Promoting to Opportunity: Evidence and Implications from the U.S. Submarine Service

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Abstract

What are the long-term consequences of an early career promotion? To answer this question with causal estimates, I study a natural experiment: the United States submarine force during the first half of the Second World War. When allocating promotions, the US Navy's Bureau of Personnel endorsed enlisted men recommended by captains who had sunk enemy ships. Defects in the Mark 14 torpedo, however, meant that submarines were substantially less likely to sink ships, irrespective of crew quality, if the strength of the geomagnetic field in their patrol zone was too different than the historical field strength near Newport, Rhode Island. To identify exogenous variation in promotions, I construct a vector of instruments using quasi-random variation derived from submarine patrol locations. Leveraging a novel dataset linking enlisted men's naval data to their later life outcomes, I find that conditional on surviving the war, promoted sailors lived 2.4 years longer than their non-promoted counterparts. Furthermore, exogenously promoted sailors lived in wealthier ZIP codes at the time of their deaths. These effects are pronounced for sailors who received submarine-success triggered promotions to the rate of chief petty officer, suggesting the importance of developing and exercising managerial ability for later life well-being.

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1 Introduction

Do early career promotions influence later life outcomes? *A priori*, anecdotal evidence and the well-documented positive correlation between socioeconomic status and health suggest the answer is obvious. But stress exposure is not monotonically decreasing in stature; research on the causal effect of occupational rank on health is both sparse and inconclusive (Lleras-Muney et al., 2012; Nicholas, 2020). Besides increased stressors of higher rank, it is not immediate that there is path dependence to an "accidental" promotion. Individuals' early labor market experiences are characterized by high mobility between jobs (Topel and Ward, 1992) and difficulty signaling quality to employers (Altonji and Pierret, 2001; Farber and Gibbons, 1996). Because the median young worker is so mobile, noisily signals his quality, and may not be able to transfer acquired skills across jobs, it is not clear that advancement within any one early career position should decisively improve his later life well-being.

To evaluate the long-run consequences of promotion, I study a historically important natural experiment: the US Navy's WWII submarine fleet. Promotions aboard these submarines were affected by military success; the submarine torpedoes responsible for success were unduly affected by technical defects. My data, which match sailors to their wartime careers and later life outcomes, find large returns to idiosyncratic promotion for longevity and socioeconomic status (SES). I find that the longevity returns are especially large for sailors promoted to management; this observation is consistent with the acquisition and development of managerial talent serving as a vehicle for the long-term consequences I observe.

I digitized the service histories of 4,821 enlisted men serving aboard 72 fleet submarines. These men all served aboard a submarine before June 30th, 1943, that had completed at least one war patrol. The navy preserved records of their service in documents referred to as "muster rolls." Accordingly, I am able to reconstruct sailors' tenures aboard submarines and the rates they attained in the course of their service. I then assign metrics of their submarines' success during their time aboard. Metrics is plural as I assign to sailors *both* the wartime understanding of their submarines' success and the truth as determined by postwar historians. I further match submariners to their later life outcomes leveraging their pages on the United States Submarine Veterans, Inc. (USSVI) website. These pages are maintained by an organization of retired submariners. They feature dates of birth and death, communities of final residence, and wartime serial numbers. To my knowledge, this is among the first matched datasets whose units of analysis are enlisted military personnel; past work leveraging military contexts studied officer ranks who are easier to track longitudinally.

Enlisted personnel were a population of men largely in their 20s and early 30s during WW2. Following the war, they would be affected by the demobilization of the United States Armed Forces, wherein the USN shrank by 85%. They comprised the bulk of a submarine's crew: a typical split between enlisted men and the officers to whom they were subordinate was 60 and 5. Although they were vital to a submarine's operations and held differing roles and responsibilities, they were not responsible for tactical decision-making.[1] Hence, the experiences of an enlisted man were subject to the idiosyncracies of broader wartime conditions and the officers to whom he was assigned. Further complicating matters were a series of design flaws with the Mark 14 torpedo. The Mark 14s were the primary weapon of the USN's fleet type submarines, large ocean going boats capable of extended patrols of six to eight weeks in length. Three defects – an unreliable torpedo depth system, a faulty magnetic exploder, and an incompatible physical exploder – compromised the performance of the Mark 14. Each of these defects obscured the existence of the other. They would not be addressed in their totality until November of 1943, some 23 months after the start of the war. For these reasons, submarine performance, as measured by sinking enemy units, was orthogonal to the abilities and efforts of the officers and enlisted men who served (Blair, 1975).

Promotions in this context were recommendations made by a submarine's captain to the USN Bureau of Personnel (BuPers) to advance an enlisted man in rate. In any setting, endogeneity concerns are pronounced when the explanatory variable in question is promotion. Within the military, it is particularly plausible that characteristics relevant for early career promotions will jointly determine later life outcomes. To overcome these identification challenges, I construct a set of three instruments that identify plausibly exogenous variation in sailors' rates.[2]

First, I assign to each sailor the number of attacks in which their submarine(s) participated during their specific tenure aboard their submarine(s), hereafter *attacks*. Enlisted men's agency to determine their postings and mission profiles was limited, and their agency to decide to attack enemy shipping more limited yet. Even so, one may be concerned that enlisted men were assigned to submarines on the basis of their abilities. However, I find no relationship between pre-war understandings of submarine captains' ability and the number of attacks which he authorized.

[1] In other words, it was not up to enlisted sailors whether to "engage the enemy more closely," to use the Nelsonian phrase. Such decisions, including determination of the parameters of attacks against enemy shipping and whether or not to attack at all, were the purview of the submarines' officers.

[2] In what is certainly not an isolated example of confusing terminology within the naval service, when applied to enlisted men, military ranks are "rates." Only officers' military ranks are referred to as such. To be consistent, I maintain this distinction in the text to follow.

This suggests that the navy would not have been able to reliably assign sailors to more aggressive captains. Additionally, using the average time a sailor spent at each rate prior to beginning wartime submarine service, I find, if anything, *negative* selection on this proxy for ability into more aggressive undersea service.

Second, I construct a quantification of the fog of war, hereafter Δ. Δ is the difference between wartime understandings and the truth of submarine success. The intuition is that captains would promote more enlisted men if they and their superiors believed their submarines to be more successful than they actually were. Because Δ incorporates postwar information, it constitutes an entirely imagined portion of perceived success and hence is orthogonal to the abilities of any individual enlisted man.

Third, I leverage spatiotemporal variation in the Earth's magnetic field that influenced torpedo success, hereafter *magnet*. The primary detonation system aboard the Mark 14 relied on detecting the magnetic field emitted by the target's hull. It was never live tested in tandem with the torpedo in which it was incorporated. Accordingly, at no point before the war did the United States Navy realize that the reliability of the torpedo would vary over the vast swathes of the Pacific. Then, the sentimental attachment of the officers who developed these "wonder weapons" to their flawed creations led to the suppression of news about this variability until June 24, 1943.[3] The Δ and *magnet* instruments support the estimates that use the *attacks* IV and allow for over-identification tests that reinforce the credibility of the exclusion restriction.

I find significant persistence of promotions in the short-term. I match 3,166 sailors to their rates in the navy at semiannual intervals through June 30th, 1945. Six months after the official revelation that the Mark 14 magnetic exploders were defective, promoted sailors were 0.74 pay grades ahead of their non-promoted counterparts. On June 30th, 1945, shortly before the end of the war on the 15th of August, 1945, those sailors were still 0.65 pay grades ahead. These results indicate that the promotions I observe in the larger sample are not ephemeral. Even as the submarine fleet tripled in size, non-promoted compliers did not catch up.

Beyond short-term persistence, promotion affected later life outcomes in economically meaningful ways. By matching 3,799 sailors to their death records, I am able to estimate the returns of promotion to longevity. Conditional on surviving the war, I estimate promoted sailors lived for 2.4 years longer. The average non-promoted war survivor in my sample lived to 75.7. To proxy

[3]Submarines out of Pearl Harbor would sail from July 1943 onward with deactivated magnetic exploders. However, not until November of 1943 would Admiral Ralph Christie, the most stalwart defender of the "feature," be forced to turn off the detonation system for submarines sailing from Australian ports.

for wealth, I match sailors to the median value of a single-family home in their ZIP code of final residence in the year of their deaths. I have this housing data at the ZIP5 level dating back to 1975. Accordingly, I match 1,782 out of 2,913 sailors who did not pass away before 1975. I estimate a promotion effect of 14% higher home prices. Within the national distribution of such ZIP-level home values, I find promoted sailors' communities are 7.1 percentiles higher. I find suggestive evidence that the home price effects are not driven by increased geographic mobility of promoted sailors. Promoted sailors are no more likely than non-promoted sailors to have passed away in a different state than the one in which they were born.

To consider the role that acquiring rate-specific human capital may have had in generating the observed effects on later life outcomes, I study the differential effects of promotion to the rates of chief petty officer (CPO) and petty officer first class (PO1c). The highest enlisted rate, CPOs take on additional managerial and administrative tasks. In the submarine context, CPOs would oversee all enlisted men within a rating.[4] PO1cs, the second highest enlisted rate, although benefiting from additional status by virtue of their higher rate, were not so responsible for other sailors. I find precisely estimated [$p = 0.004$] longevity returns of 10.2 years to promotions to CPO whereas promotions to PO1c yield imprecisely estimated returns [$p = 0.11$] of 3.7 years.

To summarize, I find that even under wartime conditions, when incentives for meritocratic promotion were especially high-powered, the navy did not totally attenuate the stickiness of promotions following an information shock. I further identify large, significant returns to early career promotion, along health and economic dimensions. These results can be viewed as complementary to work on affirmative action in American and Indian higher education (Bagde et al., 2016; Bertrand et al., 2010; Bleemer, 2020), which find persistent influence of career outcomes for lower-SES groups positively shocked by quota policies. Additionally, I identify an exceptional influence of promotion to a managerial role. This suggests that the observed effects of promotion operate not only through increased status but also through the acquisition and exercise of managerial talent. Hence, the findings here should not be taken in a zero-sum sense; as one example, a rotation system among labor market entrants in leadership capacities may yield qualitatively similar dividends.

My work complements research on the interaction of employer learning with personnel decisions. Models by Gibbons and Waldman (2006), Lazear (2009), and Milgrom and Oster (1987) suggest the importance of initial conditions to long-term labor market outcomes. Empirical evidence regarding

[4] Rating denotes an occupational class within the USN, e.g., fire controlman, torpedoman's mate, electrician's mate. Confusingly but importantly, ratings are distinct from rates, which refer to miltary ranks within the enlisted context.

the importance of asymmetric information to optimal worker allocation is not consistent (DeVaro and Waldman, 2012; Kahn, 2013). An adjacent manifestation of personnel market failures is the Peter Principle – the idea that every employee is promoted to his level of incompetence (Peter et al., 1969). Studying 131 firms, Benson et al. (2019) find evidence consistent with the Peter Principle, and conclude that firms make a trade-off between the benefits of promotion-based incentives and the costs of managerial mismatch. I find that an informational shock in the aggregate – the public admittance that Mark 14 torpedoes were deeply flawed – may have allowed officers to induce some reshuffling in the enlisted rates. That promoted enlisted sailors remain 0.65 pay grades ahead at war's end suggests that a wholesale realignment would have had greater costs than benefits to the navy, perhaps for morale reasons.

This paper also provides evidence on the persistence of early career shocks. Empirical evidence on the deleterious effects of negative entry shocks is generally consistent. Researchers find persistent earnings losses to graduating into a recession (Oreopoulos et al., 2012; Oyer, 2006) and being laid off because of a recession (Davis and Von Wachter, 2011). Evidence on the persistence of positive shocks is less clear. Evaluations of modern job training programs are mixed (Card et al., 2018; Schochet et al., 2008; Schochet, 2018); most find modest, imprecise estimates of efficacy at best.[5] Pecenco et al. (2020) finds persistent returns to entrepreneurship from a lottery that allocated managerial roles for government contracts but convergence in incomes five years after the lottery. Medium-run follow-ups to the U.S. Department of Housing and Development's Moving to Opportunity lottery find minimal positive to outright negative influence on the earnings and employment rates of adults and older youth (Katz et al., 2001; Kling et al., 2007). On the other hand, younger children whose families take up the program reap large returns to later life income (Chetty et al., 2016), an effect which holds up more generally for social safety net interventions (Hendren and Sprung-Keyser, 2020). Most closely related to my work, Aizer et al. (2020) find returns to height, lifetime earnings, and longevity from participation in the New Deal era Civilian Conservation Corps.[6] They suggest that short- to medium-run evaluations of job training and social safety net programs alike may underestimate the lifetime returns to participation.

I further address the debate surrounding the social determinants of health, to which the Whitehall Studies (Marmot et al., 1978, 1991) are seminal. These studies, whose sample consisted of British civil servants, established the positive, cross-sectional relationship between SES and health.

[5]As one example, Schochet (2018) finds a two percent increase in wages twenty years after participation in Job Corps, a training program run by the U.S. Department of Labor.

[6]These are, per year of training, one inch, 5.5%, and one year, respectively.

Anderson and Marmot (2012), using the Whitehall cohorts as a basis, identify the causal effects of promotion on coronary heart disease within the British civil service. They find results that suggest reductions in the incidence of heart disease by 2.6 - 12.8 % over 15 years. Relatedly, Redelmeier and Singh (2001) esimate that Oscar winners live 3.9 years longer than losers, and Rablen and Oswald (2008) estimate gains of 1 to 2 years for Nobel Prize winners. Such positive effects between status and health are not universal: Boyce and Oswald (2012) and Johnston and Lee (2013) find negative consequences for stress levels and mental strain. Borgschulte et al. (2021) finds that increased stressors are responsible for a two year decline in longevity in CEOs, where stressors are proxied by intensity of CEO monitoring. Nicholas (2020), attempting to replicate the Whitehall results in the context of a 1930 cohort of white collar employees of General Electric, finds a mortality *penalty* of three to five years for upper level executives. In contrast to much of this literature, my paper studies a specific population of men from blue-collar backgrounds at the beginning of their careers. For these individuals, I find unambiguously positive returns to longevity from promotion. Furthermore, promotions into higher-stress managerial roles appear to be particularly important for increased life spans.

My paper proceeds as follows. Section 2 gives background on the U.S. submarine campaign in the Pacific Theater. Section 3 describes my data and gives descriptive statistics. Section 4 describes the construction of my vector of instruments and the empirical strategy I use to isolate causal effects. Section 5 presents my main results on longevity and SES. Section 6 discusses potential mechanisms through which idiosyncratic promotions influenced later life well-being. Section 7 concludes.

2 Background: the U.S. Submarine Campaign against Japan

Japan is poor in natural resources. In the 1850s, the arrival of the American Commodore Perry's "Black Ships" in Tokyo Bay stirred the island nation from self-imposed isolation. With the realization that its fortunes would sink or swim with the tides of industrialization, Japan began the Meiji Restoration. By the 1900s, Japan was a great power with a fledgling colonial empire. For a host of reasons well beyond the scope of this paper, nationalism reached feverish heights in the 1930s with the ascension of the Shōwa Emperor. Japanese nationalists were convinced that to stand tall among the nations of the world and acheive Hakkō Ichiu, it had to control natural-resource rich China.[7] This accentuated difficulties in Japan-United States relations. The United States was committed to an Open Door Policy in China: no one power should be dominant in commercial trade with

[7] Roughly translated, Hakkō Ichiu means "all the world under one roof." The extent to which Japanese politicians and military leaders took this literally remains a matter of debate.

that nation. The Japanese invasion of China in 1937 made such a policy untenable. Regarding the Japanese seizure of southern French Indochina as the last straw, the United States imposed an asset freeze and trade embargo in July 1941.[8] To satiate the war machine's need for vital natural resources like oil and bauxite – resources no longer accessible with the embargo – Japan decided to seize the Dutch East Indies. Confounding Japanese plans to seize the East Indies was the Gordian Knot of the Philippine Islands. The Philippines, then controlled by the United States, lay directly astride the trade routes on which Indonesian resources would flow to Japan. Therefore, military leaders determined that the American presence on the islands had to be eradicated so as to ensure the safe arrival of raw materials in Japanese ports (Frank, 2020).

Hence, Japan decided to attack Pearl Harbor on December 7th, 1941, beginning the Pacific War. Figure A1 depicts the scope of the Pacific Theater, which stretched from the Aleutian Islands of Alaska to the Solomon Islands off New Guinea to the Indian frontier with Burma. American war planners considered the vast areas over which they would fight a war against Japan. They planned for unrestricted submarine warfare accordingly. Experience from the First World War and the campaign against Nazi Germany in the Atlantic Ocean demonstrated the vulnerability of island countries and their sea lanes of communication to submarine blockade. Indeed, the submarine service would bear primary responsibility for the destruction of the Japanese economy–the 263 American submarines that went on war patrols collectively sank about 5 million tons of Japanese shipping. This was more than half of all Japanese shipping lost from all causes during the war (Alden and McDonald, 2009).

But the early to middle stages of the submarine campaign were hobbled by teething problems; the main culprit for these was the Mark 14 torpedo. The torpedo, per the Bureau of Naval Ordnance (BuOrd), would supposedly give "the United States a tremendous advantage over any prospective enemy." This was because it featured a top-secret magnetic influence exploder. The idea was as follows. Instead of exploding against the side of a ship's hull, the torpedo would use the magnetic field emitted by the hull to determine when it would explode. Ideally, this would take place while the torpedo was running underneath the ship's keel. Doing so would lead to nearly uncontrollable flooding. Even if the ship survived, breaking such a structurally pivotal part of the ship would lead to it becoming a constructive total loss. Yet the combination of the two systems, developed during the cash-crunched Depression years, was never actually live tested. At no point in the development

[8] To make clear the extent to which the oil embargo impacted Japan's war effort, in 1939, Japan produced 2.3 million barrels of oil domestically; it imported 27.2 million barrels from the United States and 6.3 million from other sources (Anderson, 1975).

process did the USN fire the Mark 14 torpedo, equipped with the Mark VI magnetic detonator, so that it would explode against a target ship as would happen in wartime. As such, U.S. submarines set sail in December of 1941 with their torpedoes suffering from three faults. First, the Mark 14 did not run steadily at depth, prohibiting the magnetic exploder from picking up the target's magnetic field. Second, the magnetic exploder itself was faulty. Due to the different strengths of the Earth's magnetic field across the Pacific Theater relative to the New England coast where the exploder was developed, the torpedo tended to explode prematurely. 1920s physics recognized that the geomagnetic field was not everywhere equally strong. However, naval torpedo designers failed to ascertain the extent of the interaction effects between the geomagnetic field and the local magnetic fields emitted by the hulls of target ships. Third, the backup contact exploder, which was a copy of an exploder design from an older model of torpedo, was also faulty. Each of these flaws concealed the existence of the others, and so only in November of 1943 would the submarine service receive reliable torpedoes.

Notably, junior officers associated with BuOrd were united in their belief that the torpedoes worked as designed. Unfortunately for the USN's submarine crews, those officers were, by the Second World War, admirals directing the submarine campaign. This situation lasted through September of 1943.[9] Thus, submarine captains received conflicting signals about the extent to which these torpedoes were or were not actually defective. Some captains repeatedly witnessed the torpedoes failing to perform according to specification. Yet the admiralty insisted that all was going according to plan and that any shortcomings were the sole fault of captains and their crews. Furthermore, some successes were achieved–through June 1943, American submarines sank 1.2 million tons of Japanese shipping.[10] The dilemma facing American submarine commanders was best summarized by the words of Admiral Ralph Christie. Christie commanded U.S. submarines operating out of Fremantle and was intimately involved with the Mark 14's development. Expressing his frustrations with Admiral Charles Lockwood, who commanded submarines operating out of Pearl Harbor and gave somewhat more credence to his skippers' reports of malfunctioning torpedoes, Christie remarked: "(Lockwood) is [against] the torpedo but brags about the tonnage sunk. What sunk them, spuds?" (Blair, 1975)

[9] While the USN identified the three primary flaws in the Mark 14 by September, corrected torpedoes would not reach submarines until November of 1943.

[10] I present especially egregious anecdotes from Blair (1975) of the early days of the submarine campaign in Appendix A.1.

2.1 Submarines and their Crews

The naval theorist Alfred Thayer Mahan and his book *The Influence of Sea Power Upon History* decisively influenced the world's navies in the 20th century; in particular, it romanticized the notion of the "decisive battle." Wars would be won or lost in a single, cataclysmic engagement between battleships.[11] Indeed, the annihilation of the Russian Navy at the hands of the Imperial Japanese Navy in the 1905 Battle of Tsushima seemed to vindicate this thesis.

In the framework of the decisive battle, fleet submarines were to support the battleships.[12] Scouting ahead of the battle line, they would report on the positions on the enemy fleet. Should they be in a position to do so, they would also attempt to sink enemy warships. Toward this end, they were built to a common specification. The navy designed its fleet submarines to be roughly 300 feet long and 1,500 tons displacement. It generally equipped the ships with 24 torpedoes, which could be fired from 10 torpedo tubes, six forward and four aft. As the most advanced and capable submarines in the fleet, these torpedoes were the Mark 14 type. Given this level of equipment, they were capable of extended patrols; submarines could spend up to 56 days away from port. Figure A2 displays an example of a fleet submarine and a Mark 14 torpedo.

Unwitting victims to the ignorance of the admiralty regarding the Mark 14s' many faults were the USN's submarine crews. Although the precise crew complement varied over the course of the war as additional systems were installed, it typically numbered 65. Of these 65, 5 were officers and 60 were enlisted men. Most officers during the first half of the war were graduates of the United States Naval Academy in Annapolis. They were responsible for planning, organizing, and leading submarine operations. Every officer occupied a higher rank in the military hierarchy than any enlisted man, irrespective of the rate of the enlisted man and his tenure within the navy. Accordingly, they were responsible for assigning enlisted men to tasks. They also recommended enlisted men for promotion. These enlisted men were less educated than officers and largely born to working-class or farmworker parents, and were on average 22 years old at the war's outbreak.

All enlisted submariners were volunteers–once in the navy, one had to opt into submarine service. The process was competitive. Basic Submarine School (BSS), a requirement for submarine

[11] By the Second World War, battleships were ships extending at least two football fields (600 feet) in length and displacing well over 30,000 tons. They carried guns between 11 and 18 inches in diameter and were armored against weaponry of similar caliber.

[12] Besides fleet submarines, the United States also employed a different type of submarine, the S-class. These boats, derisively referred to by sailors as "pig boats," were about half the size of the fleet submarines. Because of their smaller size, these submarines were never equipped with the Mark 14. Hence, they and their crews are not part of the analysis that follows.

service, was oversubscribed. A 1946 study of accepted applicants found that these sailors received a score of 58 on the Average Navy Battery Test, a general naval aptitude exam. The average score for all enlisted personnel was 50. This suggests submariners were positively selected on aptitude. Even with this positive selection, trainees departed BSS at high rates.[13] After completing BSS, the Bureau of Naval Personnel allocated them to submarines as wartime conditions demanded. The navy, recognizing the special nature of submarine service, rewarded volunteers with extra pay (approximately 20% over the usual pay schedule) and better food. The unique experience of submarine service led officers and enlisted men alike to maintain uniquely high levels of *esprit de corps* (Goodman, 2016).

As the analysis that follows studies promotions within enlisted men, I describe the promotion process here. Within the 60-strong complement of enlisted men, there was an internal chain of command. Enlisted men were assigned according to a 7-grade hierarchy. The USN called each grade a ”rate.” Advancing rates required endorsement by the captain of the ship aboard which the sailor served. There were certain sailing minimums required for promotion, but in practice, these were rarely enforced. I present a wartime document that gives a general overview of this process in Figure A3. Sailors in rates five through seven were nonrated and served as general apprentices to higher rated sailors in rates two through four. Those sailors were referred to as petty officers. They were also considered "rated." Rated entails that sailors had specialized within a particular area of operations aboard the submarine.[14] Petty officers held command responsibility for nonrated sailors. The highest pay grade among enlisted rates was rate one which denoted chief petty officers. These officers held overall command responsibility for all enlisted men within their rating. I present a graphical representation of this promotional path in Figure A4. Additionally, captains could recommend enlisted men for further promotion to warrant officer, whose position in the military chain of command lies in between enlisted men and flag officers. Rarely, as the wartime situation and their individual merit warranted, captains recommended enlisted men for officer ranks.

[13] Historians approximate 25 to 30% of the accepted applicants to have left the school in the first two weeks. The school used its six weeks of training to weed out applicants who did not have “the personality to tolerate the cramped living conditions on a submarine” into the general service (Goodman, 2016).

[14] The three most popular ratings for submariners were Torpedoman’s Mate, Electrician’s Mate, and Motor Machinist’s Mate. A complete list of ratings can be accessed at `https://www.uniform-reference.net/insignia/usn/usn_ww2_enlisted.html`.

3 Data and Descriptive Statistics

In this section, I describe a novel longitudinal dataset for 4,821 enlisted submariners serving aboard USN fleet submarines. These sailors embarked for war patrols between the Attack on Pearl Harbor on December 7th, 1941, and June 30th, 1943, 6 days after Admiral Chester Nimitz ordered all submarines sailing from Pearl Harbor to deactivate their magnetic influence exploders. I henceforth refer to the period in between these dates as the "magnetic interval."

3.1 Individual Level Submariner Data

To identify individual enlisted men, I digitize submarine crew rosters that the USN's Bureau of Personnel (BuPers) mandated officers prepare on a quarterly basis. Using wartime serial numbers, I match sailors in the rosters to their pages on the United States Submarine Veterans, Inc. website. I further match these sailors to their mortality records in the National Archives' public release of the Social Security Administration's (SSA) Numident file. When I am unable to perform that match, I match to death records using FamilySearch, an online genealogical database centralizing records from various public and private data sources. When last place of residence information is available, I match on ZIP codes to local single-family home values using historical home prices from Zillow and the Federal Housing Financial Agency (FHFA).

Historical Muster Rolls: These muster rolls are crew rosters. There are two types. The first contain the full name of the sailor, their military service number (serial), rate, date of enlistment, date first received aboard the submarine, and place of enlistment. BuPers required that captains prepared these rolls every 90 days, although captains sometimes updated them with greater frequency. I present an example from the USS Grayling in Figure B1. The second, called "Report of Changes," describe any modifications to a submarine's enlisted complement; these may include changes of ratings, receptions and transfers to and from other ships, hospitalizations, among other events. I present an example from the USS Greenling in Figure B2.

USSVI: As a veterans' organization, the USSVI maintains a website to help submariners find shipmates, reunion information, and access crew lists. The web pages are maintained by navy veterans and their families; USSVI has no official affiliation with the U.S. Navy.[15] The dedication of USSVI members toward documenting the silent service's history leads to extensive coverage for

[15]These pages can be accessed at `https://www.ussvi.org/Boats.asp`. The USSVI relies on the same back-end as `http://www.decklog.com/homeport.asp`, a more comprehensive listing of naval veterans.

Second World War submariners. Information listed on sailors' profiles can include name of spouse, date of death, date of birth, location of birth, years served in the navy, highest rank achieved in naval career, list of ships served aboard, and any awards received. Using the muster rolls to identify individuals who meet my criteria for inclusion, I am able to identify 4,821 sailors present in both sources.

SSA Numident File: the SSA's public use Numident file contains data on about 50 million deaths between 1936 and 2007. The information contained therein includes their full name, race, state or country of birth, date of birth, date of death, age at death, the 9-digit ZIP code of residence at time of death, and the state in which they received their social security number. The algorithm I used to match between the Numident file and the muster rolls was as follows. First, I restricted the Numident file only to males born prior to 1930, the last plausible year in which sailors appearing in the muster rolls could have been born (the USN required all enlisted men to be at least 17 years of age, although some slipped through the cracks). I match exactly on full name and month and year of birth. If there were multiple matches, I match on day of birth.

Online Genealogical Databases: I use three genealogy websites to supplement mortality data from DeckLog and the Numident – familysearch.org, findagrave.com, and oneternalpatrol.com. Family Search is a free service provided by the Mormon church that centralizes ancestral records from across the internet and public use archival records. Because Family Search acts as a data aggregator, permits users to input their own family histories, and includes coverage beyond the years for which the Numident file is extant, it allows me to make additional matches to later life outcomes. Find a Grave contains records on gravestones for over 190 million individuals. Because it allows for user entry of information, it sometimes includes obituaries and other information pertaining to the deceased. On Eternal Patrol is a website maintained by the Pacific Fleet Submarine Museum that documents the lives of all 3,630 wartime submarine fatalities in the U.S. Navy; in particular, it has birthdays and birth locations for these sailors.

Housing Values: As a proxy for end-of-life SES, I obtained historical valuations of single-family homes by combining data from Zillow and the FHFA's housing price index (HPI) time series. Zillow uses a proprietary algorithm incorporating both public, user generated, and listing service real estate data to calculate home values. The HPI reflects realized price trends in home sales. The Zillow sales price data are extant from 1996 whereas the HPI is available from the late 1970s for some geographies; combining the two sources permits me to create a panel at the ZIP5 level between 1975 and 2020. Of the 2,913 sailors who lived past 1975 that I was able to match to death records, I mapped 1,782 (61.1%) of them to the median value of single-family homes in their ZIP code of final residence. As an alternative SES proxy, I also compute the percentile rank of sailors' final ZIP code of residence in the national distribution of ZIP5 home values in the year of their death (home price rank). This formulation reduces the scope for a secular increase in the price of housing to bias my results.

3.2 Submarine Torpedo Performance

Data on torpedo performance aboard submarines come from two sources. I assemble these data for 72 fleet submarines that used the Mark 14 torpedo with the magnetic exploder. The USN also operated older submarines which used the older Mark 10 torpedo that relied on a physical contact exploder; those submarines are not included in my dataset.

Submarine Operations Research Group (SORG): During the war, SORG tabulated both successful and unsuccessful attacks, subject to the endorsements of admirals, from submarine commanders' patrol reports into a standardized format.[16] Thus, the SORG records represent the USN's contemporaneous understanding of submarine success. These data are rich and include the latitude and longitude of the attack, the date and time of the attack, the number of torpedoes fired, the number of torpedoes reported hit, among other characteristics. SORG attempted to verify patrol reports with traditional radio signal intelligence. It was not generally privy to the ULTRA intelligence network, the USN's top secret intelligence gathering apparatus. Nonetheless, it was regarded even after the war, as the best wartime compilation of submarine success.

Alden and McDonald (2009): hereafter AM, this is the definitive work on the true success of U.S. submarine attacks during the Second World War.[17] AM augments SORG records with ULTRA as well as Japanese sources. In general, the AM records address numerous false positives in the SORG data. Besides the less charitable interpretation of over-claiming as some combination of military hubris and motivated reasoning, sea conditions and enemy counterattacks usually made prolonged verification of attack success an unwise exercise. All these factors taken in combination led AM to correct substantial inaccuracies in SORG with respect to the damage inflicted on Japanese shipping by U.S. submarines.

[16] The website `combinedfleet.com` digitized the SORG records. They can be accessed at: `http://www.combinedfleet.com/sorg.php`. I present an example of the digitized records in Figure B3.

[17] I present an example of the data in AM's tables in Figure B4.

3.3 Sample Description

To fix ideas, I characterize the military experience of the median enlisted man in my sample. He enlisted in the navy in 1940. He served on one submarine during the magnetic interval for approximately nine months. He began his tenure as a petty officer, third class, and was promoted one time to the rate of petty officer, second class.[18] Through his patrols, he participated in 10 attacks against enemy ships. His ship expended 2.8 torpedoes in each of these attacks. His superiors understood 30.4% of all of those torpedoes to have exploded successfully; the reality was that 20.5% of them did so.[19] I give the full set of summary statistics for these sailors in Table 1.

I next turn to describing sailors' attributes as revealed by the non-archival datasets to which I matched. Figure B8 plots the distribution of birth years for 3,833 matched sailors. The median birth year is 1919. Figure B9 plots the distribution of longevity for all 3,799 matched sailors. The bimodal distribution reflects the high rate of wartime casualties in submarine service.[20] Figure 1 presents the longevity distribution for 3,100 war survivors. The median life span was 76.8.[21] Figure B10 plots the distribution of median home prices in the sailor's final ZIP code of residence in the year of his death. I converted all home values to constant 2000 US$. The median value is $142,440. Figure B11 plots the distribution of the home price rank of sailors. The median rank is the 55th percentile.

4 Empirical Framework

In this section, I describe my strategy to identify the causal effects of promotion through an instrumental variables approach. Given the setting of this study, the reader may be concerned that *wartime* promotions are endogenous to later life outcomes. Captains may have selected men for promotion based on characteristics advantageous to health and well-being decades after wartime service. Alternatively, men who distinguished themselves in the heat of combat may have been more risk-seeking or overconfident, attributes with an ambiguous relationship to wealth and longevity. Accordingly, I construct three instruments – *attacks*, Δ, *magnet* – to exploit plausibly exogenous variation in promotion decisions. Sections 4.1, 4.2, and 4.3 address the construction of and justification for each of these instruments in turn. Section 4.4 describes the integration of these instruments into a two-stage least squares framework.

[18] I present the distribution of average observed promotions at the submarine-level in Figure B5.

[19] Figure B6 and Figure B7 present the full distribution of the AM and SORG metrics.

[20] The submarine service's casualty rate of 22% was the highest of any branch in the military (Blair, 1975).

[21] This compares quite favorably to the general population. For the 1919 birth cohort, life expectancy at age 45 was 70.7 Goldin and Lleras-Muney (2019).

4.1 Instrument the First: *attacks*

My first instrument is the number of attacks in which a sailor participates during his submarine service contemporaneous with the magnetic interval. Expressed symbolically:

$$attacks_i = \sum_{j=1}^{J} \sum_{a_i=1}^{A_i} \mathbb{1}[a_i \in K_j] \tag{1}$$

Where i indexes sailors, j indexes submarines, a_i is an attack in which sailor i participates, and K_j is the set of all attacks K led by submarine j. I present the distribution of $attacks_i$ in Figure C1.

Three arguments underlie the use of *attacks*. First, enlisted men's assignments to submarines were consequences of wartime needs. Enlisted men had limited ability to influence the timing and location of their submarine service (Green, 2012). Second, submarines operated under conditions of strict radio silence. Atmospheric conditions did not permit flawless reception of transmissions that updated submarine captains on the locations of enemy shipping. Furthermore, the source material itself, though derived from the impressive work of the codebreakers at Station HYPO, was not perfect.[22] Last, although enlisted men facilitated attacks against enemy submarines, they did **not** exercise discretion over whether to attack. Such decisions were the purview of the submarine's captain.

A concern about the use of *attacks* as an IV is selection of sailors into more aggressive submarine service; to allay these concerns, Table C1 presents results regressing the number of attacks in which a sailor participates on the speed at which he advanced through the enlisted hierarchy prior to his wartime submarine service. I take that speed, measured in months per rate, as a proxy for sailor ability. The results suggest, if anything, *negative* selection on this measure into an aggressive submarine tenure. Column 4, estimating on the full sample of 4,335 sailors who participated in a nonzero number of attacks, estimates that an additional month spent per rate increases $attacks_i$ by 0.04. This specification includes fixed effects for sailors' start rate. Because some sailors only began wartime submarine service months after the Attack on Pearl Harbor, one may then be concerned that this result is driven by differences in the pre-war and wartime promotion regimes. Perhaps sailors who began service before the war spent more time in each rate due to a slower pace of advancement, but then participated in more attacks mechanically. Splitting the sample accordingly, I find weak evidence for positive selection for sailors with pre-war submarine service. There are somewhat more strong findings for negative selection for sailors who only began submarine service

[22] Blair (1975) notes: "Countless times, U.S. submarine captains were vectored to [high value military targets] only to find that, because of navigational errors on the part of the Japanese or themselves, these high-speed prizes passed just beyond attack range and could not be overtaken."

after the outbreak of the war. These counter-intuitive results suggest that BuPers was not allocating personnel to submarines based on the perceived future aggression of that submarine's patrols.

Such an argument for selection of sailors into more aggressive submarines also relies on the Naval Admiralty's ability to forecast future submarine performance based on commander attributes. To test this, I identify the class ranks of all 137 submarine captains who led the 72 fleet submarines I study during the magnetic interval. To do so, I digitized the class standings of the 16 Naval Academy classes to which these 137 captains belonged. I present a binscatter of the relationship between a captain's class standing and the number of attacks he led in Figure C6. The binscatter controls for the number of patrols the captain led as well as the theaters in which he sailed.[23] The nature of this relationship is evidently weak. The regression coefficient is -0.02 ($SE = 0.012$) suggesting an economically and statistically insignificant relationship between observable measures of commander ability and his wartime aggression. This again suggests that submarine aggression was something that could not be pre-determined by BuPers and sailors alike.

4.2 Instrument the Second: Δ

The second instrument is the difference between the wartime understanding of submarines' performance and the truth of their performance as revealed by postwar historians, hereafter Δ. Δ can be thought of as a quantification of the fog of war.[24] Expressed symbolically:

$$SORG_i - AM_i = \frac{claims_i - truth_i}{torpedoesfired_i} = \Delta_i \tag{2}$$

Where *claims* is the number of torpedoes recorded in SORG as having successfully exploded during the sailor's tenure, *AM* is the number of torpedoes recorded in AM as having actually exploded during the sailor's tenure, and *torpedoesfired* is the total number of torpedoes fired by the submarines on which the sailor served during his time aboard. I present the distribution of Δ in Figure C2.

Δ introduces plausibly exogenous variation in promotions for the following reasons. First, Δ incorporates information unavailable to the navy during the war. The SORG reports were collated on the basis of the mandatory patrol reports captains filed with the navy at the end of each patrol. Attacks described in the patrol report would then be sent to superior officers for endorsement on

[23] US submarines sailed from four ports: Brisbane, Dutch Harbor, Fremantle, and Pearl Harbor. The naval admiralty allocated patrol zones (theaters of operation) to each of those ports based on their geography.

[24] The concept of the fog of war was first raised by Prussian military strategist Carl von Clausewitz in his treatise *On War*. He writes: "War is the realm of uncertainty; three quarters of the factors on which action in war is based are wrapped in a fog of greater or lesser uncertainty."

the basis of signals and cryptographic intelligence. These reports were not totally accurate. Figure C4 reflects the evolution of torpedo performance within the submarine fleet on a monthly basis for the first 25 months of the war. The near parallel slope of the two metrics is reflected in Figure C5, which plots the time series for Δ by the same criteria as the previous figure. It shows that captains and admirals alike consistently believed that about 10 percent more torpedoes exploded than was actually the case.[25] That the regression coefficient of .0005 (SE = .001) is statistically indistinguishable from zero suggests that it was not the case that captains somehow became more skilled at concealing the truth of their failures to higher-ups as the war went on. It is indicative that Δ is truly capturing a measure of noise. Second, an individual enlisted sailor had very little to do with Δ. Δ is a construct of captains' patrol reports and the ability of the naval high command to verify those reports.

One could postulate that less able captains have higher Δ – to mask their lower seamanship, such captains would take liberties in describing their successes. The existence of this relationship would compromise my interpretation of Δ as idiosyncratic noise. To check this, I repeat the exercise carried out for *attacks*; I plot captains' Δ against their Annapolis class ranking. I present the binscatter in Figure C7. The regression coefficient is -0.0008 (SE = -0.0005) again finding that pre-war measures of commander ability do not correlate with Δ. This suggests that more- or less- able commanders were unable to manipulate perceived wartime success in their favor. Therefore, it is unlikely that BuPers somehow allocated sailors to submarines based on the ability of its captain to obfuscate his true success.

4.3 Instrument the Third: *magnet*

On the 8th of May, 1926, the Newport torpedo station conducted a live fire test that, in the opinion of the presiding officers, would be "the opening of a new phase in torpedo warfare." This was the test of the Mark VI magnetic influence exploder retrofitted onto the older Mark 10 torpedo. Success by German magnetic mines during the First World War inspired Newport to develop its own version of a magnetic detonation device. The test, conducted against a decommissioned submarine, was a partial success. The first torpedo fired, foreshadowing future events, ran too far underneath the target. But the second torpedo successfully detonated and destroyed the target submarine. This would be the only live fire test of the Mark VI until the Second World War. The combined Mark VI

[25] The most dramatic case of these discrepancies was that of Commander Roy Davenport. Quoting Blair (1975), "Credited with seventeen ships sunk for 151,900 tons during the war, his score as confirmed by JANAC was only eight ships for 29,662 tons... Most of the medals awarded submarine skippers during the war had been given out on the basis of ships or tonnage scores. Should they now be withdrawn? There was no way, and nobody was inclined to do it."

and Mark 14 torpedo system would never be tested in peacetime.

My third instrument, *magnet*, exploits the variation in torpedo performance induced by the Earth's magnetic field. While properties of the geomagnetic field, including its spatio-temporal variation, were known to the scientists at the time of the Mark VI's development, less known was the extent of that variation.[26] Especially unknown, given the lack of testing, was the interaction it had with the magnetic fields emitted by the hulls of target vessels. In other words, the magnetic exploders, calibrated to work off the coast of Rhode Island, did not work with the same efficacy at different locations around the globe. Hence, using the International Geomagnetic Reference Field (IGRF) Model, a mathematical description of the magnetic field valid from 1900 until 2025, I calculate:

$$\Delta_{l,t}^{mag} = |VertIntens_{RhodeIsland,5/8/1926} - VertIntens_{l,t}| \tag{3}$$

Where l indexes attack locations, t indexes attack dates, and $VertIntens$ is the vertical intensity of the Earth's magnetic field as predicted by the IGRF. Next, I save the predicted values from a regression of $AM_{l,t}$ on $\Delta_{l,t}^{mag}$: $\hat{y}^{mag}$. Figure C10 plots a binscatter of this relationship for both the AM and SORG measures. It is remarkably linear. At the median absolute deviation from the conditions of the live fire test (50,845 nanoteslas), 10.2% less torpedoes are estimated to explode. The relationship is robust to theater fixed effects (C11) and captain fixed effects (C12). Interestingly, although the relationship is obvious in studying the true outcomes in panel (a), it is less obvious when looking at wartime understandings. This somewhat assuages the naivete of the admiralty – by "controlling" for certain factors, they could make the observed negative relationship in Figure C10, panel (b), disappear.

To estimate the number of torpedoes predicted to explode based on variation in Δ_{mag} for each attack, I calculate:

$$estmag_a = \hat{y}_a^{mag} * torpedoesfired_a \tag{4}$$

Where a indexes attacks. Using the predicted attack success rate, I can then recompute sailor-specific success rates substituting $estmag_a$ appropriately. Expressed symbolically:

[26] Today, in order to capture irregularities with the geomagnetic field, NOAA measures it with "satellites, and approximately 200 operating magnetic observatories worldwide, as well as several more temporary sites." I present a representation of the field today in Figure C9.

$$magnet_i = \frac{\sum_{a_i=1}^{A_i} estmag_{a_i}}{\sum_{a_i=1}^{A_i} torpedoesfired_{a_i}} \tag{5}$$

Where A_i is the set of all attacks in which a sailor i participated. I present the distribution of *magnet* in Figure C3.

Tables C2, C3, and C4 test for correlation between *magnet* and the AM, Δ, and SORG measures respectively. On the right hand side, I include *magnet*, a month time trend, and their interaction term. If it was the case that the navy knew of these magnetic influence failures and seriously attempted to address them, then there should be a positive and statistically significant coefficient on the interaction term. The null that the coefficient on the interaction term is zero fails to be rejected for all specifications. These estimates are robust to ship and captain fixed effects. This strengthens the argument that *magnet* was a truly exogenous factor that influenced submarine torpedo performance which neither enlisted man nor officer nor flag officer could influence.

4.4 Model Specification

In my preferred specification, I leverage all three instruments in the first stage, such that:

$$Promote_i = \alpha + \beta_1 f(magnet_i) + \beta_2 f(\Delta_i) + \beta_3 attacks_i + \gamma_{startrate_i \times tenure_i} + e_i \tag{6}$$

Where i indexes sailors, *Promote* indicates the amount of pay grades advanced by the sailor, f is a third degree polynomial, and $\gamma_{startrate \times tenure}$ are two-way fixed effects between the sailor's entrance rating and his naval tenure.[27] I present the results of this first stage regression in Table C5.[28] Each set of instruments significantly predicts promotions. Δ and *magnet* will not be sufficiently powered to act as standalone instruments; however, by adding them to the first stage, I can perform over-identification tests to justify the validity of the *attacks* instrument with respect to the exclusion restriction.

Then, the second stage regression is:

$$Y_i = \alpha + \beta \widehat{Promote}_i + \tilde{\gamma}_{startrank_i \times tenure_i} + \epsilon_i \tag{7}$$

Where Y_i is some outcome of interest. The identifying assumption is that conditional on fixed effects that address time-invariant unobservables for sailors with common wartime starting rates (*startrate*) and enlistment years (*tenure*), the instruments are not systematically correlated with factors that

[27] The choice of the third degree polynomial allows for non-monotonicities in the relationships of promotion with Δ and *magnet*. The results are qualitatively unchanged by a choice of polynomial degree > 1. These are available on request.

[28] I present results with standard errors clustered at the submarine level in Table C6.

affect later life outcomes except through their effect on promotions.[29] In identifying the causal effects of promotion, the LATE complier definition will apply – i.e., promoted individuals refer to sailors who are able enough to merit promotion given a large positive exogenous shock but are not able enough to merit promotion in the absence of that shock – unless explicitly specified. These compliers, on average, should be of similar ability. The instruments will not consider variation from 'always-takers' – sailors sufficiently able to distinguish themselves even on unlucky submarines – and 'never-takers' – lower ability sailors who will not be promoted even if their submarines are exceptionally lucky.

5 Results

In this section, I report on the primary results of my analysis. Section 5.1 describes IV estimates of the effects of promotion on longevity. Section 5.2 describes IV estimates of the effects of promotion on proxies for SES. All of these results are conditional on surviving the Second World War.[30] In light of sailor-specific tenures aboard submarine(s), I report robust EHW standard errors in the main tables. However, Appendix D presents corresponding tables in which the reported standard errors are clustered at the level of the submarine aboard which the sailor served longest. The statistical significance of my results is not compromised by these alternative standard errors.

5.1 Mortality

Table 2 presents results for the IV estimates of the returns of longevity to promotion. Column 1 uses *attacks* as the sole instrument, columns 2 and 3 add Δ and *magnet* respectively, column 4 includes all 3 instruments, and column 5 adds birth year fixed effects. The F-statistic is strong irrespective of the excluded instruments. Likewise, the point estimates are stable across specifications. Column 5 reports the estimate from my preferred specification; I estimate an early-career promotion increases longevity by 2.4 years, on average. For each specification, I provide the over-identification J-statistic with its associated p-value. The tests suggest the alignment of the LATEs across each instrument. I consistently fail to reject the null that the over-identifying restrictions are valid. Hence, even if the

[29] One cannot entirely dismiss the possibility that these instruments are correlated with other co-determinants of later life outcomes; for example, a more aggressive submarine tenure may have contributed to post-traumatic stress disorder. Cesur et al. (2013) identify a causal effect of combat exposure in the War on Terror on PTSD onset. If my instruments are related to post-war trauma or mental health shocks, then one should interpret my estimates as *lower bounds* of the true effect, given the deleterious consequences of service-related trauma for later life well-being as identified by Angrist (1990), Angrist et al. (2011), Bedard and Deschênes (2006), and Savoca and Rosenheck (2000), among others.

[30] One should expect minimal bias from attrition. Because of the nature of undersea warfare, out of 52 submarines lost in WW2, only 7 did not go down with all hands. In light of the discussion in Section 4 regarding the challenges BuPers would have faced in selective assignment of sailors to submarines based on predicted performance, this should assuage concerns for positive selection of the sample due to attrition.

attacks instrument is correlated with unobservables that also influence longevity, my data imply that such correlation would not invalidate the exclusion restriction on *attacks*.

Table D1 reports the corresponding OLS estimates. That the IV estimates are substantially larger than the OLS estimates may reflect the idiosyncratic nature of these promotions. Economists have long recognized that the salience of a shock to an individual reflects deviations from that individual's expectations or reference groups (Deaton and Paxson, 2007). In this context, the expected career advancement for high type seamen may be dramatically higher than lower ability seamen. If the true data generating process does include such deviations, then these OLS estimates would suffer from significant attenuation bias, as these unobserved expectations would enter negatively into the DGP.

5.2 Socioeconomic Status

Table 3 presents results for effects of promotion on my first SES proxy: the median value of a single-family home in the sailor's final ZIP code of residence in the year of his death. I log transform the variable to ease interpretation of the coefficients. I estimate a promotion to increase log home prices by 14%, on average. Once more, the F-test remains strong across all specifications. The null that the over-identifying restrictions are valid is marginally rejected in columns 2 and 5 and it is rejected at the 5% level in column 5. Nonetheless, the estimated magnitudes are stable across specifications with overlapping confidence intervals. The OLS estimates, presented in Table D3, again suggest significant attenuation bias therein.

One may be concerned that the effects I observe in Table 3 are driven by a secular rise in the real price of housing over time. To mitigate these concerns, I reformulate the home price variable. For each ZIP code with extant housing price data, I assign the percentile rank of that ZIP code's median home price in the national distribution of ZIP-level median home prices. Accordingly, Table 4 presents IV estimates of the effect of a promotion on home price rank. With this reformulation, I fail to reject the null hypothesis of the J-test in all specifications. In my preferred specification, an additional promotion increases home price rank by 7.1 percentiles. This is about 2.9 times more than the positive and statistically significant OLS estimates I present in Table D5.

6 Mechanisms

In this section, I discuss mechanisms that may contribute to the economically significant effects I identify in Section 5. Section 6.1 tests for short-term persistence of idiosyncratic promotions within the wartime USN. Section 6.2 considers the role that promotion to the rate of chief petty officer – a rate which held more managerial responsibilities than other rates in the enlisted hierarchy – may have had on later life health. Section 6.3 presents results on the extent to which geographic mobility influenced the SES findings.

6.1 Short-term Persistence

Were promotions persistent in the short run? The U.S. Navy began the war with 114 submarines, some of which were totally obsolete. Over the course of the Pacific War, a further 201 submarines were commissioned. The tripling of the submarine fleet would have led to an abundance of positions into which sailors could have been promoted. Therefore, it is possible that the gap between promoted and non-promoted compliers could have significantly closed by the end of the war in mid-1945. To test this, I match sailors to their rates at 6-month intervals following the magnetic interval through the 30th of June, 1945. Table 5 presents IV estimates for the effects of promotion on sailors' later-war rates.[31] I present these results for 3,166 sailors whose rates I was able to identify at each interval. Odd columns instrument for promotions using *magnet* and Δ; even columns instrument for promotions using the full set of instruments. On December 31st, 1943, I estimate a promotion during the magnetic interval led to a rate advantage of 0.74 pay grades. This shrinks to 0.65 on June 30th, 1944. It shrinks further to 0.63 on December 31st, 1944, before rising slightly to 0.65 on June 30th, 1945.

The persistence of this rate gap adds two major points to the analysis. First, the idiosyncratic promotions were not ephemeral. They do not reflect measurement error present in the wartime records nor were they quickly unwound with the public revelation of the Mark 14s' failures. This strengthens the argument that early career promotions had later life consequences. Second, although the navy had the spare positions to "rectify" the imbalances, as evidenced by the larger magnitude of the IV relative to the OLS estimates, it did not do so. The navy neither rapidly accelerated the promotion of non-promoted sailors nor did it significantly decelerate the promotion of promoted sailors. This is consistent with the navy deciding that the benefits of preserving the hierarchy, influenced by quasi-random forces as it may have been, outweighed the costs of addressing sub-optimal personnel allocations.

[31] I report the OLS estimates in Table E2 and IV estimates with clustered standard errors in Table E1.

6.2 The Role of Managerial Experience

Were certain kinds of promotions more efficacious than others in delivering long-run returns? In particular, what were the long run consequences for sailors who were exogenously boosted into positions of authority? To answer this question, I study sailors who achieved the rates of petty officer first class and chief petty officer during the magnetic interval. Petty officers first class received a boost in pay and higher status aboard the ship but their responsibilities were not substantively different than the responsibilities of petty officers second class. On the other hand, chief petty officers were responsible for managing all the enlisted men within their ratings.[32] They would also be liaisons between the officer ranks and the enlisted crew to ensure the cohesive functioning of the submarine. It is precisely the effect of these unique professional and managerial responsibilities I wish to identify.

To do so, I adopt a control function estimation strategy.[33] The control function allows for a heteroskedasticity-robust test of the equivalence of the IV and OLS estimates. This allows me to test whether promotions to either CPO or PO1c are endogenous to later life well being. If CPOs assume additional responsibilities and managerial tasks, then I should strongly reject the null hypothesis. Absent idiosyncratic shocks, captains should recommend sailors for promotion to CPO based on their abilities to assume leadership roles. In addition, if I observe pronounced effects on longevity for sailors promoted to CPO relative to PO1c, this would be consistent with the departure from expectations hypothesis described earlier. I make some modifications to the framework to address the different probabilities that enlisted men at particular rates upon beginning their wartime submarine service have of advancing into either the CPO or PO1c rates. My first stage is then:

$$\begin{aligned}\mathbb{1}_i(finrate = k) &= \alpha + \psi f(Z_i) + \gamma \mathbb{1}_i(startrate = j) \\ &\quad + \eta f(Z_i) \times \mathbb{1}_i(startrate = j) + \kappa attacks_i + \nu_i \end{aligned} \tag{8}$$

Where k is a dummy for promotion into either rate 6 (PO1c) or rate 7 (CPO), j indexes wartime start rates, and Z corresponds to either the Δ or *magnet* instruments.[34] Then, in the second stage, I regress:

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[32]The United States Navy's Chief Petty Officer Creed describes a CPOs' role as follows: "It is required that you be the fountain of wisdom, the ambassador of good will, the authority in personal relations as well as in technical applications."

[33]I present the equivalent IV estimates in Table E3.

[34]Because of the cubic polynomial in Z, I am not powered to include interaction effects between start rate fixed effects and both Δ and *magnet*.

$$Longevity_i = \alpha + \beta \mathbb{1}_i(finrate = k) + \tilde{\gamma}_{startrate_i} + \rho \hat{v}_i + \epsilon_i \quad (9)$$

Where $\hat{v}$ are the saved residuals from equation 8. Due to the additional estimation demands placed by the interaction terms and the smaller sample I was able to match to real estate data, I am not powered to estimate precise effects of my SES proxies in this estimation framework.

I present the results in Table 6.[35] They are again conditional on surviving the war. In columns 1, 2 and 5, I use *magnet* as Z; in columns 3, 4, and 6 I use Δ as Z. In columns 1 and 3, the estimation sample includes sailors who started between rates 3 (seaman first class) through 6. There are 2,880 such sailors in my data. Of these sailors, 328 (11.4%) received promotions to CPO. The average war survivor was born in 1913 and lived to 75.8. In columns 2 and 4, the sample includes sailors who started between rates 2 (seaman second class) and 5. There are 2,966 such sailors in my data. Of these sailors, 714 (21.4%) received promotions to PO1c. The average war survivor was born in 1917 and lived to 75.5. Columns 5 and 6 include all sailors strictly below CPO at the start of their wartime submarine service. These samples are selected to avoid rates for whom I never observe advancement to CPO or PO1c.

These results are consistent with the historiography and the hypothesis that it is unexpected experience with leadership that lends itself to later life well-being. First, while a Hausman test allows me to reject that the OLS and the IV estimates of the returns to promotion to CPO are equal, I fail to reject the null for promotions to PO1c.[36] This substantiates the extent to which the CPO rate carries additional roles and responsibilities in the enlisted hierarchy. Second, in my preferred specifications using *magnet* as Z, I estimate returns of 10.2 years ($SE = 3.4$) to exogenous promotion to chief. I estimate imprecise although positive returns of 3.7 years ($SE = 2.2$) for promotions to PO1c. The magnitude of the return to exogenous promotion to leadership suggests the relevance for these specific promotions for the general gradient I observe between later life well-being and wartime promotion. Regrettably, my data for studying the postwar careers of my sample are incomplete. Future work to investigate whether certain types of promotions translated into an extended naval career or into entering white collar private sector positions would be fruitful.

6.3 Geographic Mobility

Are my observed effects of promotion on SES mediated by increased geographic mobility of submariners? Figure E1 presents the birth states for the 2,431 (50.3%) of submariners for whom

[35] I present the results from an alternative probit first stage in Table E4.
[36] I present the OLS results in Table E5.

I was able to match this information.[37] The distribution of submariners' birth places is generally consistent with the geographical distribution of the American population in the first half of the 20th century. Figure E2 presents the states of final residence for the 2,761 matched sailors. In comparing the two maps, the prevailing migration trends of the 20th century are evident. Sailors migrated from the Midwest and East Coast toward warmer climates in the sun belt. This is reflected in Figure 2, which reflects migration patterns for 1,762 sailors whose states of residence I observe at both birth and death.[38]

To test whether promoted and non-promoted sailors relocated at differential rates, I present IV estimates for changing state of residence between birth and death in Table E6. Although the estimates are positive across specifications, they are imprecisely estimated. This suggests that the SES effects I observe are not driven by selective migration of promoted sailors toward destination states especially exposed to rising real estate prices. The level of spatial aggregation of my mobility data prohibit me from making more specific arguments about the types of communities into which sailors moved. It may be possible that although promoted and non-promoted sailors migrated at equal rates, promoted sailors relocated to wealthier communities within popular receiving states. Future work could usefully exploit administrative data with finer levels of aggregation to make progress on testing this hypothesis.

7 Conclusion

Past literature is divided on the importance and direction of the long-term consequences of early career promotion; in this paper, I describe novel evidence on the ramifications of idiosyncratic wartime promotion of Second World War submariners. Using a set of three instruments that yield plausibly exogenous variation in promotions, I find promoted compliers live for 2.4 years longer. Additionally, as a proxy for SES, I find that the median house in their ZIP codes is 14% more valuable and 7.1 percentile ranks higher in the national distribution of ZIP code-level home values. These are large, economically significant effects. The longevity effect is larger than the average life expectancy lost per person from particulate pollution (1.8 years), smoking (1.6 years), and alcohol

[37] The reader may be somewhat surprised by the prominence of Illinois, Ohio, and Pennsylvania relative to Florida. However, in the 1930s those states were ranked third, fourth, and second by population in the union, respectively. Florida was ranked 27th. Today, the respective rankings of Illinois, Ohio, Pennsylvania, and Florida are sixth, seventh, fifth, and third.

[38] The total number of sailors for whom I have both birth and last state of residence data, conditional on surviving the war, is 1,600. The reason for this discrepancy between the larger samples appropriately matched and presented in the maps is because birth state information is often missing for war survivors. On the other hand, the Pacific Fleet Submarine Museum, which manages https://www.oneternalpatrol.com/, conducted extensive research into the backgrounds of lost submariners. This research included identifying town and state of birth.

and drug use (11 months) (Greenstone and Fan, 2018). That they address attenuation bias in the OLS estimates suggests the importance of deviations from expectations in the data generating process for later life well-being. I further investigate the mechanisms through which promotions influenced long-run consequences. First, I find that idiosyncratic promotions were sticky. Promoted sailors were still well ahead of their non-promoted complier counterparts at the end of the war. Second, exogenous promotion to the rate of chief petty officer was particularly influential for longevity. A Hausman test strongly rejects the equivalence of the IV and OLS estimates. This suggests a particular role for acquiring and developing managerial experience in sailors' later life outcomes. Finally, I check whether promotions encouraged sailors to be more mobile and relocate to states with higher economic performance. I find little to suggest that promoted sailors are any more likely to change their state of residence than non-promoted sailors.

My results suggest that there are real returns to an unexpected promotion. It is likely that exogenously promoted individuals were able to use the opportunities they received through their higher status to improve their long-run outcomes. The persistence of these early-career promotions, which ex ante have ambiguous effects on later life well-being, suggests that programs that allocate opportunities to individuals not on a strictly meritocratic basis may yield substantial dividends for those so shocked. Second, I estimate especially large effects on longevity for individuals exogenously shocked into a management role. This result is important because it is not zero-sum. It may be that early career programs intended to foster leadership and team-building skills, conditional on that development being subject to high-powered incentives, could yield qualitatively similar returns. Military contexts lend themselves well to research on the persistence of shocks – camaraderie among veterans leads to communities preserving the memories and histories of their compatriots long after those individuals completed military service. In future work, I will leverage such detailed record-keeping to investigate veterans' civilian careers to answer outstanding questions on intermediate outcomes.

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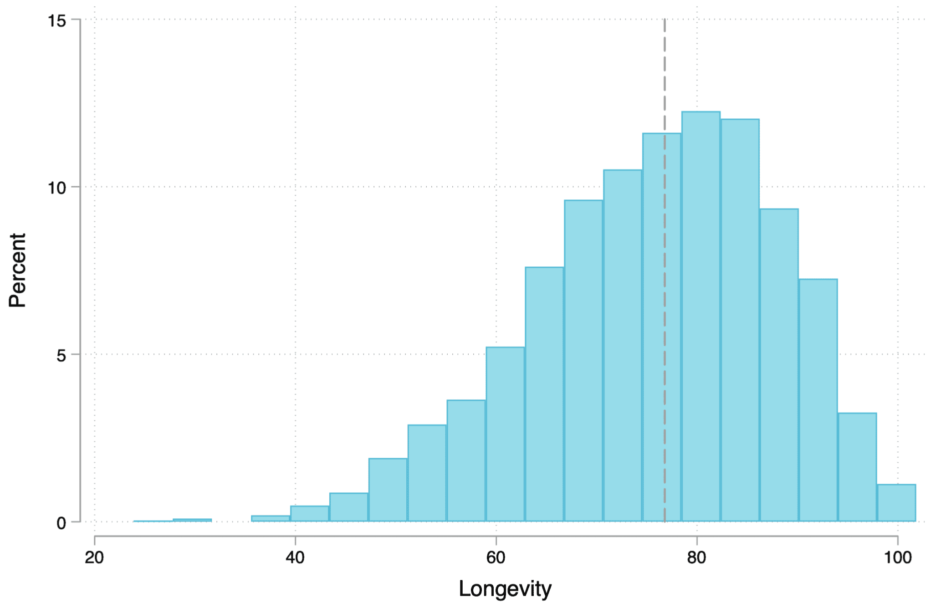
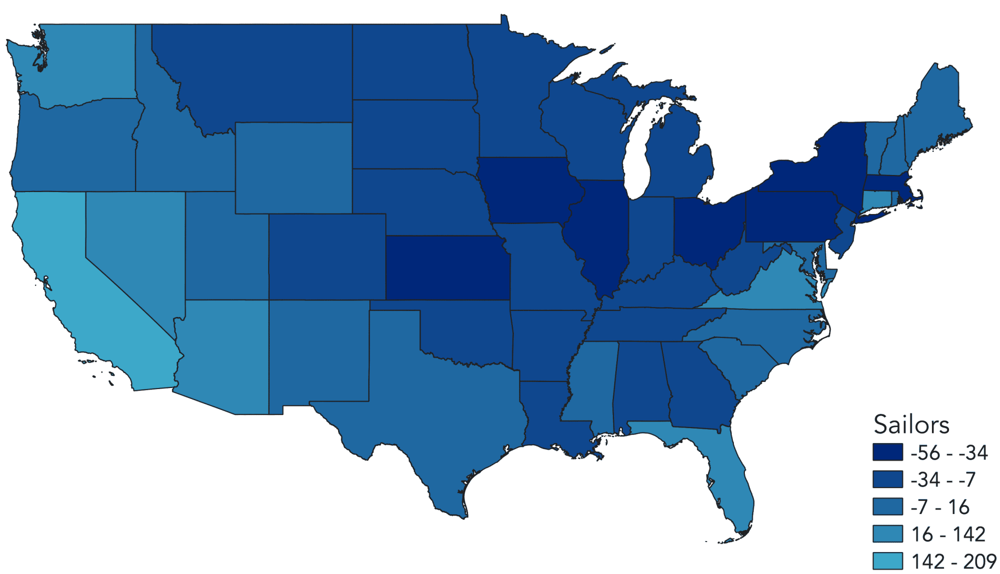
Figures and Tables

Figure 1: Histogram of Longevity Conditional on War Survival



This histogram presents the distribution of longevity for 3,100 sailors who survived WW2.

Figure 2: States by Net Migration



Note: This map shows migration patterns for 1,762 sailors for whom I have both states of birth and states of final residence.

Table 1: Sailor Summary Statistics

	Mean	σ	Minimum	Maximum	N
Enlistment year	1,939.4	2.8	1,917	1,943	4,821
Submarines	1.1	0.3	1	4	4,821
Service interval	288.3	159.2	30.0	546.0	4,821
Starting rate	4.0	1.5	1	7	4,821
Promotions	1.0	1.0	-2	6	4,821
Attacks	11.4	8.0	1	40	4,335
Torpedoes	32.6	22.7	1	122	4,335
AM	0.21	0.15	0	1.0	4,335
SORG	0.32	0.15	0	1.0	4,312
Δ	0.11	0.13	-0.33	0.67	4,312
magnet	0.21	0.04	0.08	0.29	4,318

Note: AM is the AM measure of torpedo success. Service interval is the number of days the sailor served aboard submarines between December 31st, 1941 and June 30th, 1943. SORG is the SORG reported measure of torpedo success. Δ is the difference between SORG and AM. *magnet* is the proportion of torpedo successes predicted by variation in the vertical intensity of the Earth's magnetic field.

Table 2: **Longevity** on Promotions

	Longevity (1)	Longevity (2)	Longevity (3)	Longevity (4)	Longevity (5)
Promotions	2.6**	2.6**	2.4**	2.4**	2.4**
	(1.1)	(1.1)	(1.0)	(1.0)	(1.1)
N	2,825	2,825	2,817	2,817	2,812
KP Wald rK F stat	248.6	64.7	72.0	42.1	39.2
Hansen's J		1.9	2.6	5.3	4.8
		[0.59]	[0.46]	[0.50]	[0.57]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is the sailor's longevity. All regressions include rate $\times$ tenure fixed effects. I restrict the sample to only those sailors who survived the war. Standard errors are robust. Standard errors are in parentheses; p-values are in brackets. ${}^{*}p < 0.1$, ${}^{**}p < 0.05$, ${}^{***}p < 0.01$.

Table 3: **Home Prices** on Promotions

	Log Home Prices (1)	Log Home Prices (2)	Log Home Prices (3)	Log Home Prices (4)	Log Home Prices (5)
Promotions	0.14**	0.15**	0.10	0.11	0.14**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
N	1,617	1,617	1,613	1,613	1,584
KP Wald rK F stat	158.5	41.6	46.4	27.4	26.0
Hansen's J		6.8*	3.6	11.2*	12.7**
		[0.08]	[0.31]	[0.08]	[0.05]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is the log of the median value of a single-family home in the sailor's final zip code of residence in the year of his death in constant 2000 U.S. Dollars. All regressions include rate × tenure fixed effects. Standard errors are robust. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 4: **Home Price Rank** on Promotions

	Home Price Rank (1)	Home Price Rank (2)	Home Price Rank (3)	Home Price Rank (4)	Home Price Rank (5)
Promotions	7.1**	7.5***	6.2**	6.6**	7.1**
	(2.9)	(2.9)	(2.8)	(2.8)	(2.9)
N	1,617	1,617	1,613	1,613	1,584
KP Wald rK F stat	158.5	41.6	46.4	27.4	26.0
Hansen's J		4.0	3.3	8.2	10.6
		[0.27]	[0.34]	[0.22]	[0.10]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is the percentile rank of the median value of a single-family home in the sailor's final zip code of residence in the year of his death within the national distribution of such values. All regressions include rate × tenure fixed effects. Standard errors are robust. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5: **Later-War Rates** on Promotions

	12/31/43 (1)	12/31/43 (2)	6/30/44 (3)	6/30/44 (4)	12/31/44 (5)	12/31/44 (6)	6/30/45 (7)	6/30/45 (8)
Promotions	0.88***	0.74***	0.74***	0.65***	0.79***	0.63***	0.78***	0.65***
	(0.13)	(0.07)	(0.13)	(0.07)	(0.14)	(0.08)	(0.16)	(0.08)
N	3166	3166	3166	3166	3166	3166	3166	3166
KP Wald rK F stat	16.82	46.44	16.82	46.44	16.82	46.44	16.82	46.44
Hansen's J	8.41	12.26*	3.86	5.29	4.78	7.26	9.37*	11.03*
	[0.14]	[0.06]	[0.57]	[0.50]	[0.44]	[0.30]	[0.10]	[0.09]
Attacks Instrument		✓		✓		✓		✓

Note: The dependent variable is the sailor's rate at the date referenced in the column header. All regressions instrument promotions with cubic polynomials in *magnet* and Δ. Standard errors are robust. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

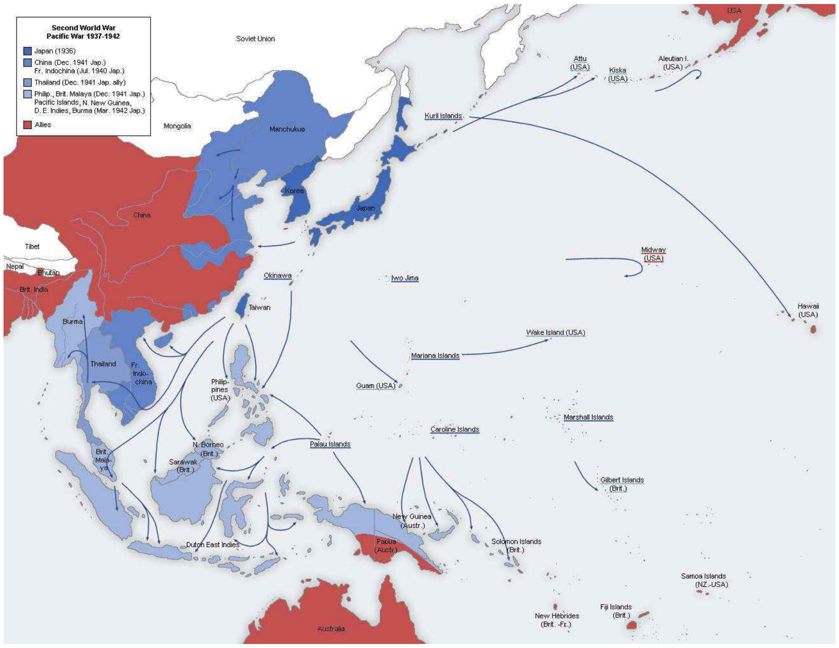
Table 6: **Longevity** on Promotion Types

	(1) longevity	(2) longevity	(3) longevity	(4) longevity	(5) longevity	(6) longevity
Promoted to	10.24***		12.56***			
chief	(3.42)		(3.67)			
Promoted to		3.71		3.54		
first class		(2.19)		(2.68)		
Promotion					2.19***	2.24***
					(0.76)	(0.72)
$\hat{v}$	-8.83**	-2.95	-11.20***	-2.76	-2.15***	-2.20***
	(3.48)	(2.35)	(3.88)	(2.54)	(0.74)	(0.79)
N	2,191	2,207	2,198	2,213	2,815	2,823
magnet & Attacks	✓	✓			✓	
Δ & Attacks			✓	✓		✓

Note: I restrict the sample to only those sailors who survived the war. Columns 1 and 3 include sailors who started at rates 3 through 6; columns 2 and 4 include sailors who started at rates 2 through 5; columns 5 and 6 include sailors who started at rates 1 through 6. All regressions include rate fixed effects. Standard errors are based on 999 wild bootstrap replications. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

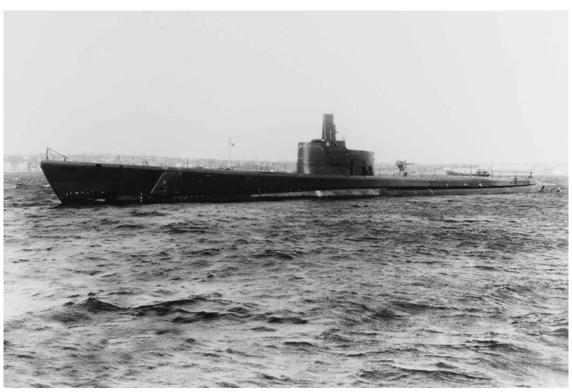
A Appendix to Section 2

Figure A1: Japanese Expansion during the Pacific War



Note: The maximum extent of the Japanese Empire in the summer of 1942.

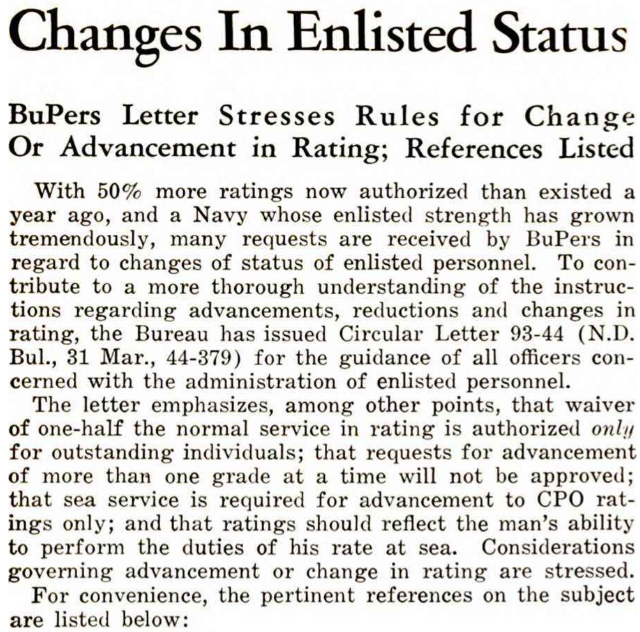
Figure A2: A Fleet Submarine and Its Torpedoes



(a) USS Growler (SS-215)

(b) The Mark 14 Torpedo

Figure A3: BuPers Circular about Promotion



Changes In Enlisted Status

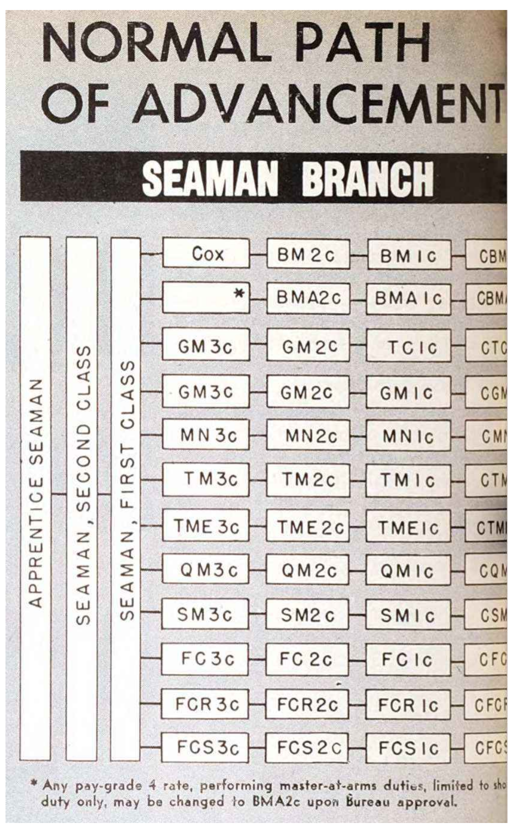
BuPers Letter Stresses Rules for Change Or Advancement in Rating; References Listed

With 50% more ratings now authorized than existed a year ago, and a Navy whose enlisted strength has grown tremendously, many requests are received by BuPers in regard to changes of status of enlisted personnel. To contribute to a more thorough understanding of the instructions regarding advancements, reductions and changes in rating, the Bureau has issued Circular Letter 93-44 (N.D. Bul., 31 Mar., 44-379) for the guidance of all officers concerned with the administration of enlisted personnel.

The letter emphasizes, among other points, that waiver of one-half the normal service in rating is authorized *only* for outstanding individuals; that requests for advancement of more than one grade at a time will not be approved; that sea service is required for advancement to CPO ratings only; and that ratings should reflect the man's ability to perform the duties of his rate at sea. Considerations governing advancement or change in rating are stressed.

For convenience, the pertinent references on the subject are listed below:

Figure A4: Promotional Paths for Seamen



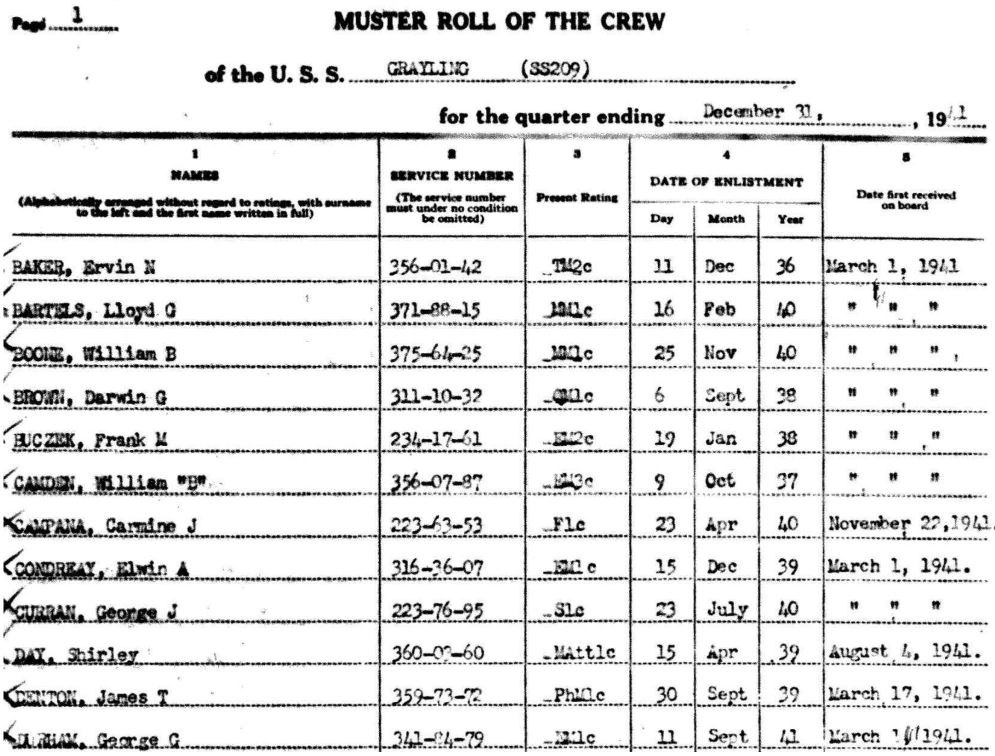
Note: Example paths of advancement for seamen. Seaman ratings cover general-duty deck and administrative tasks.

A.1 Selected Examples of Malfunctioning Torpedoes Described by Blair (1975)

- William Brockman's 6/4/42 attack on the carrier Kaga at the Battle of Midway: "Three rescued from Kaga reported seeing three torpedoes fired from a submarine at 2:10, about the time Brockman fired. Two of the torpedoes missed. The third struck amidships but failed to explode. It shattered, throwing loose the air Bask, which Boated free and served for a while as a life preserver for several of Kaga's crew" (pp. 244-245).
- John Addison Scott's 4/8/1943 attack on the carriers Hiyō, Jun'yō, and Taiyō: "Going deep to evade, Scott believed he heard at least seven hits. The crew cheered wildly, believing Tunny's unparalleled attack had sunk at least one and possibly two Japanese capital ships... Then Jasper Holmes brought in disappointing news from the codebreakers. The auxiliary carrier Taiyo (Otaka) had been damaged slightly but, according to the Japanese account, all four torpedoes aimed at the other carrier exploded prematurely some 50 meters away. Hiyo and Junyo had escaped unharmed" (pp. 412-413).
- Dan Daspit's 7/24/1943 attack on the 19,000 ton whale factory ship Tonan Maru III: "In all, eleven of Daspit's [15] torpedoes, fired under almost perfect conditions, had been duds. When he returned to Pearl Harbor, the normally cool and unflappable skipper was in a rage" (pp. 436).

B Appendix to Section 3

Figure B1: Document describing submarines' crew rosters.



Page 1

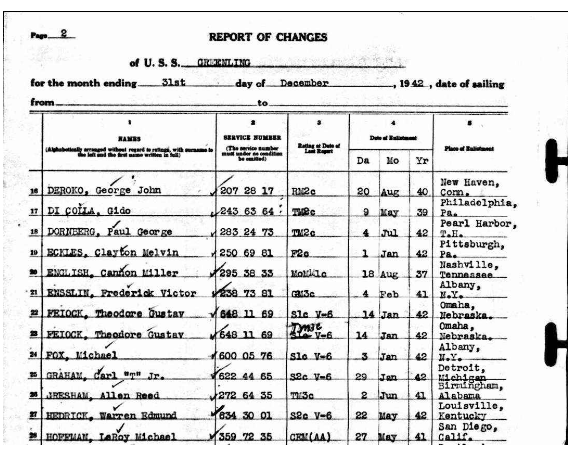
MUSTER ROLL OF THE CREW

of the U. S. S. GRAYLING (SS209)

for the quarter ending December 31, 1941

1 NAMES (Alphabetically arranged without regard to ratings, with surname to the left and the first name written in full)	2 SERVICE NUMBER (The service number must under no condition be omitted)	3 Present Rating	4 DATE OF ENLISTMENT Day	Month	Year	5 Date first received on board
BAKER, Ervin N	356-01-42	TM2c	11	Dec	36	March 1, 1941
BARTELS, Lloyd G	371-88-15	MM1c	16	Feb	40	" " "
BOONE, William B	375-64-25	MM1c	25	Nov	40	" " "
BROWN, Darwin G	311-10-32	GM1c	6	Sept	38	" " "
HUCZEK, Frank M	234-17-61	EM2c	19	Jan	38	" " "
CAMDEN, William "B"	356-07-87	EM3c	9	Oct	37	" " "
CAMPANA, Carmine J	223-63-53	F1c	23	Apr	40	November 22, 1941.
CONDREAY, Elwin A	316-36-07	EM1c	15	Dec	39	March 1, 1941.
CURRAN, George J	223-76-95	S1c	23	July	40	" " "
DAY, Shirley	360-07-60	Mattlc	15	Apr	39	August 4, 1941.
DENTON, James T	359-73-72	PhM1c	30	Sept	39	March 17, 1941.
[illegible], George G	341-84-79	MM1c	11	Sept	41	March 1/1941.

Figure B2: Document describing changes to submarines' crew rosters.



Page 2

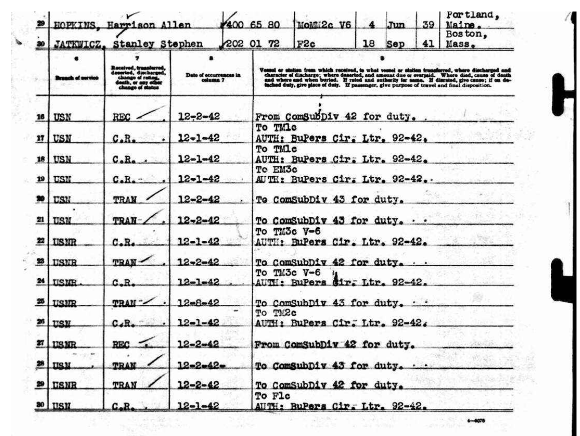
REPORT OF CHANGES

of U. S. S. GREENLING

for the month ending 31st day of December, 1942, date of sailing from ___ to ___

	1 NAMES (Alphabetically arranged without regard to ratings, with surname to the left and the first name written in full)	2 SERVICE NUMBER (The service number must under no condition be omitted)	3 Rating at Date of Last Report	4 Date of Enlistment Da	Mo	Yr	5 Place of Enlistment
16	DEROKO, George John	207 28 17	RM2c	20	Aug	40	New Haven, Conn.
17	DI COLLA, Gido	243 63 64	TM2c	9	May	39	Philadelphia, Pa.
18	DORNBERG, Paul George	283 24 73	TM2c	4	Jul	42	Pearl Harbor, T.H.
19	ECKLES, Clayton Melvin	250 69 81	F2c	1	Jan	42	Pittsburgh, Pa.
20	ENGLISH, Cannon Miller	295 38 33	MoMM1c	18	Aug	37	Nashville, Tennessee
21	ENSSLIN, Frederick Victor	238 73 81	GM3c	4	Feb	41	Albany, N.Y.
22	FEIOCK, Theodore Gustav	648 11 69	S1c V-6	14	Jan	42	Omaha, Nebraska.
23	FEIOCK, Theodore Gustav	648 11 69	TM3c S1c V-6	14	Jan	42	Omaha, Nebraska.
24	FOX, Michael	600 05 76	S1c V-6	3	Jan	42	Albany, N.Y.
25	GRAHAM, Carl "T" Jr.	622 44 65	S2c V-6	29	Jan	42	Detroit, Michigan
26	JRESHAM, Allen Reed	272 64 35	TM3c	2	Jun	41	Birmingham, Alabama
27	HEDRICK, Warren Edmund	634 30 01	S2c V-6	22	May	42	Louisville, Kentucky
28	HOFFMAN, LeRoy Michael	359 72 35	CEM(AA)	27	May	41	San Diego, Calif.

(a)



29	HOPKINS, Harrison Allen	400 65 80	MoMM2c V6	4	Jun	39	Portland, Maine.
30	JATKWICZ, Stanley Stephen	202 01 72	F2c	18	Sep	41	Boston, Mass.

	6 Branch of service	7 Received, transferred, deserted, discharged, change of rating, death, or any other change of status	8 Date of occurrence in column 7	9 Vessel or station from which received, to what vessel or station transferred, where discharged and character of discharge; where deserted, and amount due or overpaid. Where died, cause of death and where and when buried. If rated and authority for same. If disrated, give cause; if on detached duty, give place of duty. If passenger, give purpose of travel and final disposition.
16	USN	REC	12-2-42	From ComSubDiv 42 for duty.
17	USN	C.R.	12-1-42	To TM1c AUTH: BuPers Cir. Ltr. 92-42.
18	USN	C.R.	12-1-42	To TM1c AUTH: BuPers Cir. Ltr. 92-42.
19	USN	C.R.	12-1-42	To EM3c AUTH: BuPers Cir. Ltr. 92-42.
20	USN	TRAN	12-2-42	To ComSubDiv 43 for duty.
21	USN	TRAN	12-2-42	To ComSubDiv 43 for duty.
22	USNR	C.R.	12-1-42	To TM3c V-6 AUTH: BuPers Cir. Ltr. 92-42.
23	USNR	TRAN	12-2-42	To ComSubDiv 42 for duty.
24	USNR	C.R.	12-1-42	To TM3c V-6 AUTH: BuPers Cir. Ltr. 92-42.
25	USNR	TRAN	12-8-42	To ComSubDiv 43 for duty.
26	USN	C.R.	12-1-42	To TM2c AUTH: BuPers Cir. Ltr. 92-42.
27	USNR	REC	12-2-42	From ComSubDiv 42 for duty.
28	USN	TRAN	12-2-42	To ComSubDiv 43 for duty.
29	USNR	TRAN	12-2-42	To ComSubDiv 42 for duty.
30	USN	C.R.	12-1-42	To F1c AUTH: BuPers Cir. Ltr. 92-42.

(b)

Figure B3: Submarine Attacks Data (SORG)

Submarine Operations Research Group Attack Data

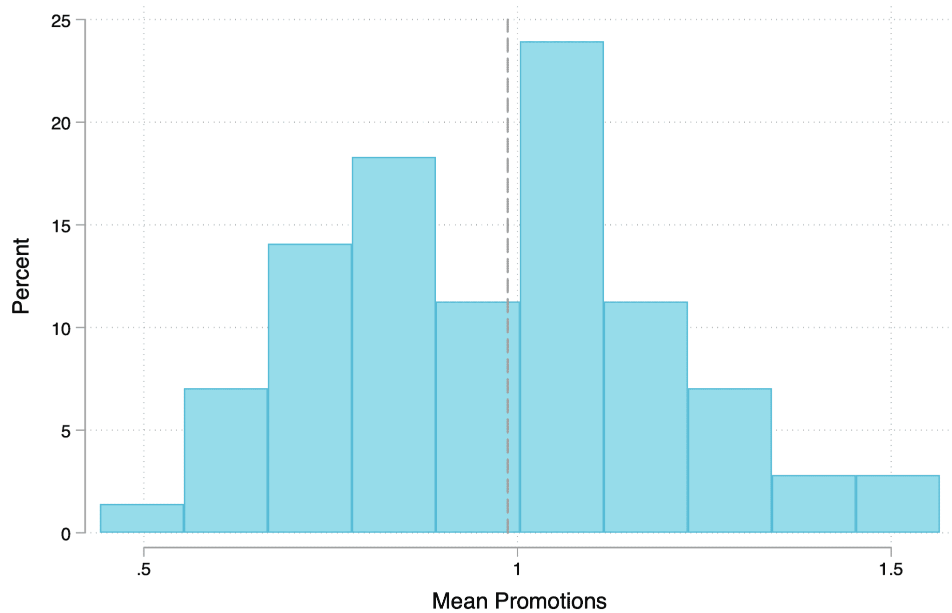
USS Cuttlefish (SS-171)

Patrol Number	Date	Hour (00-23)	Operational Command	Latitude	Longitude	Approach Light Condition	Approach Image Method	Approach Surfaced or Submerged	Attack Light Condition	Attack Image Method	Attack Surfaced or Submerged	Weapon Used	Number of Torpedoes Fired	Number of Torpedo Hits Claimed	Target Type	Result	Estimated Target Tonnage
1	1942-02-28	11	Pearl Harbor	28 N	130 E				Daylight	Periscope	Submerged	Mark XIV Torpedo	2	0	AK	No Damage	1500
1	1942-02-28	19	Pearl Harbor	28 N	130 E				Night	Visual	Surfaced	Mark XIV Torpedo	4	0	AK	No Damage	7000
2	1942-05-19		Pearl Harbor	15 N	145 E				Daylight	Periscope	Submerged	Mark XIV Torpedo	2	0	DE	No Damage	
2	1942-05-23		Pearl Harbor	1703N	14420E				Night	Periscope	Submerged	Mark XIV Torpedo	1	0	AK	No Damage	
3	1942-08-18		Pearl Harbor	3218N	13229E				Daylight	Periscope	Submerged	Mark XIV Torpedo	2	0	DD	No Damage	
3	1942-08-21	19	Pearl Harbor	31 N	130E				Daylight	Periscope	Submerged	Mark XIV Torpedo	3	2	AK	Sunk	10000
3	1942-08-21	19	Pearl Harbor	31 N	130E				Daylight	Periscope	Submerged	Mark XIV Type 1 Torpedo	1	1	DD	Damaged	1500
3	1942-08-30		Pearl Harbor	31 N	131 E				Daylight	Periscope	Submerged	Mark XIV Type 1 Torpedo	2	0	AK	No Damage	
3	1942-09-04		Pearl Harbor	34 N	133 E				Daylight	Periscope	Submerged	Mark XIV Torpedo	3	0	AK	No Damage	
3	1942-09-05	02	Pearl Harbor	34 N	133 E				Night	Visual	Surfaced	Mark XIV Type 1 Torpedo	3	2	AO	Not Final Attack on Target	19600
3	1942-09-05	02	Pearl Harbor	34 N	133 E				Night	Visual	Surfaced	Mark XIV Type 1 Torpedo	1	0	AO	Not Final Attack on Target	19600
3	1942-09-05	02	Pearl Harbor	34 N	133 E				Night	Periscope	Submerged	Mark XIV Type 1 Torpedo	1	1	AO	Sunk	19600

Figure B4: Submarine Attacks Data (Alden & McDonald)

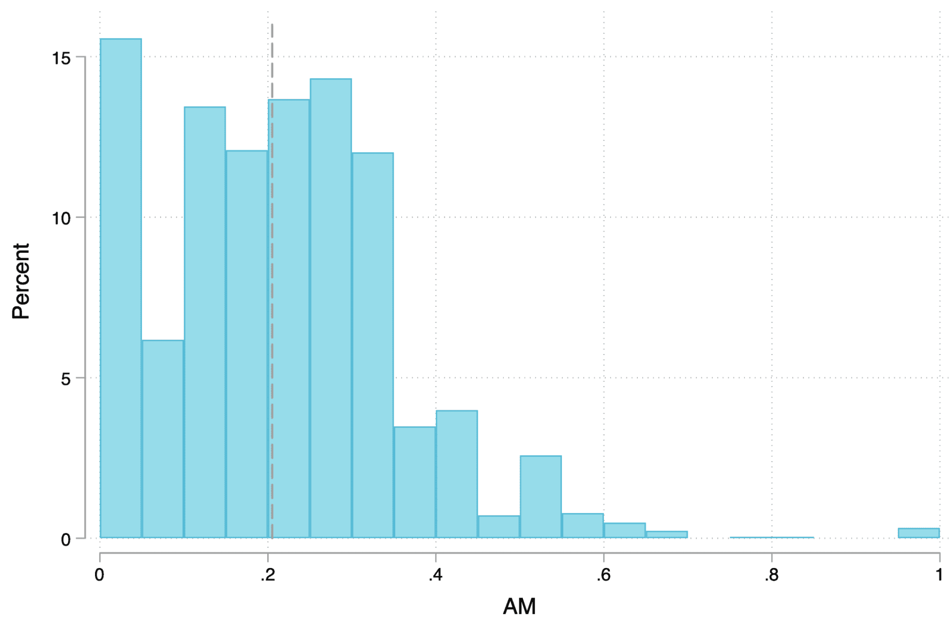
Submarine ***Attack No.***	**Ptl**	**Commander** ***Reference Source(s)*** ***Comments***	**Mo/Yr**	**Dt/Hr** ***Date***	**Position** ***Location***	**Target** ***Type***	**Size Est.** ***Tons***	**Attack Data** ***Vessel Name***	**Claim** ***Damg.*** ***Eval.***
239 WHALE 681	3	Burrows *Claim Unconfirmed* *PR says hits seen, b/u noise, later oil slick. 03*	Mar 43	20/08	16-03N 143-08E	AK	9600	T2/3DUP	S
276 SAWFISH 682	1	Sands *ISM* *W* *PR says many 3 inch hits but target left at high speed in heavy seas. GF says was on patrol with Kamitsu M & Fukuichi M #5; M1 says 5 killed; GF list says ret to owner postwar.*	Mar 43	20/12 *20*	32-55N 152-11E *32-50N 152-00E*	PC *XPkt*	300 *148*	GD *Shinsei M.*	D *M* *S* *D1*
237 TRIGGER 683	4	Benson *M* *I* *PR says low order detonation, listed to port, stopped & started again. M1 says became unnavig-able. [I gives tons as 2629; S 10 May 44 by 236 SILVERSIDES.]*	Mar 43	20/14 *20*	03-44N 144-12E *03-48N 144-12E*	AK *XPG*	7500 *2631*	T1/3DUP *Choan M.* *[#2 Go]* *{Choan M. #2}*	D *H* *D1*
277 SCAMP 684	1	Ebert *SM* *I* *PR says splash seen, no expl. WS1 says hit under fwd mast by dud torp ca 1630 20 Mar @ 41-06N - 141 27E, run aground because of flooding, still there when torp again 11 Jun by 275 RUNNER & abandoned. [J credits RUNNER only.]*	Mar 43	20/17 *20*	41-06N 141-26E *Off Tomari Is.*	AK *C-AK* *C*	2600 *1338* *{1450}*	T3/3DUP *Seinan M.*	D *L* *S1P*
277 SCAMP 685	1	Ebert *M* *PR bel missed. M1 says hit by 3 duds 22 Mar at this location. [No sub att that date.]*	Mar 43	20/18 *20*	41-06N 141-20E *Off Shiranuka Lt.*	AK *XAK*	6300 *6343*	T0/3DUP *Tatsumiya M.*	0 *L* *L3*
180 POLLACK 686	6	Palmer *Note* *PR says hit heard. SORG lists as same ship hit again 21 Mar 43.*	Mar 43	20/17	03-58N 172-09E	AK	6700	T1/4DUP	D *XR*
233 HERRING 687	3A	Corbus *U* *PR says hits heard, screw noise stopped, crackling heard. [Rohwer says U-163 left Lorient 10 Mar, missing after 15 Mar, should have been far from this posit; Rohwer & Kemp believe S 13 Mar by HMCS Prescott at 45-05N 15-00W.]*	Mar 43	21/01 *21*	44-13N 008-23W *Sub position*	SS *SS*	500 *1120*	T2/2NSR *{U-163}*	S *S* *03XE*

Figure B5: Distribution of Average Observed Promotions Aboard Submarines



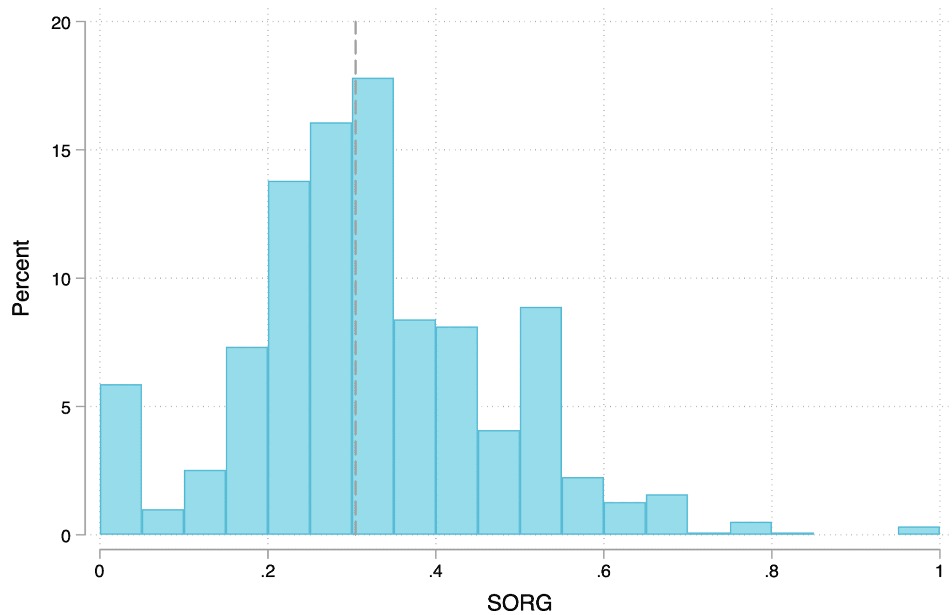
This histogram presents the distribution of the mean number of promotions I observe in my data at the submarine-level.

Figure B6: Success according to AM



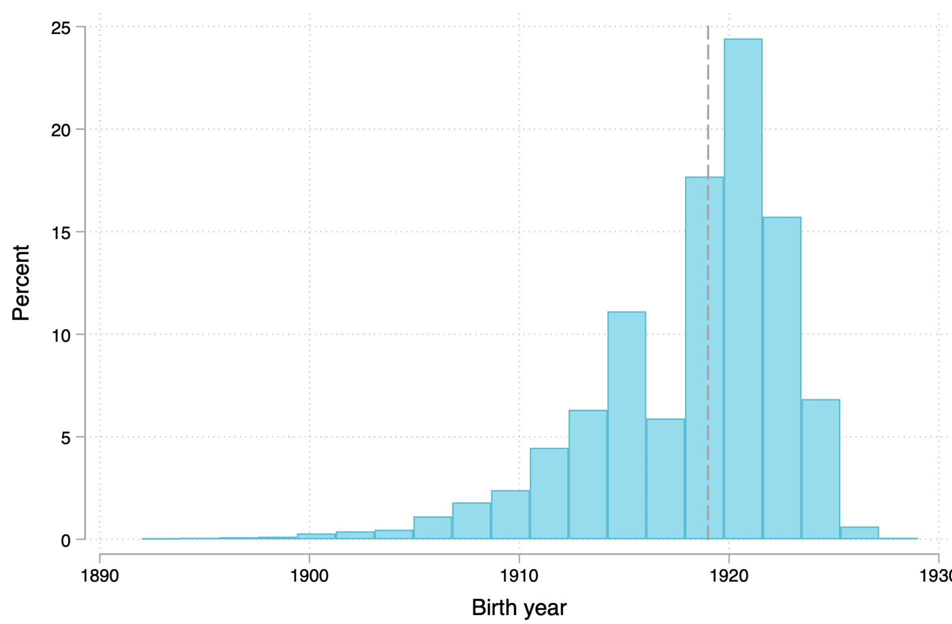
This histogram presents the distribution of AM_i for 4,335 sailors matched to a submarine attack in Alden and McDonald (2009).

Figure B7: Success according to SORG



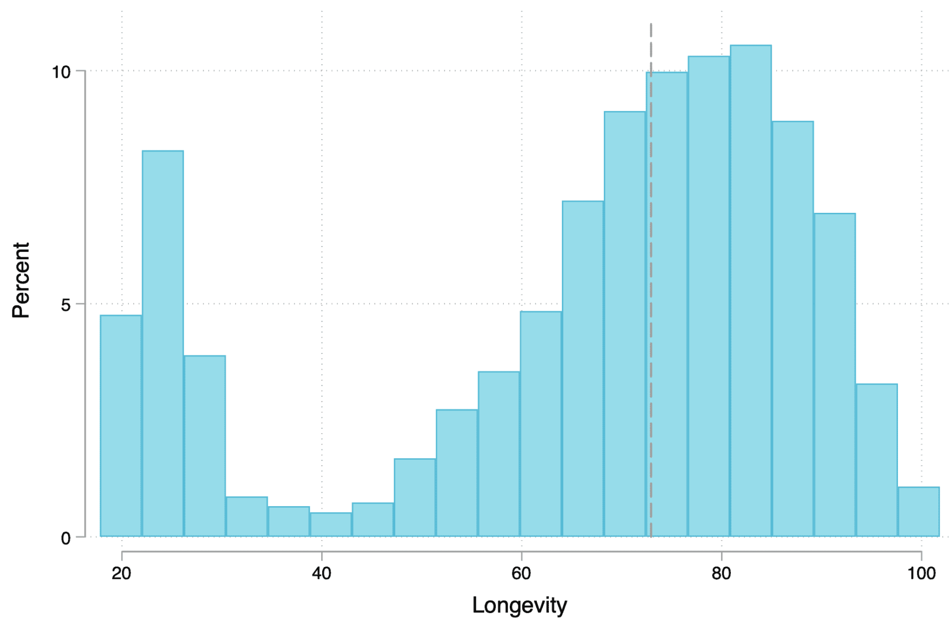
This histogram presents the distribution of $SORG_i$ for 4,312 sailors matched to a submarine attack in the SORG records.

Figure B8: Distribution of Birth Years



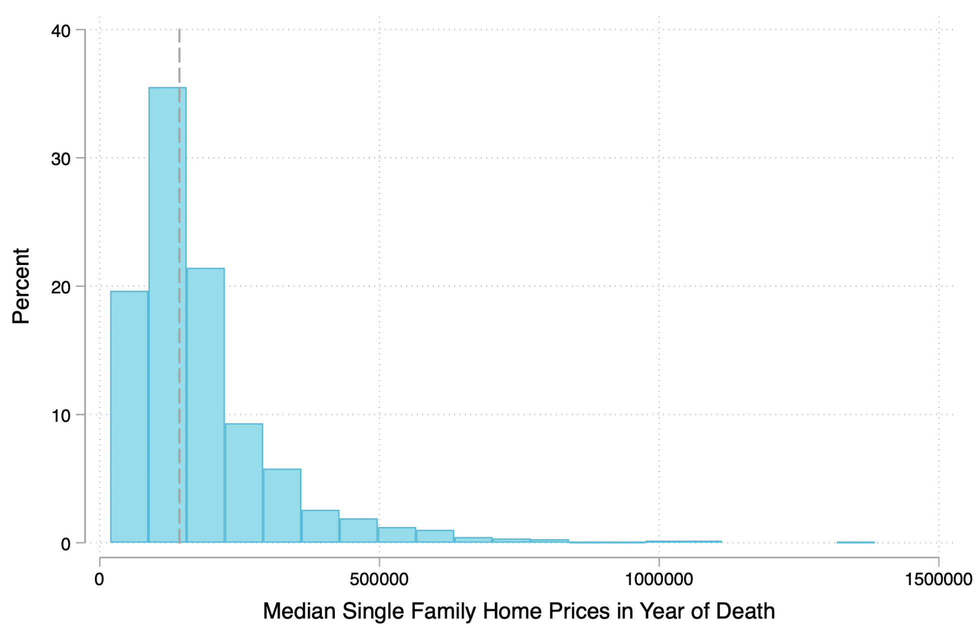
This histogram presents the distribution of birth years for 3,833 sailors matched to their birth years.

Figure B9: Distribution of Longevity for All Matched Sailors



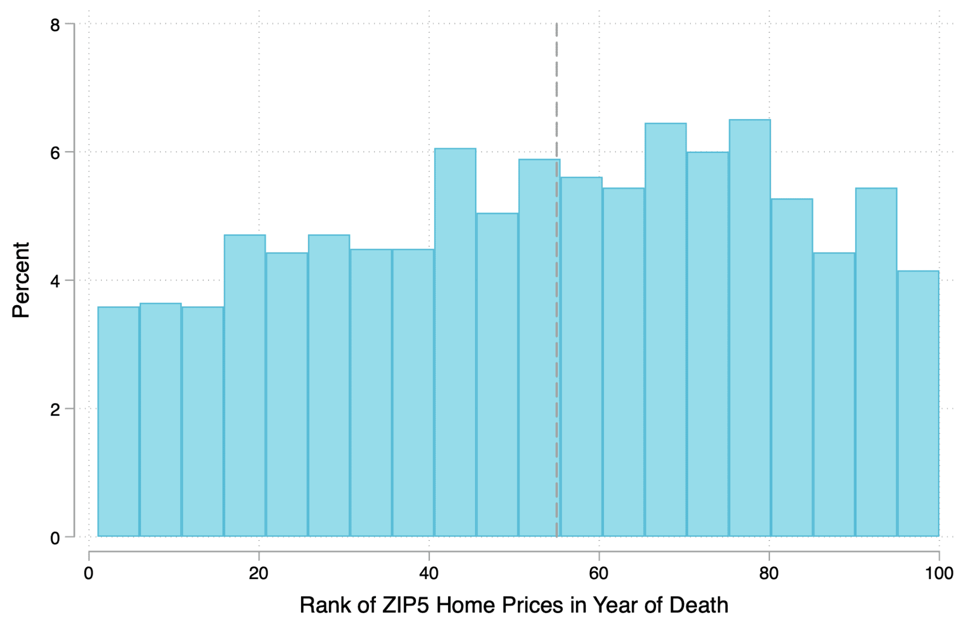
This histogram presents the distribution of birth years for 3,799 sailors matched to their mortality data.

Figure B10: Distribution of Home Prices



This histogram presents the distribution of home prices for the communities of 1,782 sailors matched to real estate records in the years of sailors' deaths.

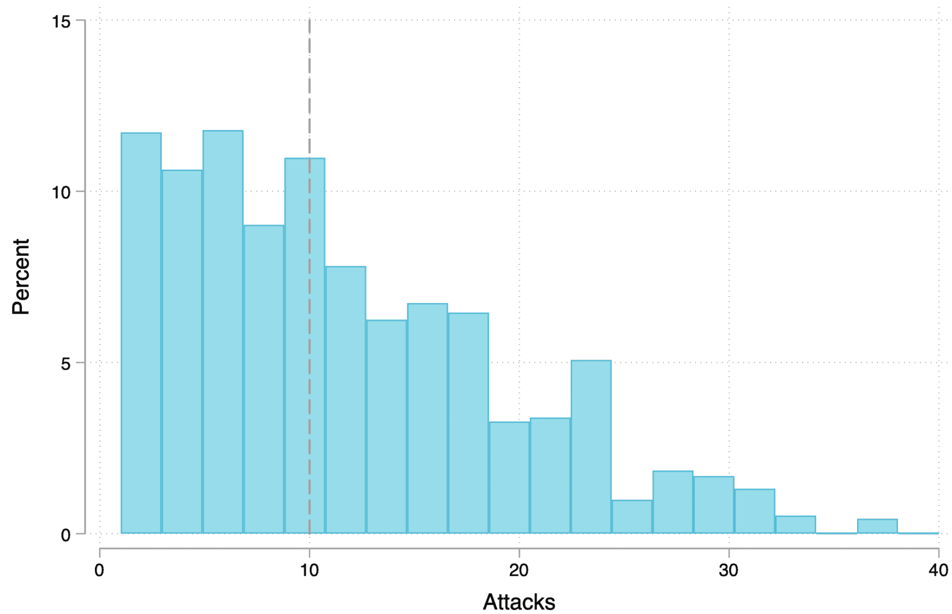
Figure B11: Distribution of Ranked Home Prices



This histogram presents the distribution of home price rank for the communities of 1,782 sailors matched to real estate records in the years of sailors' deaths.

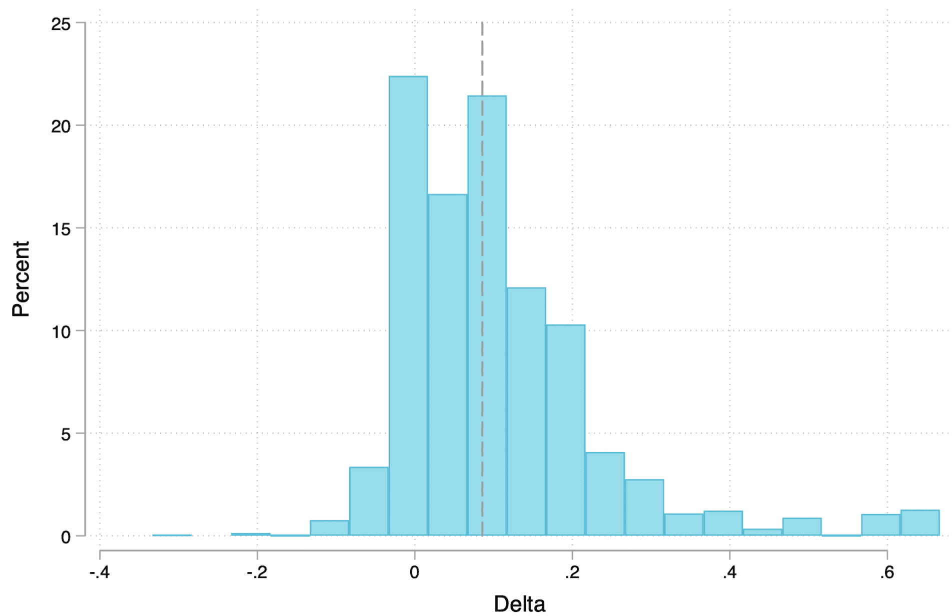
C Appendix to Section 4

Figure C1: Histogram of Sailors' Attacks



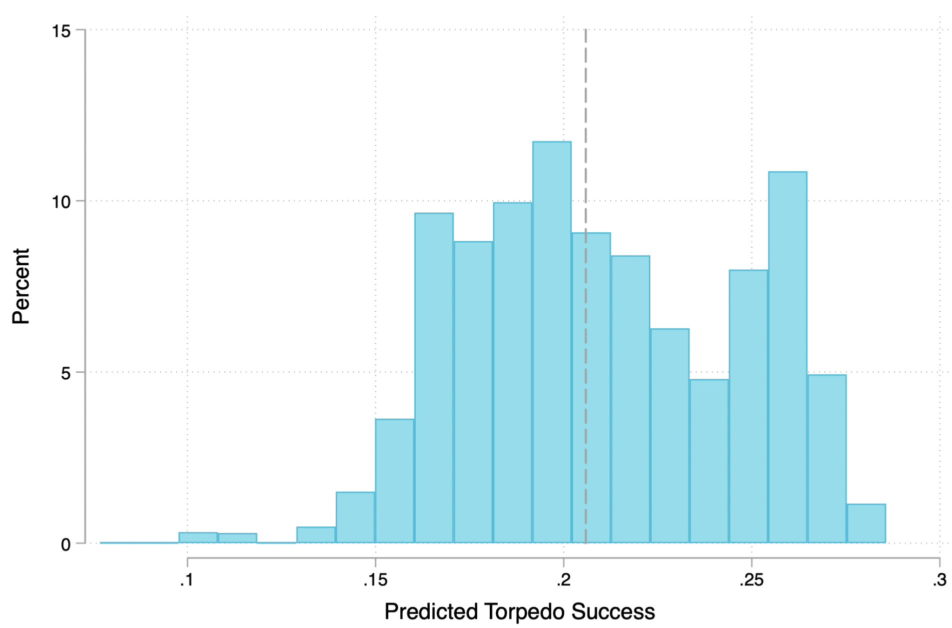
This histogram presents the distribution of attacks for 4,335 sailors who participated in an attack against enemy shipping.

Figure C2: Histogram of Δ



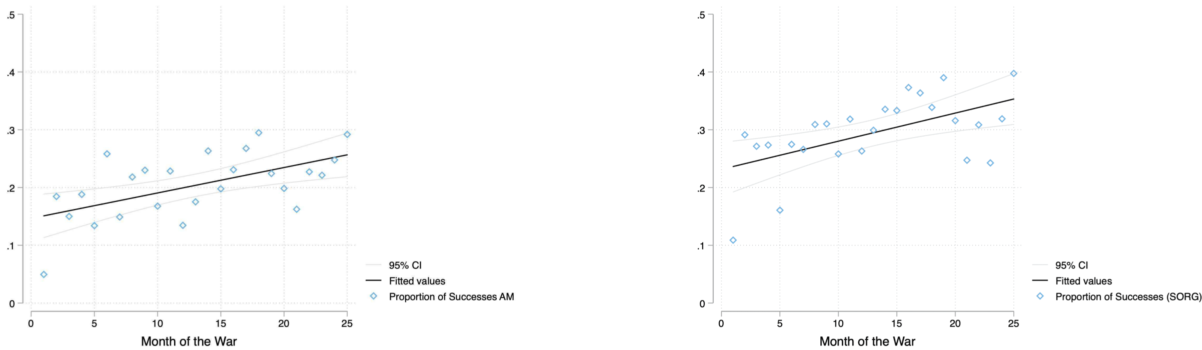
This histogram presents the distribution of Δ for 4,312 sailors who participated in attacks recognized in both AM and SORG.

Figure C3: Histogram of *magnet*



This histogram presents the distribution of *magnet* for 4,318 sailors whose attacks were associated with latitude and longitude coordinates.

Figure C4: Time Series of AM and SORG

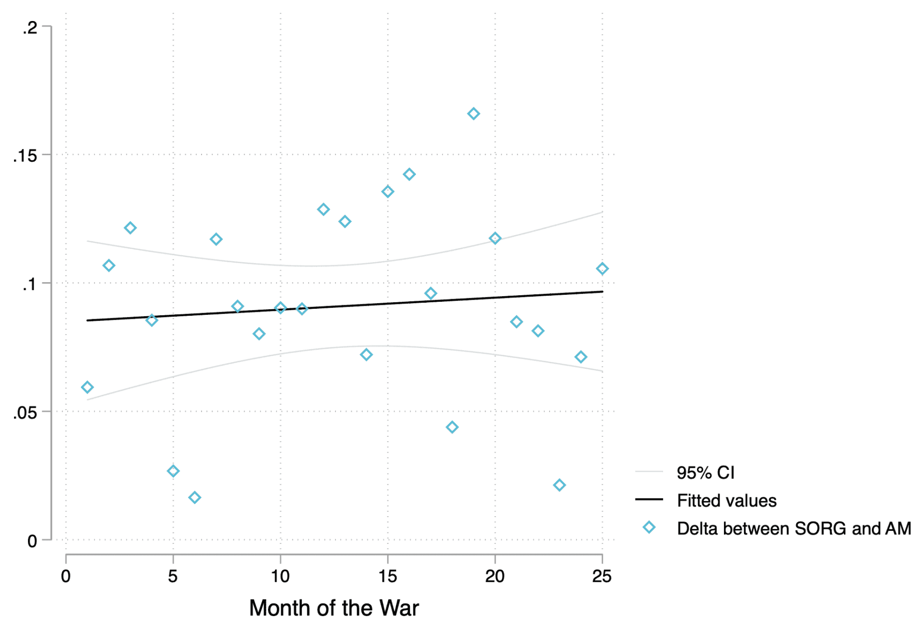


(a) AM

(b) SORG

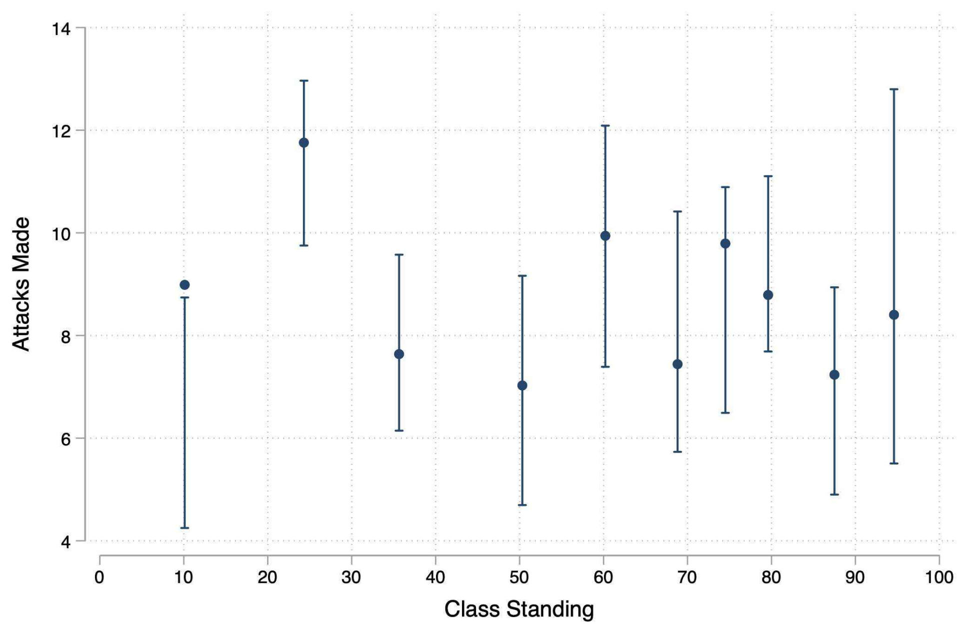
This time series plots fleet wide SORG and AM at the month level from December 1941 through December 1943.

Figure C5: Time Series of Δ



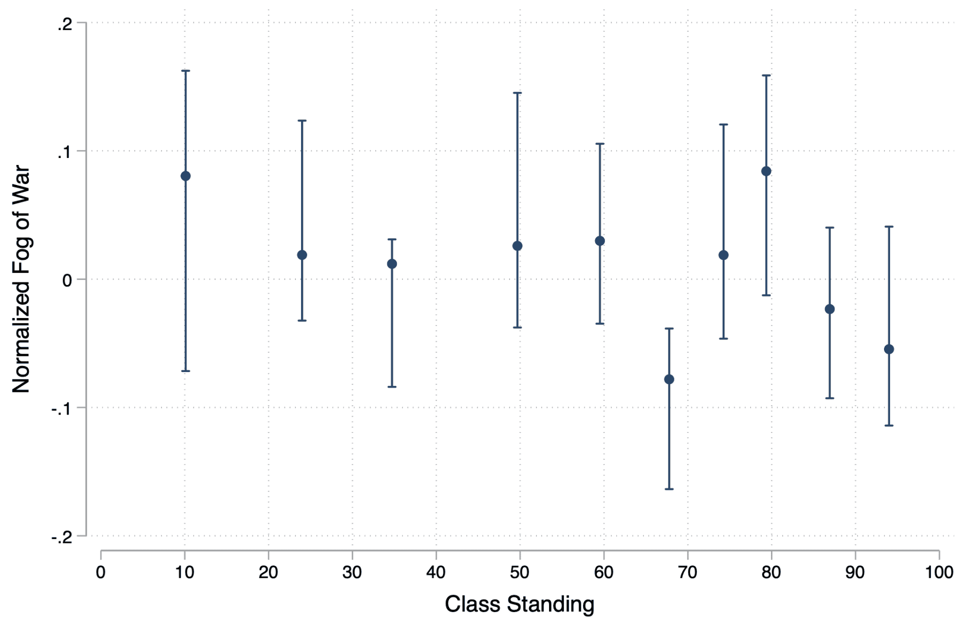
This time series plots fleet wide Δ at the month level from December 1941 through December 1943.

Figure C6: Binscatter of Attacks by Captains' Class Standing



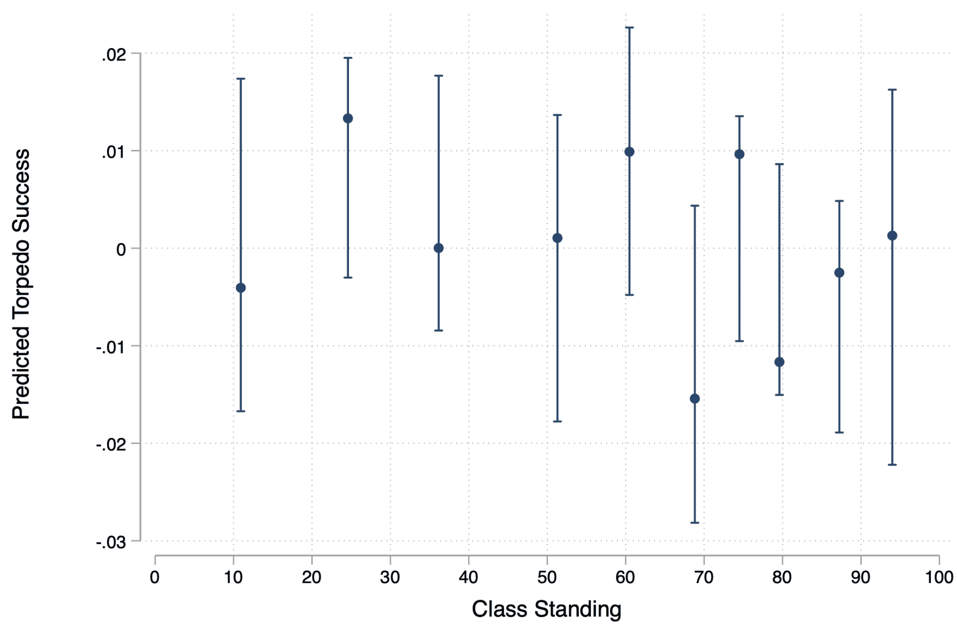
Note: $N = 137$. The Y-axis is the number of attacks led by the captain. The X-axis is the standing of the captain within his Naval Academy class. I control for number of war patrols that the captain led and the theaters in which he sailed. 95% confidence intervals are based on a cubic B-spline estimate of the regression function to the binned scatter plot.

Figure C7: Binscatter of Δ by Captains' Class Standing



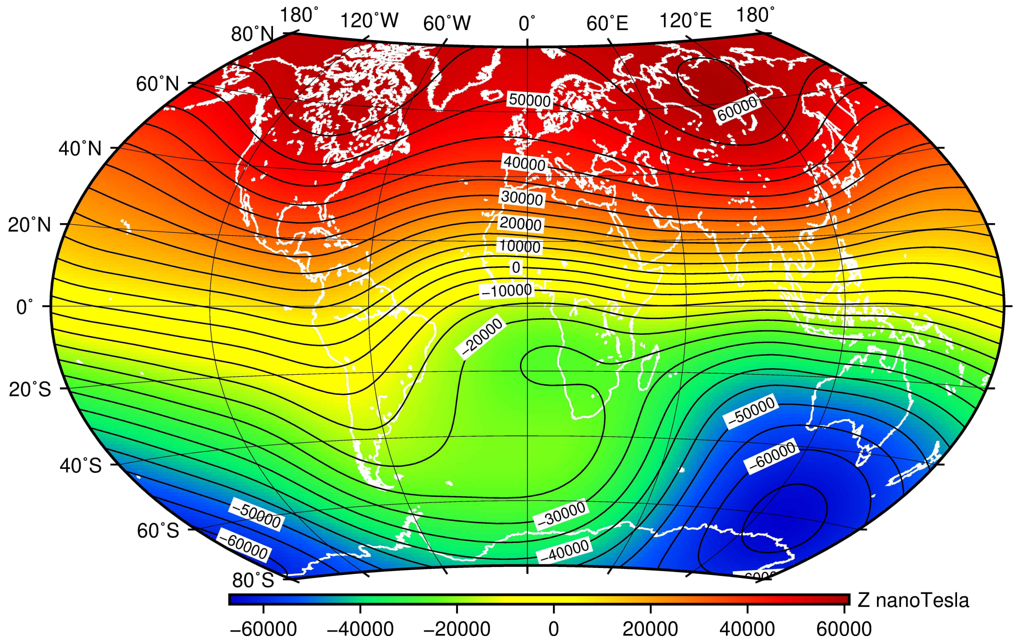
Note: $N = 135$. The Y-axis is Δ. The X-axis is the standing of the captain within his Naval Academy class. I control for the number of war patrols that the captain led and the theater in which he sailed. 95% confidence intervals are based on a cubic B-spline estimate of the regression function to the binned scatter plot.

Figure C8: Binscatter of *magnet* by Captains' Class Standing



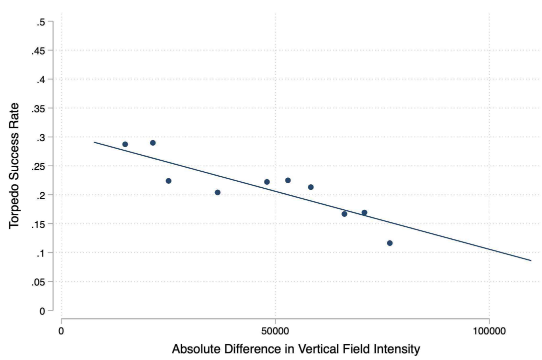
Note: $N = 134$. The Y-axis is the number of attacks led by the captain. The X-axis is the standing of the captain within his Naval Academy class. I control for number of war patrols that the captain led and the theater in which he sailed. 95% confidence intervals are based on a cubic B-spline estimate of the regression function to the binned scatter plot.

Figure C9: Spatial Variation in the Earth's Magnetic Field

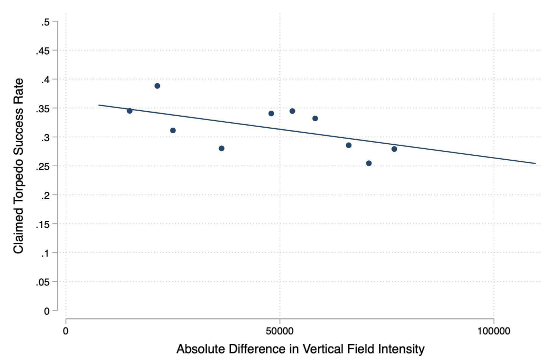


Produced by the UK's Natural Environment Research Council, this map shows the vertical intensity of the Earth's magnetic field in 2020.

Figure C10: Torpedo Successes on Δ_{mag}



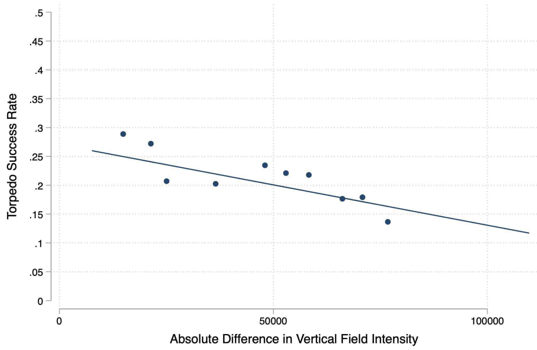
(a) AM



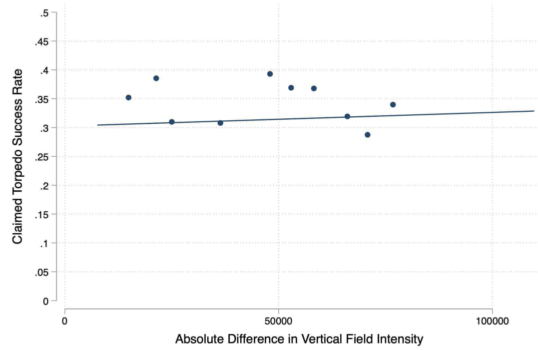
(b) SORG

Binscatters of the relationship between the success metrics and Δ_{mag}. $N = 1244$ in (a) and $N = 1242$ in (b).

Figure C11: Torpedo Successes on Δ_{mag} (Theater FE)



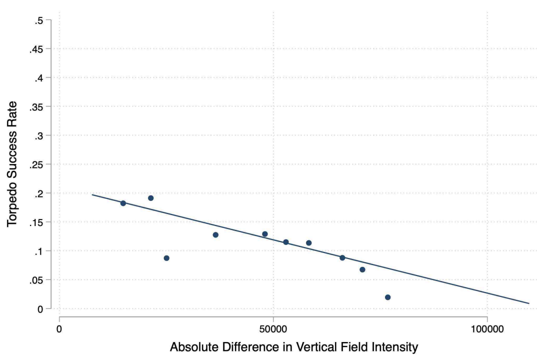
(a) AM



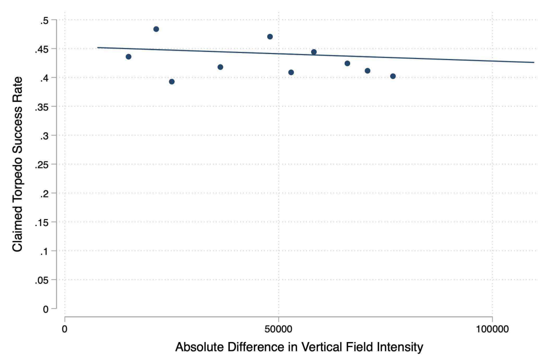
(b) SORG

Binscatters of the relationship between the success metrics and Δ_{mag} inclusive of theater fixed effects. $N = 1244$ in (a) and $N = 1242$ in (b).

Figure C12: Torpedo Successes on Δ_{mag} (Captain FE)



(a) AM



(b) SORG

Binscatters of the relationship between the success metrics and Δ_{mag} inclusive of captain fixed effects. $N = 1244$ in (a) and $N = 1242$ in (b).

Table C1: **Aggression of Tenure** on Pre-Sub Service Rate of Advancement

	Attacks (1)	Attacks (2)	Attacks (3)	Attacks (4)	Attacks (5)	Attacks (6)
Months per rate	0.04*	-0.04*	0.05*	0.04*	-0.03	0.05**
	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)
N	4,335	1,864	2,471	4,335	1,864	2,471
Sub Service	All	Pre-war	Wartime	All	Pre-war	Wartime
Start Rate FE				✓	✓	✓

Note: The dependent variable is the number of attacks in which the sailor participated over the course of his submarine tenure between December 7th, 1941, and June 30th, 1943. Months per rate is the average number of months spent at each rate before beginning wartime submarine service. Sub service splits the sample into those sailors who began submarine service before the war and those who began during the conflict. In Columns 4-6, I include fixed effects for the rate at which the sailors began their wartime submarine service. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C2: **magnet** on AM

	magnet (1)	*magnet* (2)	*magnet* (3)
AM	-0.57	-0.42	-0.22
	(0.46)	(0.45)	(0.43)
Month	0.00*	-0.00	0.00
	(0.00)	(0.00)	(0.00)
AM × Month	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
N	482	467	429
adj. R^2	0.00	0.19	0.28
Ship FE		✓	
Captain FE			✓

Note: The dependent variable is the predicted torpedo success rate based on Δ_{mag} for submarine-month duals. Standard errors are robust in Column 1, clustered at the ship level in Column 2, and clustered at the commander level in Column 3. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C3: **magnet** on Δ

	magnet (1)	*magnet* (2)	*magnet* (3)
Δ	-0.11	-0.60	-0.57
	(0.76)	(0.69)	(0.78)
Month	0.00*	-0.00	0.00
	(0.00)	(0.00)	(0.00)
Δ× Month	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
N	482	467	429
adj. R^2	0.01	0.21	0.30
Ship FE		✓	
Captain FE			✓

Note: The dependent variable is the predicted torpedo success rate based on Δ_{mag} for submarine-month duals. Standard errors are robust in Column 1, clustered at the ship level in Column 2, and clustered at the commander level in Column 3. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C4: **magnet** on SORG

	magnet (1)	*magnet* (2)	*magnet* (3)
SORG	-0.27	-0.39	-0.16
	(0.39)	(0.39)	(0.38)
Month	0.00**	-0.00	0.00
	(0.00)	(0.00)	(0.00)
SORG × Month	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
N	482	467	429
adj. R^2	0.00	0.20	0.29
Ship FE		✓	
Captain FE			✓

Note: The dependent variable is the predicted torpedo success rate based on Δ_{mag} for submarine-month duals. Standard errors are robust in Column 1, clustered at the ship level in Column 2, and clustered at the commander level in Column 3. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C5: **First Stage** of Promotions

	Promotions (1)	Promotions (2)	Promotions (3)	Promotions (4)	Promotions (5)	Promotions (6)
Attacks	0.03***			0.03***	0.03***	0.03***
	(0.00)			(0.00)	(0.00)	(0.00)
Δ		1.26***		-0.13		-0.14
		(0.22)		(0.24)		(0.25)
Δ^2		-5.96***		0.02		0.00
		(1.12)		(1.25)		(1.31)
Δ^3		6.00***		1.25		1.10
		(1.51)		(1.64)		(1.71)
magnet			-79.07***		-76.22***	-77.88***
			(22.81)		(23.12)	(23.16)
$magnet^2$			492.42***		423.46***	430.65***
			(112.45)		(113.60)	(113.74)
$magnet^3$			-940.06***		-743.43***	-753.47***
			(182.03)		(183.47)	(183.65)
N	4,307	4,284	4,290	4,284	4,290	4,267
adj. R^2	0.41	0.35	0.37	0.41	0.42	0.42

Note: The dependent variable is the number of pay grades advanced by the sailor during his submarine service between December 7th, 1941 and June 30th, 1943. All regressions include rate $\times$ tenure fixed effects. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table C6: **First Stage** of Promotions (Clustered SE)

	Promotions	Promotions	Promotions	Promotions	Promotions	Promotions
	(1)	(2)	(3)	(4)	(5)	(6)
Attacks	0.03***			0.03***	0.03***	0.03***
	(0.00)			(0.00)	(0.00)	(0.00)
Δ		1.26**		-0.13		-0.14
		(0.49)		(0.51)		(0.53)
Δ^2		-5.96***		0.02		0.00
		(2.12)		(2.19)		(2.49)
Δ^3		6.00**		1.25		1.10
		(2.80)		(2.89)		(3.24)
magnet			-79.07**		-76.22*	-77.88*
			(38.96)		(39.32)	(39.43)
$magnet^2$			492.42**		423.46**	430.65**
			(193.86)		(192.94)	(192.96)
$magnet^3$			-940.06***		-743.43**	-753.47**
			(318.56)		(312.74)	(312.07)
N	4,307	4,284	4,290	4,284	4,290	4,267
adj. R^2	0.41	0.35	0.37	0.41	0.42	0.42

Note: The dependent variable is the number of pay grades advanced by the sailor during his submarine service between December 7th, 1941 and June 30th, 1943. All regressions include rate $\times$ tenure fixed effects. Standard errors are clustered at the level of the submarine on which the sailor served longest. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

D Appendix to Section 5

Table D1: **Longevity** on Promotions (OLS)

	Longevity (1)	Longevity (2)	Longevity (3)
Promotions	0.3	0.2	0.1
	(0.3)	(0.3)	(0.3)
N	2,850	2,825	2,819
Rate FE	✓		
Rate × Tenure FE		✓	✓
Birth year FE			✓

Note: The dependent variable is the sailor's longevity. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table D2: **Longevity** on Promotions (Clustered SE)

	Longevity (1)	Longevity (2)	Longevity (3)	Longevity (4)	Longevity (5)
Promotions	2.6**	2.6**	2.4**	2.4**	2.4**
	(1.0)	(1.0)	(0.9)	(0.9)	(0.9)
N	2,825	2,825	2,817	2,817	2,812
KP Wald rK F stat	61.7	17.8	19.0	11.8	11.1
Hansen's J		1.7	3.1	6.4	6.8
		[0.64]	[0.37]	[0.38]	[0.34]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is the sailor's longevity. All regressions include rate × tenure fixed effects. I restrict the sample to only those sailors who survived the war. Standard errors are clustered at the level of the submarine on which the sailor served longest. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table D3: **Home Prices** on Promotions (OLS)

	Log Home Prices (1)	Log Home Prices (2)	Log Home Prices (3)
Promotions	0.02	0.01	0.03
	(0.02)	(0.02)	(0.02)
N	1,641	1,617	1,588
Rate FE	✓		
Rate × Tenure FE		✓	✓
Birth year FE			✓

Note: The dependent variable is the log of the median value of a single-family home in the sailor's final zip code of residence in the year of his death in constant 2000 U.S. Dollars. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table D4: **Home Prices** on Promotions (Clustered SE)

	Log Home Prices (1)	Log Home Prices (2)	Log Home Prices (3)	Log Home Prices (4)	Log Home Prices (5)
Promotions	0.14**	0.15**	0.10	0.11*	0.14**
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
N	1,617	1,617	1,613	1,613	1,584
KP Wald rK F stat	68.08	19.07	18.61	12.38	11.62
Hansen's J		9.7**	4.6	11.3*	12.1*
		[0.02]	[0.21]	[0.08]	[0.06]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is the log of the median value of a single-family home in the sailor's final zip code of residence in the year of his death in constant 2000 U.S. Dollars. All regressions include rate × tenure fixed effects. Standard errors are clustered at the level of the submarine on which the sailor served longest. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table D5: **Home Price Rank** on Promotions (OLS)

	Home Price Rank (1)	Home Price Rank (2)	Home Price Rank (3)
Promotions	2.02**	2.31***	2.47***
	(0.80)	(0.89)	(0.93)
N	1,641	1,617	1,588
Rate FE	✓		
Rate × Tenure FE		✓	✓
Birth year FE			✓

Note: The dependent variable is the percentile rank of the median value of a single-family home in the sailor's final zip code of residence in the year of his death within the national distribution of such values. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

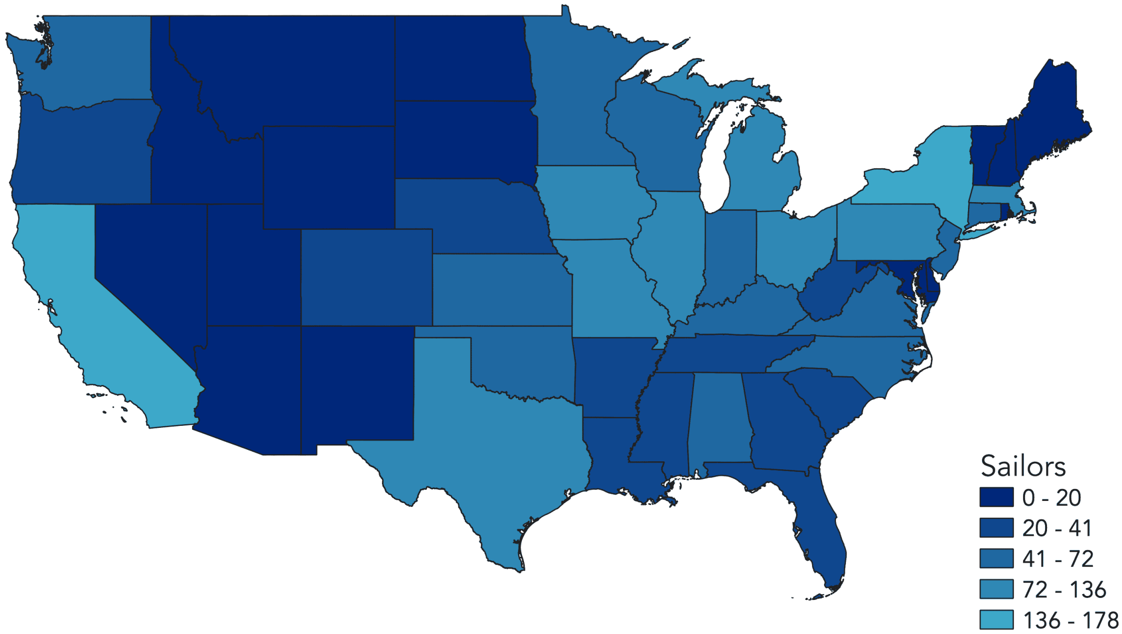
Table D6: **Home Price Rank** on Promotions (Clustered SE)

	Home Price Rank (1)	Home Price Rank (2)	Home Price Rank (3)	Home Price Rank (4)	Home Price Rank (5)
Promotions	7.1**	7.5**	6.2**	6.6**	7.1**
	(3.0)	(3.0)	(2.9)	(2.9)	(3.0)
N	1,617	1,617	1,613	1,613	1,584
KP Wald rK F stat	68.1	19.1	18.6	12.4	11.6
Hansen's J		6.8*	4.0	11.9*	12.9**
		[0.08]	[0.26]	[0.06]	[0.04]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is the percentile rank of the median value of a single-family home in the sailor's final zip code of residence in the year of his death within the national distribution of such values. All regressions include rate × tenure fixed effects. Standard errors are clustered at the level of the submarine on which the sailor served longest. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

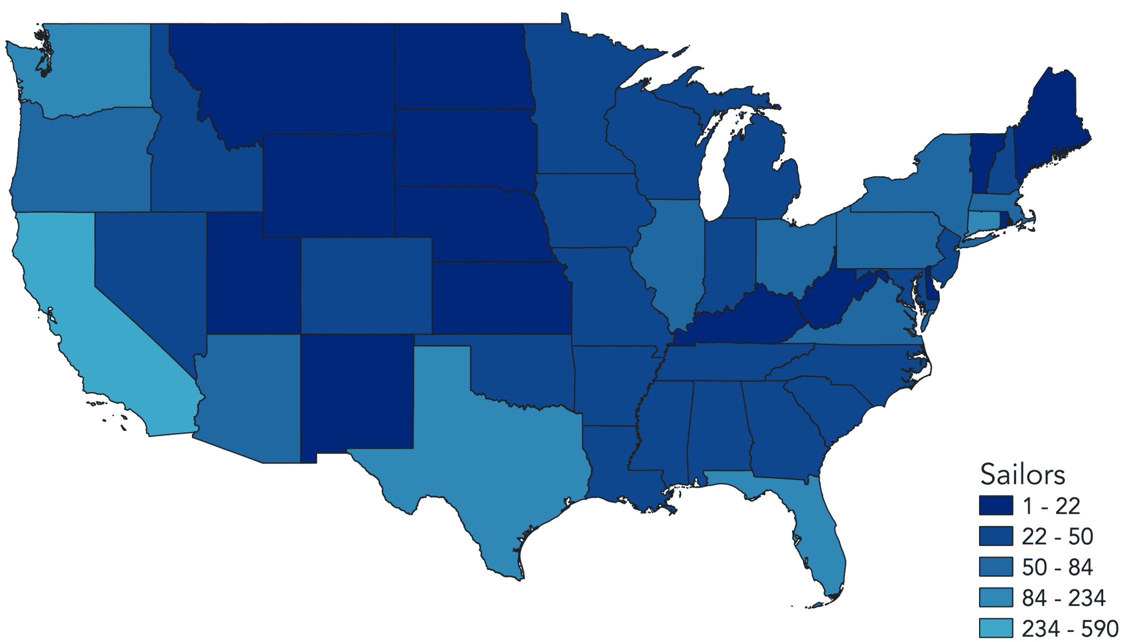
E Appendix to Section 6

Figure E1: Birth States of Submariners



Note: This map shows the states of birth for the 2,431 sailors for whom I have that information.

Figure E2: Final States of Residence of Submariners



Note: This map shows the states of birth for the 2,761 sailors for whom I have that information.

Table E1: **Late-War Rates** on Promotions (Clustered SE)

	12/31/43	12/31/43	6/30/44	6/30/44	12/31/44	12/31/44	6/30/45	6/30/45
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Promotions	0.88***	0.74***	0.74***	0.65***	0.79***	0.63***	0.78***	0.65***
	(0.13)	(0.07)	(0.15)	(0.08)	(0.17)	(0.08)	(0.19)	(0.08)
N	3166	3166	3166	3166	3166	3166	3166	3166
KP Wald rK F stat	4.48	15.91	4.48	15.91	4.48	15.91	4.48	15.91
Hansen's J	4.89	6.45	2.41	3.02	3.66	3.85	4.95	5.58
	[0.43]	[0.37]	[0.79]	[0.81]	[0.60]	[0.70]	[0.42]	[0.47]
Attacks Instrument		✓		✓		✓		✓

Note: The dependent variable is the sailor's rate at the date referenced in the column header. All regressions instrument promotions with cubic polynomials in *magnet* and Δ. Standard errors are clustered at the level of the submarine on which the sailor served longest. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E2: **Late-War Rates** on Promotions (OLS)

	12/31/43	6/30/44	12/31/44	6/30/45
	(1)	(2)	(3)	(4)
Promotions	0.48***	0.44***	0.41***	0.39***
	(0.03)	(0.03)	(0.03)	(0.03)
N	3182	3182	3182	3182

Note: The dependent variable is the sailor's rate at the date referenced in the column header. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E3: **Longevity** on Promotion Types (IV)

	(1) longevity	(2) longevity	(3) longevity	(4) longevity	(5) longevity	(6) longevity
Promoted to chief	9.95***		12.23***			
	(3.49)		(3.87)			
Promoted to first class		3.79		3.72		
		(2.38)		(2.58)		
Promotion					2.37***	2.43***
					(0.79)	(0.79)
N	2,191	2,207	2,198	2,213	2,815	2,823
KP Wald rK F stat	10.9	15.3	7.8	12.9	27.1	23.8
Hansen's J	13.3	7.5	11.9	13.1	15.5	13.9
	[0.35]	[0.82]	[0.45]	[0.36]	[0.63]	[0.74]
magnet & Attacks	✓	✓			✓	
Δ & Attacks			✓	✓		✓

Note: I restrict the sample to only those sailors who survived the war. Columns 1 and 3 include sailors who started at rates 3 through 6; columns 2 and 4 include sailors who started at rates 2 through 5, columns 5 and 6 include sailors who started at rates 1 through 6. All regressions include rate fixed effects. Standard errors are robust. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E4: **Longevity** on Promotion Types with Probit First Stage

	Longevity (1)	Longevity (2)	Longevity (3)	Longevity (4)
Promoted to chief	8.96***		9.88***	
	(2.49)		(2.66)	
Promoted to first class		3.78*		3.96*
		(2.00)		(2.13)
$\hat{v}$	-4.46***	-1.80	-5.01***	-1.91
	(1.53)	(1.13)	(1.58)	(1.20)
N	2,192	2,207	2,199	2,213
magnet	✓	✓		
Δ			✓	✓

Note: I restrict the sample to only those sailors who survived the war. Columns 1 and 3 include sailors who started at rates 3 through 6; columns 2 and 4 include sailors who started at rates 2 through 5. All regressions include rate fixed effects. Standard errors are based on 999 wild bootstrap replications. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E5: **Longevity** on Promotion Types (OLS)

	Longevity (1)	Longevity (2)
Promoted to chief	2.03**	
	(0.89)	
Promoted to first class		0.98
		(0.67)
N	2,198	2,213

Note: I restrict the sample to only those sailors who survived the war. Column 1 includes sailors who started at rates 3 through 6; column 2 includes sailors who started at rates 2 through 5. All regressions include rate fixed effects. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E6: **Changed State of Residence** on Promotions

	Moved States (1)	Moved States (2)	Moved States (3)	Moved States (4)	Moved States (5)
Promotions	0.05	0.04	0.03	0.03	0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
N	1,459	1,459	1,454	1,454	1,439
KP Wald rK F stat	151.2	40.2	43.6	25.9	25.3
Hansen's J		4.3	2.3	6.4	6.5
		[0.23]	[0.51]	[0.38]	[0.37]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is a dummy variable for whether the sailor passed away in a state different than the one in which he was born, conditional on surviving the war. All regressions include rate × tenure fixed effects. Standard errors are robust. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E7: **Changed State of Residence** (OLS)

	Moved States (1)	Moved States (2)	Moved States (3)
Promotions	0.01	0.00	0.01
	(0.02)	(0.02)	(0.02)
N	1,480	1,459	1,444
Rate FE	✓		
Rate × Tenure FE		✓	✓
Birth year FE			✓

Note: The dependent variable is a dummy variable for whether the sailor passed away in a state different than the one in which he was born, conditional on surviving the war. Standard errors are robust. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table E8: **Changed State of Residence** on Promotions (Clustered SE)

	Moved States (1)	Moved States (2)	Moved States (3)	Moved States (4)	Moved States (5)
Promotions	0.05	0.04	0.03	0.03	0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
N	1,459	1,459	1,454	1,454	1,439
KP Wald rK F stat	56.5	17.6	15.8	11.1	10.5
Hansen's J		4.3	2.7	6.6	6.4
		[0.24]	[0.43]	[0.36]	[0.38]
Attacks Instrument	✓	✓	✓	✓	✓
Δ		✓		✓	✓
magnet			✓	✓	✓
Birth year FE					✓

Note: The dependent variable is a dummy variable for whether the sailor passed away in a state different than the one in which he was born, conditional on surviving the war. All regressions include rate × tenure fixed effects. Standard errors are clustered at the level of the submarine on which the sailor served longest. Standard errors are in parentheses; p-values are in brackets. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.