

# A VISUAL GUIDE TO THE S-CLASS SUBMARINES 1918-1945 PART 1: THE PROTOTYPES

BY

DAVID L. JOHNSTON

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Throughout the rich history of the United States Navy Submarine Service, there are several submarines that have become iconic and are among the first mentioned in history texts. The *Holland*, *Gato*, *Nautilus*, and *George Washington* always receive top billing when discussing submarine history and deservedly so. They were technological pathfinders or the parent of large and important classes that won wars or kept the peace. But, in the 1920's, an entire class of submarines achieved that iconic status and came to represent the Silent Service in the minds of the public.

Designed during WWI when German U-boats were running amuck in the Atlantic, the S-class of submarines were to be our Navy's first true ocean going attack submarines. All previous classes had been designed for harbor defense or coastal patrols and were not suited for blue water operations. The S-class, while not a true Fleet Boat as the Navy defined that term, were to be longer ranged, faster, more heavily armed, and more habitable than any previous submarine class. They wound up being too late to see action in WWI, but they began to enter the fleet just as the Roaring 20's started. The 51 submarines of this class comprised the largest single class of submarine in the U.S. Navy until WWII, and it made up the bulk of our Navy's submarine force during the 1920's and 30's. Some of the S-boats served right up to the end of WWII, an unheard of longevity for the time.

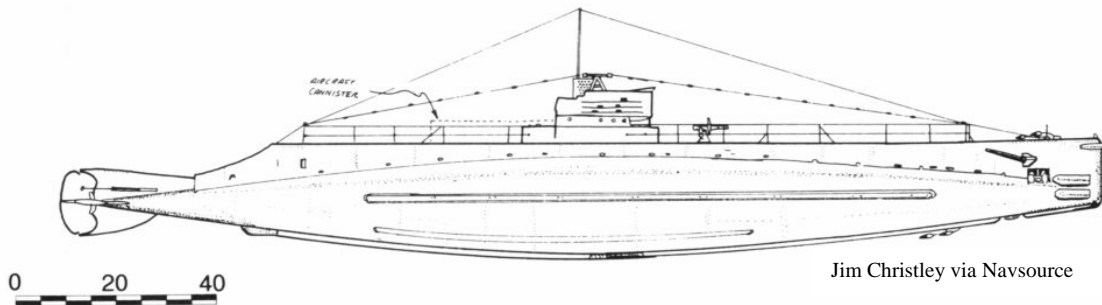
One of the accepted definitions of the word *class* is "a number of things regarded as forming a group by reason of common attributes, characteristics, or qualities." In the Navy, a class of warships will meet this definition, but in addition the ships will also look and be outfitted in such a manner as to be nearly identical. The layman might be surprised to learn that the 51 S-class submarines were anything but a homogenous, identical group and were in fact a class in name only. The S-class was actually made up of no less than six distinct groups that were built by four different manufacturers. The Navy considered all 51 boats a single class because they were all designed to meet the same set of performance and military specifications. These specifications were approximately 800-1000 tons submerged displacement, length approximately 250 ft., surface speed 18-20 knots, submerged speed 14 knots for 1 hour and 10 knots for 3 hr, surface range radius of 5000 nautical miles, and 4 bow torpedo tubes (two reloads each).

Up until about 1916, the Electric Boat Company of Groton, CT. (EB) had been the defacto design agent for U.S. submarines and enjoyed a near monopoly on construction. Several factors, though, had led their relationship with the Navy to become strained. The

incorporation of patented features that stunted competition, poorly performing engines built by one of their subsidiaries, and what many officers felt was undue use of political influence led to a feeling of ill-will towards the company. In order to reduce its dependence on EB, the Navy's Bureau of Construction and Repair wanted to have its own in-house design capability and thus designated the Portsmouth Naval Shipyard in Kittery, Maine as the Navy's lead submarine design entity. Congressional oversight committees also felt strongly that some level of commercial competition was needed. Thus, the Navy's General Board kept the characteristics as general as possible, to give the various designers a free hand. Three prototypes were to be developed for the new 800 tonner, Portsmouth and EB submitted their designs, with a third coming from the Lake Torpedo Boat Company of Bridgeport, CT.

## ELECTRIC BOAT

Electric Boat's model became the USS *S-1* (SS-105). This design is sometimes referred to as the "Holland" S-boat, a reference to EB's founder John Holland.

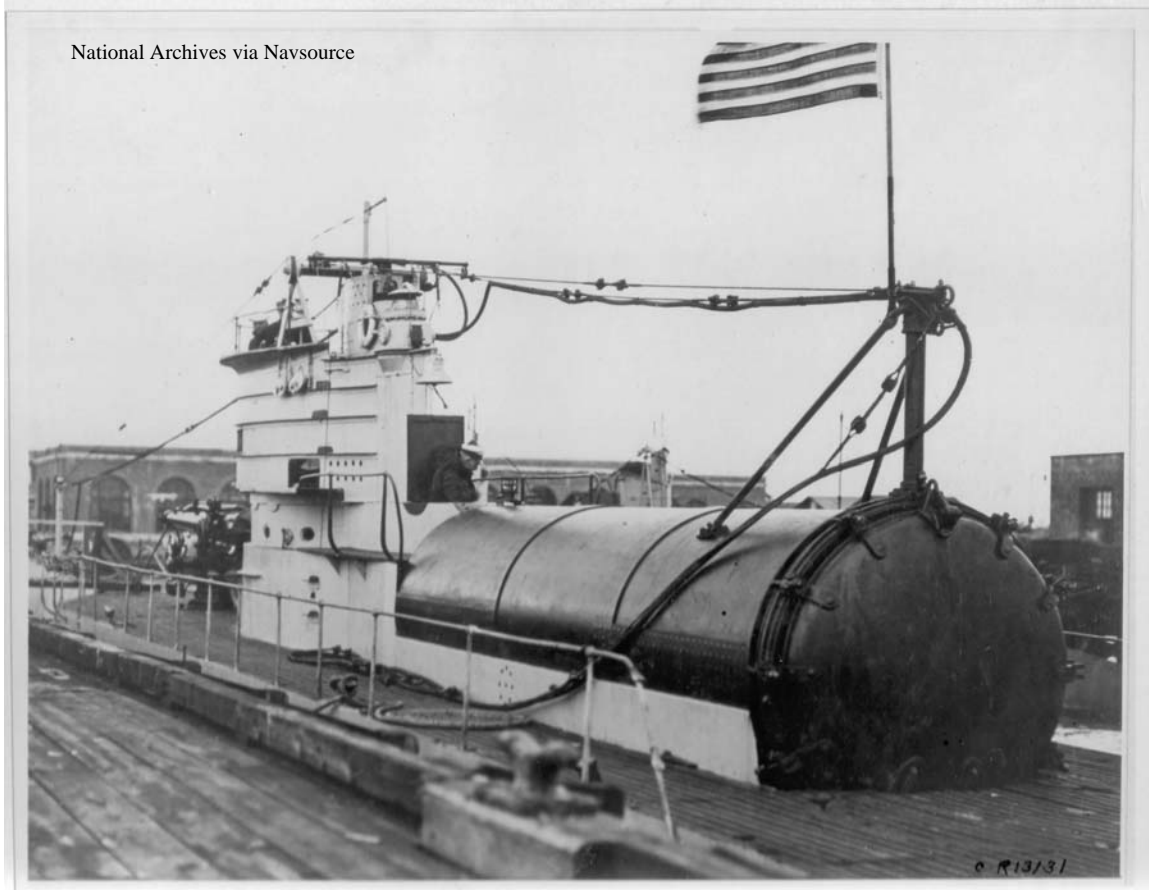


It was a single hull design, with all ballast tanks internal to the pressure hull. The hull was a rounded spindle shape with a narrow superstructure atop it that ran  $\frac{3}{4}$  of the way to the stern before the skeg tapered sharply down to the rudder. The rudder itself was placed at the very end of the hull, in line with the hull's axis and aft of the twin screws. She had four 21-inch torpedo tubes forward, a prominent hawse pipe at the far forward, upper end of the superstructure, and a single starboard side anchor. A squared off conning tower

Photo # NH 99772 USS S-1 underway during trials, circa April 1920



fairwater sat dead center on the superstructure, supporting the periscopes and radio aerials. As built, she sported a small 3-inch/23 caliber deck gun that partially retracted, breech end first, into a watertight tub that penetrated the superstructure forward of the fairwater and into the pressure hull over the forward battery. A circular gun shield attached to the barrel formed the watertight top of the tub. A desire to reduce drag and thereby increase underwater speed led to the adoption of this unusual gun. Lessons from German experience with larger guns were still forthcoming. Her bow planes retracted aft into the superstructure, one of the earliest examples of this feature. She was, in effect, an enlarged version of the earlier EB R-class boats. EB did not at this time have the large construction yard in Groton and thus contracted the *S-1*'s construction to the Fore River Shipbuilding Co. of Quincy, Massachusetts. On her trial runs, a portion of the conning tower fairwater surrounding the bridge was not installed, a common construction technique of the time. Note also in the above photo the angular fairwaters for the bow plane pivots on the forward superstructure. This feature was repeated on some, but not all of the later EB S-boats. Overall, the *S-1* had even, well-proportioned lines. This was mostly due to the fact that alone among the three prototypes, EB split the boat's main battery into two halves, with half forward of the control room, and half immediately aft. This was a favored feature of EB designs, which added a level of mechanical redundancy. A fairly successful boat, the *S-1* was chosen in 1926 to conduct the Navy's first (and as it turned out, only) tests in carrying and launching an airplane from a submarine. For these experiments, she was fitted with a small, horizontally mounted cylindrical hanger aft of the fairwater. It held a single Martin MS-1 floatplane partially disassembled.

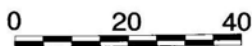
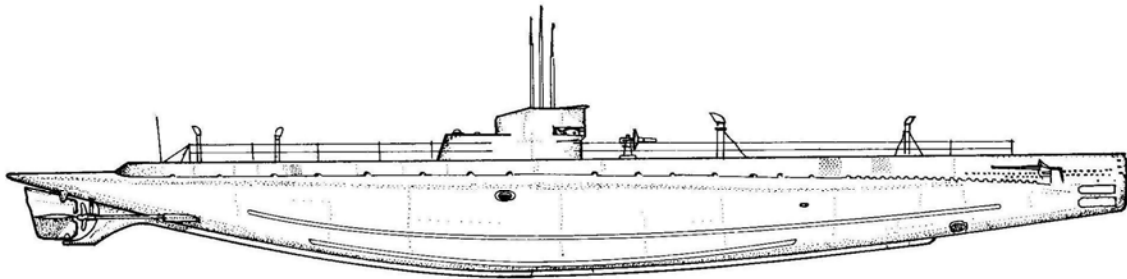


She was also refitted with a larger, more powerful 4-inch/50 caliber deck gun, necessitating the widening of the deck around the gun. This gun replaced the 3-inch/23 caliber disappearing mount that was roundly disliked by the crew as being unreliable and lacking punch. Notice also in this picture that the bridge fairwater has been installed.



## LAKE TORPEDO BOAT CO.

The brilliant but eccentric Simon Lake and his Lake Torpedo Boat Company were EB's only real competition in the years leading up to the S-boats. They were chosen to submit a design that became the USS S-2 (SS-106). A modified double hull design it was generally cylindrical in shape, but tapered sharply upward forward (which resulted in a vertically narrow bow) and aft, which ended in Lake's trademark horizontal "shovel" stern. Her rudder was mounted beneath the stern (as opposed to EB's axial mounted rudder), whose pivot structure also supported the stern planes. The superstructure ended



Jim Christley via Navsource

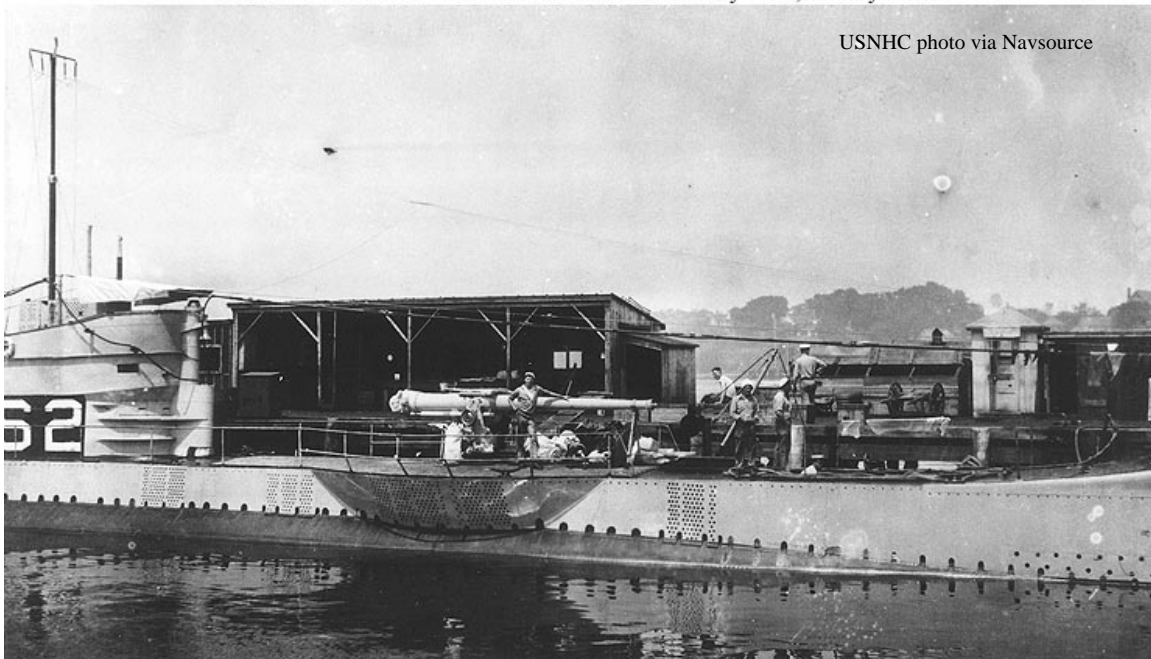
short of the stern. She also had a starboard side anchor and fully retractable bow planes. Her battery was situated forward of the control room, and that the visual effect of pushing the conning tower aft a little. Like the *S-1*, she conducted her initial sea trials without the bridge fairwater installed.

Photo # NH 41992 USS S-2 underway, probably during trials in 1919

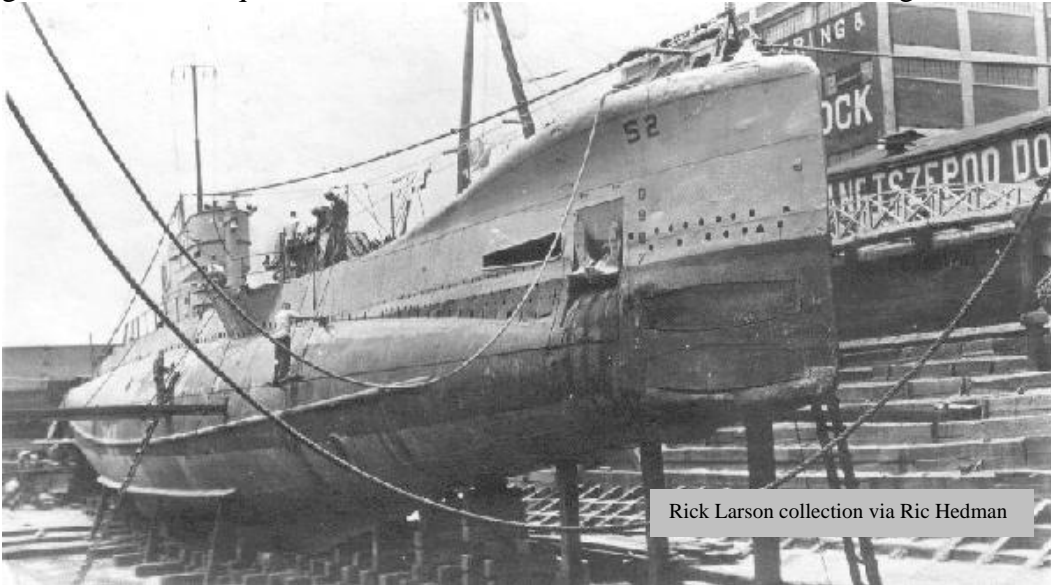


Initially built without a gun, she was also refitted with a 4-inch/50 caliber weapon. Similar to *S-1*, her deck around the gun mount had to be expanded outward to provide adequate space for the large gun, in this case a considerable amount. A portion of her

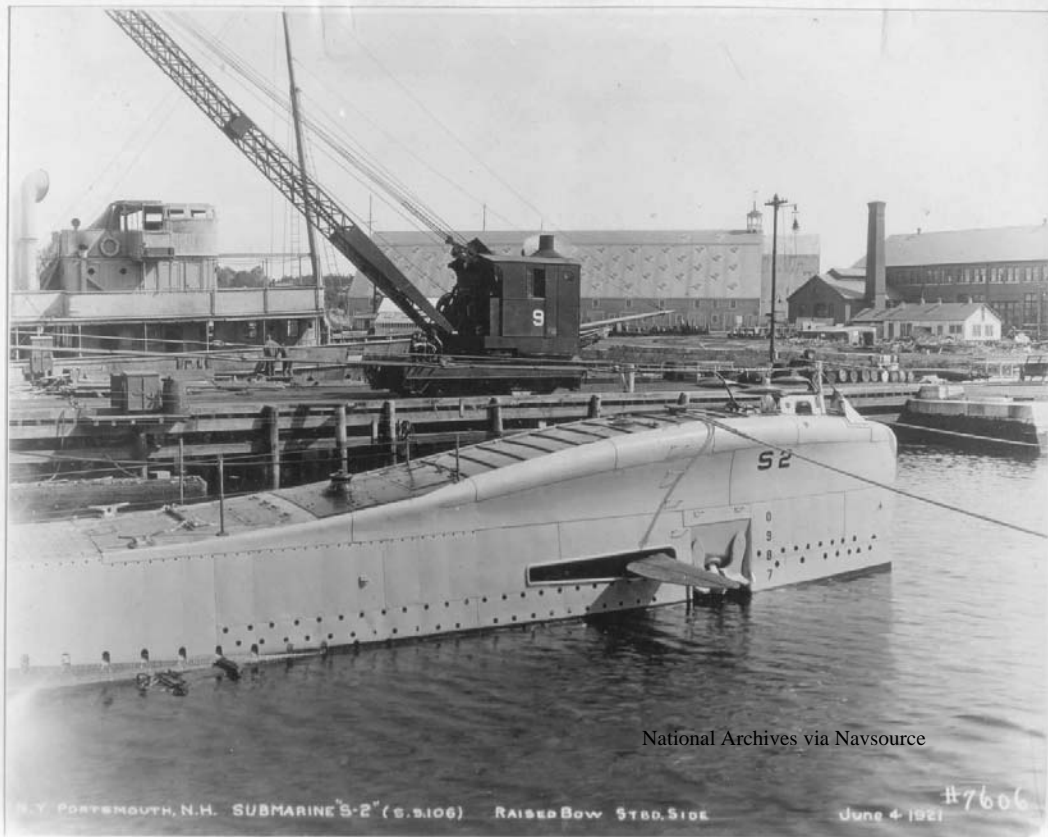
Photo # NH 101010 USS S-2 at Portsmouth Navy Yard, 22 July 1921



superstructure amidships was designed to be watertight while surfaced. This was to provide much needed reserve buoyancy while surfaced, but unfortunately the added buoyancy was actually needed in the bow. A thorough series of sea trials after her commissioning revealed that she tended to burrow into the waves while surfaced, making for a very wet deck and bridge. Accordingly, Simon Lake designed a fix for this problem that resulted in the addition of a bow buoyancy tank external to the superstructure. This gave the S-2 a unique look and was reminiscent of several British designs.



Rick Larson collection via Ric Hedman



National Archives via Navsource

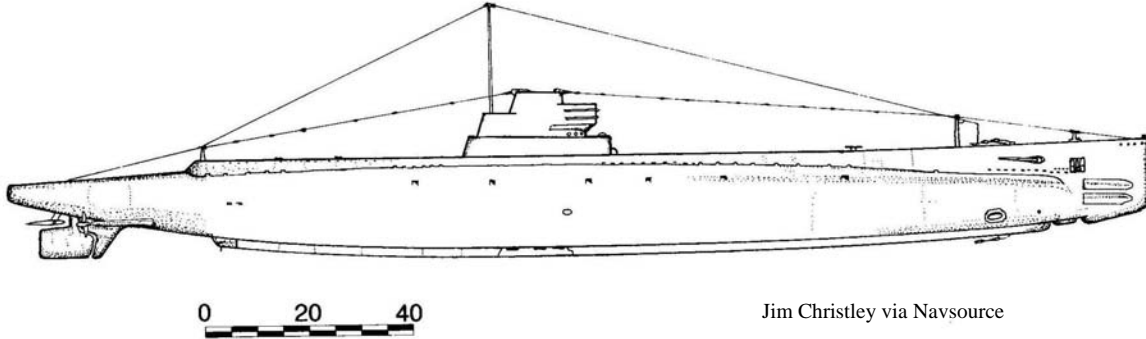
N. Y. PORTSMOUTH, N.H. SUBMARINE S-2 (S.S.106) RAISED BOW \$180,510K

June 4 1921

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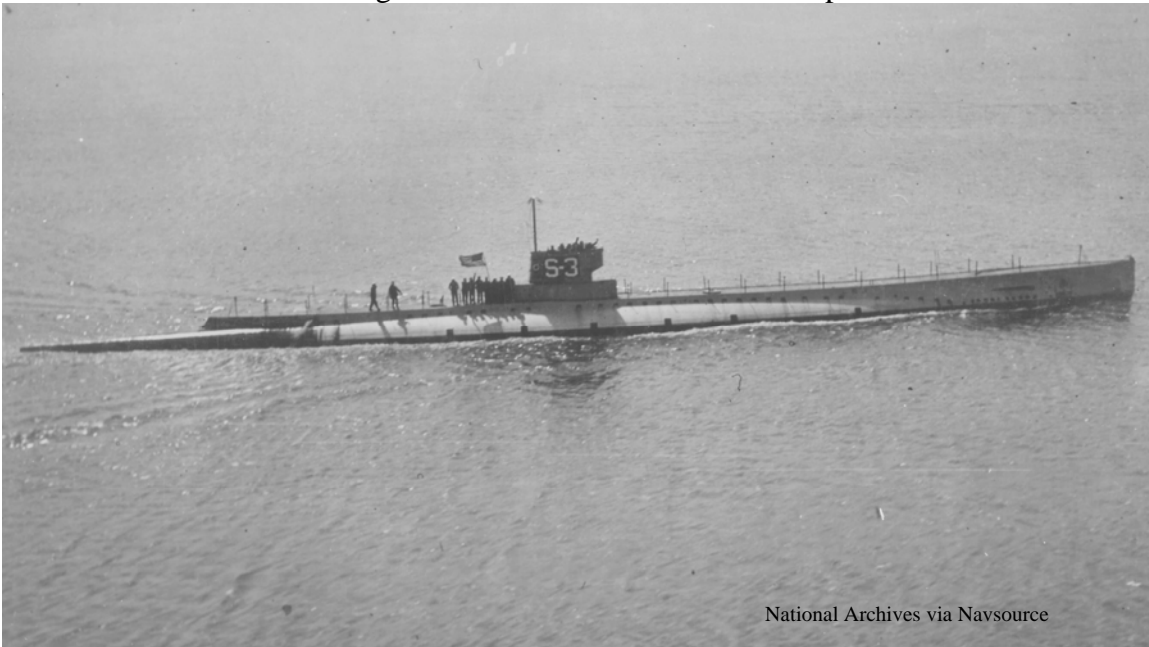
## PORTSMOUTH NAVAL SHIPYARD

The Government's design for the S-boats (sometimes called the "Bureau" design, after the Bureau of Construction & Repair) was built at Portsmouth Naval Shipyard and eventually commissioned as the USS *S-3* (SS-107).



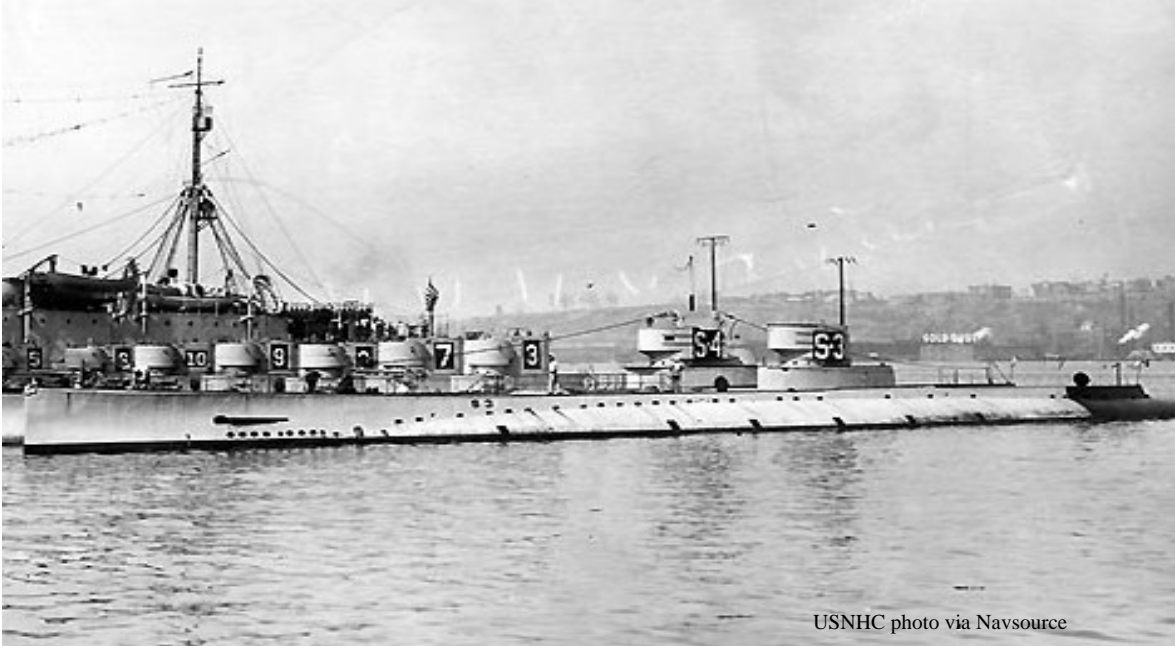
Jim Christley via Navsource

A full double hull boat, all of her main ballast tanks were contained exterior to the pressure hull. She was considerably longer (231 ft. vs. 207 ft. for *S-2* and 219 ft. for *S-1*) and a little wider than the other two boats, giving her a long, sleek appearance. Similar to *S-2*, her battery was contained in one large compartment forward of the control room, which had the visual effect of pushing her conning tower well astern. Despite this, I think that the Government design was the most visually striking of the three, with graceful lines that are more memorable than the boxy, squared off look of the EB design. The long hull had far less curve to it and it had a vertical "chisel" stern. The rudder was underneath the stern similar to *S-2*, but the stern planes were suspended on their own support post above the rudder. Her conning tower fairwater had a distinct shape.



National Archives via Navsource

The bridge fairwater bulged far forward and hung over a prominent ready-use ammunition locker. The deadlights for the conning tower itself were easily visible directly between these two structures. The superstructure was quite narrow and ended far short of the stern.



Also built without a deck gun, *S-3* had a standard 4-inch/50 added later, and this necessitated the widening of the deck forward of the conning tower. Like the other two prototypes, she had a starboard side anchor, but did not have the prominent hawse pipe at the bow like the *S-1*.

## CONCLUSION

Simon Lake's *S-2* had her share of problems and was not well liked by her crews. Forced to work around EB's patented features, Lake's solutions ended up having less than desirable results. She was a slow diver due to her partially watertight superstructure and poorly designed flooding and venting mechanisms for the main ballast tanks. Her flat top internal tanks (as opposed to EB's patented U-shaped tanks) required more bracing and greatly reduced internal available space, making her a very cramped boat. The piping arrangement leading to the ballast tanks was overly complicated and her forward and aft trim tanks were so large that they were prone to develop a free surface effect, which adversely affected underwater control. This was Lake's last internal design to be accepted by the Navy. No contract for any further boats of this type was awarded to Lake, although he did build S-boats of the Government type under license (See part two of this series).

Although ultimately proven to be flawed in many areas, both the *S-1* and the *S-3* designs were deemed satisfactory enough to warrant series production. The *S-1* had better underwater maneuverability, was a fairly fast diver, and her single hull construction eased exterior maintenance. The *S-3* had better engines and a longer range. In the end, the Navy felt that both types were nearly evenly matched, but EB ended up with the bulk of the construction, mostly due to the much larger construction capacity they enjoyed with her contractors Union Iron Works and Fore River Shipbuilding Co.



## **ACKNOWLEDGEMENTS**

This article would not have been possible without the photographs collected and published by Michael Mohl at Navsource.org and Ric Hedman at Pigboats.com. Ric also provided valuable editorial advice. I would also like to offer my personal thanks to the late Rear Admiral Edward Ellsberg, whose 1929 book *On The Bottom* inspired me as a kid.

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A VISUAL GUIDE TO THE S-CLASS SUBMARINES  
1918-1945  
PART 2: THE GOVERNMENT BOATS

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Of the three S-boat prototypes, Electric Boat's *S-1* and the Government's (sometimes called the Bureau design, for the Bureau of Construction and Repair) *S-3* were picked for series production. The Navy strongly desired an in-house design and construction capability, thus the *S-3*, while less than perfect, was satisfactory enough to warrant follow on boats. The first group consisted of *S-4* through *S-9* and they were all built by the Portsmouth Naval Shipyard in Kittery, Maine. They were near copies of the *S-3* prototype.

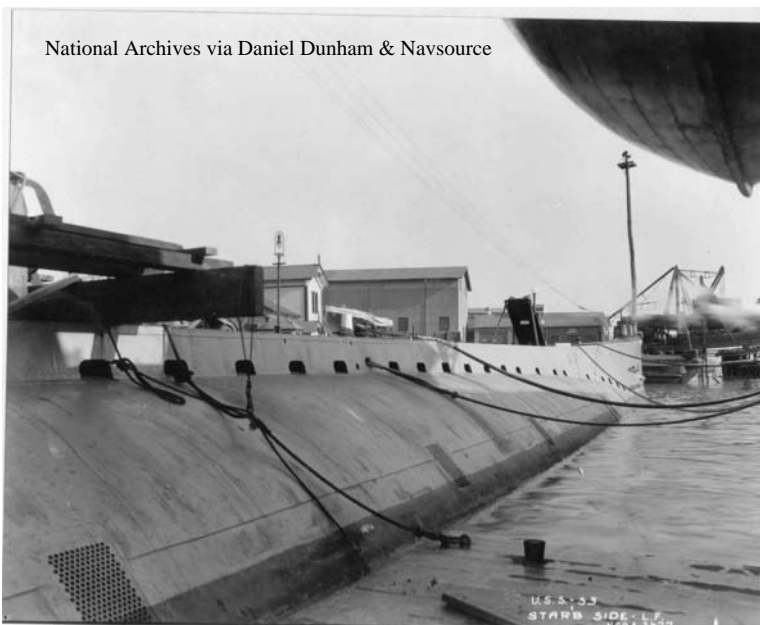


Milne Special Collections via Ric Hedman

This is an excellent shot of the ill-fated *S-5*, probably while on trials in early 1920. Unlike the prototype *S-3*, all of the follow-on boats were built with the gun mount foundation already installed and the deck flared out around the mount, although several boats did not actually have the gun installed until after commissioning.

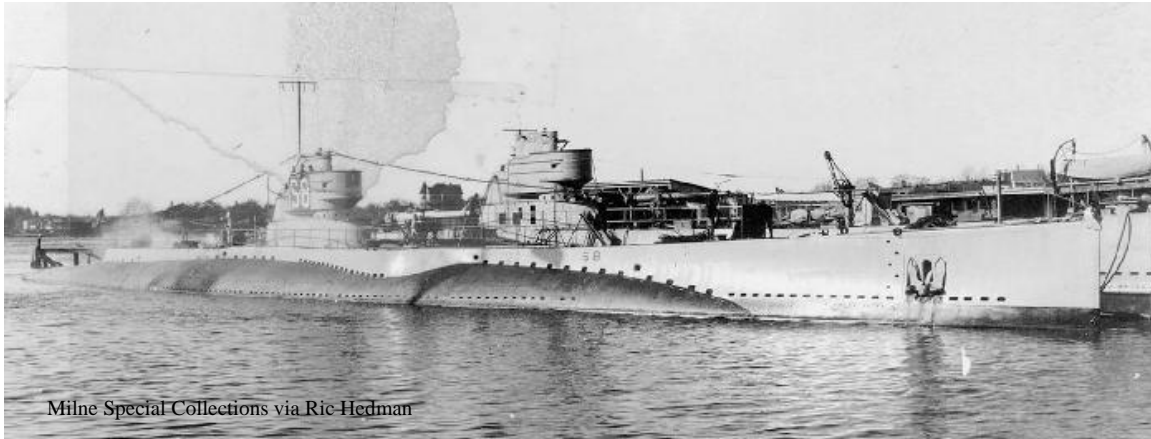


In an effort to preserve surface buoyancy, the Government design split the main ballast tanks into upper and lower sections, each with their own vents and flood ports. This had the unfortunate side effect of making the Government design very slow divers. The upper



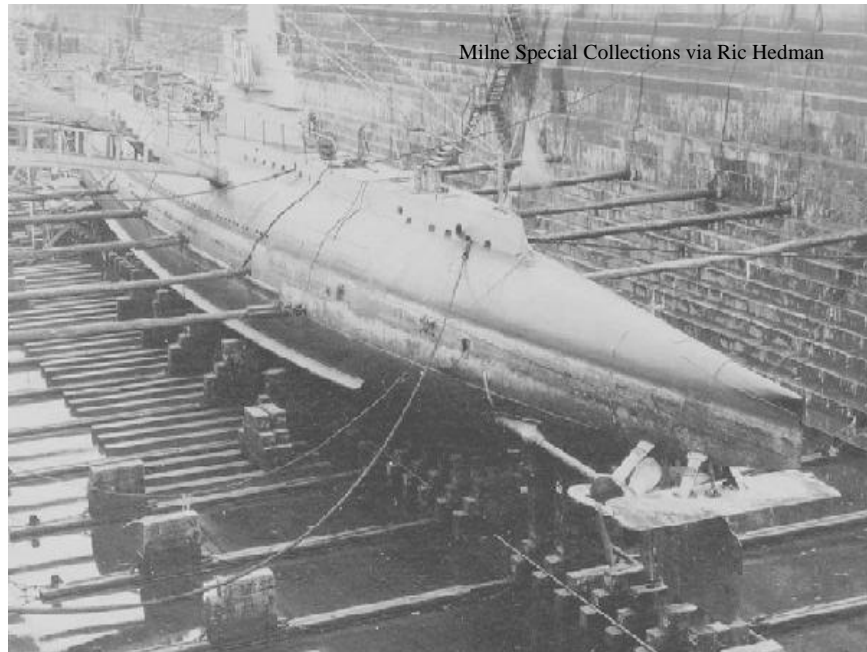
tanks would not begin to flood until the boat had settled enough to submerge the upper flood ports. The later boats had additional upper flood ports added, but this only resulted in a minor decrease in dive times. The Government boats were rated at 100 seconds from fully surfaced to periscope depth, as compared to the EB boats at 75 seconds. In an apparent attempt to further alleviate this problem, *S-8* and *S-9* were modified during construction,

moving the bow planes to below the water line and making them fixed in place and non-retractable.



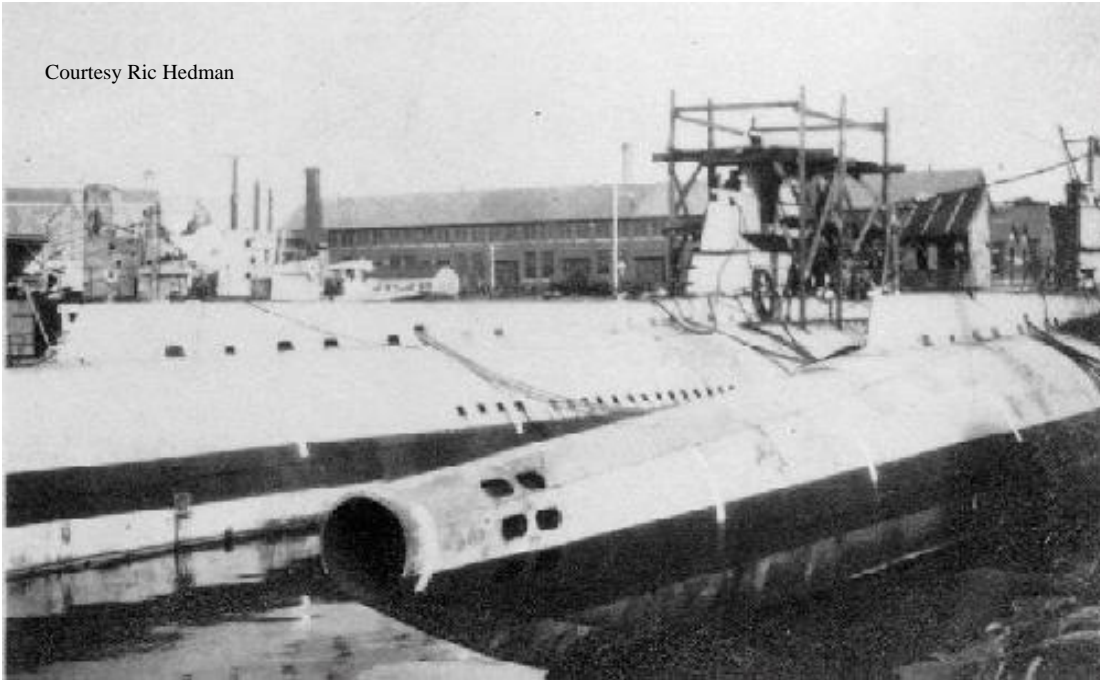
An angle iron guard was built around the planes to prevent them from being damaged by tugs or by contact with the pier. Compare this photo of *S-8* with the one above of *S-7* and the absence of the bow plane slit just aft of the anchor becomes apparent.

This photo of the aft end of *S-8* gives a good view of the characteristic vertical “chisel” stern of this group. You can also see the fairly unique arrangement of the stern diving planes, one large plate suspended on its own pivot posts above the rudder.



The second group consisted of *S-10* through *S-13*. They were also to have been direct follow-ons of the Government *S-3* design (although with the *S-8* bow plane modification). However, studies of captured German submarines left the Bureau designers very impressed with the U-boat’s stern torpedo tubes.

Courtesy Ric Hedman

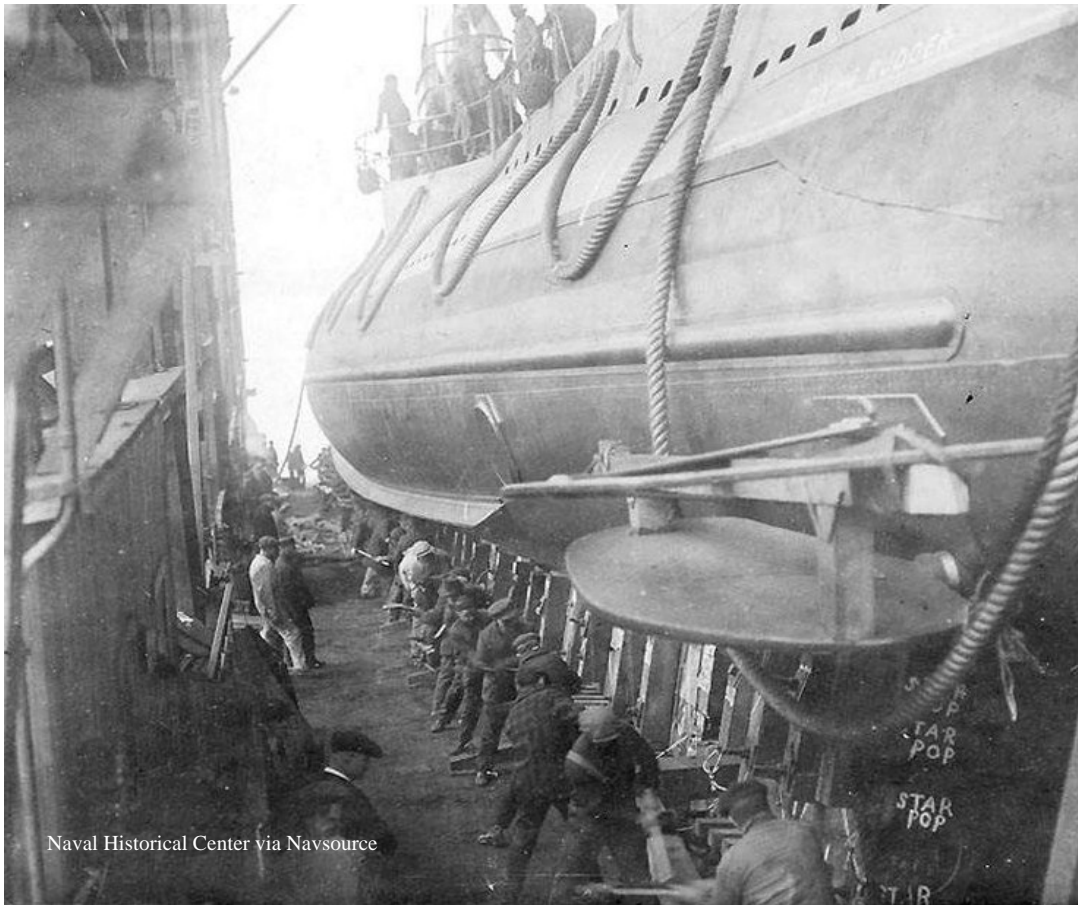


Accordingly, *S-10* through *13* were redesigned during construction with a single 21 inch tube, with the breech letting into the large motor room that this design already had. This greatly altered the characteristic chisel stern and from the right angle made this group easy to spot.

U.S. Navy via Navsource



As stated, these four boats all had the *S-8* bow plane modification and this launch day photo of *S-10* below gives a good shot of the plane and guard arrangement.



Naval Historical Center via Navsource

To keep the plane from being damaged during the stresses of launch, a wooden beam and two blocks have been temporarily installed under the plane guard, bracing the plane and holding it in place. This brace would be removed after launch. This next photo of *S-10* gives a good shot of the stern plane and rudder arrangement of the Government type. You

can also see how the stern was rearranged to accommodate the stern torpedo tube for the *S-10* group.

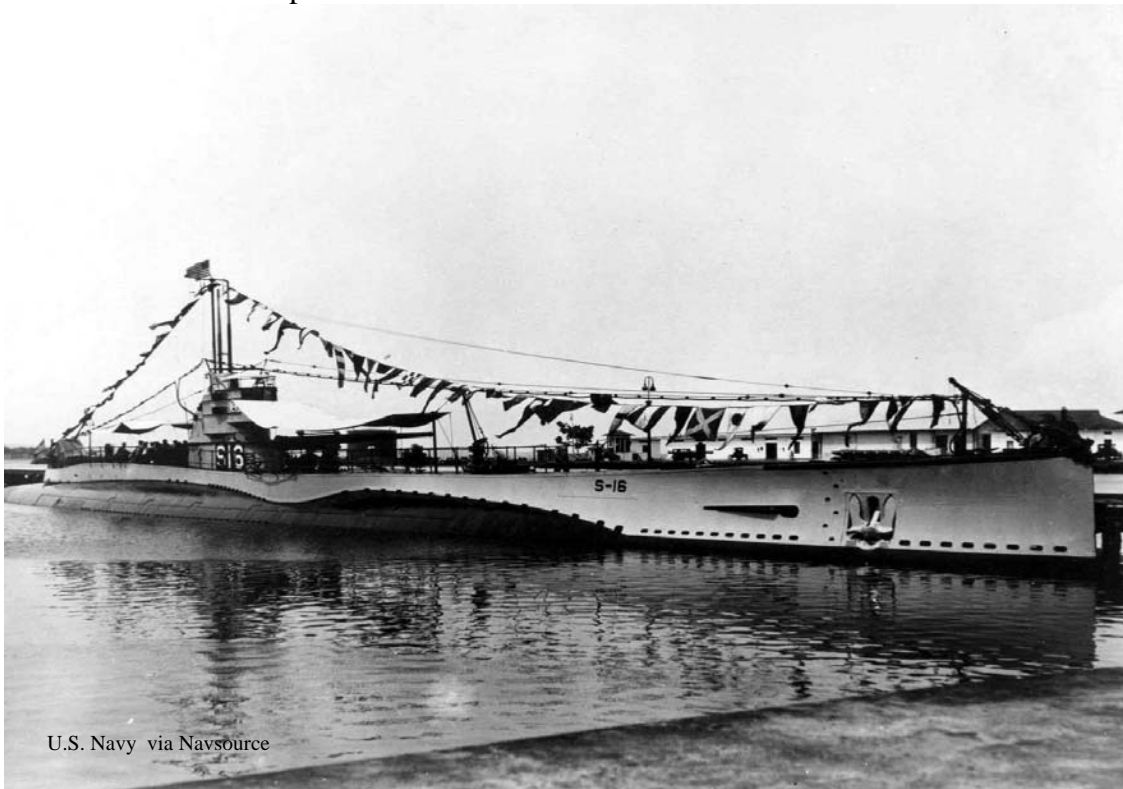


National Archives via Daniel Dunham & Navsource

Electric Boat had been strongly criticized for the poor performance of the diesel engines made by their subsidiary the New London Ship & Engine Company (NELSECO). These engines were license built derivations of the German Maschinenfabrik-

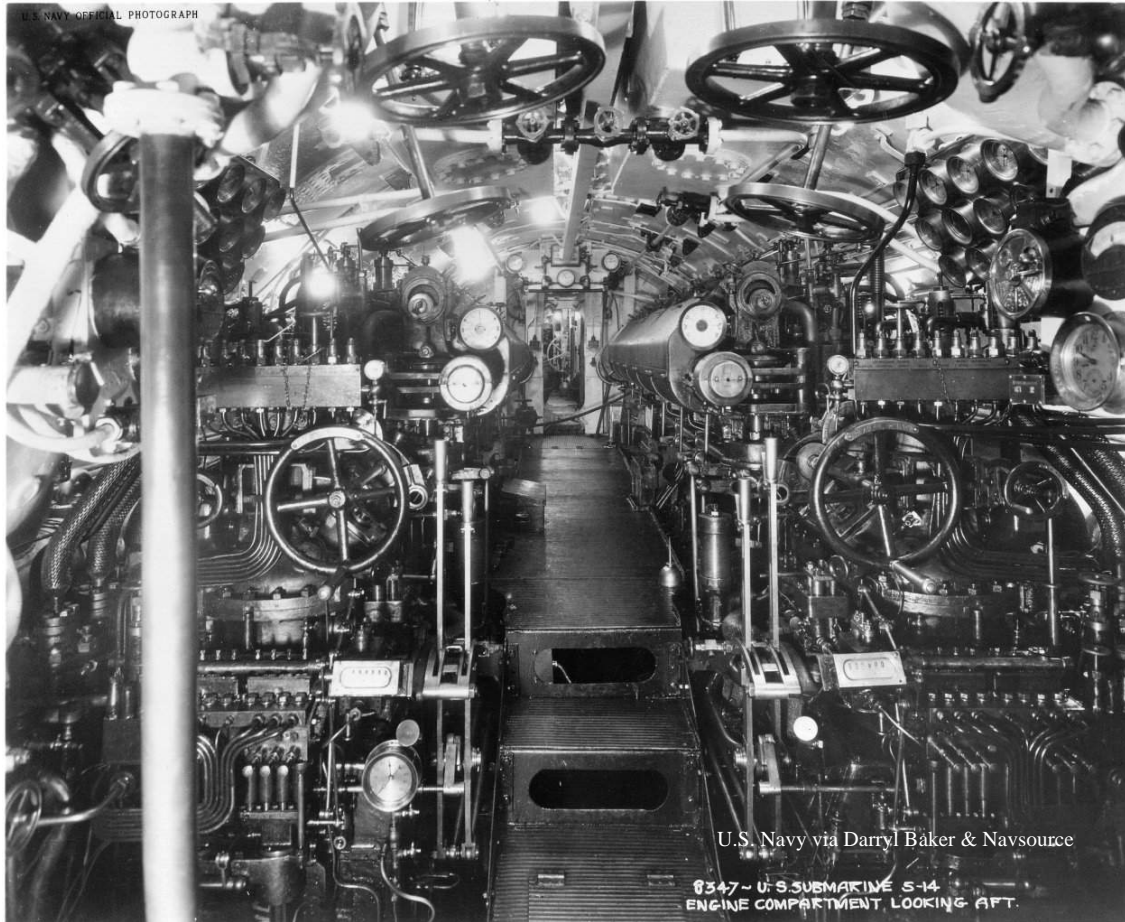
Augsberg-Nurnberg (MAN) company designs. Inferior American metallurgy and manufacturing processes of the time made these copies less than perfect. They suffered from excessive torsional vibrations that frequently broke crankshafts. Unfortunately, at the time the NELSECO engines were the only ones that would provide the necessary horsepower in a package small enough and light enough to fit into a submarine hull. The Bureau was forced to purchase the NELSECO designs and built engines directly from NELSECO plans at navy yards. These engines were installed in the *S-4* group boats and accordingly they battled engine problems throughout their career. However, the *S-10* group was engined with a MAN design that was built directly by the New York Navy Yard, eliminating the NELSECO middleman. These engines, while still not perfect, were tremendous improvements and were considered to be quite reliable.

Simon Lake's *S-2* was the last of his in-house designs to be purchased by the Navy. Due to its numerous flaws and Lake's lack of large-scale production capacity, he was not awarded a contract for *S-2* follow-ons. However, the Navy had a keen interest in maintaining a commercial competitor to EB and offered a contract to Lake to build copies of its own Bureau design. Lake, his pride stinging a little from the rejection of *S-2*, took the contract and built *S-14* through *S-17* at his Bridgeport, CT. yard. These boats were straight copies of the *S-4* group, without the *S-10* stern tube and reverting to the above water retractable bow planes.



The only major difference from the original group is not apparent externally. In a timely development, Simon Lake chose engines built by the Busch-Sulzer subsidiary of the famous Busch Brewing Company. These 4-cycle engines, although considered to be

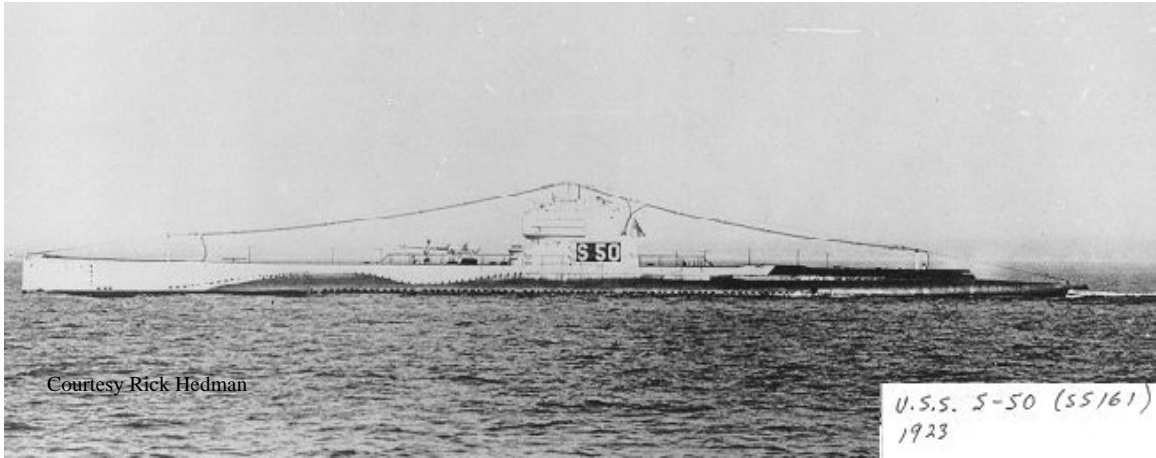
underpowered, were well liked and quite reliable, making the *S-14* to *17* the most successful of the Government boats.



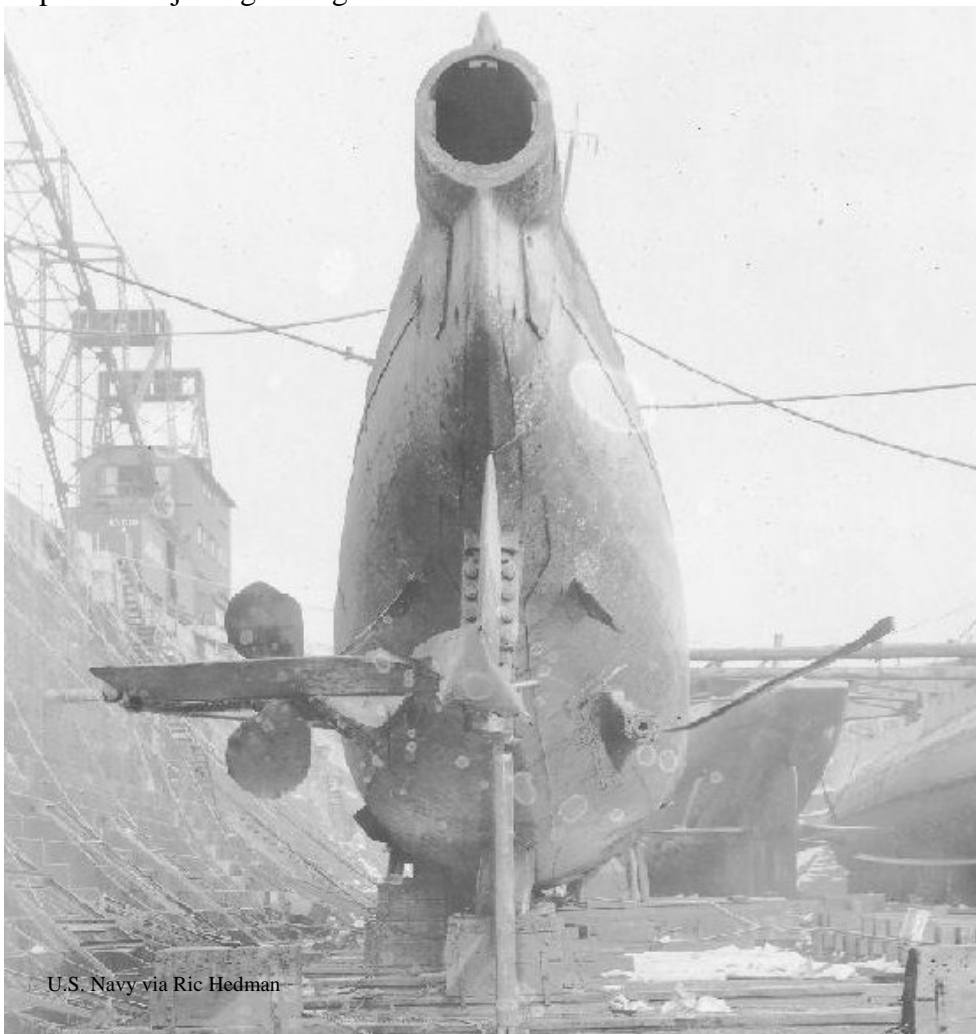
These four boats, along with the *S-11*, *12*, *13* and *48* were the only Government boats to serve all the way through World War II, the rest having been discarded in the 1930's to meet treaty requirements. Refitted during the war, these boats received more powerful MAN diesels (which required larger mufflers, necessitating raising the after deck to accommodate them), rescue/marker buoys, and the removal of the ready service ammo locker on the forward edge of the conning tower fairwater.

The last of the Government design S-boats was the *S-48* through *51* group. These four boats were also built by Lake and proved to be the last submarines the Lake Torpedo Boat Company would build for the Navy. The *S-48* group design was a derivative of the *S-10*, but was the most altered of all the Government S-boat groups.

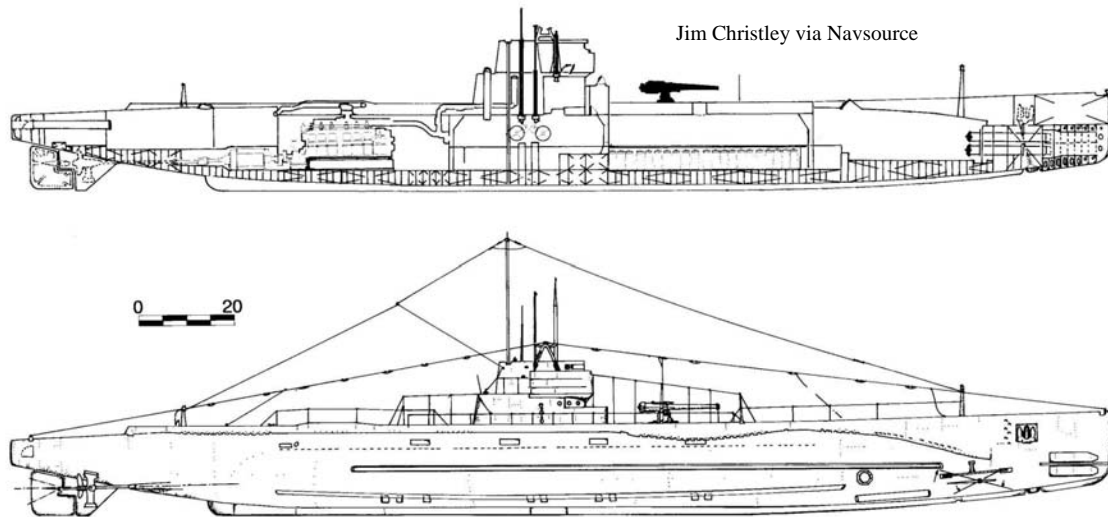




Lengthened by 9 feet, they separated the single large Maneuvering/Torpedo Room of the *S-10* to *13* group into two separate spaces, with the electrical controls for the main motors divided from the torpedo room by a bulkhead. Instead of the *S-10* style finely tapered stern faired around the muzzle end of the tube, the *S-3* style chisel stern returned, with the torpedo tube jutting through the center of the chisel.



The above photo of a damaged *S-48* shows her in drydock with the starboard shaft and stern diving plane removed, but this gives a good view of this design's arrangement of the aft torpedo tube.



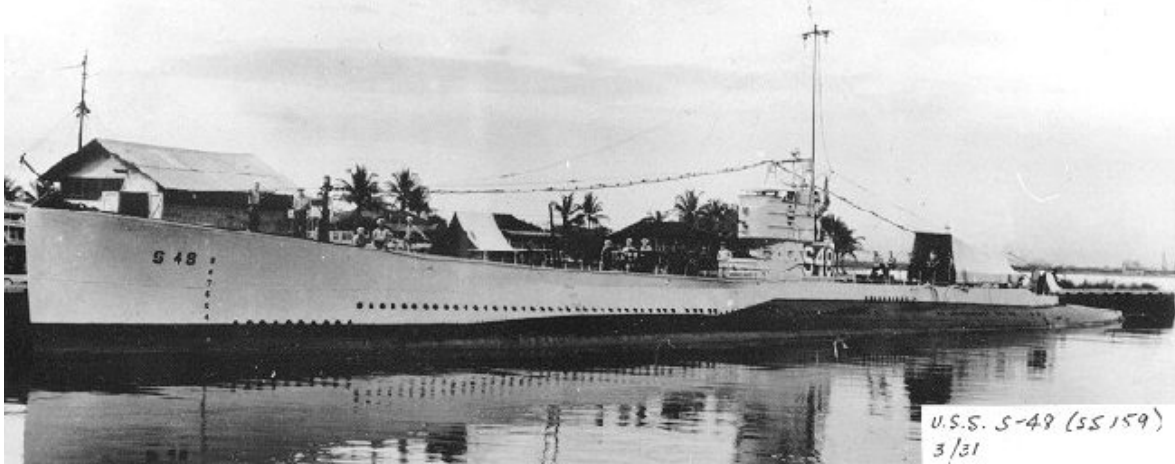
The forward base of the conning tower fairwater was changed to incorporate a full gun access trunk with a hatch leading into the Control Room. This replaced the smaller ammo storage locker on all the previous groups. These boats also reverted once again to the below water, fixed bow planes with guards as seen on the *S-8* through *S-13*. They also had a different arrangement for the stern planes and rudder, a design that would presage the arrangement on the later Fleet Boats. They were powered by a heavier, 2-cycle version of the Busch-Sulzer diesel.

By 1925 it was becoming apparent to the Navy Department that the far reaches of the Pacific Ocean would be a prime operating area for our submarines. Unfortunately, the *S*-boats lacked sufficient range to make adequate patrols in the Pacific. Several ideas were bandied about, including the construction of a submarine tanker to refuel *S*-boats during patrol. However, it was feared that the loss of the tanker sub would seriously hamper operations of the attack boats. The scheme that was decided on was a complete rebuilding of the Government design *S*-boats (the *EB* single hull boats were not capable of being heavily modified). This plan called for lengthening the boats by 26 feet, adding a stern tube to the boats that didn't have them, re-engining the boats that didn't already have *MAN* engines, and a complete redesign and rebuild of the interior. Initially, this plan seemed like a real bargain, as it would cost about a quarter of what a brand new design 1250 ton boat would cost.

*S-48* ran aground in January 1925 and was heavily damaged. She was quickly salvaged, but it was decided to take her in hand and make her the prototype for the General Board's modification scheme. She was lengthened by 25 ft. 6 in., new *MAN* engines were installed, and she was completely rebuilt internally. The most significant internal change was the splitting of the main battery. Previously, the Government design had the battery all in one large compartment forward of the Control Room. The *S-48* rebuild split the

battery into two compartments, forward and aft of the Control Room, with the crew's and officer/chief's berthing split as well. Additional buoyancy tanks were added and she received one of the first air conditioning plants installed in submarines. In this configuration, she was a precursor to the later Fleet Boats.

U.S. Navy via Ric Hedman



All these modifications, while generally successful, failed to correct the basic deficiencies of the design. The cost of the modifications had spiraled upward, reducing the economic advantages versus a new design, and when compared to the estimated remaining life span for the boats (2-5 years), it was becoming rapidly apparent that the program wasn't going to work. The Submarine Officers Conference of 1927 successfully argued against any further modifications of the S-boats and pushed for a new construction program, which would eventually become the Fleet Boats.

The *S-48* served well through the end of World War II (although with two periods in decommissioned reserve), providing training services to submarine crews and ASW forces. *S-11* through *17* also served during the war, making patrols in the Caribbean.

*S-4* was sunk in a collision with a Coast Guard cutter in 1927. After a dramatic but ultimately futile attempt to rescue six survivors in the torpedo room, she was subsequently raised, partially reconditioned, and put back into limited service as a test boat to develop new salvage techniques. Towed to various fleet locations she provided valuable training in submarine salvage techniques and trained numerous submariners in escape procedures from an escape trunk installed in her motor room.



*S-5* was lost in a diving accident and was not recovered. *S-51* sank in 1925 after a collision with a steamer. She was salvaged, but never recommissioned and was eventually sold for scrap. The remainder of the Government design S-boats, having failed to live up to the Navy's expectations, were discarded under the terms of the London Naval Treaty in the early 1930's.

The *S-49* clung to life after decommissioning. She was purchased by a civilian firm, rendered incapable of diving, and used as an exhibition boat touring the Great Lakes and many other U.S. ports, attracting scores of visitors. In this guise, she had a large "C" painted on her bow, which apparently designated her as a Civilian vessel.



Eventually reacquired by the Navy, she was used as a test hulk in experimental work until she accidentally foundered in the Patuxent River, Maryland in 1942.

Final honors go to the USS *S-15* (SS-120). She was the last operational Government design S-boat, serving the Navy well until 11 June 1946, when she was finally decommissioned and her name struck from the Navy register. This closed the book on an elegant and iconic, albeit flawed chapter in our submarine history.



## ACKNOWLEDGEMENTS

This article would not have been possible without the photographs collected and published by Michael Mohl at Navsource.org and Ric Hedman at Pigboats.com. Ric also provided valuable editorial advice. I would also like to offer my personal thanks to the late Rear Admiral Edward Ellsberg, whose 1929 book *On The Bottom* inspired me as a kid.

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