I Can Ex-Plane

A Study of Site Formation of Submerged Aircraft in Saipan

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3 December 2010
Declaration

This thesis represents original research undertaken for the Masters in Maritime Archaeology Degree at Flinders University. It was completed in 2010. The interpretations presented in this thesis are my own and do not represent the view of any other individual or group.

Samantha Andrianna Bell
December 2010
Abstract

There has been little development of site formation theory in the study of submerged aircraft as a maritime archaeological resource. This thesis examines the application of previously established “process-oriented” frameworks for shipwreck site formation to submerged aircraft sites. Furthermore, this thesis includes an additional process which adapts previously established site formation diagrams, contributing to the understanding of these sites.

Four submerged World War II aircraft are examined using previously established shipwreck site formation models. These sites include: an Aichi E13A, Kawanishi H8K, Martin PBM Mariner and TBM Avenger which were all sunk in Tanapag Lagoon, Saipan, CNMI. A review of literature pertaining to this study is developed and includes shipwreck site formation, submerged aircraft studies, site formation studies on submerged aircraft and management of submerged aircraft. This thesis provides a history of the Battle of Saipan and histories of the individual aircraft examined in this study.

Investigations of these sites were completed over several field seasons resulting in site plans and photographic documentation of cultural and environmental impacts affecting all four sites. Based on the data collected, an analysis is made of the processes affecting the site formation of each aircraft. This thesis compares previously established extracting filters and scrambling devices of shipwreck sites to submerged aircraft. This thesis discusses the ability to understand submerged aircraft using site formation models developed for shipwreck sites, and the adaptations necessary to understand these sites. The benefit of this research for heritage managers is also discussed. Finally, areas of
future research are presented including further investigations in Saipan as well as submerged aircraft site formation.
Acknowledgements

There are many people I must acknowledge, without whom this thesis would have never been possible. First and foremost I would like to extend an abundance of gratitude to my supervisor Jennifer McKinnon without whom I would have never been able to complete this study. Her assistance in the development of this research and her willingness to deal with countless email and verbal correspondence with me is greatly appreciated.

Additionally, I would like to thank Mark Staniforth, whose has shared his vast knowledge and expertise in maritime archaeology. Further I would like to thank Emily Jateff, who helped provide insight on various issues in maritime archaeology and has made my experience at Flinders University enjoyable.

Many parties were involved in the fieldwork conducted for this project - the effort of all is greatly appreciated. Ships of Discovery is at the forefront of these parties as without their work obtaining the National Park Service American Battlefield Protection Program Grant, this project would have never been possible. “This material is based upon work assisted by a grant from the Department of the Interior, National Park Service. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Department of the Interior.”

Gratitude is also extended to the Commonwealth of the Northern Marianas Islands’ Historic Preservation Office for sharing their knowledge of the islands’ history and extensive library. Further thanks must be given to those who worked so diligently on the site plans for the four sites in February including: Shawn Arnold, Karolyn
Gauvin, Peter Harvey, Toni Massey, Jennifer McKinnon, Jason Raupp, Della Scott-Ireton and David Steinberg. I would also like to acknowledge all those who participated in the June 2010 practicum contributing to the collection of my data: Rachel Katz, Ash Fowler, Karolyn Gauvin, Kelly Greenwalt, Roger Halliday, Matthew Hanks, Peter Harvey, Emily Jateff, Ania Legra, Jennifer McKinnon, Jenni Milochis, Sarah Nahabedian, John Naumann, Jeffrey Pardee, Jason Raupp, Kotaro Yamafune.

I would like to give additional special thanks to maritime archaeology students, Matthew Hanks, Britt Burton and Toni Massey for their supportive help throughout the process of completing this thesis.

Finally, I must express gratitude to my family and friends for keeping me sane by providing encouragement and understanding during this time. I love you all!
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<tr>
<td><strong>Aileron</strong></td>
<td>A movable aerofoil used to control the balance of an aircraft in flight; a hinged flap in the trailing edge of a wing.</td>
</tr>
<tr>
<td><strong>Ammo Box</strong></td>
<td>A box which holds ammunition.</td>
</tr>
<tr>
<td><strong>Cowling</strong></td>
<td>The removable covering over the engine of an airplane.</td>
</tr>
<tr>
<td><strong>Cultural Factors</strong></td>
<td>Site formation processes which are affected by human inference; these may include but are not limited to jettisoning, salvage operations and recreational diver impacts (Gibbs 2006:4).</td>
</tr>
<tr>
<td><strong>Dihedral Wing</strong></td>
<td>An angle made by an aircraft's wing, which is less than 180 degrees.</td>
</tr>
<tr>
<td><strong>Environmental Factors</strong></td>
<td>Site formation processes which are affected by the environment including physical, biological and chemical (Ward, et al. 1998:561).</td>
</tr>
<tr>
<td><strong>Extracting Filters</strong></td>
<td>Processes which extract material from the wreck assemblage (Muckelroy 1978:159).</td>
</tr>
<tr>
<td><strong>Flying Boat</strong></td>
<td>A seaplane whose main body is a hull adapted for floating.</td>
</tr>
<tr>
<td><strong>Gun Mount</strong></td>
<td>A fixed mount that allows the gun to be freely traversed and/or elevated whilst keeping the gun in one fixed position.</td>
</tr>
<tr>
<td><strong>Nose</strong></td>
<td>The front end of an aircraft.</td>
</tr>
<tr>
<td><strong>Opportunistic Salvage</strong></td>
<td>Non-systematic removal of wreck artifacts commencing soon after the wrecking event (Gibbs 2006:14).</td>
</tr>
<tr>
<td><strong>Pontoon</strong></td>
<td>A seaplane float.</td>
</tr>
<tr>
<td><strong>Scrambling Devices</strong></td>
<td>Stages in the process of wrecking which involve the rearranging of artifact material (Muckelroy 1978:159).</td>
</tr>
</tbody>
</table>
Steering Column  The shaft that connects the steering wheel to the steering gear assembly.

Site Formation Process  Process through which an organized assemblage of artifacts comprising a ship and its contents must pass through to produce the collection of items observed on the seabed (Muckelroy 1978:157).

Systematic Salvage  Professional salvers hired following the wrecking of the vessel in order to remove all or some cargo, fittings and structural elements (Gibbs 2006:14).

Tail fin  Vertical stabilizers located at the aft end of an aircraft intended to reduce aerodynamic side slip.

Turret  A revolving tower or enclosure for a gun and gunner on an aircraft.

Wingspan  The distance between the wingtips of an aircraft
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>CNMI</td>
<td>Commonwealth of the Northern Marianas Islands</td>
</tr>
<tr>
<td>EH</td>
<td>English Heritage</td>
</tr>
<tr>
<td>IJN</td>
<td>Imperial Japanese Navy</td>
</tr>
<tr>
<td>KBS</td>
<td>Korean Broadcasting System</td>
</tr>
<tr>
<td>NHHC</td>
<td>Naval History &amp; Heritage Command</td>
</tr>
<tr>
<td>RAAF</td>
<td>Royal Australian Air Force</td>
</tr>
<tr>
<td>SCRU</td>
<td>Submerged Cultural Resources Unit</td>
</tr>
<tr>
<td>SLW</td>
<td>Spring Low Water</td>
</tr>
<tr>
<td>UDT</td>
<td>Underwater Demolition Team</td>
</tr>
<tr>
<td>USN</td>
<td>United States Navy</td>
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Introduction

The study of submerged aircraft as an archaeological resource is a relatively new field which has been examined by few maritime archaeologists. Most maritime archaeologists are not trained to understand submerged aircraft wreck sites as extensively as they are trained to understand shipwreck sites. Cooper emphasizes this point by stating, “I am a nautical archaeologist whose work in developing a program for naval submerged cultural resources management ran headlong into the problems of evaluating submerged aircraft wrecks as a potential cultural resource” (1994:135). As most maritime archaeologists have little background in this area, the study of submerged aircraft will contribute to understanding a broader scope of underwater archaeological resources beyond shipwrecks. Additionally, as the majority of archaeology conducted on aircraft has remained “relic-orientated” (Gould 1983:117), further theoretical research will broaden the spectrum of aircraft studies moving their research into the academic field of underwater archaeology.

One of the best ways to gain knowledge of submerged aircraft wrecks is by researching and understanding their site formation. As the wrecking event of aircraft and shipwrecks are vastly different, it is speculated that the processes affecting their site formation may be distinct. Thus, it is necessary to understand the various factors involved in the site formation of submerged aircraft wreck sites to determine if there is a correlation with shipwreck site formation. This thesis intends to explore how useful site formation theory can be to the investigation of submerged aircraft and to identify and examine the site formation processes involved in these sites. Few
studies have investigated the site formation of submerged aircraft, yet the results have proven successful in expanding our knowledge of historical events (Coble 2004, Jung 1996, 2001, 2007a, 2007b, 2008, 2009). The importance of site formation research is emphasized by Schiffer (1987:7) who states: “To make justifiable inferences the investigator must consider and take into account the factors that have introduced variability into the historical and archaeological records.” Submerged aircraft have considerable archaeological potential; the application and development of site formation theory for these sites will broaden our understanding of the sites themselves and how to conduct appropriate research.

Aims and Objectives

This thesis represents the initial study of theoretical and methodological practices in submerged aircraft archaeology and the application of site formation theory. The objective of this thesis is to answer the following research questions:

- Can submerged WWII aircraft sites in Saipan, CNMI be investigated and understood using previous shipwreck models of site formation “process-oriented framework?”

- What adaptations to shipwreck site formation “process-oriented frameworks” are necessary for the interpretation of submerged aircraft sites?

- Does a site formation “process-oriented framework” developed for submerged aircraft wrecks allow for a comparative analysis and broader understanding of those aircraft and the cultural and environmental factors involved in their observed distribution on the seabed?
This thesis utilizes previously established process-orientated shipwreck site formation models and applies them to four historic submerged aircraft sites located in Saipan, Commonwealth of the Northern Marianas Islands (CNMI). The sites chosen for this study include: an Aichi E13A Japanese reconnaissance float plane, a Kawanishi H8K Japanese flying boat, a Martin PBM Mariner U.S. flying boat and a TBM Avenger U.S. torpedo bomber. All four sites were involved in World War II operations and vary in their observed site distribution.

The archaeological and historical investigations record the four sites in situ and this data is used to determine if shipwreck site formation theory can be applied to submerged aircraft sites. Additionally, this thesis proposes adaptations to shipwreck site formation models in order to comprehend submerged aircraft sites and factors contributing to their site formation. Results of this study intend to create a broader understanding of site formation for known submerged aircraft sites in Saipan which can illuminate their role in World War II.

**Location**

All four sites are located in Tanapag Lagoon on the North-West side of Saipan, the largest island in the CNMI (Figure 1.1). Saipan served as the venue for a pivotal battle in the Pacific during World War II. Evidence of this can be readily seen on the island including strafing on cliff faces, deteriorating Japanese tanks and monuments to those who lost their lives. Sherman tanks still can be seen offshore sitting eerily in their battle position with only their turret visible above the water (Figure 1.2).
Tanapag Lagoon also hosts a number of World War II wreck sites that cannot be seen from the shoreline, but are easily accessible to the diving community. Known sites include amphibious landing craft, a freighter, barges and four aircraft (Carrell 2009).

In 2009, the National Park Service American Battlefield Protection Program Grant awarded Ships of Exploration and Discovery, a not for profit group, funding to create a World War II underwater heritage trail in Saipan, CNMI. Ships of Discovery in collaboration with Flinders University have conducted fieldwork over two years in order to identify and document archaeological remains from World War II. Results of this field work are intended to be used to create brochures, underwater guides to the sites and shore based interpretive material (McKinnon 2010).
As tourism is a growing industry in Saipan, this project will benefit the local economy as well as create a sense of cultural heritage appreciation. During the June 2010 fieldwork season, students from a variety of universities were invited to participate in a Flinders University practicum to gain archaeological field experience and the opportunity to be involved in the preliminary stages of heritage trail development. The data collection for the four submerged aircraft sites investigated for this thesis was conducted at this time.
Sites

Aichi E13A

The Aichi E13A, allied code named “Jake,” was a Japanese long distance reconnaissance float plane. Japanese forces operated more aircraft of this type than any other aircraft type during World War II (Francillon 1970:277). The site is located offshore near Mañagaha Island, a small vacation island on the far side of Tanapag Lagoon. This aircraft lies upside down on the seabed and many of its features remain intact. Features of this aircraft include: bomb dropping mechanism, camera sight hole, and wing float.

Kawanishi H8K

The Kawanishi H8K, allied code named “Emily,” was a large four engine Japanese reconnaissance flying boat. Its performance during the war was considered exceptional with fast flying capabilities and more superior hydrodynamic qualities than any U.S., British or German contemporary (Green 1962:13). This aircraft lies inverted on the seabed with a substantial wreck site distribution. The large wingspan of the Kawanishi H8K lies in the middle of the wreck scatter. This site is visited heavily by recreational divers and includes both Korean and Japanese monuments. Features found on this site include nose turret with gun pointing towards the surface, cockpit with pilot chair and controls, all four engines with propellers attached and fuselage with original paint.
Martin PBM Mariner

Martin PBM Mariner was a U.S. flying boat used in offensive campaigns during World War II. Mariners were involved in all major campaigns in the Pacific including the Battle of Saipan where it participated in attacks on Japanese submarines, freighters and aircraft (Hoffman 2004:xiii). Site distribution is substantial with the largest portion of the wreck lying inverted. Features of this site include gun turret, gun mount, ammo boxes, control levers, tail section and the aircraft’s discernible dihedral wing.

TBM Avenger

The TBM Avenger was a U.S. torpedo bomber which was the most widely produced naval strike aircraft of all time (Tillman 1999:6). Avenger played a significant role in the Battle of Saipan providing offensive support contributing to the U.S. victory. The site is located inverted on the fringing reef with environmental factors substantially contributing to its observed seabed distribution. An interesting feature of this site includes the landing gear fully extended which breeches the surface during low tides.

Significance

The significance of this research is multifaceted. First and foremost, this thesis aspires to improve upon the comprehension of submerged aircraft site formation by adapting previously established shipwreck site formation models to their study. This enables maritime archaeologists, who are primarily trained in shipwreck site formation, to understand the factors which create and affect the archaeological record
of submerged aircraft in comparison to shipwreck sites. Further, this study assists researchers in understanding the extracting filters and scrambling devices involved in the formation of submerged aircraft sites as well as assisting in management considerations. Additionally, this work provides a stepping stone for further study into submerged aircraft site formation processes by proposing adaptations to shipwreck site formation models which may be improved upon with additional research. This contributes to the growth of methodological and theoretical discussions within the discipline.

The submerged aircraft sites used in this research represent a major battle that has been often referred as the “D-Day of the Pacific War” (Goldberg 2007). These aircraft serve as a reminder of the battle itself, paying tribute to the thousands of soldiers who lost their lives. As World War II was heavily influenced by aircraft combat, the sites also reflect the various advancements of naval aircraft technology. Diversity in types of aircraft wreck sites located in Tanapag Lagoon is not often found in the archaeological record in other parts of the Pacific which makes their study as a whole significant. Individual archaeological research of the sites also provides historical information which can broaden our understanding of the aircraft and the personnel who used them.

The submerged aircraft sites in Tanapag Lagoon are significant independently as well as to the study as a whole. The Martin PBM Mariner has been referred to as the fighting flying machine and is often overshadowed by the more famous PBY Catalina flying boats (Hoffman 2004:xiv). Its significance is substantial as this type of flying boat was used by the United States Navy (USN) from World War II through the Korean War. However, few underwater archaeological studies have been
completed and those that have, focused on salvage efforts (Martin BPM Mariner Patrol Bomber 2010). Kawanishi H8K flying boats are also rare; a fully intact World War II representation can be found at the Museum of Maritime Science in Tokyo, Japan and a submerged Kawanishi H8K is also located in Chuuk Lagoon, Federated States of Micronesia but has not been researched in depth (Jeffrey 2007). The Aichi E13A was used quite successfully by Japanese pilots for long range reconnaissance as well as bombing missions and kamikaze attacks later in the war (Francillon 1970:279). Many submerged sites of this aircraft type are known, however, these sites have not been examined archaeologically. The TBM Avenger is different from the other sites because not only were thousands of these aircraft types used during the war, many of them can be located fully intact and displayed in museums. This site provides an excellent example of environmental impacts on aircraft wrecks due to its location on the reef.

**Thesis Outline**

This chapter provides a brief introduction to the importance of submerged aircraft studies in underwater archaeology including understanding their site formation. Research questions for this thesis are presented along with a brief description of how these questions will be answered. An introduction to the sites is given as a basis for this study along with a description of the location, why these sites were chosen and the larger project they contribute to. Finally, the significance of this research is also given.

Chapter Two reviews prior research of shipwreck site formation, beginning with definitions of key terminology which are followed by the examination of
Muckelroy’s initial research. Criticism and modifications are proposed in order to provide the theoretical background for this study. Previous studies of submerged aircraft and site formation of submerged aircraft sites are investigated in order to gain knowledge of research conducted in the field. The application of theoretical approaches in these studies is also examined. Additionally, this chapter addresses the management considerations and legislation of historic submerged aircraft.

Chapter Three provides a firm background on the Battle of Saipan including the war up to the battle from the U.S. perspective and the Japanese perspective, the battle itself and the aftermath of the invasion. Furthermore, histories are provided for each aircraft to emphasize their role in the Battle of Saipan and the importance of investigation. This chapter also outlines the specifications of each aircraft.

Chapter Four describes in detail the methodology used to gather information essential to answer the research questions. An examination of archaeological surveys previously conducted on the sites provides a firm understanding to the methods chosen. Following this, explanations are given as to the survey techniques used during the February 2010 field season and the purpose for choosing these methods. Additionally, methods used for documenting the cultural and environmental impacts are explained as well as methods for recording aircraft wreck scatter. Methods used in gathering historical documentation are presented and a description given for their use in this study. An explanation is given on how the data collected will be used and processed in order to understand the site formation of the submerged aircraft sites.

Chapter Five presents the data collected and its relation to site formation processes of submerged aircraft wrecks. A description of the observed site distribution is given for each site. This is followed by an analysis of site formation
processes affecting the sites including environmental and cultural impacts. After each site is analyzed individually, a comparison of factors affecting all four sites is presented. Finally, an analysis of the extracting filters and scrambling devices which contribute to the site formation of shipwreck sites are examined for their application to all submerged aircraft sites.

Chapter Six uses the analysis in chapter five to answer the research questions. A determination is made if submerged aircraft sites can be examined using previously established shipwreck process-orientated site formation models. Adaptations deemed necessary to examine submerged aircraft are proposed with alterations to previous shipwreck site formation models. This chapter also investigates the effectiveness of this study in the understanding submerged aircraft. Additionally, management considerations are addressed based on the results of this investigation. This chapter also includes possibilities for further research, and concludes the thesis by reviewing the aims of the research, analysis and findings.
Literature Review

Introduction

The study of submerged aircraft is not considered a branch of maritime archaeology. As defined by Muckelroy (1978:4), maritime archaeology is “the scientific study of the material remains of man and his activities on the sea.” Since submerged aircraft wrecks are examples of human activities in the air, their study does not fit this definition. The Encyclopedia of Underwater and Maritime Archaeology distinguishes the difference between maritime archaeology and underwater archaeology by stating, “The term [underwater archaeology] refers to the environment in which the work is undertaken, as well as specific approaches required for working underwater, and the unique levels of preservation not usually found on dry land sites” (Delgado 1997:436). The critical problem with these definitions is that those who practice underwater archaeology are usually maritime archaeologists. If maritime archaeologists are trained to understand sites associated with seafaring, then a large portion of underwater archaeological resources are being investigated by archaeologists who are ill equipped to study them. Furthermore, the study of submerged aircraft is completely absent in Delgado’s Encyclopedia of Underwater and Maritime Archaeology, which was published in 1997. This omission emphasizes the recent nature of the study of submerged aircraft in underwater archaeology. Submerged aircraft are significant archaeological resources which can broaden our understanding of the vehicles themselves and human interaction with them.

This chapter introduces definitions synonymous with shipwreck site formation, followed by an examination of literature on site formation models and their
development, to create a theoretical and methodological framework for this research. Further, this chapter recognizes previous studies on submerged aircraft as a sub-discipline of underwater archaeology in order to establish methodologies, research frameworks, legal constraints and knowledge gained. Studies combining submerged aircraft and site formation are also examined for their contribution to the field and their use of site formation theory. Finally, this chapter analyzes management issues faced by heritage managers and their ability to protect these sites.

**Definitions**

The study of shipwreck site formation theory involves terminology that has been developed over decades by a number of maritime archaeologists (Muckelroy 1978; War, *et al.* 1998; Gibbs 2006). For the purpose of this thesis, the following definitions are provided in order to create a basis for understanding site formation terminology synonymous with shipwreck site formation:

- **Site formation process**: Process through which an organized assemblage of artifacts comprising a ship and its contents must pass through to produce the collection of items observed on the seabed (Muckelroy 1978:157)

- **Scrambling devices**: Stages in the process of wrecking which involve the rearranging of artifact material (Muckelroy 1978:159)

- **Extracting filters**: Processes which extract material from the wreck assemblage (Muckelroy 1978:159)

- **Cultural factors**: Site formation processes which are affected by human inference; these may include but are not limited to jettisoning, salvage operations and recreational diver impacts (Gibbs 2006:4)
• **Environmental factors:** Site formation processes which are affected by the environment including physical, biological and chemical (Ward, *et al.* 1998:561)

• **Systematic salvage:** Professional salvers hired following the wrecking of the vessel in order to remove all or some cargo, fittings and structural elements (Gibbs 2006:14)

• **Opportunistic salvage:** Non-systematic removal of wreck artifacts commencing soon after the wrecking event (Gibbs 2006:14).

**Site Formation Theory**

Archaeological site formation theory was developed with the idea that the archaeological record is processual. In other words, each site experienced certain processes which contribute to the formation of the observed site distribution. Archaeologists are responsible for understanding processes that may affect an archaeological site in order to recover valuable and accurate information from a site.

According to Schiffer (1987:7),

Formation processes are of two basic kinds cultural, where the agency of transformation is human behavior; and non-cultural, in which the agencies stem from processes of the natural environment…Cultural formation processes can be defined more concretely as the process of human behavior that affect or transform artifacts after their initial period of use in a given society…Noncultural formation processes are simply any and all events and processes of the natural environment that impinge upon artifacts and archaeological deposits [sic].

Schiffer (1987:8) stressed the importance of creating new principles and adapting site formation processes in order to develop a strong foundation for archaeological inference. These concepts of site formation processes have been applied in both terrestrial and maritime archaeological practices.
Keith Muckelroy (1978) published the seminal work on shipwreck site formation in which the importance of identifying various processes that affect shipwreck sites in order to decipher the evidence present on the seabed were discussed. Muckelroy (1978:158) presented a visual diagram of shipwreck site formation stating, “The flow diagram…represents the processes through which that organized assemblage of artifacts comprising a ship and its contents will have passed to produce the collection of items excavated on the sea-floor” (Figure 2.1). This visual representation of process-oriented site formation includes both extracting factors and scrambling devices which are essential for archaeologists to understand. According to Muckelroy (1978:165), three types of extracting filters that affect the observed seabed distribution of a shipwreck site: the process of wrecking, salvage operations and the disintegration of perishables. Two scrambling devices affect shipwreck sites which include: the process of wrecking and seabed movement (Muckelroy 1978:175). Considered the inaugural work for shipwreck site formation study, this diagram has been criticized and redeveloped or expanded by subsequent publications (Keith & Simmons 1985; Hardy 1990; Ward, et al. 1998; Gibbons & Adams 2001; Gibbs 2006).
One notable expansion to this diagram was developed by Gibbs (2006) who focused primarily on the cultural processes involved in the site formation processes (Figure 2.2). Gibbs (2006:4) proposed, “By adopting a process-oriented framework, we can integrate and synthesize the documentary, oral and archaeological evidence of human response to shipwreck into a structure which parallels the physical progress of danger.” As an alternative approach, Gibbs (2006:7) suggests that in order to understand cultural processes an understanding into the nature of the event is necessary. For instance, a “catastrophic” shipwreck event is going to have a different human reaction than an “intentionally deposited” wreck or abandoned vessel. Furthermore, Gibbs examined disaster response models in order to understand human
reactions during stages of disaster as well as post-disaster reactions including rescue and salvage. Gibbs also provided definitions for two separate types of salvage including systematic salvage and opportunistic salvage. Systematic salvage involves professional salvers who are commissioned to remove all or some of the wreck material and/or cargo. Opportunistic salvage includes a very quick and non-systematic removal of material which is dependent on the accessibility of the shipwreck. Unfortunately, Gibbs fails to recognize terminology used for salvage by recreational or treasure hunting ventures.

![Figure 2.2 – “Cultural factors in shipwreck site formation” (Gibbs 2006:16).](image)

An alternative approach to Muckelroy’s shipwreck process diagram is the adaptation suggested by Ward, Larcombe and Veth (1999). Their research provided a
framework for natural processes involved in shipwreck site formation with an emphasis on shipwreck site disintegration; their work depicted these environmental factors as measurable parameters (ibid. 1999). Major classes of environmental processes affecting shipwreck sites include physical, biological and chemical factors. Physical processes include various items which can cause physical changes to the wreck site. For example, sediment scouring and loss of wreck structure due to wave action were acknowledged as physical processes (ibid. 1999:562). Biological processes included burrowing organisms or biological growth affecting the wreck structure which can be measured using growth rate equations (ibid. 1999:563). Chemical processes involve the reaction of the chemical make-up of shipwreck products with the sea; these processes can be measured using corrosion rate and growths rates of concretions (ibid. 1999:563). The flowchart presented in this study features the adaptations incorporating these processes (Figure 2.3).

All three of these studies contribute to the understanding of site formation processes creating and affecting the observed seabed distribution of shipwreck sites. Research in this area enables maritime archaeologists to understand the environmental and cultural factors affecting shipwreck sites. These works also provide the basic theoretical and methodological framework for this research. Nonetheless the application of these studies to the investigation of submerged aircraft is minimal as will be outlined below.
Submerged Aircraft Site Studies

Numerous archaeological studies have been conducted on submerged aircraft around the world. A major portion of the archaeological work conducted on submerged aircraft sites were the result of avocational interests in a particular aircraft or wrecking event. Gould (1983:105) provided one of the first examples of middle range theoretical adaptations to aircraft sites comparing information gathered from archaeological investigations of the Spanish Armada of 1588 with the Battle of Britain in 1940. These aircraft sites were excavated by Essex Aviation Group, an aviation archaeology advocate group, who created a report concerning excavation details and historical background of the aircraft and their involvement in battle. Gould (1983:117) summarized their work and criticized the salvaging of many items from various aircraft claiming this form of aviation archaeology had a “strongly relic-
orientated” emphasis. Unfortunately, this “relic-oriented” approach is how the field of aviation archaeology began and it has yet to shed that stigma as the idea of salvaging aircraft wreck sites is still very appealing in the public’s eye. Nevertheless, the following is a chronologically ordered discussion of the development of archaeology focused on submerged aircraft.

In 1996, an archaeological team from Naval History and Heritage Command (NHHC) assisted the Puerto Rico Council of Underwater Archaeology in the investigations of three separate aircraft in Puerto Rico’s waters (Puerto Rico U.S. Military Wreck Survey). The objectives of this project were to: locate sites, record positions, identify types of aircraft, provide assistance in historical research, identify the wrecks where possible, consider the sites for a potential preserve project, and assess sites for potential hazards and human remains. As a result of this survey, a B-29 Superfortress was identified near Aguadilla, however, specific details of the observed seabed distribution or aircraft condition were never published. A wooden hull construction aircraft was located off El Desecho Island. A possible PBY was located on Motor reef, but their remains were also not published. These sites were all documented using photography and videography (Puerto Rico U.S. Military1996). While these investigations were a promising start, a lack of archaeological research and publication has been completed since this survey. This is disappointing considering the rare example of a wooden framed aircraft was located and stands to have immense archaeological potential.

In 1997, the Catalina Club of Western Australia commissioned Michael McCarthy, a maritime archaeologist from the Western Australian Maritime Museum, to write a report of the feasibility of locating, raising and conserving one of four
Catalina Flying Boats scuttled off Rottnest Island (McCarthy 1997:2). The report suggested the use of side scan sonar surveys in order to locate the wreck sites as the large structural components of the aircraft should still be relatively intact. McCarthy (1997:13) explained problems with raising an aircraft from this site by stating, “fifty years of corrosion in a salt water environment in either case will most likely lead to severe corrosion and possibly the collapse of the engine mounts.” A description was given to suggest that an immense expense would be necessary to raise the aircraft due to the sediment weight, the time and cost it would incur to conserve the Catalina once it reaches the surface (ibid. 1997:14). Even though the report was prior to any archaeological survey, McCarthy demonstrated an important role an archaeologist plays in educating the public in the protection of historic aircraft wreck sites.

An archaeological field school season was conducted by East Carolina University, the University of Hawaii at Manoa and the National Park Service in 1994. The focus was to indentify an aircraft and determine if it was destroyed as a result of the Japanese attack on Pearl Harbor. Speculation and inaccurate primary sources surround the mystery of a Catalina wreck site located in Kaneohe Bay (Rodgers, et al. 1998:8). These sources provided conflicting evidence as to whether the craft was sunk due to Japanese attack on Pearl Harbor. Investigations into the distribution of the site uncovered a mooring block and buoy, which remained consistent with moorings at the time of the attack, and steel cable which leads into the sand presumably to the aircraft. The aircraft was also identified as a PBY-5, as opposed to a PBY-5A, which suggests the craft was contemporary to the attack. Additional evidence provided by this study resulted in the orientation of the wreck which is
facing east-southeast remaining consistent with the wind direction of smoke columns revealed in post-attack photographs. While the evidence was not conclusive, it strongly suggested that this aircraft was sunk during the attack on Pearl Harbor (Rodgers, et al. 1998). The benefit of this field work included not only expanding our knowledge of historic events from the archaeological record, but also provided initial training for maritime archaeology students in submerged aircraft.

In 2000, Matthew Holly completed a report of the submerged cultural resources in Kwajalein Lagoon located in Majuro Atoll for the Marshall Islands’ Historic Preservation Office. The objective of this work was to complete a non-disturbance survey of the known wreck sites in the lagoon in order to develop a management plan and understand the effects of the diving public (Holly 2000:9). While this survey was concerned with a variety of submerged resources, five aircraft were examined including a TBM Avenger and a Martin PBM Mariner. For each site, a brief history was given followed by a description of current site conditions. This information was complimented by photographs of the wreck sites. Information was given about accessibility to divers and suggestions for site management. Even though this study provides descriptive detail of the wreck sites examined, detailed archaeological investigations were not conducted nor were site plans created. Furthermore, few recommendations were made for site management (ibid. 2000:97). Further research of these aircrafts was not conducted on these sites.

Additional investigations conducted by the NHHC include the search for a PBJ sunk in Lake Badin, North Carolina which was primarily conducted by submerged aircraft specialist Wendy Coble (2004). The objectives of this project included: locating the aircraft, determining the reason for the crash, exploring options
for aircraft recovery and burial of crew with a possibility of displaying the aircraft as a memorial. The project was riddled with funding and equipment issues often dealt with by maritime archaeologists including magnetometer discrepancies, damage to the side scan sonar computer, towing cable malfunctions and boat operational issues (ibid. 2004). The first field season consisted of magnetometer and side scan sonar surveys of the predicted wreck site location, with no success. During the second season the search area was expanded and additional side scan surveys were conducted. This survey located anomalies which had similar characteristics to a PBJ tail section and fuselage, but do to the depth and black water conditions an underwater investigation was not recommended. Evidence for the PBY was promising but inconclusive, and research was ceased due to financial issues (ibid. 2004).

In 2004, the NHHC also participated in a pre-disturbance survey of training aircraft wrecks in Lake Michigan. Side scan sonar investigations were conducted in order to located aircraft wreck assemblages related to World War II training. This survey was unsuccessful in locating related aircraft (The Navy’s Historic Aircraft 2004). This was unfortunate as the preservation of an aircraft in Lake Michigan would likely be excellent due to its fresh cold water and anaerobic environment.

Julie Ford completed a thesis entitled “WWII Aviation Archaeology in Victoria, Australia” in 2003. In it she examined the archaeological potential of locating and examining aircraft wrecks in Victoria, Australia. Victoria played an important role in Australian aircraft construction and had three training facilities during World War II. This study examined historical documentation in order to determine wreck site locations of aircraft lost during training operations. Results of
this study included the location of 75 aircraft wreck sites in Victorian waters; of these wreck sites, 14 different types were identified (Ford 2006). However, no further research of these aircraft has been conducted to date.

In 2007, William Jeffrey completed his dissertation on the submerged World War II resources in Chuuk Lagoon. The objective of his research was to understand the effect of World War II on the local population and their perspective of the submerged resources in Chuuk Lagoon in order to develop management options (Jeffrey 2007:7). Surveys conducted for this research included 20 shipwrecks and 8 aircraft. Side scan sonar and site measurements were used in order to identify the submerged aircraft wreck sites. It was noted by Jeffrey that side scan sonar surveys were unsuccessful as it was difficult to distinguish aircraft wreck remains from the seabed topography (ibid. 2007:197). While this research located and identified several submerged aircraft wrecks, the sites were not fully documented archaeologically. However, Ian MacLeod (2006) conducted corrosion studies on the aircraft in Chuuk lagoon, and the subsequent publication contributes to the understanding of the corrosion potentials of submerged aircraft.

The NHHC’s website describes several salvage efforts made by their archaeological team on a Martin PBM Mariner which was sunk while being ferried across Lake Washington in 1949. Since its wrecking, attempts were made in 1980 and 1990 to salvage the wreck to no avail. The Marlin/Mariner Association, with help from the NHHC archaeological team and other associated groups, made an attempt to recover the remains of this lost aircraft. With over a month’s effort and 500 dives later, a small portion of the tail section was recovered, conserved and given to the National Museum of Aviation. It was concluded to leave the Mariner where it
lie and explore the idea of using the wreck as a preserve for recreational divers (Martin PBM Mariner 2009). The work completed on this aircraft provides a prime example of issues archaeologist face with submerged aircraft. While interested groups were mainly concerned with salvaging the aircraft, archaeologist should have emphasized the difficulty and extreme cost of this venture and proposed alternative options.

While not completely inclusive of all research conducted on submerged aircraft, the above review has demonstrated a wide range of research conducted on submerged aircraft wreck sites. Some of these studies have contributed to our understanding of historical events, while others require additional in depth research. Submerged aircraft archaeology appears to be moving away from the focus of salvage operations to studies conducted on what knowledge can be gained from the wreck site in situ. Further, as theoretical approaches for these sites continue to evolve, more information will be recovered from submerged aircraft wreck sites. The following section will highlight additional research that was left out of the above discussion because it directly contributes to the understanding of site formation studies of submerged aircraft.

**Site Formation Studies on Submerged Aircraft**

Site formation studies of submerged aircraft can provide substantial insight to our knowledge of historical events. Few archaeological studies have directly addressed site formation of aircraft as an important area of archaeological inquiry. The majority of work in this area has been completed by Silvano Jung who completed both his Masters (2001) and PhD (2009) theses on site formation of submerged
aircraft sites. Additionally, Jung has published a number of journal articles on his results (1996; 2007a; 2007b; 2008a; 2008b). His research was completed in two geographic locations; the first sites involved the PBY Catalina flying boats sunk in Darwin Harbor (2001), and after completing this research, Jung (2009) began research into the site formation of Catalina’s in Roebuck Bay, Broome.

Jung’s (1996) initial archaeological study of Catalina flying boats focused on the seven Catalinas which were sunk at the East Arm end of Darwin Harbor. Three were U.S. Navy aircrafts which were lost at their moorings during the Japanese air raid in 1942. Two were Royal Australian Air Force (RAAF) aircrafts which were sunk towards the end of the war and two RAAF Catalinas were lost after World War II (Jung 2001:3). The initial archaeological work was undertaken in 1995 with the aim of verifying the number of reported Catalina wreck sites (Jung 1996:23). As a result of this survey, archaeologists were able to locate four of the seven flying boat wrecks reported in East Arm. Following this, it was essential to positively identify the Catalinas. The diagnostic features of aircraft type as well as evidence of site formation processes were recorded (Jung 2001:125). Jung states, “Archaeologists investigating the Catalina wreck sites must also be aware of how each aircraft was lost because evidence for their wrecking events can help indicate how the wreck sites could be identified” (Jung 1996:33). This statement emphasizes the importance of understanding the site formation of submerged aircraft as it could indicate the identity of a wreck.

Other survey methods included deconstructive modeling; the process of using an airframe line drawing and distorting it to match the archaeological record (Jung 2001); he later refers to this method as the “defabrication method” (Jung 2007a:26).
Through the study of site formation processes of these wreck sites, Jung was able to develop wrecking sequence diagrams for the known Catalina wreck sites (Jung 2001:169, 171, 175, 177). Jung’s research on submerged aircraft site formation enabled him to identify which wrecks were USN Catalinas and which were RAAF Catalinas. Similar research was conducted on Catalina flying boat wrecks in Roebuck Bay, Western Australia.

Silvano Jung has published several works on the archaeological research conducted on the Catalina wreck sites which were sunk in Broome, WA during World War II. The Battle of Broome was a Japanese air raid resulting in the loss of 100 lives (Jung 2008:1). Initial archaeological work involved locating the Catalina wrecks and performing non-disturbance surveys (Jung 2007b:32). A historical photograph taken shortly after the air raid which depicts smoke columns rising from the wreck site, which was used to provide evidence of possible wreck locations. The photograph was georectified and combined with an admiralty AUS chart along to predicted possible locations of wreck sites and targets from previous side scan sonar work (ibid. 2007b:34). Eleven sites and side scan targets were located, analyzed and compared. The results of this research included locating 14 of the 15 wreck sites and identifying the majority of these wrecks through artifactual evidence (ibid. 2007b:42).

Once the wreck sites were located, further archaeological investigations were conducted on the site formation of the wreck sites. The Broome flying boats wrecks provided an interesting comparative study as all the Catalinas were sunk within minutes of each other. As six of the aircraft were visible during Spring Low Water (SLW), Broome’s extreme seasonal low tide, archaeologists exercised three different
survey techniques: terrestrial, underwater and aerial. Site plans of these wrecks were created using a “defabrication method” which “utilizes a set of historical aircraft line drawings, which are altered according to archaeological data, to develop wreck site plans that illustrate the condition of surviving frames” (Jung 2007a:26). Terrestrial surveys of the sites proved difficult as the SLW only allotted 40 minutes to survey the wrecks, and some of the material culture could not be examined. It was concluded that the wrecks should be inspected underwater as longer survey time could be allotted and assessment of the entire wreck would be accessible.

Another survey included taking aerial photography, using a helicopter, which was beneficial in obtaining plan views of the observed seabed distribution. This provided an alternative prospective in “site recording, interpretation and discovery” as these sites are quite large and extend over a vast distance (ibid. 2007a:27). Through these survey methods it was determined that the Catalina wrecks face either west or south. The archaeological record also indicates that the Catalinas did not experience a high speed impact (i.e. falling from the air) (ibid. 2007a:30).

After completing his research, Jung was able to determine that these sites feature the process he refers to as “wing inversion”. Jung explains “where the port wing settles upside-down on the starboard side of the fuselage (upside-down) and vice versa for the starboard wing” (Jung 2009:23). This wing inversion can be caused by two different types of aircraft damage: “centre-of-mass damage” and “engine/wing damage.” These damage types in relation to site formation are specific to Catalina flying boats as their floats create their balance and when these are damaged the entire aircraft capsizes (ibid. 2009:24). Archaeological evidence at Broome suggested that firing at the wings and fuselage of the Catalinas resulted in
“engine/wing damage” which caused the “wing inversion” of the starboard wing on some sites (ibid. 2009:25-26). Site surveys completed on the Catalina wrecks demonstrated “wing inversion” which lead Jung to conclude that these sites are in situ from the air raid and have not been affected by post-depositional impacts, such as salvage, which was originally suspected. The orientation of the wrecks’ bows was likely due to the direction of the currents at the time of wrecking.

Silvano Jung has published a substantial amount of the research conducted on submerged aircraft site formation. His work is evident of the variety of methods possible when investigating submerged aircraft. His research proved the merit of the archaeological study of submerged aircraft and how their study can expand our knowledge of historic events.

**Submerged Aircraft Management**

A major hurdle in submerged aircraft archaeology was the struggle to obtain recognition as valuable archaeological resources. Whipple (1995:12) wrote, “Presently, the lack of research on aircraft’s role in U.S. culture means that old aircraft and aircraft crash sites are often regarded as junk except by the relatively few restoration enthusiasts and those who supply them.” This is demonstrated best by the exclusion of aircraft in Delgado’s *Encyclopedia of Underwater and Maritime Archaeology*. He stresses the need for management and preservation plans for historic aircraft sites which would allow systematic identification, evaluation and nomination of significant historic aircraft to the U.S. National Register. However, the creation of a database for historic aircraft has proven difficult due to the overwhelming numbers of aircraft crash sites (Whipple 1995:10). According to
Diebold (1993:1), the difficulty that aircraft archaeology faces is the lack of standards for evaluation and a deficiency in aircraft preservation terminology. Like Whipple, Diebold emphasized the importance of nominating historic aircraft to the U.S. National Register and further explained the process of the nomination of a B-17 aircraft which was added to the register in 1993.

The U.S. National Park Service developed a bulletin entitled, “Guidelines for Evaluating and Documenting Historic Aviation Properties” (Milbrooke 1998). This bulletin was primarily created to outline criteria and the process of nominating aircraft to the National Register. It provided a brief history of aviation in the U.S. and described the different types of aircraft sites. Criteria for nomination were also presented as well as details on appropriately documenting a site and an outline for properly preparing the nomination. This bulletin made it essential for historic aircraft to be added to the National Register, however, it did not require the same amount of detail or emphasis of historic significance as the English Heritage guides provided. Cooper (1994:135) emphasized the need for this bulletin in hopes that it would have a similar effect as the bulletin for evaluating shipwrecks has had for the registration and protection of historic shipwrecks. Cooper emphasized the need to create methodology and theory for the archaeological study of aircraft in order to properly document, evaluate and preserve these sites.

In 1986, the Protection of Military Remains Act was passed which made disturbing military aircraft sites illegal in the UK (Holyoak 2002:657). English Heritage (EH) took a proactive approach to the management of historical aircraft sites. According to Holyoak (2002:657), “It is English Heritage’s view that these are significant archaeological sites, and as such merit greater recognition and more
careful treatment by archaeologists and those engaged with their management. In order to uncover the research value of aircraft wreck sites, EH developed a publicly accessible guide called “Military Aircraft Crash Sites: Archaeological guidance on their significance and future management.” This guide provided a brief history of military aircraft sites and the history incorporated with salvaging these sites. It continued by explaining management plans and work completed by EH including the location, identification and total amount of crash sites in England. Criteria were presented for assessing the national importance for individual sites and management options. A subsequent publication was created for EH by Wessex (2008) Archaeology that specifically addresses aircraft at sea. This report followed a similar pattern and includes subjects on the importance of aircraft studies, legal protection of sites, case studies of previous work and management issues surrounding these sites (Wessex Archaeology 2008). Both guides are continued to be used today by EH.

In October 2004, U.S. Title XIV or Sunken Military Craft Act became law as part of Ronald W. Reagan’s National Defense Authorization Act for the 2005 fiscal year. It enabled protection for any and all U.S. military craft despite age or location (Sunken Military Craft Act 2004). The Act also included protection for foreign military craft in U.S. territorial waters. Strict penalties for violators were included in the Act; however no enforcement plan was given. Authority for enforcement is given to the U.S. Coast Guard, but the Act does not directly hold them responsible for upholding the Act (ibid. 2004). While this Act provided protection for submerged military craft, without a proper management plan for these sites, it would be difficult to enforce.
Historical Background

Introduction

The Battle of Saipan was an important strategic victory for the United States (U.S.) during World War II. The historic importance of the battle is often over shadowed by other offensive actions such as the Normandy invasion and military actions in Europe as well as the subsequent attack on Iwo and Chichi Jima soon after the battle began (Goldberg 2007). It is important to note the thousands of miles military forces had to travel in comparison to their European counterparts and the preparations necessary for such an undertaking. This chapter seeks to reflect upon the events leading up to the Battle of Saipan from both the U.S. and Japanese perspectives. Following this, a description of the battle and its aftermath will be given. Historical backgrounds will also be given for the aircraft investigated in this study including their design, production and involvement in the war.

The U.S. Prior to the Battle of Saipan

Several meetings and conferences were held between allied leaders to decide the best approach to the war in the Pacific. In August 1943, the Quadrant Conference was held with President Roosevelt, Prime Minister Churchill and the Combined Chiefs in attendance. One of the results of this conference was to advance in the Pacific with a “two-pronged” attack: Admiral MacArthur would attack New Guinea and proceed into the Philippines while Admiral King would concentrate his efforts on the Central Pacific (Goldberg 2007:13). The following month Admiral King met with Admiral Chester Nimitz, Commander in Chief of U.S. Pacific Forces and their
discussion included developing a strategy for the Central Pacific. It was determined that their next objectives would be to acquire the Gilbert Islands followed by the Marshall Islands. This would bring U.S. troops closer to the Marianas Islands which was the primary focus of Admiral King who believed that this would cut off the Japanese communication line and would allow establishment of U.S. bases for bombing Japan (Goldberg 2007:13). It was not until the Cairo Conference in November 1943 that the Marianas Islands were added as an objective in the Central Pacific campaign, with the attack on the Marianas tentatively scheduled for 1 October 1944. Once offensive actions began in the Pacific, the timetable for Operation Forger, the military name for the invasion of the Southern Marianas islands, was changed and new strategies were developed.

The U.S. troop advance in the Central Pacific began with an attack on the Gilbert Islands in November 1943 followed by an attack on the Marshall Islands in January 1944. While it only took three days to secure the Gilbert Islands, there were a significant number of U.S. casualties. It was evident after attacks on the Gilberts Islands, that intelligence regarding enemy position, reef locations and tides were essential to prevent U.S. casualties. Prior to attacking the Japanese base at Kwajalein, Marshall Islands, U.S. naval forces began air bombardment to successfully prevent Japanese air forces from attacking U.S. troops during landings. Operations on the islands proved successful, securing them within a week (Macintyre 1966:164). Soon after securing the Marshall Islands, Admiral Marc Mitscher led Task Force 58 to the Southern islands of the Marianas to weaken Japanese forces (Reilly 1994:26). Lessons learned from earlier campaigns would be put into practice during the Marianas campaign.
Prior to the invasion, U.S. forces attempted to gain as much information about Saipan and the Japanese forces occupying the island. Reconnaissance missions were conducted on 18 April and 29 May 1944, consisting of aerial photographs of Japanese troops defensive measures and weaponry (Goldberg 2007:23). These photos led U.S. intelligence to believe that there were far fewer numbers of Japanese soldiers than expected. The result of this caused the U.S. troops to encounter greater Japanese troop resistance than originally expected. Additional reconnaissance work included underwater demolition teams (UDT) whose mission included recording the depth of the lagoon to determine which vessels could be used during the invasion (Kauffman 1986:237). The reconnaissance work completed prior to the invasion assisted, but did not provide a fully comprehensive understanding of the island terrain, which enabled Japanese troops to continue fighting weeks after the initial landing of U.S. troops.

Japan Prior to the Battle of Saipan

Japanese Imperial General Headquarters suspected that the U.S. would invade the Palau Islands after their defeat in the Marshall Islands and began to prepare for an attack in that area. Plans for Operation A-Go were issued in May 1944 where the Japanese Combined Fleet would attack the incoming U.S. fleet (Rottman 2004:19). The Japanese military leaders however, misjudged U.S. military strategies, which gave them very little time to prepare for the upcoming invasion of Saipan. Additionally, rivalries between Japanese military forces led to miscommunication resulting in uncoordinated defenses prior to the attack (Russell 1994:11). Lieutenant General Obata Hideyoshi was in charge of military forces on the Marianas, Palau
Islands and Chichi Jima. Prior to the invasion, Obata had left the Marianas for the Palau Islands, leaving Vice Admiral Nagumo Chuichi and Lieutenant General Saito Yoshitsugu to command Japanese troops on Saipan and prepare for U.S. invasion.

At this point, Japan was losing its stronghold in the Pacific, and the U.S. was forcing Japan to move from the offensive to the defensive. They had lost control of the Gilbert and Marshall Islands, and were working diligently to provide reinforcements to fortify Saipan after the February bombardments (Goldberg 2007:31). Thirty thousand Japanese troops were sent to Saipan, many of them were without adequate weaponry or awareness of the battle plan (ibid. 2007:34). Attempts were made to build new airfields and seaplane bases; nine new airfields and two seaplanes bases were completed before U.S. troops arrived on Saipan (Rottman 2004:22). Japanese military leaders believed that an invasion was due in November, and even though Japanese troops had quickly erected pillboxes, blockhouses and other forms of fortification, much of their artillery forces were not ready for battle when U.S. forces approached in June. Nevertheless, Japanese troops intended to use the natural defense structures of Saipan to their advantage including caves and rock formations and were quite successful at this approach (Goldberg 2007:36).

**Battle of Saipan**

The Battle of Saipan, code named Operation Forager, began several days before the landing of troops on the island (Russell 2004:14). The initial attack on Saipan began with air bombardment on 11 June 1944; this bombardment would last three days and focused on hindering Japanese airfields as well as any ship within the area (Morison 1953:174). As a result of this bombardment, roughly 150 Japanese aircraft
were destroyed (Wheeler 1983:244). This had a significant effect on Japanese forces preventing an air attack on incoming U.S. troops. Additional bombardment came from nearby battleships, cruisers and destroyers who provided substantial impact to the island with constant shelling. Under the cover of this bombardment, the UDTs worked at blasting gaps in the reef for the troops to easily access and land on the beaches. After these preparations, U.S. troops prepared to land on the southwest beaches of Saipan.

On the morning of 15 June 1944, landing craft and Amtrak battalions positioned themselves for arrival loaded with assault troops. Aircraft continued strafing the beach while the landing craft began their approach as the aircraft moved into the interior. As U.S. troops reached the shore, Japanese troops fired from higher ground. Their locations were scattered and hidden making it difficult for the U.S. soldiers to locate where the Japanese forces were firing from. Waves of U.S. troops continued approaching the beach finding their enemy more difficult to defeat than originally planned. After the first day of invasion, the U.S. troops secured half of the expected beachfront (Rottman 2004:53). Japanese counter attacks continued through the night with little success, and the U.S. marines continued to fight to secure the southern sector of Saipan.

U.S. troops continued their advance on the southern sector of Saipan with their focus on securing Aslito Airfield. Their advancement towards the airfield proved difficult due to terrain and enemy attack, but the airfield was secure after several days. After the first week of the invasion, the southern sector of Saipan was secure with considerable casualties on both sides. On 22 June 1944, U.S. troops continued advancement north into central Saipan experiencing difficulties with the rugged
terrain. Japanese troops were beginning to become disjointed and scattered, with their resources becoming scarce (Rottman 2004:65). On 7 July 1944, Lieutenant General Saito launched Japanese troops on a final “bonsai” attack on U.S. forces. The attack began two kilometers North of Tanapag in Matansa Village where Japanese troops assaulted several U.S. battalions (Russell 1994:24). Their efforts proved unsuccessful and thousands of Japanese soldiers lost their lives and hundreds of U.S. soldiers killed (Rottman 2004:68). Just prior to the bonsai attack, Lieutenant General Saito committed suicide by plunging a samurai sword into his stomach (Thompson 2002:30). U.S. troops encountered little resistance after this effort and Saipan was declared secure on 9 July 2010.

**Aftermath of the Battle of Saipan**

The aftermath of the Battle of Saipan had several of consequences for both Japan and the United States. Many Japanese civilians jumped off cliffs committing suicide for fear of U.S. capture. Casualties from the battle were substantial with 3,426 U.S. soldiers killed and an estimated 29,500 Japanese soldiers killed in action (Rottman 2004:88). Additionally, 14,560 civilians were placed in internment camps (including 1,173 Koreans) and it is estimated that 22,000 civilians committed suicide (including Japanese, Koreans and native islanders) (Willmott 1999:147). After U.S. victory, civilians on Saipan were afraid of being imprisoned and tortured, thus a vast number committed suicide, some with children in hand (Collier 1975:149). The Japanese National Defense Zone had been pierced and with the new U.S. base in Saipan, B-29 bombers were well within range of mainland Japan. The result of this battle ended any prospect of Japanese victory in the Pacific theatre (Goldberg
Before the battle, Japanese military leaders believed success in the Pacific was still possible, however after this defeat their mentality began to change.

**History of Aircraft Studied**

Naval air forces played an essential role, for both nations, throughout the war in the Pacific and in the U.S. victory at Saipan. In a report describing their victory in the Pacific War, the U.S. military asserts that control of the air was essential to the success of every major military operation in the Pacific (Summary Report: Pacific War 1946:27). As discussed above, air bombardments weakened Japanese forces prior to the ground forces penetration of Saipan by focusing their attacks on airfields and Japanese planes (Mason 1986:205). This reflects the defensive threat that aircraft played during World War II and the importance of diminishing the opposing forces’ aircraft. Goldberg (2007:26) emphasizes this point by stating, “In all of these operations the outcome was positive for the U.S., not only because the numbers favored the United States but also because the United States was producing far more planes than Japan”. This section provides a history for the four aircraft used in this research and their role in the Pacific War.

**Aichi E13A**

The Imperial Japanese Navy (IJN) required a long range floatplane to provide escort to maritime convoys (Caoimh 2004: 154). In September 1937, the IJN commissioned Aichi, Nakajima and Kawanishi to develop a three-seat reconnaissance floatplane that was able to travel long distances and high speeds (Francillon 1970:277). The Aichi design team was led by Kishiro Matsuo whose aircraft design
was similar to the Aichi two-seat version of a similar aircraft the E12A1. The first prototype of the Aichi E13A1 was completed in 1938 with a 1,060 hp Mitsubishi Kinsei 43, 14 cylinder, air-cooled radial engine (ibid. 1970:277). In December 1940, the design was accepted by the IJN and was given the designation of Navy Type 0 Reconnaissance seaplane Model 1. This number is significant as it was numerically the most important Japanese Seaplane (ibid. 1970:277). The Aichi E13A1 made its combat debut in 1941.

Aichi E13A1 participated in a number of significant operations which contributed to its future use in the IJN. The aircraft was successful in attacks on the Canton-Hankow railway in China and also flew reconnaissance patrols before the attack on Pearl Harbor (Caoimh 2004: 154). These initial successes inspired the IJN to have the aircraft operating from ships and shore bases where they were active (Francillon 1970:278). It was given the allied code name “Jake” and according to Baker (1992:13), male names were assigned to fighter aircraft types and reconnaissance seaplanes. The Aichi E13A1 was also used in bombing missions during the war where air opposition was limited. The aircraft did have its limitations including a small fuel tank, minimal crew protection and limited defensive armament.
Table 3.1 – Specifications for the Aichi E13A (Francillion 1970:281).

<table>
<thead>
<tr>
<th>Aichi E13A</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type:</strong></td>
<td>Single-Engine twin-float reconnaissance seaplane. All-metal construction with fabric covered control surfaces.</td>
</tr>
<tr>
<td><strong>Accommodation:</strong></td>
<td>Crew of three in tandem enclosed cockpits</td>
</tr>
<tr>
<td><strong>Powerplant:</strong></td>
<td>One Mitsubishi Kinsei 43 fourteen-cylinder air-cooled radial, rated at 1,060 hp for take-off and 1,080 at 2,000 m, driving a three blade propeller</td>
</tr>
<tr>
<td><strong>Armament:</strong></td>
<td>One flexible rear-firing 7.7mm type 92 machine gun. External load: one 250 kg bomb, or four 60 kg bombs or depth charges</td>
</tr>
<tr>
<td><strong>Dimensions:</strong></td>
<td>Span 14.5 m; length 11.3 m; height 7.4 m; wing area 36 sq m</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>Empty 2,642 kg; loaded 3,640 kg; maximum 4,000kg</td>
</tr>
<tr>
<td><strong>Performance:</strong></td>
<td>Maximum speed 203kt at 3,000 m; cruising speed 120 kt at 2,000 m; climb to 3,000 m in 6 min 5 sec; range 1,128 nautical miles</td>
</tr>
<tr>
<td><strong>Production Count:</strong></td>
<td>1,418</td>
</tr>
</tbody>
</table>

Figure 3.1 – Aichi E13A line drawing, courtesy of aviastar.org.
Kawanishi H8K

Design of the Kawanishi H8K began in August 1938, after the IJN contracted Kawanishi Kokuki K.K. to develop a large four engine maritime reconnaissance flying-boat (Francillon 1970:307). The original design included retractable stabilizing floats, but these were later abandoned due to weight issues (Green 1962:131). Later models would include retractable stabilizing floats. Kawanishi had a strict range for the H8K which lead to the decision to use eight smaller unprotected fuel tanks on the wings and six large tanks in the hull. The tanks in the hull were arranged in such a way that bilge pumps could pump gas from a damaged tank into an undamaged tank (Francillon 1970:307). Armament was also an important issue in the design, and Kawanishi developed the defense armament with three turrets (nose, dorsal and tail) with 20mm Type 99 Model 1 cannons as well as 7.7 mm machine guns in each of the two hatches. A prototype was completed in December 1940 and its maiden voyage was completed in January 1941. Alterations were necessary to the prototype including an increase in hull depth. After these changes the aircraft was put into production.

The Kawanishi H8K was first used in combat in 1942 and the aircraft proved quite useful to the IJN. It was used in an offensive bombing attack against Oahu in March 1942 which ended unsuccessfully. When used in its original role as a maritime reconnaissance aircraft, it proved more successful as the aircraft was able to complete its mission and defend itself appropriately (ibid. 1970:309). Kawanishi H8K was later dubbed “Emily” by allied forces that used female codes names for seaplanes (Baker 1992:13). It received the reputation from allied forces as being one of the hardest Japanese aircraft to shoot down (Francillon 1970:310).
In the Pacific, Kawanishi’s were used extensively as reconnaissance planes, bombers and transports (Jablonski 1972:232). The Kawanishi H8K was considered the “backbone” of the Japanese Navy’s maritime-reconnaissance element during World War II (Wragg 1984: 193). According to Green (1962:131), “Possessing an exceptional performance, it was, in fact, the fastest flying boat to serve any of the combatants, and its hydrodynamic qualities were superior to those of British, American or German contemporaries.” The Kawanishi H8K is considered to be the finest and fastest flying boat of World War II by some (Jablonski 1972:231; Allward 1981:119).

Table 3.2 – Specifications for the Kawanishi H8K (Francillion 1970:313).

<table>
<thead>
<tr>
<th>Kawanishi H8K</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type:</strong></td>
<td>Four-engine long-range maritime reconnaissance flying boat or transport flying boat. All metal construction</td>
</tr>
<tr>
<td><strong>Accommodation:</strong></td>
<td>Crew of Ten</td>
</tr>
<tr>
<td><strong>Powerplant:</strong></td>
<td>Four Mitsubishi MK4A Kasei 11 fourteen-cylinder air-cooled radials, rated at 1,530 for takeoff, 1,410hp at 2,000 m and 1,340 hp at 4,000 m, driving four-blade metal propellers</td>
</tr>
<tr>
<td><strong>Armament:</strong></td>
<td>20 mm Type 99 Model 1 cannon in dorsal and tail turrets and 7.7 mm Type 92 machine-guns in two beam blisters, ventral and cockpit hatches and bow turret</td>
</tr>
<tr>
<td><strong>Dimensions:</strong></td>
<td>Span 38m; Length 29.13 m; Height 9.15 m; Wing Area 160 sq m</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>Empty 15,502 kg; Loaded 24,500 kg; Maximum 31,000 kg</td>
</tr>
<tr>
<td><strong>Performance:</strong></td>
<td>Maximum speed 234kt at 5,000 m; cruising speed 160 kg at 4,000 m; climb to 5,000 m in 14 min 33 sec; range 3,888 nautical miles</td>
</tr>
<tr>
<td><strong>Production Count:</strong></td>
<td>167</td>
</tr>
</tbody>
</table>
Martin PBM Mariner

The Martin PBM Mariner has been dubbed the “Fighting Flying Boat” due to its service as a heavily armed reconnaissance flying boat (Hoffman 2004:1). The Mariner is often over shadowed by the infamous Catalina flying boats; however the Mariner offered considerable military capability in comparison to the Catalinas (PBM Mariner 1950:1). The Martin PBM Mariners were the second most widely used U.S. flying boat during World War II (Allward 1981: 116). The USN designated the Catalina flying boats as patrol bombers, and were in need of a heavily armed flying
boat for use in bombing naval shore bases as well as missions for locating and attacking warships (Hoffman 2004:1). Thus, the Navy invited proposals for a two-engine aircraft that fit those needs. The Martin Company was granted the development contract to produce a single prototype (ibid. 2004:3). In 1939, the Martin Company developed a three-eighths scale model of the design to test the projected performance. After several modifications a full size test PBM was created and tested. This PBM again went through some substantial modifications and the first service ready PBM-1 was delivered in 1941 (ibid. 2004:6). During its long career, the PBM Mariner served in many different roles under the USN. According to Shanline (1985:33),

“...PBM Martin Mariner served the U.S. Navy as a long-range patrol bomber used in reconnaissance and for a variety of purposes ranging from cargo transport to ferrying the troops. One of its very important functions was rescuing airmen who were downed in the ocean or the survivors of surface vessels in trouble.”

With the mission to rescue downed airmen, the PBM Mariner was an extremely significant aircraft during World War II.

PBM Mariners were used for search, patrol, reconnaissance and rescue missions during the Battle of Saipan (Hoffman 2004:39). During the battle, Mariners were operating in the sea outside of the lagoon which made them susceptible to rough waters, severely damaging one aircraft (ibid. 2004:39). After U.S. troops had declared victory in Saipan, PBM Mariners used the Japanese built seaplane bases in Tanapag Lagoon as it provided protection from rough waters. Mariners provided support to “mop-up” operations through August 1944, and patrolled the lagoon to provide anti-submarine screening (ibid. 2004:40).
Table 3.3 – Specifications for the Martin PBM Mariner (Caoimh 2004:204).

<table>
<thead>
<tr>
<th>PBM Mariner</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Maritime reconnaissance flying boat</td>
</tr>
<tr>
<td>Accommodation:</td>
<td>Crew of seven or eight</td>
</tr>
<tr>
<td>Powerplant:</td>
<td>Two 1,700 hp Wright R-2600-12</td>
</tr>
<tr>
<td>Armament:</td>
<td>Two flexible 0.5 in. machine-guns each in nose and dorsal turrets; plus single 0.5 in. in tail and two beam positions; max bomb load or depth-charges, 907 kg</td>
</tr>
<tr>
<td>Dimensions:</td>
<td>Span 35.97 m; length 24.38 m; height 8.38 m; wing area 130.80 sq m</td>
</tr>
<tr>
<td>Weight:</td>
<td>Empty 14,687 kg; maximum 26,310 kg</td>
</tr>
<tr>
<td>Performance:</td>
<td>Maximum speed 319 km/hr at 3,962 m; normal range 3,438 km; initial rate of climb 125m/min; service ceiling 5,151m</td>
</tr>
<tr>
<td>Production Count:</td>
<td>1,366</td>
</tr>
</tbody>
</table>

Figure 3.3 – Martin PBM Mariner line drawing, courtesy of aviastar.org
**TBM Avenger**

Grumman and Vought both competed for the contract to develop a torpedo bomber for the USN. Prototypes were made of both designs, Grumman’s TBF Avenger proved to be lighter, faster and had wing folding which was its most attractive characteristics from the Navy’s view (Drendel 2001:2). The first round of production of Grumman’s Avenger was completed in 1942, and Avenger received its name from the Japanese attack on Pearl Harbor 7 December 1941. When Grumman’s company became focused on producing the carrier-based Hellcat fighter, production of the Avenger was transferred to General Motors in 1943 where it was given the designation TBM Avenger (*ibid.* 2001:2). Thousands of TBM Avengers were produced by GM during World War II.

The Avenger was known as a rugged torpedo plane which was effectively used against surface vessels in the Pacific theatre (Avenger:1). Avengers played an active role in Rear Admiral Marc Mitcher’s Task Force 58 who was involved in the Battle of the Philippine Sea (Tillman 1999:27). The majority of their involvement consisted of bombing, ground support, anti-submarine patrol and reconnaissance. Grumman’s Avenger also participated in the initial air bombardments and strafing of Saipan preceding the ground troop landings (Hoffman 1950:36). Avenger squadrons were focused on attacking Japanese aircraft carriers and combating Japanese aircraft units. Avengers served with the Royal Navy, Royal New Zealand Air Force and the French Navy. The last TBM Avengers were retired in 1962 (Avenger:1).
Table 3.4 – Specifications for the TBM Avenger (Caoimh 2004).

<table>
<thead>
<tr>
<th>TBM Avenger</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type:</strong></td>
<td>Torpedo Bomber</td>
</tr>
<tr>
<td><strong>Accommodation:</strong></td>
<td>Three to five</td>
</tr>
<tr>
<td><strong>Powerplant:</strong></td>
<td>One 1,700 hp Wright R-2600-8</td>
</tr>
<tr>
<td><strong>Armament:</strong></td>
<td>One fixed forward-firing 0.3 in. gun; one 0.5 in. gun in dorsal, one 0.3 in. gun in ventral positions; max bomb or torpedo load 726 kg.</td>
</tr>
<tr>
<td><strong>Dimensions:</strong></td>
<td>Span 16.52 m; length 12.19 m; height 5 m; wing area 45.52 sq. m</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>Empty 4,572 kg; Maximum 7,215 kg</td>
</tr>
<tr>
<td><strong>Performance:</strong></td>
<td>Maximum speed 404 km/hr at sea level; cruising speed 233 km/hr; normal range 1,955 km; initial rate of climb 436m/min; service ceiling 6,828m</td>
</tr>
<tr>
<td><strong>Production Count:</strong></td>
<td>9,839</td>
</tr>
</tbody>
</table>

Figure 3.4 – TBM Avenger line drawing, courtesy of richard.ferriere.free.fr
Methodology

Introduction

The initial archaeological report conducted on the four submerged aircraft sites examined in this study was completed by SCRU in 1991 (Carrell). At this time a full archaeological investigation of these sites was not conducted as the primary focus was aimed at locating and identifying submerged historic resources. Since this initial report, several archaeological surveys have been conducted; however, it was not until the February 2010 field season that the first systematic archaeological surveys of the sites and further investigations were completed. This chapter examines previously completed archaeological surveys of the sites in order to further discuss the methods involved in collecting data for analysis. Following this, an in depth detail of the survey methods utilized in creating site plans for the wreck sites will be provided. The methods used in recording the environmental and cultural impacts affecting the aircraft sites will be discussed. This will be followed by methods used in obtaining additional wreck scatter information. An explanation will also be given of the methodology used for analyzing the data collected. This chapter will introduce methods used to obtain historical records. Finally, the limitations of this research will be recognized in order to acknowledge any discrepancies.

Archaeological Investigations of Submerged Aircraft in Saipan

Initial archaeological surveys in Saipan were completed by the U.S. National Park Service’s Submerged Cultural Resources Unit (SCRU). Work completed for this survey covered all aspects of maritime culture and submerged resources in
Micronesia, including World War II resources. Field work was conducted between 1981 and 1988 with a written report completed in 1991 (Carrell 1991). The objective of this work was to locate and identify sites, but the report also discussed management issues (ibid. 1991). As a result of this study, the submerged aircraft sites were located and three sites were possibly identified. The Martin PBM Mariner remained unidentified at this time. At this point, site plans for the submerged aircrafts were not completed; however a mud-map for the Aichi E13A was created (Figure 2.4). This work provided the foundation for further study in CNMI, but it would be another decade before the sites were further investigated by archaeologists.

Figure 4.1 – Mud-map created during the initial survey of the Aichi E13A (Carrell 1991:507).
Between April and May 2008, Jason Burns and Michael Krivor from Southeastern Archaeological Research, Inc. (SEARCH) conducted a remote sensing survey and diver identification in Tanapag and Garapan Lagoons, which focused on World War II resources. During this survey, 778 magnetic anomalies were identified from magnetometer surveys of which 54 of these anomalies were investigated by divers in Tanapag Lagoon (Burns 2008b). In Garapan Lagoon, 765 magnetic anomalies were identified of which 88 anomalies were investigated by divers (Burns 2008a). Two anomalies investigated include the Kawanishi H8K and the TBM Avenger; however, neither the Aichi E13A nor the Martin PBM Mariner were included in the survey report. A side scan sonar image was made of the Kawanishi H8K (Figure 4.2). Additionally, an isolated aircraft prop was located and Burns (2008b:74) suspects that due to the size of the magnetic cluster it is likely an aircraft could be buried in the area.

Figure 4.2 – Side scan sonar image of Kawanishi H8K flying boat wreck (Burns 2008b:73).
In 2009, Toni Carrell of Ships of Discovery compiled and edited an overview of the islands’ maritime history which covered indigenous watercraft through World War II and beyond. The work was completed over several months with the help of National Park Service funding. The objective of the report was to obtain baseline information and sources for further study as well as assisting in the management of these sites (Carrell 2009). This report provided detailed descriptions of the submerged aircraft sites as well as some historical background, but did not yield archaeological site plans for the aircraft sites. The Martin PBM Mariner remained unidentified as of this publication (ibid. 2009:509).

Recently, Jennifer McKinnon, of Ships of Discovery and Flinders University, was awarded a National Park Service American Battlefield Protection Program Grant in order to create a World War II underwater heritage trail in Saipan, CNMI. With the help from the local Heritage Preservation Office, professional archaeologists from the U.S. and Australia, and Masters students from Flinders University, this project has focused on identifying and documenting submerged and land-based World War II resources. Fieldwork for this project has been conducted over several seasons in 2009 and 2010. As a result, site plans for all four submerged aircraft sites have been drawn and additional data captured through video and photography. Due to time constraints, site plans were limited to the major aspects of the wreck assemblage on two sites and the smaller artifacts in the wreck scatter were not all documented. In the future, this project intends to create interpretive brochures, underwater site guides and interpretive material for the non-diver, and will enable the local population and visitors to engage in the preservation of the submerged heritage in Saipan, CNMI.
Site Plan Development

Initial survey work for the four submerged aircraft sites occurred during the February 2010 field season. The time allotted for each site depended on the aircraft size and wreck distribution. The survey of the Aichi E13A was conducted on 23 February 2010, Kawanishi H8K was completed on 23 and 24 February, Martin PBM Mariner was conducted on 18 and 19 February, the TBM Avenger was completed on 16 February 2010. On all sites, the baseline was set along the wingspan of the plane. Baseline offset measurements were utilized in the mapping of major aircraft structure. Two teams split the mapping duties between the starboard and port side of the aircraft. Measurements of the wreck scatter were collected using the trilateration method. Delgado (1997:427) defines trilateration as,

A technique for mapping the X,Y coordinates of points on a site using distance measurements from an unknown point to two or more points that have been already mapped and thus are of known coordinates. The unknown point is then plotted using a scale and rule [sic] and a compass on a plan view of the site.

The advantage of using trilateration for these sites includes obtaining accurate measurements of aircraft wreckage which may be a significant distance away from the baseline. Also, this enabled smaller or moveable objects to be added to the site plan. Due to time constraints, an adapted method of trilateration was used to collect measurements for the site plan. Numbered tags were created and placed on various identifiable features around the wreck site, and distance and bearings were then taken from a central datum at each numbered location. Measurements were taken for each artifact or feature and photographs were taken in order to document what the tag was attached to for site plan development (Figure 4.3). This method proved beneficial as it was efficient and adhered to time constraints.
Given time constraints, the archaeology team documented as much of the sites as possible, but some portions of the wreck scatter still remained absent from documentation. However, the Aichi E13A and TBM Avenger sites were fully recorded (Jennifer McKinnon 2010, pers. comm., 8 November). The purpose of creating site plans for the submerged aircraft wrecks was for public interpretation in the underwater heritage trail material rather than specific site distribution questions (Jennifer McKinnon 2010, pers. Comm., 8 November).

Draft site plans were created using the data gathered from the baseline offset and trilateration surveys. The site plans were drawn on graph paper and later transferred onto mylar. Finalization of the site plans occurred over a period spanning from September through November 2010, and were completed at the archaeology
laboratory at Flinders University by Samantha Bell.

A scale of 1:50 was used in creating the site plans for the Aichi E13A, while the TBM Avenger scale was 3/8 inch. The reasoning behind using an imperial scale for the TBM Avenger was because it was built in the U.S. However, an imperial scale was not used in recording the Martin PBM Mariner wreck site because its identity was still unknown. The wreck distribution of the Aichi E13A and TBM Avenger sites is fairly condensed in comparison to the flying boats whose scale was considerably larger. A 1:100 scale was used for the Kawanishi H8K and Martin PBM Mariner as both sites incorporate substantial wreck distribution.

While the majority of the wreck scatter was gathered for both the Aichi E13A and the TBM Avenger, smaller artifacts found in the wreck scatter of the PBM Mariner and Kawanishi H8K still remained undocumented. It became necessary to record these smaller artifacts during the June 2010 field season in order to document them on the site plans and adequately assess the wreck distribution. Methods for these searches will be discussed shortly.

Photographic Survey Methodology

As emphasized in the NAS Guide to Principles and Practices of Underwater Archaeology, photography is one of the most powerful tools available for the archaeologist (Bowens 2009:71). Photographic images can often illustrate items on a wreck site which cannot be seen underwater by the naked human eye. Thus a photographic survey method was utilized for this research project. This research uses this survey method specifically to document the environmental and cultural impacts affecting the four submerged aircraft wreck sites. The photographic images were
then used to enable an analytical comparison between site formation processes affecting shipwreck sites and those affecting submerged aircraft sites. An interesting and unexpected advantage of this survey method was the ability to observe changes in the observed seabed distribution of the sites between the February 2010 and the June 2010 surveys. As the June 2010 fieldwork season in Saipan included several projects, four different cameras were used for this survey including: Ixus 990 IS, Canon PowerShot A640, a Canon PowerShot A630 and a Canon Digital Ixus 990 IS.

The first photographic surveys were conducted on 13 and 14 June on the Martin PBM Mariner and the Kawanishi H8K with one day including two dives per dive team allotted for each site. Survey of the Mariner site was completed on 14 June 2010, while the Kawanishi survey was conducted on 15 June 2010. Due to the size of the wreck distribution on both sites, two separate dive teams were deemed necessary to collect the photographic data. One dive team was designated to record environmental features and another dive team was assigned to document cultural features. Examples of environmental features collected by the dive team include biological data, evidence of disintegration and the presence of rust. The dive team who collected data concerning cultural impacts focused on a variety of features including evidence of salvage, material subsequently deposited on site, movement of artifacts on the seabed, anchor damage and the presence of graffiti. This team also documented obvious or potential indications of the wrecking event in the archaeological record. A one meter scale was used during the photographic documentation of larger aspects of the wreck while a 20 centimeter scale was used to document small features on the wreck such as small artifacts and cultural impacts. As both the Martin PBM Mariner and Kawanishi H8K wreck sites contain many features
which are spread vastly over the site, divers were allotted more time for survey than on the smaller aircraft sites.

Both the Aichi E13A and TBM Avenger sites were surveyed on 16 June 2010, with the TBM Avenger survey conducted first. Since the wreck distribution for the Aichi E13A and TBM Avenger sites was confined to a very small area, one day was deemed necessary to collect data at both sites with a single dive per site. One dive team was designated to record both environmental and cultural features of the site. As with the Martin PBM Mariner and the Kawanishi H8K, a one meter scale was used during photographic documentation of larger aspects of the wreck while a 20 centimeter scale was used to document smaller features on the wreck.

Wreck Scatter Recording Methods

As previously discussed in this chapter, the site plans created in February 2010 for the wreck sites had considerable time constraints which did not allow for full documentation of all wreck scatter present. The June 2010 fieldwork season provided the opportunity to include smaller items of the wreck assemblage which had not been previously documented in the site plans. Radial and circle searches were completed from various datum points on the wreck site to locate any additional artifacts which were not previously documented. These searches enable a comprehensive analysis of the wreck site by understanding the distribution of the majority of the wreck scatter. The main focus was the two flying boat wreck sites since the smaller wreck assemblages had been well documented. However, radial and circle searches were also conducted on the Aichi E13A and the TBM Avenger to ensure the sites were fully documented. As the June field season also experienced time constraints, not
every aspect of the wreck assemblage could be recorded. It is estimated that two weeks of survey would be necessary to complete a full and accurate site plan for the flying boats (McKinnon 2010, Pers. Comm., 8 November).

Dives to obtain this data were conducted in conjunction with divers performing photographic surveys. The end of a tape-measure was held at a datum point by a diver while one or two additional divers separated themselves evenly along the tape and began looking for wreck items not included on the site plans. When circular searches could not be conducted due to an obstructing feature, radial searches were performed. In order to ensure that new items were recorded, the February 2010 site plan was traced onto mylar for each dive team. This enabled divers to record exact locations of artifacts and features identified. The use of these site plans also allowed for a rough positioning of new items found in relation to already recorded items. Any movement of items from was noted but this was limited to smaller artifacts in the wreck assemblage.

**Analytical Methodology**

In order to adequately analyze collected data and understand the similarities and differences between shipwreck site formation and submerged aircraft site formation processes, several analytical methods were used. First, a complete description of the observed seabed distribution was completed for each site. Site plans for all four wreck sites were finalized on mylar and digitized using a scanner and Photoshop providing a visual representation of the site distribution. Photographic data depicting the environmental factors affecting each site was analyzed and compared with that of shipwreck sites. In order to create a
comprehensive analysis, a table was developed from Ward, Lacombe and Veth’s (1999) work regarding environmental processes including evidence of material floating away, sediment budget and noting the hydrodynamic environment (Table 4.1).

Table 4.1 – Table used to recognize the environmental profile for each site.

<table>
<thead>
<tr>
<th>Environmental Profile</th>
<th>Material Floated Away</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment Budget</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
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<tr>
<td>Sand</td>
<td></td>
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<tr>
<td>Mud</td>
<td></td>
</tr>
<tr>
<td>Hydrodynamic Environment</td>
<td></td>
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<tr>
<td>High Energy</td>
<td></td>
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<tr>
<td>Low Energy</td>
<td></td>
</tr>
</tbody>
</table>

Once the environmental factors affecting each submerged aircraft site have been recognized, an analysis of cultural factors will be completed. The analysis will use previously developed site formation processes affecting shipwreck sites as a model to examine the photographic data collected. Extracting filters and scrambling devices located on the aircraft will be identified for each site. Additionally, any evidence that may suggest how the aircraft ended up in its current location will also be presented. Once an analysis of the sites has been completed on an individual basis, a comparative analysis will be conducted to find similarities amongst the four submerged aircraft wreck sites. Furthermore, this analysis will be used to compare the data from the submerged aircraft sites with processes established for shipwreck sites. Table 4.2 demonstrates an example of the table which will be completed for the combined sites; it lists cultural processes that affect shipwreck sites as recognized
by Gibbs (2006:16). Checkmarks will be added to the table when their existence is evident on the aircraft sites.

Table 4.2 – Table featuring cultural processes found on shipwreck sites, which will be examined in the analysis.

<table>
<thead>
<tr>
<th>Cultural Processes for Shipwrecks</th>
<th>Aichi</th>
<th>Kawanishi</th>
<th>Mariner</th>
<th>Avenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliberate Running Ashore</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refloating</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jettisoning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvage of Jetsam/Lagan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survivor Salvage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic Salvage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opportunistic Salvage</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Intentional Deposition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abandonment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Subsequently Deposited</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>on Sites</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Additional methods of analysis included comparison of site plans and photographs to identify relationships between the sites and their seabed distribution. Photographic data collected during the February 2010 field season were compared to the June 2010 field season to identify any changes to the sites. This includes similarities between the sites that may be used for understanding site formation of aircraft. Further, items and processes which do not affect shipwreck sites, but affect aircraft wreck sites, were identified using this method.

**Historical Research**

Several types of sources were consulted in completing the historical research for this study. A database, which was created by a Flinders University Masters
student, was consulted for primary and secondary historical resources regarding the Battle of Saipan. During the June 2010 field season, visits to the American Memorial Park provided a basis for understanding the battle from a local perspective and the impact it had on the island and the local population. Secondary historical books were gathered from the museum shop regarding the history of the Battle and the TBM Avenger. Several secondary historical books and online forums were consulted to discover histories of the aircraft studied. Further primary historical source material includes articles and books pertaining to the histories and experiences of the aircraft examined. The U.S. archives website was consulted to obtain records regarding post-battle salvage, however these records remain inaccessible. The Library of State South Australia has a substantial collection of books and pamphlets relating to World War II aircraft and the Battle of Saipan.

Email communications were conducted to translate the Japanese and Korean monuments found on the Kawanishi H8K. Additionally, the Korean Broadcasting System (KBS) production company, who placed the Korean monument on the Kawanishi site, was contacted to obtain a history of the monument placement and gain knowledge if any part of the assemblage was relocated at that time. Unfortunately no response to this communication has been received. Professional maritime archaeologists who have considerable experience in submerged aircraft were consulted for their opinions of site formation as well as their opinion of aircraft archaeology and its future as a maritime archaeological resource. The use of these sources provides a concrete historical background to the Battle of Saipan and the individual aircraft. Furthermore, these sources were used to decode the wreck assemblage in order to identify possible answers to their observed seabed distribution.
**Limitations**

Before the dissection of data in the following chapter, several limitations of this study must be recognized. First, it must be noted that the author is an English speaker without the comprehension of Japanese or Korean languages. This limits the availability of Japanese records, primary sources and histories of Japanese aircraft. Additionally, it makes translations of monuments difficult. Further limitations include time constraints to obtain full records and comprehension of the sites. As the majority of research conducted was in Australia, access to U.S. records proved challenging and time consuming. Since this study was completed over a six month period of time, it is suspected that additional records could be found if more time were warranted. Supplementary time to investigate the sites would also provide the availability to create site plans which fully incorporate all artifacts on site as well as continued tracking of artifact movement on the seabed.
Analysis

Introduction

The four submerged aircraft sites used in this study were examined in order to identify similarities and differences with shipwreck site formation processes as previously outlined by Muckelroy (1978), Ward, Larcombe and Veth (1998) and Gibbs (2006). Thus each site was examined using the methods discussed in the previous chapter to distinguish environmental and cultural factors affecting the wreck sites. This chapter will present those data collected at each submerged aircraft site, and a comparative analysis of site formation processes affecting the four sites will be investigated.

Figure 5.1 – Google Earth map with approximate locations of submerged aircraft wreck sites. Accessed created 26 September 2010.
Aichi E13A

The Aichi E13A wreck site is located off the small vacation island of Mañagaha at a depth of seven meters. This aircraft remains relatively intact and lies inverted on the sandy seabed with the aircraft remaining structurally intact with a condensed seabed distribution. The aircraft is listing to port at an angle of approximately 30 degrees with the port wing imbedded in the sand and the starboard wing rising above the seabed. An overall photograph of the site is demonstrated in Figure 5.2. Additionally, the tail section of the aircraft tapers into the sandy seabed. A bomb dropping mechanism is visible in the centre of the aircraft wings and aft of this feature, the presence of a reconnaissance camera sight hole is noted. Landing gear is found near the site but as it does not appear to be associated with the aircraft, it has been excluded from the site plan. The site plan is illustrated in Figure 5.3.

Figure 5.2 – Photograph depicting overall view of Aichi E13A wreck site. Photo courtesy of Ships of Discovery, taken by D. Ulloa June 2010.
Figure 5.3 – Site Plan for Aichi E13A.
Environmental Impacts

The effects of environmental processes on this site are minimal in comparison to the other three wreck sites. Table 5.1 outlines the environmental profile for the Aichi E13A wreck site. This site is located on a large sandy seabed with small patches of reef found near the aircraft. The sand grain size is fine and covers the majority of the northern wing and end of the tail. No obvious signs of sand scouring were present on site. However sediment changes were noted on the aircraft pontoon between the February and June 2010 field seasons which likely demonstrates seasonal shifts in sediment. While the site experiences light current it is located in a low energy environment which has little effect on the wreck site. A thin mucilaginous layer, as described by Macleod (2006:128), covers the aluminum surface of the aircraft. Small portions of disintegration of aluminum are noted on the wings as well as near the bomb dropping mechanism in the center of the wreck (Figure 5.4). These items are distinguished as black patches on the site plan in Figure 5.3. Coral growth is apparent on various parts of the aircraft with the largest growth located on the nose cone of the propeller. According to Macleod (2006:129), marine organism respond to the release of iron and these features have iron components.

A variety of fish species and invertebrates are also found onsite but their presence has had no affect on the aircraft. During the June 2010 field season, Ash Fowler, a biology PhD student from the University of Sydney, conducted biological assessments of fish species living on the submerged World War II sites in Tanapag Lagoon. His research produced the following summary of fish species on the Aichi E13A:
There are mainly small fish species at this wreck, likely due to its low relief. Shoals of distinctly banded scissortail sergeants (*Abudefduf sexfasciatus*) can be seen near the plane wings, avoiding potential predators by darting into the wreck for cover. Near the engine and propeller, numerous dusky gregories (*Stegastes nigricans*) can be seen in amongst the brown algae. These damselfish are often referred to as ‘farmer’ damsels, as they cultivate and fiercely protect small patches of brown algae, even attacking and biting divers. Although it appears there are two species, males of this species change color to a dark brown during the breeding season (Ash Fowler 2010, pers. comm., June).

The environmental processes affecting the site are similar to those affecting shipwreck sites. The main difference between the two is the manufacturing material used and how it interacts with the natural environment. Aluminum is a much lighter material which does not experience the same biological growth as observed on metals containing iron. A full discussion on this subject can be found in Macleod (2006).

Table 5.1 – Table explaining the environmental profile of the Aichi E13A.

<table>
<thead>
<tr>
<th>Environmental Profile</th>
<th>Aichi E13A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Floated Away</td>
<td>No Evidence</td>
</tr>
<tr>
<td>Sediment Budget</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>✓</td>
</tr>
<tr>
<td>Mud</td>
<td></td>
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<tr>
<td>Hydrodynamic Environment</td>
<td></td>
</tr>
<tr>
<td>High Energy</td>
<td></td>
</tr>
<tr>
<td>Low Energy</td>
<td>✓</td>
</tr>
</tbody>
</table>
Cultural Impacts

Archaeological evidence suggests that this aircraft was intentionally deposited on the seabed. Further, it is hypothesized by the author that this aircraft has been salvaged prior to its intentional disposal on the seabed. While no historical record of intentional disposition of the Aichi E13A has been located at this time, the archaeological record supports this hypothesis. The following paragraphs will elucidate on extracting filters and scrambling devices identified in the archaeological record from the site formation surveys.

Figure 5.4 – Photographic evidence depicting disintegration of aluminium aircraft sheathing. Photo courtesy of Flinders University, taken by S. Bell June 2010.
There are several features indicative of systematic salvage as an extracting filter contributing to the observed seabed distribution including key aspects of the aircraft is missing from the wreck assemblage. Only one of the two floats was located on site and the float present appears to have been severely damaged. Historical photographs show evidence of the Aichi E13A having an engine cowling. However, no cowling is present on the observed wreck site (Figure 5.5). While it is possible that the cowling could have been lost during the wrecking event, it is unlikely that this would happen without damage to the propeller or engine. The presence of damage to the propeller or engine was not noted.

Figure 5.5 – Photographic evidence of missing engine cowling. Photo courtesy of Flinders University, taken by K. Gauvin February 2010.
Furthermore, the starboard wing is missing a large portion of its wing tip which may have been removed during salvage operations or due to a wrecking event. Additionally, the ailerons are missing from the trailing edge of both wings. This may be an indication of systematic salvage as defined by Gibbs (2006:14) as they are major structural elements missing from both wings of the aircraft. The alternative is they were lost in a wrecking event. Finally, probing suggests that the tail fin is not present on the aircraft which is also suggestive of systematic salvage. There is no evidence such as twisted, warped or ripped metal to suggest that the tail section was disjointed from the aircraft during a wrecking event, unlike that on the Mariner wreck site. The combination of these missing features contributes to the theory that the Aichi E13A could have been salvaged prior to disposal in Tanapag Lagoon.

Other physical attributes found on the aircraft and aspects of the wreck assemblage also contribute to the hypothesis that the Aichi E13A was intentionally disposed. For instance, Figure 5.6 demonstrates what appear to be exit points for bullets found near the tail of the aircraft. The bullet holes do not appear to have caused any substantial damage to the aircraft that may have caused its sinking or crash because of their location in the tail section where there is an absence of operational machinery. If this aircraft was intentionally deposited on site, these bullet holes may be evidence of this event. They could possible denote why the aircraft was abandoned in this location, as being damaged and not worth retaining. Additionally, the alleged bullet holes could be a contributor to its disposal. It is possible that the aircraft did not initially sink when placed in the water due to air pockets. Because the heavier portion, the engine, would sink first and bullets may have been shot at the aircraft’s tail in order to hasten the disposal. A similar process was apparent at the
“scuttling” of the PBY Catalina Flying Boats of Rottnest Island, where one source indicated the use of tomahawks to create holes in the side of the aircraft in order for the craft to sink (McCarthy 1997:7).

Aft of the bullet holes, a small section of crimping is also present on the tail and may be identified as a scrambling device (Figure 5.7). It is suspected that this could be due to lifting the aircraft on or off a vessel or towing with the use of a chain or rope. As the aluminum alloy which comprises the aircraft exterior is made of a light material, a large chain or rope could easily create the crimping apparent on the aircraft wreck. Disposal practices were often scattered in post-battle scenarios, and detailed records of these disposals are sparse, however the intentional sinking of
surplus or damaged aircraft is documented in the historical record (Veronico, Grantham and Thompson 2000:11).

Adjacent to the Aichi E13A is landing gear which is not associated with the aircraft itself as the Aichi E13A did not have landing gear and the gear are too large in size. As demonstrated in Figure 5.8, the landing gear is attached to a section of aircraft sheathing. The presence of an aircraft tire was not noted on the landing gear, which may indicate the removal prior to deposition or its subsequent disintegration. As the landing gear is fairly large, it is suspected it is from a substantial aircraft, yet circle searches on site did not uncover any additional aircraft parts which may be

Figure 5.7 – Photographic evidence depicting crimping near the tail of the aircraft (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.

Adjacent to the Aichi E13A is landing gear which is not associated with the aircraft itself as the Aichi E13A did not have landing gear and the gear are too large in size. As demonstrated in Figure 5.8, the landing gear is attached to a section of aircraft sheathing. The presence of an aircraft tire was not noted on the landing gear, which may indicate the removal prior to deposition or its subsequent disintegration. As the landing gear is fairly large, it is suspected it is from a substantial aircraft, yet circle searches on site did not uncover any additional aircraft parts which may be
associated with the landing gear. Nevertheless, its presence on site adds to the hypothesis that this area was used as a dumping ground for discarded aircraft parts.

![Photo of landing gear](image)

Figure 5.8 – Photographic evidence of landing gear lying adjacent to aircraft (1m scale). Photo courtesy of Flinders University, taken by K. Gauvin February 2010.

It should be noted that modern cans and bottles were present on site as material which has been subsequently deposited on site by recent visitors.

**Kawanishi H8K**

The Kawanishi H8K wreck site is located well east of Mañagaha Island in the middle of Tanapag lagoon at a depth of nine meters. The aircraft lies inverted on the
seabed with a vast wreck site distribution (Figure 5.9). Figure 5.10 depicts the site plan for the Kawanishi H8K flying boat with the aircraft’s extensive wingspan lying in the centre of the wreck distribution. All four engines and propellers remain on site. Engine 1 (Figure 5.11) and its undamaged propeller lies face-down near its nacelle, while the other three engines are far from their original position. Engines 2 and 3 are located parallel to each other south of the aircraft wing, engine 2 (Figure 5.12) and its propeller stand on a reef outcrop with the propeller blades remaining undamaged; however the nose cone has some damage. Engine 3 (Figure 5.13) lies face down with its propeller blades bent at the tips. Engine 4 (Figure 5.14) and its propeller are found near engine 2 and 3 with the bent propeller detached from the engine lying face up.

Figure 5.9 – Photograph depicting the overall wreck scatter of the Kawanishi H8K. Photo courtesy of Ships of Discovery, taken by D. Ulloa June 2010.
Figure 5.10 – Site Plan for Kawanishi H8K.
Figure 5.11 – Photograph depicting Engine 1 (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.

Figure 5.12 – Photograph depicting Engine 2 (4m scale). Photo courtesy of Flinders University, taken by S. Arnold February 2010.
Figure 5.13 – Photograph depicting Engine 3 (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.

Figure 5.14 – Photograph depicting Engine 4 (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.
North of the wing is the aircraft cockpit which includes pilot chair, controls and steering column (Figure 5.19). The aircraft bow turret remains fairly intact with machine gun in place as well as remnants of window plexiglass (Figure 5.15). Near these features, two memorials have been subsequently deposited on site (Figure 5.21 and 5.22). The site is well known by dive operators and is visited frequently by local recreational divers and visitors to the island. Communication with a local boat driver has revealed that there is a sandy patch north of the wreck and most boat drivers usually anchor there which is why little anchor damage was identified on site (Sheldon Preston 2010, pers. Comm., 14 June).

Figure 5.15 – Photograph depicting bow turret with machine gun (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.
Additional features of the wreck site include portions of the fuselage with some of its original paint schemes intact. Evidence suggests that these paint schemes are mottles. Baker (1992:47) explains this term as evenly distributed and often not consistent in the manner of scribbles and striping. This definition remains consistent with evidence found on the Kawanishi H8K; two different evenly distributed patterns are noted and the patterns used are similar to those described by Baker. As demonstrated in Figure 5.16, the paint schemes are evenly distributed however there appears to be inconsistencies with the shape of the patterns as some squares are longer than others and give the impression that they were completed in a hastened fashion.

Figure 5.16 –Photographic representations of paint schemes found on the Kawanishi H8K (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.
Environmental Impacts

Table 5.2 examines the environmental profile for the Kawanishi H8K wreck site. This site is primarily located on a fine grain sandy seabed with some wreck debris located on adjacent reef. As with the Aichi E13A, the presence of sand scouring was not noted on site. The site is considered low energy as defined by Ward, Larcombe and Veth (1999:565); however because the site is located in the northern portion of the lagoon, the site often has a current which can be difficult for recreational divers. A mucilaginous layer covers the aluminum alloy sheathing of the aircraft. While coral is not found on the aluminum portions of the aircraft, coral growth is much more prominent on this site than the Aichi E13A. Marine growth is found on the propeller blades and nose cones as well as the inside of the wing (Figure 5.17). Additional marine growth is found on the gun in the turret and on components which are manufactured with iron (Macleod 2006:129). Disintegration is prevalent on the aircraft and is especially noted on the engine nacelle (Figure 5.18).

Figure 5.17 – Photographic representation of coral growth on Kawanishi H8K wing (1m scale). Photo courtesy of Flinders University, taken by M. Hanks June 2010.
A variety of fish species and invertebrates are also found on site which does not appear to have an adverse affect on the wreck. The prominent fish species living on the Kawanishi site are described by Fowler (Ash Fowler 2010, pers. comm., June) below:

Highly mobile fish species move between the scattered debris of this wreck and the surrounding natural reef, including whitecheek surgeonfish (*Acanthurus nigricans*) and sunset wrasse (*Thalassoma lutescens*). Smooth flutemouths (*Fistularia commersonii*) can also be seen hovering over rubble near the wreck, either solitary or in small groups of 2-4 individuals. Large big-eye bream (*Monotaxis grandoculis*) rest under the main wing section during the day, however come out at night to feed on gastropod invertebrates over rubble areas near reefs. The secretive lemonpeel angelfish (*Centropyge flavissima*) can be seen occasionally, usually hiding among the more dense coral.

The environmental factors do not appear to be causing significant damage to the

Figure 5.18 – Photographic representation of disintegration on Kawanishi H8K nacelle (1m scale). Photo courtesy of Flinders University, taken by M. Hanks June 2010.
wreck site.

Table 5.2 – Table examining the environmental profile of the Kawanishi H8K.

<table>
<thead>
<tr>
<th>Environmental Profile</th>
<th>Kawanishi H8K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Floated Away</td>
<td>Wrecking Event</td>
</tr>
<tr>
<td>Sediment Budget</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>✓</td>
</tr>
<tr>
<td>Mud</td>
<td></td>
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<tr>
<td>Hydrodynamic Environment</td>
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<tr>
<td>High Energy</td>
<td></td>
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<tr>
<td>Low Energy</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Cultural Impacts**

There are a variety cultural factors contributing to the observed seabed distribution of the Kawanishi H8K. Both extracting filters and scrambling devices have been identified that indicates the site may have developed as a result of an actual wrecking event. Additionally the effects of the diving public are identified as a scrambling device. Impacts of divers on the cockpit section have been significant as is evident in photographs taken between the February and June field seasons (Figure 5.19). The cockpit control panel has been broken off its mount and subsequently balanced giving the appearance of its original position. Furthermore, the steering column has been moved to the opposite side of the cockpit chair. It is evident that in a few short months some major impacts have affected this section of the wreck site from visiting divers.
Additionally, graffiti has been etched in the mucilaginous layer on the aluminum surface of the aircraft on two noted locations including the wing of the aircraft and the turret. These graffiti were not present during the February 2010 field season (Jennifer McKinnon 2010, pers. comm., October). There were no distinctive words identified in the etched graffiti. The etching on the bow turret is indiscernible, but there appears to be more random scratching than the graffiti on the wing. Initials appear to be etched on the west wing of the aircraft, but the letters are not completely distinguishable (Figure 5.20). It is apparent that the first letter of the etching is “X” with an incomprehensive second letter and the last letter being “T.” These initials could represent the initials of the inscriber themselves or this may have been done to personally memorialize one’s attendance at the site.

Figure 5.19 – Photographic evidence of diver impact on Kawanishi H8K cockpit between February 2010 and June 2010. Photo courtesy of Flinders University, taken by S. Arnold (February) and S. Bell (June) 2010.
Smaller artifacts located on site have been moved from their original positions. Figures 5.21 and 5.22 provide examples of items moved on site. A ladder like metal object has been propped up against the southern side of an aircraft wing. The purpose of the ladder’s placement is uncertain. Additional movement of artifacts on site includes the stacking of ordnances around the Japanese monument. It is probable that these artifacts were moved to this location to signify the memorial placed on site.

Figure 5.20 – Photographic evidence of etching on the west wing of the Kawanishi H8K (10cm scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.
Figure 5.21 – Photographic evidence of ladder moved on wreck site (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.

Figure 5.22 – Photographic evidence of piling of small artefacts around Japanese monument (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.
Two monuments have been subsequently deposited on the wreck site in memorial to those lost during the battle. The first and largest monument was placed well before the wing of the Kawanishi H8K by Challenge! Earth Exploration a television adventures series previously aired on the Korean Broadcasting System (Figure 5.23). The larger panels of the monument state in both Korean and English, “Spirits sacrificed in the Pacific War, rest in peace, KBS Challenge! Earth Exploration, Inmolt Engineering Co. Ltd.” One side of the square monument lists the director, producer and others involved in the television program’s placement of the monument. The other side has a series of memorial poems and statements (Jack London 2010, pers. comm.. 25 September). While it is uncertain why a Korean monument was chosen to be placed on a Japanese aircraft, one poem on the side of the monument dedicates the memorial, “to spirits who hired to the compulsory military service and died during the Pacific War,” an additional poem relates, “Anger, tears and grunge.” As only one translation was received for the poem, it is uncertain whether the word “grunge” is accurate. These remarks clearly show a close connection with those lost during the Battle of Saipan, and emphasize that the Korean soldiers were forced into service.
Figure 5.23 – Photographic representation of Korean monument found on Kawanishi H8K wreck site (1m scale). Photo courtesy of Flinders University, taken by S. Bell June 2010.
The Japanese monument is much smaller than the Korean monument and small artifacts from around the wreck site have been piled around the monument (Figure 5.24). As previously discussed, the artifact movement is seen as a scrambling device, but the monument represents a process of deposited items subsequent to the wrecking event. The monument appears to be an epitaph for an individual (Jun Kimura 2010, pers. comm., 15 October). As the first few letters are in a special writing style, they are indiscernible; however the last four characters translate to “Underwater (seabed) War Memorial.” The shape of the monument is similar to that of a wooden stupa used for modern Japanese Buddhist style graves.

Figure 5.24 – Photographic representation of Japanese monument found on Kawanishi H8K wreck site. Photo courtesy of Flinders University, taken by S. Bell June 2010.
The locations of the four engines provide an additional scrambling device which is subject to inquiry as a potential cultural factor. It remains uncertain if the engines are *in situ* or if they have been subsequently placed in their current locations. Engine 2, in particular, has a questionable position as it is standing on its edge in a fashion that implies it may have been placed there intentionally for the purposes of aesthetics (Figure 5.12). Masahiro Nomura (2010, pers. comm., 28 June), a local dive guide and shop operator, has hypothesized that the engines may in fact lie *in situ*, and the aircraft may have been sunk during take-off. He explains that take-off procedures for the Kawanishi H8K typically begin with the start of two of the four aircraft engines. He believes that this aircraft was involved in a take-off and was sunk or wrecked at that moment. His evidence for this scenario includes engines 3 and 4 whose two propeller blades were bent from high speed impact while engine 1 and 2 have propellers that remain undamaged from impact implying the propellers were stationary when the aircraft was sunk. Nevertheless, it remains possible that these engines could have been moved from their original position and placed at their current location.

As movement of the engines would require significant equipment, there are two possibilities of companies who may have contributed to their movement for aesthetic purposes. The first option is Deepstar Submarine which provides a tour in the lagoon that includes World War II wreckage. Masahiro Nomura (2010, pers. comm., 28 June) suspects that the company has moved wreck items to a location their submarine frequents. Figure 5.25 depicts a pile of wreckage from a variety of unrelated sites that the submarine company visits on tours. It is possible that this company may have moved the engines to their current location to create a more visually stimulating
scene. The second possibility includes KBS who was responsible for placing the large Korean monument on the site. It is likely that the company would have had the necessary equipment to move the engines during the placement of the monument. Both companies have been contacted regarding their possible role in the movement of the engines; however no response has been received to confirm their involvement.

![Figure 5.25](https://masadive-saipan.com/)

Figure 5.25 – Photographic evidence depicting the wreckage pile visited by Deepstar Submarine. Photos courtesy of masadive-saipan.com. Accessed June 2010.

Similarities and differences can be identified in the comparison of processes affecting shipwreck sites and the Kawanishi H8K. The process of the wrecking event is recognized as both an extracting filter and a scrambling device which also affects shipwreck sites. Evidence of systematic salvage was not evident on site; however there are indications of the existence of opportunistic salvage. For instance, a local dive shop owner is in possession of the identification plates which have been removed from the Kawanishi H8K (Figure 5.26). Additionally, the local historic preservation office was informed of a piece of aircraft deposited on a beach, which is suspected to come from the Kawanishi H8K (Jennifer McKinnon 2010, pers. comm., 2 September). This provides further proof of opportunistic salvage conducted on this
Another scrambling device recognized on the wreck site, includes the impact of the diving public who move smaller artifacts to various locations around the site. The presence of graffiti is not included in the processes which affect shipwreck sites; however this is a process impacting the Kawanishi H8K site. Furthermore, there are two types of material subsequently deposited on site including refuse and memorials.

**Martin PBM Mariner**

The Martin PBM Mariner remained unidentified until the February 2010 field season when it was positively identified by archaeologists. Some of the characteristics which lead to its identification include the aircraft’s immense dihedral wingspan. As few World War II aircraft feature this wing type, the options were narrowed downed and measurements of key features led to the final conclusion that this aircraft is a Mariner flying boat. An overall photo of the site is depicted in Figure 5.27. As apparent in the Mariner site plan (Figure 5.28), the wreck distribution is
extensive with the port wing lying in the center of the observed site distribution. This aircraft also lies inverted on the seabed with a depth of seven meters. The wing features an exploded fuel tank (Figure 5.29) and engine nacelle (Figure 5.30); however the engine and propeller were not located on site. East of the wing, lies a portion of the aircraft tail which shows some of the tail fin framing (Figure 5.31). Adjacent to this feature, is a gun turret (Figure 5.32) and gun mount (Figure 5.33). West of the wing exhibits a large anchor (Figure 5.37) and chain near some aircraft sheathing.

Figure 5.27 – Photograph depicting overall view of observed seabed distribution of Martin PBM Mariner. Photos courtesy of Flinders University, taken by K. Gauvin February
Figure 5.28 – Site Plan for Martin PBM Mariner.
Figure 5.29 – Photographic representation of exploded fuel tank on Martin PBM Mariner wreck site. Photos courtesy of Flinders University, taken by S. Bell June 2010.

Figure 5.30 – Photographic representation Martin PBM Mariner engine nacelle. Photos courtesy of Flinders University, taken by S. Bell June 2010.
Figure 5.31 – Photographic representation Martin PBM Mariner tail fin. Photos courtesy of Flinders University, taken by S. Bell June 2010.

Figure 5.32 – Photographic representation Martin PBM Mariner gun turret. Photos courtesy of Flinders University, taken by S. Bell June 2010.
Environmental Impacts

Table 5.3 examines the environmental profile for the Martin PBM Mariner, which is similar to that of the Kawanishi H8K. The Mariner also lies primarily on a fine grain sandy seabed with portions of reef dispersed around the wreck site. The presence of scouring from sand movement was not identified on site. A slight current occurs on site but does not appear to have a substantial affect on the wreck itself. As with the previously discussed wreck site, the Mariner also features a thin
mucilaginous layer on the aluminum surface of the aircraft. This layer is also found on the fuselage which appears to be composed of aluminum. A wide variety of biological growth is found on site included several types of hard and soft coral. The aluminum tail section of the Mariner has a large patch of soft coral growth, which is contrary to biological growth seen on the Kawanishi H8K and Aichi E13A. It is suspected that certain tail section components may be manufactured with iron (Macleod 2006:129). The anchor on site is also covered in coral growth and is definitely comprised of traces of iron. Disintegration of aluminum is also found on the aircraft wing (Figure 5.34).

Figure 5.34 – Photographic evidence of disintegration on Martin PBM Mariner wing. Photos courtesy of Flinders University, taken by S. Nahabedian June 2010.
A variety of fish species and invertebrates are also found on site, but do not appear to have an effect of the wreck site. Fowler (Ash Fowler 2010, pers. comm., June) describes the fish inhabitants as follows:

Large recesses in this wreck provide shelter for more cryptic species. Schools of juvenile bluestripe snapper (*Lutjanus kasmira*) can be seen sheltering under the main wing section, along with soldierfish (*Myripristis* spp.) and squirrelfish (*Neoniphon* sp.). The relatively large eyes of soldierfish and squirrelfish indicate their nocturnal habits, these species move out of cover during darkness and feed on invertebrates and small fish.

Areas with substantial coral growth cause some concern for the heritage management of the site; however the bulk of the site is not significantly affected by environmental factors.

Table 5.3 – Table examining the environmental profile of the Martin PBM Mariner

<table>
<thead>
<tr>
<th>Environmental Profile</th>
<th>PBM Mariner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Floated Away</td>
<td>Wrecking event</td>
</tr>
<tr>
<td>Sediment Budget</td>
<td></td>
</tr>
<tr>
<td>Gravel</td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td>✓</td>
</tr>
<tr>
<td>Mud</td>
<td></td>
</tr>
<tr>
<td>Hydrodynamic Environment</td>
<td></td>
</tr>
<tr>
<td>High Energy</td>
<td></td>
</tr>
<tr>
<td>Low Energy</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Cultural Impacts**

The Mariner site features several different types of cultural factors which affect its observed seabed distribution including extracting filters and scrambling devices. As expected, the wrecking event acts as both an extracting filter and scrambling
device. Evidence of this is apparent is the immense dispersal of the wreck assemblage and items lost during wrecking. Another scrambling device affecting the aircraft includes anchor damage. As Saipan is a small island whose income is highly affected by tourism, local knowledge of new wreck site locations spreads rapidly. Further, as the identification of this site continues to become local knowledge, it is visited more frequently and now features more anchor damage than in previous months. The anchor damage is most prominent on the wing section of the aircraft; an example of which is depicted in Feature 5.35.

Figure 5.35 – Photographic evidence of anchor damage on Martin PBM Mariner wreck site (1m scale. Photos courtesy of Flinders University, taken by S. Bell June 2010.)
Since the February 2010 field season, the site has been more frequented by divers (McKinnon 2010a) which is having an impact on its site formation. Ordnance and smaller artifacts have been moved from their original positions. Evidence of this can be seen in Figure 5.36 depicting items photographed during the February 2010 field season and their subsequent location in the June 2010 field season. These items have been piled up in one area in a similar fashion to the piling which occurred on the Kawanishi H8K site. Fifty caliber rounds were also located on site with gun powder spilling from the casings. It is possible that this was caused by the diving public breaking the casings open during relocation. A large shoe sole was also moved to this location and piled with the rounds.

Figure 5.36 – Photographic evidence of small artifact movement on Martin PBM Mariner wreck site (1m scale). Photos courtesy of Flinders University, taken by S. Arnold February 2010 (top), P. Harvey February 2010 (bottom) and S. Bell June 2010 (center).
A large stockless anchor is found west of the Mariner wing (Figure 5.37). It is suspected to be a potential mooring anchor although it is possible that the anchor could have been deposited on site after the wrecking event. The anchor is heavily impacted by soft coral and is situated between two massive coral heads. Its anchor chain runs into one of the large coral heads. To date, no information regarding the types of mooring anchors used on Mariner aircraft has been located. However, the anchor is dissimilar to the folding anchors used on PBY Catalina flying boats (Jung 1996: 39) and is much larger than similar flying boat anchors.

Figure 5.37 – Photographic evidence of large anchor on Martin PBM Mariner wreck site (1m scale). Photos courtesy of Flinders University, taken by S. Bell June 2010.
When comparing the cultural impacts of the Martin PBM Mariner with those processes found on shipwreck sites, many similarities are observed. As previously recognized, the wrecking event acts as a scrambling device and extracting filter. An additional extracting filter includes suspected systematic salvage which may have occurred as evidenced by the missing engine and propeller. Neither of these items were located on site nor suspected of disintegration as the aircraft lies in a low energy environment which would not cause disintegration or scrambling of items as substantial as the engine and propeller. As with the Kawanishi H8K wreck site, public diving behavior is considered a scrambling device with the movement of small artifacts on the seabed. Several examples of refuse were noted on site, including cans and bottles in various locations on site.

**TBM Avenger**

The TBM Avenger aircraft is located on the edge of the fringing reef at the opening of Tanapag Lagoon with a depth of 4.5 meters. The site is well known by local boat and dive operators. The aircraft lies inverted on the seabed with a condensed site distribution mainly consisting of the aircraft wingspan. Figure 5.38 provides an overall view of the TBM Avenger wreck site. The site plan for the TBM Avenger wreck site is depicted in Figure 5.39. What is not clearly represented in the site plan is the aircraft’s hydraulic landing gear which is fully extended in its landing position. The landing gear surface during low tides, and is used as a mooring by surfers who moor their boats and swim outside the reef to surf. Adjacent to the landing gear are the wheel wells which are clearly visible in the site plan and
were also fully occupied with coral growth. The wreck lies in shallow water which is easily accessible to both the diving and snorkelling public. It is apparent from the site plan that little remains of the bulk of the aircraft. The aircraft is missing its tail section along with its engine and propeller. Small portions of wreck debris are scattered south-easterly of the wing section; however these items are not depicted on the site plan. The engine and propeller of the Avenger are absent from the wreck assemblage.

Figure 5.38 – Photograph depicting overall view of TBM Avenger wreck site. Photos courtesy of Ships of Discovery, taken by D. Ulloa 2010.
Figure 5.39 – Site Plan for the TBM Avenger.
Environmental Impacts

As previously stated, the TBM Avenger site is subject to significant environmental impacts. Table 5.4 examines the environmental profile of the site, which is different from the other three aircraft as the hydrodynamic environment is considered high energy. Due to the constant bombardment of high energy wave action, the mucilaginous layer, which is apparent on the previous sites, is not present on the majority of the aircraft’s aluminum sheathing. It was noted in a few places that are protected from wave action by large hard coral heads, but does not cover nearly the same amount of area. The hydrodynamic environment has also caused the disintegration of larger portions of the wings, primarily along the connecting seams of aluminum (Figure 5.40). Where sand is present, mainly on the eastern side of the wreck, the grain size is fine but does not cover any portion of the aircraft. Since the site is located on the reef it is unable to use the lagoon for protection from wave action like the other aircraft wrecks.

Table 5.4 – Table examining the environmental profile of the TBM Avenger.

<table>
<thead>
<tr>
<th>Environmental Profile</th>
<th>PBM Mariner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Floated Away</td>
<td>Wrecking Event</td>
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<tr>
<td>Sediment Budget</td>
<td></td>
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<tr>
<td>Gravel</td>
<td></td>
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<tr>
<td>Sand</td>
<td>✓</td>
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<tr>
<td>Mud</td>
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<td>Hydrodynamic Environment</td>
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<tr>
<td>High Energy</td>
<td>✓</td>
</tr>
<tr>
<td>Low Energy</td>
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</tbody>
</table>
The coral reef has had significant impact on the Avenger and continues to grow around the wreck and in the landing gear wheel wells. Furthermore, coral growth is prominent on the aircraft. Between the landing gear, on the underside of the aircraft, are large heads of hard coral. Even though the wreck is located on the reef, fewer species of fish and invertebrates were noted near the aircraft than on the previous sites. Fowler (Ash Fowler 2010, pers. comm., June) describes the biological life inhabiting the wreck as follows:

This small plane lies in a shallow surgry location behind the main reef break. Schools of herbivorous steephead parrotfish (*Chlorurus microrhinos*) and brown surgeonfish (*Acanthurus nigrofuscus*) can be seen grazing on algae covering the wreck and surrounding reef. Small groups of sixbar wrasse (*Thalassoma hardwicke*) swim through the landing struts [stet] of the plane searching for small crustacean and fish prey. Territorial jewel damselfish
(Plectroglyphidodon lacrymatus) can be seen in holes among the wreckage, with smaller fish possessing the iridescent blue spots that give this species its name.

Environmental factors have had a considerable impact on the TBM Avenger wreck site. It is expected that in another fifty years, the coral growth could possibly conceal the wreck completely.

**Cultural Impacts**

The cultural impacts on the site are difficult to determine as the wreck has been exceedingly affected by environmental processes. As with the previously discussed aircraft wreck sites; the wrecking event of the TBM Avenger is both an extracting filter and a scrambling device. An interesting cultural feature from the wrecking event for the Avenger site is the fully extended landing gear. This is potentially a sign of pre-impact procedures implemented by the aircraft pilot. There are also some additional cultural impacts of note on the site. First, conversations with a local boat driver have disclosed the usage of the landing gear on the wreck as a boat mooring for local surfers (Sheldon Preston 2010, pers. comm., 16 June). The effect of mooring does not appear to have a negative impact on the aircraft itself. However, prolonged use of the landing gear as a mooring could cause severe damage if the boats collide with the aircraft during rough swell conditions.
Currently there is a mooring line south of the wreck for boats to use when visiting the wreck site. Unfortunately, this mooring line is not easily identified unless the boat driver has previous knowledge of the mooring. When the mooring line is followed down to the seabed there is a cement block which was initially thought to be a monument for the wreck. However, as indicated in Figure 5.41, closer inspection reveals that the block informs the reader of a high voltage cable located in the sand. This is disconcerting as many tourists and locals visit this site and the cable is not easily visible. However, this cable and mooring line represent material which has been subsequently deposited on site.

![Photographic representation of cement block near TBM Avenger wreck site (1m scale). Photos courtesy of Flinders University, taken by S. Bell 2010.](image)

Another possible factor contributing to the TBM Avenger’s observed site distribution is the presence of systematic salvage. As previously mentioned, the engine and propeller have not been located, this is similar to that of the Martin PBM Mariner site. There is a distinct possibility that these items were lost in the reef as components of the engine are more susceptible to marine growth, based on the wreck
location in a high energy hydrodynamic environment. Alternatively, the engine and propeller may have been systematically salvaged; however no historical evidence has been located to date to confirm this.

Environmental Impacts for All Four Submerged Aircraft Sites

The Aichi E13A, Kawanishi H8K and Martin PBM Mariner sites all experience similar environmental processes, while the Avenger is exceedingly affected by a high energy environment. The aforementioned aircraft are protected from wave action, strong currents and sand scouring by the Tanapag Lagoon fringing reef. The Avenger is the exception due to its position on the reef resulting in constant wave action. The fine grain sand sediment budget is consistent on all four aircraft sites, which does not appear to have an adverse affect. The movement of sand on the seabed was noted as being seasonal based on observations during the February and June 2010 field seasons. The mucilaginous layer described by Macleod (2006:128) is prevalent on all sites, although its presence on the Avenger wreck is minimal likely due to its location. Coral growth is also observed on the aircraft and is most prominent on sites with exposed components manufactured with iron. As a result of its location on an entirely sandy seabed, the Aichi is least affected by environmental processes such as coral and marine growth. The Avenger is the most affected by environmental processes where coral head growth has dominated the aircraft structure, and disintegration is prominent.
Cultural Impacts for All Four Submerged Aircraft Sites

Table 5.5 examines the cultural processes established for shipwreck sites and compares them with the processes found on the four known submerged aircraft wreck sites in Tanapag Lagoon. It is apparent from this table that many processes which affect shipwrecks do not necessarily affect the submerged aircraft sites investigated. There was no observed evidence to suggest the presence of deliberate running shore, refloating, jettisoning, salvage of jetsam/lagan/flotsam or survivor salvage on any of the submerged aircraft; however this does not preclude these activities occurred.

All four sites have experienced a variety of foreign material deposition from subsequent human interaction. This material takes several forms including refuse, monuments, mooring lines and high voltage cables. It is important to recognize the difference in the types of material found on the wreck sites because the incentive of this process can vary depending on the material deposited. For example, the motivation for placing a monument on site is significant as a memorial, whereas the presence of cans and bottle as refuse is less meaningful; however no less telling about cultural behavior.

Evidence of possible systematic salvage was evident on three of the four sites, while possible opportunistic salvage is only observed on the Kawanishi wreck site. It is possible that the other sites have also experienced opportunistic salvage but that is less easy to detect. Intentional deposition and abandonment were only recognized on the Aichi wreck site.

The interaction between the diving public and the wreck sites can been described as a scrambling device with the movement of small mobile objects around
the seabed as observed on the Kawanishi and Mariner sites. As the Kawanishi wreck site is visited frequently by the diving public, it experiences greater cultural impacts. It is suspected that as the Martin PBM Mariner becomes more widely known, it too will experience more of the similar cultural processes which affect the Kawanishi H8K.

Table 5.5 – Table examining the cultural processes affecting the four submerged aircraft sites in Tanapag Lagoon.

<table>
<thead>
<tr>
<th>Cultural Processes for Shipwrecks</th>
<th>Aichi</th>
<th>Kawanishi</th>
<th>Mariner</th>
<th>Avenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deliberate Running Ashore</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Refloating</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Jettisoning</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Salvage of Jetsam/Lagan/Flotsam</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Survivor Salvage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systematic Salvage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Opportunistic Salvage</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Intentional Deposition</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abandonment</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Subsequently Deposited on Sites</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Comparison of Submerged Aircraft Site Formation and Shipwreck

Site Formation

The preceding section focused on using previously established shipwreck site formation models to identify site formation processes affecting the four submerged aircraft. This section examines the extracting filters and scrambling devices apparent on shipwreck sites in comparison with those affecting the submerged aircraft sites. Additionally, this section will introduce aircraft site-specific extracting filters or scrambling devices that are necessary in assessing site formation of submerged aircraft sites.

Extracting Filters

When comparing extracting filters affecting shipwreck sites with filters affecting submerged aircraft sites; many similarities can be observed. Muckelroy (1978:165) identifies three extracting filters which lead to the loss of shipwreck material including: the process of wrecking, salvage operations and the disintegration of perishables. Gibbs (2006:16) augments these processes to incorporate jettisoning, systematic salvage and opportunistic salvage. While some of these categories are more relevant to submerged aircraft sites, others are less relevant. However, it is surprising how many of the processes affecting shipwreck site are also applicable to submerged aircraft sites. This section breaks down the extracting filters of shipwrecks sites and explains their application to submerged aircraft.

Process of Wrecking

The process of wrecking acts as an extracting filter contributing to the loss of
material on submerged aircraft sites. Aircraft are composed of small parts many of which are constructed with light, buoyant material. Some examples of items which may be lost during the wrecking event include padding used for the pilot’s chair, plastic knobs, strapping material and tubing to name a few. These items could easily float away from an aircraft during the process of wrecking. Additionally, items found within the aircraft, such as cargo, safety equipment or personal items, may also be comprised of material lost during the process of wrecking. This process is apparent on all four aircraft wreck sites examined as the aircraft are no longer intact and large portions are not on site. These items may have floated away or have been lost during wrecking. Either way, the wreck assemblages of the four aircraft are vastly different from their original assembly and one of the major causes of the loss of aircraft structure is the wrecking event. Even the Aichi site, which is suspected to be intentionally deposited, shows signs of the wrecking event acting as an extracting filter. On this site, portions of the pontoon have been damaged and one pontoon is not even present.

Systematic and Opportunistic Salvage

Evidence suggests that systematic and opportunistic salvage may have occurred on all four sites and therefore are processes affecting submerged aircraft sites. The two U.S. aircraft are the most likely candidates for systematic salvage. This is demonstrated by the absence of the aircraft engines and propellers from the wreck sites. Although no historical evidence has been located to substantiate this, due to the size and mass of the engines and propellers it is implausible for these items to have floated away during the wrecking event. Furthermore, it is doubtful that these items
have subsequently disintegrated; although this may be possible for the engine Avenger wreck site due to its location in a high energy hydrodynamic environment. The face of the Mariner’s nacelle shows no evidence of damage from engine separation during the wrecking event, as is apparent on the Kawanishi H8K wreck site. Additional evidence of possible systematic salvage is observed on the Aichi E13A site. Major components of the aircraft are missing, including the engine cowling, portions of wing and tail fin. As aircraft are manufactured with interchangeable parts which are replaced frequently (Diebold 1993:3), it is only logical that an aircraft which is no longer air worthy would be salvaged for parts to be used on a working aircraft, especially in an instance of war.

Opportunistic salvage is often distinguished on shipwreck sites by the absence of smaller artifacts or minor structural elements (Gibbs 2006:14). Signs of opportunistic salvage are difficult to distinguish on the aircraft sites investigated. For instance, the presence of opportunistic salvage on the Kawanishi site was not evident during the photographic archaeological survey. The information regarding opportunistic salvage on the wreck was gathered from personal communications with a local dive shop and internet research. The opportunistic salvage of the Kawanishi identification plate may emphasize its significance to the local population; however it is removed from its original context on the aircraft which may have provided additional information.

The Martin PBM Mariner does not appear to show signs of opportunistic salvage. However, based on the pile of wreckage visited by the tourist submarine, it is possible that a chair from the Mariner has been removed and aesthetically placed
for submarine tours. This chair is not suspected to be from a Japanese aircraft as U.S. aircraft tended to have larger, wider chairs (Masahiro Nomura 2010, pers. comm., 28 June). No evidence exists to suggest that opportunistic salvage occurred on the TBM Avenger or Aichi E13A wreck sites. While the findings at these sites show little signs of opportunistic salvage, this evidence is circumstantial and cannot be said for all submerged aircraft sites.

World War II aircraft wreck sites are prone to opportunistic salvage from a variety of interested groups, including metal salvage and amateur excavations. One example of this includes the sites located in Chuuk Lagoon, where Jeffrey (2007:2, 203) explains how sites were initially salvaged for their metal as well as small artifacts taken by divers as souvenirs. Further, Holyoak (2002:657) investigates amateur excavations of submerged aircraft sites in England, and demonstrates how the majority of artifacts gathered in these excavations are taken as souvenirs. Those partaking in these types of amateur excavations are often referred to as “wreck chasers.” Several books have been written on the subject of wreck chasing and the recovery of aircraft sites (Hoffman 2001; Page 2007; Veronico 1995). It is crucial for archaeologists to recognize these types of opportunistic salvage processes in order to accurately assess submerged aircraft sites.

**Jettisoning**

Jettisoning is considered by Gibbs (2006:9) to occur during the “pre-impact warning phase” of a shipwreck where crew members attempt to slow or stop the imminent disaster. While jettisoning is not visually apparent on the four sites investigated, the fully extended landing gear of the Avenger suggests a form of “pre-
impact warning.” The pilot may have extended the landing gear in order to slow or stop the aircraft wrecking or en route to the airstrip. Aircraft are made of light material and their structure is aerodynamic; however it is unlikely that jettisoning material would slow or prevent an aircraft sinking even if time was warranted. For example, a flying boat sunk at its mooring may warrant enough time to jettison material and cargo on board.

Alternatively, self-ejection by the pilot and crew is a form of jettisoning which has not been studied by underwater archaeologists. While this may slow an aircraft from wrecking, it would potentially save the life of the aircraft crew members. Further fuel dumping or munitions dumping may also be considered a form of jettisoning, although the presence of this in the archaeological record would prove difficult to distinguish. The presence of jettisoning was not observed on any of the four sites investigated.

**Disintegration of Perishables**

The disintegration of perishables affects the site formation of submerged aircraft wreck sites. The Aichi, Kawanishi and Mariner have all experienced minor impacts from disintegration with the majority of damage concentrated to small patches on the aluminum sheathing of the aircraft. Major disintegration damage is evident on the Avenger site due to its location in a high energy hydrodynamic environment. The damage from disintegration is most prominent on the seams of the aluminum sheathing of the aircraft exterior. Further, many items on aircraft are not manufactured to withstand the marine environment such as items made of organic material. For example, aircraft wings prior to World War II were covered in canvas
which is more susceptible to disintegration in the marine environment than wooden shipwrecks. Due to the nature of the marine environment, submerged aircraft sites experience disintegration of perishables as an extracting filter.

**Scrambling Devices**

As with the extracting filters, the scrambling devices which affect shipwreck sites are also apparent on submerged aircraft sites. Muckelroy (1978:169) describes two major categories of scrambling devices with the first being the wrecking itself. From the moment of impact, the ship and its contents enter a stage of disorder as it descends to the seabed. The second scrambling device recognized by Muckelroy (1978:175) is the process of seabed movement and its affect on shipwreck sites. This section also proposes a new scrambling device observed on the submerged aircraft sites which incorporates modern influences affecting the sites.

**Process of wrecking**

Submerged aircraft wrecks experience the process of wrecking, not only as an extracting filter, but also as a scrambling device. This is apparent on all four sites investigated. For example, the four submerged aircraft sites lie inverted on the seabed. There are a couple hypotheses of why this may occur. It is suspected that this is due to the weight distribution of heavy items inside the aircraft. These items may shift during the wrecking process causing the aircraft to invert as it sinks to the seabed. Furthermore, as cockpits and other heavy machinery are often mounted on the top of the aircraft, this is may cause aircraft to capsize during their descent. Through his research on site formation, Jung (2001) has uncovered a historic photo which depicts a PBY Catalina nearly capsizing after the loss of its starboard pontoon.
As three of the four aircraft studied are float planes, a possible reasoning for their inversion could be due to damage to one of their wing floats causing the aircraft to capsize on the surface prior to sinking. However, this theory is not valid for the Avenger wreck site because the aircraft is a torpedo bomber rather than a float plane.

The observed seabed distribution of the Kawanishi and Mariner wrecks provide another example of the process of wrecking as a scrambling device which affects the wreck assemblage. The site distribution for both wrecks is vastly dispersed with many items a fair distance from their original location. As hypothesized by Masahiro Nomura (2010, pers. comm., 28 June), the Kawanishi engines and propellers current location south of the aircraft wing may represent a scrambling device resulting from the wrecking event. The process of wrecking affects the observed site distribution of all submerged aircraft wreck sites.

**Seabed Movement**

The effect of environment processes has been previously discussed as an extracting filter; however, their affect on submerged aircraft sites is also recognized as a scrambling device. The Avenger wreck site has been substantially affected by high energy hydrodynamic processes. Wreckage from the Avenger can be found meters away from the aircraft itself. It is difficult to determine from the archaeological record if their placement is due to the wrecking event or as a result of environmental impacts. However, of the four submerged aircraft sites, the observed seabed distribution of the Avenger is the most likely to be affected by seabed movement as the other sites are protected by the lagoon.

While the sites investigated are not visibly affected by seabed movement, other
submerged aircraft sites have experienced seabed movement as a scrambling device affecting their observed site distribution. One example of this is the Catalina wreck sites in Roebuck Bay, Western Australia. The 15 aircraft wreck sites experience extreme tidal changes and cyclones which have affected wreck distribution and movement of larger portions of the aircraft are suspected (Jung 2008a:274). Furthermore, due to the large tidal fluctuations experienced by the wreck sites, sand scouring on the aircraft exterior has been observed (Jung 2008a:274). It is clear that the effect of seabed movement contributes to the site formation of submerged aircraft.

**Modern Influences**

Another scrambling device observed on the four aircraft wreck sites includes the process of modern influences. It incorporates several factors including the movement of small objects on site by recreational divers, graffiti and anchor damage. The movement of small artifacts by divers was observed on both the Kawanishi and Mariner wreck sites. The Kawanishi site has several small artifacts piled around a small Japanese monument which has been placed on site subsequent to the aircraft wreck. Additionally, a ladder has appeared to have been moved from its original location and placed on the aircraft wing. The Mariner artifacts have not been placed around a monument like the Kawanishi, but appear to be piled up around a pile of 50 caliber rounds. Further, a 50 caliber round has also been pulled apart onsite, which is suspected to be the result of diver interaction with the site.

Another impact contributing to the process of modern influence includes the presence of graffiti. The Kawanishi wreck site was the only site which was observed to be affected by etched graffiti. While this site formation process will be discussed
further in the following chapter, it is important to recognize it in this section as a scrambling device which may not affect shipwreck sites. Further interactions include anchor damage on site, which is most prevalent on the Mariner site. Anchor damage is not exclusively found on submerged aircraft sites as it is often contributes to the site formation of shipwreck sites.
Discussions & Conclusions

Introduction

The previous chapter presented the data collected from the four submerged aircraft sites. A comparison was made between the processes affecting shipwreck sites and their application to submerged aircraft sites. As all four sites vary in their observed seabed distribution, a multitude of site formation processes were identified. However, it is also clear that other factors, which are not represented in the four sites examined, need to be considered when investigating submerged aircraft sites. This chapter intends to answer the research questions previously outlined for this study and includes adaptations to shipwreck site formation models for submerged aircraft sites. The submerged aircraft site formation model follows the basic model established by Muckelroy (1978). Further, this chapter will provide further intentions of this study and its importance for cultural heritage managers. Finally, a summary and conclusion of the research examined in this thesis will be presented.

Can submerged World War II aircraft in Saipan, CNMI be investigated and understood using previous shipwreck models of site formation “process-oriented framework?”

Based on this research, it can be concluded that aircraft wrecks are capable of being investigated and understood using previously developed shipwreck models. Submerged aircraft undergo certain environmental and cultural processes that also affect the formation of shipwreck sites. The environmental factors outlined by Muckelroy (1978:158) include disintegration of perishables as an extracting filter and
seabed movement as a scrambling device. Ward, Larcombe and Veth (1999:564) expand this research further by explaining that the type of site deterioration is dependent on the hydrodynamic environment which can be categorized as high or low energy. A high energy environment is susceptible to a physically dominated deterioration, which is evident on the Avenger wreck site. Low energy environments are subject to chemically and biologically dominated deterioration; this is apparent on the three remaining sites which are covered in a mucilaginous biological layer with intermittent coral. As submerged aircraft wrecks reside in the marine environment, they endure the same environmental factors affecting shipwreck sites. Aircraft are also manufactured with very different material than ships, and thus their corrosion rate is incomparable. With this stated, further research is necessary to develop a comprehensive analysis of corrosion potentials for submerged aircraft as little research has been conducted in this field.

Cultural factors affecting shipwreck sites are classified as extracting filters and material subsequently deposited on site by both Muckelroy (1978:165) and Gibbs (2006:14). These factors have been previously identified as the process of wrecking, jettisoning, systematic and opportunistic salvage. Gibbs (2006:7) also includes a disaster response framework which contributes to the observed seabed distribution of shipwreck sites. These include: pre-impact phase, impact stage, recoil stage, rescue stage and post-trauma stage. While these stages might not always be apparent in the archaeological record, it is important to acknowledge them when attempting to understand the site formation of a shipwreck site. As aircraft wrecking typically occurs relatively quickly, there may be little time to react in the pre-impact phase by
the pilot and crew. Possible actions or strategies by the pilot and crew may include self-ejection, fuel dumping, evacuation and an attempt to slow or stop the aircraft from wrecking. The fully extended landing gear on the Avenger wreck site is an example of what may be present on site to demonstrate a response to the pre-impact phase. Shanline (1985:37) describes a Martin PBM Mariner which was descending rapidly towards a possible wrecking, but with some strategic flying, the pilot was able to regain control of the aircraft and land the plane safely without injury. This provides an example of actions during the pre-impact warning phase in which the disaster was avoided.

Cultural response to the impact stage of the wrecking process of aircraft is difficult to determine from the archaeological record. It is suspected that if one survived the wrecking event, one would gather necessary items for their survival until rescued. Unlike shipwreck sites, it does not seem feasible that the crew would need to jettison heavy items or attempt a refloating of the aircraft. However, items such as life jackets and distress signals may be used in order to attract attention for rescue. While not examined in this study, the development of a survivor camp in the recoil stages would be an option for aircraft that may have wrecked near shore. One example of a survivor camp situation which affects the site formation of aircraft occurred on Anatahan Island, CNMI. Japanese holdouts on the island, who had survived a shipwreck near shore, salvaged items from a B-29 bomber that they had come across. They used parachutes to make clothing, oxygen tanks for holding liquids, aluminum sheathing for making pots and knives and machine gun springs for fishing hooks (Japanese Holdouts from Shipwreck 2010). While these efforts were
not by aircraft survivors, it does provide evidence of the use of aircraft parts in a
shipwreck survivor camp situation.

Additional cultural factors of submerged aircraft sites can be investigated
through certain extracting filters including: the process of wrecking, systematic
salvage and opportunistic salvage. Systematic and opportunistic salvage are
processes of the rescue and post-disaster response stages. Both systematic salvage
and opportunistic salvage are noted on the sites examined in this study and should be
considered when examining submerged aircraft sites. Although the post-trauma stage
of disaster response is not found in the archaeological record, it is a continued process
which affects survivors of the wrecking event. If the aircraft wreck was a casualty of
war, the post-traumatic affect can have a profound effect on the life of a survivor.
Additionally, while the factors outlined by Muckelroy, Gibbs, Ward Larcombe and
Veth are typically pertinent to submerged aircraft sites some adaptations are
necessary in order to completely understand the site formation of submerged aircraft.

What adaptations to shipwreck site formation “process-oriented frameworks”
are necessary for the interpretation of submerged aircraft sites?

While submerged aircraft site formation can be investigated using previously
established shipwreck models of site formation using “process-oriented frameworks,”
several adaptations are necessary to consider when examining these sites. Figure 6.1
represents an adjusted site formation diagram for submerged aircraft incorporating
ideas from Muckelroy, Gibbs, Ward, Larcombe and Veth.
Figure 6.1 – Flow diagram featuring environmental and cultural factors affecting submerged aircraft sites.
The basic layout of the diagram follows Muckelroy’s original diagram, with the exception of salvage operations which is split into systematic and opportunistic salvage in accordance with Gibbs adaptation. As systematic salvage typically occurs relatively soon after the wrecking event, this is placed under the process of wrecking and before any disintegration of perishables. Opportunistic salvage can occur any time after the wrecking event and can be repeated over a long period of time. For this reason it is placed beneath disintegration of perishables. Gibbs’ addition of storage, intentional deposition and abandonment are also incorporated into the diagram, as their contribution to the site formation process is evidenced from the data collected.

Environmental factors contributing to the observed wreck distribution are exhibited as scrambling devices and extracting filters. As the same environmental processes affecting shipwreck sites also affect submerged aircraft sites, no adaptations were necessary for this aspect of the diagram. However, it should be noted that aircraft, particularly World War II aircraft, are not constructed to last for substantial lengths of time (Whipple 1995:11). Additionally, aircraft are manufactured of lighter material for longer flight times and aerodynamic properties. Bearing this in mind, submerged aircraft wreck sites are going to have different interactions with their natural environment than shipwrecks which are comprised of strong heavy material built to survive the harsh conditions of the sea. Although these processes show similarities with previously developed shipwreck site formation models, the diagram also features adaptations which should be considered for aircraft sites.

The major difference in the site formation models developed for shipwreck sites and the proposed submerged aircraft diagram is the addition of modern
influences. This process on aircraft wreck sites is multifaceted yet it is essential to recognize as it contributes to the story of the aircraft wreck and the evolution of its site formation. Material subsequently deposited on site is one example of a modern influence which affects the observed seabed distribution. Neither Muckelroy nor Gibbs elaborate on this issue as being an important process for the wreck site. However, data collected in this research indicates that material subsequently deposited on sites can take many forms and it is important to distinguish between the two types. The first type is recognized as refuse or material deposited on site without a particular purpose or association with the wreck site. This is most apparent on sites examined where cans and bottles are scattered amongst the wreck assemblage. The second type is associated with memorializing the site in some way. An example of this process would be the Kawanishi wreck site, which includes two monuments from separate nationalities deposited on the wreck site: Korean and Japanese. It is important to consider the significance of the Korean monument and the motives for placing a monument on a Japanese World War II aircraft. Additionally, what is the significance of a celebrity adventure television program to be involved in the placement of the monument? Further, Carrell’s initial report on the submerged resources located in Micronesia exhibits the Aichi propeller with an empty sake bottle and memorial prayer stick (Figure 2). These items cannot be situated in the same category of refuse, as their placement on site was done with a specific purpose and represents a distinctive chapter in the history of the wreck site. Material subsequently deposited on site is one aspect of the modern influence process affecting submerged aircraft sites.
Modern influences can be considered as a scrambling device through the process of public diving interactions with the wreck site. The Kawanishi and Mariner are excellent representations of how recreational diver activities can act as a scrambling device. Kawanishi is a well-known recreational dive site in Tanapag Lagoon and the effect of divers as a scrambling device can be seen through the movement of objects on site including: piling small artifacts around the small Japanese memorial and the placement of the ladder on the aircraft wing. Further the cockpit of the aircraft has also been affected by divers with the control panel broken from its mount and subsequently balanced on its original location as well as the rearranging of the steering column. This was observed within a short time period between the February and June 2010 field seasons, and thus should be considered an

Figure 6.2 – Empty sake bottle and prayer stick on Aichi E13A site (Carrell 1991:509).
active scrambling device affecting these sites. The Mariner is not as well known as the Kawanishi, however it has experienced similar movement of objects. The movement of small artifacts has increased on the site as observed between the February and June 2010 field seasons; objects are also piled in a similar manner to those found on the Kawanishi site. An increase in anchor damage was also observed during the June field season; this implies an increase in visitation to the site by the diving public and thus an amplified effect on the site by this scrambling device. Modern influences can also be processes affecting the appearance of the wreck.

Graffiti is an additional process of modern interaction which has an effect on the aircraft examined in this study. This process cannot be classified as an extracting filter, scrambling device or material subsequently deposited on site as the graffiti observed was etched into the biological mucilaginous layer forming on the aluminum wing of the Kawanishi. Thus, this process is in a category of its own as a contributor to the observed seabed distribution. Research was conducted in order to search for the presence of graffiti on shipwreck sites, however no information was located. However, the presence of graffiti has been noted on land-based public interpretive signs on shipwreck trails (Smith 2003:126). Graffiti is often seen as vandalism on rock art sites as an unacceptable form of social behavior (Moser 1992). However, Field (2009:52) argues that graffiti over a period of time may retain historic significance as a contributor to our understanding of an archaeological site. As the graffiti appears to be in the form of initials it is difficult to determine if its presence is due to memorial or an alternative reason. The combination of these adaptations, help us to further understand the processes affecting submerged aircraft sites.
Does a site formation “process-oriented framework” developed for submerged aircraft wrecks allow for a comparative analysis and broader understanding of those aircraft and the cultural and environment factors involved in their observed distribution on the seabed?

A site formation “process-oriented framework” developed for submerged aircraft does allow for a comparative analysis and a broader understanding of factors involved in their observed wreck site distribution. While it may be true that an archaeological investigation can be conducted using previously developed shipwreck site formation models on submerged aircraft sites, there are some additional processes which contribute to our understanding of these sites. The investigations of the four submerged aircraft sites used in this study provide examples of how a site formation “process-oriented framework” can contribute to understanding the site formation of aircraft. The condensed site distribution of the Aichi E13A along with the suspected systematic salvage and adjacent unassociated landing gear lead to the hypothesis that the aircraft was intentionally deposited on site. Similarly, the TBM Avenger too has a condensed site distribution; however, there is little evidence on site to suggest that this site was intentionally deposited. The fully extended landing gear provides evidence to a response of the pre-impact warning stage implying that this aircraft likely crashed into the reef.

The Kawanishi H8K has a vast observed site distribution that still has some unanswered questions in its site formation. However, if Masahiro Nomura’s hypothesis with the engine placement is correct, the aircraft was in the process of taking off when it sunk. The effect of modern influences is considerable, yet this process contributed to our further understanding of the significance of the site. The piling of small mobile artifacts and the placement of two separate monuments
suggests that this site is important to a multitude of people. This is also apparent in the removal of the identification plates. The Martin PBM Mariner site also shows signs of a significant wrecking event with the exploded fuel tank and immense site distribution.

It is important to understand the contemporary nature of aircraft and the passion the public has for wrecked aircraft. The search for aircraft wrecks seems to be an obsessive passion aimed at preserving the history or story of aircraft wrecks. Most authors, who have written books on the subject, recognize some kind of connection with the aircrafts, whether it is a veteran who previously flew the aircraft for the military or a childhood fascination (Hoffman 2001; Hoffman 2004). This is important to consider when investigating aircraft sites archaeologically.

If modern influence as a site formation processes is necessary to understand the observed seabed distribution, then comprehension of the public attitude around aircraft sites is also essential. An example of this is the presence and movement of small mobile artifacts on the seabed. The submerged aircraft sites in Tanapag Lagoons are widely visited by the diving public and are considered a great importance to the local population. While significant shipwrecks are often salvaged by the diving public, the small artifacts located on the aircraft wrecks in Saipan are still present. Additionally, they act as underwater commemorations to the wreck through the act of collection and redistribution. Further, the act of placing monuments on the site also demonstrates the significance of these wrecks to different nationalities.

With a battle fought in a remote area such as Saipan, information about the specific sites may not be readily available and it is imperative to contact the local historic preservation office and others who may have information on the sites. For
instance, one of Saipan’s local dive shops, MASA Dive shop, has conducted a considerable amount of historical research on the submerged aircraft sites in Tanapag Lagoon (MASA Dive Saipan 2010). This research has provided additional locations to investigate submerged aircraft locations in the lagoon, as well as provided identification plates for two submerged aircraft wrecks. Also, because the dive shop operator is Japanese, he is able to provide an alternative perspective on the wreck sites. The research completed by the local population has provided a broader understanding of the significance and site formation development of the four submerged aircraft wreck sites. Archaeological investigations of submerged aircraft sites need to recognize the significance of their site formation and the modern interactions involved in their observed seabed distribution in order to provide an appropriate management plan.

**Management Considerations**

The preliminary objective of this research has broadened our understanding of the processes that affect the site formation of submerged aircraft wreck sites. With the results of this study, maritime heritage managers may be made aware of the factors affecting submerged aircraft sites, which will enable proper cultural heritage management of these types of sites. Further, this study provides new forms of cultural site formation which should be recognized in management considerations by heritage manager to acknowledge in the development of a management plan. When considering management options for the four sites examined, the process of modern influence is an important factor to recognize. The aircraft signify an important battle to the local and visiting populations who have taken a keen interest in the history of the sites. Additionally, the local population uses the sites as a source of income by
providing diving tours for visiting tourists.

All four submerged aircraft sites will be included in an underwater World War II heritage trail in Saipan. The sites are going to see an increase in visitation, which will undoubtedly cause additional diver impacts in attracting different types of visitors. It should also be noted that Japanese tourists comprise the majority of visitors to Saipan with their primary motive to visit the beaches on holiday (Sayers and Spennemann 2006:378). The creation of an underwater heritage trail in Saipan will likely attract tourists who are enthusiastic about eco-tourism, wreck diving or World War II history. It is anticipated that this will further affect the aircraft sites as more tourists will be visiting for the specific purpose of diving World War II wreck sites. The interaction this diving population may have with the aircraft wreck sites could have a substantial effect and thus proper management plan should be put in place.

As both the Avenger and Mariner sites have been affected by boat anchoring and mooring, the establishment of a mooring system for these sites would prevent further damage. Even though the Avenger has a line which can be used for mooring adjacent to the site, the line is not visible to boat operators who are unaware of its existence as it is submerged (Figure 6.3). A mooring line on the Mariner site would help prevent further anchor damage to the aircraft structure. Furthermore, the Aichi wreck site is located in a high boat traffic area and the placement of a mooring buoy may deter boat drivers from a route which may harm the diving public. As buoys are found throughout the lagoon marking hazards, the placement of moorings on site could force boat drivers to find alternative routes to their destination.
An additional management consideration for all four aircraft sites is the nomination of the sites to the National Register of Historic Places. This will provide the local Historic Preservation Office additional funding to monitor the sites (National Register of Historic Places 2010). The registration will also recognize the historical significance of these submerged sites in the Battle of Saipan. Regular monitoring should also be conducted and changes to the sites over time should be noted. It will be interesting to examine the further development of the site formation of these four submerged aircraft sites after the creation of the underwater heritage.

Figure 6.3 – Submerged line used for mooring adjacent to the Avenger wreck site (1m scale). Photo courtesy of Flinders University, taken by S. Bell 2010.
The interpretive material created for the underwater heritage trail will inform visitors of the history and significance of each site. This material will be presented in several forms including brochures, underwater dive guides, posters, interactive website and shore based interpretive material (McKinnon 20101). A draft of the underwater interpretive guide for the Aichi E13A is depicted in Figure 6.4. This guide provides both a history of the aircraft and a description of the site itself. Further, it provides visitors with information about anchoring at the location to help prevent anchor damage on site. This guide is short yet informative and hopes to discourage diver damage to the site.

Figure 6.4 – Draft underwater interpretive guide for the Aichi E13A wreck site. Image courtesy of Ships of Discovery, created by J. Hunter and J. McKinnon 2010.
Future Research

As previously established, this study is preliminary and has immense potential for future research. The diagram created outlining processes affecting submerged aircraft sites needs to be applied to additional submerged aircraft site investigations. This will allow for critique and supplements to be added in order to continue to broaden our understanding of submerged aircraft. Further, ethnographic studies into the purpose of moving small objects on site and graffiti on the wreck site may also provide information necessary to understand these sites. Additionally, further studies into the corrosion potential of aircraft are needed especially for aircraft in non-tropical environments. Archaeological research into the process of jettisoning prior to the aircraft wrecking event would provide useful information in the site formation of aircraft.

The four site investigated in this study continue to have research potential in themselves. Historical research into aircraft salvage is necessary in order to accurately assess whether systematic salvage has indeed occurred on any of the submerged aircraft sites. Further, any information on the disposal of aircraft in Tanapag Lagoon would conclude if the Aichi E13A was intentionally deposited on site. Inspections of the pile of wreckage visited by the touring submarine would prove interesting to establish if these items had been moved to their current location. Additionally, an interview with the owners of Deepstar Submarine might shed light on their involvement with the moving artifacts on site.

Conclusions

This thesis has demonstrated the archaeological significance in understanding the processes affecting submerged aircraft wreck sites. While “process-oriented
frameworks” previously developed for shipwreck sites can be used in the study of submerged aircraft site formation, an adaptation provides further understanding of these sites. The extracting filters and scrambling devices that affect the site formation process of submerged aircraft have been investigated. It is important to recognize the modern influences which affect submerged aircraft sites as these processes contribute to comprehending the significance of the wreck site.

This research can also be used by maritime heritage managers who have not been trained to understand these types of sites. Maritime archaeology training is focused primarily on shipwreck sites which experience different processes of wrecking than aircraft sites. As aircraft wrecks are from recent history, the public feels more emotionally connected to this type of site than a classical shipwreck. This should be acknowledged by heritage managers in developing a management plan for these sites in order to fully understand the significance of submerged aircraft sites.
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