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Statement for the Record for the U.S.-China Economic and Security Review Commission
Hearing on "Part of Your World: U.S.-China Competition Under the Sea"

Chair Schriver and Vice Chair Kuiken, Members of the Commission and Commission Staff, thank you for the opportunity to submit this statement for the record. In offering my best discernment regarding the subject of your hearing, I am drawing on the work of the Naval War College's China Maritime Studies Institute (CMSI), which for all of its more than two decades' existence has devoted particular focus to analyzing undersea warfare efforts by the People's Republic of China (PRC).[2] Importantly, however, I am expressing solely my personal views, which do not represent the policies or estimates of the Naval War College, the Navy, or any other organization of the U.S. government.

Executive Summary

China is investing heavily in undersea warfare development as part of a broader effort to challenge American military advantages in the Indo-Pacific. While the United States retains substantial qualitative superiority in submarine operations and undersea warfare, the People's Liberation Army Navy (PLAN) is making steady progress across multiple dimensions of the undersea domain.

Over the next five years, several developments are likely to affect U.S. operations in the Indo-Pacific:

1. Industrial advantages in shipbuilding capacity enable China to scale production of naval platforms more rapidly than the United States.
2. Continued modernization of China's submarine force includes a possible shift to focusing on the production of nuclear-powered submarines only—the absolute global gold standard.
3. A critical component of how the PLAN is moving to address deficiencies in the undersea domain is the expansion and enhancement of an integrated maritime sensing architecture. This includes a system-of-systems of seabed sensors, unmanned underwater systems, ocean surveillance ships, and maritime patrol aircraft.
4. China is rapidly increasing its inventory of unmanned undersea platforms, including gliders and large unmanned undersea vehicles (UUVs).
5. Military-Civil Fusion (MCF) programs leverage China's large civilian shipbuilding, oceanographic, and research enterprise for military-relevant applications.
6. China's development of a credible, resilient sea-based deterrent may increase Beijing's confidence in its ability to manage U.S. military intervention in a regional conflict, especially China's vulnerability to U.S. nuclear coercion.
7. Even as China develops an undersea second-strike capability, its primary undersea operational focus remains anti-surface warfare.
8. Despite the PLAN submarine force's current focus on countering surface threats, however, it will get better at anti-submarine warfare (ASW) over the next several years.
9. PRC analysts continue to regard undersea superiority a key advantage for the U.S. Navy, but American platform numbers are constrained and qualitative margins are under threat.

10. U.S. Navy undersea advantages, already challenged, are eroding.

China's ASW capabilities are uneven but improving. Particularly within the First Island Chain, China is developing a layered detection architecture. Beyond the First Island Chain, however, Chinese ASW capabilities remain significantly more limited. Despite these advances, the United States retains major advantages in submarine stealth, operational experience, and global undersea surveillance networks. Maintaining these advantages will require sustained investment in submarine production, undersea sensing systems, UUVs, and allied cooperation.

A Strategic Priority from the Very Top

The PRC is investing enormous effort and resources to improve its ability to fight in a key arena long dominated by America and its allies: the undersea domain. This is driven in part by the uniquely powerful efforts of paramount leader Xi Jinping, the world's foremost navalist statesman today and the greatest navalist head of state since World War II.[3] Over the past eight decades, no other national leader has placed such a concerted emphasis on naval development over so many years (13+) and mobilized so many resources to achieve such dramatic growth in fleet force structure, associated systems, and related capabilities. Xi has personally influenced PLAN force structure decisions, including the prioritization of nuclear-powered ballistic missile submarines (SSBNs).[4]

This is part of Xi's unprecedented emphasis on nuclear weapons development and deployment, including the establishment of a comprehensive nuclear triad, which is affording China the world's fastest growing nuclear arsenal at over 600 operational warheads and counting.[5] As part of its nuclear triad's sea leg, China has now fielded the *Julang*-3 (JL-3/Great Wave-3) (CSS-N-20) SLBM on its *Jin*-class (Type 094) SSBNs. The Pentagon's 2025 China Military Power Report assesses the JL-3 at roughly 10,000 km range, enabling strikes on large portions of the Continental United States (CONUS) from suitable patrol areas. The report's aforementioned "Fielded Nuclear Ballistic Missiles" figure depicts the JL-3's 10,000 km range covering Washington, DC and most of CONUS, with the exception of Florida and a swath of the southeast.[6]

As part of his navalist emphasis, Xi has expanded the PLAN's outlook and mission by adding two new layers to its first service-specific strategy, assigned by 1986, of "Near Seas Active Defense." This imperative to advance Beijing's contested sovereignty claims while countering foreign intervention in the Yellow, East, and South China Seas accordingly remains the core, most critical priority. Meanwhile, however, in 2015 Beijing officially affirmed that the PLAN had acquired an additional layer of strategy: "Far Seas Protection," to safeguard China's burgeoning overseas interests.[7] By 2018, China's Navy had acquired a third layer of strategy: "Near Seas Defense, Far Seas Protection, [Global] Oceanic Presence, and Expansion into the Two Poles" (近海防御, 远海防卫, 大洋存在, 两极拓展).[8] Dalian Naval Academy, for instance, now offers a "Polar Region Navigation" course.

While this latest strategic layer is currently being operationalized, it is already clear that the undersea domain and seabed are receiving unprecedented PRC emphasis. The seafloor supports undersea cables, transmitting 97+% of global data flows, which China seeks to be able to safeguard, manipulate, or exploit as it sees fit. The seabed is the focus of an impending

renaissance in mining rare earth elements and other valuable minerals. China will seek to protect extraction sites and related operations with military and civil maritime forces. It may leverage mining activity to establish and expand force presence in strategic areas, such as the Exclusive Economic Zones of Pacific island countries with which it has extraction agreements or abyssal areas (e.g., in the Clarion-Clipperton Fracture Zone) to which it has gained access through the International Seabed Authority (ISA).

In addition to being a largely untapped treasure house of valuable resources, these still-largely-uncharted depths represent an emerging domain for new forms of warfare.[9] PLAN discussions of seabed warfare (including defending, compromising, and attacking undersea cables) are centered on the "deep sea" (深海) as a realm of growing importance for military competition and conflict. The "deep sea" is one of three new frontier domains (the other two being the polar regions and outer space) prioritized for special PRC attention and resourcing. All three receive Xi's strong support and are potent areas of Sino-Russian collaboration. While sources differ regarding at what depths the "deep sea" begins, PLA experts consistently attach growing importance to the "deep sea" as a battlespace. Some go so far as to deem it the essential basis for achieving sea control—"using the deep to control the sea" (以深制海). My CMSI colleague Ryan Martinson also finds that "PLAN sources dating back to at least 2009 have highlighted China's ISA contract zones as national interests that must be safeguarded against potential threats."[10]

As in other areas, China seeks to leverage MCF in developing new technologies and techniques to help the PLAN seize the initiative in future deep-sea conflict. Martinson judges that MCF may be particularly useful "in the analysis and interpretation of the 'big data' sets associated with underseas warfare, with the ultimate goal of creating a 'transparent' ocean battlefield, including in the undersea domain."[11] With regard to MCF-related hardware, China is paving the way with innovative development and testing of such equipment as seabed landers, which draw in part on space vehicle technology—a testament to PRC attempts to integrate its advances across new frontier domains. Such vehicles offer persistent seabed presence and operations, and even potential utility for deep-sea weapons presetting at military chokepoints.[12]

Based on a series of overarching national development goals that Xi has designated for 2027, 2035, and 2049, two major aspects of military maritime advancement stand out. First, Xi's Centennial Military Building Goal of 2027 is a capability development deadline designed in large part to afford him a full-spectrum toolbox of military operational capabilities to be able to threaten to use—or, in a worst-case scenario, actually use—against Taiwan.[13] Based on its longstanding assumption that the United States (and possibly key allies) would likely intervene in such an inherently maritime contingency, China is determined to undermine as much as possible longstanding American dominance in the undersea domain[14] while targeting its regional bases and long transpacific logistics train.

Second, as part of his longer-term ambitions to fully realize the "Rejuvenation of the Chinese Nation," Xi has directed the development of a "world-class military," including a "world-class navy."[15] Originally projected for 2049, the completion timeline appears to have been moved up considerably. The goal is to achieve a PLAN that is superior to the U.S. Navy in important respects, particularly vis-à-vis Beijing's mission priorities. Undersea capabilities development is critical to achieving this gold standard overall, as well as to supporting and protecting advanced

operations of carrier groups and other task forces far from China-based capabilities and infrastructure. China's Navy clearly intends to be able to conduct the full range of naval operations wherever it operates around the world, including undersea warfare. This means submarine patrols in the Indian Ocean, which have already occurred; in the Arctic Ocean, for which PRC scientists are currently laying the technological and operational foundations; and eventually perhaps even the Atlantic Ocean, where Beijing is developing important interests that may be contested.[16]

In sum, undersea warfare is a core component of PRC naval strategy. Perhaps most importantly, PRC strategists deem undersea warfare essential to countering U.S. Navy strengths. Within the First Island Chain, it is critical to achieving the PLAN's aim of sea control in wartime. Beyond the First Island Chain, particularly in the Western Pacific and Indian Ocean, effective undersea operations are deemed necessary to counter U.S. Navy domain superiority and thwart third-party intervention in an East Asian conflict. PRC leaders also consider undersea warfare important for the long-term protection of China's global interests.

China's Undersea Advances

As part of the world's most dramatic military buildup in general, and naval buildup in particular, since World War II, China is engaged in the most dramatic large-scale improvements in undersea capabilities since the Cold War. Key results to date, and likely near-term trends, regarding China's undersea efforts include the following. China's navy already has by far the world's largest fleet, with over 400 battle force ships including over 60 submarines.[17] Over the next five years, China's undersea capabilities are likely to improve substantially in multiple areas. These include continued modernization and nuclearization of the PLAN submarine fleet, expansion of maritime surveillance systems, and growing deployment of unmanned undersea platforms.

China has a large force of potent diesel-electric submarines and is beginning to produce greatly improved nuclear-powered submarines. The Soviet Union denied technical support to China, which had to design and build nuclear-powered submarines on its own. China successfully produced functional submarines, but not effective ones. Starting around 1996, Russia began to supply considerable support. In recent years, China has greatly enlarged and enhanced shipbuilding facilities that can produce both conventional- and nuclear-powered submarines. Expanded infrastructure at Huludao's Bohai Shipyard, in particular, demonstrates increased physical plant building capacity.[18] Previously uneven PRC technological progress in submarine construction, including stubborn weaknesses in propulsion and quieting, has been ameliorated as Beijing has exploited its partnership with Moscow to obtain access to cutting-edge submarine-related technologies.

As part of the world's most numerous conventional submarine force, the PLAN currently operates the world's largest fleet of air-independent-power (AIP) submarines.[19] An improved Type 039C variant of the *Yuan*-class AIP submarine features a new, angled sail and an integral towed array sonar (the PLAN's first conventional submarine to be so equipped).[20] China also invests heavily in research and manufacturing and produces numerous experimental submarines.[21]

China is now making noteworthy progress in the all-important area of submarine quieting through improvements in nuclear propulsion; based in part on technology transfer from Russia, both consensual and via espionage, as part of Russo-Chinese sharing of undersea technology and expertise more broadly.[22] Through "imitative innovation," China has modified proven Russian submarine technology in nuclear reactors, sound isolation mounts, towed arrays, and torpedoes to meet its needs. Having significantly expanded its nuclear-powered submarine production infrastructure and finally reaching requisite technological levels, China appears geared henceforth to focusing on building, in significant numbers, nuclear-powered submarines—the absolutely unrivaled gold standard, with utterly unmatched potential in propulsion, endurance, sensor and weapons operations, and overall performance.[23]

Half a century since the first Type 091 *Han*-class nuclear-powered attack submarine (SSN) was commissioned, China is producing significantly more advanced nuclear-powered submarines than it could in the past.[24] China's Type 095 SSN[25] has the potential to approach the capabilities (propulsion, quieting, sensors, weapons) of Russia's *Improved Akula I*-class SSN. China's Type 096 SSBN has the potential to approach most capabilities (propulsion, sensors, weapons; albeit quieting like *Improved Akula I*) of Russia's *Dolgorukiy*-class SSBN. Should China jump from an early *Victor III*-like platform to an *Improved Akula I*-like platform, the implications for the United States and its Indo-Pacific allies would be profound. The Type 096 will provide the PLAN with its first truly survivable undersea second-strike platform, perhaps one capable of effective open ocean deployments.

China has launched its first-ever class of nuclear-powered guided missile submarines (SSGNs): Type 093B *Shang III*, whose vertical launch system (VLS) tubes can accommodate both anti-ship and land-attack cruise missiles (LACMs).[26] Stealthy PLAN SSGNs, produced at scale, would be able to conduct anti-surface warfare operations far from China's shores, threatening U.S. Navy movements throughout the Indo-Pacific. Armed with LACMs, the new submarines could target U.S. installations ashore, from Guam to Honolulu and even perhaps the West Coast. Both the anti-surface and land-attack capabilities would add redundancy to the advanced shore-based ballistic missiles already fielded by the PLA Rocket Force (PLARF). If PLAN SSGNs achieve a large, out-of-area presence, they could force the U.S. Navy to adjust its disposition to address this threat.

Another significant element to watch will be the Type 041 *Zhou*-class SSN, produced not at Huludao but in Wuhan's recently-relocated-and-expanded Wuchang Shipyard and powered by a micro nuclear reactor.[27] Possibly sundered by corruption-related procurement problems, according to the Pentagon's latest *China Military Power Report*, the first hull sank at the pier.[28] However, if China has successfully resolved the issues responsible, a rapid and numerically significant buildout of these relatively small and relatively affordable submarines may ensue, giving the PLAN a set of all-nuclear-powered platforms ideally suited for lurking quietly in the Near Seas and performing ASW there. Successful ASW involves detecting, tracking, and, if necessary, engaging enemy submarines for destruction. Here, as in other areas of undersea warfare, China is working hard to improve across the board.

A Growing System-of-Systems

PLA doctrine views undersea warfare as best conducted through an integrated "system-of-systems." PRC analysts fear strong U.S. and allied undersea capabilities, but the PLAN is determined to close the gap as much and as quickly as possible while pursuing superiority of its own in other areas (e.g., through joint operations with the PLARF).

China's MCF strategy plays a major role in undersea capability development. Among its many military maritime superlatives,[29] China possesses the world's largest fleet of oceanographic research vessels, which conduct extensive seabed mapping and marine surveys—including in Bering Sea waters above the U.S.-claimed extended continental shelf, potentially in a direct challenge to American maritime claims.[30] Such research can support submarine operations and maritime domain awareness. While imperfect and under development, China's effort to achieve maritime domain awareness throughout the water column and into the seabed is comprehensive and relentless. It draws in part on civilian and dual-use inputs, including the world's largest organizational system for acquiring technology by all means possible and applying it for military purposes; the world's largest research and survey fleet, whose bathymetric analysis and mapping helps guide future submarine operations;[31] and a national scientific system that provides globally-unparalleled incentives for world-class experts and their protégés to advance prioritized technological frontiers and explore the ocean depths. Influential, strongly-funded-and-supported Chinese Academies of Sciences and Engineering Academicians and next-generation understudies pioneer their exploration and facilitate dual-use leveraging of operational and developmental Arctic and Antarctic communications facilities, space support ships, icebreakers, "Transparent Ocean" submarine detection systems, robotics, manned and unmanned submersibles, and seabed stations.

To detect and track foreign submarines operating near PRC-claimed waters, China has developed such ASW platforms as the KQ-200 maritime patrol and reconnaissance aircraft and the Type 816 *Dongjian*-class ocean surveillance vessel. Since 2017, PRC shipyards have launched, and the PLAN has likely commissioned, seven *Dongjian*-class ocean surveillance ships, offering an improved capability for acoustic detection of undersea threats.[32] This new generation of ocean surveillance ships is almost certainly designed to help (in coordination with other sensors and platforms) alleviate longstanding weaknesses in the PLAN's ASW capability and in China's undersea security more broadly. That so many *Dongjian*-class ships have been built so fast underscores the importance that PLAN leaders place on the undersea domain and on addressing shortcomings in long-range undersea detection and target identification.

China Electronics Technology Group Corporation (CETC; 中国电科)'s "Blue Ocean Information Network" (蓝海信息网络), integrating space, air, shore, sea, and undersea systems, exemplifies the comprehensive, overlapping, layered architecture of sensors and networks that China is assembling around its maritime periphery.[33] Another important example is the Sound Surveillance System (SOSUS)-like Underwater Great Wall/Underwater Observation Network (水下长成/水下观测网) and undersea early-warning system (水下预警探测体系) that China is deploying, with special focus on strategic approaches likely of disproportionate importance to enemy submarines.[34] PLAN ASW capabilities are also being enhanced through a focus on developing and deploying UUVs and underwater gliders.[35] Even China's Maritime Militia incorporates marine scientists and engineers, some with "deep sea" expertise, and is involved in the emplacement and monitoring of sonobuoys and other sea-based sensors.[36] These networks

remain under development but reflect a clear effort to build a layered maritime surveillance architecture integrating multifarious manned and unmanned platforms, sensors, and other systems.

In recent years, China's Navy has invested heavily in developing other new capabilities to boost its awareness of—and ability to forecast—the undersea operating environment, but PLAN experts believe that their meteorology and oceanography capabilities significantly lag those of the U.S. Navy. This comparative ignorance of the ocean battlespace environment constitutes a major impediment to PLAN submarine and ASW operations, especially beyond the First Island Chain. Further afield, PLAN ASW capabilities remain more limited due to fewer deployed sensors, limited patrol aviation, and constrained logistics infrastructure. As a result, China's Navy remains less capable of conducting sustained ASW operations in distant waters.

China is investing heavily in autonomous systems, including underwater gliders and large UUVs. These systems can perform persistent sensing missions and may eventually support mine warfare, undersea surveillance, and seabed warfare. China has begun to prioritize mine warfare and the PLAN has a comprehensive, sophisticated sea mine program. The PLAN has a large, diverse inventory of sea mines including advanced variants and trains extensively in minelaying. Like other navies, the PLAN lags greatly in the inherently challenging field of mine countermeasures (MCM). However, China produces modern MCM ships with remote operating vehicles and a full catalog of sweeping equipment and is working hard to improve its ability to use them.[37]

The PLAN either has or is poised to integrate UUVs into its operational force. It seeks to build larger UUVs to carry more capable payloads and perform a broader range of operations. PLAN experts generally assume that China's development of autonomous platforms for naval operations lags American UUV development but are striving to close the gap.

PLAN mine warfare capabilities may be enhanced with large AUVs including the HSU001 Large Displacement Unmanned Underwater Vehicle (LDUUV).[38] China's most recent military parade of 3 September 2025 included both legacy and next-generation unmanned underwater vehicles, with the previously revealed HSU-001 displayed alongside newer, larger XLUUV designs—highlighting the maturation and scaling of China's undersea unmanned systems portfolio.[39] Of note, systems publicly paraded by China tend to have already reached the equivalent of initial operational capability (IOC).

The PLAN's development of a new heavyweight torpedo, roughly comparable to the MK48 ADCAP and the European *Blackshark*, and improved sonar systems for its submarine force could pose a difficult challenge for U.S. submarines, despite enduring acoustic disparities. The adoption of the YJ-18, YJ-19, and CJ-10 submarine-launched cruise missiles poses major threats to both the U.S. surface fleet and U.S. bases and installations in the Western Pacific.

With the aforementioned developments, China's Navy has moved closer to its goal of being prepared to win a "high-end naval war" and improved its chances of detecting, tracking, and attacking potential future adversaries in the undersea domain.

Enduring Personnel and Organizational Challenges

Uneven personnel quality and chain-of-command inefficiencies likely pose enduring challenges for China's submarine force, which has experienced massive changes and faces persistent difficulties in personnel recruitment, training, and command structures. Rapidly incorporating new platforms, technologies, concepts, and communications requirements strains personnel; but is mitigated by increased attention to effective training, personal care, and physical and mental support and recovery. Outstanding performers, particularly personnel who occupy high-stress billets like submariners, are increasingly rewarded with convalescent rest and recreation, including at dedicated support facilities.[40] Meanwhile, recent reforms and expanded training efforts indicate a strong institutional focus on improving operational effectiveness.

Xi has personally prioritized enhanced submarine force development and training.[41] In response, PLAN submarine force training is adapting to recent changes in military strategy and doctrine. Submarine crews now train more regularly under "realistic" combat conditions involving longer durations and greater distances. Expanded educational opportunities, advanced ship-based simulators, and virtual reality technology further progress ashore; the latter two modalities helping overcome outdated training equipment reportedly still present in academies and accommodating China's ten-plus submarine variants.

Beginning in 2015, "above-the-neck" reforms in the PLA in general, and PLAN specifically, directed the development of a new joint operational command system that resulted in commensurate changes to PLAN submarine force command and control.[42] Follow-on "below-the-neck" reforms did not reorganize PLAN submarine force command structure but rather significantly transformed its composition and quality, relocating in-service submarines to ensure balanced distribution of the many newer, more capable submarines across the fleet as older platforms were decommissioned. This has implications for both intra-PLAN coordination and inter-service coordination overall. Infrastructure improvements at PLAN submarine bases presage further changes to submarine force structure.

Over the past decade, the PLAN has made considerable progress in recruiting and professionalizing non-commissioned officers (NCOs, 士官), who constitute ~70% of the crew on all front-line PLAN vessels; including submarines, where they have assumed increasingly important roles. Career progression for commissioned officers remains rigid, with technical officers facing limited advancement opportunities unless they transition to non-technical roles—a potentially mismatched incentive structure.

The PLAN onboards roughly 200 new submarine officers annually.[43] As many as 60 high-performing former enlisted personnel are recruited for command-track academic education. Out of ~140 high school students recruited, ~40 go through the PLA Naval University of Engineering (海军工程大学) in Wuhan, which recruits the second-highest average national exam (高考) scorers of all PLA education institutions. However, these high performers go into dead-end engineering tracks; to pursue further promotion many elect a subsequent career change to the political officer track.

Roughly 100 high school student recruits go through the PLAN Submarine Academy (海军潜艇学院) in Qingdao, which recruits the lowest average national exam scorers of all 18 PLA education institutions. They become observation and communications, navigation, and operations officers who compete for submarine force leadership positions. Recruitment limitations apparently reflect undesirable submarine conditions and non-transferability of skills upon discharge/retirement. China clearly wants a larger submarine force, but no expansion of the officer pipeline is yet discernable, in contrast to upticks in PLAN pilots and PLARF personnel. This bears close observation moving forward.

China's Political Commissar system is considerably more agile, sophisticated, and warfighting-oriented than its Soviet progenitor. Political Commissars are not yesteryear's ideologues—as memorably depicted in *The Hunt for Red October*—but rather perform roles akin to U.S. Navy chaplains, counselors, and judge advocate generals in one person. When they perform well, they can be force multipliers. When they perform poorly, they can be great detractors to mission accomplishment. Notably, most political officers reporting to submarines lack prior experience aboard submarines and related operational understanding, although efforts are underway to ameliorate this. Commissars increasingly receive military training, but their skillsets are largely interservice-fungible and they often transfer into the PLAN, particularly from the PLA Army. The co-equal command dyad, in which Commissars head frequent consensus-based Party Committee meetings that make all major peacetime decisions within PLAN units, disempowers Commanding Officers and their operational focus. The former are said to lack understanding of equipment, the latter of personnel issues.

Personnel and organizational challenges converge in a submarine's Party Committee (艇党委), where important decisions are made—led by the Political Commissar as Secretary, with the Commanding Officer serving as Deputy Secretary, and no NCOs present.[44] This mandatory "dual-command leadership" (双首长制) framework structure—replicated across the PLA and mirrored throughout China's entire Party-State-Military system—may present the single greatest bottleneck and impediment to real-time submarine operations in difficult conditions, particularly in wartime.

Additionally, PLAN submarines often deploy with personnel senior to the Commanding Officer, which subverts shipboard chain-of-command, stresses the system, complicates decision-making, and has allegedly resulted in accidents. The presence of higher-echelon leadership aboard (e.g., the Commanding Officer or Political Officer of the superior flotilla) triggers the assembly of an "interim party committee" (临时党委). Instead of the submarine's own Commanding Officer and/or Political Commissar, these senior cadres guide decision-making. During operations leading up to the 2014 *Submarine 372* accident, for example, the Flotilla Commander (dual-hatted as Task Commander) acted as the at-sea interim Party Committee Secretary. He was joined by the Flotilla Political Department's Director as Deputy Secretary, and five other members of the submarine's crew.

While further research is needed to more fully understand the decision-making dynamics and operational implications in this critical area, PLAN submarine-based command structures clearly add complexity and friction points that could well prove to be a weak link in the chain precisely at the times of highest stakes. They could represent a critical weakness, causing real-time

decision-making bottlenecks or distraction, particularly in crisis or conflict. In the judgment of Roderick Lee, "These factors all provide opportunities for exploitation…they…create temporary vulnerabilities that could last…minutes to hours. Temporary shocks at the right time and place likely can create paralysis…."[45] Theoretically, wartime command and control expedients could be authorized, but the entrenched system might struggle to adapt. Operating under constraints in consulting higher echelons ashore stemming from technical bandwidth limitations and/or communications security requirements may make dual-command structures aboard PLAN submarines more consequential and potentially detrimental than aboard PLAN surface ships.

Data fusion may be another area of potential weakness, both for the PLAN in general and its submarine force in particular. Fusing intelligence from underwater arrays, other sensors, and signals intercepts in real time may represent a complex challenge. "In a joint firepower strike campaign, the PLA would likely employ organic ISR [Intelligence, Surveillance, and Reconnaissance] capabilities to provide battle damage assessment supporting long-range fires but probably will struggle with performing this action in a time-sensitive manner to enable re-attack recommendations due to the complex intra-service coordination required for such actions," the Pentagon judges. "Although the PLA has exercised joint operations, a joint firepower strike campaign requires close coordination between PLA services and operations groups, which the PLA probably will face challenges in effective coordination for multiservice strikes."[46]

Conclusions and Recommendations

Although the United States retains significant advantages in undersea warfare, China is investing heavily in technologies and systems that could steadily narrow remaining gaps.

- Enduring American strengths include superior submarine stealth, operational experience, and global sensing networks. These advantages remain a cornerstone of American military deterrence and power projection in the Indo-Pacific.
- However, China is striving to develop undersea capabilities as part of a broader effort to counter U.S. military strengths and complicate potential U.S. intervention in regional conflicts. Improvements in China's submarine force, maritime sensing networks, unmanned underwater systems, and naval industrial capacity are gradually strengthening China's position in the undersea domain.
- In the near term, China is unlikely to match the full spectrum of U.S. undersea warfare capabilities. Nevertheless, within the First Island Chain regarding scenarios of greatest concern (e.g., vis-à-vis Taiwan), China is developing a layered detection architecture that could increasingly challenge U.S. submarine operations.
- China's massive industrial base and MCF strategy give it advantages in scaling technologies and platforms over time. Maintaining U.S. undersea superiority will require sustained investment in submarine production capacity, autonomous systems, seabed sensing networks, and allied cooperation.
- In addition to maintaining their own advantages to the maximum extent possible, the United States and its allies should exploit potential vulnerabilities in China's dual-command (Political Commissar) decision-making structure, data fusion, and reliance on dual-use information and technology access.

U.S. Navy undersea advantages are being challenged, with significant implications. American conventional deterrence in the Western Pacific hinges in large part on superiority in undersea warfare; erosion of this superiority poses a grave threat to American interests and Indo-Pacific security and stability. American, allied, and partner decision-makers must therefore do their utmost to understand and counter developments in PRC undersea warfare.

Undersea warfare remains perhaps the greatest enduring domain of American military advantage over China. Even here, however—as in so many areas—China is making concerted efforts across the waterfront and is partially closing some of the remaining gaps. Sino-American rivalry is intensifying, and the PLAN is fixated on preparing for high-end conflict with the U.S. Navy. This impetus has yielded tremendous funding for research and development, and, ultimately, new systems, platforms, and training regimens. Much new PLAN hardware looks remarkably similar to that currently fielded by the U.S. Navy, which, aside from being seen as the PLAN's main enemy, is also regarded as the paragon of a "world-class" navy—which the PLAN itself aspires to become. The PLAN's commitment to emulating U.S. Navy capabilities has also led to, or at least informed, dramatic changes to how China's undersea forces are trained and organized. These reforms have been very hard, and not yet entirely successful, but nevertheless serve as a testament to the PLAN's will to change and address perceived shortcomings.

In at least one critical way, China's undersea enterprise is already leading even the United States: production capacity. PLAN conventional- and nuclear-powered submarines are built in large, advanced facilities, many recently expanded and further improved. Together, they dwarf those currently available in the United States. Industrial capacity is a critical factor in the innovation process that China is leveraging to the hilt by transforming ideas and designs into the large-scale production needed to meet wartime requirements.

Moreover, China has somewhat different, and arguably easier, military problems to solve: the scenarios most important to Beijing, first and foremost regarding Taiwan, represent distant "away games" for U.S. forces but prioritized "home games" for China's armed forces. PLAN undersea forces need not do what U.S. Navy undersea forces do or operate out-of-area at such a large scale. They must simply be able to reliably detect and prosecute—or at least degrade the effectiveness of—an inherently limited number of U.S. Navy submarines operating in certain key areas within and around the First Island Chain. China's undersea warfare enterprise is laser focused on this asymmetric requirement.

This critical asymmetry means that even as China seeks a gold-standard "world-class" military in coming decades, it can already attempt to compensate for its lingering limitations and qualitative inferiorities with geographically proximate systems, such as fixed arrays and deployed platforms, MCF, and quantitative superiority (in both absolute and regionally-concentrated numbers), munitions, and the infrastructure and industrial base to support them. Additionally, Beijing can contest U.S. military logistics by targeting the basing infrastructure and extended supply lines on which Washington would rely to flow forces in-theater. In characteristic fashion, China is urgently pursuing an "all of the above approach."

The danger to U.S. forces and their assigned missions is clear and present. American undersea capabilities are unprecedented in sophistication but are limited in number and up against a sustained, well-resourced effort of PRC countermeasures and compensatory capabilities. The Pentagon's recent *China Military Power Report* underscores this in no uncertain terms: Beijing "continues to make steady progress toward its 2027 goals, whereby the PLA must be able to achieve 'strategic decisive victory' over Taiwan, 'strategic counterbalance' against the United States in the nuclear and other strategic domains, and 'strategic deterrence and control' against other regional countries. In other words, China expects to be able to fight and win a war on Taiwan by the end of 2027."[47] While Beijing's success in this regard is by no means foreordained, undersea warfare advancements represent a significant component of its unrelenting challenge to historical American overmatch.

Descriptions of submarine training and tactics indicate that anti-surface warfare remains the primary operational and tactical objective for PLAN submarines. However, animated by a belief that the U.S. Navy submarine force poses a grave threat to PRC national security, China's Navy is investing in a range of initiatives to improve its ASW capabilities. These developments include rotary- and fixed-wing aircraft equipped with magnetic anomaly detectors, periscope-detecting surface search radar, dipping sonar, and sonobuoys; light detection and ranging technologies; space-based synthetic aperture radar; optical infrared sensors that detect thermal wakes and bioluminescence; ocean surveillance ships equipped with towed-array sonar; and seabed sensor arrays.[48] None of these technologies is likely to shift the undersea balance in the near term, but PLAN ASW capabilities will increase substantially in coming years.

While China has made major advancements undersea, it retains significant vulnerabilities, which should be exploited accordingly. PLAN submarine crews are becoming increasingly adept at pursuing straightforward missions, but U.S. and allied forces' development and employment of innovative concepts of operations can impose uncertainty on PLAN submarine commanders and confront them with situations outside predicted parameters. This will slow decision cycles as commanders consult potentially complex, inefficient PLAN chains of command. It may allow U.S. and allied forces to operate inside their PLAN rivals' observe, orient, decide, act (OODA) loop to maintain initiative and advantage in decision-making.

Finally, China's MCF strategy leverages civilian oceanographic research for military purposes but exposes itself in the process. PRC researchers are obtaining sensitive foreign (especially U.S./Western) analytical and design methodologies, technologies, and oceanographic research under the guise of academic exchange and such activities as "climate change research." Heightened vigilance and allied/partner cooperation is needed. Congress should consider strengthening oversight of foreign participation in U.S. oceanographic research, expanding monitoring of dual-use marine research partnerships, and improving export controls on sensitive oceanographic technologies.

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[1] The views expressed here are solely Dr. Erickson's personal academic perspectives. They do not represent the policies or estimates of the Naval War College, the Navy, or any other organization of the U.S. government.
[2] This statement draws in part on China Maritime Studies Institute, "Chinese Undersea Warfare: Development, Capabilities, Trends," *Quick Look Conference Summary* (Newport, RI: Naval War College, 5 May 2023),

https://usnwc.edu/_images/portals/0/NWCDepartments/China-Maritime-Studies-Institute/Naval-War-College_China-Maritime-Studies-Institute_CHINESE-UNDERSEA-WARFARE_CONFERENCE-SUMMARY_20230505cb9e.pdf; and Andrew S. Erickson and Ryan D. Martinson, eds., *Chinese Undersea Warfare: Development, Capabilities, Trends* (Newport, RI: Naval War College Press, forthcoming 2026). For CMSI background, see John B. Hattendorf, *Sailors and Scholars: The History of the U.S. Naval War College, 1884–2009*, Second Edition, Vol. 2 (Newport, RI: Naval War College Press, 2025), 546–49, 553–54; 412–13, 418, 468, 530, 640, 649, 695–96, 729; and Andrew S. Erickson, "CMSI's 20th Anniversary! China Maritime Studies Institute Established Two Decades Ago within Naval War College," *China Analysis from Original Sources* 以第一手资料研究中国, 2 October 2024, https://www.andrewerickson.com/2024/10/cmsis-20th-anniversary-china-maritime-studies-institute-established-two-decades-ago-within-naval-war-college/.

[3] Andrew S. Erickson, *The People of China's Navy and Other Maritime Forces: Extended Summary of Conference Findings*, *China Maritime Report* 47 (Newport, RI: Naval War College China Maritime Studies Institute, 28 May 2025), https://digital-commons.usnwc.edu/cmsi-maritime-reports/47/.

[4] For related analysis, see David C. Logan, *China's Sea-Based Nuclear Deterrent: Organizational, Operational, and Strategic Implications*, *China Maritime Report* 33 (Newport, RI: Naval War College China Maritime Studies Institute, December 2023), https://digital-commons.usnwc.edu/cmsi-maritime-reports/33/.

[5] Office of the Secretary of War, *Military and Security Developments Involving the People's Republic of China 2025* (Washington, DC: Department of Defense/War, 23 December 2025) [Hereafter: CMPR 2025], 28, https://media.defense.gov/2025/Dec/23/2003849070/-1/-1/1/ANNUAL-REPORT-TO-CONGRESS-MILITARY-AND-SECURITY-DEVELOPMENTS-INVOLVING-THE-PEOPLES-REPUBLIC-OF-CHINA-2025.PDF.

[6] CMPR 2025, 86. JL-3 coverage by the Pentagon report in 2025 and over the past decade traces how the sea-based leg has been maturing into a genuinely intercontinental component of China's deterrent. The 2024 report depicts the JL-3's 10,000 km range on a similar "Fielded Nuclear Ballistic Missiles" figure (p. 106) to the one in the 2025 report. The 2024 report states that, in "the PRC's first credible sea-based nuclear deterrent," the PLAN's 6 *Jin*-class SSBNs, each with 12 vertical launch cells, may be equipped with the 5,400 nautical mile (nm) range JL-3 or the 3,900 nm JL-2 (CSS-N-14). "The PRC probably fielded the extended-range CSS-N-20 (JL-3) SLBM on the PRC's JIN class SSBN, giving the PRC the ability to target CONUS from littoral waters and enabling the PLAN to consider bastion operations to enhance the survivability of its sea-based deterrent. The SCS [South China Sea] and Bohai Gulf probably are the PRC's preferred options for employing this concept," the 2024 report elaborates. "PRC sources claim the JL-3 has a range of over 5,400 nm, which would allow a JIN armed with this missile to target portions of CONUS from PRC littoral waters. The PLAN's next generation SSBN, the Type 096, is expected to enter service the late 2020s or early 2030s. Considering the 30-plus-year service life of the PRC's first-generation SSNs, the PRC will operate the Type 094 and Type 096 SSBNs concurrently." The Pentagon's 2023 report has a similar figure and similar wording. The 2022 report does not depict the JL-3 in its "Nuclear Ballistic Missiles" figure. It states that "The PRC probably fielded the extended-range CSS-N-20 (JL-3) SLBM on the PRC's JIN class SSBN," followed by the aforementioned bastion-related wording. In its sole mention of the JL-3, the 2021 report explains that "The current range limitations of the JL-2 will require the JIN to operate in areas north and east of Hawaii if the PRC seeks to target the east coast of the United States. As the PRC fields newer, more capable, and longer ranged SLBMs such as the JL-3, the PLAN will gain the ability to target the continental United States from littoral waters," followed by the aforementioned bastion-related wording. The 2020 report contains a shorter version of this single mention. The 2019, 2018, 2017, and 2016 reports posit that the JL-3 will be deployed on the Type 096 SSBN. Pentagon reports from 2015 and earlier do not mention the JL-3 at all. See Andrew S. Erickson, "World's Fastest Nuclear Force Ramp-Up: Strengthening for China's 2027 Goal Despite Disciplinary Removals," *China Analysis from Original Sources* 以第一手资料研究中国, 27 December 2025, https://www.andrewerickson.com/2025/12/worlds-fastest-nuclear-force-ramp-up-strengthening-for-chinas-2027-goal-despite-disciplinary-removals/.

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[9] This paragraph draws on Ryan D. Martinson, "China's Military-Civil Fusion Development Strategy in the Deep-Sea Domain," draft chapter in the National Bureau of Asian Research's forthcoming book on "China's Strategic New Frontiers."

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[11] Ibid.
[12] Elsa B. Kania and Chen-Yi Tu, "Frontier Scientists: The People of the PRC's Emerging Maritime Domains of Deep Sea and Polar Development," chapter in Erickson and Martinson, eds., *Chinese Undersea Warfare*.
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[18] Henry Boyd and Tom Waldwyn, "Boomtime at Bohai: China Ramps Up Submarine Production," IISS, 16 February 2026, https://www.iiss.org/online-analysis/military-balance/2026/02/boomtime-at-bohai-china-ramps-up-submarine-production/; Sarah Kirchberger, *China's Submarine Industrial Base: State-Led Innovation with Chinese Characteristics*, *China Maritime Report* 31 (Newport, RI: Naval War College China Maritime Studies Institute, September 2023), https://digital-commons.usnwc.edu/cmsi-maritime-reports/31/.
[19] For submarines, a distant second-best alternative to nuclear power is an advanced variant of conventional power, such as AIP. AIP greatly extends the time a submarine can cruise at low speed without draining its battery and risking detection in recharging it by raising an air intake and an exhaust tube. It also allows saving main storage battery energy accumulated for relatively fast evasive maneuvers. However, an AIP submarine has far too little power or stored energy to resemble a "baby nuke." AIP cannot be drawn down quickly and does not add to the time a boat can operate at its maximum speed: the rate at which it can convert stored energy to power is low. Moreover, AIP systems use liquid oxygen as the oxidizer, necessitating large tanks and cumbersome, dangerous refueling processes. See Andrew S. Erickson, Jonathan Ray, and Robert T. Forte, "Underpowered: Chinese Conventional and Nuclear Naval Power and Propulsion," in Andrew S. Erickson, ed., *Chinese Naval Shipbuilding: An Ambitious and Uncertain Course* (Annapolis, MD: Naval Institute Press, 2016), 238–48.
[20] H.I. Sutton, "Submarine Guide: Chinese Navy's Latest Type-039C Yuan Class," *Covert Shores*, 8 July 2021, https://www.hisutton.com/Chinese-Type-039C-Yuan-Class-Submarine.html.
[21] H.I. Sutton, "New Satellite Images of Chinese Sailless Submarine," *Covert Shores*, 8 October 2019, https://www.hisutton.com/China_Sailless_Submarine.html; Natalie Shen and H.I. Sutton, "Recent Developments in PLAN Conventional Submarine Capabilities," chapter in Erickson and Martinson, eds. *Chinese Undersea Warfare*.
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[23] Propulsion determines how fast and far a ship can go; overall power determines what it can accomplish in a given location. The density of water (805 times greater than air—calculation based on seawater at 60 degrees at 1,026 kg/m^3, and air at standard temp and pressure at 1.275 kg/m^3) imposes an unforgiving reality on these dynamics: the cubic relationship between power and speed. For a ship to go two times faster, eight-times the power is needed; three times faster requires twenty-seven times the power. Long-submerged endurance requires considerable electrical power for heating/cooling, ventilation, and atmosphere control to keep the crew healthy—not to mention offering conditions favoring recruitment and retention. Lastly, advanced submarine tactical systems require high and growing amounts of power to operate, and cool, their associated sensors and combat system. Nuclear power is the ultimate gold standard in submarine power. It is essential for long-term, long-range, high-performance operations. While conventional power or a small (~300 KW) nuclear reactor may be adequate for slow, stealthy anti-access operations close to home waters, full-scale nuclear power—in the hundreds of megawatts—is needed for high-

speed, high-performance, long-range submerged operations. Demanding arctic or tropical environments only increase the disparity. For example, submarines must typically reduce speed in warm-water environments such as the Persian Gulf. Thermodynamics is a tough opponent: the higher the water temperature, the lower the heat-rejection ability of a steam plant and the less work that can be extracted from the steam. See Andrew S. Erickson, "Australia Badly Needs Nuclear Submarines: AUKUS Nuclear Submarine Deal Is a Massive Boost for Australia's Navy," *Foreign Policy*, 20 September 2021, https://foreignpolicy.com/2021/09/20/australia-aukus-nuclear-submarines-china/; Erickson, Ray, and Forte, "Underpowered: Chinese Conventional and Nuclear Naval Power and Propulsion."

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[25] Alex Luck, "First Chinese Type 09V Nuclear Powered Attack Submarine Appears At Bohai," *Naval News*, 2 December 2026, https://www.navalnews.com/naval-news/2026/02/chinese-type-09v-next-generation-ssn-appears-at-bohai/.

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[27] Dr. Sarah Kirchberger and CAPT Christopher P. Carlson, USN (Ret.), "Neither Fish Nor Fowl: China's Development of a Nuclear Battery AIP Submarine," Center for International Maritime Security (CIMSEC), 22 January 2025, https://cimsec.org/neither-fish-nor-fowl-chinas-development-of-a-nuclear-battery-aip-submarine/.

[28] CMPR 2025, 29.

[29] China has the world's largest Navy, Coast Guard, and Maritime Militia by number of ships; the world's largest fleet of space support ships; and global port infrastructure networks and logistics support and emerging overseas facilities. On the civilian side, PRC sea power is supplemented by the world's largest fishing fleet, number of fishers, aquaculture and pisciculture industries, merchant marine, and marine sector overall, as well as a large nationally flagged tanker fleet. In 2023, China achieved the world's largest commercial fleet in terms of gross tonnage in shipping capacity. Andrew S. Erickson, "Foreword," in Meyer, Bond, and Carlson, *Modern Chinese Maritime Forces*, 3.

[30] Ryan D. Martinson, "China's Summer of 2024: The Missing Chapter," *CMSI Note* 10 (Newport, RI: Naval War College China Maritime Studies Institute, 16 October 2024), https://digital-commons.usnwc.edu/cmsi-notes/10/.

[31] Ryan D. Martinson, "China's Blue-Water Research Fleet: Science in Service of Strategy," *CMSI Note* 19 (Newport, RI: Naval War College China Maritime Studies Institute, 4 February 2026), https://digital-commons.usnwc.edu/cmsi-notes/19/.

[32] This paragraph draws on Devin Thorne, *China's T-AGOS: The Dongjian Class Ocean Surveillance Ship*, *China Maritime Report* 36 (Newport, RI: Naval War College China Maritime Studies Institute, March 2024), https://digital-commons.usnwc.edu/cmsi-maritime-reports/36/.

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[34] Ryan D. Martinson, "Civil-Military Fusion in Undersea Technologies: The Case of the Lingshui Array," chapter in Erickson and Martinson, eds., *Chinese Undersea Warfare*.

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[36] Ryan D. Martinson, "China's Military-Civil Fusion Development Strategy in the Deep-Sea Domain."

[37] Brian Waidelich and George Pollitt, *PLAN Mine Countermeasures, Platforms, Training, and Civil-Military Integration*, *China Maritime Report* 29 (Newport, RI: Naval War College China Maritime Studies Institute, July 2023), https://digital-commons.usnwc.edu/cmsi-maritime-reports/29/.

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[39] Alex Luck, "Chinese Military Parade Details New Naval Missiles, Drones," *Naval News*, 4 September 2025, https://www.navalnews.com/naval-news/2025/09/chinese-military-parade-highlights-naval-drones-and-missiles/. For broader developments, see H.I. Sutton, "Chinese Navy (PLAN) Extra-Large & Extra-Extra-Large Underwater Vehicles," Covert Shores, 27 October 2025, https://www.hisutton.com/Chinese-XLUUVs.html; H.I. Sutton, "What The World Is About To Learn About China's Extra-Large Underwater Drones," *Naval News*, 16 August 2025,

https://www.navalnews.com/naval-news/2025/08/what-the-world-is-about-to-learn-about-chinas-extra-large-underwater-drones/.

[40] Conor M. Kennedy, *A Hundred Men Wielding One Gun—Life, Duty & Cultural Practices Aboard PLAN Submarines*, *China Maritime Report* 39 (Newport, RI: Naval War College China Maritime Studies Institute, June 2024), https://digital-commons.usnwc.edu/cmsi-maritime-reports/39/.

[41] Christopher H. Sharman and Terry Hess, *PLAN Submarine Training in the "New Era"*, *China Maritime Report* 34 (Newport, RI: Naval War College China Maritime Studies Institute, January 2024), https://digital-commons.usnwc.edu/cmsi-maritime-reports/34/.

[42] Michael Dahm and Alison Zhao, *Bitterness Ends, Sweetness Begins: Organizational Changes to the PLAN Submarine Force Since 2015*, *China Maritime Report* 28 (Newport, RI: Naval War College China Maritime Studies Institute, June 2023), https://digital-commons.usnwc.edu/cmsi-maritime-reports/28/.

[43] Unless otherwise specified, this and the next five paragraphs draw on Roderick Lee, *PLA Navy Submarine Leadership—Factors Affecting Operational Performance*, *China Maritime Report* 27 (Newport, RI: Naval War College China Maritime Studies Institute, June 2023), https://digital-commons.usnwc.edu/cmsi-maritime-reports/27/.

[44] More broadly, no PLAN Master Chiefs are part of any Party Standing Committees or Party Branches. This and the next paragraph draw on RDML Phil Yu, U.S. Navy (ret.) and Benjamin Rosen, "Be Focused, Be Humble, Be Happy: Career Progression, Organization, and Training of PLA Navy Submariners," chapter in Erickson and Martinson, eds., *Chinese Undersea Warfare*.

[45] Lee, *PLA Navy Submarine Leadership—Factors Affecting Operational Performance*.

[46] CMPR 2025, 44.

[47] CMPR 2025, vi.

[48] See, e.g., Eli Tirk and Daniel Salisbury, *PLAN Anti-Submarine Warfare Aircraft—Sensors, Weapons, and Operational Concepts*, *China Maritime Report* 38 (Newport, RI: Naval War College China Maritime Studies Institute, May 2024), https://digital-commons.usnwc.edu/cmsi-maritime-reports/38/.