2013-04-30

Dive Industry Use Patterns and Economic Dependency on Apra Harbor's Coral Reefs

Kathryn E. Sellers
University of Miami, ksellers609@gmail.com

Follow this and additional works at: https://scholarlyrepository.miami.edu/oa_theses

Recommended Citation
https://scholarlyrepository.miami.edu/oa_theses/418

This Open access is brought to you for free and open access by the Electronic Theses and Dissertations at Scholarly Repository. It has been accepted for inclusion in Open Access Theses by an authorized administrator of Scholarly Repository. For more information, please contact repository.library@miami.edu.
UNIVERSITY OF MIAMI

DIVE INDUSTRY USE PATTERNS AND ECONOMIC DEPENDENCY ON APRA HARBOR’S CORAL REEFS

By
Kathryn E. Sellers

A THESIS

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Master of Science

Coral Gables, Florida
May 2013
A thesis submitted in partial fulfillment of
the requirements for the degree of
Master of Science

DIVE INDUSTRY USE PATTERNS AND ECONOMIC DEPENDENCY
ON APRA HARBOR’S CORAL REEFS

Kathryn E. Sellers

Approved:

John McManus, Ph.D.
Professor of Marine Biology
& Fisheries

M. Brian Blake, Ph.D.
Dean of the Graduate School

Maria Estevanez, M.B.A.
Senior Lecturer
Marine Affairs & Policy

Daniel Suman, Ph.D.
Professor of Marine
Affairs & Policy
SELLERS, KATHRYN E. (M.S., Marine Affairs and Policy)  
Dive Industry Use Patterns  
And Economic Dependency on  
Apri Harbor’s Coral Reefs  
(May 2013)  

Abstract of a thesis at the University of Miami.  

Thesis supervised by Professors John McManus and Maria Estevanez.  
No. of pages in text. (94)  

The island Territory of Guam is about to experience a large U.S. military buildup. This buildup will set Guam as host of the largest U.S. military presence in all of Asia, with correspondingly advanced Naval base facilities. Part of Naval Base Guam capacity improvements will include significant dredging in Apra Harbor, home to the island’s only deep-water lagoon. This lagoonal area is not only host to a United Stated Naval base, but is also host to Guam’s commercial port and a highly attractive area for many recreational tourism activities. As a preparatory step before dredging activities occur, the island’s dive businesses have been surveyed in order to establish baseline socioeconomic information on the use of Apra Harbor’s coral reefs and to assess the potential impacts a Navy dredge project might have on dive businesses utilizing Apra Harbor coral reefs. This study concludes that Apra Harbor’s coral reefs are an incredibly important asset to Guam’s dive businesses, as the reefs are used for approximately 60% of dives annually conducted by surveyed businesses. One hundred percent of surveyed businesses utilize Apra Harbor coral reefs for dive and/or snorkel trips, which cater mostly to the industry’s largest clientele: novice divers/ snorkelers. Depending on the amount of dredge-based sediment settling on Apra Harbor’s reef areas, the Navy dredge project has the potential to impact $1,253,340 in annual total revenues made by surveyed dive businesses. Given that Apra Harbor’s coral reefs are highly utilized and depended upon by surveyed businesses, it is
presumed that dredge-based sediment settling on the Harbor’s coral reefs will directly impact dive business activity occurring within Apra Harbor both during and after dredging occurs.
Acknowledgements:

Support and guidance for this project were provided by Master’s Thesis committee members John McManus, Ph.D., Maria Estevanez, Daniel Suman, Ph.D., and Liana Talaue-McManus, Ph.D. A large thank you is also extended to family and friends who have supported me along this journey.
# TABLE OF CONTENTS

LIST OF FIGURES ........................................................................................................................................... v

LIST OF TABLES ............................................................................................................................................... vii

CHAPTER I: Background of Identified Problems ....................................................................................... 1
  1.1 MILITARY BUILDUP BACKGROUND ......................................................................................... 1
  1.2 DREDGING APRA HARBOR ........................................................................................................ 2
  1.3 EFFECTS OF DREDGING APRA HARBOR .................................................................................. 5
  1.4 GOALS AND OBJECTIVES ........................................................................................................ 9

CHAPTER II: Dive Industry Background .................................................................................................. 11
  2.1 GUAM’S DIVE INDUSTRY .......................................................................................................... 11
  2.2 DIVE INDUSTRY ATTRACTION TO APRA HARBOR’S WATERS ........................................... 13
  2.3 OTHER SIMILAR STUDIES ........................................................................................................ 14
  2.4 STUDY SIGNIFICANCE ............................................................................................................ 15

CHAPTER III: Methods and Materials ................................................................................................... 17
  3.1 SURVEY ........................................................................................................................................ 17
  3.2 SPATIAL ANALYSIS .................................................................................................................... 19
  3.3 ECONOMIC ANALYSIS ............................................................................................................. 20

CHAPTER IV: Results ............................................................................................................................ 23
  4.1 APRA HARBOR USE ................................................................................................................ 23
  4.2 ECONOMIC INFORMATION ..................................................................................................... 26
  4.3 PERCEPTIONS OF POTENTIAL DREDGING IMPACTS ............................................................. 32

CHAPTER V: Discussion .......................................................................................................................... 34
  5.1 APRA HARBOR BASELINE ....................................................................................................... 34
  5.2 APRA HARBOR IMPACT ANALYSIS ....................................................................................... 38

CHAPTER VI: Conclusions ...................................................................................................................... 48
  6.1 LIMITATIONS ............................................................................................................................ 48
  6.2 RECOMMENDATIONS ............................................................................................................... 48

Figures ......................................................................................................................................................... 56
Tables ......................................................................................................................................................... 78
References .................................................................................................................................................. 81
Appendices .................................................................................................................................................. 88
LIST OF FIGURES

FIGURE 1 ................................................................................................................. 56
FIGURE 2 ................................................................................................................. 56
FIGURE 3 ................................................................................................................. 57
FIGURE 4 ................................................................................................................. 58
FIGURE 5 ................................................................................................................. 59
FIGURE 6 ................................................................................................................. 60
FIGURE 7 ................................................................................................................. 60
FIGURE 8 ................................................................................................................. 61
FIGURE 9 ................................................................................................................. 61
FIGURE 10 ............................................................................................................... 62
FIGURE 11 .............................................................................................................. 62
FIGURE 12 ............................................................................................................... 63
FIGURE 13 ............................................................................................................... 64
FIGURE 14 ............................................................................................................... 65
FIGURE 15 ............................................................................................................... 65
FIGURE 16 ............................................................................................................... 66
FIGURE 17 ............................................................................................................... 66
FIGURE 18 ............................................................................................................... 67
FIGURE 19 ............................................................................................................... 67
FIGURE 20 ............................................................................................................... 68
FIGURE 21 ............................................................................................................... 69
FIGURE 22 ............................................................................................................... 70
Figure 23 ........................................................................................................ 71
Figure 24 ........................................................................................................ 72
Figure 25 ........................................................................................................ 73
Figure 26 ........................................................................................................ 74
Figure 27 ........................................................................................................ 75
Figure 28 ........................................................................................................ 76
Figure 29 ........................................................................................................ 77
LIST OF TABLES

TABLE 1 .......................................................................................................................... 78
TABLE 2 .......................................................................................................................... 78
TABLE 3 .......................................................................................................................... 78
TABLE 4 .......................................................................................................................... 79
TABLE 5 .......................................................................................................................... 79
TABLE 6 .......................................................................................................................... 80
CHAPTER I: Background of Identified Problems

1.1 Military Buildup Background

In the eyes of the United States Military, the unincorporated Territory of Guam is a strategic piece of land. With cautious eyes on Asia and politics in Japan, the United States has slated Guam to host what will be the largest U.S. military presence in all of Asia (Frangos, 2013). A multipronged military buildup for the island (The Buildup) was inaugurated in 2009 with the bilateral “Agreement Between the Government of the United States of America and the Government of Japan Concerning the Implementation and Relocation of the III Marine Expeditionary Force Personnel and Their Dependents From Okinawa to Guam,” (Kan, 2010). The purpose of this agreement is to reduce U.S. forces in Japan, while maintaining the U.S. force presence in the Pacific theater (Lepore, 2011). The primary piece of The Buildup involves the relocation of 5,000 Marines from Okinawa to Guam and an associated construction of a new Marine Corps base on Guam (Kan, 2012). The Air Force will also be involved in The Buildup; a component called “Guam Strike” is designed for the purposes of enabling intelligence, surveillance, reconnaissance, strike, and aerial refueling capabilities. “Guam Strike” will come to Anderson Air Force Base along with the transfer of the Pacific Air Force’s expeditionary training center from Korea (Lepore, 2011). In conjunction with moves made by the Marine Corps and Air Force, the Navy will enhance facilities, infrastructure, and logistical capabilities at Naval Base Guam in order to accommodate the berthing of transient nuclear aircraft carriers and their support vessels. In addition, the Army National Guard will build facilities at an existing installation, Navy Barrigada, to accommodate the increase in personnel for the Army’s “Grow the Force” initiative (Lepore, 2011). The
Buildup consists of many components, all of which require significant facilities and infrastructure construction to occur on Guam. As all components of The Buildup move to Guam, the Territory must also provide its own construction efforts in order to improve roads, sewage, water, and an overburdened public hospital to accommodate for the increased military presence on island (Harden, 2010).

Despite these elaborate plans, The Buildup has yet to break ground on Guam, as it has been pushed back for several years due to opposition from the public, cost overrun, and criticism from U.S. Congress for inadequacies in project proposals (Frangos, 2013). The project is currently on hold, as the Pentagon has reopened a previously concluded 2010 Environmental Impact Statement (EIS) produced by the U.S. Navy’s Joint Guam Program Office due to an overwhelming amount of concern for inadequacies within the EIS (Frangos, 2013). Project numbers have additionally been cut, as the plan to relocate 8,600 Marines to Guam has been reduced to 5,000 personnel (Frangos, 2013). An EIS public comment period is open until 2014 to allow for the public to voice concerns on behalf of The Buildup’s effect on land usage and potential damage to coral reef ecosystems. Despite this holdup, though, The Buildup has been included in the U.S. 2013 defense budget, as President Obama has allocated $102 million in funding for “pieces” of the project (Frangos, 2013). In all, it is projected that 2015 will be the earliest possible start date for this $24 billion project (Frangos, 2013).

1.2 Dredging Apra Harbor

As per Naval actions within The Buildup, construction of a new deep draft wharf and associated turning basin is required in order to support USS Nimitz and next-generation Gerald R. Ford type transient nuclear powered aircraft carriers in Apra Harbor (Figure 1).
Due to the U.S. desire to facilitate an increase in the presence of aircraft carriers in the Western Pacific, it has been determined that Apra Harbor’s infrastructure will support such carriers during berthing days. Utilization of a berthing location in the Western Pacific instead of the Eastern Pacific (San Diego or Hawaii) would allow for maintenance support and supplies to be closer to areas of operation, and, therefore, increase the availability and presence of carriers in the region. Such an increased presence would enable quick responses to crises (Joint Guam Program Office, 2010). This change will ultimately help the Department of Defense in its efforts to redefine the United States’ posture in the Pacific (Lepore, 2011).

Apra Harbor is already a temporary home to the U.S. Navy’s aircraft carriers. Apra Harbor’s Kilo Wharf (Figure 2) hosts aircraft carriers approximately 16 days out of the year, as it is the area’s only Navy wharf that currently meets carrier draft requirements, as well as the necessary security and channel capabilities (Joint Guam Program Office, 2010). Although Kilo Wharf may seem like an ideal place for the continuation of aircraft carrier berthing, this setting does not have the appropriate number of berthing days or facilities available to host longer and more frequent visits from the largest ships in the Navy’s fleet (Joint Guam Program Office, 2010). Because the number of desired berthing days is intended to increase from approximately 16 to 63 days per year, Kilo Wharf is predicted to be overtaxed by longer and more frequent aircraft carrier stays.

To rectify this limitation, the U.S. Navy has chosen two alternative wharf locations for aircraft carrier berthing within Apra Harbor (Joint Guam Program Office, 2010). In reviewing these locations many factors were considered in the examination
process. These factors include: construction costs and challenges, navigational issues, security capabilities, channel access, turning basin configurations and locations, structural designs, and environmental impact. The result of in-depth analysis led to the selection of two alternative wharf area possibilities: Polaris Point and the Former Ship Repair Facility (Figure 3) (Geiger, 2011). Although Polaris Point has been named as the Navy’s preferred site, an official wharf selection is pending on the outcome of the Pentagon’s revised Environmental Impact Statement (Frangos, 2013).

Both Polaris Point and the Former Ship Repair Facility are located at the entrance of Inner Apra Harbor Channel (Pike, 2011). To accommodate such large ships, Navy requirements on draft and clearance must be adhered to no matter which choice is made for the final berthing location. Nuclear aircraft carriers require 442 ft. of clearance in front of a wharf, a minimum channel depth of -49.5 ft. plus 2 ft. of allowable over-dredge, a minimum turning basin with a 2,200 ft. radius, and channel widths of at least 600 ft. (Joint Guam Program Office, 2010). With such depth requirements, dredging of Apra Harbor must occur from the Inner Apra Harbor Entrance Channel to the turning basin and wharf area. Figure 4 depicts the projected dredge area, including the turning basin options and alignment with Apra Harbor’s current channel.

As chance would have it, Inner Apra Harbor Entrance Channel lies adjacent to large and diverse coral reefs. In an effort to minimize impacts on surrounding coral reefs, the Navy has chosen a channel alignment option (Sharp Bend) that will dredge the least amount of substrate possible (Figure 5). This Sharp Bend channel will, for the most part, follow the existing navigational channel, but will have to make a 54-degree dredged cut between two patch reef areas referred to as Jade Shoals and Western Shoals. Of the
channel alignment options taken into consideration, this is the least favorable for navigation, but the most environmentally friendly scenario (Joint Guam Program Office, 2010). Also, to enable the berthing of a carrier, the establishment of a turning basin is necessary in front of the chosen wharf location. A turning basin is a circular area free of obstruction that provides a sufficient space for maneuvering of an aircraft carrier to be berthed on its right side. Although the recommended radius for such a turning basin is 2,200 ft., the radius for an Apra Harbor turning basin has been reduced down to 1,092 ft. in order to reduce possible environmental impacts (Joint Guam Program Office, 2010). Though still in compliance with aircraft carrier requirements, a priority has been given to reducing the amount of impact this dredge project is capable of having on Apra Harbor.

In all, it is estimated that 608,000 cubic yards of dredged material will be removed if Polaris Point is the selected wharf site and approximately 479,000 cubic yards will be removed if the Former Ship Repair Facility is chosen (Geiger, 2011). The dredge footprint for Polaris Point (Figure 6) comprises a total of 53 acres where 25 of those acres consists of coral cover, while the Former Ship Repair Facility (Figure 7) consists of 44 total acres, 24 of which are coral (Fuentes, 2010). In accordance to the Environmental Impact Statement produced for The Buildup, dredging at either alternative will likely be a 24-hour a day operation that will scoop 1,800 cubic yards of sediment per day for six to eighteen months (Joint Guam Program Office, 2010).

1.3 Effects of Dredging Apra Harbor

1.3.1 Biological Effects

Despite a concerted effort to minimize the effects of dredging, this navy dredge project ultimately poses harsh consequences to Apra Harbor’s coral reefs. Considering an
average of 50% of the proposed dredging areas includes coral cover impact, the most
direct effect of dredging activities will be the complete and irreversible destruction of
benthic habitat (Joint Guam Program Office, 2010). This scenario poses a very long-term
effect, where the removal of coral reef habitat and live/hard bottom systems will reduce
the structural complexity of the environment, resulting in fewer places for marine
organisms to live, forage, spawn, and hide from predators. The National Oceanic and
Atmospheric Administration (NOAA) has classified Apra Harbor as essential fish habitat
(EFH), as it consists of waters and substrate necessary to fish (finfish, mollusks,
crustaceans, and other forms of marine animal and plant life) for spawning, breeding,
feeding, or growth to maturity (Joint Guam Program Office, 2010). Apra Harbor contains
habitat of great significance where a plethora of organisms depend on its welfare. Five
NOAA classified sensitive management unit species frequent this EFH: Napoleon Wrasse
(*Cheilinus undulatus*), Bigeye Scad (*Selar crumenophthalmus*), Scalloped Hammerhead
(*Sphyrna lewini*), Bumphead Parrotfish (*Bolbometopon muricatum*), and Stony Corals
(*Scleractinia*) (NMFS, 2013). Two federally endangered species, the Green Sea Turtle
(*Chelonia mydas*) and the Hawksbill Sea Turtle (*Eretmochelys imbricata*) inhabit Apra
Harbor reefs. There are also a number of endemic species such as the Elephant Ear
Sponge (*Ianthella basta*) and rare species including *Pavona cactus* (Plucer-Rosario,
1987). For many organisms, the destruction of coral reef habitat can mean one of two
things - they can either adapt and move to another reef area or perish (Joint Guam
Program Office, 2010). It can be surmised that dredging in such a sensitive and unique
coral reef environment as that found in Apra Harbor will pose devastating biological
consequences.
Dredging will additionally contribute to indirect biological impacts. These indirect impacts come mostly from the degradation of water quality and the sedimentation of habitat (Joint Guam Program Office, 2010). While sediment retention devices (silt curtains) will be deployed during dredging activities to minimize the dispersal of sediment within the water column, it is expected that some fraction of sediment will escape and impact surrounding corals and filter feeding invertebrates. A sediment plume is an inevitable effect of in-water construction, even in the most ideal of conditions. Sediment plumes, depending on their density, can easily contribute to decreases in dissolved oxygen content and a lack of adequate sunlight for photosynthetic dependent organisms. On a global scale, such sedimentation is considered to be one of the most common and serious anthropogenic influences on coral reefs (Grigg, 1990). Impacts associated with sediment burial of coral reefs includes reduced photosynthesis and increased respiration, tissue mortality, reduced growth, increased mucus secretion, reduced fertilization, and reduced larval survivorship/recruitment (Grigg, 1990). Overall, though, the influence of sedimentation varies with the type of oceanographic conditions experienced, coral species present, adaptation abilities, type of sediments involved, and the duration of sediment exposure (Marszalek, 1981). In addition to dredging’s secondary impacts, secondary effects from The Buildup’s on-land construction efforts are predicted to affect the Harbor’s water quality, as increased silt from vegetation removal is predicted to enter into Harbor waters (Schumann, 2012). Unfortunately, there is no formula to predict how much secondary effects of dredging will impact Apra Harbor coral reefs. However, we can predict that it will degrade the ecology of the general area and leave an unnatural overall footprint on Apra Harbor reef sites.
1.3.2 Socioeconomic Effects

Such damage caused by dredging in and around the coral reef ecosystem not only disturbs biological aspects, but also creates a disturbance for tourism businesses that depend on the health of coral reefs. Apra Harbor is known as one of the most popular spots for recreational tourism activities to occur in Guam, as it hosts activities ranging from submarine tours, scuba diving, snorkeling, and fishing trips, to sunset boat cruises, jet skiing and kayak rentals, and dolphin watches (Joint Guam Program Office, 2010). The dredging of Apra Harbor will not only create a hazard to work around for the recreational tourism industry, but will also create a disturbance to the area’s aesthetic appeal both above and below the waterline. Noise and air pollution will increase on Guam, not only during dredging, but also with the accompanying components of The Buildup construction. Because tourists are most often attracted to Guam to see a clean, pristine tropical island environment, The Buildup can widely detract from visitors’ experiences at this vacation spot (Schumann, 2012). With tourism numbers naturally fluctuating on Guam due to world politics or weather events, there is worry that Buildup construction and dredging activities could negatively affect tourism numbers in the coming years.

The tourism industry is incredibly important in Guam, as its economy is largely dependent on the industry. Over the last 30 years, tourism has grown to be the island’s second largest income source at $1.35 billion annually, following national defense (CIA, 2013), and the fourth largest employment sector (Schumann, 2012). Bringing tourists to the marine ecosystems of Guam is considered a large component to the industry, as 77% of Guam’s visitors come to the island for pleasure; the highest rated activities include
parasailing, health spas, and water based activities such as snorkeling, scuba diving, jet skiing, kayaking, and charter fishing (Van Beukering, 2007). A Guam Visitors Bureau 2001 Tourist Exit Survey shows that, on average, 28% of tourist sector revenues depend on healthy marine ecosystems, where coral reef value amounts to U.S. $95 per visitor (Van Beukering, 2007). With an average of one million people visiting Guam each year, the tourism value relating to Guam’s coral reefs is equated to approximately $95 million per year (Van Beukering, 2007). Contributing to such a high value within the second most influential industry (tourism) on the island, coral reefs are oftentimes considered to be one of the most precious economic assets Guam has to offer (Hensley, 1993).

1.4 Goals and Objectives

Concrete information on how the recreational tourism industry might be affected by an Apra Harbor Navy dredging project is lacking within the 2010 Environmental Impact Statement created for The Buildup. This study will, therefore, act as a pilot project in order to address recreational tourism socioeconomic dependencies on Apra Harbor. Though Apra Harbor boasts numerous recreational tourism operations, this study will concentrate on the most important water sport in Guam (Van Beukering, 2007) and also the most dependent of water sports on the health of coral reefs: the dive industry. In this study, the dive industry is defined as businesses that specialize exclusively in diving and/or snorkeling, transport patrons to specific sites with the use of a dive boat or van, businesses that operate from a fixed location, and businesses that operate throughout the year (Shivlani and Suman, 2000). Despite the fact that Apra Harbor is known as a popular spot for dive industry activity, there is no baseline information available on how the reefs are utilized or how valuable the Harbor’s reef areas are to dive business
operations. As a result, the goal of this study will take a two-pronged approach as it will:

1) gain baseline information on dive business’ spatial use and economic dependency on Apra Harbor’s coral reefs; 2) develop an impact analysis to determine how Guam’s dive businesses might be affected by a Navy dredge project. The following objectives will be used in accomplishing this two-pronged goal:

1) Survey Guam’s dive businesses in order to gain baseline information on:
   a. Apra Harbor use
   b. Business economics
   c. Perceptions of Potential Dredging Impacts

2) Identify business coral reef use patterns and spatial spread of dredge based sedimentation through the use of a Geographic Information System

3) Evaluate dive industry interactions with the local economy through the use of local spending multiplier analyses

4) Determine potential business revenue displacements in correlation with dredge-based reef sedimentation.
CHAPTER II: Dive Industry Background

2.1 Guam’s Dive Industry

“Due to incredible water visibility, warm year round water temperatures, prolific coral reefs, and historic wrecks, scuba diving and snorkeling in Guam have become popular activities for tourists and residents alike” (Dances With Shadows, 2007). Many experts often consider Guam to be among the best diving destinations in the world, as it has the capacity to provide dives that suit all skill levels and sites that appeal to all interests (Dance With Shadows, 2007). The allure of Guam’s tropical environment especially attracts many Japanese and American tourists, where the Japanese make up 75% of the annual tourist population (Tourism Economics, 2012). Guam is a particularly popular destination for the Japanese, as it is a relatively short flight away from Japan and cheaper to visit than areas within their own country (Hanauer, 2001). With such a Japanese dense tourist population, most of the dive boats on Guam cater to Japanese clientele.

In 2007, Guam’s dive industry represented a direct economic value of $5,200,000 when accounting for both local and visitor dive activity (Van Beukering, 2007). The industry hosts approximately 60,000-80,000 of the one million tourists that come to Guam each year, along with an estimated 2,500 to 3,000 local residents (Hanauer, 2001). Between local and tourist activities, it is estimated that 300,000 dives of varying levels are preformed throughout Guam’s waters every year (Burdick, 2008). Though there are many advanced dive outings offered by island dive businesses, it is reported that “most local dive operators cater primarily to novices from Asia taking advantage of the low-priced group packages” (Hanauer, 2001). Many tourists come to Guam specifically for
certification dives, where most have already completed course pool work and academics in Japan (Hanauer, 2001). Guam’s attraction as a novice dive destination is additionally emphasized with reports stemming from the Pacific Association of Dive Industry (PADI) that state over 5,000 Open Water or entry-level dive certifications were distributed in Guam alone during 2003 (Porter, 2005). It has also become well known that tourists visiting Guam, for the most part, do not come to the island for diving and diving alone. Dive trips in Guam are oftentimes scheduled around shopping or site seeing tours, as many boats will routinely return to dock before 4pm in order to allow for tourists to have an opportunity to catch their bus tours (Hanauer, 2001). This schedule depicts how Guam, though an excellent area for diving, is not a destination spot for the “extreme” diving culture. Diving on this island is oftentimes considered as just one of many activities in which tourists can participate. Guam’s role in the dive culture, as depicted by many authors, is not to act as a prime gateway to Micronesian diving, but, rather, as a place for novice divers to learn the sport or for experienced divers to test dive equipment and skills before moving onto other destinations, such as Palau or Fiji (Hanauer, 2001).

In a 2001 study conducted by Guam Visitors Bureau (GVB), 13 dive companies were identified to operate on the island (Van Beukering, 2007). Given that more than a decade has passed since the assessment, it can be surmised that the number of licensed dive companies may have changed over time, as tourism arrival numbers have fluctuated up and down in past years (Ruane, 2012). This number of licensed dive companies does not account for all of the island’s dive operations, though, as Guam is known to have a large contingency of unlicensed dive companies called “fly-by-nighters,” which operate out of vans and handle small groups of tourists (Van Beukering, 2007). For the licensed
dive companies documented by GVB in 2001, it was found that many operate out of either Apra Harbor or Hagatna and carry between 16 and 35 divers/snorkelers to dive sites (Port Authority of Guam, 2012).

2.2 Dive Industry Attraction to Apra Harbor’s Waters

Apra Harbor lies on the central-western side of Guam and is located approximately six nautical miles east-northeast of Agana, Guam’s largest city. It is the only natural, deep-water, protected lagoonal area in the entire Marianas Archipelago (We Are Guahan, 2010). The Harbor is protected by the Orote Peninsula, which houses Guam’s U.S. Naval station to the south and Cabras Island, the main hub for commercial industry, to the north (Figure 8) (Pike, 2011). Due to the combined activity of commercial and Naval vessel traffic, Apra Harbor is home to the busiest port in Micronesia, as it hosts 635 commercial vessel calls per year (as of 2012) (Port Authority of Guam, 2012) and approximately 100 U.S. Navy vessels calls per year on top of its resident fleet activity (Joint Guam Program Office, 2010). Despite the fact that the Harbor hosts a large amount of vessel traffic, its bottom substrate remains fairly intact from an ecological standpoint. Apra Harbor is famous for housing both patch and fringing reefs with some of the highest coral percent cover on the island of Guam (Guam Reef Life, 2010). Along with having high coral cover, the Harbor hosts approximately ninety species of coral – more than the number of coral species found in the entire Caribbean Basin (Guam Reef Life, 2010). Apra Harbor coral colonies are located primarily in the eastern portion of the Harbor and close to the entrance of Inner Harbor. Coral cover in Apra Harbor, as a whole, is dominated by a single species, *Porites rus*. Other common coral species include such varieties as *Porites lutea, Pavona cactus*,
Acropora aspera, and Porites cylindrical (Dollar et al., 2009). Large sea cucumbers (Thelenota annas) are common on the sea floor around shoal areas as well as elephant ear sponges (Lanthell basta), brown algae (Padina spp.), green algae (Halimeda spp.), and y-branched algae (Dictyota spp.) (Dollar et al., 2009). This type of habitat structure plays a very important role in the foundation of reef fish communities. In a study conducted by the University of Guam, a total of 119 species of reef fish representing the identification of 28 families have been recorded in Apra Harbor (University of Guam, 2009). On average, the families Acanthuridae (surgeonfishes, tang and unicornfishes), Caesionidae (fusilier fishes), Lutjanidae (snappers), Scaridae (parrotfishes), and Lethrinidae (porgies, rudderfishes, scavengers and emperors) are recorded to have the highest biomass within the Harbor (University of Guam, 2009). Such high coral cover and fish biomass inevitably attracts dive businesses to Apra Harbor’s coral reefs. Most tourist-based diving and snorkeling is referenced to occur in Apra Harbor, as it presents calm, sheltered, and scenic conditions for entry-level divers and snorkelers.

2.3 Other Similar Studies

This specific study will be the first to analyze dive operator spatial patterns within the Territory of Guam. Representing both a spatial and economic analysis, this study will take into consideration two different sister studies. Van Beukering et al. constructed “The Economic Value of Guam’s Coral Reefs” in 2007 in order to make an all-encompassing economic valuation on Guam’s coral reefs. This study also recognized the dearth of information available on the island’s dive industry and compiled a general overview on the industry’s economics. Information analyzed in Van Beukering’s 2007 study was gathered from a 2001 Guam Visitors Bureau tourist exit survey study: “Wedding, Dive
and Waterpark Study.” Van Beukering summarizes diver experience and ethnicities, total number of dives made per year, and average dive costs. Van Beukering also estimates dive industry total economic value by analyzing tourist-based information on trip cost, number of people, trips per person, and number of trips. This Van Beukering study essentially lends the first economic overview on Guam’s dive industry. The economic baselines created in Van Beukering’s study will act as a formidable baseline and comparison for this study. An appropriate paper to base the spatial portion of this study on is that of Manoj Shivlani and Daniel Suman’s 2000 “Characterization of the Commercial Dive Operator Industry in the Florida Keys National Marine Sanctuary.”

This study took place before the implementation of the Florida Keys National Marine Sanctuary in order to examine sanctuary economic impact to the dive industry, sanctuary effects on dive operator use patterns, and social perceptions and attitudes aimed towards the Sanctuary implementation process. Data stemming from the Shivlani and Suman study was gained from personal surveys conducted with dive industry operators. Shivlani and Suman’s methodologies will be very much mirrored in this study, as it similarly surveys dive operators on spatial and economic information before major change to spatial uses makes way.

2.4 Study Significance

This study will provide the first analysis of spatial use and economic dependencies on Apra Harbor coral reefs. This study will, therefore, allow for a preliminary understanding on how important Apra Harbor reefs are to recreational tourism activities occurring on Guam. Additionally, this study allows for the first formal evaluation of perceptions felt by Guamanians on how they believe their livelihoods might be altered by the dredging
project and associated Buildup activities. The study lends an overview on the socioeconomic challenges the dredge project will come to face within one of the recreational tourism industries occurring on Apra Harbor reef areas.

Such a baseline study is incredibly important before major change comes to the area, as it will help support damage assessments and needed adaptive management decisions that will ultimately take place after dredging occurs. If socioeconomic compensatory mitigation becomes an option after dredging, such a socioeconomic baseline will allow the Department of the Navy and associated project managers to clearly view the effects of the dredge project on local dive businesses. Additionally, a socioeconomic piece, such as this, acts as a beneficial baseline marker for other altering projects that might be planned in the Harbor’s future, such as the upcoming expansion of the commercial port facility.
CHAPTER III: Methods and Materials

3.1 Survey

3.1.1 Estimation of Dive Business Population and Apra Harbor Coral Reef Sites

Determination of Guam’s dive business population came through the use of varying resources hosted by the World Wide Web, as there is no one singular or inclusive unit that lists Guam’s dive businesses. Such sources included:

- Individual business websites
- Online phonebook
- Guam tourism websites
- Hotel ads or websites

Through the use of these criteria, 34 dive businesses were identified to operate on Guam. Apra Harbor coral reefs cited in the survey and throughout the study were determined in a similar way, as a variety of searches were conducted on the World Wide Web and a dive guide was used to obtain and vet information. Sources included:

- "Final Environmental Impact Statement: Guam and CNMI Military Relocation- Relocating Marines from Okinawa, Visiting Aircraft Carrier Berthing, and Army Air and Missile Defense Task Force" by Joint Guam Program Office, 2010
- Individual business websites
- Guam tourism sites
- "Diving & Snorkeling Guam & Yap" by Tim Rock, 1999

Filtering through the above information highlighted coral reefs that have the potential to be impacted by the Navy dredge project and those that are commonly frequented by the dive industry. Reef sites that were both used by the dive industry and within Apra Harbor
were included in this study. A total of 14 coral reefs were selected for this study (Figure 9).

3.1.2 Survey Design & Activities

A survey was developed in order to gain baseline information on dive business interactions with Apra Harbor coral reefs (Appendix A). This survey is split into three specific sections in order to gain information on spatial uses, economic dependencies, and perceptions on potential dredging impacts on business:

1) Apra Harbor Use

Respondents of either the owner or managerial status were asked to specify if their business ran year round; the average number of dive and snorkel trips made per week; whether or not the business takes trips to Apra Harbor coral reefs; Apra Harbor coral reefs used; frequency of Apra Harbor coral reef use; number of hours spent at Apra Harbor reefs.

2) Economic Information

Respondents were asked to specify the average number of patrons each snorkel and/or dive trip hosts; number of personnel the business employs; employee hourly wages; average trip prices; percent of patrons that rent gear and gear rental costs; average cost per month for fuel & oil, vessel & gear maintenance, trip supplies, dock space and other miscellaneous costs; replacement value for vessel and electronic equipment, dive and snorkel equipment, and compressors; average amount of fuel burned per each trip; cost of government licensure fees.
3) Perceptions of Potential Dredging Impacts

The conclusion of this survey allowed respondents to express how they felt they might be affected by an Apra Harbor dredge project; state whether they would continue to bring dive trips to Apra Harbor while dredging occurred; and specify tolerance levels to dredge-induced sedimentation on utilized coral reefs.

An opportunistic sample of 34 businesses was sent surveys either via the form of e-mail, U.S. Postal Service, or both. An initial survey and associated cover letter invitation were sent via e-mail on January 7, 2013 to dive businesses with expressed e-mail addresses. Survey Monkey was the chosen survey host for this exercise. Survey Monkey was open for a period of one and a half weeks, and a total of five surveys were returned, four of which were 100% complete and used in this study.

On January 19, 2013, hard copy surveys and associated invitation cover letters were mailed to all businesses that had not responded to the online surveys and to businesses lacking e-mail addresses. Six surveys ranging from 80-100% complete were returned during this round. In all, 10 of the 34 businesses contacted for this study returned completed surveys, yielding a 29% return rate.

3.2 Spatial Analysis

Information gained from the survey’s Apra Harbor Use section was logged into Geographic Information System (GIS) ARC Map software courtesy of UM RSMAS. A satellite basemap was acquired from Bing.com (geographic coordinate system: NAD 1983 (HARN)), as it shows the most updated and graphic image of Apra Harbor. All
coral reef GPS coordinates were acquired from dive business websites, the Joint Guam Program Office 2010, or via online nautical charts.

Reef coordinates were entered into a master Microsoft Excel spreadsheet that hosts fields representing reef-use data, as gained from business surveys: total number of times per week each reef is visited, number of businesses utilizing each reef for snorkel trips, number of businesses utilizing each reef for dive trips, and direct economic value of each reef. This master spreadsheet was added to GIS Arc Map and exported as a shapefile. Use of this shapefile’s symbology tab allowed for the display of each field section’s frequencies with the use of graduated symbols and colors in a spatial realm.

The georeferencing toolbar was also a utilized tool in spatial analysis as it enabled the alignment and manipulation of pdf data (Joint Guam Program Office EIS dredge footprint plans, Lackey 2012 sediment dispersal data, and a NOAA nautical chart) with GIS Arc Map. Georeferencing was used to align pdf data to fit the spatial parameters of the Bing Apra Harbor basemap. After alignment, new shapefiles were created with the use of the editor toolbar that allowed for the tracing over of desired comparison areas. Attribute information was added to each new shapefile with help of the editor toolbar. Such Georeferencing allowed for the eventual comparison of dredge project plans in conjunction with coral reef data gained in this study.

3.3 Economic Analysis

Economic analysis is based off of eight survey results, as two businesses withheld financial information. Calculations within this section, though averaged, are very business specific. As per each business, yearly: wage costs (hourly wage*hours/week*number of employees*weeks/year), business expenditures ((fuel & oil + vessel &
gear maintenance + trip supplies + dockage + miscellaneous) * 12months per year), taxes
(approximate tax category rate), licensure fees, trip revenues (snorkel:
trips/week*weeks/year*trip rate*patrons/trip + dive: trips/week*weeks/year*trip
rate*patrons/trip), and gear rental revenues (dive: rental percent* patrons/trip*rental
rate*trips/year + snorkel: rental percent*patrons/trip*rental rate*trips/year) were
calculated. Throughout the study, such yearly numbers were summed together across
surveyed businesses and averaged in order to represent an average number for the group
of businesses as a whole. Both trip revenue and gear revenue calculations are based off of
Van Beukering’s conclusion that Guam hosts 46 diving weeks in a year (Van Beukering,
2007). Calculations for employee wages are based on a 48-week year when accounting
for holidays, vacation, boat maintenance days, and foul-weather days.

“Total revenue” for this study is defined as the amount of money made before
wages, business expenditures, taxes, and licensure fees are subtracted from revenue made
from dive/snorkel trips and gear rentals. “Net revenue” is referred to as the actual profits
made by a business after wages, business expenditures, taxes, and licensure fees are
subtracted from total revenue. The Financial Analysis Method, as standardized by the
World Resources Institute, was used in calculating the net revenue made by dive
businesses. This method involves calculating the total revenue of dive businesses (yearly
dive and snorkel revenue + yearly gear rental revenue) and subtracting business operating
costs (yearly: fuel & oil, vessel & gear maintenance, dock space, trip supplies,
miscellaneous costs, labor costs, license fees and taxes) to arrive at business net revenues
(Burke et al., 2008). For unincorporated businesses, an average personal income tax of
22.5% was used to calculate tax expenses (Pacific Daily News, 2007), while standard
Guam tax percentage rates for corporations, as per business income ranges, were utilized to calculate tax payments for each business (Global Property Guide, 2013).

Additionally, calculations were made for the purpose of evaluating the economic significance of specific reef areas within Apra Harbor. Such calculations were made by summing the total number of trips individual businesses make to each reef per week and multiplying that number by the individual business’ average number of people/ trip, average price/ trip, and number of diving weeks/ year. By summing across business results for each reef site, a yearly estimate was calculated for the economic significance of each Apra Harbor reef area.
CHAPTER IV Results

4.1 Apra Harbor Use

A total of 10 surveys were returned during this voluntary survey period, yielding a 29% return rate. The number of returned surveys received in this study is quite comparable to the 2001 Guam Visitors Bureau (GVB) study, which determined 13 dive businesses to exist on the island of Guam in 2001 (Van Beukering, 2007). This comparable business information lends space for comparative analysis to occur between this study and the 2007 Van Beukering analysis of the 2001 GVB study.

Of the 10 surveys received, business owners completed 70% of the surveys, while business managers completed the remaining 30%. All surveyed businesses run year-round operations, 100% of which utilize Apra Harbor coral reefs for dive and/or snorkel trips. Four of these businesses are wholly dependent on Apra Harbor reefs, as 99-100% of their trips take place at Apra Harbor reef areas. Forty percent of businesses run between six to seven dive trips per week, while 30% of businesses will run between 12 through 14 plus trips per week. One business does not run dive trips and hosts only snorkel trips. Figure 10 displays the number of dive trips conducted per week by surveyed businesses. Businesses hosting snorkel trips tend to run a higher number of trips per week, as 40% of the surveyed businesses run 14 or more snorkel trips within a week’s period (Figure 11). Two of the businesses surveyed do not offer snorkel trips, as they only concentrate on diving.

Each of Apra Harbor’s reefs receives use from the surveyed businesses. Reefs most popular among dive trips (attracting between six to eight businesses) consist of Western Shoals, Outhouse Beach, Gab-Gab II, and Fingers Reef (Figure 12). For
those reefs clustering around Western Shoals (Middle Shoals/Unnamed Reef, Big Blue Reef, Jade Shoals, Barge Reef, Anchor Reef, Surprise Reef), they appear the least popular among businesses, as only two to four businesses take dive trips to those reef sites. Reefs frequented most by snorkel trips consist of: Western Shoals, Fingers Reef, and Gab-Gab Reef (Figure 13). Western Shoals and Fingers Reef are the two most utilized reefs for snorkel trips, as between four to six businesses utilize the reefs. Gab-Gab Reef is utilized by a moderate number of businesses for snorkel trips (three to four businesses), while Jade Shoals, Outhouse Beach, and Dogleg Reef/Family Beach are used by a low to moderate number of businesses (one to three businesses). Figure 13 also depicts that Vecki’s Reef, Hidden Reef, Gab-Gab II, and Middle Shoals/Unnamed Reef are not utilized for snorkel trips, most likely due to their unsuitable conditions for snorkeling activities. Depths for all Apra Harbor reef areas are depicted in Figure 14, a bathymetric contour map provided by the U.S. Army Corps of Engineers. Within this figure, it is depicted that Hidden Reef, Vecki’s Reef and Gab-Gab II are areas that reach depths of at least 133 ft., depths not accommodating to snorkel trips. Middle Shoals, on contrary, is a very shallow reef that is surprisingly not frequented by snorkeling activity.

A graphical representation for the total number of businesses each Apra Harbor reef hosts for both dive and snorkel trips alike is displayed in Figure 15. Overall, Western Shoals receives use from the most businesses for both snorkel and dive trips alike. This does not come as a surprise as Western Shoals is well-known for: consistently good conditions no matter the weather type; a diverse and abundant amount of marine life; excellent conditions for snorkelers and novice divers alike (Rock, 1999). Fingers Reef hosts the second highest number of businesses in its waters for both snorkeling and
diving, most likely due to its shallow nature, which is ideal for snorkelers and divers alike (ScubaGuam, No Date). Figure 15 also depicts how Apra Harbor reefs are most utilized for dive trips. Each reef evaluated in this study receives the most activity from businesses that bring dive trips to the area.

Using data provided on how many times each business frequents each individual reef site per week, the number of visits made to each reef area was summed across surveyed businesses (Figure 16). Aligning with results from business use above, Western Shoals is the most utilized of all reefs in Apra Harbor, as it receives at least 45 visits per week from the surveyed businesses. Outhouse Beach is placed as the second most utilized reef at 44 visits, while Gab-Gab II is ranked third at 20 visits per week from surveyed businesses. Although Fingers Reef receives the second highest number of businesses in its waters, it is ranked as the fourth most visited reef within the Harbor. This result depicts how the number of businesses utilizing each reef does not necessarily correlate with the amount of reef use. Survey participants also reported that the lesser utilized reefs, such as Hidden Reef, Jade Shoals, and Middle Shoals are not necessarily used on a consistent weekly basis, but are utilized more along the timeline of once or twice a month. Also, operators stated that some reefs are more frequently visited when bad weather conditions are present offshore. Such reefs consist of: Gab-Gab Reef, Fingers Reef, Family Beach, Outhouse Beach, Western Shoals, and Jade Shoals. Reefs within Apra Harbor, therefore, might have more use than depicted by the weekly assessment made in this study. Calculating on the cautious side, without bad weather or inconsistent uses in consideration, this study estimates that Apra Harbor reefs receive approximately 60% of the overall dives conducted by the surveyed businesses each week. Table 1
depicts the breakdown for this percentage calculation. Assuming each dive or snorkel trip consists of two dives, each trip was multiplied by a factor of two in order to derive the number of dives conducted by surveyed businesses each week. Summing together the number of visits operators reported making to Apra Harbor’s reefs each week and equating one visit to one dive allowed for the percent at which Apra Harbor reefs are used weekly to be derived. Being a tropical year-round destination, with a year-round dive industry (as reported in surveys), the Guam dive industry is considered to have an even demand throughout the year. At a minimum, Apra Harbor is approximated to host 60% of the dives made in Guam’s waters each year. This is, once again, considered a minimum approximation for use, due to inconsistent and foul weather uses.

4.2 Economic Information

Eight of the surveyed businesses provided economic information. On average, it is found that dive businesses charge patrons $99 for a standard two-tank dive and $59 for a typical snorkel trip. This average price for a two-tank dive trip compares well to Van Beukering’s average tourist dive trip cost of $96 in 2007. Businesses running dive trips average 13 patrons per trip, while businesses running snorkel trips have a higher average of 28 patrons per trip. Two of the surveyed businesses reportedly run snorkel trips with 60 or more passengers per each trip. Given that snorkeling is a less equipment-based activity, as compared to diving, more passengers can be fit into one trip. Of the patrons participating in each trip, an average of 90% of patrons rent snorkel equipment and 50-75% rent a full suite of dive equipment. On average, businesses will charge $22 for the rental of a full suite of dive equipment. Fees for snorkel rentals are quite insignificant, as 90% of businesses running snorkel trips do not charge a fee for equipment rental. This is
an interesting alignment given that approximately 90% of patrons participating in snorkel trips need equipment.

When calculating across all surveyed dive businesses, the average number of employees per business consists of: seven full time employees; four part time employees; one seasonal employee. Full time employment is the leading form of employment for surveyed businesses. Seasonal work is not a prevalent form of employment for the island’s dive businesses, as only two businesses reported seasonal personnel. The average hourly wage for full time employees rests at $14/ hour, $13/ hour for part time, and $16/ hour for seasonal. The seasonal employment average is much higher than anticipated. There may be two different reasons for this answer: 1) the average is inconclusive, as only two figures were reported; 2) licensed captains (requiring a higher pay grade than mates) may be hired for seasonal employment. Overall, it is found that the surveyed dive businesses support 100 employees who average an annual personal income of $27,510 per year.

Dive operators were additionally asked to report basic costs incurred while running a dive business. Operators reported costs ranging from business start-up to typical monthly costs of running trips. Average costs for business start-up are included in Table 2 and average monthly costs for running trips are summarized in Table 3. Table 2 demonstrates how the most expensive costs for dive businesses lie in start-up costs for equipment. An investment in the vessel and associated electronic equipment is the most expensive start-up cost at an average of $395,626. Expenditures on diving and snorkeling equipment is the second most costly start up factor at $35,000, while costs for compressors are the least costly of all at $22,000. Although compressors are not invested
in by all businesses, it is a category that has been included in the standard start-up cost category, as 50% of the surveyed businesses host compressors. Considering that Van Beukering 2007 determined that eight compressors existed on Guam, this study has captured an average cost for approximately 62% the island’s compressors.

Table 3 takes a close look at the average monthly costs a single dive business is capable of incurring by running trips. The highest expense stems from fuel and oil costs, which average approximately $3,764 per month. Gear and vessel maintenance requires approximately $2,336 per month, while trip supplies and miscellaneous costs will run $1,386 and $731 per month, respectively. The lowest monthly cost for dive businesses is associated with dock space, averaging at $629 per month. On a yearly basis, dive businesses must pay licensure fees to both the Government of Guam and the U.S. Coast Guard, ranging from $100 to over $400. Both fees range from business to business in accordance to business size, classification, and vessel tonnage (Guam Department of Revenue and Taxation, 2007). Summing together monthly costs including an average licensure fee of $275, it is found that a single dive business will spend an average of $106,307 per year on operational costs for running trips (excluding employee pay, mortgages payments, or tax payments).

Of the eight surveyed businesses, 62.5% make the largest portion of their revenues on dive trips. When summed between dive and snorkel trips, a single dive business will make an average total revenue of $1,558,028 from these two trip types yearly. In addition to snorkel and dive trip revenues, total revenues made from gear rentals average at $25,343 per business annually. Summed over the surveyed businesses, annual earnings amount to $6 million in net revenue. Given that Van Beukering valued
the dive industry at 5.2 million in 2007, the number derived in this study acts as a valued comparison as tourism numbers as of 2011 have only dropped by 30,000 people since 2007 (Schumann, 2012) and cumulative inflation since 2007 has risen by 1.2 percent (Coin News Media Group LLC, 2013).

The direct economic value of each Apra Harbor coral reef has additionally been calculated. Such calculations are based off business specific information, including number of trips made to each reef per week, the average number of people per trip, average trip cost, and number of diving days per year. Totals for each reef area were summed across the surveyed participants in order to depict the direct economic value of each Apra Harbor coral reef (excluding associated gear rental revenues) over the course of a one-year period. As described in Table 4, Outhouse Beach is the most economically valuable reef area in Apra Harbor, as it contributes to $4,070,310 in total revenues made by the surveyed businesses. Western Shoals, the most visited of Apra Harbor reefs, is the second most economically significant reef in the Harbor, as it contributes to $3,527,165 in total revenues. Despite the fact that Western Shoals is the most visited reef in terms of trips, Outhouse Beach receives a larger average of patrons per trip, qualifying it to be a more economically significant reef. Middle Shoals and Jade Shoals appear to be the two least economically significant reef areas, as they both contribute to approximately $41,630 in total revenues made by surveyed businesses per year.

To evaluate the extent to which island dive businesses impact the local economy, an economic impact analysis was intended for this study in order to evaluate how dive business activity generates additional waves of economic impact in Guam. Such calculations are traditionally quantified by using the U.S. Department of Commerce’s
Regional Inter-industry Impact Model-Version II (RIMS II) to calculate impacts on interrelated industries (Murray, 2001). This RIMS II model utilizes a combination of direct survey data obtained through national surveys on inter-industry interaction and a number of regional assumptions (based on the structure of area industries) in order to gain a standard set of regional multiplier coefficients that depict inter-industry relationships within a region (Murray, 2001). Unfortunately, as with other territories under United States jurisdiction, Guam does not have a set of standard regional multiplier coefficients available for economic analyses under the RIMS II model (Ruane, 2011).

Because of the island’s faulty and inadequate economic records, a standard set of regional economic multipliers have not been developed for Guam. Guam’s economic analyses today are regularly based off of Hawaiian multipliers, as Hawaii is the only U.S. state with a fairly similar economic and geographic setting. However, this economic setting is not similar enough, as the use of Hawaiian multipliers is not an exact or even close method for estimating regional economic impacts within Guam, as careful comparisons between Guam and Hawaiian economies have not been conducted or accounted for (Ruane, No Date). As depicted in Maria Ruane’s 2011 study, “Macroeconomic Multipliers: The Case of Guam,” Guam is known to have more local spending leakages than Hawaii, as spending on military bases, off island internet purchases, and spending during off island trips compete more with the local economy of Guam than that of Hawaii (Ruane, 2011). Guam’s high local economy leakage rate acquires lower monetary capture rates than Hawaii. Although Hawaiian numbers are standardly used to analyze Guam economics, it becomes apparent that such numbers are not truly aligned with Guam’s economic character. Hawaii’s economic multipliers are
also outdated, as they were last calculated in 2002 (Bradley, 2013). Unlike stateside analyses of Guam’s economy, this study will not utilize Hawaiian multipliers within a RIMS II model in order to understand the flows of money that the surveyed businesses contribute to within in the local economy.

In order to create a more Guam-centric analysis within this study, two local spending multipliers, estimated specifically for the Territory of Guam, were utilized to determine a preliminary understanding on how dive business generated funds interact with the local economy. In a 2011 study conducted by Ruane, Guam is estimated to have a local spending multiplier of 1.3 when taking into account the extra leakages present in the local economy. The US Navy’s Joint Guam Program Office also calculated a local spending multiplier for Guam within The Buildup’s 2010 EIS. The Joint Guam Program Office estimates a 1.82 local spending multiplier based on an estimate of local spending that does not take into account leakages. Ruane and EIS multipliers have been utilized to estimate how earnings made by dive business employees mingle within the local economy. Table 5 compares Ruane and EIS multiplier estimates for indirect and total outputs stemming from employee earnings. Ruane’s 2011 indirect economic output of $825,300 is considerably lower than that of the EIS estimated output of $2,255,820. As afore mentioned, the multiplier developed by Ruane takes into account the extra leakages Guam is known to have, while the multiplier developed by the Joint Guam Program Office is a spin off from the Hawaiian local spending multiplier of 1.89 (Joint Guam Program Office, 2010). While there is no exact answer right now in reference to Guam multipliers, it can be safe to assume that secondary impacts stemming from income made by the 100 employees of surveyed dive businesses begin at $825,300 annually.
4.3 Perceptions of Potential Dredging Impacts

When asked to express how business might be affected by a Navy dredge project, 70% of operators stated that they would be negatively affected by such an operation. Interestingly enough, 20% of operators said that they would be affected positively by a dredge operation. Of the two businesses predicting a positive benefit, they appear to specialize in dives elsewhere in Guam and do not concentrate a high percentage of trips in Apra Harbor. It is hypothesized that during dredge operations, these businesses will have the capacity to push advertising for their dive trips that will not take patrons to a dredge zone. A single business (1%) stated that a Navy dredge project would not affect normal operations, even though 33% of that business’ operations occur within Apra Harbor.

When asked whether businesses would continue conducting trips in Apra Harbor while dredge activity occurred, 80% of operators said yes, while 20% said that they would not continue trips in Apra Harbor. Two businesses stated, as a side note, that they had no choice but to continue bringing operations to Apra Harbor while dredging occurred, as they would otherwise go out of business. Finally, businesses were asked to make an evaluation on how much dredge-based sedimentation they were willing to withstand on the Apra Harbor coral reefs they frequented. Seventy percent of businesses said they would continue bringing trips to Apra Harbor reefs if they experienced minor sedimentation, 60% stated they would continue trips to Apra Harbor reefs if moderate sedimentation occurred, and 30% said they would continue trips if large amounts of sedimentation occurred. Once again, two businesses stated in this section that they had no
choice but to continue diving Apra Harbor reefs despite their state, as they would otherwise go out of business.
CHAPTER V: Discussion

5.1 Apra Harbor Baseline

5.1.1 Apra Harbor Reef Use

Each of the businesses surveyed in this study demonstrate a strong allegiance to the beginner diver and snorkeler clientele. This becomes apparent when examining the most frequented dive/ snorkel spots in Apra Harbor. Two use hot spots occur both at Western Shoals and Outhouse Beach, which are located at the eastern end of Apra Harbor. Western Shoals is the most utilized of all reefs in the Harbor, as it is visited by the surveyed businesses at least 45 times per week. It is a logical result that Western Shoals is the most visited of reefs in the Harbor, as it boasts consistently good dive conditions for year-round diving on its western side. The reef is ideal for both snorkel and dive groups, as it slopes from 10ft-80ft. of depth, water in the area has slim to no currents, and the reef boasts an abundant amount of life (Rock, 1999). As put by dive master Harris Moore, Western Shoals is an ideal place for dive businesses to go, as it is a perfect spot for large multi-level groups (Moore, 2013). Operators can take large groups to one spot and people of all skill sets would be happy with the dive or snorkel. Outhouse Beach, receiving 44 visits or more by surveyed businesses each week, is very popular with dive trips, while also receiving use by snorkel trips. Outhouse Beach popularity correlates with the fact that it is a frequently visited spot for SCUBA certification dives (Dive Scovered, No Date). On any given day, it is reported that five to ten businesses will typically gather at Outhouse Beach to conduct Open Water Certification dives. Although this coral reef area is documented to have little marine life it is an attractive spot for the dive industry; the site, like Western Shoals, is dive-friendly in any type of weather
condition due to its sheltered location (Dive Scover, No Date). It can be surmised that the
two most popular reefs in Apra Harbor have gained their popularity due to the fact that
they are accommodating to both novice divers and snorkelers alike and both can be
utilized in most every weather scenario.

Some reefs less utilized than Western Shoals and Outhouse Beach are those that
are only available to dive trips due to depth. Gab-Gab II Reef, receiving a moderately
high number of visits by surveyed businesses at 20 visits per week, is popular only with
dive trips. Gab-Gab II is a deeper reef in Apra Harbor; it has a top plateau resting at 30
ft., which descends down to approximately 100 ft. in depth. This is recorded as a popular
dive, since large schooling fish are attracted to the site because of fish feeding stations
sponsored by the local Atlantis Submarine tour (Scuba Guam, No Date). The fish in the
area have become quite tame and will often swarm around divers making it an attractive
spot (Scuba Guam, No Date). Vecki’s Reef, visited 12 times per week by surveyed
businesses is also strictly utilized by dive trips, as the reef stretches down to 120 ft. in
depth (Scuba Guam, No Date). Vecki’s Reef is predominantly known as a deep drift dive
that requires more technical skills than a newly certified diver should be expected to
perform. These reefs are highly utilized by dive trips, yet, overall, they are moderately
utilized, since they cater only to one activity.

Moderately used reefs for both dive and snorkel activities (visited between 6-15
times per week) consist of Fingers Reef, Gab-Gab Reef, and Family Beach. These
moderately used reefs are clustered at the Western half of Apra Harbor and immediately
along the shoreline. Fingers Reef receives moderately high use from both dive and
snorkel trips, as it is situated at a depth appropriate for both activities (between 15-100
ft.). This reef is filled with many different species and acts as a popular second stop for many dive boats heading back to shore from an offshore trip (Rock, 1999). Gab-Gab Reef receives a moderately high amount of both dive and snorkel activity, since much like Fingers Reef, it has an all accommodating depth range of 10 ft. to 80 ft. (Rock, 1999). Gab-Gab offers shallow coral valleys and good condition mini-walls. Gab-Gab reef most likely receives more use than indicated by the surveyed dive businesses, as it is located within the U.S. Naval Station limits and very close to shore (Scuba Guam, No Date). Gab-Gab is an easy shore dive or snorkel for anyone with Naval Station access (Scuba Guam, No Date). Family Beach hosts a moderately low amount of snorkel activity and a moderate amount of dive activity. This shore or boat dive has a reputation for idyllic beach diving for both beginner and experienced divers alike. With a small canyon that runs parallel to the beach, diving is typically done in 6-30 ft. of water along the canyon walls. Family Beach is not as popular as neighboring Outhouse Beach, as it is privately owned and fees are oftentimes charged for beach access (Huff, 2012).

Coral reefs receiving moderately low use, ranging from four to six visits from surveyed businesses per week are clustered very close together on the western side of Western Shoals: Barge Reef, Anchor Reef, and Surprise Reef. Although these reefs to the west of Western Shoals are known for their abundance of life and pristine conditions, they are not as popular as their other counterparts. Reason for this might come from the fact that they are more challenging dives; depths at these locations range from 40 ft. - 120 ft.

Reefs in the lowest category of surveyed business visits per week (two to four visits) consist of Jade Shoals, Middle Shoals, Big Blue Reef and Hidden Reef. Hidden Reef,
located in the midst of the Harbor entrance, ranges from 40-134 ft. in depth. Hidden Reef is often considered a more advanced dive, as NITROX is recommended for this site (Scuba Guam, No Date). Following with the theme of many advanced dives in the Harbor, Hidden Reef is assumed to not be as popular as others due to its level of dive difficulty. As for Jade Shoals, Middle Shoals, and Big Blue Reef, the reef systems are situated in a less desirable place for dive and snorkel activity, since they are all clustered together along the main shipping lane used by both commercial and Navy vessels (Figure 17). It is hypothesized that the volume of traffic running through the immediate area might contribute to a less desirable location to bring trips to.

Overall, Apra Harbor may be seen as an area that caters to novice snorkelers and divers on its coral reefs. Apra Harbor is an attractive place being that it has safe, sheltered harbor conditions; its sheltered conditions are ideal during most weather conditions, and its reefs provide a high amount of scenery. Apra Harbor is not only ideal to the novice diver type looking for good coral scenery, but is also an attractive spot for dive operators, as well. Given its proximity to shore, operators have the opportunity to take patrons to an area that can please every level type; operators can save on fuel, as run times to spots are short; and, operators are able to make it back to dock in time to host a second trip for the day (Moore, 2013). Apra Harbor is an ideal place for dive operations to occur, since it offers maximum benefit to the beginner clientele that frequents the island and the operators that cater to that clientele.

5.1.2 Apra Harbor Significance

Apra Harbor’s appeal to the basic level tourist diver and dive operators results in the Harbor receiving approximately 60% of the dives and snorkels conducted in Guam’s
waters each week. Accounting for an average of 46 diving weeks in the year (Van Beukering, 2007), Apra Harbor reefs are estimated to host 8,004 dive/snorkel trips annually. Utilizing a minimum average of 13 people per dive trip and 28 people per snorkel trip, Apra Harbor is capable of hosting between 106,453 and 224,912 divers and snorkelers, respectively, every year. This is, once again, a minimum estimate, as this number does not account for recreational diving conducted by locals on private boats or from shore. Such numbers, though, are verified when comparing the total number of dives conducted in Guam waters each year with Van Beukering’s 2007 study estimates. Van Beukering estimated Guam to host between 187,492 and 374,984 dives per year (based on 46 diving weeks); this study, while also utilizing the number of 46 diving weeks per year, estimates that a range of 176,198 - 372,269 dives are made in Guam’s waters each year, as per the surveyed businesses. Trips to Apra Harbor’s reefs, ultimately, contribute to $13,547,345 in total revenues gained by surveyed businesses annually. Overall, Apra Harbor is not a light use area for the surveyed businesses.

5.2 Apra Harbor Impact Analysis

With a footprint located close to the entrance of Apra Harbor’s Inner Harbor area, the Navy dredge project will not harm a majority of the reefs utilized by Guam’s dive businesses. A handful of reefs, though, are in danger of direct impacts and heavy secondary impacts; these include: Jade Shoals, Middle Shoals and Big Blue Reef. Western Shoals is additionally predicted to incur low-level secondary effects from this project. Though Western Shoals is predicted to receive the least amount of impact when compared to Jade Shoals, Middle Shoals and Big Blue Reef, it must be remembered that Western Shoals is the most depended upon reef in Apra Harbor (and possibly Guam as a
whole). Western Shoals acts as the largest attraction to Apra Harbor, as it is utilized at least 45 times a week for trips, by 80% percent of surveyed businesses. In terms of the dredging project, Western Shoals lies in a precarious position, since it immediately borders the planned dredging zone. Jade Shoals, Middle Shoals, and Big Blue Reef, though not as depended upon by the island’s dive businesses, do hold economic importance; each of the three reefs will host between two to four visits from the surveyed businesses each week. Figures 18 and 19 represent the proximity of Western Shoals, Jade Shoals, Middle Shoals and Big Blue Reef to the two alternative dredging footprints (Polaris Point & Former Ship Repair Facility). Dredging of Polaris Point would entail a cut out of Middle Shoals, as well as a cut along the very edge of Jade Shoals. Dredging of the Former Ship Repair Facility will cut into parts of Middle Shoals, as well as Big Blue Reef. This dredging footprint, like Polaris Point, also runs along the very edge of Jade Shoals.

In order to evaluate the extent to which these reefs may be affected by dredge-based sedimentation, the most recent Apra Harbor sediment dispersal study, Lackey 2012 “Transport of Resuspended Dredged Sediment Near Coral Reefs At Apra Harbor, Guam” was examined. Lackey 2012 utilizes the US Army Corps of Engineers Partial Tracking Model (PTM) to quantify the fate of suspended materials within the Harbor. PTM is a Lagrangian Model designed specifically to track suspended sediments and other constituents released from specific sources, such as dredges, placement sites, outfalls, etc. in complex hydrodynamic and wave environments (Lackey, 2012). Lackey 2012 sediment dispersal projections are based off of the parameters set forth by The Buildup’s
2010 EIS. In accordance to the 2010 EIS, the dredge project will be a 24 hour-a-day operation that will generate approximately 1,800 CY/day for 8-18 months.

Due to the characteristically weak currents in the area, Lackey 2012 projects sediment deposition to fall largely within the confined vicinity of the defined dredge footprint area. Lackey 2012 predicts that, by project end, only a few areas will have sediment deposits outside of the dredge footprint. Figures 20 and 21 have been developed to display Lackey’s dredge-based sediment accumulation projections for both Polaris Point and the Former Ship Repair Facility by project’s end in conjunction with the location of surrounding coral reef areas (Western Shoals, Jade Shoals, Middle Shoals, Big Blue Reef). These sediment accumulation projections within the figures are based on a worst-case scenario, where dredge activity will occur for 12 months at 1800 CY/day and the silt curtain will have a 90% efficiency (Lackey, 2012).

Within Figure 20 Polaris Point sediment accumulation projections, Middle Shoals and Big Blue Reef are predicted to be the only reefs affected by sediment accumulation. Both Middle Shoals and Big Blue Reef will receive an estimated maximum of 0.60 g/cm² of dredge-based accumulation by project end. Dredging of the Former Ship Repair Facility (Figure 21) is projected to bring approximately 0.60 g/cm² of dredge-based sediment accumulation to Big Blue Reef and anywhere from 0.60 - 3.90 g/cm² of dredge-based sediment accumulation to Middle Shoals. Both dredging scenarios for Polaris Point and the Former Ship Repair Facility do show that most of the sediment accumulation will stay within the dredge footprint area. Overall sediment accumulations escaping from both the dredge footprints areas are projected to range from 1.70 g/cm² along the immediate
footprint edges to 0.60 g/cm² within 1,300 feet of both footprint areas.¹ Lackey 2012 additionally predicts that Harbor exposure to high amounts of sedimentation will be kept at a minimum, as only between 1.6 ft. and 3.3 ft. of material will be dredged at most locations. Acquiring 1800 CY of dredged material per day, it is predicted that each site will only be dredged for a total of one or two days. This short time period is expected to keep coral exposure to intense sediment plumes at a minimum.

Dredging activities will not only cause the settlement of sediment on surrounding areas, but will also cause the suspension of sediment within the water column. Such suspension of extra particulate matter within the water column can alter the delicate balance of sun penetration that photosynthetic coral reefs depend on (Grigg, 1990). In order to determine the extent to which coral reefs surrounding the dredge footprint area might be affected by sediment suspension, Figures 22 and 23 have been created to display Lackey 2012 particulate suspension projections for Polaris Point and the Former Ship Repair Facility. Suspension values displayed in these figures have been vertically averaged over the water column for the course of a 12-month dredging period. Just like the earlier sediment accumulation projections, suspension projections are based on a worst case scenario where dredging will occur for 12 months at 1800 CY/day with a 90% silt curtain efficiency (Lackey, 2012). Like the earlier settlement projections, suspended sediment resulting from Polaris Point dredging activities are predicted to be mostly concentrated within the dredge footprint area. Each of the immediate reef areas is also projected to receive some form of sediment suspension within their associated water column. The eastern portion of Western Shoals is calculated to receive between 0.005 - 0.008 kg/m³ of sediment suspension within its water column. The eastern portions of

¹ GIS Arc Map “Measure Tool” provided the measurements used in area calculations.
Middle Shoals and Big Blue Reef are projected to be affected by 0.005 kg/m$^3$ of extra particulate matter within the water column, while Jade Shoals is expected to be minimally disturbed, since its water column may host 0.005 kg/m$^3$ of suspended materials speckled across the area. Dredging of the Former Ship Repair Facility is projected to lead to suspended solids occurring in large quantities both within and outside of the dredging footprint. Approximately 40% of the Western Shoals water column is projected to be affected by suspended solids ranging from concentrations of 0.005 kg/m$^3$ to 0.008 kg/m$^3$. The eastern portion of Middle Shoals and the western portion of Jade Shoals are both predicted to experience between 0.005 – 0.008 kg/m$^3$, while the south eastern portion of Big Blue Reef is expected to receive between 0.005 – 0.01 kg/m$^3$ of suspended solids concentration in its water column.

Given the oceanographic patterns present in Apra Harbor, it is seen that most sediment suspension and settling will be directed to the east. The spread of such suspended materials in this direction will be of concern to operation managers, as Sasa Bay Marine Preserve (Figure 24) lies directly east of the dredge zone. Figure 25 displays Lackey 2012 projections on sediment settling and suspension and its spatial correlation with the Sasa Bay Marine Preserve area. In this figure, it is shown that no matter what wharf site is selected, dredge based materials are projected to enter into the mouth of Sasa Bay. Construction of the Former Ship Repair Facility is projected to contribute to the highest sediment suspension possibilities within the Preserve, while Polaris Point construction is projected to incur the largest amount of sediment accumulations within Sasa Bay Marine Preserve.
Known impacts associated with particulate filled water columns and sediment settling on coral reefs include reduced photosynthesis and increased respiration, tissue mortality, reduced growth, increased mucus secretion, and reduced fertilization, reduced larval survivorship and recruitment, and mortality (Grigg, 1990). There is no doubt that the coral reefs surrounding the dredging footprint will be affected by this project. There is question, though, as to how affected these coral reefs will be, as the degree of impact depends on many different variables. Firstly, much has to do with the duration at which sediment coverage and associated sunlight blocking lasts for photosynthetic corals. Given that Apra Harbor hosts weak currents, it can be predicted that the calcium carbonate-based sediment projected to settle on reefs will not be quickly cleared off by oceanic conditions (Lackey, 2012). There is worry that once sediment accumulates on surrounding coral reefs, it will take a long time to be naturally removed. Secondly, much has to do with the type of coral species present in the surrounding Harbor area and the natural sediment tolerances of species. Luckily, *Porites rus*, *Porites lutea*, and *Porites cylindrical* are three of the more commonly found coral species located at the eastern portion of Apra Harbor (Joint Guam Program Office, 2010). Known to thrive across turbidity gradients driven by proximity to terrestrial run off, the *Porites* family is famed for being one of the most persistent and sediment tolerant corals in the world (Padilla-Gamiño, 2012). It is also hypothesized that most all species naturally growing within Apra Harbor will have some form of natural sediment tolerance, as Apra Harbor is a deep-water lagoon that naturally experiences the pulsing of sedimentation within its system (NOAA CoRIS, 2013). Thirdly, the extent to which these naturally sediment tolerant coral species will be harmed by dredging activities will have much to do with the
sediment threshold species are currently at due to both natural and anthropogenic stressors. The U.S. Geological Survey sites that human activity in Guam has already significantly increased the rate of sedimentation along many of the island’s coastlines (USGS, 2012). These human activities are related primarily to urban development, unregulated use of off road vehicles, and illegal wildfires set for hunting. When heavy rains come to Guam, an excessive amount of unstabilized soils are washed down the coast and into the nearshore waters (USGS, 2012). Given the sediment that already flows into Apra Harbor, there is threat that the coral reefs are already close to the edge of their natural environmental tolerances for sediment. Another potential source of sedimentation from a Navy dredge project and additional sediment run off from associated Buildup construction activities could possibly push certain Harbor species over the tipping point of their natural sediment tolerance levels. Lastly, the extent of dredging impacts on coral reefs will have much to do with project management. If silt curtains are not properly maintained or if chronic accidents such as spillage of dredge material outside of silt curtains occurs, effects on coral reefs will elevate to an even higher level. Overall, the effect on corals surrounding the project footprint will depend on a variety of factors that will come into play throughout the course of the project. Let it be hoped that Mother Nature also cooperates, so that more intense sediment plumes do not come into play over the project time period.

5.2.2 Apra Harbor Impact Analysis- Socioeconomic

All businesses surveyed in this study interact weekly with Apra Harbor coral reefs. Seventy percent of the surveyed businesses utilize Apra Harbor for 52-100% of the trips they make. Four of these businesses utilize Apra Harbor for 99-100% of trips that
they offer. Hosting 60% of all dives made on a weekly basis, it is safe to assume that Apra Harbor holds a strong pull within the local dive industry. Hosting the highest percentage of trips made within the Harbor and the second most significant economic value ($3,527,165), Western Shoals is viewed as an incredibly valuable resource by surveyed dive businesses. Reefs utilized to a lesser degree by the dive industry, but within the main impact and secondary affect area of the dredging project, consist of Jade Shoals, Middle Shoals, and Big Blue Reef. Jade Shoals and Middle Shoals are each directly responsible for $41,630 in total annual revenues made by surveyed dive businesses, while Big Blue Reef directly contributes to $79,810 in total annual revenues. When summed together, the dredge project footprint is planned to occur around and potentially affect coral reefs that are worth over $3,690,235 to annual total revenues made by the surveyed businesses.

Of surveyed respondents, two businesses state that they would stop utilizing Apra Harbor reefs for trips, if a dredging operation were to occur within the Harbor. Both of the businesses providing this answer are fully dependent on Apra Harbor for 100% of their trips. If this dredging project occurs, it will automatically displace $110,700 in annual total revenues made by the two businesses. Table 6 depicts how dredge-based sediment buildup on Apra Harbor reefs can potentially affect or displace revenues made by the surveyed businesses. The table demonstrates the potential economic displacement that dredge-based sedimentation might cause businesses that utilize reefs located within the impact zone as depicted by the Lackey 2012 data (Western Shoals, Jade Shoals, Middle Shoals, Big Blue Reef). If minor sedimentation were to occur on Apra Harbor reefs, three businesses state that they would stop bringing trips to reefs affected by minor
siltation, resulting in a potential of $430,164 in displaced revenues. If a moderate amount of sedimentation were to occur, economic displacement could amount up to $570,780, as four businesses state that they would move away from using Apra Harbor reefs. Seven businesses additionally state that they would not return to use Apra Harbor reef sites affected by high amounts of dredge-based sedimentation. Monetary displacement from such a high amount of sedimentation is evaluated at $1,253,340. Overall, it is noticed that the smaller businesses surveyed in this study are most sensitive to change in Apra Harbor, as they utilize Apra Harbor for a very high percentage of their trips. Even though these small businesses rely almost solely on Apra Harbor, 20% say that they will stop all business within the Harbor if a Navy dredge project occurs. On the other hand, larger businesses show a high tolerance to the amount of sedimentation they are willing to withstand at reef sites. This finding might cater to the idea that smaller businesses cater more to quality, while larger businesses running larger trips might cater more to quantity. In addition to direct monetary displacement due to reef sedimentation levels, there comes the possibility of direct losses incurred by businesses, as tourism numbers are thought to decline during the construction of Buildup components. It is predicted that neighboring Japanese tourists will hear of the massive amounts of construction occurring on Guam, as a whole. As projected by Schumann 2012, the tourism numbers on Guam could decline during the construction of Buildup components on the Island. Monetary losses during this buildup could potentially be much greater for surveyed dive businesses, when taking into account additional declines in tourist numbers.

Within the socioeconomic realm of evaluating industry impacts, there lies the reaction and reception from those who had taken surveys. For every survey that was
received via the U.S. Postal System, businesses paid for extra postage (even though proper postage had already been provided), presumably to make sure that their completed surveys were received. Also, for operators who took their surveys online, e-mails were sent in order to thank this study for thinking of their business and to provide additional information that might be of use within the study. This interaction, in itself, makes a poignant statement that, yes, the dive industry feels that it will be affected by a dredging project. As an anonymous operator wrote along the margins of a hardcopy survey, “Any more dredging and siltation [in Apra Harbor] would certainly detract greatly from dive operations, sub tours, and even snorkeling.”
CHAPTER VI: Conclusions

6.1 Limitations

Limitations found within this study come mainly from the long distance nature at which surveys were conducted. With an inability to speak directly with respondents, it was difficult for this study to acquire additional details that would have naturally surfaced during face-to-face interviews. Additionally, provided that all research on Apra Harbor reef sites was conducted from afar, there is no guarantee that all Apra Harbor reef sites utilized by dive businesses have been included in this study. Travel to a study site is needed in order to gain a thorough baseline understanding of the utilized resources.

The economic multiplier analysis for this study is of a limited nature, as Guam lacks a set of regional multipliers. As previously stated, Guam, like other territories under the jurisdiction of the United States, lacks a set of standard regional multiplier coefficients available for economic analyses under the RIMS II model (Ruane, 2011). Surveys developed for this study were not designed to attain information needed to create a set of study-based multipliers for regional impact analysis. Utilizing a single local spending multiplier, as was done in this study, does not describe the full extent of impact that dive businesses have on the island’s local economy.

6.2 Recommendations

6.2.1 Socioeconomic Baseline

Developing a comprehensive socioeconomic baseline study for Guam’s recreational tourism industry would be a proactive step for the Territory of Guam, regardless as to whether or not The Buildup comes to the island. Tourism is Guam’s
second largest industry yielding $1.35 billion yearly (Guam Economic Development Authority, 2013). Recreational tourism is the third largest contributor to revenues made by the tourism industry, as it contributes to 13% of sales made (Tourism Economics, 2012). Despite the major impact recreational tourism has on the island, very little is known about its specifics. Tourism Economics published a 2012 study, “The Economic Impact of Tourism in Guam,” of which covers the swath of components that comprise Guam’s tourism industry. Unfortunately, though, this study does not delve past the umbrella term “Recreation and Entertainment” and individual recreation industry analyses are left unmentioned in the study.

Developing a detailed recreational tourism socioeconomic analysis is important for the Government of Guam, as it would give the government the capacity to monitor recreational tourism growth and deficiencies. Such information would allow for the ability to effectively regulate the industries and modify for specific needs and requirements. As argued by McDavid 2003 in “The State of Tourism: A Caribbean Perspective,” the sustainability of a recreational tourism industry requires regional governments to be more proactive in planning the industry’s growth and development. With a history of fluctuating tourism numbers on the island, it would behoove the Government of Guam to be proactive in researching and, eventually, helping to better manage the recreational tourism component of its tourism industry.

The capacity for such a baseline study is already in place within the Guam Visitors Bureau Research Department. This department conducts monthly tourist exit surveys in order to gain baselines on tourist demographics. A yearly or quarterly survey based on recreational tourism activities could be substituted as an exit survey in order to
obtain specifics on recreational tourism activities. Tourist exit surveys, coupled with industry data gained either from public records or industry surveys, would offer a comprehensive baseline analysis on recreational tourism. Retaining an updated baseline socioeconomic study on recreational tourism would be especially useful to an island whose economy is very much centered on this avenue of tourism.

6.2.2 Mitigation

The 2010 Environmental Impact Statement produced by the Joint Guam Program Office presents a list of possible compensatory mitigation activities being considered provided that corals are adversely impacted by the Apra Harbor dredge project. Four potential mitigation categories have been developed within the EIS: watershed restoration and management, coastal water resource management, Apra Harbor water resource management, and mitigation banking (Joint Guam Program Office, 2010). Unfortunately, this list of mitigation categories does not currently take into consideration monetary compensation protocols for businesses that might lose revenue because of altered coral reef conditions or tourism declines on the island due to the overall Buildup activities. As a form of post-dredging compensation that would fall in line with managing the water resources of Apra Harbor and also be of benefit to the local dive industry, it is recommended that a limited marine spatial plan be implemented within Apra Harbor.

Whether it be from the passing of commercial or Naval vessels, to recreational tourism activities such as diving, snorkeling, jet skiing, boat tours, submarine tours, fishing, to commercial fishing, and local recreational activities, Apra Harbor is an incredibly small area (less than 2 miles² (5 kilometers²)) with a high amount of activity occurring both above and below its waterline (Figure 26). With the conclusion of
Build up, it is expected that the added population of personnel and their dependents from the Marines, the Army, the Air Force, and the Navy might add to the amount of tourism and recreation activity occurring within Apra Harbor. Although it would be ideal to create a comprehensive marine spatial plan for the already crowded Apra Harbor, due to issues with law enforcement on the island, it is recommended that a limited marine spatial plan addressing an updated Navy restricted zone and a marine preserve be considered as a possible form of mitigation. Considering military and local tourism activities have historically come into conflict over space availability within Apra Harbor (Marianas Variety, 2009), it is recommended that the Navy restricted area be transparently updated within the Harbor in order to accommodate for security requirements necessitated by nuclear aircraft carriers. Though the Navy currently has a set, restricted area within Harbor waters, area restrictions will have to be updated and enlarged once either Polaris Point or the Former Ship Repair Facility is chosen as the official aircraft carrier wharf facility. As dictated by security protocol, U.S. Navy aircraft carriers require 250 ft. of secured area around their hulls (Joint Guam Program Office, 2010). Figure 27, has been developed in order to depict the in-water restricted area needed if Polaris Point or the Former Ship Repair Facility were chosen to host aircraft carriers. Given that the Nimitz and Gerald R. Ford type carriers have flight decks ranging from 256 ft. - 257 ft. wide and share a total length of 1,092 ft. (U.S. Department of Defense, 2012), security zones measured perpendicular to Polaris Point or the Former Ship Repair Facility shorelines stretch 507 ft. in width and 1,562 ft. in length. If the Former Ship Repair Facility is chosen, a minimum approximate area of 34,465 ft. will be added to the current in-water Navy restricted zone.² If Polaris Point is the chosen

² Length measurements courtesy of GIS Arc Map “Measure Tool.”
location, a minimum area of 772,668 ft. of additional restricted area will have to be added
to the current restriction zone in Harbor waters. Developing a specified area for security
restrictions that will not change regardless of aircraft carrier presence would make cause
for less opportunity for confusion on security restriction zones when carriers are present.
Such a maneuver would aim for less conflict between the Navy and the tourism industry
in the long term, as restriction zones would be clearly understood.

Marine spatial planning would also be of benefit to the coral reefs impacted
heavily by the direct and secondary effects of dredge-based sedimentation. Zoning off a
small no-take marine preserve over the most impacted reefs, presumably Big Blue Reef
and/or Middle Shoals would allow for an uninterrupted recovery phase for those reefs.
The marine preserve would ideally prevent fishing activities from occurring within the
zone to discourage additional impacts, including anchor damage, build-up of
monofilament fishing line, and the depletion of fish populations (NOAACoRIS, 2010).
Dive activities, already found to be minimal within the area as per the surveyed
businesses, would be allowed to continue on the condition that dive businesses utilizing
the preserve would be required to gain a permit. Such a plan would help to deter the
amount of dive activity coming to the preserve, yet allow for it to be available for
businesses that rely on the area for income. Zoning of a marine preserve would not only
allow for a stress-free recovery for the highly affected corals, but would also allow for
adaptive management activities, as planned by the Joint Guam Program Office EIS to
occur without conflict. A marine preserve would allow for projects centered on physical
restoration techniques (artificial reef creation or repair), coral nursery establishment and
maintenance, coral transplantation methods, and monitoring to occur in an environment
where restoration efforts do not compete with a high amount of exterior activities (Nature Conservancy, 2013). The creation of a small preserve would also create connectivity with neighboring no-take Sasa Bay Marine Preserve. Sasa Bay consists of a mangrove swamp that skirts the coastline in a narrow band, as well as four to five strings of patch reef found in the deeper parts of the embayment (NOAA CoRIS, 2010b). Sasa Bay is, therefore, known as the Harbor’s essential nursery area. The creation of a preserve area on a patch reef, located outside of the Harbor’s nursery, would act as an ideal connector area to Sasa Bay for juvenile and adult fishes. The creation of a preserve along a patch reef area would act as a protectorate to the juvenile and adult life history stages of many organisms residing within the Harbor. Such a set-up would have the potential to increase rates of juvenile recruitment within the Harbor.

Choosing coral reefs of lesser economic value for a marine preserve set-up would allow for the least amount of conflict possible in the implementation of a preserve area. Figure 28 displays the economic value of each Apra Harbor coral reef. Big Blue Reef and Middle Shoals are coincidently the least economically valued reefs within the Harbor (as per the businesses surveyed in this study), as their values range from $41,630-$79,810 annually. The placement of a marine preserve within the vicinity of these adjacent reefs would appear to be the least economically disruptive approach to partitioning a marine preserve when referencing the information gained by the businesses surveyed in this study. Zoning off an area that was highly impacted, yet not highly depended upon would be ideal for a preserve set-up in the area. Additionally, Big Blue Reef is located within the vicinity of the Navy restricted area. Creating a no-take marine preserve within that area would ideally help to reduce user conflict even more.
Additionally, the coral cover found on Big Blue Reef and Middle Shoals currently consists of some of the most dense percentage cover in Apra Harbor. As depicted in Figure 29, courtesy of NOAA Center for Coastal Monitoring and Assessment, coral cover at these reef areas ranges from 50-90%, among the highest coral cover percentile. Establishing a preserve in an area that hosts high coral cover before the dredge project begins would be a beneficial form of mitigation practice, as the preserve could potentially restore a high amount of biodiversity to the area. Investing time and money into making a marine preserve out of a fuller reef area is oftentimes considered to be a more worthwhile venture, since fuller reefs are more likely to survive global stressors than less developed reef areas with less diversity. Of the many characteristics managers look for when designating an MPA or preserve, the quality of a reef’s resilience abilities or potential longevity is rated at the top of the list (Spalding et al., 2007). With the amount of damage Big Blue Reef and Middle Shoals are expected to incur, and their amount of economic value and coral percent cover, either coral reef area has the ideal background for the makings of a marine preserve for mitigation purposes.

If this limited marine spatial plan were to be implemented within Apra Harbor, dedication to the enforcement of this scheme will be greatly needed in order for the plan to have success and gain later support from the public. A high priority must be set to the enforcement scheme, as Guam is known to have consistent issues with the enforcement of existing laws and environmental regulations (Richmond, No Date). However, if a successful implementation of marine use zones occurs within Apra Harbor, it would help to deter spatial conflict between the U.S. Navy and tourism operations as Navy capacity increases within the Harbor, as well as aid in restoring the local ecosystem in a way that
does not detract and can only improve the scenery provided by the local dive industry utilizing Apra Harbor.
Figures

Figure 1. Apra Harbor, Guam (U.S. Geologic Survey, 1978)

Figure 2. Kilo Wharf Location within Apra Harbor
Figure 3. Alternative Warf Locations: Polaris Point & Former Ship Repair Facility (Joint Guam Program Office, 2010)
Figure 4. Overall Dredge Footprint and Turning Basin Options for Polaris Point and the Former Ship Repair Facility (Joint Guam Program Office, 2010)
Figure 5. Channel Alignment Options (Joint Guam Program Office, 2010)
Figure 6. Polaris Point Dredge Footprint (Joint Guam Program Office, 2010)

Figure 7. Former Ship Repair Facility Dredge Footprint

(Joint Guam Program Office, 2010)
Figure 8. Apra Harbor: Orote Peninsula and Cabras Island (Marianas Yachet Club, 2002)

Figure 9. Apra Harbor Coral Reefs
Figure 10. Dive Trips Per Week

Figure 11. Snorkel Trips Per Week
Figure 12. Number of Surveyed Businesses Utilizing Reefs for Dive Trips
Figure 13. Number of Surveyed Businesses Utilizing Reefs for Snorkel Trips
Figure 14. Bathymetric Map of Apra Harbor

Figure 15. Number of Businesses Frequenting Each Reef for Dive and Snorkel Trips
Figure 16. Total Number of Visits or Trips Apra Harbor Reefs Receive Each Week from surveyed businesses

Figure 17. Shipping Lanes Near Jade Shoals, Middle Shoals/ Unnamed Reef, Big Blue Reef (NOAA, 2008)
Figure 18. Reef Proximity to Polaris Point Dredge Zone

Figure 19. Reef Proximity to FormerShip Repair Facility Dredge Zone
Figure 20. Polaris Point Dredge Based Sediment Accumulation Projections
Figure 21. Former Ship Repair Facility Dredge Based Sediment Accumulation Projections
Figure 22. Polaris Point Dredge Based Sediment Suspension Projections
Figure 23. Former Ship Repair Facility Dredge Based Sediment Suspension Projections
Figure 24. Sasa Bay Marine Preserve
Figure 25. Dredge-Based Sediment Accumulation and Suspension Within Sasa Bay Marine Preserve
Figure 26. Apra Harbor Activity
Figure 27. Current Navy In-Water Restricted Area vs Projected Aircraft Carrier In-Water Restricted Area Additions
Figure 28. Coral Reef Economic Values
Figure 29. Apra Harbor Benthic Habitat Cover
Tables

Table 1. Percent of Trips Made to Apra Harbor

<table>
<thead>
<tr>
<th>Number of Trips/Week</th>
<th>Number of Dives/Week</th>
<th>Number of visits to Apra Harbor/Week</th>
<th>Percent of Total Dives Made in Apra Harbor/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>144</td>
<td>288</td>
<td>174</td>
<td>60.4%</td>
</tr>
</tbody>
</table>

Table 2. Average Business Start-up Costs

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Average Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vessel &amp; Electronic Equipment</td>
<td>$395,626</td>
</tr>
<tr>
<td>Diving &amp; Snorkeling Equipment</td>
<td>$35,000</td>
</tr>
<tr>
<td>Compressors</td>
<td>$22,000</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$452,626</strong></td>
</tr>
</tbody>
</table>

Table 3. Average Monthly Costs Incurred by Running Trips

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>Average Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel &amp; Oil</td>
<td>$4,764</td>
</tr>
<tr>
<td>Vessel &amp; Gear Maintenance</td>
<td>$2,336</td>
</tr>
<tr>
<td>Trip Supplies</td>
<td>$1,386</td>
</tr>
<tr>
<td>Miscellaneous Costs</td>
<td>$721</td>
</tr>
<tr>
<td>Dock Space</td>
<td>$629</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$8,836</strong></td>
</tr>
</tbody>
</table>
Table 4. Economic Values of Apra Harbor Reefs

<table>
<thead>
<tr>
<th>Reef:</th>
<th>Economic Value per Year:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outhouse Reef</td>
<td>$4,070,310</td>
</tr>
<tr>
<td>Western Shoals</td>
<td>$3,527,165</td>
</tr>
<tr>
<td>Fingers Reef</td>
<td>$1,563,770</td>
</tr>
<tr>
<td>Gab-Gab II</td>
<td>$1,332,850</td>
</tr>
<tr>
<td>Gab-Gab Reef</td>
<td>$538,200</td>
</tr>
<tr>
<td>Vecki’s Reef</td>
<td>$494,730</td>
</tr>
<tr>
<td>Family Beach</td>
<td>$488,980</td>
</tr>
<tr>
<td>Anchor Reef</td>
<td>$363,860</td>
</tr>
<tr>
<td>Barge Reef</td>
<td>$363,860</td>
</tr>
<tr>
<td>Surprise Reef</td>
<td>$363,860</td>
</tr>
<tr>
<td>Hidden Reef</td>
<td>$276,690</td>
</tr>
<tr>
<td>Big Blue Reef</td>
<td>$79,810</td>
</tr>
<tr>
<td>Middle Shoals</td>
<td>$41,630</td>
</tr>
<tr>
<td>Jade Shoals</td>
<td>$41,630</td>
</tr>
</tbody>
</table>

Table 5. Local Spending Multiplier Effect

<table>
<thead>
<tr>
<th>Source</th>
<th>Total Employment (Jobs)</th>
<th>Total Earnings ($)</th>
<th>Local Spending Multiplier</th>
<th>Indirect Output ($)</th>
<th>Total Outputs ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruane (2011)</td>
<td>100</td>
<td>$2,751,000</td>
<td>1.30</td>
<td>825,300</td>
<td>3,576,300</td>
</tr>
<tr>
<td>EIS (2009)</td>
<td>100</td>
<td>$2,751,000</td>
<td>1.82</td>
<td>2,255,820</td>
<td>5,006,820</td>
</tr>
</tbody>
</table>
Table 6. Potential Revenue Displacement

<table>
<thead>
<tr>
<th>Sedimentation Amount</th>
<th>Number of Businesses Vacating Affected Apra Harbor Reef</th>
<th>Amount of Direct Dive/Snorkel Revenue Displaced as Per Reefs Predicted to Be Affected by Lackey 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Sedimentation</td>
<td>3</td>
<td>$430,164</td>
</tr>
<tr>
<td>Moderate Sedimentation</td>
<td>4</td>
<td>$570,780</td>
</tr>
<tr>
<td>High Sedimentation</td>
<td>7</td>
<td>$1,253,340</td>
</tr>
</tbody>
</table>
References


Appendices

Appendix A

Survey of Guam’s Dive Businesses

Please circle, check, or fill in your answers.

Apra Harbor Use:

1) What is the name of your business (this will be kept confidential)?

____________________________________________

2) Are you the business:
   a. Owner
   b. Manager
   c. Other (Please specify) ____________________

3) Does your operation run year round?
   a. Yes
   b. No

4) Please indicate the average number of dive and/or snorkel trips your business makes each week:

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Trips per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None 1 2-3 4-5 6-7 8-9 10-11 12-13 14 +</td>
</tr>
<tr>
<td>Dive</td>
<td></td>
</tr>
<tr>
<td>Snorkel</td>
<td></td>
</tr>
</tbody>
</table>

5) Does your business bring dive or snorkel trips to any of Outer Apra Harbor’s coral reef areas?
   a. Yes
   b. No
6) Please indicate if your business conducts either dive or snorkel operations at each of the following Outer Apra Harbor coral reef areas (see attached map for spatial reference).

<table>
<thead>
<tr>
<th>Coral Reef Area</th>
<th>Type of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hidden Reef</td>
<td>Dive</td>
</tr>
<tr>
<td>Vecki’s Reef</td>
<td>Snorkel</td>
</tr>
<tr>
<td>Gab-Gab Reef</td>
<td>None</td>
</tr>
<tr>
<td>Gab-Gab II</td>
<td></td>
</tr>
<tr>
<td>Finger Reef</td>
<td></td>
</tr>
<tr>
<td>Anchor Reef</td>
<td></td>
</tr>
<tr>
<td>Barge Reef</td>
<td></td>
</tr>
<tr>
<td>Surprise Reef</td>
<td></td>
</tr>
<tr>
<td>Family Beach/ Dogleg Reef</td>
<td></td>
</tr>
<tr>
<td>Outhouse Beach</td>
<td></td>
</tr>
<tr>
<td>Western Shoals</td>
<td></td>
</tr>
<tr>
<td>Jade Shoals</td>
<td></td>
</tr>
<tr>
<td>Unnamed Reef</td>
<td></td>
</tr>
<tr>
<td>Middle Shoals</td>
<td></td>
</tr>
<tr>
<td>Big Blue Reef</td>
<td></td>
</tr>
</tbody>
</table>
7) Please indicate the average number of trips your business makes to Outer Apra Harbor’s reefs each week.

<table>
<thead>
<tr>
<th>Coral Reef Area</th>
<th>Number of Trips Per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Hidden Reef</td>
<td></td>
</tr>
<tr>
<td>Vecki's Reef</td>
<td></td>
</tr>
<tr>
<td>Gab-Gab Reef</td>
<td></td>
</tr>
<tr>
<td>Gab-Gab Reef II</td>
<td></td>
</tr>
<tr>
<td>Finger Reef</td>
<td></td>
</tr>
<tr>
<td>Anchor Reef</td>
<td></td>
</tr>
<tr>
<td>Barge Reef</td>
<td></td>
</tr>
<tr>
<td>Surprise Reef</td>
<td></td>
</tr>
<tr>
<td>Family Beach/</td>
<td></td>
</tr>
<tr>
<td>Dogleg Reef</td>
<td></td>
</tr>
<tr>
<td>Outhouse Beach</td>
<td></td>
</tr>
<tr>
<td>Western Shoals</td>
<td></td>
</tr>
<tr>
<td>Jade Shoals</td>
<td></td>
</tr>
<tr>
<td>Unnamed Reef</td>
<td></td>
</tr>
<tr>
<td>Middle Shoals</td>
<td></td>
</tr>
<tr>
<td>Big Blue Reef</td>
<td></td>
</tr>
</tbody>
</table>
8) While at Outer Apra Harbor’s reefs, how many hours does your operation generally spend there per each trip?

<table>
<thead>
<tr>
<th>Amount of time</th>
<th>Dive</th>
<th>Snorkel</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Hour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Hours</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other (Please Specify): ________________________________

Economic Information:

9) What is the average number of patrons that participate in each type of boat trip?

<table>
<thead>
<tr>
<th>Type of Trip</th>
<th>Number of Patrons per Trip</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 or less</td>
</tr>
<tr>
<td>Dive</td>
<td></td>
</tr>
<tr>
<td>Snorkel</td>
<td></td>
</tr>
</tbody>
</table>

10) How many employees work for your business?

<table>
<thead>
<tr>
<th>Employment Type</th>
<th>Number of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 15+</td>
</tr>
<tr>
<td>Full Time</td>
<td></td>
</tr>
<tr>
<td>Part Time</td>
<td></td>
</tr>
<tr>
<td>Seasonal</td>
<td></td>
</tr>
</tbody>
</table>
11) What is the average hourly wage per employment type (excluding tips)?

<table>
<thead>
<tr>
<th>Employment Type</th>
<th>&lt;5/hr.</th>
<th>5-10/hr.</th>
<th>10-20/hr.</th>
<th>20-30/hr.</th>
<th>30-40/hr.</th>
<th>40-50/hr.</th>
<th>50-60/hr.</th>
<th>&gt;60/hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Part Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12) How much do you charge each customer for an average snorkel or 2-tank dive trip (without equipment rentals)?

<table>
<thead>
<tr>
<th>Trip Type</th>
<th>&lt;30</th>
<th>30-45</th>
<th>45-60</th>
<th>60-75</th>
<th>75-90</th>
<th>90-105</th>
<th>105-120</th>
<th>120-135</th>
<th>135-150</th>
<th>150-165</th>
<th>165-180</th>
<th>180-195</th>
<th>&gt;200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snorkel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13) On average, what percentage of customers rent a full package of dive or snorkel equipment per trip?

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Dive</th>
<th>Snorkel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

14) On average, how much does it cost a patron to rent a full package of dive or snorkel equipment per trip?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Rental Price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>5-10</td>
</tr>
<tr>
<td>Dive</td>
<td></td>
</tr>
<tr>
<td>Snorkel</td>
<td></td>
</tr>
</tbody>
</table>
15) What is the average cost per month for each of the following?

<table>
<thead>
<tr>
<th>Item(s)</th>
<th>Monthly Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;500</td>
</tr>
<tr>
<td>Fuel &amp; Oil</td>
<td></td>
</tr>
<tr>
<td>Vessel &amp; Gear</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>Trip Supplies</td>
<td></td>
</tr>
<tr>
<td>Dock Space</td>
<td></td>
</tr>
<tr>
<td>Misc.</td>
<td></td>
</tr>
</tbody>
</table>

16) Please provide your best estimate for the 2012 replacement value of the following items:
   a. Vessel and electronic equipment $___________________
   b. Diving/ snorkeling equipment $___________________
   c. Compressors $___________________

17) On average, how many gallons of fuel does your vessel burn per each trip?
   a. None
   b. 5-25 Gallons
   c. 25-45 Gallons
   d. 45-65 Gallons
   e. 65-85 Gallons
   f. 85-105 Gallons
   g. 105-125 Gallons
   h. 125-145 Gallons
   i. 145-165 Gallons
   j. 165-185 Gallons
   k. 185-205 Gallons
   l. More than 205 gallons
18) Does your business pay any yearly government licensure fees? If so, how much?
   a. No
   b. $50-100
   c. $100-150
   d. $150-200
   e. $200-250
   f. $250-300
   g. $300-350
   h. $350-400
   i. More than $400

Perceptions of Potential Dredging Impacts:

19) If dredging occurs in Apra Harbor, how do you feel your business will be affected?
   a. Negatively
   b. Positively
   c. Not Affected
   d. I don’t conduct business in Apra Harbor

20) If you currently conduct dive or snorkel operations in Apra Harbor, would you continue conducting operations there while a dredging project occurred?
   a. Yes
   b. No
   c. I don’t conduct business in Apra Harbor

21) Would you continue bringing patrons to an Apra Harbor reef if it experienced some form of sedimentation from a dredging operation?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Sedimentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate Sedimentation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Amount of Sedimentation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

☐ I don’t conduct business in Apra Harbor