Techno Relics

A Framework for Computation, Materiality, and Fabrication in the Anthropocene

Sumer Singh Matharu
University of Calgary, SAPL / Sumer Singh Studio

Joe Crawford
Perkins&Will

Ugonna Ohakim
Perkins&Will



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ABSTRACT

This paper explores the potential of material, computation, and fabrication methodologies broadly engaging a critical understanding of the human epoch, also known as the anthropocene era, and its impact on Earth's geology. Man-made materials have arguably become ubiquitous and a massively distributed part of the environment, while also placing an involuntary burden on local ecologies. Nature has taken its course and swallowed these synthetic materials to create new compositions of complex conglomerations, thereby blurring the boundaries between the agency of man, nature, and technology (Corcoran et al. 2014). The discipline of architecture, too, must reconsider its own boundaries, and evolve to design and fabricate with these techno relics, defined here as a remnant of the technological impact on our planet.

In order to understand how these techno relics can be used by designers, this paper presents a general framework for the research, discovery, and validation of computational and fabrication processes. This is done through the examination of the background research in using aluminum waste by leveraging pre-existing digital and physical processes. Furthermore, the paper situates the background work within the broader context of how these techno relics can be mined, or collected. This is done through the examination of a case study that follows plastic waste in the Pacific Northwest through an Indigenous lens, providing possible architectural solutions that are relevant to the building typology in the remote communities most affected.

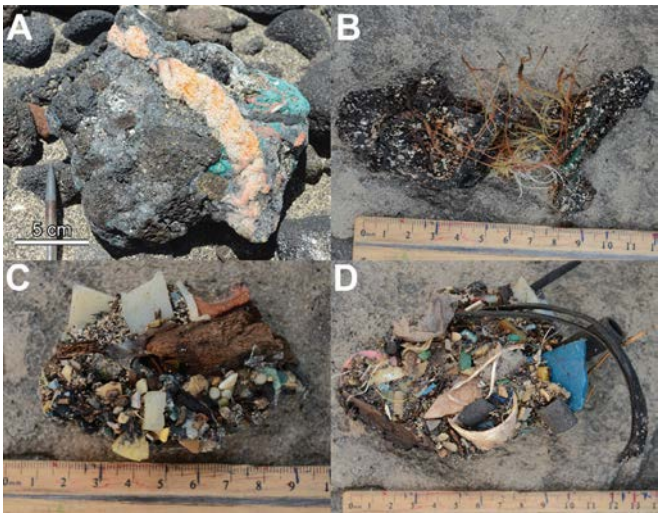
1 Forest structures at Ellen Island.

INTRODUCTION

This paper is intended to be a direct response to this year's conference theme, "Habits of the Anthropocene". Through the use of digital materiality, craft, and its relationship to the digital, the study of damaged ground and ecologies through Indigenous voices, this paper intends to address the global material challenges as a result of capitalism and consumerism. By considering the involuntary environmental displacement of people in hyperlocal ecologies, this paper sheds light on place-specific research, computation, and making that can then be geographically distributed.

We have reached a point where human activity through technological means is causing a significant and irreversible impact on the planet's climate, as well as its ecosystems (Zalasiewicz et al. 2014). If our planet has already swallowed and accepted these materials, and begun processing them through naturally occurring phenomena, then so, too, we must understand how to use these materials (Corcoran et al. 2014). All the while, we must understand how this global phenomena is affecting local ecologies and what we can do to augment this impact. For example, plastiglomerate (Figure 2), a plastic rock-like coagulation with other naturally occurring materials mostly found in coastal regions, forms a distinct marker of the informal anthropocene or human epoch (Corcoran et al. 2014). It is an unfortunate, yet compelling, opportunity to understand how these materials can be injected into our existing material streams, embracing them into our design thinking, computational, and fabrication processes (Jensen et al. 2018). Therefore, the term "techno relic" can be defined as a physical or conceptual artifact from the pre-anthropocene era that has undergone transformation(s) through technological and natural phenomena, characterized by the significant influence of human activities on Earth's geology and ecosystems.

This paper takes the position that exploring techno relics does not have to involve entirely new digital or physical methods of production. Rather, existing production systems can be leveraged for re-adaptations and novel computational methods. Techno relics, like any manmade materials, contain embedded energy. In order to calculate this energy, we must track the raw materials, design, manufacturing processes, and, presently, the digital embodied energy in both architecture and design (Zalasiewicz et al. 2014). Software and digital products have expended energy, programming hours, and logistics. Arguably, by tracing the materials to be explored, and using narratives to define and leverage existing digital workflows that complement the necessary physical workflows, the gross energy expenditure can be minimized. This paper also takes the position that physical workflows do not necessarily have to be heavily automated. If we are to situate disruptive research, design, and making in hyperlocal ecologies, there may not always be an opportunity for industrialization, which is the very cause of the issues at hand. Therefore, embracing manual and disruptive forms of making that are activated by experimental computation are encouraged in the background research, as well as the case studies presented in this paper.



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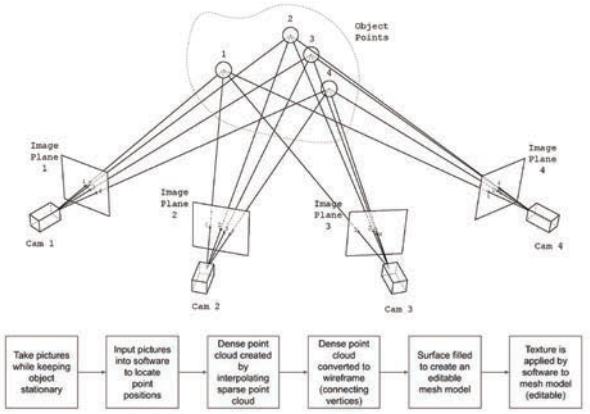
2 Samples of plastiglomerate (Figure 4 from Page 4 of Corcoran et al. 2014).

The structure of the paper is as follows: after this introduction section, the background of the research and the framework for the computation, materiality, and fabrication in the anthropocene will be discussed. Then, the paper will focus on a case study utilizing the framework. This will be followed by a discussion of the opportunities and challenges for architects and designers in the anthropocene. Finally, the paper will conclude by summarizing the potential contributions of this framework, and suggesting the potential for further research.

BACKGROUND

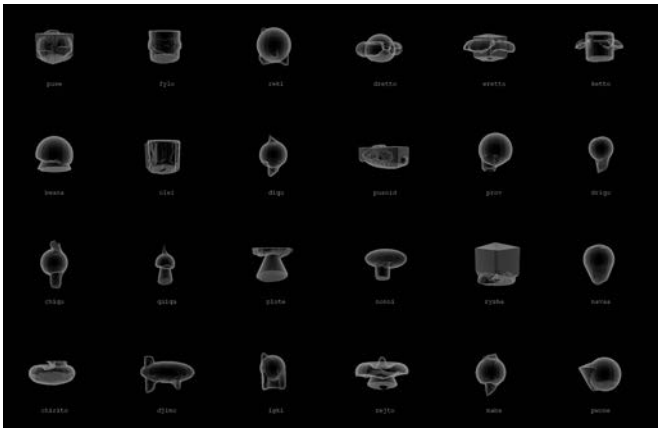
Design and Architecture as a Flow of Complex, Interconnected systems

Understanding the flow of materials, as it pertains to the traditional supply chain systems on our planet, is essential for developing the computational and fabrication workflows needed to use techno relics (Turpin 2013). According to Turpin, looking at supply chain systems through the lens of the anthropocene allows us to think at the largest planetary scale possible, further allowing us to map out the interconnectedness between various agencies involved. This means that, as designers, we can deconstruct and trace materials from their origin to end of life, in order to



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3 Photogrammetry bundle principle.



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4 Database of hybrid primitive geometries.

then construct narratives that can help drive the research and use of techno relics. After all, as Gero mentioned, "designers are change agents in society.", and "Design exists because the world around us does not suit us, and the goal of designers is to change the world through the creation of artifacts." (Gero 1990). This suggests that it is imperative that architects and designers position themselves where continuous change is informed by changes in our immediate surroundings, and that of the world around us.

Manmade versus Organic Materiality

With the advent of the anthropocene, we are now observing that natural processes will consume and process both manmade, as well as organic, materiality (Corcoran et al. 2014). Evidently, a new kind of stratigraphy is being developed, coined "technostratigraphy" (Zalasiewicz et al. 2014), visibly marked by the remnants of the technosphere, "the interlinked set of communication, transportation, bureaucratic and other systems that act to metabolize fossil fuels and other energy resources'' (Haff 2013). The problem we are faced with is that this technosphere is essentially a non-self-processing or self-recycling paradigm (Haff 2013) resulting in the widespread distribution of technofossils (Zalasiewicz et al. 2014). So the argument here is that if natural processes and the technosphere are not yet fully capable of closing the life cycle for technofossils, then we must take it upon ourselves to investigate, create, modify, and deploy new material workflows that can capture and utilize these materials. There is an opportunity within the intersection and blurring of the boundaries between the agency of man, nature, and technology.

Research Discovery and Initial Tests

As part of a graduating senior research studio in utilizing Machine Vision in Architecture (Parker and Taron 2016) at the University of Calgary's SAPL (School of Architecture, Planning and Landscape), a novel process of intentionally misusing photogrammetry algorithms was created. For the sake of this research, we define photogrammetry as "the process of creating a 3D mesh model through the construction of a point cloud extracted from 3D spatial dimensions from a collection of 2D photographs" (James et al. 2015). While this paper does not go into the mathematical details of photogrammetry, it is summarized in Figure 3.

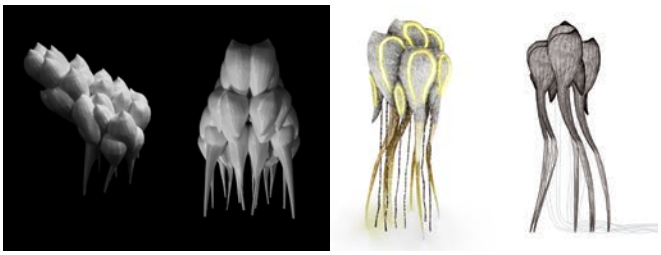
Within this methodology, two objects can be fused together to create a new and novel hybrid object. While multiple photogrammetry platforms were tested, Autodesk Recap 360 was the most successful in providing effective results. Using photogrammetry, 3D mesh models are created through the analysis of each photograph to extract "key features which are invariant to scale and rotation that may be potentially used to align the photos" (James et al. 2015). Using this principle, and intentionally using the same 3D fiducial markers in a scene, where the main object is replaced by another, the image sets of the two different objects were input into the Autodesk Recap software, thereby producing a mesh model of the fusion of the objects.

To create a case for these hybrid models, primitive geometries were used, and the result was a database of hybrid primitive geometries that could be used as unique and novel departure points for design. The question then became: if a cube is no longer a cube, how does one design with it, therefore provoking the hypothesis that unique primitives could lead to unique opportunities and outcomes in architecture and design. A sample database of these geometries can be seen in Figure 4.

Aside from the process and the results, the implication of this research of misusing photogrammetry led to the idea that existing digital processes can be capitalized to create



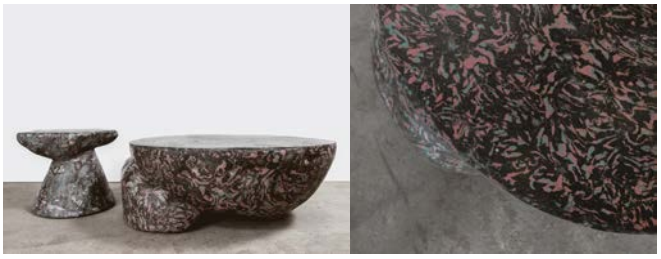
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5 Apparatus to blast pressurized metal dust with an adhesive medium.

6 Digital artifact design.

7 Digital artifact fabrication.

8 Scagliola hacking on digitally fabricated forms.

entirely new results. This means that the expended energy within the creation of the computational process is minimized. If physical material streams can be injected with waste and recyclable materials to create a closed loop of circularity (Jensen et al. 2018), why then can we not do the same to digital mediums, in this case, existing software? This can also be seen as an implication of techno relics in architectural representation and digital prototyping, referring to past methods of conveying design ideas, and early attempts at computer-aided design (CAD) tools being leveraged within entirely new workflows.

In the next section, we discuss the discovery of the materiality and fabrication processes.

Materiality and Fabrication

During the computer numerical control (CNC) cutting of aluminum, fine chips no bigger than 3 mm x 3 mm in dimension are produced, while using a 1/4-inch-diameter, O-flute router bit (Figure 5). The initial tests on the utility of these aluminum chips came from testing fine steel dust produced during abrasive disc cutting of structural elements. An apparatus was created to use pressurized air to blast the steel dust with pressurized glue (Figure 5).

Once it was determined that metal dust had to be coagulated using a medium, it was decided to utilize paverpol (Nicoletti 2005), a water-based, non-toxic textile hardener that is used in the sculpture industry, often as a medium for various materials to be applied onto free form surfaces. Utilizing this material with the aluminum chips on a substrate, and then fine-sanding and polishing afterwards, resulted in a compelling and novel way of capturing this byproduct.

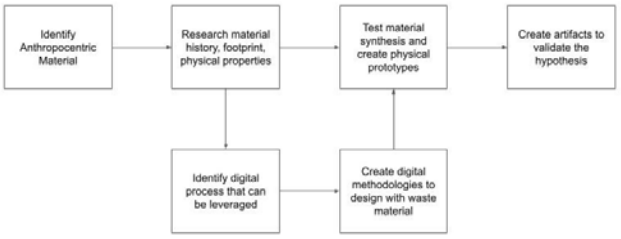
Artifact Creation

Once the digital process, along with the material tests were completed, the methodology for a final prototype was planned. In order to do this, one of the forms was selected from the database of new primitives, namely the result of the fusion between a sphere and a cone. After sculpting and aggregating with this geometry, the final form was created in Autodesk Maya (Figure 6).

To fabricate the digital artifact above, the form was rationalized for digital fabrication of the upper half by CNC milling styrofoam, while creating the base using welded steel connections. Final images can be seen in Figure 7.

In order to further test the hypothesis of utilizing existing systems of knowledge, further prototypes were created through the hacking of an existing process called scagliola (Baraldi 2008), originating from 15th century Italy, which is a type of imitation marble made by mixing gypsum, animal glue, and mineral pigments. By understanding the artisan technique of making scagliola, and replacing its ingredients, while also augmenting the recipe, a new mixture was created that could be applied to digitally fabricated positive substrates of the so-called new primitives. The plaster was replaced with cement, the animal glue replaced with basalt fiber, and the mineral pigments replaced with waste and leftover latex paints from construction sites. To test this, further artifacts were created using the new primitive geometries by CNC milling the forms using styrofoam (Figure 8).

This background research laid the foundations for a



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9 General methodology for case studies.

10 Pacific Northwest ocean plastic context A.

11 Pacific Northwest ocean plastic context B.

semester-long senior research studio called Techno Relics at the University of Calgary's SAPL in Winter 2021, during the COVID-19 pandemic. In addition to the implications of techno relics in contemporary architectural representation and digital prototyping, the research studio focused heavily on material artifacts through the process of making, thereby uncovering the broader shifts in techno-culture (the evolving relationship between technology and culture). Embracing techno relics within contemporary architectural discourse can serve as a reminder of the importance of balancing innovation with sustainability, respecting historical context, and acknowledging the impact of technocultural changes on the profession. The following section demonstrates a case study project that originated from this framework called Ocean Plastics, addressing the Great Pacific Garbage Patch in the Pacific Ocean through an Indigenous lens (Moore 2003). The general methodology used by this project is shown in Figure 9.

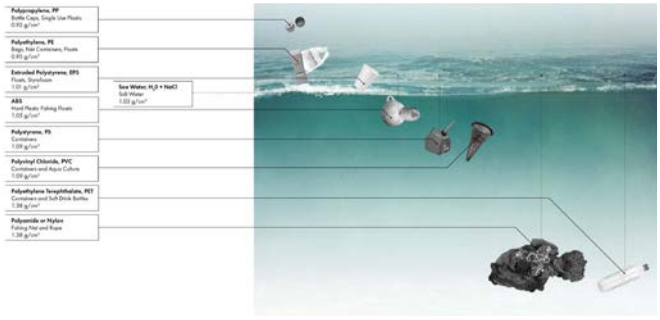
OCEAN PLASTIC

In 2018 alone, 359 million tons of plastic were produced. It is estimated that each year, eight million metric tons of plastic enter the ocean (Parker 2019). This annual accumulation has resulted in five gyres (a large system of circulating ocean surface current, particularly those involved with large wind movements) in the earth's oceans (Stuart 2021). The largest of these islands is the great Pacific garbage patch which covers an area of 20 million square kilometers, and is estimated to weigh 80,000 tons (Lebreton 2018).

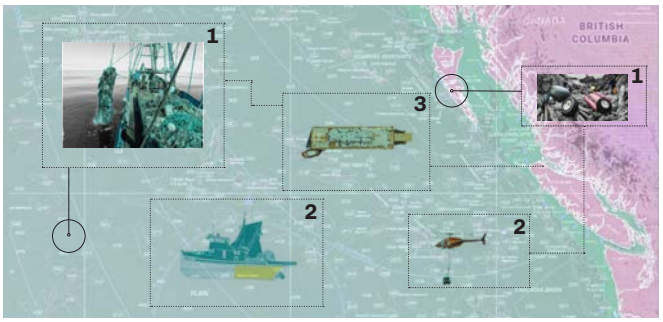
In the ocean, entanglement and ingestion kills thousands of marine animals each year. However, the breakdown of this plastic poses a greater risk with the biomagnification of micro and nano plastics though the food chain. It is estimated that eight percent of the Pacific garbage patch is micro plastic, and this number is quickly increasing as particles continue to break down, placing greater urgency on removing plastic objects from the ocean (Parker 2019). Driven by this increasing global concern, there have been significant advancements in biotechnology, biomaterials, and bio-derived/biodegradable plastics aimed at producing alternative forms of plastics. Scientists have embarked on experiments involving microorganisms capable of producing biodegradable plastics like polyhydroxyalkanoates (PHAs) using plant sugars (Sehgal and Gupta 2020). Biomaterials, such as mycelium and bio-derived materials like algae, corn, and sugarcane are also being explored as potential alternatives to petrochemical-based plastics, which are notoriously difficult to recycle (Otoni et al. 2021). While these innovations hold promise of achieving circularity in plastic use, challenges remain in terms of cost-effectiveness, scalability, and appropriate disposal of these biomaterials to make them sound substitutes (Corcoran et al., 2014). In this project, the authors acknowledge the existing research in these fields, while focusing on creating a distributed, localized approach to addressing the plastic problem.

Research Discovery and Initial Tests

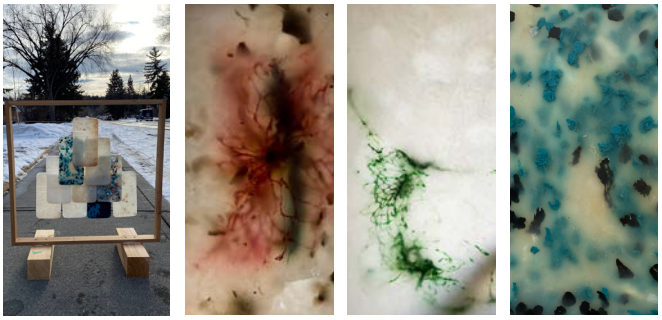
This research focused on uncovering the opportunities of ocean plastic in an architectural application with a specific focus on remote Pacific Northwest communities. The Pacific Northwest is home to many Indigenous and mixed coastal communities that are extremely dependent on the natural environment for food security and cultural processes (Steedman 2011). Therefore, the hyperlocality



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12 Pacific garbage patch composition.

13 Collection scenario.

14 High density polyethylene samples.

15 Parametric variation: pseudo code.

16 Forest structure shingle variation.

17 Forest structure components.

of the site and its proximity to the abundant plastic present in the Pacific Northwest further informed the basis of connection to this year's conference theme. By bringing to light the impact on the remote Indigenous communities, and investigating the weaving of old and new material knowledge through the implications of techno relics, this case study offers methods of surpassing the challenges created by mass consumerism, while mitigating further ecological damage. Collages in Figures 10 and 11 showcase the context of the ocean plastic crisis in the context of the Pacific Northwest.

A list of guidelines were identified to direct the methodology. These parameters were:

1. Convert ocean plastic into a usable building material that embodies its origin, yet fits into a Pacific Northwest architecture typology.

2. Promote and facilitate the collection, sorting, and fabrication of ocean plastic on a community level.

The first phase of this project involved extensive research into the properties of different types of plastics, plastic fabrication, its impact on the natural environment, current initiatives to remove it from natural environments, and methods of repurposing it.

Validating the composition of ocean plastic was done through conversations with individuals actively involved in coastal garbage collection, and researching published surveys completed by The Ocean Clean Up (Egger 2022). It was found that commercial fishing equipment consisting of hard plastic floats, aquaculture baskets, nets and rope, and PE foam blocks make up for an estimated 46% of the plastic in the garbage patch (Figure 12) (Nicolas 2020).

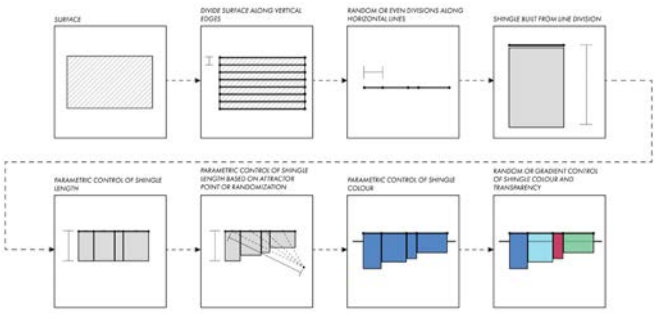
Collection Process

There is existing infrastructure in coastal communities, such as decommissioned fish canneries and underutilized commercial fishing vessels with carrying capacities exceeding 100,000 pounds. These assets are highly underutilized on the coast due to the collapse of many salmon and herring stocks (Nelson and Turris 2004). In one scenario, plastic can be collected along the shorelines by local community members, and transferred to barges via helicopter or marine vessel. In the second scenario, fishing vessels and barges would collect the garbage from pre-identified locations in the Pacific Ocean, as described in Figure 13. In both scenarios, the plastic would be transferred to the refitted canneries for retrieval and processing

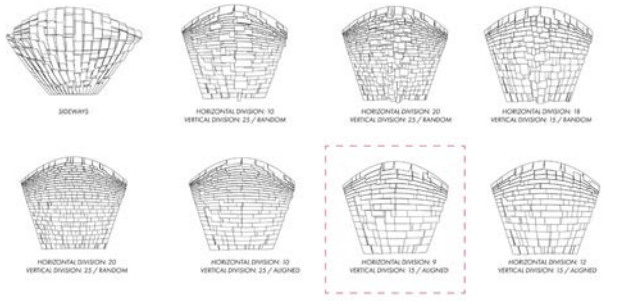
Material and Fabrication

For the scope of this research, High Density Polyethylene Plastic (HDPE) was selected as a viable resin to explore based on it resistance to cold brittleness, low volatile organic compound (VOC) off-gassing, and resistance to ultraviolet (UV) degradation with the addition of light stabilizer additives (Olam 2023). It is commonly found in the ocean in the form of fishing floats and other commercial fishing equipment (Egger 2022).

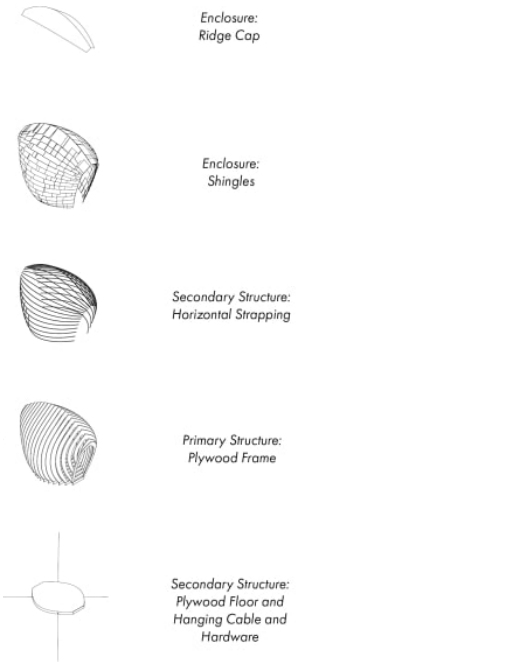
Samples with different combinations of colors and HDPE



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sources were generated using heat molds in a small toaster oven. Interesting transparency opportunities have been observed with the HDPE plastics samples, as well as opportunities with the integration of other common ocean plastics, such as netting or rope. Even the integration of shells that collect or coagulate with ocean plastic have been tested in samples.

High Density Polyethylene was found to be extremely impact- and compression-resistant. It can withstand high impact, and has a high flexibility to the point of creasing before breaking. Other material properties explored were the melting and burning points, and ideal cooking time and temperature: 200°C for 45 minutes in a store-bought toaster oven generated the best compression mold results without burning the recycled resin. Samples can be seen in Figure 14.

Additional explorations analyzed the fabrication capabilities of the plastic samples using a table and mitre saw, drill, and the CNC, thus requiring a non-specialized fabrication process that can be made accessible in remote communities. Using adaptable molds, plastic could be melted into adjustable width and length dimensions, as well as curve requirements of the proposed surface. This would enable a mass customization process that could be shifted to many different project requirements.

Artifact Creation

A building typology study was completed from a series of buildings on Haida Gwaii, an archipelago located in the northwest coast of British Columbia, Canada, which is home to the Haida Nation. The Haida have inhabited the island since time immemorial, and have a deep connection to the land and sea. Haida Gwaii sits off the mainland of British Columbia, directly adjacent to the Pacific Ocean, which results in a constant influx of marine debris, like plastics, posing unique challenges to its ecosystems, and a threat to abundant food sources from the ocean, like wild salmon and halibut, which the Haida and coastal inhabitants are dependant upon for sustenance and cultural practices (Talmazan 2016). Ecosystem collapse would have devastating effects on the Haida people and culture (Steedman 2011).

It was determined that western red cedar is a commonly found exterior cladding material in the form of a shingle or shake. This informed the development of a recycled ocean plastic wall shingle, considering the general affordances of plastic (waterproof, moldable, rot-resistant, water insoluble, relatively temperature-resistance, translucency potential) where in a Pacific Northwest environment, building envelopes must respond to driving wind and rain, salty air, and extremely humid climates. This shingle could then be parametrically varied to create the artifact, a forest shelter intended to perform similarly to a canvas tent, where no defined air barrier exists, allowing fresh air to circulate, while rain and wind are kept out.

The digital methodology explored the parametric variation opportunities that a wall shingle design can employ. The width and length of the shingles can be varied, as well as the color and transparency, based upon the recycled



18 Final artifact winter visualization.

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plastic or added pigments used (Figure 15).

The pseudo-code driving the parametric variation analyzes any surface, curved or flat, and divides the surface into horizontal lines, which are broken up into random or even divisions. The shingle is built from these line divisions into interlocking formations. Parameters can then be deployed to this array which varies in shingle length, color, and translucency. Some of the parametric variations of the forest shelter can be seen in Figure 16. A breakdown of the forest structure's components can be seen in Figure 17.

The physical prototype can be seen through the visualization in Figure 18.

High-grade cedar shakes require old growth western red cedar in the Pacific Northwest. As these material sources dwindle and the remaining old growth forests are considered for protection, the plastic shingle offers a weather- resilient alternative that does not rot under humid conditions or crack when applied to a curved surface.

IMPACT AND REFLECTION

The Techno Relics research studio was an experiment in using anthropocentric materials for design and fabrication. Over the course of the semester, the students researched and utilized existing methods of production to understand how to leverage these materials. One of the main challenges faced by the students during the course of the research was shop closures and access restrictions to fabrication facilities. This forced the students to create research methodologies that could be executed in their living rooms, homes, basements, etc., and a focus was placed on creating artifacts as a means to test the hypothesis (Gero 1990). Not only was this valuable in terms of academic resilience and overcoming these challenges, but it forced the students to think outside the paradigms of mass industrial processes that have been the very cause of distributed waste across the technosphere (Zalasiewicz et al. 2014).

The ocean plastics research creates a methodology that is deployed to tackle a problem that is not caused by the remote communities, but forces them to deal with it by attempting to shift the paradigm around exterior facade materiality. This plastic embodies its own story of decades at sea, and each formed object maintains unique characteristics. There is also a direct connection developed between the communities collecting this plastic and utilizing it. This project considers new ways of utilizing by-products of the anthropocene and harnessing it in ways that are ecologically regenerative which, in turn, enables remote communities to continue to thrive. The use of low-tech physical tooling, in combination with computation methodologies, provides a unique departure point for the use of a single product, the shingle.

CONCLUSION

In response to discovering and utilizing techno relics during a time of shop and classroom closures, the research studio reinforced the potential of design studios to be simultaneously digital and physical in their exploration. To note here, other than the architectural implications, is the act of prototyping that resulted from the studio. As Gero discusses in his paper, "design is an exploration process, what is relevant only manifests itself as the design proceeds and varies with the decisions taken."

(Gero 1990). The exploration of how post-anthropocene materials should be used and paired with digital processes was done through a process of discovery, hacking and augmenting existing systems of knowledge, and the creation of artifacts. Furthermore, Gero goes on to explain that at the early stage of the design process (or hypothesis), a prototype will contain function and behavior (Gero 1990). Therefore, the structure may be included in detail at a later stage.

Next Steps

Next steps exist in both the fabrication and in the collection processes. A process of mass customization with the use of interlocking panelized structure could be developed as a means of utilizing the structural characteristics of the recycled plastic and removing the need for wood framing (Figure 1). The standard shingle shape used in the research removed variables found in more complex shapes and fastening techniques, and provides a typology familiar to the local context and builders. However, further exploration into alternative structural forms and fastening strategies with ocean plastic are obvious next steps for research. In addition to the material research, quantifying the embodied energy in the ocean plastic collection and fabrication processes would be useful to understand.

To quote directly from Turpin, he stated, "In the Anthropocene, designers, activists, and philosophers will all have the earth they deserve" (Turpin 2013). Through the research done in this paper, architects and designers can begin to use a general methodology of discovery, computation, physical making and, ultimately, the injection of anthropocentric material back into our material streams. The leveraging of existing methods of production and the act of artifact creation through physical making will make these techno relics more accessible, encouraging architects and designers to think beyond contemporary materials, while finding novel solutions for localized stewardship.

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IMAGE CREDITS

Figure 2: © Cocoran, Patricia L., Charles J. Moore, and Kelly Jazvac, 2014

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Sumer Singh Matharu is an Instructor for the Master of Architecture degree at the University of Calgary SAPL, founder of the critical design practice, Sumer Singh Studio, and a co-founder of the Design-Fabricate-Build practice, Mercedes and Singh. He is a Mechanical Engineer, graduate of the Master of Architecture program at the University of Calgary SAPL, and graduate of the Master of Advanced Computation for Architecture and Design program at the Institute for Advanced Architecture of Catalonia (IAAC). Sumer operates within an architectural framework at the intersection of computation, fabrication, engineering, and digitalization of contemporary AEC practices.

Joseph Crawford is a member of the Métis Nation of Alberta Region 3. He holds a Master of Architecture from the University of Calgary SAPL. His time living in rural and remote Canada, most recently Haida Gwaii, and working with Indigenous communities has influenced his practice as one that recognizes ecological, rural, and Indigenous perspectives. Most notably, Joseph worked as a designer for the Vancouver Hudson’s Bay redevelopment, the Vancouver Art Gallery, and as a builder on the SGang Gwaay Longhouse in Gwaii Haanas. Joseph is currently a Junior Designer at Perkins&Will.

Ugonna Ohakim is a Junior designer at Perkins&Will in the Calgary office. Prior to that, he graduated from the University of Calgary SAPL with a Master of Architecture degree, where his research focused on the intersection of design and computation. He finished his bachelor's degree, with a first class from the University of Liverpool in England, with a Bachelor of Arts Honors in Architecture. He will be part of the next cohort of students at the Masters in Advanced Computation for Architecture and Design at the Institute for Advanced Architecture of Catalonia (IAAC).