

Immersion Suits for Alaskan Commercial Fishermen:

An Analysis of Marine Survival Equipment

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Table of Contents

Commercial Alaska Fishing	3
History of Commercial Alaska Fishing.....	3
User.....	3
Defining the Market.....	4
How Can We?.....	4
Product Classification.....	4
Product Problems to Be Solved.....	5
User Jobs to Be Done.....	6
Environment.....	6
Product Rules.....	7
Product Jobs to Be Done.....	8
State of the Art Market Comparison Immersion Suits.....	9
Immersion Suit Materials and Manufacturing.....	11
Intellectual Property Landscape.....	12
Color Trends.....	13
Graphic Trends.....	14
Logo and Branding.....	15
Physiological Research	16
Biomechanical Research	18
Psychological Research.....	18
SWOT	19
Research Methods Used for Collecting User Data.....	20
Performance Testing Plan.....	23
Final Prototype.....	27
Testing Results.....	31
Conclusion.....	32
Thesis Impact Moving Forward.....	33
Professional Statement.....	33
Clifton Strengths.....	33
Golden Circle Statement.....	34
Mentor.....	34
References	35

Commercial Alaska Fishing

Being a commercial fisherman in Alaska is considered one of the most dangerous occupations in the United States. Every year the Bering Sea provides between 5-6 billion pounds of seafood, accounting for about 60% of total U.S. seafood harvests (Capozzi, n.d.-a). Catching this amount of seafood every year is no easy task, and it comes with an enormous amount of risk for the thousands of workers who participate. Workers are often at sea for weeks at a time and safety isn't guaranteed, with the Bering Sea claiming 88 souls from 2013-2022 (Beacon,2023). Many of the deaths on commercial fishing boats are caused by vessel losses, and men going overboard with improper equipment leading to drownings (Woodford, USCG, 2022). Fishermen risk their lives in this industry to try and fulfill the demand for seafood throughout the country, therefore they should be equipped with superior safety protection equipment that will ensure their safety.

History of Commercial Alaska Fishing

Fishing in Alaska has long been a way of life for its inhabitants, primarily for the Alaska natives who inhabited the area before colonization and statehood. However, since the late 1880s, many settlers rushed to Alaska to build fish camps and canneries to take advantage of the abundant fish and shellfish resources available for harvest. This influx of people and activity marked the beginning of commercial fishing in Alaska. Since then, commercial fishing in Alaska has been a crucial part of its economy, with seafood being the state's top export (Capozzi, n.d-b). Commercial fishing produces around 58,000 jobs and 5.6 billion dollars in economic activity for Alaska every year (Capozzi, n.d.-c). With commercial fishing being so prominent in the state, it is not uncommon for many families to have close ties and depend on this industry.

User

Commercial fishermen in Alaska vary in age with crews often assembled based on fishing experience. However, a recent study from 2018 revealed that the average age of commercial fishermen in Alaska is now 50 years old, an increase of ten years from the previous generation (Graying of the Fleet, 2018). The aging of commercial fishermen without younger replacements is what is referred to as the “graying of the fleet.” Women also participate in the industry however they only make up 15% of total commercial fishermen (Gross, 2019). This analysis focuses on male users, aged between 20 and 60 years old, who participates in commercial Alaska fishing industry.

Defining the Market

With commercial fishing providing 5.6 billion dollars in economic activity for the state of Alaska (Capozzi, n.d.-d), the products proposed for this market will be focused on the American domestic market. According to the Alaskan Seafood Marketing Institute, the approximate number of commercial fishermen workers consisted of 31,300 individuals yearly (Alaska Seafood Marketing Institute, 2022). The US Coast Guard mandates that there must be one Coast Guard-approved immersion suit of the appropriate size, per person, on board while fishing. The approximate market reach for these products consists of around 31,300 individuals (United States Coast Guard, n.d.).

How Can We?

How can we provide Alaskan commercial fishermen with improved survival immersion suits that will increase survival rates during maritime emergencies?

Product Classification

To increase survival rates during maritime emergencies, the most important piece of equipment to a fisherman going into a body of water is an Immersion suit. Immersion suits are dedicated personal protective equipment apparel designed for users who must enter extremely cold bodies of water. They are traditionally stored in PVC coated bags to prevent corrosion to the suit. The US Coast guard mandates

immersion suits for any commercial vessel operating North of 35 degrees North latitude (OLRC Home, n.d.).

Product Problems to Be Solved

As mentioned, the most important piece of equipment these Alaskan fishermen must have, but hope to never have to use, is the immersion suit. The purpose of Immersion suits is to prevent cold shock upon entering cold water and lessen the effects of hypothermia. This is achieved by providing thermal insulation, floatation, and visibility. This is especially important as the Pacific Ocean in the Alaska region is extremely cold, averaging a temperature of 32°F (Bering Sea Water Temperature, n.d.). Currently, immersion suits are considered to be a difficult piece of equipment to use due to the weight of the suit material, and the donning process. The donning process of an immersion suit takes thorough practice to be able to don efficiently and correctly. This poses several safety issues, as unexperienced fishermen may not have ample time to don their immersion suits during a maritime emergency. Current suits also require users to have ample space to deploy their suits from storage bags and to lay out the suit before donning can begin. Open space is not a luxury that most fishing boats have, making the donning process extremely difficult if there are multiple users trying to don their suits all at once. Providing users with a quicker deployment that also takes up less space will help facilitate the overall donning process.

Immersion suits are currently viewed as a last resort piece of equipment due to the clumsiness and lack of ergonomics. To change this current perspective of immersion suits, they need to be able to allow the user more mobility and usefulness, to increase their potential usefulness. Providing proper protective equipment for the hands is also important as they are used by fishermen for most jobs on board the ship. However, when a ship is going down, there are still circumstances when a sailor might need to access their hand dexterity. An example of this would be a user performing duties in the engine room or a captain radioing the coast guard. If users were afforded both high insulation and improved hand dexterity,

some users might be more inclined to don their suits earlier, allowing them further time to prepare for water ingress.

User Jobs to Be Done

Fishermen on board commercial Alaskan fishing vessels have various jobs. These jobs include conducting fishing operations, performing maintenance, all while complying with the rules and regulations of local, national, and international fishing regulations. Fishing operations on board include deploying and operating fishing equipment such as nets, pots, and traps to catch specific types of seafood (CareerExplorer, 2023). This work is done primarily on the docks of vessels and requires workers to be exposed to the elements while performing this work. When this work is done, workers are then tasked with sorting their catch to responsibly adhere to commercial fishing regulations. This process is also done on the deck and can be very time-consuming, extending the period of exposure to the elements. Often, crew workers may also have to perform maintenance and repair to both their fishing vessels and the equipment they use for fishing. This part of the job can be very hazardous for the crew as they are performing tasks on heavy and dangerous equipment while under stress from the weather and time. During these tasks, workers can often become fatigued and are more susceptible to accidents occurring. This fatigue can lead to workers making mistakes, increasing the probability of accidents.

Environment

Commercial Alaska fishing occurs in the Pacific Ocean, primarily the Gulf of Alaska, as well as the Bering Sea straight located between Alaska and Russia. The Bering Sea is the harshest environment of the three locations with water temperatures averaging 37 degrees Fahrenheit and air temperatures ranging from 14 to 39 degrees Fahrenheit. The Bering Sea is also where most of the groundfish production volume comes from, accounting for 83% of total groundfish catch (Fisheries, n.d-a.). In 2022, 4.5 million pounds of red Alaskan king crab was caught in Bristol Bay, the easternmost point of the Bering Sea, with a valuation of 43 million dollars (Fisheries, n.d-b). Most commercial Alaska fishing occurs from March to

October, as this is when the weather is most favorable. However, certain species of fish and shellfish have seasons that begin during the typical off season.

The Bering Sea is considered one of the most difficult bodies of water to navigate with severe storms creating powerful waves of forty feet plus, strong winds, and creating ice accretion on board ships (*Bering Sea - New World Encyclopedia*, n.d.). Low visibility due to fog is also common, making the navigation of vessels more difficult.

Product Rules

Immersion suits were first introduced to fishing firms in 1930 by the American Life Suit Corporation (Popular Mechanics, 1930). They have since evolved quite drastically with safety being the primary function and now have very strict guidelines to follow. The US Coast Guard is the entity responsible for rules and regulations of commercial fishing boats in Alaska. Ships must adhere to their regulations to be able to operate. The US Coast Guard mandates that all commercial fishing vessels must contain safety immersion suits if ships are operating anywhere above 32 degrees latitude (46 USC 3102: Immersion Suits, n.d.). The US Coast Guard also has regulations for immersion suits (46 CFR Part 160 Subpart 160.171 -- Immersion Suits, n.d.) specifically:

- Each person on the ship must have an immersion suit. Also, extra immersion suits should be provided for the watchkeepers.
- Immersion Suits may be of the kinds that are Insulated, Un-insulated, or wearable with a life jacket (all should have sufficient buoyancy).
- Must be made of 4.75mm neoprene waterproof material
- Mandated to be made in international red or orange in color to promote visibility.
- The immersion suit should be unpacked and donned within 2 minutes without any external help or assistance.

- The individual must jump from a height of at least 4.5 meters into the water without injury to life or damage to the immersion suit.
- The suit should be able to cover the whole body except the face. Hands should be covered unless permanently attached gloves are provided.
- Retro-reflective tapes must be fitted.
- It shall not sustain burning or continue to melt after being enveloped in a fire for 2 seconds.
- Everyday work must be able to be carried out upon wearing.
- The wearer should be capable of climbing up and down a vertical ladder of at least 5 meters in length.
- The wearer must be able to swim a short distance.
- The immersion suit is worn in cold weather when the temperature is below freezing.
- The suit does not allow the body temperature to drop by more than 2 degrees when immersed for 6 hours when the water temperature is between 0 and 2 degrees °C.
- The wearer of the suit, with or without the lifejacket, shall be able to turn from a face-down position to a face-up position in less than 5 seconds.
- If a life jacket is required along with the immersion suit, it should be worn over it without assistance.

Product Jobs to Be Done

For commercial Alaskan fishermen the most important piece of equipment during a maritime emergency is the immersion suit. Immersion suits are only needed in extreme cases of emergency where there is no option but to ingress the water. Simply put, immersion suits are responsible for increasing chances of rescue and survival, protecting against hypothermic temperatures and environments. To accomplish these jobs, an immersion suit must be able to be deployed quickly and donned within the 2-minute window. The immersion suit must also provide the user with an ample amount of dexterity in the glove or mitt while using the suit. Suit failure would be defined as a suit that has been breached by

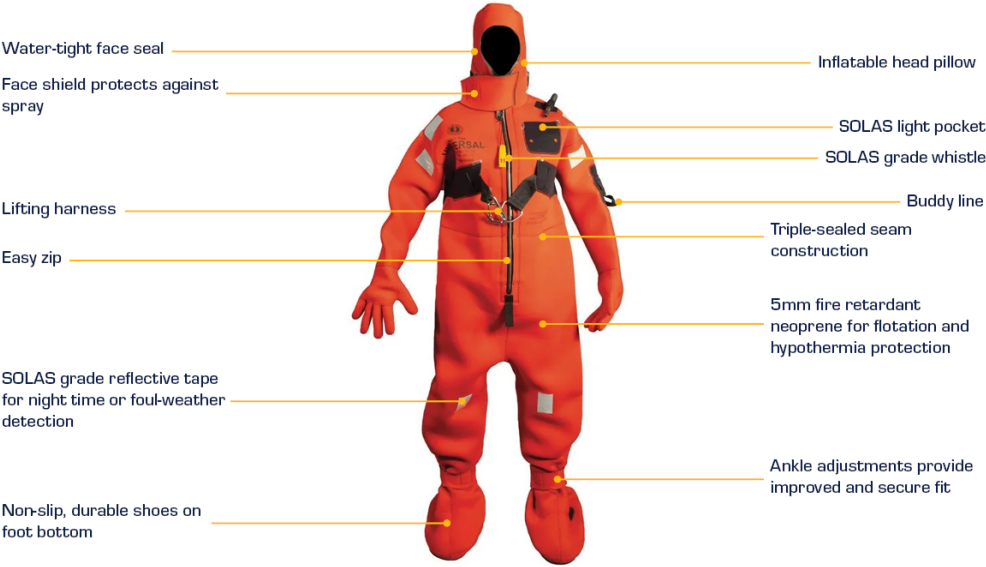
enough water that it will not keep the user thermos-insulated, a zipper that cannot be zipped rendering it useless, and

State of the Art Market Comparison Immersion Suits

Immersion suits follow very strict guidelines to adhere to government compliances. Because of this, many of them appear very similar with few differentiating details. The top three immersion suits currently available on the market include offerings from Mustang Survival, Kent Commercial, and Imperial. All three of these brands make immersion suits that are US Coast Guard and SOLAS-approved. SOLAS approval involves meeting the requirements of the International Convention for the Safety of Life at Sea, set by the International Maritime Organization. The SOLAS convention is generally regarded as one of the most important of all international treaties concerning the safety of merchant ships. These set regulations make it simple for companies to follow certain guidelines when designing immersion suits. Figure 1 shows the anatomy of an immersion suit.

Figure 1

Immersion Suit Anatomy



Mustang Survival's offering of immersion suit is labeled as Neoprene Cold Water Immersion Suit with Harness with a model number MIS230 HR (Fig.2) and an MSRP of \$490. Mustang's offering is designed specifically for commercial operations including transport vessels, drilling rigs, supply ships, steamships, and commercial fishermen, and only comes in the International Fluorescent Red coloration. Mustang's suit boasts triple-seam sealed waterproofing construction, and adjustable ankle straps, and is made of 5mm fire retardant neoprene to protect against hypothermia. The suit also comes equipped with five-fingered insulated gloves to allow for digit dexterity and warmth. As with most immersion suits, this suit also includes a 1000lb rated retrieval harness, reflective tape, a neoprene pocket for a personal light beacon, and a buddy line. Mustang also made sure to include a water-tight face seal to ensure water does not enter the suit through the neck opening and potentially cause the suit to fail by filling up with water. One of the biggest differences that separates this suit from other immersion suits is that Mustang manufactures their suit in four different sizes: child, adult small, adult universal, and adult oversized.

Kent Outdoor manufactures a suit labeled as the Kent Commercial Immersion Suit (Fig.3) with model number 154000-200 and an MSRP of \$450. Similarly built, the Kent immersion suit is also made of 5mm fire retardant neoprene. Kent's immersion suit differentiates itself in a few different ways including, articulated seams for easier donning, gloves positioned so sleeves turn at the elbows for easier donning, and an inflatable head pillow. Unlike the Mustang immersion suit, The Kent immersion suit's glove design is different providing a three-fingered mitt instead of a five-fingered glove. The Kent immersion suit also stands out from the other two immersion suit competitors in that their suit is manufactured in International Fluorescent Orange with some fluorescent green. Recent studies have shown that fluorescent green can have higher visibility than traditional fluorescent orange and red, giving the Kent suit a potential competitive advantage (Galvao, 2019b). On the exterior, the suit also provides SOLAS reflective tape, a neoprene pocket for personal light beacons, as well as a buddy line and retrieval harness. Kent's immersion suit is manufactured in three sizes, intermediate, adult universal, and oversized.

The final immersion suit competitor is the Imperial Immersion Suit designed by Survitec Survival Technology (Fig.4). The Imperial immersion suit has an MSRP of \$450, with model number 18-1409X. Survitec claims that the Imperial Immersion suit has been in production since 1969 and was the very first immersion suit available for the maritime market. The Imperial immersion suit is also manufactured out of 5mm buoyant neoprene like the other competing suits. The suit is manufactured in International Fluorescent Red color along with SOLAS reflective tape on the shoulders, back, knees, and arms of the suit. Like the Kent immersion suit, the Imperial suit also has a three-fingered mitt construction, a retrieval harness, and a neoprene pocket for a personal light beacon. A defining feature of the Imperial immersion suit is the inflatable high-rider ring for additional freeboard motion. The Imperial immersion is available in four different sizes including, child intermediate, adult universal, and jumbo.

Figure 2



Figure 3



Figure 4



Immersion Suit Materials and Manufacturing

Immersion suits are rather simple when identifying the components. The main shell of the immersion suits will be 5mm fire retardant neoprene. Most immersion suits will have only one entry point to reduce the number of closures needed. This is to prevent unnecessary potential points of failure. The

most readily used closure system is a water-sealing zipper such as the YKK proseal zipper. The reflective material on the suit is primarily SOLAS-approved reflective fabric with a high candela rating. Some suits also include hook and loop fastening systems on the ankles and wrists and use products such as 3M Scotchmate Hook & Loop. For the harness part of the suit, steel D rings and carabiners are used with around 1000lb ratings.

Manufacturing of immersion suits includes the following steps:

1. Patterns are designed and materials are sourced.
2. Patterns are cut and materials are prepared for the sewing and seam welding process.
3. Pattern piece seams are glued to waterproof them and are then blind stitches with seams on the inside. Blind stitch provides waterproofing, high stretch, and invisibility when seams are sewn on the inside.
4. The suit will then have zipper closure attached through seam welding or radio-frequency welding.
5. Trims and hardware are attached to the suit.
6. The product is run through rigorous testing to ensure water tightness and to secure compliance with US Coast Guard and SOLAS regulations.

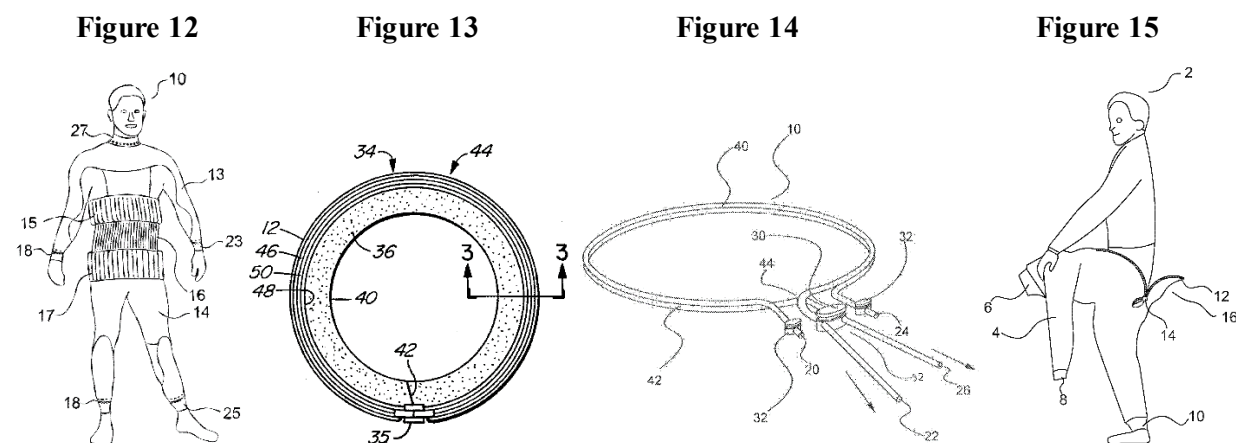
Intellectual Property Landscape

Intellectual property is an important facet of product creation that enables companies to protect their research and development and to maintain a competitive advantage. Innovations in the immersion suit market are plentiful with various companies striving to improve the safety of their product users. A crucial aspect of immersion suits is the closure system that keeps the user dry when submerged in water.

One of these systems is Ocean Rodeo Sports patent US10696364B2 (Fig. 12) (Harrington, n.d.-a), which is a friction-sealed closure system to prevent water penetration. This technology functions by overlapping stretch waterproof materials end flaps over each other to provide a to keep water out.

The second patent innovation, US5647059A (Fig 13) (Uglene, n.d.), is claimed by Mustang Survival and is a closure system that fits around the neck to provide a watertight seal. This closure unit is a three-layered system that uses a stretchy band that pushes against a soft squishy material that will form to the neck shape, providing a water-tight seal. The third patent innovation, US10364005B2 (Fig. 14) (Harrington, n.d.-b), is also a neck closure system designed by Mustang Survival. This system uses two cords that overlap, but never fully go around the circumference of the opening, to create an effective barrier against water.

The final patent innovation, US 20190174844A1 (Fig. 15) (Myerscough, n.d.), is also filed by Mustang Survival and is an access entry design for immersion suits. This patent is for a full-body immersion suit opening located on the lower back that is a single entry. This eliminates the need for multiple closure systems on a suit that seeks to eliminate water penetration.



Color Trends

Colors are important in the design and end use of immersion suits. With an immersion suit, the goal is to be as visible as possible to be rescued as quickly as possible. The current approach to this is set by the US Coast Guard along with the SOLAS convention regulations. The color mandates for immersion suits state that they must either be manufactured in International Fluorescent Red (Fig. 16) or International

Distress Orange (Fig.17) (Grand Ocean Marine, 2023). Globally, immersion suits are typically manufactured in International Fluorescent Red, and Immersion suits produced for the American maritime market are typically produced in Distress Orange. A recent study carried out by Mustang Survival and WorkSafeBC found that high visibility green (Fig.18) was the most conspicuous color both in approaching and leaving distances (Grand Ocean Marine, 2023). The high-visibility green outperformed red, orange, and yellow in their respective order. The study's findings indicate that there may be a change in regulations that could provide higher visibility in cases of water immersion.

Figure 16



International Fluorescent Red

Figure 17



Distress Orange

Figure 18



High Vis Green

Graphic Trends

Graphics are not a design item that is common on immersion suits. Immersion suits however are mandated to always have at least 200cm² of retroreflective material (Fig.19) visible no matter the body's position in the water (46 CFR Part 160 Subpart 160.171 -- Immersion Suits, n.d.-a). The US Coast Guard mandates that immersion suits must be equipped with this material and that it be a minimum of Type 1 quality (46 CFR Part 160 Subpart 160.171 -- Immersion Suits, n.d.-b). Type 1 retroreflective material, also known as engineering quality retroreflective, has a candela score of 75. The Candela scale is a scale that determines how much light is reflected by retroreflective material and the higher the Candela score the more visible it will be when reflecting light (Rob, 2023). Currently, retroreflective tape is typically applied to the back (fig.20), shoulders (Fig.21), knees (Fig.22), and head in very simple rectangular shapes. This could be an opportunity to innovate graphic or pattern designs that provide better visibility.

Figure 19



Figure 20



Back retroreflective

Figure 21



Front Retroreflective

Figure 22



3/4 Retroreflective

Logo and Branding

Logo and Branding on immersion suits occur on the right-hand chest for the top three immersion suits on the market including Kent, Imperial, and Mustang. Logos, sizing, government compliances, care

instructions, and donning instructions are also included. These items are applied in black through heat transfer or screen printing. The sizing of logos and branding is minimized to maximize the color visibility of immersion suits. Currently, the logos of Mustang Survival (Fig.23), Imperial (Fig.24.), and Kent (Fig.25), are minimalistic with some marine animal influences. There is an opportunity in the design of the product line to include graphical branding elements and language that stray from what is currently available, to be disruptive, and to be more aesthetically pleasing. This is something that could push consumers to buy this product instead of what has been available for so long.

Figure 23



Figure 24



Figure 25



Physiological Research

Sudden cold-water immersion is a nightmare scenario for commercial fishermen. Being forced to evacuate a ship can have many effects including life-threatening physiological effects. Cold shock response (CSR) is a series of cardio-respiratory responses that the body induces when it is immersed in cold water (Eglin et al., 2015). CSR is triggered by a sudden fall in skin temperature and is followed by a gasp reflex as well as hyperventilation. These factors can increase the probability of drowning if the submerged individual's face is underwater. For individuals who have pre-existing heart conditions, CSR

can trigger a potentially fatal response like a heart attack (You're Not a Polar Bear: The Plunge into Cold Water Comes With Risks, 2023).

Humans have a set body temperature, also known as the body set point, of 98.3°F. This internal temperature is regulated by the hypothalamus, a part of the brain (Institute for Quality and Efficiency in Health Care (IQWiG), 2016). Skin temperature makes up 30% of the body set point, with core body temperature making up the other 70% (Winn, n.d.). As a result, cold water immersion can have a big impact on the overall body set temperature. When body temperature falls below the set point, heat retention responses like shivering and skin constriction are activated (Metabolic Heat Production - Labster, n.d.). The longer an individual is in the water, their oxygen uptake will increase causing the heart to pump blood faster to try and warm up the body (Winn, n.d.). The body will also begin to rush blood away from the extremities and into the core in an attempt to protect vital organs (You're Not a Polar Bear: The Plunge Into Cold Water Comes With Risks, 2023). As the person becomes colder and colder the body will find it harder to deliver blood to working muscle groups. This is because hemoglobin, the molecule responsible for carrying oxygen in red blood cells, will bind harder to oxygen molecules, making it harder to release oxygen across the body (Winn, n.d.).

Hypothermia is a medical condition that arises from the body being unable to keep up with heat loss causing the body to reach low, and potentially fatal body temperatures (Hypothermia - Symptoms and Causes - Mayo Clinic, 2022). Hypothermia can develop in individuals if water temperatures are at or below 70°F. In the case of emergency cold water immersion, this condition can be accelerated by water temperature since water conducts heat away from the body 25 times faster than air (Outdoor Action Program, Princeton University, n.d.). With the Bering Sea averaging a temperature of 37°F year-round exhaustion and or unconsciousness would occur within 15-30 minutes, and the total expected survival time would be 30-90 minutes (Michael, 2022). For these reasons, survival immersion suits are crucial for commercial fishermen's survival in cases of emergency.

Biomechanical Research

When crew members are in the water, they are at the mercy of the ocean. Conditions can be torrential in the form of 40+ foot waves, ice storms, and extreme cold. Once in the water, individuals have very little influence on their movement. The recommended advice in marine emergencies, where you are already in the water, is to stay still to try and conserve heat and energy. Survival immersion suits are made of 5mm waterproof neoprene that helps with maintaining buoyancy however, water conditions may affect suit buoyancy effectiveness (*46 CFR Part 160 Subpart 160.171 -- Immersion Suits*, n.d.). Survival immersion suits are also notorious for being ill-fitting and awkward to wear, which can also affect the effectiveness of movement in the water. If a person is to try and stay afloat or attempt to keep their head above water, it is recommended for them to tread water, however, it should be noted that this action can reduce survival time by 50% (Michael,2022). This is the most efficient method of keeping one's head above water and consists of gently but constantly moving the legs in either a scissor kick, frog kick, or flutter kick. Kicking can alternate from one leg to the other, but individuals must try to do this in a slow and controlled manner to conserve as much energy as possible. For the arms, they are typically moved in a sweeping motion underwater also known as sculling. The arm motions will help with balancing and stability but are much less powerful than the leg motions.

Psychological Research

A maritime emergency like abandoning a sinking ship is a traumatic experience that affects the human psychological state. One such impact is that of the sympathetic nervous system. The sympathetic nervous system is responsible for controlling the human fight-or-flight response. Under stressful situations, the sympathetic nervous system releases chemicals to accelerate the heart rate and create mental sharpening and focus (Professional, n.d.). These chemicals are a group of neurotransmitters called catecholamines and consist of epinephrine and norepinephrine (Sports Medicine, n.d.). In this way, the

brain and sympathetic nervous system are communicating to improve the handling of dangerous and stressful situations.

A secondary psychological effect of maritime emergencies consists of the training and mental preparation of individuals beforehand. Having the knowledge and skillset on how to survive such a situation can establish a positive psychological state of preparedness and reduce the strain on mental health during an emergency (Administrator, n.d.). Training and being conscious of the dangers while out at sea will help in making the correct and necessary decisions without overthinking or panicking. This preparedness and quick thinking can make the difference between life and death (The Power of Preparedness | NOAA's Office of Response & Restoration Blog, n.d.). Once overboard, individuals will have to rely on psychological fortitude and will to survive even when the conditions are most unfavorable. Rescue organizations like the Coast Guard may be unaware of maritime emergencies and their response time can vary depending on how favorable weather conditions are. This uncertainty can affect the mental state of victims during emergencies by causing further anguish and desperation so mental preparation and training are key.

SWOT

SWOT analysis is important when developing a product to point you in the right direction creatively and to develop long-term success. By analyzing strengths, weaknesses, areas of opportunity, and threats, a designer achieves more clarity about how to design for the user. The tables below display the SWOT analysis for the proposed product line.

Table 1

SWOT Immersion Suit



	Closure System	Accessories	Materials
Strengths	<ul style="list-style-type: none"> Waterproof YKK zipper Water tight face seal Adjustable wrist and ankle straps Patented technology from main competitors 	<ul style="list-style-type: none"> Neoprene pocket for personal light beacon Buddy line provided for multi-person use compatability Lift harness compatible 	<ul style="list-style-type: none"> 5mm neoprene is great for thermal insulation SOLAS & USCG certified SOLAS approved retroreflective material
Weaknesses	<ul style="list-style-type: none"> Dependent on technology that has been around for a long time 	<ul style="list-style-type: none"> Very rudimentary options currently available 	<ul style="list-style-type: none"> Neoprene manufacturing is very specialized and requires lots of testing Neoprene can be heavy and is an outdated material choice
Opportunities	<ul style="list-style-type: none"> Opportunity to innovate proprietary closure technology or system Explore new ways of putting suit on through pattermaking 	<ul style="list-style-type: none"> Rethink the necessities of the user and how to improve what exists Increase modularity 	<ul style="list-style-type: none"> Innovative insulation technologies to be explored Looking for innovation that meets more than the minimum standards
Threats	<ul style="list-style-type: none"> Patented technology can present an issue when problem solving Testing waterproofness might be a tough problem to solve for 	<ul style="list-style-type: none"> Limited by what USCG and SOLAS mandate 	<ul style="list-style-type: none"> USCG standards are very demanding and difficult to meet, can cost over \$100,000 to successfully pass tests Fishermen may not want to pay more than what they do currently

The SWOT analysis for immersion suits is a compilation of findings that includes the top three most popular models from the top three leading market competitors, Kent, Mustang Survival, and Imperial. This SWOT analysis was done in a compilation format because all the suits have the same basic features on them with very little differentiation between them. All three suits also consist of the same three components, closure system, accessories, and materials used. The price range of the products compared is \$450-\$490.

Research Methods Used for Collecting User Data

The design direction of the proposed product line is specifically tailored for commercial fishermen in Alaska. Therefore collecting the opinions, thoughts, and experiences of these individuals is crucial to its success. The best way to gather insights is to speak to those who live and work in this community, as they are the primary source. To accomplish this, personal interviews and a questionnaire

were developed to gather this information in the mission to be thoughtful and purposeful in every design detail of the product line. Below is the questionnaire formed along with the answers provided.

Questionnaire:

1. Do you feel that current immersion suits offer enough protection in case of emergencies?

(YES) (NO)

2. Is the price of an immersion suit worth the potential benefits?

(YES) (NO) (INDIFFERENT)

3. Do you own your own immersion suit?

(YES) (NO)

4. How often do you think about your immersion suit while working on a ship?

(NEVER) (RARELY) (SOMETIMES) (ALWAYS) (OFTEN)

5. What do you think your chances of surviving an emergency are with an immersion suit?

(EXTREMELY UNLIKELY) (UNLIKELY) (NEUTRAL) (LIKELY) (EXTREMELY LIKELY)

6. Have you ever had to wear an immersion suit in a real maritime emergency?

(YES) (NO)

7. How would you rank the fitting of immersion suits?

(Poor) (Fair) (Good) (Very good) (Excellent)

8. How important is comfort when wearing an immersion suit?

(NOT AT ALL IMPORTANT) (SLIGHTLY IMPORTANT) (IMPORTANT) (FAIRLY IMPORTANT) (VERY IMPORTANT)

9. Do you think you have enough training to properly don an immersion suit in the required two-minute standard?

(YES) (NO)

10. In case of an emergency are you confident you can physically get to your immersion suit?

(YES) (NO)

Results

1. 66% yes, 34% no
2. 70% yes, 5% no, 25% indifferent
3. 15%yes, 85% no
4. 20% never, 50% rarely, 15% sometimes, 10% often, 5% always
5. 5% extremely unlikely, 15% unlikely, 45% neutral, 25 % likely, 10 %extremely likely
6. 5 % yes, 95% no
7. 70% poor,10% fair ,10% good, 5% very good, 5% excellent
8. 5% not at all important, 20% slightly important, 40% important, 20% fairly important, 15% very important
9. 90% yes, 10% no
10. 85% yes, 15% no

The questionnaire results reflect the answers of 26 individual commercial fishermen from different areas of the state of Alaska. There are various indicators and key highlights in the survey results that reflect the need for improvements in immersion suits for commercial fishing. The first key highlight of these results is related to the perception of safety with the current offerings of immersion suits. 66% of individuals answered that they believe current immersion suits do offer enough protection in case of emergencies. This athlete's perception is important as it may impact their perspective on procuring a suit for themselves individually. It may also affect the importance that fishermen have for overall safety while on the water. The survey also revealed that only 15% of commercial fishermen own their own suits, with most of them relying on the suits provided by ships. These results further establish the notion that there is work to be done regarding fishermen being in control of their own safety gear. When asked how often they think about their immersion suits while working on a ship, 20% stated never and 50% answered rarely. Once again, the results highlight the lack of importance that some individuals have towards immersion suit safety.

One of the most important highlights of the questionnaire is that of the 26 individuals who answered the questionnaire, only 5% stated that they had worn an immersion suit during an actual maritime emergency. It would be interesting to find out what the perceptions are between individuals who have gone through an emergency and those who have not. This is something that should be investigated further to get a better understanding of how to approach the two different groups. There were also important findings regarding the fitment of immersion suits. 70% of the respondents voiced that they find the fitting of immersion suits to be poor, with 20% split between fair and good, and 10% split between very good and excellent. This demonstrates that the users feel that the fitment of suits is inadequate and should be addressed in the proposed product line. Respondents also voiced that the comfort of a suit is important with 20% responding slightly important, 40% responding important, and 20% responding with fairly important. The other 20% were split with 5% not at all important and 15% responding with the highest value of very important.

Overall, the questionnaire highlights that there is a need to further develop the connection between commercial fishermen and safety. An entity trying to bring light to the dangers that fishermen can be exposed to, while fishing, is Work Safe BC. Work Safe BC provides fishermen with knowledge and data that highlight how fatigue and stress can often lead to mistakes that can have greater safety implications (Fight Fatigue — Fish Safe, n.d.).

Performance Testing Plan

The first step in the performance testing plan was to establish baseline testing of the competitive products. The results from this comparative product testing were then compared to the same testing of the newly designed immersion suit. To accomplish this baseline testing, 10 participants donned the competitive product 3 times. Each tester had their 3 individual times averaged, and at the end all 10 averages were averaged again to get a group average. This same process was then repeated for the newly designed immersion suit.

Baseline testing of immersion suit deployment will also begin with 10 participants attempting to deploy the competitive suits 3 times. Each tester had their 3 times averaged, and at the end all 10 averages were averaged again to get a group average. This same process was then repeated for the newly designed immersion suit storage bag as well.



Suit donning



Suit deployment

1. Competitor products tested:

- a. <https://www.survivalatsea.com/survival-suits/uscg-solas-approved/mustang-cold-water-immersion-suit-with-harness.aspx?variantId=012c7c5f-9772-41d7-8d0a-a81e89e5e9c4>

Mustang Survival Immersion Suit & Bag

Size: Adult Universal

Cost: \$490



- b. https://www.survivalatsea.com/survival-suits/uscg-approved/kent-immersion-suit-uscg-approved.aspx?VariantId=bff42665-299a-48fa-9724-97397d3a2e0d&gad_source=1&gclid=CjwKCAjwzN-vBhAkEiwAYiO7oAaSI6hFi03gRkLg7hsO3gk6KRX0KfaoTe9z0CQNb9I_EkS7c9BWgxoCL9IQAvD_BwE

Kent Immersion Suit & Bag

Size: Adult Universal

Cost: \$450



2. Performance metrics to collect data on:

- a. Immersion Suit
 - i. How fast immersion suit can be donned
- b. Immersion Suit Bag
 - i. How fast immersion suit can be deployed from bag to ready to don position
- c. Immersion Suit Mitt
 - i. How much dexterity the new suit glove allows user.

3. How metrics will be collected:

- a. **Immersion Suit**
 - i. Donning

1. Stopwatch timing- Users will be timed as they don the equipment using a stopwatch
- ii. Deployment
 1. Stopwatch timing- Users will be timed as they deploy the equipment using a stopwatch
- iii. Dexterity
 1. Stopwatch timing- Users will be timed as they complete the modified pegboard test

4. How data will be analyzed:

- a. Immersion Suit
 - i. Testing data time averages will be compared to validate whether new immersion suit provides quicker donning.
- b. Immersion Suit Storage Bag
 - i. Testing data time averages will be compared to validate whether new immersion suit storage bag provides quicker deployments.
- c. Immersion Suit Mitt Design
 - i. Testing data time average will be compared to validate whether new design provides superior dexterity.

Final Prototype

RULIK IMMERSION SUIT



RULIK originates from the word Qasruliq, meaning ribbon seal in native Yupik.



SUIT FEATURES



READY-STEP-GO



CHELAE GRIP



Chelae- A pair of hinged pincer-like claws

A mitt and cuff design that allows users quick access to hands allowing for increased dexterity.



BAG FEATURES

250D TPU coated nylon in International Orange



Corrosion resistant stainless steel buckle



Roll top construction



CHELAE GRIP

Fidlock Stripe magnetic system keeps glove in place and out of the way.



Testing Results

The newly designed immersion suit prototype performed better than the comp products in donning speed, deployment speed, as well as dexterity. A particular trend that was noticed with the users was the speed at which they improved their performance. Although the testers were informed on how to deploy and don suits prior to their first attempts, the results clearly show the users improving throughout their repetitions. This is a sign that with enough repetition and practice, an individual will become more proficient with the deployment and donning of an immersion suit regardless of the variety. However, the overall times of the newly designed suit show an overall trend of being quicker to both deploy and don the immersion suit even with this learning curve consideration.

SUIT DEPLOYMENT TESTING RESULTS

COMP PRODUCT

Tester	Attempt 1	Attempt 2	Attempt 3
1	12.49	10.76	10.89
2	14.78	14.58	12.93
3	12.59	11.62	12.32
4	12.92	12.45	12.60
5	13.19	12.21	13.58
6	11.89	12.78	13.42
7	12.33	13.12	11.93
8	14.42	12.24	13.45
9	10.48	13.72	11.98
10	15.04	12.94	13.31

Average time to deploy suit **12.8** seconds.

RULIK

Tester	Attempt 1	Attempt 2	Attempt 3
1	7.18	5.84	5.91
2	6.86	5.78	5.32
3	5.42	5.69	5.23
4	6.94	5.82	6.01
5	7.12	6.36	5.13
6	5.55	5.75	6.82
7	6.37	5.96	6.34
8	5.19	6.02	6.17
9	7.23	5.41	6.28
10	6.59	6.39	5.76

Average time to deploy suit **5.72** seconds.

The **RULIK** storage bag proved to be a more efficient design, allowing users to deploy their suits over **150%** faster.



SUIT DORNING TESTING RESULTS

COMP PRODUCT

Tester	Attempt 1	Attempt 2	Attempt 3
1	79.41	75.92	66.92
2	77.86	69.89	60.20
3	73.74	63.17	50.32
4	73.70	68.41	67.91
5	79.20	67.80	65.00
6	78.85	62.62	59.15
7	50.09	63.36	69.01
8	51.40	60.31	72.86
9	54.79	55.60	60.59
10	63.92	70.86	79.19

Average time to don **66 seconds.**

RULIK

Tester	Attempt 1	Attempt 2	Attempt 3
1	52.48	41.05	28.10
2	55.13	36.59	29.58
3	49.09	41.19	28.10
4	50.15	49.40	34.34
5	47.35	48.35	38.56
6	42.21	40.48	36.04
7	51.67	47.45	31.97
8	54.77	33.41	31.51
9	51.89	45.78	31.72
10	49.09	35.11	30.81

Average time to don **41 seconds.**

The **Rulik** immersion suit proved to be a more efficient design, allowing users to don their suits by an average of **20%** faster, based on testing results of 10 individuals.

GLOVE DEXTERITY TESTING

MUSTANG GLOVE

Tester	Attempt 1	Attempt 2
1	1:10.89	4:02.76
2	1:03.07	1:12.68
3	1:12.83	1:19.51
4	1:17.21	1:04.54
5	1:09.89	1:12.32
6	1:11.69	1:12.41
7	1:07.12	1:10.58
8	1:08.39	1:11.77
9	1:13.62	1:06.21
10	1:10.19	1:08.98

Average time to complete pegboard dexterity test **1:18.63.**

KENT MITT

Tester	Attempt 1	Attempt 2
1	1:50.54	1:40.56
2	1:32.06	2:03.27
3	1:38.19	1:32.22
4	2:05.93	1:49.43
5	1:51.75	1:40.23
6	2:02.83	1:50.36
7	1:45.01	1:41.42
8	2:01.61	1:39.04
9	1:47.56	1:45.14
10	2:01.79	1:49.28

Average time to complete pegboard dexterity test **1:48.38.**

RULIK

Tester	Attempt 1	Attempt 2
1	11.98	10.93
2	12.5	11.71
3	12.10	14.67
4	14.05	11.44
5	12.02	10.54
6	12.92	11.79
7	12.88	13.41
8	11.81	14.14
9	11.78	10.89
10	12.72	11.15

Average time to complete pegboard dexterity test **11.75 sec.**

The **Rulik** immersion suit proved to be a more efficient design, allowing users to complete the pegboard dexterity test **569%** (66.88 seconds) faster than the next fastest competitor, Mustang. This reflects the suits ability to provide increased dexterity to the user.

Conclusion

Through thorough testing and validation, the goal for improving the current design of immersion suits was accomplished. By providing the users with a product that can be deployed, donned and provided

improved dexterity the Rulik immersion suit is the beginning of the next generation of immersion suits. Improvements to the design of the immersion suit also provide the user with a completely different style of donning an immersion suit that will help save the lives of commercial fishermen in Alaska.

Thesis Impact Moving Forward

My passion as a designer is to create and innovate apparel that can make a difference in someone's life. Because commercial Alaska fishing is considered one of the most dangerous occupations in the United States, providing adequate survival equipment can mean the difference between life and death. There is no greater opportunity to make a difference than to design technical apparel for this demographic. This project will continue to develop, and I hope to be able to eventually bring this product to market so that I can set out to accomplish the ultimate goal, help save lives.

Professional Statement

This thesis project encompasses and displays my innovation and forward-thinking processes in solving complex problems. To better understand how and why this is done, an assessment of my strengths and beliefs is examined to determine how these factors impact the project.

Clifton Strengths

Clifton Strengths Analysis (Gallup, Inc., 2023) is a psychometric instrument used to determine a person's strengths and how those strengths can be directed into greater success and performance. The top five strengths for me are restorative, deliberative, futuristic, relator, and analytical in that order. The restorative trait is an excellent trait to have as a designer as it represents the ability to deal with problems by figuring out what is wrong and finding solutions. Deliberative strength represents the ability to take a step back and analyze the possibilities of a problem before making a decision. Futuristic strength represents the ability to be inspired by the future and think of what could be. The relator strength

represents the gratification that comes from working hard with others to achieve a goal. Finally, analytical strength represents the ability to search for reasons and causes.

Identifying and solving problems for the survival needs of Alaskan commercial fishermen requires the ability to step back and think about all the things that could go wrong. With an occupation like Alaskan commercial fishing, you have to put the needs of the user first and identify what is necessary and what is not. The ability to think ahead and think about how your solutions might affect others is a crucial step in working towards problem-solving. Strengths such as restorative, deliberative, and futuristic are ideal in addressing complex issues that come with designing survival technical apparel.

Golden Circle Statement

Improve the safety and well-being of commercial Alaska fishermen by innovating a new technical survival suit that will provide unmatched protection in the harshest conditions. Developing a reliable product that enhances survival rates in maritime disasters provides fishermen with the assurance that, even on the most challenging days at sea, they remain safeguarded and secure.

Mentor


Jim Kershaw- Design Director at Grundens

Figure 26 displays the confirmation of mentorship by Jim Kershaw

Figure 26

Jim Kershaw
Director of Product Design at Grundéns

⋮ 📹 ☆


 **Benjamin Lemus** (He/Him) • 2:31 PM

Hey Jim,

I just wanted to touch base and see if you are still able to be my mentor for my thesis project this year? This would consist of meeting twice a month to talk about design direction and to get your feedback throughout the project process. I understand your time is valuable and I am more than willing to work around your schedule.

I appreciate your time and consideration. Your guidance would be invaluable to me and I am eager to learn from your expertise. Looking forward to your response.

Best,
Ben

 **Jim Kershaw** • 6:02 PM

Hi Ben,

Absolutely. Let's schedule a reoccurring touch base over on official email. Jim.kershaw@grundens.com

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