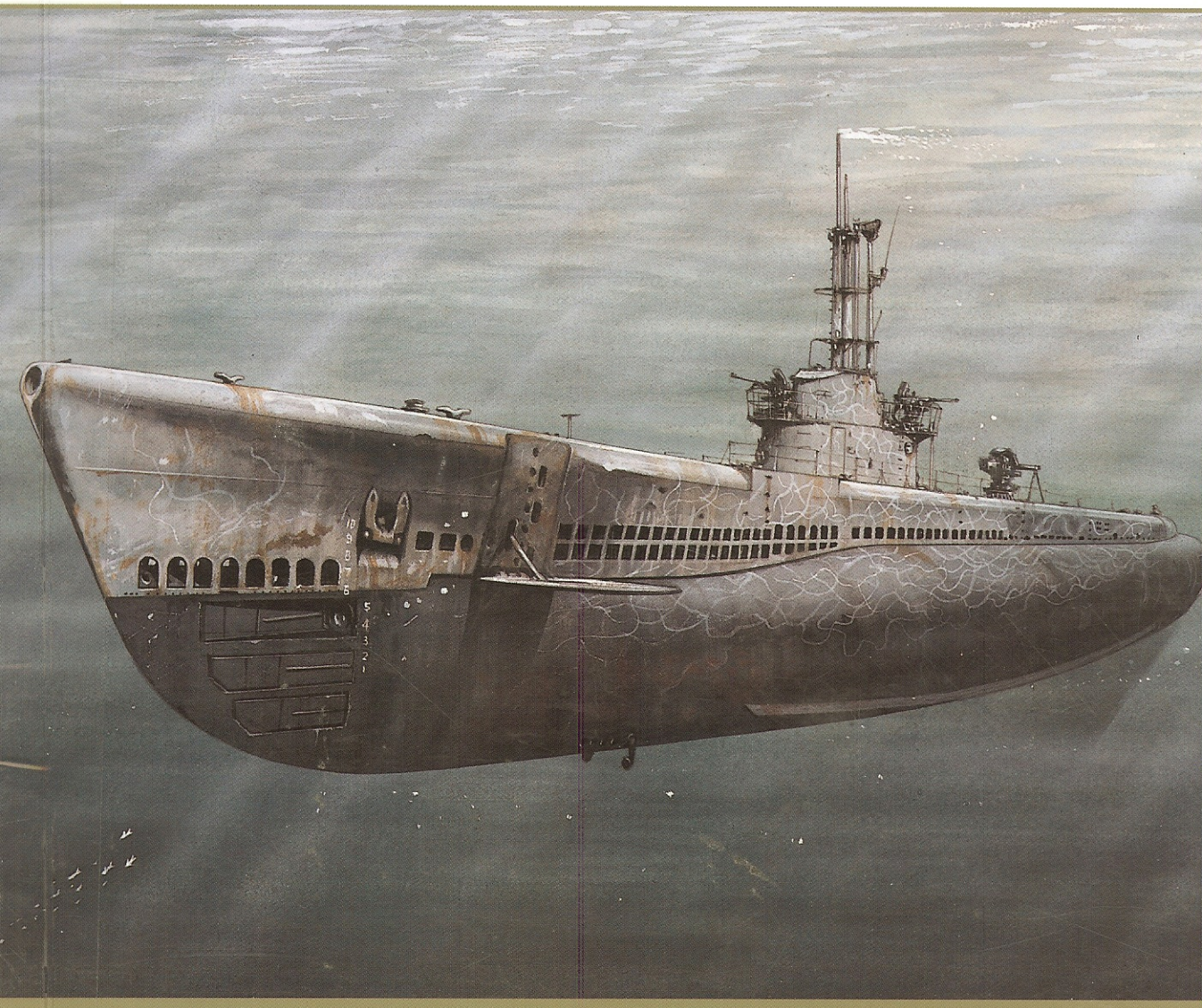
New Vanguard

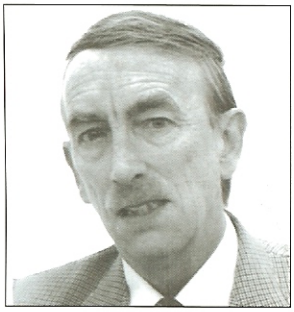
OSPREY PUBLISHING

US Submarines 1941–45



Jim Christley • Illustrated by Tony Bryan

JIM CHRISTLEY retired from the US Navy in 1982 as a senior chief petty officer, having served on seven submarines ranging from diesel to nuclear fast attacks to ballistic missile boats. A student of US submarine technical history, he has written numerous articles and a book on the subject, in addition to providing technical illustrations to several notable books on submarine design and history.



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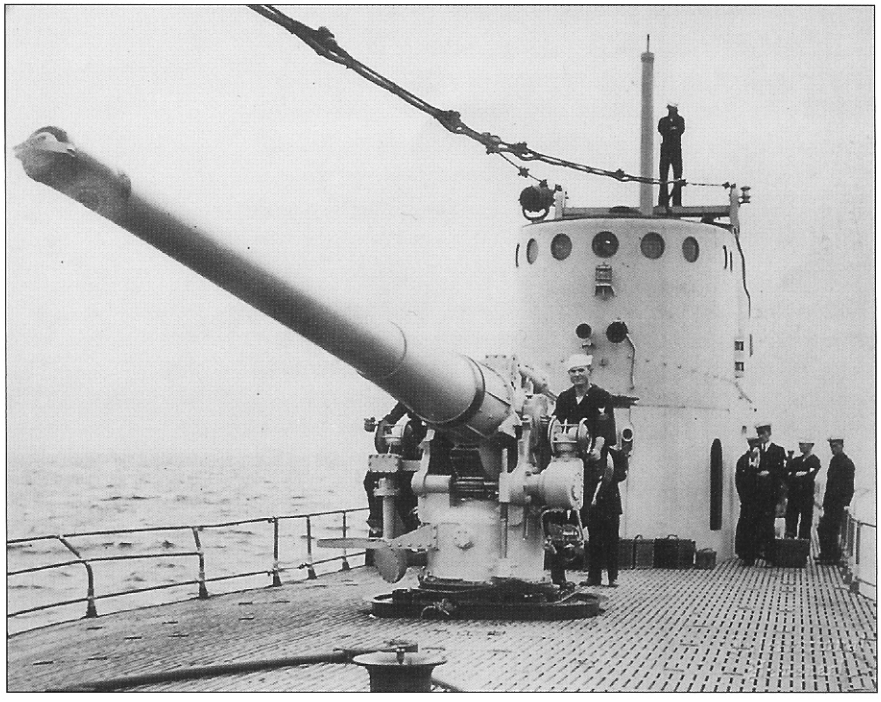

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Artist's note

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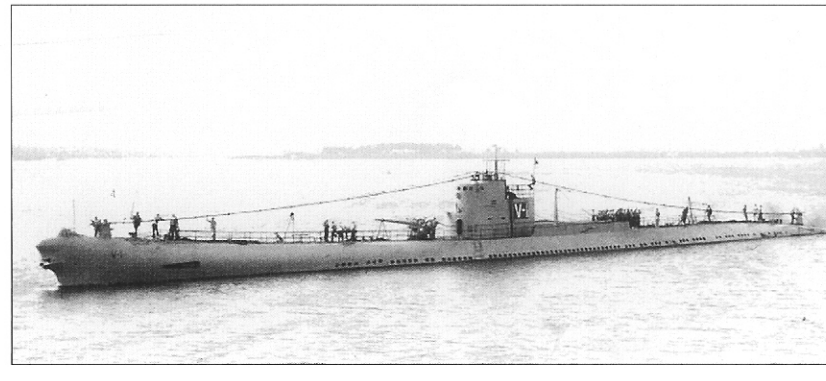
US SUBMARINES 1941–45

INTRODUCTION

The shooting portion of World War II burst on the American Navy early on a Sunday morning in December 1941, with the Japanese attack on Pearl Harbor. On that morning the face of naval warfare in the Pacific changed utterly. No longer would the war at sea be decided by squadrons of the world's largest and most powerful battleships. Instead, the strategic emphasis shifted to a combination of two more lethal and far-ranging naval weapon systems. The aircraft carrier would replace the battleship by being able to increase the deadly range of a fleet from a few tens of miles – the range of battleship guns – to the hundreds of miles range of bomb- and torpedo-carrying aircraft. In addition, the American submarine would be able to place a strangler's grip on the throat of the Japanese empire that, unlike the German U-boats' attempts to control the Atlantic waters, could not be broken. Some have said that the result of the attack at Pearl Harbor was fortuitous in that it forced the US Navy to look toward the carrier and submarine to defend the southern Pacific and the United States' western coast. This argument overlooks, however, the prewar build-up in those two weapons platforms, which seems to indicate that some individuals were looking seriously toward the future and the inevitable conflict. However, whatever the driving force, the fleet submarine of the US Navy was one of the most potent forces ever seen in naval warfare and most assuredly brought Japan to its knees.

DESIGN AND DEVELOPMENT

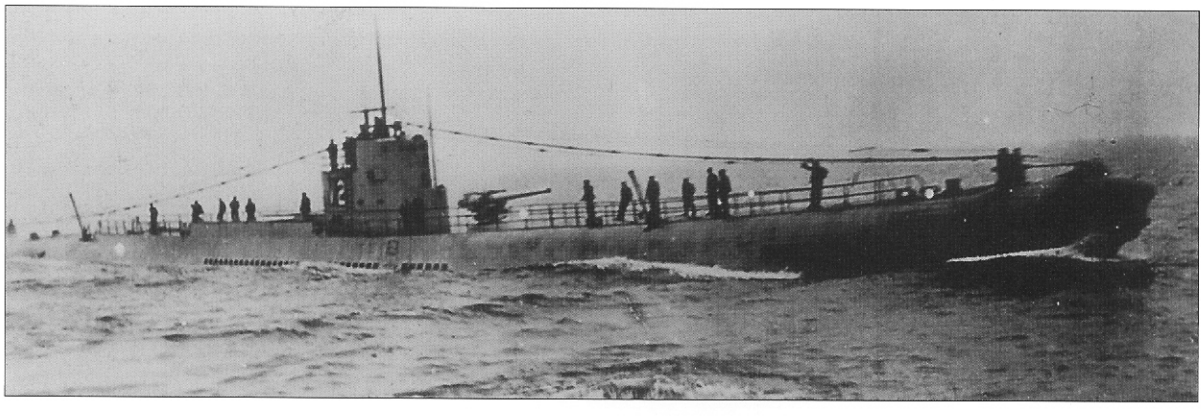
Submarine design from the earliest days of the 20th century had been divided between the need for the ship to be available to defend the



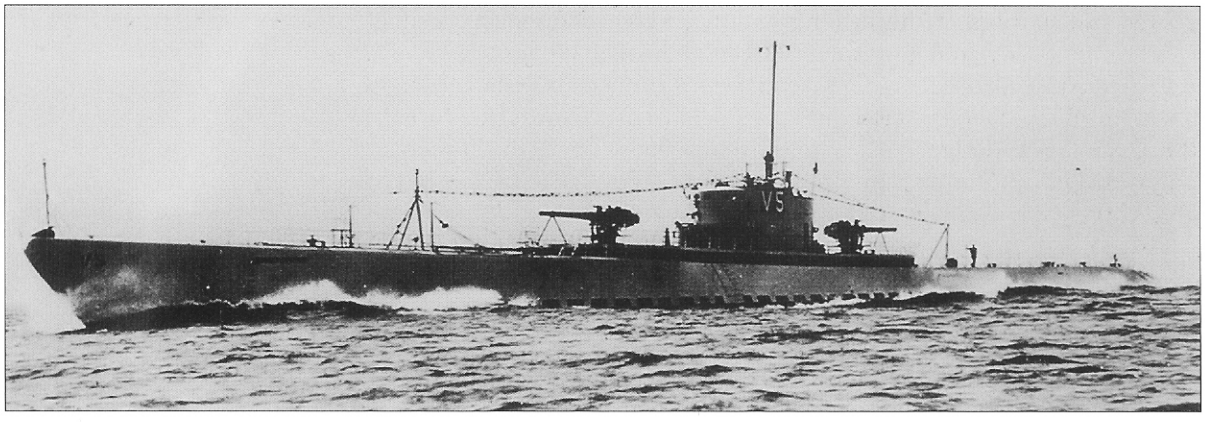
Barracuda **on the surface prior to World War II. The distinctive bow was often referred to as resembling a pug dog with a bone in its mouth. These boats were awkward and were not used extensively as patrol submarines during the war. (US Navy)**

shores and harbors of the owning country, which allowed for a small short-range boat, and the so-called fleet submarine that could move with the main battle fleet and extend its reach and threat profile by attacking an enemy fleet as the two closed. The engineering trade-offs that formed the basis of the design for the fleet submarine were most difficult to negotiate. The speed requirement of nearly 30 knots demanded a large propulsion plant and drove the size of the hull and its requisite displacement upward. Coupled with this, however, was the limiting amount of propulsion power available in the battery and the motors of the day, which defined the available submerged speed and range. The standard model propulsion plant in the early submarines of the inter-war period was one in which surface power was provided by two diesel engines, each driving one propeller shaft. Also mounted on this shaft was an electric dynamo. If the engine was driving the shaft, the dynamo could be used as an electric generator to charge the lead acid storage batteries. When the submarine submerged and was no longer able to provide the vast quantities of air required by the diesel, the engine was stopped and a clutch set between the engine and the dynamo was opened. Then the dynamo was operated as an electric motor using the stored electrical energy of the battery to drive the propeller shaft. While navies had experimented with other forms of submarine propulsion, including steam and compressed air, none had developed a system that seemed to be more effective than the direct diesel-engine drive for surface operation and electric dynamo for submerged running. Both small coastal defense submarines and larger, faster fleet submarines used this basic design. A first attempt at a fleet submarine in the US Navy was the T Class of 1916. These boats had four diesel engines providing the required horsepower to drive the 268ft-long hull at the designed 20 knots. Two engines were connected in tandem on each shaft. This design proved too complex to be reliable.

Another attempt at the large submarine design was the first three boats of what was loosely termed the V Class. Designed in 1920, these boats split the diesel plant so that two engines drove electric generators and were situated forward of the control room. Two other engines were situated aft in the standard direct-drive configuration, one to each shaft. These 2,000ton boats had grown to over 330ft in length and proved to be unwieldy in diving and maneuvering. Even in later life when converted to cargo carriers, the three were generally considered unsuccessful.



The *Bass*, *Barracuda*'s sister, with the modified surface ship 5in/51 deck gun. *Bass* suffered a bad fire during the war, which killed 24 of her crew. The boat was refurbished, but only used in a limited training role. (US Navy)

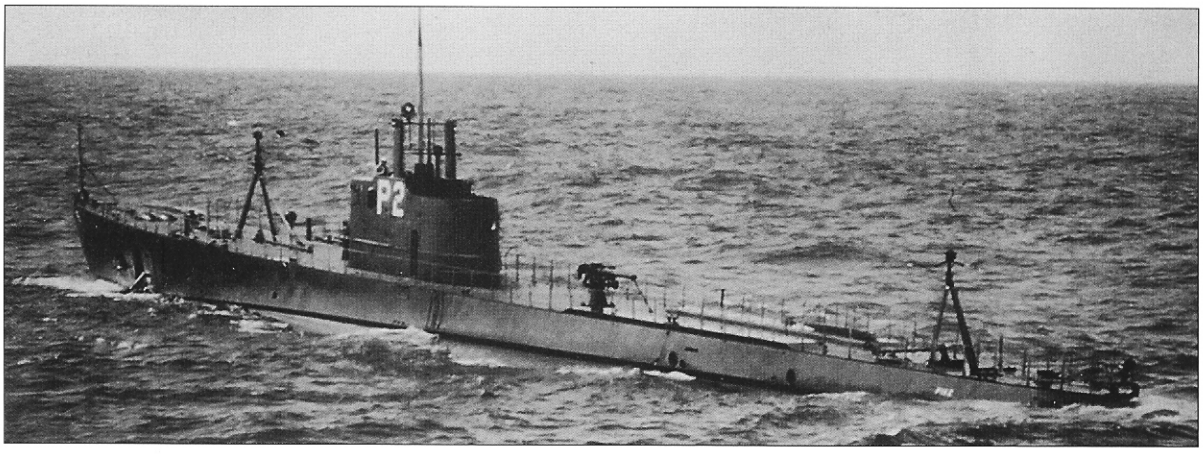


Underway at speed, the *Narwhal* shows the twin 6in/53 deck guns and the raised platform deck on which they stood. The tall mast supported radio antenna wires. These guns are now at the Submarine Base, New London. (US Navy)

Throughout the 1920s the submarine design community, which consisted of constructors, submarine commanders, and engineers, worked to develop, build, and test new designs in an atmosphere of disarmament. This work resulted in several designs that when built were to become the remainder of the V Class. *Argonaut* or V-4 was built as a minelayer capable of carrying 60 Mark 11 mines, laying these through two 40in-diameter tubes in her stern.

Two large cruiser submarines, the *Narwhal* and *Nautilus*, were designated V-5 and V-6. These were very much similar to *Argonaut* but without the minelaying tubes. All three of these (V-4, -5, -6) carried the largest deck guns of any US submarine, the 6in/53 Mark 12 Mod 2 (see below). The boats were plagued by engine reliability problems and underwent engine replacements early in the war. The *Dolphin* or V-7 was to be a bit smaller and less expensive than the six large boats that preceded her. She had a rearranged tankage and hull framing. Her internal layout was the forerunner of the standard model of fleet submarine. The last two of the V Class, *Cachalot* and *Cuttlefish*, started the trend for welded construction. The Electric Boat Company of Groton, Connecticut, which built *Cuttlefish*, used extensive welding throughout while Portsmouth Navy Yard in Kittery, Maine, retained riveting as the structural fastening method for *Cachalot*. These boats were smaller and lighter than any of the prior V Class except *Dolphin* and this proved to limit severely their speed, endurance, and ease of repair and maintenance.

The *Narwhal* in 1932 in her light gray livery, shown nearing the submarine base at Pearl Harbor. Nine years later she was tied up at the base when the Japanese attacked. This boat marked the last attempt to create a large "cruiser" submarine. (US Navy)

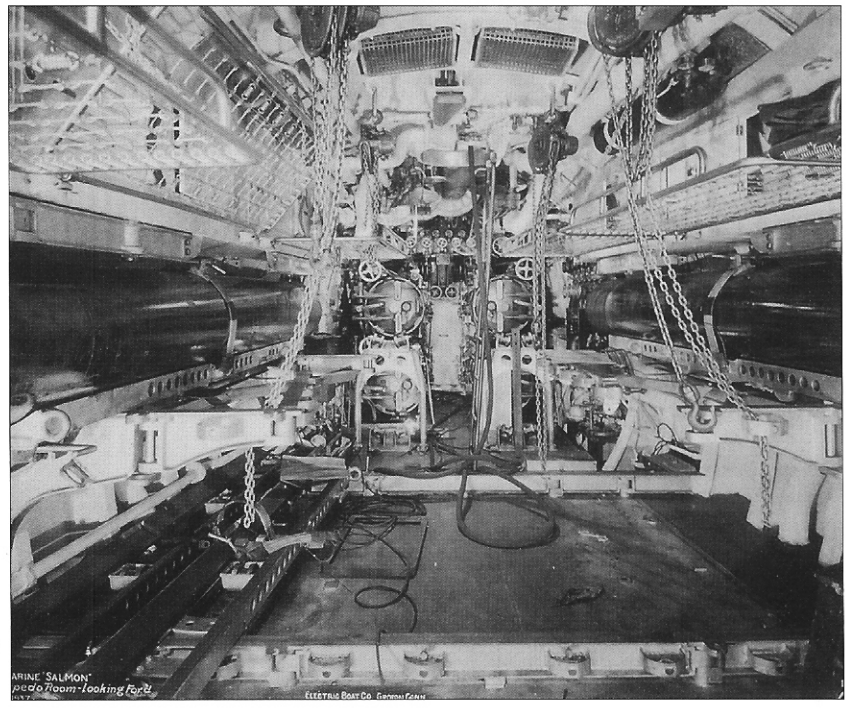


Smaller but handier than the larger early V Class boats, the *Pike* marked the beginnings of the rapid transition to the standard fleet-type submarine of the US fleet in World War II. Here with her early pendant number "P2" and an all-black Measure 9 paint scheme, she operates on the surface off the Atlantic coast. The deck gun is a 3in/50. (US Navy)

In the early 1930s the Navy embarked on an ambitious plan of submarine design and construction. The result was a set of boats that used the lessons learned from building and operating the V Class, and which had an eye to the requirements of a submarine war that would take place over the vast ocean distances in the Pacific. The submarine commanders wanted more speed and reliability, better habitability to increase crew endurance, more torpedoes and torpedo tubes, and larger deck guns. These desires had to be tempered with considerations of initial cost, manning, and the constant trade-offs of shaft horsepower, displacement, and size.

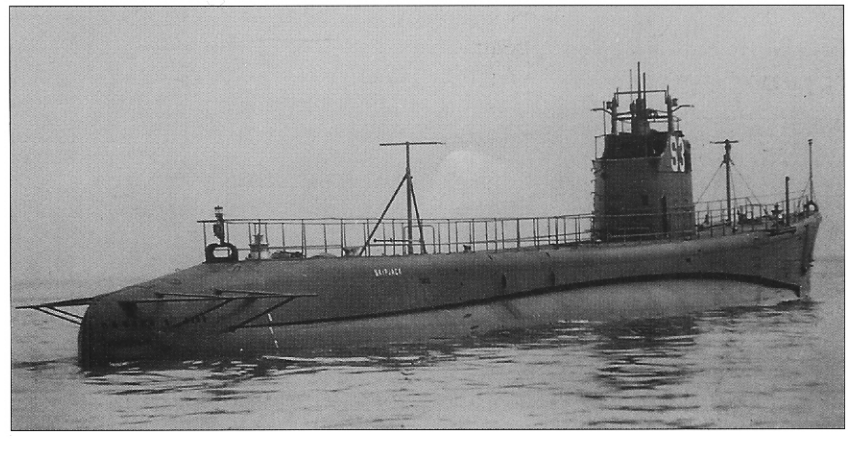
An unusual competition occurred between the private shipbuilder Electric Boat Company (EB) and the government's Portsmouth Navy Yard. Each were given the general design and specifications in the four-boat Fiscal Year (FY) 1934 build program and were separately to create the detailed design and prepare the contract designs. So the four boats were in essence prototypes of separate classes worked up from the same set of specifications. Each builder built two boats. Portsmouth built *Porpoise* and *Pike*. EB built *Shark* and *Tarpon*. This "unofficial" competition proved to be beneficial in the rapid development of the fleet submarine through the 1930s. In essence, the evolution seen in design during the decade prior to World War II can be seen through the differences in the *Porpoise* to the Tambor Class boats. This evolution culminated in the Gato and Balao Class designs, which were the mainstay boats of the war years. Starting after the large Argonaut and Narwhal Classes, boats reverted to a generally common length around 300ft and a beam of 24–27 ft. The major changes were in the number and location of torpedo tubes, the propulsion equipment arrangement, and the hull construction technique.

The arrangement of torpedo tubes started with four tubes forward and two aft, with two additional deck tubes located in the forward superstructure. The evolution ended with six tubes forward and four aft – all internal. Propulsion equipment was initially a combination of direct-drive diesels and diesel generators in a single engine room space, but led to four diesel generators, two each in two engine rooms, and the electrical controller cubicle and main propulsion motors in a separate compartment. Construction technique started with all-riveted hull, superstructure, and tankage and ended with welded construction throughout. The changes were reflected in a general sense by the class

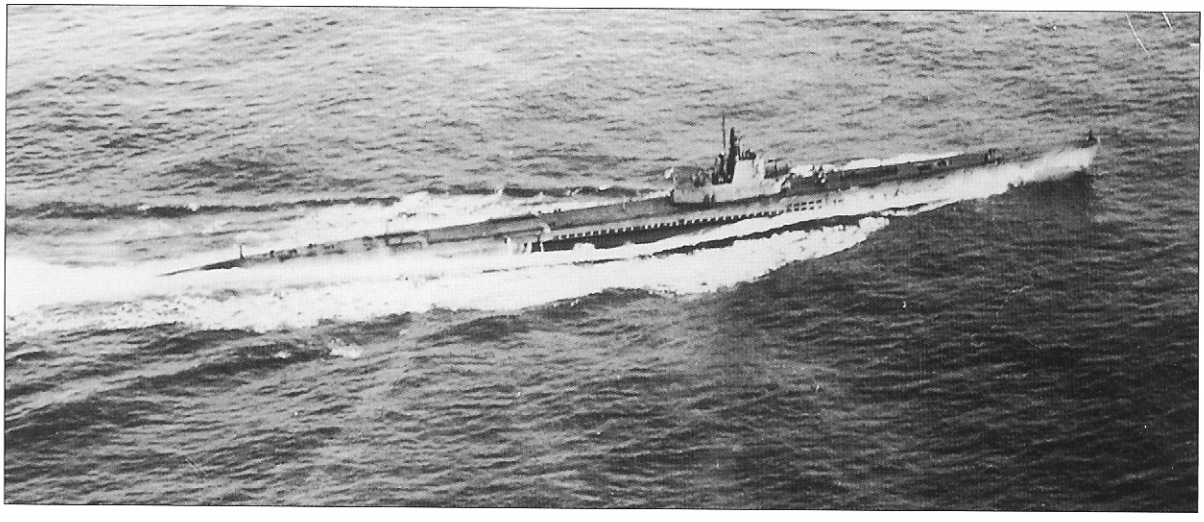


A construction photo of the forward torpedo room of the *Salmon*. The torpedo rooms differed little until after the Tench Class. Two more tubes were added and it became both more crowded and more efficient. (US Navy)

designations, but in reality they overlapped and specific ships in a class did vary widely in their technical specifications, except in the major characteristics. One interesting outcome of the unofficial competition between naval shipyards and civilian shipyards was the division within a single given class of the characteristics of the two design groups. The Portsmouth Navy Yard had the lead in the so-called "Government" or "Portsmouth" design while Electric Boat Company had the civilian design. Construction contracts awarded to naval shipyards used the Government design and those awarded to civilian yards used the EB design. Thus, Mare Island, Portsmouth, and Boston Naval Shipyards used the Government design drawings while Electric Boat, Manitowoc, and Cramp Shipyards used the EB design drawings. An experienced observer could look at certain external items and tell an EB boat from a Portsmouth boat and if a walkthrough of the boat were to be made, a



A sea trials' (new construction) view of *Skipjack* in the Measure 9 paint scheme and running with a very light displacement. The dark spots along the superstructure are the engine exhaust outlets. (US Navy)



An aerial shot of the *Skipjack* in the Measure 32/3SSB paint scheme. She is working up to her maximum surfaced speed of just under 20 knots. The cut-down superstructure and the paint scheme show the photo to be taken in late 1944. (US Navy)

determination could be made with some certainty. An example of a difference would be in the main diesel generators. EB boats used General Motors engines, such as the GM278, while Portsmouth designs used Fairbanks-Morse engines (the FM D38-8 1/8, for example).

CLASS DESIGNATIONS

Class Name	Surface Speed (Knots)	Submerged Speed (Knots)	Test Depth (Feet)	Officer Complement	Enlisted Complement	Torpedo Armament (Bow; Stern; Deck)
O Class	14	10.5	200	2	27	4
R Class	14	11	200	2	27	4
S Class (early)	15	8.9	200	4	34	4
S Class (later)	14.5	9.5	200	4		4
Barracuda Class (Also V-1 Class)	21	8	200	6	50	4; 2
Argonaut Class (Also V-4 Class)	15	8	300	8	80	4; 0; 2
Narwhal Class (Also V-5 Class)	17	8	300	8	80	4; 2; 4
Porpoise Class		8	250	5	45	4; 2; 2
Shark Class (Also the New S Class)		8	250	5	45	4; 2; 2
Perch Class	19.5	8.75	250	5	45	4; 2; 2
Salmon Class	21	9	250	5	50	4; 2; 2
Sargo Class	20	8.75	250	5	50	4; 4
Tambor Class	20	8.75	250	5	54	6; 4
Gar Class	20	8.75	250	4	54	6; 4
Gato Class	20	8.75	250	5	54	6; 4
Balao Class	20.3	8.75	400	6	60	6; 4
Tench Class	20.3	8.75	400	6	60	6; 4

EQUIPMENT

Weapons

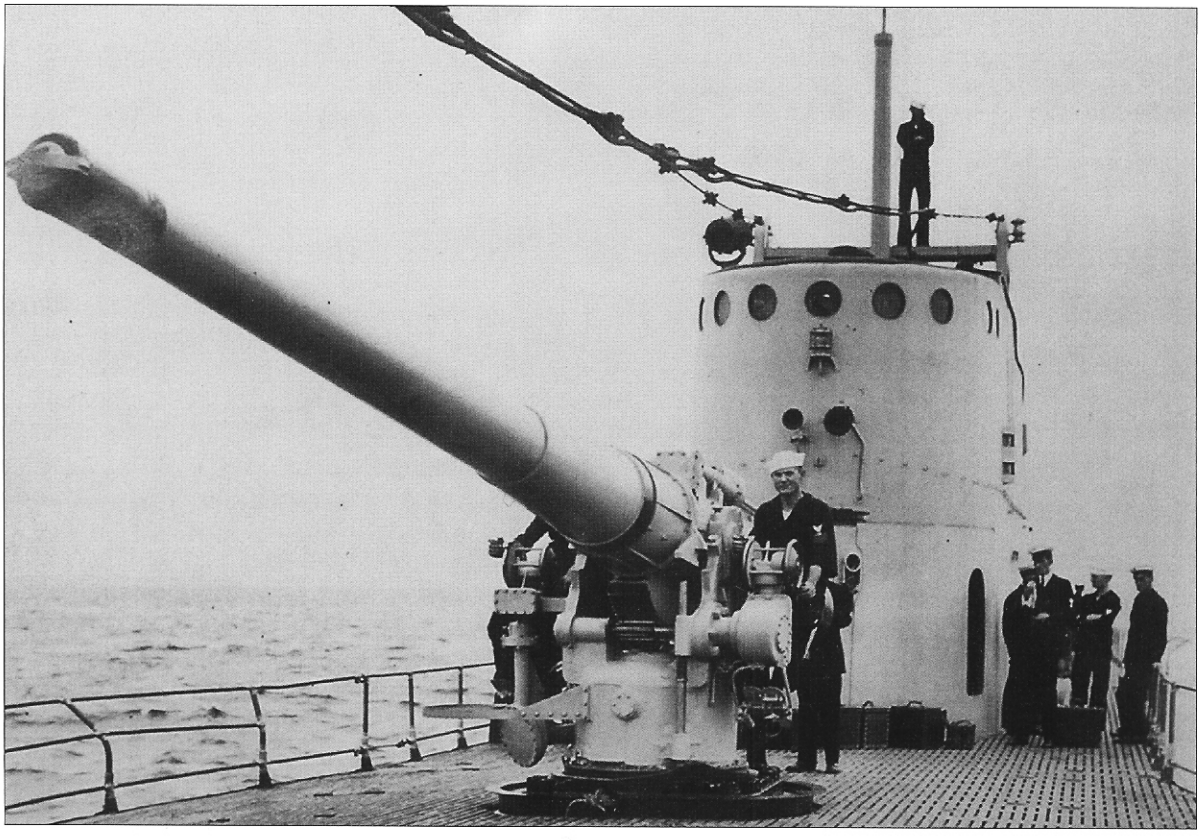
The World War II submarine had two major weapons: the torpedo and the deck gun. The two standard torpedoes were the Mark 10 and Mark 14. All were sized to fit in the standard 21in torpedo tube and were just short of 22ft long.

Torpedoes

The Mark 10 was a straight-running torpedo that constrained the submarine into having to point the torpedo tube, thus the entire submarine, at a point ahead of the target (leading the target), so the target and the torpedo arrive at that point simultaneously. The fire-control system for the boats that used this torpedo consisted of manual slide rules of various designs and a skipper (commanding officer) who could mentally solve the relative motion problem. The Mark 10 had a 497lb warhead and would run at 36 knots to a maximum range of 3,500 yards but was seldom fired at ranges exceeding 1,000yds.

The Mark 14 torpedo was more versatile. It had two speeds (31.5 knots and 46 knots) which were selected prior to firing and it could make one turn to a new course after firing. The speed selection and the setting of the amount of turn were performed either manually by operating a spindle on the torpedo tube that extended inside to turn a device on the torpedo, or electrically using a servo on the same spindle, via the fire-control computer from the conning tower. The ability to turn to a new course after firing meant the submarine did not have to be maneuvered to point the torpedo as a part of the firing solution. The Mark 14 torpedo had a 660lb warhead filled with torpex and could run out to 4,500yds at high speed and 9,000yds at slow speed. The torpedo was almost always used at high speed and with little, if any, gyro angle.

The Mark 14 is seated on a loading skid. A nosepiece is attached to the torpedo and lines connected to each side. The lines are run around cleats on each side of the skid and the torpedo is slowly lowered into the torpedo room. Once the full weight of the torpedo is on the skid the block and tackle on the derrick is disconnected. (US Navy)



This prewar staged photo shows the largest deck guns carried by US submarines, the 6in/53. The closed bridge helm position design was carried over to all the new classes until the Balao Class. As the boats needed to reduce their visibility, this high, enclosed bridge structure was converted to a platform for an antiaircraft gun. (US Navy)

The Mark 14 torpedo used the Mark 5 and Mark 6 exploders. The Mark 5 was a contact exploder and the Mark 6 was a magnetic influence exploder. The magnetic exploder was designed to detonate the warhead under the keel of the target. Unfortunately for the submarine force, both of the exploders had serious design flaws and the torpedo ran 10ft below the set depth. The problems with the torpedoes were exacerbated by the secrecy blanket thrown over the magnetic exploder and the reluctance to blame the lack of kills on anyone other than the submarine skippers and the weapons personnel that maintained and prepared the torpedo. It wasn't until late 1943 when the contact exploder problem was fixed, the depth problem cured, and the magnetic exploder was dispensed with that the submarines were sent out with properly operating torpedoes. However, one problem with torpedoes still remained. The bubble trail left by the exhaust of the alcohol/high-pressure air-fired turbine engine tracked pointedly back to the firing submarine. To overcome this problem, an electric motor/battery system was devised. The new electric torpedo was designated the Mark 18. The same size as the Mark 14, it had a slower speed (30 knots), a lighter warhead (575lb), and a maximum range of 4,000yds. Very late in the war the Mark 23 was introduced. It was to be fired when deeply submerged (greater than 150ft) and used a hydrophone mounted in the nose of the weapon to direct it toward the loudest noise. It only carried a 95lb warhead. This light weight charge was, however, sufficient to hole a submarine or knock the screw or rudder off a troublesome escort. These torpedoes were introduced too late in the war to make any real impact on the outcome.

A shellman awaits the firing of the 5in/25 deck gun while the loader, with his hand out, ensures the recoil path stays clear. The size of the ammunition for this gun is shown in the shellman's arms. The deck around the gun is open and likely slippery and wet. There is also a notable lack of cover against enemy fire. (US Navy)

Deck guns

A deck gun type is defined by its bore diameter and bore length. Further refinement of the gun type is by the mark and modification number. The bore diameter is normally given in inches and the bore length is given in calibers. A caliber is one bore diameter. Thus for a 3in/50 gun, the bore diameter, measured land to land, is 3in. The length of the bore is 50 calibers or 150in. Each major type was also given a mark number by the Bureau of Ordnance (BuOrd). A gun could have the same bore size and length and be a different mark. When discussing the entire range of 5in guns in the Navy, it is useful to use the mark number. For submarine guns only, it is normally not necessary. Modifications to a particular mark were also numbered. Thus, a gun was fully described with its bore diameter, bore length, mark, and mod numbers.

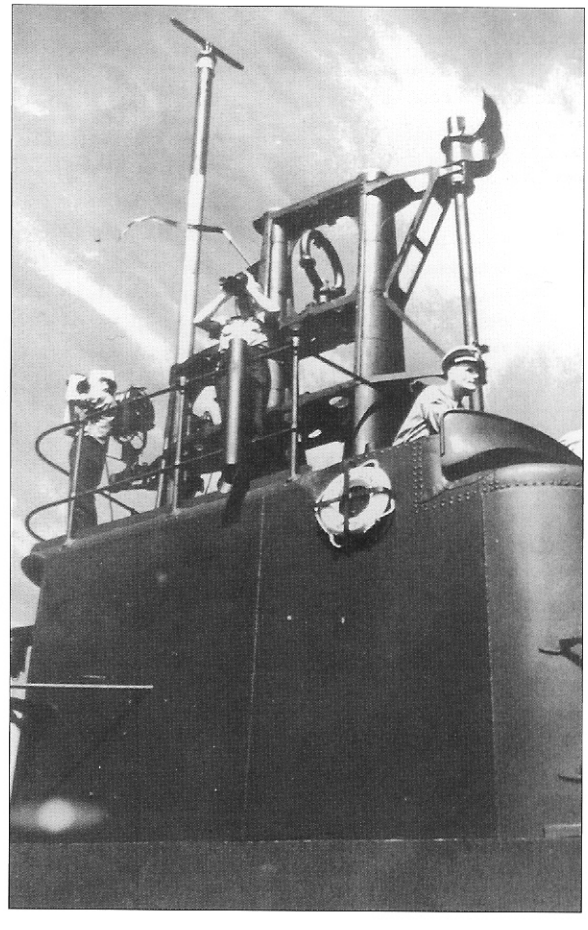
Generally the fleet submarine entered World War II with a 3in/50 deck gun mounted aft of the conning tower. A few months into the war commanding officers were authorized to have the gun aft removed and remounted forward where its firing could be directly supervised from the bridge if so desired. There were some notable exceptions to the 3in/50 in the original designs' installation. They were the three large "cruiser" submarines: the USS *Argonaut* (originally designed and built as a minelayer), the USS *Nautilus*, and USS *Narwhal*. These three had two large 6in/53 guns mounted, one forward of the conning tower and one aft.

The 6in/53 Mark 17 Mod 1 was the largest deck gun carried by a US submarine. During World War II a variety of gun types were carried. These included the 3in/50 Mark 11 Mods 4, 5, 6, and 7. These weapons could fire a 13lb projectile to a maximum range of just over 14,000yds. By June 1944 the 4in gun in a wet mount was ready. The 4in gun came in two types, the 4in/50 Mark 12 Mod 6 and the 4in/50 Mark 12 Mod 44

(the main difference between the guns was the method of keeping the bore watertight). These could fire a 33lb projectile to a maximum range of over 16,000yds.

The V-1 to V-3 had 5in/51 guns as their initial installation. The 5in/51 was adapted from the battleship 5in open mount and carried the Mark 13 Mod 11 designation – only the USS *Tambor*, USS *Tautog*, USS *Thresher*, and USS *Tuna* were equipped with this type (it was removed from V-1 to V-3); two more boats were supposed to get them but most likely got the 5in/25 instead. The gun that became the standard during the latter stages of World War II, and which replaced the 3in and 4in guns as boats went thorough mid-war overhauls, was the 5in/25 Mark 40 Mod 0. It was first installed as a new construction in USS *Spadefish* in 1944 and could fire a 53lb projectile to a range of over 14,000yds. Seven boats were fitted with two 5in/25s and a fire-control system. Only one, the USS *Sea Cat*, was ready before war's end. The others were the USS *Manta*, USS *Entemedor*, USS *Sea Dog*, USS *Sea Poacher*, USS *Sea Robin*, and USS *Sennet*.

Early in World War II it was seen that the range of the .50-caliber and .30-cal. machine guns in the antiaircraft role was too short to be effective. Therefore the Bofors-designed 40mm antiaircraft gun and the 20mm Oerlikon type were selected to be standard equipment aboard US submarines. The 40mm was the Single Mount Base Ring type Mark 3 Mod 0. The 20mm came in two varieties: the single mount open or shielded pedestal type Mark 10 Mod 0 and the twin mount open or shielded pedestal type Mark 24 Mod 5. These guns would be mounted on platforms forward and aft of the bridge (fore and aft of the conning tower) or in the case of the 20mm occasionally on the main deck. The Bofors 40mm only became available for submarines after mid-1944. Most boats had one or two of the 20mm Oerlikon antiaircraft guns. Only once did a submarine skipper engage in a gunfight, tackling an enemy that proved to be lethal to the submarine. That submarine was the S-44 which, thinking it was shooting at a freighter, found it was in fact a Japanese destroyer. The S-44 was sunk in that action on October 7, 1943.



This photo of the bridge and periscope structure of the *Cero* shows two of the standard radars used. From forward to aft (right to left) are the SJ radar antenna with its curved solid reflector, the forward periscope (#1) and the aft periscope (#2) shown housed, then the tall SD radar mast. Between the periscope supports is the circular VLF loop. (US Navy)

Periscopes

Standard periscopes on submarines of World War II (Gato class and successors) were:

- Type 2 (designated 89KA-40/1.414HA). Head diameter was 1ft 5in, with an optical length of 40ft. It had a 32-degree field of view and could elevate so the upper edge of the vertical field of view was at 90.5 degrees from the horizontal.
- Type 3 (designated 91KA-40/1.99). It had a larger head (2ft) and was used as a night periscope.
- Type 4 (designated 93KN-36/3.75). It replaced the Type 3 as availability allowed. It had an ST "range only" radar antenna in the head window.

Sonar

The letter/letter-number designation of a particular system is not an acronym, such as the word "Radar" or "Asdic," but a letter or letter-number identifier. This nomenclature system evolved into a three-letter joint Army/Navy system after the war. The first letter was the major category, the second a subset of that category, platform, or usage designator and so on.

Standard sonars used during the war were:

- WCA and WDA 18–24KHz active installation, which used the JK array and the QB and QC listening and echo-ranging equipments. The WCA was standard equipment at the beginning of the war. The WFA, incorporating the many technical changes installed as upgrades during the war, began to be installed as standard equipment in early 1945.
- WDA passive (with bearing deviation indication later in the war).
- JP 70Hz to 12KHz passive adapted from small boat sonar. Introduced and installed from early 1942.
- JT 100Hz to 60KHz passive used a 5ft-long line array that could be rotated to scan. The JT was introduced in mid-1945. The scan bearing was fed into the torpedo data computer (TDC) for fire control.

Several specialized units, rather than the general-purpose units above, were developed and used during the war. Some of these were:

- The OL (object locator): High-frequency echo-ranging equipment which was used to identify the presence of small objects such as mines close to the boat.
- QLA: A frequency modulated (FM) supersonic active equipment used in conjunction with a plan position indicator to give a sonar picture of the immediate area around the boat. It was useful for locating mines.
- Depth charge direction indicator and range estimator: These were introduced in 1944 to help a submarine with the problem of escaping the Japanese escorts.

Sometimes modifications are done by accident. On the night of February 7, 1943, Commander Howard Gilmore in *Growler* collided with an attacking Japanese gunboat. In the event Gilmore was badly wounded and two other bridge personnel were killed. Gilmore, knowing he could not make it below and that hesitation on the part of the crew would mean the possible sinking of his ship, ordered the boat submerged with him still outside. The bow of *Growler* was bent 90 degrees to port in the collision. The bent bow was cut off and replaced with another bow to effect repairs. Gilmore received the Medal of Honor for his selfless act. (US Navy)

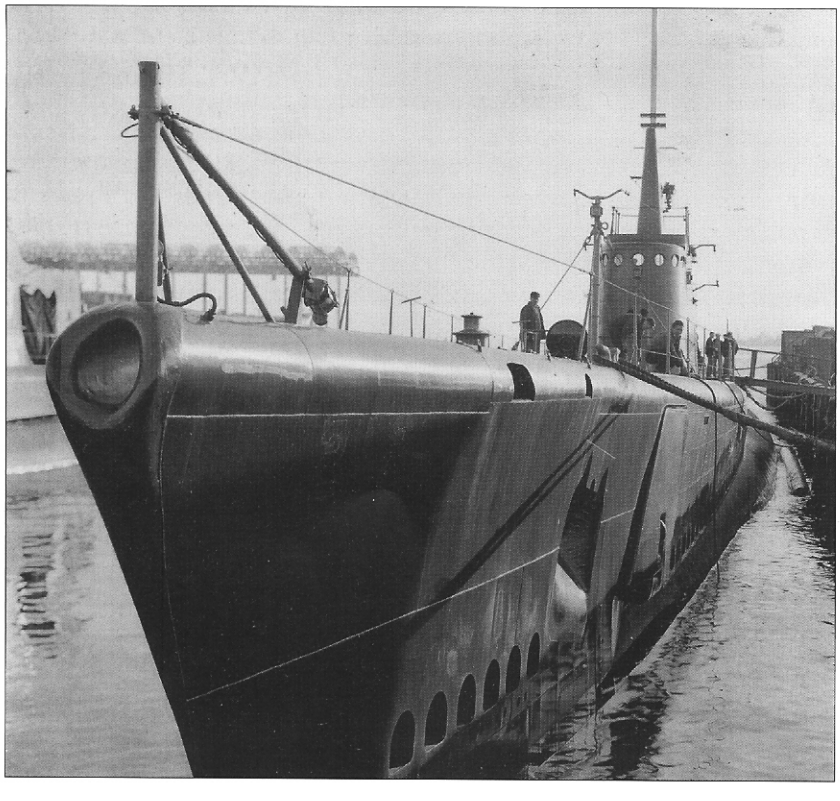
Radars

Standard radars used during the war were:

- SD: A range-only unit on a retractable mast with a "T" top, it served as early warning against attacking aircraft.
- SJ: A centimetric (10cm) surface search radar based on the British-provided magnetron. The SJ-1 was introduced in 1944 with a plan position indicator, which gave the familiar sweeping picture of the area surrounding the submarine.
- ST: A microwave surface search radar with its antenna in the periscope. It used the SJ installation to give range, but the bearing information was a function of the periscope's pointing.
- SV: An S-band air search radar to replace the SD. Introduced in early 1945 but not standard until war's end. Its mast could be raised and lowered, making it usable with the boat submerged near periscope depth.
- SS: An X band (3cm) surface search radar installed on only a few boats at war's end.

Communication

In the early part of the war instructions and information were transmitted in an encrypted format in what is normally called the Fox broadcast. This broadcast sent all the messages to be communicated to all the boats three times each night. As the war continued and the amount of radio traffic and the numbers of submarines increased, as well as the need for enhanced control over communications, the standard Fox broadcast was discontinued for submarines in favor of



The bow of *Gato*. The hole in the bow to the left of the photo is the "bullnose," more properly called the towing fairlead. The openings near the waterline near the bow are flood ports for the bow buoyancy tank. Aft of the last opening is the anchor recess followed by the port bow plane folded against the superstructure. On the deck forward of the bridge (round windows), with the "y" shaped yoke atop, is the forward radio antenna stanchion. The round object just to the left of the base of this stanchion is the forward torpedo room hatch cover. The high bridge enclosure and faired periscope supports are visible further aft. (US Navy)

other transmission schemes, although the fundamental means of contact remained the same. Radio messages were sent to the entire submarine fleet with the addressees a part of the heading of each message.

Maintenance

Submarines, although extremely robust, have items that break down and/or become damaged. This is particularly true when a submarine is involved in combat. Therefore a maintenance program for repair of damage and derangement, as well as for improvement of equipment, was vital to the proper operation of the submarine forces. Refits, the quick turnaround work done between patrols, were scheduled to last 14 days. The boat's crew was replaced by a refit crew. After the refit, the regular crew came back aboard, loaded stores and ammunition, and went back out on patrol. This system of efficient and regular refits, with the crew being rested, and the extensive and regular overhauls directly increased the reliability of the submarine and the expertise of the crew.

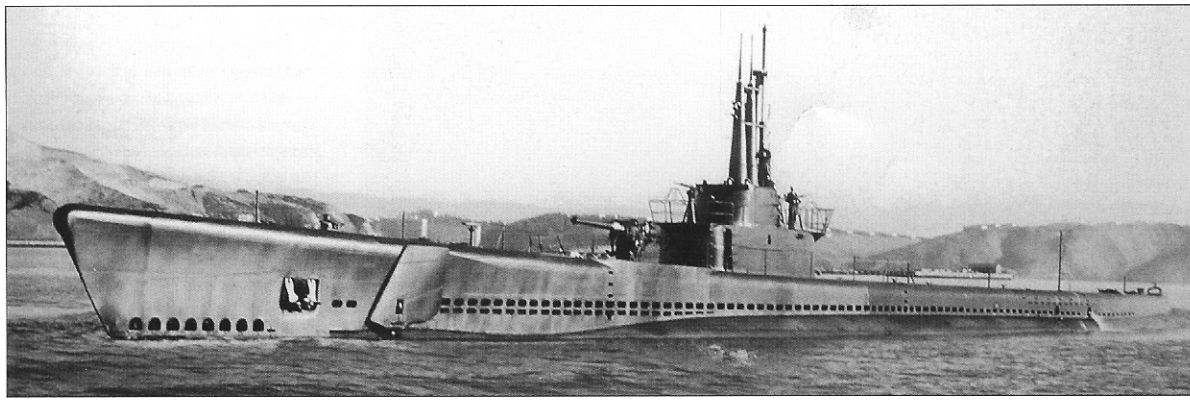
THE BOAT – BALAO CLASS

On the tip of the bow was the towing fairlead, commonly called the bullnose. From here to the rounded fairing streamlining on the stern the submarine was 307ft long and at the widest point just over 27ft across the tanks. The hull and superstructure might have been painted with one of three paint schemes. These were designated by "Measures" (see Plate C). General descriptions are:

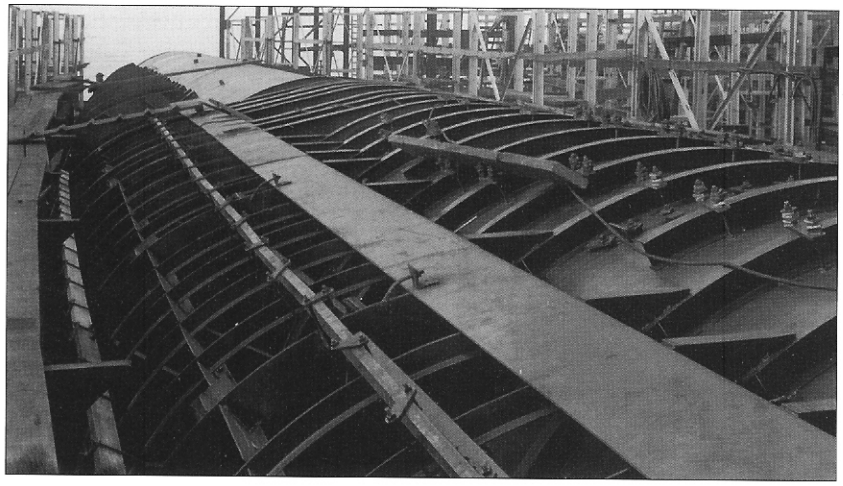
Measure 9: Entire submarine above the waterline was painted black, the painting to be carried over all parts that were visible from the air, including the numbers, capstan, and running light boards and bridge rails. The underbody was painted with the current issues of bottom anti-fouling paints, which were normally black.

Measure 10: The submarine above the waterline was painted Ocean Gray, which was a blue gray. The underbody was painted with the current issues of bottom anti-fouling paints, which were normally black. Due to problems with this paint (it had a tendency to turn milky as it aged after application), Measure 9 was the preferred scheme.

Measure 32: Two variants of this scheme were used. Measure 32/3SSB used gloss black for the deck to just short of the deck edge, then flat



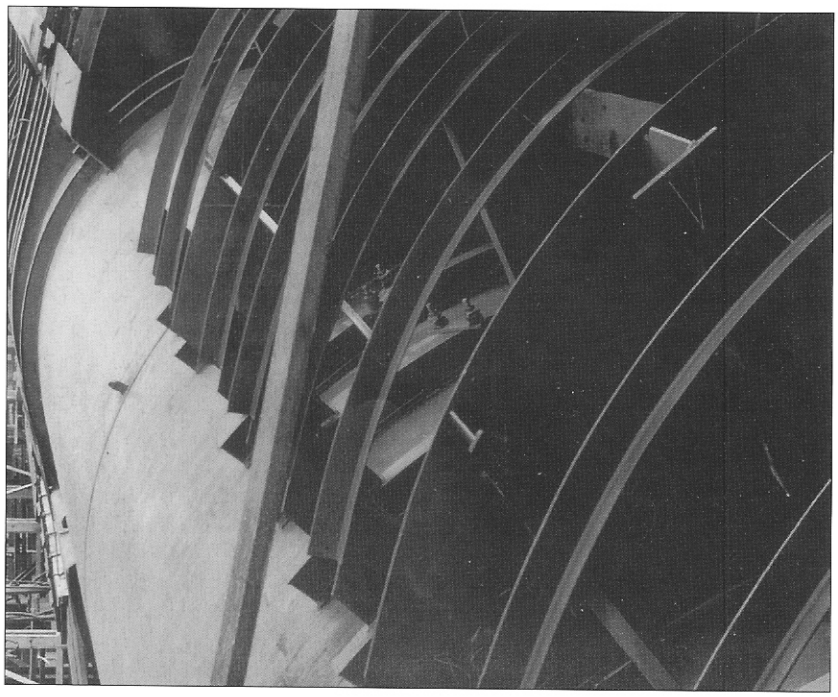
The *Skate* in what is known as a new construction "wedding" photo. Forward is the 4in/50 deck gun. Note that the expanded numbers of limber holes is now in new construction, not just additions in overhauls. (US Navy)



A view of *Harder* under construction. This view of the boat is looking toward the stern. The framing to the left is the support framing for the tank plating. Toward the right are the frames for the plating of the pressure hull. (US Navy)

black, which was shaded with dark and light gray over the deck edge to light gray on the vertical surfaces. All horizontal surfaces were painted flat black. The sides were shaded from light gray to a darker gray near the conning tower, then to flat black about midway between the conning tower and the stern. Measure 32/9SSB was similar, except dark gray was used instead of light gray in all vertical surfaces.

The superstructure deck was a series of wooden slats about an inch and a half square with a like space between, or a metal deck pierced with holes to form a perforated decking. This design ensured that air didn't get trapped under the deck as the boat submerged. The visible portion of the submarine was nearly all what is termed "free flood." This was a light metal fairing that covered the upper pressure hull and the tank tops that enfolded the pressure hull.

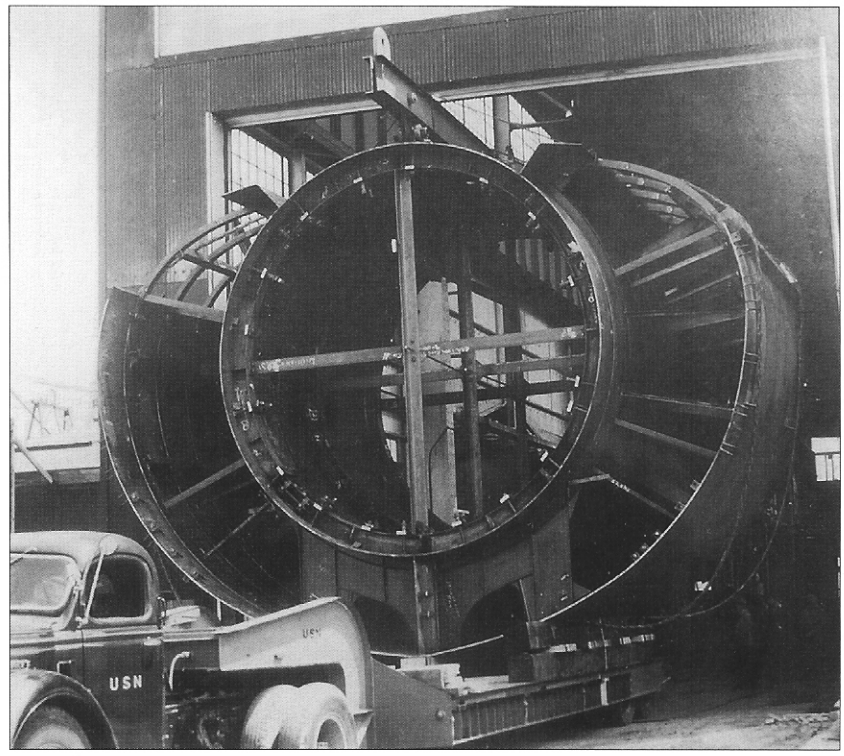


The superstructure framing on the *Harder* under construction at the Electric Boat Company. This view of the starboard side looking toward the bow shows the framing that supported the superstructure. The rounded portions of plating below the framing are the tanks that surround the pressure hull. (US Navy)

Between the superstructure deck and the pressure hull aft of the conning tower were nested runs of air induction and engine exhaust piping, main and fuel ballast tank vent risers, and the foundation for the deck gun. Forward of the conning tower the superstructure was largely empty except for some piping and the remainder of the main and fuel ballast tank vent risers, and on most boats an additional deck gun foundation. Forward near the bow planes a hatch led to a ladder that extended down through the forward escape trunk to the forward torpedo room. This cylindrical space, nearly 40ft long and just less than 19ft wide at its widest, was the forward-most of the seven watertight compartments that comprised the main pressure hull. One additional watertight compartment was a smaller horizontal cylinder placed on top of the pressure hull; this was the conning tower.

At the forward end of the torpedo room were the doors of six air impulse type torpedo tubes. They had an inside diameter of just over 21in and were 22ft long between the insides of the inner and outer doors. Nested in a maze of piping that supplied air, water, and hydraulics to operate the tubes, they appeared hidden. Each tube had a hydraulically operated outer door and shutter. These operated together so that when the outer door was opened it swung inboard toward the centerline and at the same time, on an attached linkage, a long narrow fairing piece called the shutter door, hinged on its forward end, also swung inboard.

Taking up much of the remaining space in the torpedo room were reload Mark 14 torpedoes. Four were level with the upper tube with two on each side. Below that were four more, again two on each side, level with the next tube set down. On a level with the lowest tubes were



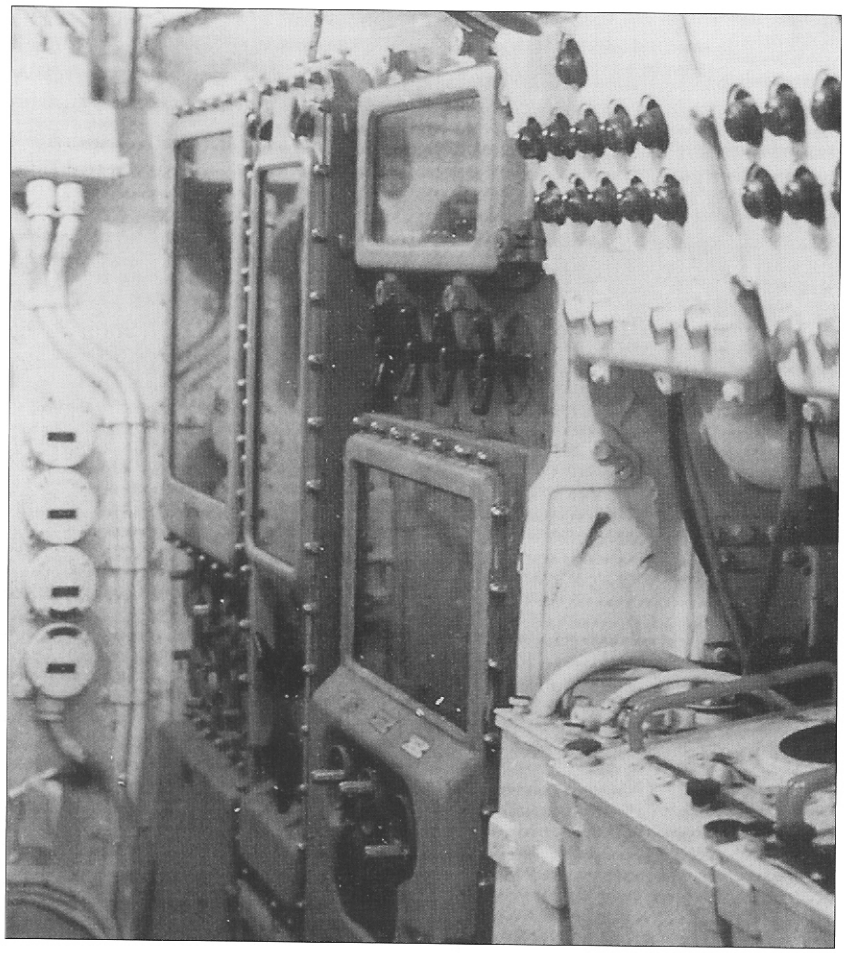
A section of a submarine being taken from the erection building to the ways. This photo shows clearly a section of a typical fleet submarine hull. The circular section stiffened by the cruciform supports (which would be removed when the section was in place) is the pressure hull. Surrounding that are tanks that may have been used for ballast or fuel depending on their position along the boat. (US Navy)

four more torpedoes. These, combined with the six loaded tubes, gave the boat an 18-torpedo punch from the forward end.

Forward battery

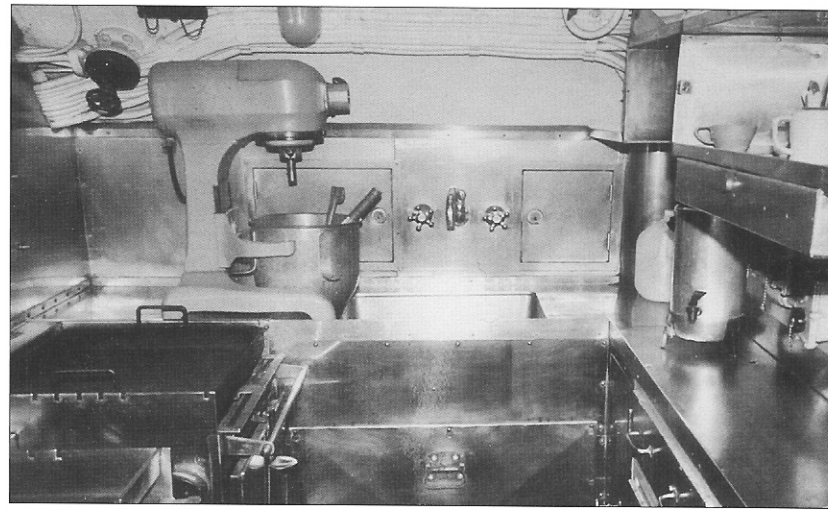
Through a watertight door in the after bulkhead of the torpedo room was the forward battery. This compartment was divided in two by a watertight deck. Below the deck was the forward half of the storage battery. This part of the battery consisted of 126 lead acid cells. Each cell was about 16in square and 48in high. They were connected in series by a set of lead-coated copper intercell connectors and to the main propulsion cubicle aft by a set of large copper busbars and cables.

The upper level of the compartment was divided into port and starboard halves by a narrow passageway down the center of the space. In the light metal partitions that defined the passageway were doors to the wardroom, which was just a 3 x 6ft table with bench seats on both sides. On the forward and aft end of the table were chairs for the captain and executive officer. Additional doors were entries into the six-man officers' berthing, the three-man officers' berthing, the nine-man chief petty officers' berthing, and the captain's stateroom. The captain was the only one aboard with a room of his own – it was a bit smaller than an average clothes closet.



A view of the equipment along the after port side of the conning tower. The glassed enclosures toward the left are the cabinets of the torpedo data computer (TDC). The upper panel with the lamps on the right of the photo are the ready indicator lights for the torpedo tubes. Below that is the PPI (Plan Position Indicator) scope for the SJ radar. (US Navy)

This is the entire galley on the boat. The size of the mixer in the left center gives some idea of the size of the space where the cooks would prepare meals for 80 men. The cooks and the meals were the best the Navy could provide as an offset for the cramped and crowded living conditions on submarines. (US Navy)

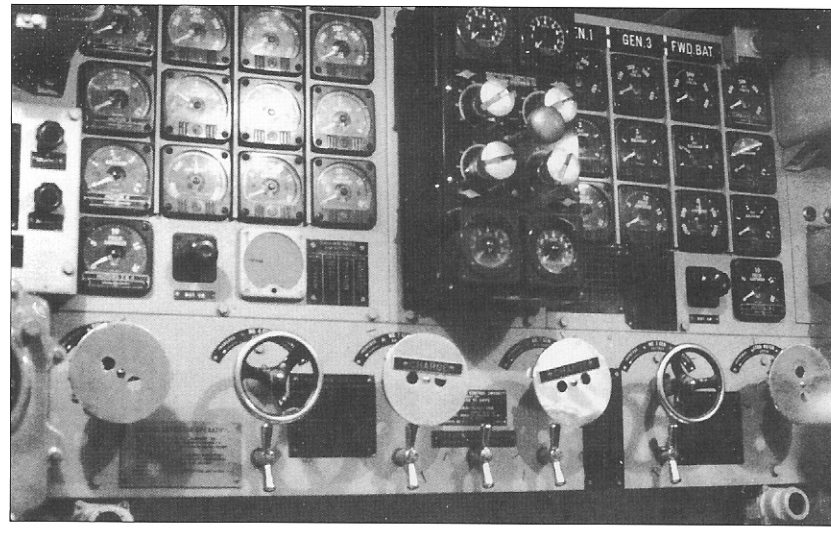


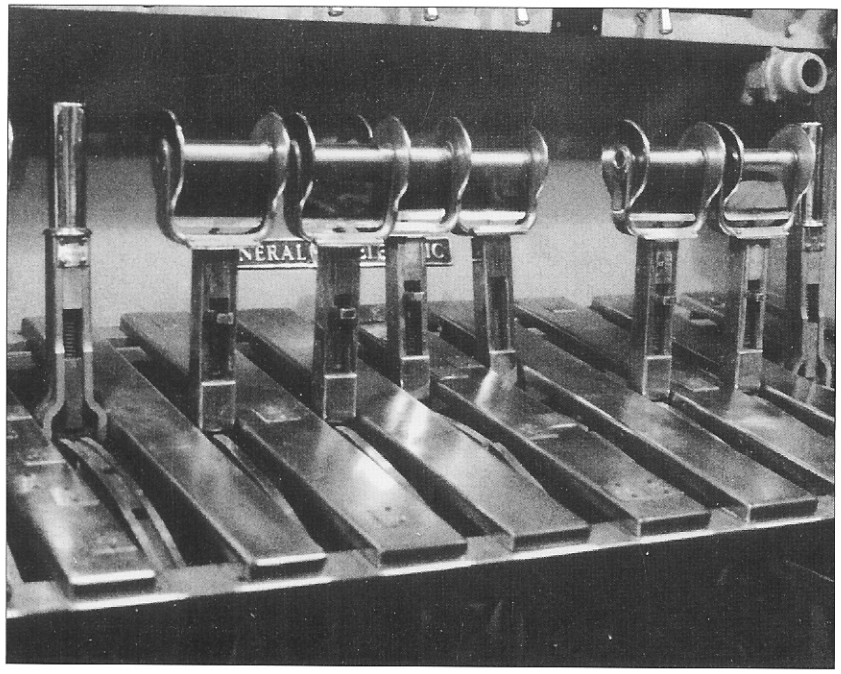
Control room

Through a watertight door in the starboard side of the aft bulkhead was the control room. It was in this space that the diving, surfacing, depth, and trim were controlled. On the starboard side were some large switchboards for indicators and communication as well as forward electrical distribution and gyroscope control. Further aft along the starboard side were manifolds for distributing and controlling high-pressure and medium-pressure air to the ballast tanks and trimming tanks, as well as low-pressure air to the ballast tanks for the final emptying operation.

On the port side starting from the forward end was the hydraulic control manifold, which had operator valves for opening and shutting the main vent valves and air intake valves for the boat. In addition, there was a panel with a set of red and green indicator lights that showed the position of the major hull openings, such as hatches. Red indicated a hatch or air induction valve was open, green meant shut. This board was called the "Christmas Tree" and when all openings were in position for diving, all the lights turned green, giving rise to the term "green board." Aft of the

The four diesel generators, two lead acid storage batteries, and two main propulsion motors were controlled from a central location in the maneuvering room. This photo shows the meters and rheostats used to perform the control functions. The handles shown in the next picture operated levers to which sets of electrical contacts were attached. These contacts interconnected the batteries, generators, and motors in various configurations to provide surface and submerged propulsion and battery charging. The flexibility and reliability of this system were superior to almost any other submarine propulsion system until the advent of nuclear power. (US Navy)





Directly below the control cubicle meters and rheostats shown in the previous picture are handles that operated linkages connected to electrical contactors. These handles are positioned to connect the generators, motors, and batteries in various combinations required for propulsion and battery charging. (US Navy)

hydraulic manifold was the diving stand with bow and stern plane operators and the trim manifold, which controlled the water in the trimming tanks. On the aft end of the compartment was a room that contained all the radio transmitters and receivers, with barely enough space for two operators. Below the walking deck in the control room was the pump room in which were arranged hydraulic pumps, air compressors, the trimming pump, and other small pumps and equipment.

Conning tower

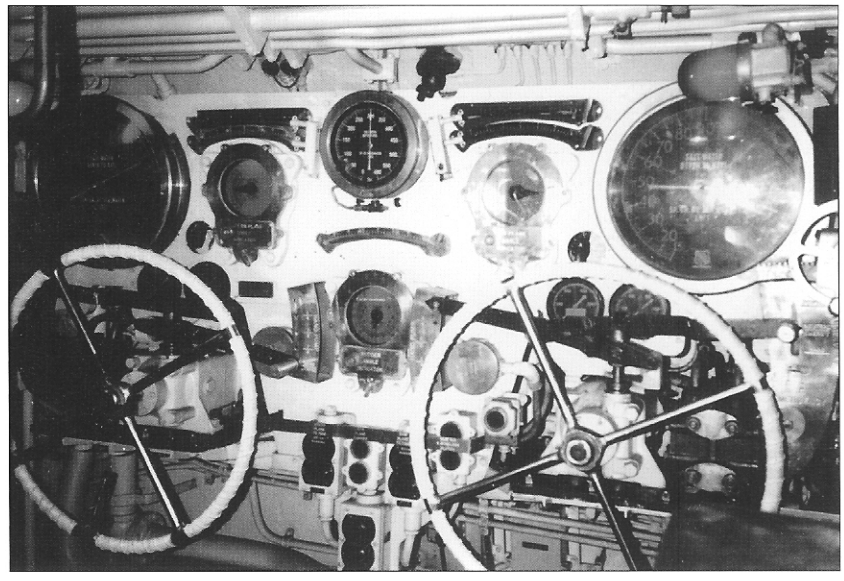
Above the control room was a small 10ft-diameter by 20ft-long cylindrical compartment in which were housed the fire-control torpedo data computer, a chart table, a radar console, and the two periscopes. When raised, the inner optical end of the periscope was just below standing eye level. In the forward end of the space was the helm stand. A ladder leading to the bridge hatch was in the forward starboard corner and a ladder and hatch leading to the control room were on the port side just aft the helmsman.

After battery

Continuing aft through another watertight door was the after battery. This space housed the galley, crews' messing tables, and berthing for nearly half the crew. The after battery was divided by a watertight walking deck, as was the forward battery. Under the deck were the ammunition stowage magazine, food storage space, and another 126-cell battery.

Forward and after engine room

Through another watertight door was the forward engine room. Both engine rooms were nearly identical, with two diesel generators occupying much of the space. A walking deck ran down the center of the spaces and a watertight bulkhead separated the forward and aft engine



The diving stand of a fleet submarine. Situated midway through the control room on the port side, it was the watch station of three crewmen while the boat was submerged. The bow planesman sat at the right wheel (forward) and the stern planesman sat at the left or after wheel. Behind them stood the diving officer who supervised the planesmen and the other control room watchstanders. The large gauges are shallow-depth gauges with a single deep-depth gauge at the top between the wheels. To the right and left of this gauge are two angle indicators that, operating like a carpenter's level, show the longitudinal angle of the boat. (US Navy)

rooms. In the forward engine room were two electric distilling units that processed sea water to make fresh water for the batteries. A smaller diesel generator called a "dinky" was located in the lower level of one of the engine rooms. It was used to charge the batteries if all the other engines were used for propulsion.

Maneuvering room

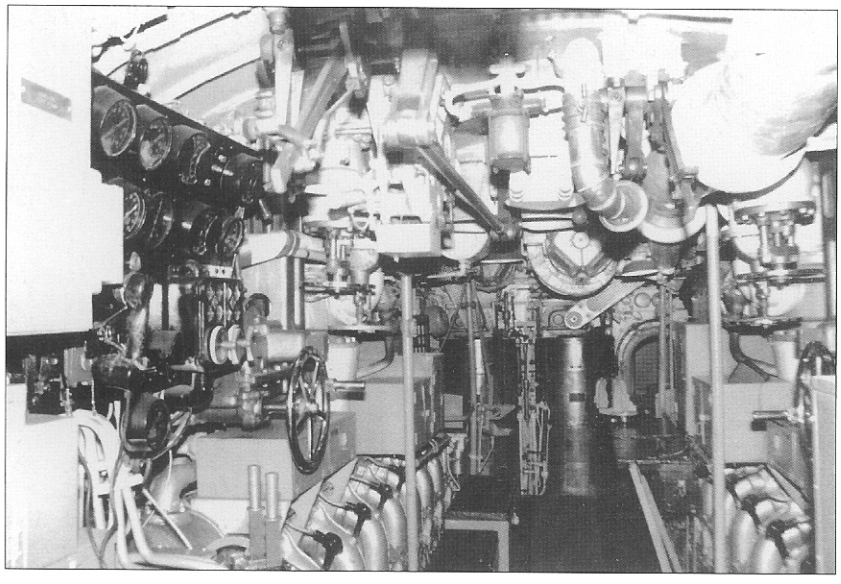
Sandwiched between the engine rooms and the after torpedo room was a small watertight compartment called the maneuvering room. Occupying the majority of this space was the main propulsion control cubicle. Really a large manually operated switchgear and DC motor controller, the cubicle routed electricity from each of the four main diesel generators, the dinky diesel, and the two storage batteries to connections for the main propulsion motors. The cubicle could connect one or more generators to either the motors or batteries or both for various combinations of battery charging and/or propulsion. Speed controls and rheostats allowed the operation of the motors at various speeds and the generators at various voltage and currents.

After torpedo room

Through a watertight door in the aft bulkhead of the maneuvering room was the after torpedo room. Like the forward torpedo room, this space housed torpedo tubes and spare torpedoes. Four tubes faced aft and there was room for eight reload "fish." In addition to the torpedoes the space was used for berthing for nearly 24 men.

Tanks

Around the pressure hull was a series of tanks: main ballast tanks for diving and surfacing and fuel ballast tanks, which could serve as fuel tanks and when empty, ballast tanks. In addition, a safety tank, which held the same amount of water as the conning tower or the main induction piping would if flooded, could be blown dry to compensate for that damage. There were enough fuel tanks around the pressure hull to



Another view of a typical engine room. The space is dominated by two diesel generators, in this case General Motors 278a engines. In the right center are two cylindrical vapor compressor distilling units, which on a good day could produce just a bit more water than the crew used, 500 to 1,000 gallons each unit. (US Navy)

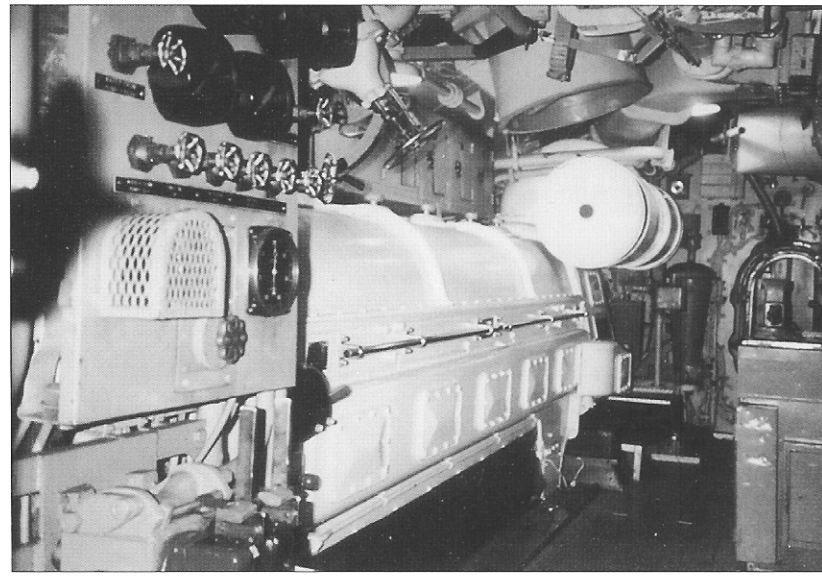
hold nearly 120,000 gallons of diesel fuel, sufficient for a trip of 10,000 miles at 10 knots.

OPERATION

The operation of the submarine was relatively independent of the task to which a particular boat might be assigned on a patrol. The at-sea cycle varied little from day to day, except when performing specific mission elements and/or while attacking or under attack. Upon leaving Pearl Harbor for patrol, the boat would be escorted by a destroyer escort or similar vessel to a point well away from the island, to protect it from attack by friendly forces. Although estimates vary slightly, there were about 1,635 patrols conducted during the war, with each patrol varying from 35 to 65 days and the average length being 50 days. The patrol was generally divided into three periods: the transit out to the patrol area(s), the patrol proper, and the transit home. The transit time across the vastness of the Pacific to the patrol areas was lengthy, sometimes taking 50 percent or more of the patrol cycle. A solution for this long transit period was sought and late in the war the time was shortened successfully by using advanced bases such as Guam.

Wielding the weapon

At the beginning of the war the Submarine Force suffered from four serious problems. First, the Mark 14 torpedo with the Mark 5 and Mark 6 exploders didn't work as was intended. If there was a single problem it could readily be identified and fixed. However, there were three simultaneous problems with the weapon and these manifested themselves simply in the torpedo either missing its target or not exploding. The next problem affecting the performance of the submarine force was perceived by many as the lack of aggressiveness of the individual submarine commanders. Adding to this problem was the inexperience of the captains in tactics, ship handling, the effects of long

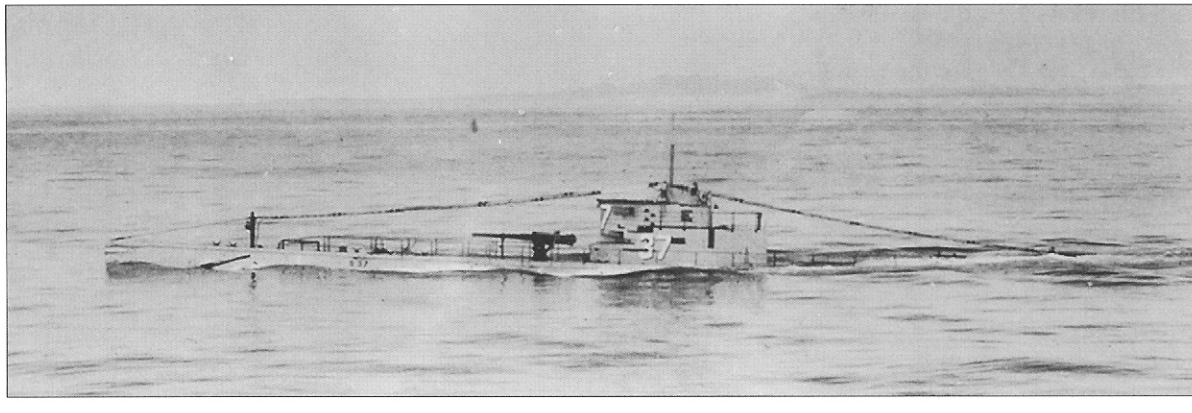


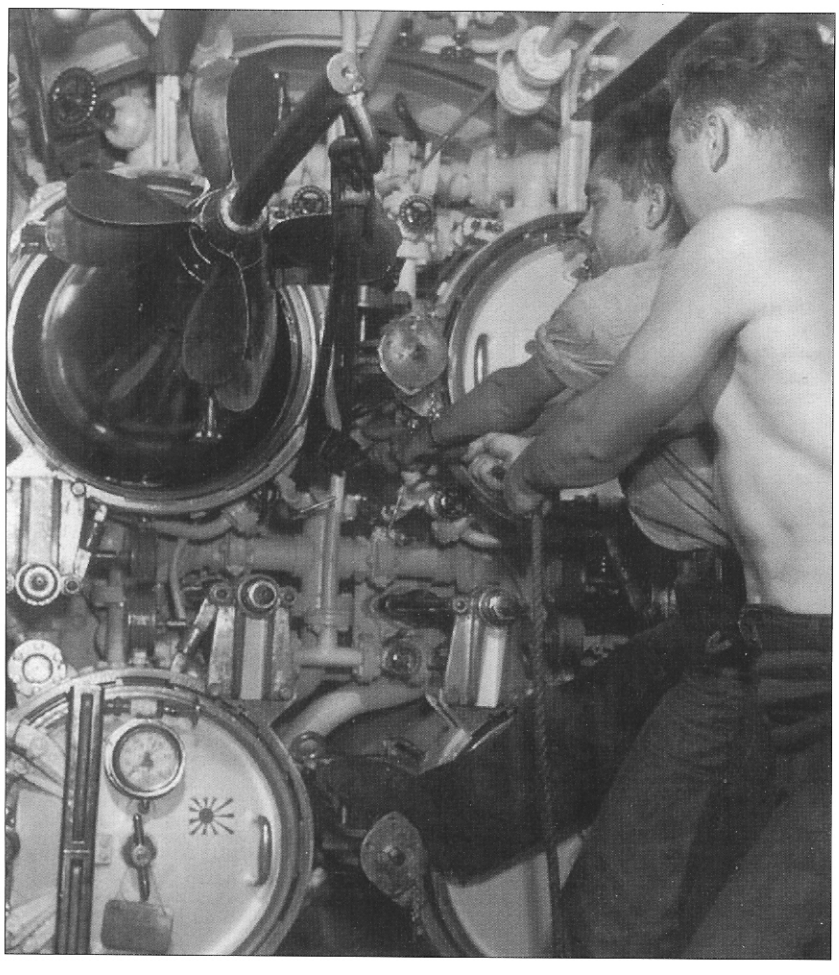
The engine room on the *Torsk* shows one of the Fairbanks Morse diesel generators. The cone-shaped device to the left of the watertight door is a centrifugal fuel oil purifier. Diesel oil was taken from the tanks outside the hull, run through the purifier and discharged to a clean fuel oil tank in the lower level of the engine room. This process helped ensure the reliability of the diesel generators and thus the submarine as a whole. (Author's photograph)

patrols under arduous conditions, and the condition of the submarines they had to work with. Few boats were equipped properly for operations in tropical waters. Many had engine design defects that eventually required wholesale replacement of one engine type, and the ability to work the torpedo fire-control problem was proving more difficult than first thought.

The third serious problem that plagued the force was the lack of a comprehensive strategy for conducting the submarine war in the Pacific. During much of the early war the force was used reactively and defensively, trying to intercept convoys and task forces in a manner that wasted much valuable patrol time. The area commander – Commander Submarines Pacific (ComSubPac) or Commander Submarines South West Pacific (ComSubSoWesPac) – was in receipt of intelligence from code breakers who were reading much of the Japanese naval code. The code breakers supplied the area commanders with information on movements of the Japanese naval and merchant shipping. These messages and this intelligence, generally called ULTRA (after the level of classification), were used to move submarines to areas where they might find targets. This movement had a down side. The communication to and, in the early days,

Traveling in a trimmed-down crash-dive condition, the *S-37* displays her prewar pendant number and a 4in/50 deck gun. (US Navy)





Torpedomen in *S-38* load a Mark 10 torpedo into Number 2 torpedo tube. All torpedo handling was manual with block and tackle. The flag painted on the lower port tube (Number 4 tube) marks that tube as the one from which the torpedo was fired that sank the *Hayo Maru* in Lingayen Gulf. (US Navy)

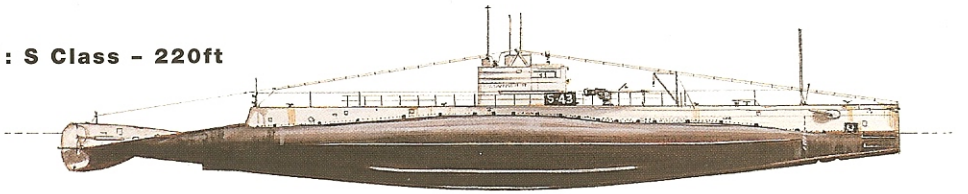
from the submarines gave the Japanese direction-finding information on the location of the submarines. In addition, the constant movement of the submarines wasted valuable time through their transiting from one location to another looking for "possible" targets.

The final and perhaps the most telling problem was the unfortunate choice of leaders early in the war. In a time when cooperation and a team effort were vital, there were clashes between force commanders that slowed the identification and correction of the torpedo problem and the strategy problem.

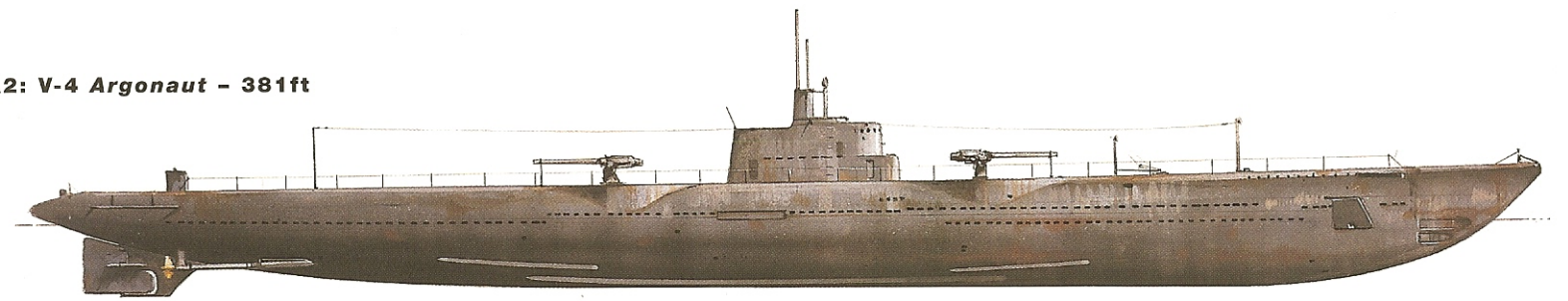
The situation was corrected somewhat when Admiral Charles Lockwood was placed in command of the submarine force at Pearl Harbor and started to be given a quota of the new boats being built. His view of submarine strategy was focused on conducting long-range offensive patrols in Japanese home waters to slow the importation of raw materials. In addition, instead of having his submarines chase Japanese merchant and warship convoys all over the place, he would station boats at "choke points:" places where convoys would have to transit to and from the home waters. The instructions would be to patrol these points and sink whatever came through. Lockwood and Admiral Nimitz were in agreement that the submarine force should be used in an aggressive and offensive manner.

A: Submarine evolution

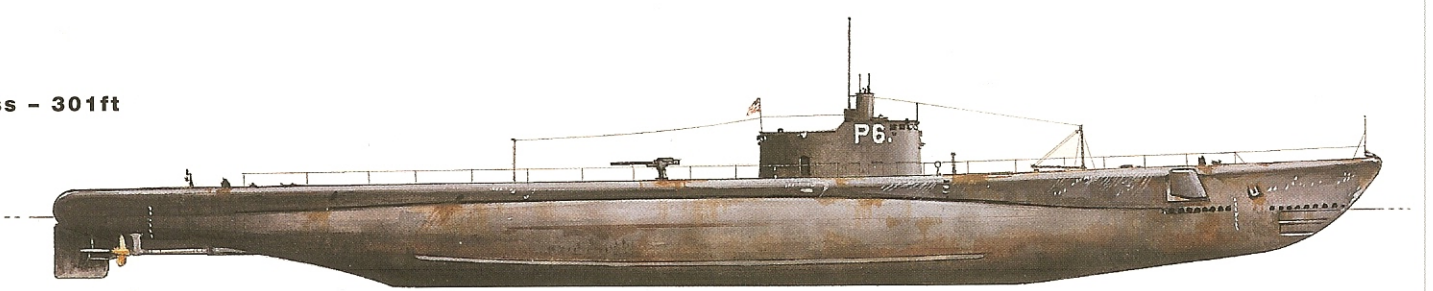
A1: S Class – 220ft



A2: V-4 *Argonaut* – 381ft



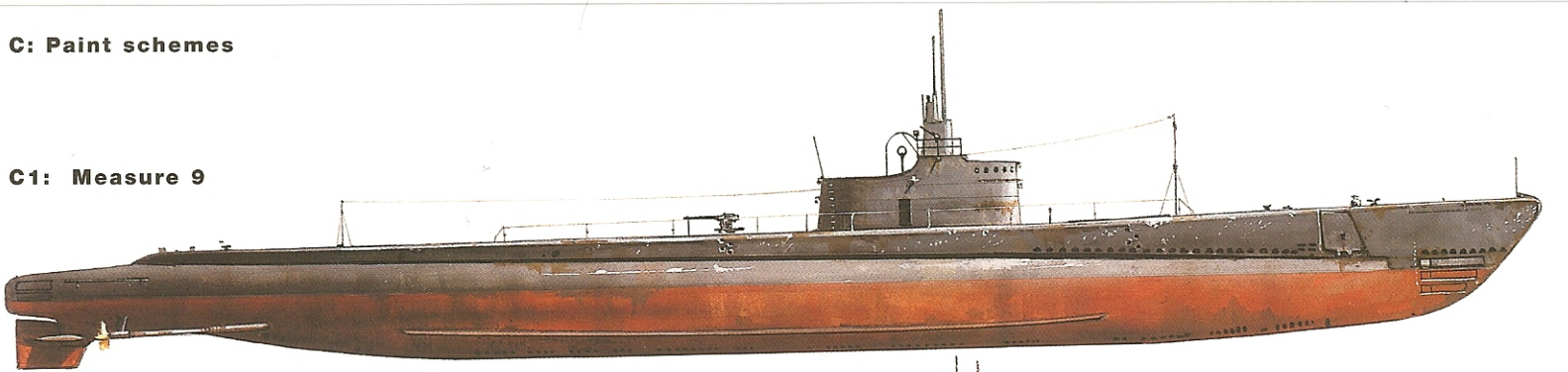
A3: Perch Class – 301ft



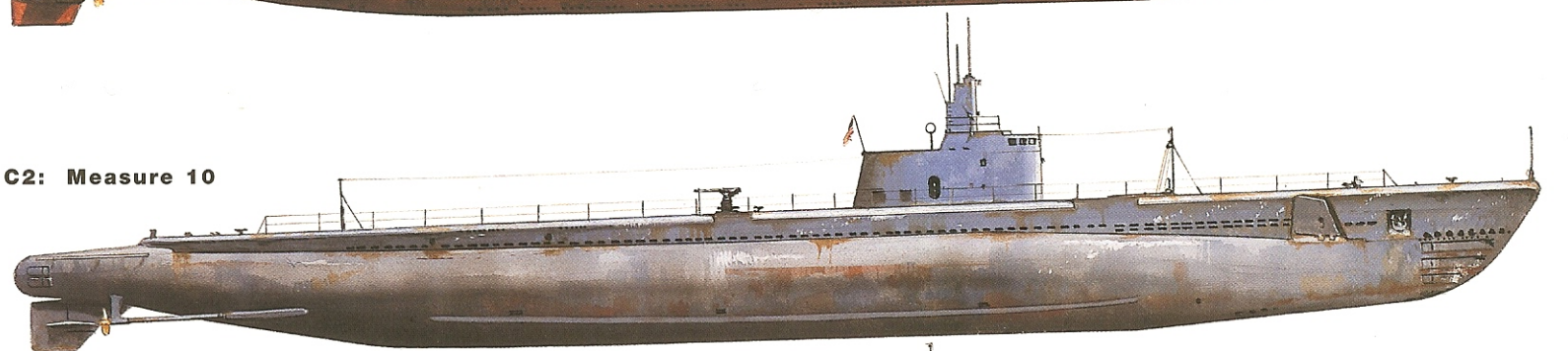
B: USS *Tang*

C: Paint schemes

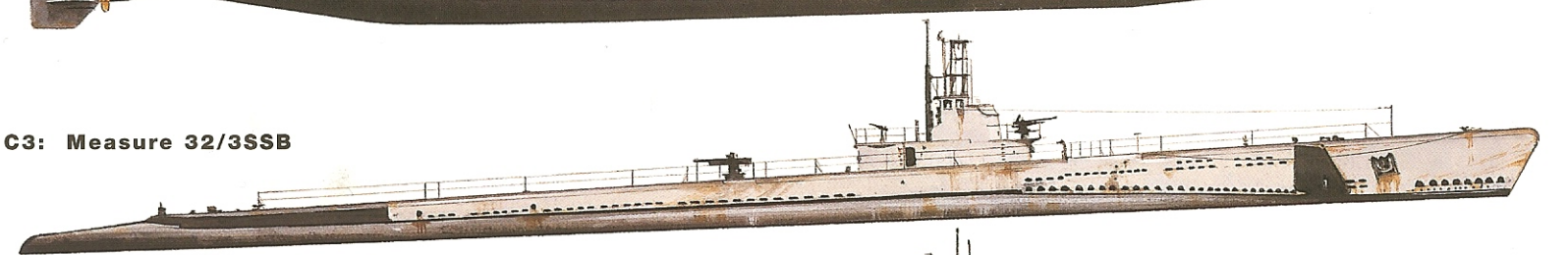
C1: Measure 9



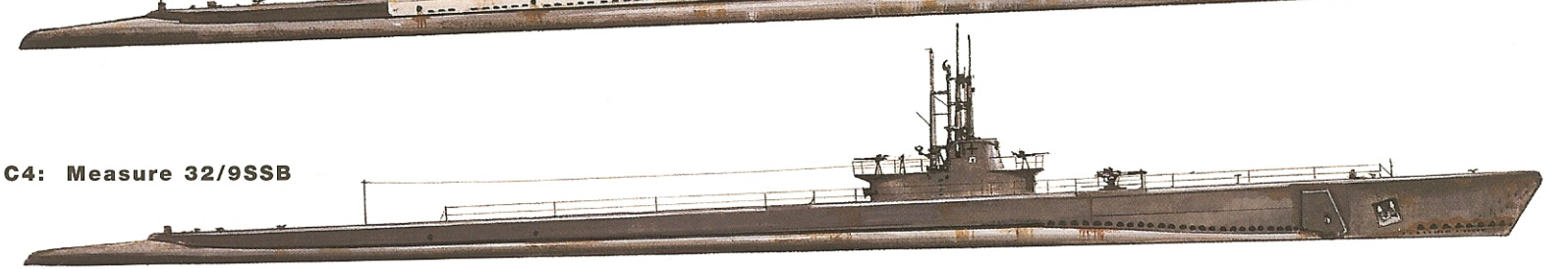
C2: Measure 10



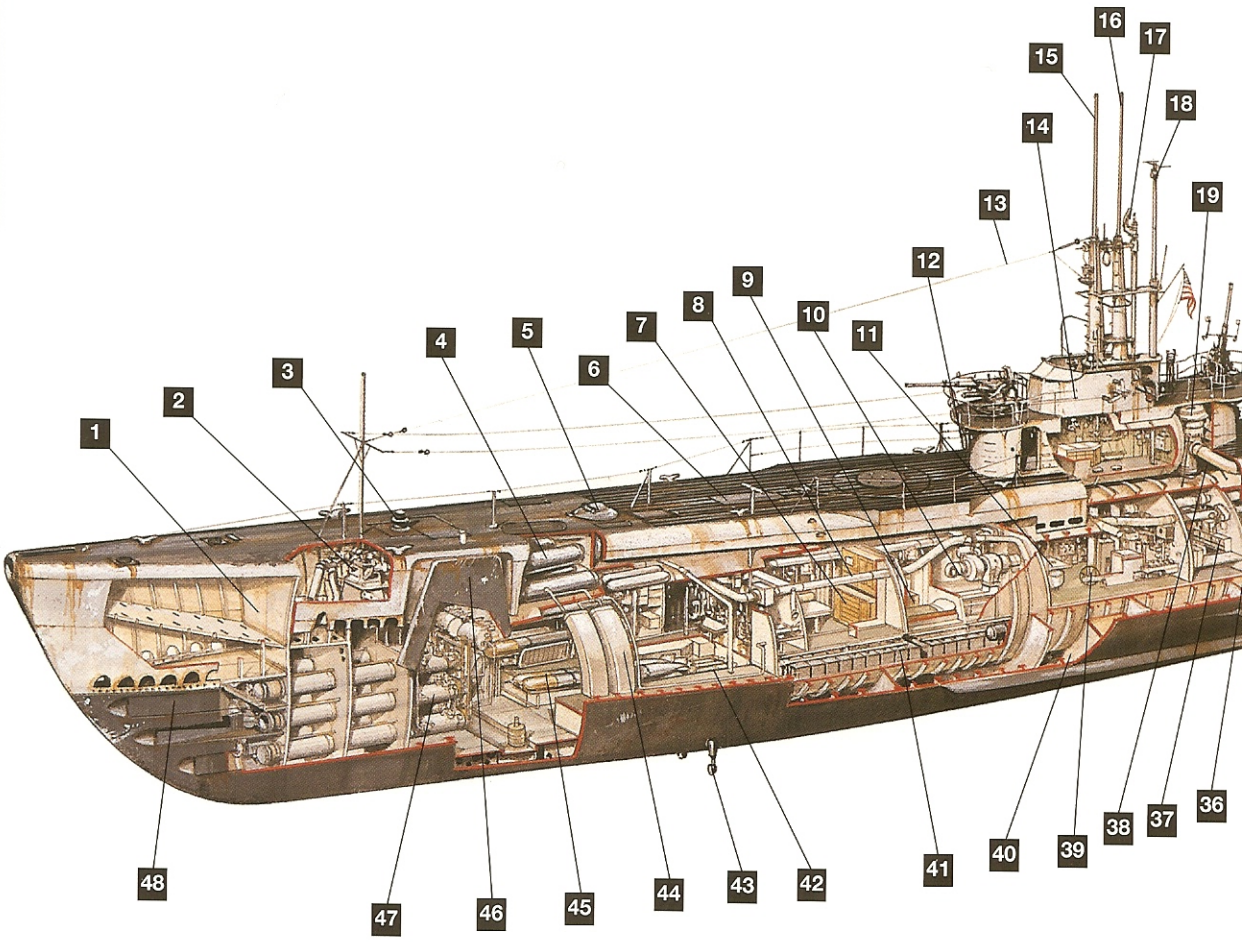
C3: Measure 32/3SSB



C4: Measure 32/9SSB

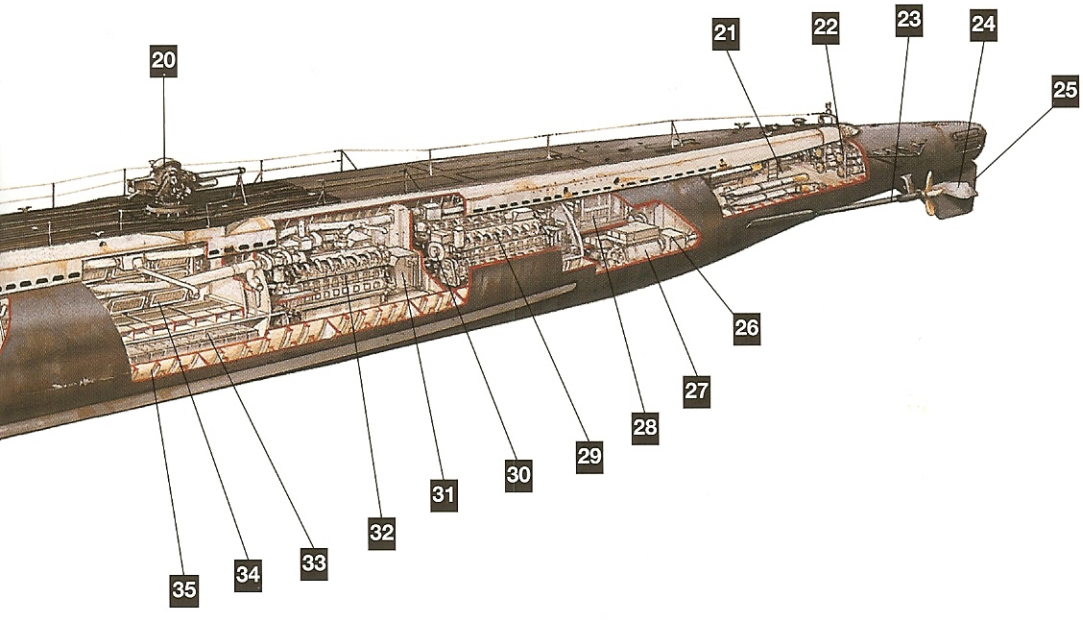


D: BALAO CLASS SUBMARINE

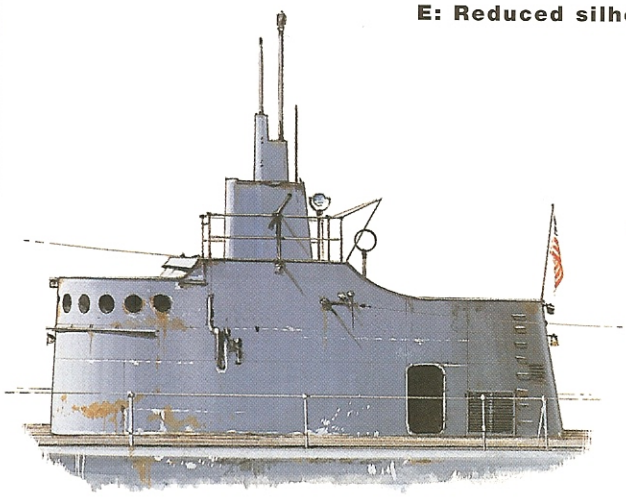


KEY

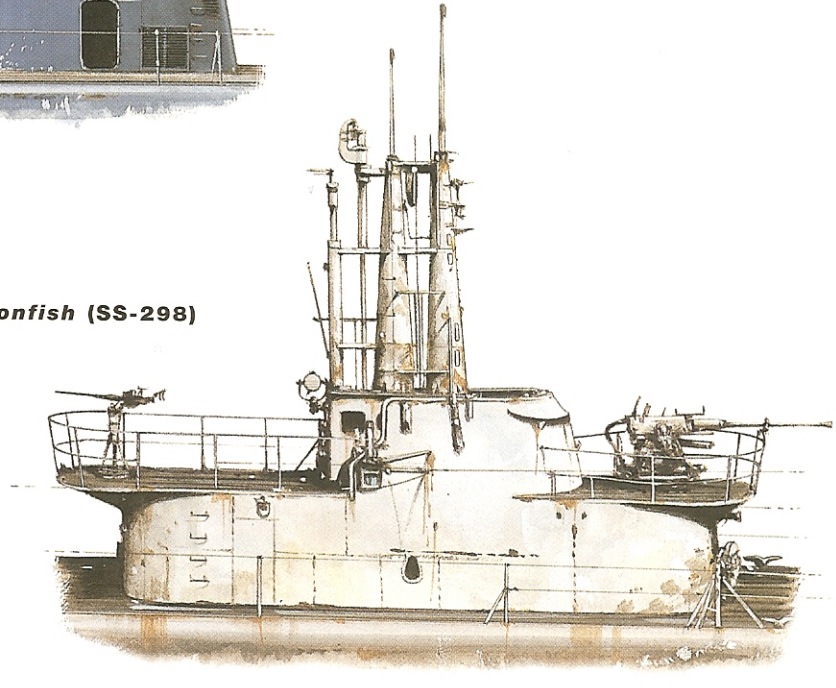
1 Bow buoyancy tank, used to give initial positive lift to the bow when surfacing
2 Windlass
3 Capstan
4 Torpedo impulse flasks
5 Forward escape hatch
6 Torpedo loading hatch
7 Wardroom, in the forward battery compartment
8 Ventilation exhaust main
9 Wardroom stateroom no. 2
10 Forward battery blowers
11 Steering stand
12 Forward ammo ready locker
13 Antenna
14 Conning tower
15 Periscope no. 1
16 Periscope no. 2
17 SJ radar mast
18 Radar SD antennas
19 Engine induction and ship's supply outboard valve
20 Deck armament (varies)
21 Stowage for four torpedoes
22 Aft torpedo tubes (four)
23 Propeller shaft
24 Stern plane
25 Rudder
26 Port reduction gear
27 Port main motor
28 Main propulsion controls
29 Main diesel engine no. 4
30 Auxiliary generator
31 Main generator
32 Main diesel engine no. 2
33 After battery space
34 Crew's mess
35 Fuel ballast tanks
36 Galley
37 Radio room
38 Engine air induction lines
39 Diving station
40 Negative tank
41 Forward battery space
42 Main ballast tanks
43 Underwater sound equipment
44 Emergency fresh water
45 Forward torpedo room
46 Bow plane
47 Torpedo tubes (six)
48 Torpedo tube shutters



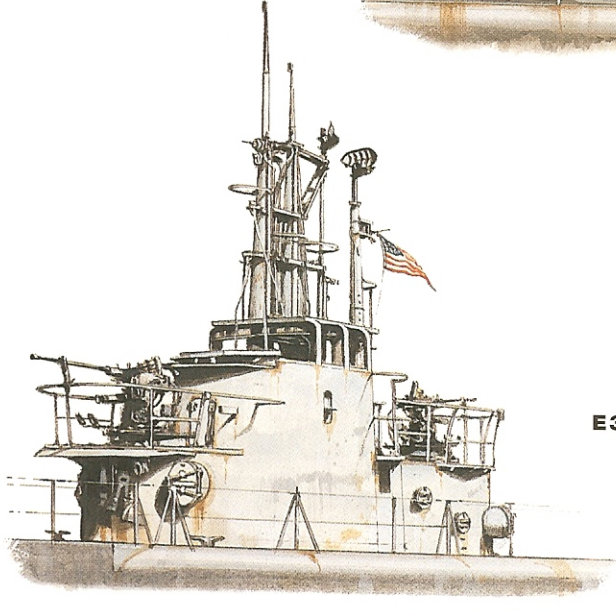
E: Reduced silhouettes



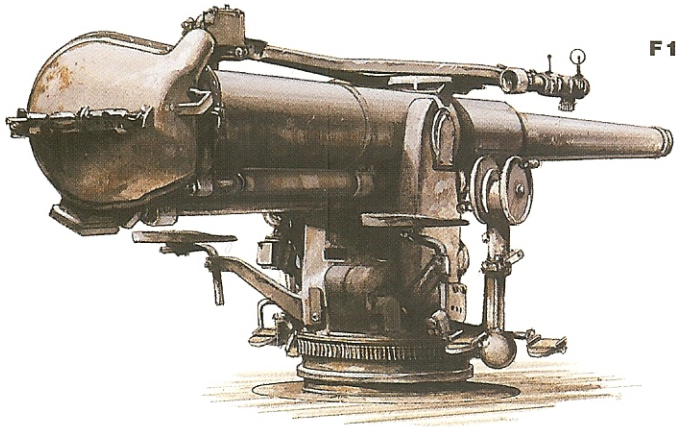
E1: Tambor Class USS *Trout* (SS-202)



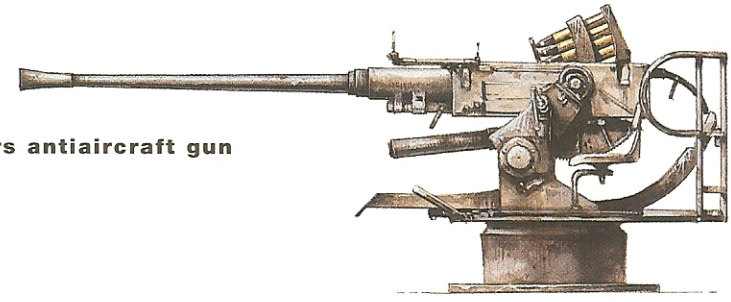
E2: Balao Class USS *Lionfish* (SS-298)



E3: Gato Class USS *Flasher* (SS-249)

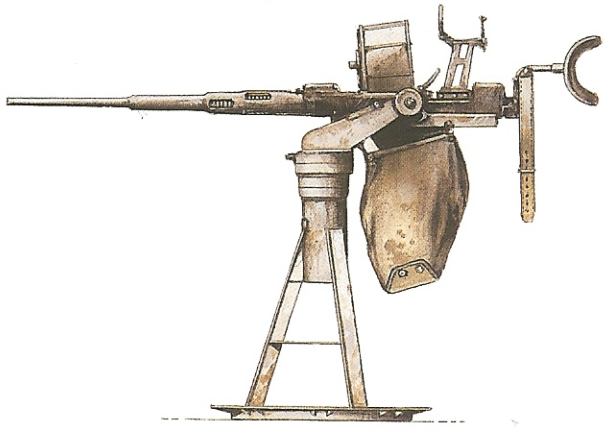


F1: 4in/50 Mk 12a deck gun



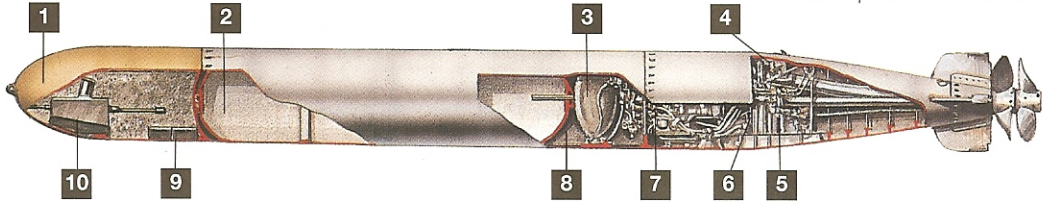
F2: 40mm Bofors antiaircraft gun

F3: 20mm Oerlikon machine gun



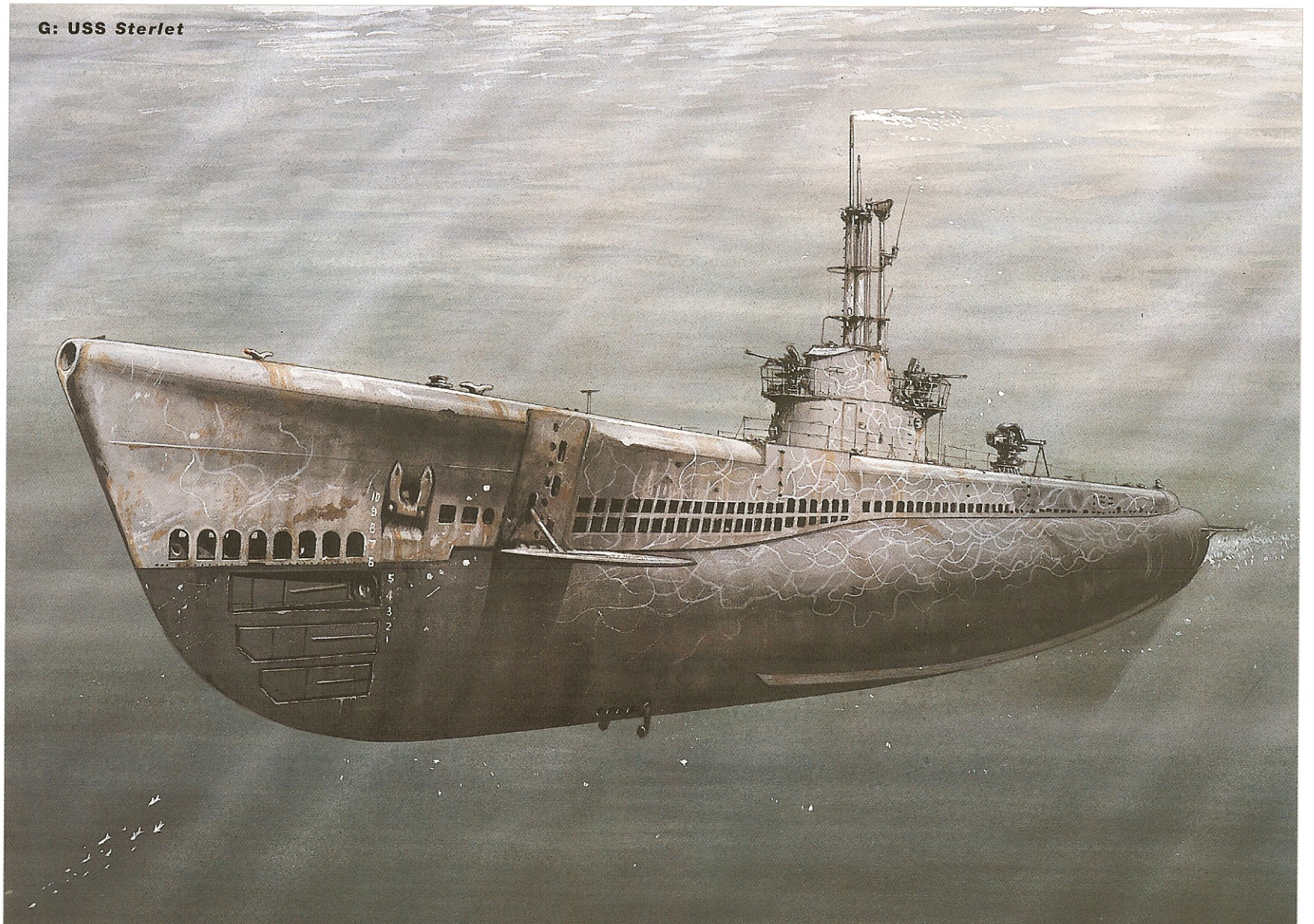
KEY

1 Warhead
2 Air flask
3 Fuel flask
4 Starting gear
5 Gyro mechanism
6 Depth mechanism
7 Main engine
8 Water compartment
9 Ballast
10 Exploder mechanism



F4: Mark 14 torpedo

G: USS *Sterlet*



FORCE STRENGTH BY YEAR

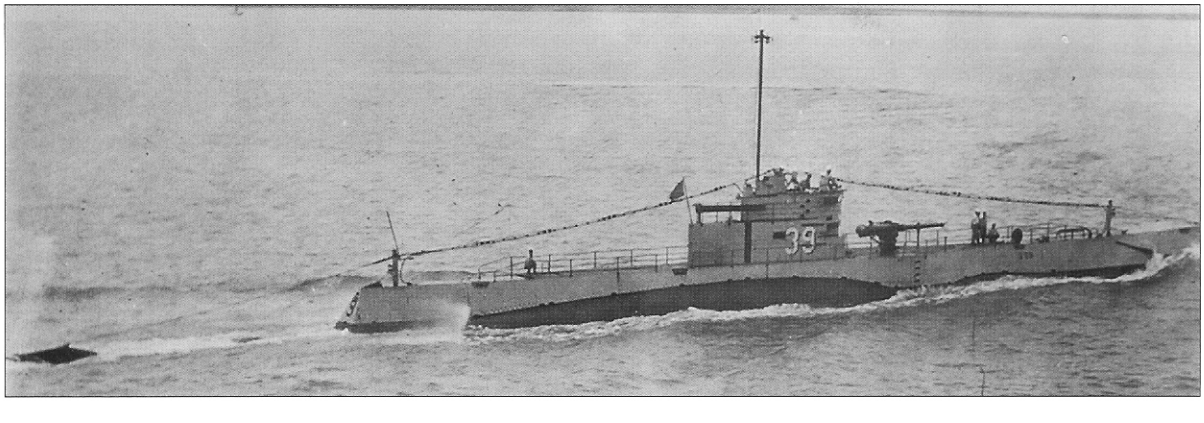
Number of boats available by year

Class	1941	1942	1943	1944	1945	War's End	Patrols
O	8	7	7	7	7	5	0
R	17	16	14	13	13	11	3
S	37	37	28	26	23	0	189
Barracuda	3	3	3	3	3	0	20
Argonaut	1	1	1	0	0	0	3
Narwhal	2	2	2	2	2	2	31
Perch	6	6	5	3	3	0	53
Salmon	6	6	6	6	6	5	71
Sargo	10	9	9	8	7	6	109
Tambor	6	6	6	5	4	4	70
Gar	0	6	6	4	1	1	57
Gato	1	13	37	65	59	54	587
Balao	0	0	0	25	89	105	423
Tench	0	0	0	0	10	15	19
Total Patrols							**1,635**
Force Strength	97	112	124	167	227	208	

Finally in late 1943, nearly two years after the start of the war, the problems with the torpedoes were identified and corrected. The Gato and Balao Class submarines were making their appearance in sufficient numbers to relieve the older boats that had seen the brunt of the fighting. Also by this point the majority of the non-aggressive commanders had been replaced. The ability of the captains to use the available equipment and the men under their command to form an effective information management team started to solve the difficulties of the torpedo fire control. The submarine force strengthened its stranglehold on the Japanese empire.

Tactics

The World War II fleet submarine normally patrolled on the surface in its area because this allowed the lookouts, periscope, and radar to be higher, and this increased the distance at which a target could be detected. The situation would change depending on the weather (visibility),



***S-39* underway with the prewar gray and black livery. The object astern is the upper portion of the rudder. *S-39* was lost when she ran aground on Rossel Island off the Louisande Archipelago on August 1, 1942. All hands were rescued. (US Navy)**

probability of enemy aircraft patrolling the area, and time of day (boats normally ran submerged at early light and dusk). An attack started with initial sighting of a target. This might have been a masthead on the horizon, a smoke smudge, or radar contact. When the contact was made, the crew, always ready for an attack, would start the offensive procedure.

The captain, notified of the contact and aware of the overall tactical situation, would decide whether to prosecute the attack, report the contact by radio to other submarines and headquarters, or take some other action as he had been directed by headquarters. If he elected to attack the contact, he would put into motion the elements of his attack plan. This attack plan evolved over the course of the war as the lessons learned about successful and unsuccessful attacks were analyzed.

One of the basic skills that a captain had to have if he were to use his ship effectively was that of ship handling. He needed to know his ship's characteristics and the dynamics of how it was driven, including such things as tactical radius (how far the boat moved forward and to the side given a rudder order at various speeds) and how far it could travel submerged and surfaced at various speeds in different sea states. These elements had to be known by the captain and every officer tasked with piloting the boat to an extent that it became force of habit. There was no time in a tactical situation to sit down with pencil and paper and calculate how the attack was developing. For example, if a contact with a masthead height of 60ft was sighted while the submarine was submerged and the closing speed between the submarine and the target was 12 knots, that contact could be within firing range in nine minutes.

The only proven way for this skill level to be achieved was through practice and extensive sea time – time spent on the bridge in all weathers, in all traffic conditions, time making surface approaches, submerged approaches, time perfecting the ship's tactical team and the captain's management of that team. In the prewar period, that sea time was not available. The Depression and sparse budgets meant submarines spent a great deal of time alongside a pier, and when they did make approaches it was normally during carefully scripted fleet exercises. The skill level required for effective use of the submarine was not being achieved. However, as the war progressed this shortcoming was overcome.

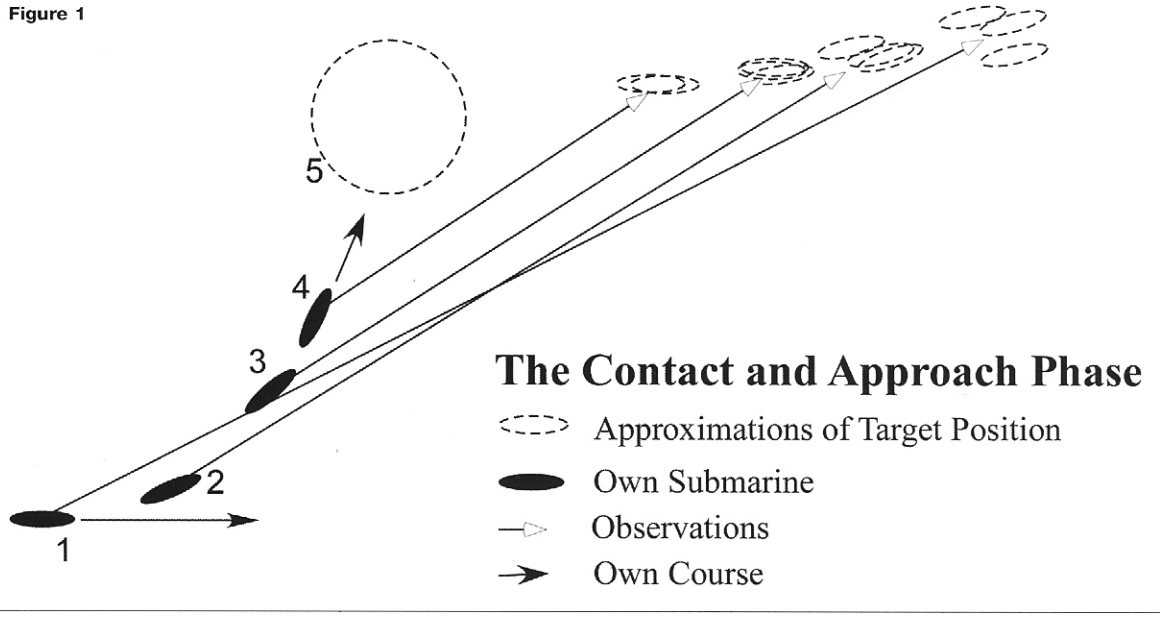
The contact phase

On sighting the contact, the captain would turn the boat directly at the contact and maintain that course, watching the contact for movement to the right or left. He would immediately assemble his tactical team, called the fire control party. This was a set group of officers and enlisted men with specific duties. The captain was the approach officer. He was responsible for the success of the attack and his primary duty was tactical ship handling.

The ship's executive officer (or Number One in Royal Navy terms) functioned as the assistant approach officer. He was responsible, among other things, for managing the entire conning tower plotting team and coordinating the flow of information to the captain.

Figure 1
Contact and approach
1 First contact: course, range, and speed of target unknown.

Figure 1



2 Sub turns toward target to start estimation of course, range, and speed.
3 Estimations of course, range, and speed of target become more accurate. Sub turns toward attack position.
4 Sub adjusts speed and course to arrive at optimum firing position. The target's speed and range become clearer by continued observations and correction of the variables in the relative motion problem.
5 Optimum firing area. Target at closest point of approach and submarine facing the target.

Figure 2

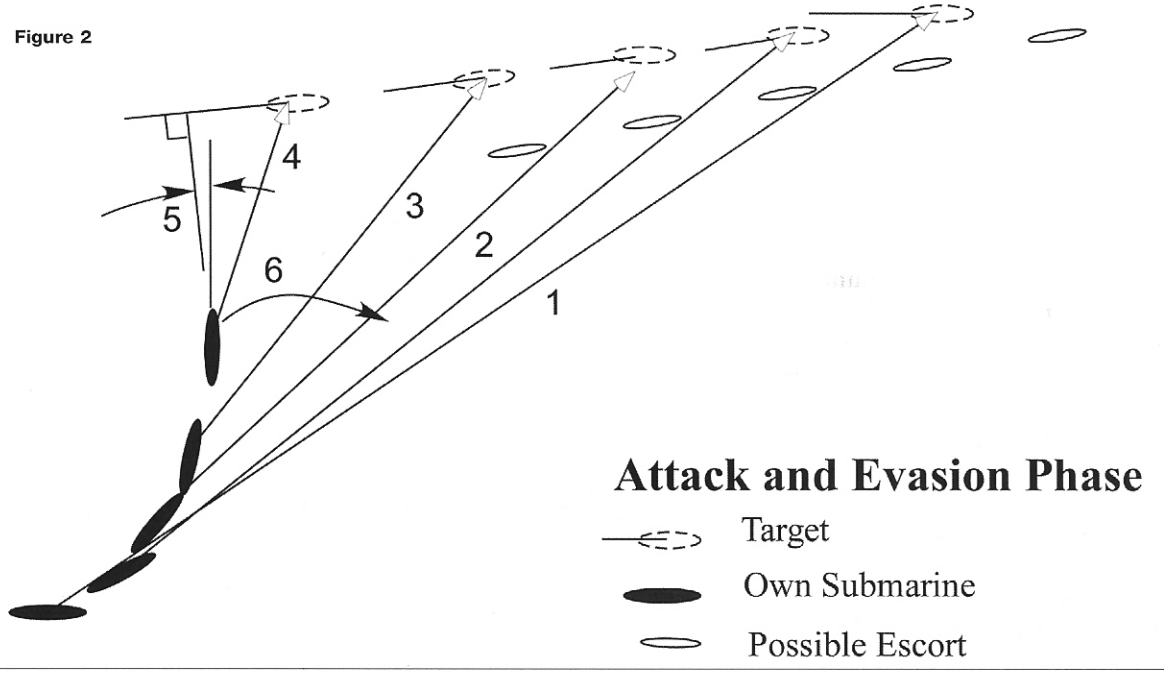


Figure 2

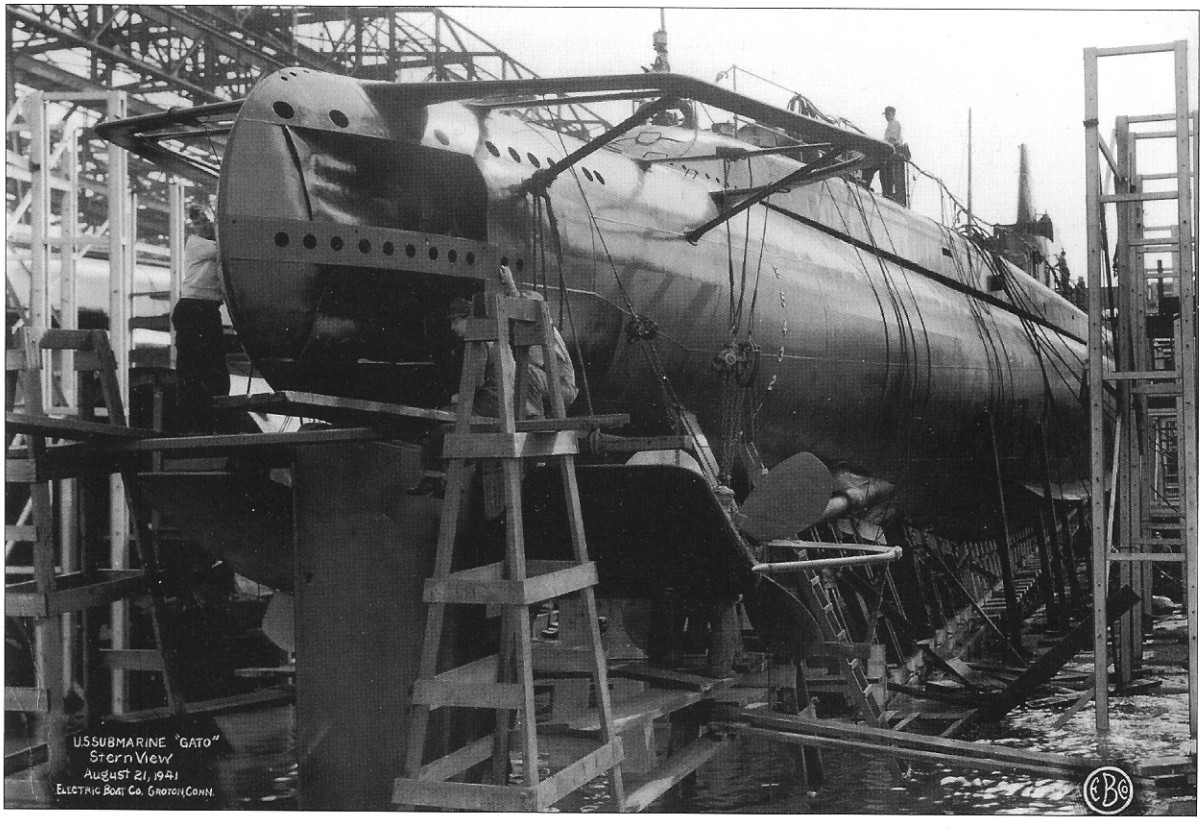
Attack and evasion phase

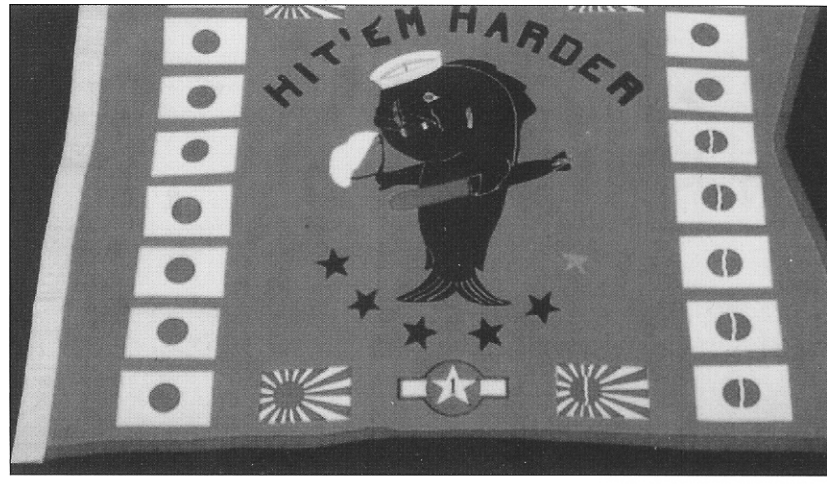
1 Target speed and range estimates nearly accurate. Watching for target zigs (course changes).
2 Observation indicates that a solution has been made.
3 Further observation verifies solution.
4 Firing position, lead angle, and spread calculated. Torpedoes fired.
5 Torpedo gyro angle. Right-hand line as torpedo leaves tube; left-hand line is torpedo track.
6 One possible evasion track. Highly dependent on many variables such as weather, acoustic conditions, and possible escort action.

The approach phase

The main objectives of the approach phase were to maneuver the ship with course and speed to close with the target without detection by escorts, and to obtain a firing position and a fire-control solution. The course and speed were selected to "collide" with an area whose radius was the torpedo run and was centered at the target. By this phase the ship should have been at full battle stations and rigged for a silent running condition, the level of which depended on ambient acoustic conditions and if the target was escorted by antiship warfare (ASW) vessels. For torpedo fire control, an officer had to know the speed and course of his own sub, the speed and course of the target ship, the speed and course of the torpedo, and the range from the sub to the target. The submarine's course was given by the gyrocompass and its speed was

The stern of the *Gato*. Typical of the remainder of the class and of the two subsequent classes, Balao and Tench, two of the four torpedo tube muzzles are seen here. The structure above and forward of the tubes is the starboard screw guard. It prevented the stern from bumping against something that would damage the screw, seen below. Forward of the wooden tapered structure was the starboard stern plane. Between it and the port plane was the rudder. (US Navy)



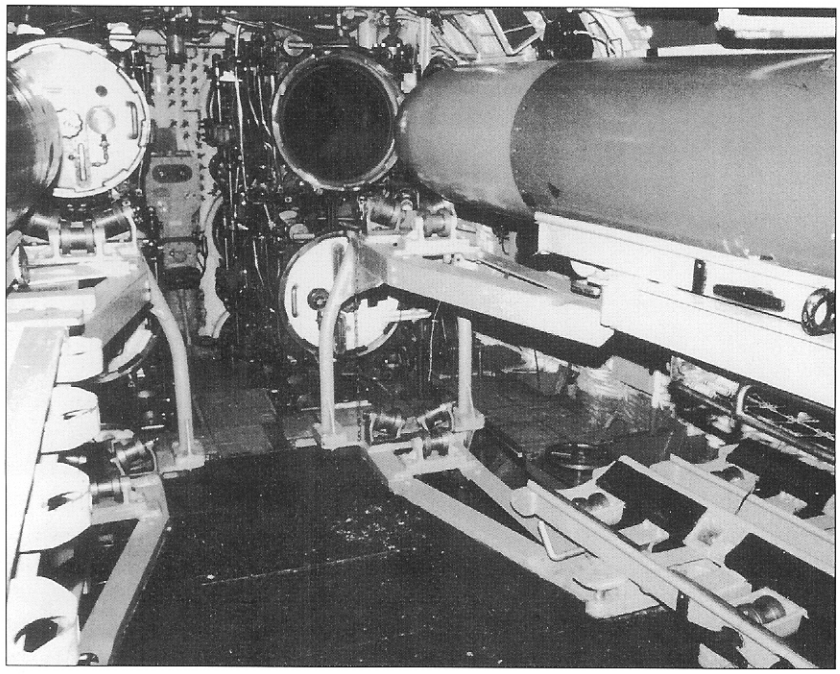


***Harder*'s battle flag. Most, if not all, the boats made informal battle flags that reflected their war record. The white rectangles with red circles indicate merchantmen sunk; the naval ensign indicates warships sunk. Broken red circles indicate ships damaged. The stars are the patrols and the Air Force symbol with the number one signifies the numbers of airmen rescued. (US Navy)**

provided by the electromagnetic pit log. The torpedo's speed was a given and its initial course was directed by the sub's course (and whether the torpedo tube was forward or aft facing). This left only the target's course, speed, and range to be determined. Range was estimated by stadimeter (an optical range finder built into the periscope optics), by telemeter (which utilized the known optical field of view and installed marks in the optics and knowledge of the length of the target vessel and/or its masthead height), or directly by ST radar built into the observation periscope. Range was the most difficult measurement to make accurately without radar and the greater the range, the more likely the error. Thus for good firing solutions, ranges of less than 2,000yds were desired. The target ship's course could be estimated by observing the angle on the bow, which was the observed angle of the target ship relative to the observer (this took vast amounts of practice). A target's speed could be estimated by passive sonar, using blade rate count, or estimated by a skilled observer using bow wave, stern wake, and other clues. The mathematics of this observe, estimate, compensate, and predict method could be maintained by the torpedo data computer. The TDC maintained the relative position picture and allowed for input of the estimated speed and range of the target. It would calculate a predicted bearing from the submarine to the target and when the predicted bearing and actual bearings matched it could be assumed that errors in target range, speed, and course were minimized.

The attack phase

It was the objective during the attack phase to place the submarine in the optimum firing position. This meant a bow-on attitude to the target with a range of 600 to 1,200yds. The attack phase might have involved the penetration of an escort screen. The entire focus of the submarine was then on reaching the firing point, keeping track of the escorts, and making the tubes ready. At the end of this maneuver the function of the fire control party was to reach a decision that the range, speed, and course of the target were correctly identified and that an optimum firing solution had been reached. The minimum torpedo gyro angle was desired because range errors were amplified by increasing gyro angles. Thus it was best practice to have the submarine pointed directly at the



The after torpedo room compared with the photo of the forward torpedo room shows the narrowing of the submarine's afterbody. The torpedoes on the right and left are Mark 14s. The breech door of Number 8 tube is open ready to receive the torpedo, which would be loaded by attaching block and tackle to the aft end of the torpedo and sliding it into the tube. (US Navy)

target and within 1,000yds of the target as the target neared the closest point of approach. Once the firing point had been reached, the torpedoes were fired. If a spread was to be fired, the first aiming point would be at the middle of the target, the second at the stern, and the third at the bow.

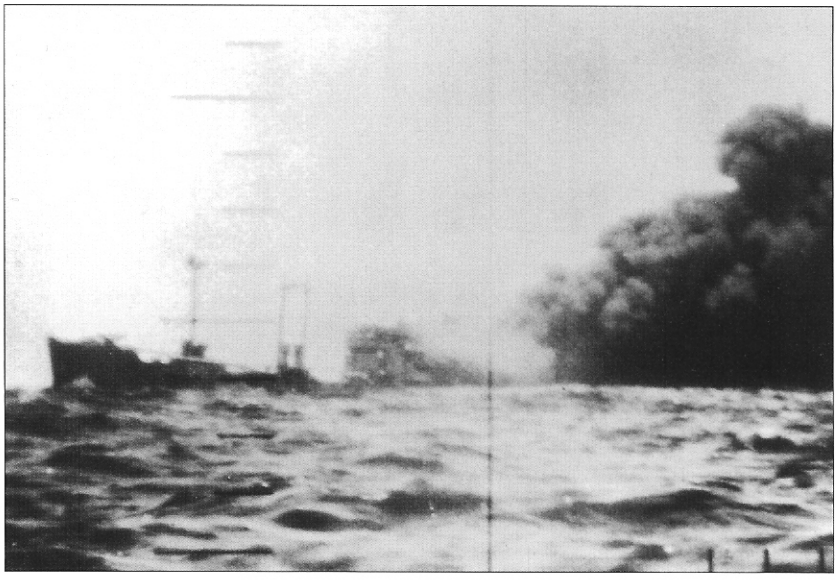
The evasion phase

The goal of this phase was to evade post-attack enemy responses in either an offensive or a defensive manner and maximize the chances to "fight another day." Offensive measures meant sinking the attacking escort, often the only response for a submarine to ensure its own survival. Defensive actions involved diving deep immediately, making speeds below the cavitation[1] threshold, keeping the escort on the bow or quarter with a small aspect, and taking advantage of silence and layers (thermocline).

OPERATIONAL HISTORY

December 8, 1941 found the United States with no operational battleships in the Pacific Ocean and only three modern aircraft carriers. Three days later, with the loss of the British warships HMS *Repulse* and HMS *Prince of Wales*, the Allies had no capital ships in the Pacific at all. However, the US Navy had 50 submarines. Of these, seven were in various stages of overhaul and not immediately available. Four boats were on patrol, two near Midway, and two near Wake. Stationed in Manila Bay in the Philippines were 29 boats. The remainder were at Pearl Harbor (four

1 Cavitation is the formation of bubbles on the propeller surface and edges. These bubbles occur because of the sudden low-pressure areas that form around a propeller blade at a high speed. When the bubbles collapse they cause noise that is detectable to enemy sonar.



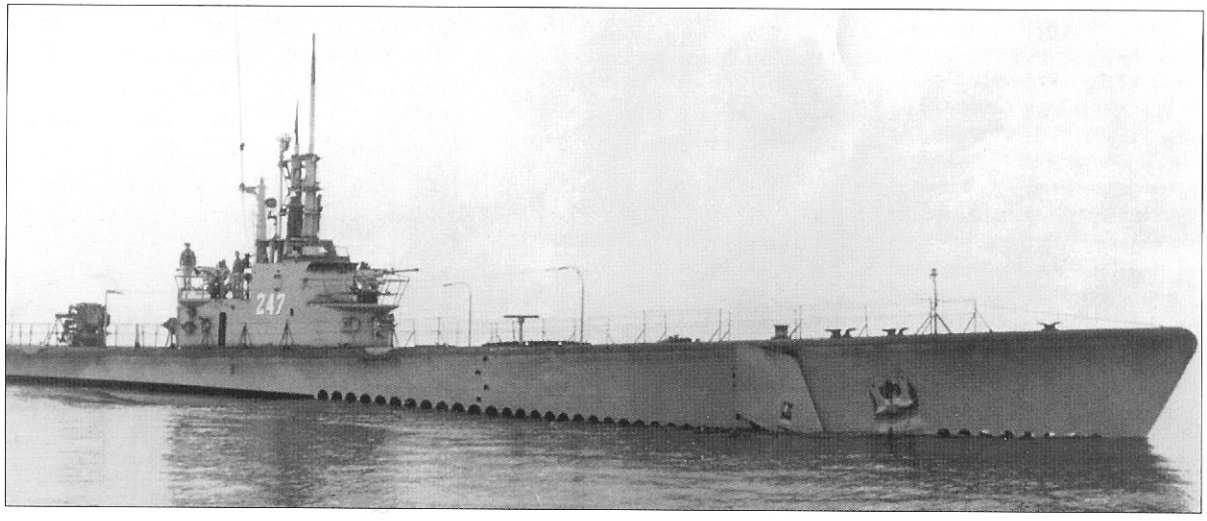
A burning and sinking cargo ship. Very seldom were photographs taken of targets. In this photo, the evidence of destruction seems clear; the ship is seemingly hull down on the verge of going under and clearly on fire. (US Navy)

at the submarine base and five at the Pearl Harbor Naval Shipyard) or coming from training patrols, from the West Coast. The view the Japanese held of the American submarines was voiced by Foreign Minister Baron Kijuro Shiderhara: "The number of submarines possessed by the United States is no concern to the Japanese inasmuch as Japan can never be attacked by American submarines." He was incorrect.

The order from the Chief of Naval Operations, Admiral E.J. King, to these submarines was simple. "Conduct unrestricted submarine warfare on the Empire of Japan." On December 11 the *Gudgeon* left on its first war patrol. Provisioned for a patrol of over 45 days, she headed for the strait between Shikoku and Kyushu (Bungo Strait). This patrol was a harbinger of things to come. Single submarines with independent, aggressive skippers in command could transit the Pacific to bring the war to the Japanese home waters and start to tighten a noose around the neck of the empire.

Twenty-nine of the submarines were stationed in the Philippines at Cavite, the naval base near Manila. Of these, six were S Class boats designed prior to WWI. The S Class, as a group, were slowly being replaced by newer boats as they became available. The remainder were a combination of the boat classes designed and built in the mid- to late 1930s and were the most modern boats available. Several were on patrol in areas close to the Philippines on December 7, but when word of the attack at Pearl Harbor burst on the fleet, ten of the boats that were ready to get underway immediately or were already on patrol headed for areas around Indo-China and the shipping lanes most frequently used by the Japanese. The boats were armed and given the order from the commander of submarines in the United States Asiatic Fleet, "You will sink or destroy enemy shipping whenever encountered" – of course this mission was not made easier by their malfunctioning torpedoes.

The submarines formed the only offensive naval weapon possessed by the Allies in the Pacific at the time and their captains took the fight directly to the enemy. Through 1942 and early to mid-1943 the submarines in Manila were forced to retreat to what were then makeshift bases in



A post-war photo of the *Dace* (SS-247) showing her in a Measure 32/3SSB paint scheme. Her horizontal surfaces are black and verticals are light gray. The deck gun mounted aft is a 5in/25. (US Navy)

Australia. They were, however, deployed without a comprehensive strategic plan on patrols, so instead of being proactive they were responding to what the Japanese were doing. As the war continued, lessons learned took hold and the limited sinkings of the early days were transformed into impressive results. Toward the end of 1943, US submarines were sinking warships and merchants faster than the Japanese could replace them. Most actions were meetings with small convoys or single ships, followed by a setup, and attack. However, the tallies from these small combats started to add up.

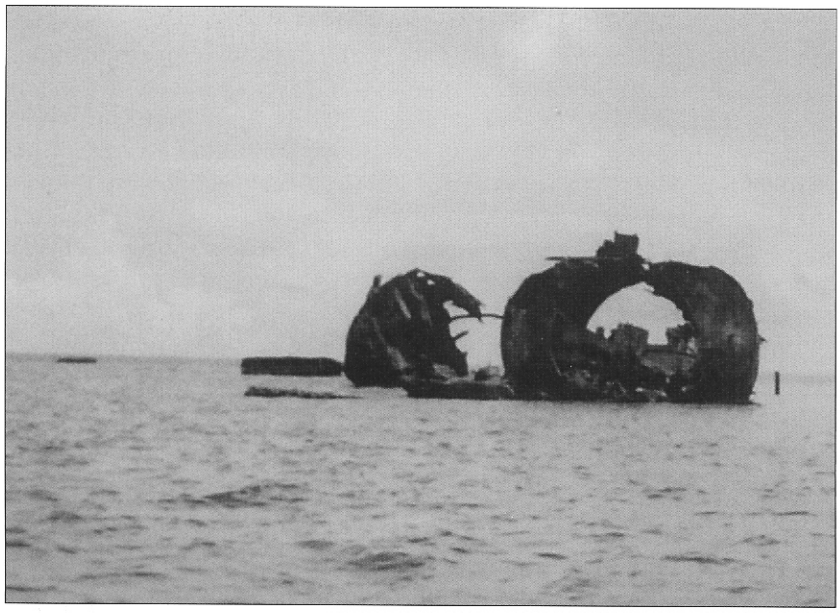
April 1944 saw a change in US submarine targeting priorities. It became "open season" on the bane of the submarine – the destroyer. One of the skippers that took full advantage of this change was Commander Sam Dealy, skipper of the "hit 'em again" USS *Harder*. *Harder* killed its first destroyer on April 13, 1944 when it sank the IJN *Ikazuchi*. Then, while transiting to pick up some British agents on Borneo, Dealy came in contact with a convoy of tankers escorted by two or three destroyers. He was making an end-around approach when he was spotted by one of the escorts, which immediately made an attack. Instead of breaking off the approach and evading the destroyer, *Harder* killed the attacking ship with a spread of three torpedoes, two of which hit. By then the convoy was out of reach. Dealy continued his transit of Sibutu Passage the next day. Driven to submerge by an aircraft sighting, he rose to periscope depth and raised a scope carefully. In his image was an approaching destroyer at 4,000yds and closing fast. At 650yds range Dealy fired three torpedoes directly down the throat of the advancing warship. The IJN *Hayami* was destroyed. A patrol vessel closed the position of the evading *Harder* and dropped depth charges. Six of the *Hayami*'s sisters saw the commotion and moved into the fray. Dealy chose to remain quiet and continue to his rendezvous. After having picked up the agents, he headed out to transit the passage again. Two destroyers were patrolling the passage's north end. Dealy waited, submerged in firing position, and when the two targets overlapped he fired four torpedoes. One passed the closer warship's bow, but two then hit the bow and amidships. The fourth torpedo passed close under the burning destroyer's stern and hit the further ship. Two destroyers in one salvo, three in this patrol, so far.

The following day, *Harder* encountered a large convoy of warships, battleships, cruisers, and escorts. One of the destroyers, probably called by aircraft covering the convoy, started a high-speed attack. *Harder* was headed toward the destroyer and at 1,500yds fired three torpedoes straight at the advancing threat. One or more hit at a likely range of less than 500yds. The destroyer was struck down. After this encounter one of the extracted agents requested he be taken back to where he was picked up, saying that being behind enemy lines seemed safer. Admiral Toyoda reported that his fleet had been discovered in the anchorage at Tawi Tawi by a large force of submarines and had suffered the loss of four destroyers. The large force of submarines was only the *Harder* and the *Redfin*. *Harder* was credited with having sunk three destroyers, and damaged at least two more in four days – a remarkable achievement.

October 1944 saw the *Dace* under the command of Commander B.D. Claggett and *Darter* under Commander D.H. McClintock teamed up in a two-boat "wolfpack" patrolling through the area off Palawan and north of Borneo. They were warned that intelligence had word of a possible transit through the area by a Japanese naval force. Indeed, the force was Kurita's battleships with the giants *Musashi* and *Yamato* in the battle group. Split into two groups, the larger was opposed by the two American submarines. Late on October 21 *Darter* tracked this force but could not close on the high-speed task group, which he correctly guessed was heading for Balabac Strait and the American Leyte landing.

Meanwhile *Dace* attempted but failed to gain a good firing position. *Darter* transmitted continuous position reports about the force while he could. The two submarines met that night on the surface to exchange information when *Darter* reported a radar contact. They took off in pursuit of the second group of ships. *Dace* was assigned to pursue and to attack the right-hand column while *Darter* took the left. McClintock did not want an attack at night because he wanted to see and report the number of enemy ships and the make up of the Japanese force. At dawn he reported that the first four ships in their column were heavy cruisers and the fifth was a battleship. He hit the first cruiser with five torpedoes, and then fired stern tubes at the second. The first cruiser was extensively damaged and started to sink rapidly. *Darter* was so close that the entire length of the burning ship could not be seen in the periscope without turning it. As the cruiser sank, destroyers raced about trying to find the attacker. Twenty-four minutes after the first torpedoes struck, four more explosions sounded. *Dace* had found her first targets. She was positioned ahead of the starboard column, which she had identified as two cruisers and a battleship. Claggett was ready, as was his crew. He had a chance to fire at the cruisers if they stopped maneuvering enough to present a good solution; if not, he could always take on the battlewagon. In his view he had eight heavies and four destroyers. The escorts seemed to be over toward what he assumed was *Darter*'s position.

Dace fired her entire bow salvo at two cruisers that were overlapping the battleship target and scored four hits. *Darter* evaded the destroyers as they changed targets and went after *Dace*. McClintock started a high-speed surfaced end-around to get ahead of the task force again, then just after midnight ran aground on Bombay Shoal at nearly 20 knots and high tide. *Dace* came to periscope depth to look for more targets after being worked over by some destroyers. In McClintock's sights were two



Remains of *Darter*, reportedly in the mid-1980s. The boat's hull had submitted to the ravages of tide and time, the salvage torch, and, according to some reports, practice bomb runs by various navies.

more cruisers and some destroyers milling around. He was maneuvering to get in firing position when a single-word radio message came in from *Darter* – "Aground." According to Captain Harry Caldwell (USN ret.), who was a lieutenant aboard *Dace* at the time, Claggett had a choice to continue an attack and possibly stir up the destroyers even further or to break off and go to the aid of the *Darter* and her now exposed and vulnerable crew. Caldwell said that Claggett felt there was no choice. *Dace* broke off, maneuvered clear, and headed off to *Darter*'s assistance. *Darter* was indeed aground and had to be abandoned and destroyed. Dace took off the entire crew and left the submarine high aground with all classified papers and equipment destroyed, before returning to port. The US crews left behind two heavy cruisers, *Agato* and *Maya*, sunk, one by each submarine and a third, the *Takao*, so heavily damaged it limped back to Singapore and sat out the remainder of the war. The *Darter*'s crew, a well-honed fighting team, was assigned in its entirety to a new boat, the *Menhaden*, being built at Manitowoc, Wisconsin.

Not only did the US submarine force sink ships, it was also used as a surveillance tool, taking photos of and reporting information on various land areas, as well as putting ashore and extracting coast watchers and agents. In February 1944 submarines were stationed near Truk to perform two tasks: one, to cut off the escape routes of ships that might try to get out from under the Allied air attacks that were soon to rain down; two, stand by in specific areas to rescue downed airmen – to act as lifeguards. The idea for this deployment came originally from Admiral Charles Pownall, who headed up the air attacks on the Gilberts in early 1944. Admiral Charles Lockwood, ComSubPac, took the idea and quickly set up a scheme for controlling the submarines in specific areas so that he could direct them toward the locations of downed aviators. One such operation involved the rescue of nine aviators inside Truk lagoon. *Tang*, the submarine assigned to the rescue, couldn't reach the men so a cruiser's float plane landed inside the lagoon to pick them up. With nine men aboard, however, it couldn't take off so it taxied out over

LOSSES

Number of men lost	Name of boat	Date lost
4	USS *Sealion* (SS-195)	December 10, 1941
0	USS *S-36* (SS-141)	January 20, 1942
47	USS *S-26* (SS-131)	January 24, 1942
59	USS *Shark* (SS-174)	February 11, 1942
9	USS *Perch* (SS-176)	March 3, 1942
0	USS *S-27* (SS-132)	March 19, 1942
69	USS *Grunion* (SS-216)	August 1, 1942
0	USS *S-39* (SS-144)	August 14, 1942
105	USS *Argonaut* (SS-166)	January 10, 1943
74	USS *Amberjack* (SS-219)	February 16, 1943
70	USS *Grampus* (SS-207)	March 5, 1943
74	USS *Triton* (SS-201)	March 15, 1943
73	USS *Pickerel* (SS-177)	April 3, 1943
4	USS *Grenadier* (SS-210)	April 22, 1943
42	USS *R-12* (SS-89)	June 12, 1943
77	USS *Runner* (SS-275)	July 1, 1943
71	USS *Pompano* (SS-181)	September 1, 1943
76	USS *Grayling* (SS-209)	September 9, 1943
75	USS *Cisco* (SS-290)	September 28, 1943
55	USS *S-44* (SS-155)	October 7, 1943
81	USS *Wahoo* (SS-238)	October 11, 1943
76	USS *Dorado* (SS-248)	October 12, 1943
82	USS *Corvina* (SS-226)	November 16, 1943
61	USS *Sculpin* (SS-191)	November 19, 1943
78	USS *Capelin* (SS-289)	December 1, 1943
75	USS *Scorpion* (SS-278)	February 1, 1944
77	USS *Grayback* (SS-208)	February 26, 1944
81	USS *Trout* (SS-202)	February 29, 1944
79	USS *Tullibee* (SS-284)	March 26, 1944
80	USS *Gudgeon* (SS-211)	May 12, 1944
84	USS *Herring* (SS-233)	June 1, 1944
80	USS *S-28* (SS-133)	June 4, 1944
50	USS *Golet* (SS-361)	June 14, 1944
78	USS *Robalo* (SS-273)	July 26, 1944
79	USS *Harder* (SS-257)	August 24, 1944
83	USS *Flier* (SS-250)	September 13, 1944
99	USS *Escolar* (SS-294)	October 1, 1944
87	USS *Shark* (SS-314)	October 24, 1944
0	USS *Darter* (SS-227)	October 24, 1944
78	USS *Tang* (SS-306)	October 25, 1944
86	USS *Seawolf* (SS-197)	October 3, 1944
87	USS *Albacore* (SS-218)	November 7, 1944
81	USS *Growler* (SS-215)	November 8, 1944
82	USS *Scamp* (SS-277)	November 16, 1944
81	USS *Swordfish* (SS-193)	January 12, 1945
89	USS *Barbel* (SS-316)	February 4, 1945
85	USS *Kete* (SS-369)	March 20, 1945
89	USS *Trigger* (SS-237)	March 28, 1945
84	USS *Snook* (SS-279)	April 8, 1945
85	USS *Lagarto* (SS-371)	May 30, 1945
85	USS *Bonefish* (SS-223)	June 18, 1945
86	USS *Bullhead* (SS-332)	August 6, 1945

the reef to the waiting submarine. In another instance an aviator was towed from under shore-battery fire off Guam to a safer area by his hanging on to the periscope of the submerged submarine. In yet another, the *Harder* nearly ran up on the beach at Wolei to rescue aviators from under fire of Japanese troops. The lifeguard services resulted in the saving of 504 downed airmen including one who was to become the 41st President of the United States, George H. Bush.

CONCLUSION

At its peak, the United States Naval Submarine Force consisted of about 230 submarines and just over 17,000 men. This personnel number is less than a fully equipped infantry division. The force's effect was far beyond its size. Submarines sank Japanese merchant shipping in every month of the war. They sank 1,150 ships for a tonnage total of just shy of five million tons – 55 percent of all Japanese shipping losses. The other 45 percent was sunk by all the other forces (all Allied air forces, surface forces, and mines) combined. The Japanese losses were consistently greater than their ship construction totals. In addition, the submarines sank 214 Imperial Japanese Navy vessels for a tonnage total of another half million tons. In comparison, the German effort in the Atlantic accounted for roughly the same number of Allied ships sunk, but at a cost to the Axis of nearly 22,000 men and nearly 1,000 submarines. The US Submarine Force lost 52 submarines from all causes and just over 3,500 men. This toll in such a small group of men was the highest percentage loss of any unit in any branch of the US Armed Forces during World War II.

BIBLIOGRAPHY

Blair Jr, Clay, *Silent Victory; The US Submarine War against Japan*, Annapolis, MD, Naval Institute Press (1975)

Friedman, Dr Norman, *US Submarines to 1945; An Illustrated Design History*, Annapolis, MD, Naval Institute Press (1995)

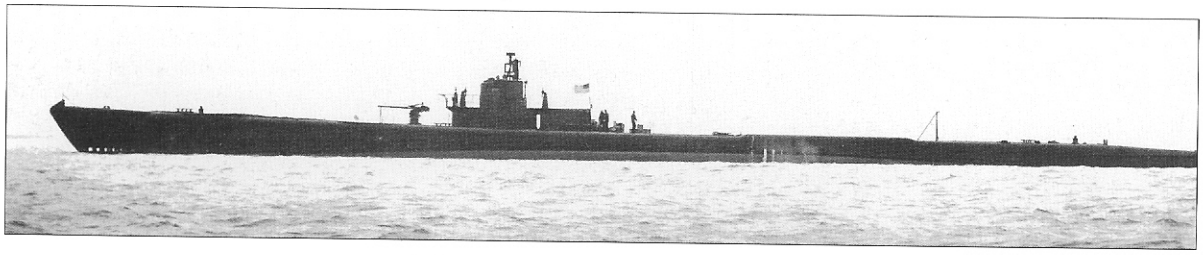
Friedman, Dr Norman, *Naval Weapons Systems*, Annapolis, MD, Naval Institute Press (various editions)

Submarine Force Library and Museum, *Boat Books* (undated internal library publication)

Submarine Qualification Notebook of Commander Gerald Levey, USN (Ret.)

Personal interviews with Commander Gerald Levey, USN (Ret.)

Later in the war, the boats with the enclosed bridge had their high superstructure cut down and converted to antiaircraft gun platforms. Some, as in *Pickerel* here, had the aft mounted gun moved forward. (US Navy)



COLOR PLATE COMMENTARY

A: SUBMARINE EVOLUTION

A1: S Class – 220ft

The evolution of the submarine leading up to World War II started with the S Class designed during World War I. This class embodied the idea of a small coastal submarine that could be operated from bases in the Philippines, Hawaii, and the East Coast of the United States to repel enemy fleets.

A2: V-4 *Argonaut* – 381ft

The idea of a submarine that could operate with the fleet as a fleet unit was not realized even with boats as large as the *Argonaut*. Diesel engines of the late 1920s and early 1930s didn't have sufficient power-to-weight ratios to propel submarines at the consistent 17 to 22 knots required for fleet operations. The engineering and hydrodynamic trade-offs resulted in large submarines that were slow to dive and unwieldy when operating submerged. After building six large boats of three different classes, the engineers started to design a smaller submarine. Several designs were built, each improving on the last. Primary changes were in engine number, type, and configuration.

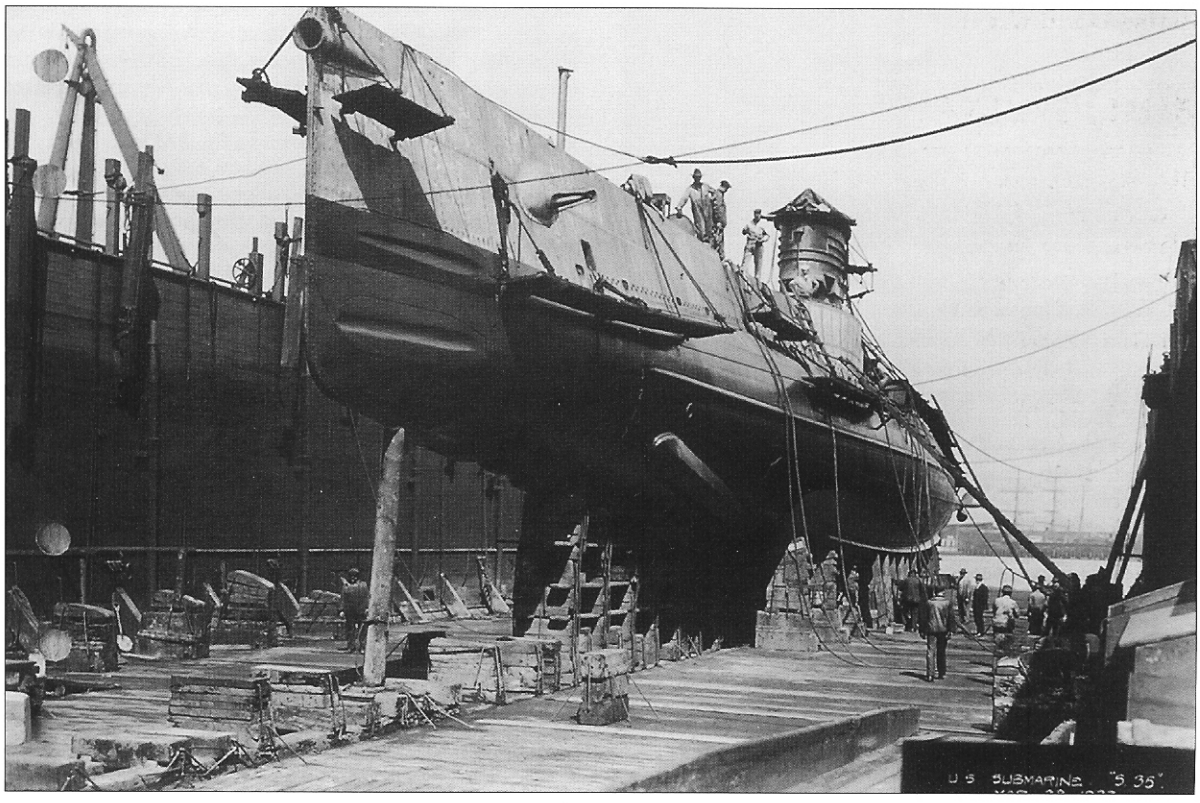
A3: Perch Class – 301ft

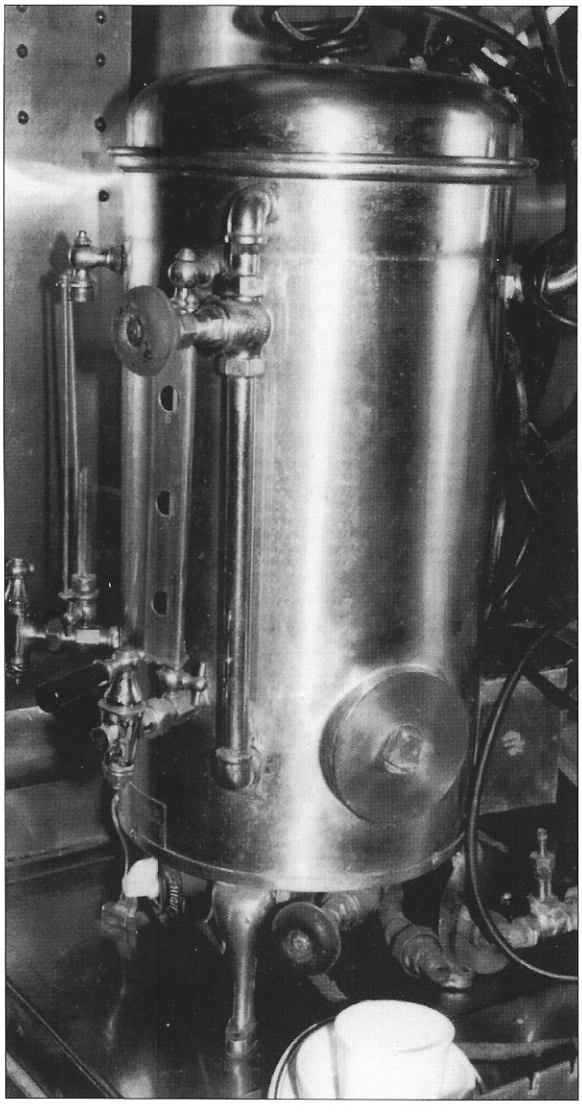
The evolution resulted in a submarine of the Gato Class, which contained a flexible diesel electric power plant, a healthy load of torpedoes, and could operate without support for over 60 days at sea ranging over the 3,000-mile expanse of the Pacific Ocean. One of the designs that just predated the Gato Class was the Perch Class, of which the *Pickerel* is shown.

B: USS *TANG*

The USS *Tang* (SS-306) was directed in October 1944 to blockade the north end of the Formosa Strait. On October 11 Commander Richard O'Kane reported that he had sunk two heavy freighters. He attacked a convoy on the 23rd and the following night found another Japanese convoy, heading north. *Tang*, on the surface, roared into the midst of the convoy and O'Kane fired the bow tubes. Two torpedoes raced toward a transport, two more at another transport, and the final two at a tanker. The convoy formation disintegrated in a melee of tracers, burning ships, and angry destroyer gunfire. *Tang* soon found itself surrounded again and to open an escape route fired three reloaded torpedoes at another tanker, a freighter, and a charging destroyer. The destroyer blew up as the torpedo struck, creating a gap through which *Tang* charged. She had two torpedoes left. O'Kane maneuvered to fire these at a transport. The first torpedo ran hot, straight, and normal. The second, however, made a circular run that slammed into the *Tang*'s side over the aft end of the maneuvering room. Fatally wounded, the submarine sank in 180ft of water. Several men were thrown from the

The *S-35* in dry dock well before the war. Just to the right of the centerline blocks is an early form of sonar array. Above the suspended catwalk is the port bow plane, which is retracted into the superstructure. The tube in the bow houses the towing shackle point. (US Navy)





A vital piece of equipment aboard American submarines was the coffee pot. Restaurant-style commercial coffee urns were installed just outside the galley. The fresh water and drain piping were permanently connected to the urn. Coffee grounds were stored in tins stacked outboard the engines. It was a requisite skill for junior men who were assigned as mess deck assistants (called messcooks) to be able to make a proper pot of coffee. A proper pot was defined as one tasting good to the chief petty officers aboard, who were the most senior of the enlisted crewmen. And woe unto the messcook who allowed the pot to become empty. (US Navy)

bridge into the water and eight more made successful escapes from the forward torpedo room using the escape trunk and Momsen Lungs (escape apparatus). Of these men, nine survived to be picked up by Japanese forces and imprisoned. All survived the harsh POW treatment and were liberated at the end of the war.

C: PAINT SCHEMES

The US submarines of World War II were painted in one of four paint schemes. These were designed to blend in with the ocean under most circumstances and conditions. Measures 9 and 10 were replaced in late 1943 and throughout 1944 and 1945 with Measure 32/3SSB and Measure 32/9SSB.

C1: Measure 9
C2: Measure 10
C3: Measure 32/3SSB
C4: Measure 32/9SSB

D: BALAO CLASS SUBMARINE

This illustration shows the standard design and layout for the Gato, Balao, and Tench Class submarines. This was the mainstay submarine design for the US Submarine Force during World War II.
See plate for full details.

E: REDUCED SILHOUETTES

E1: Tambor Class USS *Trout* (SS-202)

The changes in the look of the US submarine during World War II were largely driven by the need to reduce the silhouette. Pre- and early-war bridge and conning tower structures were cut down in two phases; one was the reduction of the aft portion and the placement of an antiaircraft gun on the resulting platform. The open door is for access to the deck for the gun crew.

E2: Balao Class USS *Lionfish* (SS-298)

All Balao and Tench Class were built with this reduced silhouette. The placement and type of deck gun depended on a combination of the commanding officer's preference, the gun type availability, and the foundation structure available. This view shows a 20mm antiaircraft gun on the aft platform and a 40mm forward. The two periscopes are extended. The third mast is the SJ radar with the ST mast just aft.

E3: Gato Class USS *Flasher* (SS-249)

Later the boats of the Gato Class and earlier types received a further reduction that placed another antiaircraft gun on a forward platform and opened the periscope support structure. The periscope and mast structure lost its fairing. To retain the structural strength lost by the removal of the fairing, the support structure was beefed up by the addition of steel beams from one side of the conning tower structure to the other.

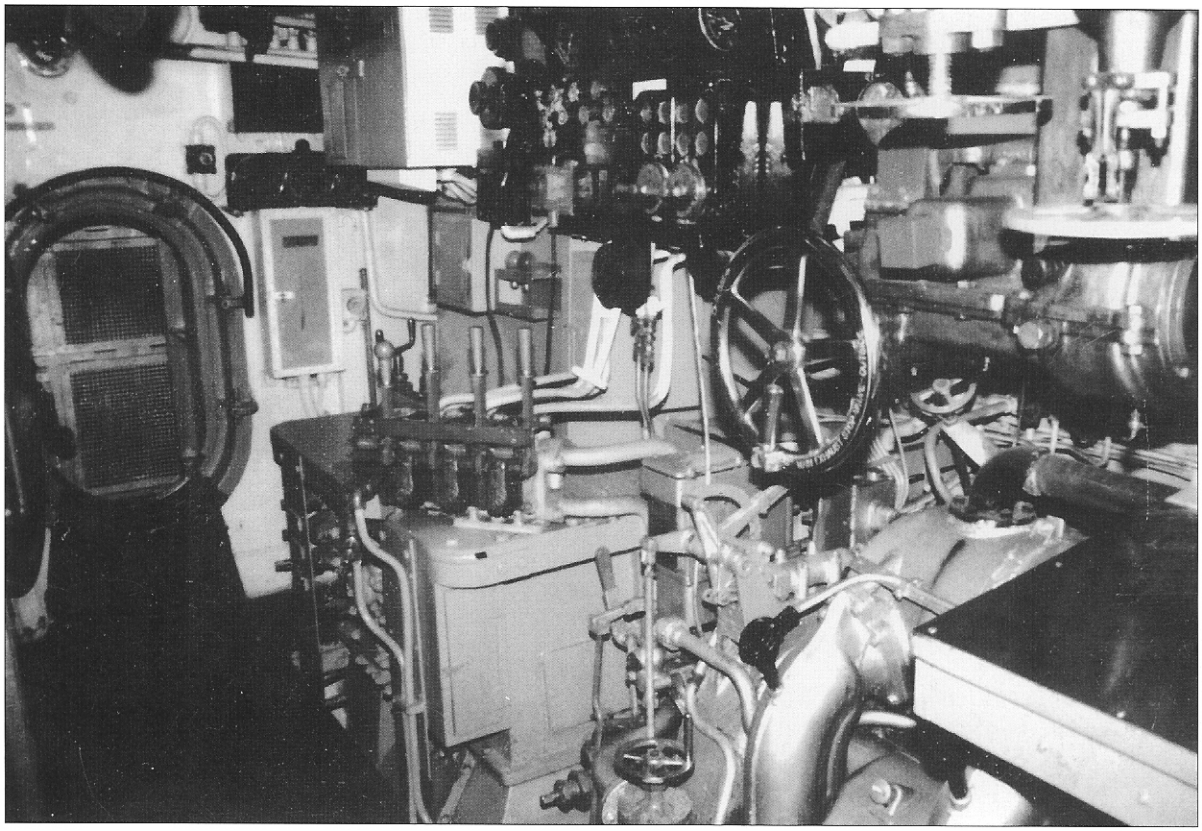
F: WEAPONS

F1: 4in/50 Mk 12a deck gun

A mainstay weapon sited forward or aft of the conning tower, the gun could fire a 33lb high-explosive shell to a range of just over 16,000yds. It had a watertight tampion for the muzzle and a watertight cover for the breech. Later modifications to this size weapon used stainless-steel breech mechanisms and bore, thus negating the need for the tampion and breech cover. The gun design was much the same as the mid-sized surface-craft gun designs perfected over the previous 50 years. Used only in the direct-fire mode, it served the Submarine Force well.

F2: 40mm Bofors antiaircraft gun

The antiaircraft gun was the Bofors design Mark 3 Mod 0. It could fire a projectile weighing nearly 2lb to a horizontal



A view of the after engine room looking at the engine control stand of a General Motors Model 278A diesel generator. The watertight door that led to the maneuvering room is to the left in the photo. The upright handles to the right were hydraulic valves that operated the inboard and outboard engine induction and outboard exhaust valve. (US Navy)

range of 11,000yds or a maximum altitude of 22,000ft. Mounted on the fore or aft conning tower platforms later in the war, this gun gave the boats a more serious sting against enemy aircraft or more often against small surface craft.

F3: 20mm Oerlikon machine gun

The 20mm antiaircraft gun was the Oerlikon design heavy machine gun. It replaced the .30-cal. and .50-cal. machine guns with which the submarines were originally equipped for protection against aircraft attack. The gun had a range of 4,800yds horizontally or an altitude range of 10,000ft with its quarter-pound shell. Normally the gun had a single-barreled mounting, but a twin-barreled gun was seen on some boats late in the war.

F4: Mark 14 torpedo

The Mark 14 torpedo was the primary torpedo type used by all but the S Class boats during the war. Early problems with the exploder and depth control were solved and the production numbers ramped up so that by mid-1943 the submarines were well supplied with accurate, deadly torpedoes. Overall it was 20ft 6in long and 21in in diameter with a loaded "ready to fire" weight of 3,300lb. The forward section carried the warhead, which was loaded with 668lb of TPX explosive. The mid body had an air flask that was charged with 3,000psi air and an alcohol tank. These supplied fuel and oxygen to a turbine engine contained in the after body that, through a set of counter-rotating screws, could drive the torpedo to a range of 4,500yds at high speed or 9,000yds at slow speed. Normally used at ranges less than 1,500yds in high-speed mode, the Mark 14 proved so effective that its service life lasted into the late 1970s.

G: USS *STERLET*

USS *Sterlet* (SS-392) is only one of the many submarines that gave great service during World War II. Most of the older boats that were available at the war's beginning were retired at war's end and were scrapped. Others were placed in reserve and "mothballed" in case they might be needed. Some served on. The changes in service required by the Cold War and the advances in submarine design, most notably the nuclear-powered submarines, changed the look and mission of these World War II boats. *Sterlet*, shown here in her final action of the war, in post-war years lost her deck guns and gained a sleek faired sail. Some boats received more powerful batteries, snorkels, and clean deck structures that gave a higher underwater speed and greater endurance. These boats kept watch on Soviet ports and ships from the late 1940s through to the mid-1970s when they were relieved of their duties by the newer nuclear boats. The author served aboard *Sterlet* from 1965 to 1968 as she participated in her last war in Vietnam. She was retired in late 1968 and used as a torpedo test target in early 1969.

INDEX

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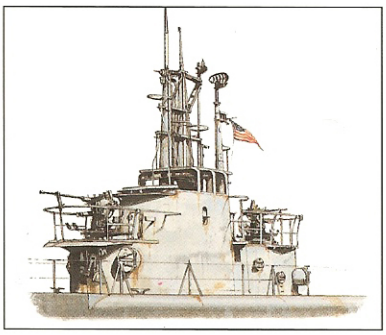

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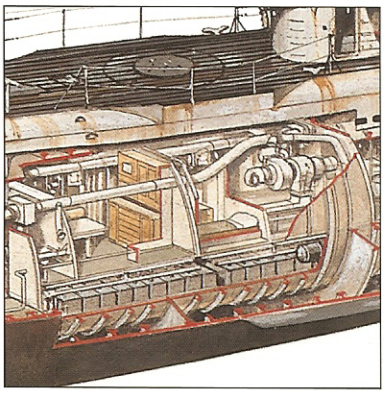

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Photographs

Naval warfare in the Pacific changed completely with the Japanese attack on Pearl Harbor in 1941. The strategic emphasis shifted from battleships to much more lethal, far-ranging weapons systems; one of these was the submarine. This book details the design and development, classes, weapons and equipment, tactics, and operational history of the US submarine in World War II. Detailed tables, photographs, and superb color plates depict the force that had an effect far beyond its size – the submarine accounted for 55% of all Japanese shipping losses, despite suffering the highest percentage loss of any unit of the United States Armed Forces in World War II.

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