AMAKASU MARU NO. 1: AN ANALYSIS OF A REMOTELY OPERATED VEHICLE SURVEY ON A WWII JAPANESE REQUISITIONED SHIPWRECK IN THE PACIFIC

By

Andrea Yvonne Yoxsimer

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Thesis Advisor: Dr. Jennifer McKinnon

Major Department: Program in Maritime Studies, Department of History

ABSTRACT

The Pacific Theatre of World War II left behind a plethora of archaeological sites, many of which are still being located. In 2016, the National Oceanographic and Atmospheric Administration (NOAA)*'s Okeanos Explorer* mission to Wake Island located one such site. Utilizing a remotely operated vehicle (ROV), the team believed they had located the remains of the Japanese warship *Hayate*, but markings on the side of the vessel indicated that this was instead the site of *Amakasu Maru No. 1* (Cantelas and Wagner 2016). Sunk by the US submarine *Triton* on 24 December 1942, *Amakasu Maru No. 1* was a requisitioned water tanker in the Imperial Japanese Navy (IJN) (Jentschura et al. 1970).

Vessel requisition was a common practice within the IJN and while some of these sites have been archaeologically investigated, many have yet to be located. This research provides a detailed study of the *Amakasu Maru No.1* wreck site utilizing a site formation framework. A detailed literature review was also conducted to determine the amount of archaeological research already completed on IJN requisitioned vessels throughout the Pacific and their current levels of site preservation. A comprehensive catalog of this subject was produced which will be of

assistance to future researchers interested in developing a study on similar vessels throughout the region. To make the subject material more accessible to the public, an ESRI Story Map was developed utilizing the cataloged information detailing the placement, as well as the extent of research, that has been conducted on each of these sites.

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Andrea Yvonne Yoxsimer

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Andrea Yvonne Yoxsimer

APPROVED BY:

DIRECTOR OF THESIS: _____

Jennifer McKinnon, Ph.D.

COMMITTEE MEMBER: _____

Nathan Richards, Ph.D.

COMMITTEE MEMBER: _____

Todd Bennett, Ph.D.

CHAIR OF THE DEPARTMENT OF HISTORY: _____

Jennifer McKinnon, Ph. D.

DEAN OF THE GRADUATE SCHOOL: _____

Paul Gemperline, Ph.D.

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Abbreviations

AUV	Autonomous Underwater Vehicle
CH	Cultural Heritage
CPNAM	Contractors Pacific Naval Air Bases
D2	Deep Discoverer
ESRI	Environmental Systems Research Institute
FSM	Federated States of Micronesia
GIS	Geographic Information Systems
IJA	Imperial Japanese Army
IJN	Imperial Japanese Navy
NOAA	National Oceanic and Atmospheric Administration
OER	Office of Ocean Exploration and Research
ROV	Remotely Operated Vehicle
SFP	Site Formation Processes
SMCA	Sunken Military Craft Act
SOP	Standard Operating Procedures
UCH	Underwater Cultural Heritage
US	United States
WWII	World War II

Chapter 1 Introduction

Introduction

The Pacific Theatre of WWII was one of the most expansive naval engagements throughout history. Utilizing many of the small island chains dotting the area as naval bases, the Pacific War left a trail of archaeological sites that provide valuable information about both the United States (US) and Imperial Japanese Navies (IJN), as well as the battles they waged against one another. Unfortunately, external interactions with these sites are causing irreversible damage. These interactions include natural processes such as corrosion, and irresponsible human interaction such as artifact collecting and salvage (Spennemann 1992). Due to the impacts of these activities, recording and protecting these sites must be a priority.

Researchers have begun cataloging and examining these resources throughout the Pacific, however many of the sites are in locations that make recording them more challenging (Maharaj 1999; Jeffery 2007). One such site that has been challenging to reach due to the depth of its location is *Amakasu Maru No. 1*. This vessel was sunk by USS *Triton* off the coast of Wake Island on 24 December 1942 and came to rest at a depth of 840 meters. The vessel was located on 11 August 2016 by a National Oceanic and Atmospheric Administration (NOAA) team aboard *Okeanos Explorer.* The team planned a remotely operated vehicle (ROV) dive to find the Japanese destroyer *Hayate*, which was the first Japanese warship sunk in WWII on 11 December 1941 (Cantelas and Wagner 2016; Jentschura et al. 1977).

While conducting a ROV dive on the target, researchers quickly realized the vessel they were examining was not *Hayate*. The vessel was the incorrect shape to be Kamikaze-class *Hayate*, and diagnostic features of the wreck including the engine placement, rudder design and presence of the vessel's name welded onto the bow, indicated that this was in fact the water carrier *Amakasu Maru No. 1* (Van Tilburg 2016). This vessel was a peace-time ship that was

refitted for use during the war and therefore provides a wealth of information about requisitioned vessels in the IJN. By examining both the history and archaeological remains of this vessel in relation to the use of IJN requisitioned vessels throughout WWII, this thesis provides more information on archaeological site formation processes impacting *Amakasu Maru.* A comprehensive summary of other archaeologically investigated shipwrecks throughout the Pacific is also included, providing comprehensive data that may be of assistance to studying other IJN requisitioned vessels in the future.

Amakasu Maru No. 1 Historical Background

The construction of *Amakasu Maru* began in 1939 by Kawaminami Kogyo Zosensho K. K. at Koyagi Jima (Casse et al. 2020). The vessel was a 1,913-ton peacetime Standard Type cargo vessel constructed for Amakasu Sangyo K.K. The ship was completed on 6 February 1940 and was requisitioned as a water tanker by the IJN on 31 March 1941. *Amakasu* conducted many voyages throughout the Pacific leading up to the start of the war, and "on 1 December 1941 [the vessel was] assigned to the Fourth Fleet, 6th Base Force, Marshall defense water supply unit as an auxiliary water tanker, Otsu category" (Casse et al. 2020). The vessel continued to operate extensively throughout the Central Pacific until its sinking event. On 24 December 1942, *Amakasu Maru No.1* was leaving Wake Island on its way to Ponape when it was torpedoed by USS *Triton* SS-201 at approximately 9:00 A.M. The ship sank two nautical miles south-southwest of Wake Island and all twelve of the vessel's crew were lost. The vessel was removed from the IJN's list of vessels by Internal Order 108 on 1 February 1943 (Casse et al. 2020)

Amakasu Maru No. 1 Site Formation

The scientists involved with the 2016 *Okeanos Explorer* mission had several key objectives during their ROV dive onto the target believed to be *Hayate*. These objectives included "confirming the ID of the wreck, completing a perimeter survey of major features, noting battle damage, and assessing the status of deterioration" (Van Tilburg 2016:1). While the target was not *Hayate*, researchers were still able to record data regarding the identity of the vessel and the environment in which it rests.

Video footage captured by the ROV shows the vessel resting on sand with a slight list to starboard (FIGURE 1.1). There are two large holes on the lower portion of the hull which were potentially caused by torpedo damage from the vessel's sinking event. The vessel shows signs of deterioration including the collapse of masts and deformed cabin spaces. 'Rusticles' are abundant throughout the vessel indicating biological processes such as corrosion are impacting the site. While the primary objectives for the dive were archaeological in nature, researchers did note the presence of several biological species. Both the archaeological and biological data are important for the site formation survey conducted in this thesis.

Research Questions

Little is known archaeologically and historically about requisitioned vessels within the IJN throughout WWII due to lack of primary archival documentation and lack of archaeological survey. The primary goal of this thesis is to contribute to the knowledge of these understudied vessels through a detailed site formation survey of the *Amakasu Maru No. 1* site, along with a comprehensive analysis of archaeological work conducted on other requisitioned vessels throughout the Pacific. The site formation processes impacting *Amakasu Maru No. 1* are analyzed utilizing the ROV video footage and corresponding expert commentary gathered during

the 2016 *Okeanos Explorer* mission to Wake Island. Studying *Amakasu Maru No. 1* in more detail provides a case study allowing for the comparison of deep-water ROV research methods to other methods that have been utilized in the past. The secondary goal of developing a review of the archaeological work carried out on requisitioned IJN vessels conscripted into service during WWII provides a comprehensive database of previous work, allowing easier access for future researchers interested in this topic. The main research questions that will be addressed are as follows:

1. What are the site formation processes that have occurred on the *Amakasu Maru No. 1* site since the vessel sank and are these processes similar to those that have occurred on other previously researched vessels?
2. What is the history of vessel requisition within the Imperial Navy during WWII?
    a. Was vessel requisition a forward-thinking strategy or a last minute attempt to provide vessels to support the war effort?
3. What archaeological investigations have been conducted on other requisitioned vessels from the IJN throughout the Pacific?
4. What is the history of *Amakasu Maru No. 1* and what were the criteria that made it a suitable choice for vessel requisition?

Justification

The Pacific Theatre of WWII is the subject of extensive research since the conclusion of the war. While researchers have poured over documentation and archaeological investigations have been conducted on terrestrial sites, there has been a noticeable gap in research on underwater Japanese wrecks. There are several potential explanations for the minimal research

on this topic. WWII history is minimally studied by Japanese researchers and is a sensitive subject for many Japanese citizens. This is due to a multitude of reasons including a vagueness regarding the war timeline, as well as a sense of shame instilled by Western powers regarding Japanese action throughout the war (Koshiro 2001). While the US sees the bombing of Pearl Harbor as their entrance into WWII, the Japanese see no definitive start to the war and instead acknowledge a "loose (though overlapping) sequence of different wars" (Koshiro 2001:425). This concept of 'endless' war was exacerbated by external influences, most notably the US and the Soviet Union, highlighting the atrocities carried out by the Japanese military throughout WWII. These influences fostered a sense of shame regarding the war within Japan that is still prevalent in Japanese culture today (Koshiro 2001). Additionally, the Imperial Navy destroyed many of its official documents at the end of the war (Howarth 1984). The minimal official documentation available adds to the limitations associated with these sites.

Though sites such as *Amakasu Maru No. 1* present challenges to the researcher, several of these sites have been researched in the past. Compiling these different studies into one cohesive database will help future researchers understand the work that has been completed and what still needs to be undertaken to add to this wealth of data.

Theoretical framework

This thesis utilizes site formation theory to examine the NOAA video footage of the *Amakasu Maru No. 1* wreck site. This framework examines processes that are defined as "factors that create historic and archaeological records" (Schiffer 1987:7). While this definition holds true for both terrestrial and underwater projects, the nature of the underwater environment creates new hurdles for archaeologists attempting to learn more about a site's history. These distinct

characteristics were defined by Keith Muckelroy in his book *Maritime Archaeology*. Muckelroy (1978: 165-181) defines two key factors affecting wrecks as 'extracting filters' and 'scrambling devices' . Extracting filters remove objects from the site and can be anything from salvaging attempts to currents displacing smaller objects. Scrambling devices, on the other hand, are mechanisms that rearrange the materials found on the site. These could range from currents to marine animal interference.

Since the publication of Muckelroy's seminal work, many researchers have conducted studies and developed methods of examining site formation processes affecting shipwrecks. Some of these works have categorized various sinking events and utilized historical examples to support their claims, while others have expanded on Muckelroy's initial wreck formation flow chart to include the cultural impacts on wreck sites as well (Stewart 1999; Gibbs 2006). As researchers began to realize a site formation processes survey must find ways of classifying anthropogenic input on a site, they also began to acknowledge the importance of understanding the biological environment in which the wreck rests. As Colin Martin (2013:1) states:

> …unless they take account of the environment within which the remains lie, and seek to understand the complex mechanisms of destruction, dispersal reordering, decay and stabilization with which the relevant area of seafloor has reacted to the intrusion of a wreck, they will be unable to interpret the observed remains as archaeological phenomena

This interaction with the surrounding biological environment is particularly important when examining deep-water wrecks because there is minimal anthropogenic interaction with these sites post-wrecking. These interactions are generally limited to impacts from trawling and anchor cables (Church 2014). Deep-water sites distinguish themselves from their shallower counterparts by being in areas inaccessible to SCUBA divers, specifically any site below 50 meters. Due to the increasing ability to examine deep-water wrecks, researchers are beginning to delve into the specific processes impacting these sites in greater detail. While surveying four WWII-era iron hulls that wrecked in the Gulf of Mexico, Robert A. Church (2014) developed a mathematical formula for determining the initial site formation, as well as distribution, of each deep-water site. Utilizing this model, Church believes researchers will be able to find further components of sites with known locations, as well as determine the location of sites if the sinking event location is known.

FIGURE 1.1. Screen capture of ROV footage of Amakasu Maru's bow with a slight list to starboard during the NOAA *Okeanos Explore*r mission to Wake island (NOAA 2016b)

While deep-water wrecks face fewer impacts from human interaction, they do interact extensively with the biological environment, leading to site deterioration. These events range from marine life impacts to sediment shifts to natural corrosion processes (Brennan and Ballard 2013). *Amakasu Maru No. 1* is currently experiencing all these environmental interactions which are slowly impacting the site (Van Tilburg 2016). Using this site formation processes framework to examine the *Amakasu Maru No. 1* site provides information about the wrecking event of the vessel, as well as the biological processes that have affected the site post-wrecking. This case study on a deep-water Japanese WWII wreck adds to the current knowledge researchers have regarding IJN requisitioned vessels.

Methodology

Due to the COVID-19 pandemic, this thesis utilizes desktop methods and preexisting data to complete the necessary research. Therefore, the methodology does not involve any fieldwork and relies heavily on analysis of data collected by other researchers.

Data Collection

The video footage collected during the 2016 *Okeanos Explorer* mission to Wake Island was reviewed as part of this research. Various characteristics of the site were noted, including wrecking event damage, current environmental and biological processes impacting the site, as well as any post-wrecking anthropogenic input. A photogrammetric model was attempted utilizing the ROV footage, though due to the lack of hull coverage and video angles, it was determined that development of this model was not possible. Based on the inability to develop a model from the footage, as well as utilizing deep-water ROV footage to analyze site formation processes, a list of benefits and drawbacks regarding ROV use in deep-water archaeological

surveys was developed. Additionally, a standard operating procedure (SOP) was developed to help future researchers interested in both photogrammetric models and site formation processes surveys to successfully conduct deep-water ROV site surveys.

A further component of this research involved learning about other archaeologically investigated IJN requisitioned vessels in the Pacific. To accomplish this, scholarly journals and publications detailing site surveys throughout the Pacific. After a comprehensive list was developed, a detailed account of the historical background of each vessel, as well as the current levels of site preservation and any imminent environmental or anthropogenic threats these sites may face was created.

While reviewing other archaeological studies is important, these surveys were sometimes conducted more than thirty years ago. Therefore, accessing popular sport diving message boards was also important to learn more about the current levels of preservation and activities conducted on the selected sites. Sport divers provide valuable information regarding shipwreck sites to archaeologists and generally are the first to locate sites (Giesecke 1987).

Finally, an ESRI Story Map was created with all the information collected for each wreck discussed throughout the study. This includes *Amakusa Maru No. 1* and any other archaeologically researched IJN requisitioned site throughout the Pacific. Information regarding the history of the vessel (if known), the nature of the research conducted, and any other relevant information is included on the map. This allows easy access for the public to learn more regarding this research topic. Note: In accordance with the National Historic Preservation Act, the location of any site that is deemed at risk of damage due to human interaction is not disclosed on the map.

Limitations

There are several important limitations that must be addressed. The first is the language barrier. Many primary sources have not been translated from Japanese. Therefore, the only method of accessing these sources is reading translated reviews and analyses of these works. Subsequently, there is an inherent risk of bias or misinterpretation that cannot be addressed.

The lack of primary IJN documents is also a limitation. The IJN destroyed many of their official documents at the end of WWII, however the Japanese Monographs and other firsthand accounts of the war, such as Masuo Kato's *The Lost War* (1946), were consulted to provide insight into the pre-war and wartime events.

The final important limitation is the amount of data available. The NOAA *Okeanos Explorer* research team conducted one ROV dive on the site with expert commentary associated with it. While this dive has generated a large amount of data, there is no way to collect further data if something is unclear or more information is required. The finite amount of data currently available for this site limits the amount of interpretation that is possible.

Thesis Structure

This thesis is organized into seven chapters. Chapter 1 introduces the research questions of project, as well as outlines the justification, theoretical framework, methodology and limitations of the research. Chapter 2 provides a historical background of requisitioned vessels within the IJN, along with background information on Wake Island and the primary vessel being examined, *Amakasu Maru No. 1*. Chapter 3 examines the theoretical framework of site formation processes, focusing on deep-water site formation. It also provides information on the benefits and drawbacks of using ROVs for deep-water surveys. Chapter 4 explains the methodologies utilized to complete the research goals of the thesis. Chapter 5 offers an analysis of the site

formation processes impacting the *Amakasu Maru* site utilizing information obtained from the ROV video footage. Chapter 5 also provides a standard operating procedure (SOP) for future researchers interested in deep-water site formation surveys utilizing ROV data. Chapter 6 answers the research questions listed in Chapter 1 and discusses limitations and future research recommendations.

Chapter 2 Historical Background

Introduction

The IJN grew exponentially beginning in 1853 when Japan opened its borders. This accelerated growth allowed Japan to challenge the greatest navies in the world by the onset of WWII. The logistical ramifications of their expedited growth and the challenges of being an island nation led to problems throughout the war. Examining the use of merchant vessels throughout Pacific Theatre provides a clear example of these issues. The extensive requisitions of merchant vessels by both the army and the navy created several key complications that plagued Japan throughout the war. First, the requisition of so many merchant vessels decreased the rates of civilian shipping to and from Japan. This decrease reduced imports into Japan, leading to building material and food deficiencies. Second, Japan made minimal prewar provisions to supervise and protect merchant class vessels during wartime leading to inefficiency and unnecessary losses. Third, sweeping drafts sent skilled mariners to the frontlines leading to reliance on inexperienced labor later in the war. All these factors created inefficiencies in shipping and eventually led to the loss of over 8.5 million tons of cargo vessels throughout the war (Parillo 1993:205). While the IJN was a formidable opponent for any navy by the early 1940s, several factors, including large-scale requisitions, lack of foresight regarding merchant vessel supervision and protection, and crippling drafts, were primary factors in the collapse of Japan's merchant fleet and subsequently, the defeat of the IJN in the Pacific Theatre.

Brief History of the IJN

The history of the IJN is one of rapid expansion and growth. In less than one hundred years, Japan moved from a period of isolationism to successfully challenging the most powerful

navies in the world. Ironically, however, the country responsible for forcefully opening the borders of Japan would eventually become their biggest rival.

Due to the spread of Western religion, Japan officially sealed its borders in 1637 (Howarth 1983:5). This border closure led to a period of complete isolationism for over two hundred years. Throughout this period, Japan experienced minimal influence from the outside world. While this was a period of relative peace within Japan, the lack of influence from outside sources led to stagnation in technological advancements.

> …while the rest of the world moved on, Japan remained where she (sic) was, a static, unchanging society. The sea was not a lifeline but a shield; ships were not a blessing but a curse, the bearers not of prosperity but of danger and insecurity (Howarth 1983:6).

This period of seclusion ended abruptly when Commodore Matthew Perry and four modern US steamships arrived in Edo, Japan on 14 July 1853. Understandably, the arrival of the US vessels shocked Japanese officials, who quickly began to understand that their outdated technologies left them vulnerable (Evans and Peattie 1997:3-4). The desire to rapidly improve Japan's naval defenses created friction among the various Shogun states, eventually leading to a civil war. This war resulted in the dissolution of the multiple Shogun states and the acceptance of the Meji Emperor (Howarth 1983:9; Evans and Peattie 1997:7).

The Japanese Navy at this time consisted of only a few ships acquired from Western countries. However, the influx of modern technology allowed them to advance rapidly. A naval academy was established in 1869, and officers from the Royal Navy became instructors

(Howarth 1983:12; Evans and Peattie 1997:10). While cadets in the academy learned standard subjects such as naval science and seamanship, they were also put through rigorous physical training and instilled with "Japanese military values of loyalty, courtesy, valor and simplicity" (Evans and Peattie 1997:10).

Japan quickly put its modernized navy to the test in two wars, the Sino-Japanese War of 1894-1895 and the Russo-Japanese War of 1904-1905. Both wars led to quick and definitive Japanese victories, boosting the nation's confidence in their naval strategy. While the IJN looked to Great Britain as a model for developing their navy, they also became enamored with the work of Alfred Thayer Mahan and his concept of victory through one ‘decisive battle' (Parillo 1993:9-10; Sumida 1999:50).

Mahanism and the IJN

Alfred Thayer Mahan came to prominence in the late 19th century with his seminal work *The Influence of Sea Power upon History, 1660-1783* (1890). This work examined the history of Western sea power through a tactical lens dividing naval strategy into four areas, including: concentration of force; the importance of central positions or lines; interior lines of movement concerning the central positions; and the relevance of communications in force employment (Bose 2020:52). Mahan argued that the battleship was of primary importance to any fleet, and all other vessels were 'subservient.' By focusing on the importance of this one vessel and offensive strategy, Mahan believed the outcome of a war could come down to one 'decisive battle,' and for many of the conflicts Mahan had examined, it did. Unfortunately for the IJN, Mahan based his research on the tactics employed by wooden sailing craft. War strategy had, however, changed drastically over the past hundred years.

Japan first tested its modern navy in the Sino-Japanese War of 1894-1895. The conflict arose over the influence of the Korean Peninsula. Positioned between Japan and China, Korea provided an essential gateway to mainland Asia that Japan did not want under the influence of its centuries-long rival, China (Howarth 1983:24). China had long considered Korea a 'tributary state,' and Japan now saw an opportunity to diminish Chinese influence over the region, as well as to challenge China's "[domination] of the East" (Howarth 1983:25). The war was swift, with a string of victories for both Japan's army and navy. The most notable naval battle was the Battle of the Yalu River, which occurred on 17 September 1894. Chinese casualties numbered near 1,000 and the loss of five of their 12 battleships, while the Japanese reported only 90 deaths and no lost ships. Despite the discrepancies in losses, both sides claimed victory. A Chinese reporter in Port Arthur, however, reported "that the [Chinese] officers and sailors did not seem very anxious to get their ships refitted for sea" (Howarth 1983:31). While this battle was not the last of the war, it gave Japan a notable strategic advantage in the area, allowing them to determine when and where they wanted to attack next (Fung 1996:1028).

The Sino-Japanese War officially ended on 17 April 1895 with the signing of the Treaty of Shimonoseki. Soon after the treaty's ratification, Russia began moving large numbers of vessels into Port Arthur. The presence of Russian vessels so close to Japan, and the unsuccessful attempts at peace negotiations between the two countries, led to the Japanese declaration of war on 10 February 1904 (Howarth 1983:59).

While the Japanese declaration of war occurred on 10 February, the Japanese had already conducted a surprise attack on the Russian troops at Port Arthur two days earlier (Howarth 1983:65; Evans and Peattie 1997:97). The Japanese attack caught the Russian troops completely unaware. While only three of the seven Russian battleships in the port were hit, this action

effectively signaled the beginning of the war (Howarth 1983:65). After an arduous year of attacking the port, Port Arthur fell to the Japanese in 1905, and the defeat was quickly followed by the decisive Japanese victory in the Battle of Tsushima on 27-28 May 1905 (Howarth 1983:91-98; Evans and Peattie 1997). Historians would later state of the war, "few naval battles have been so decisive as the smashing victory achieved by Admiral Togo's Japanese fleet" (Grove 2005:54). The Japanese victory was a culmination of several critical factors, including the lack of modernized Russian military equipment and the superior strategy employed by Admiral Togo. The most notable factor leading to Japan's success in the battle, however, was the state-of-the-art battle cruisers within the Japanese service. These modern war vessels and the well-trained sailors who operated them provided a swift victory for Japan, signaling the war's end. This battle, and its reliance on offensive strategy and craft, helped solidify Japan's conviction in the effectiveness of the 'decisive battle.'

WWI demonstrated the evolutions of war strategy and was a learning experience for all countries involved. These changes involved rapid technological improvements and tactics such as trench warfare. All these strategies increased the period of engagement, therefore, minimizing the probability of a single 'decisive battle.' Not only had military tactics on land changed, but naval strategy also advanced to rely on a large variety of vessels, including submarines and aircraft, as well as flotillas of lesser combatant vessels. These alterations to essential vessel types decreased the importance of the battleship in the outcome of a naval engagement. There were now many avenues through which a navy could be successful at sea (Parillo 1993:6-7). Japan, however, was not a major participant in the war and mostly attacked German-held positions in the Pacific and provided support for Great Britain in the Mediterranean (Evans and Peattie 1997;

Howarth 1983:124-126). This minimal participation in the war hindered Japan's understanding of the evolution of modern warfare.

The influence of Mahanism was extensive. Mayer's work, *The Influence of Sea Power upon History, 1660-1783,* became a naval college textbook and therefore was ingrained in the theoretical framework of Japanese war philosophy. The importance placed on the battleship led to generations of Japanese officials disregarding the necessity of a varied naval fleet (D'Albas 1959:89). This neglect damaged the civilian economy by diverting vital economic resources away from the merchant fleet towards frontline naval construction.

Bushido and the IJN

Along with Mahanism, Japanese samurai ideology remained prevalent throughout the country and played a prominent role in the Japanese view of military engagement. The concept of *bushido* developed out of the teachings of Zen Buddhism and Confucianism and was the code of conduct used by samurai during the Shogunate rule within Japan. This philosophy was based on "honor, duty, courage, and a willingness to sacrifice one's self in battle or in ritual suicide" (Bunker 2001:134). This philosophy permeated all areas of Japanese society and was even taught to Japanese schoolchildren in the 1930s. Due to the widespread acceptance of *bushido*, it is no surprise that it became a leading philosophical doctrine followed by all military sects during WWII. While this philosophy produced loyal and brave soldiers, it also had several adverse effects that greatly hindered the Japanese war effort (Bunker 2001:134-135).

Since their inception, the Imperial Japanese Army (IJA) and the IJN were at odds. Due to their land-based interests, the IJA took inspiration from armies such as the French or Germans, while the IJN embraced the teachings of Great Britain. This division led the IJA to request

resources to protect Japan from terrestrial invaders such as China or Russia. At the same time, the IJN looked to the sea for potential danger from foreign powers such as the United States. These opposing interests led to extraordinarily bitter battles to secure funding for their own interests. In the 1930s, the navy even threatened to destroy the national parliament building rather than let it fall to the army. These continual battles led to a significant rift between the two military branches and a tendency for individuals to place their loyalty in either the army or the navy, but very rarely both (Parillo 1993:19).

This intense rivalry led to very minimal cooperation between the two branches resulting in unnecessary excess:

> The damage inflicted by the army-navy rivalry went far beyond military operations. The armed forces seldom cooperated in research...each service branch used different wavelengths for its own aircraft identification devices, so neither army nor navy operators could distinguish enemy planes from those of the rival service. The armed forces also obstructed mass production by refusing to establish common standards for weapons and equipment. Components, too, varied from the army to the navy, down to the threads on otherwise identical screws (Parillo 1993:22).

This duplication in resource allocation extended into the development of two shipping management administrations. These two administrations rarely communicated, leading to a lack of coordination, which made both fleets vulnerable to enemy attack. This lack of communication is evident in the Chuuk raid of February 1944 when the navy failed to warn the army about an

imminent attack due to "an ill-defined chain of command and control of movements" (Second Demobilization Bureau 1951:14). The extreme loyalties that emerged from *bushido* philosophy created factionalism between the IJA and IJN, leading to resource redundancies that hindered the Japanese war effort.

Japanese Resource Needs

Due to its location and rapid industrialization, Japan has relied heavily on overseas trade since its reintroduction to the world economy in the late 19th century. By the onset of WWII, Japan imported two-thirds of its required industrial products such as iron ore, lead, and petroleum to support its growing industrial economy (Kato 1946:159). The imports did not stop, however, with economic products. Foodstuffs became a second significant import due to the population explosion that occurred in the early 20th century. For example, Japan reported importing 3,000,000 tons of husked grains annually prior to WWII. This heavy reliance on external materials to support the Japanese economy and population led the Cabinet Planning Board to estimate that the civilian economy required 3,000,000 tons of merchant shipping to continue operations throughout the war (Parillo 1993:34). Though the Japanese government accepted these figures, the US Board of Economic Warfare believed the Japanese economy would need upwards of 4,000,000-5,000,000 tons to continue normal operations "provided that the armed forces cooperated with each other, the shipyards of Southeast Asia were fully utilized, and the merchant marine maximized its cargo space by efficient operation" (Parillo 1993:35). While the vast discrepancies between these two figures may be attributed to inaccurate calculations by either party, the extensive tonnage estimated by both demonstrates Japan's reliance on shipping to maintain its economy.

Oil was one of the most essential imports on which Japan relied. Both the IJN and IJA utilized oil for the operation of their machines. In 1923 it was estimated that 500,000 tons of Japan's warships ran on oil, though Japan did not produce nearly enough oil at home to support the needs of these vessels (Parillo 1993:40). In 1933 Japan produced approximately 1,000,000 barrels of oil while the United States produced 900,000,000 barrels that same year (American Council Institute of Pacific Relations 1934). This inequality in oil production was not lost on Japanese officials and led to the development of the 1934 Petroleum Industry Law. This law increased government intervention in the petroleum industry, essentially eliminating international influence (Kato 1946:157-158).

Along with the passage of this law to reduce foreign influence, Japan developed several other strategies to increase oil reserves in preparation for war. One of these strategies involved the development of synthetic oil (Kato 1946:158). Exploiting the Manchurian shale deposits initially made this venture possible though Japan quickly depleted these resources. Therefore, the development of alternative synthetic oil sources was never fruitful.

A second method for reducing foreign dependence on fuel procurement involved stockpiling fuel before the outbreak of war. By the time they went to war with the United States, Japan had created a reserve of 8,000,000 tons of petroleum products. While this was a substantial amount of oil at the time, IJN oil requirements alone reached 300,000 tons per month (Parillo 1993). FIGURE 2.1 shows the rapid depletion of Japanese stockpiled fuel from the end of 1941 through the summer of 1945.

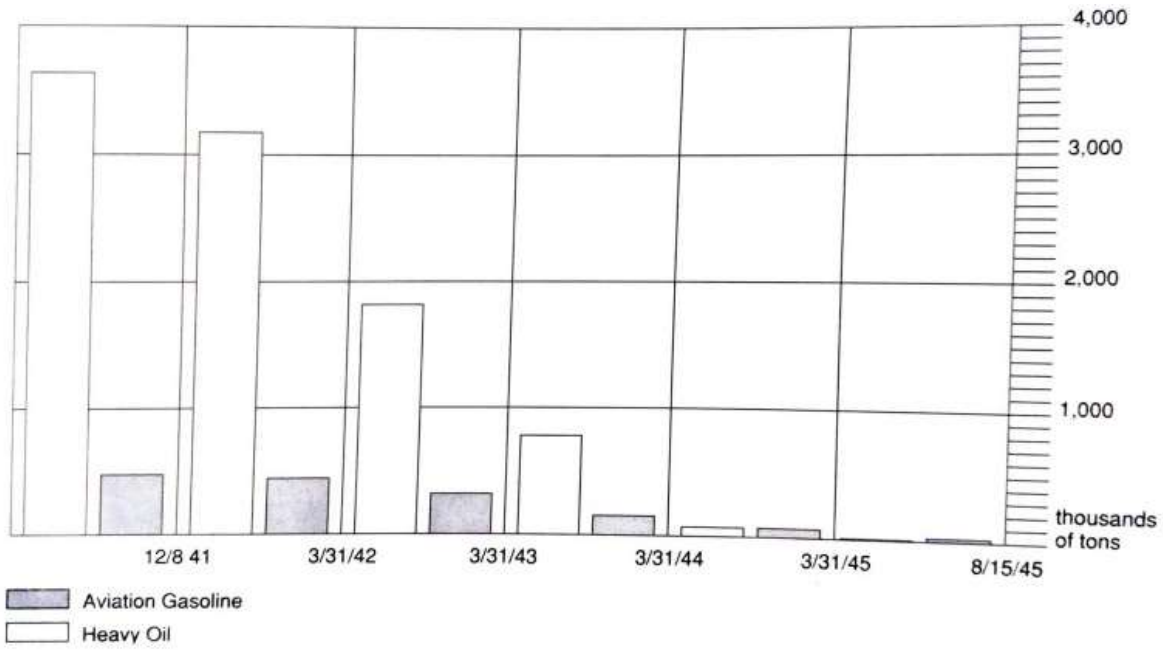

FIGURE 2.1. Stockpiled fuel in Japan from 1941 to 1945 (Parillo 1993:44)

As Japanese officials began to realize that synthetic fuel production was inefficient and that they would quickly deplete their pre-war stockpiles, they began to look for other areas of oil production that they could exploit. An article published in June of 1940 on the relations between Netherlands-India and Japan shows the concern Dutch East Indies colonists felt regarding Japan's oil needs (Vandenbosch 1940:254). These concerns were warranted, and colonizing resource-rich Southern areas was discussed at the Imperial Conference on 6 September 1941 (Ike 1967:148). Japan eventually took control of the Netherlands' East Indies oil fields later that year (Parillo 1993:45). This resource helped alleviate Japan's severe oil crisis though it quickly exposed Japan's lack of transport vessels, specifically oil tankers. This scarcity of oil tankers and its impact on Japan's war effort will be discussed later.

Pre-war Preparations

Since the arrival of Commodore Perry, Japanese officials understood the need to modernize their maritime vessels. This modernization process began with a reliance on foreign-built ships. The dependence on foreign ships changed with the Shipbuilding and Navigation Encouragement Laws of the 1890s. These laws provided government subsidies for Japanese builders to begin producing domestic vessels, bolstering both the commercial and naval fleets. These programs were immensely successful and increased Japan's merchant fleet tonnage from 709,000 tons in 1896 to 1,527,000 tons in 1905 (Lockwood 1954:548; Parillo 1993:52). The dramatic increase in vessel production did not lessen, and by the end of WWI, Japan was a leading producer of cargo vessels. Their only limiting factor was a deficiency in the amount of available steel. The end of WWI signaled a transition back to a peacetime economy in which civilian entities could not afford to continue buying the costly merchant vessels produced during the war effort (Parillo 1993:53). This shift back to a peacetime economy led to a depression in the shipbuilding industry that sharply diminished production rates.

Prior to WWII, the IJN focused primarily on the construction of battleships and battlecruisers, shifting resources away from the development of support vessels they believed were of secondary importance. In the five years leading up to WWII, the navy produced an annual average of 400,000 tons of warships while the merchant ship industry received less than half the allotment of steel for vessel construction (Parillo 1993:17).

To stimulate the production of merchant vessels, the Ministry of Communications created the "scrap and build" subsidy program. This initiative provided funds for shipbuilders who scrapped freighters over 25 years old and built new vessels in their place. This program provided extra financial incentives for constructing vessels with speeds over 13.5 knots (Lockwood 1954:548; Parillo 1993:58). The "scrap and build" initiative was immensely successful and was

renewed in 1936. The program rejuvenated the merchant-class vessel industry, though the speed stipulations placed on the new vessels demonstrated the military intervention associated with the program. In a naval engagement where wartime bases were often located far away from a nation's home base, having carriers able to keep up with the frontline fleet may provide a significant advantage. This military intervention was further extended in 1938 when the government assisted in the construction of two liners capable of "high speeds and large capacity but also room for mounting large-caliber naval guns" (Parillo 1993:58-59). While the navy provided government funding for constructing merchant-class vessels, the variety of vessels constructed was not well-rounded. Vessels such as fleet train units, cargo ships, and troop transports were overlooked, creating deficiencies within the merchant fleet. This shortsighted planning led to the use of battleships for menial tasks such as oil and troop transport later in the war (Parillo 1993:15).

The government naval building programs of the 1930s were effective in rejuvenating many aspects of Japan's merchant fleet, and by the outbreak of war, Japan had the third-largest merchant fleet in the world (Parillo 1993:60). While the construction programs were successful, the plans to manage this resource were less so. In an interview after the war, one Japanese official stated, "it would be safe to say that no definite preparation whatsoever had been made for escorting operations until immediately before the outbreak of war" (Second Demobilization Bureau 1951:2). Some efforts were made in the years prior to the war, including the development of the Cabinet Planning Board in 1938 though all were ineffective. The Cabinet Planning Board was a committee of primarily civilians attempting to determine the economic needs that the war would incur. This board produced numbers that were later deemed highly inaccurate, though they were not questioned when first produced (Kato 1946:169; Ike 1967:220-221). Along with

inaccurate figures, military officials provided very weak planning documentation, such as The Annual Commerce Protection Plans of the Major and Minor Naval Stations. This document was approximately thirty pages long and only covered rudimentary planning details such as:

1. Policy for the execution of escorting operations;
2. Personnel and ship units available in time of war;
3. Outline of system and organization of escorting organs;
4. Routes;
5. Ports of shelter;
6. Reporting; communication and liaison (Second Demobilization Bureau 1951:2).

Many high-ranking military personnel later acknowledged this surprising lack of planning for merchant shipping protection. Lack of labor and material, as well as insufficient funds to complete the ambitious battle fleet upgrades the IJN needed, led officials to prioritize specific programs, thus overlooking others (Second Demobilization Bureau 1951:3).

Along with Japan's minimal strategy, physical escort operation planning was insufficient. Before the outbreak of war, merchant shipping protection was under the purview of the Defense Preparations Office, though only two officials devoted their full attention to the subject before 1942. Four naval districts and four 'guard districts' were created to defend Japanese home seas. Resident port officers were assigned to each of these posts to oversee escort operations within their jurisdiction (Parillo 1993:65; Second Demobilization Bureau 1951:3). Government officials quickly realized that entrusting the entire nation's escort operations to these few individuals was impractical. Therefore, the Merchant Ship Protection Law was passed on 17 March 1941. This

law increased naval control over the protection of merchant shipping. Though the navy now had more control over shipping operations, it did not have a significant impact on the local level: "in the local areas, the various naval stations did practically nothing in the way of concrete measures and had no opportunity to conduct positive training or exercises" (Second Demobilization Bureau 1951:3).

At the onset of war on 7 December 1941, Japan had succeeded in bolstering its frontline battle fleet and merchant fleet to formidable levels. Their force was not without its weaknesses, however. Their unbalanced construction programs led to a deficiency in specific important merchant-class vessels that became a hindrance during the war. This oversight led to a scarcity of transport potential that negatively impacted the war effort. The lack of extensive logistical preparations for escort operations left Japanese shipping lanes vulnerable to enemy attack, and this mismanagement increased requisition rates which impacted the civilian economy. The culmination of these factors had devastating effects on Japan's war effort in the Pacific.

The IJN and WWII

The government required the assistance of many merchant vessels for the initiation of war. At the start of hostilities, the navy immediately requisitioned 482 merchant vessels culminating in 1,740,000 tons (Parillo 1993:75). Troop transport was one of the primary reasons for this initial requisition (Ike 1967:159). The placement of troops and the movement of rations and supplies required large numbers of vessels. To accommodate troop needs, authorities allocated between three to five tons of space per person. The strain of these initial troop transport missions waned slightly with the continuation of the war though troop and supply transport

became more challenging due to resource requirements to continue operations in China, as well as enemy submarine attacks on the merchant fleet.

Along with the initial strain from troop transport on the newly requisitioned merchant vessels, experienced personnel were also drafted into service at the onset of war. After the outbreak of conflict in China, the IJN compiled a database of reserve officers and seamen. The IJN utilized this database to draft individuals into active service after Pearl Harbor. The loss of large numbers of experienced mariners all at once led to novice sailors controlling the merchant fleet. Due to their inexperience, the merchant fleet was inefficient resulting in decreased productivity of the minimal fleet that remained after military requisition. Additionally, the absence of seasoned mariners to draft later in the war forced military personnel to recruit women, prisoners of war, and impressed workers into service (Parillo 1993:81). This lack of experience was palpable.

The crippling draft was arguably due to a lack of communication between the War Department in charge of military drafting and the department charged with war production. Factories would request experienced personnel be exempt from the military draft, though these individuals were often on the frontlines before the request could be granted. Due to the loss of essential personnel, this draft also negatively impacted Japan's food production. The lack of food led to extreme rationing and resentment towards both the army and the navy (Kato 1946:167).

Of all the transport vessels required to support the war effort, tankers were arguably the most important. Japan's reliance on foreign oil required oil tankers for transportation. Pre-war strategists acknowledged that this oil demand would only increase during the war. A comparison between Japan and Great Britain demonstrates the tanker’s importance. Tankers comprised 15% of Great Britain's merchant fleet at the beginning of the war while they only accounted for 8% of

Japan's. The IJN requisitioned over 100,000 tons of civilian oil tankers to support wartime operations (Parillo 1993:79). While the IJN possessed 78% of the nation's tankers at the beginning of the war, heavy losses decreased this percentage to 31% by mid-1944.

Along with the requisition of civilian tankers, the IJN also confiscated civilian cargo ships to convert into tankers. From 1941 to 1942, over 400,000 tons of shipping were converted into tankers (Military Supply Division 1947:1). This extensive requisition program continued to strain a civilian fleet that was already under increased stress due to previous requisitions made by both the army and the navy throughout the war.

Japan also implemented a construction program to increase tanker production in conjunction with requisitioned and conversions of cargo vessels to tankers. This initiative shifted shipyard resources away from naval ship construction, demonstrating Japan's delayed understanding of the merchant vessels' importance. Unfortunately, this postponed interest in tanker construction could not replace the extensive tanker losses. Japan lost 8.5 million tons of cargo vessels throughout the war (Military Supply Division 1947:3; Parillo 1993:205;).

While the need for tankers was profound, it was not the only vessel requisitioned for the war. In fact, requisitions for the war effort began as early as the 1930s. Before Pearl Harbor, the IJN drafted 1,740,200 tons of merchant shipping while the IJA had already drafted over 2,000,000 tons (Graham 2005:68). These requisitions included general shipping vessels as well as 'shadow' warships. These warships were classified as ocean liners to circumvent the international building restrictions prior to the war.

Japanese Shipping

Japan utilized three main shipping routes to supply both the home island and troops abroad by 1941 (FIGURE 2.2). The first of these routes was primarily for the disbursement of troops to the active combat zones and returned to Japan empty. The second lane transported 'military traffic' to Palau, with branches breaking off to the southern Philippines and the Caroline Islands. The third route "had the Japan-Singapore route as its trunk, with several lines forking off toward Manila, Hong Kong, Saigon, the East Indies oil ports, Burma, and other busy depots where resources collected" (Parillo 1993:126). Southbound convoys received odd number designations while northbound groups received even numbers. Vessels utilized these routes extensively at the beginning of the war but were soon impacted by enemy action. Successful US campaigns significantly damaged these routes throughout the war. By 1944 the Japan-to-Chuuk route was gone, and the Palau lane disappeared after US action in September 1944. Other routes faded that year as well, and by 1945 only a few routes to northeast Asia remained (Parillo 1993:127). FIGURE 2.3 shows the severely reduced Japanese shipping routes in 1945.

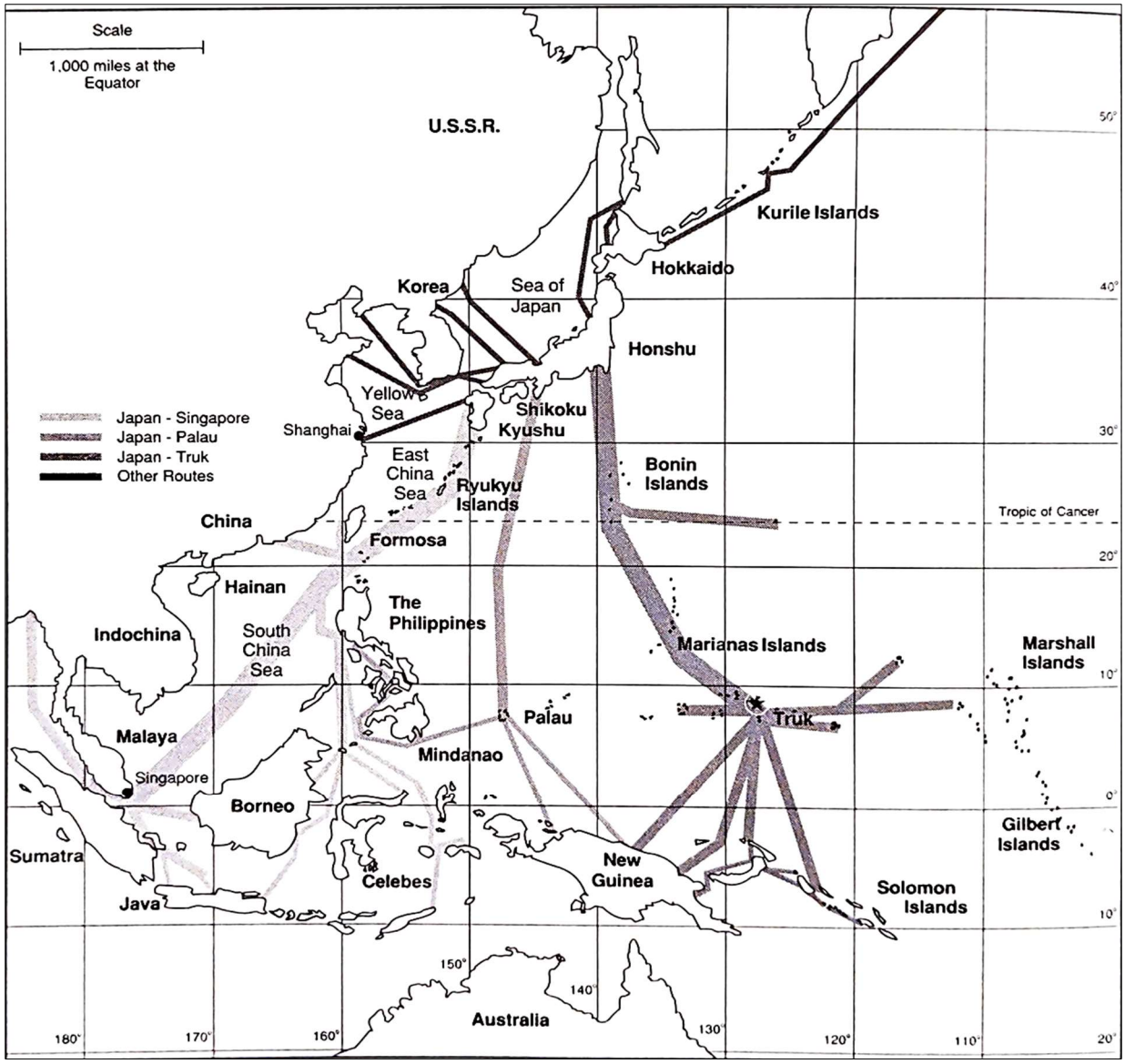

FIGURE 2.2. Japanese Shipping Routes, 1942 (Parillo 1993:126)

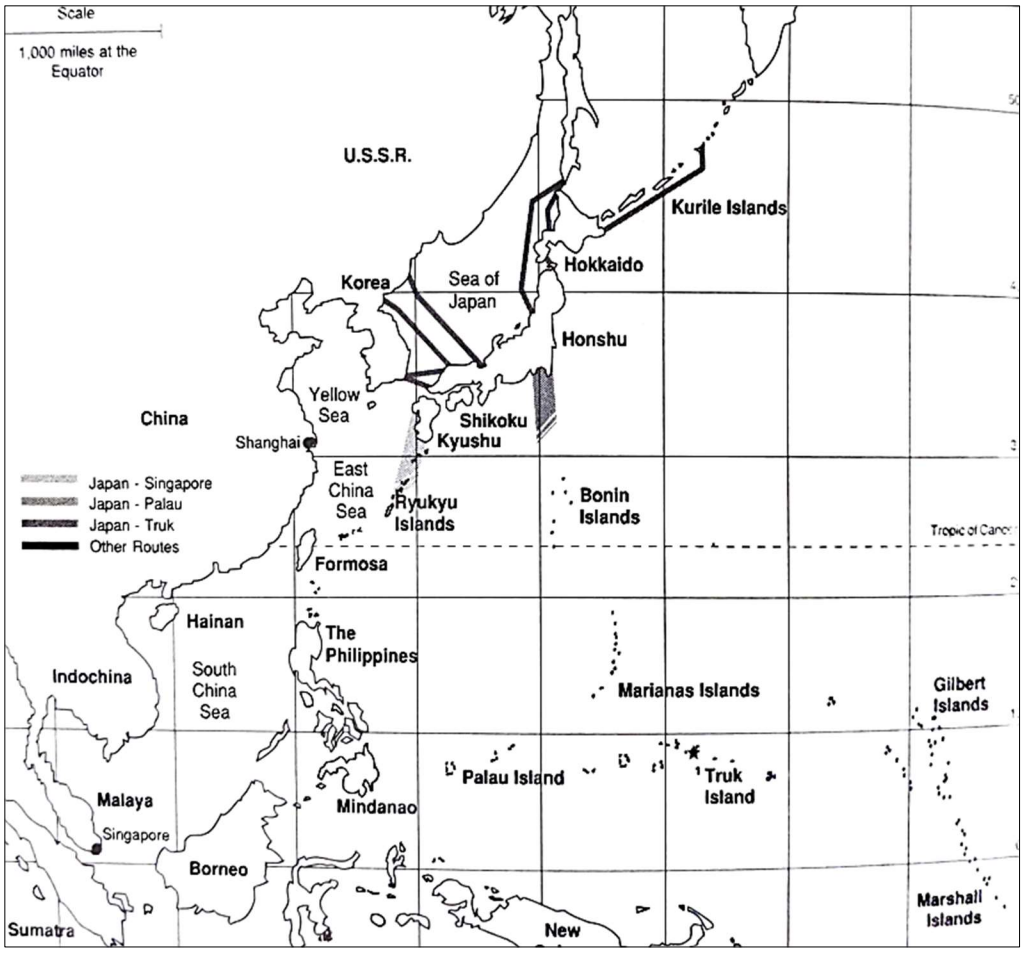

FIGURE 2.3. Japanese shipping routes, 1945 (Parillo 1993:144)

The beginning of the war also led to the development of the First and Second Surface Escort Units on 10 April 1942. These were the first two units allocated specifically for shipping protection, though they were meager in size. The First Escort Unit consisted of "ten obsolete destroyers, two torpedo boats and five converted gun boats," and the Second Unit fared no better with "four obsolete destroyers, two torpedo boats and one converted gun-boat" (Second Demobilization Bureau 1951:4). Perhaps unsurprisingly, these small forces did little to protect merchant vessels from enemy submarine attack.

While submarine losses in 1941 fell within the pre-war estimates, losses quickly skyrocketed, causing the authorities to readdress their strategy, including increased

communication, more effective anti-submarine weapons, educational programs, and the use of mine barriers (Second Demobilization Bureau 1951:6). These alterations were ineffective, however, at ebbing the losses inflicted by US submarines. Initial minimal losses early in the war may have resulted primarily from US error. Several issues, including defective torpedoes and faulty detonators, hindered the effectiveness of early US submarine action (Morison 1948:193). In 1942, US submarines only sank 884,928 tons of Japanese merchant vessels. As these numbers were within range of pre-war estimates, Japanese officials became complacent. This inaction would prove disastrous to Japanese forces later in the war. In 1944 alone, US submarines sank 3,694,026 tons of Japanese merchant vessels (Parillo 1993:204). FIGURE 2.4 portrays this drastic increase in losses due to submarines later in the war.

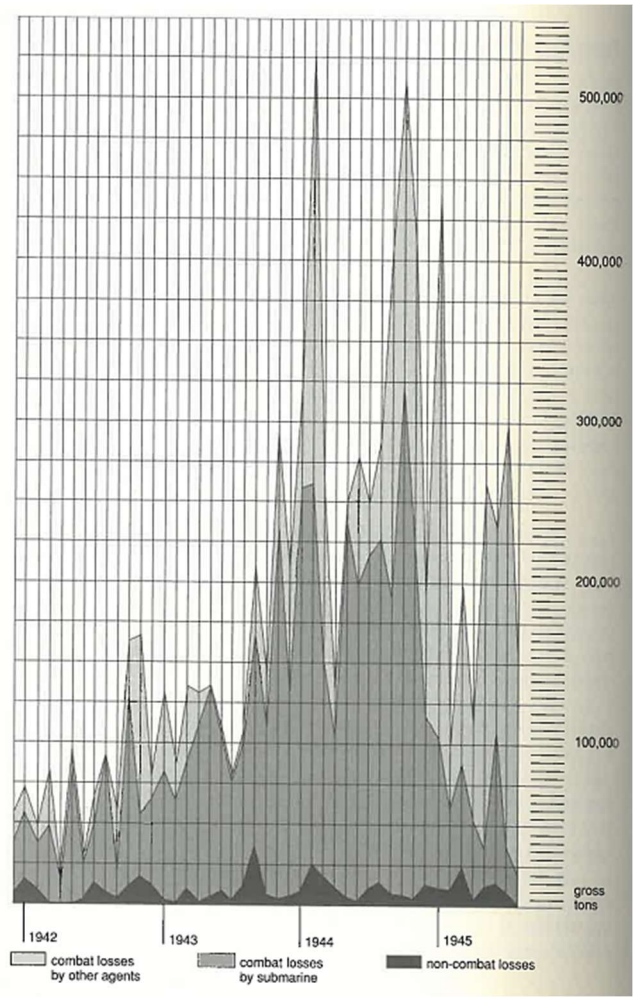

FIGURE 2.4. Japanese merchant vessel losses from 1942-1945 (Parillo 1993:206)

While Japanese officials acknowledged that US submarines would pose a threat, they did not anticipate that the US would rely on them so heavily (Kato 1946:164). That is not to say that Japan did not prepare for submarine warfare at all. Leading up to the war, Japan invested heavily in its submarine program. Unfortunately, several factors rendered this force essentially ineffective. First, while Japan invested in submarines before the war, they were massive. Due to their large size, they were not agile in the water and created a large sonar target for enemy attack. Second, training for submarine technicians focused primarily on offensive tactics due to the IJN adherence to Mahanistic principles. Finally, by 1943 shipping lanes were strained due to enemy attack and lack of efficient convoy systems. Officials were desperate and began using

submarines for supply transport. This inefficient use of submarines pulled them off the frontlines and therefore eliminated the offensive capabilities of the IJN's submarine fleet. When speaking about the effectiveness of the IJN submarine fleet after the war, Admiral Fukudome stated, "they considered themselves superior in technique in the field of submarine warfare to any in other navies. But when it came to the test of actual warfare, the results were deplorable" (Boyd and Yoshida 1995:189). While the submarine fleet was ineffective at stopping US attacks, Japan also utilized other strategies to minimize the losses sustained by US submarines.

To mitigate future damages, the Navy developed the Grand Escort Headquarters on 15 November 1943. This organization controlled transport protection in all eight naval districts and became the overseer of the First and Second Surface Escort Units. While the Headquarters was not without its issues, it was a significant step forward as it created one cohesive organization that transmitted the same message to all traveling merchant vessels (Parillo 1993:69; Second Demobilization Bureau 1951:7). The Grand Escort Headquarters maintained control over all shipping until the Battle of Saipan dealt a crushing blow to Japanese forces. In the wake of the defeat, Order No. 33 was issued by Imperial General Headquarters. This order transferred control of shipping to the Combined Fleet as of 9 August 1944 (Parillo 1993:71). The Combined Fleet quickly altered shipping procedures and developed four main escort fleets. Unfortunately, these fleets were poorly equipped, and the few antisubmarine vessels allocated for shipping protection were removed to be utilized elsewhere.

On 9 January 1945, one of these new escort fleets was attacked by US aircraft in the South China Sea and was decimated. The aircraft sank all the tankers, three freighters, a training vessel, and three coastal defense vessels (Parillo 1993:71). This disastrous loss and other

merchant losses led shipping oversight to be returned to the Grand Escort Headquarters. By this time, however, the merchant fleet had already sustained irreparable damage.

The skill of the US submarine fleet did more damage to Japanese shipping than just attacking their merchant fleet. A side-effect of underestimating America's use of submarines in the upcoming war, and a distaste for the time-consuming nature of the convoy system, culminated with Japanese officials not allocating adequate resources to the development and preparation of convoys before the war (Kato 1946:164; Parillo 1993:133). This initial distaste for convoys led officials to adopt the concept of independent sailing zones. The reasoning behind these zones was that if the IJN could eliminate the potential for enemies to access certain areas, merchant ships would be able to sail independently of convoys. This system would ensure a continual flow of goods and eliminate the need for merchants to wait for the formation of a convoy to sail. The Japanese chose the Sea of Japan as the perfect location for the sailing zone as it was close to home and easy to defend (Parillo 1993:130). To ensure its protection, the IJN deployed mines in La Perouse Strait. Early decreases in lost shipping tonnage garnered initial support for the project. The inability to feasibly extend these independent sailing zones further away from the home island, however, eventually led to the embracement of convoys to protect merchant shipping.

The IJN finally accepted the convoy system and in June 1943, the Navy General Staff published *The Principles for the Protection of Surface Traffic During the Greater East Asia War*. This work outlined, "general rules, escort policy, jurisdictional areas, sea lane control, sea lane jurisdiction, direct escort, indirect escort, disposition when enemy is confronted, salvage, warning service, communication liaison, reports and a glossary of terms" (Second Demobilization Bureau 1951:9). Though the report seems extensive, this system was under-

regulated. Each convoy was assigned a navigation control officer who oversaw the convoy's formation and handling any inter-ship communication. While this position provided a level of continuity among all convoys, the officers were generally merchant marine reserve officers and were often older than the optimal combat age. Once the Grand Escort Headquarters was established in late 1943, officers from Headquarters could also determine the convoy's formation leading to confusion regarding the chain of command. By February 1944, the IJN lost 548,736 tons of merchant vessels. This loss constituted approximately 10% of the entire merchant fleet (Parillo 1993:137).

Eventually, to streamline convoy management, the Escort-of-Convoy Headquarters was established in April of 1944. The Headquarters was staffed with convoy commanders. Unfortunately, "none had experience with convoys or antisubmarine warfare, and each received his assignment about one week preceding the convoy's departure" (Parillo 1993:136). The system was reorganized in the summer of 1944 when officials created the Escort Force commander position. The position was generally filled by an admiral who accompanied the convoys on their missions. This system followed one set in place by Great Britain and was effective, though dangerous. Three Japanese admirals lost their lives fulfilling the duties of this office (Parillo 1993:136). While the IJN eventually embraced an effective convoy system, it was already 1944 and was too late to make a significant difference for the dwindling merchant fleet.

The loss of supply chains led new vessel construction to dwindle. By 1943, the production of battleships and aircraft halted due to a shortage of steel (Kato 1946:161). This shortage of material was a severe problem not only for the frontline efforts. The merchant fleet was losing excessive amounts of tonnage throughout the war:

> From December 1941 to the end of 1942 Japan lost 1,484,000 tons of merchant shipping, and 2,568,000 tons in 1943. In 1944 she lost 3,285,000 tons, and in the first six months of 1945, an additional 798,000 tons were sent to the bottom of the ocean by Allied planes and submarines, making a total war loss of 8,135,000 tons (Kato 1946:163).

While Japan captured 273,000 tons of enemy shipping, this tonnage could not assuage the strain felt by the merchant fleet. Along with the losses, some requisitioned merchant vessels were also converted to warships during the war, further depleting the number of usable vessels.

Throughout the war, merchant vessels were converted into various warships, including patrol craft, fleet carriers, escort carriers, gunboats, and minesweepers. These vessels were essential for frontline operations. For example, the only 'new' submarine tenders created during the war were four converted merchant vessels. These ships provided relief for frontline vessels and reduced labor in warzones for the already strained battle fleet. From 1941-1945, 825,516 tons of merchant vessels were converted to auxiliary naval craft, not including transport vessels (Parillo 1993:80).

Towards the end of the war, submarines were not the only major force threatening the merchant fleet. The B-24 Liberator could carry four to five mines and was, therefore, an efficient means of threatening Japanese shipping routes. US forces employed a range of mines, including acoustic, magnetic, and hydraulic. This variety was troublesome for the Japanese. It was not uncommon for a vessel to be sunk by one type of mine while sweeping for another. The threat imposed by mines only heightened with the introduction of the B-29 Superfortress to the Pacific Theater in 1944. This plane had a range of 1,500 miles and could carry eight to nine mines.

Arguably the most considerable impact of mines on Japanese shipping was the mining of the Shimonoseki Straits. Prior to US mining, 1,250,000 tons of shipping traveled through this strait every month. After mining, however, the strait was closed for an average of two weeks per month. The loss of this vital shipping lane was a crippling blow to many Japanese enterprises, though most notably the coal industry. Many industries relied on this resource and were desperate once it was no longer available (Parillo 1993:197; Naval Analysis Division 1958:162).

Mines were an effective method of sinking ships. Approximately half the vessels that struck a mine sank. In deep-water, this number increased to a staggering 70% (Parillo 1993:202). Even the ships that did not sink after being hit were impacted as the average repair time was between seventy to ninety-five days. Along with extensive sinkings and the removal of vessels from operation due to extended repair times, the sheer fear of their presence led merchants to require extra sweeping before venturing into dangerous waters. By the end of the war, Japan's merchant fleet lost two million tons of shipping to mines (Parillo 1993:195; Naval Analysis Division 1958:161).

Submarines and mines were arguably the most significant contributor to the destruction of Japan's merchant fleet. In an US study published after the war, researchers argued that it was the extensive amount of sinkings inflicted on the Japanese that led to their defeat, "the greatest single cause of the failure to maintain an adequate merchant marine was the Japanese' failure to prevent wholesale sinkings" (Military Supply Division 1947:3). Though plagued by material deficiencies and mismanagement, Japanese shipbuilding efforts may have sustained the Japanese war effort if they had not lost such extensive tonnage (Parillo 1993:172).

Since the completion of the war, analysts have pinpointed many factors contributing to Japan's Pacific Theatre loss. It is a complex topic, to be sure. In his work, Mark Parillo (1993:207) argues:

> A multitude of obstacles hampered the performance of Japan's merchant marine in the Pacific war. In order of their impact, they were: primitive antisubmarine doctrine and technology, an escort contingent mired in quantitative and qualitative poverty, an undeveloped convoy system, significant failures in the arena of cryptanalysis, shoddy administration, extensive commandeering by the military, and inadequate protection from mines.

While there were many reasons for the defeat of Japan in WWII, the oversight of support vessel construction and protection was a grave error on the part of the IJN. Throughout the war, nearly four million tons of merchant vessels were drafted into service. These ships were a critical component of the navy that allowed the war in the Pacific to continue for as long as it did.

Background of Wake Island

Wake Island is a small Pacific atoll that consists of three islets: Wake, Peale, and Wilkes. This little atoll only measures 2.85 square miles with minimal geographical features and strong currents surrounding the islands (Bryan 1959:1). The atoll was documented by explorers throughout history who have located the island but refused to land their vessels due to the treacherous conditions. The first was the Spanish explorer Álvaro de Mendaña y Neira in 1568, followed by Samuel Wake in 1796. While Samuel Wake named the island, he did not attempt to

land. The first recorded landing on the island was US Lieutenant Charles Wilkes in 1841 (Bryan 1959:2). Due to minimal natural resources, the island was not considered strategically significant until tensions began to mount in the early twentieth century.

The atoll lies approximately equidistant between Honolulu and Tokyo, giving it military importance in the Pacific Theatre of WWII (see FIGURE 2.5) (Bryan 1959:1). Due to the Washington Naval Treaty that was in effect until 1936, no overt naval base development was allowed in the Pacific until the treaty expired (Gilbert 2012). In 1935, Pan Am Airlines announced its plans for a transpacific flight to the Philippines with fuel stops on Guam and Wake (Wukovits 2003:18). President Roosevelt agreed to help build these facilities on the atoll, including a service facility for the planes on Wake. By agreeing to assist Pan Am, Roosevelt began the construction of infrastructure on the island without breaking the terms of the treaty (Gilbert 2012). Work on the island progressed slowly until 1938 when a Naval investigation into possible Pacific naval bases listed Wake as a critical "early-warning system should the Japanese adopt aggressive moves" (Wukovits 2003:19). This report altered the construction plan and timeline on Wake Island to include preparations for war.

The construction contract was awarded to various civilian contractors known collectively as the Contractors Pacific Naval Air Bases (CPNAB) though the majority of the work on Wake Island went to the firm of Morrison-Knudson (Charles River Editors 2020). The contracts for civilian workers involved spending nine months on the island working six days per week for the impressive salary of $125 per month plus expenses (Wukovits 2003:21). This enticing proposition lured many construction workers to the island. By the time war arrived, there were "1,145 civilian workers, 72 Pan Am employees, and 524 military personnel, including 6 Army,

69 Navy, and 449 Marines" (Wukovits 2003:47). While both military and civilian personnel labored to prepare the island for battle, time and lack of resources worked against them.

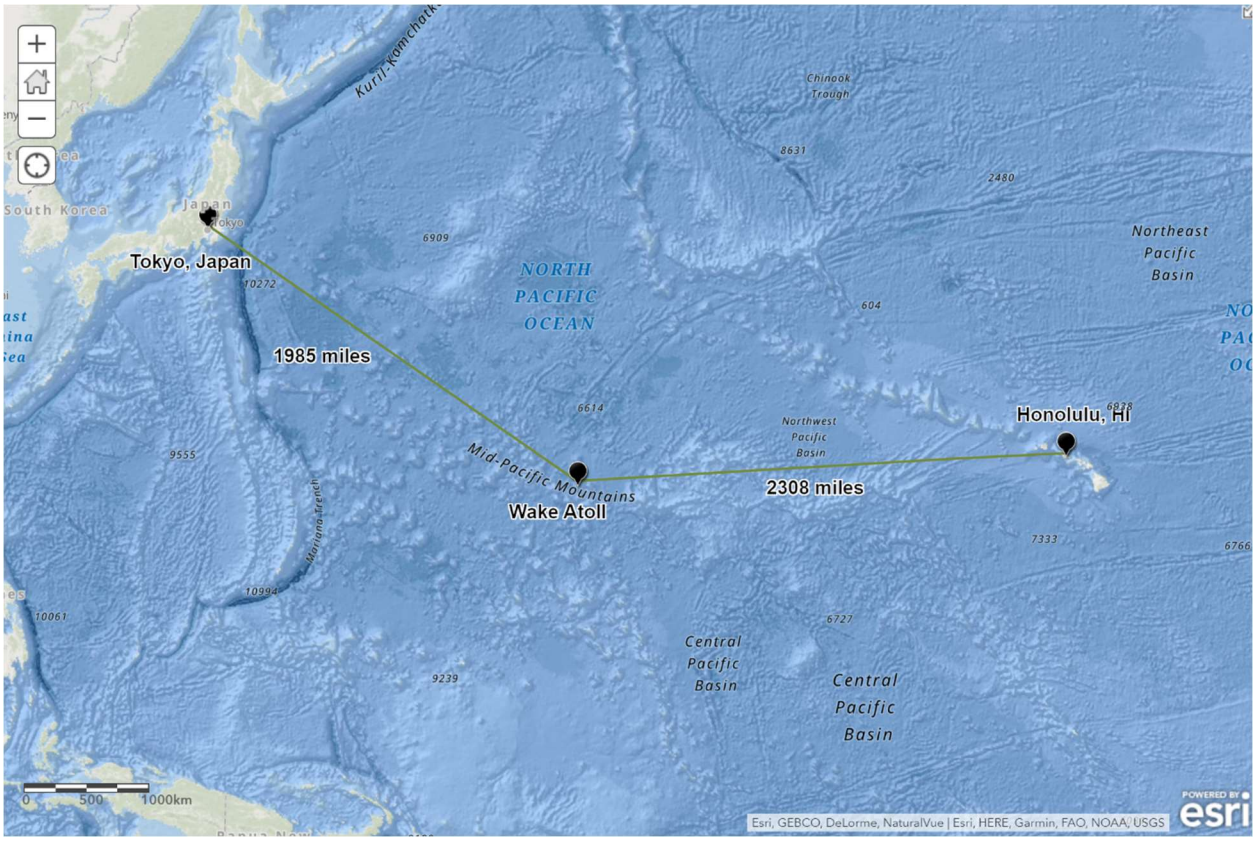

FIGURE 2.5. Distances from Wake Atoll to both Honolulu, HI and Tokyo, Japan (Image created using ArcGIS software)

Not only were the Marines on Wake Island running out of time to fortify the atoll as war became imminent, there were also not enough supplies present to adequately defend it. There was a shortage of guns and ammunition, but most importantly, the radar allocated for Wake never left Pearl Harbor (Wukovits 2003:44). Though both the marines and civilians worked tirelessly to fortify Wake, their lack of resources quickly became evident when the island was attacked on 8 December 1941 (7 December Hawaiian time).

At around 11:50 A.M. local time, the first Japanese planes flew over Wake (Wukovits 2003). Due to the lack of radar, soldiers on the island did not spot the planes, and therefore eight of the US's 12 fighter planes sat on the island's incomplete airstrip. Along with the 600 55-

gallon drums of gasoline that lined the airstrip, these aircraft became easy targets for the Japanese planes. Within 15 minutes, all eight of the grounded planes were destroyed. Many US individuals, both military and civilian, lost their lives, and the island was in chaos. Conversely, the Japanese did not lose a single plane and sustained the loss of only one soldier (Wukovis 2003:59-62).

Two subsequent air attacks occurred on 9 and 10 December, and while the Japanese aircraft caused damage by striking both the hospital and several battery encampments, the US personnel fought back. US forces destroyed at least four of the Japanese bombers. Believing they had severely hindered the US defenses on Wake, the Japanese military planned a surprise landing on the night of 11 December (Charles River Editors 2020). Japanese forces approached the island with a small fleet and, once within firing range, were severely damaged by the US batteries on the island. With two vessels heavily damaged, *Yubari* and *Oite*, the Japanese force quickly retreated (D'Albas 1957:59). On the other side of the island, the Japanese vessel *Hayate* was heavily attacked and quickly sank (Charles River Editors 2020). Recognizing their lack of preparation, Captain Koyama stated, "Our losses are heavy, the enemy artillery is very efficient; our preparations are inadequate" (D'Albas 1957:59). The Japanese forces did not make the same mistake again.

Japanese forces carried out air attacks on the island between 12 and 20 December and attempted a second landing on 22 December (D'Albas 1957:59). While the Japanese forces still struggled to land their vessels amongst the dangerous currents and heavy fire from the US batteries on the island, they were able to reach the island around 2:30 A.M. (Charles River Editors 2020). US forces were severely outnumbered, but many believed they would be able to hold the island. Therefore, the surrender by Major Devereux and Commander Cunningham came

as a shock to many. It was reported that Devereux never left headquarters and was unaware of the success of his troops before advising Cunningham to surrender. Twenty-eight marines were killed in battle, while the recorded Japanese losses reached over 500 (Charles River Editors 2020).

The island remained under Japanese control until the end of the war, though Japanese vessels were continually threatened by potential US attack. *Amakasu Maru No. 1* was the victim of such an attack. On 24 December 1942, *Amakasu* was torpedoed by USS *Triton* SS-201 and sank along with the twelve crew members aboard the vessel (Jentschura et al. 1970; Van Tilburg 2016).

Though the Battle of Wake Island was an IJN victory and led to the Japanese occupation of the island, there are minimal details in Japanese sources regarding the battle or subsequent island occupation. For example, in the Japanese Monograph No. 102, the battle is summed up in one sentence "within the two months after the operation commenced in December 1941, the Gilbert Islands and Wake Island were mopped up and occupied" (Goldstein and Dillon 2004:246). While it rarely receives more than a brief mention in many Japanese sources, countless books are published in the United States regarding the events and many of the titles easily demonstrate favoritism while accounting the events. These include *A Magnificent Fight: The Battle for Wake Island* and *Pacific Alamo: The Battle for Wake Island*, among others. This battle became a glowing 'underdog' tale that has led to notable bias displayed in many of the sources consulted.

Amakasu Maru No. 1 Historical Background

The construction of this vessel began in 1939 by Kawaminami Kogyo Zosensho K. K. at Koyagi Jima (Casse et al. 2020). The vessel was a 1,913-ton peacetime Standard Type (D) cargo vessel constructed for Amakasu Sangyo K.K. The vessel was completed on 6 February 1940 and was requisitioned as a general transport vessel by the IJN on 31 March 1941. The vessel had one triple expansion reciprocated steam engine and a cruising speed of ten knots. *Amakasu* measured 271.7' in length with a beam of 40.0'. The armaments for the vessel included "one 8cm/40 deck gun, one single 25mm Type 96-gun, two single 13mm Type 93 M.G.s, one 7,7mm M.G., five rifles, 2 D.C.s, [and] one hydrophone" (Casse et al. 2020). From 1937 to 1943, four Standard Type (D) cargo vessels were requisitioned including *Asayama Maru*, *Kisogawa Maru*, *Goryu Maru*, and *Amakasu Maru No. 1* (FIGURE 2.6).

Amakasu conducted many voyages throughout the Pacific leading up to the start of the war, and "on 1 December 1941 [the vessel was] assigned to the Fourth Fleet, 6th Base Force, Marshall defense water supply unit as an auxiliary water tanker, Otsu category" (Casse et al. 2020). The vessel continued to operate extensively as a water tanker throughout the Central Pacific until its sinking. The vessel was removed from the IJN's list of vessels by Internal Order 108 on 1 February 1943 (Casse et al. 2020; Alden 1989:25).

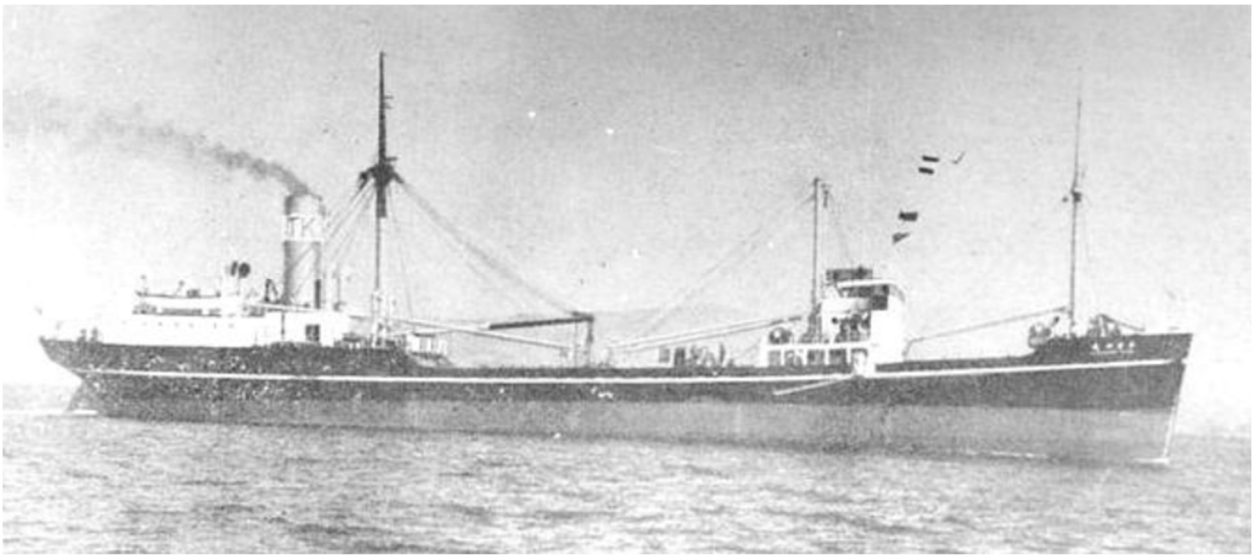

FIGURE 2.6. *Kisogawa Maru*, *Amakasu Maru No. 1*'s sistership (Casse et al. 2020)

Amakasu Maru No. 1 Site Location

In 2016, NOAA researchers developed a ROV dive plan to examine a target off the coast of Wake Island. This target was first located during a multibeam survey and believed to be *Hayate*, a Japanese destroyer lost during the Battle of Wake Island in 1941 (FIGURE 2.7). The ROV utilized for the survey was *Okeanos Explorer* ROV *Deep Discoverer* (D2). The goals of this survey included "confirming the ID of the wreck, completing a perimeter survey of major features, noting battle damage, and assessing the status of deterioration" (Van Tilburg 2016:1). During the dive, researchers quickly realized that the vessel was not *Hayate* due to several key factors. These included: "engine aft design with bridge well forward, single-screw single rudder design, masts at forecastle and poop, kingposts near bridge, [and] welded-bead ship name on bow and transom in Japanese and English" (Van Tilburg 2016:2). While the target was

not *Hayate*, researchers were still able to record data regarding the vessel's identity and the environment in which it rests.

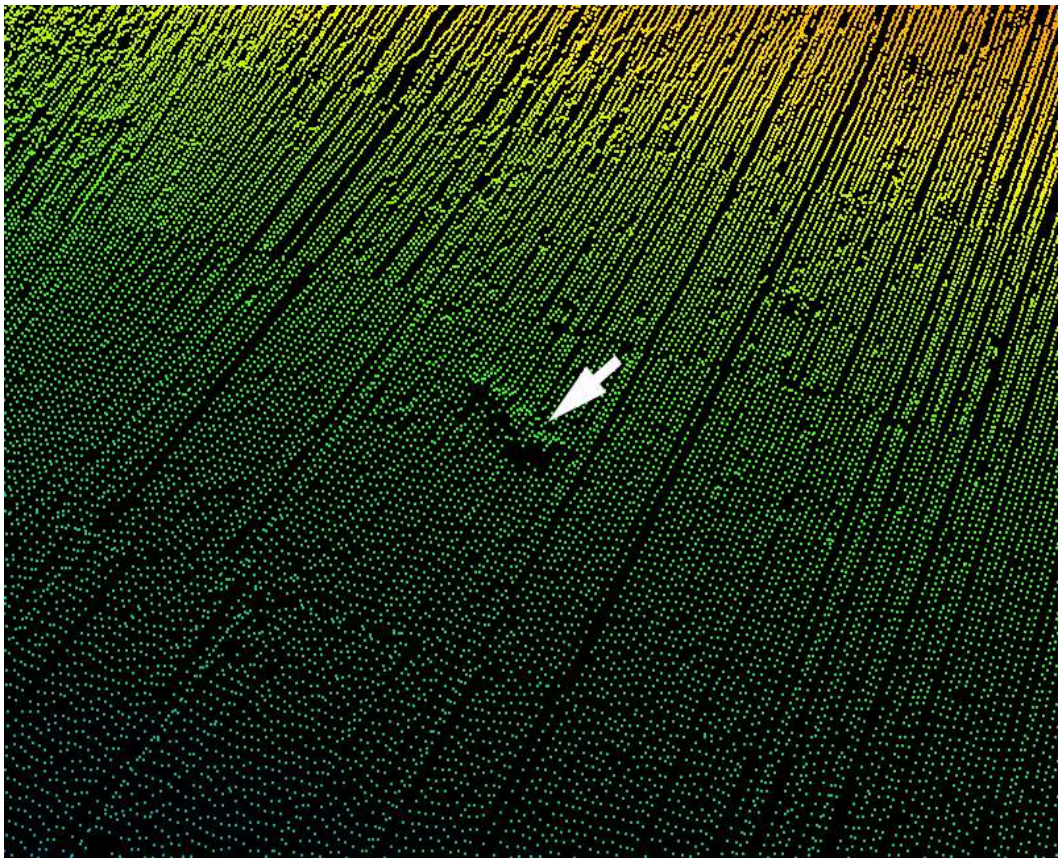

FIGURE 2.7. Multibeam data of wreck off the coast of Wake Island believed to be Japanese destroyer Hayate (Cantelas and Wagner 2016)

The vessel rests at a depth of approximately 840 meters on a primarily sandy seafloor. While approaching the vessel, the ROV spotted some debris. Researchers believed this to be wooden planks, potentially decking, from the vessel. Once the ROV reached the vessel, starboard and overhead video footage were collected. The current prevented survey of the port side of the vessel.

Video footage captured by the ROV shows the vessel resting on sand with a slight list to starboard. Two large holes on the lower portion of the hull were potentially caused by torpedo damage from the vessel's sinking event, though one source states that USS *Triton* torpedoed the

vessel's port side. The ship shows signs of deterioration, including the collapse of masts and deformed cabin spaces. 'Rusticles' are abundant throughout the vessel indicating biological processes such as corrosion are impacting the site (National Oceanic and Atmospheric Administration 2016a:4-5). While the primary objectives for the dive were archaeological, researchers did note the presence of several biological species, including:

> A number of different invertebrates including sponges (Hyalonema sp and Dictyaulus sp), gorgonians including Iridogorgia sp, Acanthogorgia sp, and other unidentified species., anemones, particularly species in the family Hormathiidae, and fises (Neoscopelus sp, Sladenia sp, and an ophidiid) (National Oceanic and Atmospheric Administration 2016a:5)

Upon completing their survey, researchers moved on to a second and third potential site in the area. These two subsequent sites turned out to be ‘large rocky formations’ and therefore further investigation was not warranted.

Conclusion

The creation of the IJN is an exceptional feat. The ability to develop such a formidable navy and subsequently challenge the most powerful navies in the world, all within one hundred years, is incredible. Due to their rapid expansion, however, the IJN faced growing pains that impacted their success in WWII. Adherence to Mahanism led to primarily offensive war strategies that underestimated the need for defensive tactics. Lack of varied support vessels led to excessive strain that hindered the civilian economy and reduced shipping rates. These factors, along with minimal shipping support and protection, greatly impacted Japan throughout the war.

Requisitioned merchant vessels became essential means of supporting Japanese efforts throughout the Pacific Theatre. While a greater appreciation of the necessity of shipping support and protection prior to WWII may have shifted the outcome of the war in Japan's favor, there is no doubt that the use of requisitioned merchant vessels allowed conflict in the Pacific to carry on for so many years.

Chapter 3 Archaeological Theory and Methodological Background

Site Formation Process Theory

This chapter explores the origins and applications of site formation process (SFP) theory within underwater archaeology, focusing on deep-water site formation processes. Due to the nature of deep-water environments, archaeological material experiences unique external influences during the wrecking event and the post-depositional period. Deep-water SFP theory assisted in analyzing the *Amakasu Maru No. 1* site through the examination of the NOAA video footage collected during the 2016 *Okeanos Explorer* mission to Wake Island.

SFPs were initially examined and defined by Schiffer (1987:7) as "factors that create historic and archaeological records." While this definition holds for both terrestrial and underwater projects, the nature of the underwater environment creates new challenges for archaeologists attempting to learn more about a site's history. Muckelroy (1978) was the first to apply this theory to underwater sites and argued that depositional and post-depositional processes influenced underwater site formation. Muckelroy discusses both periods and provides a flowchart chronicling the vessel's journey through the wrecking event and post-wrecking period (FIGURE 3.1). After the wrecking event, Muckelroy defines two main post-depositional factors that alter sites. These are extracting filters and scrambling devices (Muckelroy 1978:275). Extracting filters remove items from their original context (i.e., the ship). Muckelroy (1978:275) identifies the three main processes that lead to the removal of artifacts from a site as the process of wrecking, salvage operations, and the disintegration of perishables. He acknowledges that not all materials associated with the wreck will sink with the vessel. Often ships contain movable materials that are light enough to float away, therefore removing themselves from the context of the wreck. Salvage operations, both historic and modern, demonstrate anthropogenic impacts that may occur on wreck sites. The intentional removal of artifacts from sites further reduces the data

present for archaeological analysis. Finally, not all materials preserve at the same rate within the underwater environment. This variation leads to a biased array of artifacts as some materials may be fully deteriorated at the time of archaeological analysis (Muckelroy 1978:275-278).

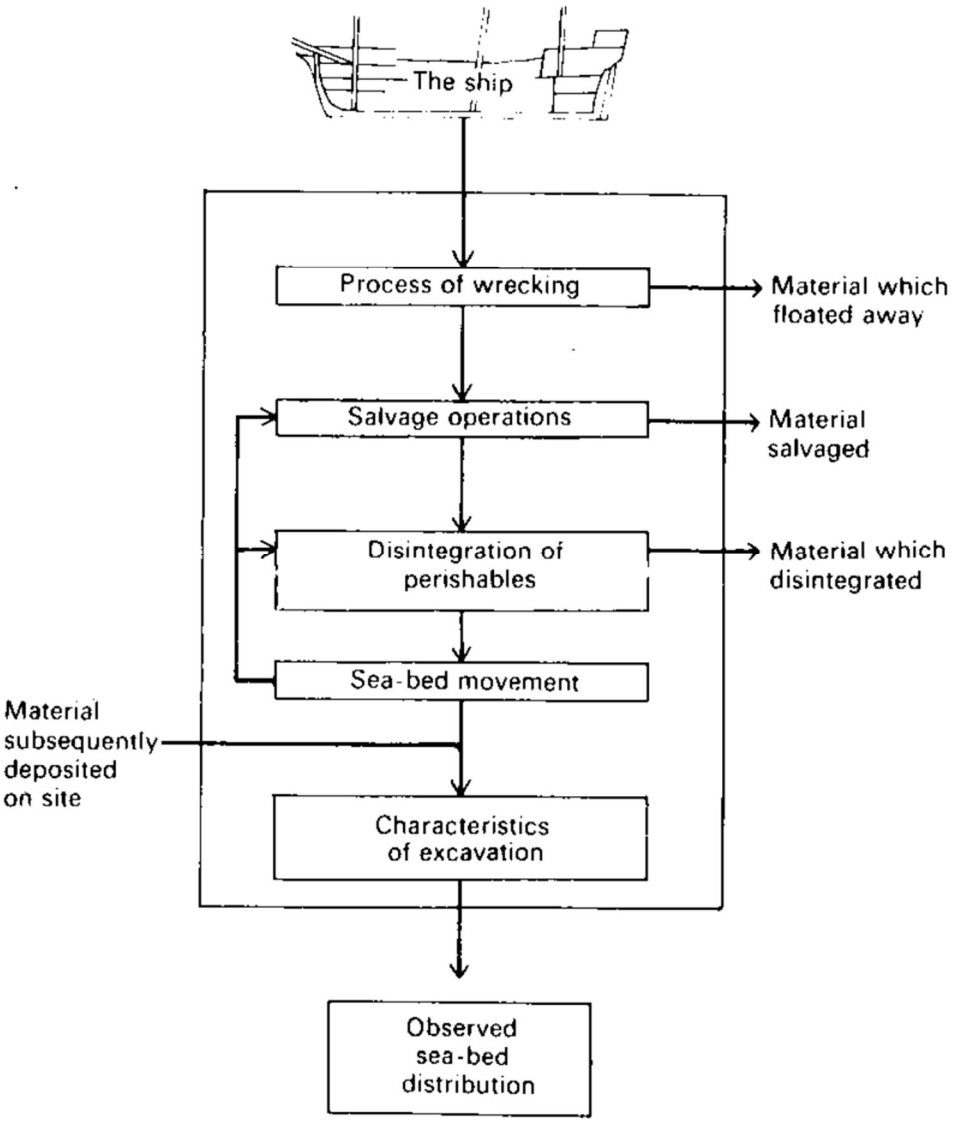

FIGURE 3.1. Muckelroy's flowchart representing the evolution of a shipwreck (Muckelroy 1978:269).

Scrambling devices are the second component of Muckelroy's SFP theory. These devices rearrange artifacts associated with the wreck and can occur both at the time of wrecking as well as after the wreck becomes a part of the seascape (Muckelroy1978:278). During the wrecking

process, artifacts move from a level of high organization while aboard the ship to some varying degree of disorder once they become integrated into the underwater environment. Seabed movement also impacts the site after the artifacts have assimilated into the sediment. This movement can include environmental processes such as wave action, marine animal interactions, and currents (Muckelroy 1978:283-288).

Muckelroy's discussion of extracting filters and scrambling devices mentions cultural incursion, though it primarily addresses the environmental impacts on underwater sites. This contrasts with Schiffer's concept of C-transforms and N-transforms. In his work, Schiffer (1975:836) argues that archaeology is inherently a behavioral science, and to understand the formation of archaeological sites, a set of cultural laws is required. C-transforms are cultural processes that impact the formation of archaeological sites. N-transforms, however, are the "post-depositional phenomena, especially the modification and destruction of artifacts and ecofacts by chemical and physical agents" (Schiffer 1975:840). Schiffer later expanded on his views of site formation through a discussion of archaeological context. Artifacts are in the 'systemic context' when interacting with the behavioral system (Schiffer 1987:3). This period involves any time the artifact is being acted upon by cultural influences. In contrast, the 'archaeological context' refers to periods when the artifact only interacts with the natural environment. Unlike Schiffer's earlier call for a rigid set of laws to describe SFP, he states that artifacts often move between the systemic and archaeological context throughout their lifetimes, creating a much more fluid concept of site formation (Schiffer 1987:3-4).

The models put forth by Muckelroy and Schiffer were widely accepted within the archaeological community, however as the field advanced, a more complex set of guidelines addressing SFP was required. Ward and her colleagues (Ward et al. 1999:562) stated that both

Schiffer and Muckelroy "have outlined the broad relationships between wrecks and their physical environment but fail to effectively link the physical attributes of the wreck site with the processes controlling wreck formation." An updated version of Muckelroy's flowchart was developed to provide a more comprehensive view of the processes impacting wreck site formation to address this concern (FIGURE 3.2).

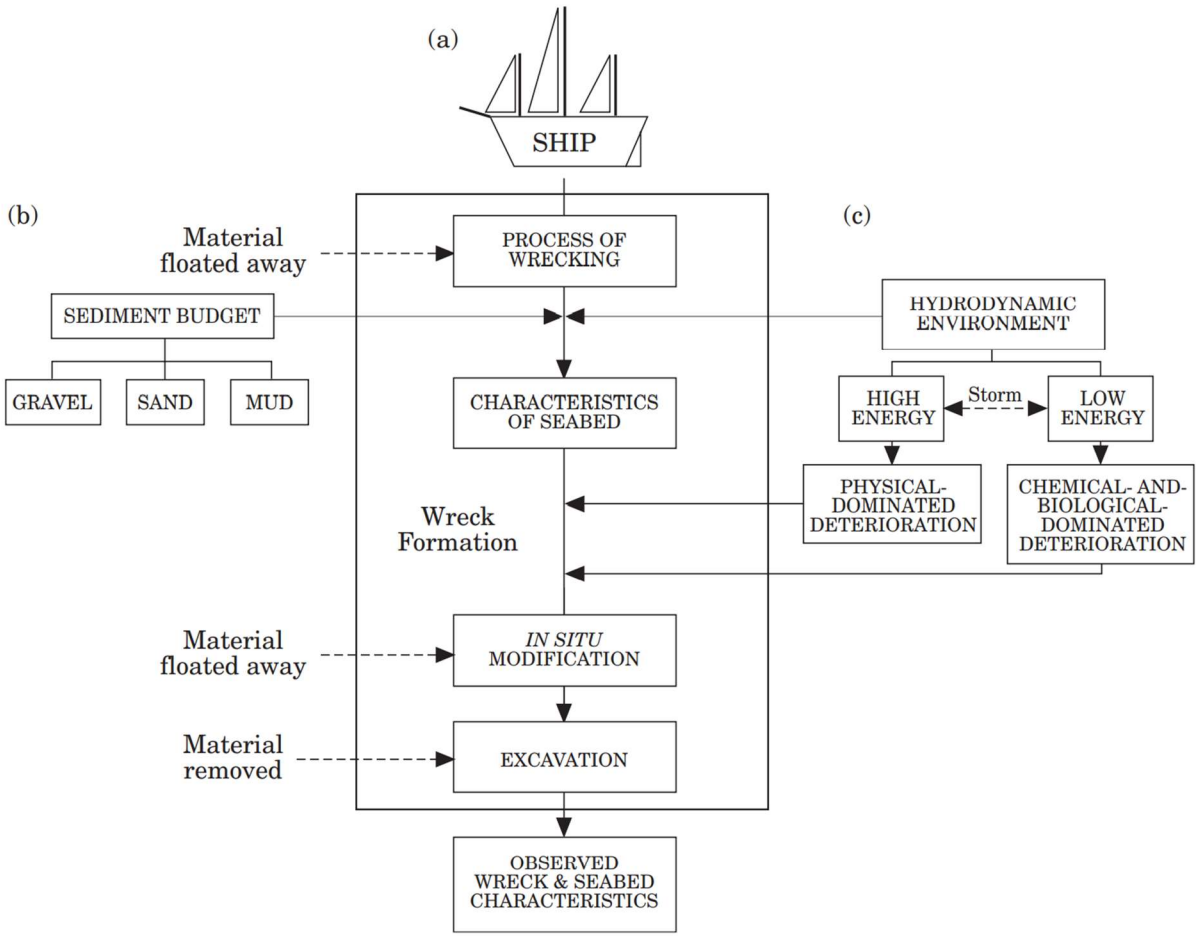

FIGURE 3.2. Flowchart depicting the various processes influencing wreck site formation (Ward et al. 1999).

This model stresses the importance of understanding the impacts of the natural environment on wreck site formation, specifically physical, biological, and chemical influences. The authors acknowledge the importance of variation among environments, though they state

that in most underwater environments, physical factors will be the first to impact a site, followed by chemical and biological processes. The intricate and multifaceted relationship between a wreck site and its surrounding environment demonstrates the interdisciplinary nature of site formation. It shows the need for the field to move away from the concept of site formation being a 'single process of disintegration' as Muckelroy's initial flowchart portrayed towards a more holistic approach (Ward et al. 1999:565-569).

Another researcher attempting to provide greater depth to the study of SFP during this time was David Stewart. Stewart (1999) argued for the separation of factors into depositional and post-depositional processes. The primary depositional process is the wrecking event, though there are various methods for a ship to sink, including intact, disintegration, capsize, intentional deposition, inundation, and refuse. All these varying depositional methods will create unique arrays of artifacts on the seafloor. Therefore, by examining the artifact distribution of a site, researchers may learn more about the vessel's wrecking event (Stewart 1999:568-574). Stewart divides post-depositional processes into both cultural and environmental to provide a holistic view of the factors impacting sites (FIGURE 3.3).

While Stewart creates a comprehensive list of factors impacting underwater sites, he acknowledges that research on this topic is still ongoing. Processes such as bioturbation are still under-researched, and there is a strong possibility that some elements affecting these sites have not yet been identified. Stewart concludes his paper by urging for the continued study of this topic, stating:

> Underwater sites, like those on land, are the result of complex formation processes that can result in the mixing of strata, the destruction of artifacts, and

deposition of new material. For that reason, understanding the formation processes present must become a primary goal of archaeologists studying submerged sites (Stewart 1999:585).

Formation Process	Possible Effects	Example	Reference
Cultural			
Reclamation	Loss of movable objects; trampling damage; movement of artifacts	1715 Spanish Plate Fleet	Cockrell and Murphy, 1978; Murphy, 1983
Construction	Destruction of site		
Fishing	Dragging of artifacts; addition of fishing implements	Bozburun	Hocker, 1995
Dredging	Destruction of sites in harbors or shipping channels		
Refuse and loss	Addition of material to existing sites	Byzantine anchor on the Bronze Age Uluburun wreck	Pulak, 1993:11
Environmental			
Marine borers	Destruction of wood	Most wrecks located in warm waters	Robinson, 1981; Turner and Johnson, 1971
Bioturbation	Some damage, especially to organic materials; stratigraphic displacement	*Kennermerland*	Ferrari and Adams, 1990
Waves, tides, and currents	Heavy wear to artifacts due to water abrasion; loss of spatial patterning		Waters, 1992:275–280
Colluvial action	Downward movement of artifacts	Bozburun	Hocker, 1995

FIGURE 3.3. List of post-depositional processes impacting underwater archaeological sites (Stewart 1999:584).

Since the publication of Stewart's work, several important studies on SFP have been published. Gibbs (2006) examined the subject through the unique lens of the disaster response model. This model aims to provide more information on the "human behaviors before, during, and after a shipwreck, as well as the processes of recovery of material and the long-term relationships between people and wrecks" (Gibbs 2006:5). By viewing shipwrecks through a cultural model, researchers may be able to answer unique questions regarding the wreck site

itself, as well as the artifacts that may or may not be present at the site. While Gibbs focuses mainly on the cultural impacts to sites, he acknowledges that environmental factors are impacting sites simultaneously.

The development of SFP theory in maritime archaeology has slowly evolved to include an understanding of both the anthropogenic and environmental impacts on underwater sites. Researchers acknowledge that to understand why a site is the way it is, they must take into account a variety of factors ranging from the human behavior during the sinking event to the broad range of environmental processes that occur post-wrecking (Schiffer 1975; Ward et al. 1999; Gibbs 2006; Martin 2013:47).

While understanding the cultural input of SFP is necessary, the interaction with the surrounding biological environment is essential when examining deep-water wrecks because there is minimal anthropogenic interaction with these sites post-wrecking.

Deep-water vessel wrecking

Many shipwrecks occur within several hundred meters of a shoreline; however, researchers estimate that up to 20% of all shipwrecks have occurred in deep water (Soreide 2011:156; Wachsmann 2014:202). The wrecking event is of particular importance for deep-water sites as "the forces that have most affected deep-water wrecks are those on the surface that caused the ship to sink, those acting during the sinking process, and the impact with the seabed" (Soreide 2011:157). These wrecks occur for many reasons, including weather, physical damage, collisions, acts of war, fire or explosion, or deliberate abandonment. No matter the method of wrecking, the journey through the water column to the seafloor causes high degrees of strain on the vessel. This stress can cause lasting damage. Unlike shallow-water wrecks that do not have a

long descent to the seafloor, deep-water wrecks can be traveling for extended periods, allowing them time to reach terminal velocity. It is estimated, for example, that RMS *Titanic* reached speeds of up to 25-30 mph during its descent (Soreide 2011:156; Wachsmann 2014:206). As the vessel sinks, drag forces may rip components of the upper hull off the vessel leaving a debris trail from the wrecking location to the eventual resting place of the hull.

While surveying four WWII-era ferrous hulls that wrecked in the Gulf of Mexico, Robert A. Church developed a mathematical formula for determining the initial site formation, as well as distribution, of each deep-water site. This model aims to account for the many factors affecting vessels as they sink "including, but not limited to, subsurface currents, density and temperature of the water, density and shape of the falling object, etc., which all play a role in the hydrodynamic drag and drag coefficient of an object as it falls" (Church 2014:29). Utilizing this model, Church believes researchers will be able to find additional components of sites with known locations and determine the present location of sites if the sinking event location is known.

Just before contacting the sediment, a pressure wave created by the descending vessel will create a crater in the seafloor within which the vessel will come to rest. This crater allows for the partial burial of the vessel's hull immediately upon contact with the bottom. This impact can create a significant impression in the sediment. The forceful movement of water into the air compartments throughout the vessel can cause damage to the ship. Vessels will often come to rest on their keels due to their low centers of gravity and the hydrodynamic forces acting upon them (Soreide 2011:156; Church 2014:27-28; Waschmann 2014:206).

Deep-water site characteristics

Deep-water sites distinguish themselves from their shallower counterparts by being in areas inaccessible to SCUBA divers, specifically any site below 50 meters. Due to this deeper location, human interactions are generally limited to impacts from trawling and anchor cables. The increasing ability to examine deep-water wrecks has allowed researchers to delve into the specific processes impacting these sites in greater detail (Soreide 2011:159; Church and Warren 2008; Wachsmann 2014:208).

While deep-water sites sustain less impact from anthropogenic contact, they are still heavily influenced by their surrounding environment. There are five 'depth zones' that constitute the ocean environment: the epipelagic zone, mesopelagic zone, bathypelagic zone, abyssopelagic zone and the hadalpelagic zone (O'Leary and Roberts 2018:2). The epipelagic zone ranges from the surface to 200 m and is influenced by atmospheric conditions such as wind, waves, and surface temperature changes. The mesopelagic zone, also known as the twilight zone, reaches depths of 1 km and can have extreme changes in water density and temperature. This zone is prone to thermoclines (drastic changes in temperature) and haloclines (drastic salinity changes). The bathypelagic zone, or the midnight zone, reaches depths of 4,000 meters is unaffected by surface-level changes, and the currents in this zone vary from surface currents due to increased water density (Warrant and Locket 2004:671). The abyssopelagic zone reaches depths of 6,000 meters and maintains nearly freezing temperatures, leading to reduced biodiversity. Finally, the hadalpelagic zone is the deepest area of the ocean and reaches a depth of 10,994 meters in the Mariana Trench. This research primarily examines the epipelagic and mesopelagic zones. Understanding the characteristics of these varying depth zone is essential as these physical characteristics affect the formation processes of wrecks in these areas.

Chemical processes such as oxidation also impact deep-water site formation. Deep-water environments generally exhibit low temperatures, high water pressure, reduced dissolved oxygen and increased salinity levels which work together to reduce corrosion processes. This combination promotes the preservation of artifacts in this environment. While these environments generally slow the rates of metal corrosion, the reactions can still occur. Therefore, artifacts covered with sediment have a higher probability of preservation compared to their shallow-water counterparts (Soreide 2011:161; Wachsmann 2014:207).

The third environmental component that impacts deep-water shipwrecks is physical processes. These can include currents and tides. While currents can impact sites in these conditions, their movement rates are typically around 1-2 cm/s, unlike surface currents that are influenced by winds and can reach much higher speeds. Much like currents, tides are generally milder in deep sea environments and will have more minimal impacts on archaeological sites (Soreide 2011:161).

Biological processes are the last primary group impacting deep-water sites. The biological processes impacting deep-water sites vary from shallow wrecks due to higher water pressure and lower average water temperatures. Due to the oxygen-poor conditions of deep-water environments, aerobic bacteria continue oxidizing, though at much slower rates than shallower environments. Along with aerobic bacteria causing damage, sulfate-reducing anaerobic bacteria is often found on deep-water sites. During the reduction processes of this organism, rust forms, decreasing the structural integrity of metal hulls. Depending on the depth and oxygen content of the site, deep-sea critters such as worms, crustaceans, and fish can also alter sites. While marine organisms may impact wrecks in deep-water conditions, these wrecks can also alter the surrounding environment by acting as habitats or artificial reefs, increasing the

biodiversity of the area (Soreide 2011:162-163; Hamdan et al. 2020). While all four of these environmental processes affect archaeological sites, it is essential to remember that variations in location, temperature, and depth can all modify preservation conditions.

Deep-water wrecks face fewer impacts from human interaction, though they interact extensively with the biological environment, leading to site deterioration. These processes range from physical to biological to chemical and all can have sustainable impacts on the structural integrity and longevity of underwater sites. One way to examine the site formation processes occurring on deep-water sites is through ROV footage. While this is an effect way to examine deep-water sites, there are both benefits and drawbacks to the technique that should be addressed.

Deepwater ROV Benefits and Drawbacks

The methodologies available to study deepwater sites are limited due to the inability of divers to reach these depths. While researchers have found methods of examining these sites, there are benefits and drawbacks associated with each. The 2016 footage of *Amakasu Maru* was captured utilizing ROV technology. Therefore, this section discusses the various pros and cons associated with conducting surveys using this technology.

Benefits

There are several reasons archaeologists continually use ROVs for deep-water site surveys within maritime archaeology. Most notably, ROVs can reach sites that are inaccessible to divers due to depth, as well as temperature. Since the early 2000s, researchers have been using ROVs to access deep sites and have produced data that would not be feasible without this technology. One important example of this is the work on deep-water sites within Turkey's Black

Sea. During their survey of the ancient shoreline in 2000, Robert Ballard and his colleagues utilized two underwater observation vehicles to identify potential sites based on over 200 sonar targets collected within the research area. These two vehicles included an imaging vehicle, *Argus,* and an ROV, *Little Hercules*. Both vehicles had maximum operating depths of 3,000 m, making them optimal for the deep-water conditions of the Black Sea (Ballard et al. 2001:610-612).

Working in conjunction with one another, *Argus* and *Little Hercules* identified four shipwreck sites and a submerged human habitation site (Ballard et al. 2001:607). One of the shipwrecks was radiocarbon dated to the late Byzantine period, thus providing new data regarding this era of ship construction within this region (Ballard et al. 2001:621). Not only did ROV technology help identify several significant sites that will contribute to understanding ship construction techniques from this region and period. This project demonstrated the benefits of ROVs for surveying potential deep-water sites.

ROVs also allow researchers access to sites inaccessible to researchers due to extreme temperatures. In 2007 a wreck was discovered by a group of researchers from the Norwegian University of Science and Technology (NTNU). This wreck is located in Trygghamna Fjord, which has long been a popular anchorage spot, at a depth of 30 to 40 m (Mogstad et al. 2020:2). Researchers identified the vessel as *Figaro*, a whaler that sank in the harbor in 1908 (Mogstad et al. 2020:2). In 2015 researchers conducted an initial site survey utilizing an autonomous underwater vehicle (AUV) equipped with a sidescan sonar to collect imagery of the wreck and a mini ROV to collect video footage (Mogstad et al. 2020:4). While the survey was temporally efficient (researchers completed the survey in less than twelve hours), visibility was a significant

issue. The waters within the fjord fill with sediment during the summer months, which significantly decreases visibility.

The Polar Night Research Cruise put on by the Arctic University of Norway completed the 2016 survey. The ROV chosen for this survey had "an HD video camera, stereo cameras for the photogrammetry, and an underwater hyperspectral imager" (Mogstad et al. 2020:4). These more advanced ROV components were necessary for fulfilling the season's goals of developing a 3D photogrammetric model of *Figaro*. The project effectively produced a 3D model of the wreck, which would not have been possible so quickly with solely divers due to the cold environment of the harbor.

Along with the ability to access previously inaccessible sites, ROVs are more efficient than diver surveys because surface intervals and multiple dive teams are unnecessary. Such was the case with the 2016 survey of sites off Ishigaki Island, Japan. While the site only reaches a maximum depth of 35 m, researchers opted to employ an ROV for two primary reasons. First, though divers could easily access the site, an ROV is not limited to bottom time and, therefore, can survey the site more quickly and efficiently than divers. Additionally, video footage of the ROV dive allows for continuous site recording during the dive. This methodology allows for increased data collection of a site during the survey. Second, researchers retrofitted the ROV to be controlled with a video-game controller so untrained individuals could pilot it. This alteration allowed for public engagement as researchers could invite non-divers to interact with the site by driving the ROV (Ono et al. 2016:81). This example demonstrates the efficiency of ROVs to complete surveys in less time, therefore minimizing time and resource costs to a project. It also illustrates the ways in which researchers can utilize ROVs to engage with a broader audience.

ROV technology is becoming much more accessible to researchers, and therefore new and exciting uses for the vehicles are being seen all the time. One of the most exciting uses for ROVs is telepresence surveys. Telepresence surveys broadcast ROV video footage live online, allowing scientists and researchers on land to tune in and provide expert commentary while the ROV is still surveying the site (Brennan et al. 2018:98). This methodology has increased interdisciplinary collaboration concerning underwater archaeological sites, most notably shipwrecks. Telepresence surveys gained popularity in the United States in 2000 when a report written by leading ocean explorers and scientists titled *Discovering Earth's Final Frontier: A US Strategy for Ocean Exploration* called for the development of research vessels equipped with state-of-the-art technology for expanding our understanding of the underwater environment (Brennan et al. 2018:100). *Okeanos Explorer* and E/V *Nautilus* have taken on this role and are referred to as the 'ships of exploration' (Brennan et al. 2018:100). The telepresence capabilities of these ships have been essential in shipwreck site surveys from Turkey to the Mediterranean Sea to the Gulf of Mexico. According to Brennan, these surveys are shifting the way archaeologists view underwater sites, "we are seeing a paradigm shift among the archaeological community…to include biological research as an integral part of site formation processes at shipwreck sites, as an example" (Brennan 2018:118).

Along with engaging onshore professionals and curious individuals through telepresence surveys, ROVs also provide educational opportunities to engage students through a broad range of scientific principles. NOAA's Office of National Marine Sanctuaries has developed educational materials for school-aged children that introduce them to the theory and practice of ROVs. One curriculum targeted at sixth to eighth-grade children teaches them how to build an ROV while also providing important learning objectives including:

- Learn the science principles necessary to construct an ROV, such as Newton's Laws of Motion, buoyancy and properties of air;
- Understand the engineering design process and that it is reiterative;
- Design and build an ROV for competition;
- Describe how ROVs are used in the marine sciences and underwater archaeology;
- Compare the technology of an ROV to other technologies;
- Learn more about our nation's National Marine Sanctuary System (NOAA 2020)

Educational curriculums such as this one are a beneficial method of public outreach because they can help increase students' interest in history and archaeology and introduce them to other subjects such as physics and engineering (McManamon 2000:11).

Finally, ROVs can be customized to perform tasks specific to an individual's research goals. This customization is beneficial as it allows for precise adherence to the research agenda. While most archaeologists do not have the funding to develop state-of-the-art ROVs uniquely designed for their research goals, some researchers are developing methods of altering current ROVs to best suit their research aims. The ROV 3D Project is an example of such modifications. This project aims to develop automatic 3D imaging procedures that can perform underwater using acoustic and optical data. ROV 3D is a collaboration between the LSIS university research laboratory and two commercial partners: Compagnie Maritime d'Expertise (COMEX) and SETP (Drap et al. 2015:2).

Researchers used this customize prototype survey model to record the Cap Benat 4 wreck off the coast of Bormes Les Mimosas in southern France. The wreck rests at a depth of 328 m

making diver survey impossible. The experimental ROV mapped the site in two hours, utilizing 12,000 photos and 250 million points (Drap et al. 2015:21). Several 3D models were developed utilizing the collected data.

Drawbacks

While ROVs provide many benefits for deep-water site investigations, several drawbacks with the technology must be addressed. Due to the location of deep sites, several environmental conditions can impact the efficacy of ROV survey. First, underwater currents can hinder the ROV's ability to survey all site areas. This limitation was the case with *Amakasu Maru No. 1*, as the ROV could not record the vessel's port side due to strong currents. Because many of these sites are difficult to reach, the inability of the vehicle to examine a particular aspect of the wreck may mean that component of the site will not be examined for many more years, if not ever.

The second notable environmental issue impacting these sites involves their depth. The depth of deep-water sites means very little sunlight reaches these areas and may lead to dark or difficult to interpret footage if the ROV is not equipped with the proper lighting. This issue can be overcome with specialized lighting packages, though it cannot be overlooked when planning a deep-water survey (Coleman et al. 2008:661; Drap et al. 2015).

ROVs are technologically advanced machines that can perform various tasks depending on the vehicle. While these features can be beneficial in archaeological investigations, it also means that ROVs are not cheap. Depending on the size and technological gadgets associated with it, these vehicles can range from thousands to millions of dollars and often require specialized pilots and technicians to operate and maintain them. The various costs associated with these vehicles quickly become a limiting factor for the individuals that have access to them (McLean et al. 2020).

Along with high cost, these vehicles are limited to a particular survey range. ROVs are tethered systems. Therefore, the operating range of an ROV is limited to the length of its cable. Therefore, the vehicle must remain near the surface vessel for the survey's duration. This limitation can become problematic if weather or ocean conditions are not conducive to surface vessel presence. Also, because these submersibles are piloted from the surface, decreased visibility may limit the areas that can be surveyed as pilots must rely on video footage captured by the vehicle to maneuver it on the site (Chen et al. 2014:141; Petillot 2019:95). The culmination of these drawbacks, as well as the rapid development of new technologies, has led some researchers to argue that AUVs may soon replace ROVs in deep-water site surveys (Auster 1997:73).

Archaeologists already use AUVs in their investigations, both independently and in conjunction with ROVs (Mogstad et al. 2020; Roman and Mather 2010). This technology has several significant benefits that differentiate it from ROVs. First, the AUV is autonomous, and therefore it does not need to be tethered to the workboat. This independence minimizes the entanglement hazards and umbilical length limitations associated with ROVs (Mogstad et al. 2020:4; Bingham et al. 2010:703). Other notable differences between the two technologies involve the support vessel. Due to the need for tethering ROVs, support vessels must constantly be positioned above the site while the survey is in progress. The support vessel must also accommodate the ROV pilot and the operator control unit (OCU), which minimizes the vessels qualified for ROV surveys. AUVs, however, do not require proximity to the support vessel. Additionally, due to the autonomous nature of the vehicle, a broader range of vessels may be used in these operations because they require minimal onboard equipment for operating procedures (Bingham et al. 2010:703).

Conclusion

Using a deep-water site formation processes framework to examine the *Amakasu Maru No. 1* site provides information about the vessel's wrecking process and the environmental processes that have affected the site post-wrecking. By understanding more about the environmental conditions surrounding Wake Island, and reviewing the NOAA footage of the shipwreck site, more information regarding the vessel's history as well as potential future preservation risks are understood. This case study on a deep-water Japanese WWII wreck also provides information on site formation processes affecting other deep-water Japanese wrecks in the Pacific.

Chapter 4 Methods

Introduction

This thesis utilizes several methodologies to complete the necessary data collection. To develop the 3D model of *Amakasu Maru No. 1*, the video footage captured during the 2016 *Okeanos Explorer* mission was downloaded from the NOAA Ocean Explorer Video Portal and organized into a spreadsheet delineating the video segment lengths and progression throughout the dive. A Blender 3D model was then made of the vessel using *Amakasu's* sistership, *Kisogawa*, as a template. The texture paint function was used to paint the model depicting the coverage of each video segment. This demonstrated where on the vessel each video segment surveyed. This model allowed for determining which video clips would be helpful in the creation of the model. The useful footage was imported into Photoshop where stills were extracted from the footage and color corrected. These color corrected stills were exported to Metashape where a model was attempted.

This thesis also performed a literature review to create a database regarding other Japanese merchant class vessels requisitioned by the IJN throughout the Pacific that have been previously archaeologically investigated. The investigations range from brief site surveys to more intensive archaeological investigations (APPENDIX A). Many of these sites have become popular sport diving destinations, so post-wrecking human interaction has become an essential component of these sites that must be acknowledged (Browne 2016:59). Statistical analyses of the various characteristics impacting these sites were conducted and are provided within this chapter. The results of this literature review also assisted in the development of an ArcGIS Story Map that demonstrates the location (if known) of the wrecks, as well as information on its operational history and present-day description. A detailed description of these processes is discussed below.

Photogrammetry

The NOAA footage of *Amakasu Maru No. 1* captured in 2016 was split into several categories: ROVHD, CPHD, PTMAN, and SBMAN. For the purposes of this thesis, the ROVHD footage was examined because the ROV, *Deep Discoverer* (D2), recorded more video footage of the wreck than the other instruments. Also, the ROVHD video footage was of higher quality. The ROV measurements are listed in TABLE 4.1.

TABLE 4.1. Deep Discoverer measurements (NOAA 2016a)

Deep Discoverer (D2) Measurements	CTD
	Depth
	Altitude
	Scanning Sonar
	USBL Position
	Heading
	Pitch
	Roll
	HD Camera 1
	HD Camera 2
	Low Res Cam 1
	Low Res Cam 2
	Low Res Cam 3
	Low Res Cam 4
	Low Res Cam 5

After downloading the footage from the NOAA Ocean Explorer Video Portal (https://www.ncei.noaa.gov/access/ocean-exploration/video/), video segments were input into a spreadsheet. This spreadsheet listed the video title, the video's starting time, ending time, and total video segment length. ROVHD recorded 116 video segments throughout the dive. This spreadsheet was a beneficial organizational tool for the development of the Blender model. A table of this spreadsheet was created and is listed in APPENDIX B.

Blender Model

Blender is a free online software that "supports the entirety of the 3D pipeline – modeling, rigging, animation, simulation, rendering, compositing and motion tracking, and even video editing" (Blender 2021). Using this application, an approximate 3D model of the vessel was created using a photograph of *Amakasu Maru*'s sistership, *Kisogawa Maru*, as the template. *Amakasu*'s sistership was utilized because no photographs of *Amakasu* have been uncovered. The purpose of this model was to help model which portions of the vessel were recorded by the ROV. Therefore, precise measurements and realistic representation were unnecessary to complete the aims of this model.

FIGURE 4.1, Initial Blender model constructed using the dimensions of *Kisogawa Maru*

The first step to making the model was placing a cube in the workspace with the *Kisogawa* photo intersecting it. This cube was then extended to the lengths of the vessel. The exact vessel dimensions were input for the X, Y, and Z axes to ensure the proper hull proportions were met. A segment was added to the middle of the object which allowed the stern to be manipulated to the correct shape. The same process was repeated to create the proper bow shape.

To mark mast positions, cylinders were placed on top of the rectangular hull shape. These cylinders could not be integrated into the hull shape mesh as this would confuse the shape's geometry. Finally, the object was UV unwrapped so it could be painted.

Once the model was created, the texture paint tab was used to mark where on the vessel each video segment surveyed. While this is an estimation of video coverage, it allowed the for viewing where video segments overlapped in video coverage and where there was scant data available for the 3D model. Any area not surveyed appears black on the Blender model. FIGURE 4.2 demonstrates the lack of survey coverage present on some components of the hull.

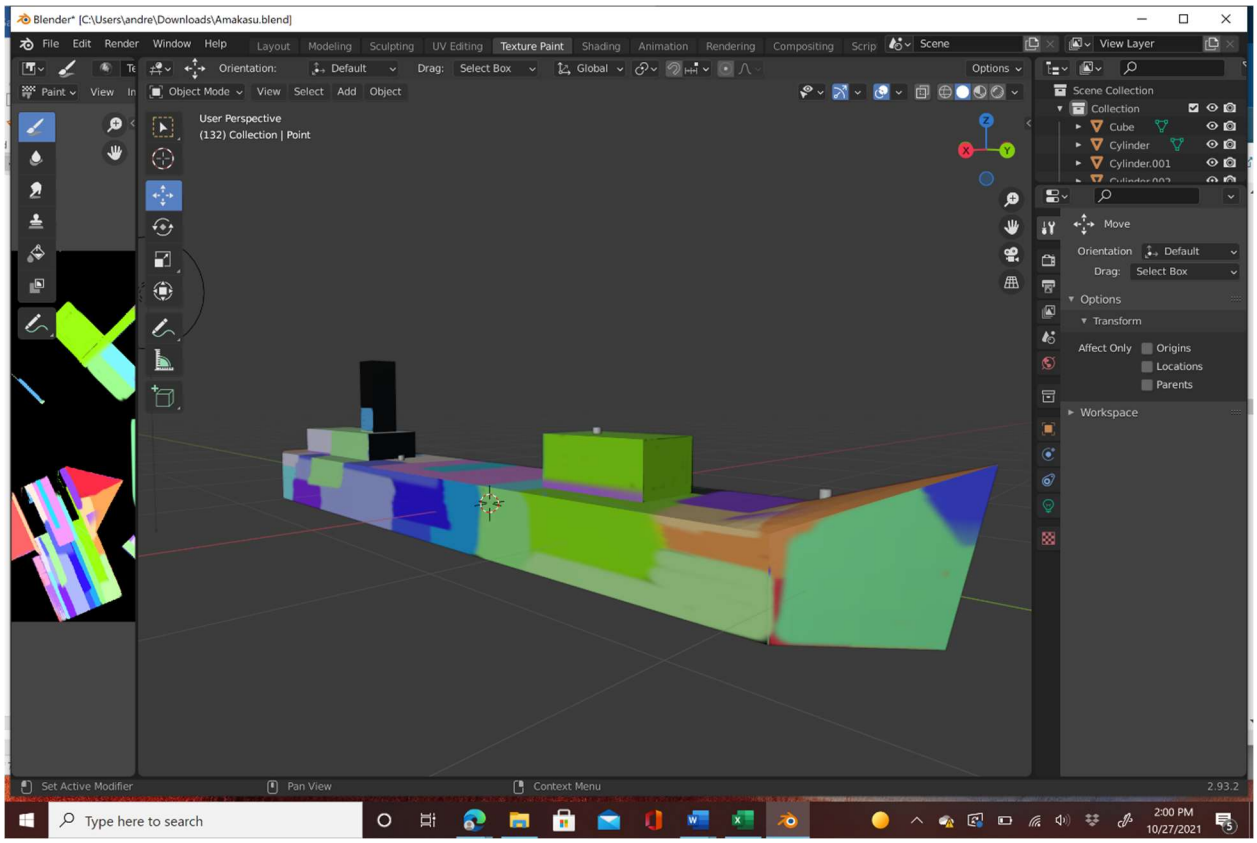

FIGURE 4.2. Blender model of *Amakasu Maru No. 1* mapping the areas of coverage by NOAA Okeanos Explorer 2016 expedition. All areas in black were not surveyed by the ROV.

The percentage of hull coverage was approximated. Due to the ability of the ROV to survey the starboard side of the vessel and most of the remaining deck and superstructure, it is

estimated that roughly 70% of the vessel was examined during the survey. This estimation does not cover internal hull components or areas of the hull that are presently resting in the seabed.

Photoshop

The Blender model allowed for determining which video clips surveyed the vessel, and which segments were not useful for the development of a 3D model. Next, the video segments were uploaded to Metashape and stills were recorded from the footage once every two seconds. This timing was chosen due to the speed of the ROV during its survey. Because of its slow movement, a snapshot of once per second was deemed unnecessary. Once the stills were captured a model was attempted, however the program had difficulty determining distinguishable features on the wreck so color correction was required.

The stills were transferred to Photoshop and color corrected using a 'Neutralize and Fade' setting of 10. This process was automated to batch color correct all photos at once. First, a new action was created, labeled 'CC', and recorded. The workflow for this color correction is listed in FIGURE 4.3 and FIGURE 4.4:

Image → Adjustments → Match Color… → Fade set at 10, Neutralized

FIGURE 4.3. Photoshop photo color correction workflow

File → Automate → Batch…→ select source folder and destination → OK

FIGURE 4.4. Photoshop automated batch color correction workflow

These photos were saved to a USB drive under a folder labeled CC_09022021. The color corrected photos from each video clip were organized into their own file. This was undertaken to

maintain organization throughout the color correcting process. All of these files were saved to a USB drive in one master folder labeled CC_09022021.

Metashape

Once the photos were color corrected, they were imported back into Metashape. Each individual video clip file was imported into Metashape independently. For the first modeling attempt, all video clip files were put through the workflow together. While the computer was able to produce a result, it in no way resembled a ship. Subsequently, each individual video segment file was run through the workflow through 'build dense cloud' using the settings listed in TABLE 4.2. Once the dense clouds were produced, the points with dense cloud confidence ranges between 0-4 were deleted from the model. This range was selected to ensure high confidence when the chunks were merged.

Once a confidence range of 5-255 was established for all chunks, they were ready to be merged. This was an extensive process of trial and error. Chunks portraying similar hull components were aligned and merged. The settings for aligning and merging chunks are listed in TABLE 4.3. This often-produced unsatisfactory results, though with time the hull's bow became visible through the merging of particular chunks. The video segments used to make the bow model were T212415, T212723, T212957, T234356, T234534, and T235029. Images captured from the Metashape model are presented in FIGURES 3.5-3.7. Unfortunately, because the hull was not fully surveyed, the entire hull could not be modeled. Also, due to minimal camera angles, not all components of the hull could be merged together for a complete model of the vessel's starboard side.

TABLE 4.2. Metashape processing settings

Workflow	**Settings**
Align Photos	Accuracy → High

	General Preselection Reset current alignment Key point limit → 40,000 Tie point limit → 4,000
Build Dense Cloud	Quality → Medium Depth filtering → Mild Calculate point colors Calculate point confidence
Build Mesh	Source data → Dense cloud Surface type → Arbitrary (3D) Face count → High Interpolation → Enabled (default) Calculate vertex colors
Build Texture	Texture type → Diffuse map Source data → Images Mapping mode → Keep uv Blending mode → Mosaic (default) Texture size/count → 4096 x 1 Enable hole filing Enable ghosting filter

Table 4.3. Metashape chunk merging settings

Workflow	**Settings**
Align Chunks	Method → Point based Accuracy → High Key point limit → 40,000 Apply masks to → None
Merge Chunks	Merge dense clouds

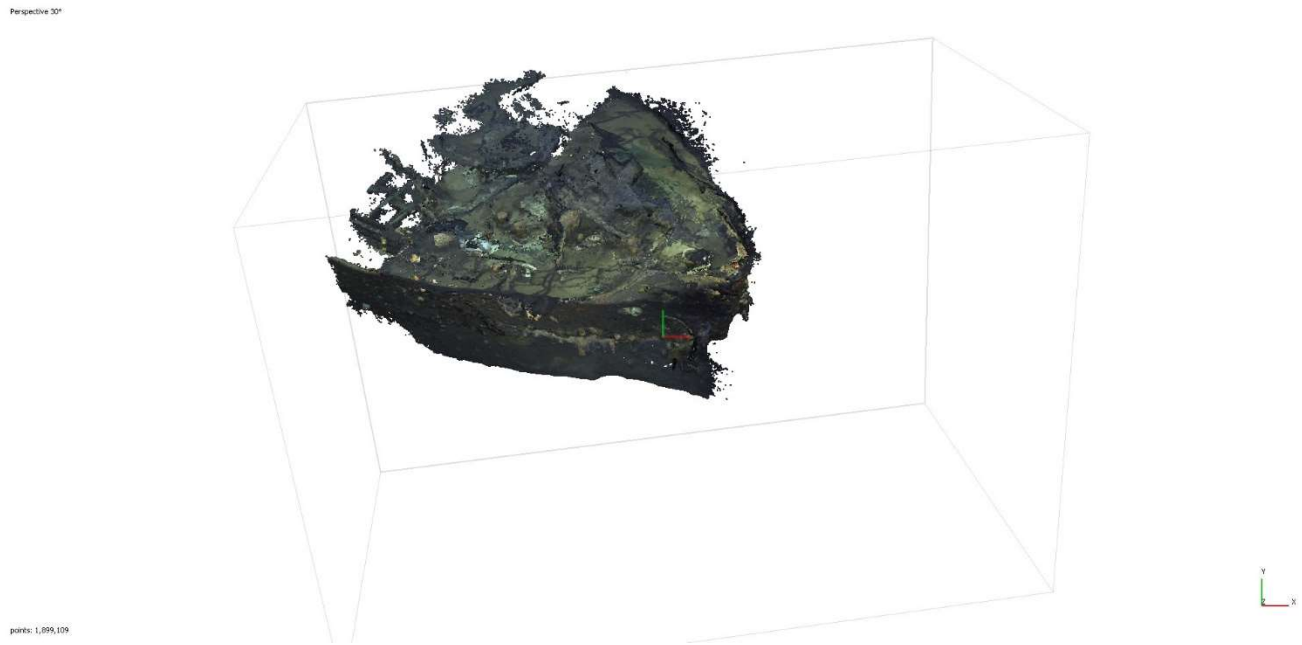

FIGURE 4.5. *Amakasu Maru No. 1* bow dense cloud

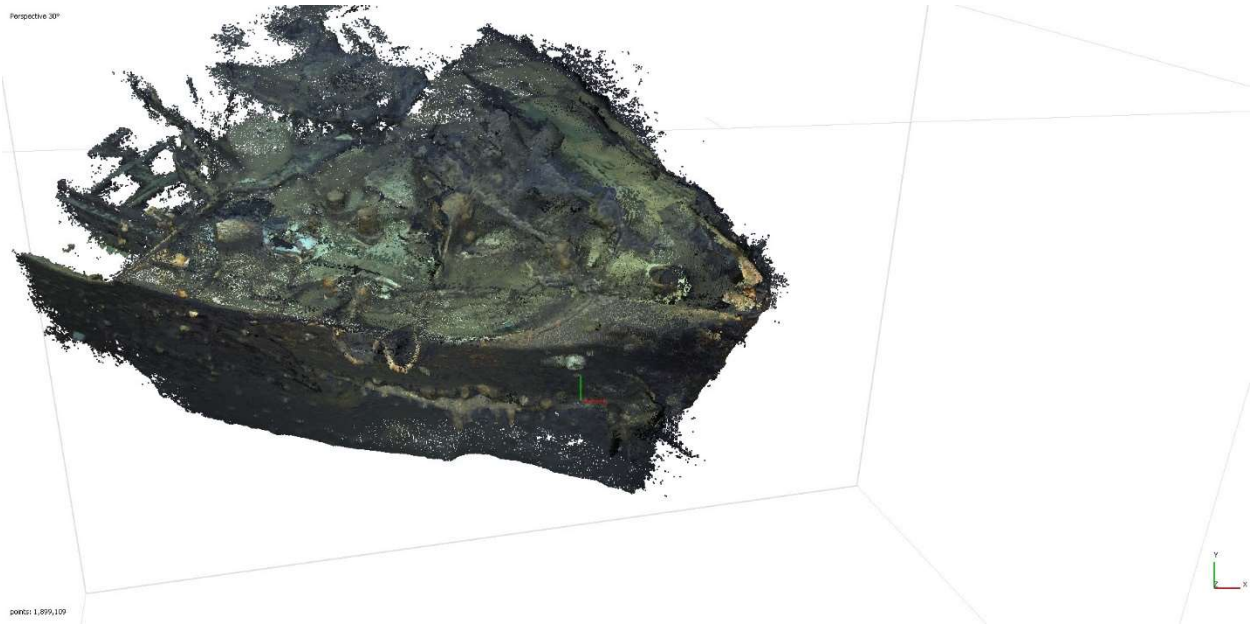

FIGURE 4.6. *Amakasu Maru No. 1* bow mesh

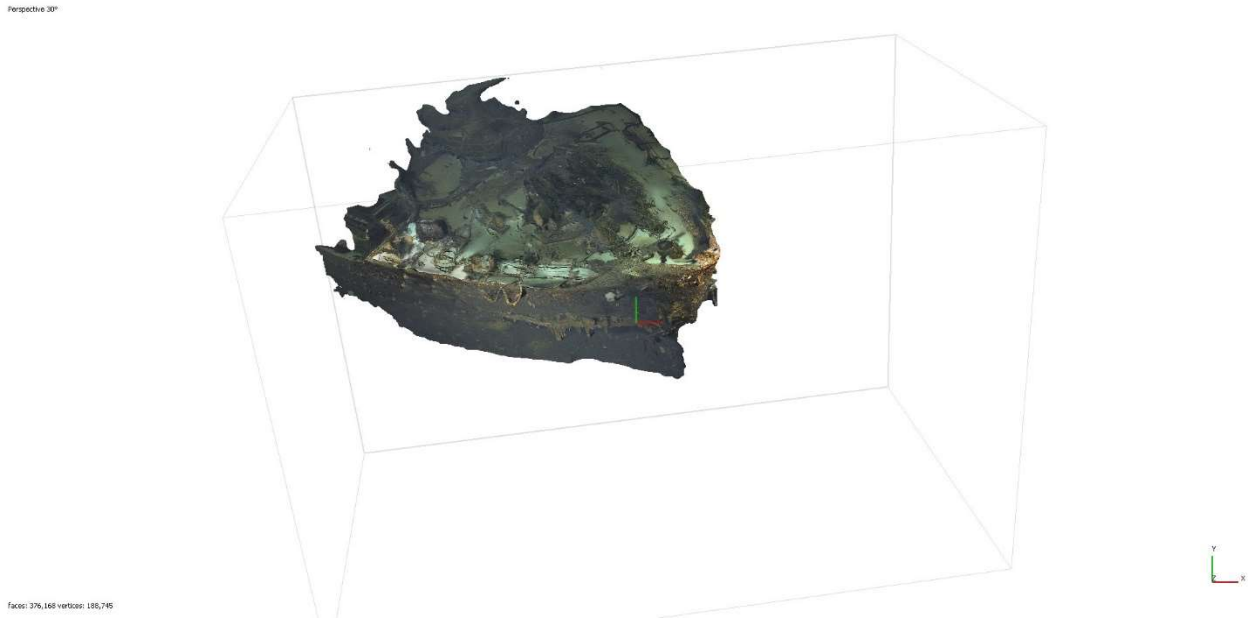

FIGURE 4.7. *Amakasu Maru No. 1* bow texture

Literature Research

Primary literature sources were consulted to complete this thesis. As will be discussed in the limitations, the inability of the author to read Japanese limited the primary source material accessible for research to sources which were translated into English. One important source accessed for this project were the Japanese Monographs (Second Demobilization Bureau 1951). These documents were operational records provided by top Japanese army and naval personnel after the completion of the war. This primary source material was beneficial because many official Japanese military documents were destroyed either through military action or deliberately at the end of the war. This source was accessed with caution, however, as many of the monographs were prepared solely from the memory from the interviewee and many of the translators were unfamiliar with either US or Japanese military terminology (Second Demobilization Bureau 1951:3). Other primary sources were accessed, including US military

operational documents and primary accounts of the war and its outcomes. Many of these sources were accessible online or through the East Carolina University library.

Secondary sources were also accessed for this thesis and were valuable for the development of the historical background of requisitioned vessels within the IJN. One particularly beneficial source was *The Japanese Merchant Marine in World War II* (1993) by Mark P. Parillo. This source provided extensive background on the subject which was essential for understanding the topic.

Peer-reviewed journal articles were helpful to determine which shipwreck sites had previously been archaeologically investigated. The field notebooks for these investigations were not accessible, however, and therefore journal articles outlining survey results were essential. Due to the optimal conditions throughout the Pacific, many of these previously investigated shipwreck sites are now popular recreational diving destinations. To understand the extent of the anthropogenic input on these sites, local dive shop websites and diver blogs were reviewed.

The site information collected from all sources was organized into an Excel spreadsheet (APPENDIX C). Multiple site characteristics were grouped into geographic characteristics, vessel characteristics, biological impacts and anthropogenic impacts. This allowed for greater organization which was beneficial for analyzing common site characteristics.

ArcGIS Story Map

In the 1990s, Environmental Systems Research Institute (ESRI) developed an online geographic information systems (GIS) mapping program titled ArcGIS. The program encompasses four primary applications including ArcMap, ArcScene, ArcGlobe and ArcCatalog (ESRI 2021). The software has expanded over the decades and now also includes ArcGIS Story Maps. This application, “allows content creators to add text, photographs, videos, 3D models,

and maps…to a web page where users can access additional content by scrolling down through different slides" (Howland et al. 2020:353). Due to the interactive nature of the application, Story Maps have become an effective tool for public engagement with archaeological material. The software has several benefits including its ease of use, and its compatibility with other software utilized for data collection in archaeology including the integration of outside GIS information and photogrammetric models.

This technology is being used by researchers interested in battlefield archaeology to learn more about WWII operations, as well as the lasting impacts wartime operations had on communities (Semen et al. 2016; Koutsi and Stratigea 2019). In their 2016 analysis of key events throughout Transylvania and Romania during WWII, Camelia-Georgiana Semen and her colleagues utilized ArcGIS software to trace movement within the region utilizing a variety of feature classes. This data-rich map was embedded into a Story Map, allowing the public to engage with the history of the war throughout this region (Semen et al. 2016). This application is effective at providing visualizations of historic battlefronts and can also be used to interact with present day stakeholders regarding the history of their homelands. This Cultural Heritage (CH) left behind after a war has several layers of importance. It can provide communal connections to a shared past within a region and can also be a source of income to an area in need of tourism revenue. This is the case on the island of Leros. To help residents connect with their shared history, as well as potentially provide sources of heritage tourism, Dionisia Koutsi and Anastasia Stratigea (2019:961) utilized ArcGIS software to show the location of battlefield artifacts both on land and underwater. This online map allowed community stakeholders easy access to artifact information and allowed them to interact with their shared heritage. The applications for Story

Maps regarding WWII history are broad and a beneficial method of disseminating research to the public.

This thesis utilized the ArcGIS Story Maps application to portray the locations of all Japanese WWII requisitioned shipwrecks throughout the Pacific that have been archaeologically investigated. To develop this Story Map, a literature review was conducted to determine which vessels have been previously investigated. These investigations ranged from simple surveys conducted by researchers to multiple-day endeavors (APPENDIX A). Once a comprehensive list was collected, the locations of each site were located and recorded. Unfortunately, specific geographic coordinates were not available for every site.

To determine the locations of the sites without listed coordinates, several dive shops and live aboard dive companies that operate in the area were contacted. For wrecks that are not current dive destinations and whose current location could not be found, the general location was utilized, and the inaccuracy was noted in the site description.

Once the site locations were determined, a 'pin' was dropped at each site and a site description was added. These site descriptions include the historical background of the vessel, and present-day condition of the site. The description also notes any salvage work conducted on the site and if the site is a popular recreational diving location. Pictures of the vessels, both historic and current, are added to the descriptions. A list of the vessels recorded can be found in TABLE 4.4. The Story Map also includes a clip of the ROV footage collected during the NOAA dive on *Amakasu Maru No. 1*.

Several recreational diving websites were consulted to learn more about preservation levels at the various wreck sites. These sources proved to be immensely helpful for several reasons. First, these sites listed many diving destinations in order of popularity. It can be

inferred, therefore, that more popular sites are more commonly visited during dive tours and therefore are at a greater risk of anthropogenic damage. Second, these websites often listed the specific GPS coordinates of the sites which the archaeological surveys did not. These GPS coordinates were helpful for increasing the accuracy of the Story Map.

Along with information regarding each site, images of many of the sites are also provided on the page. By including images (both historical and current), brief descriptions of each vessel and its current resting position, the ArcGIS Story Map provides a simple and effective method for the public to interact with the material presented in this research. This map will also be a beneficial addition to the overall ArcGIS Story Map library. A search of the ArcGIS website indicates that this topic has not been mapped and published prior to this thesis.

The completed Story Map can be accessed here:

https://storymaps.arcgis.com/stories/e5a6cfbe7597449e9d5c75a1b6bb0e06

TABLE 4.4. Japanese requisitioned vessels previously archaeologically surveyed throughout the Pacific

Vessel Name	**GPS Location (If known)**	
	Latitude	**Longitude**
Amatsu Maru	7.336111	134.439722
Aratama Maru	13.336217	144.77135
Buoy #6 Wreck		
Chuyo Maru	7.340367	134.4395
Fujikawa Maru	7.344639	151.884861
Gosei Maru	7.311194	151.887389
Goshu Maru	7.345	134.446667

Gozan Maru	7.326667	134.430556
Hino Maru		
Hoyo Maru	7.371139	151.844528
Kamikaze Maru	7.276389	134.419167
Kibi Maru	7.315278	134.448611
Kitsugawa Maru	13.4562	144.64935
Nagisan Maru	7.5	134.5
Nichiyu Maru		
Nissho Maru No. 5		
Raizan Maru	7.347222	134.436667
Ryuko Maru	7.5	134.5
Sankisan Maru	7.295472	151.868944
Sapporo Maru		
Shinkoku Maru	7.400111	151.779111
Shoun Maru	14.166667	145.166667
Teshio Maru	7.406717	135.407067
Tokai Maru	13.457333	144.657833
Unidentified Maru No. 1		
Unidentified Maru No. 2	7.328447	134.465989
Unidentified Maru No. 3		
Urakami Maru	7.311667	134.448056
Yubae Maru		

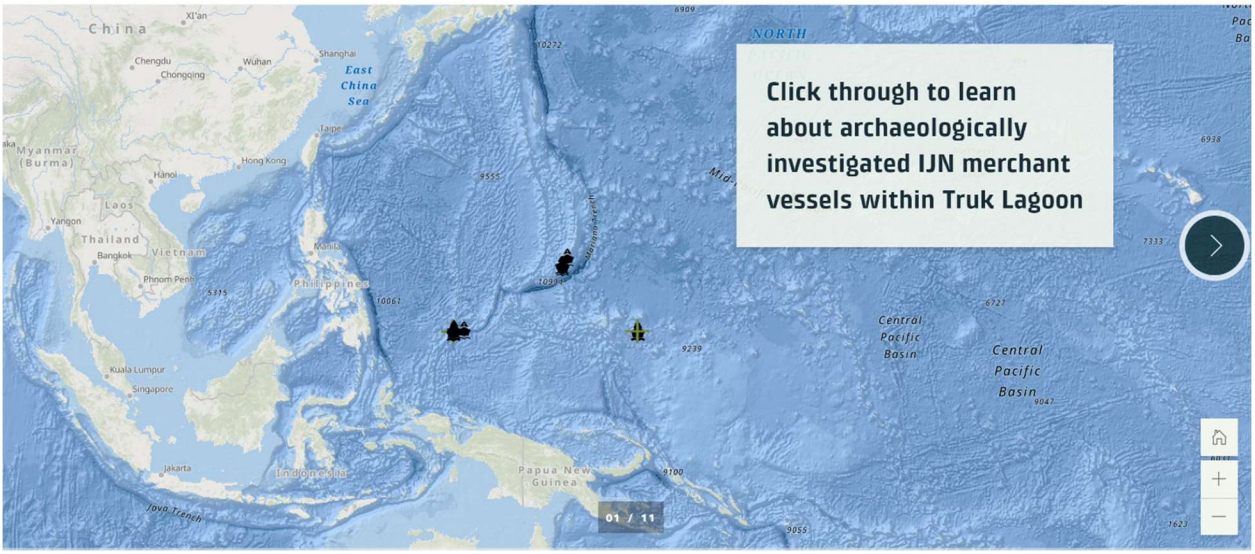

FIGURE 4.8. Title section of ArcGIS Story Map

FIGURE 4.9. Maps demonstrating the locations of wrecks, along with historical and present day site descriptions are included for each site in the story map

Statistical Analysis of IJN Requisitioned Sites in the Pacific

Utilizing the information provided in the Site Formation Spreadsheet (APPENDIX C), simple statistical analyses were run to determine the level of attribute similarity of these sites. These attributes range from the location and depth of the wreck, to various forms of anthropogenic input on the site and geologic features such as substrate characteristics. By examining these statistics, several common characteristics are noticeable regarding these various

sites. First, the majority of these sites are in less than 500 meters off the coast. This statistic is skewed, however, as shallower sites are much more accessible to humans. Therefore, it would make sense that the large majority of examined wrecks would be in this water depth range. Most of these wrecks rest in a sandy substrate in an upright position. The observed marine life was more varied for many of these sites, though corals and various tropical fish species are most commonly observed on these sites.

Over three-quarters of these sites are active tourist destinations. Due to their popularity, it is difficult to determine if these sites were known about prior to becoming tourist destinations, or if they are now widely known due to the tourism industry. Whichever is the case, active tourism may put these sites at higher levels of risk. Other anthropogenic activities, such as salvage, are also common with 44% of the sites recording some form of salvage. Anchor damage was not commonly reported on these sites, though due to the large levels of active tourism occurring in these areas, this is always a potential threat. While simple statistical analysis of these sites helps researchers determine levels of preservation and future potential threats, it must be stated that not all attribute categories were recorded for each site. Therefore, for certain attributes some sites fell into the 'unknown' category. Subsequently, some degree of error exists among these percentages as not all information is known for each site.

Conclusion

This thesis attempted to develop a 3D photogrammetric model of *Amakasu Maru No. 1* utilizing video footage downloaded from the NOAA Ocean Explorer video portal. This footage was edited using Photoshop and imported into Metashape. Video clips were combined to create models of various components of the wreck. A literature review was also conducted to learn

more about the history of requisitioned vessels within the IJN, as well as learning which IJN requisitioned vessels within the Pacific have been archaeologically investigated. The vast majority of these investigations have only included a brief survey of the sites. This minimal archaeological investigation is compounded with the popularity of many of these wreck sites within the recreational diving community. The list of these vessels, as well as their historical and present-day descriptions, were combined to develop an ArcGIS Story Map. This map provides a means of public engagement with the results of this thesis.

Chapter 5: *Amakasu Maru No*. 1 Site Analysis

Introduction

Since its wrecking event on 24 December 1942, *Amakasu Maru No. 1* has been impacted by the surrounding underwater environment. Assessing these environmental and biological factors is essential for understanding current levels of site preservation. Additionally, the benefits and drawbacks of this ROV survey were assessed. Finally, a standard operating procedure (SOP) was developed to assist researchers in preparing for, and successfully carrying out, deep-water ROV site surveys in the future.

Wake Island Characteristics

Wake Island is a coral landmass located approximately equidistant between Honolulu, HI, and Tokyo, Japan. The island has an area of approximately two and a half square miles and is a part of the Wake Atoll (Office of Insular Affairs 2021). The atoll consists of three islands, including Wake, Peale, and Wilkes, though Wake is the largest of the three islands. The atoll is an unincorporated United States territory and is one of the most isolated island groups globally, boasting a population of only approximately 302 inhabitants. (Office of Insular Affairs 2021). Due to its close association with United States military activities, access to the island is strictly regulated. Therefore, nonmilitary activities such as tourism or commercial fishing are not common.

Wake has a tropical climate with an annual average temperature of 85.6 degrees Fahrenheit and an average annual precipitation level of 34.95 inches (Western Regional Climate Center 2010). The three islands are components of an underwater volcano's upper lip and surround the atoll's central lagoon, which is the volcano's crater (Office of Insular Affairs 2021). Due to its geographical formation, deep water surrounds the atoll. Typhoons and other tropical

storms do occasionally impact Wake, including Super Typhoon Olive (1952), Super Typhoon Sarah (1967), and Super Typhoon Loke (2006). The average surface water temperature surrounding Wake ranges from 80-87 degrees Fahrenheit. There is a general .5 to 1 knot SSW current around the island, though erratic currents have been recorded in the vicinity (NOAA Office of Coast Survey n.d.).

The Wake Island Airfield was designated a National Historic Landmark in 1985. The complete atoll is part of the Pacific Remote Islands Marine National Monument, covering 370,000 square nautical miles. While the majority of the National Monument is protected by the Secretary of Commerce and the Secretary of the Interior, due to the significant military presence still on Wake, the Department of Defense regulates the atoll in conjunction with the Pacific Air Forces Regional Support Center and the U.S. Fish and Wildlife Service National Wildlife Refuge (Hirsh and Rex n.d.).

Amakasu Maru No. 1 Site Characteristics

USS *Triton* torpedoed *Amakasu Maru No. 1* off the coast of Wake Island. The vessel came to rest at a depth of approximately 2,755 feet (840 meters), approximately one mile (1,605 meters) offshore. Because the wreck rests at a depth greater than 50 meters, it is classified as a deep-water wreck. Therefore, different factors impact the site compared to its shallow-water counterparts. The vessel rests in the 'mesopelagic zone.' This ocean zone ranges in depth from 200 – 1000 meters and is often called the 'twilight zone' due to the minimal sunlight that reaches these depths (Woods Hole Oceanographic Institution 2021). While precise temperature changes vary depending on location, there is a steep thermocline within the mesopelagic ocean zone (National Weather Service 2021) (FIGURE 5.1). Though this zone experiences drastically

decreased temperatures, researchers are realizing that it is still teeming with biodiversity. Scientists are quickly discovering that this area has more biomass than all other ocean zones combined (Woods Hole Oceanographic Institution 2021). Along with decreased temperatures, the mesopelagic zone generally has lower rates of dissolved oxygen and higher salinity levels. All these factors combine to alter iron corrosion rates at these depths (Kuroda 2008; MacLeod 2016; Waschmann 2013).

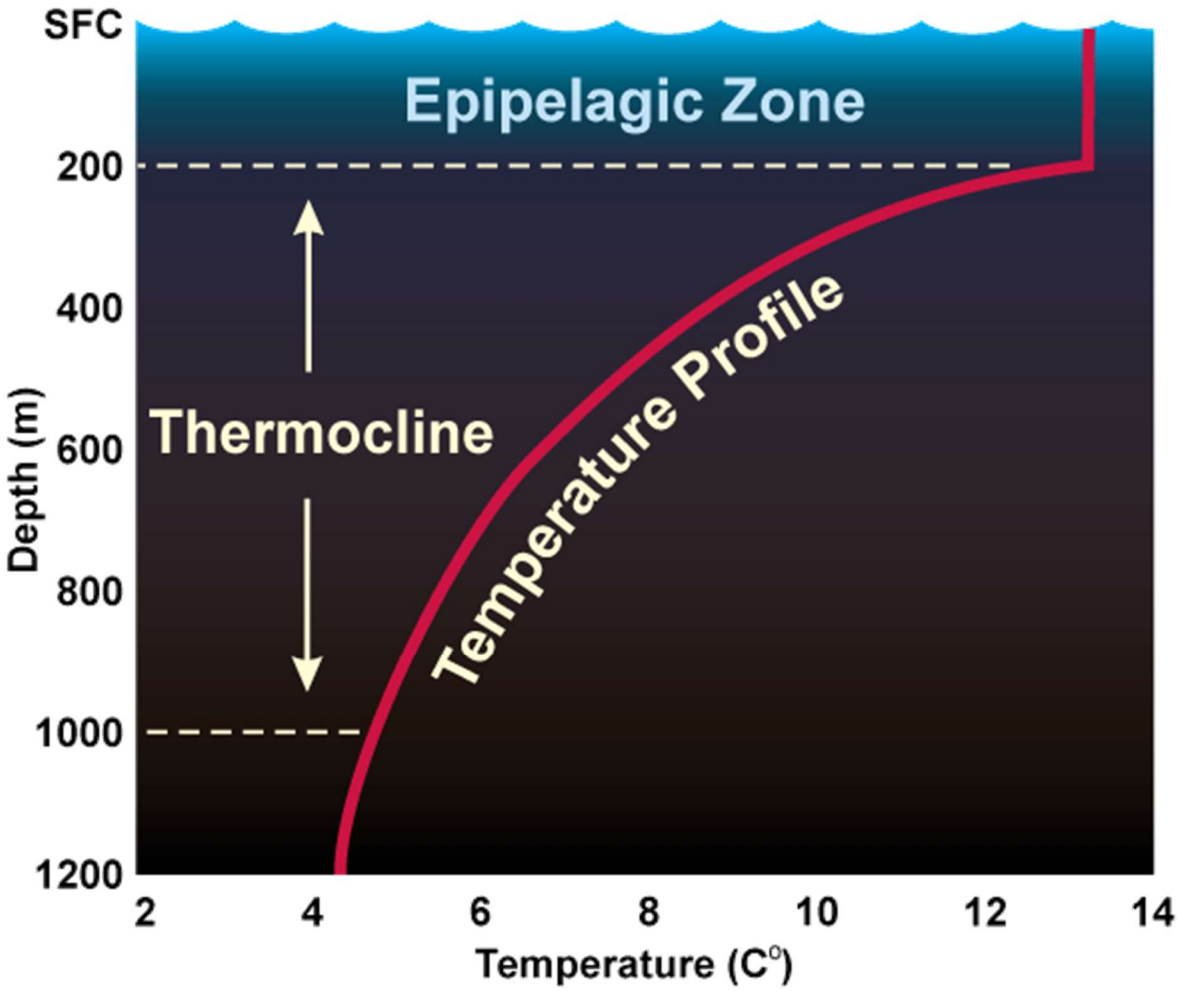

FIGURE 5.1. Average mesopelagic thermocline (National Weather Service 2021)

The process of iron corrosion occurs when water encounters a ferrous object, such as a ship's hull. As iron acts as both the cathode and the anode, it can facilitate the complete chemical reaction. The only external input needed to complete the reaction is the input of oxygen. The

oxygen interacts with the iron's cathode, undergoing a reduction to accept two electrons producing hydroxide ions. This process, along with the oxidation of iron at the anode, leads to corrosion of the iron with the result being the formation of rust (MacLeod 2016:2).

While dissolved oxygen is the only external input required to initiate the reaction, there are several factors that can impact rates of corrosion on a hull including "water depth…the amount of water movement, salinity, temperature and the composition of the metal" (MacLeod and Richards 2011:107). All these factors are integral to consider when examining corrosion levels on shallow water sites. Deep-water sites, however, are most significantly impacted by the amount of dissolved oxygen in the water and the composition of the metal (Kuroda 2008:6). Deep-water environments are not influenced heavily by water movement as wave action and strong currents generally do not reach these depths (Soreide 2011:161). Also, due to the lack of sunlight reaching these locations, temperatures drop and begin to equalize (Kuroda 2008:6). Generally, high salinity levels will increase rates of corrosion within a water interface. This is due to the ability of sodium ions to increase the rate of electron exchange between the iron and hydrogen ion. Research indicates, however, that increased salinity only increases corrosion rates up to 3% salinity (30 practical salinity units (PSU)). When PSU levels surpass 3%, dissolved oxygen rates will decrease, therefore reducing the amount of oxygen present to initiate the reaction (Zakowski et al. 2014:4872; Webb 2020).

During the 2016 NOAA dive, sensors on the ROV (*D2*) collected data regarding the temperature, salinity and dissolved oxygen content at, and around the site. On the site, average temperatures remained around 39.7 degrees Fahrenheit, salinity levels around 34.4 PSU, and dissolved oxygen levels around 1.8 mg/L. A salinity level of 34.4 PSU translates to 3.44% salinity. This is above the 3% cutoff, indicating that this salinity level decreases corrosion

because the higher the salinity, the lower the amount of dissolved oxygen in the water (Zakowski et al. 2014). This hypothesis is supported by the dissolved oxygen level recorded at the site. Average ocean level dissolved oxygen levels rest at approximately 8 mg/L (Webb 2020). This rate decreases with increased depth until reaching the oxygen minimum layer at 1000 meters (FIGURE 5.2). As *Amakasu Maru* rests at a depth of 825 meters, it is above this layer and therefore drastically decreased dissolved oxygen levels are expected.

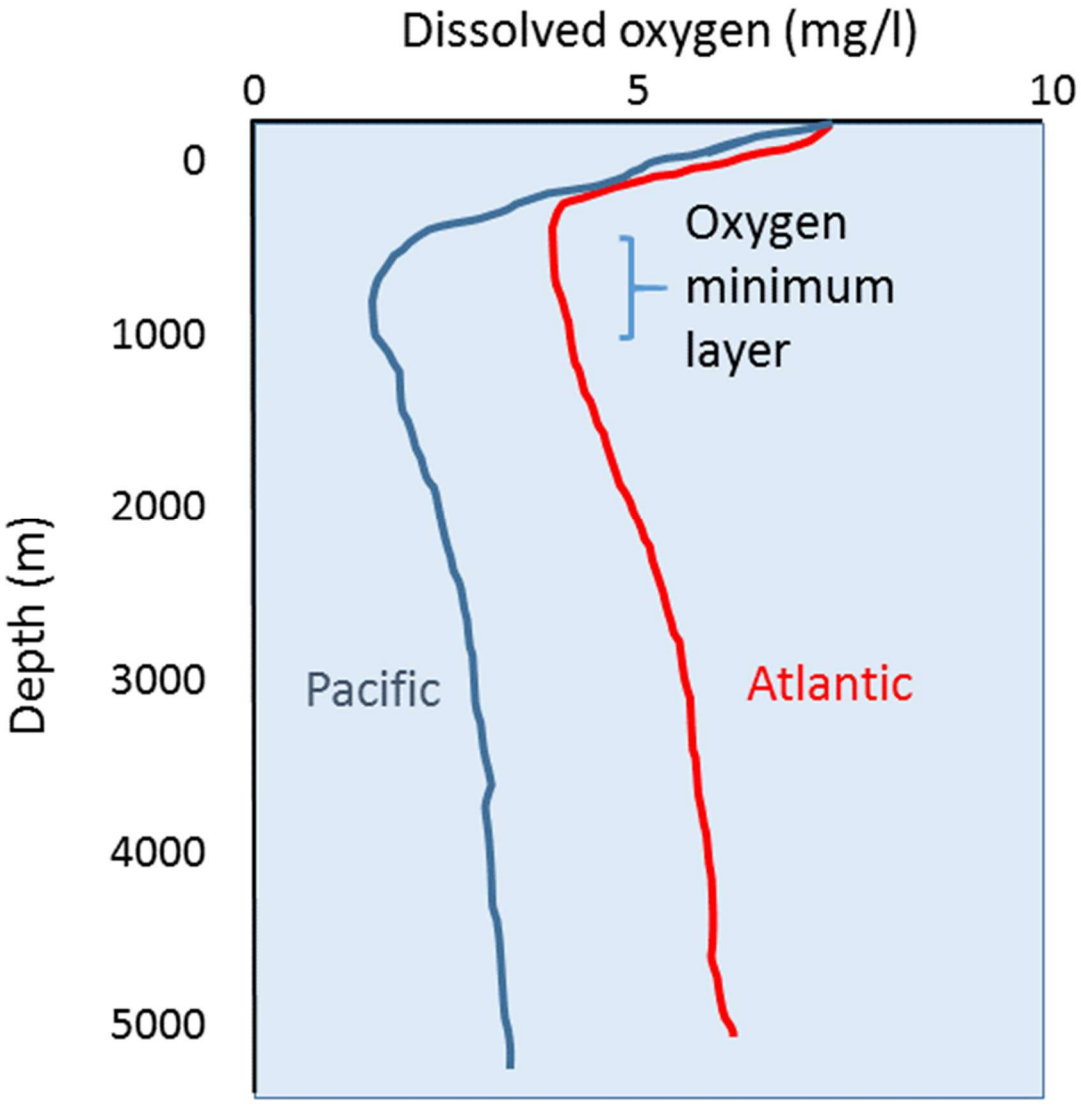

FIGURE 5.2. Dissolved oxygen ocean levels (Webb 2020)

Deep-water shipwrecks generally exhibit lower levels of deterioration due to the reduced dissolved oxygen levels and increased salinity levels at these depths. They also experience unique modes of anthropogenic input. Due to the higher biomass levels, the mesopelagic zone is quickly becoming a key area exploited by commercial fisheries (Woods Hole Oceanographic Institution 2021). This increase in fishery interest is a potential threat to shipwrecks in this zone as trawling lines and anchors can cause severe damage to shipwreck sites (Brennan et al. 2016). This threat is just beginning to be quantified, though experts agree that deep-water wrecks resting on sandy, level substrate face significant peril due to this practice (Brennan et al. 2016).

Amakasu Maru No. 1 wrecking event and current site preservation

Amakasu was torpedoed on 24 December 1942. The 2016 *Okeanos Explorer* mission to the site noted evidence of this event. Two holes were observed in the lower portion of the hull. These holes may have been caused by the wrecking event or due to impact with the seafloor post-wrecking. The lower aft hull hole is seen in FIGURE 5.3.

The vessel came to rest on the seafloor in a generally upright position with a slight list to starboard. The hull does show evidence of deterioration. Despite the cold temperatures (39.7 degrees Fahrenheit average) and anoxic environment (1.8 mg/L average), ‘rusticles’ are forming in abundance on the hull. These localized pockets of corrosion generally occur on deep-water wrecks, due to the increased pressure of these locations. Rusticles generally form on areas of the hull with defects or iron pitting and indicate chemical processes, such as corrosion, are occurring on the wreck (Silva-Bedoya et al. 2021). Other signs of deterioration include the collapse of masts and the deformation of cabin spaces (National Oceanic and Atmospheric Administration

2016a:5). These features may have occurred during the vessel's wrecking event or post-wrecking due to corrosion processes.

FIGURE 5.3. Lower aft hull damage most likely the result of a torpedo that struck the hull by USS *Triton* on 24 December 1942 leading to the vessel's sinking event (NOAA 2016b)

There is an underwater current present at the site. Unfortunately, the strength of the current was not measured during the dive, however it was strong enough to limit the survey's coverage. Only the top and starboard sections of the hull could be surveyed. While the current was a limiting factor regarding the survey range, this current does not play a significant role in the rates of deterioration on the wreck due to the deep location of the site (Kuroda et al. 2008:6; Soreide 2011:161).

Amakasu rests in a primarily sandy substrate with approximately 85% of the vessel exposed. Silt covers the remaining decking and upper levels of the vessel, though it appears that the process of inundation is slow. While the substrate is primarily sand, there are rocks

surrounding the wreck that have caused damage. For instance, the propeller appears to have been damaged when coming into contact with a nearby boulder (FIGURE 5.5).

FIGURE 5.4. *Hyalonema* sponge on *Amakasu Maru's* hull with *Acanthogorgia* in the background (NOAA 2016b)

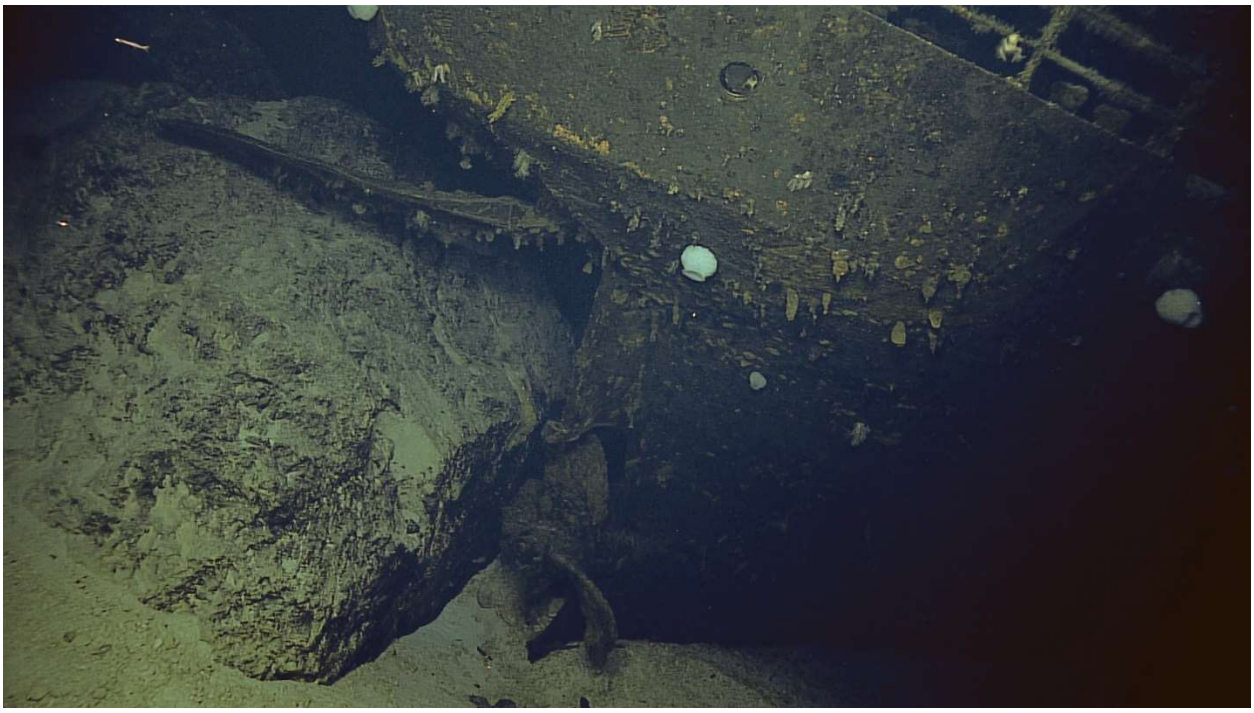
FIGURE 5.5. Rudder damage due to contact with boulder (NOAA 2016b)

During the 2016 *Okeanos Explorer* survey of the site, researchers noted the presence of several biological species residing on and around the wreck. These included several "species of sponges (*Hyalenema* sp. and *Dictyaulus* sp), gorgonians including *Iridogorgia* sp, *Acanthogorgia* sp, and other unidentified species, anemones… and fishes (*Neoscopelus* sp, *Sladenia* sp, and an *ophidiid*)" (National Oceanic and Atmospheric Administration 2016a:5). Presence of corals and biological activity on the wreck is important as concretions that develop on the wreck help to reduce the rate of corrosion. This reduction in corrosive potential happens when organisms cover the reactive steel and therefore reduce the amount of hull exposed to dissolved oxygen (Mondal and Raghunathan 2017:99). Some of the biological inhabitants of the wreck are shown in FIGURES 5.4 and 5.6.

FIGURE 5.6. *Sladenia* fish resting on *Amakasu Maru* superstructure (NOAA 2016b)

While approaching the wreck, researchers noted a scattered debris field containing wood fragments. This field seems to be near the wreck, though exact measurements were not taken. The wood appears to be shaped like planking and experts noted the presence of what appears to be teredo worm damage, increasing the likelihood it originated from the wreck (FIGURE 5.7). This field was relatively small. It contained minimal wood and no cargo or other materials associated with the vessel. Due to the small nature of the field, it is difficult to determine whether this scattering occurred at the time of wrecking or if currents carried these small fragments away from the site post-wrecking.

FIGURE 5.7. Screenshot from 2016 ROV footage showing wood planking in debris field (NOAA 2016b)

The wreck was positively identified during the *Okeanos Explorer* mission. Researchers noted the ship name welded on the vessel's stern in both Japanese characters and the English alphabet. The vessel's English name is visible in FIGURE 5.4 under the *Hyalonema* sponge. The Japanese name is shown in FIGURE 5.8.

There are several factors that are impacting preservation levels at the *Amakasu Maru No. 1* site. High salinity levels, cold temperatures, and low dissolved oxygen levels may impact corrosion rates on the site. Furthermore, concretions found on a wreck may also inhibit corrosion processes. This claim is supported by the presence of corals and other concretions coating *Amakasu Maru*, reducing the available exposed iron required to react with dissolved oxygen for corrosion processes to occur. By reviewing the video footage collected during the 2016 mission, along with an examination of the telepresence transcription, *Amakasu's* hull appears primarily intact with only minor damage including collapse of internal compartments, loss of decking, and the collapse of masts. While environmental and biological factors would indicate that hull

deterioration is slow, only a minority of the hull is buried in sediment. There is a higher risk of deterioration for the approximately 85% of exposed hull (Soreide 2011:161).

The primary anthropogenic risks for deep-water sites are trawling and anchor cables. This, however, does not appear to be a major concern for *Amakasu* for two reasons. First, there were no anchor or trawling scars noted upon arrival at the site, nor were any seen as researchers moved away from *Amakasu* towards the next research target. Second, the *Amakasu* site is within the Pacific Remote Islands Marine National Monument which is a protected ocean area. Also, travel to and around Wake Island is strictly regulated by the United States military. Therefore, there is minimal risk of commercial fishing damage to this site. No matter the amount of protection a wreck site has, however, this is always a threat that should be noted for deep-water sites.

FIGURE 5.8. *Amakasu Maru No. 1* listed in Japanese characters on the vessel's stern (NOAA 2016b)

Deepwater ROV Benefits and Drawbacks

As discussed previously in the Archaeological Theory and Background chapter, there are several notable ROV benefits and drawbacks associated with deep-water sites. Many of these pros and cons were noticeable during the *Amakasu* site survey. Perhaps most obvious, *D2* was useful for accessing *Amakasu* due to the depth and temperature of the site. *Amakasu* rests far outside SCUBA range with temperatures averaging around 39.7 degrees Fahrenheit. Also, *D2* was more efficient than divers would have been. The total bottom time for the dive was eight hours and forty-nine minutes. The amount of data collected during that time would have been impossible with a diver-based survey. Arguably the most important benefit of utilizing an ROV for this project, however, was the ability to conduct a telepresence survey. By interacting with interdisciplinary researchers on shore, more information was recorded on the site including biological species identification, and most significantly, vessel identification.

There are, of course, several notable drawbacks to ROV survey. As discussed earlier, there was a current present at the site. While the current is most likely not strong enough to impact site preservation levels, it was strong enough to limit the areas of the hull available for survey. The second drawback is the site depth. Due to the location, minimal light reaches the wreck. This has the potential to decrease the quality of the collected footage. This problem was well mitigated, however, as *D2* is equipped with twenty LED lights providing ample lighting to view the deep-water site (NOAA Ocean Exploration n.d.). The final notable drawback of ROV research is the survey area limitation due to umbilical cord length. This was not a problem when surveying *Amakasu*, however, as *D2* has enough cable to dive up to 19,685 ft (6,000 meters) (NOAA Ocean Exploration n.d.).

Through an examination of the pros and cons of utilizing the ROV *D2* to survey the *Amakasu* site, the benefits of this survey design vastly outweigh the drawbacks.

Deepwater ROV Site formation survey Standard Operating Procedures (SOP)

While examining the 2016 ROV footage to glean information regarding site formation, as well as attempting to develop a photogrammetric model, it was noted that there are no SOPs available for implementing this research design utilizing ROV technology. Subsequently, a SOP was developed for future researchers interested in this research topic.

Photogrammetric Model

Many factors can impact the success of a photogrammetric model. The underwater environment can increase the challenges associated with this methodology as there are further environmental factors to consider, such as current and darker conditions. Therefore, an SOP has been developed to help ensure the success of deep-water ROV photogrammetric model acquisition.

The first factor to consider is equipment. Choosing a camera with larger sensors, such as Digital Single Lens Reflex (DSLRs), is encouraged because they allow for "more precise exposure-control over the photos" (Yamafune 2016:10). Larger sensors also tend to have low noise levels, which will help ensure crisp images are used for the model. Researchers should choose a hemispherical dome port with a wide-angle lens and a fixed focus with a small relative aperture. This attachment minimizes optical noise and allows corrections for optical aberrations due to the air/glass/water interface (Yamafune 2016:8; Kwasnitschka et al. 2013:225).

While cameras with large sensors are beneficial for collecting information to develop photogrammetric models, video footage can also be utilized. High-definition video cameras are recommended for this procedure. This increases the likelihood of being able to capture crisp

images from the footage. *D2* is equipped with high-resolution cameras capable of capturing detailed images. The images extracted from the video footage were crisp, however they were not usable for the photogrammetric model. This was most likely due to insufficient image overlap.

Another important aspect of developing a successful photogrammetric model is ensuring proper lighting. Very little sunlight reaches deep-sea environments; therefore, effective lighting is essential for photogrammetric models in these conditions. LED lighting is recommended, and maneuverable strobe lights allow flexibility while surveying dark deep-water sites (Yamafune 2016:17; Drap et al. 2015:2). *D2* is equipped with twenty LED lights to help illuminate deep-water sites (NOAA Ocean Exploration n.d.). While proper lighting is essential for developing an effective model, it is also important to avoid casting shadows onto the site features. The movement of shadows across underwater images can distort the picture and decrease the alignment percentage during post-processing. Finally, equipping the ROV with scaled laser markers visible in the captured images or videos allows for precise measurement to be taken during post-processing. Scaled lasers were present on *D2* during the survey. They were spaced 10 cm apart.

Once the proper equipment is obtained, several important factors must be considered before the survey begins. The first of which is positioning the site within a local coordinate system. Due to the deep environments of these sites, this may prove challenging. However, positioning the site in this way helps to correct the scale and minimize the distortion of the final model and allow for geographical reference of the site plan (Yamafune 2016:28). Second, if possible, underwater coded targets should be placed on the site around features of interest. These targets are downloadable from Metashape and, when appropriately utilized, help to correctly align the photos within the site, therefore increasing the percentage of post-processing photo-

alignment (Yamafune 2016:25). Researchers should capture test images with the survey camera to determine the target size needed for a particular site. During field research, Kotaro Yamafune noted, "results suggest that a coded target will be recognized successfully when the diameter of its outer circle is shown between 80 pixels and 300 pixels in a photo" (Yamafune 2016:25). While this method helps to ensure successful photo alignment, the deep-water environment may present challenges.

First, divers cannot access the site, so the targets would need to be placed around the site utilizing an ROV. Second, if there are strong currents present, the targets would need to be secured to ensure they are not carried away from the site. These two factors would significantly increase the survey length, as well as the precision needed to operate the ROV during the dive. However, if placing targets on the site is possible, it is highly recommended. Finally, calibrating cameras prior to the dive is necessary. All cameras must first be calibrated to determine the parameters of the individual camera. If multiple cameras are being used, the second phase of calibration would involve determining each camera's relative position to one another. It is recommended that multiple cameras be used to capture images providing varying angles of the wreck. This calibration is an essential measurement for ensuring the photos taken from each camera are appropriately integrated into the model (Drap et al. 2015:7).

There are also several key factors to consider during the survey for creating a successful model. Perhaps most important in determining the flight path of the ROV. While environmental factors can significantly impact flight path options, creating multiple tracks that cross over one another on the site is ideal. FIGURE 5.9 demonstrates a flight path that comprehensively covers the site and provides enough image overlap to produce an effective model. For more detailed

parameters regarding the flight path for a survey, consulting the photogrammetric software manual being used in post-processing is recommended.

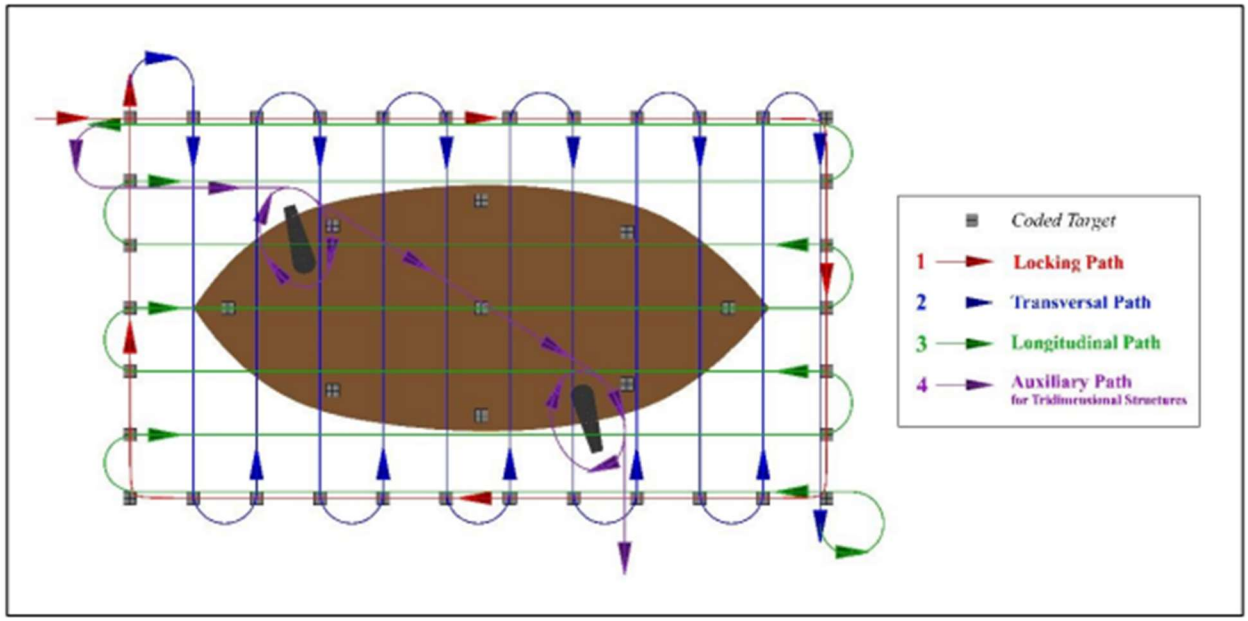

FIGURE 5.9. Potential ROV flight path for the development of a comprehensive photogrammetric site model (Yamafune 2016:28).

As stated earlier, a comprehensive flight path is essential to ensuring sufficient image overlap. It is also recommended that "two consecutive photos have an 80% overlapping area with the forward image, and a 60% overlapping area with the adjacent image for successful photogrammetry coverage" (Yamafune 2016:14). Similarly, if video footage is being captured on the site, a high frame rate frequency is important for ensuring there will be enough quality still images to be extracted during post-processing to make a model (Drap et al. 2015:2). Along with continual capture, researchers must ensure the camera stays orthogonal to the surveyed object. Camera angles greater than 45 degrees may hinder reconstruction or lead to inaccuracies (Kwasnitschka et al. 2013:226). Perhaps unsurprisingly, avoiding sudden movements during the survey should also be considered. Unexpected movement may lead to imprecise images or images that do not have the necessary overlap to utilize in the model, leading to data gaps.

Along with ensuring the continual capture of the site, researchers must also continually collect altitude measurements with correlated timestamps (Jones et al. 2009:43). These measurements will allow researchers to determine the ROVs height off the seafloor at any point during the dive and, if necessary, calculate the object's size. This procedure provides proper object scale for the photogrammetric model. A more detailed discussion of the calculations required for determining object scale is addressed in D.O.B. Jones' 2009 article "The use of towed camera platforms in deep-water science."

The video footage collected during the *Amakasu Maru* mission had several characteristics that made it an optimal candidate for 3D model development. First, *D2* is a highly advanced ROV with high-definition video capture abilities, along with twenty LED lights that sufficiently lit the wreck throughout the dive. Minimal shadows were cast onto the site, reducing the possibility of image distortion during post-processing. Intermittent GPS tracking ensured that the site would be georeferenced, and constant depth measurements were collected so the flight height was known. After attempting model development, it was concluded that the main issue with utilizing this video footage was the lack of survey coverage. The aim of the mission was exploratory, therefore comprehensive site recording was unnecessary to complete the research objective. Also, due to environmental limitations, the complete wreck site could not be surveyed. This negatively impacted model development because it eliminated the ability to obtain the proper amount of image overlap which reduced Metashape's ability to relate images to one another.

Site Formation Processes Survey

Another area of deep-water site research that can be addressed using ROVs is site formation processes surveys. The ability of ROVs to capture continual video footage of a wreck

site provides researchers with a means of collecting data on a wreck that would otherwise be unreachable. Much like photogrammetric models discussed above, however, a variety of factors must be considered when developing a site formation research design for deep-water sites. Several components should be added to the ROV prior to the expedition to provide information about site preservation. First, water temperature, water pressure, salinity and dissolved oxygen sensors should be added to the ROV. These factors impact site preservation and should be noted throughout the dive (Drap et al. 2015:2; Albahari et al. 2019). Second, if possible, equip the ROV with robotic arms to allow for testing and sample collection. For ferrous wrecks, corrosion testing can provide information regarding rates of hull deterioration and, if necessary, may allow researchers to develop a more accurate future management plan for the site. Much like the photogrammetric procedures discussed earlier, proper lighting is essential for capturing clear imagery of the vessel. Therefore, LED lights are recommended (Drap et al. 2015:2). Also, if possible, researchers should equip the ROV with one camera for capturing images and another designated for capturing video footage. Video is helpful for understanding seabed characteristics and geological formations though due to its average lower resolution, photographs are better for noting faunal characteristics (Jones et al. 2009: 46).

As discussed above, *D2* is equipped with two high-definition cameras for video capture, along with five low resolution cameras giving it plenty of methods for image capture. The ROV also has 20 LED lights for proper deep-water site illumination. *D2* has sensors to collect temperature, water depth and pressure, along with salinity and dissolved oxygen measurements. It is also equipped with robotic arms which allow it to collect samples. Utilizing the requirements listed above, it is believed that *D2* is an optimal candidate for conducting deep-water site formation surveys.

During the dive, there are several characteristics researchers should look at both surrounding the site and, on the hull, to learn more about the formation processes impacting the wreck. First, researchers should examine the debris field if one is present. Large debris fields may indicate a traumatic wrecking event. Additionally, examining the contents of the debris field may indicate the ship's cargo and, subsequently, the vessel's identity (Church 2014:28). Another feature that should be noted surrounding the wreck is the presence of trawling lines. This fishing practice can have disastrous impacts on deep-water shipwrecks. If trawling lines are noted in the site's vicinity, it may indicate the site is in danger of being affected by commercial fishing operations (Drap et al. 2015:2; Waschmann 2013). Finally, researchers should examine the substrate surrounding, and within which, the vessel rests. While deep-water environments have lower dissolved oxygen levels than their shallow-water counterparts, substrates provide even more anoxic conditions. Therefore, preservation is generally greater for wreck areas buried in the seafloor. By determining the percentage of the ship entombed in sediment, researchers can determine the average rate of preservation of various components of the site (Waschmann 2013).

Once at the site, all accessible components of the hull should be examined. This coverage will provide information regarding the current preservation of the site. Along with noting levels of preservation for various components associated with the vessel, researchers should look for cracks in the hull that may have occurred during the wrecking process. Because of the deep environment they rest in, many wrecks reach terminal velocity prior to making contact with the seafloor. Noting significant cracks in the hull may provide information regarding the vessel's wrecking event (Church 2014:33). Along with examining the hull components for preservation levels, researchers should also examine the hull and surrounding area for marine flora and fauna.

A low flying altitude is preferred when examining marine organisms, as many organisms may be difficult to see. Flying at such low altitudes, however, may be challenging depending on environmental conditions. In their research of deep-water towed camera platforms, DOB Jones and his colleagues noted that maintaining flying altitudes of 5-11.5 feet (1.5-3.5 meters) above the seafloor provided "consistent average numbers of organisms and provided a reasonable range of altitudes for effective operation of the [ROV]" (Jones et al. 2009:45). If these altitudes are impossible to maintain, a zooming lens should be added to the ROV. Researchers also must consider the camera angles being used while surveying the site. Vertical angles are best for scaling and measurements. In contrast, oblique angles provide better coverage at a specific height and a "more natural view of the seabed" which is beneficial when examining the subtle geologic changes of the seafloor (Jones et al. 2009:48).

The 2016 survey provided beneficial site formation information, though further information could have been obtained. Components of the debris field were noted whilst approaching the wreck. This was a cursory examination, however, and more time delineating the borders of the field and measuring the distance from the wreck, may have provided more information regarding the vessel's wrecking event, or impacts of post-wrecking extracting filters on the site. Due to the extended approach to the site, thorough information was collected regarding the sandy substrate surrounding the wreck. Therefore, while more debris field data would be beneficial, an adequate amount of information was collected about the surrounding environment while approaching the wreck.

Once at the vessel, *D2* was able to adequately survey all accessible hull components. This included an examination of hull deterioration along with the presence of marine flora and fauna occupying the wreck. While the ROV was not always able to maintain proximity to the wreck,

D2's camera allows researchers to "zoom in on a three-inch long organism from 10 feet away" (NOAA Ocean Exploration n.d.). This video footage, along with the sensor measurements recording the surrounding ecological characteristics, provided information regarding previous site deterioration and potential future deterioration rates. *D2* was able to fulfill all previously listed criteria for conducting a deep-water site formation survey. The only issues faced were the exploratory research design and inability to access all hull components, thus minimizing hull and debris field investigations which subsequently limited the information collected from the site.

TABLE 5.1. Deepwater ROV Standard Operating Procedures

Deepwater ROV Standard Operating Procedures	
Photogrammetric Model Development	
	Flight path (if environmental conditions allow) (1) Place coded targets around the wreck (not on it so as not to cover important features) that act as a guide for your survey lines (Yamafune 2016) (2) Run multiple tracks that cross one another to provide necessary coverage (Kwasnitschka et al. 2013) – see FIGURE 5.6 for further assistance
	Utilize multiple cameras mounted independently on ROV (Drap et al. 2015)
	Two step calibration: (1) Determine each individual camera's parameters (2) Determine relative positions of the three cameras
	Establish local coordinate system of site (Yamafune 2016) • Allows for scale correction and minimizes model distortion • Allows for geographically referenced site plan (1) Establish network of control datum points fixed around the site, taking measurements from the points to ground the site in a geographical position (if environmental conditions allow)
	Underwater coded targets • Help align photos for model (1) Center circle radii of 5-10 mm (2) Target size: "coded target will be recognized successfully when the diameter of its outer circle is shown between 80 pixels and 300 pixels in a photo" (Yamafune 2016:25)
	Include scaled lasers for post-processing measurements
	Utilize effective LED lighting (1) Multiple strobe lights with articulated arms are beneficial for dark underwater environments (Yamafune 2016) (2) Avoid casting shadows on the wreck as they distort images
	Camera (1) Larger sensors are better (DSLRs recommended) (Yamafune 2016)

	(2) High-resolution sensor with low noise level (Kwasnitschka et al. 2013) (3) Ensure high frequency frame rate of cameras
	Lens (1) Utilize a wider-angle lens as it minimizes optical noise (Yamafune 2016) (2) Wide depth of focus or fixed focus balanced with a small relative aperture (Kwasnitschka 2013:225) (3) Utilize a hemispherical domeport as it minimizes optical distortion (Yamafune 2016)
	Images (1) Two consecutive photos should have 80% overlap with forward image and 60% overlap with adjacent image (Yamafune 2016)
	Camera should remain orthogonal to object (angles of greater than 45 degrees may hinder reconstruction or lead to inaccuracies) (Kwasnitschka 2013)
	Avoid sudden movements (utilize ROV stabilization mechanisms if possible)
	Scale: continuously record altitude of ROV with timestamps to understand the size of objects on the site) (Jones et al. 2009)
Deep water Site Formation	
	Examine area around wreck to examine debris field (larger fields may indicate more traumatic wrecking event) (Church 2014)
	Equip ROV with sensor gauging water pressure and water temperature (both of these factors can affect preservation levels) (Drap et al. 2015; Albahri et al. 2019)
	Examine the surrounding area for trawling lines/anchor lines (Presence of trawling lines around wreck may indicate that the wreck is in danger of being impacted by commercial fishing) (Drap et al. 2015; Waschmann 2013)
	Faunal characteristic observation (1) Flying altitudes of 1.5-3.5 meters provides "consistent average numbers of organisms and provide[s] a reasonable range of altitudes for effective operation of the [ROV]" (Jones et al. 2009:45) (2) If high altitudes are necessary, a zooming lens should be implemented (3) A conjunction of photo a video should be used (Video is helpful for understanding seabed characteristics and geological formations though due to its average lower resolution photographs are better for noting faunal characteristics)
	Look for cracks on the hull as a characteristic of its initial contact with the seafloor • The vessel may have reached terminal velocity on descent due to depth of wreck (Waschmann 2013)
	Look at seafloor substrate (1) Due to sediment providing more anoxic conditions, the deeper the wreck rests in the sediment may mean better preservation for the bottom portions of the hull (Waschmann 2013) (2) Deep sediment may indicate the wreck will be completely buried at a quicker rate as well
	Equip ROV with means of collecting metal samples to determine rates of deterioration
	Camera angles (1) Vertical is best for scaling and measurement (necessary for photomosaics)

	(2) Oblique provide better coverage at specific height and "more natural view of the seabed" (Jones et al. 2009:48) (best for examining subtle geologic changes on seafloor)
Public Outreach	
	Organize telepresence survey if possible
	Utilize oblique camera angles to provide appealing pictures of site
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Conclusion

In summary, there are several important factors that have impacted the preservation levels of *Amakasu Maru No. 1*. These include depth, salinity levels, water dissolved oxygen content, temperature, and biological interactions with the hull. Due to the vessel's location and the absence of anchor or trawling line scars, it does not appear that anthropogenic input is a significant threat on the site. An analysis of the ROV video footage captured of the site during the 2016 *Okeanos* mission demonstrates the various benefits and drawbacks of using ROV footage for deep-water survey. Perhaps the most important benefit of ROV survey is the ability to include on-land personnel and the public with the current research utilizing telepresence survey. Additionally, to support future researchers interested in conducting deep-water ROV surveys, a SOP was developed to streamline the preparation and implementation of this survey type.

Chapter 6 Conclusion

Introduction

The previous chapters of this thesis provided historical background regarding the use of requisitioned vessels within the IJN during WWII, supplied a theoretical framework that structured the research conducted, discussed the various methodologies utilized to analyze the site formation processes impacting *Amakasu Maru No. 1* as well as other requisitioned wrecks throughout the Pacific, and analyzed the results of these methodologies. This final chapter will address the research questions posed in the introduction of this work, discuss the limitations faced throughout the research, and provide recommendations for future researchers interested in this topic.

Answering the Research Questions

Prior to this thesis, little was known archaeologically and historically about requisitioned IJN vessels due to lack of primary archival documentation and lack of archaeological survey. The primary goal of this thesis was to contribute to the knowledge of these understudied vessels through a detailed site formation survey of the *Amakasu Maru No. 1* site, along with a comprehensive analysis of archaeological work conducted on other requisitioned vessels throughout the Pacific. This thesis demonstrates that there is a lack of research readily available for individuals interested in investigating this topic, however the case study of *Amakasu Maru*, along with the analysis of other requisitioned wrecks, has provided sufficient data to answer the proposed research questions. This research has also provided several important takeaways for the researcher. First, if an ROV is fitted with sensors to take key measurements such as depth, temperature, and salinity levels, understanding the site formation processes that may be impacting a site is possible. Second, developing a photogrammetric model utilizing ROV footage

is challenging if model development is not a primary goal of the dive. This is due primarily to the specific requirements, such as lighting and comprehensive photographic coverage, required to complete a model. Finally, by comparing the processes, both anthropogenic and environmental, impacting IJN requisitioned wrecks throughout the Pacific, there is a broad range of preservation levels and threats that these sites face. Due also to the geographical locations of these sites, site management varies dramatically. This variation may potentially contribute to unequal levels of site preservation in the future.

This thesis utilized a site formation processes framework to analyze the *Amakasu Maru No.1* wreck site, as well as the other requisitioned wreck sites throughout the Pacific. Due to the depths of each site, discussions of both shallow and deep-water SFPs were required as these two depth categories experience differing anthropogenic and environmental impacts. Shallow water wrecks face more anthropogenic input than their deep-water counterparts. Many of the wrecks are common recreational dive destinations. Sport diving leads to continual human interaction with wreck sites and often leads to increased levels of site deterioration (Edney 2016:271). These impacts, along with fishing and salvage operations, make anthropogenic interactions a primary threat to shallow underwater sites.

Deep-water sites, however, face different threats. Due to their deep location, these sites experience less human interaction. The primary anthropogenic threats these wrecks face come from trawling and anchor cables (Kingsley 2009:1). While these threats can seriously impact deep-water sites, environmental and biological interactions are most common with this class of wreck site.

By reviewing the characteristics of all chosen wreck sites and completing research on the common impacts on both shallow and deep-water sites, common characteristics and variations associated with IJN requisitioned wreck sites throughout the Pacific were identified.

What are the site formation processes that have occurred on *Amakasu Maru No. 1* site since the vessel sank, and are these processes similar to those occurring on other previously researched vessels?

Amakasu Maru No. 1 is experiencing several key SFPs. Several of these processes occurred at the time of wrecking. Primarily, the rudder collided with a boulder upon impact with the seafloor, causing damage. Also, the holes on the lower starboard portion of the hull are most likely the result of the torpedo that caused the wrecking event. Other hull damage, notably collapsed masts and the deformation of cabin spaces, was also noted during the 2016 site survey. This hull deterioration may have started during the wrecking event, occurred solely post-wrecking, or is a combination of the two incidents. While not extensive, researchers also noted a small debris field during the 2016 ROV mission. This debris, consisting primarily of wood fragments, may have begun to disperse during the sinking event.

In the eighty years since *Amakasu's* wrecking event, there have been extensive post-wrecking processes impacting the hull as well. As noted previously, interior compartments are beginning to collapse, along with the loss of superstructure components, including hull decking. 'Rusticles' were noted, indicating corrosion processes are occurring, potentially decreasing the hull's structural integrity. This hypothesis is supported by temperature, salinity and dissolved oxygen measurements recorded during the ROV dive.

The *Amakasu* site is also host to a variety of flora and fauna. During their survey, NOAA researchers noted the presence of several fish species, as well as corals and sponges that now

reside on *Amakasu*. Increased coral and corrosion levels help to reduce corrosion rates as they minimize the ability for dissolved oxygen to interact with the hull. Recent research indicates that shipwrecks may increase marine biodiversity in particular areas because they act as a refuge for various species (Lengkeek et al. 2013; Hamdan et al. 2021). Due to the deep-water location, *Amakasu Maru* may be providing this role for flora and fauna residing in the area. Further research would be required, however, to confirm this hypothesis.

Much like other deep-water wrecks, anthropogenic interaction with the site appears to be minimal. There were no anchor or trawling scars in the surrounding sediment, and due to its depth, recreational diving is not a concern at the site. The only post-wrecking human interaction appears to be a manufactured light that drifted down through the water column and landed on the hull's superstructure. This minimal anthropogenic site input varies drastically from other archaeologically investigated IJN requisitioned wrecks throughout the Pacific.

While *Amakasu Maru No. 1* rests at a depth of 2,755 feet (840 meters), no other investigated wreck is deeper than 164 feet (50 meters). Therefore, all the other sites are within SCUBA diving range. Due to the warm, clear waters within the Pacific, recreational diving is a significant tourism industry and occurs on 83% of the examined sites. While recreational diving provides revenue for local residents, it can also cause wreck damage through intentional means such as looting, and unintentional methods, including diver exhalation bubbles trapped in interior spaces, increasing rates of hull deterioration (Edney 2006; 2016). Other human interaction was also noted on these shallower wrecks. These interactions included intentional damage from construction projects and salvage operations, both historic and modern, to removal of metal and other materials from the sites.

Due to their shallow locations, the other investigated sites also face warmer water temperatures and more extreme weather events, such as typhoons. While the preservation levels of other investigated wrecks vary drastically, warmer conditions and extreme weather events can lead to increased deterioration rates.

Amakasu Maru No. 1 is the only deep-water IJN requisitioned wreck archaeologically investigated to date. Limited accessibility of deep-water sites, as well as different environmental conditions impacting the sites post-wrecking, lead to unique SFPs impacting these sites. Therefore, there are very few site formation similarities between *Amakasu Maru No. 1* and other requisitioned wrecks throughout the Pacific.

What is the history of vessel requisition within the Imperial Navy during WWII?

Was vessel requisition a forward-thinking strategy or a last-minute attempt to provide vessels to support the war effort?

Throughout WWII, the IJN utilized vessel requisition extensively for resource and troop transport. Japan is an island, and therefore importing goods from mainland Asia is essential for sustaining the economy. These shipping routes were even more important in wartime. Along with sustaining the home economy, fighting in the Pacific required extensive transport to and from island bases. Japanese officials acknowledged the strain on resources required to initiate war operations and accounted for early vessel requisition to jumpstart the war. Unfortunately, however, officials did not account for the eventual success of US submarine attacks on supply routes, nor did they allocate enough pre-war resources toward the construction of support vessels. By the midpoint of WWII, vessel requisition began to skyrocket due to the ever-increasing need for vessels to support the war effort. As requisition rates increased, the home economy suffered as there was a scarcity of merchant vessels to support the Japanese population.

The pre-war oversight of support vessel construction created a domino effect that would eventually greatly hinder Japan's possibility for success in WWII (Parillo 1993; Ike 1967).

While initial vessel requisition was a deliberate strategy to begin war operations within the Pacific, inadequate shipping route protection, increased sinkings caused by enemy submarine action, and oversight in pre-war construction programs led to last-minute vessel requisitions to support a struggling war effort.

What archaeological investigations have been conducted on other requisitioned vessels from the IJN throughout the Pacific?

There has been a broad scope of surveys conducted on requisitioned vessels throughout the Pacific, both in methodology and duration. These projects have ranged from single dive exploratory surveys (*Amakasu Maru No. 1*) to sites utilized for full-scale archaeology training programs (*Kitsugawa Maru*). There is also variety regarding the protection afforded to the sites that have been surveyed. While some have been added to the National Register of Historic Places (*Aratama Maru*, *Tokai Maru*), others were intentionally destroyed to increase harbor depth (*Nichiyu Maru*).

The exceptional variation in surveys, as well as protection afforded to these sites, may cause problems for future researchers. Conducting in-depth site surveys on particular sites while only completing cursory investigations on others, along with notable variation in site management, may lead to a skewed view of the challenges these sites face in the future. Thorough and uniform investigations of each site would be beneficial for future researchers interested in current site preservation levels and the management challenges these sites face.

What is the history of *Amakasu Maru No. 1*, and what were the criteria that made it a suitable choice for vessel requisition?

Amakasu Maru No.1 was constructed in 1939-1940 by Kawaminami Kogyo Zosensho K. K. at Koyagi Jima (Casse et al. 2020). The vessel was designed as a peacetime cargo vessel for Amakasu Sangyo K. K. Due to the size of cargo ships, its new construction, and early IJN vessel requisition requirements, *Amakasu* was a perfect candidate for requisition. The ship was requisitioned by the IJN on 31 March 1941 and converted to an auxiliary water tanker. *Amakasu* operated throughout the Pacific for the last year and a half of its operational lifespan until its sinking event on 24 December 1942.

Amakasu Maru No. 1 was requisitioned by the IJN prior to the outbreak of war. Therefore, *Amakasu* was part of a concerted pre-war requisition program indicating that the ship was selectively chosen for requisition based on its design characteristics instead of desperate need, which was the case for vessels requisitioned later in the war.

Limitations and recommendations for future research

As stated in the introduction, there were several limiting factors associated with conducting this research. The primary limitation was the language barrier. The author of this thesis does not read Japanese. Therefore, available sources were limited to sources written in English, translated sources, and analyses written by other authors analyzing Japanese primary sources. This disconnect creates the risk of misinterpretation or bias that may have been undetectable. Along with a language limitation, Japanese officials burned extensive military records after their WWII defeat, significantly minimizing the primary source material available for any present-day research regarding Japan's military history.

The other primary limiting factor associated with this research was the ROV footage. The NOAA Wake Island survey was carried out in 2016. Therefore, the footage captured six years

ago is the only source of data available for analyzing *Amakasu Maru's* current levels of preservation. Also, the objective of the dive was exploratory, with site identification being the primary research goal. Subsequently, the survey footage is not as in-depth as it may have been if the survey's goals were different. Finally, environmental conditions impacted what hull areas could be surveyed during the dive. This was a major limiting factor impacting the development of a photogrammetric site model.

IJN requisitioned vessels are underrepresented in work being conducted on WWII history. Therefore, the primary recommendation is a deeper investigation of requisitioned vessel wrecks throughout the Pacific. Throughout the course of the war, over eight million tons of Japanese merchant class vessels were sunk by Allied forces (Parillo 1993:205). This staggering figure indicates that a wealth of sites that have yet to be surveyed and recorded.

Along with further archaeological investigations of requisitioned vessels, it is recommended that future researchers expand on the deep-water site formation SOP. Throughout the research conducted for this thesis, no SOPs associated with this topic were located. Therefore, the SOP presented here should be seen as a starting point for other researchers to add to in the future.

Finally, a second ROV survey of *Amakasu Maru No. 1* could provide further information about the site. The ability to survey the port side of the vessel, along with a more detailed examination of hull features, may provide more information about the vessel both during its service in the IJN, as well as the processes impacting the site post-wrecking. Additionally, if researchers capture more footage using the guidelines provided for developing deep-water photogrammetric models, a model may be successfully developed.

Conclusion

This thesis has demonstrated the ability to conduct a site formation survey utilizing deep-water ROV data. Throughout the process, the benefits and drawbacks of this research design and the necessary requirements for completing a photogrammetric model of a deep-water site utilizing ROV data have been demonstrated .The culmination of this data collection allowed for the creation of an SOP for future researchers interested in completing these survey models with ROV footage.

Along with an in-depth analysis of deep-water ROV survey, previous archaeological work conducted on other requisitioned IJN wrecks throughout the Pacific was examined. This research yielded information regarding the variation in preservation levels and protections afforded to these sites. Not only did variation exist between the sites, but there were also disparities in the scope of archaeological investigations conducted. While some sites were meticulously recorded, others were only afforded a cursory one-dive survey. Variation in research design explains this range. More thorough and uniform surveys should be collected in the future, however, what has been collected to date provides information regarding the threats these sites face. While deep-water sites, such as *Amakasu Maru No. 1,* face primarily environmental and ecological preservation threats, the shallow water sites examined are at a much higher risk of human impact. Due to these risk variations, SFPs on IJN requisitioned wrecks vary significantly due to location and depth.

Historical backgrounds and current levels of site preservation and future management risks for all archaeologically investigated requisitioned wrecks throughout the Pacific are available for free to the public through the ERSI Story Map developed for this thesis. It is hoped

that future researchers will increase the wealth of data available for this topic, and eventually, more sites will have been surveyed and available for listing on this map.

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APPENDIX A. A Compendium of archaeologically investigated IJN requisitioned wrecks in the Pacific

Rota

Rota is in the Commonwealth of the Northern Mariana Islands northeast of Guam. The island is relatively small with a land area of approximately thirty-three miles. The island has a tropical climate with an average annual temperature of 83 degrees Fahrenheit. Due to the tropical climate, the temperature does not fluctuate extensively. The island experiences a wet season from July to October and maintains humidity levels of between 79 to 86 percent (University of Washington 2021). Though Rota maintains mild temperatures year-round, the island is situated in 'Typhoon Alley'. Due to the expansive ocean mass of the Pacific, along with the minimal landmass to aid in the dissipation of these storms, super typhoons are common throughout the western Pacific (Belles 2018). In 2002, for example, Supertyphoon Pongsona hit Rota with winds of up to 85 mph. The storm was catastrophic and led to over $30 million in damages (Pacific RISA 2021). These storms are expected to get worse, however, as the impacts of climate change increase.

The Pacific Islands Regional Climate Assessment (PIRCA) produced a report in 2021 regarding the climate change factors expected to impact the Commonwealth of the Northern Mariana Islands. This report states that a rise in temperatures will lead to more severe storms, increased coral bleaching and death, as well as impacts to the islands' biodiversity (Grecni et al. 2021:5). All these factors have the potential to impact wreck sites. Rising water temperatures may speed up the levels of corrosion on wrecks, as well as lead to the deaths of corals living on the sites. The loss of corals may decrease the biodiversity present on the sites, as well as lead to areas of metal previously covered by coral growth now exposed to potential degradation

(MacLeod 2002:697). Rota relies heavily on tourism to support the economy (Pacific RISA 2021). The loss of biodiversity both on land and underwater may decrease levels of tourism to the island, therefore impacting the livelihood of local residents (Grecni et al. 2021:7).

While Rota is vulnerable to the impacts of climate change, efforts are being made to mitigate some of the potential problems. In 2017 the National Parks Service (NPS) introduced a study to evaluate the natural and cultural resources of the island. The study's findings indicate "that Rota is a special place with significant cultural and natural resources. The Chamorro archaeological sites, World War II Japanese defensive sites, and limestone forests appear to be nationally significant and suitable for inclusion in the national park system" (National Parks Service 2021). While officials are still determining the appropriate management strategies going forward, this decision may lead to increased preservation of terrestrial and underwater cultural resources in the future.

As stated above, tourism is a key component of Rota's economy. One aspect of this tourism is recreational diving. Due to the warm waters, good visibility, and proximity of many dive sites to shore, Rota has become a popular diving destination (Dive Rota 2019). Several of these popular dive sites are wrecks, including *Shoun Maru*, discussed below. Recreational diving on sites leads to management problems including the removal of artifacts, as well as hull deterioration due to increased anthropogenic contact (Edney 2016:271). Also, several of these sites allow for wreck penetration increasing potential hull damage inside the wreck. Exhaled air bubbles may get caught inside the hull and "accelerate corrosion and affect the stability and longevity of a wreck, first by damaging the layer of marine growth, then by setting vertical currents in motion that remove the protective layer of rust" (Edney 2006:219). Due to the high

rates of diving around Rota, understanding these anthropogenic impacts are important for assessing the site formation characteristics of wreck sites.

Commercial fishing operations do operate off the coast of Rota, though the techniques used are generally trolling and cast netting (Commonwealth of the Northern Mariana Islands 2020). Therefore, commercial fishing does not seem to pose a great risk to underwater cultural resources in this area.

Shoun Maru – Sasanhaya Bay, Rota

Historical background

Shoun Maru was constructed for Matsouka Kisen K.K. and was completed on 27 June 1941. The vessel was registered as a 4,396-ton bulk cargo freighter used to transport phosphate ore and was requisitioned by the IJN on 14 November 1941. *Shoun Maru* was bombed by United States Task Force (U.S. TF) 58 on 12 June 1944 and required emergency repairs off the village of Terunon. The vessel was torpedoed by USS *Yorktown's* TBF "Avenger" just days later and sunk while anchored in Sasanhaya Bay on 23 or 24 June 1944. Six crew members lost their lives during the sinking event (Casse et al. 2020; Carrell 1991:337).

Present description and analysis

Carell surveyed the wreck during her work on the island in the early 1990s. The vessel rests upright at a depth of 70 to 110 feet on a sandy substrate. There is evidence of damage both from the sinking event and salvage activities that occurred on the vessel during the late 1950s and early 1960s. Local residents report that most of these salvaging activities were carried out by long-time Guam resident Jim Tolan. Dynamite damage is present in the forward cargo holds, as well as along the port and starboard sides aft of the forward cargo holds. During her survey of

the site, Carrell noted the presence of artifacts associated with the site including paint cans, sake bottles and a motorcycle. The vessel was used primarily for the transport of phosphate ore throughout the war, though none of this cargo has been noted on the site in present day. No further research has been conducted on this site (Carrell 1991:340). The vessel has become a popular diving destination (Dive Rota 2019).

Guam

Guam is part of the Northern Mariana Islands and only 87 kilometers (47 nautical miles) southwest of Rota. Due to their proximity, Guam and Rota share many climatic similarities. Guam has a tropical climate with an average annual temperature of 82.2 degrees Fahrenheit (National Weather Service 2021). Guam was also impacted by Supertyphoon Pongsona in 2002 leading to over $700,000,000 in damages. While they share certain similarities, there are differences between the two islands as well. Guam is larger than Rota at approximately 210 square miles and its population is therefore larger as well.

Underwater cultural resources are primarily managed by the Guam Historic Preservation Office, though they often partner with other entities such as the Guam Historic Preservation and Review Board, the Guam Museum, and the Guam Preservation Trust (National Park Service 2021). Along with management from a variety of Guam governmental organizations, all military craft in U.S. territory waters, whether U.S. or foreign, are protected under the Sunken Military Craft Act (SMCA) (Neyland and Catsambis 2016). SCMA states that no military vessel can be disturbed without proper permitting, however it does not prohibit other activities to occur around the wreck such as commercial fishing and recreational diving.

Though underwater sites are well managed through governmental organizations, there are still many anthropogenic threats that these sites face. Guam is a popular diving location with sites boasting various attractions from coral reefs to marine life, as well as wreck dives. Due to the large numbers of tourists visiting these sites every year, wrecks are in continual danger of anthropogenic input.

Guam does allow commercial fishing off its coast, though there is a growing movement to introduce higher levels of regulation. In 2021, NOAA introduced a plan to increase governmental regulation of the Guam fishing industry, particularly surrounding bottom fish populations. Researchers determined in 2020 that these populations were overfished, as minimal oversight was provided to regulate this industry (Federal Register 2021). Though bottom fishing practices do not create the damage that trawling may, fish tend to congregate on structures such as wreck sites. Therefore, increasing regulation of these fishing practices may help to mitigate future damage to wreck sites surrounding Guam.

Aratama Maru – Talafofo Bay, Guam

Historical Background

Aratama Maru was constructed for Tomai Shosen K.K. in the Tsurumi Steel shipyard and was completed on 4 November 1938. The vessel was requisitioned by the IJN on 27 August 1941 and was used as a supply transport vessel throughout the Pacific. While traveling in a convoy with other ships, including *Kitsugawa Maru* (mentioned above), *Aratama Maru* was torpedoed by the USS *Seahorse* and became inoperable due to engine failure. The crew evacuated the vessel, and after drifting for several days, *Aratama* came to rest in its current

position off the coast of Gayloop Cove in Talofofo Bay (Carrell 1991:386-390; Casse et al. 2020).

Present description and analysis

Aratama Maru has been impacted extensively by both natural and human interactions post-wrecking. Due to its wrecking location, the vessel was still visible above the water's surface until Typhoon Karen hit it in 1962. Due to its accessible location, the vessel was immediately salvaged after wrecking and the salvors took the extracted items to a different vessel, *Yasukumi Maru* (Carrell 1991;387-390). *Aratama Maru* was used for target practice for the U.S. military, and from 1962-1964 copper pipes were removed from the vessel by the Pacific Rock Company.

The vessel was the site of an underwater archaeology training program put together by the Guam Department of Parks and Recreation in conjunction with the Submerged Cultural Resources Unit (SCRU) of the National Parks Service (NPS) in 1987. During this training program, *Aratama Maru's* site was mapped and video was taken of the site. The vessel was added to the National Register of Historic Places on 2 June 1988. The U.S. Navy added a mooring line on the site for scuba divers the same year (Carrell 1991:390-397; National Parks Service 1988). *Aratama Maru* was surveyed again by Toni Carrell and her colleagues during their 1990 expedition.

The vessel currently rests at a depth of 50 feet near the western reef of Talofofo Bay. *Both natural and human interactions have extensively impacted Aratama*, but most of the hull is still present. However, much of the vessel has been damaged or is missing, including the engine. Due to extensive initial salvaging, there is not identifiable cargo still present on the site.

The vessel does appear to be a diving destination. While the wreck is on the National Register of Historic Places, it is still at risk of anthropogenic inputs due to the recreational diving occurring on the site.

Kitsugawa Maru – Apra Harbor, Guam

Historical Background

Kitsugawa Maru was constructed in the Kawanan Kogyo Shipyard in Nagasaki, Japan for the Toyo Kaiun Company and was completed on 27 June 1941. The vessel was requisitioned for use by the IJN on 20 October 1943 and spent the remainder of its service as a transport ship throughout the Pacific. *Kitsugawa* was torpedoed by the U.S. submarine *Seahorse* on 8 April 1944. Though the vessel did not sink, it was severely damaged and was towed to Apra Harbor for repairs. The vessel was the subject of multiple air raids by U.S. forces over the next few months and finally sank after an attack by Air Group 10 launched from the USS *Enterprise* on 27 June 1944 (Carrell 1991:376-378).

Present description and analysis

Kitsugawa Maru rests at a depth of 140 feet in Apra Harbor. The hull remains primarily intact, with most of the wrecking-event damage occurring on the port side in the vessel's stern. *Kitsugawa* has become known as the 'bow gun wreck' due to the preservation of this feature on the site. The vessel has also sustained damage from human interaction post-wrecking. There is a large hole amidships on the port side of the hull. This damage has led to the deterioration of hull components close to the damage (Carrell 1991:376-383). There does not appear to be remnants of the vessel's cargo present on the site. This may be due to the current anthropogenic input at the site, or a side effect of the wrecking event.

Kitsugawa Maru was initially located during a survey of Apra Harbor in 1976 and was the subject of a site survey by the Guam Department of Parks and Recreation in 1978. The vessel was mapped by the U.S. Navy from 1986 to 1988 and used as a training site during this time. Toni Carrell and her team resurveyed the vessel during their 1990 survey of the area (Carrell 1991:376). The site was again surveyed in 2007 by Jeffery and Drew. During this survey, researchers noted both human and environmental impacts on the site. Most notably, a concrete block was dropped on the bow of the vessel, causing severe damage. This block was most likely intended to be part of a surface marker mooring (Jeffery and Palmer 2017:7). In a video discussing the features of the wreck, one diver Pete Peterson, stated that to find the wreck he and his colleagues would drag an anchor around the area until they "hooked it" (Peterson 2011). FIGURE 6.1 demonstrates some of the human impact currently experienced on the site.

APPENDIX A 1.1. *Kitsugawa Maru* is a popular diving destination and human interaction with the site is common (Jeffery and Palmer 2017)

Nichiyu Maru – Apra Harbor, Guam

Historical Background

Nichiyu Maru was constructed for the Kisen Nissan Steamship Company and was completed on 28 December 1933. The vessel was requisitioned by the IJN on 3 December 1940. On 5 May 1943, *Nichiyu Maru* was torpedoed by USS *Permit* and seriously damaged and retreated to Apra Harbor to undergo repairs. The vessel was spotted and attacked by USS *Caperton* on 25 June 1944. After sustaining over forty observed hits, the *Nichiyu Maru* sank to where it now rests in Apra Harbor (Carrell 1991:384; Casse et al. 2020).

Present description and analysis

The vessel rests at a depth of 100 feet and is near a commercial fuel pier. Due to its location, commercial divers blew up the top of the vessel to increase the harbor's depth for shipping activities. The forward third of the vessel remains well intact, but the remainder of the vessel is extensively broken up due to these commercial activities.

The Guam Department of Parks and Recreation surveyed *Nichiyu Maru* in 1978. Toni Carrell and her colleagues conducted a second survey of *Nichiyu* during their 1990 survey of the area (Carrell 1991:386). No further known research has been conducted on this vessel.

Tokai Maru – Apra Harbor, Guam

Historical Background

Tokai Maru was built as a cargo and passenger vessel for the Osaka Shosen Company in Nagasaki, Japan. Construction of the vessel began on 26 November 1929 and was completed on 14 August 1939. The IJN requisitioned the vessel on 17 October 1941 and used it for transport throughout the Pacific. *Tokai Maru* was torpedoed by U.S. submarine *Flying Fish* on 26 January 1943 but remained afloat. The ship was torpedoed again on 27 August 1943 by USS *Snapper* and

sank. *Tokai* came to rest at the bottom of Apra Harbor in close proximity to the WWI German vessel *Cormoran* (Casse et al. 2020; Jentschura et al. 1970:280).

Present description and analysis

The vessel lies at a depth of 95 to 110 feet, with its keel resting directly above *Cormoran's* stern. The vessel remains primarily intact, however, the 8-cm bow gun was removed by the U.S. Navy in 1965 and is on display at Polaris Point, Guam. There are still unexploded ordinances on the port side that the U.S. Navy Explosive Ordinance Disposal (EOD) team surveyed in conjunction with the Guam State Historic Preservation Office (Carrell 1991:366-376).

Tokai Maru was added to the National Register of Historic Places in 1988 due to its action throughout the war and its unique association with *Cormoran*. The vessel was again surveyed in 2007 by Bill Jeffery and his colleagues During their survey, they noted both human and environmental impacts on the site, including boat anchor damage (Jeffery and Palmer 2017:7). Penetration diving does occur on the site, which may lead to further deterioration. More recently, *Tokai* was the subject of a pollution risk assessment published in 2013. Though the vessel was deemed 'low risk,' it is continuing to be passively assessed by local divers and commercial fishermen that frequent the area (National Oceanic and Atmospheric Administration 2013:35).

Palau

Palau (or the Republic of Palau) is the westernmost Micronesian nation. The island chain gained their independence in 1978 and remained a sovereign entity instead of joining the Federated States of Mircronesia (Pacific RISA 2021). This nation is composed of six island

groups that comprise over 300 total islands. The primary island groups are Babeldaob, Koror, Peleiu, Angaur, Kayangel, Ngeruangel, and the Rock Islands (Pacific RISA 2021). Due to the extensive number of islands, there is a high variability in geography throughout the nation, though the total land area of Palau only measures 189 sq. miles (Palau Conservation Society n.d.:5).

Palau has a tropical climate with an average annual temperature of 83 degrees Fahrenheit and an average humidity level of 82%. The islands are at risk of typhoons, primarily between June and December, though the islands are outside the typhoon belt and therefore these weather events are less likely than other places in Micronesia. That is not to say, however, that they do not exist. Typhoon Surigae impacted residents of Palau in April 2021 and led the US Aid administration to provide immediate assistance to residents (US AID 2021).

A large majority of the nation's diversity is located underwater, including "the most diverse coral fauna in Micronesia, and the highest density of tropical marine habitats of comparable geographic areas around the world" (Pacific RISA 2021). This underwater diversity is being threatened by climate change, however. A drastic sea-surface warming event occurred in 1997-1998 leading to extreme coral bleaching. Over one-third of Palau's corals died (Pacific RISA 2021). This event impacted the local marine tourism industry which is a major component of Palau's economy. Due to the devastating bleaching event, Palau took steps to mitigate future climate change impacts including "implementing permit fees and visitor limits for frequented areas, placing a moratorium on mangrove clearing to protect coastal habitat, and developing marine protected areas to preserve fisheries habitat and resources" (Pacific RISA 2021). Management strategies such as these are helping species rebound from these climate change events.

Palau has become a popular diving destination due to the clear waters and marine biodiversity. Annual water temperatures remain in the high 70s to mid-80s and underwater visibility is commonly around 100 feet (30 meters) (Scuba Diving 2015). Diving in Palau has also attained high levels of popularity due to the proximity of dive sites. Most of the popular sites are close to shore, and liveaboards are common attractions (Scuba Diving 2015). Though government regulations have improved the management of many sites, anthropogenic impact is still a major concern due to the popularity of diving.

The Palauan government is also taking other measures to help protect its surrounding underwater environment. In 2015, the government began to implement a ban on commercial fishing in 80% of its waters with full exclusion in these areas complete by 2020 (Whiting 2019). This drastic move is intended to improve biodiversity within the area, specifically within the coral reefs and officials state that fish numbers have already doubled in the protected areas (Whiting 2019). This policy will also benefit shipwrecks in protected waters as commercial fishing has many potential impacts on underwater sites, most notably potential anchor damage.

Ryuko Maru – Northside of Ngerchaol (Ngarol) Island

Historical Background

This vessel was constructed as part of the 'War Standard Construction Program' and was completed in 1942 at the Tsurumi Shipyard. *Ryuko Maru* was a Type 1C vessel built alongside two other vessels, *Shinsei* and *Raizan,* of the same class. Though these vessels were constructed for use in the war, the IJN designed them as economic vessels for use after the war. The vessel was sunk on 30 March 1944 off the coast of Palau by U.S. TF58 (Carrell 1991:481-420; Jentschura et al. 1977:278).

Present description and analysis

The vessel was initially misidentified as the *Kamikaze Maru*. However, unpublished documents provided to researchers from Fujita Salvage, a company that salvaged many wrecks within the area in the 1960s, helped positively identify the wreck (Carrell 1991:418). It is unclear, however, to what extent Fujita Salvage impacted this wreck site.

The vessel is resting on the bottom of the channel leading to Kobesang Harbor at a depth of 80-100 feet. During their 1990 survey, Carrell and her colleagues noted that *Ryuko Maru* was primarily intact, with most of the damage centralized midships. The site is home to extensive flora and fauna, including turkey fish, jacks, and large black coral bushes. While salvage by the Fujita Salvage Company has not been confirmed, there is evidence that salvage has occurred on the vessel post-wrecking. This potential salvage includes the removal of the rudder, which rests near the stern of the vessel, the propeller, which was removed from the site, and the absence of bridge instruments which Carrell stated were "stripped from the site" (Carrell 1991:420-422; Bailey 1991:143-144). No work has been recorded on the vessel since Carrell's 1990 survey.

The site is presently a popular dive site. It generally does not have a current and visibility ranges from 45-60 feet (13-15 meters). Penetration diving does occur on the site (Ocean Hunters Liveaboards 2020).

Amatsu Maru – West Malakal Anchorage, Palau

Historical Background

Amatsu Maru was Standard Type 1 TL steam tanker built in 1943 under the War Standard Construction Program. The vessel was intended for economic use by the Nihon Kaiun company after the war. The vessel was assigned to the Combined Fleet in January 1944 and was

sunk by US TF58 aircraft during the DESECRATE ONE Operation off the coast of Palau on the 30 March 1944 (Ishimura 2011:7; Jentschura et al. 1977:252).

Present Description and Analysis

After the war, the vessel was partially salvaged by the Fujita Salvage Company, however the project was abandoned after an underwater explosion killed two individuals (Ishimura 2011:7; Bailey 1991:127). Dan Bailey and his colleagues surveyed the site in 1990. During his survey, Bailey noted the absence of several artifacts, including the rudder stand, compass stand, and telegraphs. Bailey believes these artifacts were most likely removed by salvors (1991:127). The next recorded work was completed on the site by Tomo Ishimura during a 2010 survey of WWII shipwrecks in Palau's waters. During this survey, Ishimura "carried out underwater archaeological survey at six selected sites" and documented the current level of deterioration at each site (2011:4). During his investigation of the *Amatsu Maru* site, Ishimura noted that the hull remains primarily intact with little evidence of deterioration apart from the damage caused during the sinking event (Ishimura 2011:7).

This vessel has become a popular sport diving destination, with many companies offering tours of the site. The site has garnered the nickname “Black Coral Wreck” due to the extensive amount of black corals currently growing on the site (Ocean Hunters Liveaboards 2020). Penetration diving does occur at the site, leading to greater risk of deterioration. This heavy traffic may increase levels of deterioration and increase the unauthorized removal of small portable artifacts from the site.

Buoy #6 Wreck – Malakal Channel, Palau

Historical Description

The identity of this wreck has not been confirmed. The vessel was confirmed to be a bonito fishing vessel due to its two portside conduits, a common feature of this vessel type (Ishimura 2011:11). These vessels were commonly requisitioned throughout the war as submarine chasers.

Present Description and Analysis

The vessel was surveyed during Ishimura's 2010 work in the area. The vessel rests at a depth of between 70 to 88 feet (21-27 meters) within the Malakal Channel. Ishimura provided a brief description of the site's present state, noting that the gun associated with the bow circular gun platform is missing (2011:11). This site has become a popular sport diving site which may account for the loss of artifacts such as the bow gun.

Chuyo Maru – West Malakal Anchorage, Palau

Historical Background

Chuyo Maru was constructed in 1943 for the Toyo Kisen Kaisha Company but was requisitioned the same year to become an army cargo vessel. The vessel was used extensively in the Mandate Islands throughout the war. The vessel was hit during two air raids on the 30 and 31 March 1944 and finally sank on 1 April 1944 (Ishimura 2011:8; Bailey 1991:131).

Present Description and Analysis

The first recorded interaction with the site post-wrecking occurred in 1989 when two salvors, Francis Toribiong and Klaus Lindemann, dove on the site. They positively identified the wreck due to ceramics aboard the vessel labeled with the Toyo Kisen company logo (Ishimura 2011:8-9). The next salvage on the site occurred in 2006 when "an English man illegally looted

some artifacts from the *Chuyo Maru* and other shipwrecks in Palau and faced two months in jail and a fine of $40,000 (USA)" (Ishimura 2011:9).

The vessel was surveyed in 1991 by Dan Bailey, who noted extensive fire damage. Many artifacts were still present on the vessel, however, including dishware, the vessel's compass, and a crystal soy sauce bottle, among others. Bailey noted that many vessel features were still intact, including much of the rigging (Bailey 1991:131-132).

The site was the subject of a subsequent survey by Tomo Ishimura in 2010. During his site survey, Ishimura noted deterioration of the wreck, including the bridge structures that were seriously damaged during the sinking event. Many aspects of the vessel are still present on the site, however, including the compass and telegraph (Ishimura 2011:8).

Much like *Amatsu Maru*, *Chuyo Maru* is a popular diving destination due to its shallow depth (between 12-40 meters), as well as proximity to shore. Penetration diving occurs on *Chuyo Maru*, potentially leading to more drastic anthropogenic impacts. Illegal salvaging has already occurred at this site. It is safe to assume this vessel, along with others in the area, faces further looting and deterioration due to sport divers if proper site management is not enforced. Other anthropogenic impacts can be seen on the site as well. In the 1990s a fishing vessel accidentally caught *Chuyo's* anchor with its own and both anchors broke. They are now visible near the site (Ocean Hunters Liveaboards 2020).

Goshu Maru – Kobasang Harbor, Palau

Historical Description

Goshu Maru was constructed for Goyo Shosen K. K. and was completed on 27 February 1940. The vessel was requisitioned on 14 September 1940 as a general transport ship. *Goshu* was

converted into an auxiliary aircraft transport in 1941. The vessel operated extensively throughout the Pacific Theatre and survived a U.S. submarine attack on 21 October 1943. The vessel sank during the DESECRATE ONE Operation on 31 March 1944, and forty-five crew members perished during the sinking event (Jentschura et al. 1970:275; Bailey 1991:134; Casse et al. 2020).

Present Day Description and Analysis

Due to the shallow location of the sinking, the vessel was salvaged extensively post-wrecking. The Fujita Salvage Company removed 3,500 tons of iron from the site. Dan Bailey and his colleagues utilized a magnetometer to find the site during their 1990 survey work. The site consists mainly of a debris field with a twenty-five-foot-high stack of fifty-gallon barrels in the center. Other artifacts present at the site include steel rods, cable, and several cross-braced ventilators (Bailey 1991:134). Due to the lack of vessel superstructure, it does not appear that this site is a popular sport diving destination.

Gozan Maru – Palau Harbor, Palau

Historical Description

Gozan Maru was completed in 1919 for the Suzuki Shoten K. K. company. The vessel was a 3,200-ton cargo ship utilized for merchant shipping until the late 1930s. The IJA chartered the vessel in 1938 though returned it to its civilian owners in 1939. The vessel was officially requisitioned by the IJA on 15 November 1941 and was returned again to its owners on 13 June 1942. The IJN then requisitioned the vessel on 14 October 1943. During the DESECRATE ONE Operation, the vessel was attacked by aircraft and sunk on 31 March 1944 (Casse et al. 2020).

Present Day Description and Analysis

Bailey and his colleagues noted that salvors had removed extensive hull components during their survey, including 250 tons of iron and 2,500 tons of cement being transported as cargo. Very little of the site remains, including small amounts of scrap metal and a single pressure gauge (Bailey 1991:134).

The site is a current recreational diving destination. Penetration diving is permitted at the site, potentially increasing levels of deterioration at the stie.

Kamikaze Maru – Ngeruktabel Anchorage, Urukthapel Island, Pelau

Historical Description

Kamikaze Maru was constructed at the Osaka Tetsukosho Sakurajima Factory for Todai Kisen and was completed on 19 March 1938. The vessel had a gross tonnage of 4,916 and was requisitioned on 3 June 1941. After the vessel was requisitioned, it was outfitted as a 'special torpedo mother boat.' It was utilized in several important strike forces throughout the Pacific, including the attack on Guadalcanal Island. The ship was sunk during American Desecrate One Operation on 30 March 1944 (Carrell 1991:447-448; Casse et al. 202).

Present Day Description and Analysis

Kamikaze Maru rests at a depth of 100-120 feet (30-36 meters) on the silty floor of the channel south of Ngeruktable anchorage. The Fujita Salvage Company salvaged the vessel, though live ammunition and gas canisters are still present on the site. The vessel is listing slightly to port, and the hull shows evidence of severe damage due to the torpedoes. There is no reef structure on the site, but it is home to many fish species, including Rainbow Runners, Sergeant Majors, and sometimes Barracuda. The vessel has become a diving site, though diving

the wreck is strongly discouraged for amateurs due to the presence of live ammunition aboard the ship (Carrell 1991:449; Ocean Hunters Liveaboards 2020).

Kibi Maru – Malakal Harbor, Palau

Historical Description

Kibi Maru was a 2,961-ton merchant cargo ship constructed in 1941. The vessel and was requisitioned by the IJA to serve in Army Transport No. 743. The vessel sank off the coast of Palau during the Desecrate One Operation. Records indicate the vessel was primarily struck by the Lexington SBDs on 30 March 1944, with subsequent attacks by Yorktown and Bunker Hill aircraft occurring later that day. Though badly damaged, *Kibi Maru* was still floating the next day and was finally sunk by Hornet aircraft on 31 March 1944 (Casse et al. 2020; Bailey 1991:136).

Present Day Description and Analysis

The site of *Kibi Maru* was rediscovered by Dan Bailey and his colleagues using photographs and magnetometer survey. Records left by the Fujita Salvage Company state that the vessel was heavily damaged during the wrecking event, and subsequent salvage efforts removed 1,000 tons of iron from the site. The site rests at a depth of approximately 50 feet (15 meters). Bailey recorded a debris field 100 feet long and 70 feet wide consisting primarily of coal and brick. Other artifacts currently on the site include beer and sake bottles, dishes, wooden boards, and 13mm machine gun casings (Bailey 1991:136). Perhaps due to the minimal ship structure left on the site, it does not appear that this site is a popular dive destination today.

Nagisan Maru – Ngeruktabel Anchorage, Urukthapel Island, Pelau

Historical Description

The vessel was built by the Tama Shipbuilding Factory and was completed in 1931. *Nagisan* was constructed as an armed cargo transport and was requisitioned by the IJN on 31 July 1941 as a general transport vessel. Throughout the war, the vessel acted as a transport vessel throughout the Pacific. USS *Flying Fish* torpedoed *Nagisan* on 6 February 1943, but the vessel was repaired. *Nagisan Maru* continued to operate throughout the Pacific theatre until the 30 March 1944, when it was bombed during the DESECRATE ONE Operation off the coast of Palau (Carrell 1991:441-442; Casse et al. 2020).

Present Description and Analysis

Nagisan Maru currently sits at a depth of 100-110 feet (30-33 meters) and is heavily damaged. Beams appear to have melted, providing evidence of a fire occurring during the sinking event. Other areas of the vessel show signs of extreme deterioration, such as the stern, which has collapsed in some areas (Carrell 1991:443-444). The site is host to extensive marine life including various types of corals, rainbow runners, Sergeant Majors, Moorish idols, batfish and barracuda (Ocean Hunters Liveaboards 2020). The vessel is an active sport diving site and therefore is most likely still experiencing anthropogenic input post-wrecking.

Nissho Maru No. 5 – Palau

Historical Description

Nissho Maru No. 5, a 782-ton cargo ship, was built for Marusho Kaiun K. K. in the Ohara Zosen Tekkosho K. K. shipyard. The vessel was completed in March 1935 and was requisitioned by the IJN on 26 August 1941 as a netlayer. The vessel operated as a netlayer stationed primarily around Yura, Japan, until it was converted into an auxiliary transport vessel

on 28 September 1943. The vessel arrived in Palau on 24 March 1944 and was sunk on 31 March 1944 during the Desecrate One Operation (Jentschura et al. 1970:206; Casse et al. 2020).

Present Day Description and Analysis

The vessel was initially salvaged by Fujita Salvage Company, "leaving a major debris field strewn over 200 feet in length and along the slope of a drop-off in water depths ranging from 30 to 80 feet" (Bailey 1991:141). Though the vessel has not been definitively identified to date, the wreckage location and documentation prepared by the salvage company led Bailey to tentatively identify the site as *Nissho Maru No. 5*. Due to the violent wrecking event and post-wrecking salvage, none of the vessel's structure still exists on the site. Bailey noted the presence of artifacts such as plates, a porthole cover, several 'torpedo-shaped objects,' and other unidentifiable artifacts. There are also remnants of the salvaging operations, including beer bottles and a single tire (Bailey 1991:141). Preliminary online investigations do not indicate that this site is a popular recreational diving destination.

Raizan Maru – Kobesang Harbor, Palau

Historical Background

Along with the previously listed *Ryuko Maru*, *Raizan Maru* was a 1C Type Merchant Ship built during the War Standard Construction Program. The vessel was built at the Namihaya Dockyard in Osaka, Japan, and completed in 1942. The vessel was used for cargo transport throughout the Pacific during the war and was sunk by U.S. TF58 during the Desecrate One Operation in Palau on 30-31 March 1944 (Carrell 1991:422; Casse et al. 2020).

Present Description and Analysis

Raizan Maru's location and depth were listed in the unpublished papers presented to Carrell's research team in 1990. Individuals at Fujita Salvage wrote these papers though it is unclear if the company did any salvage work on this site (Carrell 1991:422). Dan Bailey and his colleagues were the first known sport divers to visit the site in 1986. During this survey, Bailey noted the extensive damage to the vessel's hull. Bailey notes the vessel was "stripped of all its upper superstructure and some deck and hull plating" and notes the removal of the propeller from the site (1991:143). He posits that this damage is a culmination of the wrecking event and savage efforts post-wrecking. During a 1988 NPS-USN project, researchers collected side scan sonar at the site, which showed that the hull's side was severely damaged. During their 1991 survey of the area, Toni Carrell and her colleagues conducted a single reconnaissance dive on the site, confirming the damage shown in the side scan images (Carrell 1991:422).

This site has become a popular diving destination in Palau, and while efforts are being made to protect sites such as this one, enforcement is difficult. Due to the depth of this site, as well as its proximity to shore, mitigation of damage due to sport divers is problematic though vital for sites such as *Raizan Maru*.

Teshio Maru – Palau

Historical Description

Teshio Maru was a 361-ton trawler constructed for Kyodo Gyogyo K. K. The vessel was completed on 27 September 1930 and operated as a civilian trawler until the IJN requisitioned it on 27 October 1937. After its requisition, the vessel was registered as an auxiliary minesweeper operating mainly in the South China Sea. In March 1945, *Teshio Maru* was part of a convoy

carrying food to garrisons in Port Blair, India when two RAF B-24 "Liberator" bombers attacked the vessels. *Teshio Maru* was sunk on 25 March 1945 (Casse et al. 2020).

Present Day Description and Analysis

The vessel was not directly hit during the RAF bombing event allowing the damaged vessel to drift before it became beached on a shallow reef where it remained for several years. Many artifacts were removed from the vessel during this time, and the iron hull began to rust. The vessel was eventually dislodged from the reef (most likely during a severe storm) and rolled down the reef's steep slope to its final resting place. The vessel's port side sits at approximately forty-five feet, while the starboard side rests at eighty feet (13-24 meters) (Lindemann 1988:97-99). The hull remains primarily intact and has become a popular diving destination in the area (Lubba 2014b).

The wreck is home to many marine species including corals and various species of reef fish. Though the site has become a popular diving destination, penetration of the wreck is not advised due to the hull's deteriorating structure.

Unidentified Maru No. 1 – Ngeruktabel Anchorage, Belau

Historical Background

This vessel has been improperly identified as both *Hokutai Maru* and *Gozan Maru*. Due to its location and field examination of the site, both these potential identities have been eliminated. Though the specific identity is unknown, the vessel's sinking event has been identified as 30-31 March 1944 due to aerial raids over the area (Carrell 1991:436).

Present Description and Analysis

The vessel is primarily intact, sitting in 100 feet (30 meters) of water at a slight list to port. The primary damage to the vessel is a hole in the port side of the ship. This damage most likely occurred at the time of the sinking. The ship has a length of 389 feet and six inches with a breadth of 52 feet six inches (Carrell 1991:436-440).

Unidentified Maru No. 2 (The "Depth Charge Wreck") – Malakal Harbor, Palau

Present Day Description and Analysis

During their magnetometer survey of Malakal Harbor in 1990, Dan Bailey and his colleagues discovered a wreck resting between 45 and 110 feet (14-33 meters). The vessel does not show evidence of salvage operations, and Bailey believes this wreck has remained primarily untouched since its wrecking event (1991:148-151). The vessel has remained unidentified, though it is now a popular recreational dive site and is now referred to as the Helmet Wreck due to the helmet stacks present in the stern hold of the vessel (Lubba 2014a).

Unidentified Maru No. 3 – Malakal Harbor, Palau

Present Day Description and Analysis

Dan Bailey discovered this wreck using "a long fish net tied to the shore and buoyed with yellow floats" (1991:153). This vessel is approximately 75 yards offshore and rests at a depth of 45 to 50 feet (13-15 meters). The aft end of the vessel has sustained extensive damage. It is most likely the result of a bomb explosion during the wrecking event and dynamite charges utilized in the salvage operation conducted by Micronesian Salvage post-wrecking. Though the length cannot be definitively determined due to the damage, Bailey and his colleagues believe the vessel's beam to be around 30 feet, with a length of approximately 200 feet. Several artifacts

were discovered on the site, including lanterns, broken china, and an unidentified cylindrical object.

The site has remained unidentified though an image of the suspected vessel was captured on 30 March 1944 (FIGURE 6.2). Based on this image, the vessel is believed to be coaster under 1,000 tons. The suspected vessel pictured in FIGURE 6.2 was attacked by Bunker Hill SB2C aircraft on 30 March 1944 and sank by three Lexington dive bombers the next day (Bailey 1991:153).

Urakami Maru – Malakal Harbor, Palau

Historical Description

Urakami Maru was a 4,317-ton cargo ship built for Fukuyo Kisen K. K. The vessel was completed on 10 November 1941 and was requisitioned just two days later. The vessel was converted into a salvage and repair ship and assigned to the Sixth Fleet at Chuuk. *Urakami* operated primarily out of Chuuk and Kwajalein throughout the war and was the victim of attack during the Desecrate One Operation in Malakal Harbor. The IJN removed the vessel from the Navy List on 10 May 1944 (Casse et al. 2020).

Present Day Description and Analysis

Urakami Maru rests at a depth of 115-125 feet (35-38 meters) and is listing to starboard. Fujita Salvage Company salvaged the wreck and reportedly removed 1,300 tons of metal from the vessel. Other items from the vessel have also been removed, presumably by salvors, including brass instruments from the wheelhouse, the foremast, and the rear mast. The vessel's engine room shows signs of damage, most likely from the wrecking event, as well as salvage operations. Several letters still visible on the vessel's hull provided definitive identification

(Bailey 1991:155-156). *Urakami Maru* has become a popular sport diving destination due to its location and history, however visibility is poor due to sedimentary runoff caused by a nearby quarry (Cialkowski 2011; Ocean Hunters Liveaboards 2020).

APPENDIX A 1.2. Unidentified Maru No. 3 in Malakal Harbor 30 March 1944 (Bailey 1991:153)

Chuuk Lagoon

Chuuk Lagoon is a group of islands surrounding a central lagoon within the regional grouping of the Caroline Islands and is a part of the Federated States of Micronesia (FSM). The state of Chuuk is divided into five regions: Northern Namoneas, Southern Namoneas, Faichuk, Mortlocks, and Northwest Islands (Chuuk State Economic Development Commission 2016:7). The islands surrounding the lagoon are relatively small with a total landmass of 49.2 square miles while the lagoon itself covers 820 square miles. One important distinction to note is the difference between Chuuk and Truk Lagoon. While Chuuk Lagoon refers to the governmental state, Truk Lagoon describes the geographical location of the lagoon itself (Master Liveaboards

2021). Though the landmass is small, the lagoon boasts a population of 48,654 as of the last census (Weeks et al. 2017:7). Much like the United States, the state of Chuuk Lagoon has a government that operates autonomously from the national FSM government. Therefore, Chuuk has executive, legislative and judicial branches of government that run most operations within the lagoon (Chuuk State Economic Development Commission 2016:7-8).

Chuuk Lagoon has a tropical climate with average annual temperatures averaging 81 to 86 degrees Fahrenheit and a monthly average of 9 inches of rainfall though there is a dry season between December and March (Chuuk State Economic Development Commission 2016:11). Typhoons are a concern for Chuuk and hit the lagoon approximately once every decade (Chuuk State Economic Development Commission 2016:11; Hoot and Taborosi 2012). These typhoons have a negative impact on the underwater cultural heritage (UCH) surrounding the islands. Ian MacLeod and his colleagues measured the impacts of Typhoon Maysak on WWII iron shipwrecks in the lagoon and noted an increase in corrosion levels correlating with a decrease in concretion levels due to typhoon damage (MacLeod et al. 2017:285).

The lagoon has an average water temperature between 82-84 degrees Fahrenheit with underwater visibility ranging from 40-100 feet (12-30 meters) (PADI 2022). The reef structure surrounding the lagoon reduces the possibility of strong currents. There is extensive UCH within the lagoon, with a large number of IJN wrecks that were sank during "Operation Hailstone" on 17 and 18 February 1944. While there are many cultural resources along with delicate marine ecosystems, Truk Lagoon faces serious threats from commercial fishing operations. A 2017 survey of the lagoon's resources noted that "fishing has been identified as the most urgent and critical threat to Chuuk's marine ecosystems, with the decline of marine biodiversity clearly linked to commercial exploitation of marine resources" (Weeks et al. 2017:4).

Along with threats from commercial fishing operations, recreational wreck diving is a popular tourist attraction in the lagoon. Both of these anthropogenic activities threaten the preservation of UCH resources within the lagoon.

Fujikawa Maru – Truk Lagoon

Historical Background

Fujikawa Maru was constructed as a passenger ship for Toyo Kaiun K. K. and was completed on 1 July 1938. The vessel was requisitioned on 9 December 1940 and was converted into an armed auxiliary aircraft transport. *Fujikawa* was used in the invasion of Malaya on 8 December 1941 and afterwards operated extensively along the Japanese coast and throughout the South Pacific. On 17 February 1944, the vessel was stationed at Chuuk and was victim of the American Operation "Hailstone". *Fujikawa Maru* was torpedoed by a TBF "Avenger" from Task Group 58. The vessel was struck starboard amidships and slowly sank to the bottom of the lagoon. No casualties were reported (Casse et al. 2020).

Present Day Description and Analysis

Fujikawa Maru rests at a depth of 110 feet (30 meters) in an upright position. The vessel is primarily intact with many features well preserved. The site has several unique features associated with it including a bathtub and a Zero aircraft still in the hold. The site is now covered in marine life including a variety of corals and different fish species. There is a plaque on the deck of the wreck reading " FUJIKAWA MARU: Sunk February 17, 1944 during US Nayv's "Operation Hailstone", this plaque, placed February 1994 on the 50th anniversary of this action, is dedicated to the preservation of and respect for the remaining ships, aircraft and artifacts as a heritage for the people of Chuuk Lagoon" (Master Liveaboards 2021).

The vessel was part of Ian MacLeod's ongoing corrosion project throughout the lagoon. The aim of the research was to determine corrosion rates on vessels at different depths and locations throughout the lagoon. *Fujikawa Maru* was one of the primary vessels examined for the project. By examining corrosion processes occurring on *Fujikawa's* hull, MacLeod noted that shallower areas of the wreck are more susceptible to corrosion processes as there is higher amounts of 'wave action' which increases the amount of dissolved oxygen in these areas, subsequently increasing corrosion processes (MacLeod 2016:4).

Due to the unique artifacts, marine life and accessible location, *Fujikawa Maru* has become one of the most popular dive destinations in Chuuk Lagoon. High levels of human interaction, along with increased corrosion rates on shallower parts of the hull, may indicate that *Fujikawa Maru* has an increased risk of deterioration in the future.

Gosei Maru – Truk Lagoon

Historical Background

Gosei Maru was built in 1937 as a 1,931 ton standard coastal freighter and was requisitioned by the IJN as a transport vessel. Little was found regarding the vessel's operational history, though it is known that *Gosei* was the victim of "Operation Hailstorm" on 17 February 1944. The vessel was torpedoed by USS *Monterey* bombers and sank in Truk Lagoon on a steep incline ranging from 9-120 feet in depth (3-37 meters) (Bowyer 2021; Jentschura et al. 1970:275).

Present Day Description and Analysis

Gosei Maru rests on a steep incline and is listing drastically to port. The vessel appears to rest in a primarily sandy substrate with the majority of the vessel exposed. The vessel shows

extensive damage, primarily aft of the torpedo damage. Deterioration continues to occur on the site. One diver noted that while the first hold was easily accessible when he visited the site in 1997, the hold has since collapsed and is inaccessible (McFayden 2011). There are many artifacts still associated with the site including toilets and dishware. Looking at images captured by recreational divers, it appears that penetration diving does occur at the site which may increase the possibility of corrosion damage inside the hull. There is biological activity present at the site, notably coral coverage on the decking and propeller (McFayden 2011; Bowyer 2021).

The vessel was researched by MacLeod during his corrosion analysis of wrecks throughout Truk Lagoon. In his study, MacLeod found that while *Gosei* is a perfect candidate for corrosion due to high rates of recreational diving and shallow depth, it exhibits lower rates of corrosion than other popular dive sites, such as *Fujikawa Maru*. MacLeod posits this lower corrosion rate is due to the vessel's protected location. Due to its resting position, *Gosei* is sheltered from surrounding wave action. This reduces the amount of dissolved oxygen available for corrosion processes (MacLeod 2016:7).

Hino Maru No. 2 – Truk Lagoon

Historical Background

Hino Maru was constructed for Shokuen Kaiso K. K. as a cargo vessel. It was completed on 14 December 1935 and was requisitioned on 11 November 1941 as an auxiliary netlayer. The vessel was later altered to become an auxiliary gunboat on 20 March 1942. The vessel operated throughout the Pacific as a netlayer and gun boat until its orders were changed on 1 October 1943. It is registered as an auxiliary transport under IJN instruction No. 2041. The vessel arrived in Chuuk in April 1944 and was bombed by USS *Cabot* on 30 April 1944. The vessel finally

sank at anchor on 4 May 1944. The vessel as removed from IJN list under instruction No. 880 on 18 July 1944 (Casse et al. 2020).

Present Day Description and Analysis

Hino Maru sank in very shallow water. The vessel rests at an average depth of approximately 24 feet (7.5 meters). The vessel shows signs of extreme deterioration with minimal hull structure still present. The most recognizable feature of the site is the bow gun which is still standing upright. The gun shows signs of heavy corrosion, however. During his corrosion study, Ian MacLeod noted that the bow gun shows increased rates of corrosion due to the shallow depth of the site and is highly susceptible to pH changes (McFayden 2011; MacLeod 2006:209).

Due to its shallow depth, *Hino Maru No. 2* is a popular snorkel destination. This may increase potential damage on the site as snorkelers may dive down and hold onto the gun for a photo opportunity. The site does not appear to be a popular diving destination, however, due to the extensive deterioration of the site.

Hoyo Maru – Truk Lagoon

Historical Description

Hoyo Maru was constructed as a merchant tanker for Nippon Shosen K. K. and was completed on 5 November 1936. The vessel was run aground off Tanegajima in 1937 and was salvaged and repaired. The vessel was requisitioned on 25 December 1940 and registered as an oil transport vessel stationed out of the Kure Naval District. *Hoyo Maru* assisted in the invasions of Rabaul and Kavieng on 17 January 1942 and later that year is acknowledged as having a submarine “kill” after outgunning an attacking submarine. The vessel continued to operate

extensively throughout the Pacific until "Operation Hailstone" on 17 February 1941. The ship was bombed by USS *Enterprise* and six crewmembers are killed in action. The vessel was removed from the IJN vessel list later that year (Casse et al. 2020).

Present Day Description and Analysis

After being bombed during "Operation Hailstorm", *Hoyo Maru* came to rest at an average depth of 27 feet (8.5 meters) on a sandy substrate. The wreck split during the wrecking event and now the bow sits at a shallower depth than the stern. The vessel is highly concreted with thick coral grown on some areas. Other species, such as tiger pipefish and various sponges, have also been noted on the wreck (McFayden 2011). This site is a popular recreational diving destination and penetration diving is allowed. Therefore, this site faces continual anthropogenic input.

Hoyo Maru was examined during Ian MacLeod's corrosion project. The potential wave action due to is shallow location increases corrosion potential for this site (MacLeod 2016:8-9). This threat, along with continual anthropogenic input, increase the preservation threats *Hoyo Maru* faces.

Nippo Maru – Truk Lagoon

Historical Background

Nippo Maru was completed on 10 November 1936. The vessel was a cargo ship constructed for Okazaki Honten K. K. Nippo operated as a cargo vessel until its requisition on 24 August 1941. *Nippo* was converted into an auxiliary water tanker under IJN Order No. 1025. The vessel operated as both a water tanker and troop transport ship throughout the Pacific and even assisted in the salvage of a submarine off the coast of Chuuk. *Nippo Maru* sank during

"Operation Hailstorm" on 18 February 1944. The vessel sustained damage to both the coal hold and engine room before eventually sinking. *Nippo Maru* was removed from the IJN list of vessels on 31 March 1944 (Casse et al. 2020).

Present Day Description and Analysis

Nippo Maru rests at a depth of 160 feet (48 meters) with a list to port. The vessel sits on a reef, and is covered in concretions. The hull remains primarily intact with unique artifacts such as navigation instruments in the engine room and a tank on the deck. The vessel's five holds are still loaded with ammunition and the deck guns are still primarily intact (McFayden 2011). There is a heavy amount of marine growth on the site, particularly on objects such as the tank (MacLeod 2006:217).

During his corrosion study, MacLeod noted that *Nippo Maru* exhibited slower rates of corrosion compared to some of the other examined wrecks. This is most likely the result of the wreck's deep location (MacLeod 2006:207).

Sankisan Maru – Truk Lagoon

Historical Background

Sankisan Maru was built for Nippon Yusen Kaisha in 1920. The vessel was rated as a 6,000 ton cargo and passenger vessel, and primarily transported rice prior to the war. The vessel was requisitioned by the IJA as a cargo vessel early in the war. The vessel operated primarily as a cargo vessel within convoys throughout the war. The vessel was bombed on 17 February 1944, though it did not sink until the next day when it was torpedoed by USS *Bunker Hill* Helldivers (Pacific Wrecks 1995).

Present Day Description and Analysis

Sankisan Maru rests at a depth of 110 feet (34 meters) on sandy seafloor. The vessel was ripped in half during the wrecking event and now the aft portion of the hull is severely damaged. The front portion of the hull, however, is well intact. There are extensive artifacts associated with the site including copious ammunition and several trucks. There is a plethora of marine life on the wreck including corals and various fish species. Due to the artifacts and marine growth this site has become a popular recreational dive destination (McFayden 2011). Penetration diving does appear to occur at this site, increasing the potential corrosion rates at this site. It is unknown if salvage operations have occurred on the site.

During his corrosion analysis, MacLeod noted the presence of 'new' concretions on *Sankisan*. MacLeod posits that this new growth is the result of dynamite fishing practices. If this is the case, the site faces several anthropogenic threats from both recreational diving practices and commercial activities (MacLeod 2006:211).

Sapporo Maru – Truk Lagoon

Historical Background

Sapporo Maru was constructed for Kyodo Gyogyo K. K. as a 361-ton trawler. The vessel was completed on 25 November 1930. The vessel operated under trawling permits throughout the 1930s operating as far as California, the Gulf of Mexico and the Caribbean Sea. The ship was eventually requisitioned by the IJN on 5 December 1943 and was registered as an auxiliary stores ship. *Sapporo Maru* was sunk by USN TF 58 aircraft on 4 May 1944. Two crewmembers were killed in action (Casse et al. 2020).

Present Day Description and Analysis

Sapporo Maru was located in 2002 using side scan sonar. The vessel is mostly intact with a list to starboard and was definitively identified by Bill Jeffery and his colleagues through a comparison to vessel design drawings and the uncovering of a bell with the vessel's name etched on the side. Less than twenty-four hours of locating the bell, however, researchers could no longer find it. The bell was hidden on the site by a dive tour guide and unfortunately, police deemed this not to be illegal as the artifact was not removed from the site (Jeffery 2004; Jeffery 2012:19). This action demonstrates the amount of anthropogenic input occurring on this site.

During his corrosion study, MacLeod found that *Sapporo Maru* had high levels of concretions on the hull. He argues that these high levels of 'old' concretions are possibly due to the recent location of the site. Since the site was only located in 2002, there has been less chance for the practice of dynamite fishing to occur on the site, minimizing damage to the concretions (MacLeod 2006:211). The minimal damage to concretions reduces the rate of corrosion on the site and therefore increases site preservation.

Shinkoku Maru – Truk Lagoon

Historical Background

Shinkoku Maru was constructed for Kobe Sanbashi K. K. as a 10,020-ton tanker. The vessel was completed on 28 February 1940 and utilized for oil transport. The vessel was requisitioned on 18 August 1941 and was registered as an auxiliary oil tanker. *Shinkoku Maru* is apart of Operation "Z" which was the attack on Pearl Harbor on 7 December 1941. The vessel assisted in other notable operations such as the invasions of Rabaul and Kavieng on 20 January 1942 and the Battle of Midway on 27 May 1942. *Shinkoku Maru* was bombed SBD dive-bombers from USS *Yorktown* and torpedoed by TBF "Avengers" from USS *Bunker Hill* on 17

February 1944, though the final blow came from a USS *Enterprise* bomb on 18 February 1944. Eighty-six individuals were killed in the sinking event. The vessel was removed rom the IJN list of vessels on 31 March 1944 (Casse et al. 2020).

Present Day Description and Analysis

Shinkoku Maru rests at a depth of 40-130 feet (12-40 meters) in an upright position. The hull is primarily intact and sits in a primarily sandy substrate. The vessel is an extremely popular recreational dive site due to the extensive marine life on the site, as well as the artifacts still present on the stie. Marine species at the site include corals, anemones, gorgonian fan corals, sponges and fish (SSI 2021).

During MacLeod's corrosion study, it was noted that *Shinkoku Maru* is experiencing higher than expected corrosion levels. It was suggested that these higher levels are due to repairs completed during the vessel's lifetime. Higher levels of steel stress may correlate to higher rates of corrosion post-wrecking (MacLeod 2006:217). While this is just a theory, it does explain increased corrosion levels for the site.

Yubae Maru – Truk Lagoon

Historical Background

Yubae Maru was built as a 3,217 ton cargo ship in 1919. Very little information was available regarding the vessel's operational history, however it is known the ship was part of the "Hansa No. 5" convoy fleet in 1943.Yubae was torpedoed during "Operation Hailstorm" on 17 February 1944. The vessel came to rest in Truk Lagoon at a depth of 60-120 feet (Pacific Wrecks 1995; Bowyer 2021).

Present Day Description and Analysis

Yubae Maru sits at a depth of 60-120 feet (18-37 meters). When the vessel sank, it came to rest upside down. The hull has significant damage though the site is still popular with recreational divers. The hull is heavily concreted with corals and a variety of fish species on the wreck. There are still a number of artifacts present on the site including china, a sewing machine and navigational instruments (Bowyer 2021).

During his investigations, MacLeod noted the significant corrosion present at the site. He believes that the increased corrosion seen at the site is the result of increased stress on the hull due to the upside down position of the vessel.

APPENDIX B: NOAA Deep Discoverer video segment spreadsheet

NOAA Video Footage_ROVHD	Time Starting	Total Length	Time Ending
T201602Z_ROVHD_Shark	20:16:02	0:00:12	20:16:14
T204509Z_ROVHD_AUD_CHRIS	20:45:09	0:00:24	20:45:33
T204538Z_ROVHD_HANS	20:45:38	0:03:31	20:49:09
T204919Z_ROVHD_AUD_FRANK	20:49:19	0:02:01	20:51:20
T205124Z_ROVHD_AUD_GRAVE	20:51:24	0:02:19	20:53:43
T205344Z_ROVHD_AUD_SEARCH	20:53:44	0:01:25	20:55:09
T210255Z_ROVHD_AUD_SCIENCE	21:02:55	0:00:20	21:03:15
T210449Z_ROVHD_FSH	21:04:49	0:01:02	21:05:51
210658Z_ROVHD_DEBRIS	21:06:58	0:01:23	21:08:21
T210828Z_ROVHD_DEBRIS	21:08:28	0:01:21	21:09:49
T211046Z_ROVHD_WOOD	21:10:46	0:00:48	21:11:34
T211240Z_ROVHD_ROCK	21:12:40	0:00:43	21:13:23
T211459Z_ROVHD_AUD_APPROACH	21:14:59	0:00:25	21:15:24
T211833Z_ROVHD_AUD_WOOD	21:18:33	0:01:23	21:19:56
T212056Z_ROVHD_AUD_SONAR	21:20:56	0:00:41	21:21:37
T212143Z_ROVHD_AUD_FIRST_LOOK	21:21:43	0:03:27	21:25:10
T212415Z_ROVHD_AUD_GUN	21:24:15	0:03:02	21:27:17
T212723Z_ROVHD_HULL	21:27:23	0:01:22	21:28:45
T212941Z_ROVHD_AUD_WIDE_HULL	21:29:41	0:01:29	21:31:10
T212957Z_ROVHD_AUD_BARREL_HULL	21:29:57	0:04:43	21:34:40
T213457Z_ROVHD_HULL	21:34:57	0:01:22	21:36:19
T213636Z_ROVHD_AUD_TORPEDO	21:36:36	0:02:19	21:38:55
T214125Z_ROVHD_PATROL_WELD_AUD	21:41:25	0:03:32	21:44:57
T214623Z_ROVHD_DECK_STAIRS	21:46:23	0:00:57	21:47:20
T214745Z_ROVHD_FAN_TIGHT	21:47:45	0:01:24	21:49:09
T215002Z_ROVHD_AUD_HOSE	21:50:02	0:00:47	21:50:49
T215139Z_ROVHD_HARDWARE_SEAM	21:51:39	0:00:45	21:52:24
T215315Z_ROVHD_VALVE_TIGHT	21:53:15	0:01:37	21:54:52
T215456Z_ROVHD_PATROL_33_AUD	21:54:56	0:01:55	21:56:51
T215640Z_ROVHD_AUD_PATROL_BOAT	21:56:40	0:03:29	22:00:09
T215942Z_ROVHD_MAST	21:59:42	0:01:44	22:01:26
T220203Z_ROVHD_AUD_TORPEDO	22:02:03	0:01:40	22:03:43
T220510Z_ROVHD_WINCH	22:05:10	0:02:15	22:07:25
T221248Z_ROVHD_WINCH_TIGHT	22:12:48	0:01:33	22:14:21
T221503Z_ROVHD_MAST_WENCH	22:15:03	0:03:07	22:18:10
T221824Z_ROVHD_PROP_AUD_PATROL	22:18:24	0:02:05	22:20:29
T222116Z_ROVHD_STERN	22:21:16	0:01:24	22:22:40
T222255Z_ROVHD_WRITING_STERN	22:22:55	0:04:37	22:27:32
T222848Z_ROVHD_STERN_WRITING	22:28:48	0:03:07	22:31:55

T223539Z_ROVHD_WIDE_STERN	22:35:39	0:03:15	22:38:54
T223900Z_ROVHD_GUN_STERN	22:39:00	0:04:19	22:43:19
T224257Z_ROVHD_GUN	22:42:57	0:01:39	22:44:36
T224609Z_ROVHD_STACK	22:46:09	0:02:54	22:49:03
T224940Z_ROVHD_MAST	22:49:40	0:03:16	22:52:56
T225304Z_ROVHD_UNK	22:53:04	0:00:54	22:53:58
T225422Z_ROVHD_CARGO_HOLD	22:54:22	0:03:44	22:58:06
T225854Z_ROVHD_CARGO	22:58:54	0:02:07	23:01:01
T230111Z_ROVHD_FSH	23:01:11	0:00:58	23:02:09
T230209Z_ROVHD_AUD_BIO	23:02:09	0:00:42	23:02:51
T230326Z_ROVHD_UNK_CARGO	23:03:26	0:03:54	23:07:20
T230849Z_ROVHD_MAST_HOUSE	23:08:49	0:03:18	23:12:07
T231206Z_ROVHD_UNK_FITTING	23:12:06	0:01:48	23:13:54
T231405Z_ROVHD_GUN	23:14:05	0:04:44	23:18:49
T231917Z_ROVHD_DECK	23:19:17	0:03:39	23:22:56
T232324Z_ROVHD_PILOT_HOUSE	23:23:24	0:01:57	23:25:21
T232605Z_ROVHD_GUN_AUD	23:26:05	0:03:06	23:29:11
T233027Z_ROVHD_AUD_SITE	23:30:27	0:02:31	23:32:58
T233303Z_ROVHD_LETTERS	23:33:03	0:05:04	23:38:07
T233823Z_ROVHD_ANCHOR	23:38:23	0:01:28	23:39:51
T234013Z_ROVHD_WIDE_BOW	23:40:13	0:02:07	23:42:20
T234356Z_ROVHD_WIDE_BOW	23:43:56	0:01:38	23:45:34
T234534Z_ROVHD_BOW	23:45:34	0:04:55	23:50:29
T235029Z_ROVHD_BOW_LEAVE_SHIP	23:50:29	0:04:51	23:55:20
T235521Z_ROVHD_BOW_LEAVE_SHIP	23:55:21	0:02:05	23:57:26
T001004Z_ROVHD_FSH	0:10:04	0:00:27	0:10:31
T001219Z_ROVHD_SHI_BIO_UNK	0:12:19	0:01:13	0:13:32
T003022Z_ROVHD_BIO_UNK	0:30:22	0:00:23	0:30:45
T003057Z_ROVHD_BIO_UNK	0:30:57	0:00:33	0:31:30
T003151Z_ROVHD_BIO_UNK	0:31:51	0:00:17	0:32:08
T003526Z_ROVHD_BIO_UNK	0:35:26	0:00:19	0:35:45
T003703Z_ROVHD_JFH	0:37:03	0:00:25	0:37:28
T004222Z_ROVHD_BIO_UNK	0:42:22	0:00:16	0:42:38
T005049Z_ROVHD_BIO_UNK	0:50:49	0:00:36	0:51:25
T005224Z_ROVHD_BIO_UNK	0:52:24	0:00:15	0:52:39
T005702Z_ROVHD_BIO_UNK	0:57:02	0:00:13	0:57:15
T014347Z_ROVHD_BIO_UNK	1:43:47	0:00:21	1:44:08
T024600Z_ROVHD_DIVE_AUD	2:46:00	0:02:10	2:48:10
T024810Z_ROVHD_BOTTOM	2:48:10	0:00:55	2:49:05
T025257Z_ROVHD_SED	2:52:57	0:01:41	2:54:38
T025438Z_ROVHD_SHARK	2:54:38	0:02:02	2:56:40
T025802Z_ROVHD_SHI	2:58:02	0:03:01	3:01:03
T030108Z_ROVHD_AUD_HISTORY	3:01:08	0:02:01	3:03:09

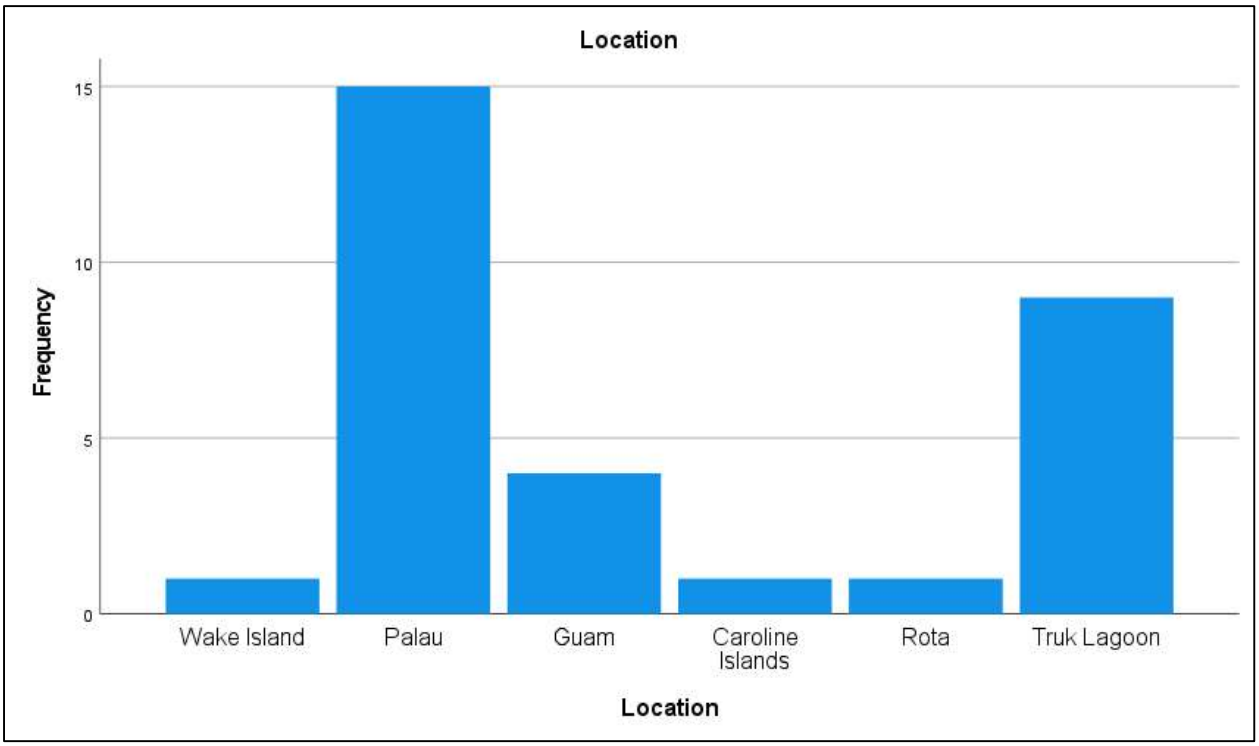
T030803Z_ROVHD_DIVE_AUD	3:08:03	0:02:05	3:10:08
T031221Z_ROVHD_POSSIBLE_ROC	3:12:21	0:04:14	3:16:35
T031636Z_ROVHD_ROC	3:16:36	0:02:27	3:19:03
T032007Z_ROVHD_SPO	3:20:07	0:01:24	3:21:31
T032429Z_ROVHD_ROC_CRACK	3:24:29	0:00:43	3:25:12
T032536Z_ROVHD_DIVE_AUD	3:25:36	0:02:01	3:27:37
T033658Z_ROVHD_BIO_UNK	3:36:58	0:01:06	3:38:04
T033808Z_ROVHD_BIO_UNK	3:38:08	0:00:19	3:38:27
T042921Z_ROVHD_BIO_UNK	4:29:21	0:00:45	4:30:06
T043012Z_ROVHD_CTE	4:30:12	0:00:59	4:31:11
T044215Z_ROVHD_BOTTOM	4:42:15	0:01:10	4:43:25
T044514Z_ROVHD_BOTTOM_FSH	4:45:14	0:01:42	4:46:56
T044752Z_ROVHD_FSH	4:47:52	0:00:20	4:48:12
T045434Z_ROVHD_APPROACH_ROC (1)	4:54:34	0:03:26	4:58:00
T045945Z_ROVHD_GEO_AUD	4:59:45	0:00:49	5:00:34
T050113Z_ROVHD_FSH	5:01:13	0:02:04	5:03:17
T050515Z_ROVHD_SPO	5:05:15	0:02:20	5:07:35
T050801Z_ROVHD_COR_SQA	5:08:01	0:01:35	5:09:36
T051247Z_ROVHD_COR_SQA	5:12:47	0:01:57	5:14:44
T051743Z_ROVHD_COR_OPH	5:17:43	0:01:00	5:18:43
T052056Z_ROVHD_ACN_GAS	5:20:56	0:01:54	5:22:50
T052339Z_ROVHD_OTHER_ROC	5:23:39	0:01:35	5:25:14
T053040Z_ROVHD_CONGRATS_MISSION	5:30:40	0:00:26	5:31:06
T053123Z_ROVHD_WRECK_OVERVIEW	5:31:23	0:00:43	5:32:06
T053408Z_ROVHD_SPO_COR_OPH	5:34:08	0:02:00	5:36:08
T053626Z_ROVHD_COR_SQA	5:36:26	0:02:08	5:38:34
T053855Z_ROVHD_COR_TUN_OPH	5:38:55	0:01:38	5:40:33
T054107Z_ROVHD_ACN	5:41:07	0:00:45	5:41:52
T054205Z_ROVHD_COR_CLUSTERS	5:42:05	0:02:36	5:44:41
T054534Z_ROVHD_SAMPLE_SQA_COR	5:45:34	0:01:15	5:46:49
T055154Z_ROVHD_COR	5:51:54	0:02:07	5:54:01
T055345Z_ROVHD_COR	5:53:45	0:01:19	5:55:04
T060420Z_ROVHD_MISSION_WRAP_AUD	6:04:20	0:05:03	6:09:23

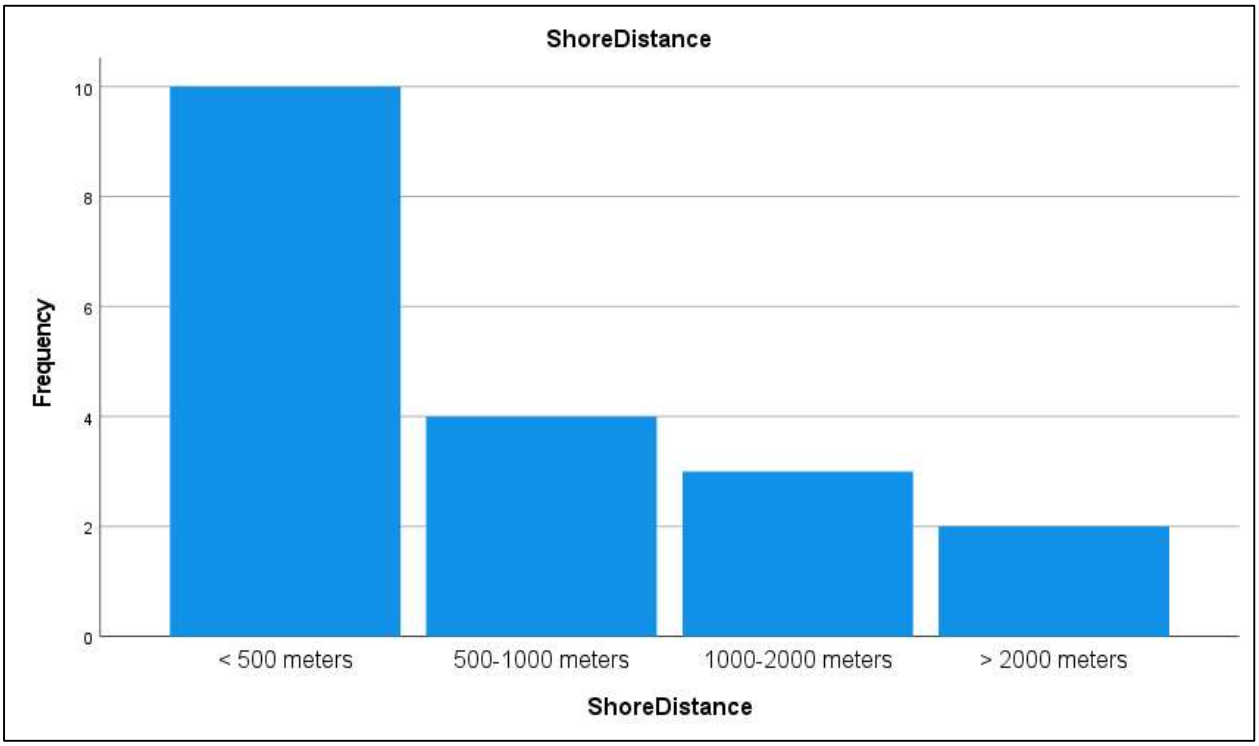
APPENDIX C: Site Formation Spreadsheet

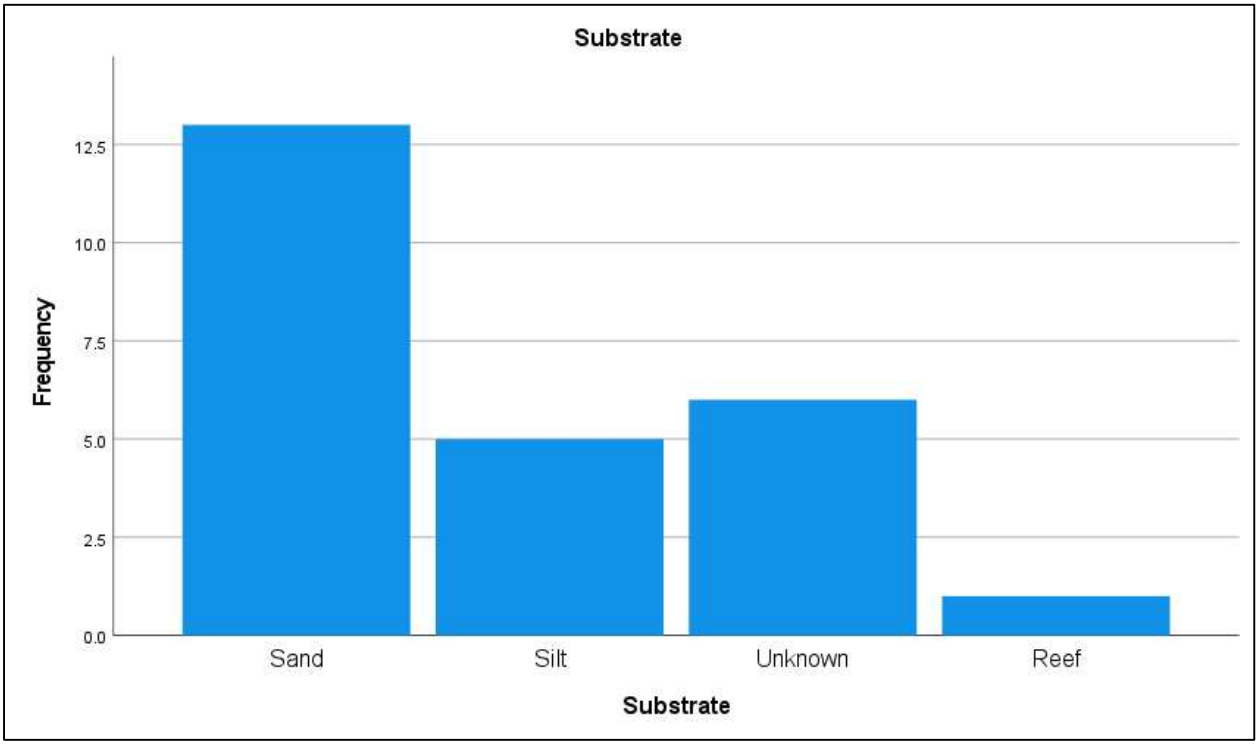
				Geographic Site Characteristics							
Vessel Name	Location	Latitude (if known)	Longitude (if known)	Distance from shore (m)	Depth (m)	Shallow or deep water wreck (0-50 m = shallow, > 50 m = deep)	Depth Zone	Avg. Water Temperature (°F)	Avg. water pressure (millibars)	Waves/Tides/Currents	Oceanfloor substrate
Amakasu Maru No. 1	Wake Island	19.28621667	166.669	1605.11	840	Deep	Mesopelagic Zone	80			Sandy
Amatsu Maru	West Malakal Anchorage, Palau	7.336111	134.439722	1039.69	40	Shallow	Epipelagic Zone	84		No current	Sandy
Aratama Maru	Talafofo Bay, Guam	13.336217	144.77135	144.22	50	Shallow	Epipelagic Zone	83	1010	No current	Sandy
Buoy #6 Wreck	Makakal Channel, Palau				21 to 27	Shallow	Epipelagic Zone	84			
Chuyo Maru	West Malakal Anchorage, Palau	7.340367	134.4395	1654.65	12 to 40	Shallow	Epipelagic Zone	84		No current	Silt
Fujikawa Maru	Truk Lagoon	7.344639	151.884861	315.61	30	Shallow	Epipelagic Zone	84			
Gosei Maru	Truk Lagoon	7.311194	151.887389	123.56	3 to 37	Shallow	Epipelagic Zone	84			Sand
Goshu Maru	Kobesang Harbor, Palau	7.345	134.446667	491.06	16	Shallow	Epipelagic Zone	84			
Gozan Maru	Palau Harbor, Palau	7.326667	134.430556	577.28	15	Shallow	Epipelagic Zone	84		No current	Silt
Hino Maru	Truk Lagoon				7.5	Shallow	Epipelagic Zone	84			
Hoyo Maru	Truk Lagoon	7.371139	151.844528	963.57	8.5	Shallow	Epipelagic Zone	84			Sand
Kamikaze Maru	Urukthapel Island, Palau	7.276389	134.419167		30	Shallow	Epipelagic Zone	84		No current	Silt
Kibi Maru	Malakal Harbor, Palau	7.315278	134.448611	210.2	14	Shallow	Epipelagic Zone	84			
Kitsugawa Maru	Apra Harbor, Guam	13.4562	144.64935	893.66	42	Shallow	Epipelagic Zone	83	1010		Sandy
Nagisan Maru	Urukthapel Island, Palau	7.5	134.5		30	Shallow	Epipelagic Zone	84		No current	Silt
Nichiyu Maru	Apra Harbor, Guam				30	Shallow	Epipelagic Zone	83	1010		
Nippo Maru	Truk Lagoon	7.382583	151.910278	224.96	48	Shallow	Epipelagic Zone	84		No current	Reef
Nissho Maru No. 5	Palau				10 to 25	Shallow	Epipelagic Zone	84			
Raizan Maru	Kobesang Harbor, Palau	7.347222	134.436667	711.6	33	Shallow	Epipelagic Zone	84			
Ryuko Maru	Ngerchaol Island, Caroline Islands	7.5	134.5		25 to 30	Shallow	Epipelagic Zone			No current	Sand
Sankisan Maru	Truk Lagoon	7.295472	151.868944	409.8	34	Shallow	Epipelagic Zone	84			Sand
Sapporo Maru	Truk Lagoon					Shallow	Epipelagic Zone	84			
Shinkoku Maru	Truk Lagoon	7.400111	151.779111	4088.11	12	Shallow	Epipelagic Zone	84			Sand
Shoun Maru	Sasanhaya Bay, Rota	14.166667	145.166667		21 to 33	Shallow	Epipelagic Zone				Sandy
Teshio Maru	Palau	7.406717	135.407067	85029.88	13	Shallow	Epipelagic Zone	84			Sandy
Tokai Maru	Apra Harbor, Guam	13.457333	144.657833	450.47	30	Shallow	Epipelagic Zone	83	1010		
Unidentified Maru No. 1	Ngeruktabel Anchorage, Belau				30	Shallow	Epipelagic Zone				Sand and s
Unidentified Maru No. 2	Malakal Harbor, Palau	7.328447	134.465989	253.35	13 to 33	Shallow	Epipelagic Zone	84			Silt
Unidentified Maru No. 3	Malakal Harbor, Palau				15	Shallow	Epipelagic Zone	84			
Urakami Maru	Malakal Harbor, Palau	7.311667	134.448056	63.06	39	Shallow	Epipelagic Zone	84		No current	Sandy
Yubae Maru	Truk Lagoon				18-37	Shallow	Epipelagic Zone	84			

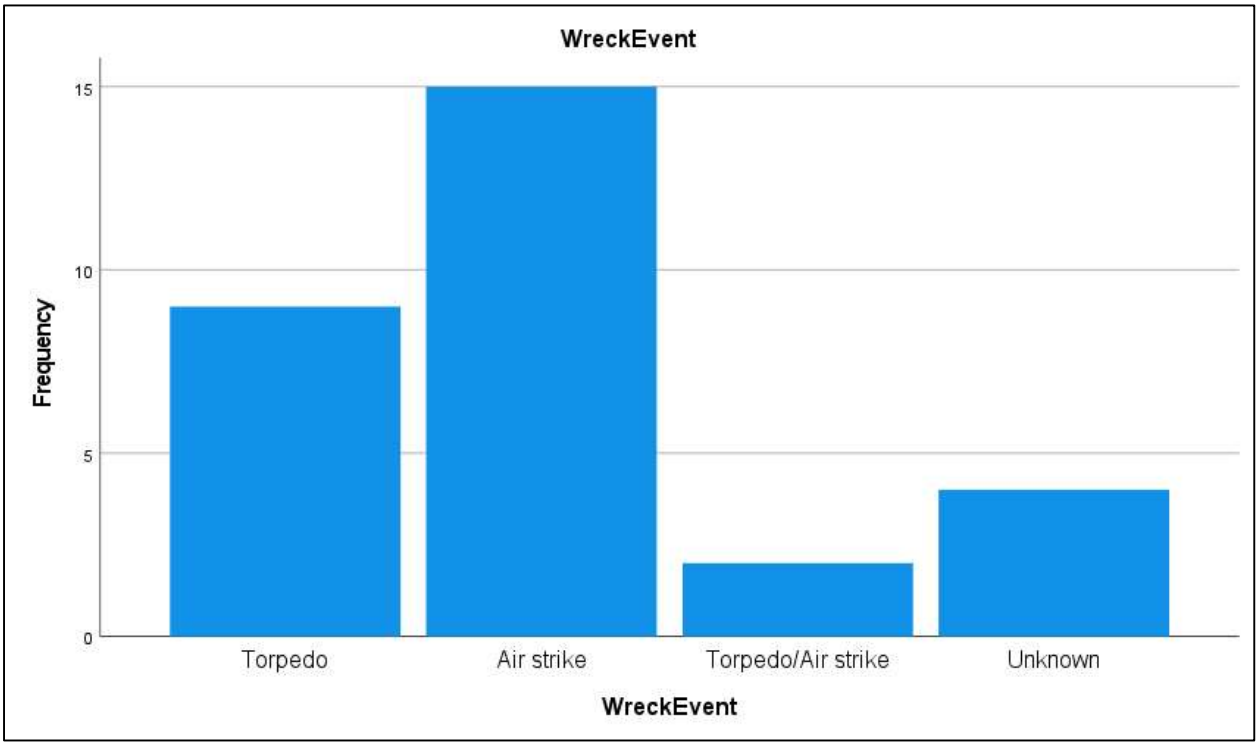
	Vessel Characteristics			Biological Impacts	Anthropogenic Impacts						
Wrecking Event (intact, disintegration, capsize, intentional deposition, inundation, refuse, military action)	Vessel final resting position	Cargo (Presence and type)	Presence of debris field?	Presence of marine life?	Archaeological Survey?	Tourism Attraction?	Salvage Operations?	Penetration diving?	Impacts from trawling or anchor cables?	Undassified Anthropogenic Impact	Notes
Military action (torpedo)	Upright		Yes	sponges, gorgonians, anemones, fishes	Yes	No	**No**				
Military action (air strike)	Upright			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes	Yes			
Military action (torpedo)	List to port			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes			Yes	Ntl. Register of Historic Places
				sponges, gorgonians, anemones, fishes	Yes	Yes					
Military action (air strike)	Upright			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes	Yes	Yes		
Military action (torpedo)	Upright	Zero aircraft		corals, fish	Yes (corros	Yes		Yes			
Military action (torpedo)	listing to port			coral coverage	Yes (corros	Yes		Yes			
Military action (air strike)			25-foot high stack of 50-gallon barrels	sponges, gorgonians, anemones, fishes			Yes				
Military action (air strike)	List to port			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes	Yes			
Military action (air strike)	Upright				Yes	Yes		Yes			
Military action (air strike)				coral, sponges, fishes	Yes (corros	Yes		Yes			
Military action (air strike)	List to port			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes	Yes			
Military action (air strike)			30 x 21 meters wide	sponges, gorgonians, anemones, fishes	Yes		Yes				
Military action (air strike)	Upright			sponges, gorgonians, anemones, fishes	Yes	Yes		Yes	Yes	Yes	
Military action (air strike)	Upright	Fuel drums	Scattering of fuel drums around wreck site	sponges, gorgonians, anemones, fishes	Yes	Yes					
Military action (torpedo/air strike)				sponges, gorgonians, anemones, fishes						Yes (near commercial fuel pier)	
Military action (air strike)	List to port	Ammunition		coral, sponges, fishes	Yes (corros	Yes		Yes			
Military action (air strike)			61 meters long	sponges, gorgonians, anemones, fishes	Yes		Yes				
Military action (air strike?)				sponges, gorgonians, anemones, fishes	Yes	Yes	Yes				
Military action (torpedo)	Upright			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes	Yes			
Military action (torpedo)		Ammunition		coral, fish	Yes (corros	Yes		Yes		Dynamite fishing	
Military action (air strike)	List to starboard	Bell			Yes (corros	Yes					
Military action (torpedo)	Upright			corals, anemones, gorgonian fan corals, sponges, fish	Yes (corros	Yes		Yes			
Military action (torpedo)	Upright	Paint cans, bathtubs, motorcycle (random assortment)		sponges, gorgonians, anemones, fishes		Yes	Yes				
Military action (air strike)	Listing to Starboard			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes				
Military action (torpedo)	85° list to port			sponges, gorgonians, anemones, fishes		Yes		Yes	Yes		Ntl. Register of Historic Placces
Military action (air strike)	List to port			sponges, gorgonians, anemones, fishes							
				sponges, gorgonians, anemones, fishes		Yes					
				sponges, gorgonians, anemones, fishes							
Military action (air strike)	List to starboard			sponges, gorgonians, anemones, fishes	Yes	Yes	Yes				
Military action (torpedo)	Upside down			corals, fishes	Yes (corros	Yes		Yes			

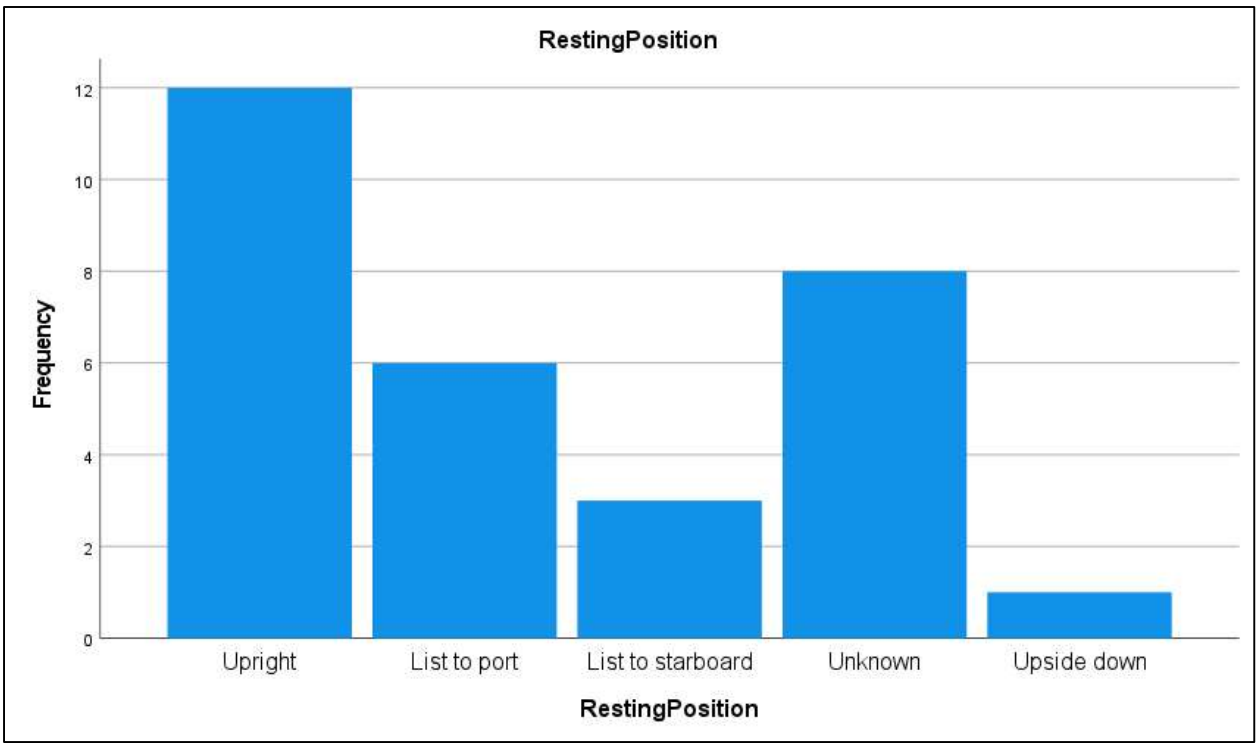
APPENDIX D: Statistical Analysis of Pacific Requisitioned Wrecks

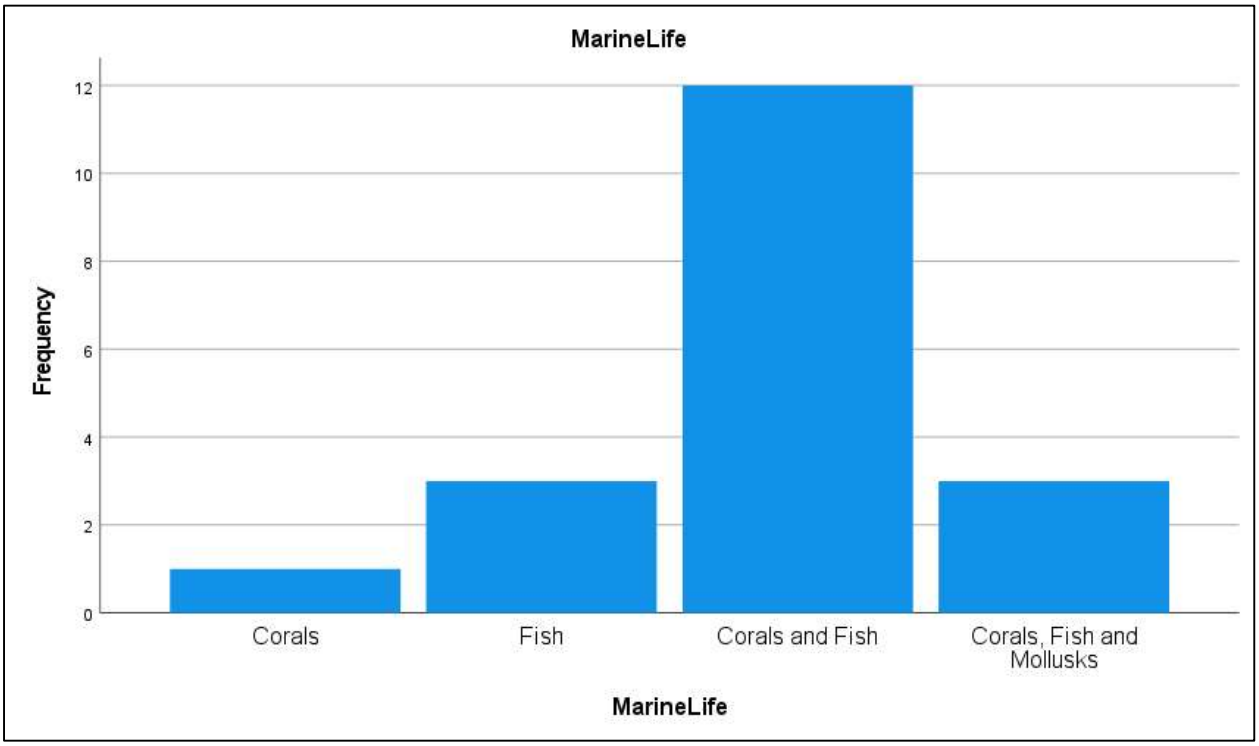


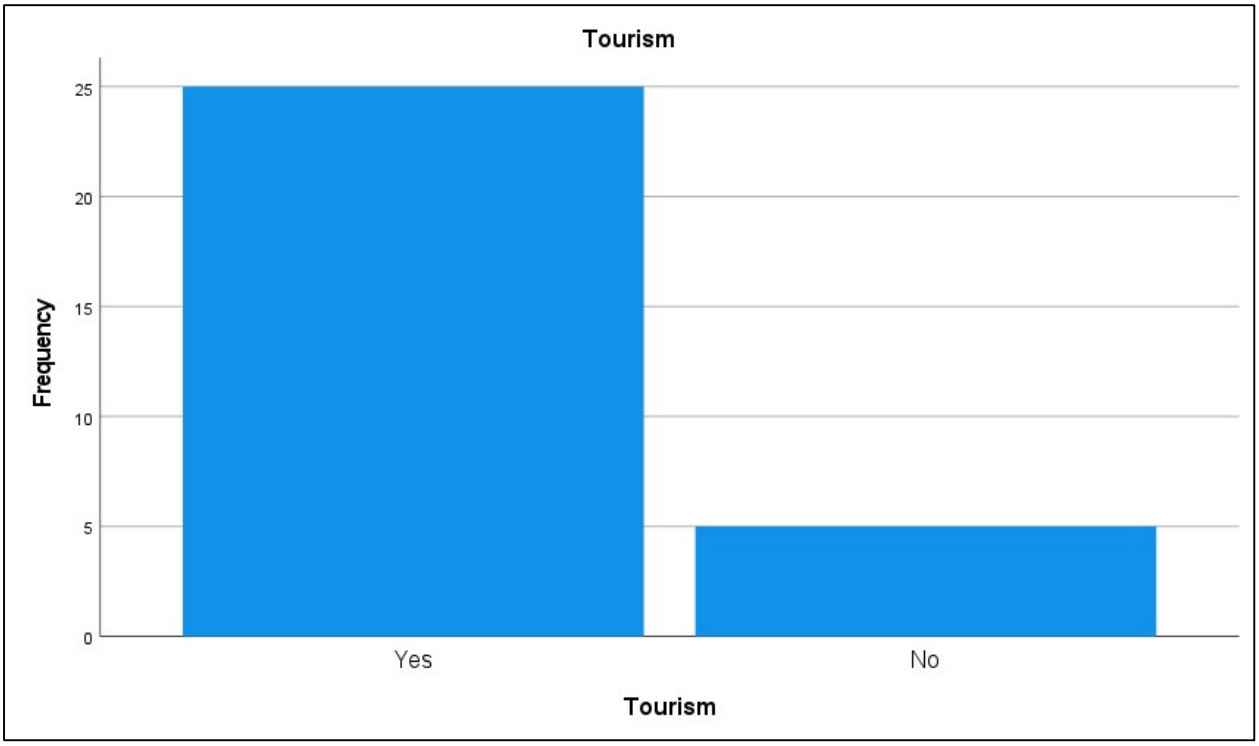


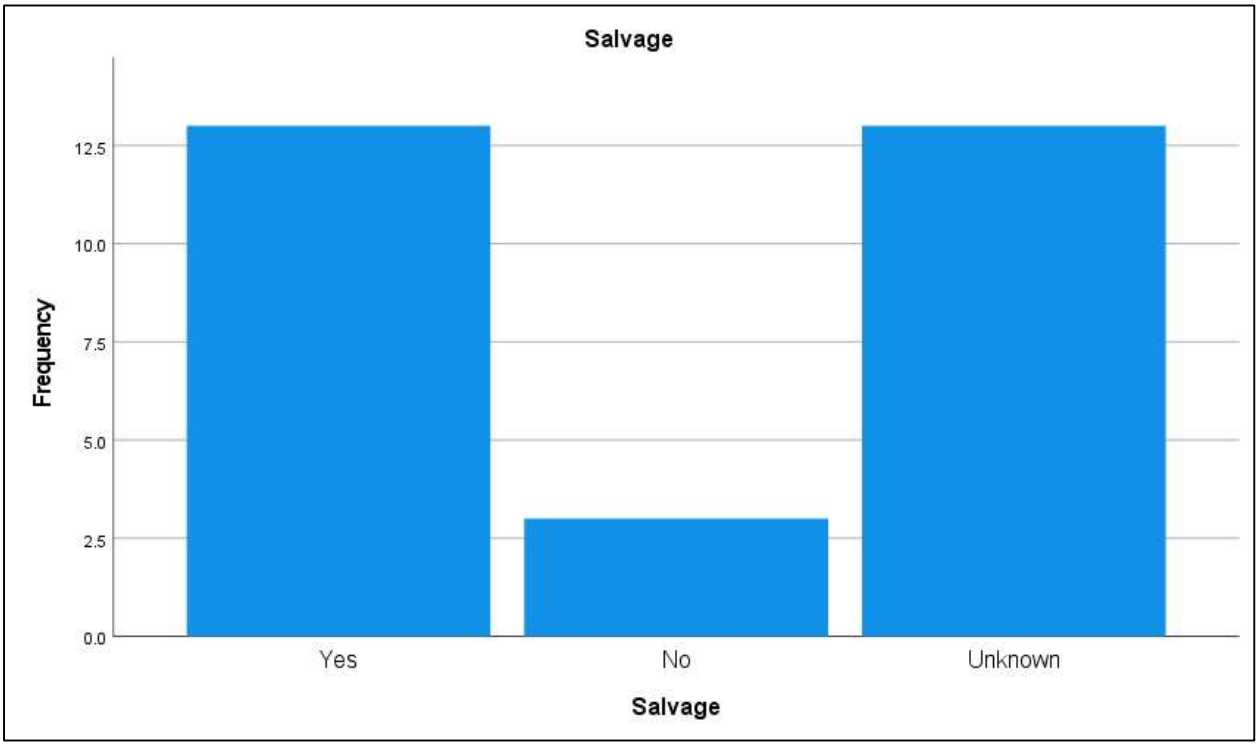

Substrate
Frequency
12.5
10.0
7.5
5.0
2.5
0.0
Sand
Silt
Unknown
Reef
Substrate


WreckEvent
Frequency
15
10
5
0
Torpedo
Air strike
Torpedo/Air strike
Unknown
WreckEvent


RestingPosition
Frequency
12
10
8
6
4
2
0
Upright
List to port
List to starboard
Unknown
Upside down
RestingPosition


MarineLife
Frequency
12
10
8
6
4
2
0
Corals
Fish
Corals and Fish
Corals, Fish and Mollusks
MarineLife


Tourism
25
20
15
10
5
0
Frequency
Yes
No
Tourism


Salvage
12.5
10.0
7.5
5.0
2.5
0.0
Frequency
Yes
No
Unknown
Salvage