May 3rd, 9:20 AM - 10:30 AM

A Matter of Ultra Importance: How Ultra's Decryption of Enigma Impacted the Outcome of World War II

Lia S. Hansen
St. Mary's Academy

A Matter of Ultra Importance:

How Ultra's Decryption of Enigma Impacted the Outcome of World War II

Lia Hansen

PSU Challenge History of Modern Europe

Mr. Vannelli

St. Mary's Academy

4 April 2024

Abstract

During World War II, one of the most prominent unsung heroes were the Allied codebreakers of Ultra who, under the thick blanket of absolute secrecy, worked tirelessly throughout the war to decrypt the German Enigma cipher. Efforts to break the Enigma cipher were underway since the beginning of the war but yielded little success until 1943 and Alan Turing's Bombe. After this point, Allied forces were able to more effectively combat Axis forces, especially German U-boats in the Atlantic ocean, while keeping the whole operation under wraps to avoid suspicion and changing of the code. This paper explores how Ultra's efforts were a key part of the Allies's overall victory in the war, due to their effects on Allied performance in the later years of the Battle of the Atlantic.

"It was thanks to Ultra that we won the war," Winston Churchill declared to King George VI after the end of World War II in 1945.[1] Ultra refers to the name of an Allied military intelligence project centered on code-breaking encrypted German, Japanese, and Italian communications after being launched in June of 1941. Its most famous and influential focus was introduced on July 9th, 1941, when British cryptanalyst Alan Turing first deciphered the German Enigma machine, revealing key German communications.[2] The German Enigma machine, a cipher device, encoded and decoded Morse code messages sent between German military forces. In the Battle of Atlantic, the longest continuous battle in World War II stretching from 1939 to 1945, encrypted messages played a particularly large role for both sides in sending instructions to their warships.[3] The Allied forces' cracking of the Enigma machine in 1943 enabled them to intercept and decode German U-boat (submarine) locations and attack plans, allowing them to better combat the German naval forces and avoid casualties of their own. Success related to deciphering Enigma's messages stretched from its immediate discovery until the war's end, with Germany's surrender. The efforts of Ultra in code-breaking the German Enigma cipher resulted in the Allied victory in World War II by providing valuable intelligence on German U-boat strategy and locations in the later years of the Battle of the Atlantic.

Control over the Atlantic Ocean through victories in the Battle of the Atlantic was critical for the Allied war effort, notably because of the much-needed transport of supplies, primarily from the United States. In the beginning of the war, the United States, even though it claimed neutrality, sold materials and supplies to the Allied forces and provided escorts for British

---

[1] John Blaxland, "Intelligence and Special Operations in the Southwest Pacific, 1942-45," essay, in Australia 1944-45: Victory in the Pacific, ed. Peter Dean, 1st ed. (Port Melbourne, Australia: Cambridge University Press, 2015), 145–68.

[2] Jennifer Wilcox, "Solving the ENIGMA: History of the Cryptanalytic Bombe," National Security Agency, 2015, https://media.defense.gov/2022/Sep/29/2003087366/-1/-1/0/SOLVING%20THE%20ENIGMA%20-%20HISTORY%20OF%20THE%20CRYPTANALYTIC%20BOMBE.PDF.

[3] Ministry for Culture and Heritage, "Turning point in Battle of the Atlantic," NZ History, January 20, 2021. https://nzhistory.govt.nz/page/turning-point-battle-atlantic.

convoys.[4] As the war progressed and the United States officially joined the Allies, being able to maintain transport across the Atlantic only became more important. Unfortunately for the Allies, Germany had a very prominent naval force; drawing knowledge from their experience in naval battles in the First World War, they increased battleship production in late 1938 before World War II had even broken out.[5] The German submarines, known as unterwasser boats (U-boats), would comb the Atlantic, searching for Allied ships as part of Germany's strategy to lay siege to Great Britain, cutting off aid from the United States. With their devastating U-boat fleets, Germany could hunt down Allied shipping convoys like packs of wolves, preventing supplies from reaching Great Britain to weaken their forces.[6] For the first few years of the war, Germany had a powerful hold on the Atlantic, so much so that a section of the ocean became known as the "Black Pit." This part of the mid-Atlantic was an area that was outside of the range of Allied aerial forces, and as a result, German U-boats were able to devastate Allied ships in this area.[7] German forces especially exploited this in 1942 and early 1943, resulting in over six million tons of shipping sunk during this time, largely because of Allied forces' vulnerability in the Black Pit.[8] Although the Allies regularly intercepted their communications, until mid-1943, they struggled to decipher the messages in time to act, leaving their naval fleets open to constant attack by the German submarines.[9]

By World War II, neither the feat of cracking the Enigma cipher nor the Enigma machine itself was new. The Enigma machine, created in 1923, was used by the German Navy as early as

---

[4] Wilcox, "Solving the ENIGMA," 12.
[5] Michael Epkenhans, "German Naval Strategy in World War I and World War II," NIDS Joint Research Series no. 19 (2019-2021): 47-48, Accessed December 2, 2023, https://www.nids.mod.go.jp/english/publication/joint_research/series19/pdf/chapter02.pdf.
[6] Wilcox, "Solving the ENIGMA," 12.
[7] Brian Dubreuil and W.A.B. Douglas, "Battle of the Atlantic" The Canadian Encyclopedia, April 25, 2010, https://www.thecanadianencyclopedia.ca/en/article/battle-of-the-atlantic.
[8] Richard Goette, "Britain and the Delay in Closing the Mid-Atlantic 'Air Gap' During the Battle of the Atlantic," *The Northern Mariner* 15, no. 4 (October 2005): 19–41.
[9] Wilcox, "Solving the ENIGMA," 17-22.

1926, after some modifications, and was well known in military circles before 1930.[10] It functioned as an advanced alphabet scrambler, originally with a three-rotor mechanism changing how the alphabet was rearranged. By releasing different lists of keys, the Germans effectively changed the settings of the machine, so previously established patterns and letter connections were useless.[11] Poland, in an attempt to bolster their military defenses successfully cracked the Enigma machine in 1932, enabling them to decipher messages until 1939, when they were invaded by Germany.[12] While less complex and dynamic compared to the Enigma machine used in World War II, Poland's decryption provided a helpful baseline for Ultra cryptanalysts and mathematicians in breaking the wartime Enigma machine.

In 1941, British Military Intelligence continued the hard work to crack Enigma. Using the knowledge of Enigma that Poland shared at a 1939 conference, the brightest mathematicians and linguists worked tirelessly to try to decipher Navy Enigma messages.[13] However, with Germany adding rotors and changing keys daily, Ultra struggled to crack the machine. In both mid-1941 and late 1942, progress was made when captured coding material from German submarines U-110 and U-559 allowed the Allies to crack Enigma to some degree.[14] However, by the end of 1942, codes were still taking at least thirty-six hours to be deciphered; while this did allow Allied forces to avoid the wolf packs to some degree, the delay resulted in Allied losses, creating a need for some way to quickly decode messages sent by the Enigma machine.[15] Enter Bletchley Park and Alan Turing who, in May of 1943, with significant help from the U-559's captured information, designed and implemented the British Bombe — a massive machine, which, in

---

[10] Gary M. Bateman, "The ENIGMA Cipher Machine," *American Intelligence Journal* 5, no. 2 (1983): 6, http://www.jstor.org/stable/44326071.
[11] Bateman, "The ENIGMA Cipher Machine," 7.
[12] Bateman, 7.
[13] Bateman, 7.
[14] Wilcox, "Solving the ENIGMA," 21-22.
[15] Wilcox, "Solving the ENIGMA," 22.

under an hour, was able to discern the key used by the Enigma machine that day.[16] Suddenly, the Allies could decipher German communications in under half a day and actively use them to both intercept and avoid U-boats in the Atlantic.

With the intelligence gained by solving Enigma, the Allies acquired information that proved valuable in both the defensive and offensive side of the Battle of the Atlantic, leading the Allies to cement their victory over the Axis powers, as evidenced in the direct comparison of statistics from before and after 1943. Before the breaking of Enigma, Allied ships were open to attack against the German navy's wolf packs. German U-boats would patrol large areas of the Atlantic, seeking out Allied convoys. Upon spotting Allied ships, the German submarines sent out an Enigma-encoded alert via radio to other submarines, which then converged on the unsuspecting Allied convoy, many times succeeding in sinking it.[17] However, once the Allies gained the ability to decipher the messages sent between the U-boats, they had the opportunity to warn the convoys, who then could avoid the wolf pack. "Evaluation of the Role of Decryption Intelligence in the Operational Phase of the Battle of the Atlantic," written by the Operations Evaluation Group of the U.S. Navy, states,

> Description intelligence made it possible to obtain a very accurate, complete, and fairly up-to-date picture of the general character of the German submarine operations: the areas of U-boat infestation, the number and identity of the boats operating in the several areas, and their objectives – whether coastal or trans-oceanic convoys, independents, mine-laying, etc.[18]

As a result, when comparing the amount of contact between Allied convoys and German U-boats across time periods in the Battle of the Atlantic, there is a significant difference between the effectiveness of German U-boats before and after the deciphering of Enigma by Turing in

---

[16] Wilcox, "Solving the ENIGMA" 27-28.
[17] Wilcox, "Solving the ENIGMA" 13.
[18] Jacinto Steinhardt, "Operations Evaluation Group Report 68," Top Secret Memorandum, Washington 25, D.C., 1953, 40.

1943. During Period I, defined as July through December of 1942, the Allies had no decryption intelligence. However, in the times after the cracking of the Enigma machine, specifically Period IV (September 1943 - March 1944), the contact rate between the convoys and U-boats was less than two-thirds of that in Period I. Additionally, the ability of U-boats during Period I and Period II (January - May 1943) to sink convoy ships decreased to almost one-sixth during Period IV.[19] The drastic drop in German Naval ability from Period I to Period IV cannot be solely attributed to the success of decryption by the Allies; the extent to which decryption directly influenced the war cannot be fully represented by statistics. However, since the solving of Enigma enabled anti-submarine measures such as convoy rerouting, Allied ships could better avoid German U-boats, contributing to the lower levels of contact and sinking. An instance of Enigma's direct influence on reducing contact between Allied and German forces occurred in early June of 1943: Ultra intercepted and decrypted messages sent out in late May by the supreme commander of the German Navy's U-boat army, the BdU. These messages informed the Allies of the movement of 17 U-boats forming a patrol line by June 1 to attack convoys involved in US-Gibraltar shipping. In response, the Allies diverted the threatened convoys so that there was no contact with the German Naval forces throughout the whole month of June.[20]

In addition to its use in defensive measures, the intelligence gained through decryption was utilized for some offensive measures, notably through Hunter-Killer operations during the summer of 1943. Allied decryptions during this time period made it possible for escort aircraft carriers (CVE groups) to zero in on vulnerable U-boats instead of having to search large areas of ocean; the CVE groups sank fifteen U-boats and damaged nine others from June to August, over half of these a direct result of prior knowledge of the U-boat locations gained through

[19] Steinhardt, "Operations Evaluation Group Report 68," 1953, 39.
[20] Steinhardt, 41.

decryption.[21] The CVE groups targeted specific ships in U-boat concentrations known as "milk cow" submarines. These ships were "larger submarines used to refuel and reprovision other U-boats at sea."[22] Thus, by sinking them, the Allied forces were impacting all of the U-boats in the area, cutting down on their efficiency by removing their source of refueling and restocking at sea. With the knowledge gained from Enigma decryption, Allied forces were able to advance their strategies in both the defensive and offensive, rerouting convoy ships away from U-boat wolf packs and instead sending CVE groups after the submarines, altogether exhausting German U-boat forces and asserting Allied dominance in the Battle of the Atlantic.

It was not only the act of breaking Enigma but the efforts by the Allies to keep their newfound intelligence a secret that enabled the code to have such a significant impact on the war. Earlier in the war, when the Allies had momentary success in cracking Enigma, their work failed to have any large effect. When the first big break in decrypting Enigma came in May of 1941, with the capture of U-boat 110, the encryption equipment and code material found on the submarine allowed Bletchley Park to read Enigma messages quickly enough to take advantage of the information, redirecting their convoys to avoid the wolf packs.[23] However, the commander of the U-boat fleet, Admiral Doenitz, noticed the blatant change in his submarine forces' performances; at the beginning of 1941, German ships were sinking a majority of Allied shipping tonnage until suddenly, after spring, roles had reversed. Doenitz grew suspicious that the Allies were reading Enigma messages, and, despite reassurances from the German High Command that Enigma was completely secure, Doetniz added a fourth rotor to the Enigma machines.[24] The machines and methods developed in Bletchley Park, designed for the three-rotor

[21] Steinhardt, 49-50.
[22] Samuel J. Cox, "H062.2 Close Quarters Antisubmarine Warfare (Part 2)," Naval History and Heritage Command, July 2021, https://www.history.navy.mil/about-us/leadership/director/directors-corner/h-grams/h-gram-064/h-064-2.html.
[23] Wilcox, "Solving the ENIGMA," 14.
[24] Wilcox, "Solving the ENIGMA," 16.

machine, were unsuccessful against the new four-rotor codes. Once again, the Allies could not decipher Enigma messages effectively, leaving their ships defenseless against the U-boats.[25] The ease with which the German navy could alter Enigma to make it again unbreakable emphasized the importance of keeping the work at Bletchley Park a secret; if Germany suspected that Enigma had been compromised, they could quickly change the machine, ruining much of the Allied codebreakers' progress and any advantages they gained from reading the codes. Therefore, Ultra prioritized secrecy when it came to its code-breaking successes, both externally and internally. To prevent Germany from becoming suspicious, the Allies sent search aircraft into areas where they already knew U-boats would be present to "spot" the ships before sending their navy to attack.[26] This way, Germany believed that their U-boats were compromised due to the Allied aircraft sweeps, not the deciphering of the code. In one instance, the Allied navy attacked U-boats in the middle of a fog so dense that the submarines could not have been spotted by aircraft, causing a German military officer to send an alert to the Military Security Service, suspecting an intelligence breach. To counter this, Britain sent a message to a factitious spy in Naples, congratulating him on his work, justifying the impossible attack on the U-boats, and removing any German concerns.[27] In Bletchley Park, secrecy was maintained through careful monitoring of who had access to any information about the cipher decryption. Anyone working in cryptanalysis first went through a thorough background investigation.[28] Even then, most people involved, as United States Naval Reserve (Women's Reserve) Georgi Ludington explained, "weren't supposed to know anything. We just did something and it didn't all fit in. We

[25] Wilcox, "Solving the ENIGMA," 17.
[26] Bill Momsen, "Codebreaking and Secret Weapons in World War II," Nautical Brass, 2007.
[27] Momsen, "Codebreaking and Secret Weapons in World War II," 2007.
[28] Jennifer Wilcox, "Sharing the Burden: Women in Cryptology during World War II," National Security Agency, 2013, 3, https://www.nsa.gov/portals/75/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/sharing_the_burden.pdf.

didn't know the big picture."[29] Only the people directly involved in the decoding process and the high-ranked members of the military knew what the work at Bletchley Park was used for, and this prevented information from leaking out.[30]

Ultra's efforts to maintain the secrecy of their code-breaking were incredibly successful. German naval forces were completely unaware that Enigma had been compromised, as evidenced in an unsigned naval report from 1944 sent to the German Navy High Command regarding Enigma's security. It stated: "…the high degree of efficiency of the enemy's aircraft Radar, so often surprising, has received remarkable and decisive assistance from directions based on the results of the direction finding service." Similarly, even after the war, the same Admiral Doenitz who had sounded the alarm that Enigma was compromised in 1941 was unaware that the Allies had cracked the Enigma machine again. His official statement in the Nuremberg trials is as follows: "The Battle of the Atlantic was nearly won prior to July 1942, when German losses were within reasonable limits. But they jumped 300 per cent when Allied aircraft, aided by radar, which came like an epileptic stroke, were used in the fight."[31] His statement emphasizes how Ultra's decryption of Enigma messages changed the course of the Battle and demonstrates the effectiveness of Ultra's secrecy measures. During the war, the German military never realized that the source of their sudden losses was not due to superior radar or direction finding but instead caused by the exposure of encoded messages revealing the positions and intentions of the German U-boats. The efforts to keep Ultra's successes secret were especially effective since Germany had a great deal of confidence in the Enigma cipher, firmly believing it to be completely unbreakable.[32] The fact that Germany never realized Enigma was compromised

[29] Wilcox, "Sharing the Burden," 9.
[30] Wilcox, "Sharing the Burden," 3, 9.
[31] Army Security Agency, "European Axis Signal Intelligence In World War II as Revealed by "TICOM" Investigations and By Other Prisoner of War Interrogations and Captured Material, Principally German," DOCID: 3560861 (Washington D.C., 1946).
[32] Army Security Agency, "European Axis Signal Intelligence In World War II as Revealed by "TICOM," 1946 .

meant they never doubted the integrity of their encryptions and changed mechanisms of the machine again, thus unwittingly enabling the Allies to read Enigma messages to the end of the war and beyond.

All of the effects that deciphering Enigma had on the Battle of the Atlantic in turn impacted the outcome of World War II. Churchill plainly states in his memoirs that the Battle of the Atlantic was "the dominating factor all through the war,"[33] displaying how by being a crucial part of the Allied victory in the Battle of the Atlantic, Ultra's decoding efforts were key to the Allied victory in the war. This is further supported by Jon Middaugh, a historian at Naval History and Heritage Command, who defines it as "one of the most important fronts in World War II."[34] The Battle of the Atlantic's significance stems from the great importance of supply routes across the ocean. Fundamentally, the Battle was a tonnage war; the Allies sought to supply Britain, and the Axis attempted to cut off any supply routes to starve Britain of the resources necessary for their war effort.[35] Since Britain was heavily dependent on imported food, fuel, and raw materials, a successful German blockade that overwhelmingly destroyed merchant ships and their cargoes would have incapacitated the entirety of Britain, leaving them open to direct attack and unable to support their military.[36] In addition to impacting Britain's defensive abilities, supply routes across the Atlantic Ocean were essential to the Allies building up air forces, troops, food, medicine, and equipment in preparation for the invasion of continental Europe in 1944.[37] Without the military

---

[33] Christopher M. Bell, "Longest Campaign: Winston Churchill and the Atlantic Battle, 1940-43," The Churchill Project, Hillsdale College, July 26, 2021, https://winstonchurchill.hillsdale.edu/bell-atlantic-battle/.
[34] Jon Middaugh, "The Battle of the Atlantic: An Overview," The Sextant, U.S. Navy, July 9, 2020, https://usnhistory.navylive.dodlive.mil/Operations/Article-View/Article/2686950/the-battle-of-the-atlantic-an-overview/.
[35] Debi Blaney, "U-576: Life and Death On a World War II German U-boat," NOAA Office of Ocean Exploration and Research, September 4, 2016, https://oceanexplorer.noaa.gov/explorations/16battlefield/logs/sept4/sept4.html.
[36] Ministry for Culture and Heritage, "Turning point in Battle of the Atlantic," 2021.
[37] Australian Government, "Battle of the Atlantic," Department of Veterans' Affairs, July 22, 2022, https://www.dva.gov.au/newsroom/media-centre/media-backgrounders/battle-atlantic#:~:text=The%20Battle%20was%20crucial%20to,of%20continental%20Europe%20in%201944.

successes in the Atlantic during 1943, in which Ultra's deciphering of Enigma played a significant role, other deciding moments in the war, such as D-Day, may have been undersupplied and short-handed, delayed or unable to happen at all, leading to a different outcome than the Allied successes that occurred. However, after losing forty-one U-boats in May 1943 alone, Doenitz ordered the temporary withdrawal of the U-boats, putting a temporary stop to the wolf packs that had plagued the supply convoys for so long.[38] While the submarines did return and continued to be a threat until May of 1945, they were never again as much of a threat.[39] After the first half of 1943, the Battle of the Atlantic's tide had turned in favor of the Allies,[40] allowing the supplies that were so vital to Britain's survival to reach the country, which in turn led to the crucial Allied military successes in the final years of the war, cementing the Allies's victory over the Axis powers.

While it is not disputed that Enigma's decoding had a significant impact on World War II, the extent to which it helped the Allies is debated. John Ferris, a Professor of History at the University of Calgary, raises doubts that Enigma helped the Allies win the war by anything more than several months, stating, "To say it did anything more than that I think is just unrealistic."[41] Although it is impossible to say for certain the significant advantages that Enigma gave the Allied forces in the Battle of the Atlantic, the Battle's importance to the overall war suggests that without Ultra's success in deciphering Enigma, the outcome of the war would have been unknown. Had Britain been unable to receive as many supplies from across the Atlantic Ocean, due to shipping routes' vulnerability to the U-boat packs, their armies would have suffered,

---

[38] Ministry for Culture and Heritage, "Turning point in Battle of the Atlantic," 2021.
[39] Australian Government, "Battle of the Atlantic," 2022.
[40] Jon Middaugh, "Battle of the Atlantic: Overview," Naval History and Heritage Command, January 2017. https://www.history.navy.mil/browse-by-topic/wars-conflicts-and-operations/world-war-ii/1942/atlantic/overview.html.
[41] Jack Guy, "Bletchley Park Codebreakers' Contribution to WWII Overstated, New Book Claims." CNN, October 21, 2020, https://www.cnn.com/2020/10/20/uk/bletchley-park-gchq-wwii-contribution-scli-intl-gbr/index.html.

possibly changing the outcome of the later years of the war. Despite the debate on the extent to which Ultra's decryption of Enigma impacted the war, it is clear that, at the very least, it did usher in an Allied victory, saving lives that would otherwise have been lost.

Ultra's efforts in solving Enigma have influences stretching beyond World War II and the years immediately following the war. The lengths the British military intelligence agencies took to maintain the secrecy of their code-breaking practices serve as a masterclass on how to operate top-secret programs in wartime. Additionally, we can learn from Germany's mistakes in their overconfidence in the security of Enigma which led them to overlook signs that the machine had been compromised by the Allies. The fact that the Allies were able to use the same decrypting methods for years emphasizes the importance of constant adaptation and caution when it comes to guaranteeing security in critical areas such as cybersecurity today.

Looking back at how breaking Enigma gave the Allies key advantages in both defense and offensive, and the impact this had on the course of the war as a whole raises the question of what will be the Enigma decryption of wars today and in the future. While today, multirotor typewriter-esque encoding machines are less commonly used in warfare, more modern areas, such as in the use of metadata or cybersecurity in protecting or sending key information during conflicts, for government activities, or other sensitive needs, could potentially play a similar role. Enigma is a prime display of how predictive information can alter the course of a war, and although it looks different today, Enigma has shown how having superior intelligence can have such a large effect on the outcome of battles or other large scale interactions.

Lastly, in researching this topic, government documents proved to be invaluable, especially formerly classified reports and evaluations written during or around the time of World War II. One main limitation encountered while conducting research was the impact of location

on the accessibility of sources. U.S. Government sources were readily available, but British or German government sources were much more difficult to view, despite the two parties being the most involved in the Enigma cipher. If future research on Enigma is carried out, referencing more sources from those countries could be incredibly helpful in gathering evidence. Additionally, some pertinent government documents may remain classified; as those are declassified and become available to the public, new data may emerge that could impact the argument on the importance of Ultra's code-breaking.

Ultra's efforts in breaking Enigma are displayed in the stark changes in the number of U-boats sunk before and after Enigma was deciphered, as well as the various ways in which information from decrypted messages was utilized by Allied forces, giving the Allies an advantage on both the defensive and offensive. These impacts from Enigma were only possible because of Bletchley Park's dedication to keeping their code-breaking top secret, preventing Germany from changing the machine to block the Allies from reading messages. Through reading Enigma messages, the Allies established their victory in the Battle of the Atlantic, which in turn helped the Allies secure key victories in Europe, leading to their overall victory in the war.

Bibliography

Army Security Agency, "European Axis Signal Intelligence In World War II as Revealed by "TICOM" Investigations and By Other Prisoner of War Interrogations and Captured Material, Principally German." DOCID: 3560861, Washington D.C., 1946.

Australian Government. "Battle of the Atlantic." Department of Veterans' Affairs, July 22, 2022. https://www.dva.gov.au/newsroom/media-centre/media-backgrounders/battle-atlantic#:~:text=The%20Battle%20was%20crucial%20to,of%20continental%20Europe%20in%201944.

Bateman, Gary M. "THE ENIGMA CIPHER Machine." American Intelligence Journal 5, no. 2 (1983): 6–11. http://www.jstor.org/stable/44326071.

Bell, Christopher M. "Longest Campaign: Winston Churchill and the Atlantic Battle, 1940-43." The Churchill Project. Hillsdale College, July 26, 2021. https://winstonchurchill.hillsdale.edu/bell-atlantic-battle/.

Blaney, Debi. "U-576: Life and Death On a World War II German U-boat." NOAA Office of Ocean Exploration and Research, September 4, 2016. https://oceanexplorer.noaa.gov/explorations/16battlefield/logs/sept4/sept4.html.

Blaxland, John. "Intelligence and Special Operations in the Southwest Pacific, 1942-45." Essay. *In Australia 1944-45: Victory in the Pacific*, edited by Peter Dean, 1st ed., 145–68. Port Melbourne, Australia: Cambridge University Press, 2015.

Callahan, Katelyn. "The Impact of the Allied Cryptographers on World War II: Cryptanalysis of the Japanese and German Cipher Machines." Georgia College & State University, December 14, 2013. https://www.gcsu.edu/sites/files/page-assets/node-808/attachments/callahan.pdf.

Cox, Samuel J. "H062.2 Close Quarters Antisubmarine Warfare (Part 2)." Naval History and Heritage Command, July 2021. https://www.history.navy.mil/about-us/leadership/director/directors-corner/h-grams/h-gram-064/h-064-2.html.

Dubreuil, Brian, and W.A.B. Douglas. "Battle of the Atlantic." The Canadian Encyclopedia, April 25, 2010. https://www.thecanadianencyclopedia.ca/en/article/battle-of-the-atlantic.

Epkenhans, Michael. "German Naval Strategy in World War I and World War II." NIDS Joint Research Series no. 19 (2019-2021): 25-55. Accessed December 2, 2023. https://www.nids.mod.go.jp/english/publication/joint_research/series19/pdf/chapter02.pdf.

Federal Bureau of Investigation. "A Byte Out of History." October 6, 2011. https://www.fbi.gov/news/stories/byte-out-of-history-using-ultra-intelligence-in-world-w

ar-ii#:~:text=Ultra%20was%20launched%20by%20British,investigative%20efforts%20during%20the%20war.

Goette, Richard. “Britain and the Delay in Closing the Mid-Atlantic ‘Air Gap’ During the Battle of the Atlantic.” *The Northern Mariner* 15, no. 4 (October 2005): 19–41.

Guy, Jack. “Bletchley Park Codebreakers’ Contribution to WWII Overstated, New Book Claims.” CNN, October 21, 2020. https://www.cnn.com/2020/10/20/uk/bletchley-park-gchq-wwii-contribution-scli-intl-gbr/index.html.

Haufler, Hervie. *Codebreakers' Victory: How the Allied Cryptographers Won World War II*. United States: Open Road Media, 2014.

Hinsley, F. H. (Francis Harry). *British Intelligence in the Second World War: Its Influence on Strategy and Operations*. London: H.M.S.O., 1979.

Kahn, David. “Codebreaking in World Wars I and II: The Major Successes and Failures, Their Causes and Their Effects.” *The Historical Journal* 23, no. 3 (1980): 617–39. http://www.jstor.org/stable/2638994.

Middaugh, Jon. “The Battle of the Atlantic: An Overview.” The Sextant, July 9, 2020. https://usnhistory.navylive.dodlive.mil/Operations/Article-View/Article/2686950/the-battle-of-the-atlantic-an-overview/.

Middaugh, Jon. “Battle of the Atlantic: Overview.” Naval History and Heritage Command, January 2017. https://www.history.navy.mil/browse-by-topic/wars-conflicts-and-operations/world-war-ii/1942/atlantic/overview.html.

Ministry for Culture and Heritage. “Turning point in Battle of the Atlantic.” NZ History, January 20, 2021. https://nzhistory.govt.nz/page/turning-point-battle-atlantic.

Momsen, Bill. “Codebreaking and Secret Weapons in World War II.” Nautical Brass, 2007.

OP-20-G. “Technical Intelligence From Allied Communications Intelligence: Volume IV of Battle of the Atlantic.” January 12, 2021. https://www.history.navy.mil/research/library/online-reading-room/title-list-alphabetically/b/battle-of-the-atlantic-volume-3-technical-intelligence-from-allied-communications-intelligence.html#intercept.

Steinhardt, Jacinto. “Operations Evaluation Group Report 68.” Top Secret Memorandum, Washington 25, D.C., 1953.

“War of Secrets: Cryptology in WWII.” National Museum of the United States Air Force. Accessed October 3, 2023.

https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/196193/war-of-secrets-cryptology-in-wwii/#:~:text=Cryptology%20is%20the%20study%20of,helped%20shorten%20the%20war%20considerably.

Wilcox, Jennifer. “Sharing the Burden: Women in Cryptology during World War II.” National Security Agency, 2013. https://www.nsa.gov/portals/75/documents/about/cryptologic-heritage/historical-figures-publications/publications/wwii/sharing_the_burden.pdf.

Wilcox, Jennifer. “Solving the ENIGMA: History of the Cryptanalytic Bombe.” National Security Agency, 2015. https://media.defense.gov/2022/Sep/29/2003087366/-1/-1/0/SOLVING%20THE%20ENIGMA%20-%20HISTORY%20OF%20THE%20CRYPTANALYTIC%20BOMBE.PDF.