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The Search for an American Submarine Strategy and Design

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The Search for an American Submarine Strategy and Design, 1916-1936

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A devastating comparison of the latest American submarines with some captured German U-boats after World War I caused a design and strategy debate in the U.S. Navy which led eventually to a complete redefinition of the American submarine's place in war.

In 1919, American naval officers had yet to define for themselves the proper role of submarines. Drawing on some of the lessons offered by the Great War, during the 1920s Naval War College problems called for submarines to operate by divisions or sections, usually in direct support of the fleet, discouraging individual offense unless an exceptional opportunity presented itself. If their seakeeping qualities allowed it, the submarines' missions were to gather intelligence, to locate enemy supply lines, and to disrupt enemy communications. Attacks upon enemy warships or merchant vessels independent of the surface fleet or of an impending surface action were never seriously considered. Those submarines unable to keep up with the fleet were relegated to coastal defense.[1]

Unfortunately, neither the navy nor American private industry could produce a technically reliable "fleet submarine" capable of keeping up with a surface force beyond 17 or 18 knots in the best conditions. This meant American submarines could not fulfill the close fleet support role assigned to them.[2]

Since American submarine technology could not meet the fleet's demands, some submariners suggested basing the fleet's demands on what the submarines could do. The state of the technology thus began to drive the strategy, rather than the converse.[3]

Beginning in 1928, those officers certain of the submarine's offensive potential wanted to abandon the burden of direct battle-fleet support in order to pursue independent offensive operations. Submarine commanders like

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Thomas Withers suggested emulating German technology and taking advantage of German operational experience. Some planners favored this move in view of the navy's postwar responsibilities in Asia and the Pacific.[4] A reliable, long-range submarine could present a significant and economical threat to Japanese warships and supply ships, while providing welcome support to the heavily burdened naval forces of the United States in the Far East.

Thus, where hitherto strategy had determined the nature of the ship, the opposite became true for submarines.

U-boats and S-boats

When the navy compared the German U-boats surrendered after the First World War to the American S-class, the superiority of the former precipitated a crisis. The S-class, the latest and most advanced of the navy's submarines, would soon be entering service in great numbers. It was already evident that they would suffer debilitating technical problems. The New London Ship and Engine Manufacturing Company (Nelseco), a subsidiary of Electric Boat Company, the navy's largest private prime contractor, had provided defective diesel engines for more than half of the class.[5] Experience with the new submarines demonstrated that they also suffered from destructive periscope vibration, terrible habitability, flawed torpedo tube shutters, and scores of other problems which frequently kept them out of service.

In November 1918, under the direction of Rear Admiral S. S. Robison, commander of Squadron 3 of the Atlantic Fleet Patrol Force, the navy began to collect information on the technical quality and performance of the vessels of the Imperial German Navy. For his report, compiled for the benefit of the technical bureaus, Robison and his assistant, Captain A. J. Hepburn, inspected the latest class of U-boats of each type. The *U-164* and *U-124* gave Robison experience with standard patrol submarines, the *UB-148* provided an example of a coastal vessel, while the *UC-105* minelayer completed the picture of German U-boat capabilities.[6] The submarine force in Europe borrowed these four boats from the British and took them to Portland, near Dorset, on 12 December 1918 for almost three weeks. It was what the American submariners discovered in those three weeks that rocked the U.S. submarine establishment and opened a twenty-year debate between the operational forces, the technical bureaus, and the General Board.

In February 1919, two months before Robison filed his report, Commander Emory Land (CC) of the Bureau of Construction and Repair (BUC&R) anticipated the admiral's findings and sent a letter to the secretary of the navy regarding the importance of gaining firsthand knowledge of the captured German submarines.[7] Land had served on the Doddridge Standardization

Board, which in the autumn of 1917 had confirmed the S-class as the standard American submarine design.[8] In July 1918 he was assigned to the staff of Admiral Sims, commander of U.S. naval forces in Europe. Immediately after the war, he toured German and Austrian shipyards. He also, of course, learned of the results of the U-boat inspections. In his letter to the secretary, Land could barely avoid using superlatives to describe the findings of the diesel, periscope, and hull tests. He was impressed as well by the cruising range of which these boats were capable. In one flight of admiration and envy he stated, "The diesel engines on these submarines are superior to any other diesel engines in any other submarines in commission in the world." He also lauded German double-hull construction for its resistance to depth charges and assured the secretary that he could not list all the superior features of the U-boat in the brief space afforded by a letter.

Two days after he sent this letter, in testimony before the navy's General Board, Land stated that bringing some of the captured U-boats to the United States was a necessity.[9] Accordingly, in the spring of 1919 the navy approved the temporary acquisition of six German submarines to allow both the technical bureaus and the operators to take complete advantage of the advances made by their former adversary: the *U-111* was a standard patrol submarine, or "Ms-boat," of approximately the same displacement as the S-class; both the *U-117* and the *UC-97* were minelayers, the first displacing over 1,000 tons and the latter 474 tons; the *UB-88* and *UB-148* performed coastal patrol roles, while the larger *U-140* was one of the long-range U-cruisers.[10]

The *U-111* and *UB-148* underwent tests supervised by the Board of Inspection and Survey which included standardization trials on the surface with varying combinations of engine and electric motor propulsion. The board also conducted submerged trials, torpedo firing trials, depth tests for hull strength, turning circles, as well as other tests to evaluate each vessel's submergence and maneuvering capabilities.[11] The U-boat Plans Committee, which arranged for the transfer of the six U-boats from England, specified that these experiments, especially on the *U-111*, should follow the regimen prescribed by the contract for the American submarine *S-2*. Captain Thomas Hart, chairman of the committee, and the next senior member, Commander Emory Land, knew all too well that the S-class would not fare well in comparison with the U-boat. But they did not anticipate the intense debate that followed.[12]

The Stirling Letter

The sense of urgency and frustration over the condition of the submarine fleet reached a climax in 1921 with a letter written to the secretary of the navy by Captain Yates Stirling, Jr., then commandant of the Philadelphia Navy Yard.[13] In this controversial letter, Stirling roundly condemned the

quality of American submarines and their ability to make a positive contribution to the navy's mission in a future war. American submarines, he declared, suffered from a litany of technical problems which rendered them totally unsuitable for service. These difficulties ranged from diesel and motor malfunctions through severe periscope vibration to poorly designed air compressors and ventilation systems.

The navy had to become more deeply involved in the design and construction of these vessels, if only to counter the risk of falling victim to a private sector monopoly. From Stirling's viewpoint, the navy had at its disposal, in the captured German U-boats, the perfect instruments for modernization. The S-class demonstrated that the navy and private industry had failed to produce a wartime equal to vessels like the *U-53*, a 700 ton Ms-boat with superior seakeeping qualities. Extensive reconsideration of current designs and, perhaps, a reevaluation of the navy's system for administering the submarine program were in order.

Stirling went on to criticize the Bureau of Construction and Repair for not taking full advantage of the opportunity to study and record the lessons offered by German technology. He accused the bureau of recommending the U-boats for early destruction despite pleas from the operating forces for more time to study and thoroughly incorporate German systems in the deficient S-class. Clearly, he meant to throw down the gauntlet and question the capability of the bureaus to design submarines and exploit new ideas.

The Stirling letter prompted a storm of protest from the technical bureaus and the General Board. Admiral David Taylor, chief of BUC&R, dissected Stirling's note in response to the secretary of the navy's request for an opinion, and pointed out that in most instances Stirling's expose contradicted matters of record.[14] Taylor assured the secretary that BUC&R had indeed made a careful study of the U-boats and had every intention of incorporating the latest in German technology in future designs.

That Taylor's very comprehensive response to Stirling did not end the matter illustrates the extent to which Stirling's observations struck a chord among the various activities responsible for submarine operation and design. When the General Board called a hearing on Stirling's claims, it turned into a testimonial by the operating forces on the utter inadequacy of the navy's submarines and clearly revealed the considerable diversity of opinion on the board and at the technical bureaus.

Before the General Board, Captain Stirling acknowledged that BUC&R had indeed recorded the specifications of the captured U-boats. But he persisted in his criticism and read selections from critical reports on the S-class solicited by him from ten of the most experienced submarine officers in the navy, including Captain Hart and Lieutenant Commanders Daubin and Gibson, who had extensive firsthand experience with the U-boats. Stirling then drove home his central theme by blaming the methods employed by the

navy to develop submarine designs for a record of mediocrity and failure. The real problem, he charged, lay with the bureaus. As Captain Hart pointed out, it had taken far too long to convince the technical bureaus of the need to examine and learn from the U-boats; the bureaus illustrated just how far removed they were from the cutting edge of submarine technology by the low priority initially given to obtaining these vessels for research in the United States.[15]

The controversy created by Stirling's letter and his testimony before the General Board illustrated the gulf between the technical bureaus and the operational submarine forces. The bureaus had in fact taken advantage of the captured U-boats in order to improve the design and systems of American submarines. Although the Bureau of Engineering (BUENG) displayed a greater flexibility in this regard than did BUC&R, both saw the importance of educating themselves in the latest German technology. Shut out of this process, the operational officers had not benefitted from the bureaus' evaluation of German technology. Concerned about the lamentable characteristics of the S-class and the possibility that the bureaus did not appreciate the insights provided by the U-boats, Stirling and those who supported him took action. In their estimation, the United States not only lagged behind in the quality of its submarines, but also the lack of communication between the designers and operators presented the navy's submarine program with a considerable obstacle.

Stirling advanced a solution to this predicament which paralleled the creation of the Bureau of Aeronautics for an equally new form of technology first applied to military purposes during the war: he recommended the establishment of a Bureau of Submarines, which would focus command authority, available money, and all the technological expertise in a single agency in order to produce the best possible undersea weapon for the navy. In the absence of such a bureau, said Stirling, submariners would have to go begging for money because those at the Navy Department naturally assumed "that they are better fitted to dispense it to the prodigal son than he would be to dispense it himself."[16]

Stirling contended that a Bureau of Submarines would overcome the natural reluctance of the other bureaus to abandon or revise a prized creation (like the S-class design), and that such a bureau would not hesitate to copy all or part of the *U-111* and its sister boats if the state of American technology made these decisions necessary. Thus, the development of a seaworthy submarine to fulfill the assigned mission would finally take a much higher priority within the navy.[17]

In its report to the secretary of the navy, the General Board did not enthusiastically embrace Stirling's suggestions.[18] It defended the S-class as the best design the navy could have generated during the war, and it stated that new insights gained from the U-boats could have a positive influence on the

future of both the S and the even newer V types if this proved financially feasible.[19] The board attributed the propulsion problems in the S-class to an unhealthy dependence upon Electric Boat, and it encouraged more navy participation in submarine design and development without going so far as to suggest the need for a Bureau of Submarines. Along with the upgrading of facilities on both coasts for repair and overhaul, the board also authorized the creation of a school for all enlisted personnel working with submarines.

A Consensus in Three Stages

Between 1922 and 1931, the navy did little about submarines but debate the various issues essential to their design and construction. Without a central authority and adequate support, only time and constant debate could distill diversity of opinion down to an acceptable modern design.

The insights gained from the surrendered German U-boats came after the war, when the S-class designs were already in production. Applying these insights to boats still under construction or already in commission proved awkward, even for the most determined.

A lack of appropriations for new construction, the submarine's low priority in the face of severe financial cutbacks mandated by Congress, and the influence of the interwar disarmament conferences only exacerbated these conditions. The submariners did not have the political clout which brought the aviators their own bureau after World War One, so the level of appropriations and the number of contracts declined. After the Portsmouth Navy Yard, the Electric Boat Company, and the Lake Torpedo Boat Company completed the last of the 51 S-class boats in 1925, the so-called V-class provided the only new work offered to the submarine construction industry for many years, outside of standard overhaul or re-engining jobs. The navy kept its own yards alive in this environment by awarding the *V-1* through *V-5* and the *V-7* and *V-8* to Portsmouth, with the *V-6* going to Mare Island Naval Shipyard. The private sector did not see another contract for new construction until Electric Boat laid the keel of the U.S.S. *Cuttlefish* (SS-171; V-9) in 1931.

During this difficult interval for both the navy and industry, the first stage of a consensus began to emerge from the many and varied viewpoints on submarine strategy and design. In April 1927, one of the key figures in this process, Admiral H. A. Wiley, then chairman of the General Board, sensed the possibility of a broad accord on design and strategy based on the characteristics of the larger German Ms-boats. He instructed BUC&R and BUENG to explore a 1500 ton type and promoted the 1175 ton *U-135* design as a basis for the discussion of specific characteristics. The latter was the first of a class of larger Ms-boats built by the Germans at the Imperial Naval Shipyard in Danzig between 1916 and 1918. Rear Admiral G. H. Rock,

assistant chief of BUC&R, objected to purchasing foreign plans or using foreign vessels as prototypes. He also resisted experimenting with the 1500 ton type and felt strongly that the General Board should first define all of the military characteristics for new submarines before the bureau went to work on the design. However, as the General Board held the authority to determine general submarine characteristics, the technical bureaus took Wiley's suggestion seriously.

Shortly thereafter the Submarine Officers' Conference (SOC) followed Admiral Wiley's lead, adopting the *U-135* as the standard for the future.[20] Most of the officers present at the 2 June 1927 meeting of the SOC agreed on an all-purpose design of 900 to 1400 tons displacement. At 1175 tons, the *U-135* fulfilled this requirement, giving the navy a reliable prototype to copy. Lieutenant Commander H. T. Smith of BUENG, a participant in the conference, even suggested building a duplicate of the *U-135* for testing and evaluation before any new designs were considered for construction.[21]

Eight months later, the accepted wisdom that submarines functioned most effectively either in coastal defense or tied directly to the battle fleet came under fire. In February 1928 Commander Thomas Withers, commander of Submarine Division Four, openly challenged both of these roles by questioning the prudence of allowing a quest for a "fleet submarine" with greater speed to adversely affect the habitability and submerged performance of American boats.[22] More than any other vessel, the submarine's very restricted internal spaces insured that any attempt to increase speed with larger engines and motors would have a profound impact upon other ship characteristics. The awkward maneuvering of the first six V-boats while submerged illustrated the validity of this criticism. Withers argued that submarines, unable to perform reliably on the surface at speeds approaching 20 knots, could not serve in the role assigned them.[23] Their slower pace drastically increased the vulnerability of a fleet, while contributing little to the effectiveness of the capital ships in action. Withers also contended that submarine commanders preferred to operate independently. Indulging this preference would allow the navy to exploit the submarine's stealth to best advantage against enemy warships, a priority which would not eliminate intelligence-gathering as a secondary mission.

Withers' approach was strongly supported by Admiral Wiley, who, having set the stage for a reconsideration of submarine design, left the General Board in November 1927 to become commander in chief of the U.S. Fleet.[24]

Moving to the Naval War College in 1930, Withers refined his ideas on submarine strategy and urged the navy to permit its submarines to operate independently and aggressively. He suggested employing submarines independently, in combined attack and reconnaissance missions. Rather than making exceptional speed the vital factor, Withers suggested that improved reliability, better habitability, and longer range would serve the navy better.

The awkward attempts at perfecting a "fleet boat," exemplified by the three 2,000 ton behemoths which spearheaded the V-class in 1921, should give way to smaller vessels capable of 15 knots on the surface, ninety days at sea, and a 12,000 mile range with satisfactory economy and dependability. Withers felt that a boat of approximately 900 tons could accomplish these ends with great practical benefit for the navy.[25]

In a letter to Secretary of the Navy Charles Adams, the president of the Naval War College supported Withers' viewpoint.[26] Research and study at the Naval War College demonstrated that working in conjunction with the fleet represented the least important of the submarine's missions. The submarine was better utilized in an independent, offensive role with a secondary intelligence-gathering task.

Sensing their liberation from strategic confinement and the possibility of revising existing designs, the operating forces welcomed Withers' ideas. Furthermore, his strategy was compatible with the position adopted by the SOC. Thus, for the first time in nearly ten years of postwar deliberations on submarine characteristics, the perspectives of strategists at the Naval War College and the opinions of the submariners coincided on the significant points of mission and displacement. In his testimony before the General Board, Rear Admiral F. H. Schofield, the navy's director of war plans, supported the submarine characteristics suggested by Commander Withers and agreed with the SOC that the *U-135* design should serve as a basis for discussion.[27]

The navy now seemed ready to recast the role of the submarine and to work with a displacement which would guarantee acceptable habitability, maneuverability, speed, and reliability, all within the limitations of American diesel technology.[28] Thanks to Withers, Wiley, and the SOC, the last two V-boats, the *V-8* and *V-9*, would display characteristics vastly different from the first vessels of their class, which represented the final attempt to achieve the large, classic "fleet submarine."[29]

Between 1928 and 1936 the process of developing the standard American submarine entered its second stage in the combining of the 1175 ton *U-135* design with the greater size and range of the German U-cruisers. The latter, such as the 1,930 ton *U-140*, provided valuable practical examples of vessels designed for range, dependability, and solo operations.[30] The appeal of these characteristics and those of the *U-135* suggested a compromise American design which would owe its displacement and power plant to the *U-135* and its space and habitability to the *U-140*.[31]

In September 1930, BUC&R proposed designs for the U.S.S. *Cachalot* (V-8) and *Cuttlefish* (V-9) based on improvements in the *U-135* design. After carefully examining the U-boat design, BUC&R came to the conclusion that the Germans must have built a vessel about forty tons heavier than the weight specified in the plans. If the bureau had remained completely faithful to the original German concept, ideal crew and storage spaces would shrink, and

the boat's small size would impede access to the propulsion plant for overhaul and repair.[32] The original design displacement would also inhibit both comfort in the tropics and the vessel's seakeeping qualities.

Thus, the designers at BUC&R developed their own variations on the *U-135* type. As an added incentive for pursuing the intermediate displacement, the London Naval Treaty agreements stipulated a limit of 52,700 for total operational submarine tonnage. If 1175-1200 ton boats could successfully incorporate the elements now considered most important, then the navy could build many more of the vessels and still remain within the limits of the treaty.[33]

Four schemes emerged from BUC&R deliberations over just how to adapt this intermediate design for American service in the *V-8* and *9*. In the first variation, the original concept changed very little save for an increase in the diameter of the inner hull in order to secure greater living and storage space in addition to greater submerged stability. In the second scheme, the bureau provided more control room space, increased accommodations for crew and refrigeration, and better accessibility to the engine. In both of these plans, designated schemes A and B, BUC&R suggested using the Bureau-M.A.N. engines built at the New York Navy Yard to insure reliability and long service with a minimum of repair and overhaul time.[34]

Scheme C incorporated most of the features of schemes A and B, but the Bureau-M.A.N. engines were replaced by new light-weight diesels developed by the Germans after the war. BUENG, however, considered these new engines risky and experimental when compared to the New York Navy Yard's well-tested product.

As its last design, scheme D, BUC&R offered the 1560 ton *V-7*, under construction since June 1930, as a control factor in the process of selection.

None of these proposed designs regarded the submarine as an auxiliary to the surface fleet. Rather than speed, BUC&R now chose a slightly increased size to assure general utility, improved seakeeping qualities, a 17 knot surface speed, reliability, habitability, and a minimum radius of 7,500 miles.

Although the design seemed complete at 1200 tons, the SOC persisted in its advocacy of a slightly larger vessel to further enhance seakeeping and habitability. In addition, many officers felt that the diverse missions assigned to the submarine required more than one type. Thus, in the third and final stage of building a consensus within the navy, the technical bureaus, the SOC, and the General Board compared the relative merits of the 1200 ton designs, larger models of 1450 to 1750 tons proposed by the SOC, and the ever-present proposals for coastal defense and minelaying boats.[35]

The argument of the operational officers for a larger alternative or variety of types did not endanger the growing consensus as much as it revealed a dogged attachment to the traditional division of responsibility between the coastal and fleet submarine. In reports to the General Board made in February 1934, both Commander Sherwood Pickering, inspector of machinery at

Groton, and Lieutenant Commander C. W. Styer, prospective commanding officer of the *Cuttlefish* (V-9) and member of the SOC, discussed fleet, minelayer, cruiser, and coastal submarines.[36] Their analyses of these various types revealed that both officers envisioned vessels of 1500 tons performing every task save coastal defense. Thus, although the image of the submarine as a coastal defense vessel had clearly survived the revision in 1930 of the submarine's primary role, the prevailing opinion among operational commanders assigned nearly every major operational function to the design which had evolved from a synthesis of the *U-135*'s characteristics with those of the larger U-cruiser.

The 1500 ton design quickly assumed the primary place within the submarine community as the best size and configuration to satisfy the navy's desire for reliability, range, and habitability.[37] In March 1936, the General Board's final recommendations for the 1937 construction program specified 1450 tons as the "minimum compatible with a proper balance of the required military characteristics to meet the intended employment of the submarine."[38] At last, the debate was over. The success of the resulting design, the *Salmon* - *Sargo* class, testified to the wisdom of the final consensus achieved within the navy by 1936.[39]

Observations

In the final analysis, the advanced state of German submarine technology and the intense American desire to surpass wartime U-boat performance provided the catalyst for a thorough reevaluation of the submarine's mission and design after the Great War. Once Stirling, Withers, and others initiated the technical debate and provided a potent antithesis to current strategic wisdom, leaders like H. A. Wiley provided a favorable environment for a new strategic and technical synthesis for the American submarine.

In this involved process of strategic revision and technical change also lay the roots of the unrestricted submarine warfare policy against Japan officially adopted shortly after the attack on Pearl Harbor. American interwar naval planners judiciously avoided suggesting that the navy's submarines should attack merchant vessels; the United States did not want to face the same charges levelled against the Germans during the First World War. But in a national emergency, would the navy prove reluctant to direct its offensive submarine strategy and its new, reliable and effective submarines against enemy merchant vessels as well as warships?

In 1961, Professor Samuel Flagg Bemis traced the origins of the American unrestricted submarine warfare decision back to 1940, and J. E. Talbott has since argued that support for this type of warfare existed within the navy as far back as 1937. In fact, the revisionist thinking of the American submarine community in the late 1920s and the designs developed as operational

expressions of these views contributed to a very favorable environment within the navy for unrestricted submarine warfare a full decade before Pearl Harbor. Although limited by international law to attacks on enemy warships, the participants in the navy's interwar fleet problems and Naval War College exercises recognized the readiness of possible adversaries to use a submarine *guerre de course*.[40] In these games, American officers playing the part of the "Orange" or "Red" enemy found themselves planning to defend against an American *guerre de course* or actually executing a strategy of this type against the United States. During this period, American naval planning for these exercises evolved from complete prohibition against sinking commercial vessels to approved operations against enemy-escorted convoys, beginning with Naval War College Joint Problem No. 1 of 1926 and ending with Fleet Problem XIII of 1932.[41] In spite of national policy and international agreements, ideas and experiences such as these laid the foundation for submarine operations against the Japanese merchant fleet. As is so often the case, rather than detached prewar discussions of proper behavior, the nature of the conflict and the capability of the navy's submarines determined the degree and manner of commitment.

By the time the Seventy Percent Expansion Act of 1940 signalled the end of America's commitment to the restrictions imposed by the London Treaty of 1930, the navy knew exactly what kind of submarine it wanted to build in quantity.[42] The success of the *Salmon - Sargo* design precipitated the mass production of the *Gato* and *Drum* classes which commenced in 1940. The navy would enter World War Two with a much better idea of the submarine's nature and mission than it had in 1919.

Notes

1. Naval War College Operations Problems, 1923 through 1927, boxes 14 and 15, Strategic Plans Division Records, U.S. Navy Operational Archives, Washington Navy Yard (OA).

For an interesting discussion of the proper use of submarines, see "Submarine," a lecture delivered by Captain George C. Day, USN, at the Naval War College, 16 Feb 1923, box 3, Lectures and Speeches Series 1, Strategic Plans Division Records, OA.

Occasionally American naval analysts seemed to reject the commercial war option employed by the Germans during the First World War as distasteful, leaving scouting, harbor defense, and mine-laying as the only honorable options open to the submarine arm of the navy. In the speech cited above, Captain Day said, "As to what submarines can do, or may be permitted to do, against enemy lines of communication and trade is a most difficult question. What they can do the Germans showed, but it is not in any way likely that we will ever use them in that way." (p. 5) It was as if the strategy were objectively dishonorable, or the environment created by the disarmament conference in 1921-22 had rendered it so.

A few at the Naval War College interpreted the U-boat war against commerce as an act of desperation by the Imperial Navy: the U-boat was only modestly effective against warships, so merchantmen were the best alternative targets. As true warships, submarines were considered best employed as scouts, screens for the surface fleet, or coastal defenders. There is a great deal of discussion about the operational, mechanical, and technological limits of the submarine, but virtually no appeal for a greater R&D effort to enable the submarine to play an expanded role. For example, "Types and Missions of Surface Vessels, Submarines, and Aircraft," by Captain Lewis Coxe, USN, 4-5 Mar 1930, box 3, Lectures and Speeches Series 1, Strategic Plans Division Records, OA.

2. Not even the first three V-class submarines of 2,000 tons surface displacement could reliably sustain 20 knots on the surface. A "fleet submarine" was defined as a submersible capable of a sustained surface speed of 21 knots under any conditions which the big surface vessels could weather. Operating with the surface fleet would require not only high speed but also a periscope capable of allowing a clear view for the submarine captain from a depth of thirty feet. The boat would also need excellent maneuverability, seakeeping qualities, and endurance. Commander John Alden, USN (Ret.), *The Fleet Submarine in the U.S. Navy* (Annapolis, Naval Institute, 1979), 5.

3. For an excellent discussion of technology's role in modifying present-day strategy, see Commander D. Conley, RN, "The Impact of Technological Change Upon Naval Policy," *RUSI Journal*, 133, #2 (Summer 1988), 35-40.

4. The London Conference of 1930 placed a limit of 52,700 tons on American, British, and Japanese submarines, but none of the disarmament conferences succeeded in abolishing the vessels as a type. The British supported abolition because the submarine posed the greatest threat to the tenuous mastery of the seas held by the Royal Navy. Consequently, the British submarine force faced a particularly difficult challenge as interwar governments strove for disarmament and budget reductions and the Royal Navy placed its priorities elsewhere. See David Henry, "British Submarine Policy, 1918-1939," in *Technical Change and British Naval Policy, 1860-1939*, Bryan Ranft, ed. (London: Hodder and Stoughton, 1977), 80-107.

5. G.E. Weir, "The Navy, Industry, and Diesel Propulsion for American Submarines 1914-1940," *Naval Engineers Journal*, 101 #2 (May 1989), 207-219.

6. Rear Admiral S.S. Robison to Commander, U.S. Naval Forces Operating in European Waters, 15 Jan 1919, series 1, file 1, box 1, Submarines/Undersea Warfare Division (Subs/UWD), OA. The term "technical bureaus" is used here to denote the Bureaus of Construction and Repair, Engineering, and Ordnance. In the Imperial German Navy, the prefix UB stood for coastal defense submarines displacing approximately 100 to 500 tons depending upon the vessel's vintage. A UC prefix designated a submarine minelayer.

7. Commander E. S. Land to Secretary of the Navy via the Chief of Bureau of Construction and Repair and the CNO, #28766-177 of 4 Feb 1919, box 2767, Secretary of the Navy General Correspondence 1916-1926 (SECNAV GENCORR 1916-26), RG-80, National Archives, Washington, D.C. (NA). The designation "CC" stood for Construction Corps. This group, which existed between 1859 and 1940, was composed of highly skilled engineering officers attached as needed to the Bureau of Construction and Repair and the Bureau of Engineering. When these two bureaus combined to form the Bureau of Ships in June of 1940, these officers were redesignated engineering duty officers (EDOs). For an excellent general discussion of the CC, see Rear Admiral J. A. Furer, USN, *Administration of the Navy Department in World War Two* (Washington, D.C.: GPO, 1959), 215ff.

8. In October 1917 the Doddridge Board met to review the recommendations of the Stirling Standardization Board, which preceded it, and to establish officially the characteristics for future submarines. Chaired by retired Commander J. S. Doddridge, this board included some of the navy's best submariue engineers and commanding officers, such as Emory Land and Commander C. W. Nimitz, representing the Atlantic Submarine Force.

S-Class characteristics follow.

Electric Boat Design (S-1, S-18-41)
Displacement: 854 tons normal
Design depth: 200 feet
Design speed: Surface, 14.5 knots; Submerged, 11 knots
Engines: 1200 BHP Nelseco
Motors: 1500 BHP Electro Dynamic

Lake Torpedo Boat Company Design (S-2)
Displacement: 800 tons normal
Design depth: 200 feet
Design speed: Surface, 15 knots; Submerged, 11 knots
Engines: 1800 BHP Busch-Sulzer
Motors: 1200 BHP Diehl

Navy Design (S-3-17) (built at Portsmouth NSY and at Lake after the navy rejected the S-2 design for mass production as inferior to the S-1 and S-3)
Displacement: 875 tons normal
Design depth: 200 feet
Design speed: Surface, 15 knots; Submerged, 11 knots
Engines: 1400 (after S-4, 1000) BHP Nelseco, Bu-MAN, or Busch-Sulzer
Motors: 1200 BHP Westinghouse

Postwar Variations Built by Lake (adapted for greater range and larger engines without encouraging results)

S-42 through *47*:
Displacement: 906 tons normal
Design depth: 200 feet
Desigu speed: Surface, 14.5 knots; Submerged, 11 knots
Engines: 1400 BHP Nelseco
Motors: 1200 BHP Electro-Dynamic

S-48 through *51*:
Displacement: 903 tons normal
Design depth: 200 feet
Design speed: Surface, 14.5 knots; Submerged, 11 knots
Engines: 1800 BHP Busch-Sulzer
Motors: 1500 BHP Ridgeway

9. Testimony on Fleet Submarine Desigu by Commander Emory Land, 6 Feb 1919, volume 1, page 59ff., General Board Hearings, OA.

10. The design of the German Ms-boat quickly took shape iu 1914 after the outbreak of World War One. Early vessels of this design displaced roughly 700 to 800 tons, very much like the American S-class. Beginning with the *U-43*, built at the Imperial Shipyard at Danzig, the Ms type went through many variations and fuuctioned as the standard German wartime submarine. The Ms designation is an abbreviation for "mobilization." For further information see E. Rossler, *Geschichte des deutschen Ubootbaus* (Munich: J. F. Lehmanns Verlag, 1975). The *UB-88* and *148* were between 510-523 tons surface displacement, and the *U-140* was of 1930 tons surface displacement.

11. Memorandum from the Assistant for Material to the Director of Naval Iutelligence, Subject: German Submarines, 27 May 1924, series 1, file 3, box 1, Subs/UWD, OA.

12. Plans Committee to CNO, #28766-177:16 1/2 of 12 May 1919, box 2767, SECNAV GENCORR 1916-26, RG-80, NA.

13. Captain Yates Stirling, Jr. to Secretary of the Navy, 28 Mar 1921, series 1, file 3, box 3, Subs/ UWD, OA.

14. BUC&R to Secretary of the Navy, 18 May 1921, box 109, 420-15, General Board Subject Files 1900-47, RG-80, NA. For the perspective of one of the BUC&R naval constructors intimately involved with submarine design, construction, aud the attention paid by BUC&R to the German advances in the field, see "Memo for the File," by Naval Constructor H. S. Howard, 14 Apr 1921, box 1254, Correspondence Regarding Ships 1916-1925, BUC&R, RG-19, NA.

15. "Situation Relative to Submarines," 30 Jun 1921, General Board Hearings of 1921, vol. 2, pp. 304ff., Scholarly Resources Microfilm, OA. Captain Thomas Hart was an early snpporter of the efforts by Stirling to push BUC&R into paying greater attention to the design and performance of the German U-boats: Stirling to Hart, 13 Apr 1921; Hart to Stirling (with enclosed remarks on Stirling's letter of 28 Mar 1921), 22 Apr 1921; Stirling to Hart, 28 Apr 1921 (folder 19, box 4, Papers of Admiral T.C. Hart, OA). See also James Leutze, *A Different Kind of Victory: A Biography of Admiral Thomas C. Hart* (Annapolis: Naval Institnte Press, 1981).

16. *Ibid.*

17. "Situation Relative to Submarines," 1 Jul 1921, General Board Hearings of 1921, vol. 2, pp. 356ff., Scholarly Resources Microfilm, OA.

18. General Board to Secretary of the Navy, 25 Jul 1921, box 109, 420-15, General Board Subject Files 1900-47, RG-80, NA.

19. The first three V-class submarines were the successors to the navy's first generation of "fleet submarines," the 1107 ton T-class. The prevailing desire of many major naval strategists to have the submarine operate with the battle fleet gave birth to the T-class design with its projected high surface speed and improved seakeepiug qualities for blue water missions. Beguu in 1916 and 1917, the T-class design called for a 20 knot surface speed provided by Nelseco diesels which could generate 1100 horsepower at 375 RPM. By November 1921, the diesels in the *T-2* exhibited excessive vibration at the planned surface speed of 20 knots and, in time, all three vessels displayed many of the same problems which tormented the Nelseco powered S-boats.

Because their Nelseco propulsion systems could not supply sufficiently reliable power, the navy decided to retire Submarine Division Fifteen's three T-class boats by 1925.

The *V-1* through *3* (SS-163/165; U.S.S. *Barracuda, Bass,* and *Bonita*) displaced 2,000 tons aud had a design speed of 21 knots which was rarely reached, eveu in the best of conditions.

The *V-4* (SS-166; U.S.S. *Argonaut*) was the only attempt made by the U.S. Navy to copy the large German U-boat minelayers of World War One. She displaced 2710 tons, and the *V-5* and *6* (SS-167/168; U.S.S. *Narwhal* and *Nautilus*) were 2730 ton attempts to adapt this larger design to conventional submarine patrol duties. All three of these submarines were armed with two 6-inch guns each. The *V-7* (SS-169; U.S.S. *Dolphin*) was the smallest yet of the V-boats at 1560 tons. See Alden, *Fleet Submarine*, 25–37.

20. The Submarine Officers' Conference, an advisory committee composed of experienced submariners, came into existence in 1926.

21. Submarine Design and Building, 2 Jun 1927, file 4, series 2, box 5, Subs/UWD, OA; William Manchester, *The Arms of Krupp* (Boston: Little, Brown and Company, 1968), pp. 352–354. At this session of the conference, the officers fully realized the difficulty of reproducing the *U-135*. Krupp had formed *I.v.S.* (*Ingenieur-Kantoor voor Scheepsbouw*) [Engineering Office for Shipbuilding] in The Hague to continue many of its projects which were prohibited by the Versailles Treaty. With the approval and cooperation of Admiral Paul Behncke, leader of the *Marineleitung* of the early Weimar Republic, a U-boat office was created at *I.v.S.* by the navy and thirty Krupp engineers from the *Germaniawerft* shipyard in Kiel. As a representative of this Dutch company, Dr. Regenbogen, a diesel engineer and part of the wartime leadership at *Krupp-Germaniawerft*, offered to sell different German submarine plans to the U.S. Navy. However, this firm did not have a complete set of plans because the Imperial German Naval Office awarded the larger Ms design to the Imperial Shipyard at Danzig, and the plans disappeared after the war, presumably destroyed by the Military Commission in control of the area around Danzig. Furthermore, affiliation with Regenbogen and cooperation in construction between his firm and PNSY or Electric Boat posed considerable obstacles in terms of technology, experience, materials, and technique. The *U-135* was never copied, but it did serve as a basis for discussion in the process of consensus-building within the navy.

22. Commander Thomas Withers, Commander Submarine Division Four, to Secretary of the Navy, 3 Feb 1928, box 109, 420-15, General Board Subject Files 1900-47, RG-80, NA.

A new development which must have encouraged Withers was the improvement in radio communication for submarines in the 1920s. By 1923 submarine radios were deemed reliable up to 300 miles. In a test in the fall of 1922, the *R-22* communicated with a boat off Block Island from a location off Cape Hatteras without any difficulty. Awash, a submarine could receive messages with a high degree of success, but sending was difficult. During the 1927–28 period, when Withers began to question the accepted wisdom about submarine strategy, NRL developed high-frequency radio transmitters for submarines. The model XE crystal-controlled high-frequency transmitter allowed communication on the surface over ranges between 200 and 500 miles depending on location and atmospheric conditions. The submerged range of the XE and its successor XK (1929) was about eighty miles. Between 1930 and 1932, the navy equipped twenty S-boats with the Model TAR transmitter, which was capable of both low and high frequency transmissions. See "Submarines" by Captain George C. Day, USN, 16 Feb 1923, box 3, Lectures and Speeches Series 1, Strategic Plans Division Records, OA; and Louis A. Gebhard, *Evolution of Radio-Electronics and Contributions of the Naval Research Laboratory* (Washington, D.C.: NRL, 1979), pp. 55–57.

Submerged reception and transmission proved a bit more difficult, but progress was made. In January 1920, an S-class submarine received German transmissions from Europe while submerged fourteen feet off New London, Ct. By 1930 it was sixty-four feet, and the navy was experimenting with periscope and loop antennas, abandoning the old "French coil" type secured to the bridge wings during World War One. See BUSHIPS to CNO, Subject: Underwater Reception of Radio Signals, 25 Oct 1940, box 4, Confidential Correspondence Regarding Research and Design of Radio and Other Communications Apparatus, BUENG, RG-19, NA.

23. Design Surface Speeds:

V-1/3 = 21 knots (rarely performed at more than 17 knots in spite of ambitious expectations)

V-4 = 15 knots (minelayer)

V-5/9 = 17 knots

The *V-7* through *9* could not perform at their design speed in anything but ideal conditions. Many of the V-boats never met these requirements at all.

24. Admiral H. A. Wiley, Commander in Chief, U.S. Fleet, to Secretary of the Navy, 1 Apr 1928, box 109, 420-15, General Board Subject Files 1900-47, RG-80, NA.

25. "Design of Submarines" by Commander Thomas Withers, 14 Aug 1930, box 111, 420-15, General Board Subject Files 1900-47, RG-80, NA. Withers also resurrected the concept of a central authority governing submarine matters by suggesting a design control office both to standardize American submarines and force industry to keep to the spirit, if not the letter, of the designs as defined by the technical bureaus and the General Board. Commander Thomas Withers to Secretary of the Navy, 14 Aug 1930, series 1, file 6, box 4, Subs/UWD, OA.

The immediate precursor of the *Gato* class of World War Two and the end-product of the interwar debate, the *Salmon-Sargo* design (1936-37) was lighter than the *V-1* by nearly 500 tons but provided a

submarine captain with slightly greater surface cruising range (11,000 miles at 10 knots), extended submerged endurance (adaptable to a fuel capacity 18,000 gallons greater than the *V-1*), and improved habitability, as well as enhanced seakeeping qualities and submerged handling. The USS *Salmon* (SS-182) was also 33 feet shorter than the *V-1*. See Alden, *Fleet Submarine*, 25, 65, 68.

26. Rear Admiral Harris Laning, President, Naval War College to Secretary of the Navy, 29 Aug 1930, box 111, 420-15, General Board Subject Files 1900-47, RG-80, NA.

27. "Military Characteristics for Submarines," 9 May 1928, General Board Hearings of 1928, vol. 1, p. 145, Scholarly Resources Microfilm, OA.

28. The S and V-class boats were constantly confronted by a plague of vibration and breakage problems with their diesel engines which significantly reduced their operational value. See G. E. Weir, "The Navy, Industry, and Diesel Propulsion for American Submarines 1914-1940," *Naval Engineers Journal*, 101 #2 (May 1989), 207-219.

29. "Building Program 1929—Submarines," 1 Apr 1927, General Board Hearings of 1927, vol 1, pp. 67ff, Scholarly Resources Microfilm, OA.

30. The Imperial German Navy's U-cruisers varied in size from 2158 tons (*U-142/150* & *U-173/200*) to 1930 tons (*U-139/141*) to a displacement of 1512 tons (*U-151/157*, which included the converted commercial-U-boat *Deutschland*). The Germans experimented with various propulsion arrangements and torpedo tube configurations. The United States used much of this technology, but could match neither the seakeeping qualities nor the reliable propulsion machinery in the early interwar years.

31. "Military Characteristics for Submarines," 9 May 1928, General Board Hearings of 1928, vol. 1, pp. 129ff., Scholarly Resources Microfilm, OA. American submarine designer Rear Admiral Andrew I. McKee (rank as of 7-1-47) incorporated many of the *U-140*'s characteristics in his design of the *V-7* (SS-169). But this plan was overshadowed by the submarine community's preoccupation with the *U-135*. See Alden, *Fleet Submarine*, 19-21.

32. The remarkable reliability of the M.A.N. diesels in the German U-boats made this access less important to the Germans than to the U.S. Navy.

33. The term "intermediate" is used here to designate a design displacing from 1175 to 1500 tons based on many of the characteristics of the *U-135*, roughly in between the old 800 ton S-class and the much larger 2,000 ton V-class fleet boats. "Submarines *V-8* and *V-9* - Preliminary Design," 15 Sep 1930, box 110, 420-15, General Board Subject Files 1900-47, RG-80, NA; and Admiral George C. Day, Senior Member of the General Board to Secretary of the Navy, 11 Aug 1930, box 111, 420-15, General Board Subject Files 1900-47, RG-80, NA.

34. The navy developed these engines from the M.A.N. machinery which powered Germany's U-boats in the First World War.

35. As it turned out, the surface tonnage of the *V-8* and *9* were 1111 tons and 1130 tons, respectively.

36. Commander Sherwood Pickering to Chairman of the General Board and Lieutenant Commander C. W. Styer to Chairman of the General Board, 10 February 1934 and 8 February 1934 (respectively), box 111, 420-15, General Board Subject Files 1900-47, RG-80, NA.

37. "Comments on Department Submarine Officers' Conference Report of 16 December 1935, subject: Submarines - Characteristics of," 20 Jan 1936, series 1, file 8, box 4, Subs/UWD, OA. This report suggested 1750 tons as the maximum suitable size for the navy's primary submarine design.

38. Chairman General Board to Secretary of the Navy, 13 Mar 1936, box 112, 420-15, General Board Subject Files 1900-47, RG-80, NA.

39. U.S.S. *Salmon*: 1449 tons, 5 officers, 50 enlisted, designed for 21 knots surfaced, 9 submerged. U.S.S. *Sargo*: 1450 tons, 5 officers, 50 enlisted, designed for 20 knots surfaced, 8.75 submerged. Both keels were laid in 1934.

40. Naval War College joint problems were worked out at the college in a war game setting, whereas a fleet problem involved an exercise at sea.

41. United States Fleet Problem VII (March 1927), VIII (April 1928), and XIII (March 1932), Microfilm reels 9, 11, and 14, Records Relating to U.S. Navy Fleet Problems, M964, RG-38, Navy Department Library; Michael A. Palmer, "Undersea Warfare and Maritime Strategy: The American Experience," unpublished paper; J. E. Talbott, "Weapons Development, War Planning and Policy: The U. S. Navy and the Submarine, 1917-1941," *Naval War College Review* 37 (May-June 1984), 53-71; Samuel Flagg Bemis, "Submarine Warfare in the Strategy of American Defense and Diplomacy, 1915-1945," unpublished manuscript, 1961, OA.

42. "Seventy Percent Expansion Act and Submarine Construction Schedules" (SOC Memo), 9 Sep 1940, series 1, file 5, box 2, Subs/UWD, OA. "Shipyard Construction Assignments" (SOC Memo), 9 Jul 1940, series 1, file 5, box 2, Subs/UWD, OA.