

# THE REDUCTION OF PLASTIC WASTE IN THE OCEAN

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# WPI



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# The Reduction of Plastic Waste in the Ocean

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# Abstract

Thailand is the sixth biggest contributor to ocean pollution in the world. Plastic pollution threatens marine ecosystems, coastal tourism, and human health. After collecting data in Krabi schools, we found that there is a correlation between the school's focus on raising plastic pollution awareness and students' waste management practices. We developed a virtual booklet for distribution to schools in Krabi, which provides educational materials on the detrimental effects of plastic pollution and teaches proper plastic waste management.

# Executive Summary

## The Problem

A 2016 study in Thailand found that an estimated 2.83 million tons of waste were disposed of improperly in coastal provinces, 12% of which was estimated to be plastic (The Ocean Conference, 2020). In Krabi, the negative impact of plastic pollution affects the local community and the marine ecosystem. As plastic waste may be left outside homes or in the streets, rain or wind storms can carry pollution into nearby rivers or streams. These rivers ultimately flow into sewers, and in Krabi, sewers are releasing wastewater straight into the ocean (Mueanhawong, 2019). Krabi has a wet season of eight months, where most of the rainfall in the year occurs and a high wind season of four months in a year (Weather in Krabi, 2016). The common weather patterns in Krabi cause inland pollution in Thailand to easily end up in the oceans.

## Our Goal

Our project team is faced with assessing the prevalence of plastic pollution in Krabi and developing a recommendation for our sponsor, the Population and Community Development Association (PDA), to clean up, manage, and prevent further plastic pollution in the oceans and beaches.

## Our Plan

Our first objective was to assess the causes and effects of plastic pollution found in the ocean in Krabi, Thailand. To fulfill this objective, our team interviewed two professors from the Department of Marine Science at Chulalongkorn University. We also observed waste management behavior relative to beaches and oceans. To further assess the causes and effects of plastic pollution, our team interviewed members of the Department of Marine and Coastal Resources and employees of the Hat Noppharat Thara-Mu Koh Phi Phi National Park and four parents of students at the Baan Gor Tong School. While our team was in Krabi, we were able to visit three schools; the Uttarakit School, the Wat Pho Riang School, and the Baan Gor Tong School. At these schools, we conducted interviews with teachers and distributed surveys to the students.

Our second objective was to gain a greater understanding of waste management methods in Krabi. To fulfill this objective, our team interviewed teachers at Krabi schools and observed the waste management behavior of the students and faculty. We also interviewed a current member of Krabi's Municipality and a former government official and environmentalist from the

Krabi Province to gain a greater understanding of current waste management methods being utilized in Krabi.

Our third objective was to develop recommendations for PDA to reduce plastic pollution in Krabi based on our findings.

## Findings & Recommendations

Our recommendations that we proposed to PDA were formed after assessing the detrimental effects of plastic pollution in the ocean and gaining a greater understanding of current waste management practices in Krabi. **We found that spreading awareness and providing education on the plastic pollution problem is essential in reducing the amount of plastic pollution in the ocean and on the shores of Krabi.** In our interview with Chuan Pukaoluan, a former government official and environmentalist in the Ao Nang Subdistrict, he stated that spreading awareness and providing education on the plastic pollution problem is essential in reducing the amount of plastic pollution in the ocean and on the shores of Krabi. Furthermore, in our interview with Dr. Suchana Chavanit from Chulalongkorn University, she stated that educating younger community members is more beneficial in the long term because it will allow them to grow up with an increased awareness of the plastic pollution problem. Additionally, when we surveyed students from Krabi schools, we found that 46% of students overall believe that the level of pollution in Thailand is average or less than average, compared to the world. We believe that this response is due to the students being desensitized to high levels of plastic pollution that have been in their community their entire lives.

As a result of our interview with Chuan Pukaoluan, **we found that reducing plastic pollution in the Ao Nang Subdistrict reduces plastic pollution on Ao Nang Beach.** Pukaoluan reported that pollution left in public places, such as on streets or outside households, can easily flow into rivers after wind or rainstorms, or directly into oceans. He informed our team that to reduce plastic pollution into the ocean, it is essential to focus on reducing land pollution.

Based on our interview with Chat Chalarat, chief of Phuket's mangrove forest development station in the Department of Marine and Coastal Resources, **we found that communication is essential between the government, schools, local businesses, waste management facilities, and environmental departments to dispose of plastic waste properly.** In the Uttarakit School we observed that after the waste was initially separated, the separated waste was then all combined and mixed together into one bin where different types of waste, such as plastics or compostable materials, are all brought to a power plant and burned together to produce energy. This defeats the purpose of separating waste in the first place. If there was more

communication between the school and the government, the waste that the school separates can be brought to a recycling plant to be renewed.

From our interview with the park ranger, Krisada Thirawut, and assistant academic marine biologist, Narakorn Kalaya, from the Hat Noppharat Thara- Mu Koh Phi Phi National Park, **we discovered that plastic pollution has decreased in Krabi since the onset of the COVID-19 pandemic.** With a further explanation from these members of the national park, our team understood this decrease had a direct correlation to the borders being shut down at the beginning of the COVID-19 pandemic. In an interview with Sarat Giangkong, Director of Engineering Division, Town Municipality of Krabi, stated that the COVID-19 pandemic reduced the amount of waste they disposed of by approximately 40% as a result of less waste being produced. In the past, the Municipality received 180 tons of waste a day, but due to the pandemic, they currently receive 120 tons of waste a day. This statistic shows that still, 50% of plastic pollution in Krabi comes from tourism. We have deduced that the remaining 50% of plastic pollution comes from households, local businesses, schools, and the fishing industry.

Additionally, in our interview with Sarat Giangkong, **we found that waste-to-energy power plants serve to be beneficial in reducing the amount of plastic pollution in landfills.** These power plants are converting the waste in landfills into energy which will help convert 128,000 square meters (32 acres) of the landfill into a public park for the community. He stated that Krabi's landfills will become obsolete within 10 years as there will be no need for them as all the waste will be processed in the power plant. He also reported that plastic is the best energy generator when incinerated in the power plant. Despite the fact that incinerating waste in power plants results in zero waste, environmentally harmful emissions are produced from burning plastics.

Our team developed a virtual booklet that can be distributed to schools in Krabi by the Population and Community Development Association. The goal of this booklet is to provide schools with resources that will enable them to better educate their students on the detrimental effects of plastic pollution and teach proper plastic waste management. This will include how to raise awareness about the plastic pollution problem, improve waste management practices, reduce plastic use, and encourage these practices in the community. This booklet will ultimately help in reducing plastic pollution in schools and communities. In the future, the booklet could potentially be modified for use in other schools in Thailand.

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# Chapter I: Introduction

Plastic is a synthetic organic polymer that can take up to 500 years to decompose (The Lifecycle of Plastics, 2018). This means that any plastic disposed of improperly; left in waterways, empty streets, open fields, etc., can remain there for centuries to come. As plastics are lightweight, durable, and cheap to manufacture, they have become a convenient option for both producers and consumers. Over the past decade, it has been estimated that the amount of plastic pollution has been and will continue to increase by 2% annually (Chinda, 2014). This increase in total generated waste supports the notion that Thailand must introduce waste management methods that are easily accessible for all community members. Moreover, Thailand is the sixth biggest contributor of ocean pollution in the world, generating approximately 2 million tons of plastic waste annually (McKinsey Center & Ocean Conservancy, 2015).

To address plastic pollution in Krabi, pictured in Figure 1 below, the Sustainable Development Goals set by the United Nations General Assembly were taken into consideration. The Sustainable Development Goals are a collection of interlinked global goals designed to achieve a more sustainable future for humanity, intended to be met by 2030 (Department of Economic and Social Affairs, 2015). The Sustainable Development Goal 14 (SDG14) stresses the need to conserve and sustainably use the world's oceans, seas, and marine resources. Oceans are our planet's life support and regulate the global climate system. They are the world's largest ecosystem, home to nearly a million known species, and contain a vast untapped potential for scientific discovery. Oceans and fisheries continue to support the global population's economic, social and environmental needs. Despite the critical importance of conserving oceans, decades of irresponsible exploitation have led to an alarming level of degradation of marine ecosystems. Thailand's current efforts to protect key marine environments and small-scale fisheries, and to invest in ocean science are not yet meeting the urgent need to safeguard this vast, yet fragile, resource.

This project pursued the SDG14 targets related to protecting the marine environment, which are to reduce marine pollution, protect and restore ecosystems, and conserve coastal and marine areas. The first target requires that countries prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution by 2050. The second target aims to sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including strengthening the community's resilience and taking action for coastal ecosystem restoration to achieve healthy and clean oceans. The third target involves conserving at least 10% of coastal and marine areas, defined by national and international law (Department of Economic and Social Affairs, 2015).

Figure 1: Map of Krabi Province



Note: Map of Thailand, with Krabi Province, highlighted yellow

Our team worked in collaboration with our sponsor, the Population and Community Development Association (PDA), Krabi Center. PDA’s focus is on education and social projects, as their mission statement is “to advocate for and improve the quality of life development in coordination with the government and transfer knowledge and experience to the people for sustainable development” (Devex, 2020).

The Population and Community Development Association of Krabi, Thailand gave our team the task of assessing the prevalence of plastic pollution in Krabi, Thailand, and developing a recommendation to clean up, manage, or prevent further plastic pollution in the oceans or beaches.

## Chapter II: Background

*Our team has constructed the following objectives to reach our goal for our sponsor, the Population and Community Development Association:*

- 1. Assess the Causes and Effects of Plastic Pollution Found in the Ocean in Krabi, Thailand.*
- 2. Gain a Greater Understanding of Waste Management Methods in Krabi.*
- 3. Develop Recommendations for PDA to Reduce the Plastic Pollution in Krabi.*

### 2.1 Plastic Waste Problem in Thailand and Worldwide

#### 2.1.1 Detrimental Effects of Plastic Pollution in the Ocean

Plastic pollution in the ocean is the accumulation of plastic objects and particles in the marine environment that adversely affects the ecosystem (Moore, 2020). Thailand has been named the sixth highest contributor to plastic pollution entering the oceans (Thai EMBDC, 2020).

Worldwide, approximately eight million tons of plastic end up in the ocean each year, and this number continues to increase as plastic consumption ensues. Plastic makes up approximately 80% of all waste found in our oceans (Marine Plastics, 2018). A 2016 study in Thailand found that an estimated 2.83 million tons of waste was disposed of improperly in coastal provinces. It was estimated that 12% of this waste was plastic (The Ocean Conference, 2020).

Plastic accumulation on the ocean floor results in inhibited gas exchange among coral, resulting in hypoxia, or oxygen deficiency, and coral bleaching (Derraik, 2002). From April to June 2016, it was discovered that 30% to 70% of the coral in these reefs were bleached as a result of pollutants that caused a change in sea temperature and salinity (Skulpichetrat, 2011).

Thailand's marine life is negatively affected by plastic indigestion and entanglement in drift nets, fishing lines, and packaging debris (Derraik, 2002). Through consumption, fish and other marine life are poisoned by toxic chemicals, such as persistent organic pollutants, found in plastic. Additionally, plastic pollution has been shown to negatively impact human health. Plastic objects, including bottles or bags, break down into pieces over the course of years (Marine Pollution, 2019). Fish consume pieces of plastic and the plastic leaches toxic chemicals into the fish's body (Marine Plastics, 2018). The addition of plastic toxins into the food chain, then poses a threat to human health.



## 2.1.2 How Pollution Flows From Thailand's Inland to the Ocean

Plastic pollution occurs when plastic products are directly deposited into the ocean or carried into the ocean from inland sources. Rain or wind can carry pollution into nearby rivers streams, and sewers which ultimately flow into the ocean (Mueanhawong, 2019). Krabi has a wet season of eight months, where most of the rainfall in the year occurs and a high wind season of four months in a year (Weather in Krabi, 2016). These weather patterns cause inland pollution in Thailand to easily end up in the oceans.

## 2.2 Waste Management in Thailand

### 2.2.1 Waste Management Practices and Recycling in Thailand

Waste management is defined as the activities and actions required to manage waste from its inception to its final disposal. Waste management is intended to reduce adverse effects of waste on human health, the environment, and natural resources (Waste Management, 2021). Waste management strategies include waste collection, material recovery facilities, incineration and energy recovery facilities, biological treatment of organic waste, and properly managed landfills.

Landfills and recycling facilities are the predominant means of waste management in Thailand. There are 112 landfills located in Thailand. The high volume of plastic produced in Thailand has resulted in 11 of these landfills facing overload capacities (Chinda, 2012). This matter has forced Thailand to invest in alternative waste management processes such as waste to energy power plants.

The Absolute Clean Energy Public Company Limited (ACE), is a power plant in Krabi Province that opened in December 2020 (MSW Krabi power plant, 2020). It produces and distributes renewable electricity by burning waste. The power plant can burn all types of solid waste such as paper, plastic, rubber, cloth, and food waste. ACE services the 14 municipalities in the Krabi area and the 48 sub-district administrative organizations to produce electricity. Burning different types of waste, such as plastics, results in toxic air emissions, such as the pollutants mentioned in Appendix A.

Waste banks in Thailand function as a community-based business that values waste as an economic commodity and asset (Wijayanti, 2015). Approximately 86% of Thailand's waste is found to be organic waste, paper, plastic, glass, and metal (Kaosol, 2009). Waste banks act as an intermediary service between the community and recycling plants and incentivizes the community to exchange their separated waste for money.

## 2.2.2 Government Recycling Incentives and Campaigns in Thailand

In a statement taken from Thailand's Country Director for Greenpeace Southeast Asia, Tara Buakamsri said, "Unless legally binding mechanisms are implemented, to reduce the impact of single-use plastic products on the environment, the roadmap will only be to raise public awareness and support voluntary measures but with no significant progress," (Greenpeace Southeast Asia, 2017). In response to plastic pollution, Thailand has enacted several campaigns, initiatives, and incentives to reduce waste pollution.

In October 2019, The Tourism Authority of Thailand (TAT) launched a major waste reduction, recycling, and clean-up project designed to convert highly populated areas into Zero Waste Cities. Zero Waste Cities are areas in which all waste that is generated is repurposed, renewed or burned and converted into energy. To manage the pollution, the TRASH Project was established. TRASH Project is an organization in which schools and communities are given resources and taught how to properly manage all forms of waste (TAT News, 2019).

In 2005, Professor Mongkolnchaiarunya, from Thammasat University in Bangkok, reviewed the effectiveness of a waste management incentive, called the Garbage for Eggs Program (GFE), for the city of Yala in Southern Thailand. GFE required the communities' cooperation in separating waste in exchange for eggs. To account for socioeconomic, environmental and regional factors, the number of eggs given depended not only on the amount and types of the recyclables brought in, but also on the quality of the separated waste, the participant's needs for eggs, and the level of community participation. GFE began in May 2000, and by the end of June 2001, 49,380 eggs were given in exchange for the collected waste. On average, 1.35 kg of recyclables is exchanged for each egg (Mongkolnchaiarunya, 2005). This study has shown that incentivized projects can be key to clean a community and can raise awareness for recycling.

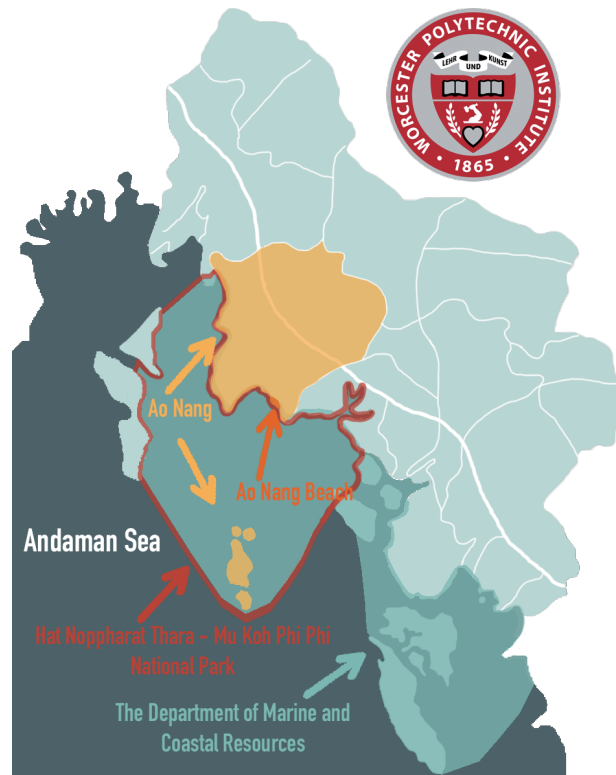
In another study named Co-Benefits of Household Waste Recycling for Local Community's Sustainable Waste Management in Thailand, conducted by the Environmental Engineering and Management Departments of Chulalongkorn University, graduate students assessed the benefits of the implementation of a Community Based Management Program (CBM) (Challcharoewattana, 2015). Findings from the study suggested that curbside recycling services, community-wide collaboration, understanding the benefits from recycling, and fair pricing of recyclables, made the program a success. The study found that with a CBM, 172.20 kg of waste can be recycled per participating person per year, which is about 926% higher than average waste management programs with recycling in Thailand (Challcharoewattana, 2015).

## 2.3 Environmental Advocacy Organizations in Krabi

In order to prevent further plastic pollution within the Andaman Sea, the Department of Marine and Coastal Resources, members of the Hat Noppharat Thara-Mu Koh Phi Phi National Park, and beach clean up organizations work alongside one another to clean up waste and educate visitors about ocean pollution.

The Department of Marine and Coastal Resources (DMCR) seeks to “secure an abundance of resources and achieve ecological balance to promote national, economic and social development,” (Department of Marine and Coastal Resources, Thailand, 2020). This is done through educational seminars, training divers to clean up ocean pollution, and organizing beach clean-ups. This department covers the coastal areas of the Krabi Province, including the town of Ao Nang, as shown in Figure 2 below.

**Figure 2: Key Locations in Krabi**



*Note: Map of Krabi Province, key locations including the Ao Nang Subdistrict, Ao Nang Beach, the Hat Noppharat Thara-Mu Koh Phi Phi National Park, and the area in which the Department of Marine and Coastal Resources oversees.*

Employees of the Hat Noppharat Thara-Mu Koh Phi Phi National Park work with the DMCR to organize beach clean-ups on the Ao Nang Beach. They aid in cleaning the national

park daily in order to retain its beauty. The Hat Noppharat Thara-Mu Koh Phi Phi National Park is labelled in Figure 2 above.

Nonprofit organizations that are already helping to clean up Thailand's shores and raise plastic pollution awareness include TRASH HERO and Adang Sea Divers. TRASH HERO is an organization with the mission to bring communities together to clean and reduce waste, through action and awareness, sustainable projects, and education (Trash Hero, 2020). The Adang Sea Divers is a tourist attraction that educates visitors on ocean pollution in coral reefs. In addition to educating visitors, the Adang Sea Divers collect plastic pollution on the seafloor and on coral beds (Conservation Projects Thailand, 2020).

## Chapter III: Methodology

Our team worked with our sponsor, the Population and Community Development Association, Krabi Center to develop plastic waste reduction methods following their mission of improving the Krabi community's quality of life through social development.

### 3.1 Objective 1: Assess the Causes and Effects of Plastic Pollution Found in the Ocean in Krabi, Thailand.

To assess the causes and effects of ocean pollution, our team surveyed students at Uttarakit School, Wat Pho Riang School, and Baan Gor Tong School, and observed the waste management at Ao Nang Beach. We also interviewed four parents of students in Krabi, professors Dr. Suchana Chavanit and Dr. Somrudee Jitpraphai from the Department of Marine Science at Chulalongkorn University, Chat Chalarat from the Department of Marine and Coastal Resources, and Krisada Thirawut and Narakorn Kalaya from the Hat Noppharat Thara-Mu Koh Phi Phi National Park. From these data collection methods, our team was able to understand where beach pollution comes from, the reason beach pollution is so prevalent, local community members' perception of pollution, and how pollution affects the environment. More information about our subjects and the information we gathered can be found below.

#### 3.1.1 Interview With Chulalongkorn University Marine Science Professors

Our team interviewed Assoc. Prof. Dr. Suchana Chavanit and Prof. Somrudee (Meprasert) Jitpraphai, both from the Department of Marine Science at Chulalongkorn University. Dr. Chavanit's research interests include marine biology, coral reef ecology, and polar science. Dr. Jitpraphai's research interests include integrated coastal management, coastal hazards and adaptations, marine and coastal tourism, and marine science education. These interviews provided our team with statistics about plastic and ocean pollution and how to best educate students on environmental issues. Some of the questions we asked included the current state of ocean pollution in Thailand, how plastic pollution affects marine life, and the effect education has on reducing plastic pollution. Professor Jitpraphai gave us recommendations on subjects to focus on as well as how to further improve our project. The interview was conducted in person and the questions asked and answers provided can be found in Appendix B.

#### 3.1.2 Interview With Parents of Students Who Attend Baan Gor Tong School

Our team interviewed four parents of students who attend Baan Gor Tong School in Krabi. We chose this school to interview parents from because they had a strong waste

management program, where they were already working towards generating zero waste. As parents came to pick up their children at the end of the school day, our team asked if they would be willing to participate in an interview for our project. From these interviews, our team gained an understanding of how students' awareness on the issue can be brought home to develop a change in their homes and the community. To gain this understanding, questions such as how often people use plastic bags, how often they separate their waste, how much they know about the current situation of plastic pollution in their community, what their recycling practices are, and how they view the impact of pollution in their daily lives were asked. The interviews were conducted in person. The interview questions and answers provided can be found in Appendix C.

### 3.1.3 Survey Students of Krabi Schools

Our team distributed a survey to school students in Krabi. The schools surveyed were Uttarakit School, Wat Pho Riang School, and Baan Gor Tong School. Uttarakit School is a large-scale primary school of about 900 students. Wat Pho Riang School teaches 355 children ranging from kindergarten to middle school students. Finally, Baan Gor Tong School doubles as an elementary school and middle school, which holds 140 students. These schools were chosen based on recommendations from PDA. The surveys provided our team with insight on how children in Krabi view pollution based on their awareness of it, and their willingness to actively make changes to reduce waste. Some questions in our survey included asking how students recycle at home and in school, how effective recycling education has been in their school, and how much they know about the situation of plastic pollution. The survey population ranged from ages 7 to 16. We received 241 total responses from Uttarakit School, Wat Pho Riang School, and Baan Gor Tong School. The surveys were administered by teachers, as a Google Form. The survey questions and results can be found in Appendix D.

### 3.1.4 Interview With Members from the Department of Marine and Coastal Resources and the Hat Noppharat Thara-Mu Koh Phi Phi National Park

To assess the causes and effects of plastic pollution found in the ocean, our team interviewed a member from the Department of Marine and Coastal Resources (DMCR) and two employees from the Hat Noppharat Thara- Mu Koh Phi Phi National Park. In one interview, our team interviewed Chat Chalarat, chief of Phuket's mangrove forest development station at the DMCR. In a separate interview Krisada Thiraut, a park ranger and diver, and Narakorn Kalaya, an assistant academic marine biologist, who both work at the Hat Noppharat Thara- Mu Koh Phi Phi National Park, were interviewed. The DMCR, which conserves and rehabilitates the coastal marine flora and fauna, works alongside Hat Noppharat Thara-Mu Koh Phi Phi National Park. These interviews provided our team with information on the amount of pollution found in the

ocean and on beaches and how tourists and the local community members dispose of their waste. Some questions asked about efforts to reduce pollution, and what the source of pollution is. The interviews were conducted in person. The interview questions and answers provided can be found in Appendix E.

### 3.1.5 Observe Waste Management Behavior Relative to Beach and Ocean Pollution

Our team observed waste management workers and tourists on Ao Nang beach in Krabi. This beach was recommended for observation by our sponsor because it is a highly visited beach, and is local to Krabi. Our observations included taking images of pollution, with a focus on plastic pollution, and taking notes on where trash and recycling cans are located and how they were utilized. This information can be used to understand how pollution is managed directly on a Krabi beach. Observations that were focused on and recorded can be found in Appendix F.

## 3.2 Objective 2: Gain a Greater Understanding of Waste Management Methods in Krabi.

To obtain sustainable management practices, our team interviewed Apisit Suknui who is a previous government official in Krabi Province, Sarat Giangkong who is the Director of the Engineering Division of Krabi's waste management facility, Kru (teacher) Wantip from Uttarakit School, Kru Monthip from Wat Pho Riang School, and Kru Onnicha from Baan Gor Tong School, and observed students waste management behavior in the above-mentioned schools. From these data collection methods, our team was able to understand how waste is managed in schools and households, who collects waste, and what facilities dispose of waste. More information about our subjects and information gathered can be found below.

### 3.2.1 Interviews With School Teachers

Our team interviewed Kru Wantip, Kru Charada, Kru Monthip and Kru Onnicha from Uttarakit School, Wat Pho Riang School, and Baan Gor Tong School respectively. For descriptions of these schools see Section 2.3. These interviews provided our team with a deeper understanding of existing recycling educational programs that exist in schools, any environmental awareness curriculum taught, and the importance of educating students on waste management. Some questions included asking about how the school manages waste, and what efforts are made in the school to reduce waste. The interview questions asked and answers provided can be found in Appendix G.

### 3.2.2 Observe Waste Management Behavior in Schools

Our team observed students at Uttarakit School, Wat Phot Riang School, and Baan Gor Tong School. Our observations included taking images of waste bins for separated materials, and pollution on school grounds. This information can be used to understand how local Krabi schools practice waste management to reduce pollution. Observations that were focused on and recorded can be found in Appendix H.

### 3.2.3 Interview with a Former Government Official in Krabi Province

Our team interviewed Mr. Chuan Pukaoluan, a former government official in Krabi Province and environmentalist. This interview provided our team with opinions and perspectives on plastic pollution in Krabi from a governmental viewpoint, and what the government is doing to prevent mass pollution. Some questions included asking about regulations in place to manage pollution, and his opinions on what can further be done. The questions asked and answers provided can be found in Appendix I.

### 3.2.4 Interview With a Member of Krabi's Municipality

Our team interviewed Sarat Giangkong, the Director of the Engineering Division for the Municipality of Krabi. This interview provided our team with a better understanding of Krabi's waste management organizations and statistics on waste in Krabi. Questions included asking about the processes used to collect waste, the types of waste brought into the facility, and the results of burning particular types of waste, including plastics. The questions asked and answers provided can be found in Appendix J.

## 3.3 Objective 3: Develop Recommendations for PDA to Reduce the Plastic Pollution in Krabi.

Once ample data was collected, we conducted a series of group discussions among our team members and advisors to formulate recommendations. Once we received feedback from our sponsor, PDA, we compiled our final recommendations and presented them to PDA. For more information on our final deliverables refer to Chapter V.

## 3.4 Challenges and Limitations

Throughout this project, there have been many obstacles that have impeded our group's ability to conduct our project as expected. Due to the COVID-19 pandemic, it was difficult to gather current and relevant statistics on plastic pollution in the Krabi area, as the focus of



concern on pollution has shifted to COVID-19. Along with this, the majority of pollution statistics available online were based on Thailand as a whole, and not specific regions of Thailand, such as the Krabi Province.

Direct data collection from our team, such as observations of waste management behavior relative to beach and ocean pollution, were affected by COVID-19 as well. Through observing plastic pollution found on public beaches, our team noticed less pollution than expected based on statistics found in past years from background research.

## Chapter IV: Findings

As explained in Chapter III, our team conducted interviews, surveys, and observed waste management behavior to assess pollution in Krabi, and the behaviors of the Krabi community concerning recycling and plastic pollution. By comparing all the data and information collected, our team gathered key pieces of information that we used to develop our recommendations, as demonstrated in Chapter V.

Our recommendations that we proposed to PDA were formed after assessing the detrimental effects of plastic pollution in the ocean and gaining a greater understanding of current waste management practices in Krabi. We found that spreading awareness and providing education on the plastic pollution problem is essential in reducing the amount of plastic pollution in the ocean and on the shores of Krabi. In our interview with Chuan Pukaoluan, a former government official and environmentalist in the Ao Nang Subdistrict, he stated that spreading awareness and providing education on the plastic pollution problem is essential in reducing the amount of plastic pollution in the ocean and on the shores of Krabi. Furthermore, in our interview with Dr. Suchana Chavanit from Chulalongkorn University, she stated that educating younger community members is more beneficial in the long term because it will allow them to grow up with an increased awareness of the plastic pollution problem. Additionally, when we surveyed students from Krabi schools, we found that 46% of students overall believe that the level of pollution in Thailand is average or less than average, compared to the world. We believe that this response is due to the students being desensitized to high levels of plastic pollution that have been in their community their entire lives.

As a result of our interview with Chuan Pukaoluan, we found that reducing plastic pollution in the Ao Nang Subdistrict reduces plastic pollution on Ao Nang Beach. Pukaoluan reported that pollution left in public places, such as on streets or outside households, can easily flow into rivers after wind or rainstorms, or directly into oceans. He informed our team that to reduce plastic pollution into the ocean, it is essential to focus on reducing land pollution.

Based on our interview with Chat Chalarat, chief of Phuket's mangrove forest development station in the Department of Marine and Coastal Resources, we found that communication is essential between the government, schools, local businesses, waste management facilities, and environmental departments to dispose of plastic waste properly. In the Uttarakit School we observed that after the waste was initially separated, the separated waste was then all combined and mixed together into one bin where different types of waste, such as plastics or compostable materials, are all brought to a power plant and burned together to produce energy. This defeats the purpose of separating waste in the first place. If there was more communication between the school and the government, the waste that the school separates can be brought to a recycling plant to be renewed.

From our interview with the park ranger, Krisada Thirawut, and assistant academic marine biologist, Narakorn Kalaya, from the Hat Noppharat Thara- Mu Koh Phi Phi National Park, we discovered that plastic pollution has decreased in Krabi since the onset of the COVID-19 pandemic. With a further explanation from these members of the national park, our team understood this decrease had a direct correlation to the borders being shut down at the beginning of the COVID-19 pandemic. In an interview with Sarat Giangkong, Director of Engineering Division, Town Municipality of Krabi, stated that the COVID-19 pandemic reduced the amount of waste they disposed of by approximately 40% as a result of less waste being produced. In the past, the Municipality received 180 tons of waste a day, but due to the pandemic, they currently receive 120 tons of waste a day. This statistic shows that still, 50% of plastic pollution in Krabi comes from tourism. We have deduced that the remaining 50% of plastic pollution comes from households, local businesses, schools, and the fishing industry.

Additionally, in our interview with Sarat Giangkong, we found that waste-to-energy power plants serve to be beneficial in reducing the amount of plastic pollution in landfills. These power plants are converting the waste in landfills into energy which will help convert 128,000 square meters (32 acres) of the landfill into a public park for the community. He stated that Krabi's landfills will become obsolete within 10 years as there will be no need for them as all the waste will be processed in the power plant. He also reported that plastic is the best energy generator when incinerated in the power plant. Despite the fact that incinerating waste in power plants results in zero waste, environmentally harmful emissions are produced from burning plastics. Additionally, in our interview with Sarat Giangkong, we found that waste to energy power plants serves to be beneficial in reducing the amount of plastic pollution in landfills. These power plants are converting the waste in landfills into energy which will help convert 128,000 square meters (32 acres) of the landfill into a public park for the community. He stated that Krabi's landfills will become obsolete within 10 years as there will be no need for them as all the waste will be processed in the power plant. He also reported that plastic is the best energy generator when incinerated in the power plant. Despite the fact that incinerating waste in power plants results in zero waste, environmentally harmful emissions are produced from burning plastics. For more information on toxins due to burning waste, refer to Appendix A.

## Chapter V: Recommendations

Our team developed a virtual booklet that can be distributed to schools in Krabi by the Population and Community Development Association. The goal of this booklet is to provide schools with resources that will enable them to better educate their students on the detrimental effects of plastic pollution and proper plastic waste management practices. This will include how to raise awareness about the plastic pollution problem, improve waste management practices, reduce plastic use, and incorporate the community in these practices. This booklet will ultimately help in reducing plastic pollution in schools and communities. In the future, the booklet could potentially be modified to relate to other Thailand schools. To access this booklet go to <https://documentcloud.adobe.com/link/track?uri=urn:aaid:scds:US:4aac612f-e9a6-4aa2-a6a4-7cc6a9d72a99>.

Our second recommendation to PDA is to consider sponsoring a future project that will connect government departments, schools, waste management facilities, and environmental departments in Krabi to increase efficiency in waste management. The Uttarakit School expressed how their waste management system is proficient inside the school, but the waste is being collected all together in one bin, and is now brought to the power plant to be burned. An extra step can be taken to ensure each type of waste is brought to proper disposal locations, such as recycling centers for plastic materials, to reduce the toxic emissions brought along with the plastic burning. The goal of this recommendation is to bring the idea to PDA so that this line of communication can be further developed in the future.

## Chapter VI: Conclusions

Krabi is a coastal province in southern Thailand contributing high amounts of plastic pollution to the ocean. The Population and Community Development Association (PDA) assigned our team to develop a recommendation to clean up, manage, or prevent further plastic pollution in the oceans or beaches. In order to accomplish this, our team had made objectives to; assess the causes and effects of plastic pollution found in the ocean in Krabi, gain a greater understanding of waste management methods in Krabi, and develop recommendations for PDA to reduce the plastic pollution in Krabi. After conducting interviews, surveys, and recording observations, we found that raising awareness of plastic pollution and educating the Krabi community on proper waste management methods would be the best means to manage and prevent plastic pollution. In a community where high levels of plastic pollution has been normalized, informing people of the detrimental effects of plastic pollution and the benefits of reducing, reusing and recycling plastic will promote behavioral change.

In order to educate and spread awareness, our team developed a virtual booklet for PDA, that can be shared with schools in Krabi. This booklet, “Reduce, Reuse, Recycle: A Guideline for Krabi Schools,” provides ways in which schools can spread awareness, manage their waste, and clean up pollution. For each method that can be completed, we offer resources to help accomplish each step. If schools effectively follow the steps in the booklet, plastic pollution will be reduced in Krabi schools and communities, which will reduce potential plastic pollution in the ocean. In the future, this booklet can be adapted to guide all schools in Thailand, to continue to improve the plastic pollution situation.

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## Appendices:

### Appendix A: Toxins Released Through Burning Waste

<b>Polymer</b>	<b>Pollutant(s) Released</b>	<b>Health Hazard(s)</b>
Polyethylene	Carbon Monoxide	Makes the body lack oxygen.
Polyvinyl chloride	Vinyl chloride Hydrochloric Acid Phosgene Dioxins Furans	Harmful to the liver and carcinogenic. Irritates the skin and respiratory system.
Polystyrene	Styrene Benzene	Harmful to the liver and nervous system, and is a carcinogen.
Fluoropolymer	Carbonyl fluoride Perfluoroisobutylene Hydrogen fluoride	Irritates the skin and respiratory system.
Fluoropolymer	Aldehyde Ammonia Cyanide Isocyanate Nitrogen dioxide	Harmful to the heart and brain. Irritates the skin and respiratory system.
Phenolic	Formaldehyde Aldehyde Ammonia Cyanide Nitrogen dioxide	Harmful to the heart, brain and respiratory system.

## Appendix B: Interviewing Chulalongkorn University Professors

Interviewing Assoc. Prof. Dr. Suchana Chavanit and Asst. Prof. Dr. Somrudee Jitprapai from Chulalongkorn's Department of Marine Science provided our team with direct information about ocean pollution in Krabi, along with an understanding of what tactics professors have found to be the most successful when it comes to educating others. Below is a list of interview questions used to guide the interview with Professor Chavanit as well as the answers we received from her. The recommendations we received from Professor Jitprapai are listed below the interview questions and answers. This interview was conducted in Thai and translated into English.

Interview Responses from Assoc. Prof. Dr. Suchana Chavanit:

1. *Could you describe the current situation of plastic waste in the ocean at this moment?*

Chavanit: Since 1957, plastic waste has created a pollution problem in the ocean. People are starting to become aware of the plastic pollution crisis. The first reason is that nowadays people are starting to conserve the environment. This creates an impact among other people. The second reason is that Thailand is ranked the 6th in the world for the worst waste management in the world which has started to make people have awareness on plastic waste.

2. *What specific areas or regions produce the most plastic waste into the ocean?*

Chavanit: Areas that contain a lot of tourists contain a lot of plastic waste, areas where there are fishers contain fishing nets, and areas in which there are tourists and fishers contain nets and plastic waste from tourist activities.

3. *What method have you found to be the most helpful in reducing plastic waste in the ocean?*

Chavanit: First, there needs to be good waste management. The waste on land needs to be cleaned up because once the waste goes into the ocean, there is a small chance it gets cleaned up, and it's hard to clean up all the waste. Second, coastal areas need to raise awareness to tourists on plastic pollution as tourists often throw their waste into the ocean after their excursions.

4. *Do you think an educational program directed to school students would help with the reduction of plastic waste in the ocean?*

Chavanit: Yes I believe this education is effective in raising awareness about plastic pollution. This is because educating children is easier than educating adults, as adults would rather do what benefits themselves. Thai people like to look for a short term fix rather than a long term fix. The education you implement needs to be adjusted to the area, Some schools don't have the technology to support advanced projects.

5. *How has Thailand, in the past and currently, worked to solve the problem of plastic waste in the ocean?*

Chavanit: Thai scientists are aware of the plastic pollution in Thailand but cannot deliver the message to people. Social media is needed to help raise awareness and spread what the scientists know.

6. *In your opinion, where should a focus be put to reduce plastic waste in the ocean? (i.e. organizations, government, waste management facilities, etc.)*

Chavanit: The waste management system needs to be improved. Everyone should participate in waste management

7. *Do you agree with the following statement? "There are many plastic waste reduction programs in Thailand, but the results of these programs are not as good as they should be."*

Chavanit: Yes, some programs don't work at all.

- a. *If you agree with this statement, what are the reasons and factors which cause this situation?*

Chavanit: We need to focus on the long term more than in the short term.

8. *What roles do you think villagers, tourists, or students should be taking to ensure the sustainability of marine resources? (SDG14)*

Chavanit: Everyone should help to reduce plastic waste and ensure the sustainability of marine resources

9. *As a member of the Department of Marine Science, have you considered working with a beach clean-up organization to create a recycling education program for students?*

Chavanit: The trick for educating students is to use pictures to tell the story which is easier than telling the theory. Numbers are used to better educate adults.

10. *What specific types of organizations have you found to be most successful in cleaning up pollution? (i.e. ocean clean-up, beach clean-up, educational organizations, etc.)*

Chavanit: The Samae San village has activities among their community on the awareness of plastic waste. The community clean-up waste on the beach every month

11. *Do you have any additional advice for our team to reach our goal?*

Chavanit: You might need to adapt your thoughts to adjust to their community and your tools might need to adapt to their living

Advice from Asst. Prof. Dr. Somrudee Jitprapai:

1. Focus on what the problem is, the places impacted, and time
  - a. The problem
    - i. The plastic waste problem comes from wind carrying waste into the ocean

- ii. Analyze the problem using SWOT analysis
      - 1. Strengths, Weaknesses, Opportunities, Threats
  - b. Places
    - i. Where is the location relative to the ocean?
  - c. Time
    - i. Season/Time of year
      - 1. Consider the weather
- 2. Research Saen Suk Municipality and their ban on single use plastic
- 3. Use Chulalongkorn University's Zero Waste program as an example when formulating recommendations
- 4. Consider the United Nations proposed Sustainable Development Goal (SDG) 14 which focuses on Life Below Water

## Appendix C: Interview With Parents of Students Who Attend Baan Gor Tong School

Interviewing four parents of students at Baan Gor Tong school provided our team with better insight on Krabi community members' opinions on plastic, and how the awareness and education of plastic pollution and waste management in the school had impacted their households. The interviews were performed in person. It was a group interview around a table and all responses below are a summary of what was discussed. Below is a list of interview questions used to guide the interview, and answers we received. This interview was conducted in Thai and translated into English.

1. *Do you ever sort your waste at your house?*

Ans: Yes, they do have a burning pot in their backyard for burning compostable waste and take all recyclable waste to sell, and for general waste, they might bring it to the garbage truck because the truck will not go into their hometown.

a. *If you sort your waste at your house, does the waste separation method come from the information your children have learned from school?*

Ans: They sort their waste in their house after their children learn waste management methods in school and adapt this knowledge to use in their homes and village.

b. *If you do not sort your waste at your house, have your children ever told you to separate waste at your house because they have studied at school?*

Ans: Some parents do not sort their waste at home, but their children are doing it according to their knowledge from the school.

2. *How often do you recycle plastic or reuse plastic in your house?*

Ans: Every day since their children bring their knowledge from school to apply in their house.

3. *What other materials do you recycle?*

Ans: Plastic, metal, and paper will be separated and then sold. Other waste, such as compost is burned in the burning pot in their backyard.

4. *How often do you use plastic bags or plastic items for buying products?*

Ans: Rarely because they mostly use a basket or reusable bags to buy things such as food, but sometimes there might be a plastic container that cannot be avoided.

5. *Do you use cloth bags/ reusable bags to buy things?*

Ans: Yes, they always use cloth bags or reusable bags to buy things.

6. *Have you refused to accept plastic bags?*

Ans: Yes, but sometimes we can't avoid accepting the bags.

7. *Is there a garbage truck from the Subdistrict Administrative Organization to collect waste at your houses?*

Ans: No, the truck can't reach their home.

a. *If there is no garbage truck from the Subdistrict Administrative Organization to collect waste, how do you and your neighbors manage the waste in the village?*

Ans: First, separate the waste into 3 main types which are recyclable waste, general waste, and compostable waste. Second, the recyclable will sell out, the general we bring to the waste collector, and compostable will be burned in the burning pot in their backyard.

b. *Could you explain to us about the waste management which you and your neighbors use in the village?*

Ans: We have a separate waste system in the house and a burning pot in the backyard for each house.

8. *Do you think plastic pollution is an important problem in Krabi?*

Ans: Yes, we know that plastic pollution is an important problem for a long time, so we are trying to reduce their use of plastic waste as much as possible.

9. *Do you think educating young students for raising awareness could improve the pollution situation in Krabi?*

Ans: Yes, it will help a lot as we can see from their use of knowledge from school to apply in their hometown through parents.

## Appendix D: Survey for School Students in Krabi

Surveying students from schools in Krabi allowed our team to gain better insight into recycling education in school systems, and students' views on pollution. Specifically, survey questions provided us with information on students' opinions on the waste build-up and general litter found near their homes, on streets, on beaches, and in the oceans. Survey questions also provided information on how students' families manage their household waste, how they go about recycling, and if anything they learned within the recycling program is transferred to their life at home. Surveys were sent electronically to school teachers at Uttarakit School, Wat Pho Riang School and Baan Gor Tong School in Krabi, for their students to complete. The surveyed population will be given to students aged 7 to 16 years old, to collect 241 survey results. The survey and results can be found below.

### 1. *How old are you?*

- 5-6 years old
- 7-8 years old
- 9-10 years old
- 11-12 years old
- 13-14 years old
- 15-16 years old
- 17 years or older
- Other \_\_\_\_\_

Uttarakit School	Wat Pho Riang School	Baan Gor Tong School
1.9% 7-8 years old	25.0% 9-10 years old	52.0% 11-12 years old
40.5% 9-10 years old	72.2% 11-12 years old	40.0% 13-14 years old
52.6% 11-12 years old	2.8% 13-14 years old	8.0% 15-16 years old
3.7% 13-14 years old		
1.3% 15-16 years old		

### 2. *Have you learned any of the following about plastic and ocean pollution in school?*

- Learned about plastic pollution
- Learned about ocean pollution
- Learned about both plastic pollution and ocean pollution
- Haven't learned about either plastic pollution or ocean pollution

Uttarakit School 61.7% learned plastic pollution 1.9% learned ocean pollution 29.9% learned both 6.5% learned neither	Wat Pho Riang School 86.1% learned plastic pollution 2.8% learned ocean pollution 11.1% learned both 0% learned neither	Baan Gor Tong School 64.0% learned plastic pollution % learned ocean pollution 32.0% learned both 4.0% learned neither
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3. *How often do you separate and recycle plastic?*

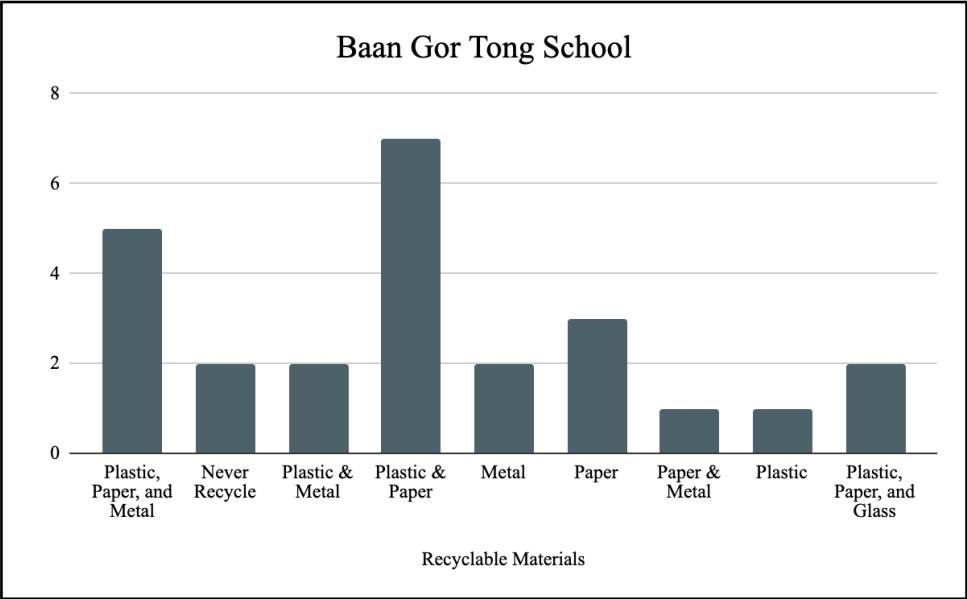
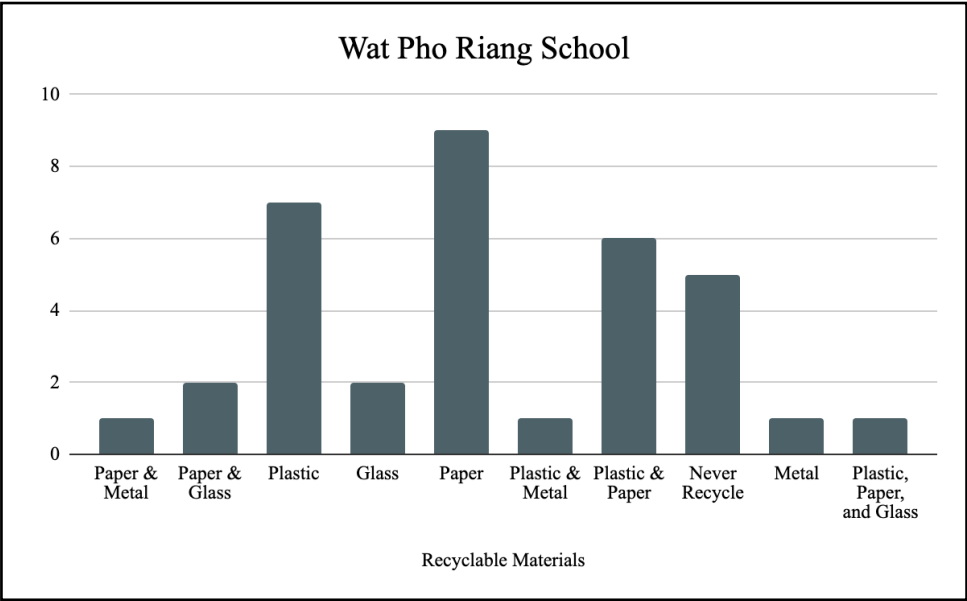
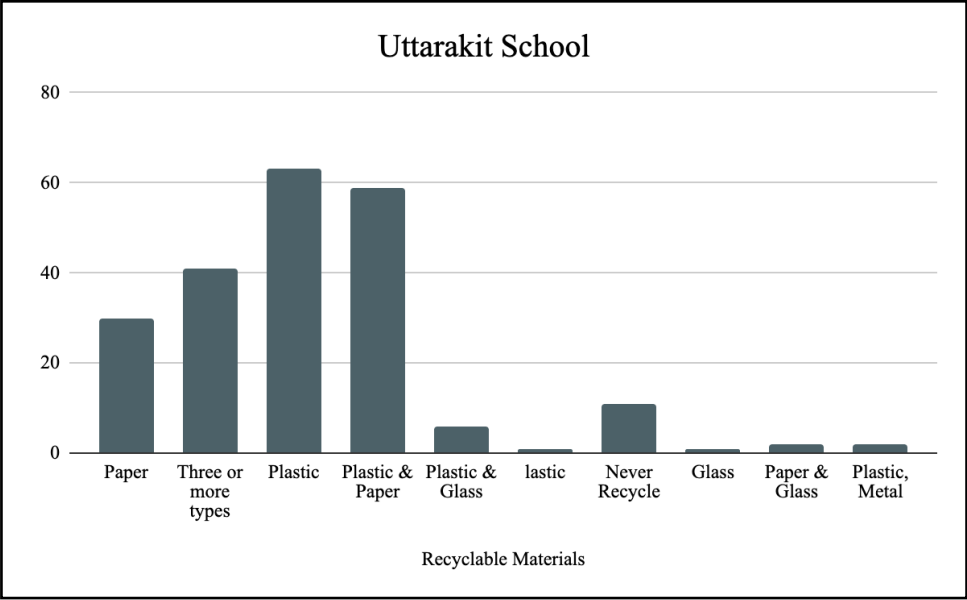
- All the time
- Very frequently
- Sometimes
- Rarely
- Never

Uttarakit School 19.1% All the time 31.6% Very frequently 43.7% Sometimes 5.1% Rarely 0.5% Never	Wat Pho Riang School 11.1% All the time 25.0% Very frequently 52.8% Sometimes 8.3% Rarely 2.8% Never	Baan Gor Tong School 0% All the time 52.0% Very frequently 48.0% Sometimes 0% Rarely 0% Never
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4. *What do you recycle at home? (CHECK ALL THAT APPLY)*

- Plastic
- Paper
- Glass
- Metal
- I don't recycle at home
- Other \_\_\_\_\_





5. *Do you notice plastic pollution on the beaches in Thailand?*

- Yes
- No

Uttarakit School	Wat Pho Riang School	Baan Gor Tong School
90.7% Yes 9.3% No	77.1% Yes 22.9% No	100% Yes 0% No

6. *Do you think plastic pollution is a major problem in Krabi?*

- Yes
- No

Uttarakit School	Wat Pho Riang School	Baan Gor Tong School
96.8% Yes 3.2% No	88.9% Yes 11.1% No	100% Yes 0% No

7. *Did you know Thailand ranks sixth in the world for total plastic pollution?*

- Yes
- No

Uttarakit School	Wat Pho Riang School	Baan Gor Tong School
46.8% Yes 53.2% No	36.1% Yes 63.9% No	84% Yes 16% No

8. *What are your views on plastic pollution in Krabi?*

- Severe pollution
- High pollution
- Average pollution
- Little pollution
- No pollution

Uttarakit School	Wat Pho Riang School	Baan Gor Tong School
13.0% Severe 40.7% High pollution 37.5% Average pollution 8.3% Little pollution 0.5% No pollution	11.8% Severe 29.4% High pollution 50.0% Average pollution 8.8% Little pollution 0% No pollution	4.0% Severe 72.0% High pollution 24.0% Average pollution 0% Little pollution 0% No pollution

## Appendix E: Interview with a Park Ranger and a Marine Biologist from The Hat Noppharat Thara-Mu Koh Phi Phi National Park and the Head of the Participation Promotion from the Department of Marine and Coastal Resources

Interviewing Chat Chalarat, Krisada Thiraut and Narakorn Kalaya, from the DMCR and national park, provided our team with direct information about pollution found in the ocean and on beaches, including the quantity of pollution and the types of materials being polluted, the consequences of pollution, and how tourists and community members contribute to pollution. The interviews were performed in person. Below is a list of interview questions used to guide the interview, and summarized answers we received. The interview was conducted in Thai and translated into English.

Results from Interviewing Members of the Hat Noppharat Thara-Mu Koh Phi Phi National Park:

1. *What is the name of the beach you work at?*

Ans: We work at Hat Noppharat Thara beach, Ao Nang beach and Railay beach.

2. *How long have you worked in this organization?*

Ans: We have worked for 4 years.

3. *How many Park Rangers work at this beach at a time?*

Ans: There are 7 units in the national park and each unit has 10 park rangers.

4. *How is the situation of marine plastic waste on the beach?*

Ans: During COVID, the plastic waste has decreased.

5. *In your opinion, where does the marine litter come from?*

Ans: Some waste comes from the fishing industry, tourists, tour companies, and local people. Most ocean pollution comes from wind directions in Krabi, so we cannot tell exactly where this waste comes from. Some collected waste has indicated that it is from a neighboring country.

6. *Could you give examples of plastic waste that you can collect?*

Ans:

a. Fishing waste

- i. Styrofoam (although this has been reduced in comparison to in the past)
- ii. Nets and fishing traps

b. Tourists (leave about 10% of their waste)

- i. Water bottles and plastic bags
- ii. Tour companies usually bring in more waste than tourists

7. *What is the organization's process of handling marine plastic waste?*

Ans: We collect the waste in the ocean as much as possible by diving to pick up waste.

8. *During the past COVID-19, what is the difference in the quantity of plastic pollution on the beaches and in the oceans that you observe?*

Ans: Waste on the beach has been noticed to drop by about 50% since COVID

9. *Does the national park have any laws or rules about littering in the national park area?*

Ans: Those who throw the waste on the beach or try to dump the waste will be charged 500 baht.

**Results from Interviewing Member of the Department of Marine and Coastal Resources:**

1. *What is the name of the beaches you work at?*

Ans: I work at Hat Noppharat Thara beach, Ao Nang beach and Railay beach.

2. *How long have you worked in this organization?*

Ans: I have worked for the DMCR for 19 years.

3. *How is the situation of marine plastic waste on the beach?*

Ans: During COVID, the plastic waste has decreased.

4. *In your opinion, where does the marine litter come from?*

Ans: Most of the waste comes from inland waste which is carried by the wind or rain to the river or sewer and all of the waste will end up in the ocean.

5. *What is the organization's process of handling marine plastic waste?*

Ans: The DMCR has created a volunteer beach clean up program.

6. *Could you describe the volunteer projects and community networks that the department of marine and coastal resources is working on?*

Ans: The volunteer beach clean up program mostly has the local people joining where most of them are fishers and have less income. This volunteer program will help them gain more money from collecting the waste.

## Appendix F: Observe Waste Management Behavior Relative to Beach and Ocean Pollution

Recording observations of Ao Nang Beach provided our team with direct information about how pollution is managed on beaches and in the ocean. Ao Nang Beach was chosen as the location where we conducted observations as it is highly visited and local to Krabi. Observations that were noted are shown below.

From what we had observed, there are waste bins located next to Ao Nang Beach that do not have a label for each type of waste. This leads to waste not being separated. However, the waste bins with labels sometimes contain different kinds of waste which “contaminates” the waste in the bin. The organizations that are responsible for cleaning up the beach will collect the waste in the bins and bring the waste to the power plant. The organizations in charge are Hat Nopparat Thara Mu Koh Phi Phi National Park, the Department of Marine and Coastal Resources, the Subdistrict Administrative Organization, and Krabi’s Municipality. By having a lot of organizations that take waste from the beach, it leads to little or no pollution on Ao Nang beach.



Ao Nang Beach staff member cleaning up trash on Ao Nang Beach.



Waste bins that are located next to Ao Nang Beach

## Appendix G: Interview With School Teachers

Interviewing Kru Wantip, Kru Monthip, and Kru Onnicha from Uttarakit School, Wat Pho Riang School and Baan Gor Tong School respectively, provided our team with direct information about waste management practices and efforts in local Krabi schools. Below is a list of interview questions used to guide the interview, and summaries of answers we received.

1. *How does this school manage waste?*

Uttarakit School: We have separating bins in our school.

Wat Pho Riang School: We do not have a waste bank or bins for separated waste.

Baan Gor Tong School: We have a waste bank and bins for different types of waste, these help a lot to separate each type of waste.

2. *Has your school worked with other organizations to create recycling education programs for students?*

a. *If the school ever joined, how was that program?*

The Uttarakit School and Wat Pho Riang School all had a program with other organizations, although the programs did not last long. The \_\_\_ School did not participate in any programs with organizations.

b. *And what are the results of the programs?*

Ans: The Uttarakit School and Wat Pho Riang School agreed that most of the programs can raise the awareness of plastic pollution well and can decrease plastic waste, but it is not sustainable.

c. *What was the motive for choosing this program?*

Ans: The schools want to be a social model for students to learn about reducing plastic waste and managing the waste properly.

3. *Are there any activities that teachers have done that are beneficial to the environment from a plastic pollution reduction perspective?*

Baan Gor Tong School: Students started to bring what they had learned at school home to educate their parents and change their recycling habits.

4. *Are there any successful projects where children apply their knowledge of plastic waste management to their homes?*

Ans: Yes, there are some students in each school who used their knowledge of waste management at home and their parents started to spread out the knowledge to their community.

## Appendix H: Observe Student Waste Management Behavior in Schools

Recording observations at Uttarakit School, Wat Pho Riang School, and Baan Gor Tong School provided our team with direct information on waste management practices and efforts at local Krabi schools. Observations included how schools sorted their waste, what kind of signage was used about disposing waste, and what types of waste that were disposed. Observations that were noted are summarized below.

From what we have observed, every student in each school that we have visited followed the waste management practices put in place by the school. The waste management systems and practices in each school included separation bins (three-bin system) and waste banks. While also having a three-bin system, Baan Gor Tong School has added a strict zero-waste program which has banned plastic products into the school. However, Wat Pho Riang School does not separate their waste because the principal does not think that it is important for them to do so. At the Uttarakit School, we noticed pollution on the ground and they had waste in their sewers even though they have separation system. On the other hand, Wat Pho Riang School does not have any separation system set in place, but the pollution on their school grounds was noted to have less litter than Uttarakit School. For Baan Gor Tong School, there is no pollution found on their school grounds.

### Uttarakit School



Pollution found in the sewer by the school



An example of plastic waste storage at Uttarakit School



An example of plastic waste storage at Uttarakit School



General waste bins that students and faculty to use at Uttarakit School



Plastic water bottles that have been repurposed as pots for plants



General waste bin (green) and recyclable waste bin (yellow) at Uttarakit School

### Wat Pho Riang School



General waste bin at Wat Pho Riang School



# Baan Gor Tong School



Three colored waste bins at Baan Gor Tong School



Waste bank at Baan Gor Tong School



Waste such as paper, plastic, and metal are separated into different compartments



Plastics, general waste, and compost separated into different colored bins



Baan Gor Tong uses their food waste as compost



Plastic bottles are repurposed as pots for gardening

## Appendix I: Interview with a Former Government Official in Krabi Province

Interviewing Chuan Pukaoluan, a previous Chairman of the Board of Directors, Sripongpanich Company Limited and Provincial Educational Organization Council and three-term prime minister, provided our team with direct information about pollution from a governmental point of view. Below is a list of interview questions used to guide the interview, and answers we received. This interview was conducted in Thai and then translated into English.

1. *Can you describe some policies the local government has enacted with relation to reducing pollution of beaches?*

Ans: In the past, the pollution in beaches at Krabi was foam pollution. There was a lot of foam in the sea and on the beaches but Krabi municipality banned using foam, and it has been very successful. Normally, foam waste comes from tour guides and tourists, but the Krabi municipality enacted the “Krabi Go Green Project” which was a green tourism campaign.

2. *Do you believe booklets would be an effective means of raising awareness for the importance of recycling and not litter in the Krabi Province?*

Ans: I think that raising awareness is important to ensure everyone recycles and does not litter in Krabi. In my opinion, without people, nature has its way. As there are humans, so they make the waste. The first problem is people, so we have to discipline people to not litter.

3. *Do you believe our solution would directly impact the amount of plastic waste found in the ocean and on beaches along the coast of Krabi?*

Ans: I believe that if people have discipline and awareness, the amount of plastic waste in the ocean and on the beaches will be reduced.

4. *What recommendation would you make to our project to make it more effective?*

Ans: It is difficult to tell local people to stop using plastic immediately. To stop using plastic effectively is finding other material to be used instead. Our team should find new material which is cheaper than plastic. Now, some people use food carriers instead of using plastic.

5. *As we saw that the process is not strong to be serious, what are the problems with the use of plastic laws?*

Ans: Firstly, the root of the problems is broken because Thais are free and Thai people study the law to find loopholes of the law. Secondly, it is caused by the time politicians use policies to campaign for the people. If politicians enact some policies that affect local people’s convenience, then they will find other politicians. Thus, politicians

use power for personal gain and not do it together. Finally, there are many loopholes in the law, and no subsequent solutions are prepared.

## Appendix J: Interview with Municipality of Krabi

Interviewing Sarat Giangkong, the Director of the Engineering Division for the Municipality of Krabi, provided our team with direct information about waste management practices in Krabi. Below is a list of interview questions used to guide the interview, and answers we received. This interview was conducted in Thai and translated into English.

1. *How long have you worked in this organization?*

Ans: I have worked for the Municipality of Krabi for 22 years.

2. *Can you explain the waste management before turning into a power plant?*

Ans: Before turning into a power plant, Krabi municipality used landfill as the waste management.

3. *Why did the Krabi municipality change the waste management system from landfill to waste power plant?*

Ans: The waste disposal center of Krabi's landfill has been closed because the amount of waste in the landfill system tends to cause problems in managing the area as well as impacts the surrounding communities. The municipality made a decision to change the process and began to move the waste from the landfill to the power plant. Then, the heavy ashes from burning waste are mixed with soil in a ratio of 1: 1 and are returned to the original landfill. Therefore, the landfill can be used for other aspects such as a public park.

4. *Can you give us more information about the waste power plant?*

Ans: The private sector does not want us to know their secret of knowhow technology, so we only know a few details. The Krabi Municipality spent 3-4 hundred million baht for the gas-type hammer stroke system. Normally, there are two types of hammer stroke systems which are gas-type and plasma-type. The advantages are that this mechanical system can burn all waste, so there is no need to separate anything. It operates at 850 degrees Celsius. The disadvantage is that the system cannot decompose heavy metals and glass.

5. *How does the waste power plant have various pollution management systems?*

Ans: The water system that helps to incinerate the waste also has water treatment. The air filtration system has multi-layer filters, and they measure the toxicity of the emissions produced by burning the waste. If it exceeds the allowable or standard toxicity value, it will notify control operators

6. *As an intermediary between any Subdistrict Administrative Organizations and waste power plant, How does Krabi Municipality manage waste?*

Ans: The waste power plant needs at least 400 tons per day of waste to generate 5 kilowatts electricity and can dispose of up to 500 tons of waste per day. Thus, the waste power plant uses 400 tons of waste from the landfill. The Krabi Municipality must send at least 100 tons of new waste per day to the waste power plant, so 16 Subdistrict Administrative Organizations have participated in the project to send waste to power plants through the municipality.

7. *During the past COVID-19, what is the difference in the quantity of plastic pollution on the beaches and in the oceans that you observe?*

Ans: The COVID-19 pandemic reduced the amount of waste by approximately 40% as a result of less waste being produced. Prior to the pandemic, they would consistently receive 180 tons of waste per day, but during the pandemic they receive 120 tons of waste per day.

8. *In your opinion, is waste separation still necessary?*

Ans: Recycling is a good practice to reduce plastic pollution. However, in view of the waste power plant, they believe that there is no need to separate the waste because the power plant burns all the plastic waste anyway and plastic is the best energy generator when incinerated for power plants. If we separate the waste, the power plant will lose their profit and benefit. Furthermore, in some areas such as Ao Nang Subdistrict, the villagers separate their waste, but the Subdistrict Administrative Organizations collects all the waste together anyway.

9. *Does this waste power plant have some disadvantages?*

Ans: The gas-type hammer stroke system has some disadvantages because it cannot handle steel and glass which take 80 tons of waste per day. If it is a plasma-type stroke system, it can be eliminated entirely. The system should have a reduction in noise pollution, as villagers have complained. When the electricity is unstable, there is a buzzing sound and white steam. Another problem is that the ashes from burning the waste are heavy and have a bad smell. The last problem is the machine which is not enough for the amount of waste that is received. However, in this view, this system is appropriate for Thais because Thai people are not very motivated to separate their waste. If the local government does nothing, the waste can go into the sea. For example, in the past, the villagers at the Phi Phi Islands threw their waste in the ocean.

10. *In how many years will the power plants have no waste problems?*

Ans: Krabi municipality made a contract with the waste power plant for 25 years, but the power plant has the potential to manage waste in Krabi for 50 years. The landfill will become obsolete within 10 years as there will be no need for a landfill because of the

power plant. From the Krabi municipality's opinion, the landfill will disappear within 5 years. Krabi will get 128,000 square meters (32 acre) of area back and turn it into a park.