Assessing the Efficacy of Anti-Submarine Measures in Broken Bay for Safeguarding the Hawkesbury River Railway Bridge.

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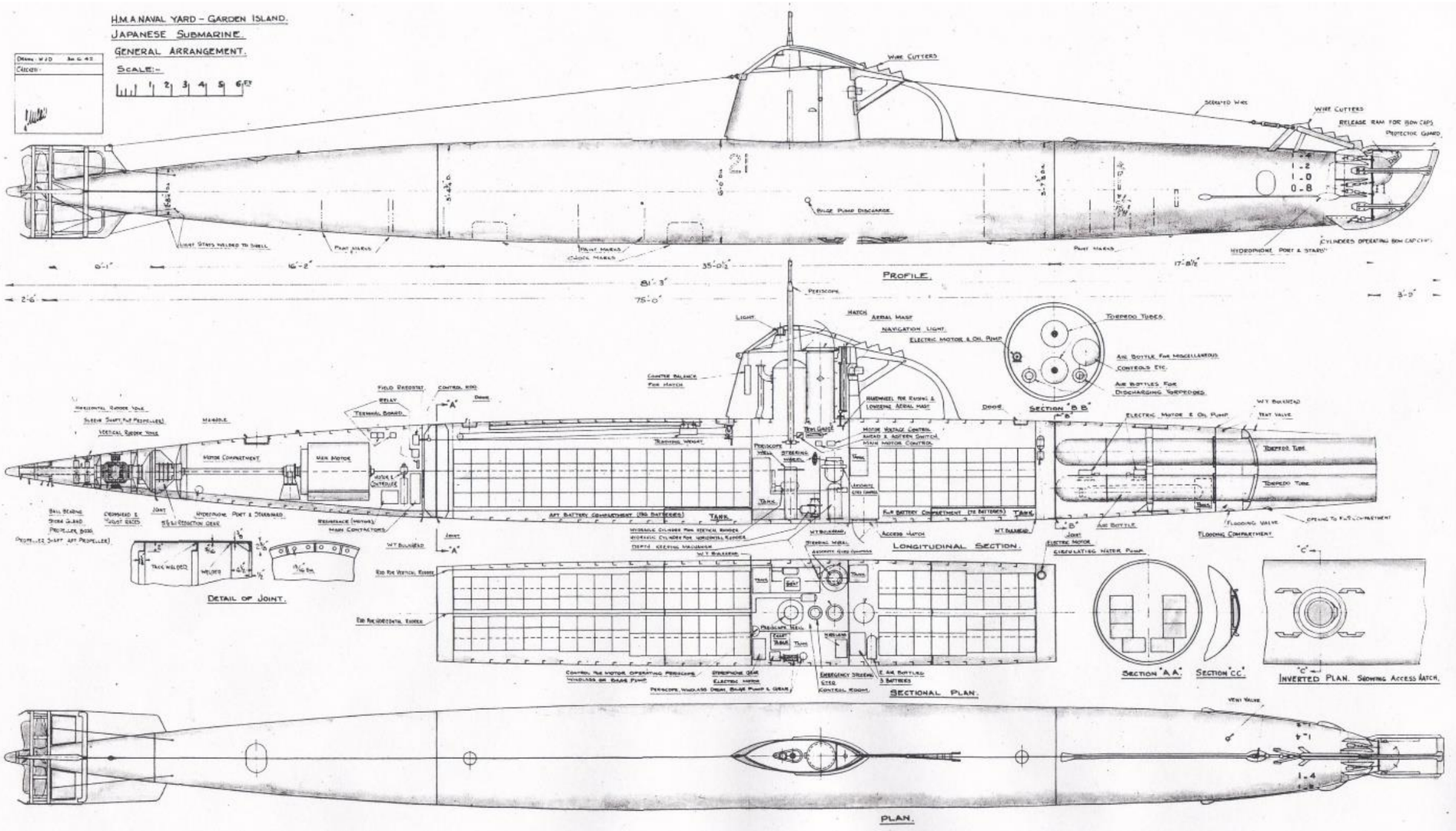
Flinders UNIVERSITY

H.M.A NAVAL YARD – GARDEN ISLAND.

JAPANESE SUBMARINE.

GENERAL ARRANGEMENT.

SCALE:-



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Abstract

This academic research endeavours to delve into the realm of conflict archaeology, focusing on the underexplored domain of anti-invasion defences during the Second World War in Australia, specifically within the locale of Broken Bay, New South Wales. Despite the prevalent scholarly interest in Second World War archaeology, a noticeable dearth of studies concentrates explicitly on maritime defence installations and their material evidence in the context of a conflict. This research seeks to address this gap by employing the principles of historical and conflict archaeology and embracing perspectives from the archaeologies of the recent and contemporary past.

The primary objective of this study is to assess the preservation status of archaeological and documentary evidence relevant to Broken Bay, New South Wales, Australia, focusing on World War II maritime defences and their efficacy in preventing potential submarine incursions. The research methodology involves critically evaluating and analysing both material and archival forms of evidence. Each source is scrutinised to discern its unique role, value, and contribution, with particular emphasis on understanding submarine strategies and abilities as prerequisites for effectively utilising the evidence.

The findings of this research highlight the validity and productivity of an archaeological approach, mainly when applied to cross-disciplinary evidence derived from the recent past. The study reveals a comprehensive yet incompletely assembled and complex archaeological evidence base, utilising official sources that offer unique, knowledgeable, and authoritative information. Integrating diverse forms of evidence facilitates the construction of meaningful narratives, shedding light on different aspects of the shared phenomenon.

Moreover, this investigation identifies a significant lacuna in maritime conflict archaeological resources in Australia, specifically about anti-invasion defences. The deficiency underscores a substantial knowledge gap regarding Australia's efforts to safeguard vital infrastructure during the war. Consequently, the study emphasises the urgency for further extensive investigations into this subject matter, advocating for a more comprehensive understanding of Australia's wartime history. The research contributes to the broader discourse on conflict archaeology by revealing this critical aspect. It underscores the imperative for continued scholarly inquiry into Australia's maritime defences during the Second World War.

Declaration

I certify that this thesis:

1. Does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university;
2. And the research within will not be submitted for any other future degree or diploma without the permission of Flinders University; and
3. To the best of my knowledge and belief, does not contain any material previously published or written by another person except where due reference is made in the text.

Paul Gale

2228194

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I am also indebted to my wife and daughter for their unwavering support throughout the past few years. Each, in a unique way, contributed to my journey towards submission. They endured holidays filled with my keyboard tapping and research ventures at archives and antique bookshops.

I look forward to our next holiday, which they eagerly anticipate as one free from computers.

Special thanks to the NSW Sport and Recreation staff Juno Point, for their assistance, granting access, and guiding me to the known archaeological sites. Without their expertise, locating some of the archaeology would have been impossible.

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CHAPTER ONE

INTRODUCTION

This research collects new archaeological data to address the adequacy of maritime defences against submarine damage during World War 2. The case study is the maritime defences that were built to protect the Hawkesbury River Railway Bridge in Broken Bay, a large oceanic bay located about 50 kilometres north of Sydney in New South Wales, Australia. The research combines archival research and archaeological fieldwork. It systematically gathers data from archival records, government documents, and published works in archaeology to identify potential sites of defensive installations and identify their respective typologies. These sites and their surrounds were recorded and analysed archaeologically, and the results interpreted in terms of contemporary national and international debates in maritime archaeology.

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1.1 Background

Since Leonardo da Vinci sketched the concept of a submersible vehicle in 1515 (da Vinci 1519: 249), submarines have been the focus of covert and deadly operations. Da Vinci (1519) said that he did not show anyone the designs of the vessel because of the corrupt and violent nature of man (White, 2001, p. 200). Four hundred years later, World War 1 saw submarines enter the naval battlefield in earnest for the first time, and as with all weapons, their designs improved with each new model. Two decades later, as World War 2 progressed, so did the technology to advance a submarine's stealth and attack abilities in the Allied and Axis navies, sinking shipping in the Atlantic and Pacific oceans and the Tasman Sea. Each ship sunk assigned a prize tonnage to the submarine that sent it to the bottom. As seen by the Japanese' I' class submarines, floatplanes and midget submarines can piggyback to supply more reconnaissance and stealth penetration of harbours (Hiromi 1996).

Hiromi (1996) states that the Japanese command had two critical points in an attack policy:

1. *To cut the lines of communication between India, Britain, the USA and Australia.*
2. *To seal off Australia from the Anglo-American powers.*

Japan aimed to isolate Australia from the rest of the world to enable occupation. Japan began to siege southeast Asia and Pacific countries in 1941, starting with Hong Kong, Guam and Wake Island. Early 1942 saw the fall of Singapore, Malaysia, Burma, Philippines, and Indonesia (Hiromi 1996) and increased naval and air attacks on Australia.

1.2 Prior Historical and Archaeological Research

In this inquiry, a comprehensive examination of existing literature on anti-submarine and invasion defences in the Australian context exposes a notable dearth of scholarly attention dedicated to this intricate domain. Chapter two of this study will be devoted to a more specific scrutiny of antecedent research endeavours. However, to establish a contextual foundation and facilitate a nuanced comprehension of prior investigations, it is essential to briefly elucidate prevalent trends in conflict archaeology at both the international and local levels. This preliminary exploration will contribute to the overall contextualisation of the subsequent focused analysis in Chapter Two, thereby enhancing the scholarly depth and breadth of the ensuing discussions. Internationally, Galili et al.'s seminal work in 2013 examining the defence strategies implemented in Haifa Bay, Israel, during World War II underscores noteworthy parallels between the anti-submarine measures implemented in Broken Bay and those in place in the Israeli context. Moreover, contemporary accounts by Semmelink and Goodlet in 1947 provide pertinent insights into the defensive infrastructure of Durban Harbour, further corroborating the congruence of strategies adopted in diverse maritime settings. Extant scholarship attests that comparable defensive configurations are also discernible in regions bordering the Atlantic Ocean.

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The European theatres of both World Wars constitute a prominent subject within the expansive academic historiography, featuring well-documented battles such as Gallipoli and the more significant Western fronts of World War I (Pollard and Banks, 2007; Gheyle et al., 2022) and the pivotal Normandy engagement in World War II. Despite the comprehensive coverage of these significant events, scholarly inquiries into general shore defences during wartime remain notably limited. Notably, Pearson and Connah (2009) identified the origin of a captured defensive gun presently exhibited at the Australian War Memorial in Canberra.

Australia's distinctive geographical location, characterised by vast oceans and expanses between land masses, historically shielded the nation from direct military conflicts on its soil.

However, Riet and Fyfe's investigation (2020) delves into the lesser-explored invasion of Christmas Island during World War II, detailing the Japanese occupation and construction of defensive sites. This incursion, transpiring on 31 March 1942, marked the first direct invasion against Australia, as Christmas Island remains a current territory of the nation. Reeves et al. (2016) contribute to the discourse on conflict archaeology by examining the aerial aspects of Darwin's bombings in February 1942, offering insights into the locations of attacks and extant structures.

Barker, Burke, Cole, and Wallis have engaged in ongoing research concerning localised Aboriginal conflicts involving the Native Mounted Police in Queensland, Australia. Their multidimensional approach, incorporating desktop analysis, field research, and ethnographical methods, has proven instrumental in addressing longstanding inquiries within Australia's conflict history.

In closer proximity to New South Wales (NSW), the academic investigation into the defences of World War I and II remains sparse, with reliance on grey literature necessitating prior knowledge of its existence. The discovery of Scobies' (2016) work exemplifies the challenges in accessing such literature, as it was identified through a web page directing the researcher to local council resources. Although there has been generalised research on Sydney's defences (Ainsworth, 2005; Gojak, 1985, 1999, 2002) and some harbour ports along the eastern coast (Walding, 2006), a critical analysis of their effectiveness remains elusive within the scholarly domain.

1.3 Aim of the Research Topic

This research endeavours to assess maritime defence structures from World War II situated in the Broken Bay area of the Hawkesbury River, located to the north of Sydney, Australia. The chosen study area harbours archaeological material of paramount significance to the defence of transportation infrastructure during the Second World War. An essential aspect of this inquiry is to comprehend the efficacy of these structures in evaluating the utility of past defence practices. This assessment, in turn, holds the potential to offer valuable insights that can inform the development of future defensive strategies and planning.

1.4 Significance of the Research Topic

It is imperative to elucidate the reasons behind the interest in and timeliness of this research topic. The following eight factors underscore the relevance of this academic inquiry:

1.4.1 Limited prior research

The evidence expounded in Chapter Two elucidates the scant attention given to this topic in Australia and, more importantly, Broken Bay. Very few defence sites are documented on the National, State or Local heritage registers, presenting a valid research opportunity.

1.4.2 Refinement of research objectives

Some literature references may mistakenly convey the thoroughness of surviving records in documenting anti-invasion defences in terms of their construction, location, purpose, and utilisation. It is crucial to scrutinise this claim for accuracy within Broken Bay's context.

1.4.3 Identification and assessment of source evidence

It is vital to identify and evaluate the available sources for this study. Understanding the merits and demerits of these sources is essential for rigorous research application and will benefit others investigating this subject in a larger context.

1.4.4 Development of historical context

Placing archaeological evidence within a broader historical context is paramount for establishing an informed and holistic narrative, a current gap for Australia. This contextualisation aims to comprehend the developmental phases of defence provision and military operations, providing a foundation for archaeological interpretation.

1.4.5 Raise awareness of research potential

The scarcity of academic studies on Australian anti-invasion defences underscores the novelty of this research. Engaging in this topic aligns with contemporary interests in conflict archaeology and highlights significant research opportunities.

1.4.6 Inform archaeological heritage management strategies

Recognising the depleted and threatened nature of archaeological resources, an enhanced understanding of physical evidence aids in developing effective heritage management strategies.

1.4.7 Characterising the research resource

The research aims to identify the types of sources available for Broken Bay, their abundance, informativeness, and potential inter-relationships. Understanding the value and contribution of these sources, both thematically and chronologically, is crucial for comprehensive research.

1.4.8 Contribute to broader research discussions

The research within the broader landscape of historical, documentary, and conflict archaeology can contribute new data and perspectives, fostering discussions on the relationships between archaeology and history within the wider disciplinary context.

1.5 Research Questions and Sub-Questions

Incorporating contemporary tactical insights into submarine attack strategies, I formulate the overarching research query: Could the World War 2 defences of Broken Bay post-Sydney Harbour attack adequately safeguard the Hawkesbury River Railway Bridge against potential damage or destruction by submarines?

To address the primary research question, the thesis necessitated an exploration and analysis of the following sub-questions

- What is the complete and detailed surface and sub-surface maritime landscape extant archaeology around Broken Bay associated with defences?
- What reuse is identifiable?
- What can graffiti tell us about the people at the time and since?
- And what impact did the defences and war *have on private and commercial interests?*

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1.6 The Study Area

Broken Bay was seemingly dormant and of marginal consequence—an unassuming bay positioned 36 kilometres north of Sydney Harbour, devoid of industrial facilities, urban centres, or notable infrastructural progress. The Bay lacked any prominent military installations, with isolated hamlets sporadically dotting its shorelines, necessitating maritime conveyance for accessibility, and a substantial river coursing through its aperture, ultimately emptying into the

Tasman Sea. Sandstone precipices encircle the locale, with some boasting small shorelines and densely rugged terrain, further fortified by indigenous Australian flora and fauna. (Anonymous 1939-1941, 1939-1946, 1939a, 1939b, 1942q, 1942ao) Sydney is close and has all the infrastructure, bases and population; Broken Bay was a backwater.

The primary focus of this thesis was to conduct a comprehensive investigation into all installed maritime defences. However, it quickly became apparent that delving into this expansive domain would require an excessively prolonged undertaking. Consequently, a strategic decision was made to exclude any defensive structures located east of Hungry Beach and Juno Point, as their primary design did not align with the specific objectives of anti-submarine warfare (ASW). This refinement ensures a more targeted and purposeful examination within the research's defined parameters, enhancing the study's precision and relevance. At Broken Bay, the only site found in Australia with such extensive, exclusive and planned defences against sub-surface incursion, the expanse of the archaeology exceeded all expectations.T

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A cartographic chart from 1942 varies the depth in two channels near Juno Point between 6.5m and 10m, more than deep enough for a Type A midget submarine to enter submerged at periscope depth of 3.3m (Mccurtie 1994: 122). Fear of invasion or attack continued to rise after the attack on Sydney with the sighting of several objects identified as submarines in Broken Bay in July 1942 (Anonymous 1942aj).

The need to protect the HRRB was such that extensive defences were planned, installed or instigated. Each location and type of defence had associated costs around construction, supply, and billeting. One Government (national) paid this cost to another (State), and the price was considerable. Supplies for troops, wages, and upkeep of buildings added further to the cost, and the men protecting the Bay were from volunteer (reservist) units such as the Australian Imperial Force (AIF). There were also the associated costs of the loss of their jobs.

1.7 Strategic Command and Defensive Infrastructure in Broken Bay

The hamlet of Brooklyn, situated on the southern mainland proximate to the Hawkesbury River Railway Bridge (HRRB), held overarching command and control of Broken Bay. However, this administrative facet remains outside the scope of this thesis, as it lacks tangible defensive infrastructure.

Juno Point emerged as the pivotal command centre overseeing an array of strategic assets, encompassing a minefield, artillery emplacements, indicator loops, coastal artillery searchlights, and the coordination of Naval Auxiliary Patrol operations (NAPs). A constellation of auxiliary structures and associated infrastructure further complemented this central defensive complex.

Hungry Beach assumed responsibility for the southern minefield across Broken Bay, featuring a compact single-control hut supported by auxiliary buildings.

Flat Rock, serving as the linchpin for the southern boom extending from Dangar Island to the mainland, hosted a singular artillery emplacement.

Table 1-1: List of known defences, tangible and non-tangible, situated around Broken Bay. The list is not comprehensive as

Defence	location	Type	Real/planned
Indicator loop	Barrenjoey to Box Head	Passive	Real
Dolphin-supported boom net	Between Barrenjoey and 1st Head	Passive	Real
Tank traps	Pittwater	Passive	Real
CASL	West Head	Passive	Real
Heavy shore artillery	West Head	Active	Real
Photo Electric Beam	Patonga to Flint and Steel	Passive	Planned[1]
Minefield	Hungry Beach	Active	Real
Control hut and support buildings	Hungry Beach	support	Real
Minefield	Juno Point	Active	Real
Indicator loop	Patonga to Flint and Steel	Passive	Real
Command and control	Juno Point	Active / support	Real
18-pounder field artillery	Juno Point and Flat Rock	Active	Real
CASL x 2	Juno Point	Passive	Real
Heavy and light machine guns	Juno Point	Active	Real
Barracks/support	Juno Point	support	Real
Support buildings	Flat Rock/Brooklyn	support	Real
2 x dolphin-supported boom nets	Dangar Island	Passive	Real
Medium machine gun	Dangar Island	Active	Real
Anti-aircraft guns	North/south HRRB	Active	Real
Support buildings	Moonee	support	Real
Naval Axillary Patrol (NAP)	Broken Bay	Active	Real
Bay restrictions	Broken Bay	Passive	Real[2]
Location restrictions	Broken Bay and surrounds	Passive	Real[3]

[1] No physical evidence is in the landscape. Construction plans and designs only.

[2] No civilian vessel, private or commercial permitted east HRRB or outside of Pittwater boom.

[3] Blackouts and removal of all street and railway signs - NSW wide.

it does not include support structures.

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1.8 Discussion

This thesis endeavours to demonstrate that an extensive examination of archival materials, scholarly publications, and local oral traditions, coupled with a comprehensive survey of tangible and intangible archaeological evidence, substantiates responses to possible submarine attacks. It is imperative to acknowledge that this thesis does not aim, nor is it feasible, to comprehensively address all categories of defence mechanisms present in Broken Bay. The pursuit of answers to a pivotal inquiry has given rise to ancillary research inquiries necessitating further investigation. As an inaugural formal academic discourse, this thesis aspires to furnish scholars, both nationally and internationally, with valuable support and direction for delving into the study of maritime conflict landscapes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The exploration of Australian Second World War anti-invasion defences in academic circles remains an underexplored domain within the growing field of conflict archaeology. Conflict archaeology, encompassing the examination of material remnants from historical inter-group hostilities throughout human history, is firmly grounded in archaeology yet marked by a distinct interdisciplinary nature.

The literature review places this study within a national and international context, in both archaeological and historical contexts. Following Gilchrist's (2003: 3-5) observations of the critical role of documents in establishing the possible location and contexts of archaeological conflict sites, a primary aim of this chapter is to identify latent archaeological material by comprehensively exploring historical documents in relation to the study area. In addition, this literature review identifies a major gap within conflict archaeology: the dearth of archaeological studies of underwater military installations.

Military archaeology offers a unique perspective into historical conflicts, shedding light on the strategies employed to safeguard territories. Scott and McFeaters (2010) emphasise the distinct visibility of military archaeology in the landscape, enabling its clear identification and study of existing and non-existing archaeological remnants, a specialisation unique to conflict archaeologists. This literature review focuses on how the imperative role of Broken Bay in Australian Fortress defence during World War II contributes to national and international debates in conflict archaeology. It delves into the threat of conflict, the potential invasion, and the lasting impact on military transport capabilities within this localised sphere. This review unearths latent archaeological material by comprehensively exploring documents addressing critical research inquiries. By drawing on works from local scholars and primary materials stored in esteemed repositories, this review seeks to reconstruct the historical narrative and developmental timeline of the defences at Broken Bay. Gibbs (2004) contends that the scope of maritime archaeology extends beyond the water line and extends inland to include associated

structures within the maritime industry. This assertion manifests in the case of Broken Bay, where all tangible and intangible archaeological endeavours are intricately linked to safeguarding the waterway and the Hawkesbury River Railway Bridge.

2.2 International Context

The field of military archaeology serves as a window into the past, offering insights into historical conflicts and the strategies employed to protect and defend territories. Scott and McFeaters (2010:104) assert that military archaeology possesses a distinctive visibility within the landscape, allowing for clear identification. Moreover, this discipline presents a remarkable capacity to study existing and non-existing archaeological remnants, a skill unique to conflict archaeologists (Scott and McFeaters 2010:114).

Another example of an underwater archaeological defence site is Scapa Flow in the United Kingdom. Coastal defence batteries (gun emplacements) were constructed along with underwater boom nets and a number of ships sunk to prevent submarine attack during WW1. After the war these were removed until the sinking of HMS Royal Oak by submarine and the installation of boom and ship defences began in earnest (Burroughs 2018:10, Christie et al 2016, pp 3-6). What is seen is defence against submarine incursion was dependent upon the person who had charge of that portfolio. Even at Scapa Flow ships were sunk to prevent ships from entering and attacking. Boom nets were strung across the entrance and Christie et al (2016) does not include guns or mines in defence of Scapa Flow.

2.3 Australian Context

The extant body of archaeological research about the tangible and non-tangible archaeology within Broken Bay is notably sparse, except for a Heritage Review conducted at Juno Point by Scobie in 2016, and the presence of grey literature authored by Gojak concerning Hungry Beach, managed by the New South Wales Parks and Wildlife agency. Regrettably, Gojak's invaluable reports suffered irreparable damage due to water incursion in 2020 at the administrative offices of Ku-Ring-Gai National Park. Consequently, the present thesis assumes critical importance as it endeavours to systematically document, analyse, and elucidate the

complex landscape of maritime conflict within this region. The 4HResearch social research group, situated in the Central Coast of New South Wales, conducted an investigation in 2016, wherein they presented concise evidence pertaining to their identification of Juno Point's military past. Significantly, the group successfully captured photographs that currently hold intrinsic value in their portrayal of the material and its present condition.

The research gap within conflict and military archaeology in Australia is demonstrated by a comprehensively exploration of documents which uncover latent archaeological material within the study area. In Gojak's examination of Australian coastal defense batteries, he observed 'noteworthy deficiencies in historical sources addressing military installations' evolution, design, and utilisation. In numerous instances, the tangible evidence stands as the sole source of insight into the methods employed to defend Australia (2002: p160).'Within the context of this research, the imperatives of the Australian Fortress defence come into sharp focus. This literature review underscores the pivotal role of Broken Bay, where the threat of conflict loomed, escalating to the harrowing possibility of invasion and ultimately leaving an indelible mark on the military transport capabilities within a localised sphere. The review peers into the annals of history to excavate the multifaceted layers of the Australian Fortress, revealing how Broken Bay's strategic significance intertwined with broader historical currents.

The assembly and analysis of these documents are vital for answering the research inquiries posed by this study. Given the absence of previous examinations of the site, the initial scope of the literature review encompasses works authored by local scholars, the likes of Jim Macken, extending to include primary materials stored in esteemed repositories such as the Australian National Archives in Canberra, Melbourne, and Sydney. A meticulous examination of materials archived at the Australian War Memorial and the NSW State Archives contributes to this endeavour. Through the review of these archival documents, the study not only enables the reconstruction of the historical narrative but also offers insights into the developmental timeline of the defences at Broken Bay.

However, it is essential to acknowledge that the extensive scope of discovery, including insights into social and economic impacts and additional defence structures within Broken Bay, surpasses the confines of this particular thesis. Therefore, while the review may provide a foundation for future explorations in these realms, the present study remains confined to its designated boundaries.

A significant contribution to the literature review emerges from a document titled 'Appreciation and Operation under–Covering Infantry Defence in Anti-Raid Role of Hawkesbury Bridge – By 2nd Australian Garrison Battalion as at 11 August 1943' (Anonymous 1943a). This document underscores the criticality and vulnerability of the Hawkesbury River Railway Bridge. The bridge is a crucial link facilitating rail traffic between Sydney's urban centre and Newcastle's industrial hubs. Moreover, it serves as the principal communication artery connecting these regions with the forces stationed in Queensland. This critical infrastructure notably shows signs of deterioration. It remains vulnerable to various modes of destruction, such as potential sabotage by a small landing party, torpedo strikes from submarines, or aerial attacks.

Page et al (2013) delineates the differing needs of anti-invasion methods during World War 2 and how each equates to the other.

2.4 Espionage and Media Reports: Early 20th Century

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The early 1900s bore witness to a series of reported espionage activities along the east coast of Australia, generating considerable intrigue and concern within the nation. These incidents, reported in print media, unveiled a covert undercurrent involving the capturing of spies engaged in suspicious activities, including photographing critical infrastructure such as the Hawkesbury River Railway Bridge (HRRB) and the charting of water depths around Sydney, Broken Bay, and various locations in Queensland. The essence of these media accounts is briefly summarised in Table 2.1, illuminating the chronicle of espionage during that period.

During this historical era, a significant and noteworthy faction emerged known as "The Australian First Movement." A unique aim marked this group's intentions: to obstruct the efforts of the Australian Defence Force in repelling potential Japanese forces that might seek to invade the nation (Anonymous 1942w). The movement's motives were deeply rooted in the belief that aligning with Japanese forces would serve to protect and secure Australia's interests. This ideology sharply contrasted with the prevailing sentiments of national defence prevalent in mainstream society.

The trajectory of this faction led them to take actions aimed at hindering the Australian Defence Force's preparedness for potential Japanese invasions. The movement's stance and activities,

advocating a different approach to national security, created a significant societal divide. Ultimately, this culminated in the arrest and subsequent prosecution of key members of "The Australian First Movement." The legal actions against these individuals resulted from their contrarian perspective on defence strategy, which was at odds with the prevailing national sentiment.

The emergence and subsequent consequences of "The Australian First Movement" highlight the diversity of opinions and attitudes that existed within Australian society during that period. This faction's actions underscore the complexity of wartime political and ideological dynamics, shedding light on an often-overlooked aspect of Australia's World War II history.

Table 2-1: Selected newspaper articles relating to spying in Australia. These articles were re-circulated across the country and are only a small example of what is held at 'Trove.nla.gov.au'

	Date	Page	Title	Summary
The Sun	Fri 9 February 1906	1	Jap Spies	Two Japanese found with plans of Sydney Harbour and fortifications by Customs at Thursday Island after being stranded when their vessel sailed without them.
The Sun	Thurs 31 October 1912	1	Three Japs on the coast	Three Japanese and one officer seen of Queensland coast sounding the depth of the water. Stated they had done most of east coast of Australia and have comprehensive charts that have been sent to Tokyo.
The Sun	Sunday 3 November 1912	1	Spies in Australia	Japanese spies captured had photographs of the HRRB supports pylons
New York Journal	Thurs 27 January 1938	5	Jap spies found in Australia	An extensive Japanese spy network has been discovered in Australia and hushed up by the Government. Japanese Naval units operating near the Australian coast.

Among the notable instances reported, The Sun (Anonymous, 1912:1) conveyed that Australian intelligence military personnel succeeded in apprehending Japanese and German

spies who were in possession of photographs depicting the pylons of the HRRB and a chart delineating the expanse of Broken Bay. The compilation of Table 2-1 further encapsulates the media's portrayal of espionage activities during this period.

Interestingly, Axis spies were not the sole force in these activities; another faction, even more significant in its scope, "The Australian First Movement", strived to impede the Australian Defence Force from repelling potential Japanese invasions. The trajectory of this faction led to the eventual arrest, prosecution, and custodial sentences for its leading members (Anonymous 1942w).

Reports from residents of Brooklyn and Newcastle surfaced with regularity, detailing foreign nationals engaging in activities such as photographing, measuring, and sketching critical infrastructure and military installations. The implications of these activities extended beyond the immediate timeframe, as the sketches and plans accumulated during these incidents found utilisation three decades later when devising strategies for potential attacks against Australia. These early-century episodes suggest that the intelligence gathered during them persisted and remained accessible to military forces, shaping their approaches to defence and countermeasures in areas like Broken Bay and Sydney.

2.5 Axis Spies in Australia Before WW2

The shadow of espionage has a long history in Australia, with its origins tracing back to as early as 1905 when the nascent Australian Government recognised the unsettling presence of covert activities within the nation's borders. Piesse (1926), in his seminal work, delved into the intricate dynamics of the pre-and post-World War I era, mainly focusing on the complicated relationship between Japan and Australia. Through meticulous exploration, Piesse illuminated the contours of Japanese engagement with the Australian landscape during this pivotal period.

Intriguingly, Piesse (1926:479) revealed that Japanese interests extended as far as the northern reaches of Sydney and the expanse of the Great Barrier Reef off the coast of Queensland. This curiosity was not without its complications, as Australian authorities met instances of Japanese surveying activities with apprehension. These encounters raised questions about the nature and purpose of such endeavours, fuelling a discourse around potential espionage and strategic intentions.

The dissemination of such revelations reverberated throughout Australia, resonating through the medium of various print publications. Accounts of these activities, often accompanied by a cloak of secrecy, circulated nationwide, evoking curiosity and concern among the populace. These publications engendered public awareness and prompted discussions on the nature of these surveying missions and their implications for Australian security.

However, uncovering governmental responses and reactions to these incidents faces challenges. The enigmatic nature of governmental archives and repositories has presented obstacles in accessing concrete documents that shed light on official perceptions and actions during this era. The scarcity of accessible government records has hindered a comprehensive understanding of how the Australian authorities navigated the complexities of espionage-related concerns in the early 20th century.

2.6 Historical Context of World War II in Australia, New South Wales

The advent of World War II brought significant shifts in the historical landscape of Australia, with the nation playing a crucial role in the global conflict. Australia exemplified its commitment to international security by deploying thousands of troops overseas to actively engage in the war effort. However, the war also had profound implications for the country's soil, ushering in a new era of challenges and uncertainties.

On 19 February 1942, Australia experienced its first direct encounter with war on its territory when enemy forces subjected Darwin Harbour to bombing raids. This event transpired following the fall of Singapore and the Japanese invasion of Malaysia (Brown & Anderson 1992: 7-8). The shockwaves of these events resonated deeply, amplifying tensions and anxieties within Australia. Subsequent attacks on Sydney Harbour on 31 May 1942 further heightened this sentiment, emphasising the vulnerability of the nation's coastlines to external threats.

Scholars like Carruthers (1982:14-16) and Powell (2012:140-150) have chronicled the heightened tensions that gripped Australia after the bombing raids on Darwin and northwestern Australia. These authors highlight the intensification of concerns, manifested in sightings and intelligence reports detailing Japanese aircraft carriers (Anonymous 1942am), the presence of submarines off the coast of Newcastle (Anonymous 1942ak), and even enemy aircraft spotted

off Townsville (Anonymous 1942am). These incidents underscored the palpable sense of vulnerability and the necessity to fortify Australia's defences.

Gill's comprehensive work (1957, 1968) further deepens the understanding of Australia's wartime maritime operations. In his volumes, he delves into the intricacies of naval activities within Australian waters during the early years of the war. He examines naval strength, trade protection, convoy systems, and mine-laying operations in volume 1 of Royal Australian Navy 1939-1942. Of particular relevance to this study, Gill provides insight into submarine activity around Australia and the establishment of Combined Defence Headquarters (CDHs) across the continent.

The second volume of Gill's work (1968) Royal Australian Navy 1942-1945 expands the purview to encompass coastal and commerce raiders, highlighting the Australian response and situation in June 1942. Gill explores critical aspects such as communication relays, breaches in communication security, submarine activities, and overall naval operations within the Australian theatre. However, it is worth noting that this volume does not include references to shore protection systems, a gap that invites further examination.

Jenkins (1992:154) contributes to understanding wartime naval activities through his meticulous documentation of Japanese submarine attacks against surface ships. His work extensively covers 14 such attacks between Mallacoota, Victoria, and Newcastle, New South Wales, between May and August 1942. This detailed exploration of these attacks offers a glimpse into the challenges posed by submarine warfare and its impact on Australian waters.

2.7 Archaeological Approaches to Studying Conflict Defences

Archaeology has emerged as a valuable lens to examine the remnants of World War II defences, offering insights into the physical and strategic landscapes of conflict. The application of archaeological methods extends beyond terrestrial battlegrounds, encompassing maritime environments and transitional zones. Gilchrist (2003: 3-5) highlights the pivotal role of documentary evidence in establishing the contexts and extent archaeology of conflict sites, underscoring the interdisciplinary nature of this pursuit.

Colls' seminal work (2012) on Nazi Holocaust landscape archaeology demonstrates the versatility of archaeological approaches in non-battlefield contexts. While World War II

conflict archaeology traditionally centres on battlefields, campaigns, and naval engagements (Blau 2004:11), Colls' work expands the scope to explore landscapes shaped by Holocaust-related events. This expansion of focus underscores the potential for archaeological methods to transcend traditional boundaries and illuminate historical narratives.

Despite the promise of conflict archaeology, research in the Australian context has been relatively limited, primarily focusing on battlefields, campaigns, and naval battles (Blau 2004:11), whilst Wesley and Viney (2022) concentrate on the interactions between World War 2 transport sightings in the Northern Territory, primarily around Arnhem Land and the rock art depicting those sightings. As mentioned in Chapter one, Burke et al (2017) in their numerous papers on the Queensland Native Mounted Police provide conflict evidence between white and black Australia and more importantly Aboriginal Australia corporally Policing each other under a white command structure. Burke et al (2017) and Grguric (2022) detail the fortification of homesteads against the ongoing conflict between settlers and Aboriginal communities in the newly westernised continent. In the context of the British Empire as it was at the time, the predominant focus of recent historiography on the Second World War revolves around grand strategy (French 2000; Mackenzie and Reid 1989; papers in Martel 2004; McInnes and Sheffield 1988; Millet and Murray 1988), with other concentrating on social history (Gardiner 1994, Morison 2001) and ethnographic studies (Brockschmidt 2005, Robinson 2017) Much of the available research stems from sources such as Cultural Resource Management (CRM) companies' grey literature (Scobie, 2016) and sporadic contributions from museums (Carter and Anderson, 2010). The majority of attention has focused on well-known military sites, such as barracks and strongholds. (Allen & Paterson 2009, Gojak 2002, Grimwade & Ginn 2002). Gibbs and Colley (2012) underscored the imperative for the integration of Cultural Resource Management (CRM) resources into a unified database in their scholarly work titled "Digital Preservation, Online Access, and Historical Archaeology: 'Grey Literature' from New South Wales, Australia." The authors posit that the amalgamation of such resources is essential to facilitate comprehensive research beyond the existing accessible data.

Commented [CS10]: A lot more recent has been done since then. You need to cite Daryl Wesley's work, also Heather Burke's, Amy Roberts' and Lynley Wallis - mostly in an Indigenous context, which means your work is filling a gap left by this other work.

Gibbs (2003) delves into the contentious nature surrounding shipwreck survivor camps in Australia, providing an in-depth analysis of the associated conflicts. His exploration extends to the infamous VOC ship Batavia, elucidating the repercussions of the resulting carnage from that particular wrecking incident. While the conflict may not be directly linked to external factors such as national entities, Gibbs contends that the moral implications (2003, p. 135 and 138) are amplified by pervasive sentiments of fear and power. This examination underscores

the enduring impact of such human emotions, encapsulating the hatred and fear instigated by the global conflict, specifically World War II, within the Australian context.

Paterson et al.'s (2023) study delves into the conflict experienced by the survivors of the Batavia shipwreck, examining the crimes committed and the subsequent punishments meted out. The authors expose the harrowing realities of the Batavia incident, illustrating how archaeological findings can shed light on the collective suffering of those marooned on the small island.

De Ruyter et al. (2023) explore the implications of rock art discovered in Awunbarna, which is associated with distinct vessels from Molucca identified as combat vessels. Through an analysis of these images, De Ruyter et al. elucidate the potential ramifications of conflicts with the local Aboriginal population, including instances of slavery and trade. While the authors acknowledge that such conflicts may be indicative of a form of invasion, they do not explicitly posit this in their paper.

Pagels et al.'s (2023) research on conflicts involving native mounted police focuses on land-based firearms and their impact on Aboriginal communities. Additionally, Wallis et al.'s (2021) work encompasses the identification of spatial considerations relevant to attacks carried out by native mounted police in Queensland, offering an indigenous-centric perspective on conflict archaeology.

Burke et al. (2011:142) observe that air raid shelters are considered a form of passive defence that mirrors the structures of boom nets and indicator loops at Broken Bay. The author also acknowledges the presence of missing archival documents in relation to air raid shelters, similar to the missing records for Broken Bay. While community oral history is not specifically addressed in this thesis, it is recognised as a significant factor in fostering community cohesion despite the potential for inflated or modified recollections of actual events Burke et al.(2011 pp. 145-149). The memories of World War 2 are rapidly slipping into the realm of forgotten personal experiences, with only a scarce number of individuals left to preserve them.

McCarthy et al (2023) employs virtual reality technology to vividly reconstruct the World War II loss of the Japanese submarine I-124 off Darwin harbour. The visual representation of the I-124 provides valuable insights into the potential application of similar methods for exploring conflict sites globally, particularly in locations like Broken Bay.

Maritime conflict archaeology extends beyond submerged shipwrecks to include aircraft that have become integrated into the underwater environment, as elucidated by O'Donnell (2020) in his research focused on Queensland. O'Donnell meticulously delineates the topography of World War II-era aircraft, both those lost in combat and due to accidents, within the waters of northern Queensland, offering detailed accounts of their types and specific locations. These wrecks are now safeguarded under the provisions of the Underwater Cultural Heritage Act of 2018, which now encompasses aircraft within its purview. O'Donnell's investigation yields valuable insights into the endeavors of World War II pilots to safeguard the shores of Australia.Notable exceptions to this trend include Anderson's work (2011) on submarine defences in Cockburn Sound, Western Australia. Anderson's research offers valuable insight into the largely overlooked realm of submarine defence systems. The paper, stemming from grey literature (Carter and Anderson, 2010), sheds light on the specificities of boom net defence systems employed in Australian ports. Anderson's work contextualises these defence systems, elucidating their strategic significance and operational mechanics.

Christie's comprehensive study (2016) of World War II Anti-Torpedo Close Protection Pontoons in Scapa Flow, Orkney, exemplifies archaeological methodologies applied to underwater contexts. Through detailed shore, surface, and underwater surveys, Christie illuminates the archaeological dimensions of torpedo defences. Sidescan imaging is a precursor to underwater exploration, offering insights into submerged archaeology. While Christie's study has implications for Broken Bay, its focus on Scapa Flow's environmental extant archaeology underscores the complexity of underwater archaeological endeavours.

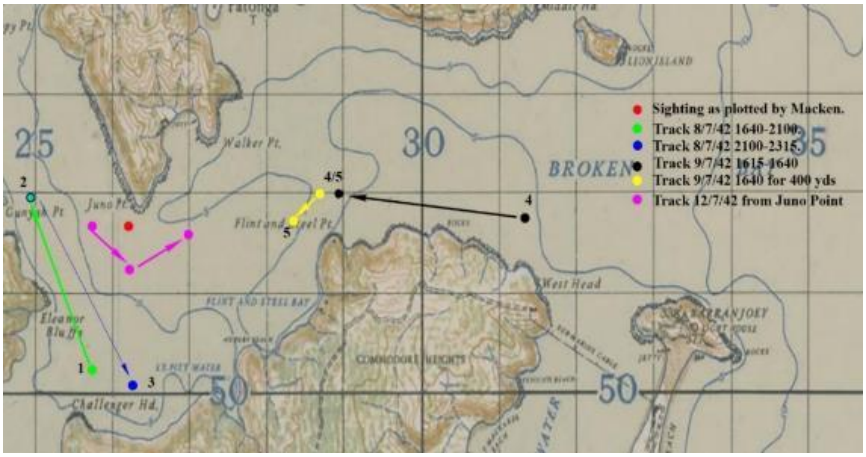
One can draw comparative insights from Forster's research (2007) on a floating boom net in Darwin Harbour. This system's reliance on maritime dynamics, including tidal movements, offers a distinctive perspective on defence strategies. While Forster's work lacks a strict archaeological focus, it contributes to understanding the operational intricacies of boom net systems and their adaptations to local conditions.

2.8 Understanding the Rationale Behind Defences in Broken Bay

A cartographic chart from 1942 (map 2-1) varies the depth in two channels near Juno Point between 6.5m and 10m, more than deep enough for a Type A midget submarine to enter submerged at periscope depth of 3.3m (Mccurtie 1994: 122). Fear of invasion or attack

continued to rise after the attack on Sydney with the sighting of several objects identified as submarines in Broken Bay in July 1942 (Anonymous 1942aj).

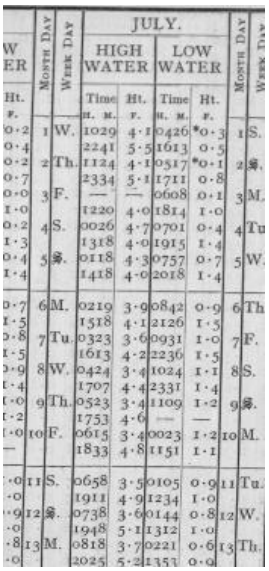
Map 2-1: 1942 chart of Broken Bay. Plots of submarine sightings as described in war diaries and the location.



A comprehensive exploration of the factors underpinning the establishment of defensive structures in Broken Bay reveals a notable dearth of prior research, with only limited grey literature available to shed light on the intricate complexity of this strategic location. Extensive results from archival storage centres have played a crucial role in identifying, locating, and comparing extant archaeological evidence within this region. The impetus for these defences traces back to the aftermath of the attack on Sydney Harbour, where intelligence from submarines' recovery and the analysis of Japanese charts (Anonymous 1942ai) pointed out the Hawkesbury River Railway Bridge (HRRB) as a potential target. Initial signals and reports concerning the Sydney Harbour attack indicated the involvement of four submarines (Anonymous 1942ai). However, subsequent investigation revealed that two submarines were lost on the night of the attack, M24 successfully evaded attack, and the fourth submarine reportedly made its way to open sea before entering the harbour (Gould 1942:2-4). The decision-making process surrounding these events was not without disputes and competing ideas from different ranks of officers, some of whom displayed tendencies of narcissism in advocating for the implementation of their proposed strategies (Anonymous 1942q).

Macken's analysis in 2008 centred on plotting submarine sightings in Broken Bay based on communications, yet the accuracy of his plotted locations remains open to questioning. The

comparison of tide tables (Figure 2-1) with the recorded sightings enables a temporal assessment of ingress and egress between Dangar Island and the Tasman Sea (Map 2-1).



	Month Day	Week Day	JULY. HIGH WATER Time H. M.	HIGH WATER Ht. F.	LOW WATER Time H. M.	LOW WATER Ht. F.	Month Day	Week Day
	1	W.	1029	4·1	0426	*0·3	1	S.
			2241	5·5	1613	0·5		
	2	Th.	1124	4·1	0517	*0·1	2	S.
			2334	5·1	1711	0·8		
	3	F.	—	—	0608	0·1	3	M.
			1220	4·0	1814	1·0		
	4	S.	0026	4·7	0701	0·4	4	Tu.
			1318	4·0	1915	1·4		
	5	S.	0118	4·3	0757	0·7	5	W.
			1418	4·0	2018	1·4		
	6	M.	0219	3·9	0842	0·9	6	Th.
			1518	4·1	2126	1·5		
	7	Tu.	0323	3·6	0931	1·0	7	F.
			1613	4·2	2236	1·5		
	8	W.	0424	3·4	1024	1·1	8	S.
			1707	4·4	2331	1·4		
	9	Th.	0523	3·4	1109	1·2	9	S.
			1753	4·6	—	—		
	10	F.	0615	3·4	0023	1·2	10	M.
			1833	4·8	1151	1·1		
	11	S.	0658	3·5	0105	0·9	11	Tu.
			1911	4·9	1234	1·0		
	12	S.	0738	3·6	0144	0·8	12	W.
			1948	5·1	1312	1·0		
	13	M.	0818	3·7	0221	0·6	13	Th.
			2025	5·2	1353	0·9		

Figure 2-1: July 1942 tide table as supplied by the Bureau of Meteorology. There are two tide times each day with each during daylight; however, no sightings of a submarine were made during daylight hours when there is a higher chance of spotting not only a wake but the submarine itself when viewed from high. The cliffs surrounding Broken Bay would have provided ample ability to site the sub-surface activity.

Soldiers and sailors of diverse ranks transmitted reports detailing submarine sightings within Broken Bay. These reports, meticulously documented in AWM52, 4/19/4/3 (Anonymous 1942aj) and NAA: MP1049/5, 2026/21/79 (Anonymous 1942-1946), predate the intelligence analysis conducted after the Sydney attack (Table 2-2). While it is not possible to definitively test the validity of these reports, considering them is significant within the context of this thesis.

Table 2-2: Transcript of signals from AWM52, 4/19/4/3 and NAA: MP1049/5, 2026/21/79 with sightings of a submarine in Broken Bay (Grammar and spelling as they appear in original text).

Map Ref#	Date	Time	Description	Tide	Moon	Comments
1	8/07/1942	20:53	The Battery Commander at Brooklyn Battery reported that a submarine was sighted 50 yards offshore and a line drawn from Juno Point to Cowan Creek at 1640 hours by fishermen	Low tide at 2331 after a high in 1707	moonless very dark night	
2	8/07/1942	21:00	The following message was received from the Garrison Bn. At Brooklyn N.A.P. Brooklyn reported to the Battery Commander Brooklyn that a suspicious object resembling a conning tower of a submarine was seen off Gunyah Point at the entrance to Cowan Creek. When the Patrol Vessel went to investigate, its spotlight failed and when the light was repaired the object had disappeared.		Waning crescent moon	
3	8/07/1942	23:05	OC West Battery reported that a N.A.P. Vessel had just returned and signalled the following message: Important message for you submarine sighted.		Waning crescent moon	

Map Ref#	Date	Time	Description	Tide	Moon	Comments
4 and 5	9/07/1942	17:00	The following report was received from West Battery at 1615 hours AA LMG Picquets on No.4 Post reported what appeared to be a swirl of water moving west in shore passing West Head Point. At 1640 hours Lt. Reynolds whilst doing a reconnaissance of Flint and Steel Bay Area was looking from Flint and Steel Point across to Brisk Bay. He was sighting a buoy through powerful glasses when he noticed an object break the surface to the height of approximately 1 foot and steadily moved in a south westerly direction for approximately 400 yards before again submerging. The object left a feather wake on each side and approximately 6 to 8 feet back from the object a small feather of water appeared occasionally as though a wire were breaking the surface of the water. The object moved at a steady speed at approximately 2 or 3 knots per hour. OC West believed the object was mechanically propelled and that it was probably a submarine.	Tide was coming in almost at slack with a high in 1753.	Waning crescent moon	Sunset 1700
6	9/07/1942	22:10	Duty BC. West reports that an object believed to be a submarine was observed in the beams of a CASLs. NAP was investigating.		Waning crescent moon	
	9/07/1942	22:20	NAP reported that they had investigated the object and signalled that all was clear.		Waning crescent moon	

Map Ref#	Date	Time	Description	Tide	Moon	Comments
7	12/07/1942	23:45	Lt. Marshall O.C. Juno Section reports that a spotter sighted a white wake proceeding downstream about 2 knots and at MP ref: 515258 Broken Bay sheet. He watched it as the search light followed but could not decide what it was. When it readied Map ref: 513262 he wok Sgt. McDonand charge detachment. At this moment the search light had to go out of action to change carbons, which took about 10 minutes. Then the wake was picked up at map ref: 516270. 3 Rounds of SAA were fired at it, but it did not stop or submerge, then 3 rounds of HE 44mm were fired and the 3rd round scored a direct hit. This was decided because of the red flame seen. The target disappeared and the patrol boat made a search but could not find anything. I left about 0030 hours and no trace of any wreckage had been found. In the morning there was absolutely no trace of wreckage or oil.	Heading out. Low tide 13/7/1942 0221 after a high 1948 (12/7/1942).	New moon	A search of the area the following day revealed that a giant turtle had been washed ashore in Juno Pt. after having been killed by a shot which was apparently a 2 pdr. Having spoken with members of the Artillery history association Manly NSW information was that a 2 lb HE round would have obliterated the turtle.

2.9 Coastal Defence Structures and Installations

During World War II, the maritime defence landscape around Australia encompassed three prominent types of physical structures: Control/range sighting buildings, Gun batteries including fort structures, and Controlled Anti-Submarine Indicator Loop (CASL) installations. Water defences featured elements such as nets, indicator loops, Photo Electric beams (PE beams), and minefields.

The initial scope of this thesis encompassed an investigation into all installed maritime defences. Yet, it expeditiously became apparent that delving into this domain would entail an unduly protracted undertaking. Consequently, they decided to exclude any defenses situated eastward of Hungry Beach and Juno Point, given that their primary design did not orient towards anti-submarine warfare (ASW).

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The need to protect the HRRB was such that they planned, installed, or instigated extensive defences. Each location and type of defence had associated costs around construction, supply, and billeting. One Government (national) paid this cost to another (State), and the price was considerable. Supplies for troops, wages, and upkeep of buildings added further to the cost, and the men protecting the Bay were from volunteer (reservist) units such as the Australian Imperial Force (AIF). There were also the associated costs of the loss of their jobs.

Brown and Anderson (1992) state there was fear in the community of attack during the war. This fear in Australia heightened because of the air raids in the north; however, it became a reality when Japanese submarines shelled the eastern suburbs (Annonymous 1942a, 1942b). Removing street and railway signs to prevent the enemy from knowing where they were (Anonymous 1943k) and enforcing blackouts (Anonymous, 1942b, Anonymous, 1942c) were other defensive actions taken by the Government

Dolphin-supported booms and indicator loops were erected in major ports of Australia during WW2 to protect against submarine/torpedo attacks (Ainsworth 2005: 72-3; Anderson 2011; Walding 2006), and where tidal extremes existed, the installation of floating booms alleviated destruction (Forster 2007). On the other hand, minefields were less common (Arnold 2013: 205; Forster 2007) and, where constructed, followed Admiralty guidelines (Anderson 2011: 17-8; Christie, Heath & Robertson 2016: 141-42). While ports like Sydney had constructed defence structures over the previous 100 years, they had erected them hastily and incompletely, whereas Broken Bay had more thought and planning (Anderson 1992: 11, 7-8, Anderson 2011:

6; Anonymous 1942f, 1942s, 1942t, 1942ab, 1942ac, 1942af, 1942an, 1943a 1943l, Arnold 2013: 47-9; Brown; G & Anderson, B. 1992: 33; Nyman 1943).

In New South Wales, the Kurnell-type control hut (Figure 2-2) was a cornerstone of coastal defence; however, Broken Bay's control huts had distinctive features. Notably, Juno Point's control hut stood out due to its larger size and unique architectural layout, with variations in its roof structure. Walding (2006:20) offers insights into remaining control huts on Moreton Island, albeit not in exhaustive detail. While discussing the installation and use of degaussing ranges associated with indicator loops and minefields, Walding (2006:7) does not touch upon the need for a degaussing range in Broken Bay, given the absence of vessel traffic and knowledge of naval patrol routes in the area.

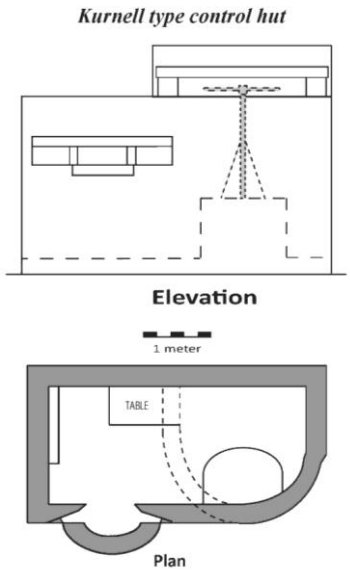

Figure 2-2: Figure adapted from NAA MP150/1/0 569/244/200 by author.

Ainsworth's work "Purely Defensive Measures: The Archaeological Network of Defence in the Sydney Region, 1788-1945" (2005) delves into the defences in and around Sydney, focusing on larger calibre guns and extensive fortifications. However, Ainsworth's coverage lacks details concerning smaller forts and gun positions similar to those in Broken Bay.

In the comprehensive studies by Forster (2007) and Horner (2013), the extensive defensive infrastructure of Fortress Australia is elaborated, with Turner and Donohue (2018) further explaining the mining of various locations, including Broken Bay. The specific type of underwater mine utilised in Broken Bay, controlled from Juno Point and Hungry Beach, is depicted in Figure 2-3.

Figure 2-3: Underwater mine used at Broken Bay sitting on a mounting/anchoring platform.

Constructed between August 10 and 20, 1942, gun positions 1 and 2, along with the CASL and power generator at Juno Point, were operational within a mere ten days (Anonymous 1943e). The design of gun positions 1 and 2 facilitated the attachment of 18-pounder artillery using anti-tank mounts, allowing for swift rotation

(Anonymous 1942l). This capacity for rapid movement and flexibility was essential for effective coastal defence in the region.

2.10 Historical Documentation on World War 2 Coastal Defence around Broken Bay

The search for historical documentation related to World War II coastal defence around Broken Bay involved navigating multiple storage centres, including the Australian War Memorial (AWM), National Australian Archives (NAA), and New South Wales State Archives (NSWSA). This process was often arduous due to document redundancy across different repositories. The National Archives, in particular, yielded extensive material comprising relevant and irrelevant content to the thesis objectives.

The historiography of Australian defence during World War II is expansive, with studies like Beaumont's (2001) comprehensive exploration of Australian defences and other works such as Grey's (2008) focusing on the broader Australian Fortress concept rather than specific shoreline defences. Extracting pertinent literature from these various archival sources provided insights into the rationale behind the swift mobilisation of resources to protect the Hawkesbury River railway bridge (HRRB).

The infiltration of submarines into Sydney Harbor in May 1942 that attacked and sank ships led to a revelation through intelligence documents retrieved from salvaged submarines. This revealed a critical vulnerability in Australia's defence and distribution capabilities: the Hawkesbury River railway bridge (HRRB) (Anonymous 1939-1946, 1942-1946, 1942y, 1942ai, 1946). Reports from The Age newspaper (Anonymous, 1942o:5) emphasised the potential disruption that incapacitating the bridge could cause, necessitating lengthy detours for trains and hampering deployment and resupply efforts.

Midget submarines, armed with torpedoes capable of destroying bridge supports, heightened concerns. An analysis of demolition materials retrieved from a submarine highlighted the destructive potential. The explosive charge within one of the disabled submarines, expertly examined by Mr Davis (1942), Inspector of Naval Ordnance, contained 30 kg of explosive encased in 16 kg of steel, showcasing its ability to damage a pylon severely. The devotion to duty of the submarine crew was evident in their activation of a charge within a disabled vessel.

Although a fort was already established at West Head in Broken Bay, equipped with 4.7" artillery guns designed to engage heavy ships, their slow loading and aiming capabilities rendered them inefficient against submarines. The need for alternative defences became evident, prompting further work on coastal defences at Juno Point. By October 1942, the control centre for middle bay defences was operational, and by December, all defences were in place (Anonymous 1942h, 1942z). A comprehensive cost breakdown of each project, converted to 2022-dollar values, is provided in Table 3. To contextualise defence expenditures with 1942 wages, the average male wage of $10.70 (2022) per week is comparable (Castles 1992:5). Table 2 illustrates a house's mean price in relation to the imperial pound and the dollar. (Johnson 1947:2).

A consolidated file from the National Archives of Australia (Anonymous 1942q) encapsulates ongoing rank and service disputes about command authority, defence type, and location. Eventually, they established an approved design consistent with the area's defensive landscape.

An example of an underwater archaeological defence site is at Haifa Bay, Israel, had a number of anti-submarine warfare defences (Galil et al 2013). These are similar to those found in Broken Bay. These defences eventually proved fatal to the submarine Scirè, an Italian submarine operating in World War II. The control hut at Haifa Bay consisted of three rooms, lower generator room, observation room and finally the upper room housed indicator loop controls and monitoring (Galil et al 2013 pp140-106). A map of defences showed controlled mines were also in use though only at the eastern side of Carmel Head and the only active protection for Haifa Bay was gun batteries and the passive indicator loops (Galil et al 2013 p 98). What is found at Haifa Bay is that a landing areas are being protected, a large beach but not a single entity such as the Hawkesbury River Railway Bridge.

Commander Moore RN (2009) in his work *Night Attacks on Harbours* mentions briefly the requirements of minefields and passive detection though considers shore batteries effective against naval incursion. It is unclear if Moore considers submarine attack as a priority.

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2.11 Discussion

This chapter facilitates a deepened understanding of military archaeology, coastal defence strategies, and the unique challenges faced by the Australian Fortress during World War II.

Through comprehensive archival analysis, the review uncovers the historical layers surrounding the defences at Broken Bay while acknowledging the limitations of its scope. The elucidation of the Hawkesbury River Railway Bridge's vulnerability further underscores this research's importance in unravelling the intricate tapestry of Australia's wartime history.

In scrutinising the defences at Broken Bay against potential submarine attacks, it is imperative to assess the Sydney attack and the effectiveness of boom nets in averting such incursions. The Hawkesbury River railway bridge emerges as a focal point of defence, distinguished by the concentration of resources channelled toward its protection. The substantial expenditure relative to the average wage underscores its critical role in wartime strategy and its pivotal position in thwarting invasion.

However, a noteworthy lacuna exists in maritime conflict archaeological resources in Australia, specifically within the Broken Bay region. This deficiency highlights a significant knowledge gap regarding Australia's endeavours to safeguard vital infrastructure during the war. Comprehensive research on various defensive measures such as boom defences, minefields, Naval Auxillary Patrol’s (NAPs), and these measures' broader economic and social consequences remains notably absent. Walding's work may offer insights into indicator loops, but comprehensive research on submarine defence within the Australian Fortress context remains largely unexplored. This literature review underscores the urgency for further extensive investigations into this subject matter, shedding light on a critical aspect of Australia's wartime history.

CHAPTER THREE

METHODS

3.1 Introduction

This chapter outlines the methods used in the conduct of this research. This includes information on how pertinent data was sourced from diverse repositories, including archives, books, and periodicals, the survey techniques used, the methods used in data analysis, the limitations of the data and the limitations of the study. The meticulous steps undertaken at every stage of the research process underscore the author's commitment to transparency and fidelity in acquiring empirical information.

The study encountered initial challenges in data collection stemming from external factors such as weather conditions and logistical constraints, reflecting the pragmatic realities of archaeological fieldwork. Diligent planning and unwavering determination ultimately surmounted these obstacles as part of adaptive research methodologies.

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3.2 Selection of Study Area

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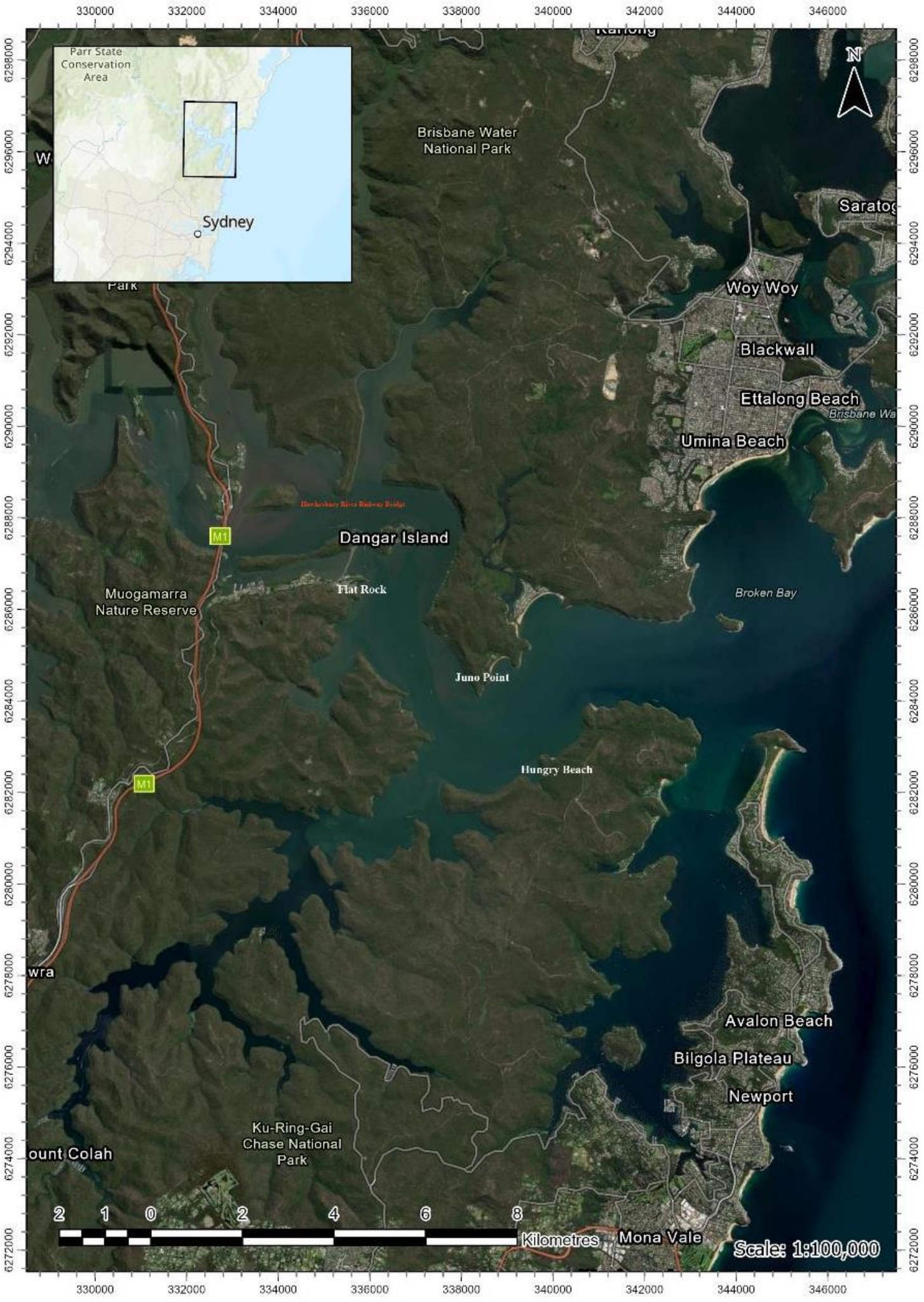
Broken Bay was selected as the study area because it is an ideal location to address the research question, Could the World War 2 defences of Broken Bay post-Sydney Harbour attack adequately safeguard the Hawkesbury River Railway Bridge against potential damage or destruction by submarines? . The study area needed to have the following qualities physical evidence of WW2 defence installations, accessibility and tactically sound location. Broken Bay fulfills all of these criteria.

The size of the Broken Bay between Barrenjoey and Dangar Island is approximately 30 $km^{2,}$ including land masses, and because of this, reduction in the water and land survey area was required.

Outer defences east of Hungry Beach were not examined; however, West Head has extensive extant surface and sub-surface archaeology.

Only those defences capable of preventing a submarine and dominate surface attack were examined to ensure that the research questions were answered.

Map 3-1: Broken Bay overview (insert reference location to Sydney Harbour).



3.3 Ethics

Commented [CS16]: All archaeology has ethical implications as it impacts upon humans, and information has to be stored ethically for future generations. Have a look at the AAA Code and Ethics and refer to what applies to your own research.

The author acknowledges the traditional owners of the lands and water in which the research was conducted are the Broken Bay tribe. While this research did not focus on Indigenous archaeology, all archaeological research on Indigenous lands will affect Indigenous people in some way.

Archaeological research has impact upon a range of stakeholders (see Zimmerman 2006:85-95). This research was guided by the code of ethics of the Australian Archaeological Association (2023). In particular, Section 2- *Principle relating to the Archaeological Record* was adhered to by taking all reasonable steps to protect the survey areas and provide archival storage of information. Documentation and photographs are currently stored on the author's personal cloud. The long-term plan for their preservation is to lodge them with Flinders University.

3.4 Forms of Data

This study draws upon a diverse array of primary source materials, including archival records, government documents, and published works in archaeology, as well as field recordings of site 1 (Juno Point), 2 (Hungry Beach), 3 (Flat Rock), 4 (Dangar Island) and 5 (Tumbledown).

3.5 Archival Research

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Following established archival research protocols, this investigation engaged repositories of historical significance. Notably, Macken's seminal works, "Pittwater War" (2002) and "Iron Coffin" (2008), served as pivotal catalysts in directing the course of inquiry towards repositories of critical import. This directive led the author to the esteemed holdings of the National Archive of Australia in Canberra, Melbourne, and Sydney, the Australian War Memorial, the National Library of Australia-Trove, and the New South Wales State Archives.

Within these repositories, an extensive compendium of documents about the defences of Broken Bay was discovered, encompassing a spectrum of topics, including fortifications,

personnel rosters, and supplementary logistical support. Although the documentation proved comprehensive in its coverage, a discernible lacuna was identified in the availability of construction plans for defence structures, which were conspicuously absent from the archival holdings. This absence underscores a limitation in the extant archival record, but at the same time, it highlights the significance of research projects such as that undertaken in this study, which analyses archaeological remains in an attempt to fill this gap in knowledge.

3.6 Government Documents

Complementing the archival holdings, government documents assumed a pivotal role in this research endeavour. These primary sources, emanating from various official bodies, provided critical insights into the administrative and bureaucratic aspects of defence infrastructure in the Broken Bay region. These documents were instrumental in corroborating and augmenting the findings derived from the archival materials.

Macken's comprehensive investigations into Broken Bay's submarine infiltration (2002, 2008) played a paramount role in guiding this phase of the research. The insights gleaned from his examinations of primary sources laid a robust foundation for subsequent inquiry into the governmental dimensions of defence planning and execution.

3.7 Newspapers

In a complementary endeavour, the author accessed contemporary newspaper articles through the National Library of Australia's Trove database, focusing on the pre-World War I and 1942 periods. These newspaper reports furnished a dynamic lens through which to examine the unfolding events of the time. The media accounts provided invaluable contemporaneous perspectives on the actualities of the events as they transpired, thus offering a multifaceted and enriched understanding of the historical milieu.

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3.9 Fieldwork Methods

Fieldwork was conducted in adherence to established protocols outlined in *The Archaeologist Field Handbook* (Burke et al 2017: 87-106, 127), which provided comprehensive guidance on survey methods and data collection procedures.

Commented [CS19]: In this context 'methodologies' reads as pseudoscience.

3.10 Accessibility and Transport

The survey area, comprising Juno Point, Hungry Beach, Flat Rock, and Dangar Island, presented unique logistical challenges. Access to these locations was exclusively attainable by vessel and was accessed in alignment with best practices for maritime archaeological investigations as Green (2003) recommended.

Juno Point, an area of particular interest, necessitated prior authorisation from the NSW Sport and Recreation manager. This prerequisite was in accordance with the Handbook's emphasis on obtaining appropriate permissions for fieldwork in controlled environments. Once clearance was secured, time-limited access was granted ensuring efficiency in data collection and survey activities.

Hungry Beach, situated within the jurisdiction of NSW National Parks and Wildlife, was designated as a public park. This compliance with protected area regulations, as advised in the *Archaeologist Field Handbook*, underscored the importance of respecting environmental and regulatory frameworks in the conduct of fieldwork.

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Initially, transportation to Hungry Beach was facilitated, and subsequently, the involvement of NSW Heritage bolstered the research endeavour. Following consultations, NSW Heritage offered crucial support, including the provision of sonar imagery, aligning with the Handbook's recommendation for leveraging technological advancements in data acquisition.

3.11 Duration and Survey Scope

There are many ways in which both terrestrial and maritime landscapes may be explored for archaeological sites. These methods include aerial and satellite imaging, as well as diving, foot

walking and geophysical methods (McCarthy et al 2019: 211-231). For the purposes of this study, a focused sonar survey was chosen as this method was likely to yield the highest possibility of accurately identifying sites.

This survey of selected areas was undertaken in collaboration with NSW Heritage, attesting to the value of interdisciplinary collaboration as advocated in the Handbook. A four-day window was allocated for data collection, in recognition of the need for strategic time management in fieldwork endeavours. This fieldwork was undertaken between March 3 and May 28, 2022.

3.12 Visibility and Coverage

A systematic survey approach was adopted for each location. Prior to on-site exploration, a comprehensive examination of archival documents was conducted. Notably, the challenging topography of the defensive landscape precluded the establishment of standard transects. Instead, a meticulous examination of the terrain enabled the identification of structures, demonstrating adaptability when confronted with site-specific constraints.

Juno Point, Hungry Beach, Flat Rock, and Dangar Island were subjected to rigorous scrutiny, combining archival research with on-site investigations. This dual-pronged approach, recommended by the Handbook (Burke et al. 2020, p.475), ensured a comprehensive evaluation of the researched locales in the absence of any oral history.

The rigorous adherence to the guidelines outlined in the Archaeologist Field Handbook underpinned the efficacy and integrity of the fieldwork methods, culminating in a robust foundation for subsequent data analysis and interpretation.

The assessment of visibility and coverage at each surveyed site adhered closely to the protocols articulated in the Archaeologists Field Handbook, encompassing critical principles from chapters dedicated to site reconnaissance, topographical considerations, and data recording techniques. Discussion of an individual site's visibility is included below.

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Commented [CS24]: Was any oral history information available?

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3.13 Site 1: Juno Point

Juno Point, characterised by an extensive overgrowth of native vegetation, presented a challenging terrain for comprehensive site examination. The limited maintenance around extant archaeological features was reflective of the Handbook's emphasis on considering vegetation cover as a crucial factor in site visibility (Burke et al. 2017, p. 266). In line with the Handbook's recommendations, identified structures were assigned general search areas guided by archival documents and the insights the NSW Sport and Recreation personnel provided. Additional areas indicated in archival documents remained unlocated, underscoring the Handbook's acknowledgment of potential disparities between historical records and on-site realities (Little, 2006, pp. 400-403).

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3.14 Site 2: Hungry Beach

Hungry Beach, devoid of associated plans, necessitated an extensive reliance on newspaper articles and archival documents for insights into the presence of billeting buildings and wharf structures. The overgrowth of bracken in the flat expanse between the beach and the sandstone hill was a pivotal consideration in assessing visibility, aligning with the Handbook's emphasis on adjusting surveying methods to accommodation vegetation and terrain features (Burke et al. 2017, p. 266). Safety concerns, leading to the exclusion of the area south of the control hut, were a prudent measure in accordance with the Handbook's prioritisation of researcher safety (Burke et al. 2017, p. 48-51).

3.15 Site 3: Flat Rock

Being part of a tourist walk, Flat Rock benefited from relatively facile accessibility, aligning with the Handbook's guidance on selecting accessible sites for thorough physical examination (Burke et al. 2017, p. 147). The critical determination of the boom net's landing point, concealed behind gum trees in a grotto positioned 3 meters above the path, was emblematic of the meticulous attention to detail emphasised in the Handbook. The conspicuous visibility of the gun platform resonated with the Handbook's acknowledgment of prominent features within

a site (Burke et al. 2017, p. 453). However, the absence of certain anticipated structures towards the southern extremity of the site underscored the Handbook's recognition of potential discrepancies between archival data and on-site realities (Burke et al. 2017, p. 400-403

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3.16 Site 4: Dangar Island

The access to Dangar Island via ferry, followed by a strategic walk across the island, adhered to the Handbook's guidance on selecting access routes conducive to thorough surveying (Burke et al. 2017, p. 147). The walk along the rocks, in alignment with the Handbook's emphasis on navigating challenging terrains, was instrumental in reaching the boulder housing two embedded anchor rings. The Handbook's directive on utilising plans for navigation was exemplified in this process (Burke et al. 2017, p. 453). The identification of securing rings for the northern boom section and the subsequent alignment to ascertain the location of additional rings at Tumbledown demonstrated the value of orienteering within a site.

3.17 Site 5: Tumbledown

Tumbledown's extensively redeveloped foreshore since WW2, with limited public access, presented a distinctive challenge in accordance with the Handbook's acknowledgment of evolving site conditions over time. The absence of evidence pertaining to securing rings or posts associated with the northern boom resonated with the Handbook's recognition of potential challenges in locating specific features, particularly in extensively modified areas (Burke et al. 2017, p. 444).

3.18 Survey Method Documentation

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The survey methodology and documentation adhered closely to the protocols outlined in the Archaeologists Field Handbook, encompassing critical principles from chapters dedicated to site reconnaissance, topographical considerations, and data recording techniques.

3.19 Field Journals and Documentation

The author diligently completed a meticulous field journal at each surveyed location. This field journal, a practice endorsed by the Handbook (Burke et al 2017: 39-41), served as a comprehensive record of observations, methodologies employed, and any notable site-specific conditions. It included detailed entries on topographical features, identified structures, and any deviations from the anticipated archaeological landscape. This meticulous documentation, a cornerstone of sound archaeological practice emphasised in the Handbook, provided a reliable repository of fieldwork observations.

3.20 Photographic Documentation

In tandem with field journal entries, the author captured an extensive series of high-resolution digital photographs at each location. These photographs served as a visual record of the site's condition, architectural elements, and any pertinent features. This practice, in line with the Handbook's recommendation for comprehensive visual documentation, ensured a robust visual record for subsequent analysis (Burke et al 2017: 50-51). These photographs are currently stored on the authors cloud and are available for viewing upon request.

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3.21 Geographic Information System (GIS) Data

Geographic Information System (GIS) information was pivotal in data acquisition and spatial referencing (Australia zone 56, 2000) (Longley et al., 2015). The author diligently stored both hardcopy and digital copies of GIS data, ensuring accessibility and preservation of geospatial information. This meticulous approach, in accordance with the Handbook's guidance on spatial referencing, facilitated the integration of spatial data with archaeological findings for comprehensive analysis.

Including field journals, photographic documentation, and GIS information storage in both hardcopy and digital formats bolstered the study's methodological rigour. These practices, firmly rooted in the best practices outlined in the Archaeologists Field Handbook, fortified the

study's analytical robustness and ensured a comprehensive approach to data acquisition and interpretation methods of analysis.

The analytical framework employed in this study draws upon established methodologies as outlined in the Archaeologists Field Handbook, specifically chapters pertaining to data interpretation, comparative analysis, and technological integration.

3.22 Methods of Analysis

Travers characterised method as 'the techniques employed in gathering data' (2001: vi), essentially delineating how the research was executed. In this investigation, a mixed-method design combining qualitative and quantitative approaches was embraced to amass a more comprehensive and robust set of data from varied primary and secondary sources of evidence.

Conventional archaeological desk-based and field survey techniques were employed to identify extant traces of anti-invasion defences in the specified study areas. Documentary, cartographic, and photographic evidence underwent thorough content analysis and coding. The outcomes within and across cases were juxtaposed to evaluate the extent to which evidence persists for Second World War anti-invasion defences in Wales.

The chosen method involved purposefully selecting a limited number of diverse source evidence classes for comprehensive cross-comparison. Elements of this approach were influenced by previous methodologies outlined in the literature review, particularly Page et al (2013, pp 359-379) methodology for defence areas. Given the expansive nature of data collection and analysis at a total bay scale, it was considered impractical within the scope of this research.

3.23 Archival Documents

The examination of archival documents constituted a pivotal aspect of this research, aligning with the Handbook's emphasis on leveraging historical records for comprehensive data retrieval. A meticulous scrutiny of available plans revealed a noteworthy disparity between the proposed defence structures for Broken Bay and the archaeological evidence on the ground.

This incongruence necessitated a supplementary investigation, involving an examination of memos, communication signals, and record books, echoing the Handbook's recommendation for a multi-faceted approach to archival data interpretation. It is crucial to note that certain plans were conspicuously absent from the archival references, underscoring the potential value of archaeology to fills gaps in historical documentation, as noted by various researchers (e.g. Frieman 2023).

3.24 Fieldwork Data

The integration of fieldwork data with archival documentation adhered closely to the Handbook’s guidance on merging empirical observations with historical records (Burke et al 2017, pp. 64-68).This comprehensive approach facilitated a nuanced understanding of the planning, construction, and defensive capacities against submarine incursion. Drawing upon established data regarding armaments, minefields, and boom nets, the study enabled an estimation of the efficacy of the active defences. This integration exemplifies the Handbook’s recommendation for a synergistic approach to data amalgamation.

3.25 Sonar Data Analysis

The inclusion of sonar data obtained from NSW Heritage bolstered the research, aligning with the Handbook's recognition of the value of advanced technological applications in archaeological investigations (Burke et al 2017, p 162 and 179). The analysis involved a meticulous comparison of the sonar-derived dimensions of a Type A midget submarine with known specifications, exemplifying the Handbook's emphasis on precision in data analysis.

3.26 Limitations of Data

The data acquisition process for this thesis was subject to several overarching limitations, primarily from temporal and financial constraints.

Foremost among these constraints were the limitations imposed by time and funding. Access to the designated locations was contingent upon the scheduling allowances stipulated by NSW Sport and Recreation and the requisite utilisation of a vessel for transport. The allocation of time at various archival repositories was likewise contingent on the availability of both temporal and financial resources, as certain lines of inquiry necessitated further exploration of interlinked information sources.

The procurement of a commercial vessel for the execution of underwater surveys, employing diverse technologies such as sonar and magnetometers, incurred substantial costs. This financial consideration constricted the extent of data collection, with a focal emphasis on shorelines and immediate maritime peripheries.

Unfavourable weather conditions compounded the challenges of site access. Significant flooding in the vicinity of Sydney, coupled with the closure of the Hawkesbury River in the Broken Bay area, impeded all vessel traffic around Brooklyn. Organising access became feasible only after the abatement of floodwaters and the resolution of associated impediments. The dearth of antecedent published research necessitated an extensive reliance on grey literature sources, albeit without comprehensive coverage of the identification and utilisation of defensive structures. While comparative insights gleaned from Australian and international literature were instructive, they were inherently constrained by the unique characteristics of Broken Bay's defences.

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3.27 Limitations of Study

The spatial expanse of Broken Bay, spanning from Barrenjoey to Dangar Island, encompasses an area of approximately 30 square kilometres, inclusive of land masses. An area this size was beyond the scope of this study. Consequently, a strategic reduction in both aquatic and terrestrial survey areas was imperative. Notably, the outer defences east of Hungry Beach were omitted from this study’s examination.

A focused investigation was directed towards defences with the capacity to thwart submarine incursions and assert dominance over surface-based threats, aligning with the research objectives.

Archival research unearthed additional information about billeting arrangements, supply logistics, anti-aircraft defences, and command structures. However, while valuable, this supplementary data did not directly contribute to addressing the research inquiries, which were the type, location and effectiveness of Broken Bay defences. Nevertheless, it held the potential to furnish identifications of the individuals who served at these locations.

The prescribed word count of the thesis further delimited these enumerated constraints. A more comprehensive research proposal, delineating an expanded scope of inquiry, would be instrumental in effecting a holistic examination of Broken Bay's defences and the men who valiantly safeguarded the Hawkesbury River and its environs.

3.28 Discussion

Gathering information from archival documents constituted the primary avenue for data acquisition, aligning with established methodologies articulated in the *Archaeologists Field Handbook* (Burke et al 2017, p. 64-68). This data was subjected to a rigorous process of cross-referencing with the surveyed locales. Comprehensively expounded within are the survey techniques deployed and a thorough exposition of the ensuing data analysis, underscored by a conscientious delineation of its inherent limitations. The limited availability of scholarly and grey literature necessitated a meticulous reliance on archival sources. However, it became evident that the grey literature, when available, lacked the comprehensive analytical depth required for a thorough investigation of extant archaeology. A comprehensive assessment of their utilisation and effectiveness remained incomplete.

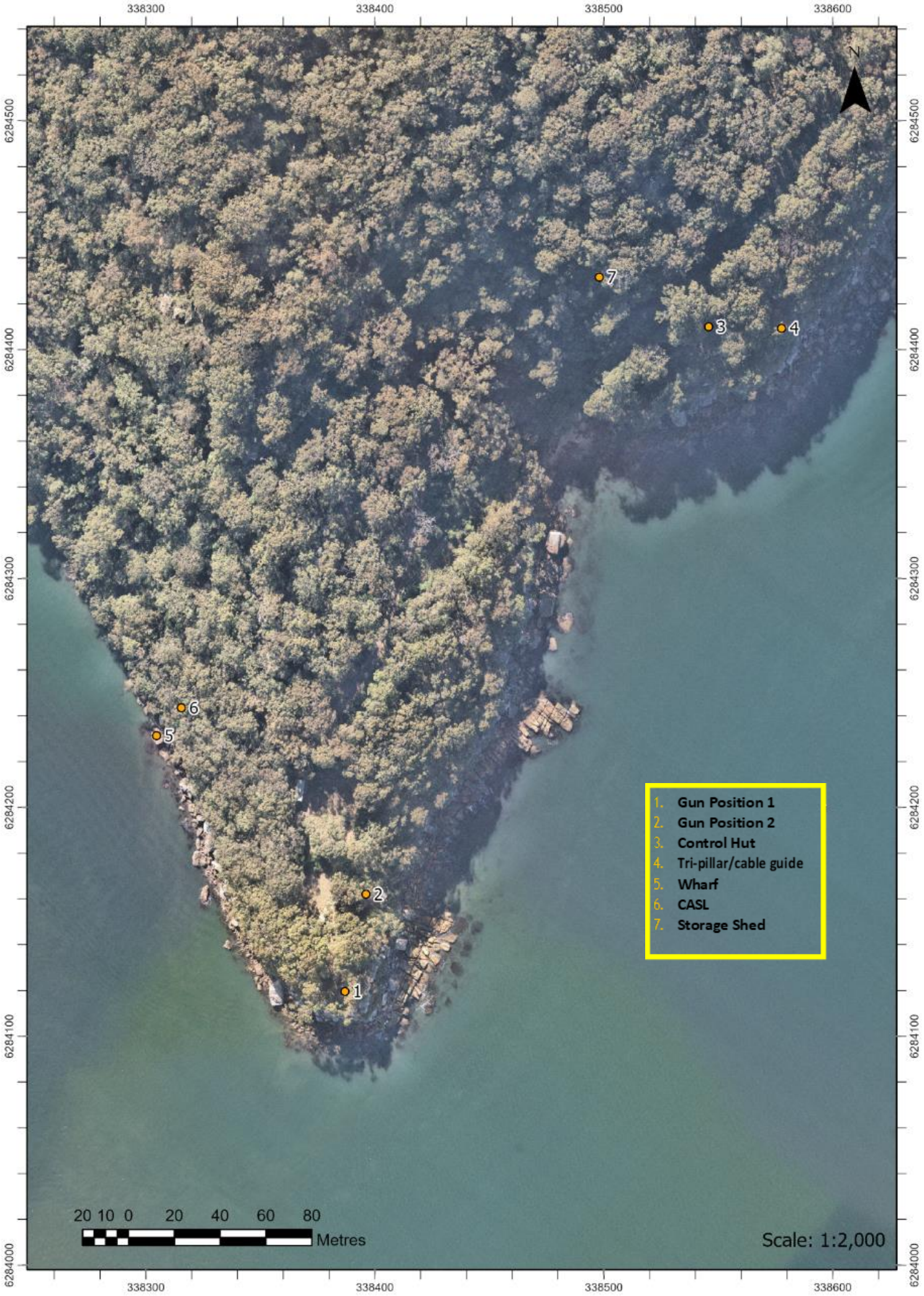
Recognising and adapting to imposed limitations, whether deliberate or circumstantial, ensured a robust and systematic approach to data acquisition and analysis. This fidelity to established protocols resulted in a methodological framework distinguished by its effectiveness and applicability, even in the presence of diverse research challenges.

CHAPTER FOUR

RESULTS

The primary objective of this study was to ascertain whether the World War 2 defences of Broken Bay post-Sydney Harbour attack on 31 May 1942 effectively shielded the Hawkesbury River Railway Bridge from potential harm or destruction by submarine incursions. In order to interrogate the aforementioned inquiry, the present investigation systematically gathered written data derived from primary sources. The primary objective was to delineate potential sites of defensive installations and their respective typologies. The data compilation encompassed specific geospatial information pertaining to extant defensive archaeology, incorporating precise measurements and analytical findings. Methodologically, the analysis relied on a meticulous examination of documents directly relevant to the identified defensive structures, with a particular focus on elucidating their tangible anti-submarine capabilities within real-world contexts.This chapter presents the results of the identification and analysis of this data.

Map 4-1: Juno Point with locations of extant defensive and auxillary archaeology.



4.1 Juno Point

The historical and archaeological evidence demonstrates that Juno Point contributed effectively to shielding the Hawkesbury River Railway Bridge from potential harm or destruction by submarine incursions by creating a central point of command and control over the defences of Broken Bay.

It was found Juno Point is an ideal defensive position within Broken Bay. An unobstructed view east through the heads of the bay provide early warning of attacking naval craft and with the inclusion of controlling indicator loops, minefield and guns enabled a substantial first line of defence and identified as unique in Australian warfare. Walding (2006) describes remaining control huts in Queensland as smaller and not containing the concentration of military arsenal as that found at Broken Bay and Juno Point.

The extant archaeological inventory encompasses two 18-pounder gun emplacements, an adjacent derrick wharf, a Coastal Artillery Search Lights (CASL) position in proximity, a storage edifice with supplementary construction in its rearward vicinity, a spacious control facility, a tri-pillar attribute, and a cable guide as described in primary archival documents (Anonymous, 1939-1946; Anonymous, 1942z).

The tri-pillar feature and cable guide④ derrick wharf ⑤, storage/diesel generator hut⑦, are located on the ground; however, since they do not form part of the active or passive defences are not further explained.

4.1.1 Gun Position 1 ①

Constructed 15m above sea level on the southeastern point and partially covered by the flora and washed soil is a concrete circle of approximately 3830 mm with an inner circle of 1160 mm raised 70 mm from the base platform. At the centre of the inner circle is a triangle ‘stamped’ into the concrete with an iron pin with six notches on the outer rim. This design of gun position (Figure 4-2) to support an 18-pounder gun provides quicker transversing speeds when adjusting fire towards a target and the triangle appears to be a survey mark; however, this has yet to be confirmed. The Botany Bay photograph is the only reference to the type of gun position found of the same design outside of Broken Bay.

The base structure extends to the edge of the cliff and has a depth of 300 mm at this point, although the entire base’s depth is unknown due to the soil and floral growth.

Figure 4-1: Gun positon 1 situated near the point of Juno Point. A- Overview of the gun position and storage bunker. B- Close-up of the centre-notch pin with a possible survey mark. C- Ammunition storage bunker. D- View from the gun overlooking Broken Bay to the e east. 1- Lion Island. 2- Barrenjoey Head.

At the northern end of the base is an ammunition storage bunker, a thick steel reinforced concrete construction with two storage facilities for gun ammunition. There are three sets of cut-off steel reinforcement bars visible in the outer roof lining of the front-facing, indicating camouflage or blackout netting preventing identification from the air of the position by the reflection of brass from the sun. Within the storage area of the bunker is a large number of graffiti that appears to be personal type.

4.1.2 Gun Position 2

Gun Position 2 was set 39m north of gun position 1; position 2 is of similar construction; however, the centre pin is not notched and does not bear a centre triangle stamped into the concrete raised platform. The ammunition storage bunker adjoins the base, although not as curved as gun 1. Instead, it is angled.

The overall sizing is almost the same with only several centimetres difference. Six steel reinforcement bars protrude from the outer front-facing roof lining and indicate a probable camouflage net, the same as gun position 1.

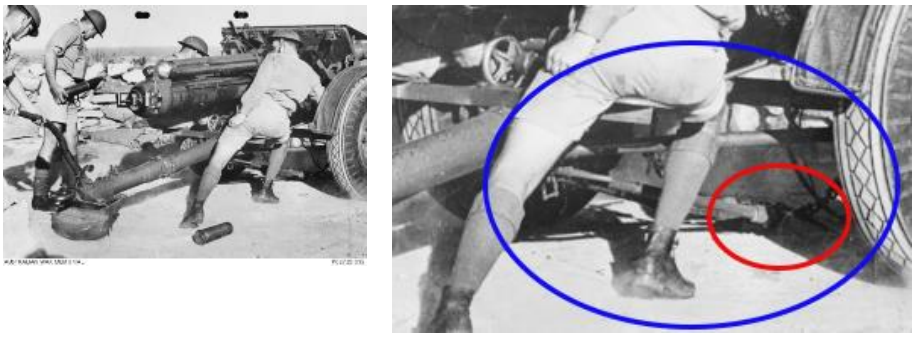


Figure 4-2: (Left) Botany Bay NSW 1942. Members of 'Henry Head' Battery with an 18 pounder MkII field gun at full recoil during practice at North Head. The yoke from an anti-tank platform is connected to a pin that is embedded in a rock and the concrete platform under the wheels (ref AWM P02729.035). (Right) Close up of above photograph showing the the yoke from an anti-tank platform. Red circle shows where the gun mounts to the platform by a pin. (Information supplied by Kevin Browning and Keith Glyde - Cutler Research Centre with permission to use).

Figure 4-3: Gun position 2. ***A****- Overview of the gun position displaying how overgrown it is compare to gun position 1. The ammunition bunker is to the left of the photographs.* ***B****- Overlooking Broken Bay. Lion Island (left) and Barrenjoey Headland (right).* ***C****- Centre pin for gun mounting. Different design and unknown why this is the case.*

4.1.3 Control Hut

Responsible for command and control of the 18-pounder guns, CASLs, indicator loops and minefields, the Juno Point control hut is a unique military structure. No other command posts in Australia mirror this architectural design with two separate rooms. Other locations like Newcastle and Moreton Bay had similar defences though fewer control features (Walding, 2006).

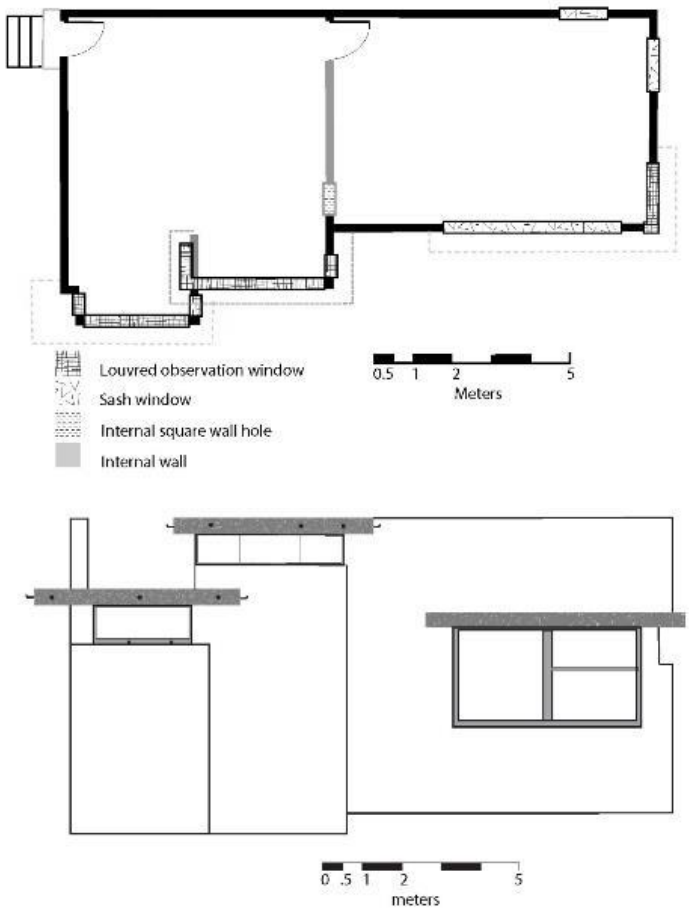


Figure 4-4:Plan and profile drawing of the Control Hut. Considerably modified from the original Kurnell type.

The two rooms, called observation and control for this thesis, have a single-entry door to the south. The observation room has two sets of windows 1.6m and 3m from the floor. Both windows are cantilevered and provide a full 270^{o} view, which is not evident due to current tree coverage. The higher of the two windows has the outline of a removed platform and, based on plans of Kurnell-type huts ranging optics are installed. These raised platforms are typical of range-finding locations within a control hut.The room is possibly an indicator loop and minefield command centre, but because of the shelving against the wall, equipment mounting screw holes and ghosting of equipment is not visible. This room is consistent with ranging and observation centres along the New South Wales coast, like that of Hungry Beach, only on a larger scale.

Original lights are installed on the roof and are in excellent condition. There are original light switches, a ‘Nilsen’ fuse switch, and a steel electrical conduit.Upon contacting Nilsen, modification/modernisation of the unit was done with the installation of modern safety switches.

Figure 4-5: Exterior of control hut displaying the state of dis-repair and construction type. A- North wall. B- East wall with observation windows. Evident are the metal rod protrusions for camouflage/blackout curtains. C- South wall with entry door. Exposed brickwork on the roof area.

Figure 4-6: Inside the control hut. It is considered all paint is original and hence lead-based. ***A-*** *Looking north from the entry door through to 2nd room. The floor is lined with masonite over the original floorboards; the construction method is evident with the negative of the original framework when concrete was poured.* ***B-*** *Looking northeast, showing a 'pass through' window now blocked.* ***C-*** *Upper observation window and the scar of an observation platform. It is likely used to mount ranging optics.* ***D-*** *Original light fixture. Also evident is some concrete cancer and rusting reinforcement. The round hole in the roof extends to the outside, and further investigation into its use is needed.*

4.1.4 Coastal Artillery Search Light (CASL)

The CASL north of the pier is an open steel reinforced concrete rectangle with the longer side facing the water and ≈5m higher than the pier. The structure is heavily overgrown, and there is evidence of a recent cliff collapse inside, with large sandstone boulders settling within it.

The three concreted walled sides have exposed reinforcement bars (10mm) and heavy iron wire (10mm) threaded through, indicating a possible camouflage net. Since there is so much debris within the structure, evidence of a floor is not visible; however, the lower outer eastern wall lays on up to 300mm of concrete 300mm thick with 100mm high.

The structure has corrugated iron sheeting inside, exposed in tiny parts through the debris, and formed within the concrete, but no further diagnostic archaeology remains. Similar styles of CASL structures are located around the country, but most have concrete walls and roofs (Figure 4-8), and all have a nearby power source, such as a generator (Walding 2006, Gojak . 1985). No evidence of any generator was found near the CASL location. However, a more thorough examination of historical documents and the environment may unearth further proof associated with the CASL.

Personnel graffiti was identified carved into the sandstone at the back of the CASL. Photographs were taken and a name and date identified, **J RYAN 43** (see grafitti). A search of the National Archives of Australia military records provides four J Ryans posted to Broken Bay in 1943; however, John Joseph Ryan service number NX78488 identification was made as a result of further investigations of available digitised service records. All service records are contained within the National Archives of Australia, Canberra (see Section 4.8)

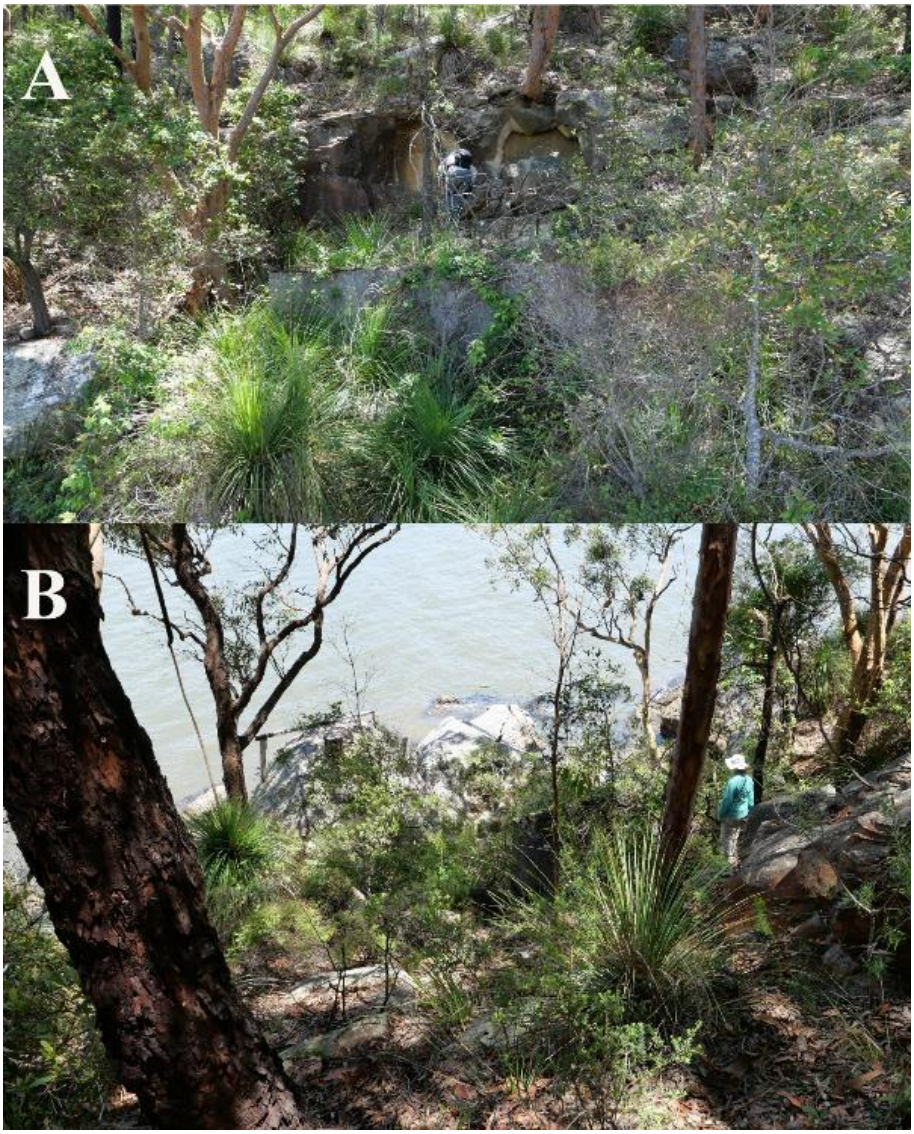


Figure 4-7: Overview of the CASL position. ***A-*** *Looking north from the wharf towards the position. The structure is partially hidden by vegetation and the sandstone cliff face (where graffiti is located) some of which has fallen into the bunker-type structure.* ***B-*** *Looking down onto the CASL (left of figure in blue), locate it in the area of the wharf.*

Figure 4-8: Looking into the CASL bunker. ***A-*** *Showing the depth. Range pole is 10cm incriments. Heavy steel loop and wire on the top of a 15cm wide wall.* ***B-*** *Bottom of the outside wall. Red brick supports the concrete wall.*

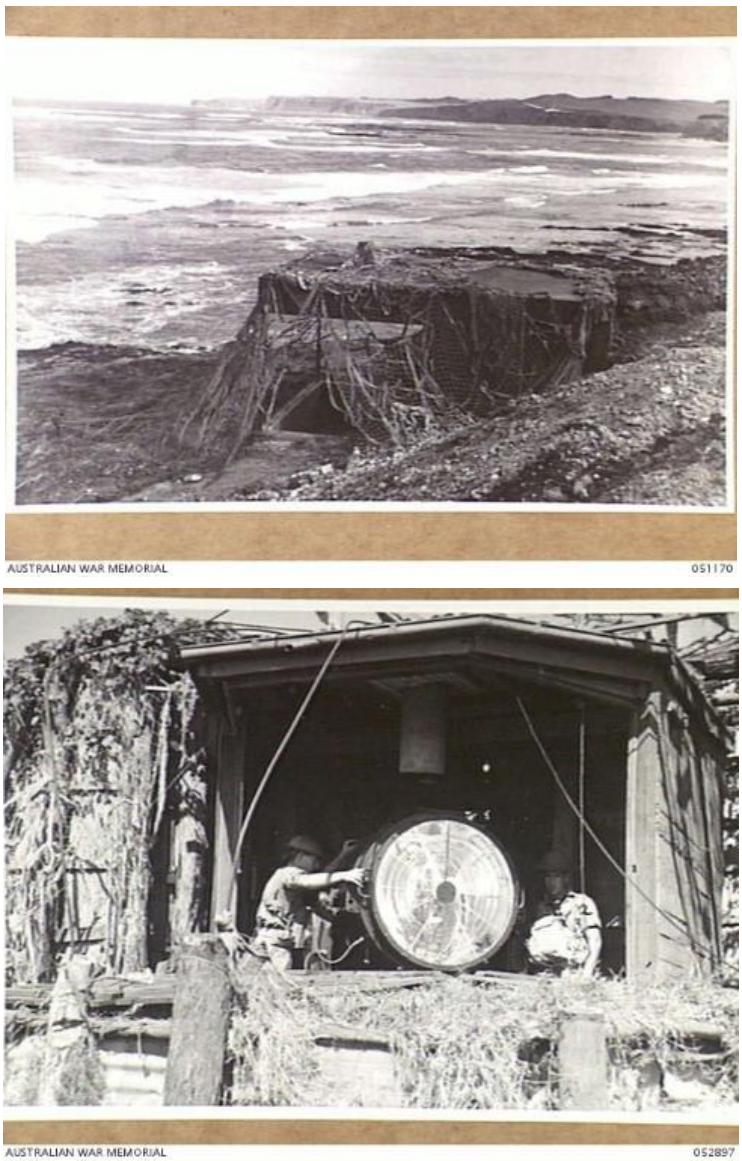
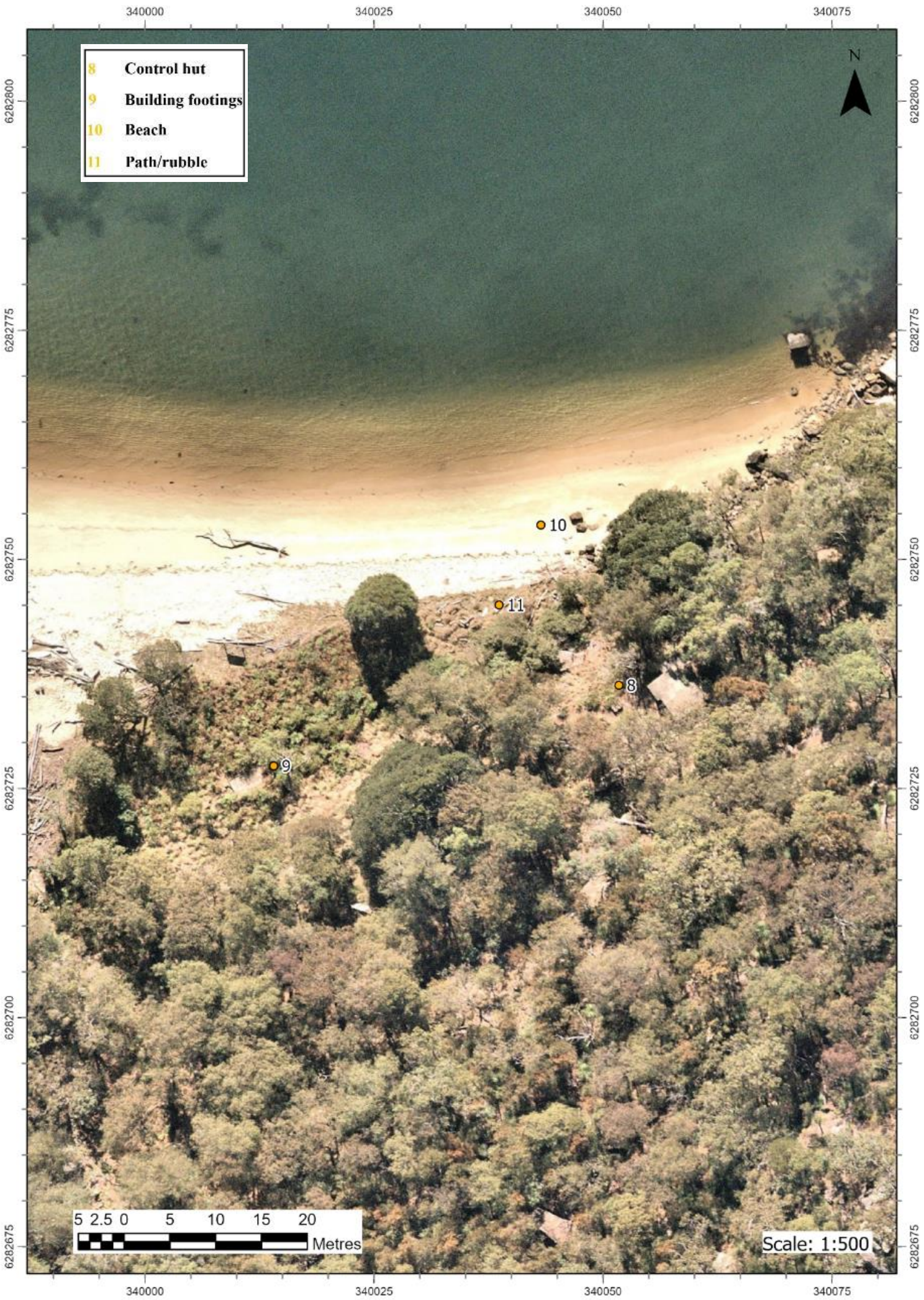


Figure 4-9: Photographs of WW2 search lights. Upper from Flinders NSW and lower Darwin NT. The upper shows the camoflague netting and there are the steel loops in the concrete wall. Darwin's has a wooden shelter rather than concrete. It is expected Juno Point had similar roofing.

Map 4-2: Hungry Beach Defences and auxillary.



4.2 Hungry Beach

The historical and archaeological records substantiate the role of Hungry Beach as a pivotal component in safeguarding the Hawkesbury River Railway Bridge, primarily through its function as a strategic vantage point for surveilling potential submarine threats and the establishment of a protective minefield to thwart potential harm or destruction by such submersible vessels.

Positioned on the southern mainland, stretching from Juno Point, Hungry Beach afforded an unimpeded observation point spanning from Barrenjoey westward to Dangar Island. Documented features of the site include a control hut (designated as O8), a wharf (designated as O10), and demountable structures intended for billeting sailors (designated as O9) during their tenure at the location. The topography of the area encompasses a diminutive beach extending approximately 100 meters, followed by an ascending landscape to a level expanse prior to a steep ascent leading to the aforementioned control hut.

Parallel to the foreshore, a concrete path (designated as O11) has succumbed to erosion, emanating from the western direction and terminating at a pillar submerged in the water. This remnant pillar signifies the remnants of a pier, originally erected for the logistical supply of troops and materials. Noteworthy is the presence of a collapsed brick-and-mortar wall spanning a length of 30 meters in an east-west orientation. The discernible stratification of at least two layers of rubble suggests a vertical structural configuration, indicative of the erstwhile existence of a substantial edifice in this locale.

Within the dense thicket of brambles and weeds, positioned on a level expanse above the path, two concrete footings are discernible, each meticulously fashioned with tie-down bolts encircling the periphery. These structural elements strongly imply their utilisation as foundations for portable huts, a conjecture substantiated by the presence of anchor points in the form of bolts, strategically embedded to secure the lower plate of the structure. The inclination towards this interpretation is reinforced by the documentation within the National Archives of Australia, specifically the document titled “Disposal of Assets Hungry Beach” (Anonymous 1942h). Notably, the eastern footing features a door oriented towards the beach, while its interior exhibits a soil floor, in marked contrast to the counterpart, which boasts a concrete flooring designated as O9.

The luxuriant thickness of the weeds and bramble conceals any additional structures, footings, or pathways within the flat terrain above the beach. Despite the current lack of visible evidence,

a compelling rationale exists to anticipate the discovery of further remnants upon more extensive investigative endeavours.

4.2.1 Control Hut 8

Steps lead up the cliff face from the flat area to the control hut. It is a smaller version than the one at Juno Point and has no command room. The site has been razed and levelled then constructed by use of drywalling the northern section of the cliff face, extending the usable area north.

The building is constructed of plain brick in a Flemish Bond style and has two observation windows, upper and lower, facing north with an overview of Broken Bay from Patonga to Flat Rock. The awning-type windows have modern steel coverings to protect the inside of the building. However, these have been propped open.

The building has been extensively damaged inside and out by graffiti, fire, and other forms of vandalism, although it is possible to ascertain the function of the control hut. Due to the black walls, there is no corporate/unit graffiti. Homelessness re-use is evident due to tents and other domestic items situated about the area and around the control hut, as well as a large amount of drug paraphernalia.

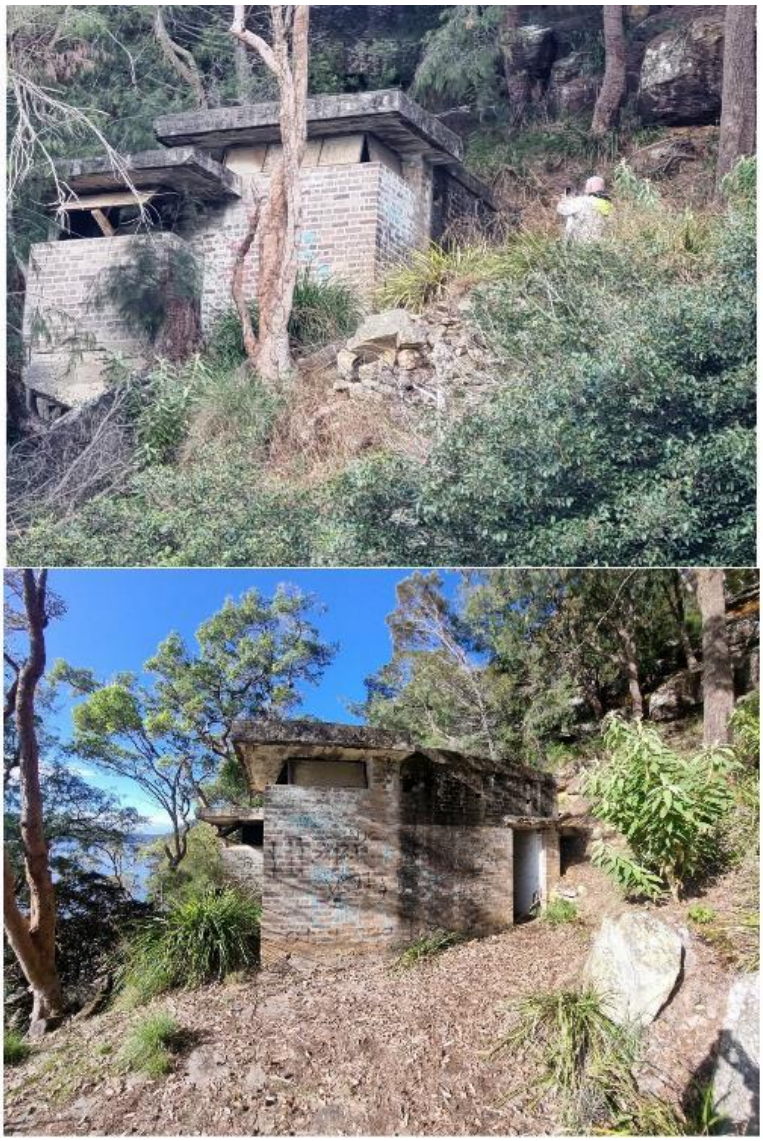


Figure 4-10: External photographs of Hungry Beach control hut. Similar design to Juno Point however does not have an extra room attached. The hut is built up on the side of a cliff using dry walling and concrete foundations are evident on the top photograph. Metal has replaced the glass, this appears to be a recent addition however as with Juno Point they are canteleavered opeening outward. The back of the hut is cut into the mountain with the access door having a large concrete lintel over it, though no hinged door is attached.

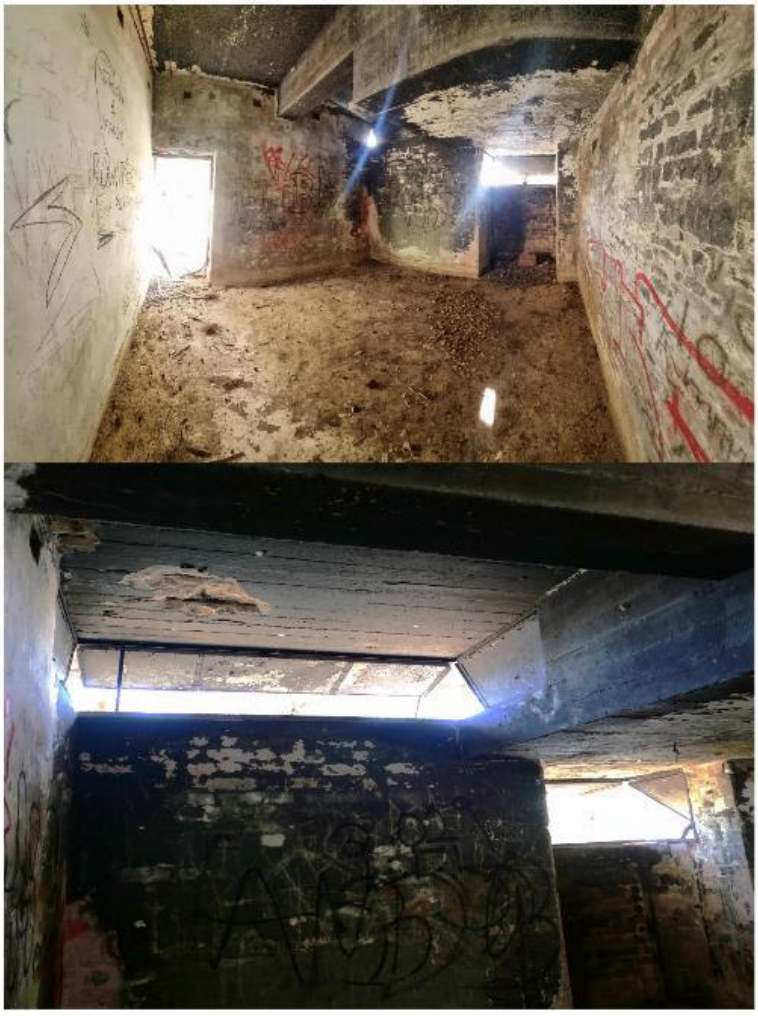


Figure 4-11: Hungry Beach control hut internal. There is a plain concrete floor and evicent brickwork behind the render type walls. The windows are set on two levels, similar to Juno Point though no scar of a mounting structure was evident. The roof is riddled with cancer and rusting reinforcment steel and it is evident that it has been on fire or exposed to fire at least once. Hungry Beach is a public accessible location whereas Juno Point is Government Land where permission is required to enter. The difference in the condition of the sites is this limiting access factor and National Park Service not recognising the significance of Hungry Beach.

Map 4-3: Flat Rock and Dangar Island overview with defensive archaeology marked.

4.3 Flat Rock

Flat Rock contributed to shielding the Hawkesbury River Railway Bridge from submarine incursions by providing a last line of defence. Flat Rock is a spur, east of the township of Brooklyn and southwest of the southern tip of Dangar Island. The location housed two defensive infrastructures, gun emplacement and shoreline boom securing.

4.3.1 Boom Support Posts [12]

Figure 4-12: Ink drawing of the posts to details weathering. (Author)

The southern boom, anchoring at Flat Rock subsequent to its fastening to Dangar Island through metal rings embedded in the bedrock, manifests distinct characteristics indicative of its historical maritime function. Notably, three circular wooden pillars are situated at an elevation of 8 meters above sea level, recessed into the natural bedrock. Unfortunately, the Each of the three posts exhibits an inclination of approximately 20 degrees, arranged in close proximity as a triad. The southernmost pillar is embedded deeper into the ground and features a metal cap secured in triplicate. The largest of these pillars, measuring 1520 millimeters from the ascertainable surface, reveals signs of an abrupt, evenly distributed break, indicative of a forceful impact. The horizontal jagged surface atop the post exhibits signs of aging, yet provides no discernible evidence of past stressors or fractures.

The adjacent smaller anterior pillar shares analogous traits, evidencing a force applied distally to the break, resulting in a tearing and snapping of the timber. Both damaged pillars are situated contiguously, oriented towards Dangar Island on a bearing of 030 degrees. Presently, the site is densely wooded, impeding the line of sight; however, it maintains a direct line of vision toward Dangar Island. An illustrative plan detailing Dangar Island booms (Figure 4-20)

elucidates the elevation above Mean Sea Level (MSL) of the upper cable that this trio of pillars would have supported.

Crucially, the absence of any indications of repair, coupled with corroboration from primary sources, substantiates the historical narrative. The southern boom, now positioned on the riverbed, is a residual consequence of the inundation resulting from the flood of 1943. This eventuality was informed by contemporaneous military command considerations, deeming the northern approach to the Hawkesbury River Railway Bridge a plausible route for potential submarine infiltration.

4.3.2 Gun Platform [13]

Positioned 20 meters above and southwest of the boom pillars, a steel-reinforced concrete gun platform commands a vantage point overlooking Broken Bay. Post-World War II, protective fencing has been installed, particularly on the southern side, given its proximity to a cliff face. The platform features a bench upon which a plaque asserts the historical deployment of anti-aircraft (AA) guns, although this claim lacks corroboration in extant historical documentation. An 18-pounder gun, akin to the configuration at Juno Point is identified as having been stationed at the site, offering an arc of fire spanning from 340 to 180 degrees. This arc effectively covers the approaches to Dangar Island from Juno Point to the northern boom. Diverging from the design at Juno Point, the base of this gun emplacement adopts a hexagonal form, with a variable visual depth ranging from 200 to 300 millimetres, the latter dimension overlooking the precipice on the southern flank. A circular inner platform, elevated at 2100 millimetres and measuring 80 millimetres in thickness, serves as a pivotal point. The presence of minor percussion marks on a brass cap positioned centrally on the platform suggests a subsequent modification, potentially a safety measure as the site has become a tourist destination.

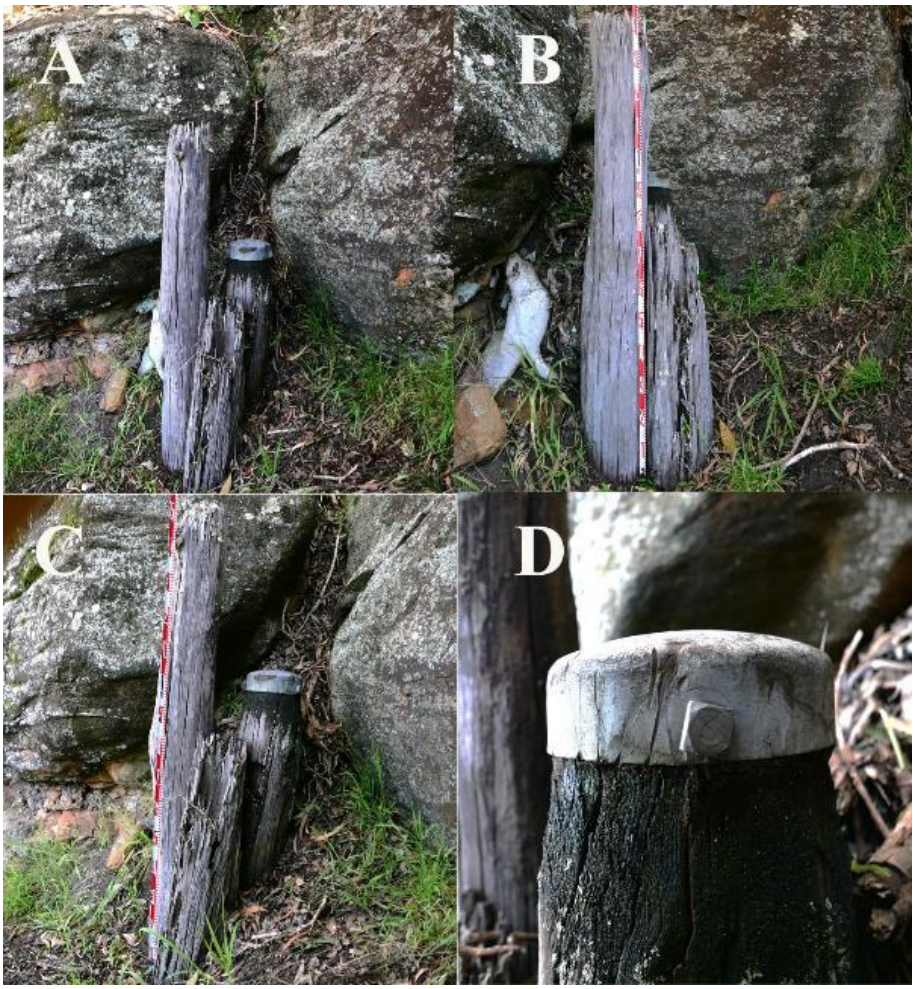


Figure 4-13: Boom supports having snapped showing the quick (long) even snap and the slower (small) tearing posibily during the flood of 1943. The remaining capped pylon displays how the large square nail was driven into it. The location of the pylons is above a tourist walking track and below the gun position.

Figure 4-14: View from the boom support posts across to Dangar Island through dense vegetation.

This inner platform, notably larger than those observed at Juno Point, lacks the characteristic large bolts within the concrete commonly associated with similar AA gun installations throughout Australia. The absence of an accompanying standing ammunition storage bunker, as seen at Juno Point, is evident; however, an extension of the larger platform toward the northwest is discernible. Although the southern extent remains subterranean, its perceived size is reminiscent of the configuration at Juno Point.

A contemporary concrete pathway traverses what is presumed to be the remnants of the ammunition storage bunker. Consistent with structures observed at Juno Point, the concrete employed in the construction exhibits an aggregate size ranging from 5 to 50 millimeters, suggestive of blue metal composition. Presently enclosed for safety, the emplacement forms part of a walking circuit around Flat Rock, serving as a designated stopping point for tourists and pedestrians alike

Figure 4-15: Gun position with modern safety barriers installed. The pin in the centre has been replaced brass capping plate flush with the concrete. The round inner circle is the same diametre as Juno Point within 10cm.

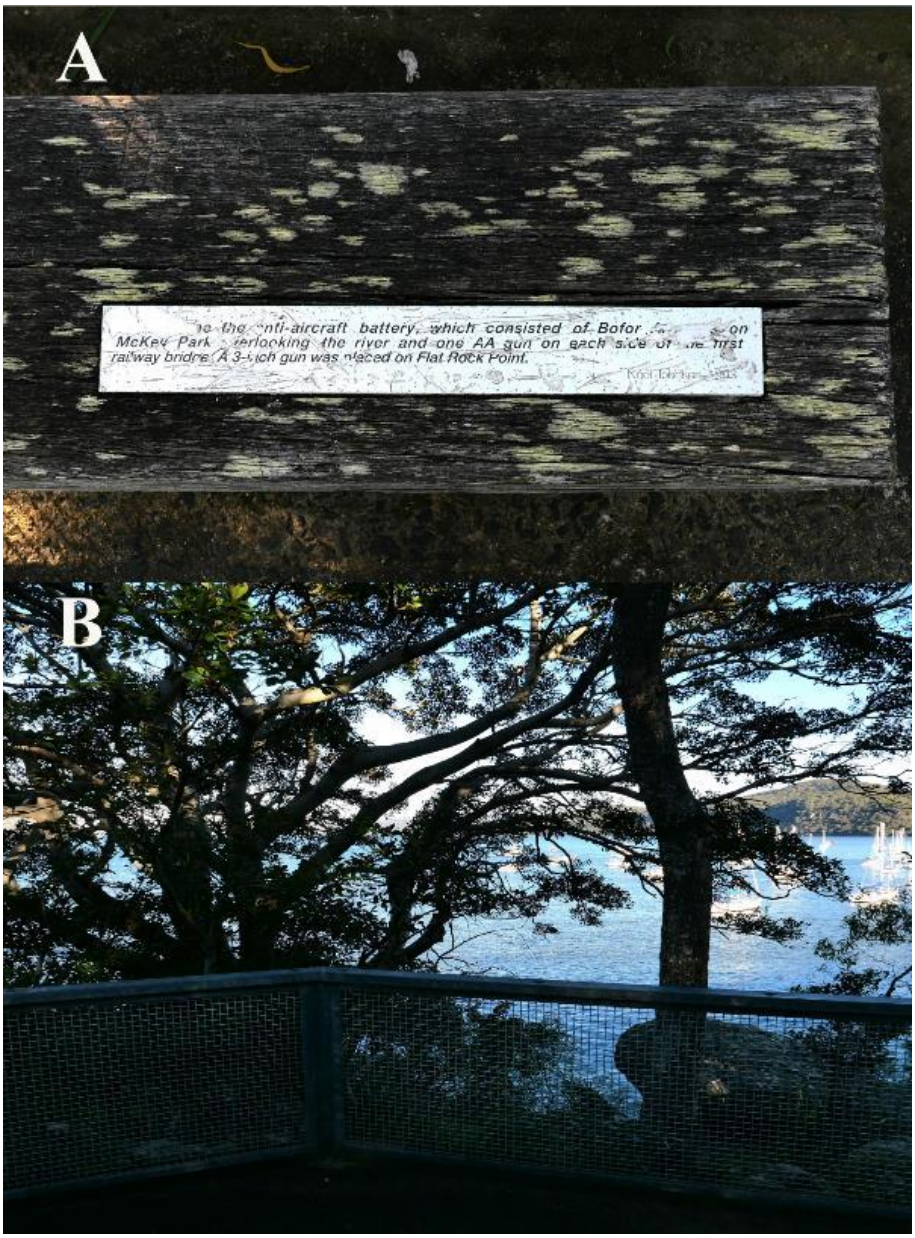


Figure 4-16: (Top) Wooden seat with a mounted plaque claiming the location was for anti-aircraft guns during the war. All anti-aircraft guns were mounted north and south of the bridge by the pylons (Anonymouts 1943j). (Bottom) View from the gun position looking towards Juno Point. With no vegetation un restricted views of any incoming vessels would be available.

4.4 Dangar Island

Dangar Island contributed to shielding the Hawkesbury River Railway Bridge from damage by submarines by acting as an anchor point for the north and south submarine boom net, large steel net which ran from the island to the mainland. Dangar Island is situated etc.

4.4.1 Southern Boom [16]

Accessible solely during low tide, the iron securing rings of the southern boom are intricately embedded within a sandstone boulder, as depicted in Figure 4-17, 4-18. These securing rings are affixed with concrete strategically positioned to maintain a direct line of sight towards Flat Rock and the securing towers at that specific location. Notably, the lower ring is aligned with Mean Sea Level (MSL), while the upper ring, positioned one meter higher, exhibits a setback of 30 centimetres and displays pronounced active corrosion, as illustrated in Figures 18-20. The extent of corrosion on the upper ring exceeds 50%, in stark contrast to the lower ring, which exhibits minimal evidence of such deterioration. Notably, both the upper and lower rings share similar dimensions, consistent with those observed on the northern boom.

Located on the same round boulder, with an approximate diameter of 3 meters, neither the iron securing rings nor the underlying boulder evince any indications of displacement or fracture away from the island. This observation stands unaffected by the inundation and structural damage incurred by the boom during the flood of 1943, which resulted in the fracturing of pillars on Flat Rock. The resilience of the securing apparatus, tethered to the geological substrate, remains evident despite the substantial environmental pressures and potential impacts experienced during historical flooding events.

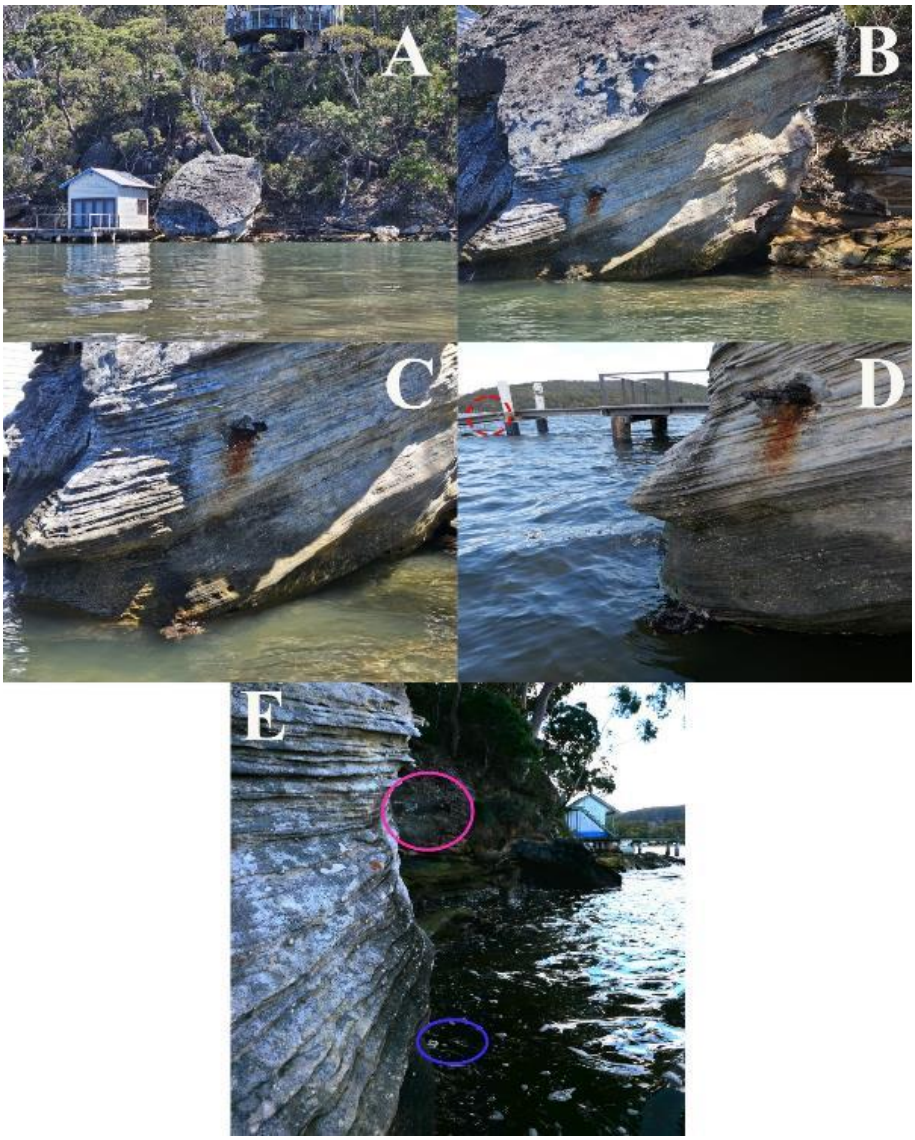


Figure 4-17: ***A-*** *View of the rock where the two mounting rings for the southern boom from Flat Rock were secured.* ***B****-Closer view of the two rings. Rust marks the top ring, with the low is just below the water.* ***C-*** *Closer view of the rings mounted on the rock evident is the setback of the top ring.* ***D-*** *View looking back to Flat Rock (red circle).* ***E-*** *View of the rings from the direction of Flat Rock and where the boulder is situated in respect to the cables.*

Figure 4-18: Close up of the securing rings. Upper ring (1-3) shows extensive corrosion and laminating, it is not affected by tidal movement since it is 1m above the bottom ring. Bottom ring (4-6) still remains in near original form, though some

laminating is evident. Each ring is secured in place by concrete, the diameter and depth of hol is unknown as no information on the rings is available. The size of these rings is the same as Dangar Island north.

4.4.2 Northern Boom [14] [15]

Subsequent to World War II, Dangar Island has undergone notable developmental transformations, witnessing the establishment of residential infrastructure and private piers extending from its shoreline. Historical documentation reveals an evolution in the island's landscape, with the 1947 (Figure 4-19) post-war aerial photographs featuring a structure adjacent to the northern boom cable securing ring (Figure 4-20, 4-21), a structure conspicuously absent from the 1961 photographs of the same locale. In contemporary imagery, obtained from the New South Wales Special Services, the extensive development encircling the cable securing rings is discernible, showcasing the proximity of local constructions to the shoreline. This encroachment raises concerns regarding potential disruptions to extant archaeological remnants and the prospect of inadvertent destruction or obscuration of any other historical remains.

Figure 4-19: : Northern Dangar Island with a square structure near the boom cable anchoring point. This structure is no longer visible and due to the extensive construction work carried out by occupants any previous archaeology has been destroyed. Photograph from NSW Government Spatial Services, film CCC61,1/01/1947.

Particularly noteworthy is the identification of a sizable iron semi-circular ring emanating from a concrete base in the aforementioned area. This ring, measuring approximately 160 x 60 millimetres in its exterior dimensions, with an internal radius of 70 millimetres, exhibits exposure limited to half its circumference. Positioned at a bearing of 130 degrees toward Tumbledown and situated one meter above Mean Sea Level (MSL), the ring aligns with the seaward anchor ring, which emerges from natural sandstone 20 meters away and also bears 130 degrees from the landward ring. Intriguingly, the exposed semi-circular portion of the seaward ring mirrors the dimensions of the landward counterpart and shares the same alignment toward Tumbledown, albeit positioned one meter below MSL.

The discernible two-meter differential between the landward and seaward rings suggests the provision of anchor points for the upper and lower cables of the boom. However, it is imperative to note that the construction of this particular boom incorporated a gate, thereby

potentially influencing the alignment toward Tumbledown. Dolphins, designed to offer stability, are integral components supporting the boom, particularly considering the inclusion of a gate in the configuration of the northern boom.

Figure 4-20: Location of two securing rings for the northern boom at Dangar Island. The rings are being resused with marine securing lines running from them. Building on the foreshore has possible destroyed or hidden any further archaeology at the location.

Figure 4-21: Close up of the securing rings with associated sizing. Securing ring F is only above wate a very low tides. Photograph D shows a large amount of concrete around the shore ring, with diameter and depth of each hole unknown. There was a gate on the northern boom.

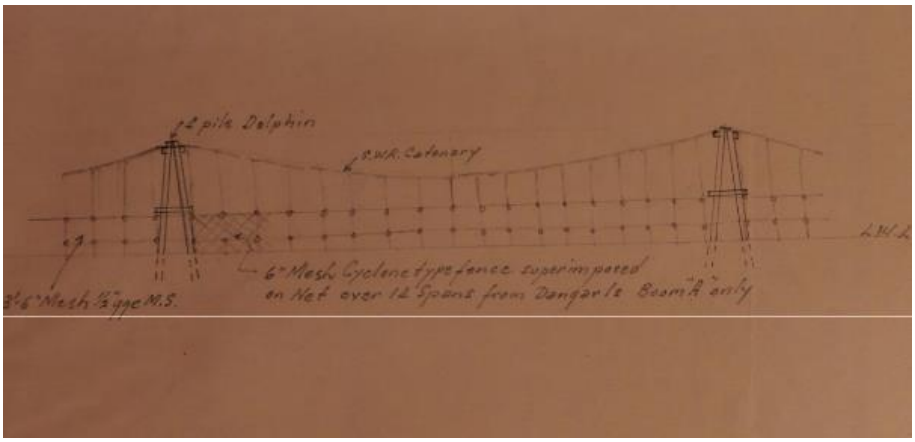


Figure 4-22: Original drawing of the southern boom from Dangar Island to Flat Rock (Anonymous 1942u).

4.5 Tumbledown

Undergoing significant development post-World War II, the landscape of the region has undergone substantial alterations, marked by the introduction of contemporary housing, piers, and various stone retaining walls. This transformation has resulted in a notable departure from the area's original natural features. A comprehensive examination of the shoreline aimed at identifying potential boom anchor points, akin to those observed at Dangar Island North, yielded no discernible extant archaeological features. This absence may be attributed to the extensive development initiatives undertaken in the vicinity, which could have potentially obscured or eliminated such historical remnants.

Simultaneous scrutiny of the entire shoreline, spanning 1500 meters from Croppy Point, failed to reveal any corroborative evidence supporting the existence of the gun position as described in AWM53, 1/6/7 (Anonymous, 1939-1945). The specific description denotes 18-pounder guns in Broken Bay mounted on concrete platforms elevated approximately 15 meters above Mean Sea Level (MSL). Contrary to this historical documentation, no visible indications of such concrete platforms or associated structures were observed along the shoreline or in the proximate terrain during the examination. The absence of these expected features raises

questions about the accuracy of the historical records or the potential obliteration of such structures due to subsequent developmental activities in the area.

4.6 Hawkesbury River Railway Bridge

The remnants of the bridge span consist of eight columns that were deliberately sabotaged in a final attempt to thwart a successful Japanese takeover, had an invasion materialised. According to National Archival documents (Anonymous (1942z, 1942ae, 1942ag, 1943j, 1944c), the bridge had been prepared for demolition in the event of its potential capture, underscoring the imperative to destroy it rather than allow it to fall into enemy hands. The previous iteration of the bridge was supported by eight pylons, facilitating passage from Long Island to the bay's northern shore.

Notably, the four central pylons exhibit approximately 100mm holes drilled at the juncture of the flat surface and the curved terminus. Additionally, five equidistantly spaced holes are evident, extending from the base to the apex. However, the northernmost pylon, in contrast, displays perforations that appear less systematically arranged. This demolition arrangement corroborates the directives communicated to the commanding authority and furnishes substantive evidence of the cause-and-effect relationship. Specifically, the cause in question pertains to the imminent invasion by Axis nations. At the same time, the ensuing effect manifests as the deliberate sabotage of the bridge aimed at impeding the Axis powers' ease of transport.

Unrelated to the central research question, the validation of the act of sabotage served to substantiate the precision of archival documentation.

Figure 4-23: The span of the old Hawkesbury River Railway Bridge front of new bridge (top), photograph of a single pylon that has six holes drilled between the round and flat sections with random holes drilled in the face of the flat section (middle). Clos up of a hole drilled in flat sections of the pylons (bottom). Hole diameter 100mm, depth unknown.

4.7 Defensive Positions and Their Effectiveness

4.7.1 18-Pounder Artillery Guns

A comprehensive defensive strategy against potential naval threats in Broken Bay was implemented through the deployment of three 18-pounder artillery guns, strategically positioned to safeguard against incursions by surface ships or submarines. Through a meticulous examination of the guns' locations and attributes, it is posited that the deployment of these artillery pieces significantly increased the likelihood of preventing a submarine incursion.

Figure 4-24: 25 pounder field artillery gun mounted on rotating ring. (located Port Hedland).

As illustrated in a previous depiction (Figure 4.2), each 18-pounder gun is mounted onto an anti-tank platform, affording rapid adaptability to traverse different angles. A tangible visualisation of such a platform is provided by a 25-pounder gun still affixed to a platform at Port Hedland RSL (Figure 4-24). Information derived Photograph by author. from this source details the area of fire, effective ranges, and the concept of "dead water," signifyingareas beneath the guns where submarine attacks are unfeasible. The 18-pounder field gun's rate of fire ranges between a sustained level of 4 rounds per minute (one every 15 seconds) and a maximum rate of 20 rounds per minute (one every 3 seconds), with a muzzle velocity of 492 m/s (Fisher and His Majesty's Stationary Offices, 1914: 56).

Utilising the formula Time = Distance/Speed, the time taken for a shell to reach its destination can be calculated. Furthermore, the formula Distance = Speed × Time allows for the

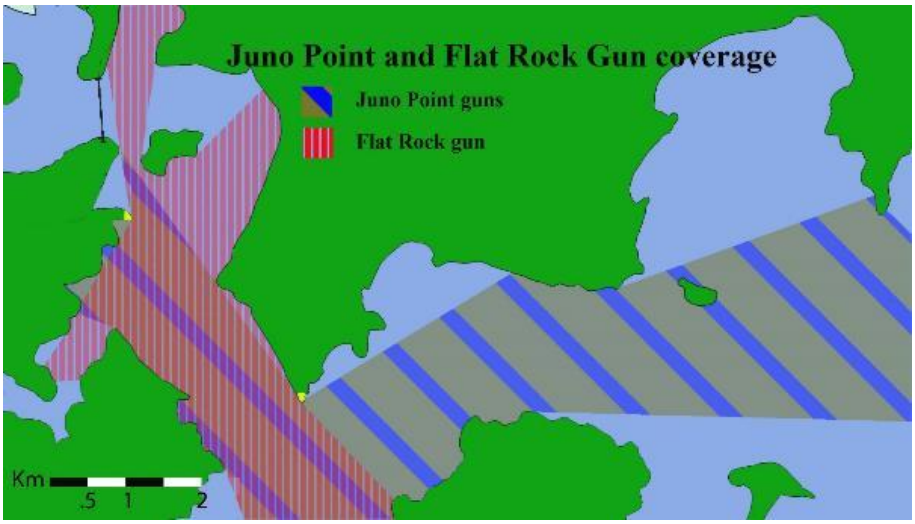


Figure 4-25: The coveage of all the guns relative to their positions. Dead zones not included since they are relatively small (50m) maximum. At all times until past Dangar Island south heading NE there are a minimum of two 18 pounder guns firing on the target (Fisher and His Majesty's Stationary Office 1914).

determination of the distance a submarine, traveling at 5 knots (9.26 km/h), can cover in a specified time. Consequently, it is established that a submarine can traverse 500 meters in 3 minutes and 33 seconds at 5 knots. Within this time frame, two guns can discharge 39 rounds at an average rate of 12 rounds per minute each.

In a specific historical instance, when a submarine was first sighted on July 9, 1942, off West Head (Anonymous, 1942aj), situated 4.5 kilometres from Juno Point's minefield, it would take the submarine 29 minutes and 9 seconds to cover that distance. In this duration, artillery fire could unleash 696 rounds of various artillery ordnance onto the submarine's trajectory, effectively incapacitating or sinking the vessel, thereby safeguarding the integrity of the minefields.

4.7.2 Minefield

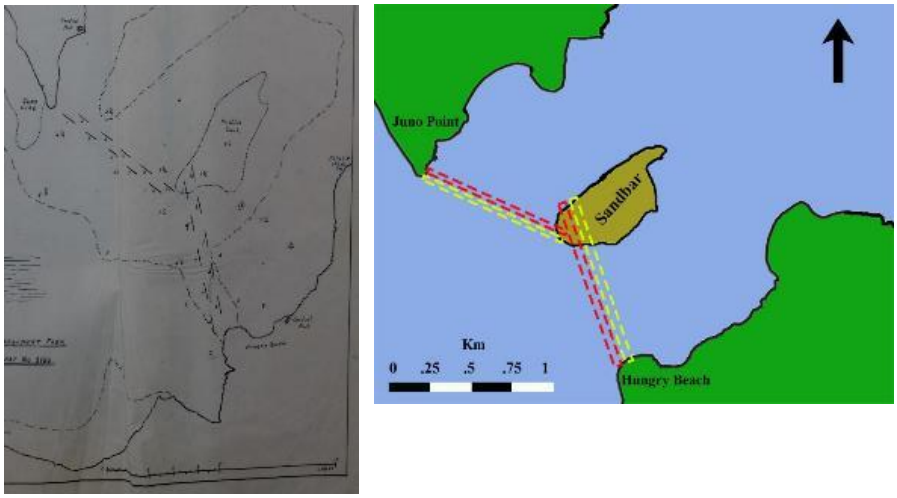


Figure 4-24: Original minefield drawing from the 1942 plans (Anonymous 1942j

Figure 4-24 delineates the plan of the Hungry Beach minefield extending towards the shoal/mud flat converging with the Juno Point minefield. Contrary to the decommissioning records of Juno Point's minefield on August 24 and September 2, 1944 (Anonymous 1942q)), no analogous documentation is available for the destruction of the Hungry Beach mines. The minefield comprised two sections, each consisting of ten groups of three mines, jointly controlled by Juno Point and Hungry Beach. Juno Point assigned numbers 1-10 to its mines, while Hungry Beach designated its mines as A-J (Figure 4-24) Explosions from these mines, as depicted in Figure 4-26, are substantial, indicative of their potential to inflict fatal damage upon an encroaching submarine.

Figure 4-26: Underwater mine used at Broken Bay sitting on a mounting/anchoring platform.

The synergy of minefields in conjunction with indicator loops, as elucidated by Walding (2006), forms an effective defence against submarine attacks. Literature by Arnold and Foster suggests that minefield construction in the early stages of World War II was notably deficient but later adhered to Admiralty guidelines. Despite this, a dearth of research exists regarding the defensive capabilities of minefields in Australia, with limited observations noted by Galil et al. (2014) in Israel.

In the hypothetical scenario of a submarine captain possessing prior intelligence (as discussed in Sections 2.3 and 2.4) and persisting in the intent to attack, the outer indicator loop, as per Walding (2006), would register, followed by the inner loop, providing speed and an estimated location in the absence of visible wake. Subsequently, after evading the guns, the submarine would encounter the double minefield, and explosive power as evidenced during the decommissioning of the Juno Point minefield. Images from this event reveal the catastrophic effects of explosions in shallow waters, posing a severe threat to submarines (Figure 4-27). Even if the mines detonated at a distance from the submarine, the concussive forces could potentially incapacitate or destroy it and fatally wound the crew.

Figure 4-27: As reported (Anonymous 1943m) the minefield/s were decommissioned over two days as two groups failed to detonate. Juno Point is the middle of the photograph and decommisiong occurred in Little Patonga Bay. The explosive nature of the three mines in group is evident in the photographs. No indication of Hungry Beach's minefield being decommissioned has been located.

Figure 4-28: Type A midget submarine involved in the attack at Pearl Harbour on 7 December 1941 (left) and Sydney Harbour (right The pitting results from concussion forces on the hull by depth charges that have less firepower than an underwater mine. Photo: Naval History and Heritage Command USA and AWM Photograph 060696.

The assessment of submarine damage extends beyond the immediate explosive impact to consider the effects on the crew. A crucial factor is the pressure wave generated by underwater explosions. Kiciński and Szturomski (2020) provide valuable insights into underwater explosion characteristics, including bubble radius and pressure wave effects. The crush depth scenario for the submarine is evaluated at 550 kPa, a value exceeding the maximum recorded depth. The resulting pressure wave from a mine explosion ranges from 120 MPa at 5 meters to approximately 5 MPa at 50 meters, indicating a substantial disparity.

Understanding pressure effects on the human body is pivotal for mine effectiveness assessment. Leibovici et al. (1996) report disparate fatality rates depending on exposure scenarios to pressure waves, highlighting the significance of spatial context. Viano (2023) reveal fatality rates of 95-100% for pressures between 400-550 kPa in an armoured vehicle. This underscores the critical importance of considering pressure wave magnitude and spatial context when assessing potential human impact in confined spaces.

The fatality rate for a human exposed to the high-pressure wave within the submarine during a mine detonation is also estimated at 100%. Immediate death may occur due to the damage sustained by the submarine's pressure hull, leaving no avenue for escape.

This observation substantiates the efficacy of individual mines in safeguarding the Hawkesbury River Railway Bridge. Simultaneously detonating mines and shore guns firing, consistently maintaining a minimum of two guns until south of Dangar Island, reinforce the comprehensive nature of the defensive strategy against potential submarine threats.

4.7.3 Booms

Should the submarine reach the booms located off Dangar Island, the southern route poses a formidable challenge, characterised by a minimum tidal current of 4 knots. This route offers a narrow margin for error, navigating waters with depths reaching no more than 8 meters and a channel width restricted to 30 meters. Conversely, the northern route presents a more favourable option, featuring deeper waters and a more moderate current. Upon circumnavigating the northern point of Dangar Island, the submarine gains an unobstructed firing line directed towards the Hawkesbury River Railway Bridge (HRRB).

Overcoming the defensive net, however, has proven to be a formidable obstacle for midget submarines. A poignant example is observed in the historical incident within Sydney Harbour, specifically when M-27 experienced complications, entangling its propellers (Perryman, 2023). This incident underscores the inherent challenges submarines attempting to breach defensive nets face. Notably, historical instances, such as the attacks on Pearl Harbor and Sydney, exemplify the potential success of incursions when the defensive net is not securely closed. These historical precedents offer valuable insights into the complexities and vulnerabilities associated with submarine warfare in confined waters.

As the submarine advances towards the defensive nets, it remains exposed to the continuous threat of gunfire emanating from the Flat Rock gun. The cessation of this firing range is only achieved upon successfully navigating around the northern head of Dangar Island, positioned on the inner side of the northern submarine boom net. This strategic maneuver marks a crucial juncture where the submarine gains a respite from the ongoing barrage, emphasising the intricate tactical challenges associated with navigating through the defended waters.

4.8 Social Context of Military Installations

Graffiti can provide insights into the context and nuances of human behaviours. Clarke and Frederick (2014, 2016) delineate how personal graffiti functions as a temporal manifestation of an individual’s lived experience. Once more, the cumulative aspect of this phenomenon carries implications for forthcoming researchers, encouraging them to move beyond perceiving it merely as an act of unauthorised defacement. Instead, they are prompted to acknowledge it as a transient snapshot of an individual’s perspective within a specific temporal context.

Cocroft's (2006) discourse on military graffiti extends beyond mere inscriptions of names and dates to encompass operational computations. It is discernible that graffiti accumulates gradually, particularly in proximity to the ammunition bunkers and the control hut at Hungry Beach. This accrual of graffiti potentially offers an avenue for subsequent investigations to ascertain the prevalence of older, more militarily significant inscriptions.

4.9 Graffiti

carvings on the sandstone rock surface located at the rear section of the CASL. Photographs, albeit challenging to interpret, were captured, ultimately revealing an inscription bearing the name "J RYAN 43" along with a corresponding date. Subsequent research in the military records archived at the National Archives of Australia yielded four individuals named J. Ryan who were stationed at Broken Bay in 1943. However, it was only through a more comprehensive examination of the available digitised service records that the specific identification of John Joseph Ryan, service number NX78488, was ascertained. These service records are all housed within the National Archives of Australia in Canberra.

The engravings provide insight into the men who were billeted at Juno Point, and their desire to be made immortal by the grafitti. No other stone engraved grafitti was located at or near any military structure, but there was at the two-gun position ammunition bunkers. No grafitti was noted at the control hut at Juno Point, but Hungry Beach had considerable damage externally and internally (Figure 4-9, 4-10).

Schofield et al. (2012) conducted an in-depth investigation of the art situated at a former RAF base in Coltishall. Their study scrutinised the various artistic styles present and emphasised the necessity of comprehending the individuals who inhabited the base during that period. The authors also offered an interpretation of institutional graffiti in contrast to personal forms of expression

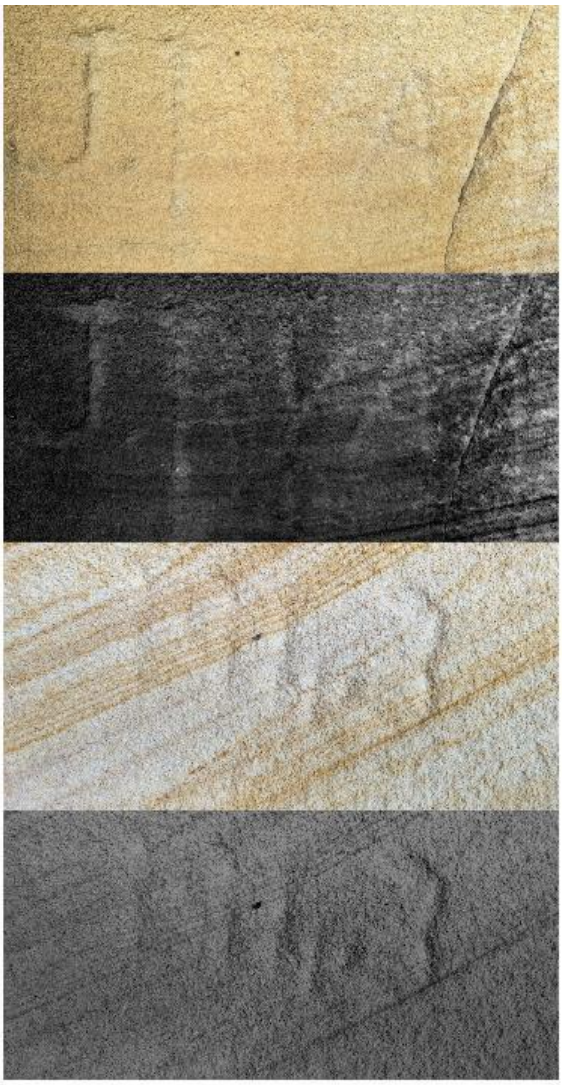


Figure 4-29: J. Ryan 43 etched into the sandstone behind the CASL. Top photo (yellow) of each group is original and bottom have undergone enhancement by photoshop.

The presence of personnel graffiti at sites in the study area was discerned. This consisted of

.

Figure 4-30: Example of graffiti in the ammunition bunker at Juno Point. Further study into the area around the isolated graffiti in a protected area might shed light on the people/students who left their mark for the future.

4.10 Re-Use of Locations

All locations that had once been critical defensive structures had modern reuse associated with them. Juno Point's control hut now stored steel cabinets in the anteroom and toilets in the main room. Modern adaption to the *Nilsen switch* panel

Figure 4-31: Reuse by vagrants. ***A-*** *Shows clothes hanging to dry, a backpack with male clothing inside as well as the Aldi bag containing female clothing.* ***B-*** *Tent set up inside the control hut.* ***C-*** *Tent and personal belongings within the tent. Over at the far lower window a large amount of drug parenphenalia was located.* ***D-*** *Possible mount for WW2 signal light now being used as a firepit with refuse within and without.*

Hungry Beach (Figure 4-28) on the day attending provided extensive reuse information, flouting the National Parks and Wildlife Act. Other illicit material was also found and National Park rangers assisting on the day initiated removal proceedings. It is relevant that humans adapt to their circumstances and use a former military site as a shelter.

Flat Rock (Figure 4-14, 4-15) and Dangar Island North (Figure 4-18, 4-19) also demonstrate reuse in the modern era and examination of this can answer other research questions.

Tracy Ireland holds a prominent position in the realm of Australian and International heritage sites. Her scholarly contributions centre on the ethical dimensions of archaeology and emphasise issues pertaining to reuse. Noteworthy publications by Ireland, including "Up Close and Personal: Feeling the Past at Urban Archaeological Sites" (2016) and "Rethinking Materiality, Memory and Identity" (2016), afford valuable insights into the cognitive, emotional, and practical facets of individuals during the respective historical periods. Consequently, her research within this thesis aligns with the domain of Graffiti.

Surprisingly, graffiti was noted from the World War II era to the present. This graffiti suggests that these inscriptions represent an individual's presence at a specific locale during a particular moment in time.

4.11 NSW Department of Planning and Environment

The NSW Department of Planning and Environment, particularly the maritime archaeologists, became cognizant of the research undertaken in Broken Bay. Subsequent discussions with these archaeologists led to the implementation of sonar scanning at designated sites within the bay as part of a coordinated survey conducted by the governmental office. The resultant imagery (Figure 4-32) was captured using a commercially available Hummingbird 1180 off-the-shelf sonar. Currently categorised as an unidentified object, the location is being withheld from disclosure pending further investigations.

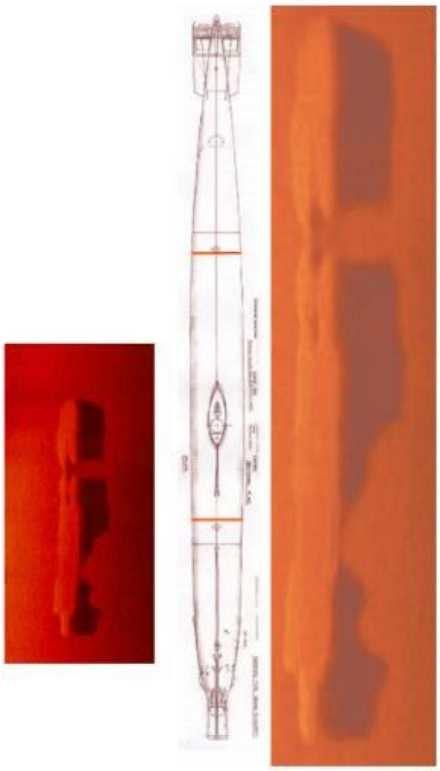


Figure 4-32: 31 presents a sonar depiction of an anomaly in Broken Bay, acquired through the utilisation of a commercially available Hummingbird sonar by Heritage NSW. The dimensions of the object fall within a margin of error comparable to that of a Type A midget submarine. The specific location is deliberately undisclosed pending further investigation by the author in collaboration with Heritage NSW. While the object's nature may potentially be attributed to sandstone boulders cascading into the bay, the proximity of surrounding boulders to the shoreline contradicts this hypothesis. Positioned in a manner consistent with the anticipated trajectory for a submarine's egress from the bay during an outgoing tide, the bow of the object is visibly inclined downward in the sonar image. Cross-referencing information gleaned from Smith (2007), the red markings on the sonar image approximate the locations of demolition charges, exhibiting congruence with observed damage in the corresponding area.

4.12 Discussion

Broken Bay demonstrates its proficiency in hosting intricate and effective defensive structures strategically positioned to enhance the protection of the Hawkesbury River Railway Bridge. The recognition of past espionage activities and the potential acquisition of bathymetric data regarding the bay's bottom profile have significantly influenced the conceptualisation and implementation of a composite defensive strategy. This strategy seamlessly incorporates artillery installations, a minefield, and protective booms, aiming to consolidate defensive capabilities and reduce the potential threat of submarine incursions. A thorough examination of the potential damage inflicted on a submarine by these defences yields valuable insights into the formidable deterrent effect collectively presented by these measures. Consequently, such an analysis provides a nuanced understanding of the calculated risks faced by submarine captains contemplating ingress with the intention of attacking the bridge.

Integrating archival, media, and carefully selected published sources with fieldwork data has established correlations between the envisioned and actualised defence structures. The analytical focus on Anti-Submarine Warfare (ASW) has emerged as a central objective, aligning with the Handbook's advocacy for specialised analysis in maritime archaeology.

A significant finding arises from the comparative analysis between field observations and archival documentation. While discernible similarities in structures exist, the once likely unobstructed and vegetation-free terrain has succumbed to overgrowth, progressively obscuring ground surfaces. This observation underscores the temporal dynamism inherent in archaeological landscapes.

CHAPTER FIVE

DISCUSSION

This research posed the question: "Could the World War 2 defences of Broken Bay post-Sydney Harbour attack adequately safeguard the Hawkesbury River Railway Bridge against potential damage or destruction by submarines?" The first chapters of this thesis presented the research question, examined existing literature, crafted a methodology, outlined and evaluated the accessible evidential sources, and subsequently assessed and analysed the importance, role, and contributions of archaeological and documentary evidence in the investigation of Second World War anti-submarine defences in Broken Bay.

In this chapter, the research is situated within the broader realms of archaeology as outlined in Chapter Two. It synthesises the findings from previous chapters to address the research questions. It is comprised of four parts, each of which addresses three key areas identified through the research. The first part compares and constrasts the Broken Bay defences around anti-submarine warfare and seeks to reason why particular defences were installed at each location. The second part explores the methodology used in this study and compares it to approaches taken in other parts of the world, highlighting the value of the methods used in this specific study. The third part discusses the issues of invading and defending Broken Bay and evaluates the defence structure to protect the Hawkesbury River Railway Bridge. It highlights the gap that this research fills within archaeology and considers the implications for the future of a focused maritime conflict archaeology discipline.

5.2 Archaeological Findings

The archaeological evidence exhibited varying patterns across the defensive positions in Broken Bay. Data from the National Australian Archives and Australian War Memorial showed a generally high value, with the efficacy assisting the field operation. New South Wales State Archives and Department of Planning and Environment provided no information around

the defence sites, with only a single grey literature document located through a local council (Scobie, 2016).

Field observation's varied significantly. At Juno Point, documentation and research around the defences were all but null. New identification of the cable guide and determination of significance of the site was ascertained. Hungry Beach provided further information with no academic or grey literature available to ascertain the extent of extant remains; the discovery and documentation of ancillary building footings and identification of paths provide an overview of life at the time for those serving, though the control hut is extensively damaged there remains evidence of wiring and mounting locations for equipment. Flat rock held a previously undocumented and unidentified structure in the three boom supports hidden from view and the gun position displaying similarities between Juno Point. Lastly Dangar Island held the original boom net securing rings, the southern two not previously documented and the northern rings on tourist brochures. All the extant archaeology provided highly valuable information around the anti-submarine defences of Broken Bay, and it was further found where protected from the general public sites are better preserved.

The richness of archaeological material in Broken Bay necessitated a reduction of the originally planned data size for an overall examination of the defences from the Tasman Sea to the Hawkesbury River Railway Bridge was more substainsial than previously thought. The amount of information from Juno Point and unknown amount of further information from Hungry Beach would facilitate future research dividing into smaller sub-areas, though with the full extant of archaeology present and potentially available in Broken Bay Juno Point and Hungry Beach are examples.

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Bias was evident in all cases, with the majority of new anti-invasion defence sites identified being hardened concrete structures. Addressing this bias in future fieldwork would require a less rapid and more intensive form of observation combined with other sources and techniques, such as excavation, metal detectors for sub-ground wiring, sonar and magnetometer for example.

5.3 Documentary Evidence

The primary source of documentary evidence for this research was derived predominantly from national repositories with some insightful information from media articles. The evidence gleaned from national archives demonstrated a notable consistency across all defensive positions, and the well-maintained records within these archives greatly facilitated a thorough and comprehensive analysis. Throughout the study, the inherent value of primary historical evidence remained significant, playing a pivotal role in elucidating defence arrangements and the location of maritime archaeological material despite occasional incompleteness.

The National Archives of Australia served as a repository for a significant volume of war diaries, memoranda, and pertinent plans associated with each location under consideration. The memoranda and communication signals were constrained, being primarily of a received nature. Unfortunately, the meticulous tracing of communication trails between all command positions was regrettably deficient. Nevertheless, the records housed within the acquired documents presented a rich source of information concerning the outcomes of operating the defence sites in Broken Bay. While not directly relevant to the present research, this collection serves as a substantial foundation for prospective investigations.

Documents of lesser significance pertaining to the configuration of the defence capability were acquired, furnishing crucial evidence regarding the efficacy of each designated anti-submarine defence in Broken Bay. The records concerning the capabilities of the 18-pounder guns and minefields offered substantiated material for evaluating the effectiveness of the defences.

Within the National Archives of Australia, certain files contained illustrated plans detailing the proposed defences of Broken Bay, disclosing information regarding the planned fortifications and potential locations. These plans served as an initial reference for prospective fieldwork; nonetheless, notable omissions were identified concerning structural plans and the precise locations of all defences.

Within the local context, the historical society in Brooklyn, New South Wales, was only cognizant of the Flat Rock gun emplacement. However, their understanding was that it was designated for anti-aircraft purposes rather than artillery deployment. The predominant body of information pertaining to the defences in Broken Bay centred around the West Head fort, which housed larger 4.5-inch shore guns specifically designed for engagements with more substantial capital ships.

5.4 Application of Findings

After the antecedent discourse, it became imperative to evaluate whether the outcomes derived from both the literature review and field research could be amalgamated to draw a conclusion regarding the efficacy of the inner defences of Broken Bay in safeguarding the Hawkesbury River Railway Bridge against submarine attacks. The results strongly suggested that the combined active and passive defensive measures exhibited substantial capabilities sufficient to repel any potential submarine incursion. These commonalities were instrumental in successfully formulating a novel, evidence-based, and informative synthesis concerning military organisational structures and defensive arrangements, explained further in the next part. Utilising Little's framework (1992), the evidence and discerned patterns were delineated as collaborative and complementary, as opposed to conflicting. It is anticipated that augmenting this synthesis with supplementary source evidence would be more facilitative than mandating a fundamental reassessment.

Cocroft (2006) and Clarke and Frederick (2016) delineated the utilisation of graffiti in a military context, elucidating its role in identifying and rationalising imprints on the surroundings. This ensures that both the personal and industrial dimensions contribute additional information. The recognition of graffiti at Juno Point and Hungry Beach offered an avenue for individual identification; however, a more detailed investigation of these incidents would be imperative for future research.

The phenomenon of re-utilisation within the discipline of archaeology has been recognised across diverse global contexts, serving as a tool, as identified by Ireland (2016) and Ireland & Lydon (2016), to yield novel insights into the specific geographical locations and, significantly, the communities it impacts. As demonstrated previously, Juno Point serves the purpose of storage, with its adjoining grounds allocated for educational activities, while Hungry Beach, designed as a leisure destination, has seen the control hut repurposed by squatters for shelter. These instances establish a foundational framework for prospective research endeavors aimed at advancing both local and international understanding in the present and future contexts.

5.5 Methodology Effectiveness

The methodology's effectiveness, involving an extensive examination of local, regional, and national data repositories for content relevant to the three cases, proved successful. It unveiled a previously overlooked realm that required intentional foregrounding (Buchli and Lucas 2002). Each pertinent record was identified, described, and its potential contribution assessed to discern broader patterns. Pagels (2023), Wallis et al (2021), and Gibbs (2004, 2012) each articulate and elucidate the necessity of accurately identifying and employing accessible reference materials, as well as utilising acquired knowledge in the respective field.

At the initiation of this research, the foundation for evidential sources related to anti-invasion defence in Broken Bay was inadequately defined and lacked comprehensive development. This study rectified this deficiency by identifying and evaluating new sources, discerning their respective strengths and weaknesses, and facilitating their informed and judicious utilisation. The employed methodology proved effective in the following ways:

5.5.1 Discovery of Novel Records

Substantial volumes of recently uncovered records within the designated evidential categories were identified for each defence site, providing clarity on the scope and characteristics of the original source evidence. Specific records newly recognised displayed a notable level of detail, particularly those related to defence formulation by ranking military personnel. These records proved to be of immense value in the reconstruction of overlooked social relationships connected to the defences, thereby addressing gaps in the social archaeology of warfare, as outlined by Gilchrist (2003).

5.5.2 Discovery of New and Forgotten Defence Sites

Unearthing fresh evidential source material facilitated the recognition of previously unidentified and forgotten anti-invasion defence sites, materials and functions, unveiling the intricate and ongoing enhancements since the May 1942 Sydney Harbour attack.

5.5.3 Identification of New Types of Defence

The sourced evidence provided elucidates the constructed and installed defences within Broken Bay. However, examination of a Photo Electric Beam (PE) extending from Patonga to Flint and Steel Point (located east of the survey area) reveals that although detailed construction plans were formulated, the actual implementation was not realised. Verification from the Department of Planning and Environment during a conversation with B. Duncan on May 7, 2022, affirms the lack of infrastructure for a PE Beam at Patonga and Flint and Steel Point.

While not introducing entirely novel defence mechanisms, the amalgamation of anti-submarine protection designs in Broken Bay contributes to a novel comprehension of their operational mechanisms and the protective efficacy inherent in each design.

5.5.4 Defence Arrangements within their Historical Context

The methodology employed herein effectively mitigated the dearth of comprehensive academic research pertaining to conflict archaeology and anti-submarine defences within Broken Bay subsequent to the declaration of war against Japan during World War II. A meticulous examination and analysis of sources, notably those housed at the National Archives of Australia, enabled the formulation of detailed military narrative accounts. This, in turn, furnished the strategic, operational, and tactical military context necessary for an evidence-based assessment of the efficacy of these defences.

This methodological approach enabled the reconnection of historical sites, fostering contextual grounding and yielding a more nuanced understanding of the roles played by source evidence in conjunction with the evolution of defensive arrangements. It is noteworthy that this approach transcended the descriptive methodologies commonly employed by a multitude of secondary sources.

5.5.5 Reframing Research Methodologies for Anti-Invasion Defence

The preceding discourse emphasises the foundational nature of case selection, which can find grounding in both historical and archaeological considerations. Although historical foundations do not inherently deviate from research methodologies applied to other historical periods, such as those pursued by scholars investigating maritime conflict, wreck sites, and invasion-centric archaeology, this represents a pioneering application of such an approach to the study of anti-

submarine defence in Australia during the Second World War. This methodological framework is considered transferable to the examination of physical evidence originating from other highly organised and hierarchical societies within the recent historical era.

In the nascent field of conflict archaeology, a significant implication arises: no solitary evidential source can comprehensively delineate anti-invasion defence arrangements during wartime within any given case, particularly when various command sections advocate diverse locations for defence sites and types. Relying solely on an archaeological evidence-based approach proves insufficient for adequately identifying, describing, analysing, or contextualising the intricate nature of the subject. While archaeology in isolation may lack the capacity for a comprehensive interpretation, its utilisation as a cross-disciplinary approach is well-suited for generating nuanced narratives, treating all evidence uniformly as material culture within a unified totality.

It was observed that a comprehensive assessment of anti-submarine defences and their impact on invasion necessitated the integration of various investigative aspects to fulfil the research aims. The identified defensive remnants serve as manifestations of how society organised itself for defence against perceived invasion. Therefore, delineating the social relationships of the creators and users of these defences, both in organisational and material terms, is imperative for constructing an informed, robust, and nuanced narrative.

5.6 Anti-Submarine Defences in Broken Bay

The preceding chapter systematically identified and delineated the capabilities inherent in the extant physical structures within Broken Bay, encompassing both the accessible land defences and those beyond the scope of direct examination. Although not all identified defences were explicitly crafted for Anti-Submarine Warfare (ASW), such as the 18-pounder artillery, their pivotal role as deterrents, capable of impeding or hindering potential incursions, remains paramount.

The following sections will furnish information elucidating the rationale behind the conclusions concerning the selection of defence locations and their effectiveness. It is further acknowledged that submarine captains necessitated specific knowledge before formulating

attack plans. Primary documents and media reports confirm the prevalence of espionage along Australian shores during the early 20th century.

5.6.1 Command and Control

Three Command and Control centres were established in Broken Bay, with Brooklyn assuming overall control of the bay's defences. Juno Point served as the central location overseeing the inner indicator loops, minefield, and guns, while Hungry Beach was responsible for controlling the second minefield. The two intermediate control centres, Juno Point and Hungry Beach, benefitted from unobstructed views, allowing for comprehensive surveillance from their positions toward the headland and outward into the Tasman Sea during World War II. The strategic positioning of these command huts facilitated visual identification of any incoming vessels, whether surface or sub-surface, within a bay where all other watercraft were restricted.

5.6.2 18 Pounder Artillery

Chapter four presented an analysis of the rate of fire, quantity of rounds, and flight time associated with each shell discharged from the guns. Table 5-1 delineates the area of fire, encapsulating the coverage of the guns within Broken Bay, while Figure 5-1 visually represents this coverage. The findings indicate that, as a deterrent, the guns offered nearly constant dual coverage throughout the journey to the Hawkesbury River Railway Bridge (HRRB), affording commendable Anti-Submarine Warfare (ASW) capabilities.

Table 5-1: Details of Juno Point positions with all defensive coverage. Flat Rock gun coverage (Anonymous (1942q).

Item	Area of fire	Range	Dead water*	
	Bearing	(M)	(M)	Bearing
No1 Gun	047° - 320°	7315	55	047° - 320°
No2 Gun	30° - 170°	7315	64 (increasing to 92 at 150°)	030° - 170°
No37 CASL	033° - 175°	Unlimited		
No38 CASL	120° – 320°	Unlimited		
Flat Rock gun	355° – 210°	7315	92	355° – 210°

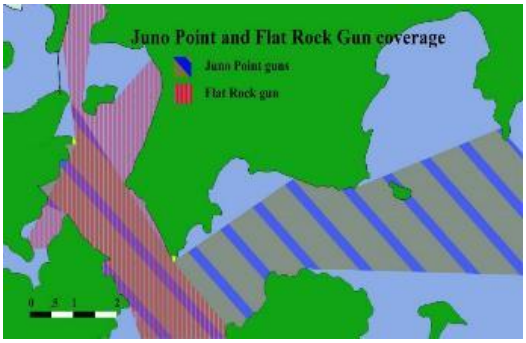

Figure 5-1: Visual representation of the 18 pounder gun coverage from Juno Point and Flat Rock. There is always two guns able to target a submarine at any one time with the overlap between the two locations.

5.6.3 Minefields

The explosive and concussive potential of individual mines, as detailed in Chapter 4, illustrates the destructive capabilities against submarines. Upon comparison with the explosive and concussive forces generated by the depth charges employed during the Sydney Harbour attack, it becomes evident that further defences are deemed unnecessary. The magnitude of these forces is such that their detonation would severely damage and potentially sink surface ships. Viano (2023, p. 16) emphasises the impact of the pressure wave on the human body, leading to injuries or fatalities.

The investigation reveals that, as a deterrent (assuming knowledge through espionage), the minefield represents an example of over-engineering. It was meticulously designed to neutralise any threat to the Hawkesbury River Railway Bridge (HRRB). The calculations

presented in Chapter 4 underscore that very few marine vessels could withstand the destructive concusive impact of an exploding mine particularly considering the navigational constraints within the restricted confines of the bay.

5.6.4 Boom Nets

A southern and northern boom net provided the last physical line of defence; only the northern boom had a gate to let vessels through. In comparing the partial success of the Sydney Harbour boom net, even though not completed at the time of attack, it managed to tangle a single midget submarine despite the anti-boom net devices installed upon it.

The same design boom net, shallower water and larger tidal flow in combination was going to be highly successful in preventing a submarine from gaining a line of sight on the HRRB to fire a torpedo at the aging structure.

5.7 Home and Abroad

The research conducted on the anti-submarine defences in Broken Bay during World War II holds both Australian and international significance. The importance of this information transcends national boundaries and contributes to the broader understanding of military strategies, defensive structures, and the impact of war on coastal regions. Here are key points highlighting the Australian and international relevance of the research findings:

5.7.1 Australia

The study delves into the intricacies of Australia's defensive measures during World War II, shedding light on the strategic importance of Broken Bay in safeguarding critical infrastructure like the Hawkesbury River Railway Bridge. The archaeological findings provide valuable insights into the physical remnants of anti-submarine defences, showcasing the material culture of wartime Australia. This contributes to the preservation and understanding of the nation's military heritage. The methodology employed in the research, including the discovery of novel records and identification of forgotten defence sites, sets a precedent for future archaeological and historical investigations in Australia. It enhances the

toolkit available for researchers studying conflict archaeology. The documentation of local historical societies' knowledge and perspectives adds a layer of community involvement, connecting the research to the people of Brooklyn, New South Wales, and fostering a sense of local identity and historical awareness.

5.7.2 International

The research contributes to the global understanding of military strategies employed during World War II. The analysis of command and control centres, artillery effectiveness, minefields, and boom nets provides a broader perspective on anti-submarine warfare tactics. The acknowledgment of espionage activities along Australian shores during the early 20th century resonates with global narratives of intelligence gathering and espionage during wartime. This aspect connects the research to broader themes of global security and intelligence operations. The findings, especially regarding the minefields and boom nets, offer a basis for comparative analysis with similar defensive structures and strategies implemented in other coastal regions worldwide. This comparative approach enriches the international discourse on coastal defence. The research methodology, emphasising the integration of various investigative aspects and cross-disciplinary approaches, can serve as a model for studying anti-invasion defences in other regions and historical periods. This has implications for conflict archaeology and military history research globally. The examination of re-utilisation within archaeology, as demonstrated at Juno Point and Hungry Beach, provides a framework for understanding the societal impact of defensive structures. This perspective can be applied to archaeological studies in different global contexts.

In conclusion, the research on the anti-submarine defences in Broken Bay offers a nuanced understanding of Australia's wartime history while providing valuable insights and methodologies with broader applications in international military history and archaeology. The findings contribute to the collective knowledge of how nations defended their coastal regions during times of global conflict.

5.8 Conclusion

This study provides valuable insights into the effectiveness of the defences in safeguarding the Hawkesbury River Railway Bridge within the context of submarine threats during World War II. The systematic identification of Broken Bay's physical structures, including accessible land defences and those beyond direct examination, revealed a multifaceted defence strategy. While not all identified defences, such as the 18-pounder artillery, were explicitly designed for Anti-Submarine Warfare their acknowledged role as deterrents signifies their significance in impeding potential submarine incursions.

The establishment of three Command and Control centres, strategic positioning of command huts, and unobstructed views from Juno Point and Hungry Beach exemplify a well-organised defence infrastructure. This strategic positioning facilitated comprehensive surveillance, allowing for the visual identification of incoming vessels, surface or sub-surface, within the restricted confines of the bay. The analysis of the guns' rate of fire, quantity of rounds, and flight time in Chapter 4 indicated their effectiveness as deterrents, offering constant dual coverage during the journey to the Hawkesbury River Railway Bridge (HRRB). The explosive potential of individual mines further illustrated their destructive capabilities against submarines. Comparison with depth charges used during the Sydney Harbour attack emphasised the redundancy of further defences, given the substantial forces at play.

This investigation underscores the minefield as an example of over-engineering, meticulously designed to neutralise any threat to the Hawkesbury River Railway Bridge. Calculations presented in Chapter 4 emphasised the limited survivability of marine vessels within the destructive impact zone, considering navigational constraints in the bay. The southern and northern boom nets, as the last physical line of defence, further strengthened the protective measures. The northern boom's design, with a gate, and the successful entanglement of a midget submarine in Sydney Harbour demonstrated the potential effectiveness of a similar design in Broken Bay.

In conclusion, the integrated defences in Broken Bay, comprising artillery, mines, and boom nets, collectively present a robust strategy for safeguarding the Hawkesbury River Railway Bridge against potential submarine threats. The meticulous planning, strategic positioning, and comprehensive surveillance measures suggest that the World War II defences were adept

at deterring and impeding potential submarine incursions, affirming their effectiveness in protecting vital infrastructure during a critical period in Australia's history.

CHAPTER SIX

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ANNEXURE 1

Table A1 presents an inventory of the locations and types of defences deployed around Australia during World War II, specifically safeguarding critical infrastructure. Instances where multiple defense types are implemented denote the protection of more than one object. Notably, no defences are allocated for the protection of railway bridges, and none exhibit infrastructure of a scale comparable to that observed in Broken Bay. This table serves as a comprehensive reference outlining the strategic defence deployments across various regions in Australia during the specified historical period.

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
Brisbane	Bribie Island	Bribie Island	6inch gun battery	US naval base, submarine base, troop rest Port facilities, major city, factories	
Cairns	East Trinity	False Cape	6inch gun battery	Port facilities, food distribution, invasion point, airstrips, major troop training facility, Catalina based.	
Darwin	Darwin	Dudley	4inch and 6pdr gun battery	major port facilities for allied ships, airstrips, invasion point	
Newcastle	The Hill	Park	6inch gun battery	Newcastle port, BHP steel works and critical factories	Horner, David (1995). The Gunners. A History of Australian Artillery. Sydney: Allen & Unwin. ISBN 1-86373-917-3.
Newcastle	Newcastle East	Scratchley	6inch gun battery	Newcastle port, BHP steel works and critical factories	
Newcastle	Newcastle harbour		Minefield and indicator loop	Newcastle port, BHP steel works and critical factories	Walding

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
Newcastle	Stockton	Wallace	9.2inch battery	Newcastle port, BHP steel works and critical factories	
Port Kembla	Port Kembla	Breakwater	6inch gun battery, indicator loop	Steal works, Port facilities, invasion point	
Port Kembla	Coniston	Drummond	9.2inch battery	Steal works, Port facilities, invasion point	
Port Stephens	Shoal Bay	Tomaree	6inch gun battery, minefield, indicator loop	Overland access to Newcastle	
South Australia	Taperoo	Fort Largs	6inch gun battery	Major city, airstrips, factories, port facilities	
South Australia	Whyalla	Hummock Hill	3.7inch gun battery	Major city, airstrips, factories, port facilities	
Sydney	Harbour		Naval vessels	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	La Perouse	Banks	9.2inch battery	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	Middle Head	Casemate	6pdr guns	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	Laing Point		Boom net	Garden Island Naval base, command, and control Navy, varied critical infrastructure	

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
Sydney	South Head		Indicator loops	Garden Island Naval base, command, and control Navy, varied critical infrastructure	Walding
Sydney	La Perouse	Henry	18pdr	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	South Head	Hornby	6inch gun battery	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	Malabar	Malabar	6inch gun battery	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	North Head	North	9.2inch battery	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	Manly	Shelly	12pdr gun	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	South Head	Signal	6inch gun battery	Garden Island Naval base, command, and control Navy, varied critical infrastructure	
Sydney	West Head	West	4.7inch gun battery	Garden Island Naval base, command, and control Navy, varied critical infrastructure	

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
Sydney	Botany Bay		Indicator loops,	Southern invasion route	Walding
Townsville	South Townsville	Magazine	6inch gun battery, minefield	forward operating base for Pacific region, US air force, troop rest, Port facilities, invasion point, airstrips	
Townsville	North Ward	Kissing Point	6inch gun battery	forward operating base for Pacific region, US air force, troop rest, Port facilities, invasion point, airstrips	
Townsville	Magnetic Island	Magnetic	6inch gun battery	forward operating base for Pacific region, US air force, troop rest, Port facilities, invasion point, airstrips	
Townsville	Pallarenda	Cape Pallarenda	4.7inch gun battery	forward operating base for Pacific region, US air force, troop rest, Port facilities, invasion point, airstrips	
Victoria	Port Phillip	Cribb	6inch gun battery	Ship building, major city, factories, access to food and supplies.	
Victoria	Queenscliff	Crow's Nest	4.7inch gun battery	Ship building, major city, factories, access to food and supplies.	

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
Victoria	Point Lonsdale	Lonsdale	6inch gun battery	Ship building, major city, factories, access to food and supplies.	
Victoria	Point Nepean	Nepean	6inch gun battery	Ship building, major city, factories, access to food and supplies.	
Victoria	Point Nepean	Pearce	6inch gun battery	Ship building, major city, factories, access to food and supplies.	
Western Australia	Albany	Princess	6inch gun battery	Food factories, port facilities	
	Darwin	East	9.2inch & 6inch battery	major port facilities for allied ships, airstrips, invasion point	
	Darwin	Emery	6inch gun battery	major port facilities for allied ships, airstrips, invasion point	
	Darwin Harbour		Floating boom net, indicator loops	major port facilities for allied ships, airstrips, invasion point	
	Darwin	Waugite	6inch gun battery	major port facilities for allied ships, airstrips, invasion point	
	Bribie Island	Skirmish	6inch gun battery	US naval base, submarine base, troop rest Port facilities, major city, factories	
	Moreton Island		Minefield and indicator loop	US naval base, submarine base, troop rest Port facilities,	

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
				major city, factories	
	Moreton Island	Cowan	6inch gun battery	US naval base, submarine base, troop rest Port facilities, major city, factories	
	Moreton Island	Rous	6inch gun battery	US naval base, submarine base, troop rest Port facilities, major city, factories	
	Lytton	Lytton	4.7inch gun battery	US naval base, submarine base, troop rest Port facilities, major city, factories	
			Minefield		Turner naval historical society
	Fremantle	Harbour	18pdr and 6 pdr gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Fremantle		Indicator loops	Naval bases including submarine, port facilities, invasion area, resupply, factories	Walding
	Fremantle	Leighton	6inch gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
	Fremantle	Swanbourne	6inch gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Garden Island	Beacon	4inch and 6pdr gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Garden Island	Challenger	6inch gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Garden Island	Collie	12pdr gun	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Geraldton	Geraldton	4inch and 18pdr gun battery		
	Rockingham	Peron	6inch gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Rottnest Island	Bickley	6inch gun battery	Naval bases including submarine, port facilities, invasion area, resupply, factories	
	Rottnest Island	Oliver's	9.2inch gun battery	Naval bases including submarine, port	

City	Location	Fort Name	Defence Type	Protecting	Non-Archival Reference
				facilities, invasion area, resupply, factories	
	Cockburn Sound		submarine boom	Naval bases including submarine, port facilities, invasion area, resupply, factories	Anderson

Annexure 2

Juno Point

Tri-Pillar Feature

Perched upon the northeastern precipice of the control hut, a topographical feature is discernible, comprising three concrete and brick pillars arranged in the configuration of an equilateral triangle, accompanied by vestiges of a wooden frame. Steel strapping secures the remnants of a wooden slat floor to these pillars. Adjacently to the south of this arrangement lies a corrugated iron water tank coated in green paint, yet its relative position renders it categorically unrelated.

To the north of this assemblage is a concrete square housing a cable management guide characterised by a smooth surface conducive to the frictionless movement of sizable cables with minimal abrasion. Despite its proximity to the triangular pillar structure, a succinct correlation between the two remains elusive.

Concrete steps, obscured by rampant vegetation, traverse the landscape, predominantly ascending the incline leading toward the control hut.

Figure A2-1: Feature overgrown. A set of bricked stairs leads from the control hut area. It is not considered the water tank is associated with the feature because of the location to the control hut.

Derrick Wharf

The derrick wharf exhibits limited extant archaeological remnants, having been established on a solitary sandstone boulder extending southward into the Bay. Substantial deterioration has transpired since its decommissioning in 1943, with a lone hardwood cross member enduring significant structural degradation. This remaining component is sustained by two hardwood pillars affixed through iron strapping and bolts, all conspicuously displaying indications of corrosion.

Situated within the sandstone is a concrete-filled pedestal formed by corrugated iron, protruding prominently from the dock. A second pedestal, similarly configured, has undergone alterations on the boulder, characterised by notches intended for vertical timber support. These notches are fastened with iron brackets and bolts, although only three persist in their original positions.

Local community recognition identifies this structure as a derrick wharf, serving the purpose of facilitating the unloading of supplies from ships through the utilisation of a crane. The construction of the derrick wharf necessitated the drilling of the sandstone to accommodate notched platforms for the placement of vertical timber supports. Iron brackets, concreted into place, serve as anchors for the affixation of the timber frame.

The foundation rock, situated at an elevation of 4 meters above Mean Sea Level (MSL), reveals subaqueous large rocks when viewed from above, impeding vessels from approaching the pier closely. The subsurface features include several timbers, iron brackets, nails, and, notably, an additional square pillar beneath the supporting boulder. The structural elements exhibit evidence of weathering and decay. Accessibility to the space beneath the boulder is limited to low tide conditions, and the site is susceptible to storm surges, rendering the origin of the dislodged pillar unclear.

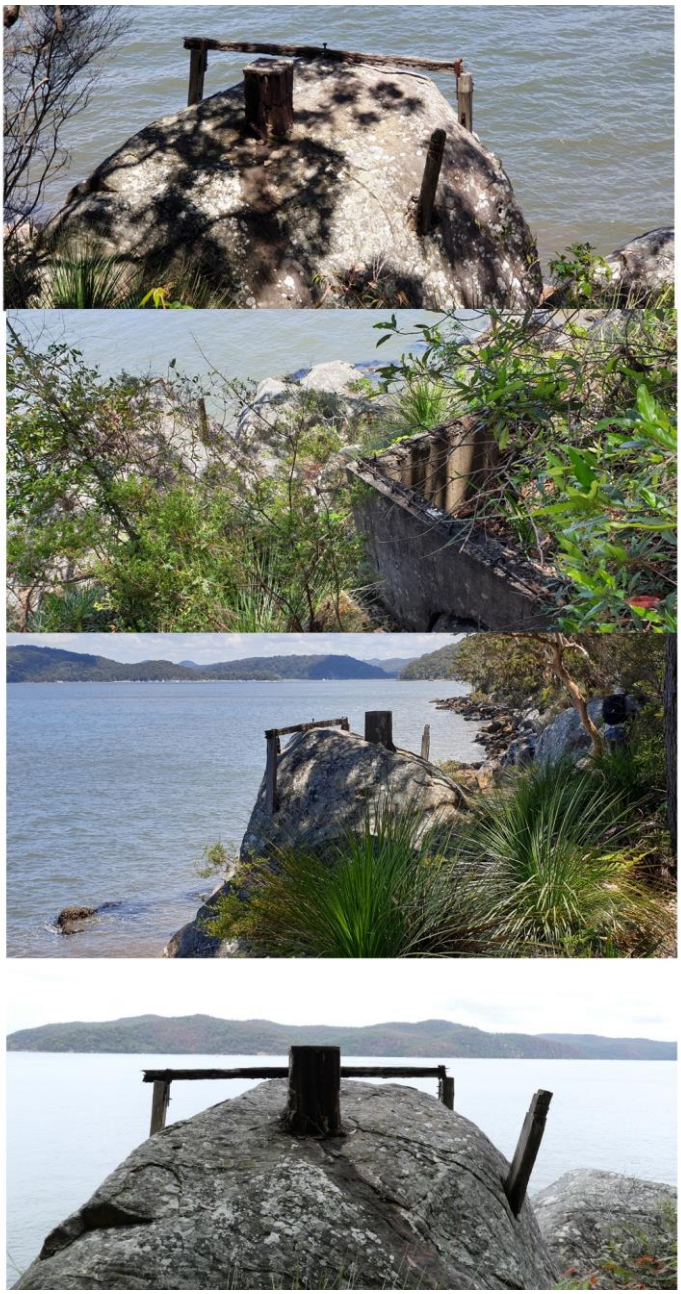

Figure A2-2 comprises images offering a comprehensive overview of the residual components of the wharf. The second image from the top specifically delineates the positioning of the wharf, situated at the middle-left section, in relation to the Comprehensive Archaeological Site Layout (CASL). This visual representation serves to contextualize the remnants of the wharf within the broader archaeological landscape, enhancing the viewer's understanding of its spatial orientation and significance in conjunction with the CASL.

Figure A2-3 comprises a series of images, each offering unique insights into distinct features within the archaeological site:

Octagonal Jar Bottom: The left-down image displays an octagonal jar bottom bearing the inscription 'Property of the Sanitarium Health Food Co.' This artifact, discovered in proximity to gun position 2, awaits further information from the Sanitarium's archivist for dating purposes.

Concrete Water Tank Sign: The subsequent image captures a sign stamped into a concrete water tank, indicating its manufacturer as 'TEE Low TANKS WELLINGTON.' The details about the company were not investigated as part of the current study.

Cliffside Dam: The visual documentation includes a dam constructed on the side of a cliff using local sandstone and concrete. Notably, the dam receives a continuous trickle of water, and an overflow clay pipe directs the excess water into the surrounding bush.

Large Photograph: The right-most image depicts a sizable photograph capturing strands of barbed wire near the derrick wharf. Barbed wire was found protruding from the ground in various locations between the gun sites and the wharf, particularly in areas accessible from the water.

These images collectively contribute to the understanding of diverse features within the site, ranging from historical artifacts and signage to infrastructure elements such as dams and the presence of barbed wire, providing valuable material for further investigation and interpretation of the site's historical context.

Annexure 3

Hungry Beach

An eroded and deteriorated concrete pathway from the western terminus now exhibits disruptions caused by erosion as it extends towards a submerged pillar. This pillar, indicative of the remnants of a pier once pivotal in facilitating the conveyance of troops and supplies, stands as a vestige of the structure's historical significance. Adjacent to this, a collapsed brick-and-mortar wall spans over 30 meters, exposing stratified layers of rubble that bear witness to the wall's erstwhile vertical composition.

Amidst the dense growth of weeds and brambles, situated on an elevated plateau above the pathway, two foundation footings constructed of molded concrete come into view. These footings are marked by tie-down bolts around their perimeters, strongly suggesting their original purpose as sites for portable huts—a designation substantiated by information gleaned from the National Archives of Australia's records on the Disposal of Assets at Hungry Beach. This inference is further supported by anchor points designed to secure the bottom plate of the collapsed wall. One featuring an east-facing door and a soil floor is noteworthy among the footings, while the other exhibits a concrete foundation.

Despite the challenges posed by the dense vegetation, the potential for the discovery of additional architectural remnants remains high, warranting further investigation to unveil the full extent of the site's historical artifacts and structures.

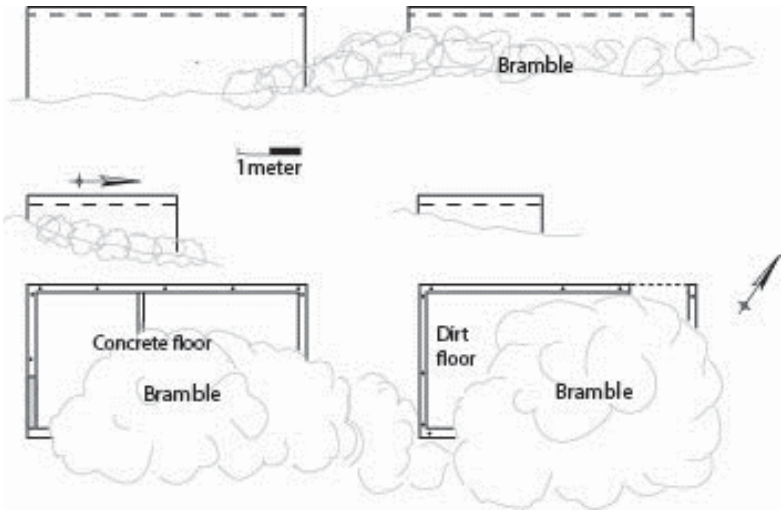

Figure 3-1: Drawing of the ancillary building footings. Possibility of the remains of Billeting and ablution blocks. Drawings by the author.

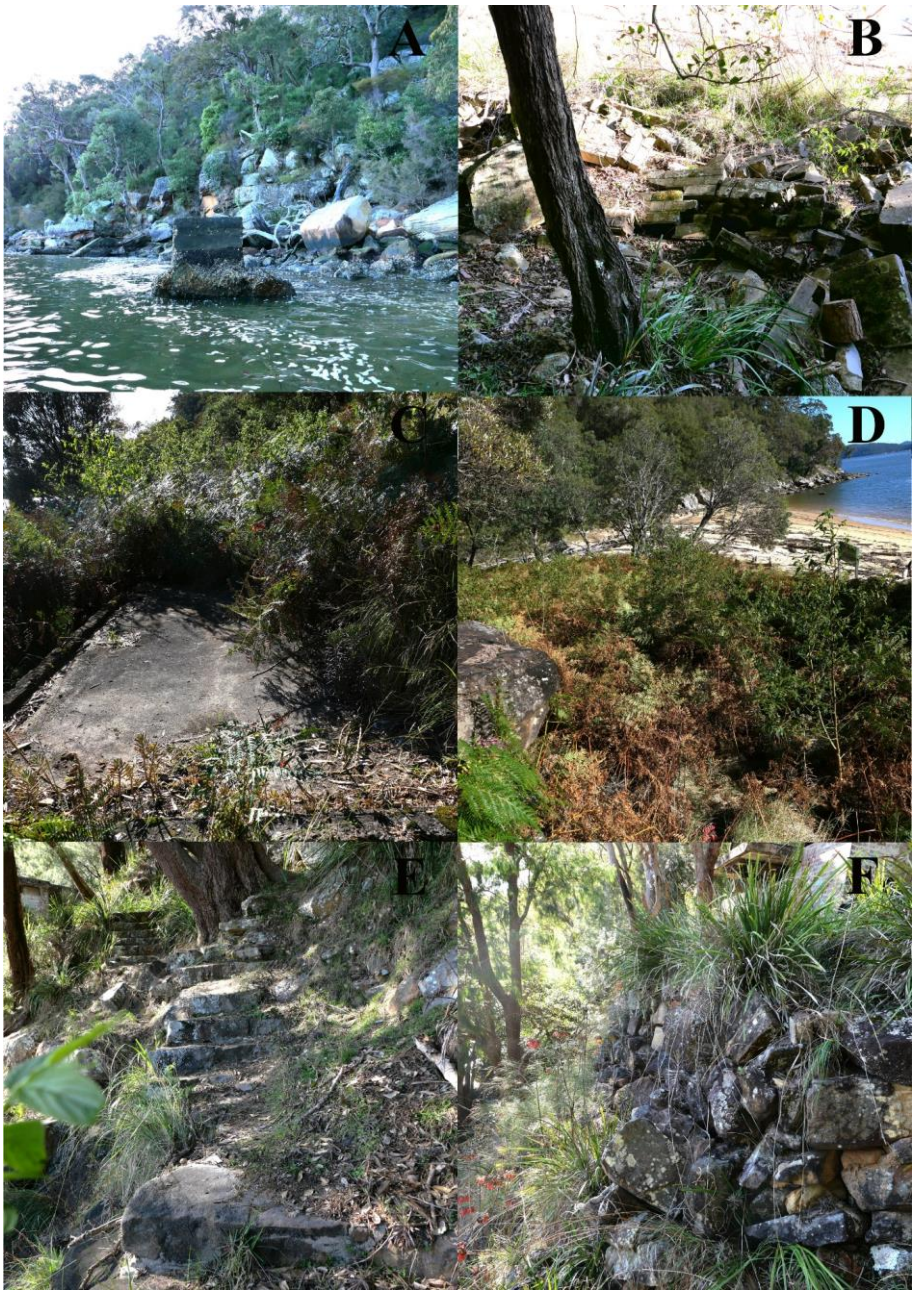

Figure 3-2 provides a comprehensive visual documentation of various features within the archaeological site: A- A prominent and sizable concrete structure positioned in close proximity to the former wharf facility. It is hypothesised that this structure may have supported a derrick, facilitating the unloading of substantial supplies such as diesel drums for the generator.

B- A collapsed brick wall whose original location remains unknown, leaving uncertainty regarding its association with a specific building or structure.
C- The concrete floor and footing of a relocatable building, as referenced in Figure 3-1, suggesting the presence of modular structures in the area.
D- An overview of the area where the foundations of the relocatable buildings are situated, characterised by dense overgrowth of bramble and other vegetation, obscuring the archaeological features.
E- Sandstone steps carved into the hillside, serving as an ascent from the relocatable buildings to the control hut.
F- Dry stone walling utilised in the construction of the location for the control hut, contributing to the site's foundational support and overall structure.
This visual compilation offers valuable insights into the diverse elements present at the archaeological site, prompting further inquiry and exploration to unravel the historical context and interconnections among these features.