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Riding the Wave of Sustainability: Eco-Surfboard Design

Capstone Project Final Report

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Abstract

Surfing is a growing recreational activity that connects people with the ocean, making sustainability a critical focus of its industry. Traditional surfboard manufacturing relies on petroleum-based materials, contributing largely to the rising problem of plastic pollution and atmospheric carbon emissions. The project goal is to develop an eco-friendly surfboard combining innovative biomaterials while including sustainable production techniques. The proposed design is to replace the conventional polyurethane and polystyrene foam cores with mycelium. Additionally, recycled cork is used as a structural outer layer, and bio-resin functions as an adhesive agent. Using plant-based materials that are compostable and safe to manipulate, the impact of surfboard production on the environment and shapers can be greatly reduced. This report focuses on the second half of the design process, including prototyping, testing and optimization of the board. The work presented in this report provides a detailed account of all project steps as well as lessons learnt and recommendations for future innovators looking to expand on this design of an eco-surfboard.

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List of Abbreviations

CAD: Canadian dollar

EPS: Expanded polystyrene

ft: Feet, unit

Lbs: Pounds, unit

Psi: Pounds per square inch, unit

PU: Polyurethane

EVA: Ethylene Vinyl Acetate

Background

1. Context

This project and report were completed for the Engineering Design 3 course at the University of McGill. This capstone design project was worked on during the winter and fall semesters of 2024.

2. Client

The client is Boréal Surf, a surf brand based in Montreal that specializes in hand-crafted surfboards and surf accessories. Sebastien, founder and shaper at Boréal, was equally a mentor on this project. The design was made to fulfill a need that exists across the entire surf industry, not only at Boréal. For this reason, the project was not synthesized to be sold or given to Boréal Surf but was made as a contribution to the wider field of eco-surfboard design. The project also developed into a collaboration with Surfrider as our cork material provider put us in contact. Surfrider is starting an initiative to recycle and repurpose old surfboards and wetsuits on the West Coast of Canada. They contacted us wanting to exchange information about our projects and work together to figure out how to use cork wraps in surfboard shaping. Because of this, they became a sort of client and collaborator in this project.

3. Design Process

This report describes the last four steps of the design cycle, as shown below in figure 1, provided by Professor Clark in Design 3.

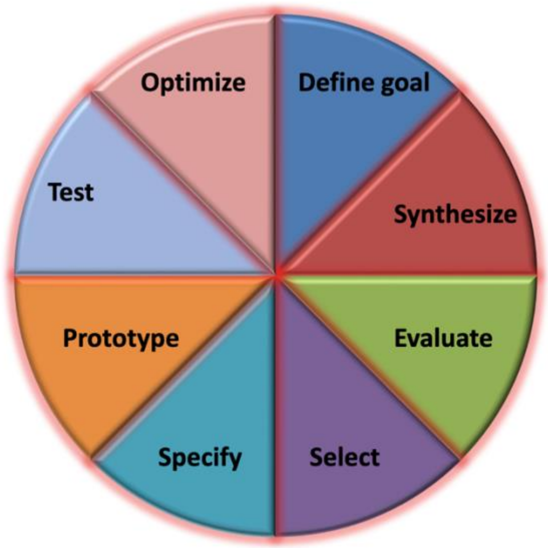

Figure 1: Engineering design cycle (Clark, 2024)

For details on the previous design steps, please see the report submitted to BREE 490, Engineering Design 2 course (Cox & Diaz, 2024).

4. Report Sections

Many sections in the report are split into subsections that deal with specific components of the surfboard design. The subsections are;

1. Mycelium: The core of the surfboard or the 'blank' which is made from mycelium.
2. Cork: The exterior wrapping of the board which is made from recycled cork sheets.
3. Resin: The resin which binds the layers.
4. Accessories: The stringer, the fins and the leash.

Analysis and Specifications

Board dimensions and properties

The design of the surfboard is a 6 ft soft-top build. Dimensions are set to 6'0" x 22.0" x 3.125" (57 Liters) based on the Odysea Log model (Odysea, 2024). These are loose measurement targets as the size and shape will vary depending on the quantity and properties of the obtained materials. The reasoning behind the soft-top design is elaborated in the economics section of the report.

The surfboard is supposed to possess all the same properties as a traditional soft-top surfboard sold on the market today. It is to be highly buoyant, salt-water proof, lightweight and maneuverable. See the specification document below which outlines the requirements for the eco-board design (figure 2).

Figure 2: Specification document (Cox & Diaz, 2024)

Mycelium

The development of an eco-friendly surfboard requires the replacement of petroleum-based foams such as PU and EPS. While they are responsible for key properties of a surfboard like buoyancy, lightweight, and strength, they are also highly polluting and take years to degrade. Identifying a sustainable alternative that meets the structural and performance requirements of these traditional foams has been challenging. Based on research conducted last semester, mycelium was chosen as the foam replacement. Recent technologies in materials science have shown that mycelium is a promising replacement for foam-based objects because of its sustainability, mechanical properties, and ease of manufacturing. Mycelium is a natural material derived from the root structure of fungi, which forms a dense and interconnected network that closely mimics the cellular structure of PU foam. Figure 3 highlights the similarities between the structural integrity of PU and mycelium called hyphae. The network of hyphae contains chitin, a polysaccharide that is responsible for ensuring the shape and rigidity of the mycelium (BiologyInsights Team, 2024). As such, the hyphae create a similar cellular pattern of synthetic foam to give proper flexibility and resistance to compression while the chitin inside keeps the piece rigid and lightweight. (BiologyInsights Team, 2024).

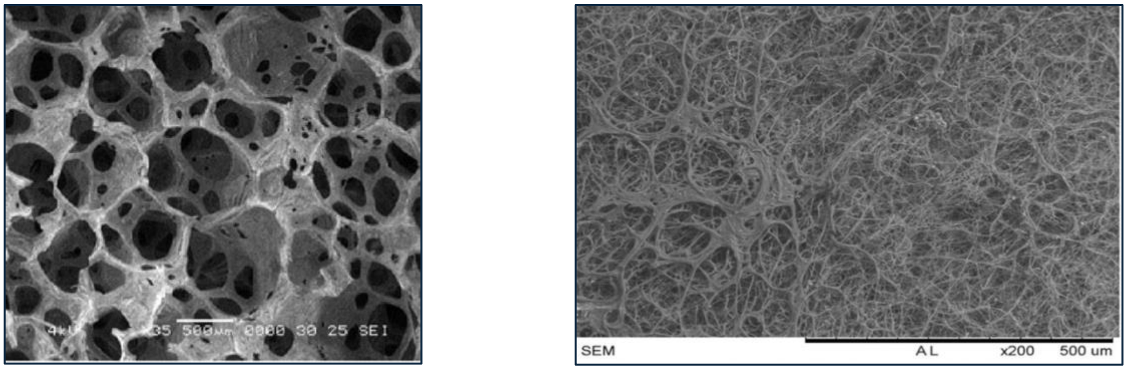

Figure 3:Microscopic structure comparison between Pu (left) (Sanoop, 2012) and mycelium (right) (Nashiruddin et al., 2021)

Furthermore, the physical properties of mycelium can be influenced by manipulating environmental factors during growth, such as moisture levels, temperature, and nutrients. Therefore, it is possible to elaborate a recipe between the substrate and mycelium that can increase or decrease the density of the foam. In surfboard design, the goal is to have a low density but also keep a good strength-to-weight ratio. This eco-material can be considered lightweight and strong enough to withstand the force of the ocean waves, which is a key property of traditional foams (Green, 2023).

Mycelium grows rapidly using plant-based residues, requiring minimal energy input and no toxic chemicals, which minimizes its environmental impact. It can be grown into a surfboard shape which minimizes material waste and simplifies the operations. The simplicity of the growth process suggests that this could be adaptable to larger-scale production. Moreover, mycelium is entirely biodegradable which resolves of end-of-life waste management. Unlike PU and EPS foams, which persist in the environment for decades, mycelium decomposes naturally without releasing harmful pollutants (Green, 2023). This characteristic validates that surfboards made from mycelium increase the circularity within the production cycle, reducing the overall impact on ecosystems. As the surfboard industry and others continue to seek sustainable alternatives, mycelium stands out as a material that not only meets environmental criteria but also delivers on performance and economic viability.

Cork

This surfboard design has a cork wrap, meaning the entire exterior of the board is exposed cork. Cork is the outer bark of the cork oak tree; it takes 25 years to grow before it is ready for its first harvest. From then on it can be harvested every nine years without killing the tree because the bark is regenerative. The properties of cork most advantageous for surfboard applications are buoyancy and lightweight, half of the volume of cork is air. It is also resistant to shock and compression because it has excellent elastic properties. Therefore, able to withstand the impacts of surfing; human force, waves, and rocks. It is impermeable to liquids, therefore waterproof, and will not absorb water in the ocean. The friction on the surface is also very high, which is good for surfing because riders will be able to maneuver the board without their feet slipping. This also eliminates the need for surf wax which is commonly petroleum-based (Good Karma Projects, 2024). For all these reasons, cork is an excellent material for surfboard applications. It has already been used by many to wrap boards and for traction pads. For example, Waterman Surfboards, based on Vancouver Island has an entire line of boards with cork decks (Waterman Surfboards, n.d). The only downside to this plant material is that it only grows in the forest surrounding the Mediterranean Sea, thus it is not local to Canada. As the market for cork is already large and well-established, there are many waste streams of cork in North America. A company named ReCORK has taken advantage of this and opened wine cork collection facilities to give a second life to this precious material (Sole, n.d). After reaching out to the company, the team was contacted by Jordan Palmer, Co-Founder/Director of ReCORK Portugal who revealed that they had been working on surf applications already. Their team was using cork sheets made from recycled insoles and corks to make traction pads (see Appendix A). They agreed to send us some sheets of cork as long as we paid for the shipping from Portugal. The team contacted the ReCORK facility in Calgary to find out if they had any sheets there that they could send us because obviously shipping something across the ocean has a large carbon footprint. Unfortunately, only Portugal manufactures those sheets so for prototyping purposes we accepted the lengthy shipping. If the project were to be scaled up and manufactured on a larger scale in Canada it would be more responsible to acquire the cork sheets from a Canadian manufacturer. It would be worth exploring a partnership with ReCORK Canada as they could start producing the sheets for surf applications as well. The sheets are of dimension 1200 x 650 cm and 1.5-2 mm thick, pictured below in figure 4.

Figure 4: Recycled cork sheets manufactured by ReCORK (2024)

Resin

The resin that was chosen for this project is Entropy Resins Clear Laminating Epoxy (Entropy Resins, 2024). It was selected for its 29% bio-based content, long working time, UV stability, and ability to coat as well as adhere materials. It is also advertised as working well for vacuum molding which was considered as a possible lamination technique for this build. This product was recommended by Boréal Surf shaper Sebastien as it has a high bio-based content and is what he uses on his boards. The Super Sap® formulation was created by Entropy using waste plant material from other industries. By diverting waste streams to produce their resins they have reduced the carbon input of their process and created a more sustainable product. The six-liter jug of epoxy was purchased from Swell Composites, a Canadian company that carries Entropy Resins, and shipped from Vancouver, British Columbia.

Accessories

The leash, fins and fin boxes of this design were considered out of the scope of the project as they make up a very small portion of the volume of the board and there are many eco-friendly options on the market. For this project the intention is to use fins and a leash owned by one of the team members. The fin boxes are to be 3D printed out of biobased. This decision is based on the principle that the most sustainable action is to use what you already own.

Prototyping

Mycelium

Growing mycelium turns out to be relatively easy to do because it requires very few resources. The first step of the process is to add three cups of water and four tablespoons of flour to each bag, shaking vigorously to mix. The bag is then sealed and the mycelium culture left to grow for 4 days. After this period, an additional tablespoon of flour is incorporated, and the pieces that have started to form are broken down by hand. All the bags were combined into the final mold.

One of the primary concerns during the process was the risk of contamination by mold or bacteria, which could impact mycelium growth. On the other hand, using a large quantity of cleaning product could also be potentially harmful to the mycelium by killing it directly. Based on the results, there were no negative effects and the prevention methods used were enough because no mold developed. Overall, the mycelium growth process was very simple with no significant issues encountered. All expectations about quality and quantity were met and the estimations about volume of the pieces were accurate. These results suggest that scaling up the production would be feasible without any significant setbacks and many of the steps could be easily automated.

Three different types of material for casting bases: wood, aluminum and plastic. The first test piece was made of old wood and made a diamond-like shape to try to mimic the form of a surfboard as much as possible. However, since wood is a porous material and there was a concern that the mycelium mixture would grow into it, the entirety of the cast got covered with plastic wrap. This approach was successful because the edges and bottom of the foam were smooth and easy to unmold. The wooden frame was holding on with nails to make sure that it retained its shape and offer enough support for the mycelium to grow into the desired shape.

A second test piece was created in a large aluminum rectangular pan. Since aluminum is an impermeable material, no additional protective medium was applied. Both test pieces turned out well, leading to the decision to combine elements from each of these cast designs to replicate on the master blanks.

The final cast design involved creating four rectangles, each measuring 1ft by 3ft and 5 in deep within a large wooden rectangular frame divided into the same number of sections. As the earlier test demonstrated it was easy to remove, stayed separate from the growing mycelium, and could be sanitized easily, the inside parts of the cast were covered by aluminum foil. However, only two out of the four sections got filled up because an insufficient amount of starting material was ready. Only half of the large-scale surf blank could be completed as shown in figure 5.

Figure 5: Microscopic structure comparison between Pu (left) and mycelium (right)

During the three-day activation period of the mixture, the test pieces were tested with sanding and shaping equipment which revealed that the interior was too crumbly to modify. It will be explained in more detail in the testing section below. This limitation required a shift in approach, as the original plan to shape four large rectangular pieces into a surfboard would not be feasible. With half the prepared mycelium still available, the need to find or to make a cast with the exact shape of a board was a priority. A sled was ultimately selected as it closely resembled the dimensions and curvature of a small surfboard or boogie board. The toboggan was purchased at Home Hardware and is made from plastic. It provided smooth edges around the mycelium piece without requiring hand-shaping or sanding. Although a plastic cast is not the ideal choice for reducing environmental impact at the production stage, it was still the most practical solution under time restrictions and the material that was available. Furthermore, using one plastic mold to make multiple mycelium blanks is more sustainable than making all boards out of plastic.

A standard surfboard typically has a single stringer, with occasional designs incorporating two positioned closely together in the middle. Initially, the design plans included a single stringer running down the middle of the board and intended to connect the left and right parts of the board in the case where the four rectangular blanks would have worked. However, after discovering how hard it was to shape and how crumbly the center area was due to a natural accumulation of hemp, changes were made. To fix these issues, a grid of wooden sticks was added to increase the structural integrity and strength of the board while also performing a similar function to a stringer. The dowel configuration is shown in figure 6.

Figure 6: Microscopic structure comparison between Pu (left) and mycelium (right)

For unknown reasons, a section of mycelium did not grow properly within the mold, leading to a crumbly area. For the lack of mycelium growth in the central section of the board resulting in a small hole, the loose hemp chunks were carefully removed and replaced with sections of well-formed mycelium taken from a test piece. To bond the replacement mycelium to the board, wood glue was applied internally to secure the wood chips, while a layer of caulking was used on the surface to replicate the texture of mycelium. This approach not only ensures a smoother surface for subsequent applications of resin and cork but also helps to eliminate irregularities that could compromise the board's structural integrity.

The final step in preparing the mycelium blanks involved treating them with heat to eliminate any active agents inside of them. Before starting to bake them, every piece was unmolded and placed in the oven directly on racks. For the smaller test samples, the pieces were baked in a standard home oven approximately at 180ºF for six hours. However, due to the size of the three larger blanks, they were placed in the heat dryer at Lods which was big enough to fit all of them. The heat settings were slightly different which is why they ended up for 16 hours at 50ºC in the oven. Given the relatively low heat and the larger and thicker dimensions of the blanks, it was assumed that an extended drying time would be required to ensure complete treatment but without compromising the structural integrity of the mycelium. This step was once again successful and required very minimal adjustments to the original plan. Figure 7 shows the mycelium pieces being dried.

Figure 7: Microscopic structure comparison between Pu (left) and mycelium (right)

Testing

Mycelium

The mycelium foam pieces were material tested by the manufacturer according to their growing instructions which were followed precisely. According to GrowBio, the density of the foam is 7.5 lbs/ft^3, comparatively the density of EPS is about 1 lbs/ft^3 (Foam Factory, n.d). It has a compressive strength of 18 psi, an elastic modulus of 165 psi and a flexure strength of 34 psi. It is also marine compostable in 180 days which is very pertinent because many surfboards get lost to the sea.

Table 1: Comparison of traditional foams versus mycelium foam

Properties	PU and EPS Foam	Mycelium
Strength	Yes	Yes
Waterproof	Yes	No
Withstand human weight	Yes	Yes
Bio-based	No	Yes
Light weight	Yes	No

The mycelium-based material has demonstrated its ability to withstand significant loads, including human weight, without compromising its structural integrity. This result demonstrates the potential of the material for practical applications, respecting strength and increasing sustainability. The picture below (figure 8) demonstrates its reliability as a viable alternative in eco-friendly surfboard construction.

Figure 8: Informal compression test of the foam

To test the mycelium foam's ability to be shaped into a surfboard, small test pieces were brought to the Boréal facility. When trying to saw into and sand the piece, it crumbled and broke in half. It was clear that the material was not uniform or strong enough to withstand normal shaping tools. This is when Sebastien suggested that the foam be grown in a mold that is already the exact shape of the desired board. This way no shaping is required, and the material can remain intact.

Economics

The budget for this project as provided by the Department of Bioresource Engineering was 500$ CAD. The team members agreed to pay any extra fees themselves if necessary. Below is a cost breakdown of everything that was purchased, rounded to the closest dollar.

Table 2: Cost of project materials (CAD)

Materials	Price
Mycelium growth kits	$ 570
Entropy resin	$ 331
Flax-basalt cloth	$ 94
Home hardware materials - Toboggan - Tape - Dowels - Caulk - Glue - Garbage bags - Plastic tarp	$ 112
Cork sheets	Free

The total came out to 1107$ CAD which is quite high because innovating a prototype for a mycelium foam-based surfboard is expensive due to several factors. First, sourcing the raw materials for mycelium foam was costly because it is a novel material only specialized supplier's manufacture. The growth kits are even rarer to find, and the closest provider is in New York state. Complete growth kits containing the strain of live matter and substrate were chosen in the interest of time. Furthermore, the trial-and-error process involved in creating a functional surfboard prototype is another significant expense, as multiple test pieces of the foam had to be grown. Additionally, eco-friendly surf materials are very niche in an already quite niche industry. These emerging technologies have limited suppliers, especially in Canada because it has a relatively small surf market. Because of this, materials had to be sourced from across the country in Vancouver BC and even in Australia (eco-cloth) which resulted in high shipping costs. Altogether, the experimental nature of the project, coupled with the innovative use of mycelium and eco-materials, means that building a viable prototype involves a significant investment of both time and money.

Boréal Surf is a small-scale business, making about 30 boards a year and this yields around 45 thousand dollars in sales. The fixed fees for his boards are 200-250$ and on average they are sold for 1400$. Because his boards are hand-crafted pieces of art, they can be sold for a lot more than a mass-produced foam board at Costco. The downside of his work is that it requires many hours of physical labor, about 20 working hours per board. A big part of his revenue comes from online sales of surf accessories like fins, traction pads and leashes. This makes his business more sustainable economically and allows him to run his business and support himself comfortably. Looking at this project and the material costs as well as market in Canada, it would be necessary to optimize production time and volume to make this eco-board product viable. In other words, the boards need to be mass produced in order to create a profit. Because the materials are so expensive, the production time needs to be reduced as much as possible to minimize labor costs and maximize production. This would entail optimized growing conditions with no contamination or death of the mycelium, reliable molds of perfect dimensions for making surfboard blanks and an efficient lamination process between the layers of the board.

A soft-top surfboard can be purchased for anywhere between 300-600$ today. For an eco-version to be competitive on the market in Canada, it would need to be sold at about the same price or slightly higher because people are willing to pay more for sustainable products. Currently the most eco-friendly blank option in Montreal is purchasing local EPS foam blanks which is what Boréal does. He purchases blocks of foam from a local manufacturer in Pointe Claire that supplies commercial EPS for roads and construction. Each block is 400$ and seven boards can be made from it, this comes out to 57.14$ per blank. To make a blank of the same size using the mycelium growth kits from this project would cost about 378$, this is over six times more money (see appendix 2 for calculations).

To reduce costs, it is recommended to develop a unique blend of mycelium strain and substrate to produce in house “growth kits”. Buying the materials in bulk and from local sources would reduce costs and create the opportunity for a circular economy by using waste organic material for the substrate. For example, tall grass from the LODS farm was recommended to us by Marc Samoisette who works on site. Furthermore, sourcing the eco-cloth and cork from a local, even just Canadian, provider would greatly reduce costs and increase the sustainability of the boards.

Recommendations and Considerations

Environmental

In this section an estimation of the carbon emissions of this surfboard construction is made to obtain a metric for evaluating the sustainability of the board in comparison to traditional builds. The emissions associated to a typical 6-foot surfboard are detailed in figure 9 below.

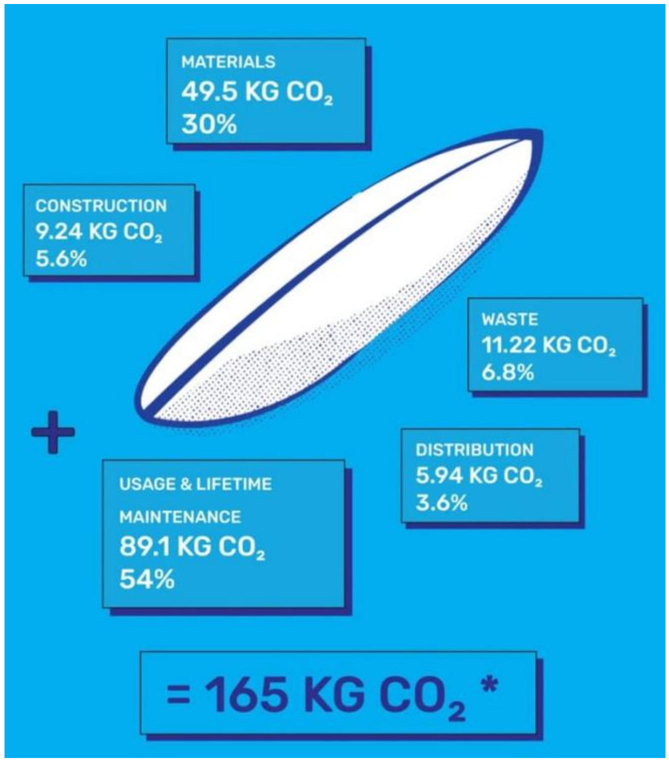

Figure 9: Carbon emissions in the life cycle of a typical 6-foot surfboard (Wavechanger, 2022)

The materials, construction and waste from making a surfboard make up 42.4% of the carbon emissions related to its life cycle. This adds up to 70 kg of CO_2 emissions. Almost all emissions associated to the board construction are from the foam blank. It takes 8kg of CO2 to produce 6lbs of EPS which is average for a surfboard blank (Lim et al., 2021). In turn, producing a mycelium-based blank requires a negligible amount of carbon, assuming it is produced in Quebec where electricity is made by hydro power. The energy required for growing the bio-foam is related to temperature control in the room while growing and oven power while drying the foam. In places where electricity is provided through renewables, the production of mycelium foam is almost carbon neutral.

Finally, the design of this board would be certified level one by the Sustainable Surf Eco-Board project (Sustainable Surf, 2024). The criteria according to the organization are as follows;

1. Plant-based, low to zero VOC resin with at least 19% bio-carbon content in the fully cured resin (the sum of all component parts)
2. Core with at least 25% recycled or plant-based content, or wood constituting at least 50% of the core by weight

The resin used is 29% bio-based, meeting the first criteria and the mycelium core is 100% plant-based fulfilling the second criteria.

Optimizing mycelium growth

The foundation of this project was the development of mycelium-based foam blanks, a material that is gaining popularity but still not quite offered on the market at the moment. Throughout the project, the optimization of the mycelium strain and substrate itself was not a focus, this could be an area to explore for improvement in the future. The project used pre-mixed packages with a fixed mycelium and substrate ratio, ensuring the successful growth of mycelium but limiting opportunities to customize the mixture to align with specific project goals. While this approach largely eliminated the risk of failed growing process, it also impacted the ability to adapt properties of mycelium to address key challenges.

Two primary issues emerged during the project: the crumbly texture at the center of the blanks and their relatively heavy weight compared to conventional PU or EPS foams. Addressing these challenges would require exploring alternative substrate recipes. For example, the hemp chips used in this project were large and presented in big quantities. Even with optimal mycelium growth, the chips contributed to excessive weight and were not entirely encapsulated. The material's strength relies mainly on the development of strong hyphal networks, and a higher starting ratio of mycelium could potentially improve growth and cohesion between the internal structure. Experimenting with substrates such as straw, sawdust, or pre-inoculated pellets, varying both in composition and particle size, could help refine the recipe to better suit the application (Webb, 2024).

Another challenge encountered was the accumulation of moisture on the blanks during the growth process. While efforts were made to hermetically seal the molds to prevent contamination by mold or bacteria, this approach led to a different problem of a buildup of clean but stagnant water from the chemical reactions around the surfaces, resulting in small yellow spots of mold. A potential solution to solve this issue would be to grow the mycelium in a controlled environment with regulated heat, humidity, and ventilation (Dean, 2024). Such environmental controls could improve mycelium growth quality and reduce spoilage risk. In the context of large-scale eco-surfboard production, access to a controlled environment would be a transformative advancement, enabling more consistent and higher-quality results while addressing these challenges effectively.

Optimizing Operations

What follows are recommendations to create an efficient production line, a sustainable supply chain, and quality control of the boards. Firstly, build a solid and completely sealed mold in the shape of a blank. This mold would have to be made of a non-organic, impermeable material like plastic or metal that allows for a smooth outer edge of foam. It would be reusable and easy to remove the foam pieces from once growth is done. Ideally, it would have some airflow to optimize mycelium concentration on the outer edges. For mass production, it would be necessary to have many molds so that multiple blanks could be made at once.

The cork sheets can theoretically be produced in Canada by ReCORK Calgary, it would not be sustainable environmentally or economically to continue shipping them from Portugal. Creating a partnership with ReCORK and getting them to produce the sheets from their Canadian facility would be ideal. This could lead to collaboration on other projects and perhaps funding help from them in the early stages of the business.

Similarly, flax cloth is not found in Canada and is difficult to purchase even from the US. Shipping from Australia is not sustainable therefore finding a business willing to manufacture it would be best. Additionally, a replacement material could be used that valorizes organic waste streams from another agricultural or food industry. Opportunities for making surfboards with flax or other plant cloth in Canada largely depend on the emergence of innovative manufacturers. As more local manufacturers and surfers embrace eco-friendly practices, the demand for flax-based surfboards is expected to grow, creating a niche market for environmentally conscious consumers and builders. This is already happening in the industry with big names like David Rastovitch, the star of Stab's new surf film which will be a "proof of concept for sustainable surfboard constructions" with all the featured boards being glassed with flax (Trnka, 2024).

Finally, resin is no exception to the struggle of sourcing eco-friendly surf supplies in Canada. The most widely used eco-resin is certainly Entropy Resins which was used in this project however it is not a completely bio-based product. At only 29-33% organic content there is still a lot of room for improvement and innovation (Entropy Resins, n.d). Some alternatives that have been explored experimentally are beeswax, soy wax, and tree sap (Dodds, 2024). While bio-based epoxies are still relatively niche in the industry and may come at a higher initial cost, the growing demand for sustainable surf supplies is expected to make these eco-resins more accessible and affordable in the future, opening up new opportunities for greener surfboard production.

The greatest challenge with establishing this product on the market is the lack of accessible and affordable materials. While more innovation is needed, it is clear that the demand for sustainable surf supplies exists, and with time and continued advancements, there is a strong potential for eco-friendly surfboards to be mass-produced in Canada.

Conclusion

The development of an eco-friendly surfboard using mycelium, recycled cork, and bio-based resin highlights the potential for integrating sustainable materials into the construction process. Through research, testing, and collaboration with pioneers in the industry like Boréal Surf, ReCORK and SurfRider, this project successfully tackled environmental challenges to create an innovative design that respects the traditional features of a surfboard.

Mycelium proved that it is a strong contingent in an alternative of PU or EPS foam due to its comparable structural strength, biodegradability and adaptability at a large-scale production. However, extended research is still needed in order to perfect the ratio and find a better growth medium that could help decrease the overall weight. Recycled cork sheets used for this board will still need more testing, but are giving encouraging results regarding the grip, buoyancy and water resistance while also increasing the sustainability of the materials. Despite minor challenges such as the fragility of the mycelium foam blanks, this project has successfully showcased innovative ideas on how to incorporate bio-based and eco-friendly materials.

Future work could focus on refining the production process, improving the quality and reliability of the foam blanks while exploring the implementation of different bio-based material options. As a team of young future engineers, this project definitely showcased the importance of collaboration and how having a team of passionate people aligning with the same goals can be extremely motivating and inspiring. Let's hope that one day, bio-based surfboards become the new norm and that all the efforts from the surf industry pay off.

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References

1. BiologyInsights Team. (2024, October 29). Hyphae and Mycelium: Structure, Growth, and Ecological Functions - BiologyInsights. Retrieved from https://biologyinsights.com/hyphae-and-mycelium-structure-growth-and-ecological-functions/
2. Corky Series Surfboard - Custom order | website-editor-copy. (n.d.). Retrieved from https://www.watermansurfboards.com/product-page/corky-series
3. Dean, Z. (2024, March 19). Preventing Mold on Mycelium: Avoiding Contamination. Retrieved from https://www.mushroom-corner.com/posts/mold-on-mycelium
4. Dodds, C. (2024, October 29). Charlie Cadin's new breakthrough in Eco-Friendly resin is all the buzz. *www.surfer.com*.
5. Entropy Resins. (2024, September 3). Entropy Resins | Biobased Epoxy Resins | Learn more. Retrieved from https://entropyresins.com/
6. Green, T. S. (2023, June 8). Mushroom packaging? Why Mycelium is the greenest alternative for styrofoam. Retrieved from https://www.sourcegreen.co/food-packaging/mycelium-packaging-styrofoam-alternative/
7. Grow.bio. (n.d.). Grow It Yourself® material. Retrieved from https://grow.bio/collections/giy-material/products/grow-it-yourself-material
8. Lim, Y. S., Izhar, T. N. T., Zakarya, I. A., Yusuf, S. Y., Zaaba, S. K., & Mohamad, M. A. (2021). Life cycle assessment of expanded polystyrene. *IOP Conference Series Earth and Environmental Science*, *920*(1), 012030. https://doi.org/10.1088/1755-1315/920/1/012030

9. Nashiruddin, N. I., Chua, K. S., Mansor, A. F., Rahman, R. A., Lai, J. C., Azelee, N. I. W., & Enshasy, H. E. (2021). Effect of growth factors on the production of mycelium-based biofoam. *Clean Technologies and Environmental Policy*, *24*(1), 351–361. https://doi.org/10.1007/s10098-021-02146-4

10. Odysea Log 6’0 - Cool Blue 20. (n.d.). Retrieved from https://surfontario.ca/collections/odysea-by-catch-surf-skippers-logs-and-wave-bandits/products/odysea-60-log-cool-blue-20

11. Our story | SOLE. (n.d.). Retrieved from https://yoursole.com/ca/our-story

12. Polystyrene Foam Data Sheet | Foam Factory, Inc. - Canada. (n.d.). Retrieved from https://canada.foambymail.com/polystyrene-foam-sheet.html

13. Polystyrene Foam Data Sheet | Foam Factory, Inc. - Canada. (n.d.-b). Retrieved from https://canada.foambymail.com/polystyrene-foam-sheet.html

14. Projects, G. K. (2019, September 24). What is in the surf wax you use? Retrieved from https://goodkarmaprojects.org/en/2019/09/23/surf-wax-environment/#:~:text=Paraffin%20wax%20can%20negatively%20impact,and%20are%20toxic%20if%20digested.

15. Qualified Criteria – the ECOBOARD project. (n.d.). Retrieved from https://ecoboard.sustainablesurf.org/qualified-criteria/

16. Sanoop, P.K. & K V, Mahesh & Nampoothiri, K. Madhavan. (2012). Multifunctional ZnO-biopolymer nanocomposite coatings for health-care polymer forms and fabrics. J Appl Polym Sci. 126. E233-E244. Trnka, H. (2024, September 12). How did Dave Rastovich become our 2024 electric acid psychonaut? Retrieved from

https://stabmag.com/hardware/how-did-dave-rastovich-become-our-2024-electric-acid-psychonaut/

17. Wavechanger. (n.d.). The carbon cost of surfboards. Retrieved from https://www.wavechanger.org/blogs/surfer-vs-planet/the-carbon-cost-of-surfboards
18. Webb, E. (2024, October 14). *Ultimate Guide to mushroom Substrates*. Urban Farm-It. https://urban-farm-it.com/blogs/mushroom-cultivation/guide-to-mushroom-substrates

Appendices

Appendix A

ReCORK Surf Applications

These pictures were sent by Jordan Palmer from ReCORK to show the work they had been doing with recycled cork sheets for surf applications.

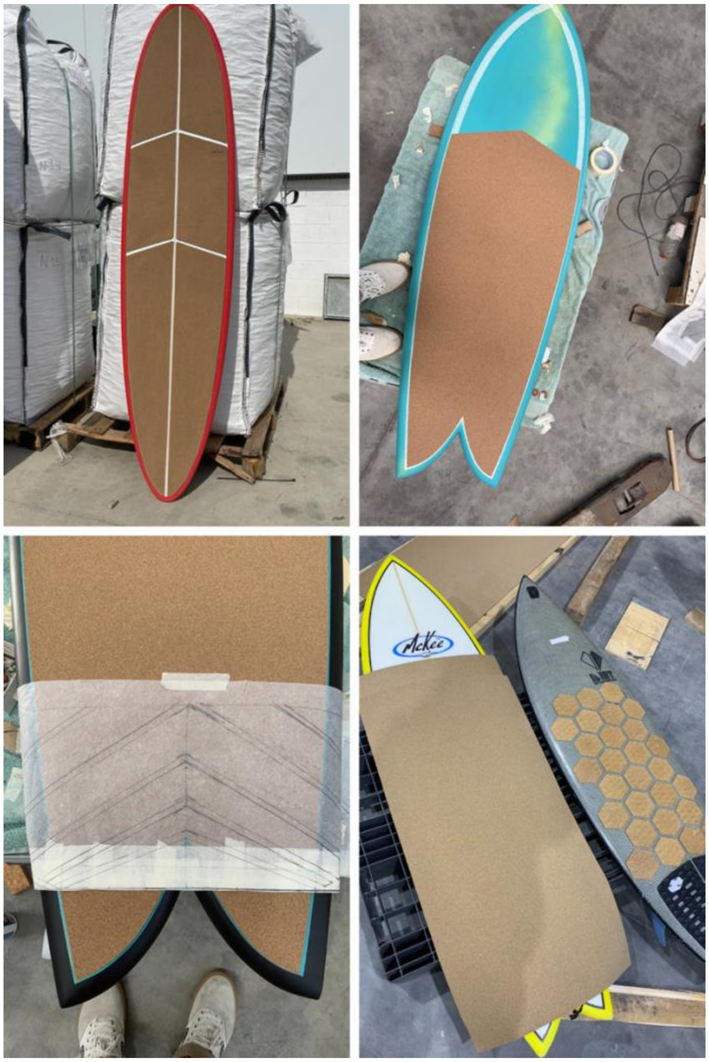

Figure 10: ReCork pictures, 2024

Appendix 2

Calculating the cost to grow a surf blank comparable to the ones at Boréal Surf.

$$4\ foot\ board = 9\ bags\ (from\ trial) \rightarrow \frac{9}{4} = 2.25\ bags/foot$$

$$6\ foot\ board = 2.25\frac{bags}{foot} * 6 = 13.5\ bags$$

$$13.5\ bags \times 28\$\ CAD = 370\$\ CAD$$