



## CHALLENGES TO PLASTIC UP-CYCLING IN SMALL ISLAND COMMUNITIES: A PALAUAN TALE

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## **EXECUTIVE SUMMARY**

Plastics in the marine environment are a growing environmental threat with mounting research on impacts, sources and management strategies. Small island communities are subject to greater threats because of dual inputs of marine plastics via ocean currents and locally used plastics, with a heavy reliance on imported packaged goods. The resulting plastic buildup on islands is often combined with a lack of infrastructure and remoteness, leaving few options for management. However, a number of existing technologies and companies are built upon reusing plastic waste as a resource to create a product of greater value, a concept commonly known as “up-cycling.” Utilizing technologies on island for plastic up-cycling or creating incentives to send them off to other nations for reuse is a theoretically beneficial method to both manage and economically incentivize unwanted marine and local plastics. Yet, up-cycling is often underutilized.

By examining Palau as a case study, a nation that experiences the common impacts of plastic but successfully recycles 50 percent of the on island waste, this report uncovers the primary challenges to up-cycling and plastic management to Palau and similarly structured island nations. Challenges can be broken down into the 5 broad categories of geography, society, government, economy, and technology. Through uncovering primary challenges in a nation that is already taking positive action, recommendations can be made to creatively overcome them.

## **INTRODUCTION**

Plastics distributed in the marine and terrestrial environment have become a key geological marker of the Anthropocene,<sup>1</sup> forever imprinting human impact on the geological timescale. Plastics are long-lasting and transported through the global economy and ocean currents creating persistent worldwide impacts.<sup>2</sup> In fact, in 2017 Lavers & Bond found that Henderson Island had the highest density of plastic debris worldwide, despite being remote and uninhabited.<sup>3</sup> The overabundance of plastic compounds the problem. In 2010 alone, 275 million metric tons of plastic waste were produced worldwide, an estimated 8 million metric tons of which entered the ocean.<sup>4</sup>

Plastics create a wide range of problems affecting health, economies, and ecosystems. As of 2016 a total of 817 species have been documented with ingested and/or entangled plastics.<sup>5</sup> Species range from tiny zooplankton<sup>6</sup> at the base of the food chain to top predators, like sperm whales.<sup>7</sup> Impacts include bodily harm, mortality<sup>8</sup> and the potential for plastics to adsorb, concentrate and transport Persistent Organic Pollutants (POPs). Common POPs include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), bisphenol A (BPA), and phthalates,<sup>9</sup> which are carcinogenic, and/or inhibit reproduction and development, and have the potential to bio-accumulate through the food chain.<sup>10</sup> Plastics can also reduce biodiversity by smothering oceanic and land habitat<sup>11</sup> or create a pathway for the spread of invasive species and pathogens.<sup>12</sup> High densities of debris on beaches can confuse and inhibit locomotion in smaller

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<sup>1</sup> Zalasiewicz et al., 2016.

<sup>2</sup> Hansen, 1990; Ryan, 1987; Goldberg, 1995; Goldberg, 1997; Zalasiewicz et al., 2016.

<sup>3</sup> Lavers and Bond 2017.

<sup>4</sup> Jambeck et al. 2015.

<sup>5</sup> Secretariat of the Convention on Biological Diversity 2016

<sup>6</sup> Cole et al. 2013; Desforges et al. 2015; Frias et al. 2014; Setälä et al. 2014;

<sup>7</sup> Unger et al. 2016

<sup>8</sup> Butterworth et al. 2012; Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel—GEF. 2012; Sherrington et al., 2014. Unger et al. 2016; Werner et al. 2016

<sup>9</sup> Karapanagioti and Klontza 2008; Hale et al. 2010

<sup>10</sup> Ryan et al. 1988; Teuten et. al 2009; Yamashita et al. 2011; Rochman and Browne 2013; Rochman et al. 2014; Browne et al. 2013

<sup>11</sup> Richards and Beger 2011; Green et al. 2015; Kuhn et al. 2015; Werner et al. 2016.

<sup>12</sup> Carpenter et al. 1972; Carpenter and Smith 1972; Minchin 1996; Winston 1982.

organisms such as crabs, gastropods, and hatchling sea turtles, respectively altering foraging behavior and the ability to reach the sea.<sup>13</sup>

Human health is also likely impacted. Mounting research marks the presence of microplastics in common food items, such as the Karami et al. 2017 study that found 16 of 17 sea salt brands from eight countries contained microplastics.<sup>14</sup> Further health impacts result from mismanaged plastics. It is common practice in undeveloped nations to burn plastics or dispose of them in open dump sites. Uncontrolled burning results in the exposure of local populations to carcinogenic, toxic, and poisonous fumes.<sup>15</sup> Dump sites or improperly controlled landfills often result in the leaching of toxic chemicals into groundwater systems,<sup>16</sup> further impacting human and animal health. Annually 20 epidemical diseases and 4 million deaths are attributed to poor waste management practices.<sup>17</sup> An often-overlooked impact of plastic is the link to global warming. Plastics are made of fossil fuels, with approximately four percent of the world's petroleum used in manufacturing and another four percent used as raw material.<sup>18</sup>

Economic impacts are also broad. They include direct economic losses in damages to fisheries, shipping, tourism, coastal aquaculture, and costs incurred to mitigate litter.<sup>19</sup> Common losses to fishing, aquaculture, and shipping are ascribed to reduced, lost, or contaminated fishing catch, damaged nets and fishing gear, fouled propellers, and damaged engines.<sup>20</sup> Indirect economic losses apply to many of the issues discussed above including the loss or damage to biodiversity, loss of recreational amenity, loss of aesthetics, poor air quality and contaminated waters.<sup>21</sup>

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<sup>13</sup> Aloy et al. 2011; Özdilek et al. 2006.

<sup>14</sup> Karami et al. 2017

<sup>15</sup> Women in Europe for a Common Future

<sup>16</sup> Hopewell et al. 2009.

<sup>17</sup> Ocean Conservancy 2015.

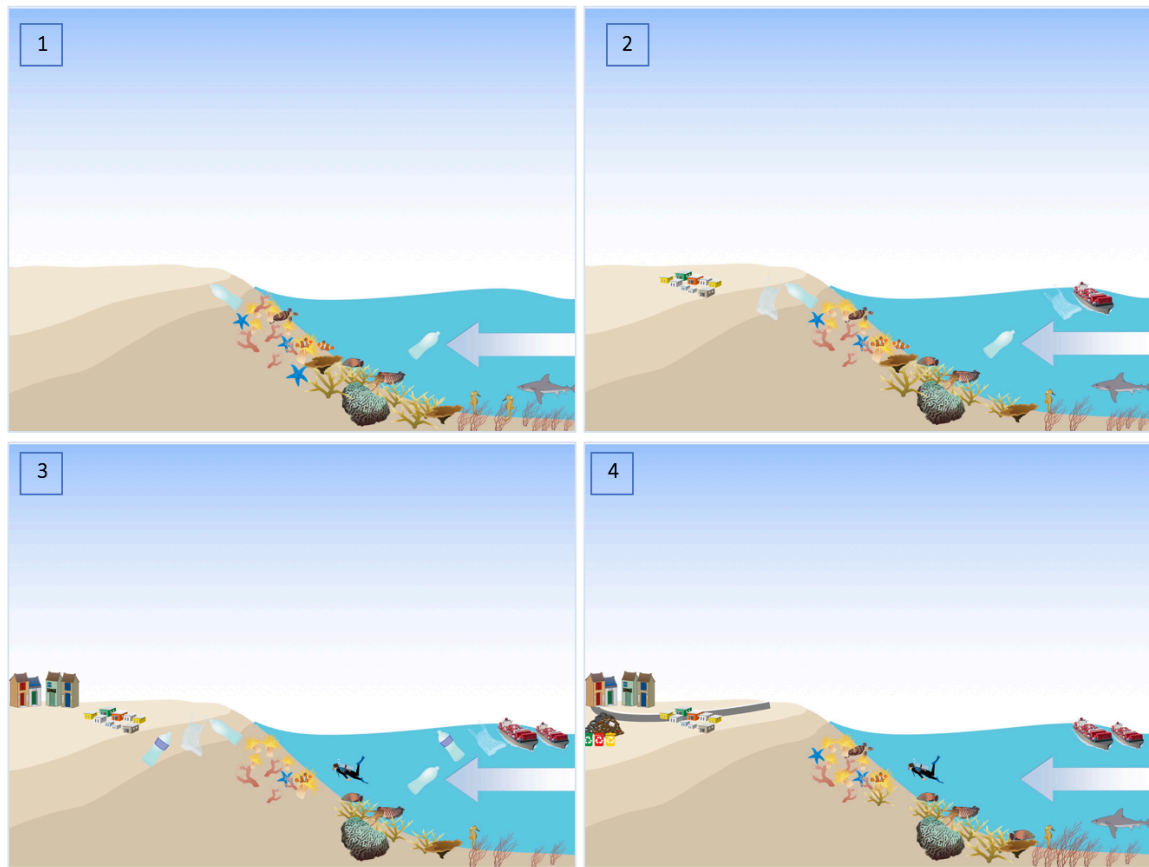
<sup>18</sup> Azzone et al. 2014; Gourmelon 2015.

<sup>19</sup> Ten Brink et al. 2009

<sup>20</sup> Ten Brink et al. 2009; NOAA, What is ghostfishing?

<sup>21</sup> Hajkovicz et al. 2005; Ten Brink et al. 2009.

As shown by Figure 1, the impacts of plastics are often intensified in small island communities. The quantity of plastics is increased through dual inputs of plastics via ocean currents and heavy reliance on imported packaged products. These inputs are intensified on islands with high population density or substantial tourism. Islands are also disparately affected by plastics due to a large coastline in proportion to land mass, leaving more space for plastics to wash ashore and a lack of space for large landfills. Remote islands experience additional pressures in the costs of transporting waste off island and importing and maintaining the infrastructure required to properly dispose of waste.



**Figure 1.**

*1) Ocean currents bring plastics to uninhabited islands. 2) Inhabited islands depend on packaged imported products resulting in plastic accumulation and local environmental stress that can lead to degradation. 3) Development and tourism require more imports resulting in more plastic and further environmental degradation. 4) Waste management, recycling, up-cycling, and collection pathways decrease plastics and provide an opportunity for renewed environmental health.*

The following case study of Palau examines a region faced with many of the challenges common to island nations and a nation taking positive action to manage its waste, including up-cycling solutions, i.e. solutions that use plastic waste as a resource of greater value. Up-cycling solutions are theoretically ideal for small island communities because they can be locally implemented, provide a variety of options, and have the potential to be profitable. Through examining a nation that is actively working on up-cycling solutions, the expansion within Palau and the potential for modeling solutions to export to similarly structured nations, can be addressed.

## **INTRODUCTION TO PALAU**

The Republic of Palau is famed for biologically rich, clear ocean waters, and fantastic diving - it boasts the most diverse coral fauna and the highest density of marine habitats of comparable geographic areas worldwide.<sup>22</sup> Located in the North Pacific Ocean, in the Northeastern corner of the coral triangle, it consists of more than 340 islands, only eight of which are inhabited.<sup>23</sup>

Palau's economy is largely dependent on the lush marine environment, with tourism as the biggest industry. In 2016 over 135,000 people visited the island, 99 percent of whom were tourists.<sup>24</sup> Additional economic sectors include trade, subsistence agriculture, and fishing.<sup>25</sup>

The population is small, with approximately 21,300 people as of 2016. Yet its per capita gross domestic product (GDP) is \$15,300, ranking it the 105<sup>th</sup> highest worldwide. This number is comparable to that of China's \$15,400 per capita GDP, and well above that of its neighboring state, Federated States of Micronesia, which has a per capita GDP of

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<sup>22</sup> NOAA's Coral Reef Information System 2016.

<sup>23</sup> Sadang 2015.

<sup>24</sup> Ngedebuu 2016.

<sup>25</sup> Central Intelligence Agency 2013.

\$3,000.<sup>26</sup> Approximately two-thirds of the population lives in the economic center of Koror, which has a land mass of only 7.1 square miles.<sup>27</sup> Babeldaob, which is connected to Koror via a road system, is the second largest island of Micronesia. It accounts for eighty percent of the land mass of Palau, and encompasses 10 of the 16 states.<sup>28</sup> The island groups are split into 16 states, all of which are regulated by state agencies under the umbrella of a national government. Regulations are the result of a mixed legal system of civil, common, and customary law.

Palau gained independence from the United States of America in 1994, yet still maintains ties under the Compact Agreement. This gives the U.S. rights to maintain military bases in Palau and makes it responsible for Palau's defenses. Direct foreign aid is also provided by the U.S. In 2010 a comprehensive review of the compact was signed and an additional \$250 million in aid was provided, with a range of federal programs to continue for the next 15 years. Palau is also eligible for U.S. grants,<sup>29</sup> such as the National Oceanic and Atmospheric Association (NOAA) small grant that supported the efforts of a Palauan NGO, the Ebiil Society, in marine debris data collection efforts. U.S. involvement in Palau is reflected by the continued use of the U.S. dollar as currency. Japan is the second largest donor to Palau, with ties dating back to the administration of Palau by Japan 1920 through the end of World War II and continued economic support after administration ended.<sup>30</sup> Cultural ties and tourism also contribute to economic support, where 21 percent of total visitors to Palau in 2016 were Japanese.<sup>31</sup> Japan tends to fund infrastructure, such as the terminal building of the International airport, main roads,<sup>32</sup> and solid waste management projects.<sup>33</sup>

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<sup>26</sup> Ibid.

<sup>27</sup> Sadang 2015.

<sup>28</sup> Ibid.

<sup>29</sup> Embassy of Japan in the Republic of Palau 2017; The Office of Website Management, Bureau of Public Affairs, U.S. State Department 2017.

<sup>30</sup> Embassy of Japan in the Republic of Palau 2017

<sup>31</sup> Ngedebuu 2016.

<sup>32</sup> Embassy of Japan in the Republic of Palau 2017.

<sup>33</sup> Interviews with Katsuo Fuji and Selby Etibek



Palau is subject to many of the usual impacts of plastics common to small island communities. Factors that contribute to the excess of plastic include: a high volume of marine plastics transported via ocean currents; the small land mass relative to extensive coastline, which creates a greater area for marine debris to accumulate; and the heavily packaged imports needed to support the Palauan population and significant tourism. Challenges in management are compounded by its remoteness. However, Palau also has a positive track record of environmental stewardship, a burgeoning awareness of plastic as a significant environmental impact, and a robust recycling center which includes a pyrolysis machine (*i.e.* a machine that can make diesel fuel from plastics).

## **APPROACH AND METHODOLOGY**

The goal of the project was an exploratory study of the challenges faced by small island communities in regard to utilization of plastic up-cycling technologies. To reach this goal I examined Palau as a case study and conducted semi-structured interviews with stakeholders in Palau from businesses, Palau state and national government, United States government, NGOs, community organizations, researchers, and waste management consultants. I conducted additional interviews with waste management professionals, NGOs, and community organizations in the Bahamas, Philippines, and United States. The majority of interview participants, *i.e.* “participants,” were already engaged in the plastic issue. I conducted 27 in person interviews in Palau in the month of May 2017 and 8 interviews with experts outside of Palau in person and over the phone April – May 2017. Through listening to the challenges, concerns, and success expressed in regard to plastic management and up-cycling, I hope to increase the potential to creatively source solutions to overcome them. Recommendations to expand solution based management for Palau and other island nations with a similar structure are provided at the end.

## CHALLENGES TO PLASTIC UP-CYCLING AND MANAGEMENT

Interview participants identified challenges in potential or actual utilization of up-cycling technologies in geography, society, government, economics, and technology. Challenges to **geography** include ocean currents transporting global plastics and the remoteness of Palau. Challenges to **society** include: a newfound or lack of awareness about wider impacts of plastics and up-cycling technologies, wide cultural usage of plastics, the need for a champion of initiatives, lack of capacity and resources, a sense of despair among those engaged in the issue, and alternate environmental priorities for NGO's and government. Challenges to **government** are in the disparity of management measures and wealth in the 16 states. **Economic** challenges are in the resources needed for initial startup and follow through of initiatives and the lack of value on most post-consumer plastics. Challenges to **technology** are in considering what technology is suitable for the situation given the geographic, societal, governmental, and economic situation of a location. These five broad categories contribute pieces to a fuller story of challenges to be considered before effective utilization of up-cycling.

### GEOGRAPHY

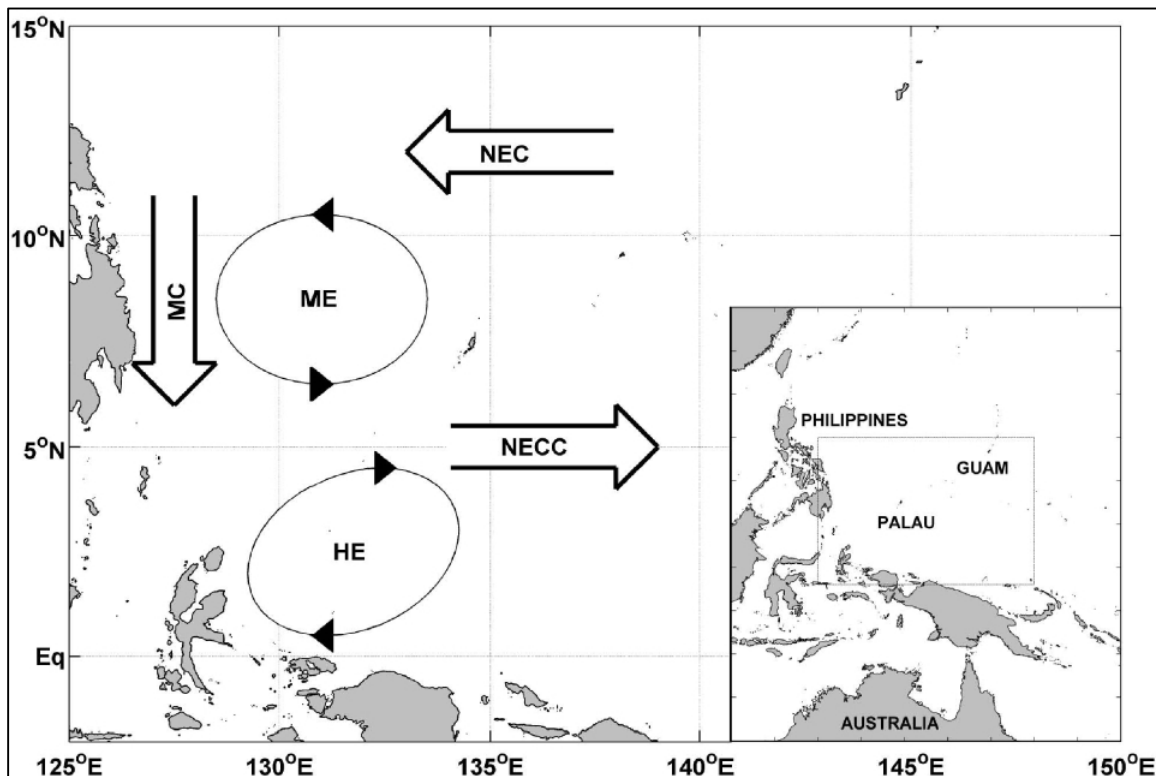
Palau is subject to plastics from foreign and local sources and excess plastics are likely to buildup in Palau due to its geography. The land mass is just under 190 square miles, but it boasts over 900 miles of coastline and an Exclusive Economic Zone (EEZ) of over 237,000 square miles.<sup>34</sup> With a coastline almost 5 times of Palau's land mass there is ample room to accumulate marine plastics on its shores. It is also nestled in the same region as the top five countries identified as accountable for 55-60 percent of global plastic leakage into the ocean: China, Indonesia, the Philippines, Thailand, and Vietnam.<sup>35</sup>

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<sup>34</sup> Sadang 2015.

<sup>35</sup> Ocean Conservancy 2015.

The excessive appearance of plastics in Palau is related to the path of global currents. The North Equatorial Counter Current originates in the tropical Western Pacific around the Philippines, Indonesia, and Papua New Guinea. This current occasionally drifts northward to hit the west coast of Palau and intensify the amount of debris that hits the west coast from the aforementioned nations.<sup>36</sup> Additional inputs of debris may originate in the Mindanao Current, which runs along the East Coast of the Philippine island of Mindanao and connects with the North Equatorial Counter Current, likely bringing local debris with it.<sup>37</sup> The transport of debris from foreign sources to Palau is corroborated by anecdotal tales of plastic debris marked with Indonesian writing or brands unfamiliar to Palau.



**Figure 2.** Heron et al. 2006 illustrates the path of the North Equatorial Current (NEC), Mindanao Current (MC), North Equatorial Counter Current (NECC), Mindanao Eddy (ME) and Halmahera Eddy (HE). Inputs of plastic debris to Palau from the Philippines and Indonesia likely originate from the NECC and MC.

<sup>36</sup> Heron et al. 2006

<sup>37</sup> Schönau et al. 2015

The remoteness of Palau also influences the buildup of plastics. Palau has few industrial and agricultural options creating a need for imports to support the population plus the tourist industry. When combined with the modern era of single use plastics common in Palauan customs, grocers, restaurants and retail stores, plastic waste buildup increases.

Geography also creates challenges in transportation of waste plastics and marine plastics. Because Palau is composed of many islands over a relatively large area given its land mass, the expense to transport waste plastics and marine plastics to a facility off island or to the economic center of Koror is large. This creates a problem in a lack of collection pathway for locally produced waste and in options for disposal and up-cycling for collected marine plastics. Up-cycling options must consider both the challenges created by significant waste and debris and of transportation through aiming at scalable technologies that are locally implemented or can utilize existing pathways for transportation.

## SOCIETY

Key societal challenges include: a lack of awareness about impacts and quantity of plastics and the concept of up-cycling; capacity, knowledge and dedication of

### Community Cleanups on the Outer Islands:

#### Trash Left Behind

*A community cleanup of beaches on Kayangel, Angaur, and Pelilu, located on the far North and South islands of Palau, was conducted by NGOs, community organizations, and government agencies in Palau in March of 2017. In Angaur, the most heavily polluted location, over 5,700 plastic beverage bottles and over 4,600 foam pieces were collected on a small stretch of beach only about 100 meters long<sup>1</sup>. The day was long, the work of collecting hot, of sorting onerous, and the hauling of trash bags strenuous. But harder than the physical labor was the realization of the extent of the problem. One person highlighted the moment he finished hauling the last trash bag from one stretch of beach, only to look down to see the opposite stretch still littered with hours more of collection, sorting, and hauling. Others expressed surprise that such a small area could accumulate such significant quantities of debris, often marked with foreign writing. There was a sense of demoralization that although now clean, the beach would re-accumulate debris days, weeks, or months later. Perhaps the hardest of all was leaving the collected trash on the island; there was simply no way to practically transport the collected trash to the recycling facilities on Koror\*.*

*\* Story derived from interviews with Joyce Beouch, Tublai Ililau, Patty Kloulechad, Susan Kloulechad, Madelsar Ngiraingas, and Sengai Sablan.*

individuals; and alternate environmental priorities. Although the majority of participants were already engaged in the issue of plastic in some capacity, not all expressed personal awareness of either the quantities or wider impacts of plastics. For example, some expressed concern about the quantity of marine plastics but were unaware of environmental impacts. Alternatively they recognized the need for environmental cleanliness, but had no awareness of the impacts of plastics to animals, ecosystems, or human health. All participants (outside of researchers) cited a new awareness found in relation to one of three instances: a microplastics presentation via the “Pristine Seas” expedition in late 2014,<sup>38</sup> the marine debris monitoring program began in 2016 through the Ebiil Society; or participation in a beach clean-up sponsored by an NGO or government agency.

The lack of awareness about up-cycling was more pronounced. When asked if they were aware of the term “up-cycling,” the majority of respondents said they were not. However, when prompted with examples, such as the Adidas initiative that reuses marine plastics to make shoes or Koror State pyrolysis (*i.e.* “plastic to bio-fuel”), there was a much wider recognition. About half had heard of similar initiatives or knew of “plastic to bio-fuel” at Koror State Recycling. Participants agreed that the lack of awareness about the impacts of plastic and up-cycling is magnified in the states outside of the economic center of Koror.

However, once prompted with examples of up-cycling, participants were overwhelmingly supportive of potential implementation, with a few key caveats. Interviewees expressed concern over the capacity of residents in a small nation where engaged individuals already wear many hats. They also mentioned that expert knowledge was key and that a successful initiative must have a champion to ensure proper utilization, get initiatives off the ground, and create follow-through. The general sentiment was that without these key societal elements, up-cycling initiatives were likely to fail.

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<sup>38</sup> Friedlander et al. 2014.

A compounding societal challenges is in current environmental priorities of NGOs and government. The top three priorities echoed were marine protected areas, fisheries and climate change. Within those priorities there was minimal inclusion of the overlap with plastic pollution. However, as plastic pollution is a burgeoning issue in Palau, and as parties become more aware of how the impacts of plastic spill over to other environmental issues that may change. This overlap is already apparent in the inclusion of the Marine Debris Program at the Ebiil Society, the WestCare Foundations kids camp beach clean, the mention of non-biodegradable waste in the Palauan Conservation Societies “Ridge to Reef” watershed based educational program, and the Conservation Officers of the Koror State Rangers who clean heavily utilized locations in the Rock Islands daily.

Unused and Unwanted:

Technology Without Efficiency

*The owner of one of the prominent Palauan resorts invested in a small-scale pyrolysis machine to reuse some of the plastics produced by the resort to light its tiki torches at night. Yet, it sits neglected and dusty underneath a sheet in the maintenance area. Before the machine can make fuel from the plastic, the plastic must be shredded. But, lacking the proper shredder the staff must cut plastics with a scissors, by hand - a time and labor-intensive task. The pyrolysis machine also requires the separating of trash to segregate the usable plastics of PP, HDPE, and LDPE, something the resort simply lacks in work plan, capacity, and motivation.*

If people are unaware of up-cycling as a solution for plastics they are unlikely to utilize it. Additionally, there may be a lack of motivation to segregate, manage, and cleanup plastics utilizable for up-cycling technologies if there is not widespread awareness of the impacts of plastics and if plastics pollution is low on the list of environmental priorities. This was widely recognized by participants in their suggestions to strengthen campaigns about the impacts of plastics.

## GOVERNMENT

Solid waste management is the responsibility of the Palauan state and national governments. The national government is responsible for the landfill and the state is responsible for collection. But there is an inequality in resources and capacity among the states, leaving Koror as the only state that currently has collection. Because Koror is where two-thirds of the population resides, it is the most practical to have the centralized recycling and landfill facility in Koror. Yet the lack of pathways for waste collection outside Koror leave the other 15 states without options for proper disposal. The National Solid Waste Management Office is working on a plan to create a new landfill and centralize recycling and collection for all 16 states, but it is a plan that may not come to fruition for many years. This results in anecdotal accounts of informal and unmanaged dump sites across the remainder of Palau.

The lack of collection pathways provided by the government, and the limited facilities provide challenges to up-cycling in that there is no current infrastructure in the states beyond Koror. Efforts must be from the ground up, resulting in a greater investment of time and resources.

## ECONOMIC

Waste management professionals interviewed highlighted the important role economics plays in effective recycling and up-cycling. Participants in Palau from the business sector and national and state waste management echoed the challenges of profitable economics in utilizing up-cycling technologies.

Many plastics are composed of low value material and costs of collection, segregation and processing can be high. Additionally, participants noted that a volume and supply of plastic feedstock appropriate for the size and effort of an up-cycling technology is necessary for feasible economic gain.

Compounding the concerns over consistent supply and a volume that is profitable are shipping and transport costs. The potential value of an already low value material is severely undermined when material must be transported a significant distance. For example, if plastics need to be shipped off island for processing, this cost is added to the already significant challenge of transporting plastics from the many islands of Palau, further undermining value.

A solid assessment of volume, supply, and demand was identified as key to lasting and profitable utilization of up-cycling. This assessment is outside of the scope of the current study but lead nicely into other potential challenges and concern. When considering up-cycling initiatives some participants wanted to know: Where will startup funds come from? What will the profit margin be? Will initiatives need to be subsidized?

## TECHNOLOGY

Additional challenges come in the consideration of technologies utilizable for Palau specifically. Careful consideration of what types of plastic a technology is capable of processing and wider environmental factors are necessary for proper implementation. Management officials of both Koror State and national waste management expressed

### Tires: Problem Not Profit

*The path to the Koror landfill is lined with a small and continuous hill of tires. In an effort to reduce the volume, thus making the rubber more compact and exportable, National Waste Management invested in a tire shredder to condense the tires into rubber waste, thus increasing the number of tires that could fit in a shipping container. Yet, even with this new technology the shipping costs are simply too great and there is no guaranteed supply after the current hill of tires is gone. It seems the tires are abundant enough to be a problem, but not profitable. They literally cannot give the tires away.*



these concerns. Calvin Ikesiil of National Waste Management highlighted how the high humidity of Palau means incineration requires great energy inputs, thus wielding it inefficient and costly.<sup>39</sup> Selby Etibek of Koror State Recycling noted only about 20 percent of marine plastics that make it to the Koror State recycling center are suitable for use in pyrolysis. This is due to the degraded quality of the plastics after extensive time in the ocean, i.e. weathering, and that pyrolysis is suitable for only 3 types of plastic.<sup>40</sup>

## **SUCSESSES IN PLASTIC UP-CYCLING AND MANAGEMENT**

The challenges Palau faces in potential utilization of up-cycling initiatives are many, but the country has also had great successes. Current success in plastic up-cycling lies in the utilization of pyrolysis at the Koror State recycling facility. Factors that contribute to this current success and create potential for future up-cycling are legislation, economics, tourism, and a culture of environmental stewardship

### UP-CYCLING SOLUTIONS

In 2004 the current director of the Koror State Recycling Center, Katsuo Fuji, was dispatched to the Solid Waste Management Office in Koror by the Japan International Cooperation Agency (JICA) as a Senior Volunteer. His start coincided with the Koror State Government Recycling Program through the Japanese government. Post contract with JICA, Mr. Fuji was hired by the Koror State Government to continue the recycling program and make it more robust. Since 2004, the center has grown from a very small facility with a staff of 2 to a robust facility with a staff of 82 and is able to recycle 50 percent of Koror's waste.<sup>41</sup> The 50 percent recycling rate is accomplished through composting, beverage bottle recycling, a glass blowing kiln, and pyrolysis.

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<sup>39</sup> Interview with Calvin Ikesiil

<sup>40</sup> Interview with Selby Etibek

<sup>41</sup> Interview with Katsuo Fuji

Pyrolysis uses high-density polyethylene (HDPE), low-density polyethylene (LDPE), and polypropylene (PP) plastics as feedstock to make diesel fuel. The primary feedstock comes from consumer products collected in Koror and brought to the recycling center. Approximately 20 percent of marine plastics collected via beach clean-ups are utilizable for pyrolysis.<sup>42</sup> The Glass Craft Center uses discarded glass in a glass blowing facility open to the public for use to make crafts to be sold to tourists or the local community.

The elements that have contributed most significantly to the overall success of the recycling facility and the implementation of pyrolysis are the initial significant financial support from Japan, and the expert knowledge and follow through of Mr. Fuji. Initial funds and infrastructure for the recycling facility originated from the Japanese government, and many of the machines throughout the recycling center prominently display the Japanese flag, making its contributions apparent. Similarly, the glass blowing center was initially supported by the Japanese government, a master glass blower was hired to teach the community, and the Master then trained community members to craft and teach others to craft to ensure longevity of the initiative. Koror State has also allocated ten percent of its budget to solid waste management, verse the .01 percent allocated by other states of Palau.<sup>43</sup> Capital expense was provided in the financial support for the initial infrastructure and operating expense in the continued allocation of funds, contributing significantly to the robustness of the facility.

Currently, the fuel produced from pyrolysis is used to power the Koror State Recycling Center, the Capital Building Head Office, and the Public Works Shop. The 2017 plans for the recycling center include expansion of pyrolysis and the building of a separate and expanded Glass Craft Center. Total current savings from the “bio-power” generated from the “bio-fuel” produced through pyrolysis are about \$100,000 annually, increasing to \$150,000 upon completion of the expanded Glass Craft Center.<sup>44</sup>

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<sup>42</sup> Interview with Selby Etibek

<sup>43</sup> Interview with Katsuo Fuji

<sup>44</sup> Interview with Katsuo Fuji

However, when considering the success of Koror State in recycling and up-cycling, it is important to remember that Koror State has been provided many advantages not available to other states. These include Koror as the wealthiest and most populated state with the most established infrastructure, including some established pathways for collection of solid waste, and a small area with well-connected roads which allow for ease of transportation of privately collected waste to the recycling facility.

## LEGISLATION

High-level governmental recognition of the plastic problem contributes some success to plastic management. Recently a plastic bag ban, SB-1027 or the “Plastic Bag Act of 2017”, was introduced. According to Senator Mason Whipps and Senator Frank Kyota, the impetus for SB-1027 came from experiencing similar plastic bag bans in Yap and China, respectively. For both Senators, the sentiment lay in the mindset that Palau, although small, is a nation capable of taking action comparable to bigger nations and economies. A similar bill was introduced in the past but did not pass. Senator Kyota noted a primary factor in the failure of the initial bill was the lack of community awareness or “buzz” about the plastic impacts. However, both Senator’s expressed hope that SB-1027 will pass with the growing awareness of the impacts of plastic in Palau. Participants noted an additional element that contributes to the potential success of bag bans and other legislation in Palau is the small population and small influence on global economy, resulting in less pushback from big industry.

## ECONOMICS

At a national level successes in plastic recycling and reduction are driven by economic incentives that work. The largest success in this arena is the Container Deposit Law (CDL). This law poses a 10 cent fee per beverage bottle on importers, allowing a .05 cent refund and .05 cent allocation to the recycling fund per returned beverage bottle.<sup>45</sup> The

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<sup>45</sup> An act establishing a recycling program for the Republic of Palau, establishing a beverage container deposit fee, creating a Recycling Fund; and for other related purposes: adopted 2006

success of the CDL is proven by a 90 percent recovery rate, with approximately 18 million of the 20 million imported beverage bottles recycled.<sup>46</sup> The bottles are cleaned and bundled at the Koror State recycling center and sold to Taiwan for further processing. The strengths of the CDL lies in the significant economic incentive for recycling, resulting in high collection and transport rates. Bottles are returned to the recycling center by individuals or by the informal waste sector, which collects bottles from household and through scavenging to return to the recycling center.

## TOURISM

The economic dependence on tourism, driven by the vitality of the ocean near Palau and unique Rock Islands, is an additional factor that contributes to success in conservation. A 2005 report estimated annual costs of solid waste pollution to tourism at \$961,000, the most significant cost category.<sup>47</sup> This dependence on tourism was widely acknowledged by participants from the government, private, and non-profit sector. All parties made the link between the ocean-centric tourism of scuba diving and other water-centric activities and the need for healthy and clean waters and marine life to sustain this economy. The recognition of environmental cleanliness is even tied in with social marketing of Palau as a “Pristine Paradise.” Susan Kloulechad of the Palau Visitors Authority, and creator of the tagline, directly reinforced this point, noting that marine debris must be removed from Palau’s beaches to deliver the promise of Palau as a Pristine Paradise.

This link between clean waters and tourism has been implicitly incorporated into the structure of the Koror State Rangers in the role of the Conservation Officers, previously called the Facelift Crew. The role of the Conservation Officers is to patrol the Rock Islands most heavily utilized by tourism and clean up any trash on the beaches. Conservation officers go out every day to clean the islands, thus ensuring that the picture of Palau visitors will see is “pristine.” The majority of the funding for the Conservation

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<sup>46</sup> Interview with Katsuo Fuji

<sup>47</sup> Hajkowitz et al. 2005.

Officers is derived from the 50-dollar Rock Island permit fee required from all visitors to the Rock Islands. The economic dependence on tourism thus promotes some environmental stewardship in regard to marine debris and could provide an avenue for up-cycling.

## STEWARDSHIP

Another strength of Palau lies in its culture of environmental stewardship. Historically conservation measures have been strong, and date back to ancient times with the traditional fisheries management measure known as “bul.” When a bul is declared there is a moratorium on an overused and diminished resource until replenished. Traditionally utilized for depleted fish stock, it is applied more widely in the modern era to strengthen larger conservation concepts such as the dedication of eighty percent of Palau’s EEZ to a National Marine Sanctuary, the ban on bottom trawling, and the enactment of the first Shark Sanctuary.

Although the majority of interviewees either did not link or only weakly correlated issues of plastic pollution to greater conservation initiatives and environmental programs, the culture of conservation and recognition of the importance of environmental cleanliness is still intrinsically tied. It provides a baseline for future conservation action surrounding plastic pollution. This was reflected in some participants positive attitude towards future change. Many suggested that if funding was provided personal capacity would grow, or vice versa; if a champion emerged, funds and resources would materialize for up-cycling.

## **DISCUSSION**

It is clear that the challenges Palau faces in utilization of up-cycling initiatives are not limited to Palau and are likely common to many other island nations far removed from mainland’s and infrastructure. Similar challenges may even be experienced in inland locations that are disconnected from adequate facilities for waste management, recycling,

or up-cycling. Technologies to up-cycle also have limitations, warranting a thorough analysis of waste steam to determine what works best. Further, though other nations experience similar challenges, not all elements that contribute to the success of Palau are exportable to other nations. Yet, opportunity for creatively sourcing solutions for up-cycling lies within these challenges.

## CHALLENGES IN COMMON

Comparable challenges were identified by the island nations of the Bahamas and the Philippines in interviews with NGOs, community organizations, and waste management professionals. Several organizations<sup>48</sup> in the Bahamas involved in piloting the Solar Kiln, a small technology that aims to up-cycle by remolding marine plastics into bricks or tiles, identified similar challenges in geography, economics, and society, as the impetus for creation of the Solar Kiln.<sup>49</sup> Geographic and economic challenges identified include: the expense of shipping recyclables off island, thus further devaluing an already low value material; the importation of 90 percent of food products; and the lack of infrastructure on island for waste management, recycling or up-cycling, forcing the burning or unsanitary dumping of plastics. Societal challenges are a lack of awareness about the impacts of plastics.<sup>50</sup> Similar challenges were again echoed about the Philippines by Jill Boughton of Waste 2 Worth Innovations,<sup>51</sup> who emphasized the economic challenge of a lack of value on certain types of plastics in conjunction with the other challenges outlined above.

## TECHNOLOGY

Technologies operate on varying scales with different strengths and weaknesses and can be broken down into four rough categories: 1) plastics for products; 2) plastics as building materials; 3) plastics for 3D printing filament; 4) plastic to energy. Not all are capable of using all types of plastic, or solely marine plastics because of salinity or

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<sup>48</sup> The Island School, The Bahamas Plastic Project, 5 Gyres

<sup>49</sup> Interviews with Michael Cortina, Marcus Erikson,Carolynn Box, Kristal Ambrose.

<sup>50</sup> Interview with Michael Cortina

<sup>51</sup> Interview with Jill Boughton

quality considerations. Some technologies require greater infrastructure or initial investment and operate on a larger scale, while others require very little investment and are only suitable for a small sector of the waste stream. Furthermore, technologies are in varying stages of development.

For example, in the Bahamas an additional primary challenge identified in regard to the Solar Kiln was its inefficiency. Although the brick produced was utilizable, it took 4 hours to make one brick and simply required too much investment of time for too little reward.<sup>52</sup> Future goals for the Solar Kiln are to increase efficiency through creating a thin tile instead of a thick brick thus decreasing manufacturing time, but still creating a product widely utilizable in everyday construction.<sup>53</sup> However, the Island School - the organization currently testing the Solar Kiln, is also developing pyrolysis on island to overcome challenges of shipping costs and to create a highly demanded product.

Jill Boughton aims to address challenges in technology and economic feasibility by first assessing where the opportunity for economic gain lies through an analysis of the waste stream. The analysis considers gaps in what is currently being recycled and what waste has enough volume and supply to be a profitable feedstock. After analysis comes a thorough consideration of the imitations of technologies, i.e. what works best for where, in the goal of creating utilizable solutions. With this careful consideration, up-cycling has been proven to work.

For example, Bureo, a company that makes skateboards from plastic fishing nets, aptly identified the problem as fishing nets, created a marketable product, a steady supply chain that involves local community, and found a viable processing facility. By working through this process, Bureo has successfully created profitable up-cycling of fishing nets in Chile.<sup>54</sup>

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<sup>52</sup> Interviews with Michael Cortina, Marcus Erikson, Carolynn Box

<sup>53</sup> Interview with Marcus Erikson

<sup>54</sup> Bureo 2017.

## EXPORTABLE FACTORS OF SUCCESS

Not all factors that contribute to success in Palau are exportable to other nations with similar challenges. Significant non-exportable factors include the substantial foreign aid and eligibility for foreign grants available to Palau, and the alignment of that financial support with a dedicated champion with expert knowledge. These advantages are apparent even within Palau in that Koror State's waste is considerably better managed than the other 15 states. Additionally, the particular combination of financial support with a dedicated champion contributes significantly to the success of the Koror State Recycling Center and allows Koror State to overcome many commonly identified challenges.

Yet other factors may be exportable to island nations that share similar attributes with Palau. Nations that depend heavily on tourism may be able to implement a similar fee structure comparable to the green fee and Rock Island permits to overcome capital and operating expense challenges both in Palau and other island nations. For example, in 2003 the Protected Area Network (PAN) fund was created to “preserve pristine and diverse environments,”<sup>55</sup> which is supported by the \$30 green fee all visitors are required to pay upon departure. The current revenue amounts to over \$4 million annually with the current trend of tourism. It may be possible to export the “tourist pays” model to overcome initial financial barriers to manage and/or up-cycle plastics in Palau or impose a similar fee in other nations. In Palau, even if \$5 were added to the green fee, a small fee given the high expenses of experiencing Palau, over \$675,000 would be generated annually. The role of Conservation Officers may also be replicated and worked into a fee structure, with funds specifically attributed to implementing and sustaining up-cycling solutions.

Legislation that bans single use plastics is applicable to all nations, island or not, but nations that have a similarly small population and lack significant influence on the global economy may be able to take advantage of the lack of pushback to create stronger laws.

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<sup>55</sup> Terrill et al. 2015



For example, the recent bag ban passed in California was faced with significant pushback from large plastic industry. This pushback contributed to a ban with many weaknesses, such as the allowance of plastics bags above 2.25 millimeters thick and the exception of retail stores and restaurants.<sup>56</sup> Palau and other small nations have an opportunity to avoid these weaknesses and create strong laws and meaningful initiative, as proven by the success of the CDL.

Societal concepts that are exportable include expert knowledge and the role of a champion. The issue of plastic is becoming more popular with knowledge growing about up-cycling and what works and what doesn't. All stakeholders interviewed were excited to share information and offered further assistance. Thus, if an individual was willing to champion the cause and reach out to those with more experience, the challenge of expert knowledge could be easily overcome.

## OPPORTUNITIES

Within Palau the culture of environmental stewardship and the sense of Palauan Pride provides opportunity for outreach and engagement. One participant identified an opportunity to leverage this by encouraging businesses, which seek to stay on equal footing, to host and champion up-cycling initiatives, a concept equally applicable to other nations. Up-cycling initiatives bring further opportunity to engage the public in wider awareness about the impacts of plastics through the inclusion of outreach and education in initiatives.

Opportunity also lies in the same geographic features which produce excess marine and locally used plastic. Based on preliminary marine debris studies in Palau, it is probable that even if plastic production stopped tomorrow, large amounts of plastic would still accumulate on the shores of Palau for years to come,<sup>57</sup> a commonality among many island nations. It is also unlikely that single use plastic consumption will stop completely

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<sup>56</sup> Senate Bill 270

<sup>57</sup> Appendix X

in the coming years. Technologies are also available to utilize at least a portion of marine plastics in up-cycling according to interviews with waste management professionals. Thus, the challenges of steady volume and supply are potentially overcome with implementation of up-cycling technology capable of using a portion of marine plastics. Yet, a full assessment of volume, supply, demand and technology is needed to determine economic feasibility and achieve full implementation.

Geographic challenges that result in low collection rates due to transportation may also be overcome with a little creative thinking. For instance, Clean Oceans International, who is developing a pyrolysis machine of small scale, and working on implementation in the remote Ulithi Atoll, is attempting to overcome the challenge of transportation by making the unit miniature and able to fit on the boat that brings supplies to the island group.<sup>58</sup> By allowing the technology to come to the community instead of vice versa, a significant challenge is overcome. With increased understanding of the supply chain in Palau and other nations, similar opportunities to utilize alternate collection pathway to increase collection may be identified. Collection may also be increased through tapping into existing organizations. For example, there may be an opportunity to modify the work plan of the Conservation Officers to include greater collection and segregation of marine debris, or through utilizing the reach of Marine Protected Area's enforcement officers to the outer islands. Additionally, the informal waste sector has already expanded collection pathways for beverage bottles due to the economic incentive provided by the CDL and regularly collects bottles in households from states connected to Koror by road without formal government collection. There may be opportunity to expand the informal waste sectors role in collection to expand to marine plastic or other household waste if the economics are viable. However, these ideas also need further exploration to determine feasibility.

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<sup>58</sup> Interview with Jim Holm

## FURTHER QUESTIONS

My interviews were largely limited to the economic center of Koror, with small additions from Babeldaob Island, and bound to those already engaged in plastics, conservation, science, or government agencies. This limitation was largely due to the accessibility of people and my timeframe in this initial exploration. As such, there is an information gap in the perspectives of business and the dis-engaged general public. Further limitations result from little publicly available data on the waste stream, budgets, and marine debris. These limitations create ample opportunity for further research in Palau in regard to funding mechanisms, the role of the individual behavior, the composition of plastic, suitable technologies, and economic feasibility.

Key questions lie in finding funding sources. Start-up funds are required to kick-start initiatives and although some up-cycling solutions have the potential to be profitable, it is possible they will need subsidies. Questions arise in determining where this funding will come from and include: 1) What is the role of corporate responsibility in funding initiatives and thus taking action in managing waste and minimizing marine debris? 2) What is the role of government money in funding upcycling initiatives? 3) Can existing fee structures be expanded to further allocate money to up-cycling initiatives? 4) What is the role of outside money in the form of grants or subsidies?

The role of individual behavior also warrants further question in determining the creation of waste and marine plastics and in opportunities for involvement in up-cycling.

Questions include: 1) What is the role of the individual in creating plastic waste and marine plastics? I.e. what are the disposal options for plastics? 2) What practices create marine plastics? 3) What are the opportunities for expanded individual involvement in up-cycling? *i.e.* Can return of waste material to the recycling center be increased through extending or shifting operating hours? Can further segregation be incentivized? 4) What mechanisms are most effective for accomplishing increased individual involvement? Economic incentives? Education?

A thorough analysis of the composition of plastic on the shores and in the waste stream is also necessary to identify where opportunity for an appropriate volume and steady supply of feedstock. Analysis should include: 1) What plastics are not getting recycled or up-cycled in the waste stream? Why not? 2) What are the types and quantities of plastics on the beaches? 3) Where are the hot spots of marine plastics? And are they easily accessible?

A consideration of suitable technologies is also necessary for fully utilizable and lasting up-cycling. Considerations should include: 1) What options for technology are most suitable for the particular composition of plastic on the beach and in the waste stream? 2) What technologies are available for local implementation to overcome the challenge of lacking transportation pathways? 3) What is the scale of the technology? And what percentage of the waste stream or marine plastics would this manage?

An assessment of economic feasibility is another key aspect that must be addressed for lasting utilization of upcycling initiatives. This should address: 1) What product is needed and utilizable in Palau (or other nation)? 2) What is the demand for that product? 3) What supply can up-cycling initiatives provide?

## RECOMMENDATIONS

Because every place has a unique set of circumstances, the following recommendations are tailored to accomplish next steps in further utilization of up-cycling and better plastic management within Palau, or answer the most pertinent questions. Yet many of the same recommendations are applicable to other small island communities faced with a similar structure.

- Expand plastic waste collection from the other 15 states to the Koror recycling center to increase the existing capacity to up-cycle and recycle through:
  - Strengthening the role of National Government in collection.
  - Examining opportunities for alternative pathways such as supply boats, the Koror State Rangers patrol boats, the National Marine Sanctuary patrol boats, or other alternative pathways.
- Increase funding dedicated to supporting increased collection via a small increase in fee on Rock Island permits, departure tax, or other “tourist pays” mechanism.
- Magnify human capacity for the implementation of and follow through of up-cycling initiative by increasing communication and collaboration between engaged organizations, government agencies, businesses, and individuals. Through increased collaboration, more people can take on a smaller role in contrast to few individuals with a large role.
- Leverage the advantages of a small population with less influence on the global economy and thus less pushback from big industry to forward progressive laws to:
  - Prohibit use of products that have multiple-use replacements such as plastic bags, bottles, and Styrofoam take out containers.

- Financially incentivize recycling and up-cycling to overcome the lack of value on post-consumer plastics.
- Conduct further research on the economic feasibility of up-cycling initiatives through an analysis of the waste stream and the composition of plastics on the beaches to assess opportunities for a steady supply of plastic feedstock.

## **CONCLUSION**

This study unearthed more questions than answers to result in an initial exploration and provide a baseline of the challenges faced by small island communities in the utilization of up-cycling technologies. But perhaps more pertinently, it provides an understanding of the right questions to pursue in the future. More directed studies and future action that seek to answer questions about funding mechanisms, individual behavior, the composition of plastics, suitable technologies, and economic feasibility, can produce real and lasting up-cycling of plastics. Up-cycling of plastics can in turn reduce plastics to relieve stress on the environment, allowing it to remain healthy and biologically rich.

## APPENDIX A: LIST OF INTERVIEW RESPONDENTS IN PALAU

RESPONDENT		BUSINESS
Dermot	Keane	Sam's Tours
Mason	Whipps	Surangel & Sons Co.
RESPONDENT		KOROR STATE GOVERNMENT
Dora	Benhart	Coastal Management Office, Department of Conservation and Law Enforcement
Collin	Joseph	Coastal Management Office, Department of Conservation and Law Enforcement
Katsuo	Fuji	Solid Waste Management Office
Selby	Etibek	Solid Waste Management Office
RESPONDENT		NATIONAL GOVERNMENT
Joe	Reklai	Bureau of Public Works
Allison	Trout	Environmental Quality and Protection Board
Tarita	Holm	National Marine Sanctuaries
Calvin	Ikesiil	National Waste Management
Susan	Kloulechad	Palau Visitors Authority
Tutii	Chilton	Palau Visitors Authority Board Member
Frank	Kyota	Senator
Mason	Whipps	Senator
RESPONDENT		NGO/COMMUNITY ORGANIZATION
Madelsar	Ngiraingas	Belau Tourism Association
David	Mason	Chamber of Commerce
Patty	Kloulechad	Ebiil Society
Susan	Kloulechad	Ebiil Society
Joshua	Eberdong	Ebiil Society Turtle Monitoring Volunteer
Tarita	Holm	Heirs to Our Ocean Palau Chapter
Joyce	Beouch	Island Conservation
Yalap P.	Yalap	Palau Conservation Society
Steven	Victor	The Nature Conservancy
Sengai	Sablan	WestCare Foundation
Tublai	Ililau	WestCare Foundation
RESPONDENT		SCIENTIFIC RESEARCH CENTER
Lori	Colin	Coral Reef Restoration Center
Pat	Colin	Coral Reef Restoration Center
Yimnang	Golbuu	Palau International Coral Reef Center
RESPONDENT		OTHER
Brandi	Todd	U.S. Embassy

## APPENDIX B: LIST OF EXPERTS CONSULTED

RESPONDENT		ORGANIZATION
Carolynn	Box	5 Gyres
Marcus	Erikson	5 Gyres
Kristal	Ambrose	Bahamas Plastic Movement
Jim	Holm	Clean Oceans International
Michael	Cortina	Island School
Tony	Kingsbury	Kingsbury Consulting
Travis	Schramek	Scripps Institution of Oceanography
Jill	Boughton	Waste 2 Worth Innovations

## APPENDIX C: MARCH 2017 CLEANUP DATA - OUTER ISLANDS OF PALAU

ITEM	KAYANGEL	ANGAUR	PELILIU
Plastic Beverage Bottle	211	5778	2501
Foam	242	4617	752
Cups (Foam & Plastics)	106	1299	1132
Personal Care Products	0	2045	730
Bottle or Container Caps	159	1414	748
Other Containers or Jugs	178	1777	576
Flip Flops	146	1458	582
Food Wrap	36	480	190
Disposable Lighter	16	397	128
Glass Beverage Bottle	40	287	95



**APPENDIX D: TOP 10 MARINE DEBRIS ITEMS WORLDWIDE AND ON  
NGERKEKLAU ISLAND PALAU**

<b>RANK</b>	<b>WORLDWIDE</b>		<b>NGERKEKLAU ISLAND</b>	
1	Cigarettes Butts	2,127,565	Plastic/Foam Fragments	3,266
2	Plastic Beverage Bottles	1,024,470	Plastic Beverage Bottles	2,142
3	Food Wrappers	888,589	Flip-Flops	908
4	Plastic Bottle Caps	861,340	Other Jugs/Containers	880
5	Straws, Stirrers	439,571	Bottle Caps	864
6	Other Plastic Bags	424,934	Foam/Plastic Cups	728
7	Glass Beverage Bottles	402,375	Food Wrappers	307
8	Plastic Grocery Bags	402,122	Glass Bottles	241
9	Metal Bottle Caps	381,669	Cigarette Lighters	230
10	Plastic Lids	351,585	Rope Pieces	221
	<b>TOP 10 DEBRIS ITEMS</b>	<b>7,304,220</b>		<b>9,787</b>
	<b>TOTAL DEBRIS ITEMS</b>	<b>13,806,887</b>		<b>10,734</b>

*Source: Worldwide top 10 marine debris items sourced from the Ocean Conservancy's 2016 International Coastal Cleanup<sup>59</sup>. Ngerkeklau Island cleanups conducted through the Ebiil Society April – September 2016.*

<sup>59</sup> Ocean Conservancy 2016.

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