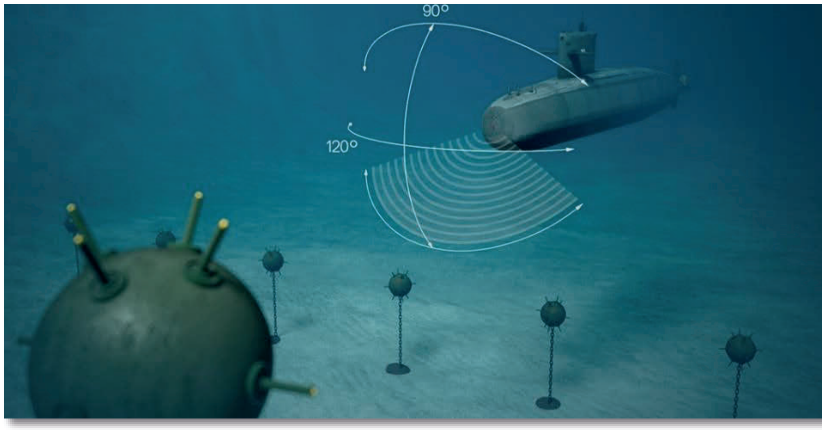
APPENDIX VI

SONAR OF WWII

This appendix covers the invention and advancements in SONAR up through and including the new systems trialed and deployed on the USS Tench to allow for more accurate identification, avoidance and destruction of marine mines.

SONAR



FM SONAR was first installed on US submarines in late 1944, during the later stages of World War II. It was initially deployed on the USS Barb (SS-220) in November of that year and was later installed on other US submarines in the Pacific Theater. During her shake-down trials out of Portsmouth Naval Yard in late 1944, USS Tench tested this new SONAR technology and was the first Tench-class submarine to take it into combat.

This technology was fitted to American submarines allowing them to safely penetrate minefields protecting the Sea of Japan. The Japanese were stunned to learn about the ability of the allies to avoid mines and intercept their merchant ships with impunity in their home waters. By detecting and sinking the Japanese merchant ships, the US submarines were able to disrupt their supply lines and limit their ability to wage war effectively.

SONAR

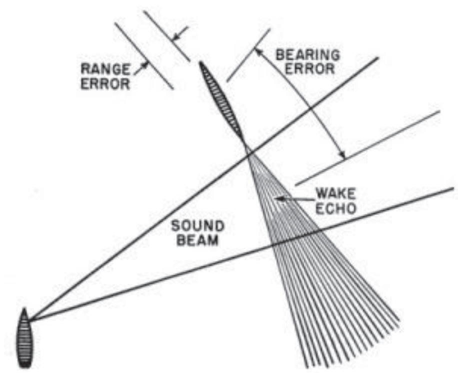
SONAR stands for **SO**und **N**avigation **A**nd **R**anging. It is a technology that uses sound waves to detect and locate objects underwater. SONAR systems emit sound waves that travel through water, and when those waves bounce off objects, they are reflected back to the SONAR system. By analyzing the time it takes for the sound waves to travel to the object and back, as well as the frequency and amplitude of the waves, the SONAR system can determine the location, size, and shape of the object. SONAR is commonly used for underwater mapping, navigation, and detecting objects such as submarines, ships, and fish.

Development of modern SONAR began in the 1920s when advancements in applying underwater sound to practical needs became abundantly clear. During this time and with advances in electronics, depth sounding by ships and echo ranging on submarines was developed. Thomas Edison and other scientists became involved in the research of passive listening devices. Other researchers explored the physics of oceanography in which later work would be based.

Work rapidly began on the development of SONAR at the onset of World War II due to the German U-boat threat. German submarines torpedoed Navy-escorted convoys at a record pace. At one point during the war, ships were being sunk faster than the U.S. could replace them. Some of the ships were sunk within view of the U.S. eastern seaboard. The mobilization of the U.S. workforce turned the tide of the war. Without the development of SONAR, the U-boat threat would probably have never been contained.

DEFINITION OF TERMS

Frequency. The frequency was an important indicator of a SONAR's capability. High-frequency SONAR had limited range but could detect small objects such as mines. Search SONAR, which was just beginning to be introduced at the end of the war, swept a range of frequencies to permit discrimination of returns from different bearings.



Pulse width. This is the duration of a single "ping" from a SONAR transmitter. The shorter the pulse width, the better the distance resolution. However, achieving a short pulse width is technically challenging, and it is more difficult to put a lot of power into a very short ping. Search SONAR did not transmit a ping, but swept continuously in frequency as it swept in bearing.

Power. This is the average transmitted power. The greater the power, the greater the sensitivity of the SONAR.

Range. This is the distance at which a submarine will typically be acquired from a SONAR platform moving at 5 knots. Range begins to degrade significantly when the SONAR platform's speed reaches ten knots, or in rough seas. The detection range is also affected by such factors as the depth of the submarine relative to the oceanic thermal profile, the size of the submarine, and the presence of an anechoic coating on the submarine.

Accuracy: This is a measure of how precisely the direction and range of a target can be determined.

SONAR HISTORY

SONAR was, and still is, the primary means for locating submerged submarines and other war assets. It relies on the fact that water is a good conductor of sound energy (much better than air) and that the steel hull of a submarine is an excellent reflector of sound.

The word SONAR originally referred specifically to what is now called active SONAR. This was preceded by passive SONAR or sound detection, which used sensitive hydrophones (underwater microphones) to detect the noise generated by the engines and screws of a submarine. A suitable directional hydrophone or set of hydrophones could determine the bearing to the submarine. Determining the distance is more difficult, typically requiring knowledge of the surface ship's course and speed and some guesswork regarding the submarine's course and speed. The fact that most surface escorts moved at a higher speed than most submerged submarines helped, but it was still difficult to determine the range with enough accuracy to score a kill with the very short-range antisubmarine weapons available, such as depth charges. Active SONAR overcame this difficulty, because it is possible to accurately measure how long it takes for a powerful sound pulse to travel from the surface ship to the submarine, be reflected, and arrive back at the surface ship.

Both the British and French navies investigated active and passive SONAR during the First World War, when the German U-boat force came close to starving out Britain. However, only the passive systems were ready in time for operational use in the war. The United States developed active SONAR technology between the wars, and U.S. researchers were the first to call it SONAR, by analogy to the word *radar*. The British referred to their systems as ASDIC, a code term going back to the First World War.

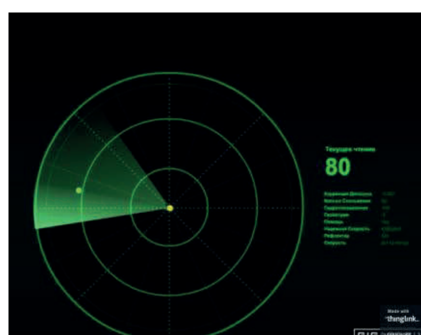
Detecting a submarine with hydrophones was quite difficult, and detecting it with SONAR was all but impossible. SONAR was highly directional. This allowed SONAR to get a good bearing on its target, but it also limited the usefulness of SONAR for search, since it took several seconds to listen for a return on a single bearing. The SONARs of the Pacific War were thus fire control systems rather than search systems, with effective search SONARs not becoming available until 1946. Range was also limited, rarely exceeding 3000 yards (2700m) even under the most favorable conditions. SONAR was generally ineffective at speeds over about 10 knots, requiring "sprint and drift" tactics in which the antisubmarine warship had to periodically slow almost to a stop to make best use of its SONAR. SONAR could not determine depth with any accuracy and was unable to track a target immediately underneath it. Thus, a submarine could sometimes evade a depth charge attack by maneuvering sharply just as the attacker passed overhead and lost SONAR contact. The depth charge explosions themselves blinded SONAR, and a submarine that survived a depth charge attack could sometimes break contact behind the "wall" of SONAR interference created by the depth charges.

Later in the war, high-frequency SONAR was developed that was capable of detecting objects as small as contact mines. This was coupled to frequency modulation (FM) that allowed the SONAR to carry out an effective short-range search. The sound beam swept a range of frequency as it swept in bearing, so that the bearing of a return signal could be determined by its frequency alone. Thus, a nondirectional hydrophone could be used for the return signal, avoiding the need to pause at each bearing to wait for the return.

FM SONAR

This American SONAR was a high-frequency, short-range SONAR designed to detect moored mines. It used frequency modulation, sweeping through frequency as it swept in bearing, so that a nondirectional hydrophone could determine the bearing of a return signal from its frequency alone. It was one of the first true search SONARs, though its range (not more than 800 yards or 730 meters under ideal conditions was inadequate for any purpose but plotting minefields.

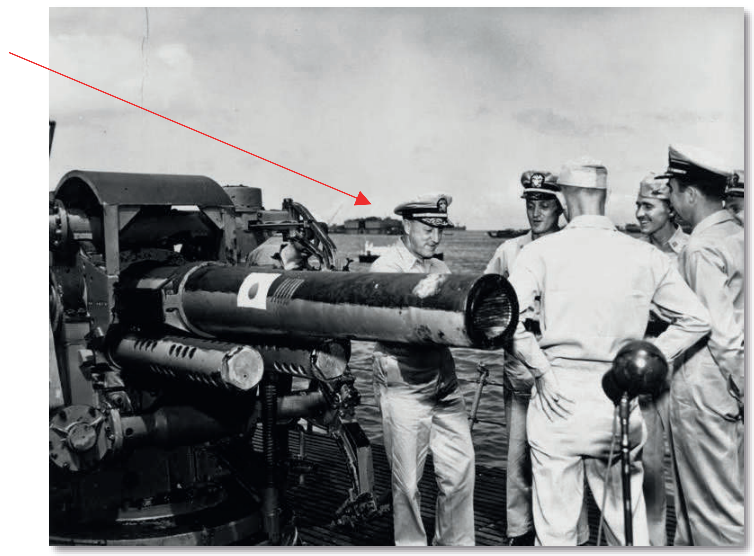
The SONAR had a Plan Position Indicator, similar to those used on the best radar, which showed mines as bright green "pears"; the SONAR also made an audible sound when its beam swept across a mine, a clear ringing note that the crews promptly dubbed "hell's bells." The audible component was important because helped distinguish actual mines from shoals of fish; the shoals gave a less distinct return that produced a muddy tone that a trained operator could easily distinguish from an actual mine.



The technology was originally developed for minesweepers, but the minesweeper force was unimpressed with its capability, and its development and deployment were taken over by the submarine service under Charles Lockwood. Lockwood saw the potential for the SONAR to allow his submarines to penetrate Japanese minefields, and the first units including USS Tench reached the fleet in time for Operation BARNEY in May 1945.

OPERATION "BARNEY": REVENGE FOR A LOST SUBMARINE

Lockwood's Revenge



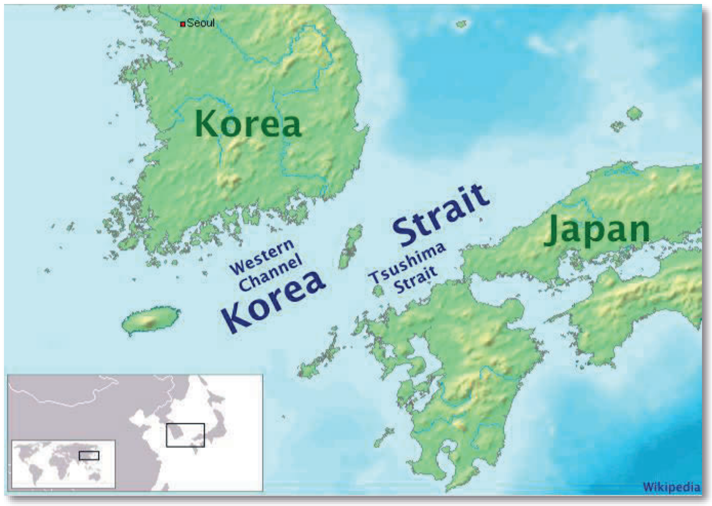
The idea for the plan to encroach on the Sea of Japan came from Vice Admiral Charles A. Lockwood, commander of the US Pacific Fleet's Submarine Force. Lockwood had become passionate for revenge against Japan after the sinking of the USS *Wahoo* (SS-238) in October of 1943. There were no survivors, and in his diary, Lockwood wrote that the sinking was "[T]he worst blow we've had." He went on to write, "God punish the Japanese!"

Lockwood's desire for vengeance wasn't immediately possible, but not long after, submarines of the US Pacific Fleet started to receive an upgrade that vastly improved the potential mission's chances for success: FM sonar. Intended to detect underwater obstacles, the implementation of FM sonar was the only way a fleet of submarines would survive the mine-infested straits leading into the Sea of Japan. Believing that *Wahoo* had struck a Japanese mine, Lockwood was at first reluctant to send any additional submarines into the Sea of Japan, but the FM sonar instilled in him enough confidence to start orchestrating another attempt.

Sieglaff

In April 1945, the Lockwood assigned Commander William "Barney" Sieglaff (Commander of the USS Tench on her first of three combat patrols) the task of training the submarines and planning the proposed mission to disrupt enemy shipping in the Sea of Japan. Dubbed **Operation Barney**, Lockwood and Sieglaff had the resources needed to pull off the secret mission, but there was still a great danger that put every crewman on the submarines at risk. The Tsushima Strait, which separated Korea and Japan, was riddled with mines. Even with the FM sonar, there was no guarantee any of the nine submarines would make it back. Despite the dangers, *Bowfin* and the other eight submarines set sail from Guam starting on May 27, well aware of the potentially deadly task that lay ahead of them.

Hell's Bells



Tsushima Strait is the southern entrance into the Sea of Japan.

The approach to the Tsushima Strait was a stressful one. The FM sonar was still a relatively new technology that could fail at any time, and the submarines were heading into a stretch of water riddled with mines. The new sonar rang out whenever a mine was 300' from the ship which, in the strait, was almost constantly. Whenever in close proximity to an explosive, the FM sonar emitted a loud ringing sound that became known as "Hell's Bells". It persisted every mile of the passage through the strait, echoing throughout the *Bowfin* and her sister submarines as nearby mines threatened to send each of them to join the *Wahoo* in her watery grave.

Along the way, cables from mines occasionally scraped against the ships, creating a very tense situation within. Dangers surrounded these ships on but they finally emerged into the Sea of Japan unscathed and ready to pull off the main objective of Lockwood's plan: attacking Japanese shipping.

Run for Home

To avoid having to return through the Tsushima Strait, after their mission was completed, the submarines traveled at high speeds through the La Perouse Strait, which was heavily patrolled by Japan. One of the eight submarines (USS Bonefish) never reemerged from the Sea of Japan, having been attacked and sunk on June 19. The other seven returned unharmed. While one ship was lost, Operation Barney, Lockwood's revenge mission, was a success.