



Maritime Security and Underwater Surveillance Technology: Lessons from the Cold War

By Mizuho Kajiwara

Abstract

The global underwater acoustic surveillance network known as the Sound Surveillance System (SOSUS) allowed the US to identify Soviet submarines during the Cold War, and its history holds important lessons for the present. Submarines conducting military operations in the world's oceans are now the most active since the end of the Cold War. As undersea competition intensifies in the Indo-Pacific among the US, China, and Russia, acoustic surveillance systems are again gaining relevance. In addition, technological developments such as Unmanned Underwater Vehicles (UUVs) have the potential to change military strategies dramatically. This article describes the ways that countries are responding to new challenges in the maritime domain. It argues that the experience of the Cold War shows that collaboration across industry, academia, and government, as well as cooperation among the US and its allies and partners, will be essential to tackling today's rapidly changing strategic undersea environment.

INTRODUCTION

In the underwater domain, there are undersea cable systems for passive sonar that collect the sound produced by submarines. The American global surveillance network called the Sound Surveillance System (SOSUS) is a fixed underwater acoustic surveillance system lined with microphones. Like human fingerprints, submarines emit unique sounds called “sound prints.” By recording these sounds and comparing and analyzing the data that influences sound propagation, such as ocean topography, currents, and temperature, it is possible to identify adversaries’ submarines.

Submarines function as a deterrent because of their stealthy nature, which allows them to approach adversaries unnoticed and to launch effective attacks based on their covert operations; however, acoustic detection technology offsets the submarine’s strengths. The signals collected through SOSUS, which stretched across the Pacific and Atlantic Ocean bottoms, were then transmitted to land-based facilities for analysis, and based on this information, patrol aircraft were deployed to contain the movements of Soviet submarines and ensure American superiority in the underwater domain during the Cold War.

The importance of this sound surveillance system has been understudied because it was long kept secret from the public. However, since the end of the Cold War, the United States government has revealed the existence of SOSUS and opened it up for use for academic purposes, such as oceanographic research, while also declassifying some official documents. This article demonstrates that the history of acoustic surveillance systems during the Cold War period holds important lessons for the present. With the conflict between the US, China, and Russia becoming more noticeable and military operations of Chinese and Russian submarines

increasing in the Indo-Pacific, the importance of acoustic surveillance systems is again increasing with technological evolution. This article argues that the experience of the Cold War shows that collaboration across industry, academia, and government, as well as cooperation among the US and its allies and partners, is essential to tackling today’s rapidly changing strategic undersea environment.

“

... the importance of acoustic surveillance systems is again increasing with technological evolution.

”

SUBMARINE TECHNOLOGY AND SURVEILLANCE SYSTEMS DURING THE COLD WAR

The history of modern submarines dates back to 1900, when the US Navy was the first in the world to adopt and field a submarine. In the 124 years since then, technological breakthroughs such as Ship Submersible Ballistic Nuclear submarines (SSBNs) powered by the inexhaustible energy source of nuclear power and Submarine-Launched Ballistic Missiles (SLBMs) have changed the form of warfare, as the underwater domain has become one of the primary combat areas. Submarines are a key method of launching nuclear weapons at an adversary, and they have exceptionally high survivability. To this day, they form a “second-strike capability” that can immediately retaliate against an adversary from anywhere in the sea.

During the Cold War, the US and the former Soviet Union each waged Anti-Submarine Warfare (ASW) in the Arctic, Atlantic, and Pacific Oceans. As the Soviet Navy strengthened its

submarine force, there was a shared awareness among US industrial and academic experts that the inability to locate Soviet submarines was a critical problem. So, the US Navy developed another revolutionary technology, the Sound Surveillance System (SOSUS). Detection by radar and radio waves is difficult in the ocean, where little radio wave penetration can be expected. Sound waves can penetrate and propagate underwater. Active sonar, which emits an acoustic signal, was developed and fielded in the late stages of World War I, but it had the disadvantage of exposing its own position. Passive sonar, which does not emit an acoustic signal but instead relies on listening sounds for detection, became more sophisticated in the latter stages of World War II. It was installed on surface ships and other vessels.

Experts across industries and disciplines, including AT&T, Western Electric, and other telecommunications and electrical companies, supported this top-secret project launched by the US Navy. Engineering, meteorology, oceanography, and physics researchers at Woods Hole Oceanographic Institution, Columbia University, Massachusetts Institute of Technology, Stanford University, and other institutions also joined the project. The discovery by geophysicist Maurice Ewing of the existence of a layer of low-frequency sound waves propagating over long distances—deep sound channels or Sound Fixing and Ranging (SOFAR) channels—and the invention of equipment capable of receiving and analyzing low-frequency signals emitted from submarines gave birth to an entirely new technological system: SOSUS. Several recently disclosed US official documents confirm that SOSUS gave the United States an advantage in the underwater domain [1].

By 1954, three land bases for analyzing information obtained from SOSUS had been established on the Atlantic, six on the Pacific, and

one in Hawaii. From the 1960s, the US and the USSR both improved their missile capabilities in terms of extended range and precision guidance. The Soviets also expanded into the world's oceans as an open-sea navy, which prompted the US to expand its detection network from the Arctic Ocean to the North Atlantic Ocean and from East Asia to the North Pacific Ocean. US allies cooperated on physical support, such as landing stations, which was essential for SOSUS operations and information gathering and analysis.

On the Atlantic side, the naval choke point connecting Greenland, Iceland, and the United Kingdom was known by the acronym “GIUK Gap.” The anti-submarine line in the GIUK Gap was monitored by SOSUS, effectively preventing the Soviet northern fleet from passing through the gap, which was at the heart of the anti-submarine warfare in the West. The United Kingdom and Canada played a significant role in aiding US efforts, as did Iceland, Denmark, and Norway to a lesser extent. Although these nations are members of the North Atlantic Treaty Organization (NATO), the US concluded defense agreements with each country to operate SOSUS due to its sensitivity as a top-secret project.

On the Pacific side, the choke points were the Soya Strait, Tsugaru Strait, and Tsushima Strait in Japan, through which submarines and ships of the Soviet Pacific Fleet had to pass before exiting the Pacific. Japan, allied with the US through the US-Japan Security Treaty, played a specific role due to its position as a choke point for the Soviets’ “sanctuary” out of the Sea of Okhotsk into the Pacific Ocean and for US military operations in the Sea of Okhotsk or the Arctic Ocean. Japan had its own underwater surveillance equipment in the three straits of Soya, Tsugaru, and Tsushima, and it also cooperated with the US military on acoustic detection [2].

As the Soviets realized that the US could detect

the location of their submarines, they improved the quietness of their vessels in the 1970s and 1980s. However, the US Navy responded in turn by developing low-frequency surveillance towed array sensor system (SURTASS) and installing it on its ships. The combined information from SOSUS and SURTASS formed the Integrated Undersea Surveillance Systems (IUSS). An unclassified US document revealed that the Soviets considered that “SOSUS is a terrible enemy of the Navy. [T]he American Command is thus [virtually able to see] every one of our submarines with very high accuracy” [3].

SOSUS is credited with contributing to the end of the Cold War. Although it was not a lethal weapon, it enabled the US to locate Soviet submarines and reduce the Soviet second-strike capability. The Soviet submarine detection system was not comparable to that of SOSUS, nor could they acquire offsetting technology in time. With the end of the Cold War, the US government decided to declassify SOSUS and to grant access to scientists for academic purposes. It also came to be used for underwater volcano and earthquake monitoring, marine mammal research, and measuring large-scale ocean temperature changes. As the threat posed by Russia declined, naval budgets for the system were cut in the early 1990s, and IUSS was scaled back.

THE RESURGENCE OF UNDERSEA COMPETITION AND UNDERWATER SURVEILLANCE

The US maritime surveillance system has continued uninterrupted to the present day. The US Navy has a vast array of intelligence, surveillance, and reconnaissance (ISR) capabilities, including over a century of undersea data, over half a century of submarine detection, and aircraft power and forward deployment capabilities, which outstrip those of other countries. However, the US and its allies,

“SOSUS is credited with contributing to the end of the Cold War. Although it was not a lethal weapon, it enabled the US to locate Soviet submarines and reduce the Soviet second-strike capability.”

including Japan, must closely consider various developments surrounding undersea cables.

In recent years, competition for dominance in the underwater domain has resumed. China has been increasing its military power and expanding its maritime interests. It has been confirmed that China has installed several floating and fixed platforms equipped with sensors and communication capabilities in the South China Sea since 2016 [4].

Given that Hainan Island, where the Chinese Navy's submarine base is located, is an essential base for China's nuclear deterrence, as well as the history of China's previous attempts to “sanctify” the South China Sea, it is reasonable to assume that the purpose of such an ocean network is for military use, including underwater surveillance. The US Navy's surveillance ship *Impeccable*, which is believed to have been conducting hydrographic surveys, was surrounded and harassed by five Chinese vessels on the high seas of the South China Sea in 2009 [5].

Russia has also continued to be a source of concern for the US. In August 2019, a top-secret Russian submarine conducting exploration activities on the ocean floor near the North Pole caught fire, killing 14 Russian crew members. The Russian government would not release details, citing “military secrecy” [6]. However, according to BBC Monitoring, US officials were aware that the submersible had a mission to intercept and jam undersea cable communications [7].



“Submarines conducting military operations such as intelligence gathering, reconnaissance, and wartime preparedness operations in the world's oceans are now the most active since the end of the Cold War.”

Moreover, submarine technology is currently entering a new phase as Unmanned Underwater Vehicles (UUVs) have the potential to change the military strategies of various countries drastically. Even though crewed submarines are powered by inexhaustible nuclear energy, they must return to shore every few months for food and crew vacations. The risk of loss of life due to accidents is also present. On the other hand, uncrewed submarines have none of these disadvantages or risks. If small UUVs equipped with artificial intelligence (AI) are deployed in the future, and if they are nuclear-powered or equipped with nuclear torpedoes, they will be much more difficult to detect and pose a more significant security threat than the large, human-crewed submarines of today. The US, China, Russia, and other countries are working hard to research and develop UUVs for anti-submarine warfare.

Submarines conducting military operations such as intelligence gathering, reconnaissance, and wartime preparedness operations in the world's oceans are now the most active since the end of the Cold War. More than 120 countries have navies, 41 of which operate submarines, and about 460 are deployed in the world's oceans [8]. The countries with the technology to build submarines are the US, Japan, China, Russia, Germany, France, Spain, the United Kingdom, the Netherlands, Italy, Sweden, and South Korea, of which six countries have nuclear submarines:

the US, Russia, China, France, India, and the United Kingdom. Brazil and South Korea are said to be aiming to build nuclear submarines [9]. Regional cooperation is also progressing. For example, the trilateral “AUKUS” partnership among Australia, the UK, and the US, is a new security framework for building nuclear submarines for Australia for the first time.

“...submarine technology is currently entering a new phase as Unmanned Underwater Vehicles (UUVs) have the potential to change the military strategies of various countries drastically.”

RESPONDING TO NEW CHALLENGES

In response to new challenges in the strategic undersea environment, there are four primary directions that countries are pursuing to improve their detection capabilities. First, they are striving to improve the accuracy of conventional sonar. Current sonar technology has improved detection of target vessels from greater distances, discrimination capabilities such as device technology, and signal processing capabilities. Combining multiple sonar systems to accurately understand the underwater domain and how that environment affects sound wave propagation and to correctly recognize the received acoustic signals through machine learning will be an issue for further development.

Second, multiple countries are pursuing the military use of marine animals. For example, the US Navy has been researching the use of marine mammals to detect mines and other obstacles since the Cold War. Dolphins are used to assist in detecting mines, unauthorized swimmers, and divers that may threaten the safety of military

vessels and civilian ships and guard ports, though these activities have attracted criticism from animal rights groups and others [10].

Third, countries are studying systems that use the unique abilities of marine organisms to detect UUVs. It has been demonstrated that marine organisms can signal or behave in observable ways when they sense the presence of UUVs; for example, Raytheon BBN and Northrop Grumman Systems have used the snapping shrimp as a biological sensor, and Florida Atlantic University is researching the use of the giant fish called Goliath Grouper, under the Defense Advanced Research Projects Agency (DARPA)'s Persistent Aquatic Living Sensors (PALS) program [11].

Fourth, many countries worldwide are researching quantum radar, a technology that might be able to accurately recognize the position and shape of objects, even in bad weather conditions such as rain or fog that prevent visibility. The US Navy is developing quantum sensing technology to detect and track platform motion underwater or in space without GPS capabilities [12]. Quantum sensing is also expected to be used for intelligence, surveillance, and reconnaissance to locate adversaries' submarines.

LESSONS FROM THE PAST

What lessons can be learned from the historical role of SOSUS in contributing to the end of the Cold War? The analysis in this policy brief suggests two main implications. First, intensive research and development by industry, academia and government that transcends specialized fields is necessary. In the US, the inability to detect Soviet submarines was agreed among experts to be the “critical problem” of Anti-Submarine Warfare, making it possible for intensive research and development. This led to the discovery of deep-sea sound channels through which sound waves could reach long distances

“...intensive research and development by industry, academia and government that transcends specialized fields is necessary.”

and the invention of equipment for analyzing and recording the low-frequency sounds produced by submarines.

Similar cooperation is necessary to tackle the challenges facing countries today. In the case of the Indo-Pacific, Japan is a critical player in stabilizing the region. Based on its updated 2022 National Security Strategy (NSS), National Defense Strategy (NDS), and Defense Buildup Program, Japan released new guidelines in 2023 to promote its R&D efforts through two approaches. The first approach is to accelerate the delivery of functions and equipment to respond to new methods of warfare in the seven fields of key capabilities identified in the NDS—including stand-off defense capabilities, integrated air and missile defense capabilities, unmanned defense capabilities, and cross-domain operation capabilities—by FY 2027 or within 10 years.

Another approach is to ensure technological superiority and create advanced capabilities by encouraging cooperation between the public and private sectors. One noticeable measure is enhancing industry, government, and academic cooperation and encouraging innovation for dual-use technologies. The Japanese government will establish a cooperative system between the Acquisition, Technology, and Logistics Agency (ATLA), outside researchers, and startups starting in FY 2024. This attempt to pursue “spin-on” approaches where technology diffuses from the private sector while also spinning off the



the outcomes of Japan's Ministry of Defense (JMOD)-led R&D is the first of its kind in history. The Science Council of Japan was previously opposed to conducting scientific research for military purposes in reflection of the involvement of scientists in World War II. However, the Science Council has recently agreed to conduct research that can have both military and civilian applications with a view that it has become difficult to differentiate these two purposes.

Second, strong cooperation and commitment among allied nations that share the same values of a maritime order based on international law is necessary. The United Kingdom, Iceland, Denmark, Norway, and Canada in the Arctic Ocean and North Atlantic Ocean, and Japan in its coastal waters and North Pacific Ocean, directly and indirectly supported SOSUS operations during the Cold War, which made it possible to establish a surveillance network over a wide area of ocean. Today, the US and its allies, such as Japan and Australia, should deepen cooperation on critical and emerging technologies crucial for maritime security, including artificial intelligence, biotechnology, and quantum, to enhance interoperability and promote efficient acquisition and maintenance amid increasing competition for technological superiority between US and China. The US and Japan signed a project arrangement in 2022 on quantum information science, which will promote research and development on quantum communication,

computing, sensors, and materials [13]. The two countries also intend to promote their efforts toward joint R&D of defense equipment [14].

It is noteworthy that the US also supports Japan's security and defense cooperation with NATO member states such as the UK and France and with like-minded partner countries in the Indo-Pacific. Bolstering the US-Japan alliance as well as building up and strengthening multi-layered security cooperation networks in the Indo-Pacific including AUKUS and the Quad—a dialogue among Australia, Japan, India, and the US—will contribute to realizing a concept of a free and open Indo-Pacific and counter growing Chinese aggression and militarization in the maritime domain.

Today, the balance of power is shifting dramatically. China, Russia, and North Korea are security threats to the countries in the Indo-Pacific that have received benefits from the free and open conditions at sea for decades. The loss of Arctic sea ice due to climate change increases the military activities of neighboring countries. Moreover, emerging technologies such as AI weapons, unmanned submarines, and autonomous nuclear torpedoes will change the battlefields and the character of warfare in the maritime domain. These changes pose new challenges for underwater surveillance technologies, suggesting that intensive and cooperative R&D investment among the government, private sector, and academia, and more commitment from US allies may be necessary to keep pace with the speed of advances if they are to maintain superiority in anti-submarine warfare.

“

...strong cooperation and commitment among allied nations that share the same values of a maritime order based on international law is necessary.

”

Mizuho Kajiwara is a member of the Keio University Global Research Institute.

This publication is part of a project on “Undersea Cables Geoeconomics, and Security in the Indo-Pacific: Risks and Resilience” that was made possible by a grant from the Japan Foundation.

The views expressed in this publication are those of the author and do not necessarily reflect the position of the Center for Indo-Pacific Affairs or any organization with which the author is affiliated.

© 2024 University of Hawai‘i at Mānoa Center for Indo-Pacific Affairs. All rights reserved.

REFERENCES

- [1] Newly declassified US government documents have unveiled more detail about the past operation of SOSUS and its impact on US superiority. These include: US Department of State, Memorandum for the President/US Position on the Limit of National Jurisdiction Over the Seabed, 1970; Central Intelligence Agency, Intelligence Memorandum/The Soviet Attack Submarine Force: Evolution and Operations, 1971; Central Intelligence Agency, Soviet Antisubmarine Warfare/Current Capabilities and Priorities, 1972; and Central Intelligence Agency, Soviet Capabilities for Strategic Nuclear Conflict/Key Judgements and Summary, 1984. Records and memoirs by members of the Integrated Undersea Surveillance System CAESER Alumni Association have also been publicized since 1993 and confirm SOSUS operations in various parts of the world.
- [2] Several National Diet of Japan deliberations from the 1970s through the 1980s have discussed SOSUS and Japan's acoustic detection system. Most of the questions were in the context of the US Navy's or Japan Maritime Self Defense Force's capabilities to detect Soviet submarines in the Sea of Japan, Sea of Okhotsk, and Eastern China Sea and the level of jointness in these operations in relation with Japan's sea lane defense policy as well as Japan's role as a US ally. These include: the Cabinet Committee on April 1, 1982; Special Committee on Foreign Affairs and Comprehensive National Security on October 6, 1983, in the House of Councilors, and Budget Committee on October 28, 1985; Cabinet Committee on August 25, 1987, in the House of Representatives. There is also evidence in the White House document "Memorandum for the President/Navy Exercise in the Sea of Japan," which was declassified in 1995, on military cooperation between the US and Japanese navies during the installation process of acoustic devices on the seabed. Details are found in Mizuho Kajiwara, *The Superiority of US Submarine Detection Technologies in the Cold War*, Doctoral Dissertation, Keio University, 2023.
- [3] Central Intelligence Agency, USSR General Staff Academy Lesson: Strategic Operations in an Ocean Theater of Military Operations, 1985.
- [4] Asia Maritime Transparency Initiative, "[Exploring China's Unmanned Ocean Network](#)," June 16, 2020.
- [5] Kevin Baron, "[Pentagon: Five Chinese Vessels Harass U.S. Ship](#)," Stars and Stripes, March 10, 2009.
- [6] BBC, "[Russia Says Details of Fatal Submersible Fire Are 'State Secret'](#)," July 3, 2019.
- [7] Val Akimenko and Howard Gethin, "[Analysis: Can Russian Submarines Cut the West's Cables?](#)," BBC Monitoring, July 3, 2019.
- [8] Mizuho Kajiwara, "[Underwater Competition in the Indo-Pacific](#)," in Alexander L Vuving (ed.), *Hindsight, Insight, Foresight: Thinking about Security in the Indo-Pacific*, Daniel K. Inouye Asia-Pacific Center for Security Studies, 2020.
- [9] James Campbell, "Seoul's Misguided Desire for a Nuclear Submarine," *Naval War College Review*, 74 (4), 2021.
- [10] Naval Information Warfare Center Pacific, "[U.S. Navy Marine Mammal Program](#)," accessed September 25, 2022.
- [11] Defense Advanced Research Projects Agency, "[DARPA's PALS Program Enters Second Phase](#)," September 28, 2020.
- [12] Rebecca Hoag, "[NPS Professor Advancing Quantum Technology for Navy Applications](#)," Naval Postgraduate School, May 24, 2021.
- [13] The White House, [FACT SHEET: The U.S.-Japan Competitiveness and Resilience \(CoRe\) Partnership](#), May 23, 2022.
- [14] US Department of Defense, "[Joint Statement of the 2023 U.S.-Japan Security Consultative Committee \('2+2'\)](#)," January 11, 2023.