the team are practicing different kinds of sports. By looking into different sports, spearfishing came to mind. But why spearfishing? None of the team members are experienced in spearfishing, but as industrial designers the team found it interesting and exciting to open up for new and unknown areas to gain new knowledge and use this knowledge to create new products.
Though, all the members are familiar with snorkeling and one of the members of the group was introduced to the sport of spearfishing recently. This introduction and basic practices of the sport revealed an interesting area within the equipment, which seemed unattended and unsuited for the rough ocean conditions in Denmark.



0.4 INITIAL THOUGHTS

With spearfishing becoming more common to practice in Denmark, the team sees an opportunity to design a product more directed towards the Danish market. Many brands are located in countries with more tradition for spearfishing than Denmark, which unavoidably will make the equipment specifically designed for the regional ocean conditions. Denmark is generally known for oceans with low visibility, high current and cold water. The team therefore sees a potential in designing a product more adaptable to the aforementioned ocean conditions.

Spearfishing is also a sport, which equipment seems to not have developed radically in many years. The small, but increasing market seems to find the simplicity of the equipment as a value both with the manufactured spearguns, but also with many and simple homemade spearguns flourishing on the market. Therefore spearfishing is seen as a market with great opportunity to design a new and potentially radical product.

Ill. 0.0.1

Phase **1.0**

RESEARCH

This phase presents all the information gathered through different methods as desktop research, interviews, a questionnaire, video observations and testing of products.
The initial research of spearfishing generates the basic understanding of the spearfishers; why they spearfish, what the sport is about and what the general user looks like. In addition to this, the research chapter contains recognizing of gaps and opportunities in the market of spearfishing.

A large part of the information gathered through this chapter is based on a questionnaire, where over 100 spearfishers have participated and answered. The team has used the answers to determine different characteristics about spearfishers, their habits and the whole act of spearfishing and the problems they encounter before, during and after they enter the water.

All the information is structured into a design brief, which will conclude on the teams focus and direction going into the phase of concept development. The design brief contains project overview, category overview, target audience and project scope with design criteria, problem statement, vision and mission. The design criteria are based on the knowledge and information gathered through the initial research and creates the frame for the projects and the demands for the future product. These will be reevaluated during the project as the team gains a broader knowledge and help guide the phase of concept development.

1.1 SPEARFISHING

Diving is a broad area and therefore the team has to look more into different categories of diving to narrow down the area of interest. Through desk research and by evaluating the answers from the questionnaire, the team gets and understanding of the common spearfisher, the sport and rules and ethics within the sport.

In general there are five types of diving; scuba diving, professional diving, free-diving, snorkeling and spearfishing (Worksheet no. 01). Spearfishing is actually a subcategory of the four other diving categories, because the sport is build upon the same techniques and principles. The five types of diving can be divided into two overall categories; with and without air-supply. Scuba diving and professional diving are done with air-supply while free-diving and snorkeling are done without air-supply. Spearfishing can be done both with and without air-supply.
The team quickly established a connection to a newly started Danish spearfishing company, Ragnarok Sub, which made the team - after some quick research - choose spearfishing as the area of interest, even though the collaboration with the company did not last long, because the team could not see enough benefits in the collaboration.

Spearfishing is performed worldwide both with and without air-supply. Spearfishers, who practice the sport without air-supply relies only on their ability to hold their breath or stays in the surface of the water and breath through a snorkel. These two different ways of spearfishing are called aspetto (one breath) and over floating (breathing through a snorkel). In Denmark it is more common to use over floating, because of the shallow waters along the coast. It is also possible to spearfish with air-supply, but the opinions on this way of doing it is very divided. The majority of spearfishers from all over the world consider it too easy, against the spirit of the sport and unethical to spearfish with air-supply [Fishwrecked, 2013].

Based on the initial investigation of diving types it was detected that spearfishing is performed in both categories of diving; with and without air-supply. Due to the fact that the majority of spearfishers seeing spearfishing with air-supply as unethical and against the whole principle of spearfishing and also being illegal in some countries, it was determined that the area of interest in the project should be narrowed further down to spearfishing without air-supply. Furthermore is the number of regulations and requirements for equipment for diving with external air much higher than for free-diving. These regulations could limit the product design. This confirms the team decision of working inside the field of diving without external air.

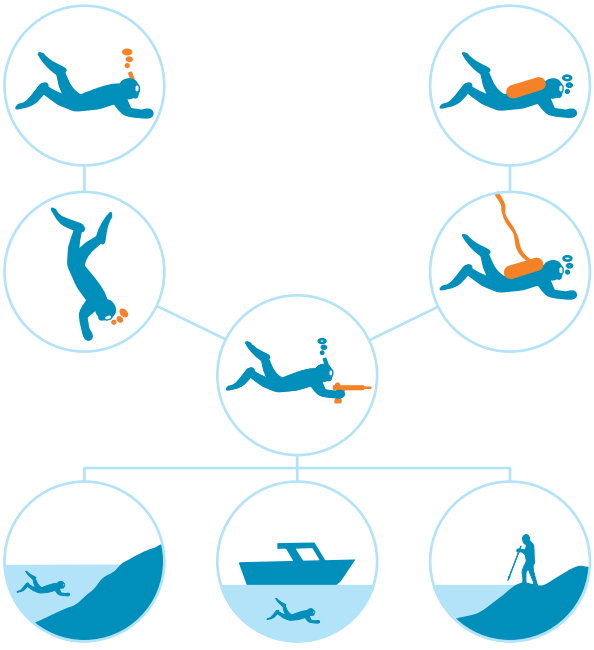
Ill. 1.1.1: Spearfishing

WHAT IS SPEARFISHING?

Spearfishing is an underwater sport where you combine free-diving or snorkeling with hunting - when doing it without air-supply. The spearfisher hunts down different species of fish, which is done with a speargun or a pole spear. This way of fishing is selective and normally it uses no bait to catch the fish. In the spearfishing world it is a well-known rule, that you only catch what you and your family are capable of eating.

Overall there are three different ways of performing spearfishing defined by the way the spearfisher enters the water (Ill. 1.1.2);

- Shore diving, where the spearfisher enters the water from the shore
- Blue water diving, where the spearfisher enters the water from a boat or kayak
- Without diving, which is an ancient method, where the performer stands above the water with a pole spear.



Ill. 1.1.2: Five types of diving and three ways of spearfishing

The most common way to spearfish in Denmark is shore diving, where the spearfisher enters the water from the shore and typically swims and dives along the coast (Worksheet no. 02). In other areas of the world, blue water diving is more common due to e.g. deeper and clearer waters.

HOW TO SPEARFISH?

To clarify the scenario of spearfishing the team has used videos from spearfishers to be able to determine the work flow. The scenario is described below and illustrated on page 11.

1. The spearfisher packs the necessary equipment (see section 1.2 Equipment) often in a dry bag or similar at home and then transport himself to the ocean.
2. When he arrives at the spot, which in Denmark often will be along the coast, he makes himself ready to spearfish by putting on all the equipment.
3. When he has entered the water he will load the speargun, so it is ready. He will lie in the surface and load the speargun. The speargun always has to be loaded below water due to safety precautions.
4. Then he will over float the area in his search of a desired fish to catch with his speargun. When he sees a fish he wants, he will - depending on the depth of the water - either stay in the water surface (low water) or take one breath and dive into the water (deep water) to shoot the fish.
5. The spearfisher will take an aim at the fish and hopefully hit his target.
6. Then he will drag the fish on the spear towards him to definitive kill it with a knife.
7. The fish will then be attached to a hook in his weight belt, so he has his hands free again to keep searching for more fish or just swim back to the coast.
8. When he is finished with his hunting, he will go out of the water, take of his equipment.
9. Some spearfishers will prepare the fish at the spot while others will bring it home and prepare it to eat.
10. He transport himself and his catches home.

The scenario is based on a video [Youtube, 2015]

! The area of interest in the project is spearfishing without air-supply!

Ill. 1.1.3-12: The scenario of spearfishing

WHO ARE THE SPEARFISHERS?

Spearfishers often start as divers or fishermen before becoming spearfishers (Worksheet no. 03). Therefore they often come with different approaches to the way of spearfishing - some see it as a sport, while others see it as a way of being self-supplying and finally some see it as meditation and a way of relaxing (Worksheet no. 04).
These three different approaches will influence the degree of aggression and thereby how selective each spearfisher is in the water.

The meditative spearfisher will in most cases not shoot and catch every fish that swims by him, but be more selective than the self-supplying or sport-oriented spearfisher.

The self-suppling spearfisher will search for and shoot the fish, which he assume he and his family are capable to eat. He is the type who spearfish every time he wants fresh fish.

The sport oriented spearfisher has two sides; the first one will often prioritize the sport of free-diving and shot fish as an additional part of the sport. The other dimension to the sport oriented spearfisher is a competitive mind. He will search for the biggest fish and shoot it to set the record.

Ill. 1.1.13-15

It is of course possible to use more efficient methods than spearguns to catch a lot of fish like fishing nets, explosives etc., but then it will go against what spearfishing is all about: be in the same surroundings as the fish, hunt on their premises and be selective in what you catch.
There might be different approaches to how you spearfish, but regardless of which approach you have, spearfishing is all about catching fish.

Ill. 1.1.16: A typical spearfisher

ETHICS AND RULES

Spearfishers are anglers and are therefore also practicing under the legislation of fishing, which means it is necessary with a fishing license. Preservation zones, seasons and minimum sizes have to be followed. It is good practice to keep distance to preservation zones in order to avoid misunderstandings with other users of the ocean. Protected fish are illegal to catch and spearfishing is only allowed in seawater. Spearfishing in areas with other anglers is frowned upon and also nearby bathing guests, because the ocean is big enough for all visitors. A spearfisher should only catch what he and his family are capable of eating, because it is illegal to sell the fish.
A speargun is a weapon and therefore the legislation for weapons applies, which means it is only legal to buy a speargun when turning 18 years or above [Undervandsitetet, 2013].

! The project will not distinguish between the different approaches to spearfishing!

1.2 EQUIPMENT

The initial investigation of equipment used in spearfishing is executed to get an insight into the equipment, the use of it, the characteristics and current problem areas (Worksheet no. 05). At this point in the research phase, the team has to validate or refute the desired direction of the project; spearfishing.

During the investigation several problems are detected in most of the equipment, which quickly validated and confirmed the potential of designing equipment for spearfishing as the main topic for the thesis project. The problems are listed under each equipment to the right.
At the same time, the investigation of the equipment has to function as the base for choosing a direction inside the field of spearfishing. Through the detection of the problems in every piece of equipment, it is possible for the team to look at the problems and sort out the less interesting parts. The team ends up with three possible products with greatest potential to look into; the fins, the float and the speargun. These three potential focus areas found in collaboration with Lamberto Azzi from Divecenter, who emphazies, that these three hold the large potential and need for development (Worksheet no. 06).

Through an evaluation of potential, group interest, scope and scale of each type of equipment, the team ends up with seeing most possibilities in the speargun. Several problems have been detected with the current spearguns on the market, furthermore has the speargun not been undergoing radical changes since the beginning of the newer spearfishing history (section 1.3).

! Based on the initial research the speargun is chosen as the direction of the project, though it is necessary to validate the speargun as a direction through further investigations!

WETSUIT:
+ Keeps the diver warm
- Harder to dive due to buoyancy
- Proportions not made for Scandinavians
- When the diver has to pee

MASK:
+ Possible to see underwater
+ Easier to hold your breath
- Often gets fogged
- Tight fit is difficult with beard or long hair

FINS:
+ Easier propulsion
- Does not fit all
- Lack of stiffness

SNORKEL:
+ Possible to breath head-down in water
- In the way when diving
- Harder to hold your breath while diving

WEIGHT BELT:
+ Easier to dive
- Badly divided on body
- Poorly fastened to the body
- Heavy and unhandy to transport

KNIFE:
+ Possible to cut free if stocked
+ Quick kill of caught fish
- Hard to take out of the sheath
- Hard to grab, due to placement on body

FLASHLIGHT:
+ Possible to see at night
+ Possible to see into caves
- High lumen value needed
- Short battery lifetime
- Cold temperatures reduce power

FLOAT:
+ Indicates where the diver is
+ Attach or store caught fish
- Harder to swim and dive
- Diver gets tangled in the line
- Hard to drop if needed

HOOK & NET:
+ Storage of caught fish
- Harder to swim and dive
- Often gets tangled
- Attached to body or float

SPEARGUN:
+ Possible to catch fish underwater
- Hard to load
- Hard to aim precise
- Short shooting range
- Hard to handle during transport
- Hard to clean

Ill. 1.2.1: Spearfishers use a variety of different equipment.

1.3 HISTORY OF SPEARGUNS

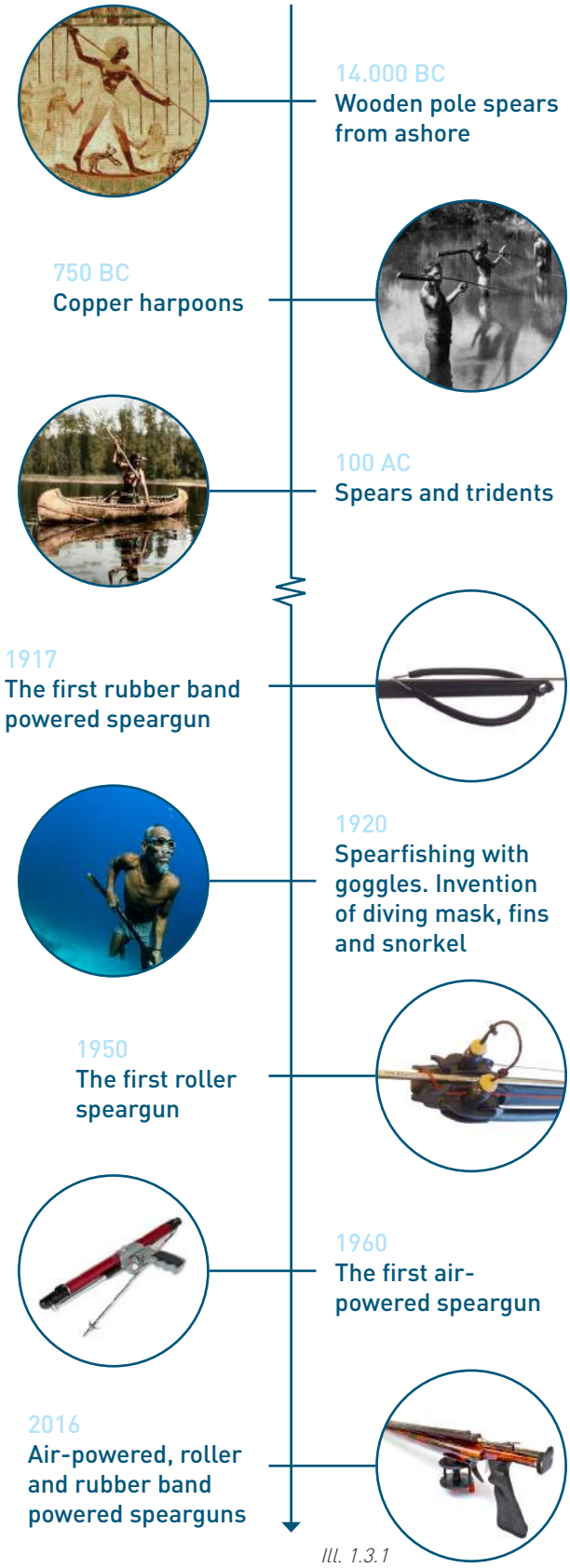
To validate the focus on spearguns an investigation of the history of the sport and the equipment is done. Furthermore the investigation will give an understanding of which techniques and technologies have been used through the history. (Worksheet no. 07).

Spearfishing is one of the oldest ways of fishing and dates back 16.000 years. Back in ancient time it was done with pole spears from ashore and the spears were made of wood [Spearfishing, 2012]. This way of spearfishing is still performed today, but normally with newer techniques and more modern spears.

The way of spearfishing in water as it is known today was developed in the early 1920's and was with simple equipment. Through the following decades the equipment have become more and more advanced. From the 1920's to the 1960's the sport evolved to a worldwide sport and in the 1960's it was suggested as an Olympic discipline but was rejected. During these forty years associations, restrictions and world record charts were made, making it a recognized sport and fishing form. The spearguns were in the 1960's renewed and evolved and in this period the two most used spearguns today (air powered and rubber band powered) was developed.
From the 1960's until today the principles of air and rubber band powered spearguns hasn't changed much. Both the rubber band powered speargun and air powered spearguns have become lighter and new materials have optimized the quality of the products, but the basic principles are still the same.

This insight of the history indicates that there has been low radical product changes through the last 50 years of spearguns. To understand why the different speargun types have not changed much it is necessary to look into what types of spearguns are on the market and furthermore investigate the pros and cons of each type of speargun.

> ! The same loading methods and product architecture has changed little through the last 50 years and rubber band and air spearguns are still the preferred speargun types!

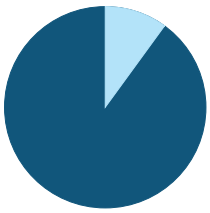


Ill. 1.3.1

1.4 SPEARGUNS

Investigating the different types of spearguns will help the team to get an understanding of the technologies used today for catching fish and also discover potential gaps on the market. Strengths and weaknesses of each equipment is clarified during this research (Worksheet no. 08).

All five types of existing spearguns have been analyzed as seen in ill. 1.4.2. Each one uses a different technology - some more advanced than others. Some types are better suited for catching specific species of fish and in specific surroundings than others which will be further elaborated in the following chapters.
The strengths and weaknesses are evaluated through the team's own initial experience with the each type of speargun, interviews with experts and by searching on the web in different forums, where spearguns are discussed and reviewed.



Ill. 1.4.1: 90 % of the spearguns from the questionnaire are rubber band powered

The questionnaire reveals that the most common types of spearguns are the rubber band powered (90%) and next the air powered (10%). None of the participants in the questionnaire states they own a spring powered speargun. The CO2 powered is illegal in most countries, which makes it the least frequent. Pole spears are not considered an actual speargun, so there are probably more who has one that stated in the questionnaire (<1%).

From the initial research on speargun types the team concludes that the rubber band and air powered spearguns are the preferred types. Each type and length of speargun has their own benefits and strengths which will have to be further investigated.

!

Air- and rubber band powered spearguns are preferred due to the benefits!

Further investigation of capabilities and benefits are needed!

POLE SPEAR:
+ Fast reload
+ Simple system
+ Good in close range
+ Variable in power

- Short range
- Large
- Low power

AIR POWERED:
+ Small and compact
+ Good for reefs, near sharp edges
+ Maintain power over time
+ High power vs size
+ Easy to maneuver

- Lose power in deeper water
- Hard to load
- Need to be serviced and oiled
- Aim can be bad

CO_2 S POWERED:
+ High Power
+ Easy to load
+ Good aim

- Illegal in most countries
- Considered as a weapon
- Loud
- Most is homemade

SPRING POWERED:
+ Easy to load

- Low power
- Bad aim
- Spring rusts easily

RUBBER BAND POWERED:
+ High precision
+ Variable power
+ Low maintenance
+ Maintain power in deep water

- Rubber bands fast wearing out
- Lack of power compared to size
- Hard to maneuver

Ill. 1.4.2: Five different ways to power the speargun

15

The team has to determine the impact and importance of different lengths of spearguns. The team has to investigate why the majority of all spearfishers - according to the questionnaire - has several spearguns instead of just one. Furthermore the team will investigate which impact the spearfishers experience level has on both equipment and the act of spearfishing.

LENGTH OF SPEARGUN

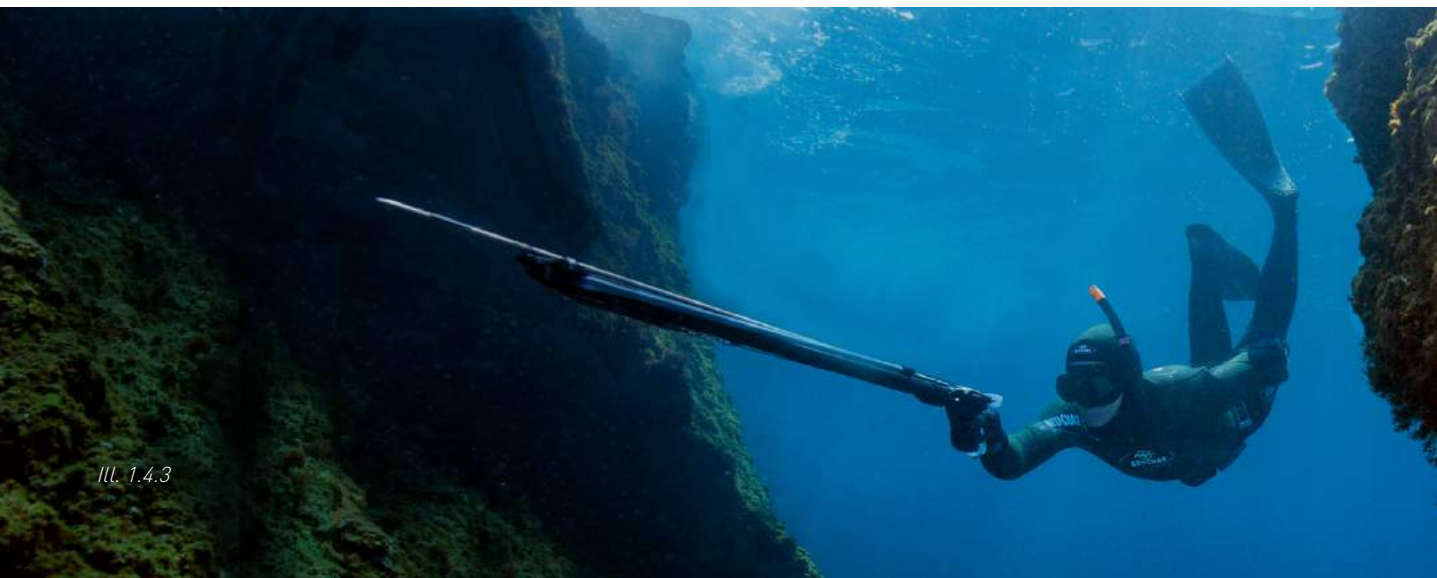
The market of spearguns consists of a large variety of lengths varying from 35-160 cm. Each length has its own benefits and purposes and surroundings which it is best suited for.
Based on the expert interviews the team has sat up a product matrix showing the benefits and the most suitable surroundings and hunting purposes (Worksheet no. 06) (Ill. 1.4.4). Despite the best suited purpose and surroundings each speargun can be used in every scenario. A speargun not suited for the purpose and/or surroundings will make the hunting more difficult regarding maneuvering, aiming, power etc.

With the length of the speargun comes the range and power. The longer the speargun is, the more power it has. Both the air powered and the rubber band powered spearguns achieve more power along with the length. The rubber band is able to be stretched over a longer distance, and the air chamber can contain more air to be compressed under a higher pressure.
The longer the speargun is, the higher the accuracy in the shot. The spear has a longer lane of support during "take-off", which makes the shot more precise.

WHY ARE SEVERAL SPEARGUNS NEEDED?

Spearfishers typically have several spearguns, which was confirmed through the questionnaire (Worksheet no. 09), but why is that?

As aforementioned each lengths fits a specific hunting purpose and surrounding the best.
The illustration to the right describes which lengths of spearguns are best suited for which purpose in terms of fish species to catch, surroundings and conditions. Furthermore pros and cons of the lengths are made and which visibility range and current they are best suited for. The team has used the matrix in Worksheet no. 09 to create an overview and understanding of the different spearguns and why it is necessary for the committed spearfisher to have several spearguns.
The smallest spearguns are suited for catching flatfish and still standing cods, where precision is not crucial. The smaller spearguns are easier to maneuver and are able to fit into tight places, which makes them suited for hunting in shipwrecks and in break waters.
The biggest spearguns are only used in clear waters with good visibility, e.g. in Norway and the Mediterranean Sea. The longest spearguns obtain a high power, which makes it suited for larger fish such as halibuts and tunas.
Often the spearfishers - according to the questionnaire - have one or two all-round spearguns which they can use most of the time. These are the sizes in between. The all-round speargun though, will most of the time not be optimal for the surroundings and conditions.
The questionnaire shows that spearguns from 50-120 cm are the ones used in Denmark.



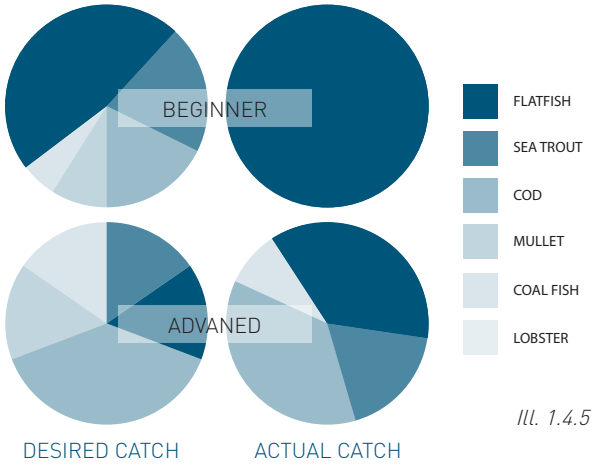
Ill. 1.4.3

<60 cm	• Flatfish • Cods	+ Easy to maneuver in high current and tight places. + Can be used by shorter users + Easy to load - Short range - Low power - Low precision	SURROUNDINGS: Sand bottom, break waters, caves, holes CONDITIONS: High current, shallow water, low visibility
65-80 cm	• Flatfish • Cods • Sea trouts • Coal fish • Mullets	+ Easy to load and maneuver in regular Danish conditions + Can be used by shorter individuals - Short-semi range - Low/medium power - Not suited for good visibility - Low-semi precision	SURROUNDINGS: Sand bottom, break waters, caves, holes, stone reefs CONDITIONS: High-medium current, low/medium visibility
85-110 cm	• Flatfish • Cods • Sea trouts • Coal fish • Mullets	+ Semi-long range + Medium-high power + Suited for good visibility - Hard to maneuver - Not suited for low visibility and high current - Not suited for wrecks and cramped spaces	SURROUNDINGS: Breakwaters, stone reefs, open water, deep dives CONDITIONS: Medium-low current, medium-high visibility
>110 cm	• Flatfish • Cods • Sea trouts • Coal fish • Mullets	+ Long range + High power + High precision - Hard to maneuver - Not suited for low visibility and high current. - Not suited for wrecks and cramped spaces.	SURROUNDINGS: Open water, deep water CONDITIONS: Low-no current, high visibility

Ill. 1.4.4

EXPERIENCE

From the questionnaire it becomes clear that the types, quality and price range of the spearguns do not vary depended on the experience level. Beginners and advanced spearfisher have in general the same spearguns (Worksheet no. 09).
The questionnaire also shows that the advanced spearfishers in general have a much higher hit rate than the beginners. The beginners hunt for every legal species of fish, but do in general not catch anything but flatfish. The advanced spearfishers often hunt for a specific specie in every hunt, and typically they catch what they hunt for (Ill. 1.4.5). This clearly indicates that the experience has a big influence on the success rate for the spearfisher.



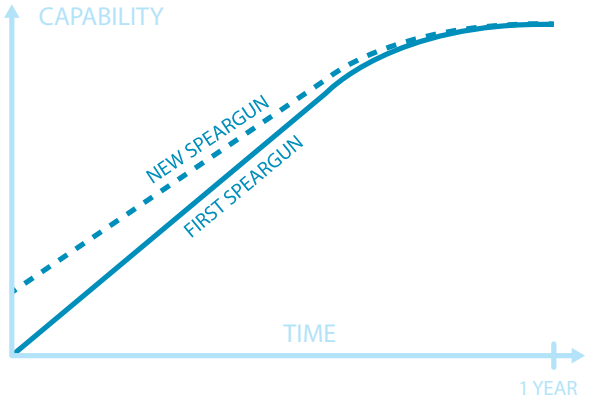
Ill. 1.4.5

The more experienced a spearfisher gets, the more spearguns he often tends to have. This should be seen as a result of the spearfisher becoming more experienced and thereby gets a better understanding of which speargun is best suited to the water conditions and surroundings he is spearfishing in. It will in some situations also be caused by the spearfisher's desire to catch fish species that are more difficult to catch and therefore needs a speargun with more range and power.
The need of several different spearguns includes some disadvantages. Not only the transportation of the whole collection of guns to the ocean, but especially the fact that every time you get a new gun, it will take about one year to learn how to shoot and handle it properly. This is stated through the expert interview with Lamberto Azzi from Divecenter, who is an experienced spearfisher

"It will take you one year to learn how to shoot with a new speargun, even if you are an experienced spearfisher!"

Lamberto Azzi, Divecenter

himself and helps guiding other spearfishers in their purchase of equipment and in practice of the sport (Worksheet no. 06). Even if the new speargun is within the same brand as the previously, it will take a great amount of time before the spearfisher gets the same experience with the new gun as he had with the old. Every time the spearfisher buys a new speargun - even if he is an experienced spearfisher - he will be set several steps back on the experience curve (Worksheet no. 10). The curve in ill. 1.4.6 shows the learning curve for getting to know a new speargun. The first speargun a spearfisher purchase will take around one year to be capable of using it entirely. When he purchases a new speargun, he will be set almost all the way back on the learning curve. Due to the gained experience, he will start a little higher on the learning curve.



Ill. 1.4.6

! It takes around one year to learn how to shoot and handle a new speargun despite your experience level!

! The length of the new speargun should somehow be able to cover a span from 50-120 cm.

1.5 EXISTING PRODUCTS

To gain a better understanding of the current spearguns the team needs to investigate the spearguns currently on the market. The investigation is done based on the Danish market, because it is where the team wants to implement their future product at first. The investigation starts with a thorough examination of the existing products, how they are used, what features and functions they contain and general pros and cons and price.

As stated in the previous chapter, the current market of spearguns can be divided into two types of spearguns; air powered and rubber band powered. A large variety of brands and models are represented within the two groups. A mapping is made based on the most common models and brands found on the Danish market. The mapping is used to create an overview of the price range of the spearguns and how function and price is related (Worksheet no. 11).

Ill. 1.5.1:

The prices typically range from around 400 DKK for a basic speargun up to 5000 DKK for a high quality speargun with extra features like line winder and carbon barrels.

Through the examination of the existing speargun models, a questionnaire and phenomenological testing of the products in water (Worksheet no. 12), it is made clear which problems a common spearfisher meets when he uses the existing products (Worksheet no. 13).

Purpose of test
To investigate how the existing spearguns function and which problems the user has before, during and after use.

Explanation of test
Different spearguns are tested in water, to determine how they work and to confirm the problems stated through the questionnaire (Worksheet no. 12). The products are evaluated on the loading, the safety mechanism, the maneuverability, the line and transport of the speargun.

Ill. 1.5.2: Testing equipment in pool

Conclusion of test
The existing spearguns have a lot of problems both before, during and after use inside all the tested parameters. The problems discovered in the questionnaire have all been confirmed as problems.

LOADING

The way the spearguns are loaded are in general very difficult to handle especially for beginners. To load a rubber band powered speargun you have to place the handle of the speargun in your chest and then reach out to the tip of the speargun and grab the rubber band and pull it all the way down to the tip in the spear (Worksheet no. 11). It is really hard to pull the rubber band all the way back to the place of attachment on the spear, because it requires a lot of strength and technique and the pressure in your chest is so high, that it often leaves bruises.
To load an air-powered speargun you place the handle of the speargun on your thigh or fin before putting the spear in the barrel to press it down. This maneuver requires a lot of force and gives you a twist in the upper body. The spear needs to be pushed all the way down into the barrel in one motion otherwise the spear will be pushed back up of the barrel which can be dangerous.

SAFETY

The safety mechanism on the majority of the spearguns tested is difficult to use and understand. The safety mechanisms do not indicate whether it is the safety that is on or it is the speargun which is on. At the same time, it can be difficult to handle the mechanism especially with gloves on, and in general to see if the safety is activated or not.
The difficulties in using the safety mechanism is frustrating to the user, he can loose a good shot at a fish if the safety does not work as he thinks and this may result in choosing not to activate the safety.

MANEUVERABILITY

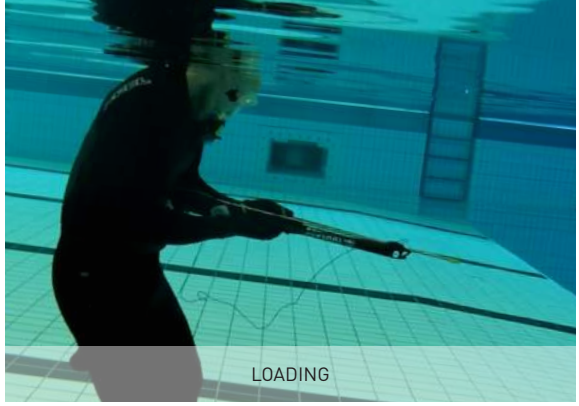
The spearguns in the cheaper end of the scale (below 2000 DKK) have in general a traditional round pipe as the barrel. Due to the shape of the speargun and the long, closed structure especially the longer spearguns are very hard and difficult to maneuver through the water. The shorter the speargun, the easier it is to maneuver.
The more expensive spearguns on the market tend to have a more hydrodynamic shape, which makes it easier to maneuver despite the long length.

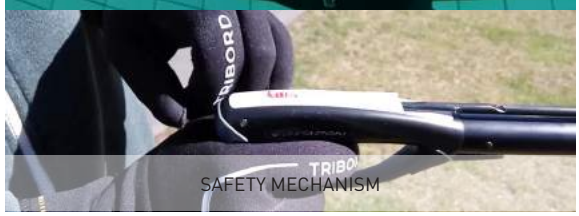
TRANSPORT

The transportation of the speargun can be difficult for the spearfisher. Whether he is driving a car, on a bike, walking or taking public transportation. The sport requires a lot of different equipment, especially in Denmark due to the cold water, and it can be hard to handle on a bike and the long spear tend to rib up the interior of the car. The spearfishers who take public transportation experience to be thrown of the bus or train because of their speargun. Besides, if the spearfisher does not have an outright speargun bag, the bag with his equipment easily becomes unhandy and looks dangerous to others.

LINE

A common problem with the existing spearguns is the line between the spear and the speargun, which gets tangled. The line is fastened in a sort of simple winding system from the spear to the tip of the speargun and back down to the handle. The line often just floats through the water both before, during and after the speargun has been fired.


LOADING


SAFETY MECHANISM


MANEUVERING


TRANSPORT


TANGLED LINE

Ill. 1.5.3-7: Some of the problems discovered during the investigation of the existing spearguns.

1.6 EXPERTS

Semi-structured interviews are made with experts in spearfishing to get more overall knowledge regarding existing products and the market potential. Spearfishing equipment stores are visited and an author/lecturer/spearfisher of the national team in spearfishing is contacted to also get a deeper insight into ocean conditions.

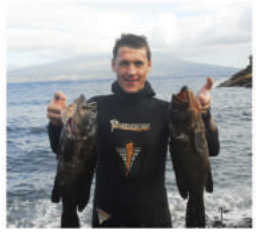
The procedure of the interviews has been a reflective process, where the team asks one expert and then gets the new knowledge confirmed by another expert. The team has evaluated the new knowledge along the process and used it to determine what they further need to get the full picture.

The team makes different semi-structured interviews depending on the interviewee, because the team knows each interviewee would have different knowledge. The result of the interviews can be found in Worksheet no. 03, 14, 15, 16, 17 and the most essential knowledge obtained from the interviews are presented as quotes in Ill. 1.6.1-5.

Divecenter, Carlsens Dykkercenter and JBL all confirme the initial hypothesis about no spearguns are designed to the Danish ocean conditions. It is stated during the interviews that the Danish ocean conditions are the worst conditions in the world for spearfishing and diving due to the low visibility, high current and cold temperatures.
The interview with Morten Rosenvold Villadsen, Undervandsitetet gives some further clarification of the Danish ocean conditions - also where in the world it is possible to find similar conditions measured on seabed, species of fish, temperature and visibility.

Another interesting finding through the interviews is the fact that beginners in spearfishing will buy a cheap and relatively short speargun only to come back in 4-6 weeks to buy a new speargun and again two months later (Worksheet no. xx - carlsen). First they need a speargun which is cheap and easy to load, so they can see if spearfishing is actually something they find interesting. When they become a bit more experienced they return to buy a new speargun. The reason spearfishers tend to buy several spearguns is due to the changing ocean conditions and the changing individual demands of the user.

"There is definitely an increasing interest in spearfishing in Denmark these years."
Undervandsitetet, Valby



"The Danish ocean conditions are the worst conditions in the world for spearfishing due to the low visibility, high current and cold temperatures!"
Carlsens Dykkercenter, Nørresundby

"Each spearfishing market is very different; water conditions, temperature, fish species etc. All these factors have made spearguns and support equipment very regional!"
JBL, California, USA

"There is no spearguns especially designed for the Danish market and conditions!"
Divecenter, Copenhagen

"We recommend our customers to buy the 65 or 75 cm speargun, because they are easier to load and maneuver around in the water as a beginner and then they will buy a longer one as they get more experienced."
Jægeren & Lystfiskeren, Aalborg

! The new speargun should be designed to fit the Danish ocean conditions!

! The team needs to determine the market potential by investigating where similar conditions are found!

1.7 **CONDITIONS**

The experts in the previous chapter states that no existing spearguns are designed directly for the Danish ocean conditions. The team needs to look more into how the Danish ocean conditions are different from more common places for spearfishing.

Stated by Hans-Henrik Carlsen, Denmark has some of the worst conditions for spearfishing. Despite these circumstances the sport still has many practitioners in Denmark and more are joining during the last couple of years.

The current spearguns are made to fit conditions of especially the Mediterranean Sea, where spearfishing is a popular sport and practiced by a lot of people. The conditions in the Mediterranean are characterized by:

- Low current
- Deep water
- Stone reefs and
- High visibility varying from 10 to 40 meters.

This gives overall some really good conditions for spearfishing, because the spearfisher is able to see and thereby shoot his speargun over a longer distance to catch the desired fish almost every time he goes out (Ill. 1.7.1).

The Danish conditions are characterized by:

- High current,
- Shallow waters,
- Sand bottom and
- Low visibility varying from 1 to 20 meters.

Though, a visibility of 20 meters usually only occurs one or two days a year. Rarely, the visibility in Denmark is above 8 meters (Worksheet no. 18), which gives some challenging conditions for spearfishing most days (Ill. 1.7.2). The spearfisher is not able to see very far in the water and therefore he cannot shoot the speargun over a longer distance due to safety precautions. The spearfisher should be able to see both the tip of the speargun, but also where the spear ends. Spearguns are typically able to shoot 2 to 8 meters depending on the length and power in the speargun and the length of the line attached to the spear. The general rule says that a speargun has a shooting range of 5x the length of the speargun. Therefore the spearfisher is able to see the end of the spear at all time in the good conditions in e.g. the Mediterranean Sea regardless of the length of the speargun. Opposite, in Denmark the spearfisher will have to change speargun depending on the visibility the particular day, because it can be dangerous to shoot and not really see what you hit. The speargun can

Ill. 1.7.1

Ill. 1.7.2

be damaged if hitting rocks etc. and you can hit another spearfisher. This means that the Danish spearfisher has to choose the length of the speargun based on the conditions and surrounding that specific day, whereas the Mediterranean spearfisher can choose his speargun from which fish his wants to catch.

The generally high current in the Danish oceans contributes to the challenging spearfishing conditions. The longer the speargun, the more likely is it to be pulled and drawn by the current in the water. The high current makes it more difficult to aim with the speargun and move it through the water. The current thereby also has great impact on the choice of speargun. Even if the visibility is high, the Danish spearfisher can be forced to choose a shorter speargun because of high current.

Denmark is not the only area with challenging spearfishing conditions. Through the expert interview with Morten Rosenvold Villadsen (Worksheet no. 16) it is determined based on his knowledge and experience where similar water conditions can be found.
Similar ocean conditions can be found all around the world; Brittany in France, Portugal, Cape Town in South Africa, Chile, Peru and Northern Australia [Worksheet no. 18] (Ill. 1.7.3). Especially the visibility is something they all have in common, and thereby they have the same obstacles as in Denmark, where you have to choose speargun depending on the visibility and current each day.

! In Denmark it is especially the visibility and current that decide which speargun the spearfisher should use a particular day!

Several places around the world have similar conditions to the Danish. This indicates a larger market potential!

Ill. 1.7.3: Places around the world with similar ocean conditions as the Danish!

1.8 FISH & HABITATS

The length of speargun to use also depends on which fish species the spearfisher wants to catch and in which surroundings. To get insight into which fish species are most commonly caught when spearfishing in Denmark and to understand which requirements this sets for the speargun, an investigation of the most common fish caught during spearfishing in Denmark is made (Worksheet no. 19).

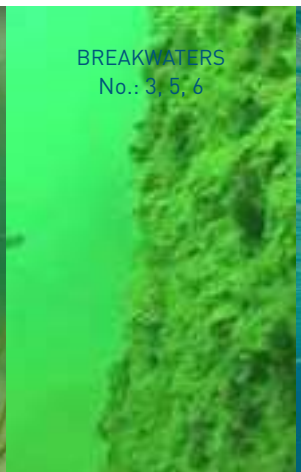
The waters around Denmark contain different types of fish where most of them are suited for eating [Undervandsitetet, 2016]. The fish live from the shallow waters near the coasts and down to the deep depths in the channels around Denmark. The type of speargun used for shooting a specific fish is depending on the specie of fish hunted, the habitat the fish lives in and the conditions at the fishing spot. Based on the questionnaire six species of fish was detected as the general most hunted fish these fish was; sea trout, mullet, turbot, coal fish, flounder and cod (Worksheet no. 19). Each fish has different habitats, sizes and behavioral patterns, which is described in Worksheet no. 20.
The most hunted fish species can in general be divided into three different categories; flatfish, still standing fish and free swimming fish.

The first category of flatfish is a combination of the different species of flatfish in the Danish waters. They have in general the same behavioral pattern and have the same technique to avoid predators. These species does this by camouflaging on the bottom of the sea and blend into the surroundings. In general, this group of fish can be caught with a short speargun without much power.

The next group of fish is the still standing fish. These fish are often hidden between seaweed or in caves which makes them hard to spot and find. In general these fish avoid predators by hiding when they feel threatened and they swim into a protected area. This leaves them hard to catch if they e.g. swim into a rock cave where the speargun can not reach. The spearguns needed for this is depending on the hiding place but in general a length of 70-80 with medium amount of power is sufficient.

The third type of fish is the free swimming. These fish are patrolling areas for finding food and they use their speed and agility to avoiding predators. In general these fish are more shy and protective than other fish species, which is why these fish are the hardest to catch because the fish keeps a distance to the spearfisher. The speargun needed for catching these fish is much depending of the visibility, but in general a 70-100 with medium to high power is used.
From the previous chapter it is clear that there are other places around the world with similar conditions as the Danish. In these areas there are other types of fish, both smaller and bigger than the typical Danish fish species. The majority of the foreign fish species can be divided into the same categories as the Danish and be caught with the same lengths and types of spearguns.

The pictures below show the habitats and the numbers refers to the fish which lives there. In worksheet no. 19 the depths and more details about the fish and their habitats are found.



1.9 TARGET GROUP

Basic knowledge about the equipment for spearfishing is collected so far by hands-on tests in pool, researching on websites and interviewing experts performing the sport and selling the equipment. To gain more knowledge about the users, questionnaires are used to find out if any segmentation of the users can be made. These methods are also used to recognize which criteria a new speargun has to fulfill.

In Denmark you are allowed to spearfish or own a speargun from the age of 18 without a permission to carry a weapon. From the age of 16 you can apply for permission to carry a weapon like a speargun. It is also required to have a license to spearfish as fishing with rod [Dansk Sportsdykker Forbund, 2016]. In Denmark there are approximately 5000 spearfishers whereof 90 percent are men (Worksheet no. 16).

Collecting more information on how the users experience the use of the speargun and spearfishing in general a questionnaire is made to understand why people are spearfishing, but also to understand how many spearguns each person has and the general problems when using them (Worksheet no. 09, 13). To see if the number and types of spearguns, and the problems experienced with them, differentiates by the level of experience each participant has to make a subjective assessment of their level of experience on a scale from 1-4, where 1 being beginner and 4 being advanced (Worksheet no. 21).

The results of the questionnaire shows spearfishers of all four groups, but with a significant majority in group 2 and 3 (semi-beginner and experienced). The groups have different levels of experience and skills measured on how often they spearfish, and which species of fish each group wants to catch compared to which they actually catch (Worksheet no. 20). The questionnaire also tells that the more experienced a spearfisher gets, the more spearguns he has - not necessarily different types, but different lengths especially.

Through the interview with Carlsens Dykkercenter it becomes clear, that spearfishers are acquiring several spearguns in different lengths in order to cover their developing needs. A beginner is often satisfied with catching the easy catchable flatfish, which requires short shooting range and thereby a short speargun (50-70 cm), but when he has done that for a couple of times he develops a desire for catching more difficult species of fish, which requires longer shooting range and thereby a long speargun (75-120 cm) (Worksheet no. 09).

From the questionnaire it seems that all four groups are having the same type of spearguns (rubber band powered), but the length varies from 50 to 120 cm. The interview with Carlsens Dykkercenter makes it clear to the team, that beginners often starts with a short speargun and then buy longer spearguns as their need for catching more difficult fish develop. The advanced group, though, has a tendency to additionally buy the longer and expensive spearguns (above 120 cm and custom made), because they tend to go on blue water spearfishing with better visibility and deeper waters.

The questionnaire also gives a picture of the less experienced spearfishers find the loading of the rubber band speargun more difficult than the experienced. They find the rubber band hard to pull back. Therefore it can be concluded, that the beginners (group 1) need only one speargun (typically short) and it has to be easy to load. Group 2-4 need several lengths of spearguns to cover their increased needs.

! Most spearfishers have several spearguns to fit their needs!

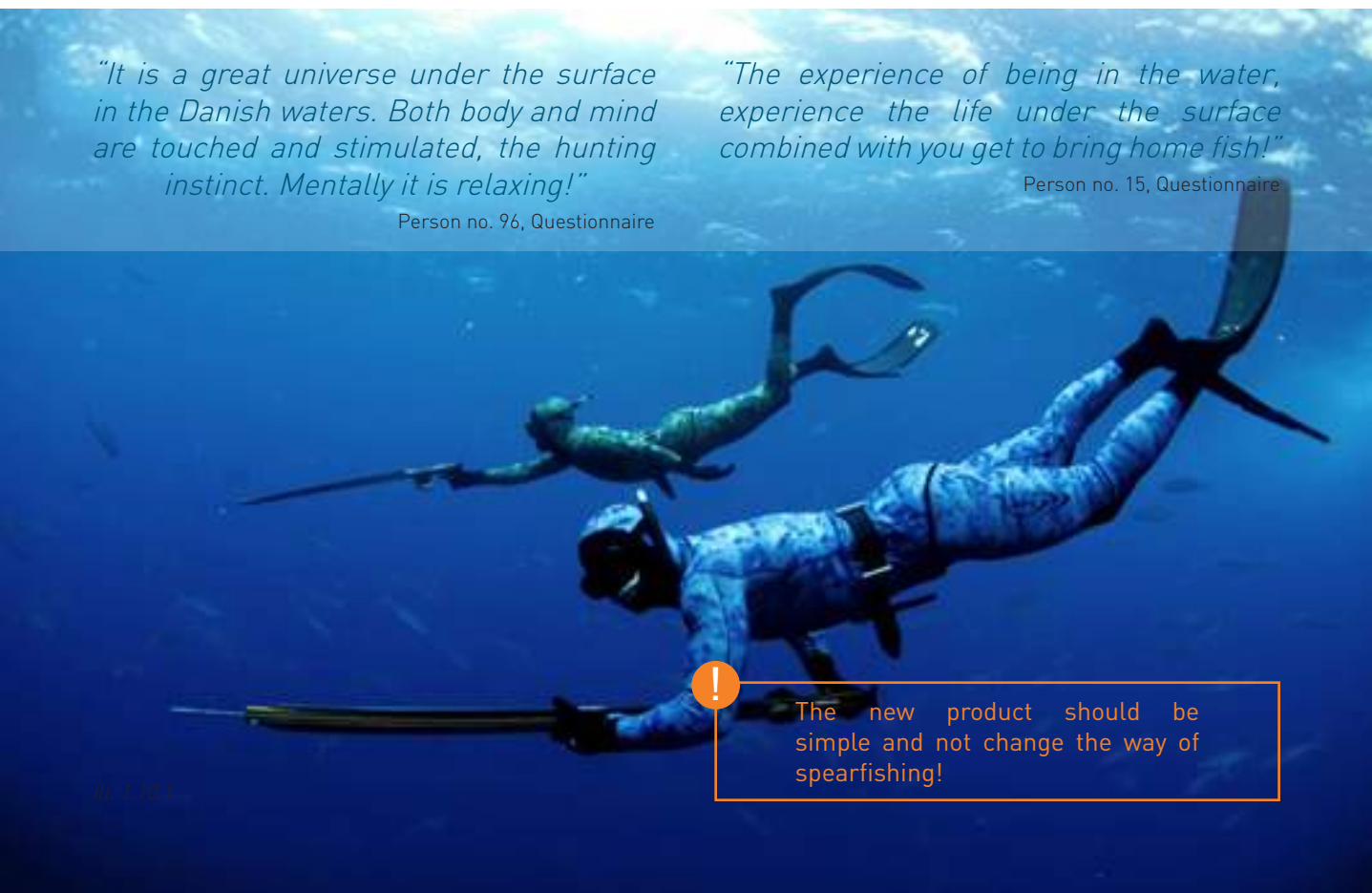
! The target group for the new speargun is spearfishers in all four experience levels - but the team delimits from blue water fishing!

1.10 THE SPORT OF SPEARFISHING

In the optic of sport, spearfishing is a sport just like soccer, hockey and minigolf. When considering spearfishing as a sport, there are several perspectives that needs to be considered when designing a new product for the sport.

The key activities in spearfishing are free-diving and shooting fish with a spear. Shooting fish with a spear is not the most efficient way of catching fish, which supports the theory of spearfishing being a sport - with a side effect of fish to bring home. If people wanted an easy fish, they would go to the supermarket instead. The people who spearfish does it for a number of different reasons; the exercise, the meditative and relaxing aspect and to be self-supplying, but the main reason for most spearfishers is the whole experience around spearfishing and being in the water. The experience of spearfishing is a crucial part of spearfishing. It is not just about going into the water and shoot a couple of fish and then go home, it is also about getting into the nature and see the unspoiled environment, where nature gets the opportunity to be nature and take over old shipwrecks or windmill foundations. This experience is not easy to find on land. Beside of the nature experience, hunting itself is an experience, where the spearfisher gets to move around in the water and hunt on the fish's premises and experience the thrill and adrenalin rush when catching the fish.

When considering a new product for spearfishing, it is necessary to determine whether it should be a product which is true to the sport or a product which rethinks the idea of spearfishing. Should the product still use a spear as the way of catching fish or would it be possible to use another way of catching fish and would this still be within the area of spearfishing? There are numerous ways of both catching and killing fish, but based on an user survey (Worksheet no. 22) it is clear to the team, that an incremental approach to the new product design will be preferred compared to a new radical innovation of the speargun and the sport of spearfishing.



"It is a great universe under the surface in the Danish waters. Both body and mind are touched and stimulated, the hunting instinct. Mentally it is relaxing!"

Person no. 96, Questionnaire

"The experience of being in the water, experience the life under the surface combined with you get to bring home fish!"

Person no. 15, Questionnaire

! The new product should be simple and not change the way of spearfishing!

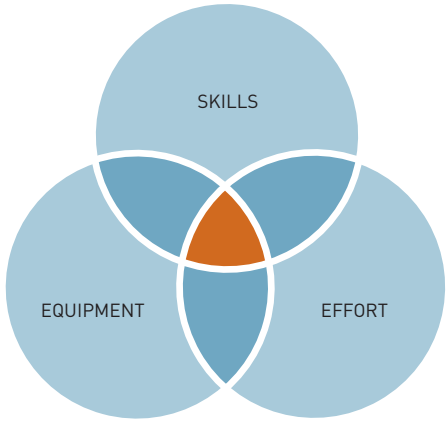
1.11 SEE-MODEL

Through analyzing the result of the questionnaire (Worksheet no. 20), it became clear that the equipment is not the only factor playing an essential part in getting success in spearfishing. The study revealed that the beginners are not catching the intended fish and have a very little success rate in catching sea trouts and other highly desired and more difficult to catch fish species even though they has the same spearguns as the advanced users.

By studying each of the four user categories divided by their experience levels, each level in general got higher and higher success rate in terms of what kind of fish they are hunting for and what they are actually catching. Through analysis it was determined that three parameters play an important part in the overall success of a spearfisher; skills, equipment and effort (Worksheet no. 20).

The parameter of skills consists of both the theoretical skills and the practical skills. The practical skills is developed through practicing the sport. The theoretical skills are developed through studying and learning about the theories that lies within the area of spearfishing and free-diving. The theoretical skills are essential to practice the sport. Knowledge regarding safety, weather conditions etc. is important to be able to perform spearfishing in a proper and secure way.
The parameter regarding equipment includes all the physical objects used for spearfishing (Worksheet no. 05). From the questionnaire it is clarified that the brand of the equipment is not the essential part in catching fish, due to the fact, that all spearguns, no matter which brand, has more or less the same problems and flaws, which could make the hunting difficult even for the advanced users.
The parameter of effort is an indicator of how much the performer is willing to put into practicing the sport. If he is not willing to spend time on developing both the practical and theoretical skills, he will never become a better spearfisher. This parameter is about prioritizing the sport. This includes both in terms of money and time, and also covers the effort the spearfisher is willing to put into going to the right fishing areas. If the spearfisher do not go to the places where the sea trouts are, he will never catch a sea trout.

These three parameters are closely linked together and interdependent to become a successful spearfisher. Through investigations of the concept and culture of spearfishing and interviews with the users, it has become clear, that there is room for improvement inside all three categories. To be able to help the common spearfisher becoming a great spearfisher, it would be necessary to improve on all three parameters.
The lack of effort put into the spearfishing could e.g. come from problems and frustrations with the speargun and the handling of this. During the investigation of the existing spearguns on the market (Worksheet no. 11) it is seen that the majority of the spearguns are hard to handle especially for beginners. There is a tendency in the level of skills, that the advanced users has a higher success rate in their hunting, even though they use the same spearguns as the beginners and still commented that they experience several problems with the spearguns. The higher success rate could therefore be linked directly to a greater level of skills coming from more experience and knowledge. When improving the equipment, it is the hypothesis that the skills and effort regarding spearfishing will improve as a result of an improved speargun.



Ill. 1.11.1: The SEE-Model explains three essential parts of an spearfisher.

! When improving the equipment the skills and effort will theoretically follow the improvement!

1.12 DESIGN BRIEF

PROJECT OVERVIEW

The project will focus on spearguns for the Danish spearfisher and the problems occurring when performing the sport of spearfishing in the Danish water conditions. Through interviews, questionnaires and analysis the scope is specified to creating an adaptable weapon for the Danish spearfisher, who wants to be able to transform and adapt their weapon to fit the changing conditions and easily be able to load their weapon.

The new product will have to compete on a market where the existing products are designed especially for areas with better spearfishing conditions than the Danish. The new product will bring new values to the user regarding different qualities and better adaption to the Danish ocean conditions. The new product is intended to be sold in spearfishing stores both in Denmark and countries with similar conditions, but as the product is intended to be adaptable to different conditions it could be incorporated in other spearfishing markets around the World.

CATEGORY OVERVIEW

When designing a new product, it is important to know the competitors and where the new product will stand out. The new product will have to compete on a market where the existing products are designed especially for areas with better spearfishing conditions than the Danish. There is a large variety in price and features in the existing products currently on the market. From the research it is made clear that the new product will have to accommodate the characteristics of the Danish ocean conditions to stand out from the competing spearguns on the market. The new product will bring some new values to the user regarding different qualities and better adaption to the Danish ocean conditions. The new product will also have to keep the spirit of the sport of spearfishing in mind, so it will meet the requirements of the traditional spearfisher.

TARGET AUDIENCE

Through thorough research consisting of interviews, questionnaires and general research, it has been determined that the target group for the new product is the spearfisher in Denmark, who loves the ocean, it's wildlife and cares about safety when diving and fishing. The target group range in all experience levels of spearfishing and includes both men and women from 18 years and up, which means they have individually needs and wishes to the spearfishing. Their reasons to spearfish is the meditative experience and the thrill when catching the right fish. The interest of the target group is to catch various species of Danish fish to bring home and eat. The trend of being self-supplied is becoming more popular and therefore this person is very much interested in catching the desired, eatable fish. This means the person is willing to spend money on the necessary equipment and especially an adaptable speargun enhancing the chances of catching the desired fish in the changing conditions of Danish oceans.

> How can a speargun be designed so it fits the Danish water conditions and similar, and how can the loading of the speargun be changed to make this easier?
>
> PROBLEM STATEMENT

Enhance the user experience before, during and after spearfishing!

VISION

Allow spearfishers to adapt to the different ocean conditions and surroundings, while also making it easier to load the speargun!

MISSION

PROJECT SCOPE

The criteria are all based on the research done so far and will be updated and specified during the development process.

DEMANDS

Adaptable to different ocean conditions
- Visibility from 1 - 20 meters
- Current from 0 - 1 m/s

Adaptable to different hunting purpose
- Still standing fish, free swimming fish and flatfish
- Surroundings: shipwrecks, reefs, sand bottom and breakwaters

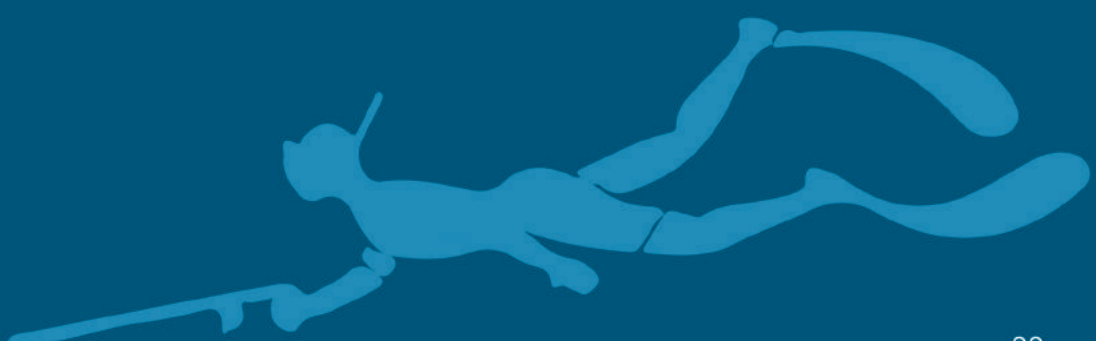
User
- Should accommodate the needs of beginners, semi-beginners and experienced spearfishers
- Usable in all four experience levels

Transportable
- Should not look like a weapon during transport
- Storage and transportation bag

Easy maintenance
- The user should be able to replace parts by themselves

Specification
- A shooting range equivalent to the most common used speargun lengths in Denmark

Business
- Price range 700 - 1800 DKK



1.13 **RESEARCH SUM-UP**

All the initial research helps the team to put up some requirements and which direction the new speargun will take. To get a better overview of what the team will focus on in the Concept Development the following Design Brief is made. This will help when decisions have to be taken upon a concept or just an idea, whether it lives up to the requirements listed here. Some might in this phase still be unmeasurable and have to be investigated further before it can actually be used as a tool for decision taking.

Phase **2.0**

CONCEPT DEVELOPMENT

In this phase the ideation and development of concepts, which is done upon the research made in the previous phase will be explained. The knowledge gained through the research combined with investigations and testings provides the foundation for the final concept idea. The developing of the concept is divided into four parts to give a better overview, due to a speargun consists of many parts and subsystems.

Though it is stated in the previous chapter, that the team should develop a product for traditional spearfishing, the team starts out in the concept development phase by challenging this statement. The team wants to definitive exclude a different way of spearfishing as a possibility.

Through the whole phase of concept developing, the team focus on and try to keep the product design as simple as possible. Overly complex ideas has quickly been ruled out.

Ill. 2.1.1

2.1 **SIMPLICITY**

Even though it has been concluded that the sport of spearfishing should not be changed with a new developed product, the team will still open up in the ideation phase of alternative solutions to catch fish. Therefore at the first status seminar, concepts, which will change the way of spearfishing radically, were presented. The concepts are the results of the initial concept development process. The concepts are a combination of the different adjustment principles tested; modularity, telescope and all-round, and a combination of different ways to kill fish and loading principles (Worksheet no. 23).

After the presentation the team evaluated the different concepts, and concluded based on the feedback, that some of the concepts were too complex to be realized. The team discovered through the research an important parameter in spearfishing equipment; simplicity. This parameter is important to integrate and be aware of in the further concept development.
During the process the team investigates the possibility in using other loading principles than the existing rubber bands and traditional air compression. During this process magnetism as compression mechanism for the air compression powered speargun is investigated shortly (Worksheet no. 24). The team decides to rule out the principle due to complexity and later on air compression as a loading principle is ruled out due to the complexity in the combination with the adjustment principle. During these stages it becomes more and more clear how important it is to have simple and integrated solutions in a product with low complexity.

2.2 **IDEATION**

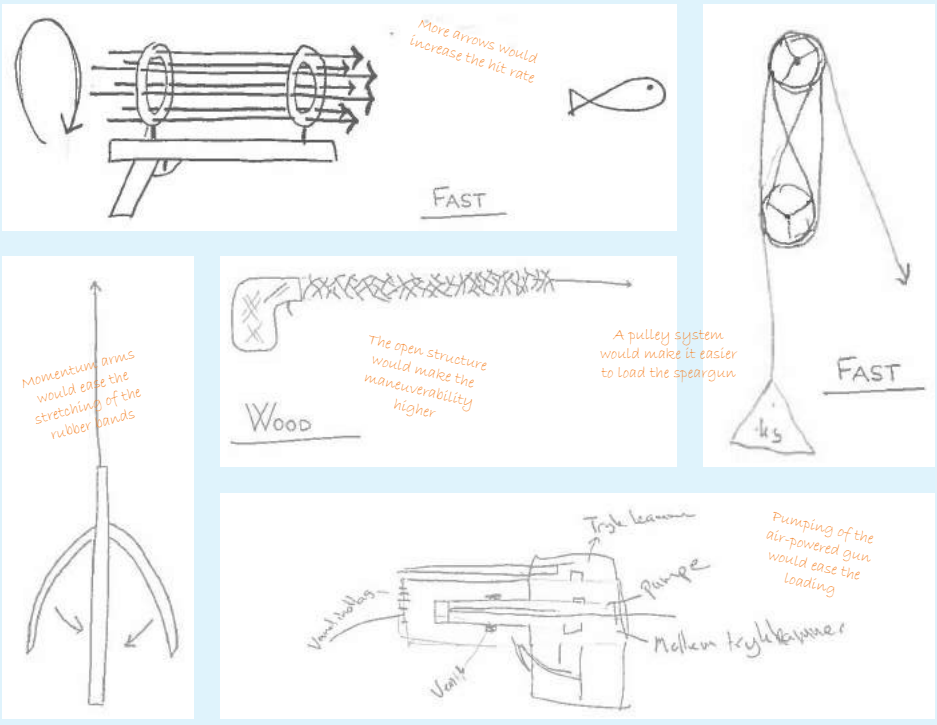
Through the research it is clear to the team that there are several problems with the existing spearguns and a lot of potential focus areas. Based on a prioritizing of the discovered problems it becomes clear to the team that one of the main focus areas in the new speargun design should be the loading of the speargun and the adjustment to different purposes and conditions, because these are some of the areas where the existing products are all the same or do not have a solution. To investigate the whole area of spearfishing the team starts elsewhere though.

To begin the ideation process the team starts out by using the association technique to come up with a lot of different crazy ideas regarding the whole speargun (Worksheet no. 25). Many of the ideas are on the ways to catch the fish and the majority of the ideas are just to unrealistic and a bit of topic for further use. Some of the ideas have potential in their principles and are considered in the following ideation process.

The association ideation is a little in every direction and the majority of the ideas are just small changes or add-ons to the existing spearguns. To widen the field of solutions and to challenge the previously stated decision of designing for traditional spearfishing, the team creates a mind-map of different ways to kill fish (Worksheet no. 26).

By evaluating the possibilities and potential within the principles and the humanity in the way of killing, the team finds potential in three ways of killing fish to look further into; shock waves, electricity and the traditional spears (Worksheet no.27).
A quick overall investigation shows that all three ways of killing fish actually are possible and all are used today.

> ! The team has to decide whether they will design a traditional speargun or a new product!



Ill. 2.2.1: Some of the sketches which had potential in their principles

2.3 CHOOSING DIRECTION

From the initial sketching and the discussion of different ways to kill fish, the team has to choose whether they would design a product true to the sport of spearfishing or if they would challenge the way of hunting under water.

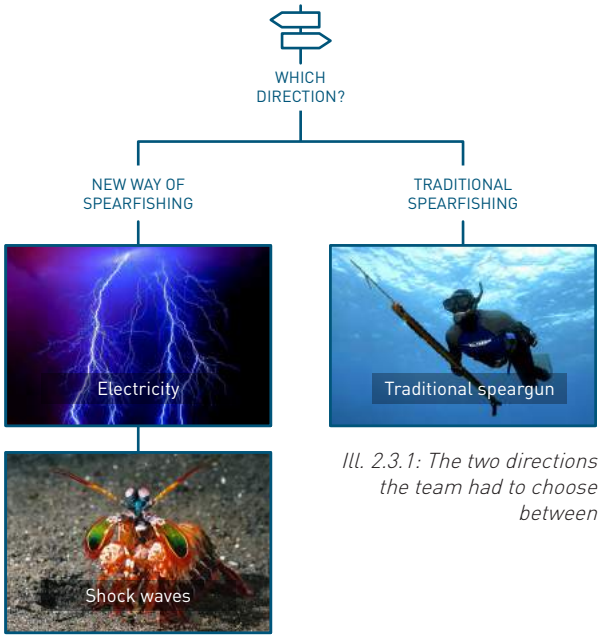
No matter which direction the team decides, there are several parameters to consider and evaluate within each direction.

NEW WAY OF SPEARFISHING

- The team would have to be sure there will be a market for a new product inside an already existing market of spearfishing and underwater hunting. The team would have to investigate if the existing spearfishers would be willing to switch their sport to the new way of spearfishing. Also, the team will have to create an interest inside a small segment of potential users and customers.
+ The benefits of designing a product for a new way of spearfishing is the limited boundaries to the design and the functions of the product.

TRADITIONAL SPEARFISHING

- If the team decides to design a product for traditional spearfishing, they would have to be sure their product will stand out from the rest of the products on the market. The new speargun should either solve the problems within the existing spearguns and/or create some extra values for the user. The new speargun should not be less favorable than the existing spearguns.
+ One benefit of designing a product for the traditional way of spearfishing is the possibility to be based on the existing spearguns and the thoughts and ideas within them.
+ Another benefit is, that the product could enter the exiting market of spearguns. The users and customers will not have to be convinced in the same way as if the product is entirely new - there are elements in the new 'traditional' speargun they can recognize from the existing spearguns.



Ill. 2.3.1: The two directions the team had to choose between

By evaluating the pros and cons and having the conclusion from section 1.10 in mind, the team can determine a direction. The conclusion from 1.10 says that the product should be able to shoot and catch fish by using a spear. This statement is potentially against a new way of spearfishing. The spear could be incorporated into an alternative speargun using electricity or chock waves, though.

Despite the potential of incorporating the spear into a new way of spearfishing, the team decides to go with the traditional way of spearfishing. Designing a product for the traditional way of spearfishing has a number of benefits compared to a new way of spearfishing. By designing for the traditional way the team is able to design based on tests of existing products and the discovered problems. Another benefits that the new product can immediately be incorporated in the existing market of spearguns and compete with the existing spearguns. The team is confirmed in their prior premonition of designing a product for traditional spearfishing.

! The team will design a product for traditional spearfishing!

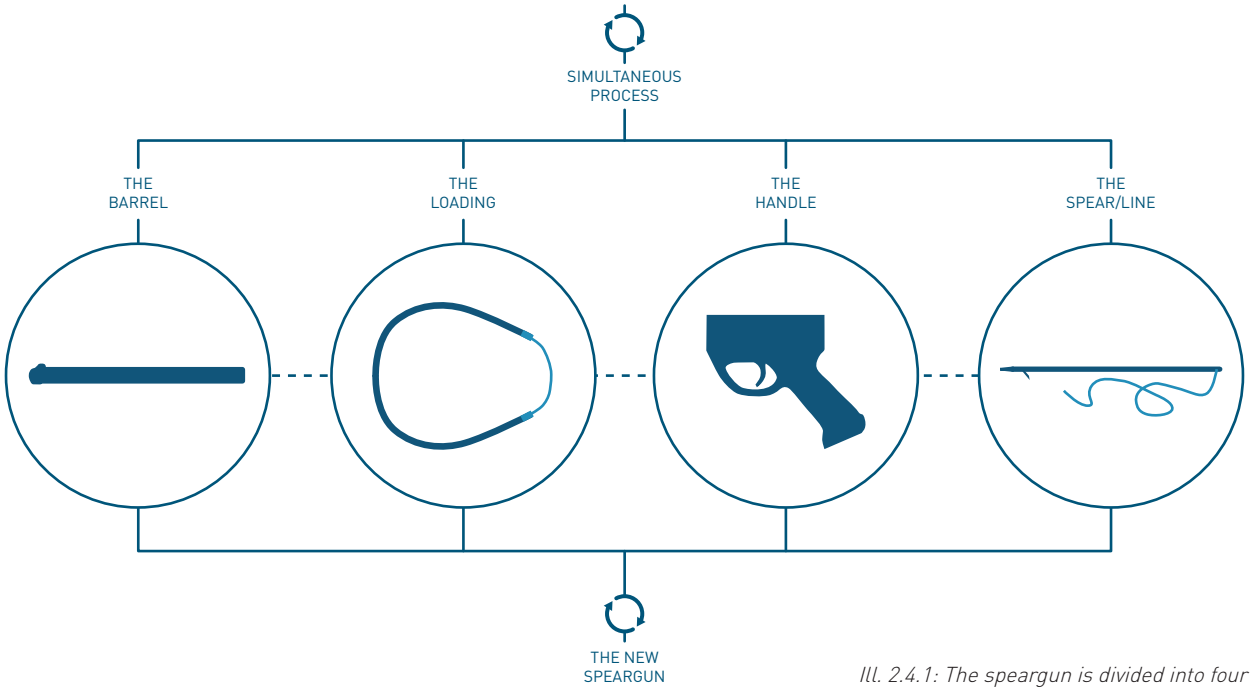
2.4 **FOUR PARTS**

After deciding to continue working on a product for traditional spearfishing, the team has to determine where to focus during the design process. The different parts of the speargun are all more or less interdependent and the team therefore has to work simultaneously on each of the parts to be able to design a product that would fit together and function as intended. The parts will be combined along the process to determine if the concepts fit together. The concept development chapter is divided into sections explaining the concept development of each part to make the process more structured and understandable.

Based on the research and the requirements listed on page 28 the team has divided the new speargun into four parts; the barrel, the loading, the handle and the spear/line.

From this point on in the process the team works simultaneously on all four of the parts. Because all the parts are interdependent the development of each part is closely linked together to make sure all potential solutions can be combined and work as one overall product.

The requirements of the speargun being able to adjust to different hunting purposes and conditions and the loading principle are the main focus points, whereas the handle and the spear and line become the secondary parts in the design process.
The two main focus points and their solutions are very much interdependent and therefore it is important to consider both requirements when conceptualizing and designing on one of them. The secondary parts are important in the entirety of the finished product, but are not the parameters carrying the product and make it stand significantly out from the existing products on the market.



Ill. 2.4.1: The speargun is divided into four parts during the design process

The main focus points in the design process are the adjustment of length and the loading principle!

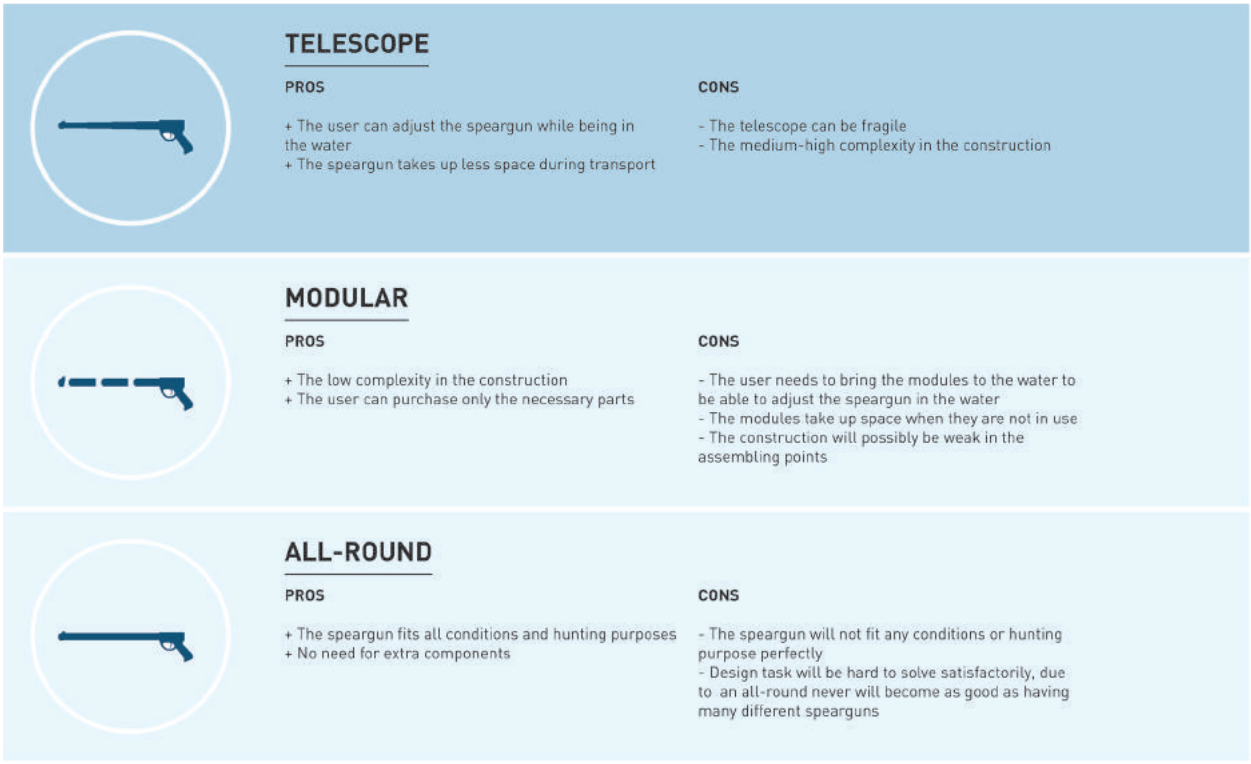
2.5 THE BARREL

To begin the design process, the team starts out by investigating different ways of accommodating the requirement of the speargun being adjustable to different conditions and hunting purposes.

To get an understanding of the possibilities within the adjustment of the barrel, the team makes an mind-map of the different ways of adjusting the speargun (Worksheet no. 28). From the mind-map the team is able to categorize the sketches into three potential principles of adjusting the speargun to different conditions and purposes; modular, telescopic and an all-round speargun.

The three principles are the base in the first sketching session where the team investigates different ways of adjusting the barrel by using the principles (Worksheet no. 29).
From the further investigation of the three directions it was determined to opt out the all-round principle (Worksheet no. 30). The design task of an all-round speargun is discussed and evaluated, and it is determined to rule out the all-round principle as a possible way of adapting the speargun due to the difficulty and complexity in the task. An all-round speargun will never become as good and sufficient as having several different spearguns and the feasibility of creating an all-round speargun better than the current speargun, will be hard to solve.
Besides, the business case for the all-round speargun would be weaker due to the customer only having to purchase one speargun and not having to buy any extra products besides for maintenance and replacement of worn out components.

Both the modular and telescopic principles would be able to adjust to different lengths and be suited for all the different hunting purposes and conditions the user could experience in the Danish oceans.
The team decides to test the remaining two principles to investigate and understand the possibilities and challenges within each of the principles (Worksheet no. 31). From the investigation the team has a better foundation for determining the adjustment principle for the product.



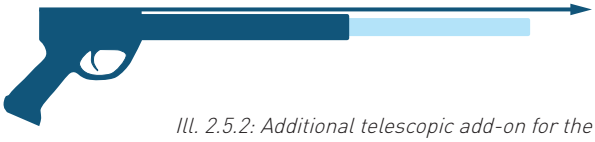
Ill. 2.5.1

FLEXIBILITY IS THE KEY

The flexibility is a parameter where the new product will stand out from the majority of the existing spearguns on the market. The values gained from the product being flexible are adjustable length, easier transport, less drag in water and stability.

By taking the user groups into consideration the team concludes that a combination of the modular and telescopic principles would be the most favorable. A business case based entirely on a modular adjustment principle would be most favorable due to all the extra components the user would purchase to complete the full length of the product. Looking at the use scenario of the product the telescopic adjustment principle would be most favorable. The user will not have to bring extra components into the water. With the telescopic principle the user can adjust the speargun while being in water without having to bring a lot of extra components (modules) to the water.

In the section of expert interviews it is determined that the user group of beginners starts with purchasing a cheap, short speargun and shortly after will purchase a longer an more expensive one. Based on this, the team estimates that the beginner user group will not spend the amount of money the whole package will cost because he will not need the whole package when having to learn how to spearfish. It is determined that it should be possible to purchase a standard length of the product and a telescope with extra length should be bought as an additional module to the standard product.



Ill. 2.5.2: Additional telescopic add-on for the standard length speargun

By dividing the product into these two components, the product will achieve the benefits from each of the principles - the user-friendly adjustment principle of the telescope and the additional sales in the business case and foundation for targeting more customers in the beginners group.

Ill. 2.5.3: Testing the telescopic adjustment principle

! The barrel should be adjusted by using a combination of modularity and telescope!

The user first purchase the standard product and later on the additional telescope module!

! The team will look more into how to combine the modular and telescopic adjustment principles!

2.6 THE LOADING

The loading principle of the existing spearguns is detected during the investigation of the existing spearguns to be difficult and require a lot of force. The team wants to explore alternative ways of loading the speargun to overcome this problem.

To begin the process a mind-map of different loading principles is done (Worksheet no. 32). The mind-map gives a lot of different ways to load the speargun. Some of the principles are quickly ruled out due to the safety and complexity within the principle e.g. loading using chemistry. From an evaluation of the remaining principles it is determined the best way to load the product should be by using either air compression or rubber bands as in the existing spearguns due to proof of the simple concepts and to the wish of maintaining the sport.

To get an understanding of how much power and strength is needed for loading the existing spearguns the team makes a test on some existing spearguns.

Purpose of test
To investigate how much force is needed to load the existing spearguns.

Explanation of test
By using a baggage weight to pull down the rubber band and load the speargun,it is possible to determine the force needed to load the speargun. The lengths tested are a 50 cm rubber band and a 90 cm rubber band.

Ill. 2.6.1: Testing [illegible] pool

Conclusion of test
From the test the team knows it requires a force of around 500N to load the existing spearguns (Worksheet no. 33).

The team estimates that the new product should be able to build up around the same amount of energy in the rubber band to be able to shoot the spear the desired lengths.

To get a more specific idea about the way of loading the product, the team makes another mind-map of the different ways of loading the product by using either air compression or rubber bands (Worksheet no. 34). The mind-map gives the team some new directions within the loading and decides to test the principles of loading with a pulley system, a momentum arm and to change the loading position. The team builds models of each principle and tests the models on themselves and on several other people (Worksheet no. 35).
The tests gives the team an indication of the durability of each principle. The team evaluates the principles from the test and by taking the user and use scenario into consideration (Worksheet no. 36).

Pulley system I



Ill. 2.6.2

"Way to much line to handle!

Pulley system II



2.6.3

"The attachment of the rubber band will be a problem!

Momentum arm



Ill. 2.6.4

"You have to turn the speargun upside down to load. Besides is it difficult to handle!

Loading position



Ill. 2.6.5

"It feels much easier to load when using the legs and feet!

The first pulley system makes it much easier to pull the rubber band backwards to load, but the line needed for pulling is very long and makes the line problem even bigger than on the existing spearguns (Ill. 2.6.2). The second pulley system is also much easier to load, but the attachment of the rubber band on top of the speargun does not work properly (Ill. 2.6.3).
The momentum arm works as they are intended, but the length of the arm has to be very long to be effective (Ill. 2.6.4). This makes it very difficult to handle the arm and the whole loading scenario becomes very uncomfortable and hard.
The change of loading positions is very effective because it is possible to use some bigger muscles and muscles groups for loading (Ill. 2.6.5).

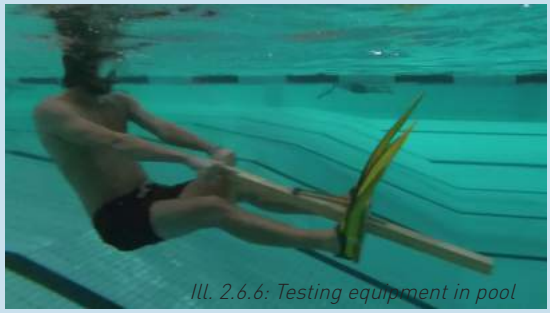
The principles tested all has their strengths but the team decides to look more into the changing of the loading position because the changing in the loading positions does not need new technical solutions and can thereby maintain simple and efficient. The team tests different ways to change the loading position and is confirmed in the premonition about using both legs for loading will be the best solution both regarding the strength possible to transfer from the legs and the actual action when loading. Besides the physical tests of the loading positions, the team gets in contact with a physiotherapist to get a validation of the test results. He confirms the tests results (Worksheet no. 37).

Besides the change of loading position the team looks into the possibility of incorporating a pulley system for decreasing the strength needed for loading the product. This incorporation is ruled out because of the complexity in the product. The whole pulley system should potentially be placed inside the barrel of the speargun to increase the complex look, though this would make the speargun more complex in it construction and difficult to maintain.

To investigate if it is possible to use the principle of loading with the feet in water wearing fins, the team makes a test in a pool (Worksheet no. 38) (Appendix no. 01).

Purpose of test
To investigate if it is possible to use the principle of loading with the feet under water.

Explanation of test
A wooden model is build and tested in a swimming pool with and without fins by both a tall and a shorter person.



Ill. 2.6.6: Testing equipment in pool

Conclusion of test
Despite the wooden model floated in water, the test showed the principle was possible and effective also while being in water and wearing fins both for the tall and shorter person.

! The loading should be done by the feet!

2.7 THE HANDLE

The handle on the speargun is an important part because it is the place where the user has most contact with the product during use. In this section it will be investigated which demands there is for a speargun handle and how it has to differentiate from other handles regarding use with gloves.

To gain an understanding of how others have designed handles, the team starts out by investigating and evaluating the handles on the existing spearguns (Worksheet no. 39). The investigation gives the team an indication of how to shape the handle regarding shape, angles, surfaces etc.

Purpose of test
To investigate the design and pros and cons within the existing speargun handles.

Explanation of test
Testing the handles on 5 different spearguns. The tests focuses on the shape, size, angle and surface of the handle and the shape of the trigger.

Ill. 2.7.1-2: Testing different speargun handles

Conclusion of test
The handle should have an angle between 60-70 degrees, it should be symmetrical so it will fit both right and left handed users and it should have curvatures for fingers. The trigger should have a shape and motion which follows the shape and motion of the finger when pulling the trigger.

To determine the best suited shape and size for the handle of the product, the team makes an experiment based on different shapes and sizes of foam models. The team makes 24 different foam models and selects five for testing on people. Because spearfishing is done both with and without gloves with a thickness up to 9 mm, the team tests the foam models with bare hands and with a 5 mm neoprene glove, which is a standard thickness in cold ocean conditions. Therefore it is important to create a handle which fits hands with gloves. The current speargun handles are not suited for wearing thick gloves when spearfishing, so the handle is often to little.

To get an objective result, the models are tested on a representative group of people outside the group with different hand sizes. The test persons are told to first try the models without gloves and determine which they find best. Afterwards they try the same models wearing a spearfishing glove.

Purpose of test
To investigate the shape and size of the speargun handle.

Explanation of test
5 foam models are tested on a group of people outside the group. The test persons test the models with and without gloves regarding shape and size.

Ill. 2.7.3: Foam models. The orange one are the ones tested

Nikolaj

Ill. 2.7.4

"This (45x30mm) is definitely the best, because you have a good, firm grip."

Madalina

"The best size and shape, but needs markings for fingers (45x30mm)."

Conclusion of test
The majority of the test persons find the oval shape with the dimensions 45x30 mm best. Many mentions the oval shape gives a firm grip and the size makes it easier to control (Worksheet no. 40).

Based on the tests and the teams internal evaluation the team determines that the shape of the handle on the product should be oval with the dimensions 45x30 mm.

The safety mechanism on the speargun is an important part of the speargun in order to feel secure when swimming with the speargun especially when spearfishing with others. The safety mechanism is placed on the handle for easy access and the team makes an investigation of the safety mechanism on the existing spearguns with different designs of safety mechanisms to determine the pros and cons of the different principles (Worksheet no. 41).

Purpose of test
To investigate the principles and pros and cons within the safety mechanisms on the existing speargun handles.

Explanation of test
Testing the safety mechanism on 5 different spearguns. The tests focuses on the shape, size and location of the safety mechanism on the handle.

Ill. 2.7.6-7: Testing safety mechanisms

Conclusion of test
The safety should block the trigger, so it is clear for the user that the safety is on when looking at the speargun. The safety mechanism should be placed on the back of the handle, so the user can see if the safety is on or off while swimming and aiming at a fish. The mechanism has to be visual both on the back of the handle and in the hole for the trigger. The motion of the safety should be up and down so it can easily be switched with the thumb while holding the speargun.

Based on the tests and evaluations of different shapes and sizes, the team has found a foundation for designing the handle for the new speargun.

!

The handle should have an 45 x 30 mm oval shape and an angle between 60 and 70°!

The handle should be symmetrical and have markings or curvatures for fingers with gloves!

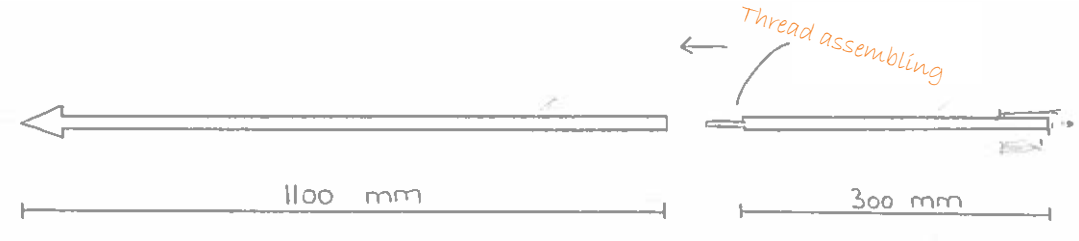
2.8 THE SPEAR AND LINE

SPEAR

When designing an adjustable speargun it is important to think about the spear as well. Each size of existing speargun has its own size of spear. The rule, according to Rob Allen, says that the spear should be 400 mm longer than the speargun (Worksheet no. 42). The spear needs to be somehow adjustable as well to add more value to the whole concept.

By making the spear adjustable the user only needs one spear instead of one for each length the speargun can adjust to. To investigate how the spear could be adjusted in length, the team makes a mind-map of different adjustment principles (Worksheet no. 43). From the investigation the team decides that the principle of adjusting the spear should be by modularity. The team decides that the spear should be able to be adjusted by adding extra modules which could possibly be assembled with threads.

Optimally, the spear should be able to adjust to the same number of different lengths as the speargun, but the spear can also be 300 or 500 mm longer than the speargun (Worksheet no. 42).



Ill. 2.8.1: Spear sizes for different speargun sizes

LINE

Through the investigation of the existing spearguns (p. 19) it was made clear, that the line between the spear and the speargun is a problem when spearfishing. Therefore, the team wants to investigate if it is possible to find a principle to keep track of the line, so it will not get tangled and be in the way when spearfishing.

The team looks into different existing ways of handling lines, cords etc. (Worksheet no. 44), and determines based on the investigation to try to incorporate the principle of the wheel on a fishing rod. The system is proven to work and it keeps track of the long line attached between the speargun and spear. This system is chosen, because it requires a simple motion of the user to collect the line.

With this system the speargun will potentially be able to shoot longer than it should, because the 50 cm long speargun will have a line fitting a 90 cm speargun. Therefore the team wants to integrate a mechanism able to adjust the line, when changing the length of the speargun. Time might though be a problem, so the team will not develop further on the chosen line principle.

Ill. 2.8.2: Fishing rod wheel system

!

The spear should be adjustable with extra modules and could be assembled with threads!

The line should be winded up using a fishing rod wheel rewind principle!

2.9 TRANSPORTATION

It is described in the research chapter that the transport of the speargun can sometimes be a problem due to the long length and the sharp tip of the spear. It makes holes in the car interior and it can intimidate people when seeing a man with a speargun.

It is necessary to make the transportation of the speargun easier for the user, so he avoids the aforementioned problematics with transporting a speargun (Worksheet no. 45). Spearfishers use different means of transportation when they go to the ocean, but car is the most used, because it can be difficult to find public transportation going all the way out to the ocean and it is often too far away to take the bicycle. It is though still important to take all means of transportation into consideration, because it is especially the public transportation and bicycle where it is important to have a speargun, which is easy to transport.

The concept of an adjustable speargun is not only chosen for the purpose of fitting the Danish ocean conditions, but also in order to be easier to transport. The new concept can adjust, so it is no longer than the standard speargun length, which will be an advantage when transporting it.

Spearfishers often have some sort of bag to carry all the equipment, which include the speargun. These bags are typically dry bags, which are specifically made for transporting equipment for all types of diving. These can be found in many different sizes, and therefore it can be difficult to make the speargun fit in all dry bags. With all the equipment needed for spearfishing it is assumed, that most spearfishers have a relatively big bag in which the standard speargun length can fit.

By making the speargun able to compress in length during transport and thereby fit in most dry bags it is possible to avoid intimidating people on the way to the ocean, especially when using public transportation. It is of course up to each spearfisher himself whether or not he wants to cover the speargun during transport, but by making it possible to adjust the speargun, the opportunity is given to the user.

2.9.1: Medium sized dry-bag for spearfishing equipment

2.10 IDENTITY OF ARDEA

In order to give the new speargun an identity a name and logo is necessary when bringing it to the market. The name and identity needs to tell that the product is used for catching fish and is dangerous.

The product is named Ardea, which is Latin for heron [Wikipedia, 2016]. Heron is a long-legged predatory bird, which uses its long and spear like bill for spearing the hunted prey. The heron is standing in shallow waters and when it sees the prey it will start moving the head from side to side to calculate the exact position of the fish and then it will spear the prey with the bill. This action is similar to the way a spearfisher will use the new speargun - the spearfisher will swim around in search of a desired fish and when it is located the speargun is maneuvered in the direction of the fish to find a good aim and then the speargun is fired to spear the fish.
The heron also has a long neck, which it retract when flying and extend when spearing its prey. This way of using its neck can be related to Ardea and how it can adjust in length for different purposes as water conditions and transportation. Ardea can be made short when transporting it and can be made as long as the visibility and current in the water allows it to.

ARDEA

2.10.1: Ardea logo, inspired by the heron

2.10.2: The heron can extracts it neck
2.10.3: The heron spears their prey

2.11 **AESTHETICS**

The team wants the product to reflect the hunting aspect and in addition, a symbol representing the aesthetics and the overall functionality of the product (Worksheet no. 46). Though the aesthetics is an important part of the overall expression of the product, the aesthetics are considered a secondary part of the product compared to the functionality.

The team wants the product to give the impression and feeling of being dangerous, intimidating and respect when being in the water. This is where the hunting takes place and the user becomes a huntsman.
Especially in the Danish society, people are in general afraid of weapons and weapon looking objects. Therefore, as soon as the product is above water - and has to be transported between the ocean and the spearfishers home - it has to look neutral and not give the impression of being something that can hunt or kill anything.
Through a style board the team finds inspiration in different species of sharks and other fish. The sharks and blue marlins posses many of the features reflected in the product. The hydrodynamic shapes of their bodies and the fins are features which potentially can be incorporated into the new speargun.

It is important to give the speargun some forward direction to make it look aggressive, but also in order to make it hydrodynamic. The spear will also help give the speargun a clear direction just as the nose on the blue marlin. Furthermore the loading pads can be used to not only imitate the hammerhead shark, but also to ease the maneuvering when swimming forward in the search of a fish.

Ill. 2.11.1: The aesthetic expression of the new speargun is inspired by sharks and marlins

2.12 UPDATED DEMANDS

DEMANDS

ADJUSTMENT
Adjustable to different water conditions
- Visibility from 1 - 20 meters
- Current from 0 - 1 m/s

Adjustable to different hunting purpose
- Still standing fish, free swimming fish and flatfish
- Surroundings: shipwrecks, reefs, sand bottom and breakwaters

USER
- Usable in all experience levels
- Fulfill the needs and demands of the beginners, semi-beginners and experienced

SAFETY
- Safety mechanism should be operated with one hand
- Should always be visible and tell the user whether it is on/off

LOADING
- The loading should be done by using the legs

BARREL
- The barrel should be adjusted by using a combination of modularity and telescope
- The barrel should have a semi-closed rail for the spear

HANDLE
- The handle should have an oval shape approx. 45 x 30 mm
- The handle should be symmetrical to fit both right and left handed users
- All interaction in the ocean has to be possible with gloves on

SPEAR
- The spear should be adjustable with extra modules

ERGONOMICS
- Fit left and right hands from 16-21 cm

TRANSPORTATION
- The product should be able to compromise to the standard length of the speargun during transport (500 mm barrel)

MAINTENANCE
- The users should be able to replace parts by themselves

AESTHETICS
- The product should be inspired in the aesthetics by sharks and blue marlins

WISHES

LINE
- The line should be winded up using a vacuum cleaner cord winder principle

SAFETY
- The product can only shoot in water

BUSINESS
- The user first purchases the standard product and later on the additional telescope module

BUOYANCY
- Weight distribution should ensure horizontal positioning in the water

TRANSPORTATION
- The product should not look like a weapon during transport

PRODUCT ARCHITECTURE
- Removable parts should be stored in the speargun to not take more space than necessary

2.13 **SUM-UP**

Ideating and developing on different concepts has led to a concept inside the four parts of the speargun, which now only needs to be detailed upon. The final concept is a speargun able to adjust to the visibility and surroundings in the water. Furthermore it is now loaded by the spearfishers legs, which will make it easier to load. During the concept development testings and investigations have been made, and these have led to a new updated list of demands. These demands will be used in the chapter of detailing to end up with a final product design, which fulfills these demands.

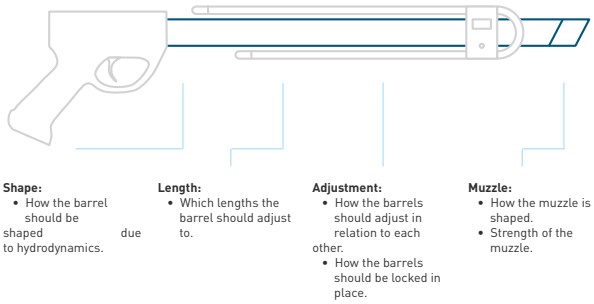
Phase **3.0**

DETAILING

This phase is based on the concept ideas from the previous phase, so a final product can be designed. The product will go through a detailing process to reach a suited shape, size and mechanisms in order to create a holistic product architecture of the speargun. Materials and production will also be presented in this phase, which later on will help in calculating both the production and sales price of the speargun. The detailing process has been an ongoing process where the different solutions and requirements to each components has to be calculated for in all the other components.

3.1 THE BARREL

From the chapter of concept development it is decided to have an adjustable barrel in addition to a standard barrel which cannot change in length. The shape, dimensions and the assemblies between the barrels are worked on and detailed in the following. The main focus areas is described below.



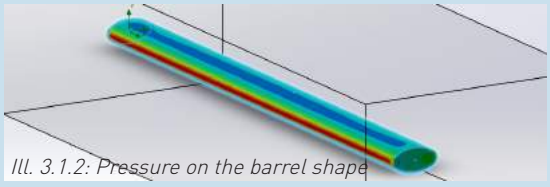
SHAPE

The team wants the aesthetic expression of the speargun to remind of sharks and marlins, but a compromise is necessary to make it functional and hydrodynamic in the water. First a SolidWorks Flow Simulation test is made to find an optimal shape for the barrel, so it experience a minimum resistance in the water (Worksheet no. 47). It is important, because the user needs to be able and have strength enough in his arms and wrists to hold the speargun in the desired position especially when aiming at a fish in high water current.
The team tests different, simple shapes and during the flow simulations it is determined to compromise the expression over functionality.

Purpose of test
To find the shape giving the least resistance in high water current.

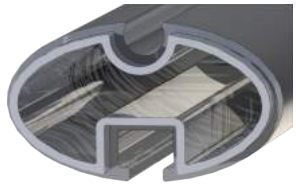
Explanation of test
The test is made in Flow Simulation in SolidWorks, where a water current of 1,8 m/s is created to run against the different, simple shapes of a 450 mm barrel.

Conclusion of test
The oval shape is the shape with least resistance/drag (Fx), when the water current comes from an angle of 0 degrees in relation to the barrel which is the most common direction of water current.



Ill. 3.1.2: Pressure on the barrel shape

The oval shape is chosen due to it's low resistance in water current. Now the oval shape has to be detailed to be functional in the matter of containing other features. The oval shape needs an integrated rail in which the spear can run (see chapter 3.4 Spear/Line). The rail guides the spear when it is fired, so it does not sag. It ensures a straight shooting line and thereby a more precise aim (Worksheet no. 42) (Ill. 3.1.3).
In the bottom of the barrel another rail is integrated which should work both as storage for spare modules, but more important is that the rail in the bottom of the barrel is made to contain the locking mechanism for the adjustment of the barrel length.



Ill. 3.1.3: Section cut of the two barrels. The carvings for spear (top) and spear modules (bottom).

ADJUSTMENT

The aforementioned locking mechanism makes it possible for the user to adjust the length of the speargun. It needs to be easy to handle and adjust without any tools and not cause a lot of trouble for the user, because then he will probably decide not to change the length even though it will fit the conditions better.
The team thought about many different ways to do this, but a solution with a spring mechanism is chosen (Worksheet no. 48). The spring mechanism is chosen, because it is a high tenacity solution made in simple standard components, reliable, cheap and with only one mounting point
In the aforementioned rail for the locking mechanism on the outer barrel five holes are drilled for adjustment (five different lengths of the speargun). The inner barrel has one hole for locking the spring component. The solution works by pulling down the hook and compressing the spring, sliding the component in the rail to the desired hole (length, red.) in the outer barrel and then sliding the inner barrel until the spring mechanism releases and locks into the hole in the inner barrel (see Ill. 3.1.4).

Ill. 3.1.4: Locking mechanism between the two barrels. The spring component locks in holes in the muzzle.

This solution creates an integrated and simple solution which fulfills more purposes and creates a simple adjustment of the barrels and rubber bands at the same time.

During the development of the locking mechanism, the team needs to test the impact of having one locking point compared to having two. The tolerances between the barrels can potentially create a blur leading to an inaccurate shot. To determine whether or not this is a problem to the solution and thereby two attachment points are needed, the team makes calculations on the impact. It is found that the longest shot of the 90 cm speargun (6,75 m shooting range) will result in a deviation in the shot of around 3 cm, which the team sees as an insignificant factor (Worksheet no. 49). The calculations confirms the solution with one spring component for locking the barrels.

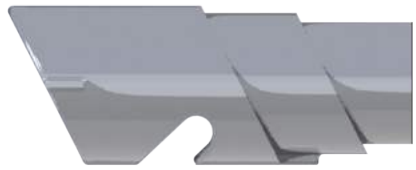
LENGTH

The lengths which the speargun can adjust to have to be chosen by comparison with the used lengths today. The team made questionnaires in an earlier stage of the project, where the conclusion is that spearfishers in Denmark use spearguns in the lengths 50 to 90 cm (Worksheet no. 09). Therefore this discovery helps deciding which lengths are necessary in Danish oceans. It is not the length of the speargun itself which is important but more the shooting range. These two are cohesive, because the length together with the rubber band decides the shooting range (Worksheet no. 42). The shooting range is in general 5 times the barrel length of the speargun, and therefore the needed shooting range in Denmark is around 250 to 450 cm measured from the handle of the speargun. The speargun will therefore have a standard length of 50 cm and an adjustable module, which makes it possible to adjust the length from 50 to 90 cm with a 10 cm span. This product architecture is decided from a user scenario and business perspective as mentioned in section 2.5 Barrel (page 36).

MUZZLE

The muzzle is normally an object placed at the end of the speargun barrel to close it and to hold the rubber bands. In the new speargun new features and solutions is integrated into the muzzle. One of these features is that the muzzle is around 45 cm and runs inside the barrel. The muzzle is hollow which creates an air chamber inside the speargun. This is done to create buoyancy and make the speargun balanced in the water. This is important to make the speargun stay neutral in the water, so the user does not have to use strength to either keep it from floating upwards or sinking down.
To ensure the speargun being neutral in the water a calculation based on SolidWorks and weight is made to determine the needed volume of the air chamber to create the necessary buoyancy (Worksheet no. 50). The test results show that the total weight of the speargun is 2,1 kg and the volume of the air chamber will help lifting up the speargun through the buoyancy. The volume of the air chamber in combination with the viscosity of the water almost evens out the weight of the speargun. All in all after the buoyancy in the muzzle and the weight of the muzzle has been subtracted, the user will have to hold what feels like 200-300 grams. Due to the fact that the air chamber is located in the front of the speargun the front, it will be close to be in equilibrium.

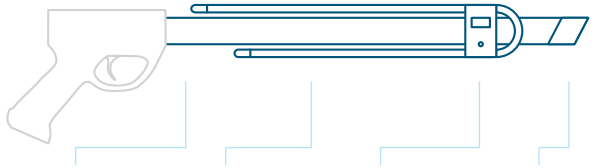
The muzzle is still used to close the barrels and lock the loading pads (see 3.2 Loading). On the bottom of the muzzle is placed a hole for containing the spear modules and a screw hole for connecting the extension barrel.



Ill. 3.1.5: Side view of the tip of the muzzle

3.2 THE LOADING

In the previous concept development chapter, the loading principle was determined to use the legs. The principle still needs a lot of considerations and modifications to be able to function as a loading principle for an actual speargun. The team has decided on some focus points within the loading mechanism, on which they will set focus during the design process:



Connection with barrel:
- How the loading mechanism will fit around the barrel
- How the loading mechanism will move along the barrel

Rubber band:
- How the rubber band will function
- The dimensions
- The attachment of the rubber band

Loading mechanism:
- The shape of the loading mechanism
- The use of the loading mechanism

Connection with muzzle:
- How the loading mechanism will lock when loaded
- How the loading mechanism will interact with the muzzle

SHAPE OF STEPPING PADS

The overall shape of the loading pads where the user will press with his feet to load the new speargun needs to be detailed and shaped. The shape of the loading pads are determined based primarily on the functionality and the association to and aesthetics of the hammerhead shark. The team builds a model and tests the shape and size (Worksheet no. 51).

Purpose of test
To find the size and initial shape of the loading pads.

Explanation of test
Three models with different lengths of stepping surface are tested. Five models with different shapes are tested. All models are tested with and without fins.

Conclusion of test
The loading pads should be longer than 40 mm but the shape does not matter much. A diameter of 6mm on the loading beam is a suited thickness. The broad flat model was the easiest to control, but will have more drag in the water.

The investigation makes it possible for the team to dimension the loading pads so they will be effective and comfortable in use.

Through an investigation of pedals on bicycles and other products, the team discovers some principles regarding shape and structure, which will be considered in the detailing process (Worksheet no. 52, 53). The open structure of bicycle pedal to reduce weight and resistance is considered in the shaping of the loading pads. When the speargun is loaded, the loading pads will be placed in the front of the speargun. This requires that the shape of the loading pads will not make it difficult to move the speargun through water. Furthermore, the loading pads should have the smallest possible stepping face so the pads will not interfere with the view over the speargun and the aim.

The test and previous investigation of pedals showed that the broader the surface are under the feet, the better control the user has to move the pads in different directions and angles. This conflicts with the requirement of having as small stepping face as possible. The results to this is by creating two beams with space between to that the user has a larger contact face, but also a open structure to create as little drag as possible.
The shape of the stepping pads are determined

Ill. 3.2.2: Loading pads

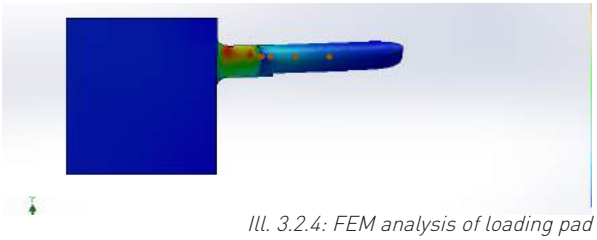
based primarily on the functionality and the association to and aesthetics of the hammerhead shark. Two surfaces placed with a gap around 20 mm makes it possible to control the loading pads and the open structure help the move through water.

CONNECTION WITH BARREL

The loading pads have to run along the barrel when loading and needs to be an open shape around the barrel due to the aim of the spear and that the shark fin of the speargun has to pass by the loading pad.

Ill. 3.2.3: Front view of loading pads

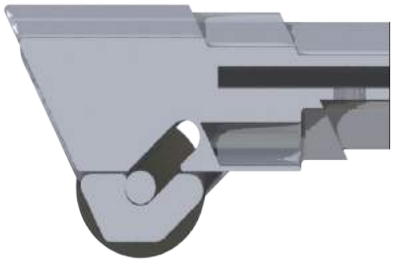
the loading pads either has to be a closed component which runs all around the barrel and over the spring component or an open component and in that way not interfere with the spring component (Worksheet no. 51). Due to the flow of the whole speargun through water, the team determines to design the loading pad component, so it will only grip the barrel and not run all the way around.
Because of the oval shape of the barrel, the loading pad component cannot rotate all the way around the barrel. This ensures a controlled motion with the legs when loading.
A FEM analysis in SolidWorks is made to see if the construction of the loading pad can handle the force, which is applied to it (Worksheet no. 54). A force of 500 N is applied and this gives a safety factor of 2,5.



Ill. 3.2.4: FEM analysis of loading pad

LOCKING WHEN LOADED

When the rubber band has been stretched and the loading pads are pushed out, the mechanism has to be locked in the position to be able to transfer the energy stored in the rubber band to the spear. The team has tried out many different ways of locking the loading pads (Worksheet no. 55). Based on evaluations of the different principles it is decided to carve a hole into the muzzle component. The loading pad components has a steel pipe as part of the stepping pads which is able to move up and down. When the loading pads are pushed down, the pipe will fall into the carving in the muzzle. This action will ensure the locking of the loading pads. By placing the locking mechanism in the muzzle, which is always on the speargun, the loading is the same every time despite the length of the speargun. The user can clearly see and feel in the feet, when the pipe falls into the carve. This makes sure the speargun cannot be loaded improperly and unsafe.



3.2.5: The steel pipe falls into the carving in the muzzle to lock the loading pads and load the speargun

RUBBER BANDS

By having the opportunity to have different length of the speargun different requirements for shooting range follows along. The shooting range is normally based on the length, size and extension of the rubber bands, which means that different rubber bands are needed. This means that if the speargun is loaded the way spearguns are today there is a need of five different rubber bands. This solution will require the user to bring all five rubber bands to the water, to make the speargun adjustable in the water as required. Instead the speargun should have only one rubber band fitting all lengths. The solution to this is the roller system (Worksheet no. 08).

Another increasing way of loading the rubber band is in a roller system. The roller system makes it possible to build up more power, because it allows a longer rubber band on the speargun. The general rules says, that a roller gun is 40% more powerful than a regular speargun in the same length. The roller system is also easier to load, because the pulling process is divided into two steps. The team decides to use the roller system, because it will utilize the whole length of the speargun and thereby add more power.
The roller system will be incorporated in the loading pads component and placed on the steel

Purpose of test
To determine the length of the rubber band

Explanation of test
Drawn model of the speargun with added rubber band. Different elongation factors are tested to see if they are able to adjust to the needed length.

Conclusion of test
The rubber band should be 500 mm and have an elongation factor of 2 (elongation of 200%). The rubber band is able to stretch to 1500 mm.

pipe running all the way through the component.

The existing regular spearguns has in general a shooting range of 5 times the barrel length and the roller guns even more [Worksheet no. 42]. Because the new speargun is able to adjust in length, the force needed will differ along with the length. The team looks into how existing rubber bands for spearguns looks and how they work. The majority of rubber bands are made of natural rubber with a latex coating [Divecenter, 2016]. To determine if it is possible to have one rubber band the team makes an investigation (Worksheet no. 56).
From this investigation it is possible to determine the length of the rubber band if the material has an elongation factor above 200%. In the investigation it is determined that natural rubber has an elongation factor of 750%, which is well enough. To incorporate a safety factor and for not making the rubber bands too hard to stretch, the team determines to use a rubber band with a length of 500 mm.

The team has investigated if it is possible to have only one set of rubber bands which fits all the different lengths of the speargun or if several are needed. The team now needs to determine the diameter of the rubber band in relation to be able to store enough energy to shoot the spear 5x the length of the speargun, as the existing spearguns. The standard diameter of the rubber bands differs from 12-20 mm, and the team makes a test and calculations to determine the diameter (Worksheet no. 56).

Purpose of test
To find the diameter of the rubber bands.

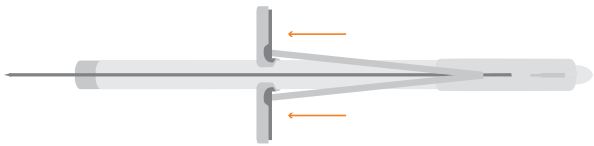
Explanation of test
Stretching rubber band on existing speargun and measuring the force needed using a baggage weight. Numbers from existing spearguns are found to have a valid comparison. The force needed to fire the spear in different lengths are determined. These numbers are compared with the force possible to store in the standard rubber bands.

Conclusion of test
It is only necessary to have one set of rubber bands, because there are two rubber bands on the new speargun. The rubber bands should have a diameter of 16 mm to store enough energy and reach a velocity of 19-20 m/s.

Wishbone:
An important part of the rubber band is the wishbone. The wishbone is the connection between the rubber band and the spear and speargun. There are mainly two different types of wishbones; metal wishbones and thread wishbones. There are pros and cons for each of them. E.g. the power transition in the thread wishbone is more smooth which gives a more precise shot whereas the metal wishbone is more robust and is not warn in the same scale as the thread.
The design of the barrel with the rail for the spear makes it necessary for the spear to have shark fins as attachment for the rubber band. This opens up for using both types of wishbones. Due to the ability of smooth transition of the power to the spear, the team determines to use the thread wishbone as attachment for the rubber bands on the new speargun.

LOADING SCENARIO

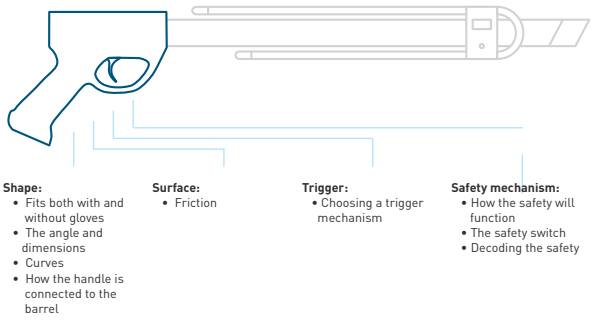
When the user has to load the new speargun he will first attach the rubber band to the shark fin on the spear and then to the hook on the bottom of the barrel. He will then place his feet on the loading pads and stretch out his legs and push down the loading pads to the tip of the speargun, where the loading pads will attach to the muzzle. Now the speargun is loaded.



Ill. 3.2.6: Loading the speargun by stepping on the loading pads

3.3 THE HANDLE

The following chapter will describe the detailing process and configuration of the handle. The interaction with the handle and the functions in the handle is considered in this chapter. The following parts of the handle, which have to be considered are:



SHAPE

The shape is important in order to raise the user experience. The user's hand needs to surround the handle naturally and give a good firm grip both with and without gloves, because a spearfisher typically uses gloves in the Danish oceans. The shape also needs to be symmetrical, so it fits both a right and left hand user.

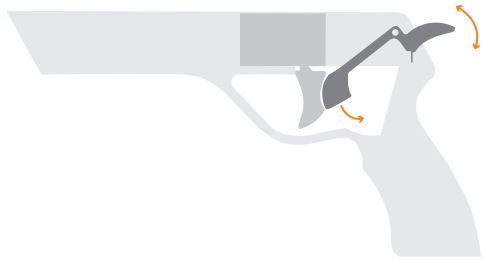
In the "Concept development" chapter it was determined to have an oval shape with the dimension 45 x 30 mm, because the oval shape stabilizes it in the hand and gives a comfortable grip.

Now the size and basic shape of the handle for the speargun is decided. The next step is to give it curves, so the different curves of the hand fits naturally around the handle. In order to find the right curves existing handles are researched and investigated to find inspiration (Worksheet no. 39). The investigation resulted in a shape of the handle, which is 3D-printed for testing. The 3D-printed model confirms the initial shape of the handle including the curvatures.

Ill. 3.3.2: 3D-printed model of the speargun handle

SAFETY MECHANISM

A safety needs to be easy understandable when it is blocking the speargun from shooting and when it is not. It has to be trustworthy, so the user feels safe and sure about when the speargun will do what according to his actions. A sketching session on how to make such a safety mechanism is made with pros and cons afterwards to evaluate on each (Worksheet no. 57). A safety mechanism which clearly and visually shows when the trigger is blocked is chosen, because no icons are needed to make the user understand it. It is also important, that it is easy and quick to switch it on and off. Therefore, a solution where it can be controlled with the hand holding the speargun is chosen. The safety is placed on the back of the speargun so a simple movement with the thumb can switch it on and off at any time. The mechanism runs in the handle and to the back of the trigger, where it clearly can be seen when it blocks the trigger and when it does not.



Ill. 3.3.3: Safety mechanism placed on the back of the handle and behind the trigger

TRIGGER MECHANISM

The trigger mechanism is an existing system and it is well-functioning. Therefore the team sees no idea in developing a new trigger mechanism and focus a lot on this part of the speargun. The trigger is more or less working the same way in all spearguns, but in order to understand the mechanism, which releases the spear when loaded an illustration of the trigger mechanism Rob Allen uses can be seen in Ill. 3.3.4. The Rob Allen trigger is the base for the investigation due to the close correspondence with the company and the business aspect later on in the process.

As mentioned in the above a new safety mechanism is integrated in the new speargun and therefore the safety on the illustration should not be considered. The way it basically works is the user pushing the trigger, which releases the solid stainless steel sear, which releases the spear.

Ill. 3.3.4: Rob Allen handle

3.4 THE SPEAR

The spear needs to be adjustable as well, as previously determined. The team decided to look more into adjustment with threads for the spear. This has to be confirmed and validated.

From a correspondence with Rob Allen (Worksheet no. 42) it was determined that the spear optimally should be 40 cm longer than the speargun. It could potentially differentiate with 10 cm in each direction, if there is a rail incorporated in the barrel for support of the spear. This discovery has given some guideline in relation to designing the adjustable spear. The team makes a test of the sizes of the speargun and which lengths the spear should cover, if being suited for spearguns from 50 to 90 cm (Worksheet no. 58).

Purpose of test
To approve the adjustment method and find the length of the modules in the spear.

Explanation of test
The speargun in different sizes are drawn and the length of the approved spear sizes are added to see if they overlap.

Conclusion of test
It is possible to assemble a spear in the lengths of 80 cm, 105 cm and 130 cm, which fits the spearguns lengths of respectively 50 cm, 60-70 cm and 80-90 cm.

To confirm the threads as a possible method for adjusting and assembling the spear, the team contacts a steel construction engineer, and discuss the method and what to be aware of when using the principle (Worksheet no. 59).

Purpose of test
To approve that the adjustment method with threads will be able to hold during use.

Explanation of test
Co-creation with an steel construction engineer. Discussion of the adjustment principle and the strength of the construction.

Conclusion of test
It is possible to use threads as the assembling method of the spear. The thread has to run over 20-30 mm.

If the spear is divided into three main components; the standard length with the tip, the end with the shark fins for the rubber band and the flat part to be attached in the safety mechanism and the third part, the extra length modules.
When the length of the speargun increases, the user can screw apart the standard module and the end module and insert the extra module in between before screwing them all back together.
To increase sales the spear tip could be a part for itself. The tip often gets warn and flat during use e.g. if it hit a stone. This would make it possible for the user to buy a new cheap spear tip instead of having to grid the old one.

The length which protrudes the speargun varies between 30-50 cm. The barrel of the speargun has a rail for the spear to support during "take off", this secures a precise shot even though the spear is not the optimal length. The length of all the spear lies inside the by Rob Allen approved sizes.

Ill. 3.4.1: The relation between the length of the spear and the length of the speargun

3.5 ASSEMBLING THE PARTS

During the detailing phase it has been an important parameter to keep the assembling and in general the construction as simple as possible. This is been done so the spearfisher can operate the speargun in water wearing gloves, and so the speargun has as few virtual and weak components as possible, which can be wrecked doing the dive. This approach leads to a constant reflecting and evaluating process where construction has been evaluated over and over to find unnecessary components within the solutions.

Through the reflective developing process screws, locking mechanisms and components have become integrated and combined solutions with more function in many of the parts. This results in a speargun which from the handle and out can be taken apart, cleaned and worn out components can be changed (Worksheet no. 60).

The assembling and disassembling user scenarios are tried to be held as simple and easy as possible. Some of the components come as pre-assembled parts to the user. These parts are assembled during the production of the speargun. The speargun comes disassembled to the user who has to assemble the last components by him self.

ASSEMBLING BY THE MANUFACTURE

A. First the handle is assembled. The trigger, safety mechanisms and in the shell of the handle are first connected and then a cap with a snap-lock encloses the shape and hide the mechanisms so the safety switch and trigger is the only part coming out of the handle.

B. When the handle is assembled, the barrel will be mounted inside the handle. The barrel is held in a locked position with two screws, where one of them is bend in and angle for winding up the line on the standard length speargun.
The barrel can be replaced by the user by releasing the screws and insert a new barrel.

C. The main base of the loading pad component will be connected with the steel beam. The steel beam will be mounted in the rail hole in the main base of the loading pads and then the bearings are pushed onto the beam. The connection between the beam and the bearings are using pressure fittings which means that the steel beam is fastened on the loading pad and cannot be removed by the user. He will have to purchase a new loading pad component if it becomes defective.

ASSEMBLING BY THE USER

When the user purchase the new speargun all the aforementioned component come assembled. The user will have to assemble the rest of the speargun himself before it is ready to bring into the water.

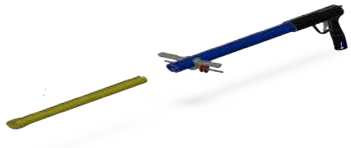
When the user purchase the new speargun all the aforementioned component come assembled. The user will have to assemble the rest of the speargun himself before it is ready to bring into the water.

1. First he has to mount the loading pad component on the barrel. This is done by sliding the loading pads onto the barrel.

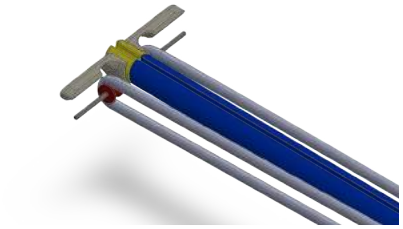
2. Then the barrel has to be connected to the muzzle. The muzzle is pushed inside the barrel and is fixed with an eye bolt.

3. The last thing he has to mount on the speargun is the rubber band. This has to be attached on the bearing on the loading pads.

1



2



3

Ill. 3.5.1-4: Assembling done by the user

Extension assembling
When purchasing the extension package the user has to disassemble parts on the basic speargun and mount the extension components.

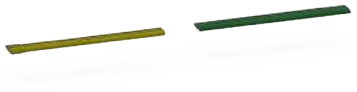
1.1 The eye bolt locking the muzzle inside the barrel has to be detached and the muzzle will be pulled out of the barrel. The screw in front of the speargun has to be detached.

2.1 Now the muzzle has to be pushed inside the extension barrel and locked with the screw detached from the basic barrel.

3.1 The extension barrel with the muzzle mounted has to be pushed inside the basic barrel on the speargun and locked with the same eye bolt.

4.1 The line wheel is mounted on the bottom side of the handle with two screws.

1.1



2.1

3.1

4.1

Ill. 3.5.5-8: Assembling done by the user

3.6 EXPRESSION

As any other products the new speargun needs coloring to reach a desired expression. It is not only the form of the speargun, that gives it a certain expression. These two in combination give the speargun its identity. Finally the Ardea logo has to be integrated in the product for it to be recognizable.

The speargun has to fit into the main surroundings where it has to be used. Furthermore it has to be noticed in the store among a broad specter of other spearguns already on the market. These are typically black with some details in other colors. Therefore, the team wants to use another color reminding the user about the context it is made for; similar ocean conditions as the Danish. The ocean in Denmark is much more green in its color compared to more tropical places, where it is blue/ turquoise and much more clear.
The barrel will appear in British racing green and the interaction surfaces will be colored in red to have a strong contrast between these two colors.
The Ardea logo is colored on the barrel in black and red in a contrast to the almond green color of the barrel. This makes it easier to see and thereby recognize the logo.
To indicate the holes for adjustment of the barrel length, thin black stripes running from the hole up the sides of the speargun. This will make it easier for the user to adjust the length without having to turn the whole speargun.

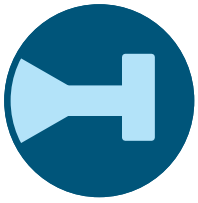
Ill. 3.6.1

3.7 MATERIALS AND PRODUCTION

The team needs to define the materials of each component in the new speargun, both in order to calculate the total weight of the product and later on the production price. The materials have to be resistant to the constant contact with seawater.

HANDLE

The handle is made in glass-filled nylon, which is generally the material most speargun brands use for their handle. Nylon is a trade name for polyamide (PA), and its key features are low friction, resistant to abrasion, high strength and poor moisture resistance. To enhance the properties of nylon it is being filled with glass fibers in order for it to be resistant to moisture (Worksheet no. 42). It is important for the handle to have a high strength, because of the high force and impact running through the speargun when fired.



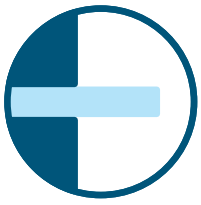
The typical processing method is injection molding, which has a low unit price, but a high tooling cost. A mold for the handle will cost around £8.000 ($11.000) (Worksheet no 42), cycle time for a complex part is around 30-40 seconds and the minimum quantity to start a production is often 10.000 units.

Glass-filled nylon cost: £2.55 ($4) per kg.

BARREL

The barrel of the speargun is in aluminum, because of its good strength, low weight and resistance to corrosion. All these features are very important for the barrel due to the context of use, the ocean, and the strength is necessary due to the high power and energy running through the barrel when the spear is fired. As an extra value to aluminum is that it is 100 percent recyclable. It is also the most used material for barrels on existing spearguns today.

Processing methods include extrusion, which is the production method the team wants to use. It is a low investment regarding tooling and is a good method for long profiles. The methods often requires a second process, which is also necessary in this case, because the barrel needs to be cut in certain lengths and angles.

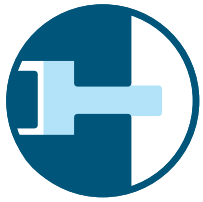


Aluminum cost: £1.28 ($2) per kg.

LOADING PADS

The lateral cylinder in the loading pad is made in stainless steel due to its non-corrosiveness and toughness. The loading pad is exposed to a lot of force, when the user loads the speargun, which is why the toughness is very important. It also has the advantage of being recyclable as the aluminum.

The processing method is forward impact extrusion, which is used for making continuous, symmetrical objects in metal. The tooling and unit cost is low, and a minimum quantity for production start is 3.000 units.



Stainless steel cost: £3.20 ($5) per kg.

The complex part of the loading pad is made in glass-filled nylon as the handle. This part needs high strength and abrasion resistant, because the loading will be exposed to a lot of pressure from the user's legs when loading.

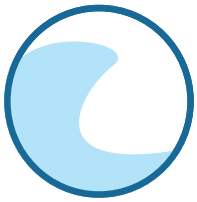
The processing method will be injection molding with a secondary process to drill a hole through the object where the aforementioned lateral, stainless steel cylinder has to be placed.

Glass-filled nylon cost: £2.55 ($4) per kg

MUZZLE

The muzzle is produced in glass-filled nylon due to its high strength and abrasion resistance. The muzzle will lock and hold the loading pad when loaded, and therefore it requires a high strength in order to be able to resist the force which the rubber band pulls with.

The processing method is rotational molding due



to the part being hollow. The method is less expensive than injection molding, because the mold is more simple and thereby cheaper, and the unit cost is low.

Glass-filled nylon cost: £2.55 ($4) per kg

SPEAR

Stainless steel will be used for the spear, because it is characterized by non-corrosiveness and toughness. The high transfer of energy and the force it is exposed to makes it necessary to use a robust material like stainless steel even though it is more expensive than e.g. aluminum.
The processing method will be forward impact extrusion as the lateral cylinder for the loading pad, but the spear will need a second processing method to make the threads for the modules. Machining is used to make these, which is a method without tooling cost.

Stainless steel cost: £3.20 ($5) per kg

STANDARD COMPONENTS

The trigger mechanism inside the handle, the line between speargun and spear, the rubber band and the rollers are all standard components, which will be bought through a supplier. These suppliers will vary depending on how the business for the new speargun will end up.

All numbers, materials and processing methods are found in the books Materials for Design and Making it - Manufacturing techniques for product design by Chris Lefteri [Lefteri, 2014] [Lefteri, 2012].

3.8 **SUM-UP**

Now the new speargun, Ardea, is fully developed and the team can begin to look at the business and marketing aspect of the product. The speargun is consisting of two sub-products, a basic speargun and a extended speargun. The extended makes it possible to adjust the speargun in different lengths and a loading pad running along the barrels will help the user to load the speargun by the legs.
All components and assemblies are developed to keep it simple, but still not compromise on the functioning of the speargun.

Phase **4.0**

BUSINESS

This phase explains the potential market and discuss different business models, which the team sees as realistic opportunities. The new speargun, Ardea, is compared to it's potential competitors in the market of existing spearguns to find the new and extra value this speargun will use to get ahead of it's competitors. Finally the production and sales price is estimated based on the materials and production methods chosen in the previous phase.

Ill. 4.0.0

4.1 BUSINESS MODEL CONSIDERATIONS

The team needs to get an overview of the different opportunities of business models in order to choose the most favorable for the team moving forward with the project.

PRODUCT ARCHITECTURE

Ardea is an adaptable speargun, but this part is sold separately. The customer will buy the standard speargun, which can not be adjusted unless the add-on part is acquired, which makes the speargun adjustable from 50 to 90 cm with a 10 cm span. The speargun is made to offer the beginner in the user group a less expensive speargun, because they are often not ready to spend a lot of money on a sport, which they have never tried before. In this way they will have the opportunity to buy the short, standard version of the speargun before buying the adjustable part.

Furthermore the speargun is made with a rail, so other add-ons can be bought in the future and then attached in this rail, such as a GoPro camera or a smart line rewinder. All this ensures that the customers most likely will return to buy more gear for the Ardea speargun.

ROB ALLEN

Many different speargun brands can be found on the market, but not many are from a country with similar water conditions as Denmark. Rob Allen is one of these brands and many spearfishers recommends Rob Allen spearguns, which caught the team's interest. The company Rob Allen is from South Africa and is also the name of the owner of the company. The team quickly took contact in the beginning of the project, which lead to some great sharing of knowledge throughout the project. Rob Allen has shown great interest in Ardea and the team believes through a face-to-face meeting and a convincing presentation, that a collaboration is possible to establish. This comes from a perspective of Rob Allen coming from a place with same bad water conditions as in Denmark, so he might be interested in either buying the project or invest in it, so we can finish it and make it ready for production. As it is right now Rob Allen does not have any similar products to Ardea, where it is loaded with the legs or is adjustable (Worksheet no. 42).

If a collaboration around the project is establish ed, either in one way or another, it will benefit both the team and Rob Allen. Adding a new product to their product portfolio would make them able to target a bigger market and have a product which distinguish from the rest of the products on the market. The team will benefit from the collaboration in terms of getting their product realized.

CHOOSING A BUSINESS MODEL

The business model opportunities have been analyzed through SWOT to see which one is preferable and with the most upsides for the team (Worksheet no. 61) Making a collaboration with another established speargun brand seems as the safe choice, but it is also the more realistic choice. A start-up company might be more interesting, but this is also the business model with most risk, so therefore collaborating is preferred. The team will aim at making a licensing agreement with Rob Allen.

Ill. 4.1.1

4.2 POTENTIAL MARKET

Spearfishing is practiced in many parts of the World and the sport is becoming more popular each year, but it is still difficult to really say how many spearfishers there actually are around the World. Official numbers are impossible to find, so the team has to estimate based on interviews with people from around the World having knowledge from experience.

The spearfishing market is different depending on the water conditions in the particular area (visibility, current, temperature, fish species etc.), which have made all the equipment including spearguns regional [Worksheet no. 17]. The current market seems to only have considered good water conditions (high visibility and low current), so therefore with the new speargun it is possible to go into a market where no one has specifically designed a speargun fitting water conditions similar to Denmark.

Graham Carlisle from Australia explains how the bad water conditions in Australia influence the amount of active spearfishers in a negative way (Worksheet no. 62). Spearfishers prefer good conditions, but when you live in Denmark, South Africa or Australia with bad water conditions, a spearfisher still wants to be able to spearfish even though the conditions are not as you wish for. Taking a look at Ill. 4.2.1 gives an indication of how many spearfishers there are in the World today. These numbers are not official, but estimations from different experts in spearfishing (Worksheet no. 63).

Ardea is made to fit similar water conditions as the ones found along the Danish coast, which will give a relative small market. As mentioned before this are conditions generally with low visibility and high current. The oceans can always change from one moment to another, which is why Ardea is capable of adapting and adjusting in length at any time. Therefore it is possible for the team to also target other markets with better water conditions than the Danish, because Ardea is made to operate in the worst possible conditions.

Ill. 4.1.1

4.3 PRODUCTION AND SALES PRICES

The production of the speargun is decided in the previously chapter. Based on the production methods and the design of the speargun, it is possible to determine an estimated production and sales price. The price estimation is done to be able to determine whether or not the business case around the product is beneficial and worth proceeding. This is done by using different calculation models and estimates based on desk research and informations found on manufacturers websites. The objective of the calculations is to find a production and sales price which can compete with the products on the current market. The prices and calculations are based on the business model where a collaboration with Rob Allen is established. The project cost is based on the team being employed at Rob Allen.

PROJECT COST

When designing a new product it is needed to get an overview of the project's extent and what size of investment there could be expected. Therefore, an estimation of the whole project including the prefaces is calculated. The different parameters are estimated based on a template model of price estimations (Worksheet no. 64). The prices are based on a collaboration with Rob Allen.
The estimation shows the size of the investment

	DKK	Basic speargun / DKK	Extension package / DKK
Wages	950.000	570.000	380.000
Approvals/Travels	250.000	150.000	100.000
Prototypes/Materials	100.000	60.000	40.000
Consultancies	200.000	120.000	80.000
Tools	200.000	120.000	80.000
Others	400.000	240.000	160.000
Total	2.100.000		

necessary to put into the project before the first product is launched. The largest factor in the calculation is the salary which is around 45% of the total budget. This factor is based on the three members of the Ardea-team being payed for the development through the project (Worksheet no. 64).

CALCULATIONS OF PRODUCTION PRICE

To be sure that the project would be feasible it is needed to calculate the production price of the hole speargun. The speargun is based on a business around a product platform, where a standard length speargun can be bought and an extension packages can be purchased along or afterwards. This means that there are two overall products which has to be calculated; the standard length speargun and the extension.

Standard length speargun
Components:

- 50 cm roller speargun with rubber bands
- Loading pads
- 2,8 m line

Extension speargun
Components:

- Extension barrel
- 2 x extension spear modules
- Line winder wheel

It is estimated that there will be sold 15.000 standard length spearguns and 10.000 extension packages during the first 3 year after launching. The number are based on sales number from Rob Allen (Worksheet no. 42). When Rob Allen started 10 years ago he sold approx. 300 spearguns per month where today he sells close to 1500 per month, divided on the different models and is expanding every year. These numbers are from a manufacturer located in a country with similar condition, which indicates that 15.000 spearguns sold on a 3 years period is not unrealistic estimate. The production price is based on outsourcing the whole production and only the assembling is done in either South Africa or Denmark.

For estimate the unit price for one speargun and one extension, the mass an volume is determined for each of the components. The weight and volume of the components help determining the unit price for each component determined from the price per weight and the tool price for the manufacturing. Finishing of each component and purchasing of standard components is incorporated in the calculation as well. The estimations are done based on a working salary of 20$ pr/h. Based on these determinations, it is possible to estimate a unit price for the basic speargun and the extension (Worksheet no. 64).

It is estimated that a full speargun will cost 60$ (395DDK), the basic speargun will costs 47$ (310DDK) and the extension packages will cost 14$ (85DDK) to manufacture. These prices are the foundation for further calculation on revenue and sales calculations.

To determine the sales prices in the stores a template for calculating the sale price is used (Worksheet no. 64). The estimate is that the covering profit from Ardea or Rob Allen has to be 75% of the production price and the retail stores in Denmark will in extend add a sale profit of 100%. Based on these calculations the sales prices in the stores will be 205$ (1350DDK) for the basic speargun and 60$ (400DDK) for the extension package.

When dividing the product into two purchasing opportunities for the customer; buying the full package with the basic 50 cm speargun and the extension, or starts by buying the basic 50 cm speargun and then return to buy the extension package, the company risks that the customer will purchase the basic speargun and not return to buy the extension package. A sales strategy could be considered. The sales price of the basic 50 cm speargun and the price of the extension package could potentially be a little higher than the full package consisting of both the 50 cm basic speargun and the extension module. This could lead people to purchase the full package instead of dividing the purchasing in two.

Despite the risk of selling less full package spearguns, the team estimates that the sales number will increase when dividing the product into two packages. It is estimated that the beginners and new spearfishers will not purchase the full package the first time, both because they do not need the extension when starting spearfishng and because they do not have the experience in spearfishing to know the values of the new speargun.

4.4 PRODUCT COMPARISON

An analysis of current spearguns has been made earlier in the project, but now that the team has a finish product design, a comparison is needed to see the difference in pros and cons, and what the added value of Ardea is.

To do this, spearguns in different price ranges are chosen to get a more representative analysis. The test is done to determine if the Ardea can compete with the other products on the market. This is important in order to understand whether or not the new speargun compromises on quality when it is flexible, so it can replace the need of several spearguns and to be able to validate if more and new values of Ardea are presented.

The test compares Ardea to three other products, and determines the pros and cons of all the

The added value of Ardea is the ability to adjust the length according to the visibility and current in the water. Furthermore Ardea makes it possible for any user in any height to load the speargun no matter what length they adjust the speargun to. Finally the product architecture is made in a way, where Ardea can be bought to fit both the beginner or the more experienced spearfisher. All this cannot be fulfilled by any other product currently on the market.

ARDEA	ROISUB DEMO2	CRESSI GERONIMO ELITE	OMER CAYMAN 2000
+	+	+	+
• Easy to load • Adjustable to water conditions • Two purchase scenarios • Possible to buy add-ons • Can be shortened for transport	• Less weight • Better for blue water spearfishing	• Less weight	• Less weight • Cheap • Few vital components • Basic, simple construction • Good build quality
-	-	-	-
• The spear has loose parts • Expensive • Several vital components	• More expensive • Harder to load • No add-ons • One length • Transportation	• Hard to load • No add-ons • One length • Transportation	• Hard to load • No add-ons • One length • Transportation
Sales price: **1800 DKK**	Sales price: **5000 DKK**	Sales price: **1600 DKK**	Sales price: **800 DKK**

Ill. 4.4.1

4.5 IMPLEMENTATION

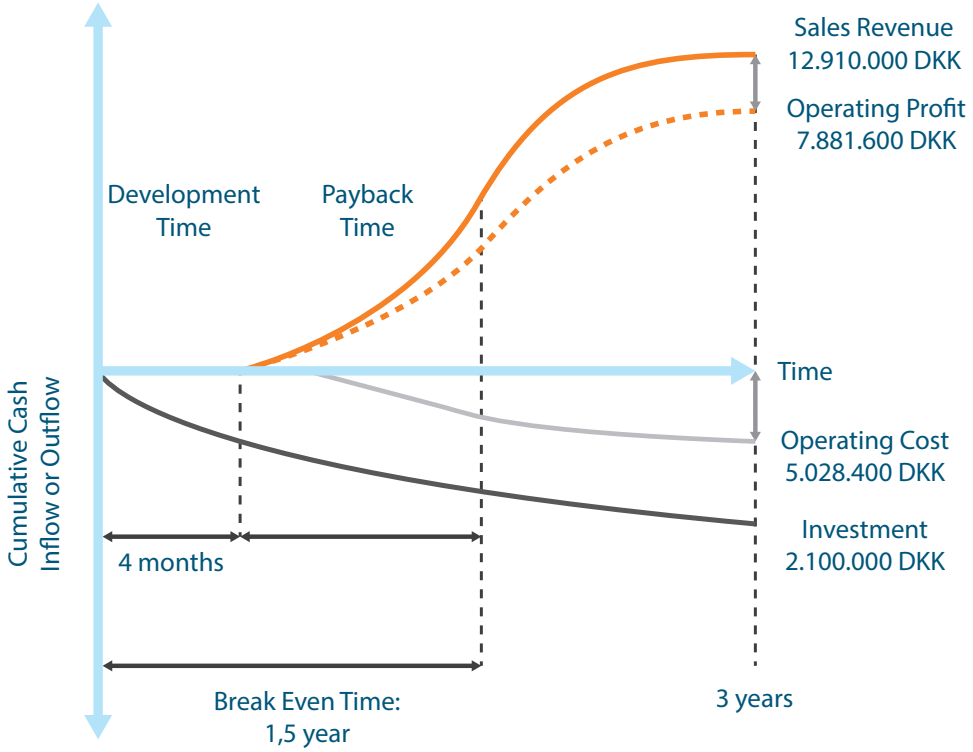
In order to understand how profitable the business case potentially can be it is important to look at the cash flow and understand when a break-even is reached.

The implementation model is based on the idea of collaborating with Rob Allen despite this has not been confirmed yet.

Ardea will in the next 4 months be developed in collaboration with Rob Allen and sent in production. The investment needed to cover the final development of the product and the tooling for production is 2.100.000 DKK. The estimated cost for production of the basic speargun is 308 DKK and for the extension package 91 DKK. This gives a sales price at 1350 DKK for the basic speargun and 310 DKK for the extension package.

A break-even is reached approximately after 1,5 year. This take into consideration the development time estimated to be 4 months and then minimum 1 year where the product has been in production. (Worksheet no. 64).

All these numbers are estimations, but if a collaboration is fully established with Rob Allen it might be even cheaper to produce the basic speargun and the extension package, because they have established a well-functioning production with bulk buy and efficient tooling. (Worksheet no. 42)



Ill. 4.5.1

Phase **5.0**

MARKETING

In this phase the team investigates on how to distinguish from competitors and be noticed when being a new brand and product. This can be difficult in a market with many different existing spearguns, which makes it even more important to understand how the competitors present themselves and their products both in the physical stores and on-line.

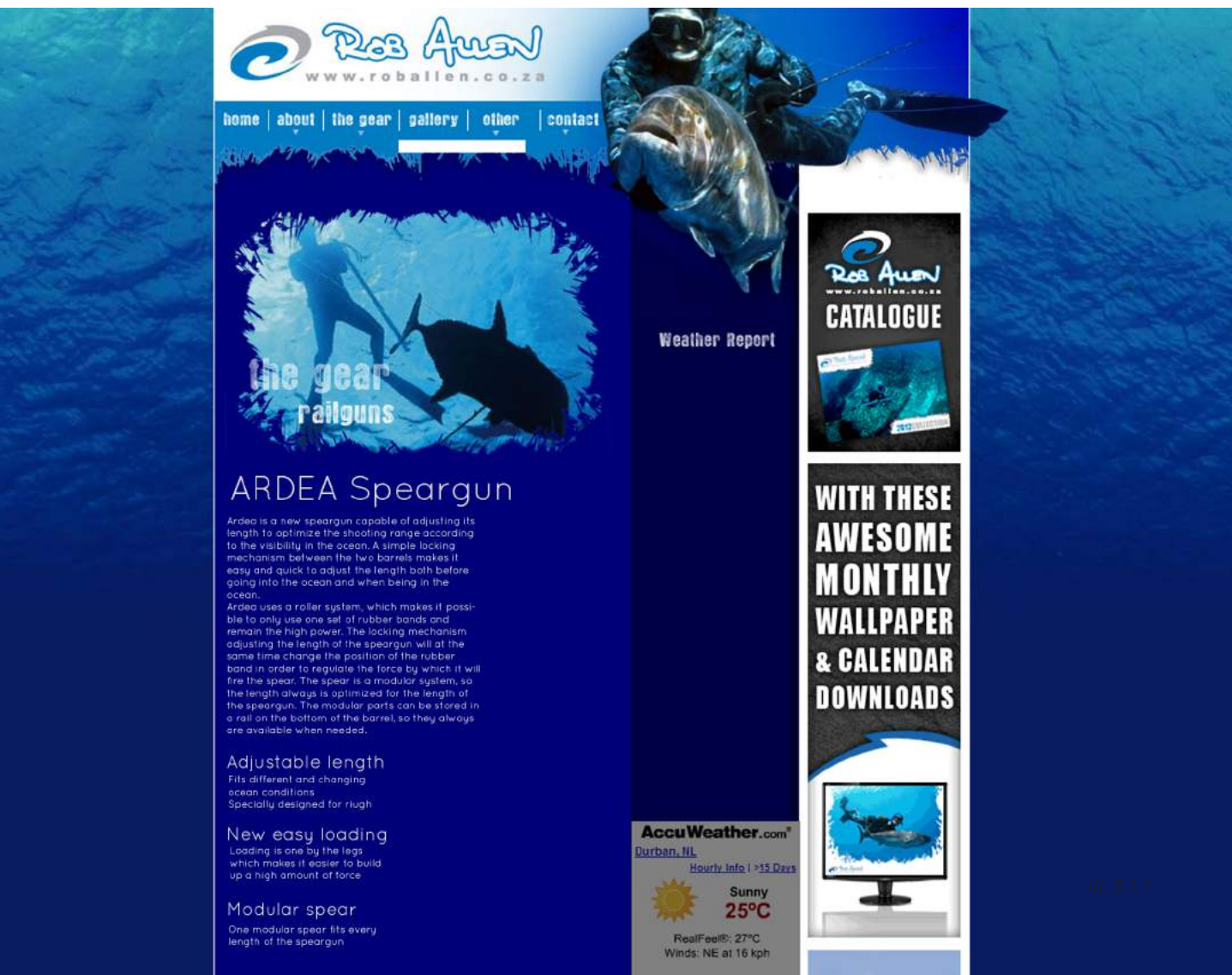
5.1 SALES CHANNELS

As a collaboration with Rob Allen has been chosen it is necessary to determine how to reach out to the customers. This can be done in a variety of different ways when a collaboration is established.

If the collaboration with Rob Allen is established, Ardea will be sold through Rob Allen's own physical store, located in Durban, South Africa, and through their website. Furthermore Rob Allen's distributors will be used for selling Ardea. The company has 14 distributors in South Africa and 24 in the rest of the world, placed both in Asia, Middle East, Australia, Africa, South America, USA, Europe including Denmark [Rob Allen, 2007]. This ensures Ardea is distributed to all over the world to get the widest possible market targeted.

Potentially, the team could create an Ardea-website for selling the product additionally to the Rob Allen sales. The Ardea-website will help present Ardea as a new, revolutionizing speargun, so it is not just being placed between a lot of other spearguns and thereby risks it disappearing in the "crowd". The website will by the time be filled with add-on products for the speargun, which also will be distributed to the other stores around the world. All products presented and sold through the Ardea-website should also be sold in the Rob Allen stores, retailers and website.

Below is a draft of a possible incorporation of Ardea presented on Rob Allen's existing website.



5.2 PACKAGING

In the previous section the team decides to make Ardea stand out on both aesthetics and on packaging. The packaging will make Ardea the only speargun on the market, which is delivered in a designed packaging fitting the speargun and graphically fits the brand Ardea.

A short ideation process is done on the packaging of the process, do to the importance of this parameter regarding the purchase experience for the user and to make Ardea stand out from the competitors. Through the ideation it is determined that Ardea should not be hidden away in a box in the spearfishing store, but instead be presented in an easily opened cardboard box placed on shelves or tables, so the speargun can be taken out and held by the interested customer. One box with speargun will work as exhibition model, while the others will be kept closed, so they are new and untouched when delivered to the customer. Alternatively, one Ardea speargun could be unpacked and placed on the wall among the rest of the spearguns, if the store does not have furnishing able to present Ardea in the cardboard box.

When a customer purchase an Ardea speargun whether it is in a physical store or on-line, he should receive a rectangular cardboard box with fitting graphics to the brand and telling what the customer can expect of the product inside the box. The box should have a top folded as a lit over the box or depending on the production price of the cardboard box, it has been suggested to close the box with magnets in the lit to make the whole package, and thereby the product, look and feel more exclusive and high-class.
The speargun should be seen from a side view when the box is opened, where it is placed in a piece of foam where the shape of the speargun is cut out.

Ill. 5.2.1

5.3 FEATURE CATALOG

When you buy a new speargun, you will receive an introduction and the needed information about use and features of the product by the retailer. Both in terms of safety but also so that the speargun is used correctly.

Today there are two ways to purchase a speargun; on-line stores or physical stores. When buying a new speargun in a physical store, the salesman will give an introduction to the speargun and how it is used. Based on the interviews with the stores visited during the research chapter it is possible t get an understanding of the purchase scenario and what the customer need to know before leaving the store with a weapon. The salesmen describes how they would tell about use, handling of the speargun and in general the safety around it and spearfishing.
The goals is that the salesmen in the stores today will introduce Ardea the same way.

When buying a speargun on-line, it becomes much harder to find information and description of all these necessary informations. When buying a speargun on-line it is sent to the customer in bubble wrap or brown cardboard box. The user will not get the same information about the product when buying it on-line. Ardea will on this parameter differentiate from the other competitors to create more value, but also to secure the product is assembled and used correctly and the user understand all the features of the product.
A challenge of including a manual to the speargun is that the users are mostly masculine men who want to hunt their own food and are therefore in a segment group which will read a user manual. Therefore the package for Ardea will include a feature catalog, which will focus more on the specs and features of the speargun and show pictures of how it is used, like in car sales materials.

Ill. 5.3.1

5.4 HOW TO STAND OUT

When entering a market, it is important for a new product to stand out, so it does not become "just another speargun" between many. Ardea needs to take all attention in the physical store, which can be difficult when hanging between all the other spearguns on a wall.

The general purchase scenario of spearguns is that the speargun is delivered in a traditional brown cardboard box to the customer, when it is ordered through websites. Inside the box is the speargun wrapped in bubble wrap and plastic bags.
If the customer purchase a new speargun in a physical store, he will meet several spearguns typically in different brands unpacked hanging on a wall placed side by side. He is able to take them all down for trying. This part of the scenario works well, because the customer is able to try, hold and feel the product before purchasing it. When the customer purchase a speargun in a physical store, he will get one of the products unwrapped, hanging on the wall handed to him in a plastic bag for transporting home.

Considering this scenario and the presentation of the existing spearguns in the stores, Ardea has a possibility to stand out from the rest regarding both the presentation in the stores and the packaging the product is delivered in to the customer. The packaging is important because it helps telling the customer why the product is better and different from other products in same category.

Besides the packaging, Ardea will stand out through the whole design of the speargun and how it appears aesthetically with the hammerhead looking loading pads, which no other spearguns have on the market.

Ill. 5.4.1

Phase **6.0**

EPILOGUE

In the following an overall conclusion of the project is made. Furthermore a reflection is made on how the project and process went. Finally it is discussed, what will and needs to be focused on after submission.

6.1 CONCLUSION

During the last three months the team has been working on developing a product for diving, and the result has become a speargun designed for Danish ocean conditions, these conditions are some of the roughest and worst a spearfisher can encounter. The team did enter the project with a vision to create a product, which not only would be revolutionary and change the sport, but also make it easier for the users to use. During the project it has become clear that spearfishing should not be changed, but instead optimized and rethought by the equipment used. This is why Ardea's product is not aiming at changing the way spearfishing is performed, but instead optimizing it by creating a speargun which is suited for changing conditions and different hunting purposes. Even though the product is an incremental innovation it still solves many of the basic user needs and problems of the current spearguns, which is why the speargun has market potential.

Currently no spearguns on the market makes it possible to change the length of the speargun in the matter of seconds and right at the spearfishing spot. This is a great value, because it is not possible to see the ocean conditions (visibility and current) before heading out to the spearfishing spot and thereby choose which speargun length is needed according to the conditions. If it becomes possible to check the ocean conditions in the near future before leaving home, then the ocean conditions are still capable of changing over short time or as the spearfisher changes his position in the ocean.

The ocean conditions a spearfisher experience in Denmark can also be found a lot of other places in around the World. This gives the project a larger potential market than first expected, which means the new speargun, Ardea, would be a better choice in many other countries than only Denmark compared to the current spearguns on the market.

Through research different problematics has been discovered. The loading method is seen as the main problem on the current spearguns, because many spearfishers find the spearguns difficult and hard to load. New and different loading methods were investigated and tested, but as the team realized how important the simplicity of the equipment used in spearfishing is, the rubber band stood out as the overall best method measured on efficiency combined with simplicity. The difference now is how the rubber bands are loaded, which is by using the legs the stretch out the rubber band and thereby load the speargun. This new method makes it easier than the current technique with the arms, because the user now uses bigger and stronger muscles groups in the human body.

The simplicity of spearfishing is so fundamental to the sport, because when beeing in the water it tools and other fragile components easily can be lost and if a component's gets wrecked it is hard i should be easy to repair in the water. Therefore are the solutions in the speargun held as simple as possible. The result of the project is a new speargun, which is easier to load for users in all experience levels and which is adjustable to the Danish ocean conditions with generally low, changing visibility and high current.

6.2 REFLECTION

ARDEA

The new speargun is able to adjust its length in five different levels according to the changing ocean condition in Denmark. These levels are with a 10 cm span, which changes the shooting range with 50 cm at each level. This might be too many adjustment levels, because an argument can be whether or not the user thinks it is worth changing the shooting range with only 50 cm when being in the water. Another thing will be whether or not the spearfisher is able to assess the visibility in a span of 50 cm without trying to shoot the speargun in all lengths. The lengths which the speargun can adjust to are chosen from which lengths the spearfishers in Denmark are using currently, and therefore the 10 cm span can be justified by giving the different users of the product the opportunity to adjust the speargun exactly in the length they prefer. Giving more opportunities by the five levels of adjustment will not make the product a lot more expensive than if it only had three adjustment levels, because all it requires is the extra processing method of making holes in the barrel of the speargun, which has to be used anyway.

THESIS

Choosing a subject which would be in all the team members interest was difficult in the beginning, but as one of the members suggested spearfishing all team members saw an interesting area to work within over the next couple of months. This was due to the fact, that all members had a common interest in working with some sort of sport, and with spearfishing the team had fulfilled this. Even though none of the team members had a lot of knowledge and experience with spearfishing, all members found it exciting to work with. This gave the opportunity to learn a new and almost unknown sport through a lot of research and thereby establish enough knowledge to design a new product with potential to come in production.
The scope of the project has been unclear at times, but stepping back and trying to understand the user, the needs and what the research actually revealed it became clear to the team. The product was from the beginning of the development process anticipated to be simple solution in it's overall construction, but the team quickly realised in the detailing phase that a simple product still needs every little detail to be encountered and solved. The team has therefore put a lot of effort into the technical details of developing simple solutions and then integrating these into a holistic product.
The team is satisfied with the outcome of the project both in terms of individual goals and the final product solution, though there is still details which have to be developed more and tested.

MANAGEMENT

The team started with using the method SCRUM for managing the project and all the tasks for each day. This method lasted not for long, because the team found it unnecessary at that point and it worked better when making a handwritten schedule for each week. At the end of the project SCRUM was used again, because the team felt a need of seeing tasks moving from "to-do" to "done", and thereby give new energy to all team

members. Another thing the team tried to do, in order to change the daily rhythm and routines to give new energy when the days felt monotone, was to work at home at one of the team members. This together with the research outside the study facilities helped to make a more dynamic process.

COLLABORATION

Initially the team had an expectation of collaborating with a company, which also was tried to establish. One of the team members had heard about this new company, Ragnarok Sub, located in Copenhagen. They had just started making their own equipment for spearfishing in Denmark and therefore the team saw great potential in collaborating with them, because it could potentially benefit both the team and Ragnarok Sub. The team could use their knowledge about spearfishing and the equipment, and also have someone able to make prototypes along the way. Them being a new company would probably make them interested in collaborating with Master Thesis students, because it would only cost them something when prototypes had to be made. Thereby they could end up with a new product for their new company without a lot of expenses.

After a meeting in Copenhagen with the owner of Ragnarok Sub it was decided by the team not to collaborate with them, because the benefits for the team were simply too few. They had no economy to put in a project like this and therefore the team saw no point in collaborating moving forward. Therefore the team ended up without any collaboration, which gave more freedom to choose a direction.

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7.3 METHODOLOGY

METHOD	ACTIVITY	APPROACH	PURPOSE
Scrum Board	Process navigation	List tasks and categorize these under "To do", "Doing" and "Done"	Make sure every member of the team has an overview over what has to be done and what is in progress
Design Brief	Expectation agreement	Correspondance between Ardea and a collaborating company	To ensure that both parties agrees on the expected outcome of the project. Align the expectations
Desk research	Knowledge collection	Internet research	To reach a higher level of understanding
Interview	Knowledge collection	Talk and mail correspond to the targeted group and field experts	To reach a higher level of understanding of the targeted group and to validate the gathered information
Brainstorming	Ideation	Drawings, post-its, conversations and evaluations, for starting the design process	To start the design process on a divergent level
Product comparison	Product knowledge	Comparing diffirent products	To reach a higher level of understanding of the current products
Surveies	Evaluation	Asking users about their experience and challenges	To get an understanding of how it is to be a spearfisher. Which problems and experiences are involved
Acting it out	Knowledge collection	Testing products in water	To get a shallow understanding of how it is to spearfish and challenges with respect to it
3D print + simulation	Concept test and evaluation	3D print different models for testing shapes and principles	Examine how the water current acts around the shape and if/where turbulence occurs

ARDEA

THE ADAPTABLE SPEARGUN

AALBORG UNIVERSITET

ARDEA

THE ADAPTABLE SPEARGUN

00 WORKSHEETS

Master Thesis - Industrial Design
Aalborg University
May 2016

Anders Poulsen

Anne Hjortflod Nielsen

Peter Vestergaard Sørensen

ARDEA		
Types of diving		
Date: 02-02-2016	Team no. 4	Worksheet no. 01

Objective:
The initial research of diving is executed to investigate the different types and approaches of diving. By gathering general knowledge and finding characteristics of each type of diving, the team is able to differentiate and identify the category of diving and target group of divers to approach in the project.

SCUBA DIVING
Scuba diving is underwater diving, where the diver gets air-supply through air-tanks containing compressed air, carried on their back. The air-tanks gives the divers greater freedom to move than an airline and longer endurance than breath holding. Scuba diving is performed both recreationally and professionally.

Equipment:
Air-tank
Wetsuit
Mask
Fins

PROFESSIONAL DIVING
Professional divers work under water. Their work typically consists of inspection, cleaning or maintenance of e.g. ships, bridges or oil rigs.
They either use airlines from the surface or air-tanks.

Equipment:
Wetsuit
Mask/helmet
Airline/air-tank
Fins

FREEDIVING
Freediving is underwater diving, where the diver relies on his or hers ability to hold their breath. They inhales air above water, and dives down as long as their breath allows. Freediving is used for several different purposes e.g. fishing and diving competitions.

Equipment:
(Wetsuit)
Mask
Fins

SNORKELING
When snorkeling, the diver swims on sea level with the head just beneath sea level and gets air through a snorkel. Snorkeling makes it possible to observe underwater attractions for an extended period of time with relatively little effort. The snorkel makes it possible for the snorkeler to breath while his or her head is face-down in the water.

Equipment:
(Wetsuit)
Mask
Fins
Snorkel

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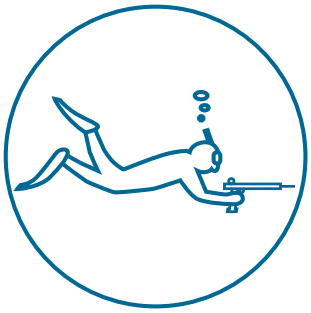

SPEARFISHING
Spearfishing is typically done either in scuba diving or snorkeling, but there is a general attitude between spearfishers that spearfishing with air supply is some sort of cheating, because you make it too easy to catch the fish. Another attitude between spearfishers is about spearfishing in the night - this is also seen as cheating, because the different species of fish are easier to catch in the night.

Equipment:
(Wetsuit)
Mask
Fins
Snorkel
Speargun

Evaluation:
From the short investigation of diving types, it is detected that there in general are four types of diving, which can be divided into two overall categories; with and without air-supply. Without air supply is seen as the right way to spearfish in the world of spearfishing.

Reflection:
From this investigation it is necessary to take a further look into spearfishing, but the team is of the opinion, that they will not focus on spearfishing with air supply, when it is already creating a negative debate inside the sport of spearfishing. The team wants to design a product, that helps increasing the experience of the existing way of spearfishing. This further investigation should give an idea about which direction to choose for the project.

Sources:
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https://en.wikipedia.org/wiki/Freediving
https://en.wikipedia.org/wiki/Professional_diving
https://en.wikipedia.org/wiki/Snorkeling

ARDEA		
Types of spearfishing		
Date: 02-02-2016	Team no. 4	Worksheet no. 02

Objective:
Research of different types of doing spearfishing is necessary to understand the different situations a spearfisher can end up in. This will help the team in understanding what a new product can be exposed for. Furthermore the team can use it for identifying what the project will focus on regarding these types of spearfishing.

BLUE WATER
Blue water spearfishing is done in open ocean waters in search for bigger fish species. Typically the spearfisher is jumped off by a boat and then floats with the current for hours before the boat picks him up again. The spearfisher will often be left with an inflatable buoy in which he can put the catched fish and extra equipment such as an extra speargun, rubberbands etc..

BOAT
Spearfishing from a boat can be necessary if the spot you want to spearfish is located long away from shore or just so it is unaccessible from shore. It is especially used when going for the aforementioned blue water diving.

SHORE
Spearfishing from the shore is probably the most common way of spearfishing, because it does not require any boat and it is easy to just jump in the water from the beach. The spearfisher enters and exits the ocean by the beach, which also makes it a bit difficult, because when you enter the ocean it can be a struggle to get through all the waves. This type is also the most used in Denmark [1] and probably also around the world, because it does not require boat or similar to access the ocean.

FRESH WATER
Fresh water spearfishing is allowed few places around the world, which means it is not that common to do. In Denmark it is illegal to spearfish in fresh water. [2] Some few spearfishers choose to do it in the winter under the ice, because the water is at it's clearest.

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Types of spearfishing		
Date: 02-02-2016	Team no. 4	Worksheet no. 02

WITHOUT DIVING
Spearfishing from land with a handspear is an very old method for catching fish. Spearfishing as we know it today comes from this type of spearfishing. Few are doing it today and it is also more difficult than the other methods, because when standing above the water you need to take into consideration the optical refraction, which makes it harder to hit the fish with the spear.

Evaluation:
Five types of spearfishing are performed worldwide (shore, boat, blue water, fresh water and without diving). In Denmark the most common way to spearfish is shore diving, because in Denmark there is a long coastline and thereby easy access to the ocean.

Reflection:
The project will delimit from fresh water spearfishing, because it is simply illegal in Denmark. Furthermore spearfishing without diving will not be focused on in the project, because this type is not really being used anymore, especially in Denmark. The three other spearfishing types will so far be focused on, but the team needs to get some more knowledge about what each type consist of when it comes to equipment - some might require more specialized and more expensive equipment than others. Furthermore the experience of the spearfisher might have an influence on which type of spearfishing you choose to do.

Sources:
https://en.wikipedia.org/wiki/Spearfishing#cite_note-14
[1] http://undervandsitetet.dk/undervandsjagt/uvjagt-steder-i-danmark/
[2] http://uvjagt.sportsdykning.dk/regler/

ARDEA		
Hans-Henrik Carlsen, Owner, Carlsens Dykkercenter		
Date: 22-02-2016	Team no. 4	Worksheet no. 03

Objective:
The team needed to get some knowledge from a salesman who know the business through many years of selling and making equipment for spearfishing. Using him to get more general knowledge about spearfishing and also answer specific questions the team has after all the initial research from other experts, the questionnaire and through searching on the internet.

Experiment/Data:
The interview called “Carlsens Dykkercenter Interview.m4a” can be found on the USB.

Anders: Hvem er kunderne generelt som kommer her - begyndere, erfarne osv.?
Hans-Henrik: Begge dele. Fra bund til top.
Peter: Nu har I meget dykkerudstyr, så er det dykkere der vil prøve uv-jagt?
Hans-Henrik: Det er som regel dykkere eller svømmere.
Anders: Hvad er forholdet mellem kvinder og mænd?
Hans-Henrik: 1/30 mænd og så er du optimist.
Anders: Kunderne når de kommer ind ved de så hvilken harpun de skal købe i forhold til elastik, lufttryk og længde?
Hans-Henrik: Nej. De “kloge” er dem som har læst noget på et forum, men de går som regel herfra med noget andet.
Peter: Som nybegynder har du så en eller anden længde som du vil sælge til folk? Har du et udgangspunkt?
Hans-Henrik: Når du starter så start med en lille (læs: kort), hvor du fanger flade (læs: fladfisk) og når du så har lært at ramme, så kan du gå videre derfra.
Peter: Er det så en 65’er eller 75’er (læs: 65 og 75 cm harpun)?
Hans-Henrik: Eller kortere. Det afhænger af personen - du skal kunne lade den.
Anders: Har man noget at bruge den helt lange til her i Danmark, altså til de danske forhold?
Hans-Henrik: Når du rigtig er på hav.
Peter: Så er det en 110’er eller derover der er okay?
Hans-Henrik: Nej, der er ikke ret mange der bruger over. Det er kun nogle ganske få der gør det.
Peter: Vi har læst at de fleste bruger 75’er eller 90’er og nybegyndere kortere.
Hans-Henrik: Ja.
Anders: Og det var nærmest 80-90 % der brugte elastik harpuner.
Hans-Henrik: Det er kun uv-jægere der bruger elastik. Dykkere bruger ikke elastikker, de bruger trykluft. Det er nogle andre ting (læs: fisk) man går efter.
Peter: Så trykluft er bedre til stillestående fisk?
Hans-Henrik: Kortere. Meget kortere (læs: skud over kortere afstande).
Peter: Er spyddende også tilsvarende kortere?
Hans-Henrik: Ja.
Anders: Hvad er forskellen på åben og lukket muzzle?
Hans-Henrik: Nogle tager pile med hajfinner på. Nogle synes det er lettere at lade med. Det øjeblik hvor du har åben muzzle har du bedre styr over det. Så snart du har affyret, så er spyddet fri.
Peter: Køber advanced længere harpuner fordi de har fået mere erfaring?
Hans-Henrik: Når du begynder at ramme begynder du at kræve mere. Når du begynder at kræve mere så er der kun en vej - kraftigere elastikker, længere harpuner. Længden på harpunen giver din træfsikkerhed - des længere harpun, des større træfsikkerhed.
Peter: Er der en grund til man ikke normalt går op over 90 cm i harpun? Vi har læst at det normalt er pga sigtbarheden.
Hans-Henrik: Du har ikke den sigte herhjemme generelt, fordi de fleste uv-jægere færdes i kystområder. Der er få stykker der går fri af kystområder. Der er få stykker selv i Nordjylland der er langt ude. De har brug for nogle rigtig lange og så har de som regel to eller tre harpuner med derud. Det er ikke altid at skuddene foregår når man neddykker. Mange skud foregår også i overfladen. Du kan ikke sige at du har én harpun som dækker alle forhold - det er noget vrøvl.
Peter: Hvordan kan vi dele harpunerne op i prisklasser?
Hans-Henrik: 500 kr, 1000-1200 kr, 2000-2500 kr og når vi så går videre derfra, så går vi over i carbon.
Anders: Hvorfor er det at der er lavet en støtte til brystet på nogle og ikke andre?
Hans-Henrik: Den er ikke til brystet. Den er lavet til at mindske rekyl.
Hans-Henrik: Hvorfor er der to elastikker på den der og ikke den anden? Det er for at opnå et lige træk, så du får en bedre lige kraft.

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Hans-Henrik Carlsen, Owner, Carlsens Dykkercenter		
Date: 22-02-2016	Team no. 4	Worksheet no. 03

Anders: Kan du sige noget i forhold til hvor ofte den enkelte kunde kommer og skifter harpunen ud?
Hans-Henrik: Det kommer an på hvor ivrig og tit han går ud. Hvis manden er ivrig, så køber han sådan en til fladfisk først og så går der 6-8 uger, så står han og skal have den næste. Så kan der gå to måneder igen og hvis han så stadig er ivrig og kan ramme og kan opnå de resultater han selv forventer så går han videre til den næste.
Anders: I forhold til dit salg ser du så en større interesse i uv-jagt?
Hans-Henrik: Ja, der er en langt større interesse, men brugtsalget påvirker stigningen, hvis man kigger på salget af udstyr.
Anders: Hvis du skal skyde, hvor mange uv-jægere er der så i Danmark, for vi kan ikke finde nogle officielle tal?
Hans-Henrik: Hvis jeg skal skyde, så er der hvertfald 2500.
Peter: Hvor er der nogenlunde de samme havforhold som i Danmark?
Hans-Henrik: England, Holland, Belgien.
Peter: Er der andre steder end bare i Europa?
Hans-Henrik: Nej, alle steder er bedre end Danmark.
Peter: Vi har hørt at det tager lang tid at skyde sig ind med en ny harpun?
Hans-Henrik: Det er rigtigt.
Peter: Hvor mange harpuner sælger du om året?
Hans-Henrik: Vi solgte nok ca. 600 sidste år.
Anders: Bør man skille hele harpunen af og gøre ren efter hver gang den er blevet brugt for at vedligeholde den?
Hans-Henrik: Vask den af og giv den noget silikonespray er nok.
Anders: Hvad er den mest normale længde (læs: harpun) at bruge i Danmark?
Hans-Henrik: 75 cm.

Evaluation:
Spearfishers in all levels of experience are coming to Carlsens Dykkercenter to buy spearfishing equipment. It is often divers or swimmers who start spearfishing. The ratio between men/women is 30/1 in spearfishing. The customers do not know what to buy and the ones who do will normally end up buying something else when leaving the store. As a beginner you should start using the shorter spearguns - the precise length depends on the size of the person, because arms-length and strength is important to actually be able to use the speargun. As you develop your technique you can buy spearguns which are longer. When you are going on the ocean you will use the longest speargun, but not many go that far away from the coast. People want to buy longer spearguns as they get better with the shorter ones. As longer speargun as better precision and power. Most people are at the coastline when spearfishing and the visibility is lower here and therefore it is not necessary with the 100+ cm length spearguns. When you have one speargun, which some people tend to call a allrounder, you do not have a speargun for all conditions anyway. You need different lengths and types of spearguns to cover all conditions and species you hunt. Which speargun you have or need is definitely a question of individual needs.
70 or 75 cm are the best lengths for the Danish conditions besides flatfish, which is the polespear.
The beginning spearfisher changes/buys new speargun after 6 weeks and again after 2 months.
There is definitely a bigger interest in spearfishing today than the past and the interest is still increasing.
The elastic gives uneven power in each side of the speargun and therefore the spears lane will curve in the water. The elastics will get damaged by the sun by time and also the saltwater.
Shaping the spear with a curve will help the spear fall 3 cm less in the water than all other spears.
Carlsens Dykkercenter sold around 600 spearguns last year both through the physical store and the website.

Reflection:
The spearfisher who has just started will typically buy a small speargun and then buy a longer and longer speargun quiet fast after his first speargun, because the smaller one gets too easy to use and he need to be challenged and a speargun with more power and precision to catch what he actually is going for. Spearfishers will therefore often end up with many spearguns in different lengths, which is something that could be a focus for the team to solve. Furthermore the team might have to rethink the target group, because right now it is all spearfishers, but as Hans-Henrik Carlsen told the team, the hard-core and very experienced spearfishers will go further out in the ocean where it is deeper, the visibility is better and therefore they will use one of the longest spearguns and most expensive. The team might have to delimit more and not focus on this group of spearfishers.

Sources:
http://www.cdcdyk.dk

ARDEA		
Questionnaire - Section 1: Approaches		
Date: 10-02-2016	Team no. 4	Worksheet no. 04

Objective:
The objective is to investigate if the performers of spearfishing have the same approach to the sport and to understand the possible different and why it is so.

Experiment/Data:
By evaluating and analyzing the answers from the Questionnaire [Appendix. 00] regarding the participants interest for the sport, it is possible to determine the most common approaches to the sport of spearfishing.

Mainly three approaches repeatedly occurs through the answers. Many participants answers that they have experience within regular fishing with a rod and/or hunting with a riffle.

> "Har fisket med stang i mange år, og tænkte det kunne være sjovt
> at se hvordan det ser du derude" Person no. 06.

> "Jeg er tidligere buejæger og triatlet svømmer. Og nu er jeg oss fridykker. [...]"
> Person no. 42.

Others enters the sport with an experience inside free diving and/or snorkeling.

> Jeg var fridykker til at starte med, det var jeg i et år og jeg har fisket før hen
> så jeg tænkte det der med harpun er da ret smart så jeg købte mig en,
> og jeg har været skydegal ligesiden. Person no. 103

> "Kan lide at snorkle, lide at fange min egen mad, bruger det som afstresning." Person no. 24

> "Interresse for fridykning og fiskeri" Person no. 18

The third main approach is to be self-suppling.

> Oplevelsen af at være i vandet, se livet under overfladen,
> kombineret med at man får noget med hjem, og at hobbyen derfor
> giver "afkast" selvom det selvfølgelig ikke økonomisk kan "betale sig". Person no. 15

> "Kan lide at snorkle, lide at fange min egen mad, bruger det som afstresning." Person no. 24

Many of the participant also mentions the nature experience as one of the reasons they spearfishing. The meditaion and mental relaxation is also a common reason.

Evaluation:
The questionnaire gives a good insight into the different approaches to spearfishing. The answers show in general three approaches to the sport of spearfishing.

Based on the answers and an evaluation of the different approaches the team makes a hypothesis regarding the way the persons inside the three approaches spearfish. Based on the answers inside the question of interest (Column G in Appendix no. 00) and a superficial evaluation of the desired vs. actual caught fish (Column H and I in Appendix no. 00) three person types and approaches are described.

The spearfisher with a free diver approach will not be aggressive in his hunting. His main focus while spearfishing is the nature experience, relaxation and thrill of controlling their own body. The aspect of catching fish is just another benefit of their hobby of free diving. The meditative free diver spearfisher will in most cases not shoot and catch every fish that swims by him, but be more selective than the self-supplying or sport-oriented spearfisher.

ARDEA		
Questionnaire - Section 1: Approaches		
Date: 10-02-2016	Team no. 4	Worksheet no. 04

“Fantastisk hobby som både giver motion, afstressning,
mental træning og mad på bordet” Person no. 53

The sport oriented spearfisher with the hunting approach coming from either regular fishing or hunting will be more aggressive in his hunting. His main focus is to catch the biggest and most difficult fish and as many as possible. The thrill of the hunt and catching the right fish is what drives him to the ocean.

“Det er super spændende, det er fedt at man ikke ved hvad der gemmer sig under overfladen.
og man får et lille kick af adrenalin når man spotter en fisk.
Elsker også at bruge fiskestang men uv-jagt er bare lidt mere” Person no. 57

The spearfisher with the self-suppling type. He is a combination of the of the other two spearfisher types. He both find joy in the nature experience and the hunting. His desire is to catch fresh fish to him self and his family. He will rather go on several hunts and bring home the amount of fish he is capable of eating that day instead of catching a lot of fish at once.

“[...] det fedt at “provide” til familien. Urmanden bliver tilfredsstillet.” Person no. 59

Reflection:
The answers from the questionnaire gives the team an understanding of the people who spearfish, what their approaches are and why they spearfish. This gives an indication of the different person types to consider in the following product design. The team has to determine whether or not the new product design should be directed to one or several types of spearfishers.

ARDEA		
Investigation of spearfishing equipment		
Date: 02-02-2016	Team no. 4	Worksheet no. 05

Objective:
The objective is to get some knowledge about all the equipment used for spearfishing. This will give an understanding of each piece of equipment a typical spearfisher uses. The scope of the investigation is to potentially find problems and opportunities in these existing products and thereby choose a product, which the team will focus on during the project.

WETSUIT

Ill. 1

The purpose of the wetsuit is to isolate and keep the user warm while diving.

Current problems:
- Wetsuit is not created for the proportions and conditions of the Scandinavian people and weather
- Wetsuits creates buoyancy, which makes it harder to dive
- Wetsuits has to be as tight as possible, which makes it hard to put on
- Problem if you have to pee while you are wearing wetsuit

MASK

Ill. 2

The purpose of the mask is to make the diver able to see under water and to keep water from getting into the nose.

Current problems:
- The mask can get fogged
- The mask does not always fit tight if the user has a beard or long hair

FINS

Ill. 3

The purpose of the fins is to increase the propulsion while svimming.

Current problems:
- The ‘shoe’ of the fins does not fit all
- The ‘shoe’ is not as stiff and closed as needed

SNORKEL

Ill. 4

The purpose of the snorkel is to make it possible for the diver to breath while the head is face-down in water

Current problems:
- The snorkel gets full of water while diving
- The mouthpiece of the snorkel makes it harder to hold your breath while diving

ARDEA		
Investigation of spearfishing equipment		
Date: 02-02-2016	Team no. 4	Worksheet no. 05

WEIGHT BELT

Ill. 5

The purpose of the weight belt is to add weight to the diver, which makes it easier to dive.

Current problems:
- The weight is badly divided on the body
- The belt is heavy and unhandy to carry around
- The belt takes up much weight when travelling

KNIFE

Ill. 6

The knife is an all-round tool for e.g. cutting lines in case of emergency or killing fish.

Current problems:
- It is often hard to take out the knife of the sheath
- The knife is often placed in an not ideal place on the body, which makes it hard to grab

FLASHLIGHT

Ill. 7

The purpose of the flashlight is to light up caves or the water in general while diving at night.

Current problems:
- The battery is quickly used up, due to the need of high lumen value
- Cold temperatures reduce the power of the batteries

FLOAT

Ill. 8

The purpose of the float is visually show where the diver is. Some floats are also used for storing items.

Current problems:
- The line connecting the diver to the float, makes it harder for the diver to swim and dive
- The diver gets tangled in the line
- The float is not easy to drop if needed

SPEARGUN

Ill. 9

The purpose of the speargun is to catch fish.

Current problems:
- Spearguns are hard to load
- It is hard to aim precise
- Speargun have short shooting range
- Spearguns loose power in cold temperature water
- Different types of spearguns are needed depending on which fish to catch
- Difficult to transport
- Hard to clean

ARDEA		
Investigation of spearfishing equipment		
Date: 02-02-2016	Team no. 4	Worksheet no. 05

NET

Ill. 10

The purpose of the net is to store the catched fish while diving.

Current problems:
- Hard to swim and dive with the net attached to the body or the float
- The net can get tangled if it is carried in the weight belt

CATCH HOOK

Ill. 11

The purpose of the hook is to store the fish while diving.

Current problems:
- The line can get tangled in other equipment
- Hard to swim or dive with fishes attached to the hook

Evaluation:
The problem areas are based on questions put out on spearfishing forums, interviews of spearfishing experts and gained knowledge through personal experiences with the sport. All these problems stated are initial problem findings by reading, interviewing and little to none hands-on tests, which are fine in the beginning stage of the project, so the team can narrow down the area of interest.

Reflection:
This investigation gives an indication of which problem areas can be encountered and used for further work, and finally choose which object to focus on the rest of the project. The current problem findings has to be investigated more to find the extend of the problems and really understand them.

Sources:
Ill. 1: http://www.dickssportinggoods.com/graphics/product_images/pDSP1-18073225v750.jpg
Ill. 2: http://ecx.images-amazon.com/images/I/71UDvzrg6iL._SL1500_.jpg
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Ill. 7: http://www.canwelum.com/upfiles/20138210341.jpg
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https://www.facebook.com/groups/272950296139488/?fref=ts
https://www.facebook.com/groups/1424574527779589/?fref=ts
Worksheet: Expert Interview - Lamberto Azzi
Worksheet: Expert Interview - Hans-Henrik Carlsen

ARDEA		
Interview with Lamberto Azzi, Owner, Divecenter & Ragnarok Sub		
Date: 24-01-2016	Team no. 4	Worksheet no. 06

Objective:
The team needed to get some knowledge from a salesman who knows the business through many years of selling and making equipment for spearfishing. Using him to get more general knowledge about spearfishing and also answer specific questions the team has after very little information gathered so far is important for this interview. Furthermore the team wants to establish a cooperation with Ragnarok Sub during the project, because they just started making equipment for Danish conditions.

Experiment/Data:
The interview can be found on the USB as “Appendix no. 2” and the most important from the interview is written in the evaluation.

Evaluation:
The shape of the tube on the speargun is important regarding water resistance, but the complex shapes which are often best are also much more expensive to produce.
The spring speargun is not really used anymore, because it does not give enough power and speed to the spear, and then it will rust in the water.
Bamboo is a very good material for spearguns, because it has a high strength and is heavy to help decrease recoil in the water.
Hybrid of carbon and bamboo could work well for a speargun, but it is difficult to find a supplier of the bamboo.
May - November is the spearfishing season in Denmark.
The rubberband can lose energy in cold waters, and is typically a problem when the water is under 5 degrees.
Spearfishers established themselves as regular spearfishers normally buy a new speargun every two years.
It is allowed to spearfish in the night in Denmark, which is illegal in other countries, because it is too easy to catch fish in the night.
There are not really spearfishing equipment made to fit the rough Danish ocean conditions, because a lot of the brands are from countries with better spearfishing conditions (higher visibility length, less water current and higher temperatures). Spearfishing is though still becoming more popular in Denmark, which he can see on the amount of sold spearfishing equipment the last couple of years.

Reflection:
Ragnarok Sub had only knowledge and experience to share and no economical resources to support the team with during the project, and therefore the team sees no idea in working together with Ragnarok Sub and will for now work independently, which gives more freedom in the concept development, but also less knowledge to support the decisions the team might take, and the team will also not have the opportunity to get help in making prototypes.

Sources:
http://divecenter.dk

Ill. XX: Lamberto Azzi, Owner, Divecenter & Ragnarok Sub

DIVECENTER.DK
The Spearfishing Specialists

Ill. XX: Divencenter’s logo

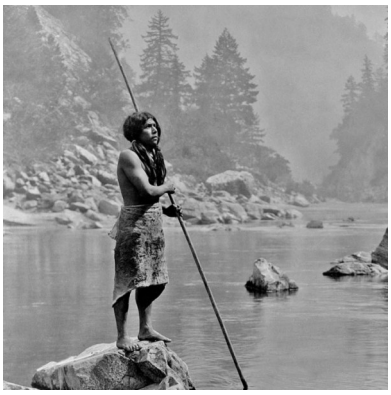
ARDEA		
History of spearfishing		
Date: 17-02-2016	Team no. 4	Worksheet no. 07

Objective:
The objective is to understand how spearfishing and the speargun have developed throughout the years. This will help in understanding why the speargun looks like it does and why spearfishing is practised the way it is today.

Experiment/Data:
TIMELINE

14.000 b.c	Wooden polespears from ashore
1430 b.c	Wooden polespears
750 b.c.	Copper harpoons
200 b.c.	Harpoons with barbed and detachable heads
100 a.c	Spears and tridents
1700th cent.	Tridents
1917	Hawaiian slings
	The first rubberband speargun
1920's	Spearfishing with swimming goggles
	Invention of diving mask, fins and snorkel
1930's	Invention of rebreathers for scuba diving
1950's	The first roller speargun
1960's	The first pneumatic speargun

Spearfishing is probably the most ancient method for hunting and catching fish, because references to it can be found in old testaments and in the Bible. Ancient caves have also been found with drawings of the human with a handspear catching fish, so the method is very old, which the timeline also tells. For many years spearfishing has only been used to be self-supplied, which many still use it for, but in the later years it has also become a sport, where spearfishers compete in catching the biggest fish in each fish species or other categories. Spearfishing as we know it today was developed in the 1920's, just with more simple equipment. The equipment though became more advanced the following years, but has not changed much since regarding the technologies and mechanisms used.





Pictures of spearfishers in action or geared up from different periods in time.

ARDEA			
History of spearfishing			
Date: 17-02-2016	Team no. 4	Worksheet no. 07	

Evaluation:
The loading methods and product architecture has changed little through the last 50 years, and rubberband and air spearguns are still the preferred speargun types today.

Reflection:
Either the spearguns have not been looked at much or then they have already found the most effecient mechanism for the speargun, because not much has happened since the 1920's. Maybe the rubberband is the most simple and at the same time efficient way of making a speargun work, but that is something the team needs to look more into by opening up (diverging) the potential mechanisms for a speargun or maybe step all the way back and look at ways of killing fish.

Sources:
http://www.newworldencyclopedia.org/entry/Spearfishing
https://thetridenthunter.wordpress.com/2013/02/21/history-of-spearfishing/
http://www.outsideonline.com/1857351/visual-history-spearfishing-and-freediving#slide-9

ARDEA		
Investigation of spearguns		
Date: 02-02-2016	Team no. 4	Worksheet no. 08

Objective:
This investigation is aiming to create an overview of pros and cons of each different type of speargun. At the same time the investigation will help give an understanding of what each kind of speargun is used for and what to have in mind when you go spearfishing in Denmark.

Experimental/Data:
Spearguns are a broad term, which include all the different kinds of hunting weapon spearfishers uses. There are different technologies and purpose of each speargun. There are mainly four recognised kind of spearguns around the world; rubberband speargun, air speargun or pneumatic spearguns, hand spears and CO_2 spearguns. Each of these subgroups of spearguns have strengths and weaknesses.

In the following each speargun type will be described on technologies, purpose, forces and weaknesses.

Rubberband speargun:
Rubberband spearguns are the most sold and used type of speargun in Denmark.
Rubberband powered speargun is using the same principles as a sling shot. Where you use one or more rubberbands to give the spear it's power. The spear is like on a crossbow, where the spear is placed in a grove and accelerated by the rubberband retracting.
There are a broad variety of different systems in the category of rubberband powered spearguns depending on conditions and type of fish which is hunted. The rubberband spearguns in Denmark are often used for fishing sea trouts, mullets and other free swimming fish.

+ High precision
+ Variable power
+ Low maintenance
+ Maintain power in deep water
- Rubberbands fast wearing out
- Lose power in cold water
- Lack of power compared to size
- Can be hard to maneuver in water

Air speargun/pneumatic speargun:
The second most sold speargun in Denmark is air powered spearguns. These spearguns are powered by a concealed chamber of air which can be compressed, giving the speargun its power. The air powered speargun contains a barrel, chamber, piston, a spear and a release mechanism. When loading the speargun the spear is forcing a piston down compressing the air building up a high pressure which is the power of the gun. Air powered spearguns is pumped with air when bought and contains the pressure until the user wants to change the pressure (closed system). The air powered spearguns are often used for shooting cods and other stagnant fish species, because it has more power and harder to aim with.

+ Small and compact
+ Good for reefs, near sharp edges
+ Maintain same power over time
+ High power vs size
+ Easy to maneuver with
- Lose power in deeper water
- Hard to load
- Need to be serviced and oiled
- Aim can be bad

Pole spear/hand spear:
This is one of the oldest types of spearguns, but has developed into a combination of a spear and a slingshot. The pole spear contains of a spear and a rubberband. The spear is often 1,5 - 3 meters which is much larger than the other types

of spearguns. In the one end of the spear you have the tip for spearing the fish and in the other end you have a rubber band. The rubberband works as a sling and you have it around your wrist. When loading the spear the spear is pulled as far back as wished for building up power in the rubberband. The trigger mechanism is the user's hand and when the spear is wished to fire the user let go of the spear and the rubberband will contract firing the spear. The spear is not that often used in Denmark but is good for still standing fish and flatfish.

+ Fast reload
+ Simple system
+ Good in close range
+ Variable in power
- Short range
- Large
- Low power

CO_2 speargun:

CO_2 spearguns is a high pressure powered speargun. The system works by having a chamber with compressed CO_2 like in the air powered speargun, the difference is that a CO_2 powered speargun uses an open system and is build to contain much higher pressure, which means much higher power. The system has to be filled up after each shot or after the container is empty. The system gives the opportunity to load the speargun easy, because it does not have a chamber that is filled with pressure all the time. This is not legal in Denmark, therefore it is not used for some specific fish species.

+ High power
+ Easy to load
+ Good aim
- Illegal in most countries
- Considered as a weapon
- Loud
- Most is homemade

Spring speargun:

This type of speargun is normally not used by any adult spearfisher. In the spearfishing community it is seen as a toy not suited for fishing. It works by a spring which is expanded and when fired the spring contracts powering the spear. The amount of power you can build up with the spring is limited and therefore this technology is not normally used.

+ Easy to load
- Low power
- Bad aim

Evaluation:

The information collected about the different speargun technologies on the market gave insight and understanding of what parameters is important in spearfishing. The result also shows that the different technologies are suited for different goals and conditions.

Reflection:

The investigation gives a good overview of the different types of spearguns within the market and what kind of conditions and fish they are best suited for. The information can be used for further mapping of the conditions and what parameters are important to have in a new product. Furthermore the team can delimit it from CO_2 powered spearguns, because they are illegal in Denmark. The spring does not seem as a smart solution, but it will not be excluded yet.

Sources:

http://www.spearfishingworld.com/how-to-choose-the-right-speargun.html
http://prime.primescubainc.netdna-cdn.com/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/y/h/yhst-14842708781123_2244_35295401.jpg
http://www.spearfishingworld.com/product_images/w/416/Shaka7__92481_zoom.png
http://ebay.primescuba.com/ebayimages/93343f08-0463-4358-95e6-1cff5764e355.jpg
http://www.maco2spearguns.com/news/Fusil%20complet.jpg

ARDEA		
Questionnaire - Section 2: Spearguns and purposes		
Date: 10-02-2016	Team no. 4	Worksheet no. 09

Objective:
The objective is to create an understanding of the spearguns spearfisher have, how many they have and if there is a difference in the main function/purpose of the spearguns in general.
Besides, the objective is to understand if there is a difference in the spearguns the spearfishers have depending on their level of experience.
The team will try to determine the which spearguns are most common which should give an indication of the length of the new product.

Experiment/Data:
By evaluating and analyzing the answers from the questionnaire [Appendix no. 00] it is possible to determine the most common lengths of spearguns used by Danish spearfishers.

To determine the general numbers of spearguns per spearfisher, the numbers from the questionnaire [Column N in questionnaire] is set up in a table, where the number of spearguns is divided into the experience levels.
The answer from the questionnaire show how many spearguns Danish spearfishers have. The answers show that the majority of the participants have 2 or more spearguns. There is a tendency that the more experienced the spearfisher is, the more spearguns he has.

Number of spearguns	Beginners (Group 1)	Semi-beginners (Group 2)	Experienced (Group 3)	Advanced (Group 4)	Percentage distribution of numbers
1	10	20	9		40
2	1	22	10	3	38
3	1	2	5		8
4		5	2	1	8
5			3	1	4
6					
7			1		1

To determine the most common lengths of spearguns used in Denmark, the answers from the questionnaire is used [Column N in questionnaire].
The answers from the questionnaire show the which lengths Danish spearfishers have depending on the experience level of the spearfisher. The percentage distribution of lengths shows that the most common lengths among Danish spearfishers are 75 cm and 90-95 cm.

Lengths of spearguns	Beginners (Group 1)	Semi-beginners (Group 2)	Experienced (Group 3)	Advanced (Group 4)	Percentage distribution of lengths
<50-70 cm	2	19	18	1	20
75	8	36	12	5	31
80-85	0	8	10	0	9
90-95	2	19	22	2	32
>100	1	6	7	3	9

From the analysis it is possible to determine the most common speargun lengths and who has which lengths. The beginners and advanced users have in general the same lengths of spearguns. The only different is that the advanced group in percentage have more long (>100) spearguns. This could be a result of the advanced spearfishers tended to travel more for spearfishing. This means they have special lengths of spearguns for places like Norway.

To determine if the different lengths of spearguns have different purposes the team asked through the questionnaire what the spearfishers used their different spearguns for [Column N in questionnaire].
The answers from the questionnaire mentioned both the surroundings and fish species as factors regarding the purpose of the lengths. The general answers are listed to the right.

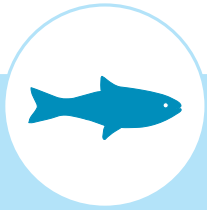
ARDEA		
Questionnaire - Section 2: Spearguns and purposes		
Date: 10-02-2016	Team no. 4	Worksheet no. 09

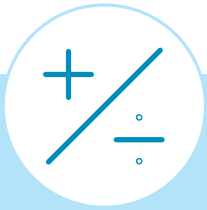
Length of speargun	Purpose based on questionnaire
<50	“Fladfisk og huletorsk” Person no. 14 “Huler, vrag og sten moler” Person no. 36
50-70	“Nat og dårlig sigt” Person no. 13 “Mole- og hulejagt” Person no. 32 “Torsk/flade. (moledyk)” Person no. 40
75	“Moler, nat og dårlig sigt” Person no. 13 “Ørred og fritgående torsk” Person no. 14 “Større fisk og åben vand” Person no. 36
80-90	“Sej/ørreder/multer” Person no. 40 “Større fisk, primært havørred” Person no. 64
95-110	“Åbent vand/ god sigt” Person no. 13 “Dybde dyk / vragt / langskud” Person no. 40
>110	“Til Norge” Person no. 66 “Standardharpun til Azorerne og Norge” Person no. 80

The answers give a clear indication of different purposes for each length.
The longest speargun (>110 cm) are not used in Denmark according to the questionnaire.
The long spearguns (80-110 cm) are primary for bigger fish and good conditions.
The medium length spearguns are used for nearly everything except deep waters and very good visibility. They are used for all kinds of fish.
The shortest spearguns are used for flatfish, still-standing fish and in tight places and poor visibility.

Further research on-line has been done to confirm the answers from the questionnaire. Here is also found information regarding different lengths and which conditions they are suited for regarding current and visibility [1] [2].
The discoveries from both the questionnaire and the online reserach are set up in a matrix, which shows the lengths and what they are suited.

ARDEA		
Questionnaire - Section 2: Spearguns and purposes		
Date: 10-02-2016	Team no. 4	Worksheet no. 09





<60 cm	• Flatfish • Cods	+ Easy to maneuver in high current and tight places. + Can be used by shorter users + Easy to load - Short range - Low power - Low precision	SURROUNDINGS: Sand bottom, break waters, caves, holes CONDITIONS: High current, shallow water, low visibility
65-80 cm	• Flatfish • Cods • Sea trouts • Coal fish • Mullets	+ Easy to load and maneuver in regular Danish conditions + Can be used by shorter individuals - Short-semi range - Low/medium power - Not suited for good visibility - Low-semi precision	SURROUNDINGS: Sand bottom, break waters, caves, holes, stone reefs CONDITIONS: High-medium current, low/medium visibility
85-110 cm	• Flatfish • Cods • Sea trouts • Coal fish • Mullets	+ Semi-long range + Medium-high power + Suited for good visibility - Hard to maneuver - Not suited for low visibility and high current - Not suited for wrecks and cramped spaces	SURROUNDINGS: Breakwaters, stone reefs, open water, deep dives CONDITIONS: Medium-low current, medium-high visibility
>110 cm	• Flatfish • Cods • Sea trouts • Coal fish • Mullets	+ Long range + High power + High precision - Hard to maneuver - Not suited for low visibility and high current. - Not suited for wrecks and cramped spaces.	SURROUNDINGS: Open water, deep water CONDITIONS: Low-no current, high visibility

ARDEA		
Questionnaire - Section 2: Spearguns and purposes		
Date: 10-02-2016	Team no. 4	Worksheet no. 09

Evaluation:
The analysis of the questionnaire shows that most spearfishers, despite their experience level, have more than one speargun. The most common lengths used in Denmark are 75 cm and 90-95 cm. This could give an indication of these lengths being the best suited for the Danish conditions.

The lengths is confirmed to have different purposes. The longest spearguns ar not used in Denmark. The medium sized spearguns are used for everything.

Reflection:
From the analysis the team gets an understanding of the number of spearguns per spearfisher and which lengths are the most common. Furthermore the team discovered that the conditions of the ocean and the fish species caught have an impact on the length of speargun. The team can use these discoveries when determining the length of the new product design.

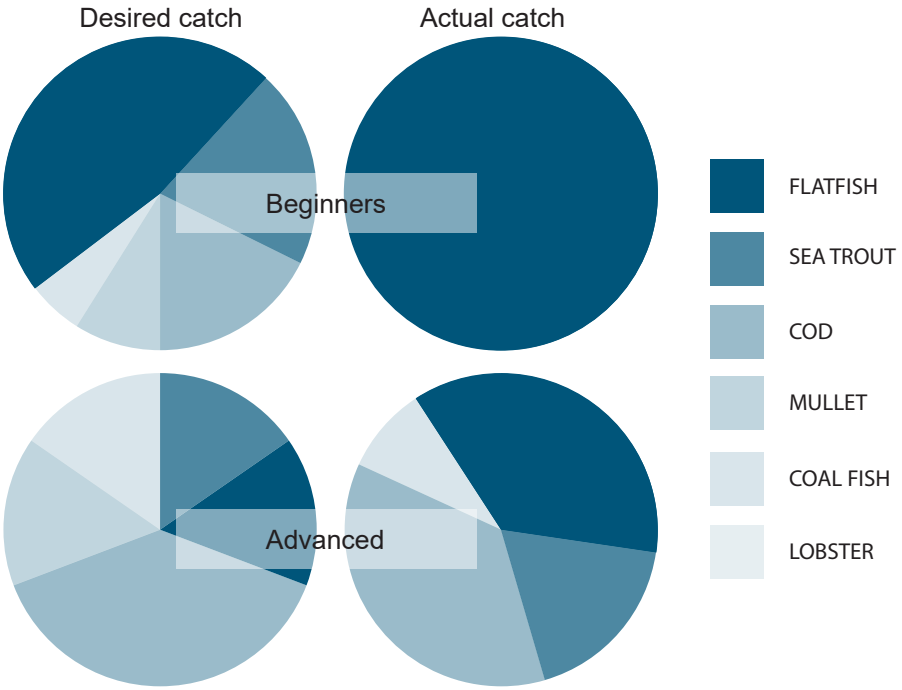
Sources:
[1] http://undervandsitetet.dk/undervandsjagt/harpun/ (10/02-2016)
[2] http://uvjaegeren.dk/forum/3-gear-snak-her-snakker-vi-om-alt-vores-udstyr/3690-harpun-laengde (10/02-2016)

ARDEA		
Learning curves in spearfishing		
Date: 04-03-2016	Team no. 4	Worksheet no. 10

Objective:
The objective of the investigation is to determine the learning curves in spearfishing. Is it difficult to perform? What is the most challenging parameter in spearfishing? How is this expressed in the experience levels?

Experiment/Data:
By evaluating the answers from the questionnaire [Appendix no. 00] it is possible to get an understanding of the difference in the user experience levels. The participants in the questionnaire was asked which fish species they want to catch when they go spearfishing and also which species they actually catch.

When these answers are compared it is clear that the beginners do not have the experience and skills developed for catching much more than flatfish.



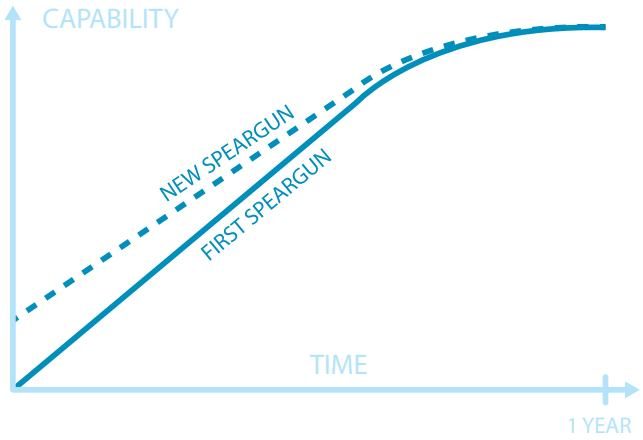
The beginners want to catch every fish they meet, but do not catch anything but flatfish. The advanced spearfishers are more selective in what they want to catch and mainly they catch what they intent to catch. The experience has a great impact on the success rate of the spearfisher.

During the interview with Lamberto Azzi (Worksheet no. 06) it was stated that it will take around one year to learn to handle your speargun no matter how experienced the spearfisher is. From the interview and the success rate it is possible to determine the some initial learning curves of spearfishing. In general two parameters are important when spearfishing and each parameter has its own learning. First of all the spearfisher needs to get experience inside the field of free diving. Free diving is crucial when spearfishing, and the spearfisher needs to be able to hold his breath for the time it takes him to aim at and shoot a fish when it has been located.

ARDEA		
Learning curves in spearfishing		
Date: 04-03-2016	Team no. 4	Worksheet no. 10

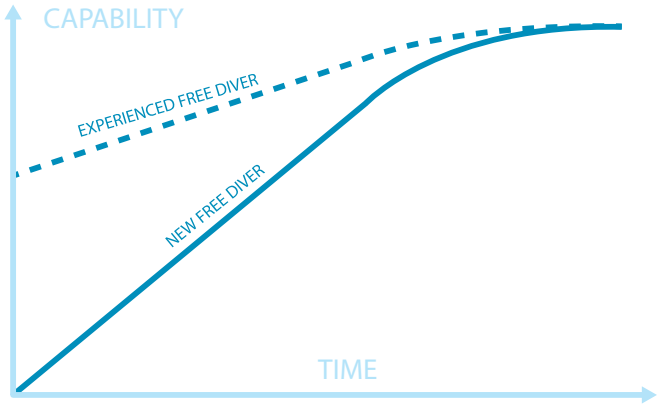
The illustration to the right (Ill. 01) shows the learning curve of free diving. The more experienced in free diving the spearfisher is when he enters the sport the higher up on the learning curve he will start. In time the curve will even out when the techniques have been learned.

The other crucial parameter in spearfishing is the speargun. Getting to know your speargun is stated to take around one year despite your experience level. When purchasing a new speargun the spearfisher will be set way back on the learning curve. The experience in spearfishing in general though will set to more experienced spearfisher higher on the learning curve than the beginner when purchasing a new speargun. The illustration to the right (Ill. 02) shows the learning curve of the handling of the speargun.



Ill. 01: Learning curve for freediving

Experiment/Data:
The more experienced the spearfisher the higher success rate he in catching the desired fish.
The learning curves of spearfishing shows that the more experienced you are in free diving when entering spearfishing, the faster you will become a skilled spearfisher, due to free diving being a huge part of spearfishing.



Ill. 02: Learning curve for speargun

Reflection:
The fact that it takes around one year to learn to handle a new speargun and the beginners having such a smal success rate gives the team something to consider in the following deign of a new speargun.

ARDEA		
Existing spearguns		
Date: 22-02-2016	Team no. 4	Worksheet no. 11

Objective:
The objective of the investigation of the existing spearguns on the Danish market is to get an understanding of the products; their features related to price, which pros and cons the different products have and to define where the new product should be placed and which solutions in the existing products to be aware of.

Experiment/Data:
The models investigated:

Roisub Demo2 100

5300 DDK

Cressi Gironimo Elite 85

2350 DDK

Esclapez Exium G2 75

1800 DDK

Cressi Saetta 50

1000 DDK

Pathos Laser Open Pro 75

1230 DDK

Seac Sub Asso 90

1100 DDK

Salvimar Voodoo 75

1100 DDK

OMER Excalibur 2000 90

1100 DDK

OMER Cayman 2000 75

695 DDK

Seac Stinger 65

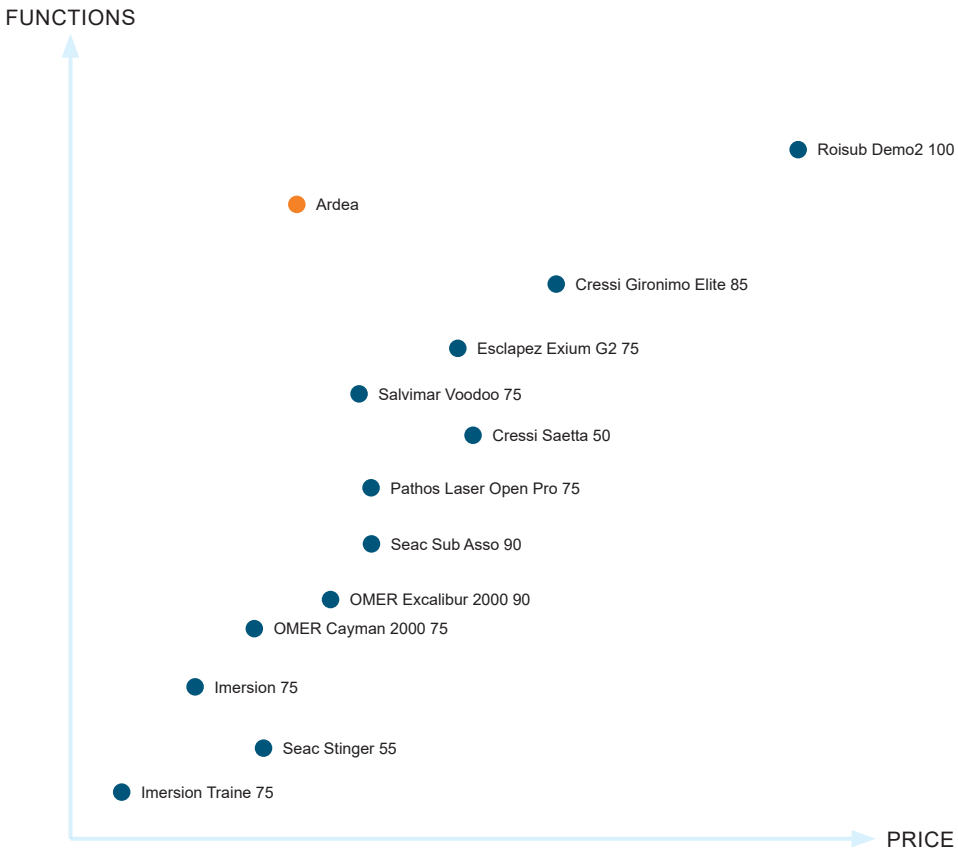
430 DDK

Imersion 75

370 DDK

Imersion Traine 75

270 DDK



Ill. C.01: The coordinate system shows where the existing products are placed when price is related to functions

ARDEA		
Existing spearguns		
Date: 22-02-2016	Team no. 4	Worksheet no. 11

Evaluation:
The current market of spearguns is currently divided into mostly two types of spearguns; airpowered and rubberband powered spearguns. A large variety of different models and brands are represented with these two types of spearguns. Below is a mapping of some of the different models of spearguns represented on the Danish market. The different models chosen for the mapping is both in terms of functions and price range.
The mapping is used for creating an overview of the price range of the spearguns and how functions and price is related.
The most expensive gun is made in high quality materials and with some of the most advanced technology. The cheapest products on the market are of low quality and have only the most basic functions - this affects both range and accuracy.

Reflection:
The investigation of the current spearguns give the team an indication of how the spearguns differentiate in price, functions and material. Thereby the team is able to estimate in what price range they expect a new speargun to be within in relation to the functions the team expect the new speargun will have.
The team has estimated that the new speargun should be placed in a price range around 700-1800 DDK. The team has to align this price with the spearguns the spearfishers actually use today in order to be compatible.

Sources:
Cressi Saetta 50
https://www.scubastore.com/scuba-diving/cressi-saetta/65042/p
OMER Excalibur 2000 90
http://www.spearfishersparadise.com.au/dispdet.php?idw=1007312338024532
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https://www.scubastore.com/scuba-dykning/imersion-challenger/617821/p?q=Imersion
Imersion Traine 75
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Salvimar Voodoo 75
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Cressi Gironimo Elite 85
*http://www.divingdirect.co.uk/spearfishing-c127/spearguns-c136/cressi-geronimo-elite-85-p943*Seac Sub Asso 90
Seac Stinger 65
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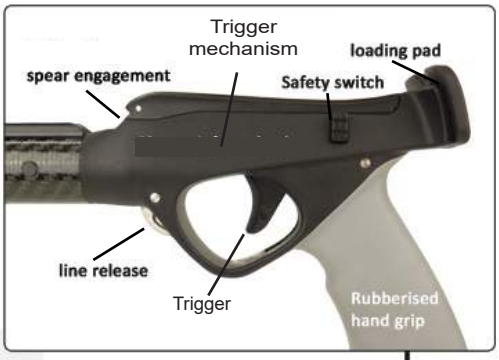
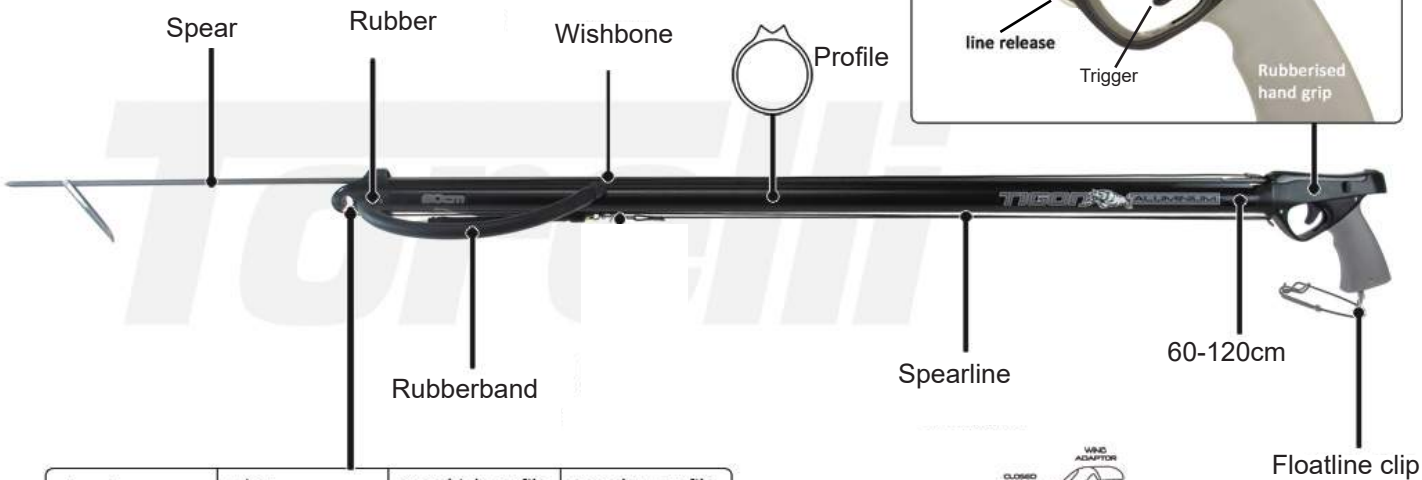
Pathos Laser Open Pro 75
https://www.scubastore.com/scuba-dykning/pathos-laser-open-pro/628572/p?q=Pathos%20Laser%20Open%20Pro%2075 03-04-2016

ARDEA		
Existing spearguns - description		
Date: 22-02-2016	Team no. 4	Worksheet no. 11

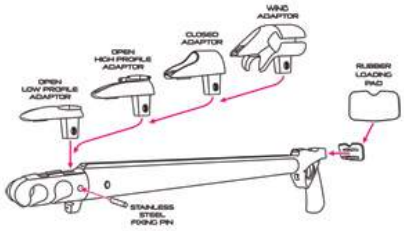
Objective:
The objective is to describe and understand the technical aspects and components of the current spearguns on the market. In general there will be described two different types of spearguns; rubber band powered speargun and air-powered spearguns. There are different length and systems of these two types of spearguns, but in general they are build upon the same principles which will be described.

Rubberband powered speargun is constructed on the same principles as a slingshot where the rubber band powers the gun and allowing the spear to shoot. The speargun can be divided into four parts; handle and trigger, barrel/body, tip and rubber, and spear. Each of the parts can be constructed in different materials and have different sizes and details, depending of purpose and price.



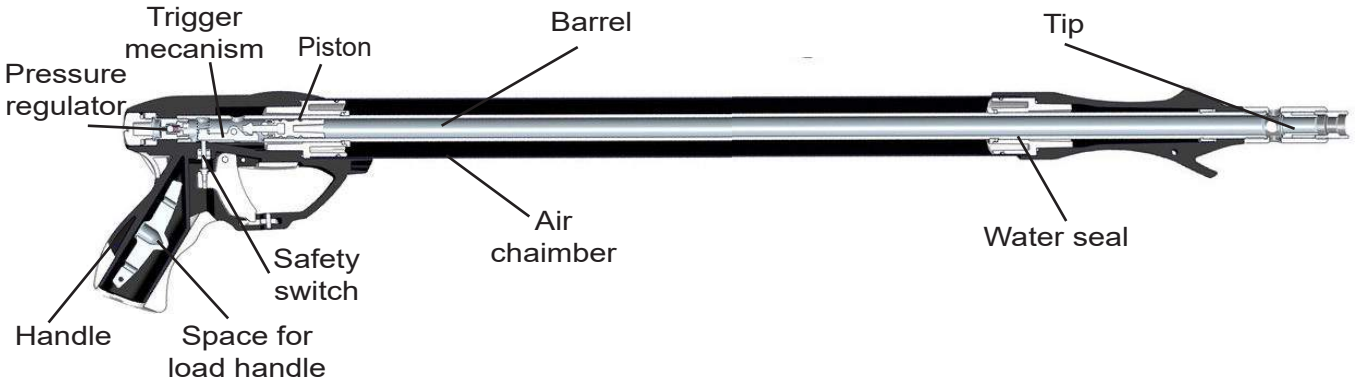


Different tip systems



The rubber band powered speargun is the most used in Denmark, due to the low complexity, low maintenance and trend. The rubber band powered spearguns can variate its power depending on length and its number of rubberbands. The more rubber bands and length the more power. In Denmark one or two rubberbands is normally used and the lengths is normally writing from 60-120. The shooting range of these spearguns variates from 1-7 meters. The materials used for rubber band powered spearguns are depending on price, but are made in both aluminum, wood or carbon. The handle in all rubber band powered spearguns is made on the same principles, as shown above.

ARDEA		
Existing spearguns - description		
Date: 22-02-2016	Team no. 4	Worksheet no. 11



Air powered spearguns are powered by air being compressed by a piston pressed back by a spear, which is the spear used for shooting the fish. The air chamber is pumped with air injected from the pressure regulator, creating a high pressure in the speargun before the speargun is loaded. Air can be compressed and with the loading tool it becomes easier to load the speargun. In general an air powered speargun has no separate part, it is all connected and is a part of a closed system. A closed system is that no air is injected during a dive and it is the same air which is compressed again and again every time the speargun is loaded. A seal in the top of the speargun seals the air from leak. This kind of speargun is the least used of these two kind of spearguns used in Denmark. The reason for this is the seal has a tendency to brake and if it does during a dive the speargun can not be repaired during the dive. Another reason is that the speargun is that it regularly have to be oiled and maintained. The length of air powered spearguns in Denmark is between 30-100 cm, depending on which hunting purpose. The materials of the speargun is mostly aluminum and nylon. The different parts is described above.

Evaluation:
The most used spearguns in spearfishing are rubber band powered and air compression spearguns. This is mainly due to their relatively low complexity and high efficiency.
The result of the investigation of how the two most used spearguns are powered gives understanding of the forces and principles are used in todays spearfishing. Furthermore this investigation gives an understanding of which components the current spearguns on the market are build upon.

Reflection:
The two most used spearguns are of low complexity, but the rubber band powered is clearly the one found at most retailers in spearfishing. This might be due to it seems to be easier to repair by the customer himself. All components seems to be easy accessible. The team needs to get more insight about the different types of spearguns and why sme are more popular than others by interviewing experts and salesmen of spearfishing equipment.

Sources:
http://torelliusa.com/media/wysiwyg/torelli_guns_fbmg.jpg
https://www.scubastore.com/f/7/72419_2/imersion-eskwad-air.jpg

ARDEA		
Existing spearguns - use		
Date: 22-02-2016	Team no. 4	Worksheet no. 11

Objective:
The objective is to understand how the interaction with the current spearguns is. Which technique is used to load it and how much force is needed to load it. Researching on this will help the team understand how much force it requires to load a speargun, which muscles you use and which areas on the body is affected.

Experiment/Data:
In the experiment the teams illustrates the loading techniques of the spearguns - these techniques are required through researching on the internet and watching all kinds of different movies about spearfishing.


Reach out and grab around the rubber band with both hands and start to pull towards yourself.


Attach the end of the rubberband also called wishbone to the notch on the spear and the speargun is ready to fire.


The way you grab around the rubberband with both hands while pulling towards yourself.


You place the speargun in your chest for support while pulling in the rubberband.


You grab around the rubber band with both hands to load the speargun.


You start pulling the rubber band towards yourself and attach the wishbone to the notch on the spear.


Place the speargun around your hips/thigh area if you are not able to reach the rubber band when placed in your chest.


Grab around the air speargun with one hand and place the other hand at the end of the spear.


Start pushing the spear into the air speargun to load it.


You place a load tip handle on the end of the spear to push the spear into the speargun.

Evaluation:
The longer the speargun is the harder it is to load, because the force required becomes higher and it becomes more difficult to reach either the rubber band on the rubber band powered speargun or the end of the spear on the air speargun as seen on the illustrations. The techniques to load the speargun also changes as the spearfisher is not able to reach either the rubberband or the end of the spear anymore, but it is always the arm muscles the spearfisher uses to load the speargun with. The force required for pulling the rubber band towards yourself can be found in Worksheet 33 about test of forces.

Reflection:
The shorter arms you have the more difficult it becomes to handle especially the long spearguns, and if you at the same time are not the strongest person it even becomes more difficult to load your speargun. The length of your speargun should not depend on your strength and armlength, because every spearfisher should be able to handle the same spearguns and have the same opportunities in the water when hunting fish.

ARDEA		
Problem finding in pool		
Date: 03-02-2016	Team no. 4	Worksheet no. 12

Objective:
To understand and test how to shoot and use current spearguns a field trip is made to a swimming pool in Hjørring. This field trip focuses on hands-on tests, understanding and problem findings of current spearguns on the market, while being in controlled conditions and still as close to the real context, the ocean. The test is done with full spearfishing equipment to simulate the situation you are in when spearfishing. The goal for the test is also to try out the sport, because some of the team members have never tried to actually fire a speargun.

Experiment/Data:
Five different spearguns is tested and they vary very much in type (rubberband-powered, air-powered and hand-spear), price, shooting range and lifespan (one is 5 months and another 30 years).

DIFFICULT TO MANEUVER

The spearguns are difficult to maneuver from side to side because of the resistance in water. The longer the speargun is the more difficult it is to maneuver, which makes sense when you suddenly have a bigger surface. All five spearguns have a circular barrel and other shapes might be more hydrodynamic.

TANGLED LINE

The line which connect the spear to the speargun, so the fish cannot escape when shot, easily gets tangled into everything especially with the speargun with closed muzzle, because the line can end up run in and out of the muzzle several times. This is a big source for irritation in the water, because it can take some time to fix the problem and while you do that a desired fish can swim right past you and then you are not ready.

HARD TO LOAD

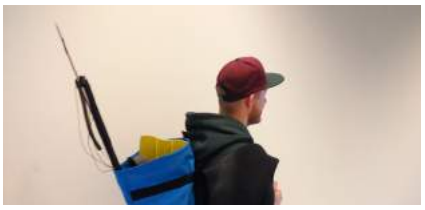
The rubberband for loading the speargun is very hard to pull all the way back to the actual point for loading (the shark fin on the backend of the spear). The longer the speargun is the harder it becomes to load it. In some spears they have integrated two shark fins, so it is possible to load it for the ones who cannot pull it back to the second one, but then you do not have the power the speargun is actually made to generate.

ARDEA		
Problem finding in pool		
Date: 03-02-2016	Team no. 4	Worksheet no. 12

SAFETY MECHANISM

The safety mechanism is difficult to handle both above and in water, and both with and without gloves. It is not optimal, when you finally find the fish you want and then you struggle with the safety. The safety also seems difficult to code whether it is on or off, because some thinks the on/off tells when the safety is on and off, while others think it tells when the speargun is on or off.

TRANSPORTATION



The transportation of the speargun is triggy, because how should you do. No cover follows with the speargun when you buy it and then some will choose to put it in their dry bag with all the other equipment for spearfishing, but as on the picture it is way too long to be in this bag. Then you can walk around with it in your hand, but then some people might be scared. It is generally just a difficult task to transport it in a discrete and comfortable way.

Evaluation:
Several problems with the existing spearguns are seen during the trip to the swimming pool. Maneuverability, tangled line, loading, safety mechanism and transportation are the ones standing out as problems which can ruin the spearfishing experience.

Reflection:
These problems can help the team in making the requirement specification and also figure out where to foccus, because going into deep with all problematics will be difficult to reach in time, so a prioritizing of these problematics will be made through the requirements. The team has to remember that they still have to make a speargun fitting the Danish ocean conditions and not only try to solve all problems found on the existing spearguns.

Sources:

ARDEA		
Questionnaire - Section 3: Problems encountered with spearguns		
Date: 10-02-2016	Team no. 4	Worksheet no. 13

Objective:
The objective is to get an understanding of the problems found in the existing spearguns. The investigation is based on the experience from the actual spearfishers who participated in the questionnaire.

Experiment/Data:
Through the questionnaire the participants are asked if they encounter any problems with their speargun both before, during and after the dive [Appendix no. 00].

The majority of the participants answers that they experience different problems with their spearguns. The problems are analyzised to determine if the problems varies from one experience level to another. The problems mentioned by the participants are described below. The numbers to the left is the experience level of the participant mentioning the problem (1=Beginner, 2=Semi-beginner, 3=Experienced, 4=Advanced).

Problems with speargun:

2	Manglende vedligeholdelse af affyringsmekanisme
2	Open muzzle havde for hårdt aftræk til at kunne ramme
1	Harpun på 110 er svær at lade
3,3	Forvirrende sikring (svær at gennemskue)
3,2,2,2,2,2	Sikring binder eller svær at håndtere
1,3,1,2,2,3,2,2,2,1,2,2	Svær at lade (i mørke og medbringe håndtag)
2,1,	Svær at sætte spyddet i
1,2,2,2,4,2,3,2,2,2,1,2,2	Alt vikler sig sammen når man har skudt (snore)
2,	Snoren knækker
2,	Snøren sidder fast
2,2,2,	Næsetung
2,2	Spyddet har sat sig fast (kendt problem for OMER)
2,2,3,2,2	Spyddet bliver skævt og slidt
3,2,2	Sand i aftrækkeren
4,2,2,	Ødelagt wishbone
3,2,2,	Slitage på elastik
3,	Luftharpun svær at skyde af
2,	Ondt i håndleddet ved længerevarende dyk
2,	Trykluft mere vedligeholdelse
2,2,	Utæt o-ring
2,3	svært at sætte spyd fast

Other problems - Transport and others:

1,2,2,1	Flydelinen er et problem (træls at svømme mens forbundet til bøje)
2,	Flydelinen knækker
2	Mærkeligt at transportere harpunen fra indre KBH til vandet
2	Harpunen er lang, så overvejer at købe trykluft fordi kortere til transport
2,3	Harpunen er svær at have med på cykel
2,2,3	Harpunen laver huller i taget eller indtræk på bil
2	Harpunen kan være svær at få plads til i små biler i længden
2	Længden af harpun er et problem under transport
3	Harpun er besværlig at have med på ferie
2	Svært at have alt udstyr med på cykel
3	Harpunen kan prikke hul i gummibåd
3	Ikke ansvarligt at have med i bil
3,	Offentlig transport
2,3	Manglende beskyttelse på spyd under transport
2	Smidt af toget pga harpun
2	Måtte ikke komme med bussen pga harpun
4	Sikringen er ikke eksisterende
3	Frustrerende at spyddet ligger ved siden af harpunen og rasler under transport

ARDEA			
Questionnaire - Section 3: Problems encountered with spearguns			
Date: 10-02-2016	Team no. 4	Worksheet no. 13	

2	Trailer er nødvendig til transport
2	Købt trolley til transport af udstyr
3	Elastomer/plastkomponenter ændrer egenskaber efter temperatur
2	Stoler ikke på sikring
3	Harpunen er usikker når den er ladt

Evaluation:
Every time a problem was mentioned by one of the participants it is written down. When another participant mentions it, the experience level indicator was added. By doing this the team is able to determine the most common problems encountered with the existing spearguns. The participants have different lengths, brands and types of speargun, which makes the result more general.
One of the most common problems encountered is that the speargun is difficult to load. Participants in all experience levels (except group 4) has mentioned this problem. This gives an indication of this problem has nothing to do with experience and thereby the problem must be with the actual spearguns. The same tendency and conclusion occurs with the problem of the tangled line when the speargun has been fired. Also the safety and transportation are mentioned by several participants as problems. The rest of the problems

Reflection:
The problems from the teams “problem finding in pool” (Worksheet no. 12) are all confirmed by the participants in the questionnaire. The stated problems gives the team a clear indication of where the speargun can be improved and what t be aware of when designing a new speargun.

ARDEA		
Morten Rex Frederiksen, Owner, Jægeren & Lystfiskeren		
Date: 19-02-2016	Team no. 4	Worksheet no. 15

Objective:
The objective is to get knowledge and insight in who is the general customer and which trends the stores selling spearfishing equipment experience through their daily interaction with the customer.

Experiment/Data:
The data of the interview can be found at the USB (Morten Rex Frederiksen - Jægeren & Lystfiskeren.m4a).

Peter: Hvor tit sælger i udstyr til uv-jagt?
Employee: Det er nok hver 14. dag. Så er det selvfølgelig forskelligt hvad de køber - er det et helt sæt, men typisk starter de ud med harpunen og så øger de til med våddragt, snorkel , briller og svømmefødder.
Anders: Kan du sige noget om kunderne - er det begyndere eller nogle der har været i gang med det i et stykke tid?
Employee: Det er typisk begyndere vi har, som gerne vil i gang med det. Få gange er der kommet nogle ind som gerne vil opgradere til en ny harpun.
Anders: Er det fordi I ser en stigende interesse i uv-jagt at I er begyndt at sælge udstyr hertil?
Morten: Vi ser en stigende interesse og så synes vi det kunne være sjovt at koble på den gang det kom frem og vi bliver også ved med at have det, men kun på et hobby niveau. Det er ikke fordi vi ikke vil mere, vi har bare ikke plads til mere.
Peter: Hører I noget om konflikter mellem uv-jægere og fiskere?
Morten: Ja, der kan godt være noget en gang i mellem, og et handler om hvordan folk de gør det - der er nogle der ikke kan begrænse sig og gør det hvor de andre gør det.
Anders: Du har ikke ret mange forskellige harpuner?
Morten: Nej, jeg har kun 3 stykker.
Anders: Ved folk hvad de vil købe når de kommer ind?
Morten: Nej, nogle vil bare gerne i gang og prøve det og vil ikke ofre det helt store på det. Det er det plan vi gør det på og bliver folk så helt bidt af det, så går de på nettet for at finde mere, så det er mere til begyndere vi har med at gøre.
Anders: Hvilke modeller foreslår du dem så at købe?
Morten: Jeg har tre gode modeller og der har jeg simpelthen valgt kvalitetsmæssigt hvad der er bedst . Den gang jeg selv startede tog jeg den største model og tænkte at jeg ikke skulle gå ned på udstyret, men jeg kunne bare ikke spænde den (læs: lade harpunen). Jeg var ved at brække to ribben, så jeg kunne simpelthen ikke få den spændt. Og så gik jeg lidt ned i kvalitet, men det vi har er ordentlig kvalitet, for vi gider ikke folk kommer afsted med noget og så virker det ikke ordentligt. Så kvaliteten er ordentlig i forhold til materiale, det er bare nogle der er lettere at spænde. Det er lettere at starte med en lidt mindre og så kan man få en størrelse større og bliver man så helt bidt af det, så går folk typisk videre.
Peter: Hvilke størrelser har I nu?
Morten: 65, 75 og 85 (læs: harpun på 65, 75 og 85 cm).
Peter: Så ikke oppe i 110 og 90?

Ill. XX: Morten Rex Frederiksen, Indehaver, Jægeren & Lystfiskeren

Ill. XX: Jægeren & Lystfiskeren logo

ARDEA		
Date: 19-02-2016	Team no. 4	Worksheet no. 15

Morten: Nej, vi havde en gang en 90'er, men den synes jeg faktisk blev for kraftig i forhold til at spænde. Men vi sælger flest af 65'eren og 75'eren.
Peter: Er der ikke nogle der spørg efter trykluft harpun?
Morten: Jo, der er nogle der gør, men det gør vi ikke i, fordi det er for kompliceret.

Evaluation:
It is mostly people who wants to start spearfishing who goes to Jægeren & Lystfiskeren to buy the necessary equipment to spearfish. At first they will often start with the speargun, because it is the most essential part of spearfishing, but as they find more and more interest in it, they will come back and buy more equipment.
The customers at Jægeren & Lystfiskeren do not know what to buy, so they will listen to the salesmen and ask for their opinion. They will often tell them to buy one of the shortest spearguns, because they are easier to load and maneuver in the water than the longer ones. As they get a better technique they will often buy a longer speargun.
They are selling a lot of 65 cm and 75 cm rubber spearguns and sometimes customers will ask for the speargun driven by air, but they are too complicated for Jægeren & Lystfiskeren to sell and help repairing.
Jægeren & Lystfiskeren sees an increasing interest in spearfishing in Denmark and therefore they decided one year ago to start selling equipment for it, but only as a niche in their store, because their main focus is still hunting on land. They are selling around 20 spearguns every year and therefore not ready to use more space in their store for spearfishing equipment in the near future.

Reflection:
There is definitely an increasing interest in spearfishing in Denmark, but not more than an already established store is ready to make it more than a niche/hobby thing in their store. They have to see more people come into their store asking for spearfishing equipment before they are ready to use more space in the store on this equipment.
It seems like the problem of loading the speargun gets more and more difficult as it gets longer, and therefore Jægeren & Lystfiskeren recommend people to start with the short ones and then buy the longer ones as their technique gets better.

Sources:
http://jaegeren-og-lystfiskeren.dk

ARDEA		
Morten Rosenvold Villadsen, Owner, Undervandsitetet		
Date: 22-02-2016	Team no. 4	Worksheet no. 16

Objective:
The team needed to get some knowledge from a spearfisher doing it on a regular basis and works in the field of spearfishing in his daily job, and therefore has a finger on the pulse regarding what is going on and how the sport is evolving.

Experiment/Data:
Hej Morten,

Hvor mange års erfaring har du indenfor uv-jagt?
10-15 år alt efter hvordan man tæller. Jeg var på Landsholdet første gang i 2007.

Hvordan transporterer du dig selv og udstyret ud til havet? (Bil, bus, cykel osv.)
Bil

Hvilke harpuner har du og hvilke længder? (Hvis flere, forklar gerne hvorfor du har forskellige brands eller længder)
Jeg bruger i øjeblikket Rob Allen i 90cm og 120cm - jeg mangler 70cm til vestkysten. 90cm er min allround harpun til DK.

Oplever du problematikker ved harpunen? (f.eks. svær at lade, linen/snoren, transport, sikkerhed/sikring osv.)
Nej, ikke rigtig. Jeg bøvlede en del med open muzzle harpuner a la ExiumG2, men min rob allen spiller.

Hvad er din "hit-rate" (hvis du kan sætte procenter på, hvor ofte du rammer dit mål)?
2/3 - men jeg rammer fisken i måske 9/10 tilfælde.

Oplever du en stigende interesse i uv-jagt i Danmark eller Skandinavien? (Kan du sætte ca. tal på hvor mange der går på uv-jagt nu og måske et par år tilbage i tiden i Danmark, Skandinavien, Europa og Verden, og kan du sige noget om kønsfordelingen?)
90/10 drenge/piger. Ja klart stigende - dog er stigningen ikke så voldsom længere. I Juli 2014 havde jeg 20000 besøg på undervandsitetet. i 2015 havde jeg 15.000 - men det betyder også noget hvordan sommervejret er.

Hvordan differentierer uv-jagt i Danmark/Skandinavien sig fra Sydeuropa og resten af verden, hvis man kan sige noget om det?
Meget. DK og Norge og Finalnd er dog vidt forskellige. Jeg taler her om DK.
Koldt, dårlig sigt, få arter, mange fladfisk, lavt vand (med mindre man jager på vrag).
Man jager ofte ved at overflyve et område. Aspetto er ikke så udbredt som i syden.

Alt udstyr, især harpunen, virker til at være designet særligt til de sydeuropæiske forhold og ikke til de nordlige - kan du sige noget om det? (Har de lavere temperaturer f.eks. indvirkning på effektiviteten af harpunen i forhold til elastikken mister energi og dermed har man sværere ved at ramme sit mål eller er der andet?)
Jeg oplever ikke problemer med harpunen. Egentlig. Størrelsen er jo det mest afgørende. Jeg er glad for Rob allen - også pga spyddet som ikke så let går i stykker, når man jager torsk i sten. Men Rob Allen er også fra Sydafrika.

Hvordan ville en optimal harpun se ud til danske forhold og behov?
http://sportsbutikken.dk/catalog/product_info.php?manufacturers_id=96&products_id=5027 - synes jeg.
uvpodcast.dk/3 taler vi en del om udstyr og harpuner.

Hvor i verden er der samme forhold som i Danmark? Samme bund, fiske størrelser og sigtbarhed.
Cape town, Chile, Portugal, Bretagne, evt Peru.

På forhånd tak.
Anne, Peter & Anders

———

Hej igen,

ARDEA		
Morten Rosenvold Villadsen, Owner, Undervandsitetet		
Date: 22-02-2016	Team no. 4	Worksheet no. 16

Kan du sige noget om hvordan havstrømmene er i Danmark? Løber det typisk vandret eller oplever man tit at strømmen kan komme lodret eller i vinkler?

Med venlig hilsen
Anders Poulsen

___

Typisk vandret.
Yderst lokalt man kan opleve lodret.

Vh Morten

___

Hej Morten,

Tak for svaret. Hvad vil strømmen i vandet typisk max være når en uv-jæger går i vandet? Vil en uv-jæger f.eks. gå i vandet hvis havstrømmen er 1,0 m/s? Eller vil sådan en strøm være for meget?

Med venlig hilsen
Anders Poulsen

____

Ill. 11.2: Undervandsitetet logo

Ill. 11.1: Morten Rosenvold Villadsen, Owner, Undervandsitetet

Strøm måles i knob.

Hvis det ikke er et problem at strømmen tager en (ex hvis man driver med en båd) så er 1,5-2 knob OK. De færreste vil dykke med mere end 2 knob. Du kan lige akkurat svømme mod 2 knob og holde dig samme sted, men ikke længe.

Jeg prøver at undgå +1,5knob

Vh Morten

Evaluation:
Morten is using a 90 cm speargun as his allrounder in Denmark, which is also the length used by most people in the questionnaire. The brand Rob Allen has a spear, which does not bend or break that easy when hunting on rocks in the water. 90 percent of the time Morten is able to actually hit the fish even though the visibility in danish waters is relatively low. Spearfishing is a sport of very few girls (10 percent are women). There is an increasing interest each year, but how big depends on the summer weather. In Denmark it is cold, low visibility, few species, a lot of flatfish and low water that describes the conditions best. Because of these conditions it is the spearfishing technique called overfloating which is being used more than it is aspetto. Spearfishers are often not going in the water if the water current is above 2 knots (1 m/s).

Reflection:
The danish water conditions seem not to be ideal for spearfishing, because of the coldness, low visibility and few species, but still the sport is experiencing increasing numbers of spearfishers the last couple of years. This means no one has actually been looking at developing spearguns for these conditions with good reasons, but with the greater interest now it makes better sense to look more into this area.

Sources:
http://undervandsitetet.dk

ARDEA		
Guy Skinner, President/CEO, JBL International		
Date: 19-02-2016	Team no. 4	Worksheet no. 17

Objective:
The objective is to potentially establish a cooperation with a company specialized in spearfishing, and then have several meetings during the project to use their expertise in our project.

Experiment/Data:
Hi,

We are a team of three people from Aalborg University in Denmark, and we are currently writing our master thesis in industrial design. The project period runs from February 1st to June with project hand-in and examination.
We are writing to you, because we have chosen spearfishing as the topic of our project and were hoping you could have an interest in collaborating with us the next couple of months. We are going to come up with a new product design, where we will focus on both the aesthetics, functionality and the technical aspect of the product. Right now we are likely to choose the speargun and try to find new opportunities regarding e.g. the way of catching the fish, transporting, securing of the gun etc.
Our primary target group will be people spearfishing in Scandinavia and those conditions, because we see an opportunity for you developing spearfishing equipment and especially spearguns specific for these ocean conditions in the near future, because the interest for spearfishing in Denmark is increasing. We are however open to other suggestions regarding our focus area. So if you have any suggestions or ongoing projects where you think we can contribute with any input or design concepts, we will be more than happy to hear about them and discuss the opportunity.
What we are expecting from you in a collaboration is your expertise and experience in spearfishing, production and material insights and possibly covering of some expenses to e.g. modelling and prototyping, visit of your company etc.
We can eventually take a skype meeting, where we can talk further about the project and align our expectations to the project and make a contract, where the rights to the project/product is agreed.

Best regards
Anne H. Nielsen, Peter V. Sørensen and Anders Poulsen

———

Anders, I wanted to thank you and your fellow students for reaching out to JBL for advice with your Master Thesis. I would be glad to offer assistance in your project. Each spearfishing market is very different; water conditions, temperature, fish species etc. All these factors have made spearguns and support equipment very regional so your desire to build a product that meets the needs of Danish divers is well founded. Please feel free to ask question and I will do my best to assist you.

Thanks,
Guy Skinner
JBL International
President/CEO

———

Hi again,

We were thinking about the spear and the shape of it - why is it round? Why is it not oval, triangle, square etc.? Is that something all speargun manufacturers have been testing several times and found as the best shape and most efficient at penetrating through the water? Or is it just because it has always been that shape through the history of spearfishing and no one has really looked at other ways to shape the spear?

Thanks,
Anders Poulsen

———

Avalability of material is the main reason, but machining is also a key factor. Most manufacturers are now using heat treated 630 stainless, this offers stiffness for efficent energy transfer from the power slings and the stainless does not rust. I do not know if there is a better shape for hydrodynamic performance, but it would be a tough sell as the shafts are very standardized. Biggest challenge with spearguns is one loading the bands and two the length needed to

achieve the power necessary for long shots.

Guy Skinner

———

Hi Guy,

We are missing some real data about how many active spearfishers there are today to help our business case. How many are there in USA, South America, Japan, France, Italy or just Europe? I guess you only have an idea about it since we can't find any official numbers and I also guess you only have an idea about USA or what? It will also be okay if you are allowed to tell us how many spearguns you produce or sell each year.
Is that something you can help with or maybe tell us who to contact if not?

Thanks,
Anders Poulsen

———

You are correct, there is really no conclusive slaes data on spearfishing. My estimate...and it is only an educated guess is aroung 45 million world wide for spearfishing gear and diving gear that is used exclusivly for spearfishing.

Guy Skinner

Evaluation:
The outcome was not as the team hoped, because JBL International was not ready to commit fully to the project, but they were more than willing to help in answering questions about anything in spearfishing during the project. Heat treated 630 stainless steel is what is normally used for the spear, because it offers stiffness for efficient energy transfer from the power slings and it does not rust.

Reflection:
JBL was one out of several spearfishing companies that the team tried to make a cooperation with, but it seems more difficult than first projected to get companies convinced on using time and potentially money on a project managed by University students they have no knowledge about. They might be ready when the team actually has something concrete to present, so it could be an idea to try contact them again in the end of the project. But by now JBL will be used to answer questions the team might have during concept development and concept specification.
The team might choose to stay with a standard spear when it comes to material and shape, because it is standardized and will cost a lot of money to start up a production for a new spear design.

Sources:
http://www.jblspearguns.com
Guy Skinner picture: https://i.ytimg.com/vi/OkN8pztqlbg/maxresdefault.jpg
JBL logo: https://pbs.twimg.com/profile_images/583385421645631488/Wsf3iaKs.jpg

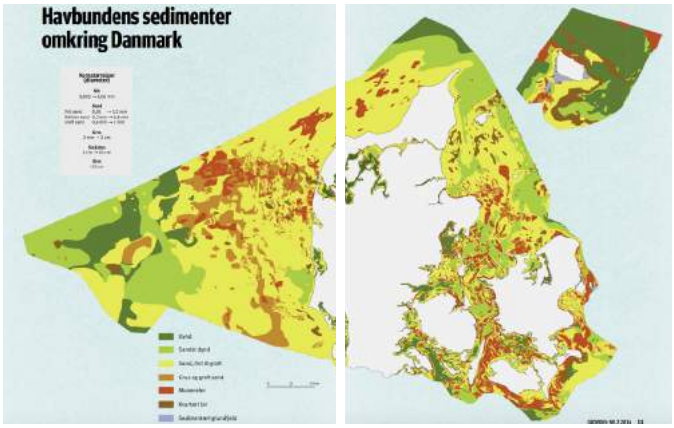
Ill. XX: Guy Skinner, President/CEO, JBL International

Ill. XX: JBL International logo

ARDEA		
Ocean conditions		
Date: 04-02-2016	Team no. 4	Worksheet no. 18

Objective:
Researching the Danish oceans current, visibility and seabed conditions will help gather informations, which can be used in understanding what the spearfisher is generally working in and by that making requirement specifications for the new developed product design.

Experiment/Data:



Ill. C.XX: Danish seabed 2014.

The Danish coastline is approximately 7000 km long and to catch fish by spearfishing you as a maximum need to go 100 m out from the coast and 4 m deep. [Undervandsitetet] The average visibility in the Danish inlets were in 2014 4,2 m and for the oceans 8,3 m, but the visibility is often lower along the Danish coastline. [Naturstyrelsen & Morten Rosenvold Villadsen] The best visibility you can experience in Danish oceans is around 20 m, but that is few days a year. Along the Danish coastline the seabed is mostly sand, but it also consists of stone at several spots.

Evaluation:
Especially the visibility in Danish waters is really low and therefore it can variate from day to day which speargun length the spearfisher is able to use. Rob Allen says; “...visibility can change on the day during the dive and or depending on the location. So, gun length is mainly determined by the visibility and the power needed is mainly determined by the fish you need to take. Big fish need more powerful guns compared to smaller fish.”

Reflection:
The shooting range for a speargun, which typically goes from 2,5 - 8 meters, is firstly decided by the visibility length in the water, therefore you have to bring several spearguns in different lengths each time you want to go spearfishing, because it is difficult to figure out the visibility length from home. It might also be an idea to be able to adjust your speargun in the water, because the visibility can change while being in the water or by change of location.

Sources:
Ill. XX: http://geocenter.dk/xpdf/geoviden-2-2014.pdf
http://naturstyrelsen.dk/media/180884/vandmiljoe-og-natur-2014.pdf
http://undervandsitetet.dk/undervandsjagt/uvjagt-steder-i-danmark/
Worksheet: Expert Interview - Rob Allen

ARDEA		
Ocean conditions		
Date: 04-02-2016	Team no. 4	Worksheet no. 18

Objective:
The team needs to research on conditions similar to the Danish ocean conditions to see if other areas could be potential markets for a new speargun. The visibility, current and water depth are the most important parameters when choosing which speargun length you need, therefore these are the ones each area is measured on.

Ill. C.XX: Danish seabed 2014.

Experiment/Data:
Denmark, Brittany in France, Portugal, Peru, Chile and Cape Town in South Africa are in different degrees similar to the Danish ocean conditions. [Morten Rosenvold Villadsen] The northern part of Australia is also similar to Denmark especially in visibility and current. [Graham Carlisle, AUF WA State Commissioner & AUF National Communications Officer].
Other areas like Southern Australia, the Mediterranean Sea, Panama and Florida in USA have visibility from 10 meters up to 40 meters. This gives some really good circumstances for spearfishing, when you are able to see over long distances and thereby also shoot over long distances.

Evaluation:
Several areas around the world experience the same ocean conditions as in Denmark, and it is not only in Europe. Areas in South America, South Africa and the northern part of Australia experience similar water conditions.

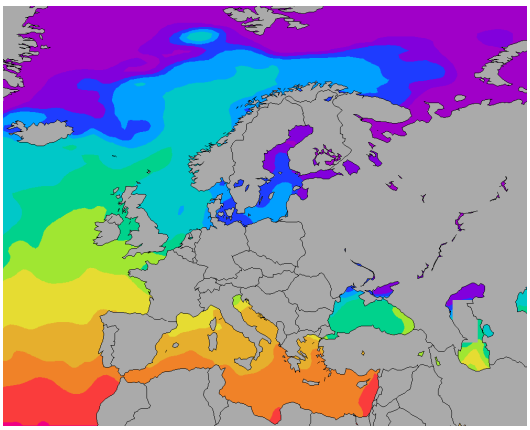
Reflection:
This will definitely help a future business plan, that other areas have the same water conditions as Denmark, especially when considering the few amount of spearfishers in Denmark. Being able to establish a healthy business the team needs to also look outside Denmark.

Sources:
Worksheet: Expert Interview - Morten Rosenvold Villadsen
Worksheet: Graham Carlisle from Australia

ARDEA		
European ocean conditions		
Date: 04-02-2016	Team no. 4	Worksheet no. 18

Objective:
The objective of researching the conditions of the european oceans is to get an understanding of how the different oceans variate in temperatures and thereby also how they variate in fish species. This will help make limitations regarding which oceans and fish species to focus on.

Experiment/Data:



Ill. C.XX: European oceans temperatures in early February 2016.

The comparison between the oceans is done by updated measurements the 4th of February 2016. The temperatures are of course at their lowest this time a year, but the comparison still gives a good sense of the general difference in temperature all year. The Baltic Sea, Kattegat and Skagerak - all surrounding Denmark and Sweden - temperatures are around 0-3 degrees. North Sea, surrounding Norway, Denmark, Britain, Germany, Netherlands, Belgium and Southern France, has temperatures around 4-8 degrees. The Mediterreanean Sea, which surrounds most of Southern Europe, is 12-19 degrees. [WeatherOnline]

Evaluation:
On the map showing ocean temperatures, it is clear to see the temperatures change drastically from Belgium and France. This change in temperatures affects the species of fish you will meet when spearfishing (NEED A SOURCE). It also affects the equipment for spearfishing, because you need thicker wetsuits for the Scandinavian conditions and it also affects the rubberbands of the speargun in a way where the energy decreases as the water gets colder, which means the spear will lose speed through the water, but this is only a problem in waters below 5 degrees, which is something not many spearfishers are spearfishing in. [Azzi, 2016]

Reflection:
The different temperatures can affect the equipment, but it depends on which technology is used for the specific equipment, but in many cases it will affect the performance of the equipment. Together with the difference in fish species, this will have a certain influence on how a new speargun is designed. The project will therefore focus on the Scandinavian oceans conditions and especially the Danish, because of the unlimited access to these oceans. Temperature is not the only factor influencing the conditions in when spearfishing - current, visibility and seabed conditions will also have an influence on spearfishing, therefore this has to be researched upon.

Sources:
Il. XX: http://www.seatemperature.org/public/europe.png
http://www.weatheronline.co.uk/cgi-app/watertemperature?LANG=en&CONT=euro&GEBIET=0003
Worksheet: Expert Interview - Lamberto Azzi

ARDEA		
Fish and habitats		
Date: 04-03-2016	Team no. 4	Worksheet no. 19

Objective:
The objective is to understand and describe what kind of fish the Danish water hosts and what habitats the fish prefer to be in. This will help the team to understand whether or not to have the different surroundings in the ocean in consideration when starting on the ideation and concept development.

Experiment/Data:
The waters around Denmark contain different types of fish where a lot of them is suited for eating. The fish live from the shallow waters near the coasts and down to the deep depths in the channels around Denmark. The type of speargun used for shooting a specific fish is depending on the specie of fish hunted, the habitat the fish lives in and the conditions at the fishing spot. Based on a questionnaire five species of fish was detected as the general most hunted fish these fish was; sea trout, mullet, turbot, coalfish, flounder and cod. (Worksheet no. 20) Each fish has different habitats, sizes and behavioural patterns.

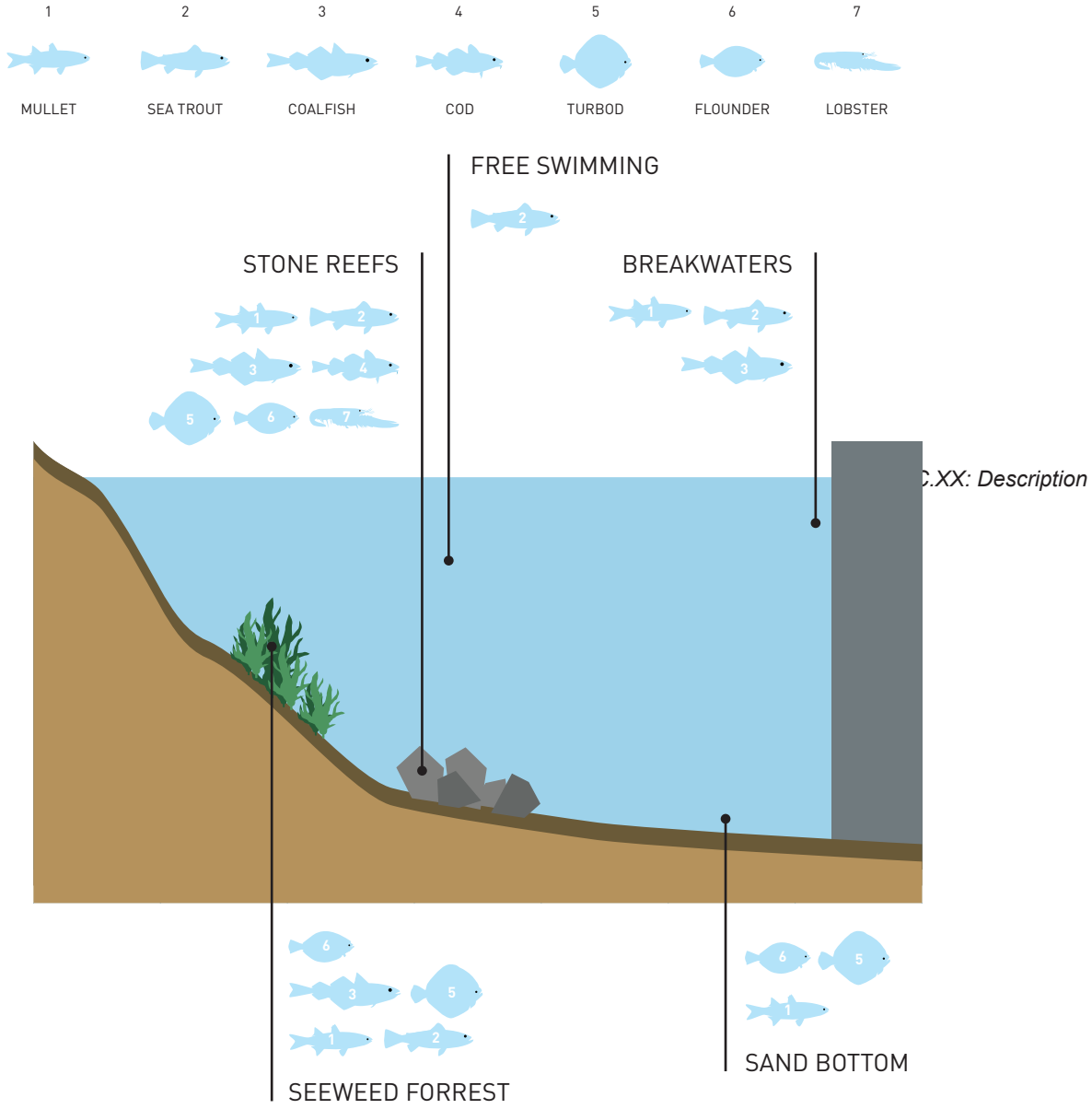
The most hunted fish species can in general be divided into three different categories; flatfish, still standing fish and free swimming fish. The first category of flatfish is combining the different species of flatfish in the Danish water. They have in general the same behavioral pattern and have the same technique to avoid predators. These species does this by camouflaging on the bottom of the sea and blend into the surroundings. In general can this group of fish be catched with a short range speargun.
The next group of fish is the still standing fish. These fish is often hidden between seaweed or in caves which makes them hard to spot and find. In general these fish avoid predators by hiding when they feel threatened and they swim into a protected area. This leaves them hard to catch if they e.g. swim into a rock cave where the speargun can not reach. The spearguns needed for this is depending on the hiding place but in general medium power is needed.
The third type of fish is the free swimming these fish is patrolling areas for finding food and they use their speed and agility to avoiding predators. In general these fish are more shy and protective than other fish species, which also is why these fish are the hardest to catch because the fish is keeping distance to the spearfisher. This means that the speargun needed for shooting these fish is much depending of the visibility, but medium to high power. The Danish conditions can be compared to other places in the World, and when comparing the different fish species found around similar conditions, a lot of the fish species found can be divided into these three groups.

The illustrations below indicates in what habitats and depths each fish species (the team focuses on the fish species most commonly caught in Danish oceans according to the questionnaires (Worksheet no. 20)) can be found and more details about the fish.

Habitats	Shortterms
Stonereef	S
Seaweed forrest	SF
Sand buttom	SB
Free swimming	FS
Breakwaters	B

Species	Minimum size (cm)	Living depth (m)	Habitats	Weight max (kg)
Sea trout	40	0-15	S,SF,FS,B	16
Mullet	0	1-20	B,S,SF,SB	5
Saithe/Coal fish	35	1-250	S,SF,B	25
Turbot	30	10-70	S,MR,SF,SB	15
Red flounder	27	5-40	S,SB,MR	10
Lobster	22	2-40	MR,S	6

ARDEA		
Fish and habitats		
Date: 04-03-2016	Team no. 4	Worksheet no. 19



Evaluation:
The three different groups of fish are different in their behaviors; some are quiet easy to catch, because they are not swimming away when a spearfisher is approaching them. Others will easily get scared by a spearfisher and some are hiding in small, narrow places - all this set some different requirements to a new product.
In general the fish species in Denmark are not the biggest fish compared to fish species in other places around the World, but the three different types of fish can be found most places.

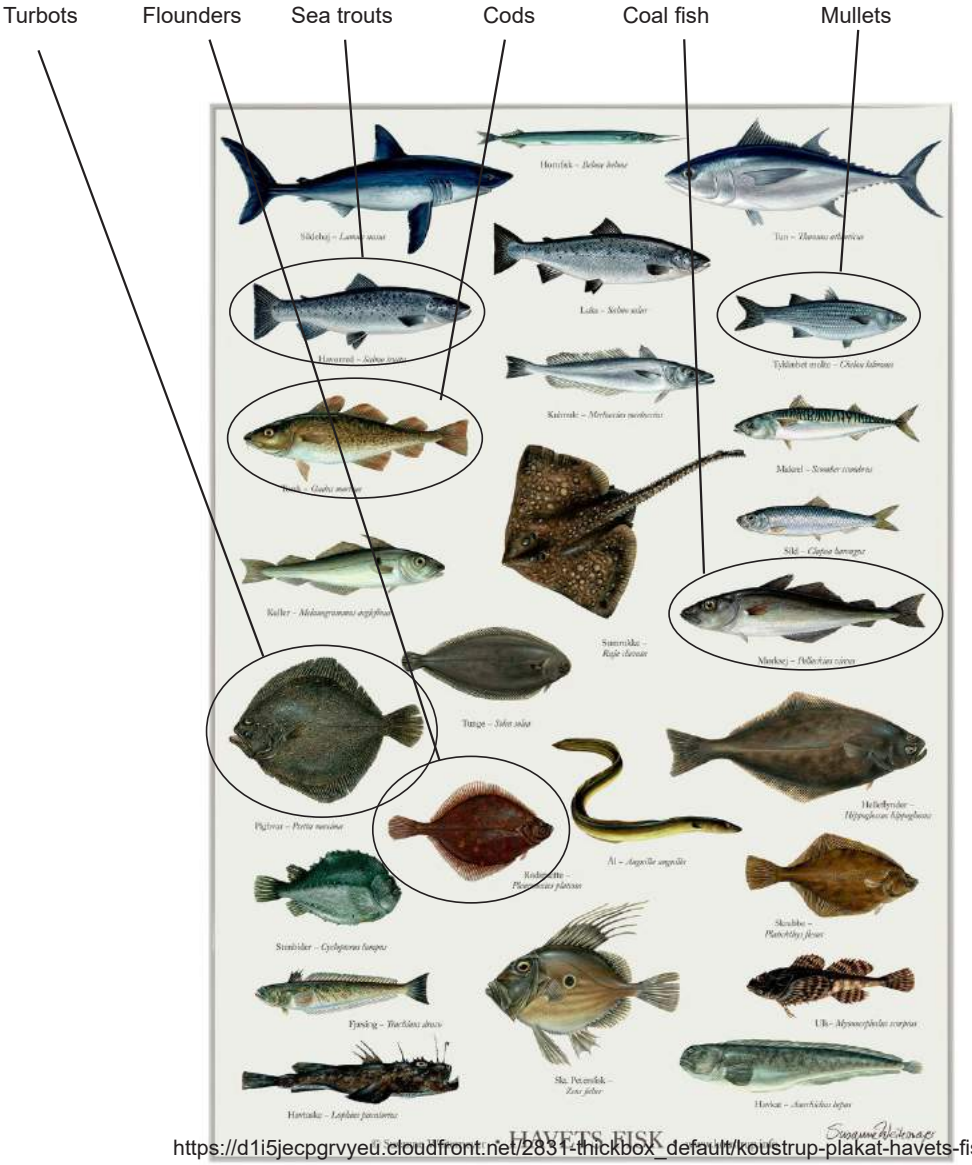
Reflection:
For further use the three different fish types can be used in the making of the requirements for the new product, because these give an overall view of what is necessary for a speargun to be able to do to give the spearfishers the best circumstances for catching the fish species they hunt.

Sources:
http://m.fisketegn.dk/fiskeleksikon.aspx?ID=45370
http://www.fiskefoto.dk/fangster/aborre-perca-fluviatilis/1
http://www.worldfishingnetwork.com/tips/species-finder/?p=p,q,r,s,t

ARDEA		
Questionnaire - Section 5: Fish species caught in Denmark		
Date: 22-02-2016	Team no. 4	Worksheet no. 20

Objective:
The objective is to get an insight into which fish is caught when spearfishing in Denmark. The types of fish could potentially set some requirements for the speargun.

Experiment/Data:
By evaluating and analyzing the answers from the questionnaire [Appendix no. 00] it is possible to determine the most common fish species caught in Denmark when spearfishing.
The participants in the questionnaire is asked which fish they catch when they spearfish. By evaluating the answers it is clear that mostly 6 species of fish are caught.
The species of fish most commonly caught in Denmark are:



https://d1i5jecpgrvyeu.cloudfront.net/2831-thickbox_default/koustrup-plakat-havets-fisk.jpg

Evaluation:
The participants all mention the same species of fish when asked which fish they catch during spearfishing. The 6 species which are mentioned are all common eating fish in Denmark.
The species of fish they hunt for does not vary depending on the experience level. What they actually catch however, varies in the 4 experience levels (Worksheet no. 10).

Reflection:
The new speargun needs to be able to shoot all these types of fish to cover the desire of the spearfishers.

ARDEA		
Four user categories and their needs		
Date: 19-02-2016	Team no. 4	Worksheet no. 21

Objective:
An investigation of the four user categories is done to identify the specific charateristics, need and demands of each of the four categories. The hypothesis was that the needs and demands of the user changes as they develop their skills and move up to a new category.

BEGINNER:
The beginner group is the most inexperienced users which has recently been introduced to the sport. The beginners are normally interested in learning the basics and try to catch any species of fish. The beginners often have basic knowledge in freediving, rod fishing, rifle hunting, snorkeling or scuba diving, but are interested in catching fish in the water. This group of spearfishers are interested in catching all species of fish which is legal to shoot, but don't have the skill, equipment and/or do the effort for catching anything else than flatfish. The beginner group has no or low knowledge in both theoretical and practical spearfishing technique.

The beginner has low or little knowledge of the spearfishing code/rules and has little knowledge of safety and equipment.
• Just started spearfishing
• Little knowledge in spearfishing theoretically and practically
• Spearfishing dives (0-15 times)
• Trying to catch all kind of fish
• Catch flatfish
• No or little experience in shooting, aiming and handling the speargun
• Often has one speargun

SEMI-BEGINNER:
The semi-beginner group has been introduced to the sport and has started to engage in the sport more regularly. Furthermore the semi-beginners have gained a foundation of knowledge of spearfishing, both in terms of theoretical and practical. The semi-beginners have knowledge of what fish species they want to hunt and where to find fish. This group is starting to have interest in shooting free swimming fish like sea trout or mullet, but still mostly shooting flatfish. The semi-beginner have also gained the basic aim of shooting and is starting to know and expand their equipment. They often have two guns or more for different purposes and conditions. In general the semi-beginners have the basic skills, are prepared to do some effort.

The semi-beginners have some knowledge in ethics and rules about spearfishing.
• Spearfished few species of fish
• Some theoretical and practical knowledge about spearfishing
• Spearfishing dives (20-40 times)
• Trying to catch flatfish and specific species of fish
• Mostly catch flatfish
• Low or some experience in shooting, handling and aiming with speargun
• Has often more than one speargun

ARDEA		
Four user categories and their needs		
Date: 19-02-2016	Team no. 4	Worksheet no. 21

EXPERIENCED:
The experienced group has lot of knowledge about the sport and has engaged in the sport regularly. Furthermore experienced has a lot of knowledge about spearfishing, both in terms of theoretical and practical. The experienced normally hunts specific fish species and knows where to find the fish. This group is mostly interested in shooting free swimming fish like sea trout or mullet, but still shoot few flatfish. The experienced has high experience about their equipment and their speargun. Their aim and shooting is precise and they have more than one speargun for different conditions. In general the experienced has skills and is prepared to do an effort.

The experienced has large knowledge in ethics and rules about spearfishing.
• Spearfished many different species of fish
• A lot of theoretical and practical knowledge about spearfishing
• Spearfishing dives (40-100)
• Mostly trying to catch a specific species of fish
• Mostly catch a specific species but sometimes flatfish
• High experience in shooting, handling and aiming with speargun
• Has in general two or more spearguns for different purses and conditions

ADVANCED:
The advanced group has huge knowledge about the sport and practice the sport a lot. Furthermore the advanced group has huge knowledge about spearfishing, both in terms of theoretical and practical. The advanced group hunts specific fish species and know where to find the fish. This group is mostly interested in shooting free swimming fish like sea trout or mullet. The advanced has huge experience about their equipment and their speargun. Their aim and shooting is extremely precise and they have more than one speargun depending on each condition. They often work within the field either as instructor, author or owner of a spearfishing store.

The advanced group travels to other countries and participate in spearfishing competitions.
• Spearfished in several other countries than Denmark
• Huge theoretical and practical knowledge about spearfishing
• Participate in championships, teach in spearfishing or owner of spearfishing store or brand
• Spearfishing dives (100+)
• Constantly trying to catch a specific species of fish
• Constantly catch a specific species of fish
• Huge experience in shooting, handling and aiming with speargun
• Has at least two spearguns

Evaluation:
The team has made four usergroups, but from the questionnaires made earlier it seems like Denmark mostly consists of spearfishers in group 2 and 3 (semi-beginner and experienced). Few people felt they were a beginner or adavnced spearfisher. This breakdown of groups does noot really help the team choose a target group, because it tells nothing about the type of speargun they use, but more about the amount of spearguns and what they know and don't know about the sport.

Reflection:
From this breakdown of the usergroups the team can choose whether or not to focus on all spearfishers or just focus on some of the groups. This depends on what the difference in which spearguns they have and use is, because are they using more or less spearguns in the same pricer range, there is no reason for the team not to focus on all groups. This has to be investigated in order to finally choose the target group for this project.

ARDEA			AALBORG UNIVERSITET
User survey			
Date: 26-02-2016	Team no. 4	Worksheet no. 22	

Objective:
The team needs to validate what direction to choose, for the new speargun design. This is done by interviewing spearfishers from the spearfishing community. The team sees two directions for further development. One is to make spearfishing futuristic and change the sport, or to keep in touch with the nature, traditions and the meditative aspects.

Experiment/Data:
The questions asked has been about how they rate the catch compared with the experience and what they gain from it.

Anonym 1:
"Jeg elsker bare at komme ud med vennerne og få noget luft fra byens larm" ,"Jeg har aldrig rigtig fanget noget, men det gør ikke så meget." "Jeg er kun ved at lære sporten, men syntes det er virkelig fedt, så kan ikke se hvorfor det skulle ændres"

Jonas Nørgaard:
"Det er da fedt når man fanger noget, men jeg kommer også fra dykning med flaske så jeg syntes bare det vigtigste er at komme i vandet og så at øve mig i fridykning." "Jeg kigger da efter fisk, men det er jo ikke altid nemt." "At ændre sporten, kommer meget an på, hvordan man gør det og om det bare er for at få flere fisk"

Nikolaj Mortensen:
"Jeg vil helst fange noget og det er da også derfor jeg tager afsted om natten, men det er også rart at komme hjem-mefra når der lige er tid til det." Jeg vil gerne komme ud og skyde noget." "Jeg kommer ud for at skyde, og det er da ikke ligeså fedt, hvis man ikke har noget med hjem man kan vise frem." "Jeg er selv igang med et harpun projekt, og hvis der var andre måder, ville jeg da nok også prøve det, men man kan sagtens fange noget med de nuværrende."

Anonym 2:
"Det er skønt bare at komme i vandet, jeg har tit ikke en harpun med." "For mig er det 100% oplevelsen og komme væk fra byen der tæller."

Evaluation:
Based on these quotes from interviews it seems that the different backgrounds effects the user in what he prioritize about spearfishing; catching fish or getting in the water. There would be both pros and cons of going in each direction, but based on these quotes, the empiric data gained through the research phase, it is chosen not to try to change the sport. But even when they are just interested in catching fish rather than the experience, they still want the sport to be as it is.

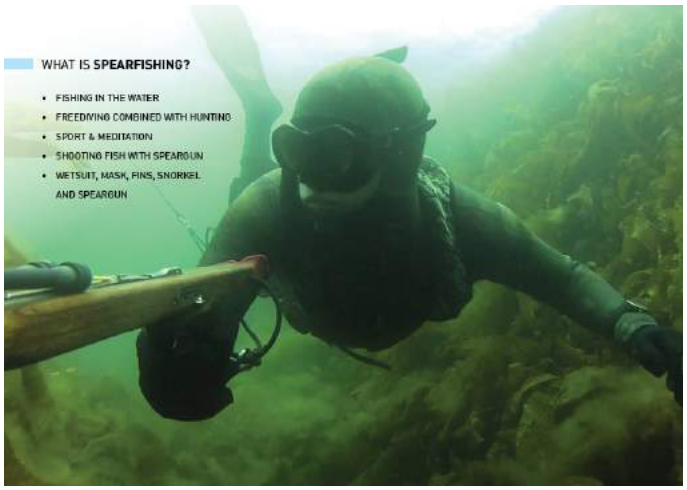
Reflection:
To maintain the sport as it is, it is needed to be aware about how the user behave and how they will use the product. In addition to this it is needed to find how the teams product will differentiate from other competitors and solve current problems.

ARDEA		
Status Seminar I		
Date: 01-03-2016	Team no. 4	Worksheet no. 23

Objective:
The objective in the first status seminar is for the team to test the scope for the project and to test some concepts and get feedback on them.

Experiment/Data:
The team presents the reseach and foundation for the project scope. Besides, the team presents three concepts at the first status seminar based on the research and initial sketching session. The concepts as both adjustments and improvements to the existing speargun and some more challenging concepts challenging the way of spearfishing today.

Page 1



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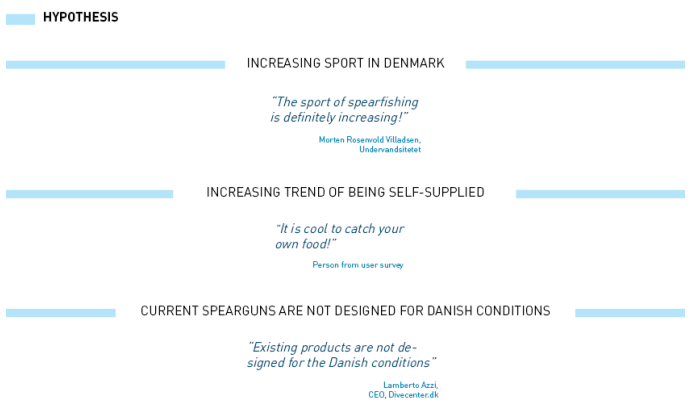

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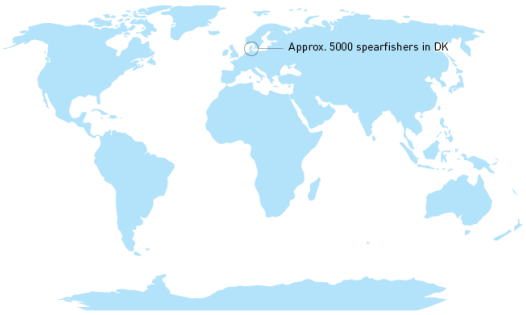
Page 4

ARDEA		
Status Seminar I		
Date: 01-03-2016	Team no. 4	Worksheet no. 23

SPEARFISHING IN **NUMBERS**



Page 5

SIMILAR **CONDITIONS**

Page 6

RESEARCH: **EQUIPMENT**

DIFFERENT SPEARGUN SIZE AND TYPE FOR DIFFERENT DEMANDS AND CONDITIONS

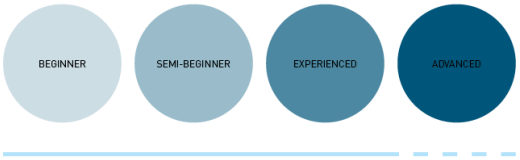
Page 7

PROBLEM IDENTIFICATION

Page 8

TARGET GROUP

BEGINNERS TO EXPERIENCED USERS
USE THE SAME TYPES OF SPEARGUNS



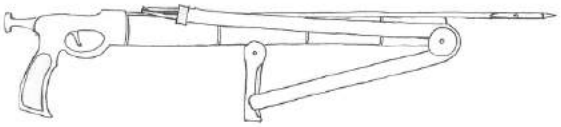
Page 9

FOCUS AREAS

- HOW TO **SHOOT AND CAPTURE** FISH
- HOW TO **ADJUST** TO DIFFERENT CONDITIONS, PURPOSE AND EXPERIENCE LEVEL
- HOW TO **SECURE** THE SPEARGUN IN AND OUT OF WATER
- HOW TO **TRANSPORT** THE SPEARGUN
- HOW TO **INTERACT** WITH THE SPEARGUN

Page 10

CONCEPT 1 | SPEARGUN 2.0



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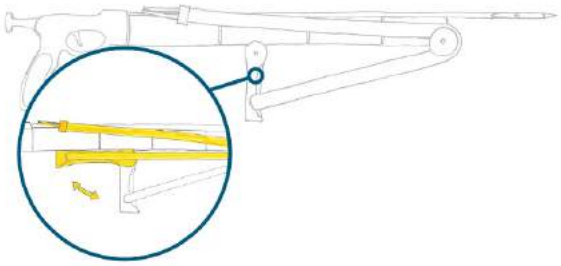
CONCEPT 1 | SPEARGUN 2.0



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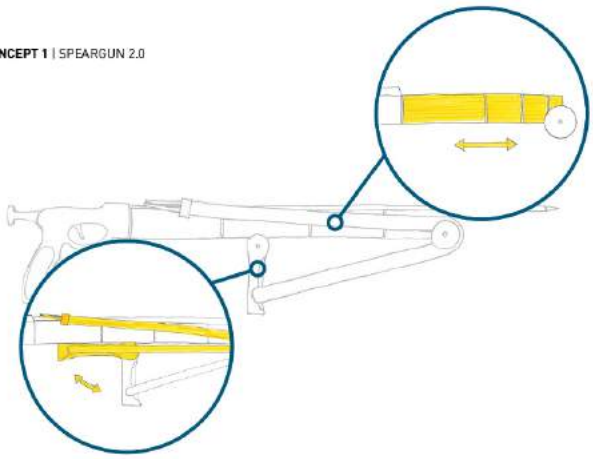
CONCEPT 1 | SPEARGUN 2.0



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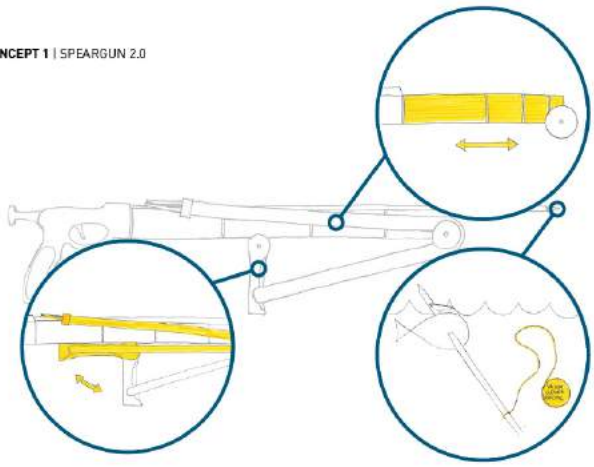
CONCEPT 1 | SPEARGUN 2.0



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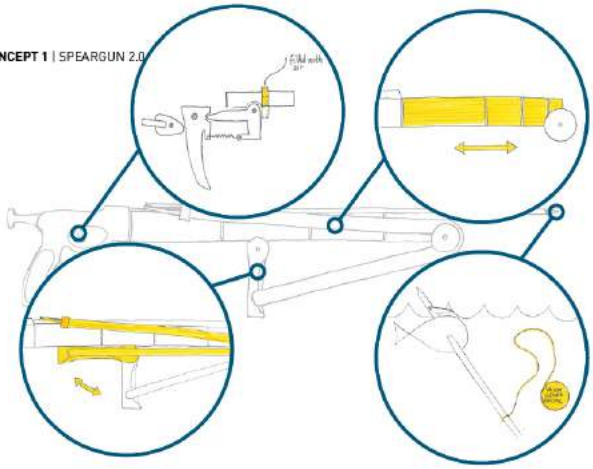
CONCEPT 1 | SPEARGUN 2.0



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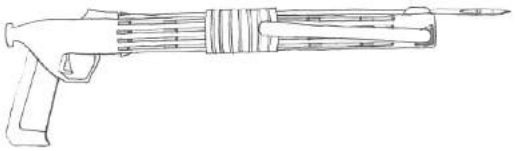
CONCEPT 2 | MAGNETIC SPEARGUN



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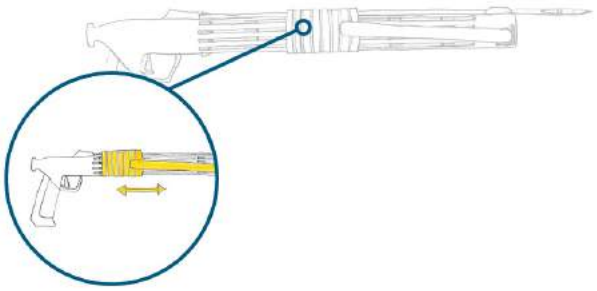
CONCEPT 2 | MAGNETIC SPEARGUN



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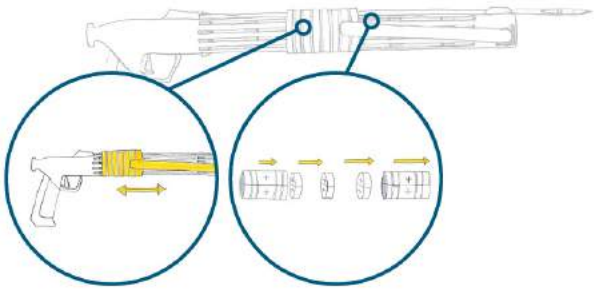
CONCEPT 2 | MAGNETIC SPEARGUN



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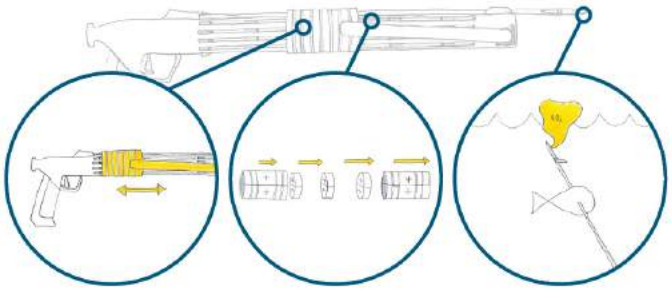
CONCEPT 2 | MAGNETIC SPEARGUN



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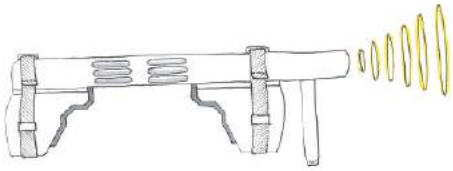
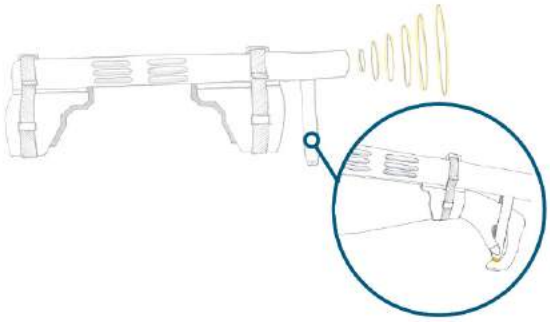
CONCEPT 3 | SONIC STUNGUN



Page 20

CONCEPT 3 | SONIC STUNGUN



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ARDEA			
Status Seminar I			
Date: 01-03-2016	Team no. 4	Worksheet no. 23	

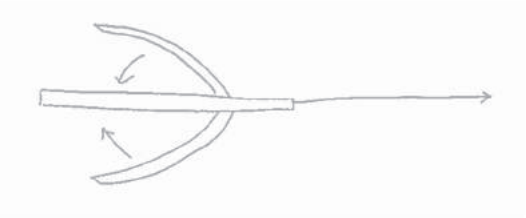
Evaluation:
The research and project scope was presented and a describtion of the problems within the makret, the conditionas and the existing spearguns was presented.
Concepts, which will change the way of spearfishing radically, were presented. The concepts are the results of the initial concept development process. The concepts are a combination of the different adjustment principles tested; modularity, telescope and all-round, and a combination of different ways to kill fish and loading principles.

Reflection:
The feedback from the status seminar was mostly on the research and and project scope. The audience mentioned several parameters within the research where the team should research and/or elaborate further.
The feedback from the status seminar mostly was on the presentation and research part and not very much on the concepts. The complexity in some of the concepts was mentioned and questioned.
After the presentation the team evaluated the different concepts, and concluded based on the feedback, that some of the concepts were too complex to be realized. The team discovered through the research an important parameter in spearfishing equipment; simplicity. This parameter is important to integrate and be aware of in the further concept development.

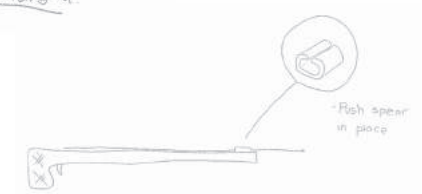
ARDEA		
Initial ideation - association technique		
Date: 25-02-2016	Team no. 4	Worksheet no. 25

Objective:
To start the ideation process the team began with spending some time on ideation through the association technique. The team listed up 18 words and selected 10 to ideate from. The word was: explosion, waterfall, childhood, wood, fast, frozen, computer, glasses, mess and order. There was spend three minutes on ideation on each word, and afterward the team discussed the sketches and sorted them into a YES, a NO and a MAYBE pile. The ideas put in the yes pile is ideas or principles that the team should definitely consider in the further ideation process. The ideas in the maybe pile has to be investigated further to see if the hold any potential.

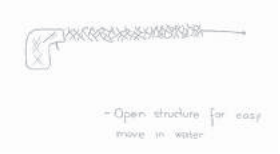
Experiment/Data:
Category: YES
Association: Fast

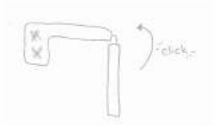


Association: Mess/Order



Association: Wood



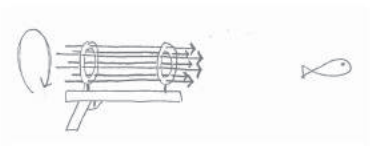


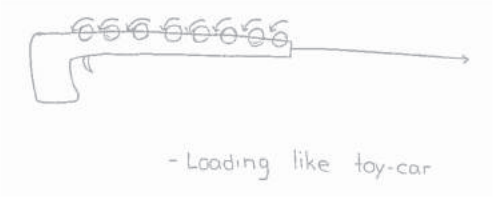
Association: Frozen

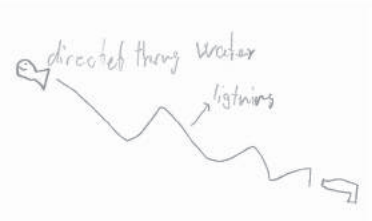
ARDEA		
Initial ideation - association technique		
Date: 25-02-2016	Team no. 4	Worksheet no. 25

Category: MAYBE

Association: Fast



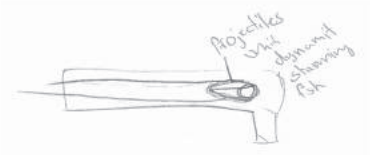




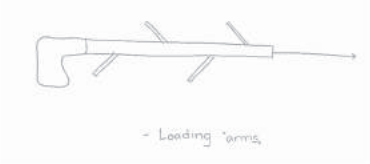
Association: Computer

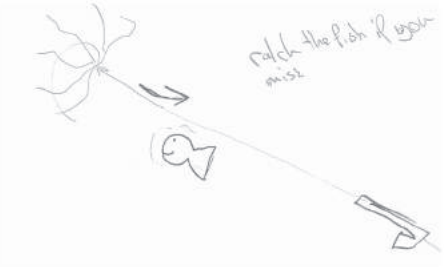
Association: Waterfall

Association: Explosion

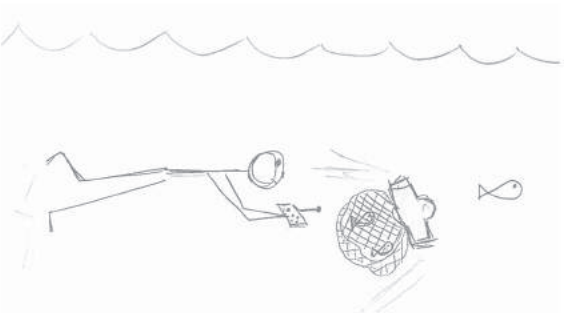


Association: Wood





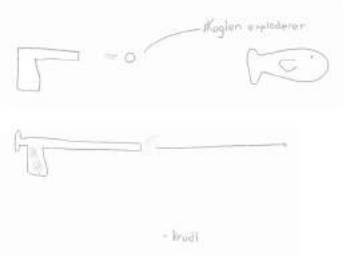
Association: Childhood

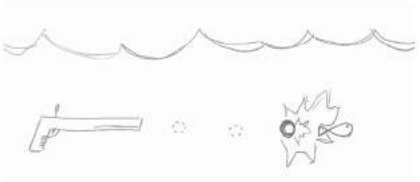


ARDEA		
Initial ideation - association technique		
Date: 25-02-2016	Team no. 4	Worksheet no. 25

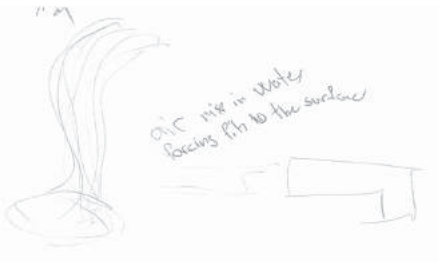
Category: NO

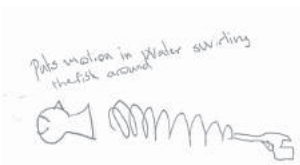
Association: Explosion

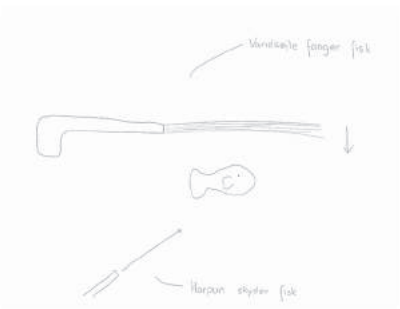




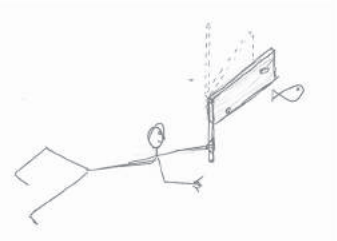
Association: Waterfall

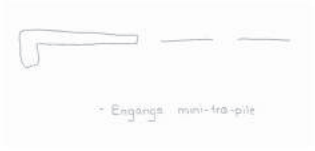




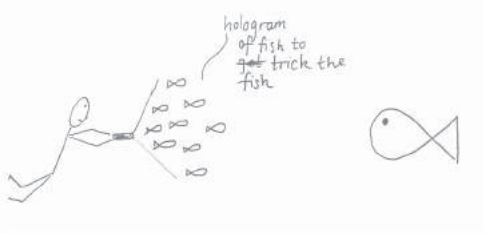


Association: Wood

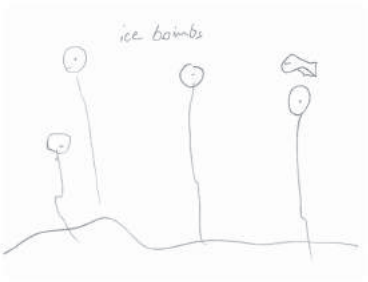




Association: Mess/Order

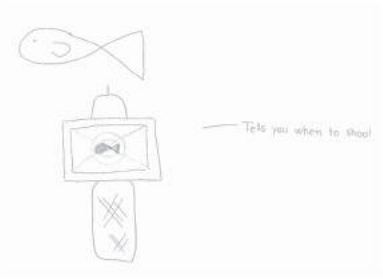


Association: Frozen

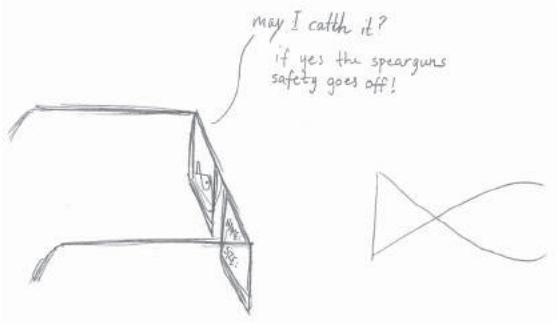


ARDEA		
Initial ideation - association technique		
Date: 25-02-2016	Team no. 4	Worksheet no. 25

Association: Computer

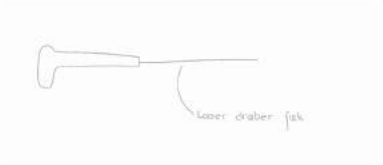


Association: Glasses



Association: Fast

Association: Childhood



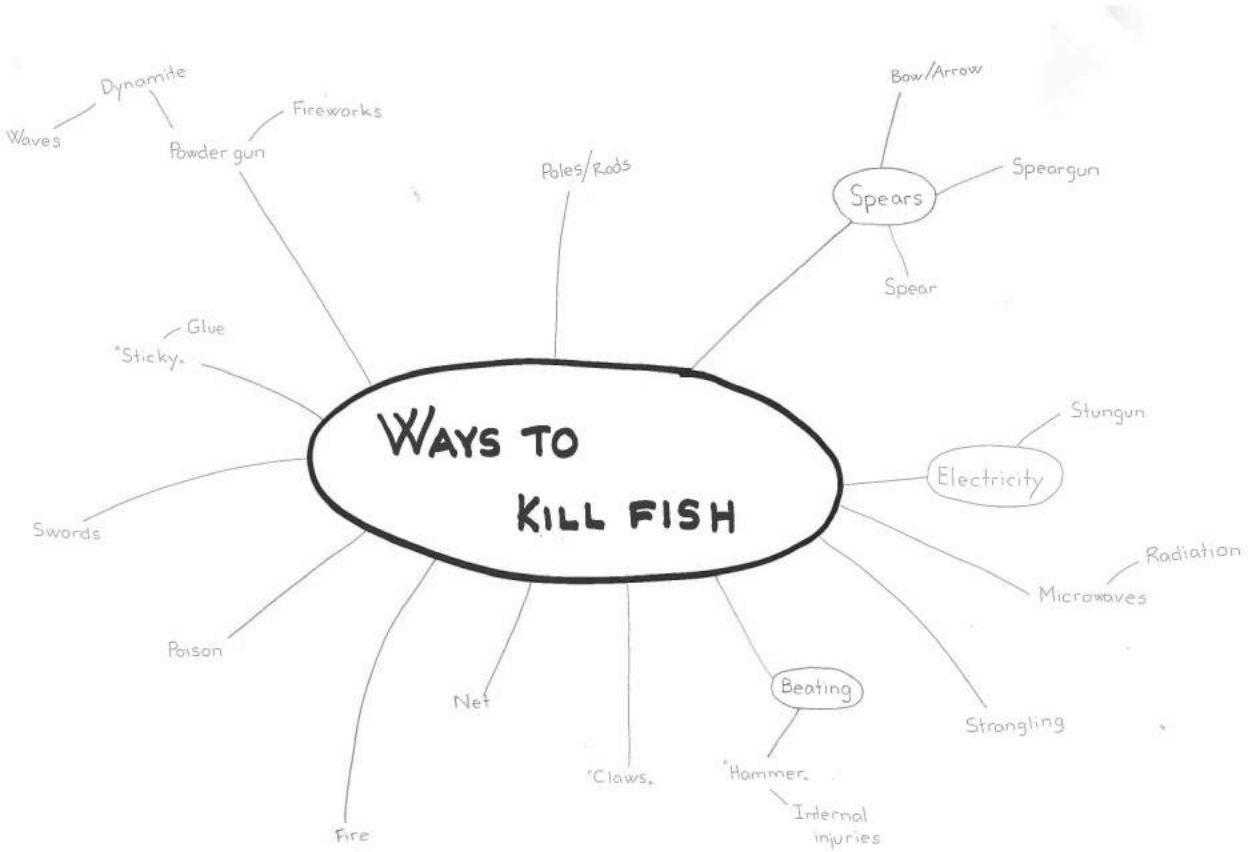
Evaluation:
The ideas which came up through the initial ideation process in ideas and principles the team can use in the further ideation and development process. The sketches will have to be evolved and combined.

Reflection:
The majority of the ideas are way to crazy and a bit of topic to be used. Some of the ideas, though, hold some potential which will have to be investigated further. Many of the ideas are just add-ons or adjustments on the existing spearguns, and the team would benefit from investigating other areas within underwater hunting.

ARDEA		
Ways to kill fish		
Date: 14-03-2016	Team no. 4	Worksheet no. 26

Objective:
The objective is to discover different ways to kill fish. To widen the solution area the team widen the area of interest to “How can you kill a fish while being under water?”.

Experiment/Data:
Through a mindmap the team will find different ways to kill fish.



Evaluation:
Some of the ways to kill fish found through the mind map is just to brutal, dangerous for the fisherman or to complex or difficult to design a product for, that they were opt out. This leaves back several different ways to kille fish, the team will have to investigate further to see if they have real potential.

Reflection:
Most of the ways of killing fish in the mindmap is against the spirit of spearfishing - mostly because it is not done with an actual spear. The team will have decide if this is something they will challenge or go back to the original way of killing the fish during spearfishing - with a speargun and a spear.

ARDEA		
Alternative ways to kill fish		
Date: 14-03-2016	Team no. 4	Worksheet no. 27

Objective:
From the mind-map of different ways to kill fish, the team found potential in three of the ways; shock waves, electricity and spears. The objective in this investigation is to find out if the three ways of killing fish will be possible to use and if they will fit the criteria within spearfishing.

Shock waves:
When investigating shock waves as a way of killing fish the research is lead to the Mantis shrimp. This little shrimp has a huge claw which it uses to stun its prey. The shock waves are created by it moving faster than the speed of sound and it is a very efficient way of killing your prey. It is naturally to look at this animal, because it lives in the ocean and uses it for killing small fish. The technology could be a nice feature in a new product for catching fish, but it will probably change the sport significantly. This is due to such a product will become really complex.

Ill. 01: Mantis Shrimp

Ill. 02: Electricity

Electricity:
Electricity is a source easy to control and it is already used in stun guns, where it is proven how it can be controlled. It could potentially be a really effective weapon to catch fish. The fact it is electricity and has to be used in water can seem dangerous in many eyes, and when the team suggested it in front of experts in spearfishing, it was not seen as the best idea in their eyes. This will probably also as the shock waves change the sport of spearfishing.

Spear:
The spear has always been used to catch fish and apparently still very much used today. It might not be the most efficient way of catching fish compared to a fishing net, where several fish are catch at once. But fishing with spear is not about that, because the ethics say that a spearfisher should only catch what he and his family can eat. The spear is making it more difficult to catch the fish. The spear will stay true to the sport.

Ill. 03: Spearfisher

ARDEA		
Alternative ways to kill fish		
Date: 14-03-2016	Team no. 4	Worksheet no. 27

Experiment/Data:
The investigation will be based on Internet research and an evaluation of the possibilities in the principles and of how they could be implemented into spearfishing/underwater hunting.

Evaluation:
The use of shock waves and electricity as the way of killing fish during underwater hunting is both possible but opt out of the team due to the fact, that it is a long way from traditional spearfishing. If the team should design a product for hunting fish using electricity or shock waves, they would probably have to create a whole new sport within the already small area of underwater sports.

Reflection:
From the investigation it became clear, that all three ways of killing fish is possible and all used around the world today. Though the possibility of using the three different ways the team decides to continue working on a product which will use spear as the way of catching and killing fish.

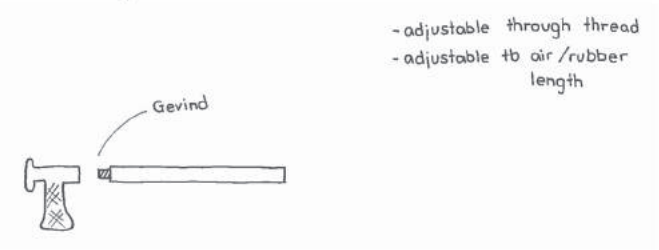
Sources:
https://en.wikipedia.org/wiki/Mantis_shrimp
Ill. 01: https://i.ytimg.com/vi/qVXGtX9HwdE/maxresdefault.jpg
Ill. 02: http://wallpaperscraft.ru/image/molniya_elektrichestvo_razryad_stihiya_opasnost_noch_linii_uzory_48451_3840x2160.jpg
Ill. 03: https://s-media-cache-ak0.pinimg.com/236x/04/3b/9f/043b9fa6c2ae102813b695978e083d53.jpg

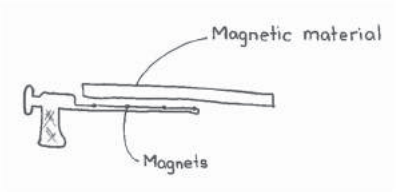
ARDEA		
Sketching session I		
Date: 15-03-2016	Team no. 4	Worksheet no. 29

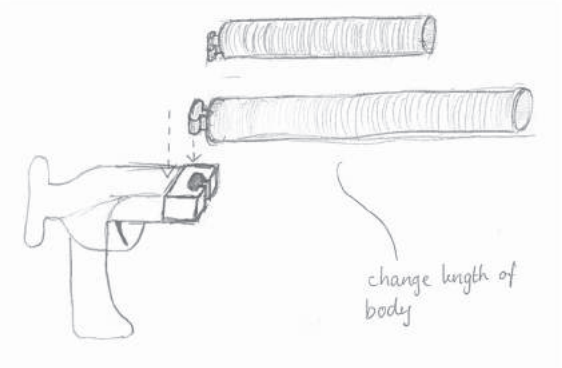
Objective:
The objective of this sketching session is to discover different ways to adjust the product based on the principles found through the previously mind-map. From the mind-map it was decided that the sketching session should focus on the adjustment principles of modularity and telescope. Besides these two principles the team decided to sketch from an all-round principle as well. The intention with the all-round adjustment principle was to see if it was possible to design one speargun which would fit all hunting purposes and conditions.

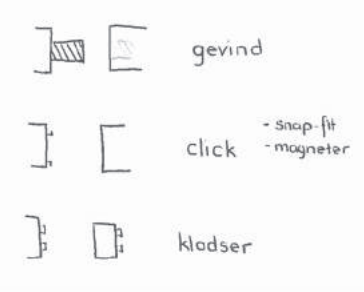
Experiment/Data:

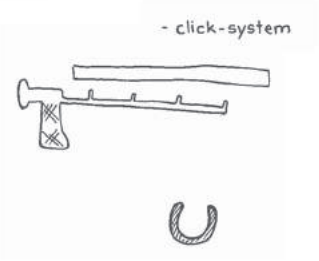
Modularity

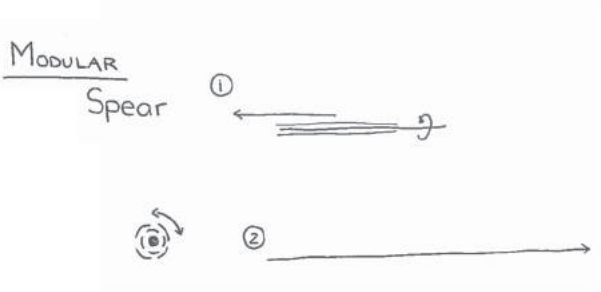




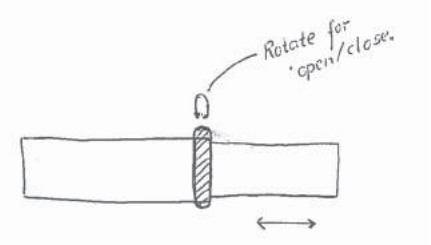


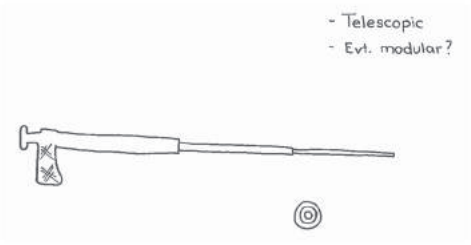






Telescope

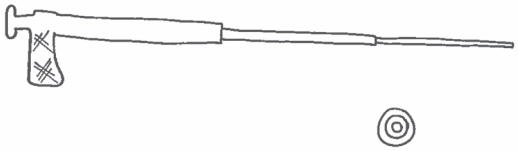




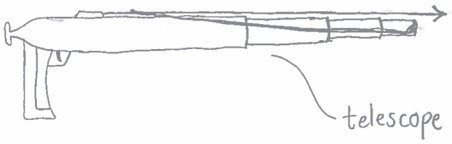
ARDEA			
Adjustment of barrel			
Date: 11-03-2016	Team no. 4	Worksheet no. 28	

ADJUSTABLE

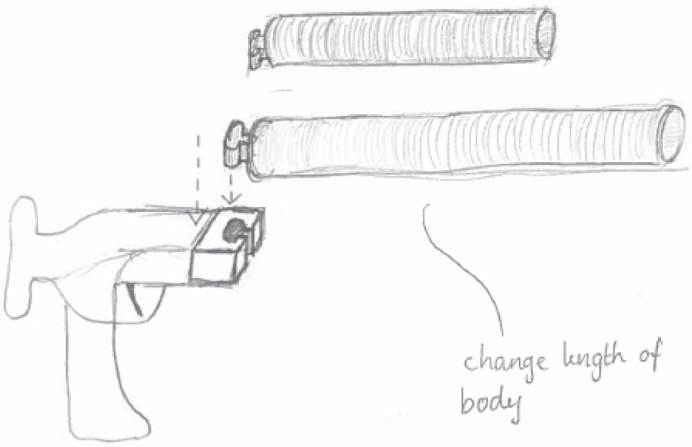
- Telescopic
- Evt. modular?



JUSTÉRBAR



MODULARITY



ARDEA		
Sketching session i		
Date: 26-04-2016	Team no. 4	Worksheet no. 29

Objective:
The team needs to create an overview of different adjustment principle of the barrel, which can be used by the user to change the length of the speargun, through brainstorming. Pros and cons will be made on each principle to find out which should be tested through mock-ups and developed further on.

Experiment/Data:
Modular:
Full-size modules
- + Only one speargun is needed
- + Strength
- + Low complexity
- + User can purchase only the necessary parts
- - Spareparts take up space when not in use
- - Spareparts have to be transported every time

Part modules - Split, Joint, Thread, Click Spring, Interlocking Shape
- + Only one speargun is needed
- + Add-ons makes it possible to upgrade
- + User can purchase only the necessary parts
- - Less strength / more weak points
- - More complexity
- - Spareparts take up space when not in use
- - Spareparts have to be transported every time

Ill. C.XX: Description

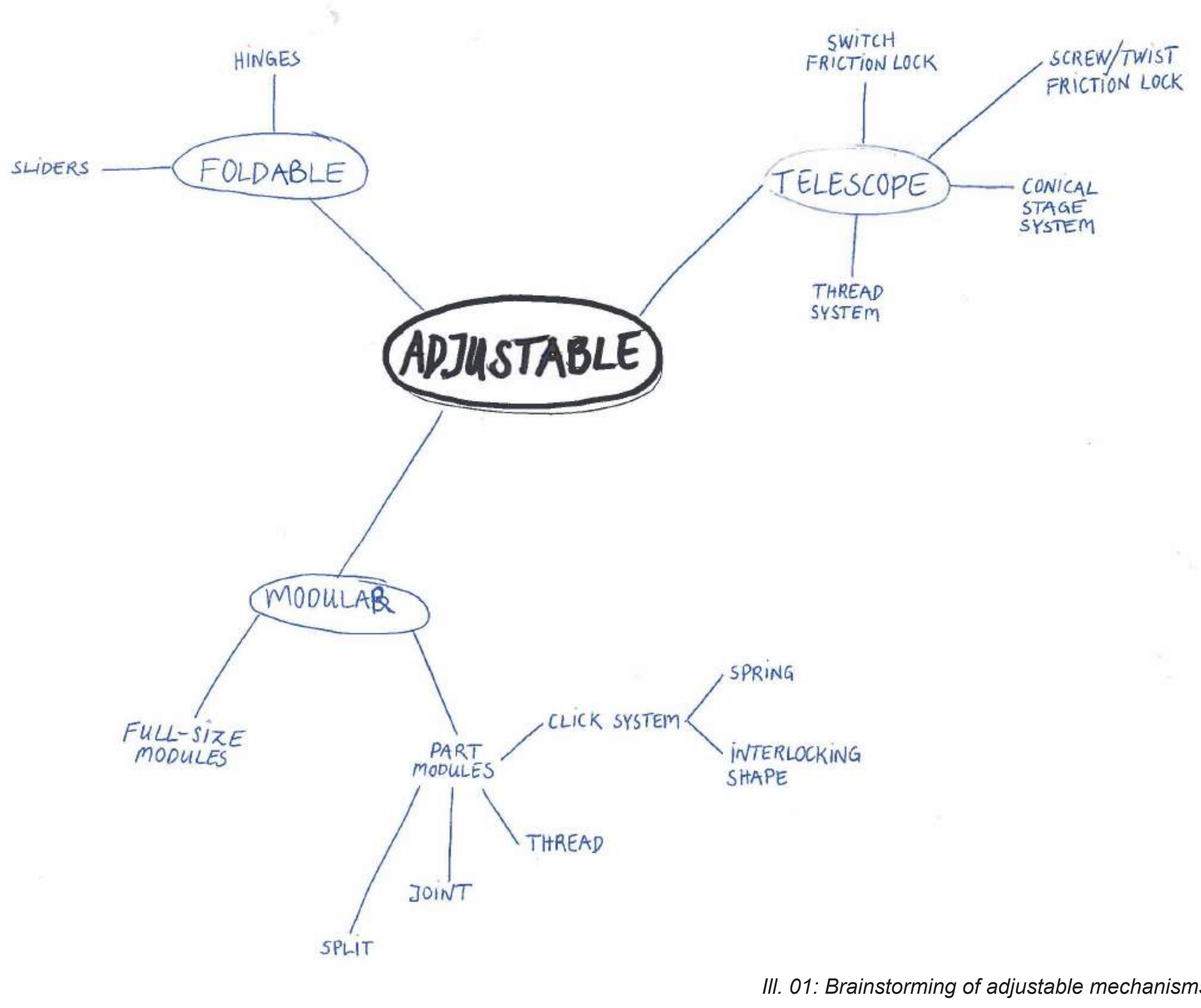
Telescope:
Switch Friction Lock, Twist Friction Lock, Conical Stage System, Thread System
- + Only one speargun is needed
- + Adjustable at the spot
- + Takes less space during transport
- - Less strength / more weak points
- - More complexity
- - Possibility of interfering with loading principle

Foldable:
Hinges
- + Only one speargun is needed
- + Adjustable at the spot
- - Less strength / more weak points
- - More complexity
- - Possibility of interfering with loading principle

Evaluation:
All mechanisms have some pros and some cons, and therefore the team has to decide which parameters are more important than others and judge by these. First of all the team has to compare it with the requirement specifications and then how would the business case look for each mechanism. The full-size modules will definitely have a higher strength, lower complexity and thereby lower risk of breaking parts. The telescope has more complexity and thereby greater risk of broken parts, but it is faster to adjust the length at the spearfishing spot and it can take less space during transport than the modular.

ARDEA	
Sketching session	
Date: 26-04-2016	Team no. 4	Worksheet no. 29

Reflection:
The process of the mind-map helped the team to consider which adjustable mechanisms they see the most potential in than others. [illegible] The team will look more into full-size modules, part modules and telescope. This leaves the foldable behind, because it does not have the necessary [illegible] the requirement specifications the team has made. The full-size and part modules have the best opportunity to make a great business case, because of the possibility to buy add-ons after the [illegible] The telescope fulfils the requirement of making the transportation easier and the adjustability quicker at the actual spearfishing spot.
The team will use the principles found through the mind-map (modular and telescope) as base for a sketching session to discover the different potentials [illegible] about the danish ocean conditions being low visibility, cold and a lot of flatfish, which Morten Rosenvold Villadsen himself told in our previous interview.



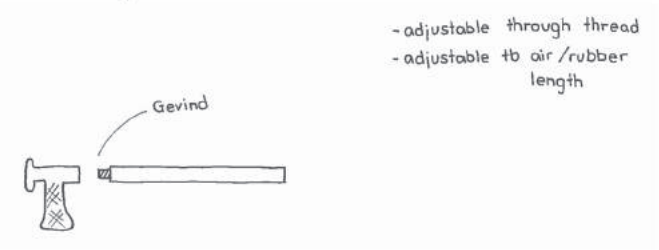
Ill. 01: Brainstorming of adjustable mechanisms.

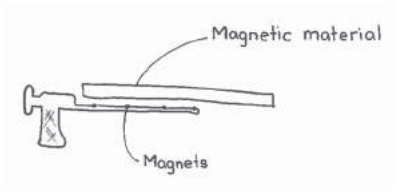
ARDEA		
Sketching session I		
Date: 15-03-2016	Team no. 4	Worksheet no. 29

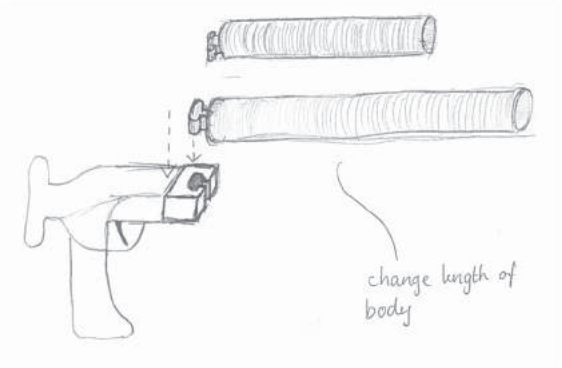
Objective:
The objective of this sketching session is to discover different ways to adjust the product based on the principles found through the previously mind-map. From the mind-map it was decided that the sketching session should focus on the adjustment principles of modularity and telescope. Besides these two principles the team decided to sketch from an all-round principle as well. The intention with the all-round adjustment principle was to see if it was possible to design one speargun which would fit all hunting purposes and conditions.

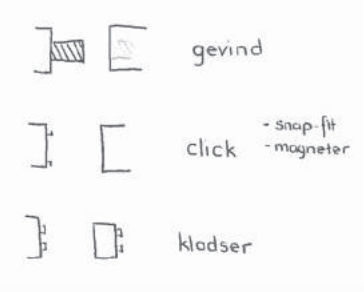
Experiment/Data:

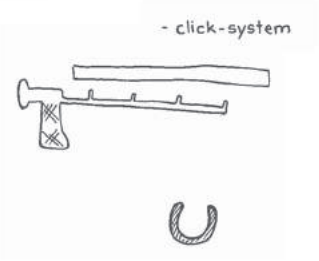
Modularity

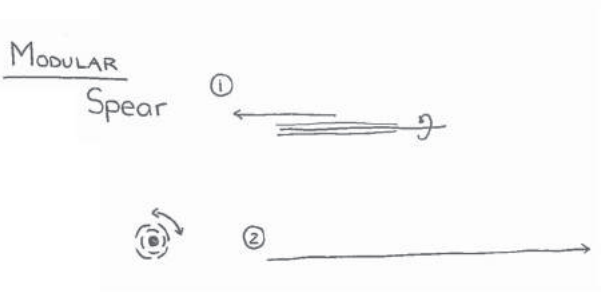




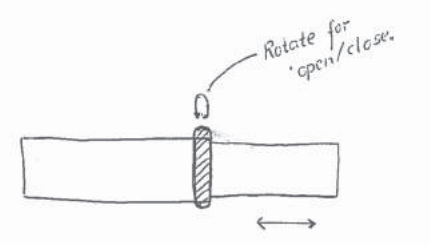


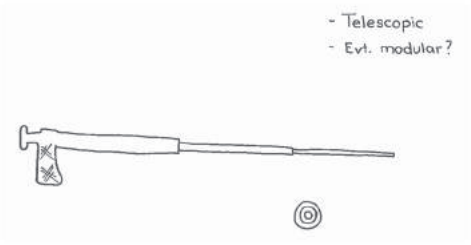






Telescope





ARDEA / PROJECT TITLE	
Sketching session / Guy Skinner, President/CEO, JBL International	
Date: 26-04-2016 / 15-03-2016 · Team no. 4 · Worksheet no. 29 / XX	

Evaluation:
From the sketching session it became clear that an all-round speargun was difficult to sketch on due to the fact that it might be like any other speargun just sited for every condition and purpose. It would be difficult to design an all-round speargun in a different way from the exiting spearguns. The main task for the team would in general be to investigate if it even would be possible to use one speargun for all purposes.

Reflection:
The sketching session gave a lot of different ideas inside the principles of modularity and telescope. These ideas will have to be further investigated and evaluated.

Objective:
The objective is to understand the whole process of spearfishing from preparing at home to spearfishing under water by observing. This would also show any problems not discovered through the questionnaires and interviews.

Experiment/Data:
Observing Morten Rosenvold Villadsen and how he normally spearfish through video material to build a scenario of pictures. The pictures should be able to illustrate each sequence of spearfishing.

Evaluation:
The pictures gives an idea of how the spearfishing actually works and the video confirmed the statements about the danish ocean conditions being low visibility, cold and a lot of flatfish, which Morten Rosenvold Villadsen himself told in our previous interview.

Reflection:
So far the team has been researching a lot through the internet and people who are spearfishing, so now the team needs to make more hands-on researching, where we try to do it ourselves to get a deeper understanding of spear-fishing and see if we find other problems and opportunities by acting it out.

Sources:
https://www.youtube.com/watch?v=MGrPr_V6xUQ
http://undervandsitetet.dk/undervandsjagt/

ARDEA		
Evaluation of the three directions		
Date: 16-03-2016	Team no. 4	Worksheet no. 30

Objective:
The objective is to investigate the potential of the three different principles found through the mind-map (Worksheet no. 29).

Experiment/Data:
Modularity:
Pros/Cons:
+ The low complexity in the construction
+ The user can purchase only the necessary parts
- The user needs to bring the modules to the water to be able to adjust the speargun in the water
- The modules take up space when they are not in use
- The construction will possibly be weak in the assembling points

Telescope:
Pros/Cons:
+ The user can adjust the speargun while being in the water
+ The speargun takes up less space during transport
- The telescope can be fragile
- The medium-high complexity in the construction

All-round:
Pros/Cons:
+ Only one speargun is needed
+ The speargun fits all conditions and hunting purposes
+ No need for extra components
- The speargun will not fit any conditions or hunting purpose perfectly
- The business case around an all-round speargun would be weak

Evaluation:
From the evaluation of the three directions it was determined to opt out the all-round principle. An all-round speargun would never become as good and sufficient as having several different spearguns. The business case for the all-round speargun would be weak due to the customer only having to purchase one speargun and not having to buy any extra products besides for maintenance and replacement of worn out components.

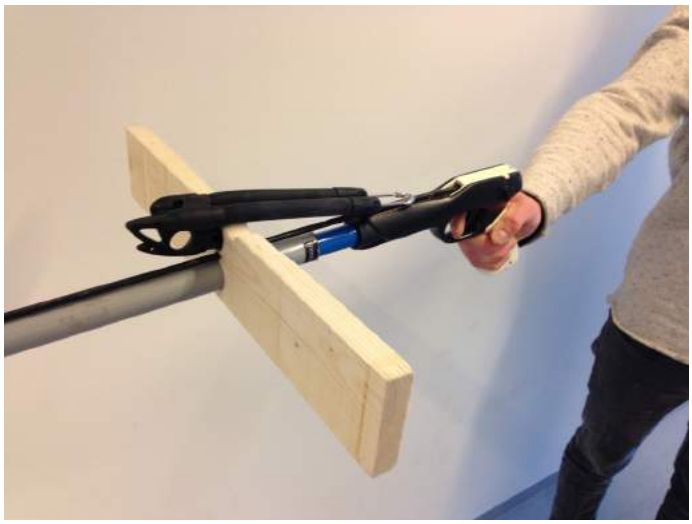
Both the modular and telescopic principles would be able to adjust to different lengths and be suited for all the different hunting purposes and conditions the user could experience in the Danish oceans.

Reflection:
From the evaluation the team is able to opt out the all-round as a principle for the product. The team will have to look more into the principles of modularity and telescope and perhaps investigate if a combination of the two would be preferable.

ARDEA		
Testing the adjustment principles		
Date: 16-03-2016	Team no. 4	Worksheet no. 31

Objective:
The team needed to find out how the adjustable principle would work integrated in a speargun and with the new loading principle, and thereby get an idea of what to focus on moving forward in the development of the product.

Experiment/Data:

Evaluation:
The adjustable principle of the barrel seems to work well, and it will definitely be possible to integrate with the new loading principle.

Reflection:
The adjustable principle was tried with one locking mechanism between the two barrels, and therefore the team has to look at other locking mechanisms between the barrels later in the development.

Sources:
Own pictures

ARDEA		
Loading Principles		
Date: 18-03-2016	Team no. 4	Worksheet no. 32

Objective:
The team need to create an overview of different loading principles, which can be used for a new speargun, through brainstorming. Each principle will be walked through by making pros and cons to find out which principles should be developed further on and tested through mock-ups.

Experiment/Data:
Rubber band:
- + Simple construction
- + Easy maintenance
- + Easy to replace
- + Low cost
- + Possible to change power of speargun
- + Maintain power in all depth
- + Even transfer of energy
- + No pollution
- + Legal in all countries
- - Short life cycle
- - Require a lot of arm strength to load
- - Fragile to sharp objects
- - Degradable to UV
- - The power decrease below 5 Celsius

Air:
- + High power
- + Maintain power over time
- + No pollution
- + Low maintenance frequency
- + Compact
- + Legal in all countries
- - Extra equipment needed to load
- - Require a lot of arm strength to compress
- - Power decreases in deep waters
- - Complex construction
- - Difficult to replace components
- - Low variation in power

CO2:
- + High power
- + Require low arm strength to load
- + Simple loading
- - Illegal in most countries
- - Loud

Spring:
- + Easy to load
- - Low power
- - Power decreases quickly over time

Electricity:
- + Easy to load
- - Feasibility is a question mark
- - Complex construction
- - Dangerous to use in water

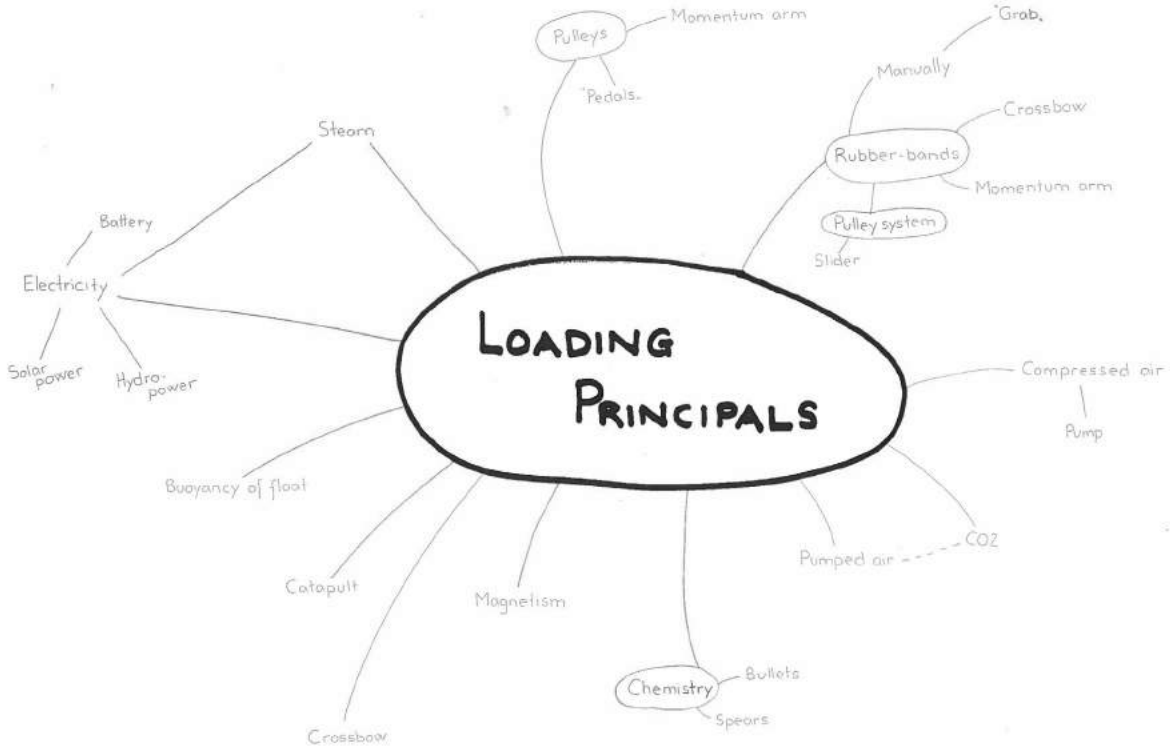
ARDEA		
Worksheet title		
Date: 18-03-2016	Team no. 4	Worksheet no. 32

Magnetism:
- + Potentially easy to load
- - Complex construction
- - Difficult to maintain
- - Feasibility is unknown

Chemical
- + Easy to load
- - Pollute
- - Complex construction
- - High maintenance
- - Dangerous to use in water

Evaluation:
Rubber band, air, CO2 and spring are all principles that are or have been used for loading spearguns. Rubber band and air are the most used principles today, because they simply have the most pros. CO2 is illegal in most countries and springs are not able to transfer the needed power. The team wanted to open up for new loading principles to see if it was possible to do the loading in another and more efficient way. Electricity, magnetism and chemicals have not been used before for loading a speargun and therefore the team wanted to look more into these principles, because they are used for a lot of other weapons. Electricity and chemicals are both principles that can be very dangerous to use in water if the system is not fully closed. Magnetism is interesting, but will possibly make a speargun very complex in it's construction and the feasibility of such a system is very insecure.

Reflection:
Through pros and cons of all principles the team decides to increase potential loading mechanisms to rubber band and air, because they not only have the most upsides, but are also already proven to work in practice. The other principles are also proven to work, but not in water and they will also make the speargun more complex and potentially more expensive. These mechanisms will potentially also change the sport of spearfishing, which the team from beginning did not want to.



Ill. 01: Brainstorming of loading principles.

ARDEA		
Force test of rubber bands		
Date: 25-04-2016	Team no. 4	Worksheet no. 33

Objective:
The objective is to investigate the force needed for loading an existing speargun to have a foundation for further calculations.

Experiment/Data:
A test is made where an exiting 50 cm and 75 cm speargun is loaded. By pulling the rubber band on the speargun with an baggage weight it is possible to determine the force needed to load the speargun. The rubber bands on the two speargun tested are 16 mm in diameter.

The force needed to stretch the rubber band is:

Stretching length	Kg	N
10 cm	22	216
20 cm	32	314
30 cm	42	412
40 cm	36	353
50 cm	45	441

The numbers from 10-30 cm stretch are based on the 50 cm speargun and the numbers from 40-50 cm are based on the 75 cm speargun.

Evaluation:
Despite the insecurities in the performance of the test it is possible to determine the approximate force needed for stretching the rubber bands. These numbers can be used in the further investigation of rubber bands regarding determining the rubber band suited for the new speargun.

Reflection:
The team now has some numbers to use for calculating the rubber bands needed for the new speargun.

ARDEA			
Force test of rubber bands			
Date: 25-04-2016	Team no. 4	Worksheet no. 33	

Ill. C.XX: Description

ARDEA		
Loading Mechanisms		
Date: 18-03-2016	Team no. 4	Worksheet no. 34

Objective:
The team needs to create an overview of different loading mechanisms, which can be used to ease the principles of rubber band and air compression, through brainstorming. Pros and cons will be made on each mechanism compared to how the existing speargun mechanisms work, to find out which mechanisms should be tested through mock-ups and developed further on.

Experiment/Data:
Rubber band & Air Compression:
Boyance from float
- + Using existing equipment
- + Not limited by arm length and strength
- - Requires diving with a lot of force
- - More difficult to load compared with hands
- - More line attached to the speargun

Air Compression:
Pumping system
- + Split the force into several sequences
- + Adjust the power you load with
- + Not limited by arm length and strength
- - Complex construction
- - Difficult to repair
- - Small damage influences the whole system

Closed magnetic system
- + Closed system
- + No maintenance potentially
- - Difficult to repair
- - Replace components
- - Small damage influences the whole system
- - Difficult to variate length and power

Rubberband:
Momentum arm
- + Less force needed to load
- + Simple construction
- + Easy to repair
- + Proven mechanism (used in spearguns in the 1970's)
- + Not limited by arm length and strength
- - More resistance surface in the water
- - Momentum arm needs to be long to be efficient
- - More weight

Several rubber bands
- + Known system
- + Adjust the power
- + Split the force into several sequences
- - Takes longer time to load
- - More parts
- - More maintenance

Several steps system
- + Split the force into several sequences
- + Adjust the power
- + Not limited by arm length and strength

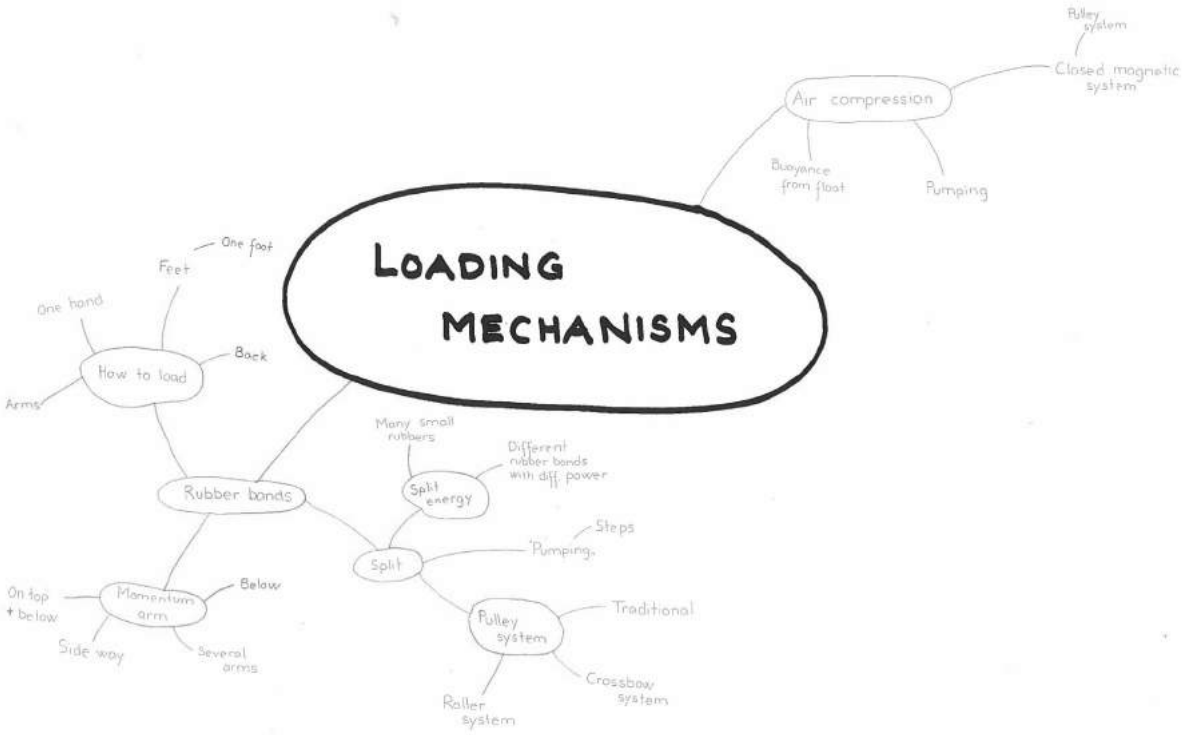
- - Takes longer time to load

Pulley system
- + Requires less force to load
- + Proven system (used in existing roller spearguns)
- + Possible to load with one hand
- + Not limited by arm length and strength
- - More parts
- - Longer loading path
- - More line
- - More weight

Change load position:
- + Use stronger muscles in the body
- + More ergonomic load positions
- + Possible to keep simple in construction
- + Flexible in the amount of power transferred
- + Easy to unload
- - Potentially dangerous during loading of rubber band

Evaluation:
Almost all of the loading mechanisms will make the speargun more complex in construction, but some more than others. The systems used in combination with air compression are difficult for the user to repair and the length of the speargun will be very difficult to change. The mechanisms combined with rubber band are all making the speargun a bit more complex, but it will help making the loading easier for the spearfisher. The change of loading position will also potentially make the loading easier.

Reflection:
The team decides to work further on the momentum arm, pulley system and the change of loading position to see the potential of each and see if it is worth making the speargun a bit more complex by using these mechanisms.

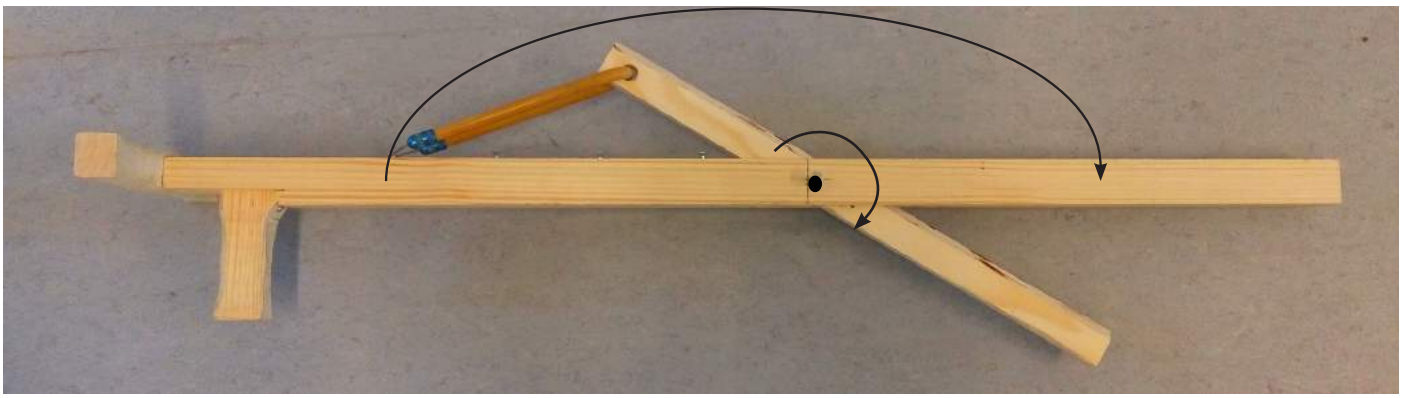


Ill. 1: Brainstorming of loading mechanisms.

ARDEA		
Rapid prototyping of loading principles		
Date: 19-02-2016	Team no. 4	Worksheet no. 35

Objective:
This worksheet describes the prototyping of different loading principles for making it easier to load the speargun. The different loading methods have been made in different materials and detail levels. Some have been tested in conditions comparable to the ones in spearfishing, while others out of context. The aim of the prototypes is to test out basic loading principles to make an indication of the possibilities of creating a new way of loading a speargun.

Experiment/Data:
1. Prototype



The first prototype was focusing on a torque arm which would reduce the force needed to load the speargun. This principle made the force needed to load the speargun feel easier, but the travel length of the rubber band is stretched in two directions, which require more force than in one direction. This results in a harder loading method than first anticipated. It still feels easier to load and has a better grip, than the current solution. Another fact which was noted during the test, was that it was hard to find the best position to load the gun (shown on pictures above). If this concept had to be developed further, it would have to look into making the travel of the rubber band shorter and optimizing the position you load it in. It was easier to load the gun, with the legs or if it was placed upside down as shown on the pictures.

ARDEA		
Rapid prototyping of loading principles		
Date: 19-02-2016	Team no. 4	Worksheet no. 35

2. Prototype




This prototype is focusing on changing the position for loading the speargun. Some of the strongest muscles in the body is in the legs and this prototype and principle is focusing on using these muscles for loading the speargun. The speargun is loaded by pushing a load pad forward and away from the body, This principle of loading the speargun worked really well and it became extremely easy to load the speargun for all users compared to the regular method. In extension to this loading principle another feature of this was integrated. This function was to use friction of the material to lock the speargun when it was loaded. This makes it possible to load the speargun in many different stages so that high and low power can be added to the gun easily. Another pro with this way of loading the gun is that the user's fingers does not get stuffed and it is easy to unload the speargun out of the water.
This loading types shows promise, but it has to be tested in water, to see how hard it is in the water, how the fins behave.

ARDEA		
Rapid prototyping of loading principles		
Date: 19.02-2016	Team no. 4	Worksheet no. 35

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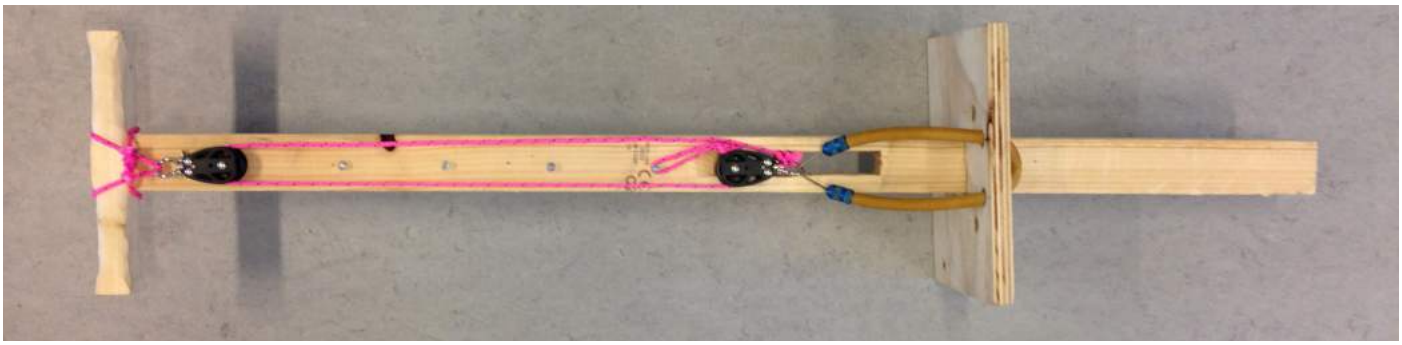
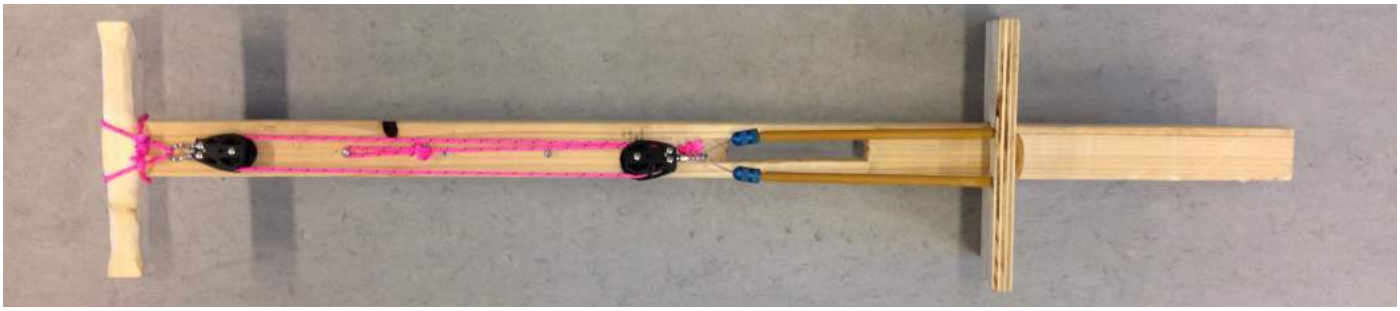
3. Prototype





This prototype is build upon a principle around pulleys, which can ease the load force needed when loading the speargun. It is building upon making the force which is needed to load the speargun lower and divided over a longer expansion length. The principle worked well and the amount of force needed to load the speargun was clearly reduced. This principle would ease the user's force needed, when loading the gun. The cons of the principle is that the loading length gets extended which means more space is needed for loading. Another con of this principle is more line and string is needed for loading the gun.

Evaluation:
The rapid prototyping gave a fast and good foundation to test out some simple methods of loading the speargun. The models can also be used further for more advanced prototyping. The test gave an understanding of the importance of looking at the anatomy of the body to find out which muscles is strongest and can ease the job of loading the speargun. Furthermore the test gave ideas for the following prototyping of new methods the speargun could be constructed on.

Reflection:
Before creating the spearguns it would have made sense to create some drawings so the measurements could be linked to the current spearguns.

ARDEA		
Further Investigation of Loading Mechanisms		
Date: 23-03-2016	Team no. 4	Worksheet no. 36

Objective:
The team needs to create an overview of different loading mechanisms, which can be used to ease the principles of rubber band, through brainstorming. Pros and cons will be made on each mechanism compared to how the existing speargun mechanisms work, to find out which mechanisms should be tested further through mock-ups.

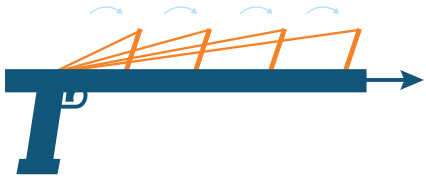
Experiment/Data:

Rubber band:
Momentum arm 1
A momentum arm placed through the body of the speargun. When loaded the arm could potentially fit inside the body and be hidden which would result in the same resistance through the water as the existing speargun.

- + Less force needed to load
- + Simple mechanism
- + Easy to repair
- - Momentum arm needs to be long to be efficient
- - Spear and momentum arm will conflict with each other
- - The user may not be able to reach the momentum arm

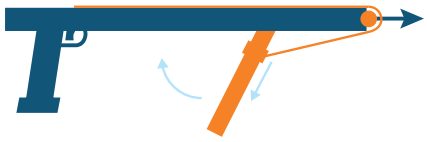
Momentum arm 2
Several momentum arms divide the force needed to load th speargun into several sequences. The arms need to be pushed forward to stretch the rubber bands.

- + Force divided into several sequences
- + Possible to build up same amount of power by using less force per step
- - The momentum arms need to be pushed instead of pulled
- - More steps and time needed to load the speargun
- - The user may not be able to reach the outer momentum arms
- - Many parts, which gives more maintenance
- - Several rubber bands need to be connected to the spear
- - Difficult to control an even transfer of energy from all the rubber bands to the spear



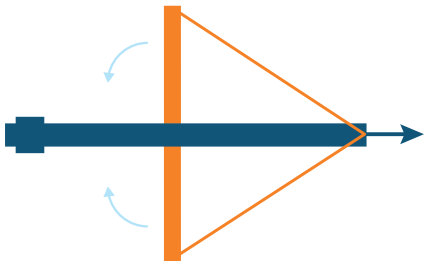
Momentum arm 3
Momentum arm placed beneath the body of the speargun. The rubber band is running through a roller at the tip of the speargun and connected to the momentum arm. The rubber band will be stretched when the momentum arm is pulled and the force needed decreases due to the roller.

- + Proven mechanism (used in spearguns in the 1970's)
- + Less force needed to load
- - Semi-advanced construction
- - Might disturb the shooting precision



Momentum arm 4
Two momentum arms placed on the side of the speargun. The two arms are pulled towards the user, which will stretch the rubber band and thereby load the speargun.

- + Not limited by arm length
- - Possibly difficult to attach the rubber band to the spear when the two momentum arms are pulled back
- - Uneven transfer of energy in the rubber band
- - Requires long rubber band
- - Might disturb the shooting precision



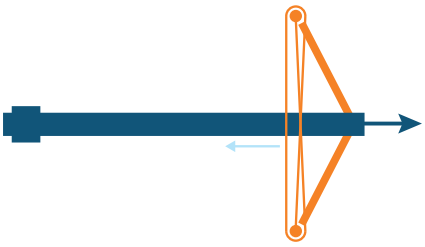
Pulley system 1
The pulley system function by a combination of two pulleys; one placed in the front of the speargun and one by the handle. The system decreases the force needed to load the speargun to a forth of the original force.

- + Requires less force to load
- + Possible to load with one hand

- + Not limited by arm length and strength
- - More parts / advanced construction
- - Longer loading path
- - More line
- - To load the speargun you need to pull the line in the pulley system three times the normal length of the rubber band
- - More weight
- - The whole pulley system should be placed inside the body of the speargun to reduce the risk of damaging the components
- - Difficult to repair or replace components

Pulley system 2

The system is similar to a traditional crossbow. The user pulls the rubber band, which is tied up in a pulley system, and drags the rubber band down to the notch in the spear for attachment and loading of the speargun.



- + Less force needed to load the speargun
- + Already existing and proven to work principle
- + Easy to replace components
- - Bad weight distribution / heavy at the tip of the speargun
- - High resistance in the water
- - Complex construction

Pulley system 3

The system works like the existing 3rd generation roller spearguns. The rubber band is attached beneath the body of the speargun and runs through a roller on both sides of the body. To load the speargun the user pulls the rubber band down to the notch of the spear.

- + Less force required to load the speargun
- + Easy to replace parts
- - Requires long rubber band
- - Length of speargun depends on arm length of the user
- - More components and risk of damaging these
- +/- Existing principle

Change load position:

Both legs

When the user uses the legs to load the speargun it is possible to use bigger and stronger muscles in the human body, and thereby it will be easier to load the speargun.

- + Use stronger muscles in the body
- + Potentially more ergonomic load position
- + Possible to keep simple in construction
- + Easy adjustment in the amount of power transferred
- + Easy to unload
- - Potentially dangerous during loading of rubber band
- - Possibly heavy in the tip of the speargun

One leg

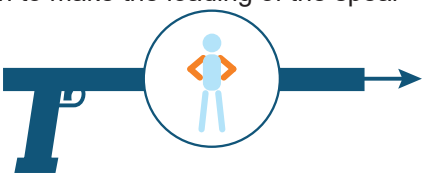
Using one leg will help the user to use stronger and bigger muscles in the body, but will probably cause inappropriate and uncomfortable twist of the body.

- + Use stronger muscles in the body
- - Difficult to load the speargun without dragging or tilting towards one side
- - Inappropriate twist of the upper body when using only one leg
- - Potentially dangerous during loading of rubber band
- - Possibly heavy in the tip of the speargun

ARDEA		
Further Investigation of Loading Mechanisms		
Date: 23-03-2016	Team no. 4	Worksheet no. 36

Both arms

Using both arms are the way you load a speargun today. This technique has proven to make the loading of the speargun really hard for most spearfishers.



- + Simple principle
- + Existing and already known principle
- - Non intuitive approach
- - Hard to load the speargun
- - Necessary to support the speargun against the chest, which causes a high pressure on a small surface

One arm

Using one arm gives the user longer range and more flexibility. It will give the user half the strength compared with using two arms and might cause inappropriate twists in the body.

- + Longer range with one arm than two arms
- + More flexibility
- - Half the strength compared to using both arms
- - More instability when loading the speargun

Evaluation:

Loading with the legs if deciding to keep the rubber bands for loading the speargun seems to be the best principle for loading the speargun in the future. It gives you more and stronger muscles to load with and it also seems more ergonomic to do it in that way, because you are not twisting in the upper body in any way.

Reflection:

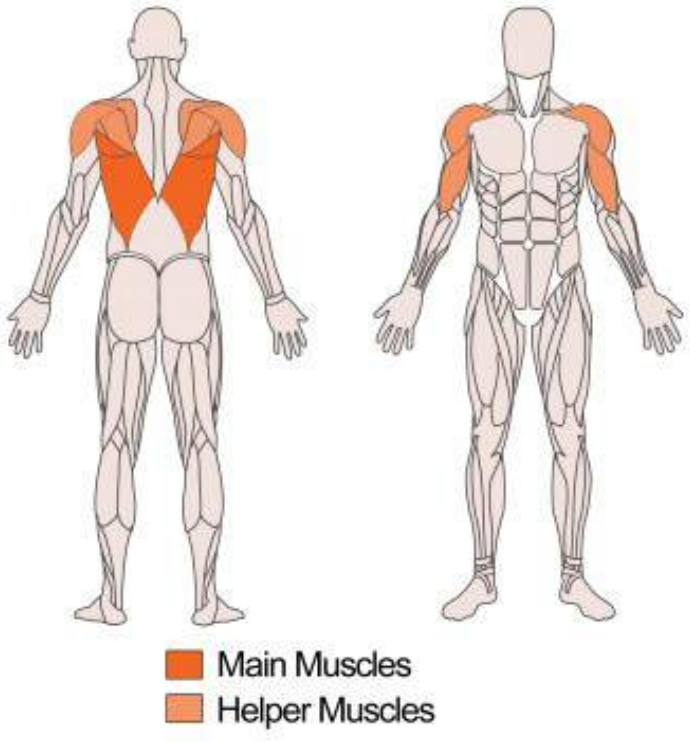
The evaluation has to be confirmed through a physiotherapist or similar, who are working or studying daily with the human body and understand how it works and how people causes injuries on their body. They can probably confirm what the team believes is a better position for loading the speargun.

ARDEA		
Investigating use of muscles		
Date: 18-03-2016	Team no. 4	Worksheet no. 37

Objective:
The team needs to get confirmation upon its hypothesis regarding the use of muscles while loading the speargun. The change of loading position will in theory make it easier to load the same amount of force as the original loading technique.

Experiment/Data:
Each loading position uses different muscle groups in the human body. The loading positions are compared to exercises from the gym in order to find the muscles used in each loading technique.

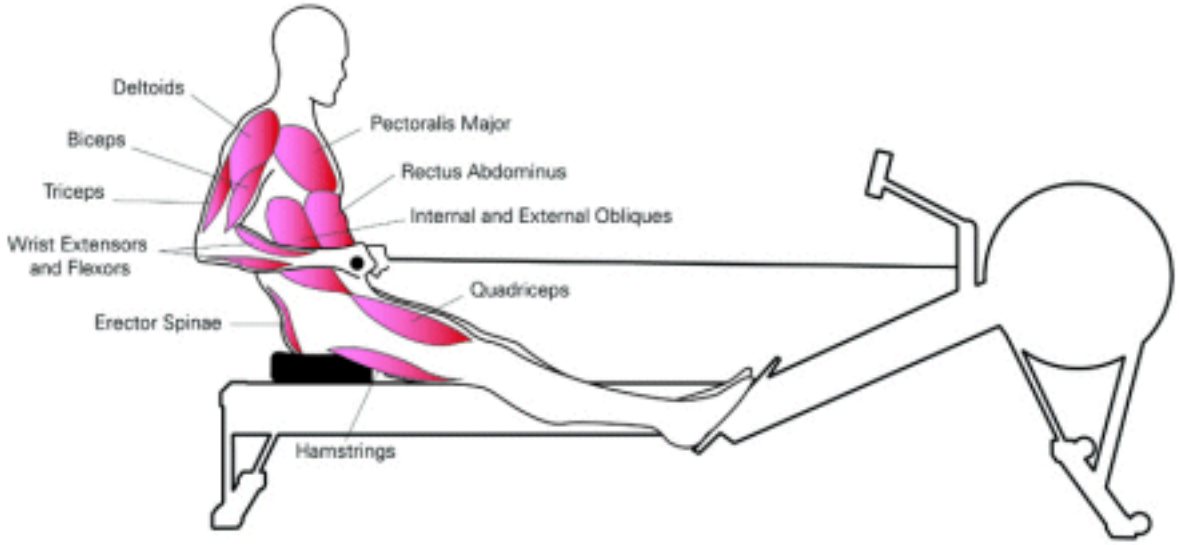
Original loading position with rubber band powered speargun:
Middle Back (Latissimus Dorsi)
Upper Arms (Biceps and rear deltoids)



Ill. X.01: Muscles used in original loading of speargun

ARDEA		
Investigating use of muscles		
Date: 18-03-2016	Team no. 4	Worksheet no. 37

New loading position with legs:
Back (Erector Spinae, Rhomboids, Trapezius)
Arms (Deltoids, Triceps, Wrist Extensors and Flexors, Biceps)
Legs (Hamstrings, Gatrochnemius and Soleus, Quadriceps, Glutes)
Front Upper Body (Pectoralis Major, Rectus Abdominus, Internal and External Obliques)



Ill. X.02: Muscles used in new way of loading speargun

The illustrations are clearly indicating the difference in the amount of muscles used in the exercises, and therefore it seems to be easier or more optimal to load the speargun with the new loading technique with the legs. The team still felt it necessary to contact a physiotherapist to confirm what is concluded from the illustrations. Kristian Duncker, Physiotherapist student, says that the new loading position will make it easier and better for the body to load the speargun with the new technique, because you will divide the force required out on more parts of the human body and have a more natural motion. It is force required to load the speargun, which is around 40-45 kg (Worksheet no. 33), because you are using bigger and more muscle groups than you do with the original loading technique.

Evaluation:
It is clear from the experiment that the new loading position uses the most and also the biggest muscle groups. Thereby it will be easier for the user to load the spearguns. The force required to load the speargun, which is around 40-45 kg (Worksheet no. 33), will not only be easier but also better for the human body, because you are using bigger and more muscle groups than you do with the original loading technique.

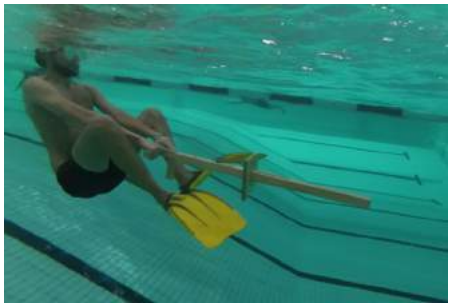
Reflection:
The team's hypothesis about the new loading position making it easier to load the speargun is confirmed. The team will therefore develop further on this loading principle and test it. The team will now have to test whether or not it is possible for all possible users of the new speargun to stretch the rubber band the required length. This length depends on the length of the new speargun, which will be chosen later in the process, but the team will test which lengths are possible for the potential users before choosing this.

Sources:
Ill. X.01: http://www.suppsrus.com.au/blog/training/exercise-and-muscle-groups/exercises-middle-back/middle-back-seated-cable-row-narrow-grip/
Ill. X.02: http://www.rowingmachineking.com/what-does-a-rowing-machine-do-for-your-body/

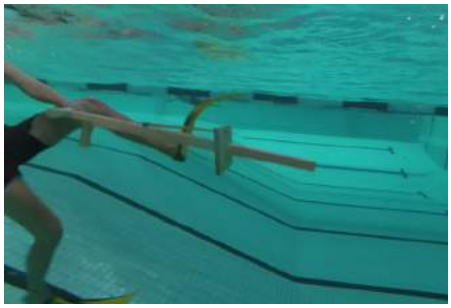
ARDEA		
Testing feet loading principle in water		
Date: 19-03-2016	Team no. 4	Worksheet no. 38

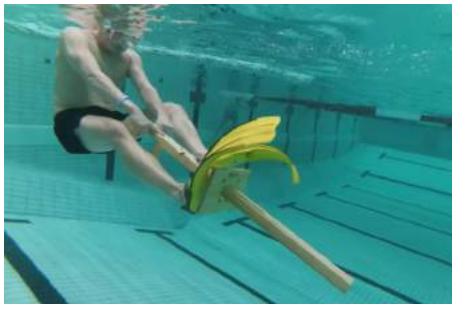
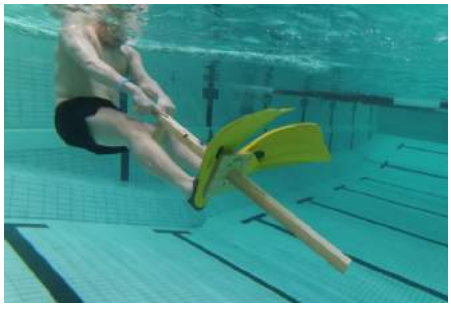
Objective:
The objective of this test is to investigate whether any problems will occur and how the loading principle behave in water compared to on land. The reason for this loading principle is tested is due to the risk of the user having problems with maneuvering and loading it in water with the fins.

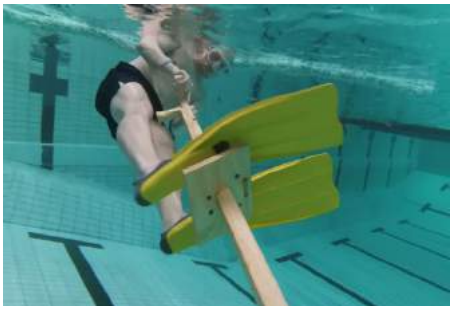
Experimental/Data:
The test is done with a mock up in a swimming pool. For the test only the most crucial components are made in order to test the loading principle and nothing more. Spearfishers are generally not spearfishing without fins, and therefore it is important for the team to test whether or not it is a problem to do and especially in a context similar to the context which it has to work in. A rubber band requiring a force of approximately 45 kg is used for the test to be able to make a comparison with the loading technique with the arms. Furthermore it is tested how much the test persons can stretch the rubber band, so the team can see how long the speargun can be and still be used by any user in any height. It is important, that the new speargun is not made in a way where some people are limited to only use the shorter speargun lengths as it is with the current spearguns.








ARDEA		
Testing feet loading principle in water		
Date: 19-03-2016	Team no. 4	Worksheet no. 38

The test was documented by recordings (can be found on the USB), and therefore image cuts are presented in this worksheet to give an idea of how the test is performed.
As seen in the video potential problems with using the fins to load the speargun were the least problem. Buoyancy of the mock-up made it a bit difficult to control and positioning the speargun in the water. The buoyancy is caused by the mock-up being made in wood.

After seeing how easy it was to load the speargun with the legs, the next step was to find out how long the test persons can stretch out the rubber band. Six persons in different heights tried to stretch out the rubber band:
Person 1 (172 cm): 95 cm
Person 2 (176 cm): 96 cm
Person 3 (181 cm): 100 cm
Person 4 (187 cm): 105 cm
Person 5 (188 cm): 105 cm
Person 6 (193 cm): 108 cm

Evaluation:
The results of the tests indicates that the fins does not affect the loading of the speargun as much as anticipated, and it does not seem to affect the further development of this loading principle. The test shows it is relatively easy to load the speargun in the water and it thereby indicates a great potential in this principle. Furthermore the test shows that the shortest stretch of the rubber band is 95 cm.

Reflection:
The test was done and gave the wished outcome, which can be used further in the design process and thereby allows for further investigation and development. The videos illustrate well how simple and easy it is to load the speargun in the new way with the legs. The loading pad is though relatively big and will create a lot of resistance in the water, and therefore this solution will in further mock-up testings be changed and made more realistic in it’s dimensions and shape.

ARDEA		
Investigation of handles		
Date: 19-04-2016	Team no. 4	Worksheet no. 39

Objective:
The objective is to investigate how the handles are shaped on existing spearguns to get an idea of which are most useable and comfortable and why they are so. The investigation will be executed through an subjective experiment.

Experiment/Data:
Based on several different spearguns it is possible to get a general idea of which features are good and which are bad regarding the handle of the spearguns.

No. 01

Ill. C.01-02: No. 01:Tigullio RAS 30

NO. 01: TIGULLIO RAS30:

Description of handle:
The handle on the Tigullio RAS 30 is a very simple design. The handle fits both right and left hand. The size of the handle fits both smaller and larger hands, both with and without gloves, though it is best suited for smaller and average hands. The shape of the handle is an oval which become more narrow the closer to the barrel. It is made from injection molded plastic, which gives some very sharp edges all over the handle. The trigger-mechanism is quite hard to activate. The shape of the trigger fits the shape of the finger and follows the finger through the movement when activating.
The safety mechanism could potentially be used with the hand holding the speargun (Right now it can't, due to the shape of the locking mechanism).

Pros:

+ The handle fits both right and left handed
+ The handle fits all sizes of hands
+ The trigger follows the shape and movement of the finger when pressing down

Cons:

- Without gloves, the edges on the handle are very sharp
- Large hands wearing gloves have to force their finger in to reach the trigger

Things to consider:
The way the safety mechanism can be handled by both right and left handed users.
The oval shape of the handle, which becomes more narrow, seams to be a good shape to secure a firm and comfortable grib.
The shape of the trigger, which follows the shape and movement of the finger.

No. 02

Ill. C.03-04: No. 02: Beuchat Mundial

NO. 02: BEUCHAT MUNDIAL:

Description of handle:
The handle on the Beuchat Mundial is devided into two components; the handle which i made from a type of rubber, which gives a firm and secure grib, and the upper trigger-part which is made from a harder material. The trigger is easy to activate. The handle fits both left and right handed users, and all sizes of hands. The handle has a shape which supports the fingers and is intended to give a more firm grib.
The trigger fits the shape of the finger but does not follow the movement of the finger when activating.

Pros:

+ The handle can be used by both left and right handed users

Cons:

- There is nothing to support the hand and help carry the weight of the speargun

Things to consider:
The symmetric shape, which makes it useable for both left and right handed users.
The simple, yet comfortable, shape of the handle.

No. 03

Ill. C.05-06: No. 03: Nemrod Gaucho II

NO. 03: NEMROD GAUCHO II:

Description of handle:
The handle on the Nemrod Gaucho II has a more advanced design. The handle is shaped to fit right the hand. The handle has an integrated support for the thumb, which gives a more firm grip. The shape of the handle is a oval cylinder, which becomes more narrow the closer to the barrel of the speargun.
The safety mechanism is placed on the left side of the handle, so it can be handled with the thumb.

The shape of the trigger fits and supports the shape of the finger when activating the speargun.
Pros:

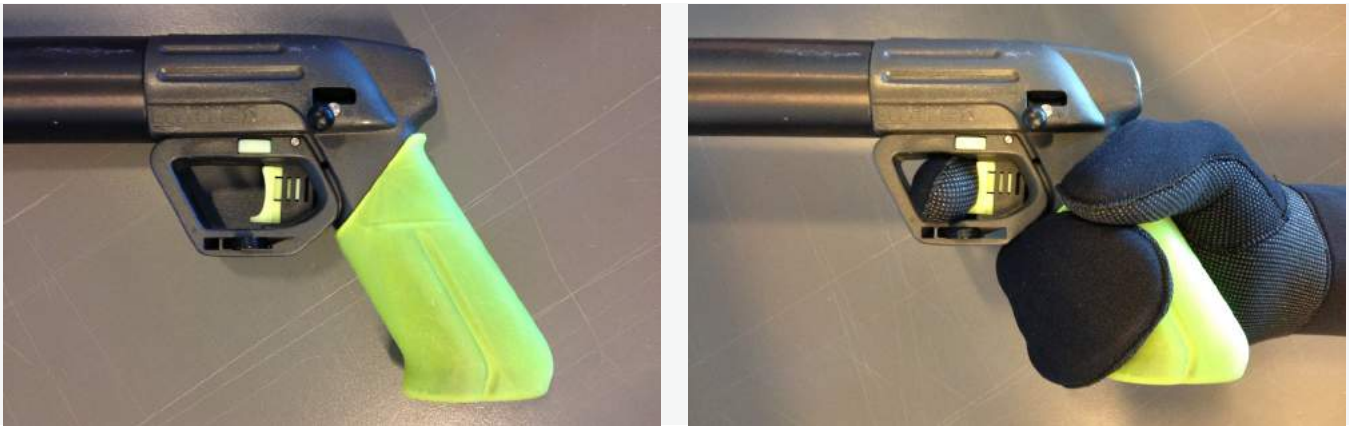
+ The support for the thumb, which gives a a more firm and comfortable grib

Cons:

- The speargun can only be used by right handed users

Things to consider:
The support integrated in the handle, to give a more firm grip and help carry the weight of the speargun.

No. 04



Ill. C.07-08: No. 04: Mares STEN

NO. 04: MARES STEN:

Description of handle:
The handle on the Mares STEN is a very simple design. The shape of the handle is an oval. The diameter of the handle is the same through out the whole handle. This makes is difficult for users with smaller hands to get a firm grib and being able to handle and control the speargun fully. The handle fits both left and right handed users. The speargun is very heavy and there is nothing to help the user carry the weight integrated in the handle.
The shape of the trigger fits and supports the shape of the finger when activating the speargun.

Pros:

+ Very simple design
+ Fits both left and right handed users

Cons:

- The speargun does not fit smaller hands
- Nothing to support the hand and help carry the weight of the speargun

Things to consider:
To integrate some kind of support for the hand to help carry the weight of the speargun.

ARDEA		
Investigation of handles		
Date: 19-04-2016	Team no. 4	Worksheet no. 39

No. 05

Ill. C.09-10: No. 05: Coralign Pro

NO. 05: CORALIGN PRO:

Description of handle:
The handle of the Coralign Pro is devided into two components; the handle which has a rough plastic surface, to give a more firm grip, and the upper trigger part which has a more smooth surface. In the bottom of the handle is a row of ribs, which makes sure the handle does not slip out of your hand. The trigger can be adjusted to fit different hand sizes. Opposite to the other spearguns investigated, this trigger is straight, and does not fit the shape of the finger.

Pros:
+ The trigger can be adjusted to fit different sizes of hands
+ The rib in the bottom of the handle, gives a more secure grib

Cons:
- The trigger does not fit the shape of the finger

Things to consider:
The ribs in the bottom of the handle to give a more secure grip

Evaluation:
The shape of all the handles are more or less oval, which gives a more secure and firm grip. All the handles are a bit wider in the bottom which both makes them more comfortable to hold and supports your hand while holding the speargun. The ones with curvatures which follows the fingers gives a more firm grip around the handle.

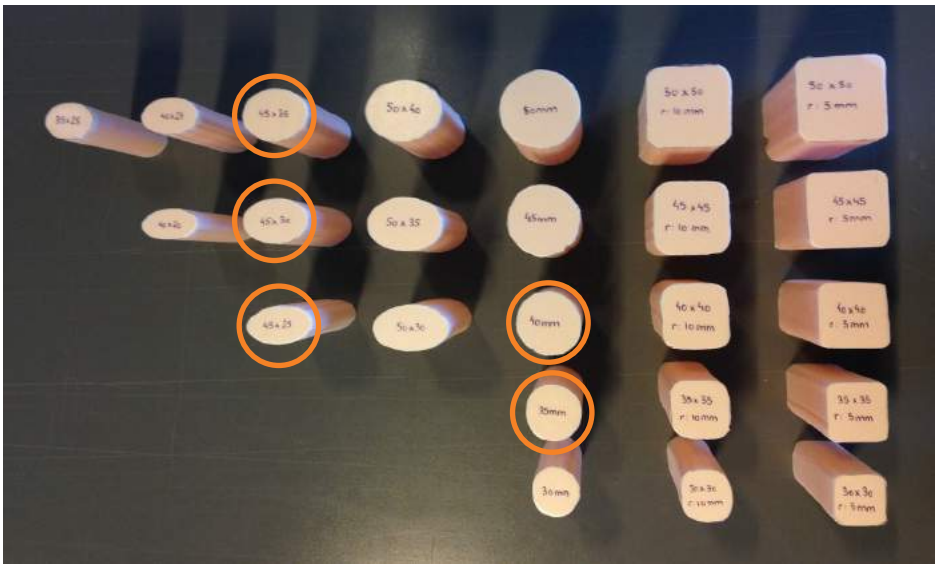
Reflection:
From this investigation it is possible for the team to determine some parameters to consider when having to design the handle of the new speargun. The parameters are;

- The thickness and shape of the “body” of the handle
- The wider bottom of the handle
- The curvatures of the handle, which follows the shape of the fingers
- The shape of the trigger-mechanism, which follows the finger and its movement
- The integration of the safety mechanism
- The fitting of the handle to different hand sizes
- The support for the hand, to help carry the weight of the speargun

PROJECT TITLE		
Shaping of Speargun Handle		
Date: DD-MM-YYYY	Team no. X	Worksheet no. XX

Objective:
The objective is to find a shape for the speargun handle, so it both fits users using right hand or left hand. Besides that, the team wants to find a size of the handle, which feels good in different sizes of hands and also with and without spearfishing gloves.

Experiment/Data:
The team has made foam models in different sizes and shapes, which are tested among several test persons to reach a representative result, so the team can decide on which size and shape would fit most users of the new speargun.



The team starts by testing all the different foam models and thereby choose which ones to go further with and make other people test. Some shapes and sizes can quickly be sorted out and therefore it has no meening to make other people test them. Five foam models are chosen for further testings to find the final shape and size for the speargun handle.

Niels

Hand size:
180 mm

35 mm
With and without glove it is difficult to get a firm grip.

40 mm
With and without glove it is too big and slips around in the hand.

45 x 25 mm
Without glove the size is good, but with it feels too small.

45 x 30 mm
Feels better than the previous and you have a good grip.

45 x 35 mm
It is too big and you need to squeeze a lot to hold it.

Jon

Hand size:
185 mm

35 mm
Should be bigger both with and without glove.

40 mm
Good size, but with glove it becomes a bit too big.

45 x 25 mm
With and without it is too thin.

45 x 30 mm
Without glove it feels small, but with you have a good grip.

45 x 35 mm
Without it is good, but with it becomes too big.

ARDEA		
Shaping of Speargun Handle		
Date: 19-04-2016	Team no. 4	Worksheet no. 40

Nikolaj

Hand size:
175 mm

35 mm
It feels too small - you have no firm and secure grip.

40 mm
It is too big - you have to use a lot of force to hold it.

45 x 25 mm
With and without glove it is very small.

45 x 30 mm
This is definitely the best, because you have a good, firm grip.

45 x 35 mm
It becomes too big, especially with the glove on.

Ingeborg

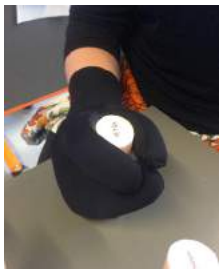
Hand size:
170 mm

35 mm
When it is round it is difficult to code how to hold it.

40 mm
It becomes too big with glove.

45 x 25 mm
It is not an optimal shape to hold around.

45 x 30 mm
It is not as good as the 45 x 35 mm.



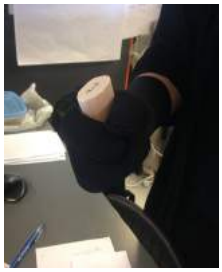
45 x 35 mm
With and without glove it is best to hold around.

Nakita

Hand size:
185 mm

35 mm
You have no good grip and it feels too small.

40 mm
It is stable without glove, but with it is too big.



45 x 25 mm
It becomes too thin with the glove on.

45 x 30 mm
The best size when using a glove.

45 x 35 mm
Very big, but can work with a glove on.

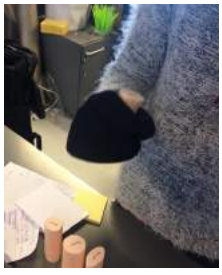
Madalina

Hand size:
165 mm

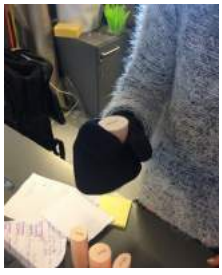
35 mm
Too short and small in diameter.

40 mm
Too big, but you have a better grip when using the glove.

45 x 25 mm
Does not feel right when holding it.



45 x 30 mm
The best size and shape, but needs markings for fingers.



45 x 35 mm
Both with and without it is too big.

ARDEA		
Shaping of Speargun Handle		
Date: 19-04-2016	Team no. 4	Worksheet no. 40

Nicoline

Hand size:
175 mm

35 mm
Fine size, but it rotates in the hand, which is annoying.

40 mm
Too big both with and without glove.

45 x 25 mm
Without glove the edges is sharp, but with it feels good and easy to hold.

45 x 30 mm
Best without glove, but with it rotates a bit in the hand.

45 x 35 mm
Without it feels good, but with glove it becomes too big.

ARDEA		
Shaping of Speargun Handle		
Date: 19-04-2016	Team no. 4	Worksheet no. 40

Evaluation:
The testing of the foam models shows that the handle with the measurements of 45 x 30 mm is the preferred one between the five tested foam models. One test person likes the 45 x 25, because it has sharp but still curved edges to stabilize it in the hand and one likes the 45 x 35 because it feels best with a glove on and still has the oval shape.

Reflection:
The people testing the foam models definitely prefer the oval shape, because it secures the handle from rotating in the hand, but some point out the importance of having some markings in the handle for the fingers, especially the thumb and little finger. In Worksheet no. 39 the team looks at existing speargun handles and how they incorporate markings for fingers. This is something the team wants to integrate in the new speargun handle to make it more comfortable and easier to code how to exactly hold it.
From this worksheet and the previous about existing speargun handles some requirements to the new speargun handle can be listed:

- An angle between 60 and 70 degrees
- Oval shape around 45 x 30 mm
- Markings or curvatures for fingers
- Symmetrical to fit both right and left handed users
- Wider in the bottom for support of hand
- Length around 110 mm
- Thinner in the top of the handle
- Hole for trigger around 35 x 60 mm
- Shape of trigger follows shape of finger/glove

Sources:

ARDEA		
Investigation of Safety Mechanism		
Date: 26-04-2016	Team no. 4	Worksheet no. 41

Objective:
The team wants to find a solution for the safety mechanism, which makes it clear to the user when the speargun is ready to shoot and not ready. Furthermore it has to be possible for both a left hand and right hand user to interact with the safety mechanism to switch it on and off by the hand you hold the speargun with. To find a solution it is necessary to research on existing safety mechanisms.

Experiment/Data:
Different existing safety mechanisms on both spearguns and other products are found and evaluated on how they work by their placement, movement, how clear they are in telling whether they are on/off and how easy they are to handle.


Ill. 1: Safety mechanism

Pros/Cons:
- + Well-positioned for right hand use
- - The safety does not indicate whether it is the safety or the gun which is on/off
- - Left hand users have to use two hands to interact with the safety mechanism

Ill. C.XX: Description


Ill. 2: Safety mechanism

Pros/Cons:
- + Well-positioned for right hand use
- + The safety does indicate whether the gun is on/off if you know the meaning of “F” and “S”
- + The yellow light on the safety mechanism clearly indicates the position of it
- - Left hand users cannot use the safety mechanism with one hand

Ill. 3: Safety mechanism

Pros/Cons:
- + Well-positioned for left hand users
- - Cannot be used by right hand user with one hand
- - “SEMI” confuses in a degree where it is difficult to decode whether it is on/off

Ill. 4: Safety mechanism

Pros/Cons:
- + Well-positioned for right hand use
- + “SAFE” and “FIRE” makes it easy to understand when the gun is ready to shoot
- - Left hand users cannot use the safety mechanism with one hand

ARDEA		
Investigation of Safety Mechanism		
Date: 26-04-2016	Team no. 4	Worksheet no. 41

Ill. 5: Safety mechanism

Pros/Cons:

- + The position of the safety mechanism makes it possible to use both left and right hand to control
- + The position of the safety mechanism on top of the speargun makes it possible for the user to see the safety
- - The safety does not indicate whether it is the safety or the speargun which is on/off
- - It can not be used by the hand holding the speargun

Ill. 6: Safety mechanism

Pros/Cons:

- + The position of the safety mechanism makes it possible to use both left and right hand to control
- + The position of the safety mechanism on top of the speargun makes it possible for the user to see the safety
- - The safety does not indicate whether it is the safety or the speargun which is on/off
- - The safety mechanism is difficult to handle - especially with gloves

Ill. 7: Safety mechanism

Pros/Cons:

- + The position of the safety mechanism makes it possible to use both left and right hand to control
- + The position of the safety mechanism on top of the speargun makes it possible for the user to see the safety
- - The safety does not indicate whether it is the safety or the speargun which is on/off

Ill. 8: Safety mechanism

Pros/Cons:

- + Possible to unlock with one hand (depends on left or right hand user)
- - Impossible to lock with one hand (depends on left or right hand user)
- - The safety does not indicate whether it is the safety or the speargun which is on/off

Ill. 9: Safety mechanism

Pros/Cons:

- + Well-positioned for right hand use in order to control it with one hand
- - Difficult to lock the safety with one hand after unlocking it
- - The safety does not indicate whether it is the safety or the speargun which is on/off
- - Left hand users cannot use the safety mechanism with one hand

ARDEA		
Investigation of Safety Mechanism		
Date: 26-04-2016	Team no. 4	Worksheet no. 41

Ill. 10: Safety mechanism

Pros/Cons
- + Possible to unlock with one hand
- - The safety does not indicate whether it is the safety or the speargun which is on/off
- - It does not indicate which side you have to slide it to lock/unlock the speargun


Ill. 11: Safety mechanism

Pros/Cons:
- - Necessary to use both hands to control safety mechanism
- - Difficult to see and decode when it is locked/unlocked
- - Difficult to use for left handed users

Evaluation:
Placing the safety mechanism at the center of the speargun handle instead of choosing either left of right side will make it possible for both right and left hand users to interact with it by the hand they hold the speargun with. In order for them to be able to actually reach the safety mechanism with the thumb it has to be placed on the back of the handle. One of the main problems with the existing safety mechanism on the spearguns, is that they do not tell whether it is the safety mechanism which is on/off or it is the speargun itself which is on/off. Making it understandable to the user no color indications should be used or “ON” and “OFF”, because it does not tell whether the safety or the speargun is on/off. On the other hand text like “FIRE” and “SAFE” makes it really clearly when the speargun is ready to shoot. The yellow light indicator on the safety mechanism makes it clear in what position it is in.

Reflection:
From all this it is possible to set up some requirements to the new safety mechanism, which will be used for development of the final safety mechanism solution:
- Placed so it is visible in shooting position
- It has to be indicated with “FIRE” and “SAFE” if the mechanism does not clearly by it’s position tell when it is on/off
- A color on the safety mechanism or the shape of it indicates clearly where it is positioned
- A contrast color will make it easier to understand the interaction areas

Sources:
Ill. 1: http://1.bp.blogspot.com/-WtS6CgRd9EU/UwO_jo_ST1I/AAAAAAAAAbc/-kGvv79vpMM/s1600/DSC00606.JPG
Ill. 2: http://2.bp.blogspot.com/-bgPV1UykNWc/UP28DUOw1TI/AAAAAAAAB0k/OW4n2YzZE3A/s1600/ISSC+04.JPG
Ill. 3: http://truthaboutguns-zippykid.netdna-ssl.com/wp-content/uploads/2015/09/SI_Safety_6.jpg
Ill. 4: http://2.op.ht/original/opplanet-how-to-clean-ar15-ar-safety-001.jpg
Ill. 5: http://truthaboutguns-zippykid.netdna-ssl.com/wp-content/uploads/2013/06/P6080005-675x900.jpg
Ill. 6-11: Own pictures

ARDEA		
Rob Allen, President/CEO, Rob Allen		
Date: 12-04-2016	Team no. 4	Worksheet no. 42

Objective:
The objective is to use an existing speargun brand made to handle conditions similar to the danish conditions to gain more specific knowledge about spearguns. Furthermore the team wants to know more about the spearfishing market around the world.

Experiment/Data:
Hi Rob Allen,

We are three Industrial Design students from the University of Aalborg in Denmark and are currently working on our Master Thesis, which is about spearfishing and more specifically about spearguns. We are missing some real data about how many active spearfishers there are today to help our business case. How many are there in Australia, USA, South America, South Africa, Japan, France, Italy or just Europe? I guess you only have an idea about it since we can't find any official numbers and I also guess you only have an idea about South Africa, which is just fine - we just need an estimate?
Is that something you can help with or maybe tell us who to contact if not?
Can you also help describing the characteristics of how the water around South Africa is typically - current, visibility length, seabed and depth?

Kind regards,
Anders Poulsen

Hi Anders,

Sorry for the delay in answering.

We don't have much in the way of actual numbers other than in South Africa. Although the population here is around 48 million we only have about 4000 spear fishermen (licences issued).

The way we look at numbers in different countries is by the quantity of shops that sell spear fishing equipment. In South Africa there are only about 20 shops that sell spearing gear.

In Australia, the population is about 1/2 that of South Africa but there are around 1250 retail shops that sell spearing gear. We are pretty sure this is mainly due to disposable income.

In South Africa the vast majority do not have disposable income and, the vast majority are not traditionally a "sea going people." In Australia it is very different, even the guy on the dole (government grants) has disposable income. In Australia they also have a much better and vast areas of coast line to dive, possibly 100 times greater than what we in South Africa.

In the USA we think there are +- 30,000 shops that sell spearing gear. Obviously this is also due to disposable income and population numbers.

I don't have anything for Europe as our gear is not really suited to that type of diving.

Regards,
Rob Allen.

Hi Rob Allen,

It's so nice you take your time to answer our questions - we are very grateful. If you can find more time, we have a question about the spear.

ARDEA		
Rob Allen, President/CEO, Rob Allen		
Date: 12-04-2016	Team no. 4	Worksheet no. 42

How many cm should or can it be compared to the speargun? Can a spear of for example 130 cm fit several speargun lengths or can it only fit one speargun length? There must be a certain length that the spear can be longer than the speargun before it loses it's effect and shooting range of 5 x the barrel length? And there must also be a minimum length of the spear compared to the speargun?

Regards,
Anders Poulsen

Hi Anders,

There are variations in spear to barrel ratio depending on barrel type. A rail barrel, where the spear rests in a rail all along the barrel generally has a spear 400mm longer than the barrel length. Some can and do use spears 100mm shorter and or 100mm longer but it is less than 3% of customers who do this. We and most other manufacturers make guns and spears every 100mm, starting at 500mm for the short guns and up to 1600mm for the longest. The spears variation follows at 400m greater so the 500 gun will take a 900 spear, the 1600 gun will take a 2000 spear.

With non railguns the spear to gun ratio is much more critical due to how the spear flexes considering it is only held in the mechanism and in the muzzle. I found the best ratio was, plus 45% onto the barrel. This is less important with a short gun but very important on a long gun. The most common back in the day before rail barrels was a 1250mm barrel with a 1820mm spear. (1250 + 45% = 1812) The next most common was a 1100mm with a 1600mm spear. (1100 + 45% = 1595)

If you used a longer spear in these guns (less than 45% ratio) the spear would sag in the middle and shoot high. If too long (greater than 45% ratio) the spear tip would hang down very slightly but enough to shoot low.

The advantage of the rail was that it kept the spear straight in the gun, much less spear whip. This made the spear much faster. Also with the rail the ratio of spear to barrel length is less and the rubber stroke is better so much more power added to the spear compared to the old non rail type.

Regards,
Rob Allen.

Hi Rob Allen,

Thank you so much for the answer and your time. We are also trying to find out which lengths are necessary for a speargun in Danish conditions or similar conditions. Could it be an idea if you as a user are able to adjust the speargun for all possible lengths (between 40 and 120 cm) with for example a 5 cm span or is it better to just have for example four fixed lengths, which the user can choose between? How do you choose the length of your spearguns?

Kind regards,
Anders Poulsen
Aalborg University

Hi Anders,

Standard guns shoot accurately (depending if correctly powered up) at about 5 x their barrel length. This distance we refer to is the distance from the gun handle to the end of the shooting line.

Standard guns can have a 2nd line wrap but generally they lose accuracy beyond 5 x barrel length.

In terms of gun length needed, this should be more or less relative to the water visibility. If the water visibility is only 4m, no point in using a gun that can shoot 5m. If you can shoot beyond your actual visibility there can be a safety

problem where you might shoot another diver. Obviously this is just a rule of thumb as visibility can change on the day during the dive and or depending on the location.

So, gun length is mainly determined by the visibility and the power needed is mainly determined by the fish you need to take. Big fish need more powerful guns compared to smaller fish.

In terms of a gun with adjustable lengths, this would be very difficult. Might not be a big deal to have an adjustable barrel but not the rubbers or the spear. The other problem is buoyancy. The barrel is a closed tube. This gives the gun buoyancy. The bigger the diameter the more the lift but, the harder it is to manoeuvre. It is important that it is not too buoyant and, not too thick. If you needed to change the lengths this will affect the buoyancy, all very difficult to keep balanced.

This is why it is better to have a boat load of different guns to use :)

Regards,
Rob Allen.

Hej Rob Allen,

Which production method is normally used for your speargun handle? Is it injection moulding? And can you tell what the price is for the production of the handle?

Regards,
Anders Poulsen

Hi Anders,

We use injection moulding, mostly glass filled nylon. Glass is very aggressive (abrasive) so the steel used and the coatings have to be top quality.

We took 2 years to design our handle before we started making the mould (moulds, 5 different moulds) 10 years ago. At the time we had to use outside designers but most did not have the computer capacity to draw the shapes :)

The first mould cost around EU22,000 and took 3 years to complete.

Over the following 10 years we have made several modifications/maintenance at a cost of around EU12,000

When we first started moulding the handle we were selling around 300 guns per month. 10 years later we are doing about 1500 per month and still increasing.

Mould design and cost since we started have come down considerably due to technology advances in design and mould making.

Knowing what we have learnt in that time, if we had to re make a new handle today it will probably cost less than EU10,000 and take less than 4 months.

Regards,
Rob Allen.

ARDEA		
Rob Allen, President/CEO, Rob Allen		
Date: 12-04-2016	Team no. 4	Worksheet no. 42

Hi Rob Allen,

Thank you so much for the useful answer.

But why glass filled nylon? Isn't nylon a polyamide and doesn't that have a poor moisture resistance, which will be bad when it is often in contact with seawater?

Regards,
Anders Poulsen

Hi Anders,

Nylon does swell with moisture, up to 2% We make the moulds to account for this. Glass filled reduces this swell depending on how much glass. We use 15% glass on some components and up to 60% on others. Nylon is also much better than other materials in terms of impact resistance. The added glass makes for a much stronger and tougher product.

Years ago there were handles out there made with cheap plastics that failed. One person was injured badly when using a gun we had made. In this case he had over loaded it way beyond normal and, the break was caused by another component failure not actually the handle but, they still tried to take legal action to cover medical expenses. We did not design or manufacture this handle so when we made our own we wanted it to be super strong.

Prior to this incident there had been 2 deaths due to handle failures that I heard about, both were well before my time.

We have a hydraulic test station where we destroy 1 in a 1000 handles to keep records of the batches and loads it can handle before breaking.

This is very important because it is just a matter of time before someone else is badly hurt or killed by doing something stupid. The fact we do these test and can show records where we have done everything possible to prevent failures it will put us in a better position if and when an accident occurs.

When our handle is loaded with the strongest set up the tension against the working parts is around 120kg (few load this much) Even if guys sets it up with crazy rubbers it will maybe get to around 170kg. this will hurt the hand when fired due to the recoil and, be very inaccurate. When we test load the handle to break point it takes between 340kg and 375kg before failing.

This is why we use glass filled nylon :)

Regards,
Rob Allen.

Hi Rob Allen,

We are very happy, that you spend so much time helping us in our Master Thesis Project.
We are currently making a fictional business case, if it is okay with you of course, where we consider you as our collaborating partner (a licensing agreement). Therefore we would like to hear you how many spearguns you approximately could sell the first year? It is a speargun with a new and simple loading method, and it can adjust in length according to the ocean conditions. An estimated production price is 100 USD.

Regards,

PROJECT TITLE		
Rob Allen, President/CEO, Rob Allen		
Date: 12-04-2016	Team no. 4	Worksheet no. XX

Anders Poulsen

Hi Anders,

When I started to make guns full time 25 years ago, I needed to make 1 gun a day (5 per week) to be viable, with just me making. I was able to do this and grow fairly constant to what we are doing today, 25 years later.

We now make about 1500 per month (375 per week) with 50 staff. The ratio of staff to gun numbers have pretty much grown fairly evenly over the 25 years.

Today, if 1 person made 1 a day that is 50 per day or 250 per week. We are currently running better than that at about 375 per week, better average than when I started. This is because today we are more efficient, able to bulk buy, better tooling etc. The product is also much more profitable because the raw material is now cheaper due to the fact we can get better prices of raw materials by purchasing in bulk.

I have no idea how to estimate your gun costs without knowing the design. This can vary so much depending on tooling costs etc.

At US$100 in my opinion it would be too expensive. Our basic gun on average retails at around this price. To give you an idea, we mark up around 75% from cost of manufacture. This gets it to a wholesale price. From wholesale to retail the average is around 100% mark up, then add vat (sales tax) at 14%.

Cost of manufacture is +- US$25 plus 75% to get it to wholesale = $43.75
The retailer adds 100% = $87.50 plus vat = $99.75

This varies much more if the product is exported to a country where import duties are high. You now need to add the transport cost, plus import duties, plus reps commission before it gets to the retail store.

The same gun that costs us $25 to make, that we retail here in our country at $100, will be between $350 and $400 in some other countries. Big difference when cost of manufacture is $25 :(

If your cost is $100 the gun could retail at around $1600 in another country.

I think there is much easier ways to be in business :)

Regards,
Rob Allen.
D i v e F a c t o r y

174 Gale Street, Durban, 4001, South Africa 29 52’ 15’’ S 30 59’ 45’’ E
Tel +27 31 3012241 Fax +27 31 3012247

www.facebook.com/RobAllenSpearfishing

https://www.youtube.com/user/RobAllenSpearfishing

www.roballen.co.za

Evaluation:
4000 spearfishermen (licences issued) are there in South Africa.
A speargun generally has a spear 400mm longer than the length of the speargun’s length. In some cases it can be 300 mm or 500 mm longer than the speargun. A speargun with a rail keeps the spear straight in the gun and thereby

much less spear whip - this makes the spear much faster.
Standard spearguns shoot accurately (depending if correctly powered up) at about 5 x their barrel length.
Speargun length is mainly determined by the visibility and the power needed is mainly determined by the fish you need to take. Big fish need more powerful guns compared to smaller fish.
The Rob Allen speargun handle is made in glass-filled nylon with 15 to 60 % glass in it.
Rob Allen produces their spearguns to a cost price of +/- 25 USD and takes 75 % from the retailer, which take 100 % from the customer.

Reflection:
Making a speargun capable of adjusting in length will be challenging, because the spear and the rubberband also needs to be adjustable in order to reach the necessary power and precision. Moving forward this will be the focus - how to make the spear adjustable and still be strong enough for all the force it is exposed for when fired.
Furthermore Rob Allen seems to be a good business opportunity in the matter establishing a collaboration, because the brand is already well-established and it comes from a country (South Africa), where they experience some of the same ocean conditions (low visibility and high current) as in Denmark.

Sources:
http://www.roballen.co.za

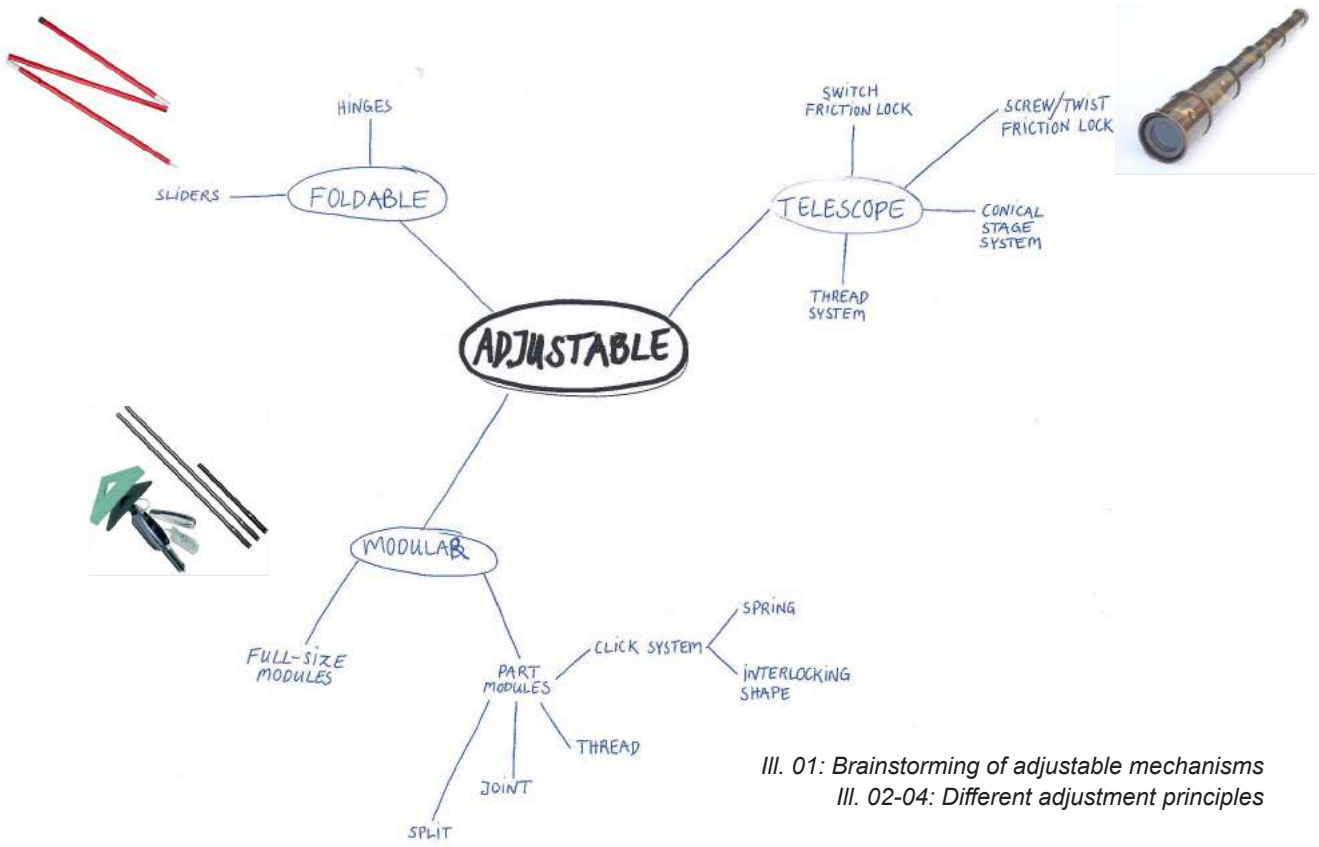
Ill. XX: Guy Skinner, President/CEO, JBL International

Ill. XX: JBL International logo

ARDEA		
Adjustment of spear		
Date: 22-04-2016	Team no. 4	Worksheet no. 43

Objective:
The team needs to design an adjustable spear to fit the adjustable speargun to make the speargun and the whole concept more valuable to the customers and users. The spear should be able to adjust in length and the team has started the design process by doing a brainstorm on different ways to adjust the length (see Ill. X.01-04).

The spear could either be folded like tent poles, it could be adjusted with a telescopic principal like an old-fashion bin-oculars or it could be adjusted with modules like the extension of a window cleaner.



Ill. 01: Brainstorming of adjustable mechanisms
Ill. 02-04: Different adjustment principles

Experiment/Data:
To be able to determine which principle is best suited for the adjustment of the spear, the team at up some pros and cons for the different principles.

Modular:
Full-size modules
- + Only one spear is needed
- + Strength
- + Low complexity
- + User can purchase only the necessary parts
- - Spare parts take up space when not in use
- - Spare parts have to be transported every time
- - The user has to have many different spears
- - The user has to either bring all sizes of spear to the water or get out of the water to get the needed spear

Part modules - Split, Joint, Thread, Click Spring, Interlocking Shape
- + Only one spear is needed
- + Add-ons makes it possible to adjust the spear in water

- + User can purchase only the necessary parts
- + It is possible to adjust the spear while being the water
- - Less strength / more weak points
- - More complexity
- - Spare parts take up space when not in use
- - Spare parts have to be transported every time
- - The user needs to bring the spear parts into the water

Telescope:
Switch Friction Lock, Twist Friction Lock, Conical Stage System, Thread System
- + Only one spear is needed
- + It is possible to adjust the spear while being the the water
- + Takes up less space during transport
- - Less strength - hollow construction / more weak points
- - More complexity
- - Less hydrodynamic shape - more resistance in water

Foldable:
Hinges
- + Only one spear is needed
- + It is possible to adjust the spear while being the the water
- + Takes up less space during transport
- - Less strength / more weak points
- - More complexity
- - Less hydrodynamic shape - more resistance in water
- - Difficult to assemble and connect the hinges

Evaluation:
All mechanisms have some pros and some cons, and therefore the team has to decide which parameters are more important than others and judge by these. First of all the team has to compare it with the requirement specifications and then how would the business case look for each mechanism. The full-size modules will definitely have a higher strength, lower complexity and thereby lower risk of breaking parts. The telescope has more complexity and thereby greater risk of broken parts, but it is faster to adjust the length at the spearfishing spot and it can take less space during transport than the modular.

Reflection:
The pros and cons have helped the team to decide on which adjustable mechanisms they see more potential in than others, and thereby which to work further on. The team will look more into modules to adjust the spear. This way of adjusting the length is possible to do while being in the water, it requires some extra parts, which makes it possible for the team to increase the additional sales. The modules will have some weak points in the assembling and the team will have to investigate if these can handle the scenarios in spearfishing or if the spear will break.

Sources:
Ill. X.01: Own illustration
Ill. X.02: http://spejdergear.dk/shop/msr-adjustable-pole-7133p.html
Ill. X.03: http://www.ebay.com/sch/Antique-Maritime-Telescopes/37972/bn_2309504/i.html
Ill. X.04: http://vinduespudsning.com/products/stingray-3-3-meter-elektrisk-vinduesvasker-til-indvendig-vinduespudsning

ARDEA			
Adjustment of spear			
Date: 22-04-2016	Team no. 4	Worksheet no. 43	

eam need to create an overview of different adjustable mechanisms, which can be used by the user to change the length of the speargun, through brainstorming. Pros and cons will be made on each mechanism to find out which mechanisms should be tested through mock-ups and developed further on.

Evaluation:
All mechanisms have some pros and some cons, and therefore the team has to decide which parameters are more important than others and judge by these. First of all the team has to compare it with the requirement specifications and then how would the business case look for each mechanism. The full-size modules will definitely have a higher strength, lower complexity and thereby lower risk of breaking parts. The telescope has more complexity and thereby greater risk of broken parts, but it is faster to adjust the length at the spearfishing spot and it can take less space during transport than the modular.

Reflection:
The pros and cons have helped the team to decide on which adjustable mechanisms they see more potential in than others, and thereby which to work further on by making mock-ups and test. The team will look more into full-size modules, part modules and telescope. This leaves the foldable behind, because it does not have the necessary upsides to fulfill the requirement specifications the team has made. The full-size and part modules have the best opportunity to make a great business case, because of the possibility to buy add-ons after the user has purchased the actual speargun. The telescope fulfills the requirement of making the transportation easier and the adjustability quicker at the actual spearfishing spot.

Sources:
Ill. 01: Own illustration
Ill. 02: http://spejdergear.dk/shop/msr-adjustable-pole-7133p.html
Ill. 03: http://www.ebay.com/sch/Antique-Maritime-Telescopes/37972/bn_2309504/i.html
Ill. 04: http://vinduespudsning.com/products/stingray-3-3-meter-elektrisk-vinduesvasker-til-indvendig-vinduespudsning

ARDEA		
Handling the line		
Date: 26-04-2016	Team no. 4	Worksheet no. 44

Objective:
The objective is investigation of different ways to handle the line on the speargun. The line is a huge problem when spearfishing despite the different types of handling the line on the speargun. As it is right now on the existing spearguns, the line either is guided back and forth along the barrel of the speargun and attached in some small hooks, which is released when pulling the trigger, or a line reel is attached somewhere on the speargun to wind up the line.

Experiment/Data:
By looking at different ways to handle the line on different products it is possible for the team to determine the best suited way of handling the line on the new speargun. The principles will we evaluated on their ability to adjust to different lengths of spearguns, their way of handling the line, the maintenance of the mechanism and the complexity.

Ill. C.01: The simple hook system on the existing spearguns

Pros/Cons:
- + Simple system
- - Not adaptable to different lengths of the speargun
- - The line is in the way when it is winded up

Ill. C.02: The line reel on the existing spearguns

Pros/Cons:
- + The line is not in the way when winded up
- - The user needs to wind the wheel many times to wind up the whole line
- - The reel will add extra weight and resistance to the speargun

Ill. C.03: Cord winder system on a vacuum cleaner

Pros/Cons:
- + The line is winded up automatically when pushing a button
- + Easy action for the user - pushing a button
- - The line can get jamed inside the sheel
- - The system will require easy maintenance, due to the easy access of sand and dirt
- - The spring making this work will take power of the spear when shot

ARDEA		
Handling the line		
Date: 26-04-2016	Team no. 4	Worksheet no. 44

Ill. C.04: No line handling system

Pros/Cons:
- + Easy handling
- - The line gets tangled into everything
- - The line can make knots

Ill. C.05: Helix telephone cord

Pros/Cons:
- + Simple system with no need for winding
- - If the line gets tangled is is very difficult to untangle
- - It requires much more force to stretch the line when shot, which will affect the shooting range of the speargun

Evaluation:
The ways of handling the line on the existing spearguns is not the best suited solution for the new speargun. Due to the fact that the new speargun can adjust in length it will not be possible to use the simple winding system with small hooks in both ends of the speargun. The length of the line will be a problem because it will not fit the hooks in every length of the speargun. This will result in the line hanging down from the speargun which will obstruct the hunting experience and handling of the speargun. The line reel could be an add-on to the new speargun...

Reflection:
From the investigation it is clear to the team that several options are possible. The line winder could be an extra add-on to the product and something the user would buy after buying the speargun. This would lead the team to integrate a simple line winder as possible on the speargun - like on the existing spearguns, and hope for the customer to buy the extra add-on as well. The team could also make it possible for the customer to attach a line reel somewhere on the new speargun - also like they already do on the existing spearguns. The team has decided to go for the cord winder principle and make the line retract only by pushing a small button integrated in the handle. The mechanism in the line winder will have to be replaceable due to the possibility of sand and dirt getting into the mechanism and make it stock. The team will therefore have to take the maintenance of the speargun into consideration when designing the line winder mechanism.

Sources:
Ill. X.01: http://banditospearguns.com/bandito-bonito-speargun/
Ill. X.02: http://www.spearfishingproducts.com.au/seatec-geko-carbon-spearfishing-speargun/
Ill. X.03: http://the-gadgeteer.com/2009/11/29/dyson-dc23-turbinehead-canister-vacuum-cleaner-review/
Ill. X.04: Own picture
Ill. X.05: http://www.rcmheadsets.com/manufacturer_category/starkey-headset-group-connecting-cords/

ARDEA		
Transportation		
Date: 11-04-2016	Team no. 4	Worksheet no. 45

Objective:
The objective of this research is to put up the requirements for what is needed under transport. There will be focus on four different types of transport will be researched; car, bike/motor bike, public transport and walking. The worksheet is created to detect which problem occurs in the different transport situations and what lengths can be a problem when transporting a speargun. Furthermore the research will use statement from questionnaire, act it out, disk research and experience.

Experiment:
Based on the questionnaire of user insight the problems about transport is identified.
Car:
This transportation method is the most used transportation form, due to the faqt that some fishing spots are placed away from the big cities. The best about using a car is that the user has a trunk or back seats where all the equipment can be placed. The main problem about transporting the speargun is that it has a tendency to rip up the interior if there is not protection on the tip. Furthermore there are some problems about the spearguns can be too long during transportation. These are the main problems when transporting the speargun.
This puts up some request for the speargun that the tip of the speargun has to be protected when not in use and that the speargun can fit in even small cars. A good length of a speargun for small cars is ca. 60 cm which fits in the hat department in smaller cars like (Skoda citigo/ vw up/ seat mii)
Bike, Scooter and motorbike:
This transportation method is not as used as the car, but is still used. Last summer one of the team members experienced the problems about transporting a 75 cm speargun around on a scooter. This was not without problems, the speargun pointed out of the back in all direction. By acting it out problem finding was recreated as shown on picture below.

The finding above creates a requirement that the speargun has to be enclosed or the speargun has to be so short that it fits the different size bags used for spearguns. The normal size of equipment bags is spending from apox 30L to 120L depending and has different dimensions. Therefor it would be optimal to create a casing for the speargun alone of make it so compact that it fits even in a small sportback.

Public transport and in public:
When transporting a speargun in public transportation the questionnaire reveals that some users find himself looked at and confronted in a negative way and rejected, when bringing a speargun on public transportation. Some get frighten and some drivers or conductors won't allow the user to use the train or bus. One person from the questionnaire uses a rifle bag which seems to make even more people concerned. The signal of bringing a weapon along in public transport is a problem, so if the speargun can not be hided in the bag, the bag for the speargun should not look like a weapon in any way. The problem seems to be that a speargun should not look like a weapon outside of the water.

When bringing the speargun around in the urban environment as shown on the picture there are the problems which has been presented above, but also the problem that the speargun has a sharp point which and can puncture or injure

objects or people. This is a big concern which to have in mind when designing a new speargun. Specialty if the speargun has to be placed in a backpack. As shown below

Evaluation:
The results of the research revealed that there is a need of:
Compact enough to fit in a small car if driving
Compact enough to fit in a bag if transporting it on bike or secure and hide it's a speargun
If transported in a car secure it doesn't rip up interior
When not in use look disarmed
When walking dos not wave around puncture other objects

Reflection:
The outcome of this research revealed that a number of requirements is needed for transportation. These requirements helps create a holistic solution with the whole user journey in mind, for this new speargun

ARDEA		
Aesthetic Expression		
Date: 25-04-2016	Team no. 4	Worksheet no. 46

Objective:
To reach the desired aesthetic expression of the speargun a research of different fish species is needed to understand how the anatomy of the oceans animals is and why. This will help guiding the team towards a speargun design, that has a connection between it's function and form. Furthermore human-made objects for the ocean is investigated to see if any inspiration can be found here.

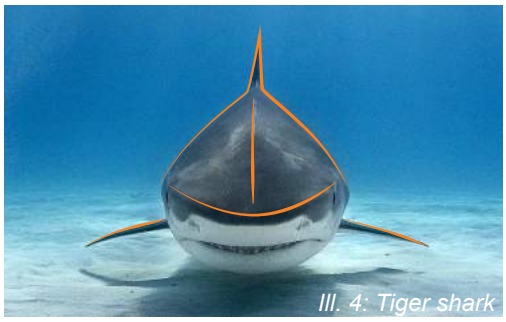
Experiment/Data:
The team looks for a speargun design, that gives the impression and feeling of dangerous, intimidating and respect when being in the water. As soon as the speargun is above water and has to be transported from the users' home to the spearfishing spot the speargun should not seem dangerous and look like something that can hurt or kill anything. Different pictures have been collected to find inspiration for shapes and specific curves which can be transferred to the form of the speargun.


Ill. 1: Hammerhead shark


Ill. 2: Hammerhead shark

The hammerhead shark is the obvious source for inspiration, because it has the characteristic head, which reminds of the loading plates on the new speargun. The shape of it's head can be used in the shaping of the loading plates for them to be hydrodynamic and intimidating at the same time.


Ill. 3: Caribbean Reef shark

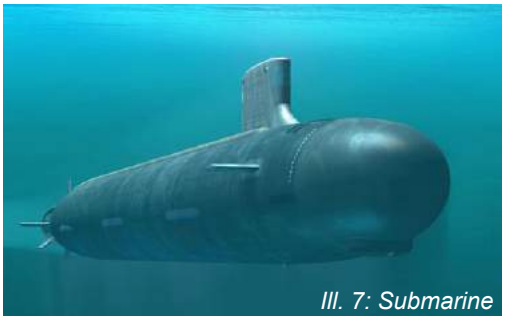

Ill. 4: Tiger shark

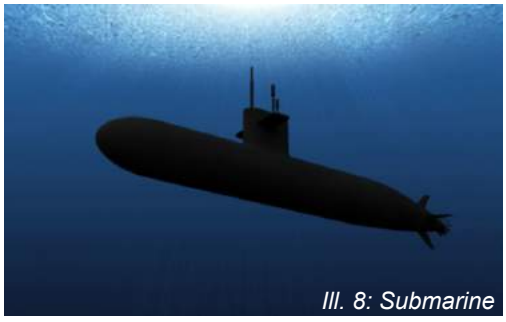
The front view of the tiger shark has some interesting curves, because they make the shark look aggressive and very targeted, which is something the speargun should express. Most curves goes from wide to narrowing down at the tip of the nose.


Ill. 5: Blue Marlin


Ill. 6: Blue Marlin

With it's spear shaped upper jaw the blue marlin is a good way to look for inspiration. The spear gives it a clear direction and the big dorsal fin makes it very beautiful especially from a side view. The fins generally help the fish to easily maneuver around in the water.


Ill. 7: Submarine


Ill. 8: Submarine

The submarine is an old invention and is still used the day today. The shape goes from a rounded nose to become thinner at the tail. In the worksheet of water flow simulations we saw that this helps leading the water smoothly away and around the object.

ARDEA		
Aesthetic Expression		
Date: 25-04-2016	Team no. 4	Worksheet no. 46

Evaluation:
t is important to give the speargun some forward direction to make it look aggressive, but also in order to make it hydrodynamic. The fins of the fish helps them maneuvering better around in the water. The shape of the fish on the pictures are all going from narrow at the nose to wide at the body to very narrow at the tail, which make them more hydrodynamic in the water when moving forward.

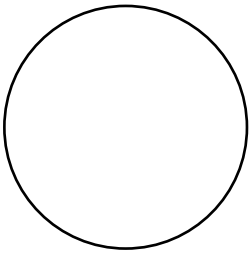
Reflection:
It will be difficult to reach a dangerous looking speargun in the water and non dangerous looking speargun above water, so therefore the aesthetic expression will only focus on how it appears in the water. It also becomes difficult to reach the forward moving curves of the different fish species in the pictures, because the new speargun will have these loading plates running along the barrel, which means it has to have the same shape from the start to the end of the barrel. This can maybe be solved with the muzzle closing and finishing the barrel if it gives the speargun some direction with an angle. The spear will also help giving the speargun a clear direction just as the blue marlin. Furthermore the loading plates can be used to not only imitate the hammerhead shark, but also to ease the maneuvering when swimming forward in the search of a fish. All this will be considered during the 3D modeling, but the functions and mechanism can make it difficult to get the desired expression, and therefore the aesthetics will be prioritized second. It can though be used as inspiration while shaping the different parts of the speargun and finally give it a holistic expression.

Sources:
Ill. 1: http://www.shark-pictures.com/thumb.php?file=images/pictures/495_1146022176.jpg&sizex=500Ill. 2: http://i.imgur.com/lqL3R0k.jpg
Ill. 3: http://3w9yz8ifp462cet4q2j4fjen.wpengine.netdna-cdn.com/wp-content/uploads/2015/03/Caribbean-reef-shark.jpg
Ill. 4: http://awesomeocean.com/2015/07/14/national-shark-awareness-day-has-arrived/
Ill. 5: http://sportfishingbluemarlin.com/wp-content/uploads/2015/01/Marlin.jpg
Ill. 6: http://cdn.c.photoshelter.com/img-get/I00004tcGfhH.9cA/s/1000/Blue-Marlin-0003.jpg
Ill. 7: http://www.ultra-os.com/images/underwater/underwater-image.jpg
Ill. 8: http://blog.lib.uiowa.edu/eng/files/2015/03/submarine.jpg

PROJECT TITLE		
Worksheet Title in water 2		
Date: DD-MM-YYYY	Team no. X	Worksheet no. XX

Objective:
The objective is to investigate different possible shapes of the barrel of the speargun, so the final design of the new speargun is optimized to make it as comfortable and easy for the spearfisher to hold the speargun steady in high water current when taking an aim at a fish.

Experiment/Data:
The experiment is flow simulations of different shapes in SolidWorks, where the water current is set to 1,8 m/s in the settings to illustrate a water current about 1,5 m/s and a spearfisher moving the speargun in the opposite direction with 0,3 m/s. The water current of 1,8 m/s is tried on different profiles to figure out how much force it requires from the spearfisher to hold the speargun steady in the water when aiming at a fish. All the profiles are 450 mm long, so the results have to be multiplied with 2 to find the force which a 900 mm speargun is exposed for. The water currrent comes from 0^{O} in the simulations.

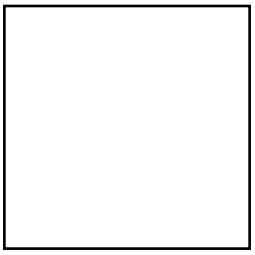


CIRCULAR PROFILE

$\sum F_x$ = 10,35 + 0,30 = 10,65 N
$\sum F_y$ = 0,11 + 0,0001 = 0,11 N

Surface area: 0,0437 m^2

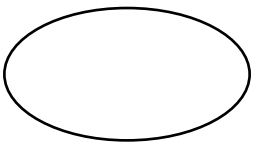
Ill. C.XX: Description



SQUARE PROFILE

$\sum F_x$ = 25,76 + 0,09 = 25,85 N
$\sum F_y$ = - 0,004 - 0,00003 = - 0,004 N

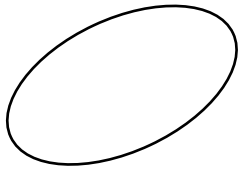
Surface area: 0,0558 m^2



OVAL PROFILE

$\sum F_x$ = 3,53 + 0,33 = 3,86 N
$\sum F_y$ = - 0,50 + 0,002 = - 0,49 N

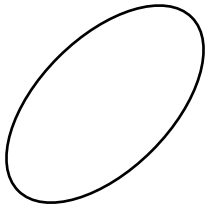
Surface area: 0,0447 m^2



OVAL PROFILE TILTED 25^{O}

$\sum F_x$ = 7,35 + 0,32 = 7,67 N
$\sum F_y$ = - 7,27 + 0,06 = - 7,21 N

Surface area: 0,0447 m^2

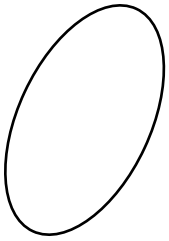


OVAL PROFILE TILTED 45^{O}

$\sum F_x$ = 15,51 + 0,29 = 15,80 N
$\sum F_y$ = - 7,26 + 0,08 = - 7,18 N

Surface area: 0,0447 m^2

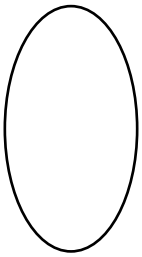
PROJECT TITLE		
Form and Flow in water 2		
Date: 29-02-2016	Team no. 4	Worksheet no. 7



OVAL PROFILE TILTED 65^{O}

$\sum F_x$ = 21, 42 + 0,24 = 21,66 N
$\sum F_y$ = -4,23 + 0,09 = - 4,14 N

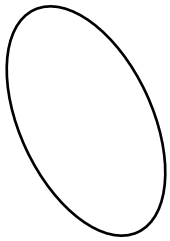
Surface area: 0,0447 m^2



OVAL PROFILE TILTED 90^{O}

$\sum F_x$ = 22,98 + 0,14 = 23,12 N
$\sum F_y$ = 0,07 + 0,002 = 0,07 N

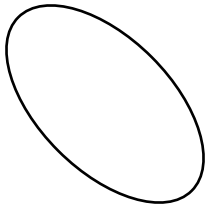
Surface area: 0,0447 m^2



OVAL PROFILE TILTED 115^{O}

$\sum F_x$ = 22,18 + 0,22 = 22,40 N
$\sum F_y$ = 4,24 - 0,09 = 4,15 N

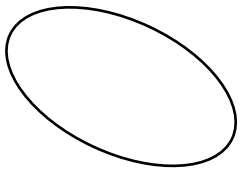
Surface area: 0,0447 m^2



OVAL PROFILE TILTED 135^{O}

$\sum F_x$ = 15,50 + 0,29 = 15,79 N
$\sum F_y$ = 7,28 - 0,08 = 7,20 N

Surface area: 0,0447 m^2

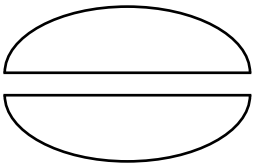


OVAL PROFILE TILTED 155^{O}

$\sum F_x$ = 7,29 + 0,33 = 7,62 N
$\sum F_y$ = 7,31 - 0,06 = 7,25 N

Surface area: 0,0447 m^2

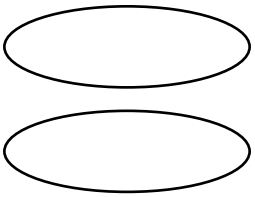
PROJECT TITLE		
Form and Flow in water 2		
Date: 28-04-2016	Team no. 4	Worksheet no. 7



OVAL PROFILE DIVIDED IN TWO

$\sum F_x$ = 4,96 + 0,68 = 5,64 N
$\sum F_y$ = - 0,07 + 0,0009 = - 0,07 N

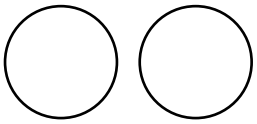
Surface area: 0,0807 m^2



OVAL PROFILE x2

$\sum F_x$ = 6,17 + 0,58 = 6,75 N
$\sum F_y$ = - 0,15 - 0,00008 = - 0,15 N

Surface area: 0,078 m^2



CIRCULAR PROFILE x2

$\sum F_x$ = 3,62 + 0,22 = 3,84 N
$\sum F_y$ = 0,02 - 0,00006 = 0,02 N

Surface area: 0,0285 m^2

To prove whether the results from the flow simulation are valid or not a simple and quick calculation is made for the square profile:

D = C_D * A * q_{inf}

To find q_{inf}:

q_{inf} = ½ * ρ * V_{inf}^2
= ½ * 1000 kg * $1,8^2$ m/s
= 1620 kg/m s^2

To find D:

D = C_D * A * q_{inf}
= 1,05 * 0,014 m^2 * 1620 kg/m s^2
= 23,81 N

The result is very similar to the result SolidWorks Flow Simulation gives ($\sum F_x$ = 25,85 N), so the flow simulation results are from the manual calculation trustworthy.

Evaluation:
The single oval profile seems to be the best shape for the barrel, because it is exposed for a minimum force when the water current comes from a 0^O angle. The water current can sometimes also come from different angles and therefore the team tested the oval in different angles to figure out how much force the oval shape will be exposed for then. The force is suddenly significantly higher, but that is a result of the bigger surface which is hit by the water current.

Reflection:
The results show that the oval profile is better than the other profiles, but as soon as the water current comes from another direction than 0^O (horizontal), other profiles like the circular become better, because the surface which is hit by the current will always be the same. It is not often that the water current comes from an angle [1] and therefore the team will go with the oval, because this is definitely the best shape for the barrel of the speargun in water current from an angle of 0^O and a horizontal movement of the speargun. A phase with focus on the aesthetics is now needed to reach a desired expression and at the same time have a hydrodynamic design.

Sources:
[1] Expert Interview - Morten Rosenvold Villadsen

ARDEA			
Detailing of locking between barrels			
Date: 26-04-2016	Team no. 4	Worksheet no. 48	

Objective:
The objective of this worksheet is to detect which locking and adjusting mechanisms is needed when adjusting the barrel length of the speargun. The goal was to create an adjustable principle which could be justed simple and without many expensive and complex components. Furthermore the spearguns barrel adjustment has to withstand high force of 500 Newton and be adjusted within the water without any extra tools. This demand combined with the requirement of using loading pads as loading principals was a hard task to solve. The goal is to come up with an overall solution and a principle which can be used in the final design of the speargun.

Experiment:
Different shapes and adjustment principals will be done with sketching on both paper, mockup model and in 3d modeling programs to get an overview of possible solutions.

It has been concluded earlier that a need of 5 different lengths of the speargun, from 50 to 90 cm on the barrel. This require a system which can span over 40 cm and can be adjusted with a 10 centimeters virality each time.

The main problem of the adjustment was that it had to be combined with other requirements (worksheet xx) and it had to be as simple and with as few components as possible. The first test of adjusting the barrel was based on an extension shaft for painting rolls, which was a cheap and simple solution. See pictures below.

This principal had pros and cons. The main proe was that i was a cheap proven concept which was easy to incorporate, But the main con of this method was that the barrel diameter had to be bigger and the fact that to use this principle it had to be round, which created problems with the loading pads, because it could now rotate and make uneven loading. Therefore new solution method was looked into.

The next solutions which was looked into was a simple slit system where a range of holes made it possible to lock the spear length.

This was an simple solution be combined with the requirement of the loading pads, rail and shape this principal was not looked into more. It had pros in terms of simple shape and could have cheap production and easy to use. The con of the split system was that it easy fell out of the holes and could not be combined with the solution as it was at the current time.

Based on trying to find another simple system, the group looked into other systems which could be found in the homes. One of the solutions was a simple telescope system which had more modules as shown below. This system did not really fulfill the need but gave inspiration to possible solutions.

Based on that system the system below was introduced, this system is used by Electrolux on their vacuum cleaners. This system seemed to work really well and with high build quality. This solution required many new components if it was to be copied the system. Moreover the system had many components which could end up having a high production price.
The process of this principle was that it worked really well, it was possible to have other shaped barrels and it was adjustable, the main problem was more small components which could brake and the high price.

As the collaboration between the different parameters needed for loading and adjusting the speargun fell in place the smartest solution seems to be a split which lock the two tubes together and can be operated within the water with gloves on.

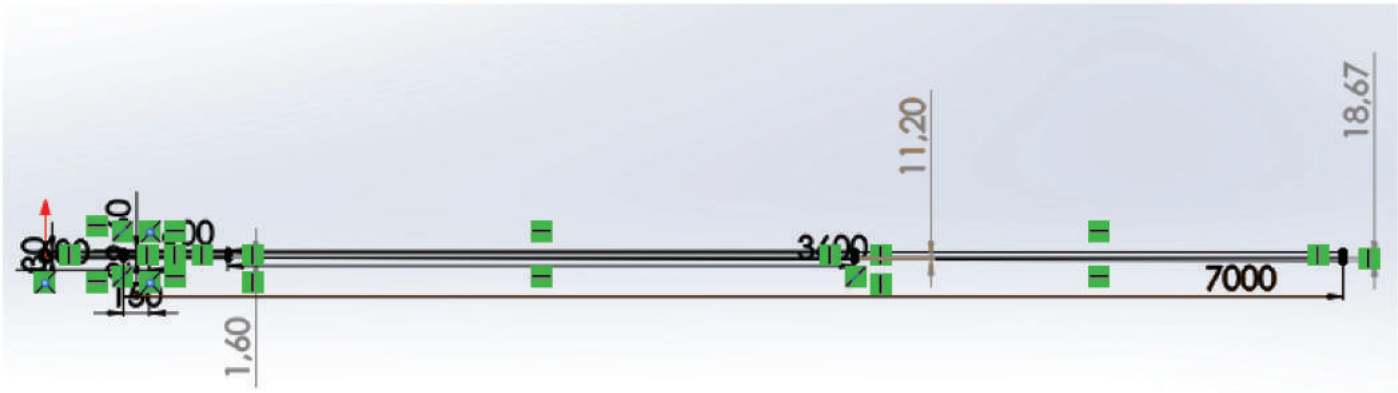
Evaluation:
The results of the research did reveal that a simple locking mechanism is needed and it has to be fitted to the different principals to make a fully functional system. The locking of the barrel is at the same time used for hooks for the locking making the solution more integrated in the hole system.

Reflection:
The outcome of this research revealed that the solutions for one problem can not just be assumed do the all the surrounding factors which has impact on the construction. The adjusting system can be further developed.

ARDEA		
Shot accuracy		
Date: 11-05-2016	Team no. 4	Worksheet no. 49

Objective:
The team had problems finding the right locking method between the barrels, due to defended possible problems. The reason that a switch lock had been ruled out in the first place was due to fragile components but mostly due to the fear that the two barrel needed two mounting points so that the blur in the barrel would be reduced. The team decided to investigate based on the solution at that point to calculate how much the spear would deviate when the spear is fired.

Experiment/Data:
The team made a line drawing in solidworks to calculate how much the blur between the two barrels would affect the accuracy when fired. The test is based on the angel that would occur then the barrel only are locked as a real Simple support with only one mount point. The number of tolerances are based on the tolerances found on aluminiums profiles. These dimensions were then used as to create the maximum distance the barrels could deviate from each other. The team did then draw up how much the barrel had overlap and how far the shoot maximum can be.



Evaluation:
The team calculated the maximum divination of the two barrels is 0,4 mm. But due to the long overlap the divination in the estuary of the spear gun, would be 1,6mm and after 3,6m the spear would deviate from the target with 11,2 mm. If the speargun is set to 90 cm the maximum reach would be around 7000 mm, at this point the deviation would be 18,67mm

Reflection:
The results show that the deviation at its maximum would be 18,67mm. By evaluating the foundings, the team did not see this as a large deviation, if compared with the fish size if the show had to be 7000mm and the surrounding factors which can affect the shot. These factors such as current or recoil, is said to have more impacts. Therefore the team concludes that this deviation should not affect the decision of choosing a direction for the barrel adjustment. Based on that the final adjusting principal with an spring eye bolt could be chosen.

ARDEA			
Shaping of muzzle component			
16-05-2016	Team no. 4	Worksheet no. 50	

Objective:
The objective of this worksheet is to describe the design process of the principal of the loading pad and how the locking mechanism works. The principal has been undergoing 13 different stages where, different concepts has been developed and adjusted. The different solutions is based on a continually reevaluating of the solutions and combining them with the findings of the other requirements of the speargun, so that an integrated solution. The goal is to find a simple solution which is intuitive, robust, simple, cheap, reliable, and can withstand high force when the speargun is loaded. Furthermore is it important for the user to be able to easy load and reload. The different principals has started out with some basic solutions, which then was tested or evaluated in other way and based upon the findings the next concepts was build upon.

Experiment/Data:
The loading of the speargun has been undergoing the following steps in the development process.
Loading by feets
Incorporate round barrel
Friction as locking mechanism
Grooves as locking mechanism
Open barrel speargun
Open barrel lock 2,0
Integrating roller system
Loading pads lock combined with adjusting barrel length
Loading pads locking in mussel
Loading pads in mussel with construction
Shaping of loading pads
Calculating on loading pads
Final product.
The 13 different stages has been different in size and has been justed to the different demands and problems which has occurred from other parts of the speargun. The hole product has been evaluated based on the other constructional solutions which has been found, in the other ongoing developing process of the speargun.

Loading by feets
Billed af træ model
The initial concept of the speargun which is made with loading pads is the one tested in the swimming pool and build as a function model. This model worked well but had the cons of the loading pad to be large, made of wood, square in the shape and being large and not adjustable. In general this model was just to verify that it was easier to load the speargun with the feet than normal, and made the foundation for using the feet and a loading pad as loading mechanism.
What to bring to next stage:
The initial idea was to use loading pads and the feet to load the speargun. Those are the main principles and foundation for the further work on the loading mechanism.

Incorporate round barrel and adjustable length:

This is the second concept of the loading mechanism on the speargun. In this stage the loading method was combined with the requirement of an adjustable barrel. This concepts revealed some new knowledge in terms of shape of the barrel and the demand of the adjustable barrel length. The problems which occurred by using an adjustable barrel with a screw lock as shown on the pictures, required a bigger gap between the two barrels and made it difficult to make a smooth loading of the pads.
What to bring to next stage:
The two barrels has to have as smooth a transition/shift from one barrel to another when using the loading pads.

Friction as locking mechanism
The current solutions of the loading pads hasso far be focusing on using friction as locking methods, this principle was elaborated and evaluated at this stage. The solution had proes in terms of no need of locking mechanisms and the speargun had infinite locking positions. Another pro was that the speargun was easy to adjust in length. The cons of the system was that the loading pads had to have the rubber bands mounted with a distance to the barrel so that a

moment which made to locking mechanism would happen. This would on the other hand affect the spear so it would be pulled upwards and make it difficult to aim. a con of this solution was also that the speargun has to rely on different surfaces with high friction so the lock would work. Another con was that the mount of the rubber bands interfere with the aim. Another finding was that the spearguns barrel was it had to be oval, square or another asymmetric shape to make the loading pads stable so that the loading pads can not rotate.
What to bring to next stage:
Alone would the friction lock probably not work, and if it did it would interfere with other requirements FX the precession of the shoot and the aim. Therefore there has to be some kind of other lock mechanisms. The loading pads should not be able to rotate and but unbalanced dooing loading

Grooves as locking mechanism
Based on the previous solutions a 3d print was made with grooves investigate if friction and grooves would work as a lock on the loading pads and what effect the wall thickness of the barrel would have. Doing the process it was determined that the loading pad had to be open in the top or bottom so that there was space for the locking mechanism of the barrel length. All these requirement made it difficult to see how the solution could work.
By printing the 3d model and investigating it in real life it became clear that this system was way too wobbly and unsafe, when 500 N+ affected the loading pads. In addition to this was that the thickness of the barrel affected the speargun much and the locking grooves did not help as much as hoped.
What to bring to next stage:
The principal of friction and grooves did not work, but the grooves could maybe be used in another solution. Furthermore the 3d printed model gave awareness about the wall thickness effect on the loading pads.

Open barrel speargun
Picture af renderede billedede.
Based upon the findings from the different concepts of how to make the speargun both adjustable in the length and combining it with a principle of loading the speargun with the feet and whole body new requirements and solution foundation had to be bade. The following concept to this was a principle of making a speargun with a open barrel which meant that the locking mechanism could be moved from holes or grooves in the barrel to the sides of the barrel. As shown on the picture. This principle had both pros and cons in terms of having an open shape which also had the pro of creating less drag in the water when the speargun was moved around. Another pro of using the open barrel structure was that the locking mechanism of barrel adjustment could be incorporated into the space in the open barrel. This solution had great potentials and was decided to work further upon. The problem was that the structure had low strength and potentially could create more drag than first anticipated. Doing the concept development the first principle of marking the loading pads into rods or beams to make the aim better and less drag when swimming around in the water. The idea was also that the shape of the loading pad could help maneuver the speargun more up or down, if the shape of the beams was shaped like wings, this was ideas which had to be elaborated on.
Earlier in the design process it was determined that is was necessary to have a open railed loading pad, but by opening the rail it was now necessary to have a closed railed loading pad to maintain stability.
What to bring to next stage:
The principle of having two barrel where the locking mechanism could be placed and the potential of less drag could be brought to the further development of the speargun. The principle of having the speargun locked in between the gap in the barrel was the main focus to bring along for further development.
The shape of the loading pads ranged to beams to minimize drag in water.

Open barrel lock 2,0
The different findings was in this phase used as guidelines to expand the solution area on the barrel and loading pads. Worksheet XX will describe further work on different shapes of the barrel and the pros and cons of open, closes, double and rail barrels. The design process where at this stage both trying to solve the aspects of adjusting the barrel length and at the same time create an easy and cheap locking mechanism for the loading pads. As shown on the pictures differed solutions was presented, but all had vital fowls which had to be solved. Some of the where production vise other where strength and other was that is affected the other requirements which was decided. Due to the complexity of the requirements the team had trouble finding a solution.
What to bring to next stage:

Not many solutions where to brouth further from this stage of this design process.

Integrating roller system
Pictures of old roller system and rail
While trying to solve the problem from the previous solution (Open barrel lock 2,0) new requirements from the rubberbands was found, this made it necessary to incorporate a roller (bearing) system into the speargun, this resulted in that the beams of the loading pads was changed as shown on the pictures. This did affect the loading pads in two ways, it made it possible weaker and it changed the axis from where the force of the rubber would affect the loading pads. This means that before when the rubber was placed on top of the speargun the speargun would create a momentum near the loading pads mount, but when the roller system is integrated the speargun now has the pull back in the center of the speargun.
Another feature which was added to the speargun doing the stage is a rail for the spear, with is integrated in the barrel for giving the speargun more precision, when shooting. This rail did not affect the shape of the loading pads.
These two nes principal which had to be incorporated did not help simplifying the design process and the solution. Til phase was also a part of the phase where it was hard to see any smart solutions.
What to bring to next stage:
The new direction from where the speargun pulled back from had to be in mind when further developing the speargun.

Loading pads lock combined with adjusting barrel length
This part of the design process was where one of the larges breakthrough came by looking on the whole construction of the speargun. So far the problem has been to integrate the locking of the loading pads and at the same time makes it possible to adjust the length of the speargun. All the current solutions was conflicting in some degree or another. Therefore the group did have to come up with a new solution and way to go, this was done by taking a step back and then go through the hole user scenario of what the user should do and how they should do it. By doing this it became clear that the only place there had to be a lock for the loading pads where in the fount of the speargun instead of along it. This is done as shown on the picture above. By making it possible to have the locking of the speargun in just the front of the speargun, the group could fulfill all the requirements which was needed in the speargun. The principal could now be a closet barrel again which gave more maneuverability, is was cheaper in production, it became simple, easier to load, all requirement for barrel, rubber bands and adjustment could be done now. The only problem now was how the speargun could be locked into the front of the speargun. This solution had to be expanded and elaborated to find the best locking mechanism as possible. There were overall two requirements. Safe when loaded (the rubberband should not be able to backfire) and the solution should have as few and simple components as possible.
What to bring to next stage:
The principal of locking the loading pads in the front of the speargun.

Loading pads locking in mussel
The next step of the design process was to integrate the locking mechanism into the muzzle of the speargun, the main idea was that a hook grouped around an object in the muzzle which made the speargun lock. The first principal was done as a hook on the speargun as shown on the picture. This principal was not as safe as it could be, another principal had fragile components. Therefore the result became as showed on picture (XX) this solution would as the principal work, but had some flaws in terms of the need of a hole in the loading pad for the mussel. Another feature to give the loading pad more strength is to use a stainless steel rod as one of the beams in the loading pad, this makes it cheaper in production, gives more strength, easier mount of roller. The biggest problem as it is in this phase of the design process is that the locking mechanism potentially has low strength.
What to bring to next stage:
The principal of making the lock integrated in the mussel and use the stainless steel beam as one of the loading pads.

Loading pads in mussel with construction
This is the final stage of the developing process before final adjusting of the shape and calculating the hole construction ends up with the solution as shown on the picture. The main feature which has been change in this stage is the cut into the muzzle so that the stainless steel beam lock itself when passing the lock hole. The reason this will happen it that the rubber will try to fall into the middle axis of the speargun and equally retract on the speaking. This means a secure and strong locking mechanism. Another feature is that the steel beam in the loading pad is moved in front of the other loading beam, this makes the stainless steel beam the most loaded beam. This is the final construction of

the loading mechanism, it seems to be the simplest and most efficient solution and suitable solution.
The next step of the design process of the loading pads is to adjust the second beam with as much strength as it can be and with and a desired shape.
What to bring to next stage:
The hole product is as it should be right now, so it is possible to crease and use.

Shaping of loading pads
The last part of the shaping is from picture XX to Picture XX this shows how the shape has changed. The reason for the changes in shape is do to aesthetically solutions, and to make the mussel look as light as possible. Furthermore should the shape reflect the fish shape, but still have a sharp edge and a profile as a wing to make it more maneuverable.

Calculating on loading pads
The loading pads is one of the most stressed parts in the whole construction, therefore is it necessary to investigate whether there is some critical points on the object. The most critical point of the loading pad would be the loading beam, made in Nylon, this has the problem that it might not withstand the force if a spearfisher wrongly load the speargun by only the nylon beams, this problem should not occur, but the fear of it happens, is the reason it will be calculated.

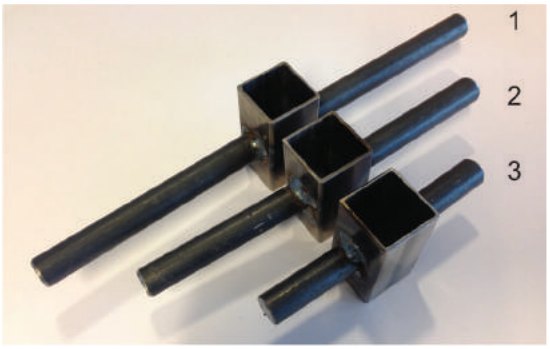
Evaluation:
The outcome of the whole design process has been an ongoing process doing the whole development of the speargun, it has not been done separately which is why it has been through so many stages. The outcome of the process is a solution which is well thought through and is close to being so close as possible.

Reflection:
The biggest problem doing the developing process of the loading pads has been to integrate the requirement of an adjustable length of the speargun. This has been the biggest challenge, due to the conviction that the speargun had to have different locking positions. The biggest breakthroughs in the design process of the loading pads has occurred when taking a step back and been asking how and what is needed when the speargun should be used. By including the user interaction the different steps of loading the speargun has become more clear and easier to understand. Unfortunately this method and discovery was first done after have been stocked in the design process for a week, but the method can be used in further projects in the “real world”

ARDEA		
Shaping of loading pads		
Date: 21-04-2016	Team no. 4	Worksheet no. 51

Objective:
The objective is to be able to set some demands for the loading pads. Through an experiment it should be possible to determine which is most comfortable when having to push 500N and to get and initial idea about the size and shape of the loading pads.

Experiment/Data:
For the experiment, a model is welded together. The idea with the model is to test different sizes of pedals both in length and width. To imitate the rubber bands on the speargun a bicycle tube is attached to the model.
Three different lengths of pedals are tested (40mm, 70mm, 100mm) and five different widths and shapes are tested.



Ill. C.01: Three lengths of pedals tested

Ill. C.02-06: Five widths and shapes of pedals tested

Ill. C.07: The welded model with bicycle tube as rubberband

Ill. C.08: The model in use

ARDEA		
Shaping of loading pads		
Date: 21-04-2016	Team no. 4	Worksheet no. 51

Experiment/Data:
The sizes and shapes of the loading pads tested were:

Sizes:
- 1: 100 x 12 mm
- 2: 70 x 12 mm
- 3: 40 x 12 mm

Shapes:
- A: 70 x 22 x 3 mm
- B: 70 x 6 mm
- C: 70 x 12 mm
- D: 70 x 22 mm
- E: 70 x 30 mm

Ill. C.09-11: The three lengths of loading pads

Evaluation:
The models were tested with and without fins to see if the pads were comfortable in both scenarios. From the experiment it was experienced that the diameter of the pipes did not mean that much in the loading experience - neither with or without fins. The pipe with the smallest diameter one was less comfortable, but not bothersome narrow due to the short time it took to load to speargun. The round shape of the pads were difficult to control and angle with the feet - no matter the diameter. The flat loading pads were possible to control and angle with the feet.
The length of the loading pads were also tested and it was possible to use all three sizes, though the largest ones were most comfortable and easiest to get a firm grip on.

Reflection:
By taking the results from experiment and the previous investigations in worksheets no. XX and no. XX into consideration, it is possible to determine the best size and initial shape of the loading pads for the new speargun. Based on these informations it is possible for the team to set up some requirements for the loading pads:

- The length of the loading pads should be ≥ 40 mm
- The loading pads should be either a flat shape or two pipes to be able to control the loading pads with the feet

Sources:
Ill. X.01-08: Own pictures.

ARDEA		
Investigation of stepping plates		
Date: 21-04-2016	Team no. 4	Worksheet no. 52

Objective:
The objective of the investigation is to get inspired by pedals and other kinds of stepping plates. By looking at other kinds of pedals, stepping plates etc. the team intentially gets inspired and is able to design the loading pads for the new speargun.

Experiment/Data:
By researching on the internet on different types of pedals and stepping plates the team has found some principles in different products, which could be interesting to incoorperate in the loading pads on the new speargun. The principles are shown on the pictures below.

Ill. 01: Stilts

Ill.02: Pogo stick

Ill. 03: Bicycle pedals

Ill. 04: Refrigerator door

Ill. 05: Motorcycle heel rest

ARDEA			
Investigation of stepping plates			
Date: 21-04-2016	Team no. 4	Worksheet no. 52	

Evaluation:
From the research on different stepping plates and pedals it is possible for the team to highlight some of the principles they find interesting and will consider in the future design of the loading pads of the new speargun. The principles are;

- The construction of the stilts, where the shape of the stepping plate has an integrated support in the shape.
- The foldable principle in the pedals on the pogo stick.
- The open structure and compressed size of the bicycle pedals.
- The simple design and thin structure of the refrigerator door.
- The idea of having a wider surface to step on and having better control of the foot and pedel on the motorcycle heel rest.

Reflection:
The team should consider the detected principles in the future design of the loading pads on the new speargun.

Sources:
Ill. 01: https://frankbentin.wordpress.com/page/26/
Ill. 02: https://shmsha.nl/index.php/speelgoed/motoriek-en-leren/product/pogo-stick-variabel
Ill. 03: http://www.clasohlson.com/medias/sys_master/8895724486686.jpg
Ill. 04: http://webshopdemeesternv.be/snel-koeler-vriezer-baker-sf-930-cbh-5b-gram.html
Ill. 05: http://www.house-of-flames.com/eng/Parts-Accessories/Dyna/Foot-Pedals

ARDEA		
Investigation of bicycle pedals		
Date: 21-04-2016	Team no. 4	Worksheet no. 53

Objective:
The objective of the investigation is to get inspired by the way bicycle pedels are shaped. The shape, sturcture and placement under the foot is parameters, which can give inspiration and show some direction in the shaping and designing of the loading pads on the new speargun. Through a subjective investigation of the pictures of the bycycle it might be possible to list some criteria for the design of the loading plates on the new speargun.

Experiment/Data:
The bicycle pedals have the same function and some of the same design criteria as the loading pads of the new speargun. They have to be both comfortable under the foot and effective to transfere the energy from the legs. The investigation of the byclye pedals will take convenience, shape and structure into account.

Ill. 01: Click bike pedal

Ill. 02: Open structure mountainbike pedal

Ill. 03: Open structure bike pedal

Ill. 04: Traditional bike pedal

The first pedal is the only click-pedal in the investigation. This means that you has a shoe with a device underneath that fits the pedal, so you attach your shoe to your pedal, thus bike when biking. Because of this, it is possible to decrease the size of the pedal. The surface where you step and transfere your energy to the pedals is a small, round surface. The smaller the stepping surface of the pedal, the harder it will feel to push down the pedal.

The second pedal in an open structure mountainbike pedal. The pedal is very flat, but wide. The wide pedal gives a bigger stepping surface which makes it easier to step down the pedal. The smal orange dots gives a more firm and secure step on the pedal.

The third pedal is made from a minimum of material to make the pedal as light as possible. To make the stepping surface bigger the pedal has a wing out in each of the four corners.

The forth pedal is a traditional bike pedal. This is the biggest and most masive pedal. The stepping surface is quite large and fits most feet.

ARDEA		
Investigation of bicycle pedals		
Date: 21-04-2016	Team no. 4	Worksheet no. 53

Evaluation:
Nowadays bike pedals have to be as light as possible so they wont add much weight to the lightweight sturcture bikes. This is why most pedals for racer and mountain bikes has an open, structured shape. The loading pads on the new speargun has also to be as light as possible so they wont weigh down the tip of the speargun and make it uncomfortable for the user to maneuver the speargun through water. The pedal on the new speargun should preferable have some kind of ribs or rough surface to secure a frim step on the pedal.
The size of the stepping surface of the pedals plays a part in how easy and comfortable the stepping becomes. Opposite the bike pedals the loading pads on the speargun should not be able to rotate.

Reflection:
From this investigation it is possible for the team to determine some parameters to consider when having to design the loading pads of the new speargun. The parameters are;

- The surface of the pedal, maybe adding some ribs or rough surface
- Structured shape to reduce weight
- The stepping surface should be larger to be more comfortable and effective
- The loading should probably not be able to rotate

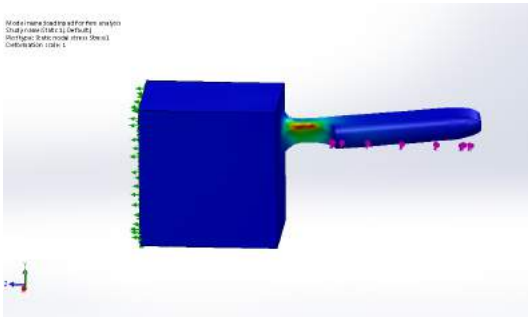
The loading pads could act like floates to help holding the tip of the speargun be horizontal in water. The loading pads could also help maneuvering the speargun through water. This is something the team will have to investigate further.

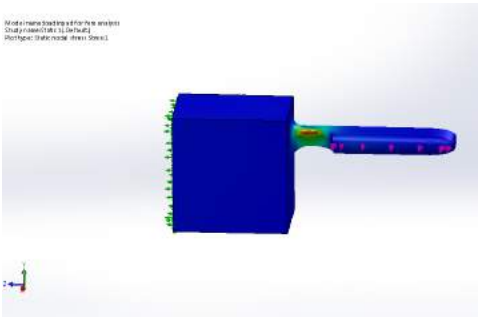
Sources:
Ill. 01: http://content.competitivecyclist.com/images/items/medium/SPP/SPP0022/BK.jpg
Ill. 02: http://www.cyclestation.com.au/giant-pinner-dh-flat-bike-pedals-black-bicycle-ped
Ill. 03: http://www.aliexpress.com/store/product/Ultralight-Magnesium-Alloy-Mountain-Bike-Pedals-CNC-Cuting-3D-Shape-Bicycle-Pedal-Road-Bike-Universal-Model/1454161_32604304469.html
Ill. 04: http://www.styleforum.net/t/218155/flat-bike-pedals-with-leather-sole-dress-shoes

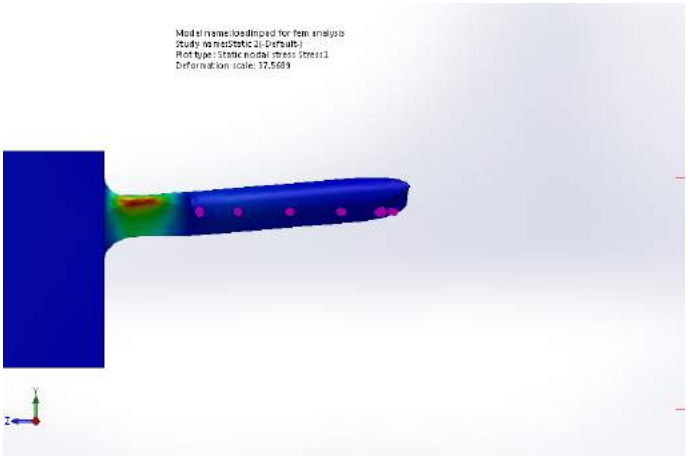
ARDEA		
FEM analysis of pedals		
Date: 26-04-2016	Team no. 4	Worksheet no. 54

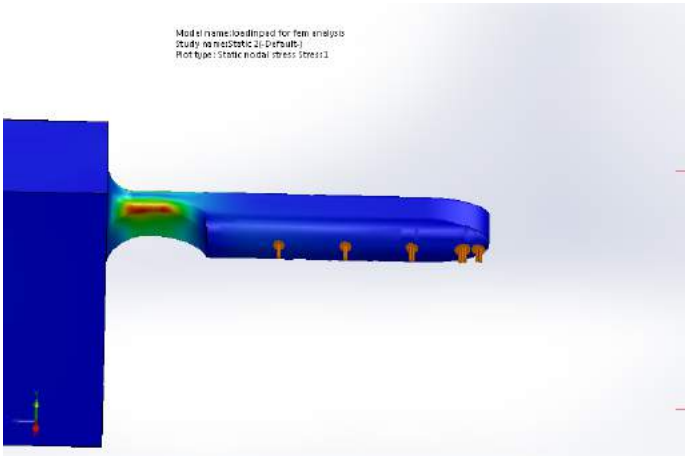
Objective:
An test is made to evaluate if the design of the loading pads will withstand the force which is added during loading. The calculations are based on worst case scenario, which is if the spearfisher decided to only puts force on one of the loading-pads beams. There normally two loading beams in the loading pads, where one of them are placed a little behind the other. The one which is placed closer to the handle than the other is the steel loading beam. This beam is the strongest and will therefore withstand the most force. When the feet need the loading pads the steel loading beam will be pushed back and a equal force will be affecting the both loading pads. The worst case scenario is if the spearfisher at some point only puts force on the nyong loading beam.

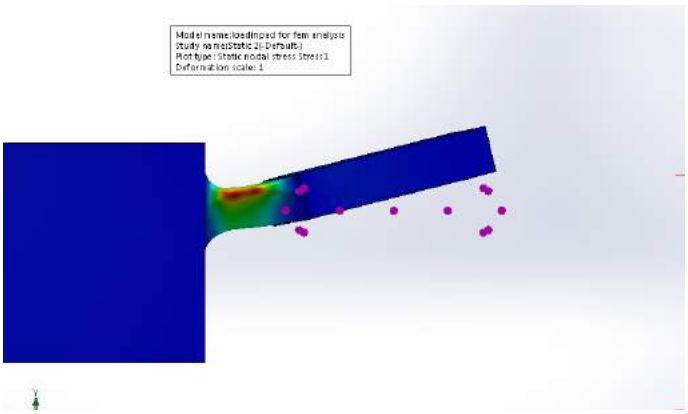
Experiment/Data:
The calculations is based on FEM analysis done in Solidworks. The model is simplify on some of the less crucial areas. The force which is max on the loading beam is 500 N. This is done to speed up the calculation process in Solidworks. Different materials was tested. Steel, nylon 66, nylon 66/g30 Nylon66/g60. These different materials had a yield strength from 200,240,260, 290 N/mm^2

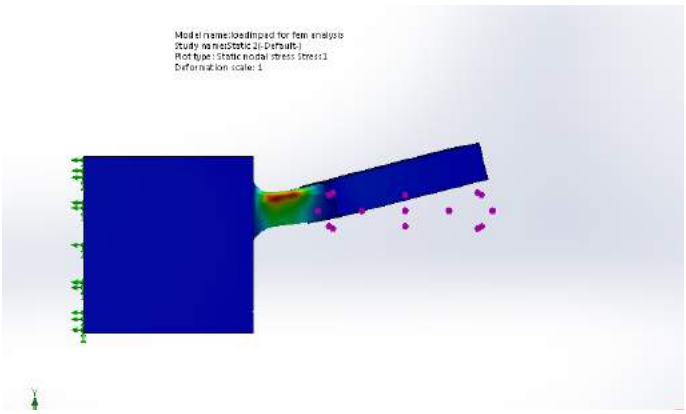




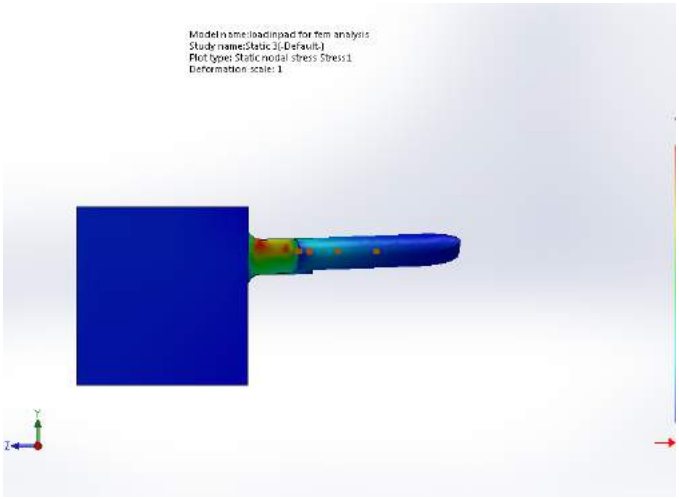


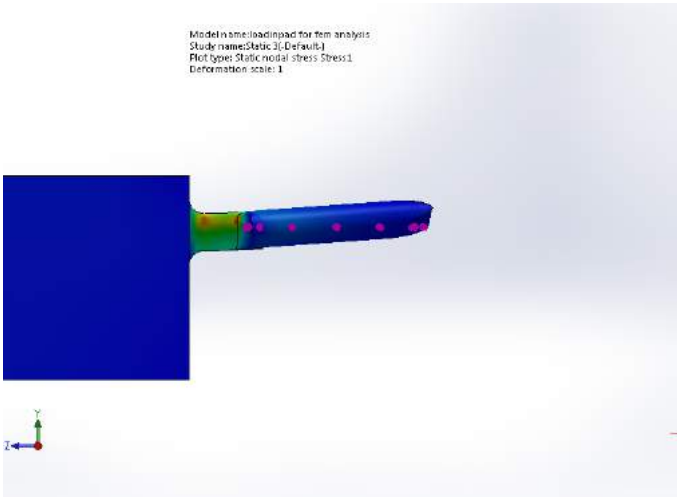


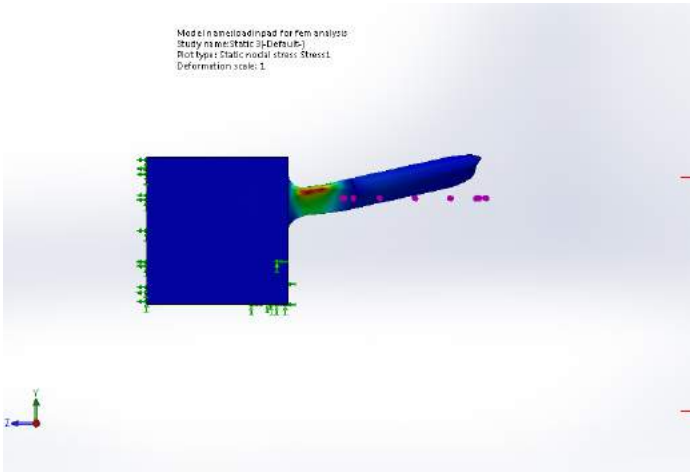




ARDEA		
FEM analysis of pedal		
Date: 26-04-2016	Team no. 4	Worksheet no. 54







Evaluation:
The result revealed that if the loading beam had a safety factor between 0,9 and 1,1 depending on the material Therefore another solution had to be found. This can be done by adding material to the critical point. By rising the loading pads surface area in the critical point, the test was done over. This resulted in a much more reliable solution.
SURFACE AREA modified from:
75mm^2 = 0,9 safety factor
123mm^3 = 1,8 safety factor
160mm^2 3x safety factor
The size of the surface area dos not affect other components, and therefore will it not be a problem to scale up the dimensions.

Reflection:
The results of the test showed that some optimizing has to be done to ensure that the strength of this component is can withstand the force. The result in the end showed that the loading beam has a safety factor of 3, which seems to be a reliable foundation, for the feasibility of the loading pad.

ARDEA		
Locking between loading pads and muzzle		
Date: 17-05-2016	Team no. 4	Worksheet no. 55

Design process and construction of muzzle
Objective:
This worksheet is made to describe the design process of the component called muzzle, this is the component which is most spearguns is the plug for the speargun but also the attachment from the rubber to the speargun, this component is normally one of the more vital components and has to withstand high tension. In the design of the new speargun has the muzzle changed from being the attachment of the rubber bands from the speargun, to being the link and lock between the loading pads and the barrel.

Experiment/Data:
The design process of the muzzle has been an ongoing process parallel with many of the other components. This component was at first anticipated as working as only a plug for the barrel, but doing the design process of the loading pads, rubber bands and barrel design, it became clear that the muzzle could maintain other functions than just being a plug. The muzzle has been designed so that it has four functions.
These four functions has been adjusted during the 3d modeling phase of the design process to optimize function and aesthetics.
A requirement for the muzzle is that is has to fit both the thin and the thick barrel

The four different functions is:

Plug for barrel
The muzzle work as a plug for the barrel which means that it ends the barrel, the reason the speargun need a plug is to protect the components in the barrel and the barrel. The other reason it still have to be a plug is so that it can give stability to the barrel. The plug dos have to fit both barrels so that is can be used also when the basic speargun is phosphated and easily can be changed to fit the extended version. The plug also work by giving the spear a smooth flow when it leaves the speargun due to the guide.

Aesthetic for product
Aesthetically continuously through the hole product is a request which the muzzle contributes to. The muzzle dos work as the tip of the speargun and is angled like the handle and some of the other components, this gives the speargun direction and make the speargun look homogeneously.

Creating neutral weight for the speargun
The muzzle is running through one of the barrel nearly the whole way through, this is because the muzzle is filled with air. The muzzle is rotation molde and contain air in the closed chamber so that the tip of the speargun will be neutralized and the speargun will give a better aim. The muzzle is also designed so that extra components for the spear can be mounted in the muzzle which equalize the weight of the speargun and thereby make it possible to have a speargun in balance when it is 500 mm long but also when the speargun is 900 mm long. This is not yet optimize and has to be adjusted to the future design, due to uncertainties of the overall weight of the speargun.

Lock for loading pads
This feature of the muzzle is one of the most important in the construction of the speargun, this makes the foundation of how the speargun will be in a locked position when the speargun is loaded. The rubber bands will try to pull the loading pads into the center axis of the speargun and backwards, by implementing a groove in the muzzle the speargun will now lock itself in the muzzle when the loading pads runs towards the speargun. It is a visible feature which make it more trustworthy than the lock in the trigger mechanism. It is clear to all that the speargun can not backfire when it is locked into the muzzle. Earlier in the design process the locking mechanism was not integrated towards the center of the speargun but around a hook, but this solution gives the construction much more strength.

Evaluation:
Based on an ongoing design process in 3d modeling programs, this muzzle has changed through the late design process and has been dependent by other components, which means the design of this component is much affected by especially the loading pads. The result of the speargun is an integrated component which is specially designed to fit the loading pad system and the shape of the barrel of this speargun.
In addition to this worksheet is that it acts as part sum up but also the background and documentation of the 3d modeling in the design process of the speargun.

ARDEA			
Locking between loading pads and muzzle			
Date: 17-05-2016	Team no. 4	Worksheet no. 55	

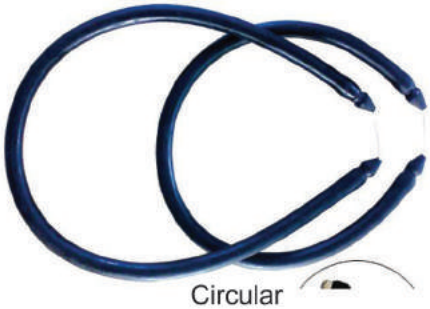
Reflection:
The outcome of this process reveals a fully integrated component, but the way to the result has been a long journey which could have be optimized if the whole design process had been done in a more structured way, on paper before the 3d modeling stage. Another solution which could have eased the design process is to take a step back one in a while and go through the hole user scenario, this was done a few times in the end of the design process and had good results.

ARDEA		
Investigation of rubber bands		
Date: 20-04-2016	Team no. 4	Worksheet no. 56

Investigation of rubber bands:
The objective of this investigation is first to gain knowledge about the different rubber bands and which kind of rubber bands are needed for the new speargun. There will in the investigation both be researched on thickness of the rubber bands and the lengths.

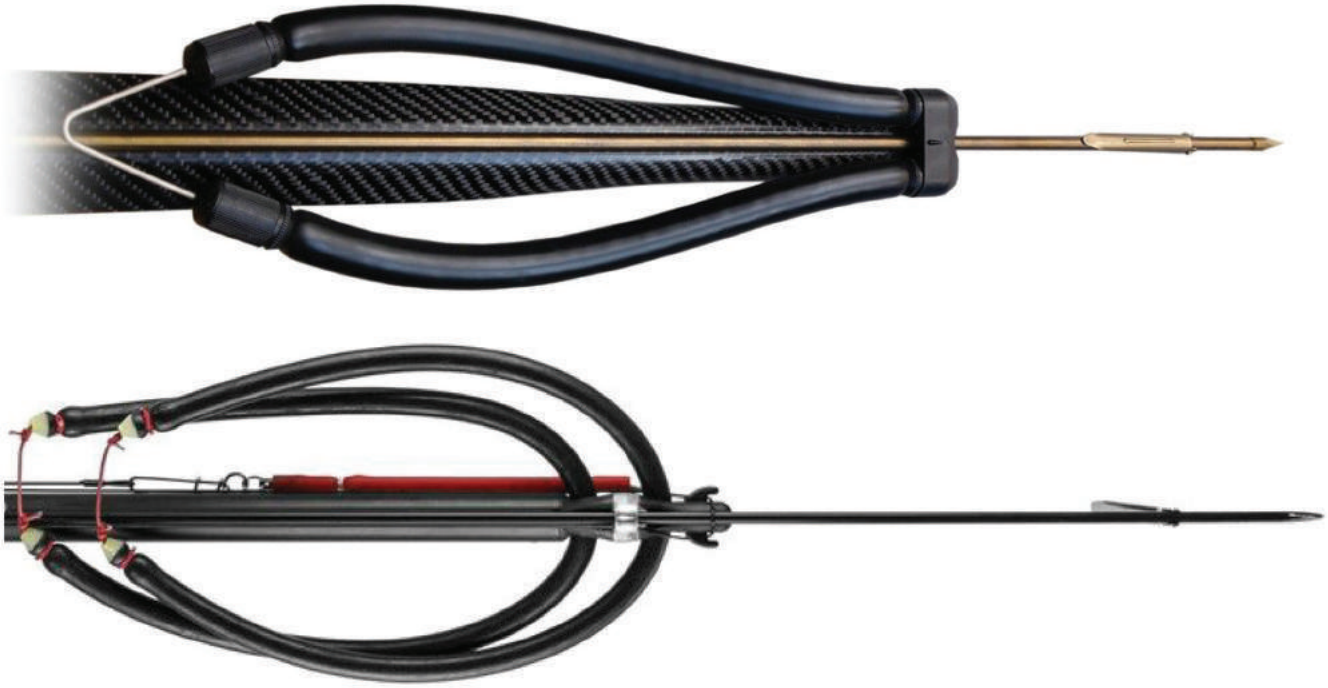
Experiment/Data:
By researching on the different brand's of rubber bands, knowledge is gained.
In general there are two different types of rubber bands; dual and circular.

Dual



Circular

These two types of rubber bands are made from the same material but has different ways of being attached to the speargun - either through a hole (circular) or crewed on with threads (dual). The type of attachment has low impact on the function and power of the speargun [1].



To make the understanding of the connection between the length of the rubber bands and the speargun as simple as possible, there will only be focused on the dual rubber bands, because these rubbers only will be affected in one direction when they are being stretched.
When looking at rubber bands, all are made as tubes in natural rubber with a coating core. The rubber bands variates in size from Ø12-20mm and have different elongation factors which normally lies between 2,8-3,5 but goes up to 7-8

for natural rubber [1] [4].

A general formula for calculating the needed rubber band is [2]:
Threaded elastic = ([length of the stem] - [wishbone length]) / [elongation factor].

By looking at a large speargun brands and what rubber bands they recommend e.g. Cressi [3]:

It becomes clear that a speargun with different lengths from 60-110 needs six different rubber lengths. This gives some issues, which has to be solved.
By looking at different rubber bands thickness with different elongation factors it make sense to have a thick rubber band as possible, due to the fact that the spear on the new speargun is heavy. The cons of using a thick rubber band is that it require more power to load, but because of the new loading technique it gives the opportunity to use thicker rubbers.

G20 Shore: 40

Tip / Casquillo: anodized duralumin

Ref	Diámeter Diámetro Ø mm	Length Longitud mm	Speargun Fusil (cm)
400032	Ø 19,5	16	55-60
400033	Ø 19,5	18,5	75
400034	Ø 19,5	20	82-84
400035	Ø 19,5	22	85-90
400036	Ø 19,5	25,5	95-100
400037	Ø 19,5	27,5	105-110
400038	Ø 19,5	29,5	115-120

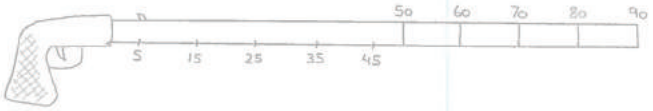
Evaluation:
The results of the research did not reveal which kind of rubber band type should be used. The circular and dual rubber bands has low impact on the function. Therefore the way the rubber is mounted on the speargun will be decided through the other criteria found for adjusting the rubber length.

Reflection:
The outcome of this research revealed that there are some issues with the current design which sets an initial demand of six different rubber lengths. The team needs to determine the way of attaching the rubber bands to the speargun before it is possible to determine the properties of the rubber band.

ARDEA		
Investigation of rubber bands		
Date: 12-05-2016	Team no. 4	Worksheet no. 56

Deciding the rubber band properties:
Further on in the process the team needs to determine which length(s) and sizes of the rubber bands are needed for the new speargun when the speargun can adjust in length. The team has to determine if it is possible to have only one rubber band on the adjustable speargun or if several are needed. For doing this the team uses the informations gathered in the first section of the investigation of rubber bands.

To determine if it is possible to use one rubber band the team make a quick investigation of length of the speargun compared to the length of the rubber band.



Rubber Length	Elonga. tion	Rubber L. End
400	250 %	1000
400	300 %	1200
500	250 %	1250
500	300 %	1500
450	300 %	1350

		Total le. ade	E_{pot}
50	50 + 45	950	8,91
60	60 + 45	1050	13,81
70	70 + 45	1150	18,59
80	80 + 45	1250	24,75
90	90 + 45	1350	31,79
cm	cm	mm	J/N/m

* The length of the rubberband

The investigation if based on the length of the rubber band when it is limply. When the rubber band is limply it needs to cover the length between the hooks for attachment without having to be stretched. At the same time the rubber band has to be able to stretch the length of a 50 cm up to a 90 cm speargun and at the same time store the needed energy to fire the spear. The first investigation shows that the it is enough to have one rubber band. The length of the rubber band is be 50 cm to cover the different lengths of the speargun. This length of rubber band requires that the elongation factor of the material is above 2 (300%). Earlier it was determined that the existing rubber bands has an elongation factor between 2,8-3,5. This confirms the length of the rubber band is able to stretch the full length of 1350 cm.

ARDEA		
Investigation of rubber bands		
Date: 12-05-2016	Team no. 4	Worksheet no. 56

Further investigation is needed to determine the diameter of the rubber band, so it is capable of transferring the needed energy to fire the spear. This is done based on a force test of a speargun rubber band.
The team tests the rubber band on a speargun by stretching the rubber band different lengths and measuring the force needed to stretch it the length. The rubber band tested has a radius of 0,8 cm and an length of 18 cm. The rubber band is a dual rubber band which mean there actually are two.

Målte værdier for spyd					
r,elastik		8 mm		0,008 m	
r,spyd		3,25 mm			
dens		7850 kg/m3			
H,spyd		650 mm			
A,ela		201,0619 mm2			
v,spyd		28716,1 mm3			
		0,225 kg			
L,0 (mm)		180			
delta,L (mm)		0	100	200	300
L,total(mm)		360	560	760	960
L,total(m)		0,36	0,56	0,76	0,96
Kraft (kg)		0	22	32	42
Kraft (N)		0	216,04	314,24	412,44
E, (målt ved forsøg)			491 N/m		
E,pot=P = E,kin=0,5*m*v^2					
Mundingshastighed	m/sek		13,97	16,85	19,30

The number of kg needed to stretch the rubber band is converted to force and used to determine the muzzle velocity of the spear when it leaves the speargun. The force calculated during the test is used in the further calculation of the of the force of the rubber bands with the stretching lengths determined previously.

The calculations are based on a spear with lengths varying in length; 800 cm for 50 cm speargun, 1050 cm for a 60-70 cm speargun and 1300 cm for a 80-90 cm speargun. The spear has a diameter of 0,75 cm. The mass of the spear is calculated to be able to determine the muzzle velocity of the spear. The calculations are still based on the rubber band with a radius of 0.8 cm.

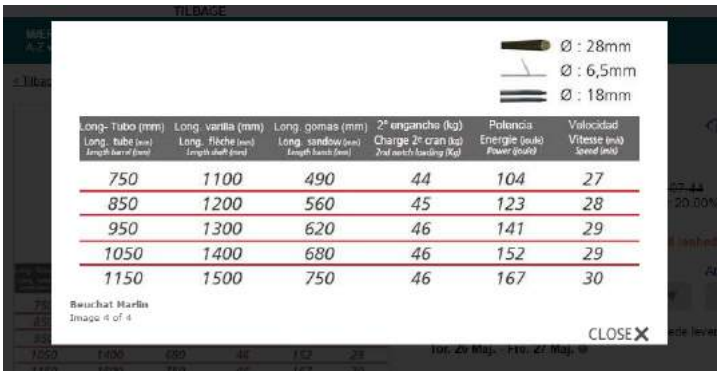
The force theoretically needed for stretching the rubber bands on the new speargun is used to determine the muzzle velocity of the spear.

v, muzzle = √ (0,5 * E, kin / m,spear)

1									
2	Elastikradius	r	9	mm					
3	Spydradius	r,spyd	3,75	mm					
4	Densitet af stål	dens	7850	kg/m3					
5	Længde af spyd	H,spyd		mm	800	1050	1300		
6	Areal af af elastik	A,ela	254,47	mm2					
7	Volumen af spyd	v,spyd		mm3	35342,9	46387,6	57432,2		
8	Vægt af spyd			kg/m3	0,277	0,364	0,451		
9									
10				Pos0	pos1	pos2	pos3	pos4	pos5
11	Spændt position		mm	250	500	600	700	800	900
12	Positionsforlængelse	x	mm	0	250	350	450	550	550
13	Flytning af elastik på undersiden			0	0	100	200	300	400
14	Samlet elastiklængde for alle elastikker		mm	1000	2000	2200	2400	2600	2800
15	Beregning af elastikkraft, P = k * delta,L		N	-	491,0	589,2	687,4	785,6	883,8
16			kg	-	50,0	60,0	70,0	80,0	90,0
17									
18	E,pot=P = E,kin=0,5*m*v^2								
19	Mundingshastighed, L=800		m/sek	-	18,99	20,80	22,46	24,01	25,47
20	Mundingshastighed, L=1050		m/sek	-	16,57	18,15	19,61	20,96	22,23
21	Mundingshastighed, L=1300		m/sek	-	14,89	16,31	17,62	18,84	19,98

The muzzle velocity calculated based on the 0,8 cm radius rubber band are higher than the muzzle velocity of the existing speargun from the test.

To get an understanding of the muzzle velocity numbers are found for exiting spearguns on the market [5].



[5]

The numbers found on-line is higher than the numbers calculated on the exiting speargun. When the muzzle velocity calculated for the 80 cm speargun, based on the numbers from the test, is compared to the number found on-line, it becomes clear that the muzzle velocity of the new speargun is smaller. The spear on the new speargun is heavier than the spear on the speargun on-line. This clearly has an impact on the velocity. The rubber band on the on-line speargun has a larger diameter than the rubber band on the new speargun, this will also influence the energy stored and thereby the velocity.

The numbers found on-line are for one of the best and most powerful spearguns on the market. The team determines the velocity gained by using the Ø16 mm rubber bands are sufficient for firing the spear. The numbers calculated are greater than the velocity gained on the exiting speargun during the test. This type of speargun has been proven to work.

Sources:

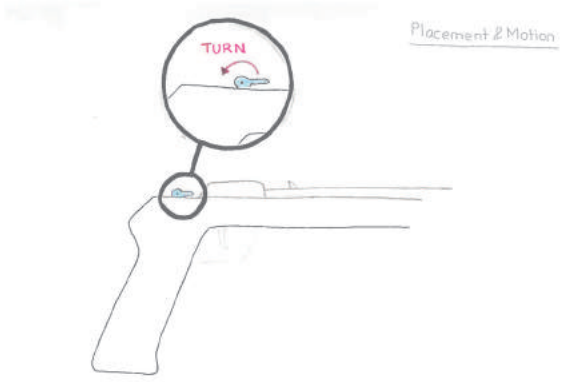
[1] http://divecenter.dk/index.php?route=information/news&news_id=9 (20/04-2016)
[2] http://divecenter.dk/index.php?route=pavblog%2Fblog&id=15 (20/04-2016)
[3] https://drms3v40st3o6.cloudfront.net/images/pdf/especificaciones/eng_cressi_bands.pdf (20/04-2016)
[4] http://www.materials.dk/showchapter.cfm?sectionId=E18 (20/04-2016)
[5] https://www.scubastore.com/scuba-dykning/beuchat-marlin/5150/p

ARDEA			
Investigation of rubber bands			
Date: 20-04-2016	Team no. 4	Worksheet no. 56	

ARDEA		
Shaping of safety mechanism		
Date: 27-04-2016	Team no. 4	Worksheet no. 57

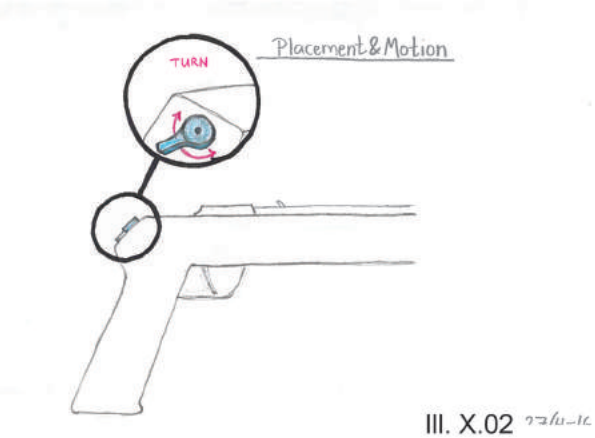
Objective:
The objective is to determine the position and motion of the safety mechanism on the new speargun. By investigating existing safety mechanisms (Worksheet no. 41) it was possible for the team to set some requirements for the safety mechanism which has been the base for the ideation on different ways to shape and position the safety mechanism on the new speargun.

Experiment/Data:
Through an ideation on the safety mechanism based on the requirements found previously, the team has set up pros and cons for each idea. The requirements were; the safety mechanism has to be usable with both left and right hand, the safety mechanism has to be visible for the user while aiming the speargun. The ideas are described below.



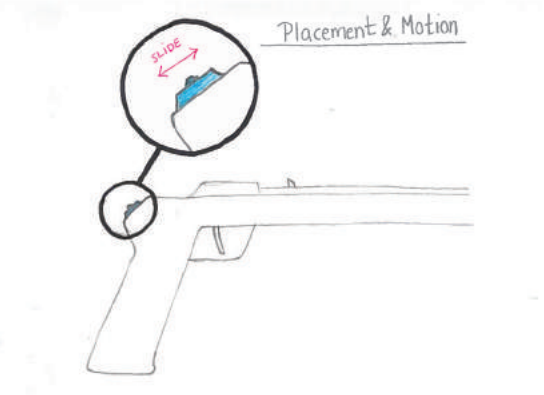
III. X.01 27/4-16

Pros/Cons
- - Difficult to reach and handle with one hand
- - Needs icons/text to be understandable (when is it on/off)
- - The user cannot see the safety mechanism while aiming the speargun due to the position of the mechanism
- - The user cannot see when the trigger is blocked/safe (the mechanic runs in the handle and is not visible)



III. X.02 27/4-16

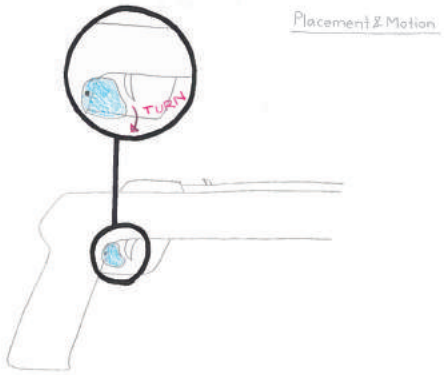
Pros/Cons
- + Easy to reach and handle with one hand
- + Can be seen from shooting position at all time
- - Needs icons/text to be understandable (when is it on/off)
- - The user cannot see when the trigger is blocked/safe (the mechanic runs in the handle and is not visible)



III. X.03 27/4-16

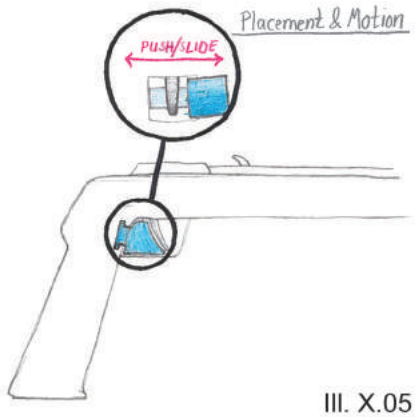
Pros/Cons
- + Can be managed by one hand
- - Needs icons/text to be understandable (when is it on/off)
- - The user cannot see when the trigger is blocked/safe (the mechanic runs in the handle and is not visible)

ARDEA		
Shaping of safety mechanism		
Date: 27-04-2016	Team no. 4	Worksheet no. 57



Ill. X.04

Pros/Cons
- + Can be used by one hand
- + Icons/text not needed to be understandable (when is it on/off)
- + The user can see when the trigger is blocked/safe (the mechanic is outside the handle and is visible)
- - The up-down motion can be difficult to handle with one hand
- - The mechanism will possibly interfere with the hand holding the speargun



Ill. X.05

Pros/Cons
- + Can be managed by one hand
- + Icons/text not needed to be understandable (when is it on/off)
- + The user can see when the trigger is blocked/safe (the mechanic is outside the handle and is visible)

Evaluation:
Based on the investigation of different ways to position and manage the safety mechanism it is possible for the team to determine the placement, motion and initial design of the safety mechanism on the new speargun.

- The safety mechanism should be placed behind the trigger and visibly and physically block the trigger.
- The safety mechanism should not interfere with the grip on the handle.
- The chosen design of safety mechanism does not need any kind of icons or text to be understandable because it is visible for the user when the trigger is blocked and when it is ready to fire.
- It would be possible to incorporate colors in the design of the safety mechanism to make it even more clear to the user when the safety is on/off. From investigating existing safeties it might need to have a color in strong contrast to the rest of the spearguns colors to indicate the interaction here.

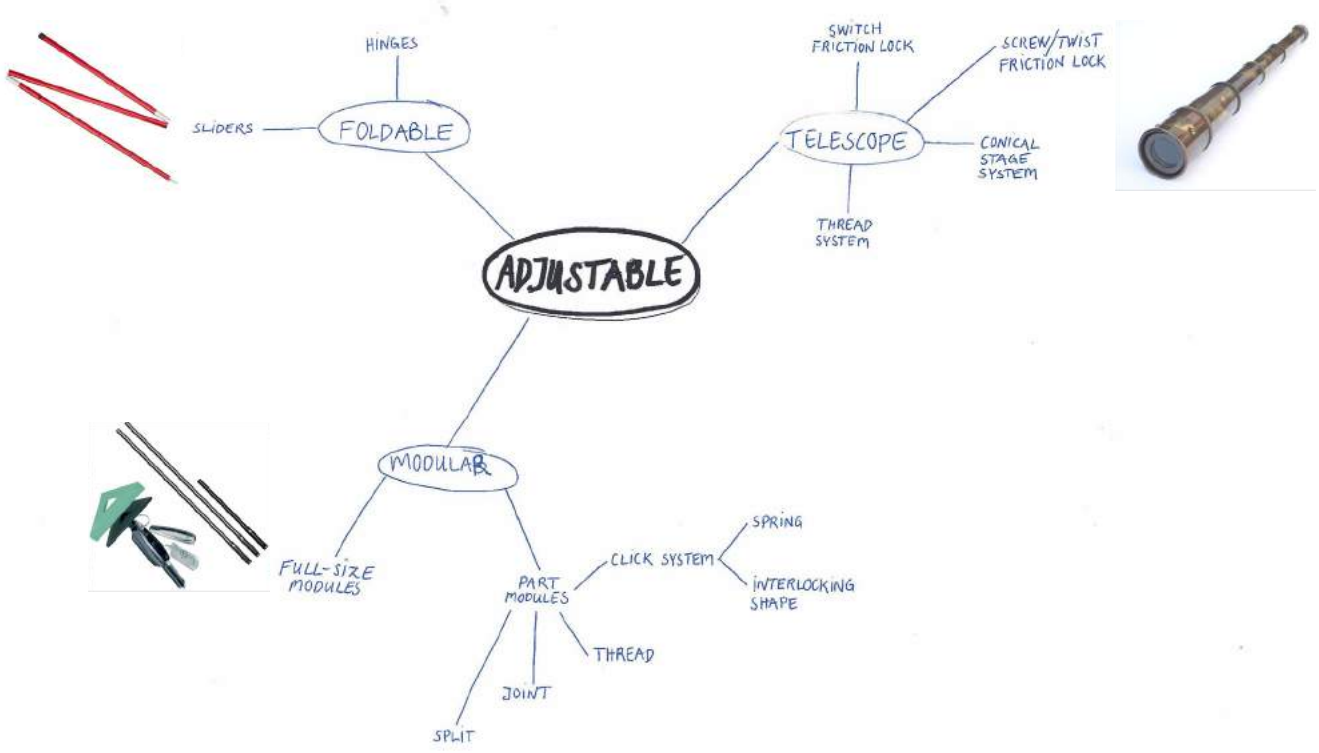
Reflection:
Based on the investigation it is possible for the team to design the safety mechanism on the new speargun so it will be easy for the user to handle and maneuver and to understand. Now it needs to be integrated into the rest of the speargun design and first then the final design of it will be determined.

Sources:
Ill. X.01-05: Own illustrations.

ARDEA		
Investigation of spear adjustment		
Date: 22-04-2016	Team no. 4	Worksheet no. 58

Objective:
The team needs to design an adjustable spear to fit the adjustable speargun to make the speargun and the whole concept more valuable to the customers and users. The spear should be able to adjust in length and the team has started the design process by doing a brainstorm on different ways to adjust the length (see Ill. X.01-04).

The spear could either be folded like tent poles, it could be adjusted with a telescopic principal like an old-fashion bin-oculars or it could be adjusted with modules like the extension of a window cleaner.



Ill. C.01: Brainstorming of adjustable mechanisms
Ill. C.02-04: Different adjustment principles

Experiment/Data:
To be able to determine which principle is best suited for the adjustment of the spear, the team at up some pros and cons for the different principles.

Modular:
Full-size modules
- + Only one spear is needed
- + Strength
- + Low complexity
- + User can purchase only the necessary parts
- - Spare parts take up space when not in use
- - Spare parts have to be transported every time
- - The user has to have many different spears
- - The user has to either bring all sizes of spear to the water or get out of the water to get the needed spear

Part modules - Split, Joint, Thread, Click Spring, Interlocking Shape
- + Only one spear is needed
- + Add-ons makes it possible to adjust the spear in water

- + User can purchase only the necessary parts
- + It is possible to adjust the spear while being the water
- - Less strength / more weak points
- - More complexity
- - Spare parts take up space when not in use
- - Spare parts have to be transported every time
- - The user needs to bring the spear parts into the water

Telescope:
Switch Friction Lock, Twist Friction Lock, Conical Stage System, Thread System
- + Only one spear is needed
- + It is possible to adjust the spear while being the the water
- + Takes up less space during transport
- - Less strength - hollow construction / more weak points
- - More complexity
- - Less hydrodynamic shape - more resistance in water

Foldable:
Hinges
- + Only one spear is needed
- + It is possible to adjust the spear while being the the water
- + Takes up less space during transport
- - Less strength / more weak points
- - More complexity
- - Less hydrodynamic shape - more resistance in water
- - Difficult to assemble and connect the hinges

Evaluation:
All mechanisms have some pros and some cons, and therefore the team has to decide which parameters are more important than others and judge by these. First of all the team has to compare it with the requirement specifications and then how would the business case look for each mechanism. The full-size modules will definitely have a higher strength, lower complexity and thereby lower risk of breaking parts. The telescope has more complexity and thereby greater risk of broken parts, but it is faster to adjust the length at the spearfishing spot and it can take less space during transport than the modular.

Reflection:
The pros and cons have helped the team to decide on which adjustable mechanisms they see more potential in than others, and thereby which to work further on. The team will look more into modules to adjust the spear. This way of adjusting the length is possible to do while being in the water, it requires some extra parts, which makes it possible for the team to increase the additional sales. The modules will have some weak points in the assembling and the team will have to investigate if these can handle the scenarios in spearfishing or if the spear will break.

Sources:
Ill. X.01: Own illustration
Ill. X.02: http://spejdergear.dk/shop/msr-adjustable-pole-7133p.html
Ill. X.03: http://www.ebay.com/sch/Antique-Maritime-Telescopes/37972/bn_2309504/i.html
Ill. X.04: http://vinduespudsning.com/products/stingray-3-3-meter-elektrisk-vinduesvasker-til-indvendig-vinduespudsning

eam need to create an overview of different adjustable mechanisms, which can be used by the user to change the length of the speargun, through brainstorming. Pros and cons will be made on each mechanism to find out which mechanisms should be tested through mock-ups and developed further on.

Evaluation:
All mechanisms have some pros and some cons, and therefore the team has to decide which parameters are more important than others and judge by these. First of all the team has to compare it with the requirement specifications and then how would the business case look for each mechanism. The full-size modules will definitely have a higher strength, lower complexity and thereby lower risk of breaking parts. The telescope has more complexity and thereby greater risk of broken parts, but it is faster to adjust the length at the spearfishing spot and it can take less space during transport than the modular.

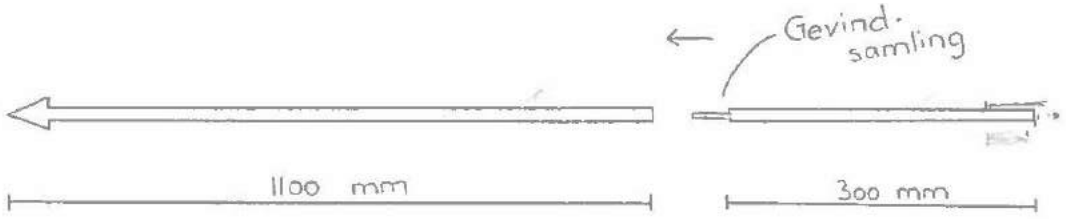
Reflection:
The pros and cons have helped the team to decide on which adjustable mechanisms they see more potential in than others, and thereby which to work further on by making mock-ups and test. The team will look more into full-size modules, part modules and telescope. This leaves the foldable behind, because it does not have the necessary upsides to fulfill the requirement specifications the team has made. The full-size and part modules have the best opportunity to make a great business case, because of the possibility to buy add-ons after the user has purchased the actual speargun. The telescope fulfills the requirement of making the transportation easier and the adjustability quicker at the actual spearfishing spot.

Sources:
Ill. X.01: Own illustration
Ill. X.02: http://spejdergear.dk/shop/msr-adjustable-pole-7133p.html
Ill. X.03: http://www.ebay.com/sch/Antique-Maritime-Telescopes/37972/bn_2309504/i.html
Ill. X.04: http://vinduespudsning.com/products/stingray-3-3-meter-elektrisk-vinduesvasker-til-indvendig-vinduespudsning

ARDEA		
Co-creation with steel construction engineer		
Date: 22-04-2016	Team no. 4	Worksheet no. 59

Objective:
The objective of the conversation about the adjustment of the spear is to investigate and determine the shape and adjustment principle of the spear.

Experiment/Data:
The team talked to an steel construction engineer, Knud Nielsen, 3D Structural Design ApS, regarding the proposed way of adjusting the spear - with modules conected and assembled with threads. The team showed some sketches of the principle (below) which is te base of the conversation.



Totallængde : 1400 mm
Samling: Gevind over afstand
Diameter spyd: 8mm (6,6, 7,0, 7,5)
Materiale spyd: Rustfrit, fjeder el. galvaniseret stål

Ill. C.01: Sketches to show the initial adjustment principle

The team has set some initial requirements for the spear;
- The total length of the spear should be 1400 mm
- The modules should be assembled with threads
- The diameter should be below 8 mm
- The spear should be made from either stainless steel, spring steel or galvanized steel

The requirements were discussed with Knud Nielsen, and he approved.

At first the diameter and material was decided to be stainless steel ≥Ø7 mm. When the diameter of the spear is ≥Ø7 mm it is possible to make the inner thread ≥Ø4,5 mm, which shoud be surficient regarding strength.
Then the principle of assembling with threads was discussed. It was determined that the thread should run over a length of 20-30 mm, which is an sufficient length both regarding strength of the assembling and the use of the assmbling method for the users (see Ill. 02).
The strength of the thread was discussed and it was suggested to make a thicker bottom of the inner thread with a small angle (see Ill. X.03). This will prevent the spear from breaking in the assemblings, because it makes the transition in the stiffness of the material, due the the changing thinkness, more smooth. It was also suggested that the end of the outer thread should have a small angle to fit the angle of the inner thread. This detail will strengthen the construction even more. This detail will depend on the manufacturing method and price.
The design of the the thread was evaluated and it was suggested to make a small hole in the bottom of the inner thread to make it possible for sand and dirt to exit the hole (see Ill. X.03).

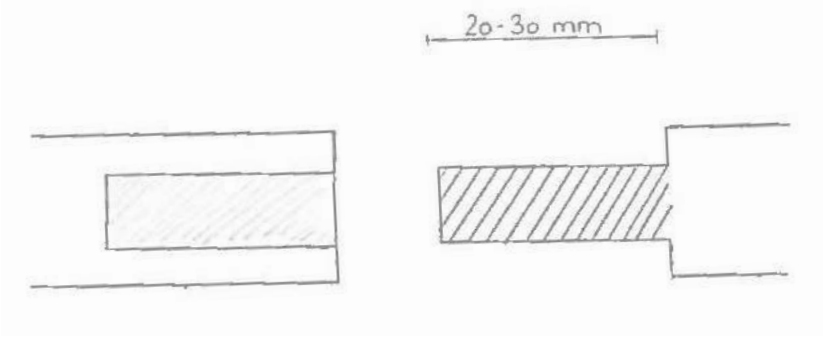
ASSEMBLING OF THE MODULES
The initial idea of the assembling of the spear is to add more length to the spear by adding a module in the end of the spear. The spear has a special flat end to make it possible to fasten the spear in the trigger mechanism. The team

realized they had to add the module somewhere in the middle of the spear to be able to make the threads in the round shape of spear.

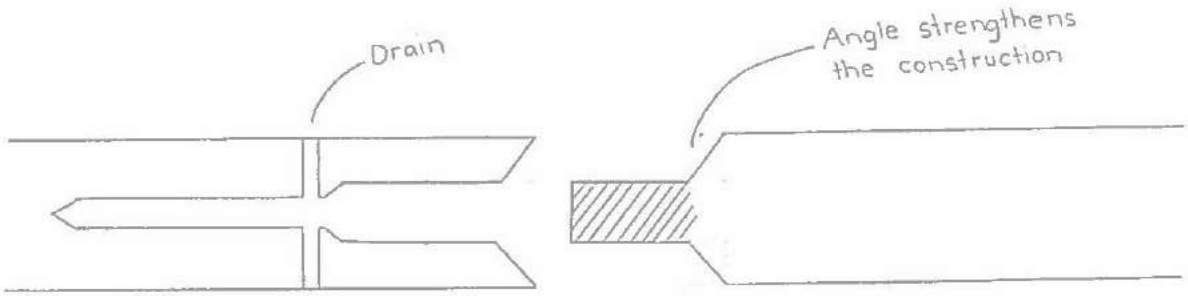
It was discussed to make the tip and end of the spear detachable with threads. It would be easier to replace both parts if they break, and regarding the end of the spear, it is only necessary to have the flat end for the trigger mechanism to grab and the attachments for the rubberbands on one part of the spear opposite if the modules were connected in the end of the spear, then there would have to be attachments for the rubberbands and the flat end on all the extra modules. It was determined to divide the spear into the following modules; the tip, a standard length, an end and two extra modules (see Ill. X.05). The modules will be assembled by fitting one module into the other and rotete to fasten the thread.

It was suggested to make a threaded sleeve to assemble the modules, which possibly could be made from a stronger material - e.g. tool steel. The modules should be connected through the sleeve (see. Ill. X.06). The sleeve would function as a connection between the modules and each module would be fasten in the sleeve with a thread. The modules would have to have the same inner thread in each end opposite the other way of assembling, where the modules would have a inner thread in one end and an outer thread in the other end.

It was also suggested to have a small “tool box” for the extra modules connected either to the line to the float or be placed on the lower leg like the divers knife.

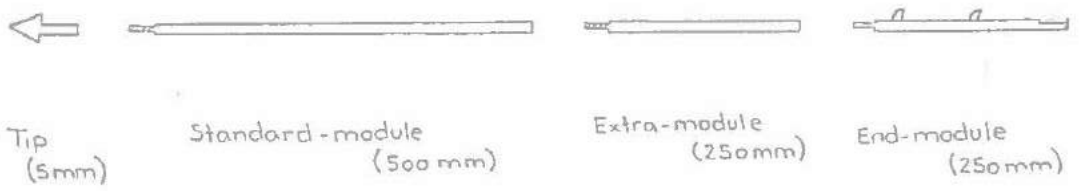


Ill. 02: The thread should run over 20-30 mm

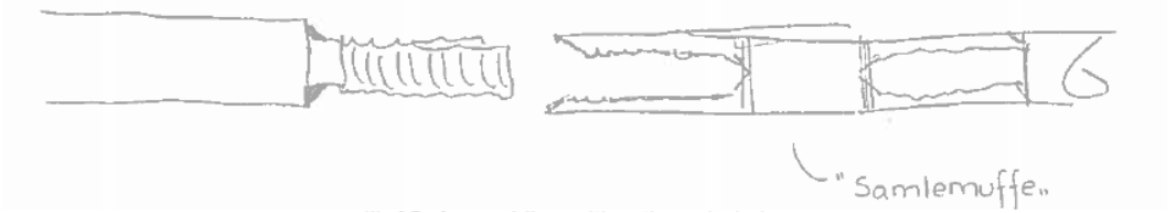


Ill. 03: The angled end of the thread provided extra strength to the construction and the drain hole makes sure sand and dirt can exit the thread

ARDEA		
Co-creation with steel construction engineer		
Date: 22-04-2016	Team no. 4	Worksheet no. 59



Ill. 04: The four different modules in the spear

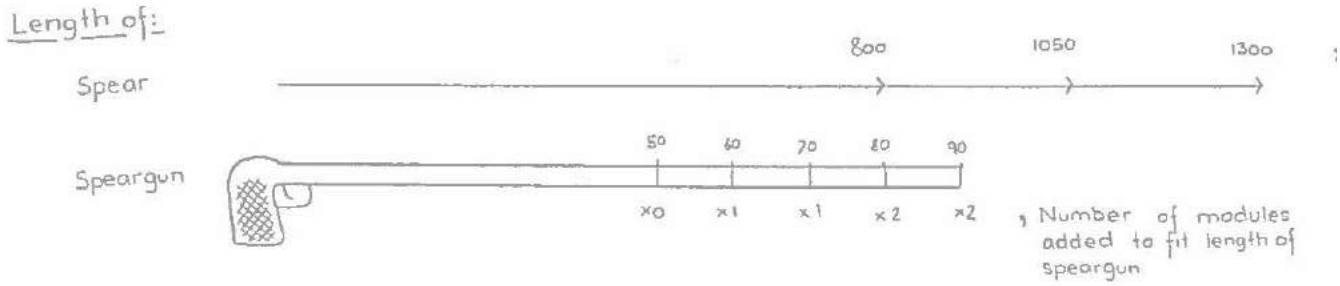


Ill. 05: Assembling with a threaded sleeve

Evaluation:
With the 4-5 modules it is possible to determined the lengths of the different modules so they will fit the different lengths of spearguns (see Ill. 05).
From the co-creation session it is possible for the team to design an adjustable spear, which can handle the different scenarios in spearfishing without breaking. From the conversation it is possible to set up some requirements for the spear, which then will assure the spear will manage the use. The requirements are:

- The spear should be made from stainless or tool steel
- The connections should be threads running over a length of 20-30 mm
- The diameter of the spear should be ≥ Ø7 mm
- The threads should have an angle in the top/bottom to prevent the spear from breaking
- The thread holes could have a small drain for sand and dirt in the bottom

The team now have some different concepts for the spear, which they will have to test and evaluate to determine which design is best - both regarding the use of the spear, the maintenance and the possibility of additional sales regarding the business case.



Ill. 06: The different lengths of spears fits different lengths of spearguns

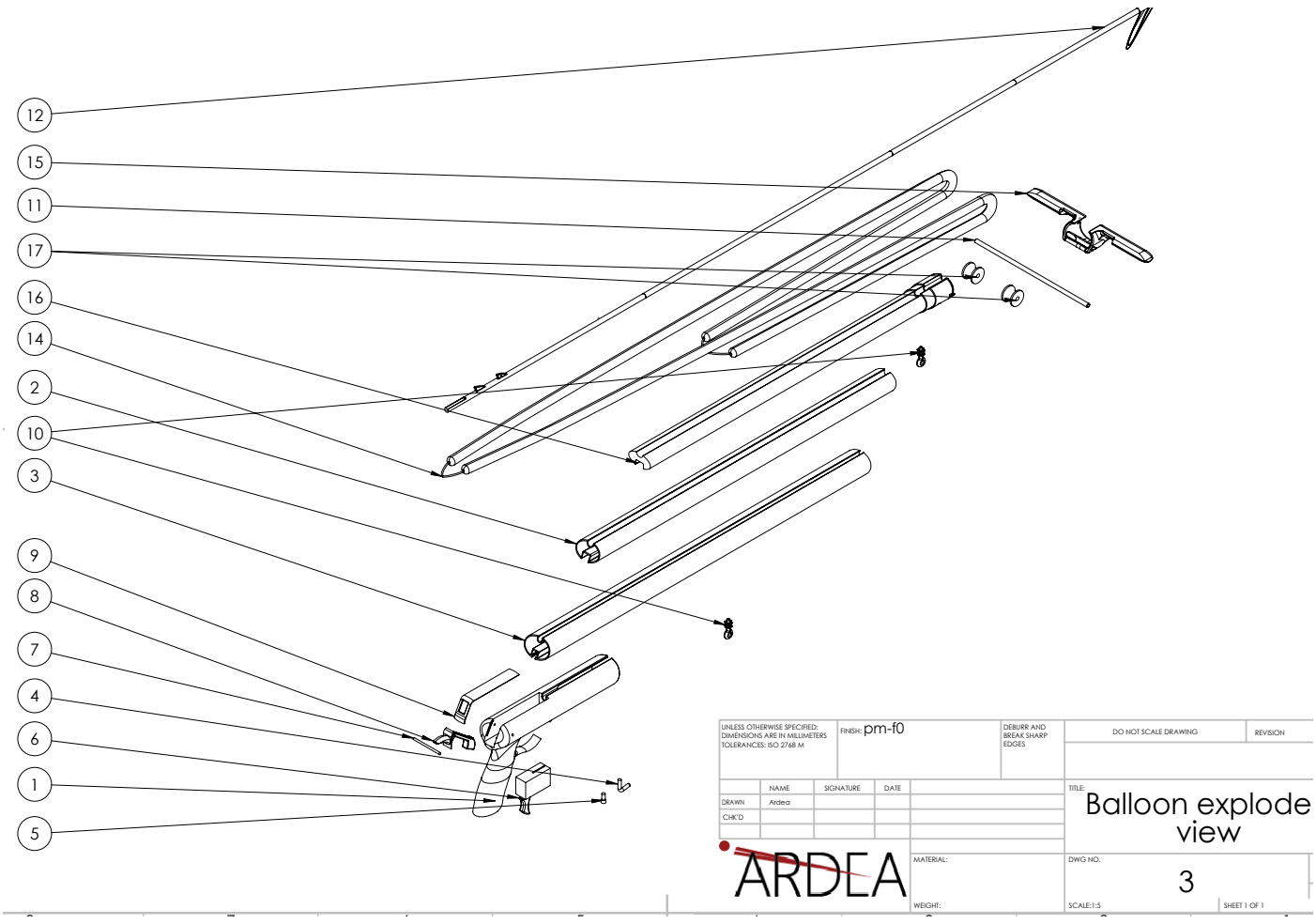
Reflection:
From the co-creation it is possible for the team to design a spear which can adjust in length to fit the different lengths of the new speargun and prevent the spear from breaking during use.

Sources:
Ill. X.01-06: Own illustrations.

ARDEA		
Assembling the speargun		
Date: 20-05-2016	Team no. 4	Worksheet no. 60

Objective:
The objective is to investigate how the parts in the speargun can be assembled in the most suitable way. This is done by looking at the components and based on this find a solution. The product has been designed so that only few components are needed. There is beside the handle only used two or three screws to hold the speargun combined. The team will now describe how and why the assembling is done as it is. The goal is also making it easier for the user to repair and change components. It is though assumed that the handle is not needed to be repaired or changed, when looking on current product, this opportunity is not needed.

Experiment/Data:
The hole barrel is screwed together with only two screws on the basic speargun, when upgrading the extension barrel and muzzle is screwed together and can be disassembled if need. The only component which can not, be disassembled easy is if the roller of steel beam on the loading pad breaks, these components are pressed together for as locking. Below is a pictures of the parts.



Reflection:
In general the speargun is assembled in any way which makes it possible for all user to disassemble the speargun if needed and adjust to the needs.

ARDEA			
Assembling of the speargun			
Date: 20-05-2016	Team no. 4	Worksheet no. 60	

ARDEA		
SWOT analysis		
Date: 06-05-2016	Team no. 4	Worksheet no. 61

Objective:
The objective is to set up two different SWOT models to evaluate on which model is the most beneficial to the team, Ardea. One model is Ardea as a start-up company, while the other model is a collaboration with Rob Allen.

Experiment/Data:

Strength - Ardea as start-up:
Knowledge about the Danish water conditions
Low national completion
Innovative products design for the market
Focus on the Danish market and similar conditions
Close to the customer

Strength - Corporation Rob Allen:
Recognized brand on the market
Established sales channels
Knowledge in production and sales
Has knowledge about similar water conditions as in Denmark

Weaknesses - Ardea as start-up:
Low capital
Low knowledge in finalizing product
No establish distribution changes
Unknown brand

Weaknesses - Corporation Rob Allen:
Less profit to Ardea
Worldwide brand would have lower focus on Danish condition
Worldwide brand would have lower focus on Danish market
Far from Danish customer

Opportunities - Ardea as start-up:
Blue ocean for being first on Danish market
Create new product with focus on worst case scenario, which can be implemented in other countries afterwards
Large profit and adjust production for market
Enter the market, when the sports is trending

Opportunities - Corporation Rob Allen:
Blue ocean for being first with a product for changing condition
Gain larger market share
New loading method which can be implemented in current speargun improve current spearguns
Create new product with focus on worst case scenario, which can be implemented in other countries

Threats - Ardea as start-up:
Easily copied by bigger brands
Competitors is established and can produce cheaper
Bigger brands can freeze, interfere or lower the price on the market
Problems to gain market in other countries due to competition

Threats - Corporation Rob Allen:
Other brands copies
The demand for the speargun changes
Product is not as easy to succeed when launched from other countries
Does not fit Rob Allens main market.

ARDEA			
SWOT analysis			
Date: 06-05-2016	Team no. 4	Worksheet no. 61	

Evaluation:
The team sees a collaboration with the South African spearfishing brand, Rob Allen, as the best and most beneficial business for Ardea. This is due to the team is new and unknown, and have to find investors and also invest a lot themselves to make a start-up company a reality. Thereby they will have a higher risk economically and compared to the potential opportunity to sell the project to Rob Allen and then make a royalty agreement, where the team will have no risk at all. Rob Allen is already well-established on the market and will therefore have an easy whey into the market with a brand new product.

Reflection:
It is always tempting to make a start-up company, if you feel you have a great product, but the team will also be realistic in this case and look at the bigger picture, because it will be a lot of hard work to break through on a market not that big yet in Denmark.

ARDEA		
Graham Carlisle, AUF WA State Commissioner, Australia		
Date: 05-04-2016	Team no. 4	Worksheet no. 62

Objective:
In order to figure out how big a market the team is working within the Australian Underwater Federation is contacted. This will hopefully give at least an estimated guess on how many spearfishers Australia have.

Experiment/Data:
Hi Graham,

We are three Industrial Design students from the University of Aalborg in Denmark and are currently working on our Master Thesis, which is about spearfishing and more specifically about spearguns. We are missing some real data about how many active spearfishers there are today to help our business case. How many are there in Australia, USA, South America, South Africa, Japan, France, Italy or just Europe? I guess you only have an idea about it since we can't find any official numbers and I also guess you only have an idea about Australia, which is just fine - we just need an estimate?
Is that something you can help with or maybe tell us who to contact if not?
Can you also help describing the characteristics of how the water around Australia is typically - current, visibility length, seabed and depth?

Thanks,
Peter V. Sorensen, Anne H. Nielsen and Anders Poulsen

———

Hi Anders

In Western Australia (WA), we have two major clubs which have 80 and 230 members each. That said, their Facebook pages collectively have 3500 local followers. As such, I would estimate that the number of beginner/intermediate/experienced & competitive spearfisherman in WA would number around 4-5 thousand. I would suggest that you cross reference these numbers by contacting the department of fisheries and asking how many recreational boat spearfishing licences (only required if you intend to dive off a boat and so does not account for those divers that don't) have been issued on the following link:
http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Recreational-Fishing/Pages/Recreational-Fishing-Licences.aspx

The same can be done for New South Wales and Victoria which requires all divers to hold a licence and as such, the numbers will be more accurate, but I would suggest that the numbers would be a little higher than WA at around 5-7 thousand due to a higher population density:
http://www.dpi.nsw.gov.au/fisheries/recreational/saltwater/spearfishing
http://agriculture.vic.gov.au/fisheries/recreational-fishing/fishing-licence

Queensland does not require any licence to spearfish and so the verification of any estimate ay be difficult, but I would email Adreno Spearfishing suppliers who may have a better estimate of spearfisherman in Queensland:
https://www.daf.qld.gov.au/fisheries/recreational/rules-regulations
https://www.adreno.com.au/

The same applies to the Northern Territory but I would estimate that due to its isolation, poor visibility and prevalence of sharks/salt water crocodiles/box jellyfish, that only about 200 spearfisherman may be found there:
http://www.nt.gov.au/d/Fisheries/recreational/

Tasmania and South Australia also do not require spearfisherman to posses licences, but due to the cold water, limited target fish species and high number of great white sharks, the number of spearfisherman are also estimated to be between 100-200 per region:
http://dpipwe.tas.gov.au/sea-fishing-aquaculture/recreational-fishing/recreational-sea-fishing-licences
http://pir.sa.gov.au/fishing/recreational_fishing

The above websites will also have publications within that can provide you with the most commons target species for each state and territory in Australia.

ARDEA		
Graham Carlisle, AUF WA State Commissioner, Australia		
Date: 05-04-2016	Team no. 4	Worksheet no. 62

Another great resource is the following publication: http://www.spearfishingdownunder.com.au/tribe/

Visibility is generally very good at an average of 8-20 meters, with some areas having much poorer visibility at 3-8 (NT, Northern Queensland and Northern WA) due to huge tidal changes in the northern regions of Australia. The opposite is the case for the southern parts of Australia where the visibility can be greater than 20 meters, when weather conditions allow. The warmer waters of the top half of Australia mainly have sandstone and coral reefs, with the southern half of Australia having mainly granite rock bottoms and sandstone reefs. There is also a significant amount of sandy bottom areas. Except for the areas that have large tidal movements, I have not experienced much current other than after a significant weather event (strong wind squall).

The majority of Australian divers (70%) dive between 0-15 meters, with the limited 30% diving deeper than 15 meters and only the top 10% of divers being able to dive deeper than 25 meters (breath hold). Some states (such as WA) do allow spearfishing using SCUBA and so a number must be apportioned to this cohort, versus the breath hold spearfishing which is practiced in the majority of the other regions. See the rules and regulations on the above websites.

I hope that this helps and should you have any more queries, please do not hesitate to contact me.

Kind regards

Graham Carlisle
AUF WA State Commissioner
AUF National Communications Officer

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Regards

Graham Carlisle

+61424190331

Evaluation:
All in all around 12.000 spearfishers can be found in Australia. This is a really low number especially compared with Denmark (5.000 spearfishers) and considering the diffenrence in size. Graham Carlisle explains it with the dangers which can be found in the Australian waters such as sharks, jellyfish etc., which Denmark is not dealing with.

Reflection:
The market for spearguns in Australia is smaller than the team expected, but it is good to know how many we are potentially can reach out to with the new speargun. It is necessary to find more numbers about the amount of spearfishers other places around the world to have a full picture of how many spearfishers there are and how many the team can sell this new speargun to.

Sources:
http://auf.com.au/sports/spearfishing/

ARDEA		
Numbers in spearfishing		
Date: 11-04-2016	Team no. 4	Worksheet no. 63

Objective:
The objective is to find out or estimate how many spearfishers there are in the World, and thereby see how big a market the team potentially will work within.

Experiment/Data:

III. 01: Mapping of spearfishers around the World

On the map estimations of the amount of spearfishers is illustrated to give an idea of the size of the spearfishing market. Spearfishing is difficult to find any numbers about, because there are no official data. The team has tried to contact several spearfishing organizations in different countries, and some responded and tried to estimate how many spearfishers they have in their respective countries.

Evaluation:
The team had some concerns about the amount of spearfishers in Denmark, because 5.000 spearfishers would be a small market and difficult to establish a new product and brand around. To have a promising business, the team had to find out if the amount of spearfishers would be the same in other countries or significantly higher, so there would be a business potential.

Reflection:
The amount of spearfishers were higher than the team expected and therefore it should be possible to design a product with the potential to come in production in the future, because there are a relatively big market.

Sources:
Worksheet no. 62 - Graham Carlisle
Worksheet no. 42 - Rob Allen
http://undervandsitetet.dk/undervandsjagt/ - 11-04-2016
http://www.ilovepescasub.com/en/spearfishing/2011/03/spearfishing-in-japan/ - 11-04-2016

ARDEA		
Calculations		
Date: 11-05-2016	Team no. 4	Worksheet no. 64

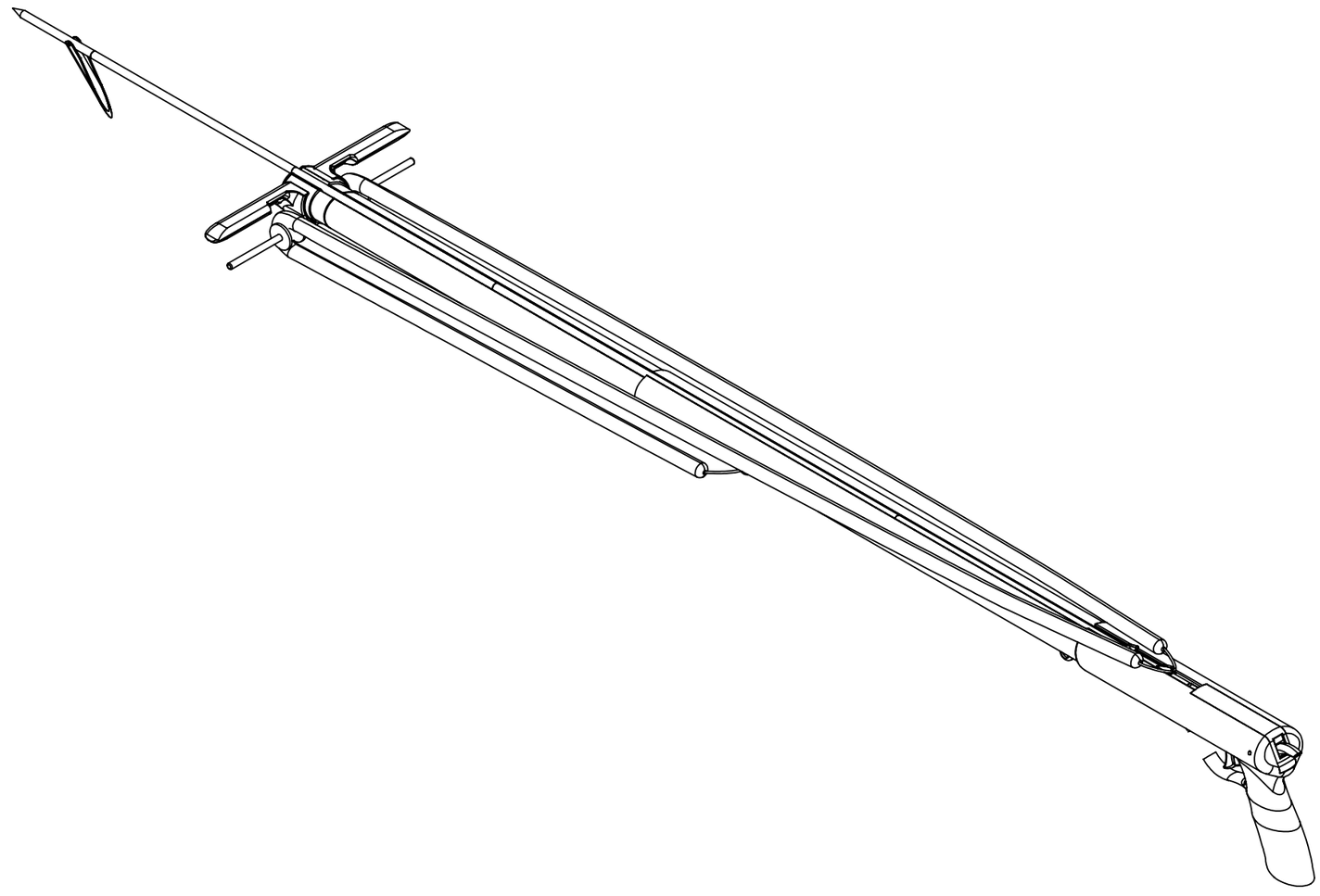
	A	B	C	D	E	F	G	H	I	J	
1	Component	Material	Dentety (KG/M^3)	Volume	Mass (kg)	Price tools $	Price pr unit tool	units pr kg	Finishing pr unit	price pr unit witho	Price pr u
2	Muzzle	Glass reinforced Nylon (15%-30%)	1300	1.76e+005 cubic millimeters	0.170	2,000$	$0.13		$1.00	$1.50	
3	Loading pad	Glass reinforced Nylon (30%-60%)	1400	5.41e+004 cubic millimeters	0.076	9,164$	$0.61		$1.00	$2.00	
4	Seel beam for loading pad	Stainless steal	7800	6.49e+003 cubic millimeters	0.050	0$	$0.00		$0.50	$1.25	
5	Barring	MIX standard component			0.020	0$	$0.00		$0.00	$2.00	
6	Trigger	Glass reinforced Nylon (15%-30%)	1300		0.010	1,575$	$0.11		$0.50	$0.12	
7	Safty	Glass reinforced Nylon (15%-30%)	1400	7.43e+003 cubic millimeters	0.015	1,575$	$0.11		$0.50	$0.14	
8	Handle	Glass reinforced Nylon (30%-60)	1400	3.13e+005 cubic millimeters	0.238	4,076$	$0.27		$0.50	$3.88	
9	Line wheel + Line	MIX standard component			0.150	0$	$0.00		$0.00	$8.00	
10	Thick barrel	Aluminium profile (xxxx series)	2800	1.54e+005 cubic millimeters	0.370	1,200$	$0.08	2,325 units pr kg	$0.50	$1.70	
11	Thin barrel	Aluminium profile (xxxx series)	2800	1.23e+005 cubic millimeters	0.330	1,200$	$0.08	2,941 units pr kg	$1.00	$1.50	
12	barrel lock	MIX standard component			0.045	0$	$0.00		$1.00	$2.00	
13	Rubberbands	MIX standard component			0.150	0$	$0.00		$0.00	$4.00	
14	Trigger mecanism	MIX standard component			0.075	0$	$0.00		$0.00	$6.00	
15	Spear	Stainless steal			0.450	0$	$0.00		$4.00	$4.00	
16	Rubber cap	Rubber				1,000$	$0.10		$0.50	$0.50	
17	Screws and other standart components	MIX standard component				0$	$0.00		$0.00	$4.00	
18	Painting and grapic	MIX standard component				100$	$0.01		$0.00	$0.50	
19	man hour (20$/h)					0$	$0.00		$5.00	$0.00	
20						**$1.46**					
21		Combined product			2.1						
22	pr speargun based on production of 20000 units					**$21,890.00**	**$1.50**		**$16.00**	**$43.09**	
23										price for standart	
24										price for extention	
25											

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Businesscase**												
2													
3													
4	**Projektbudget**												
5											devide in 5	Basic speargun	Extention pagege
6	Løn		(4 mand fuldtid i 3 mdr., 3 mdr = 475 timer. Timeløn 500kr./t)							kr. 950,000	190000	570000	380000
7	Godkendelser/rejser									kr. 250,000	50000	150000	100000
8	Prototyper/materialer									kr. 100,000	20000	60000	40000
9	Konsulenter									kr. 200,000	40000	120000	80000
10	Værktøjer									kr. 200,000	40000	120000	80000
11	Andet									kr. 400,000	80000	240000	160000
12										**kr. 2,100,000**			
13													

ARDEA		
Calculations		
Date: 11-05-2016	Team no. 4	Worksheet no. 64

	A	B	C	D	E	F	G	H
1	**Business case**							
2								
3								
4	**Produkt_dækning**							
5	**Basic speargun**					Based on 15000		
6	Sales price (customer)			**kr. 1,350**	**1350kr.**	Combined sales price basic speargun	10530000	kr.
7	Moms (25%)			kr. 270		Combined sales price extention pages	2380000	kr.
8	Sales price without moms			kr. 1,080		Average selling price for both products based on 25	**516.4**	kr.
9	Cover (distributor 50%)			kr. 540		Based on 10000		
10	Sales price (factory)			kr. 540		Combined cost price basic speargun	4627168.5	kr.
11	Cover (factory 50%)			kr. 231		Combined cost price extention pages	908102	kr.
12	Cost price			kr. 308		Average cost price for both products based on 2	**221.4**	kr.
13	Price in $	currensy 6,59		kr. 46.81				
14	**Extension package**							
15	Sales price (customer)			**kr. 397**	**400kr.**			
16	Moms (25%)			kr. 79				
17	Sales price without moms			kr. 318				
18	Cover (distributor 100%)			kr. 159				
19	Sales price (factory)			kr. 159				
20	Cover (factory 75%)			kr. 68				
21	Cost price			kr. 91				
22	Price in $	currensy 6,59		$13.78				
23								

	A	B	C	D	E	F	H
1	**Businesscase**						
2	Basic speargun sold			3,750	5,250	6,000	15,000
3	Extention pages			2,250	3750	4000	10,000
4	**Budget**						
5				**År 1**	**År 2**	**År 3**	
6	**Antal**			6,000	9,000	10,000	
7	**Pris**			kr. 516	kr. 516	kr. 516	
8	**Kostpris**			kr. 221	kr. 200	kr. 190	
9							
10	Omsætning			kr. 3,098,400	kr. 4,647,600	kr. 5,164,000	
11	Omkostninger			kr. 1,328,400	kr. 1,800,000	kr. 1,900,000	
12	Dækningsbidrag			kr. 1,770,000	kr. 2,847,600	kr. 3,264,000	
13							
14							
15	**Breakevenanalyse**						
16	Investering			kr. -2,100,000	kr. -330,000	kr. 2,517,600	
17	Dækning			kr. 1,770,000	kr. 2,847,600	kr. 3,264,000	
18	Rest			kr. -330,000	kr. 2,517,600	kr. 5,781,600	
19							
20	**Afkast (af projektinvesteringen)**					**kr. 5,781,600**	
21	**Afkastningsgrad**					**275.3%**	
22							



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS TOLERANCES: ISO 2768 M	FINISH: MIL-A-8625	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION	
			Part Nr:		

	NAME	SIGNATURE	DATE
DRAWN	Ardea		
CHK'D			

TITLE: Isometric view

ARDEA

MATERIAL:

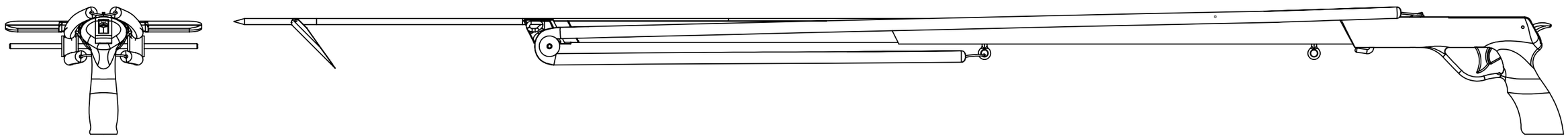
WEIGHT:2100g

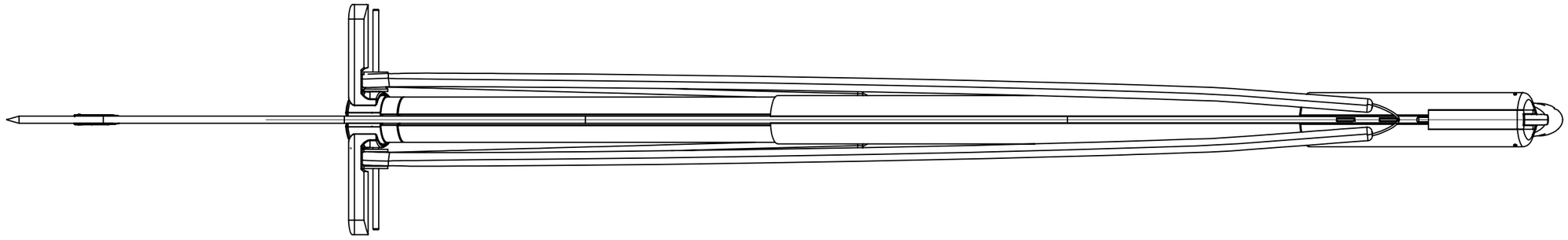
DWG NO. 1

A3

SCALE:1:1

SHEET 1 OF 1





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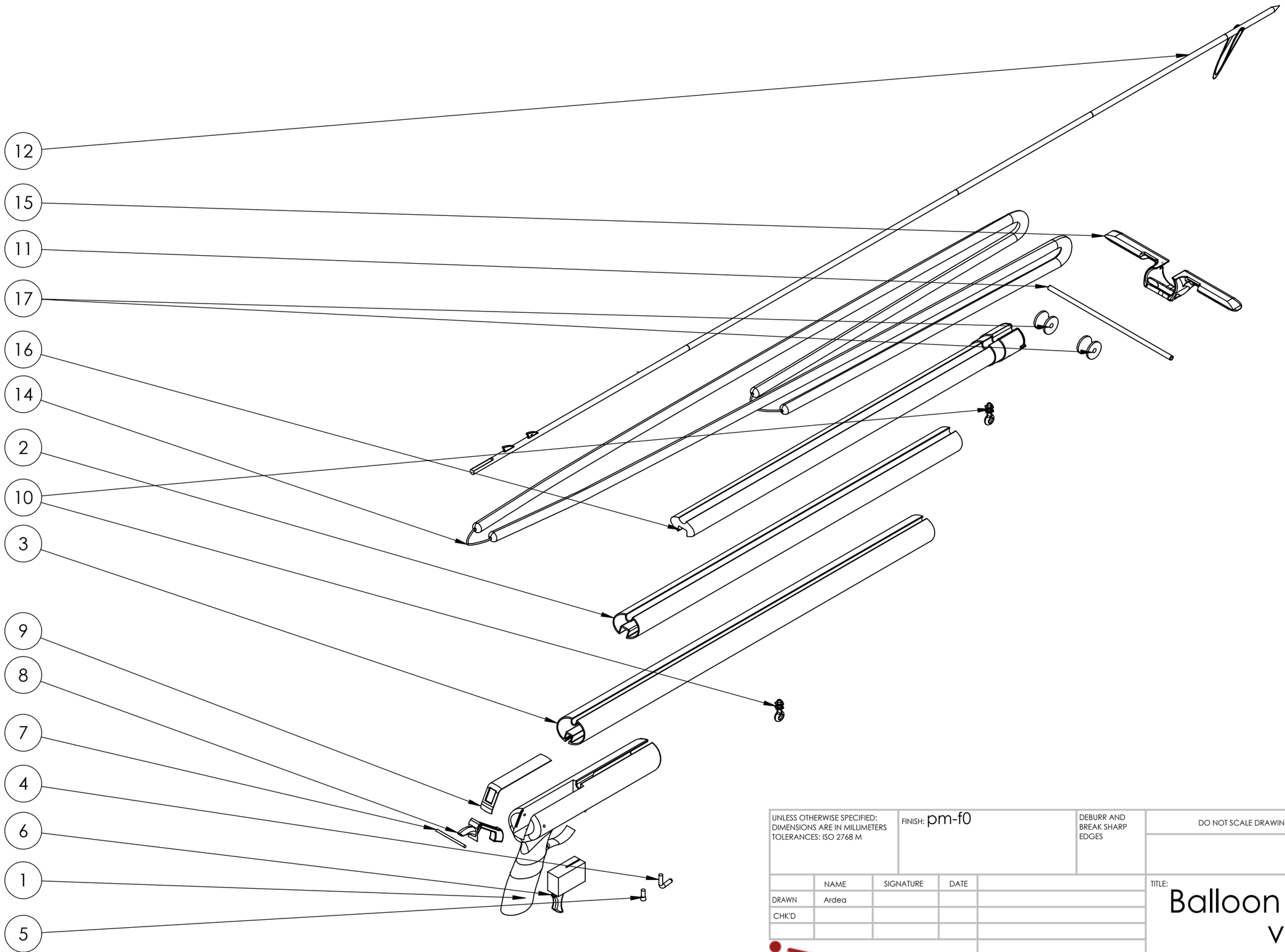
				Part Nr:	
	NAME	SIGNATURE	DATE	TITLE: 3 point view	
DRAWN	Ardea				
CHK'D					
ARDEA				MATERIAL:	DWG NO. 2
				WEIGHT:	SCALE:1:1
					SHEET 1 OF 1
					A3



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	NAME	SIGNATURE	DATE
DRAWN	Ardea		
CHK'D			

ARDEA

TITLE:

Balloon exploded view

MATERIAL:	DWG NO.	A3
WEIGHT:	3	
SCALE:1:5	SHEET 1 OF 1	

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS TOLERANCES: ISO 2768 M	FINISH: MIL-A-8625	DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING / REVISION Part Nr:

	NAME	SIGNATURE	DATE
DRAWN	Ardea		
CHK'D			

ARDEA

MATERIAL:

WEIGHT:

TITLE:

DWG NO. bill of materials

A3

SCALE:1:1

SHEET 1 OF 2

ITEM NO.	PART NUMBER	DESCRIPTION	Default/QTY.
1	1.1.0	Handle	1
2	2.2.0	Extension barrel	1
3	1.4.1	Line holder srew	1
4	1.4.2	Barrel mount screw	1
5	1.3.0	Trigger	1
6	1.2.1	Safety pin	1
7	1.2.0	Safety	1
8	1.1.1	Handle shield	1
9	3.1.0	Adjusting bolt	2
10	4.1.1	Steel load beam	1
11	7.1.0	Spear	1
12	1.4.0	Line wheel	1
13	6.1.0	Rubber band	1
15	4.1.0	Loading pad	1
15	5.1.0	Muzzel	1
16	4.2.0	Roller	2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
TOLERANCES: ISO 2768 M

FINISH:

DEBURR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

	NAME	SIGNATURE	DATE
DRAWN	Ardea		
CHK'D			

ARDEA

TITLE: Bill of materials

MATERIAL:

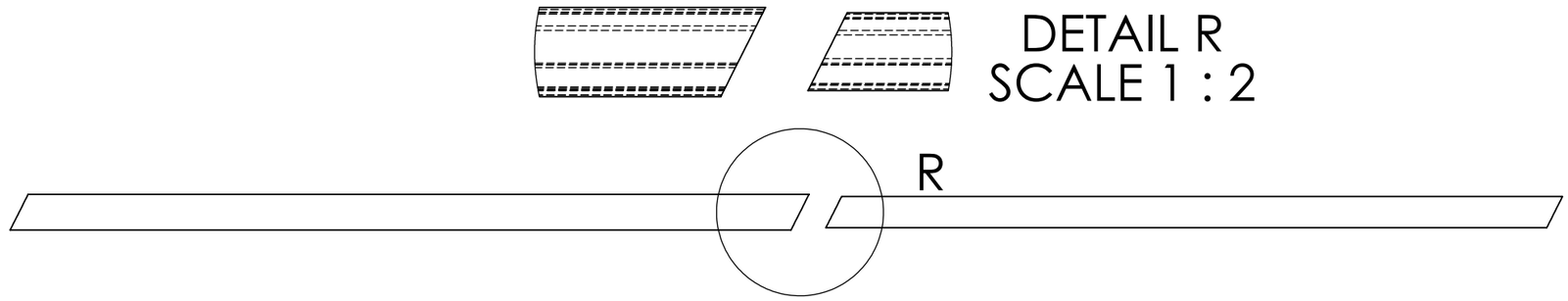
WEIGHT:

DWG NO. 4

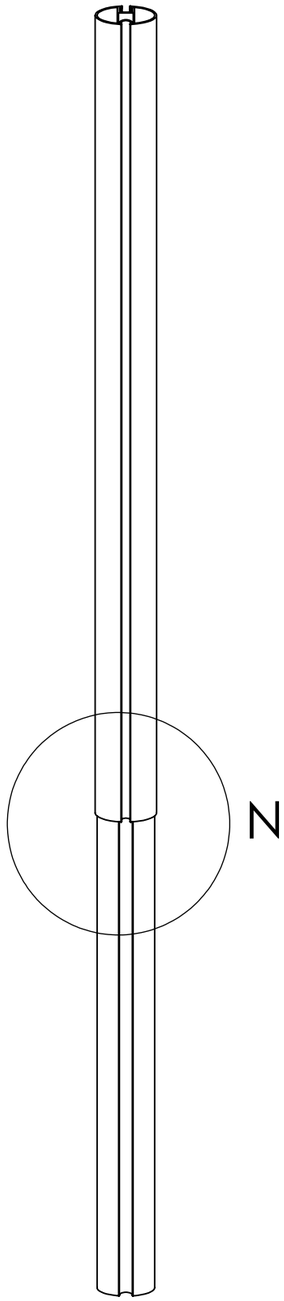
A3

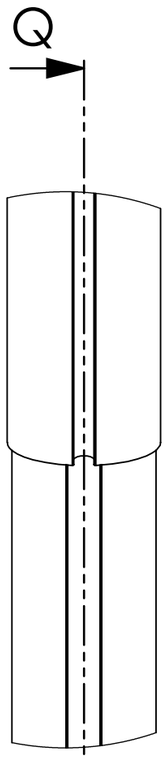
SCALE:1:5

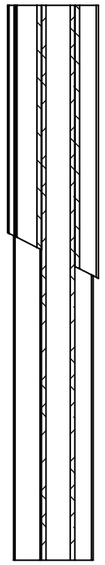
SHEET 2 OF 2



DETAIL R
SCALE 1 : 2

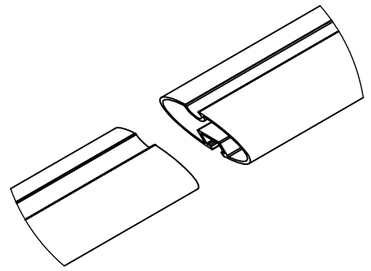






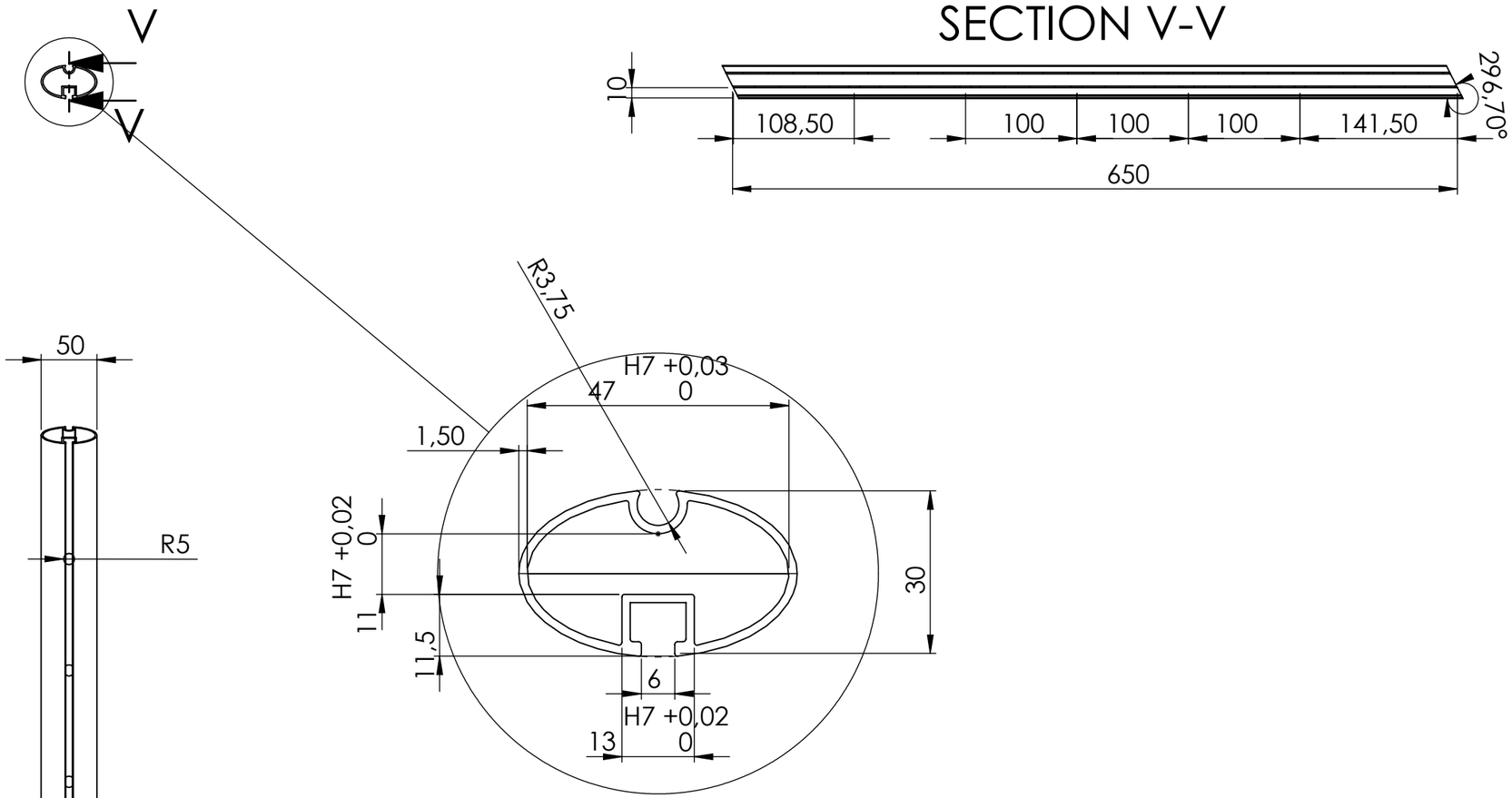
SECTION Q-Q
SCALE 1 : 2

DETAIL N
SCALE 1 : 2



DETAIL M
SCALE 2 : 5

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS TOLERANCES: ISO 2768 M	FINISH: MIL-A-8625		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION
				Part Nr:	
	NAME	SIGNATURE	DATE	TITLE: Assembly drawing	
DRAWN	Ardea				
CHK'D					
ARDEA				MATERIAL: AI XXXX	DWG NO. 5 A3
				WEIGHT:	SCALE:1:5 SHEET 1 OF 1



DETAIL W
SCALE 1 : 1

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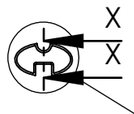
			Part Nr:		

	NAME	SIGNATURE	DATE
DRAWN	Ardea		
CHK'D			

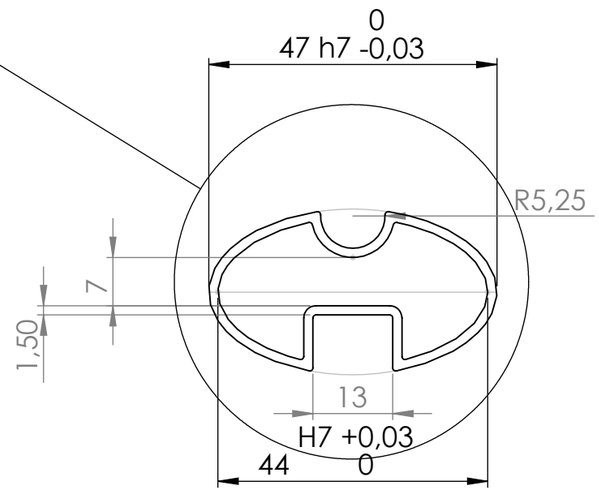
TITLE: Base barrel

ARDEA

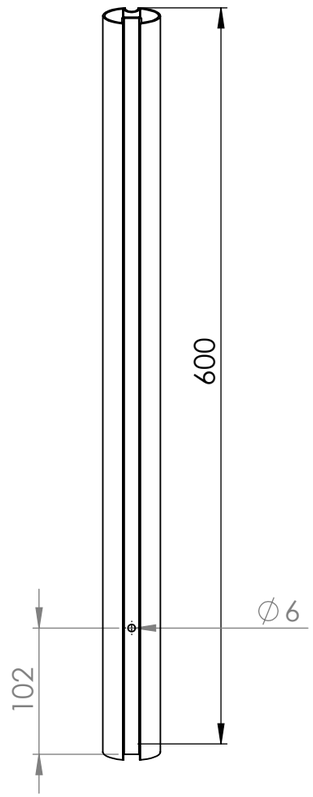
MATERIAL:AI XXXX	DWG NO. 6	A3
WEIGHT:	SCALE:1:5	SHEET 1 OF 1



SECTION X-X



DETAIL Y
SCALE 1 : 1



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS TOLERANCES: ISO 2768 M	FINISH: MIL-A-8625		DEBURR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING	REVISION
				Part Nr:	
	NAME	SIGNATURE	DATE	TITLE: Extension barrel	
DRAWN	Ardea				
CHK'D					
ARDEA				MATERIAL:	DWG NO. 7
				WEIGHT:	SCALE:1:5
					SHEET 1 OF 1
					A3