GAME ON

Strengthening the U.S. Undersea Posture to Enhance Deterrence and Warfighting Options

CGSR

Center for Global Security Research

LLNL-TR-714638

LAWRENCE LIVERMORE NATIONAL LABORATORY

Game On

Strengthening the U.S. Undersea Posture to Enhance Deterrence and Warfighting Options

Jason D. Ellis*
Center for Global Security Research
Lawrence Livermore National Laboratory
December 2016

EXECUTIVE SUMMARY

The Department of Defense (DoD) depends heavily on submarines for both deterrence and power projection. Yet, a combination of growing foreign capabilities and emerging U.S. force structure gaps highlights a rising set of operational risks to conventional deterrence in key theaters of operation. Even as DoD senior leaders emphasize a return to great power competition, the United States risks ceding a critical and long-standing competitive warfighting advantage in the undersea domain.

In a context of growing security challenges to the *status quo* in the East European and Asia-Pacific regions, the continued success of a U.S. strategy of conventional deterrence enabled through qualitative military superiority, global power projection, and theater security cooperation is in question. As capable as the current force is, it is insufficiently robust to meet growing theater operational needs; and force structure reductions over the next decade will further erode the U.S. undersea posture. At the same time, adversary capability advances suggest the undersea dimension is both an increasingly contested and high-consequence warfighting domain. For the United States, maintaining undersea dominance is integral to any credible power projection strategy—despite growing Russian and Chinese anti-access and area-denial (A2/AD) challenges.

Neither the planned resource base nor current spending priorities will close the most urgent combat capability gaps resulting from Russian and Chinese force structure investments. To maintain undersea dominance, and as a consequence strengthen conventional deterrence, DoD senior leaders should consider nine specific undersea posture enhancements:

- *Develop a mixed submarine force structure*. To close its most significant undersea warfighting gap—limited forward presence—the Navy must increase its planned submarine force structure. Ideally, it would procure more nuclear attack submarines to meet its expanding undersea requirements. But for reasons of time-urgency and affordability it should consider another available—if controversial—option: use of modern diesel-electrics as a near-term force multiplier in key operational theaters.

* The views expressed are those of the author and may not reflect those of Lawrence Livermore National Laboratory, the Department of Energy, the National Nuclear Security Administration, or any other U.S. government entity.

- *Build a combined undersea presence*. The most credible U.S. diesel-electric operational employment concept begins with the premise of forward basing in the Asia-Pacific region—where the operational shortfall is most acute. A combined squadron would help build partner capacity, enhance the U.S. undersea theater posture, raise the risks to China's A2/AD posture, and strengthen conventional deterrence prospects.

- *Accelerate fielding of unmanned systems*. The Navy has embraced a vision in which *undersea* transcends *submarines*, but its ability to realize this ambitious vision is not yet clear. A resource base of $600 million for distributed lethality over the next five years suggests more in the way of limited experimentation than robust capability deployment.

- *Develop and field an improved submarine-launched antiship missile*. Even as Russia and China are fielding long-range antiship systems, the Navy seeks to "grow longer arms." Among the options to pursue: replace the Harpoon, a short-range inventory weapon, with a modernized long-range Tomahawk Anti-Ship Missile or other alternative.

- *Offset the coming submarine-launched land-attack capability gap*. Submarines play a critical forward strike role, but planned force structure reductions will halve the existing capacity. The Virginia Payload Module is an important but incomplete remedy. Even as subs are decommissioned, the Navy should explore pier-side employment options for their sustained use as conventional launch platforms at key forward operating bases.

- *Rediscover the warfighting utility of strategic mining*. Russia, China, and other states have embraced mine warfare even as the United States has deemphasized it. Strategic mining can complicate adversary planning, raise an adversary's operational risks, and increases the chances that U.S. and allied forces will be able to deny the adversary a quick victory—buying time for more comprehensive force engagement.

- *Fill the gap in theater special operations undersea delivery.* Guided-missile submarine retirements will erode the Navy's ability to support special operations. The continued ability of fleet forces, and submarines in particular, to execute clandestine delivery and recovery from forward operating areas is a critical Joint warfight enabler.

- *Enhance the U.S. antisubmarine warfare posture*. Even as the Navy seeks to augment its offensive undersea capacity, it must ramp-up its defensive posture. Prolonged under-investment in this mission area was understandable in light of competing priorities over the past two decades, but must be a priority for the emerging undersea competition.

- *Finally, full-speed ahead on an operating concept for the "anti-A2/AD force*." A credible operating concept for would discuss the role of undersea forces in contested environments and identify specific contributions to Joint and combined theater operations. It should be backed by theater-specific experimentation campaigns.

INTRODUCTION

The American way of war centers on its ability to project power at great distances, across the spectrum of warfighting domains and in the face of growing adversary capabilities. In this context, it is difficult to overstate the importance of the maritime component of the U.S. defense posture. Since the earliest days of the republic, the United States has been a seafaring nation, championing freedom of navigation, protecting sea lines of communication, and fielding an effective expeditionary naval capability. For several decades, the Navy has proven adept and resilient in the undersea domain. And undersea dominance—the ability of the silent service to successfully undertake any mission, anytime, anywhere—is integral to the U.S. ability to counter adversary anti-access and area-denial (A2/AD) strategies in the modern era.[†]

The Department of Defense (DoD) depends heavily on submarines for both deterrence and power projection.[1] Yet, a combination of growing foreign capabilities and emerging U.S. force structure gaps highlights a rising set of risks to what Deputy Secretary of Defense Robert Work calls the "away game" operations that are central to conventional deterrence.[2] "There is an awful lot of competition," Chief of Naval Operations Admiral John Richardson observed in August 2016, "so we can't get complacent, we can't rest on our laurels for one minute, otherwise that window will close and we'll find that they've achieved parity undersea."[3]

While emerging security competitors do not boast the roughly 250-submarine fleet of the Soviet Union, their undersea warfighting prowess is arguably greater.[4] Contemporary nuclear (SSN) and diesel-electric (SSK) attack submarines in the Russian and Chinese inventories are much quieter than their Soviet-era predecessors, as are the nuclear ballistic missile (SSBN) submarines fielded by each. (A lower acoustic profile reduces a defender's antisubmarine warfare options and therefore enhances platform survivability.) They are also comparatively more lethal: modern SSNs and SSKs, together with guided-missile (SSGN) submarines, offer long-range antiship and/or land-attack cruise missile capabilities, even as classic naval offensive weapons including torpedoes and sea mines remain in play. In practice, adversary deployment of such lethal armaments broadens the threat envelope for deployed forces and complicates their ability to conduct effective operations in "denied" settings.

At the same time, the U.S. undersea presence is notably smaller than the roughly 100-submarine attack fleet fielded at the height of the Reagan-era buildup.[5] The Navy's existing

[†] The term "anti-access" refers to those actions and capabilities, usually long-range, designed to prevent an opposing force from entering an operational area. "Area denial" refers to those actions and capabilities, usually of shorter-range, designed not to keep an opposing force out but to limit its freedom of action within an operational area. See Department of Defense, *Joint Operational Access Concept*, v1.0, 17 January 2012 (http://www.defense.gov/Portals/1/Documents/pubs/JOAC_Jan%202012_Signed.pdf), p. i. The Chief of Naval Operations, Admiral John Richardson, suggested in October 2016 that the Navy would discontinue use of broad A2/AD nomenclature in favor of more specific problem-definition. See John Richardson, "Deconstructing A2AD," *The National Interest*, October 3, 2016 (http://nationalinterest.org/feature/chief-naval-operations-adm-john-richardson-deconstructing-17918). While understandable, this paper nevertheless uses the term in light of its prominent place in defense strategy and widespread continued use throughout the Joint force.

requirement for 48 attack submarines was set in 2006, "before the reemergence of the Russian fleet and before China became a factor beneath the waves,"[6] considerations influencing the revised—but not yet released—force-structure assessment of October 2016.[7] And the trend line is unfavorable, with anticipated reductions in the quantity of the current U.S. force complement of attack, ballistic and guided-missile submarines slated for the next several years. And while the United States appears to maintain a qualitative edge, the growing inventory of modern Russian and Chinese submarines are highly capable and appear to have closed much of the legacy performance gap. Thus, even as DoD senior leaders emphasize a "return to . . . great power competition"[8] driven largely by aggressive and revisionist Russian and Chinese actions, the United States risks ceding a critical and long-standing competitive warfighting advantage in the undersea domain.

Rear Admiral Michael Jabaley, the Program Executive Officer for Submarines, rightly argues that the Navy's ability to field additional SSNs beyond those already included in its 30-year shipbuilding plan is constrained by limited domestic nuclear shipbuilding capacity, competition with planned SSBN builds, and life-extension limitations on the retiring fleet.[9] Against a backdrop of continuing fiscal constraints, augmenting the existing SSN fleet would also likely come at the expense of other Navy or broader DoD modernization priorities. Defense Department senior leaders face a painful strategic choice: whether (a) to continue with the *status quo* and, contrary to identified national security interests, cede ground to great power competitors, (b) to prioritize development of a more robust undersea posture at the expense of other modernization priorities, or (c) to pursue alternative force structure enhancements designed to offset anticipated capability shortfalls but which may require significant cultural, operational, and technological changes to the existing naval posture.

Borrowing from Apple's 1997 reinvention campaign playbook, it is arguably time to "think different."[10] This paper outlines options to strengthen the nation's undersea posture for the emerging international security landscape in a context of continuing defense spending constraints. It first considers the role of power projection in U.S. defense strategy, and the high-value contributions of the silent service. It then highlights key challenges associated with Russian and Chinese A2/AD capabilities, and their developing undersea postures in particular. Finally, it identifies several possible avenues to strengthen the fleet's capabilities to meet the operational demands of the formidable undersea competition to come.

DOMINANT UNDERSEA—FOR NOW

Since at least the Kennedy Administration, when the U.S. Navy developed and fielded a secure second-strike deterrent system aboard ballistic missile submarines, the Navy has maintained credible forward-presence and global-reach capabilities. Indeed, few would disagree with Bryan Clark's sense that "today the U.S. Navy is dominant in undersea warfare."[11‡] Yet, the U.S. Navy's

‡ Joint doctrine underscores that "undersea warfare" is conducted to "establish dominance in the undersea portion of the maritime domain, which permits friendly forces to operate throughout the [operational environment] and denies an opposing force the effective use of underwater systems and weapons." In this

long-standing claim to undersea dominance is being challenged both by growing adversary undersea capabilities and by disruptive technological advancements. Fundamentally, the submarine fleet's ability to maintain its dominant posture will hinge on its ability to adapt its force structure at a pace exceeding the evolving A2/AD threat environment.

An emerging A2/AD focus

The Obama Administration's 2012 defense strategic guidance established that the U.S. military must be able to project power despite A2/AD challenges. It also underscored the need to be able to deter and defeat aggression by any potential adversary through strategies of both denial and punishment.[12] In turn, the 2016 defense posture update spotlights a "strategic transition" unfolding at the level of the international system, a "dramatically different" context than seen over the past quarter-century. As a consequence, DoD has increased its planning focus on great-power warfare and identified Russia and China as "our most stressing competitors."[13] Looking ahead, the Joint Staff anticipates that the global commercialization of specialized technologies will further the active efforts of revisionist states to challenge both the prevailing international order and access to the global commons, enabling development of asymmetric, unconventional, and hybrid warfighting approaches that "match or even exceed" contemporary U.S. military advantages.[14]

The *Joint Operational Access Concept* provides a vision for how the Joint force can continue to achieve assured access in a contested security environment. It highlights the need to "maintain the credible capability to project military force into any region of the world" in a context of armed opposition—perhaps the "most difficult operational challenge U.S. forces will face over the coming decades."[15] Of the several military capabilities required to implement the concept, some fit squarely within the Navy's undersea activities. For example:

- The ability to develop all categories of intelligence in any necessary domain in the context of opposed access (JOA-008);
- The ability to locate, target, and suppress or neutralize enemy A2/AD capabilities (JOA-009);
- The ability to interdict enemy forces and materiel deploying to an operational area (JOA-010);
- The ability to conduct and support operational maneuver over strategic distances along multiple axes of advance by air and sea (JOA-013);
- The ability to conduct forcible entry operations, from raids and other limited-objective operations to the initiation of sustained land operations (JOA-016);
- The ability to defeat enemy targeting systems, including their precision firing capabilities (JOA-018); and
- The ability to protect forces and supplies deploying by sea and air (JOA-021).[16]

---

context, undersea warfare includes offensive and defensive submarine, antisubmarine, and maritime mine warfare operations. See Joint Publication 3-32, *Command and Control for Joint Maritime Operations*, August 7, 2013 (http://www.dtic.mil/doctrine/new_pubs/jp3_32.pdf), p. xiii.

Admiral Jabaley and the Navy's Director of Undersea Warfare, Rear Admiral Charles Richard, underscore the utility of undersea operations in a contested environment.[17] Uniquely among the Joint force, U.S. undersea assets offer both the prospect of reliable access—persistent, undetected, assured, and far-forward—and a credible ability to hold critical adversary capabilities at risk. As such, they play a key role in peacetime operations, which may emphasize nuclear deterrence patrols, intelligence collection, special forces delivery, or other operations. In crisis or wartime, they provide a means to conduct offensive or defensive surface or undersea warfare missions. The undersea community anticipates that, as adversary A2/AD systems further proliferate, "the share of this Navy responsibility that falls on U.S. submarine and undersea forces will only grow."[18] Says Submarine Forces Commander Vice Admiral Joseph Tofolo, "We are the anti-A2/AD force."[19]

Emerging force structure challenges

At its core, the argument that the submarine fleet is the "anti-A2/AD force" is predicated on two critical variables: (1) platform availability and (2) payload sufficiency. The first is fundamentally an asset-density consideration: they must be fielded in sufficient quantity to be available when needed to prosecute their assigned missions. The second relates to their efficacy: they must maintain sufficient functionality to meet theater warfighting demands.

As a starting point, the existing SSBN fleet appears able to execute its assigned peacetime strategic deterrence mission. The 14 *Ohio*-class SSBNs play a critical role as the most survivable component of the nuclear triad. In DoD's view "there appears to be no viable near or mid-term threats to the survivability of U.S. SSBNs," although such threats or other technical challenges "cannot be ruled out over the long term."[20] At the same time, SSNs and SSGNs appear to face real and growing constraints even as they face challenging theater support demands. The *Virginia*-, *Seawolf*-, and improved *Los Angeles*-class SSNs are high-value assets capable of performing a range of operational assignments including intelligence, surveillance, and reconnaissance; insertion and recovery of special operations forces; cruise missile strikes against land targets; offensive and defensive mine warfare; antisubmarine warfare; and antisurface ship warfare.[21] For their part, the four existing *Ohio*-class converted SSGNs serve as forward strike platforms, carrying as many as 154 Tomahawk cruise missiles—a much larger payload volume than SSNs—and also support special operations missions.[22] In support of operation *Odyssey Dawn* in 2011, the USS *Florida* became the first SSGN to employ land-attack weapons in a combat setting.[23]

But significant force structure reductions are planned over the next couple of decades (Table 1). The current SSN inventory will fall from 52 to just 41 by 2029 and not recover the existing threshold requirement of 48 again on a sustained basis until 2042. SSGNs will be phased-out entirely by 2028, significantly eroding the Navy's current strike capacity. And the SSBN fleet will fall from 14 to 10 by 2032, rising to 12 a decade later. The total submarine force will fall from 71 to 53 ships—a more than 25 percent reduction—before bottoming and then reclaiming

some ground in the 2030s. At its 2018 high, the submarine force will comprise approximately 24 percent of the Navy's entire 295-ship fleet. At its 2029 low, it will comprise just over 17 percent of the Navy's 307-ship fleet. In this context, Navy senior leaders have established that priority number one is the *Columbia*-class SSBN (the *Ohio* replacement), followed by *Virginia* SSN augmentation.[24]

Table 1. Planned U.S. submarine inventory

Platform	2018	2023	2028	2033	2038	2043
SSN	53	49	42	44	47	49
SSGN	4	4	0	0	0	0
SSBN	14	14	13	10	10	12
Totals	71	67	55	54	57	61

Source: Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, Congressional Research Service report RL32665, May 27, 2016 (https://www.fas.org/sgp/crs/weapons/RL32665.pdf), p. 11.

Virginia

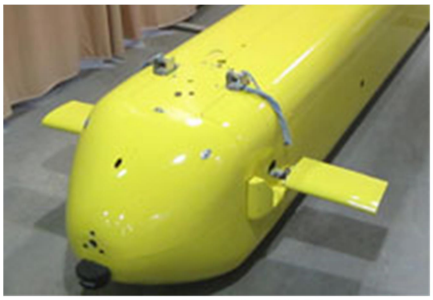
Ohio

Converted *Ohio*

Figures 1-3. Representative U.S. submarine types. (Images courtesy of the Department of Defense.)

While much smaller than the Reagan Administration's attack submarine force, the existing complement generally scales as a percentage of the Navy's total fleet.[25] But as capable as they are, they meet just about half—between 40 and 60 percent—of the mission requirements identified by regional combatant commanders.[26] The Navy's Program Executive Officer for Submarines and its Director of Naval Warfare readily acknowledge that theater commanders' "robust demand for SSN forward presence greatly exceeds that which can be provided" even with the existing 53-SSN fleet, and foresee that the smaller SSN force ahead will "require each SSN to cover more physical territory and a wider array of potential new undersea targets."[27] Worse still, while the Virginia Payload Module will eventually offer some relief, the current submarine cruise missile payload volume will be halved over the next decade as a result of planned cuts to SSN and SSGN inventories. Best case under the current plan, future submarine cruise missile strike capacity will rise to about 83 percent of that currently fielded.[28] Thus, the SSN and SSGN fleets together are already challenged with respect to both platform availability and payload sufficiency—key challenges the Navy must find a way to overcome if the submarine force is to remain the nation's "anti-A2/AD force." This is a case where quantity has a quality all its own: a smaller force structure will simply allow for fewer operational assignments, reduced operational flexibility, and increased operational risk.

While not universal, many informed observers appear to agree that effectively meeting U.S. national security interests in the emerging international security landscape will require an augmented submarine force structure.[29] For example, the independent, Congressionally-mandated *Quadrennial Defense Review* panel co-chaired by former National Security Adviser Steve Hadley and former Secretary of Defense Bill Perry in 2010 highlighted the need for a modern force on the order of 55 attack submarines, four guided-missile submarines, and 14 ballistic missile submarines which together would comprise about 21 percent of a proposed 346-ship Navy.[30] In turn, analysts from the American Enterprise Institute, Center for a New American Security, Center for Strategic and Budgetary Assessments, and the Center for Strategic and International Studies have each called for a plus-up in the existing complement of attack submarines and broader undersea support infrastructure.[31] For Admiral Harry Harris, Commander of the U.S. Pacific Command, "submarines are the original stealth platform" and a critical asymmetric warfighting advantage in the Western Pacific. Given a choice between permanently deploying an aircraft carrier and accompanying air wing or more submarines in theater, additional submarines would provide "the best way to counter Chinese naval forces."[32]



Large-Diameter UUV

Sea Hunter USV

MQ-8 Fire Scout UAV

Figures 4-6. Representative UUV, USV, and UAV types. (Images courtesy of the Department of Defense, the Office of Naval Research, and the Defense Advanced Research Projects Agency.)

To be sure, such a course of action would require either a greater resource topline and enabling shipbuilding infrastructure investments or difficult tradeoffs with other planned platform investments. The Navy intends to offset a prolonged shortfall in SSNs in part through unmanned undersea (UUV), air (UAV), and surface (USV) vehicle deployments. Indeed, taking advantage of technology developments enabling improved autonomy, computer processing, and endurance, the Navy intends to develop an exclusively unmanned squadron by 2020.[33] While specific plans remain classified, the Navy's 2004 *Unmanned Undersea Vehicle Master Plan* identified and prioritized nine prospective UUV mission areas:

1. Intelligence, surveillance, and reconnaissance;
2. Mine countermeasures;
3. Antisubmarine warfare;
4. Inspection/identification;
5. Oceanography;
6. Communication/navigation network node;

7. Payload delivery;
8. Information operations; and
9. Time-critical strike.[34]

More recently, Deputy Assistant Secretary for Unmanned Systems Frank Kelly suggested that the Navy intends for unmanned systems to help achieve air dominance, undersea superiority, and surface dominance; augment Marine ground forces; achieve battlefield mass and surprise; and secure persistent supply, sustainment, and transport. In its emerging vision, the Navy aspires to full unmanned operational capability of its preferred systems with advanced autonomy and machine learning, and ultimately seeks to field multi-domain systems.[35] Looking ahead, to the extent that multirole SSNs can shed particular tactical missions to unmanned systems, a shrinking SSN fleet will claw-back some operational flexibility and may be better positioned to meet emerging theater warfighting priorities. While they will surely remain the backbone of the nation's undersea posture, submarines will eventually need to evolve their role to satisfy the operational demands of an emerging hybrid manned/unmanned undersea fleet. Should unmanned systems ultimately prove highly capable and be fielded at scale, large-diameter UUVs may come to play a role analogous to that of an undersea aircraft carrier: conveyor of modular, networked, and lethal unmanned combat systems designed to operate behind enemy lines—whether littoral waters or blue ocean.

CHALLENGERS EMERGING

Students of modern naval history recall that the United States was not always dominant undersea. Germany employed *U-boats* against surface naval vessels, severely disrupting allied supply efforts in World Wars I and II and leading to the "hider/finder" dynamic inherent in antisubmarine warfare. Internalizing the warfighting utility of a robust undersea capability, the United States prioritized undersea dominance in the context of growing Cold War competition with the Soviet Union. For much of this multi-decade security competition, the Soviet Navy fielded submarines in greater quantity but the United States achieved and maintained a qualitative superiority. And the quantity of submarines in the U.S. inventory enabled the United States to operate effectively on a global basis. Yet today's submarine fleet is just half the size of that fielded at the end of the Cold War. The current 48-SSN Navy requirement assumes an average daily deployment requirement of 10 SSNs, rising to projected peak wartime demand of 35 SSNs.[36] But a 2029 level of just 41 SSNs leaves little margin for concurrent operations in other operational theaters, maintenance, combat replacement, unanticipated surge requirements, or other contingencies.

Even as the United States seeks to project power globally, Russia, China, and other potential adversaries are developing and fielding sea-denial capabilities designed to thwart the ability of the United States and its regional friends and allies to do so. Their collective intent is twofold: (1) preventing the United States from operating with impunity, and (2) harnessing blue-ocean and/or littoral environments for their own operational purposes. In this respect, while considerable attention has focused on various air-, space-, and land-based A2/AD challenges,

adversary capability advances suggest the undersea dimension is both an emerging and high-consequence warfighting domain. For the United States, maintaining undersea dominance is both integral to any credible power projection strategy and central to countering adversary A2/AD strategies.

Russia: advancing a revisionist agenda

Russia's 2014 Military Doctrine lists the North Atlantic Treaty Organization (NATO) first among its "external military dangers,"[37] while its 2015 National Security Strategy asserts that NATO member actions "are creating a threat to Russian national security."[38] In effect, Vladimir Putin's Russia has declared NATO its enemy, repeatedly challenged the European security order, sought to reclaim what it views as its rightful place as a great power and evinced a willingness to use force to achieve its objectives. Russia has invested in rebuilding its military strength and has begun to reassert itself on the world stage—in Georgia, Ukraine, Syria, and elsewhere. Russia's aggressive actions call into question the continued territorial integrity of key eastern alliance members and other friendly states. The specific timeline in play, the particular coercive measures Russia may employ as part of its *hybrid* warfare strategy, and the ultimate extent of its territorial ambitions are not yet clear.[39]

At the same time, Russia has proven vulnerable to international economic disruptions. While its economy has improved from the Soviet era it remains commodity-dependent, deriving more than half of its operating budget from oil revenues. Russia's foreign reserves fell more than 22 percent in 2014, sanctions imposed after Russia's invasion of Crimea have probably had some effect, and the Russian Foreign Ministry anticipated a 4.7 percent contraction in Russia's gross domestic product in 2015. At the same time, Russian dependency on commodity exports also curtailed government revenue; an estimated break-even production price of about $100 per barrel of oil versus a sub-$50 per barrel average price were expected to lead to a roughly $45 billion shortfall.[40] What this means for the military: fewer resources available for modernization, readiness, or operations.

Submarines—integral to Russia's A2/AD and deterrence postures. It is particularly striking in this context that Russian submarine patrols rose almost 50 percent by March 2015, compared with the preceding year.[41] Russian submarines have reportedly been seen over the past few years operating within 200 miles of the eastern seaboard of the United States, in the Gulf of Mexico, in the Mediterranean Sea, and off the Scottish, Swedish, Norwegian, and Latvian coastlines.[42] For Vice Admiral Clive Johnstone, Commander of NATO's Allied Maritime Command, Russian submarine activity is approaching levels not seen since the Cold War.[43] Yet while there is general agreement that Russian undersea forces are recovering from their post-Cold War low and have ramped-up their operations, there is some noteworthy interpretive variance in their operational prowess today. In Michael Kofman's view, the modern Russian submarine fleet is about one-fifth the size of the Soviet fleet, fewer than half of which is operationally ready at any given time.[44] At the same time, Lieutenant Commander Tom Spahn finds that Russia has embarked "on an aggressive effort to resurrect its undersea-warfare

capabilities."[45] In turn, former Principal Deputy Undersecretary of Defense Kathleen Hicks assesses that Russia is "expanding its undersea operations as part of a broader strategy of coercion," using submarines "to signal presence, reach, and power that achieves an effect disproportionate to the resources committed."[46]

Yet, even Kofman estimates that the Russian submarine fleet hit its post-Cold War low point more than a decade-and-a-half ago, when the K-141 *Kursk* sank after a torpedo explosion in August 2000. Since that time, Russian senior leaders have evidently increased their focus in this area, committing scarce resources to develop improved capabilities. Russia's Navy chief, Admiral Viktor Chirkov, suggests that this is "logical and necessary to guarantee the security of the state."[47] For the United States and its NATO allies, the net effect of Russia's continuing investments is, in Commander of the U.S. 6th Fleet Vice Admiral James Foggo's assessment, "an effective, skilled, and technologically advanced" Russian submarine force that is "prowling the Atlantic, testing our defenses, confronting our command of the seas, and preparing the complex underwater battlespace to give them an edge in any future conflict."[48] Former NATO Supreme Allied Commander General Philip Breedlove similarly considers that Russia's emerging undersea capabilities, as part of its broader suite of A2/AD capabilities, render an "unobstructed crossing" of the Atlantic to flow or resupply forces "a thing of the past."[49]

Table 2. Russian submarine inventory, 2015

Platform	Northern Fleet	Baltic Fleet	Black Sea Fleet	Caspian Flotilla	Pacific Fleet	Totals
SSBN	7	0	0	0	5	12
SSN/SSGN	17	0	0	0	9	26
SSK	6	2	4	0	8	20
Totals	30	2	4	0	22	58

Source: Office of Naval Intelligence, *The Russian Navy: A Historic Transition*, December 2015 (http://www.oni.navy.mil/Portals/12/Intel%20agencies/russia/Russia%202015print.pdf?ver=2015-12-14-082038-923), p. 16.[§]

Borei SSBN

Yasen SSN

Lada SSK

Figures 7-9. Representative Russian submarine types. (Images courtesy of the Office of Naval Intelligence.)

[§] Russian submarine designs differ in important respects from the multirole SSN and land-attack SSGN configurations fielded by the United States, and they continue to evolve. For convenience, this table adopts the hybridized SSN/SSGN nomenclature used by the Office of Naval Intelligence.

According to the Office of Naval Intelligence, the Russian Navy's main peacetime missions include deterrence, with SSBNs in "permanent ready" status; defense, with general-purpose naval force operations both in adjacent seas and in distant areas; and demonstration, drawing on general-purpose forces as an "instrument of state" to support Russian foreign policy. In times of increased tension and war, priority missions include protecting the sea-based deterrence force and interdicting or blunting an attack on Russia from the maritime environment. Submarines factor prominently in the deterrence and defense missions. With respect to the former, SSBNs patrol in adjacent seas ("bastions") and in operating environments such as the Arctic, and can launch long-range nuclear missiles even while moored in port. The SSN fleet provides defensive antisubmarine warfare support for deployed SSBNs. With respect to the latter, SSNs and SSKs conduct offensive antisubmarine and antisurface warfare operations in forward areas and in the littorals, respectively. Finally, SSNs and SSGNs also undertake land-attack and other special missions.[50]

In establishing acquisition priorities, Russia has emphasized SSBN recapitalization first and then the multipurpose components of its nuclear undersea fleet.[51] A total of eight *Borei*-class SSBNs are slated for procurement by 2020. A total of eight *Yasen*-class SSNs, armed primarily with Kalibr cruise missiles, are also planned for 2020. Construction on the first of this class, K-560 *Severodvinsk*, began in 1993; it is now reportedly able to undertake its assigned antisurface, antisubmarine, and land-attack missions.[52] A new, smaller SSN with SSBN-protection responsibilities has been proposed for the future fleet in order to free-up *Yasens* for other missions. At the same time, Russia has tested Kanyon, reportedly an unmanned undersea nuclear delivery vehicle designed to carry a megaton-class warhead up to 6,200 miles at high speed.[53] Finally, in addition to the *Kilo*-class SSKs currently fielded the Russian Navy is developing *Lada*-class replacements and is considering a more advanced version with air-independent propulsion.[54] Designers are also considering an alternate *Kalina*-class replacement using extended battery packs rather than air-independent propulsion.[55]

In outlining emerging naval requirements, the Russian government's news service, *Tass*, reports that contemporary European security challenges requires an undersea force structure comprised of:

- Three to four SSBNs on patrol at any given time for nuclear deterrence;
- Three to four SSNs and five to eight SSKs conducting antisubmarine warfare in support of SSBN operations; and
- 10-12 SSNs and six to eight SSGNs for antisurface warfare and other operations.[56]

Whether Russia is ultimately able to realize the full extent of its ambitious ship-building plans remains to be seen. As it ramps-up to counter what it views as a hostile NATO, the submarine fleet will likely be in great demand. Russian submarine construction "has so far been prioritized and shielded from the effects of the military's belt-tightening," according to the Center for Strategic and International Studies.[57] Analysts such as Bryan Clark agree that the Russians "have put their money where their mouth is" with respect to submarine development, viewing such

developments as "a way to generate an asymmetric advantage over U.S. forces."[58] If Spahn is correct, the *Borei* SSBN includes advanced sound-dampening and propulsion technologies comparable to a *Virginia* SSN. (Among other things, acoustic parity complicates antisubmarine warfare.[59]) And along with platform developments are noteworthy payload advances, such as the land-attack, antiship, and antisubmarine variants of the long-range Kalibr cruise missile or the long-range Status-6 nuclear torpedo.[60] In combination, such developments both provide the Russian military an expanded range of options and increase operational and strategic risks to U.S. and NATO forces. Among other things, they provide force structure which enable Russian implementation of its escalate-to-deescalate nuclear doctrine.[61]

But others, including the Center for Naval Analyses' Dmitry Gorenburg, are more sanguine: it is "not clear Russia can afford" all eight of the planned *Yasens* in light of continuing economic difficulties.[62] At the same time, Owen Cote speculates that even eight *Yasens* may not be enough to really "get our attention," if this is Moscow's intent.[63] Finally, it is worth noting the intrinsic estimative difficulties associated with Russia's evolving force posture—and the disposition of the nuclear attack and guided-missile submarines in particular. With respect to the Northern Fleet, for instance, Russia claims 42 submarines; the Office of Naval Intelligence estimates 30 (Table 2); and the Center for Strategic and International Studies estimates a range of 22-31.[64]

To some extent, this ambiguity works to Russia's advantage. Hicks finds that the ambiguity inherent in submarine warfare lends itself to a "sense of Russian undersea omnipresence," a signal that Moscow views the Baltic Sea, North Sea, Arctic Ocean, and other nearby areas as falling within its sphere of influence and that it maintains the ability to hold at risk NATO and partner sea lines of communication, key infrastructure, and other possible targets.[65] As part of an interlocking A2/AD architecture comprised of coastal missiles, interceptor aircraft, air and missile defense systems, and surface ships, submarines extend Russia's "arc of steel" ranging from the Arctic through Kaliningrad and Crimea to the Mediterranean.[66] Just as it has demonstrated its combined air-ground capabilities through operations in Georgia and Ukraine, Russia's submarine patrols in the North Atlantic, Norwegian Sea, and elsewhere afford it the ability to hold at risk NATO and friendly maritime forces. "For the first time in almost 30 years," says Vice Admiral Foggo, "Russia is a significant and aggressive maritime power."[67]

China: a rising strategic competitor

As with Russia, China views its submarine fleet both as an A2/AD—what it calls *counter-intervention*—force multiplier and as a key component of its nuclear deterrence posture. But while a resurgent Russia seeks to reclaim lost undersea prowess, a rising China seeks to newly establish itself as a formidable undersea competitor. For John Schaus, Lauren Dickey, and Andrew Metrick, while Russia's Atlantic submarine force has been the pacing threat for U.S. undersea warfare since the 1950s, looking ahead "it will be the waters of the Pacific, not the Atlantic, where the U.S. Navy will be most sorely tested."[68]

China's revisionist security ambitions in the Western Pacific puts it on a collision course with the prevailing regional security order, underwritten largely by the United States and its theater partners. Its expansive strategic aims and growing coercive capabilities conflict with the identified security objectives of U.S. treaty allies including Japan and the Philippines, as well as those of Vietnam, Indonesia, Taiwan, and other friendly states. Creeping territorial and other conflicts in the East and South China Seas may lead to use of military force, whether with the United States directly or with a U.S. partner. China publicly highlights its plans and exercises designed for a "cruel and short" war in theater, even as some Chinese officials apparently seek to "give [the U.S.] a bloody nose" for what they view as adversarial policies.[69]

China's official defense budget has risen from about $10 billion in 1997 to roughly $165 billion in 2015—a nearly 17-fold increase over the past 18 years, and a level that has consistently exceeded the rate of growth in its GDP.[70] The Director of National Intelligence sees high chances for sustained tensions between China and U.S. regional allies over territorial disputes,[71] even as DoD observes China investing in capabilities designed to counter third-party crisis or conflict intervention.[72] China's two-decade splurge has significantly enhanced its warfighting posture. While it remains unproven in combat, China now fields an increasingly capable military. RAND assesses that over a 20-year arc, China has achieved rough parity with the United States in potential Taiwan and Spratly conflict scenarios—and potentially an advantage, should Chinese objectives remain grounded in intense but short theater conflict.[73]

China's vision: a robust submarine force for a growing maritime power. During the Chinese Communist Party's 18th Party Congress (2012), then-President Hu Jintao declared an intent to "build China into a strong maritime power." While this aspirational goal is not precisely defined, it probably includes a large and effective coast guard, a capable merchant marine fleet, a robust ship-building infrastructure, an ability to extract economically important resources, and, of course, a world-class navy.[74] In turn, his successor, Xi Jinping, called for China "to do more to take interests in the sea, understand the sea, strategically manage the sea, and do more to promote China's efforts to become a maritime power."[75] An array of Chinese leaders have signaled that maritime concerns represent an emerging "vital area of national interest,"[76] and the defense white paper released in May 2015 assesses that the most likely conflict scenarios are at sea.[77]

China is investing heavily to realize this maritime renaissance. Backing this vision are exploratory concepts for development of an "oceanic space station" at a depth of almost 10,000-feet[78] and construction of a massive 125-mile underwater tunnel from northeastern China through eastern Siberia and the Bering Strait to Alaska.[79] More practically, they have led to Chinese research into unmanned undersea vehicles,[80] an increase in its air and surface antisubmarine warfare capabilities,[81] development of an "undersea Great Wall" designed to further enhance submarine detection prospects,[82] refinement of its operating concepts for antisurface warfare,[83] and procurement of a sizable fleet of modern submarines.[84] The Office of the Secretary of Defense observes that the China places "a high priority on the modernization of its submarine force."[85]

Table 3 shows the disposition of China's submarine force, but the numbers only tell part of the story. The People's Liberation Army Navy fielded a comparably-sized submarine fleet three decades ago, but it was poorly equipped and relied on antiquated technology that lagged well behind its American and Soviet counterparts. Underscoring its commitment to fleet modernization, between 1995 and 2015 they placed a total of 56 submarines into service—an average of 2.7 per year.[86] As a result of China's substantial investment over the past two decades, more than 70 percent of the current inventory is modern; and by 2020, more than 75 percent of its diesel-electrics and 100 percent of its nuclear submarines probably will be.[87] Conventional attack submarines will comprise more than 80 percent of China's 72-submarine fleet in 2020, and at least two-thirds of these will be optimized for antisurface warfare missions.[88] While China in the past imported *Kilo* SSKs from Russia and produced *Ming*-class SSKs, the more recent *Song*- and *Yuan*-class SSKs are the workhorses of this growing fleet. Comparable in armament, the *Yuans* also incorporate air-independent propulsion technology which both increases their underwater endurance and complicates detection.[89**] Taken together, Chinese submarine naval modernization translates to a larger, more survivable, and more capable operational fleet that will challenge U.S. force planning assumptions and theater warfighting strategies in the years ahead.

Table 3. Chinese submarine inventory, 2015

Platform	North Sea Fleet	East Sea Fleet	South Sea Fleet	Totals
SSBN	0	0	4	4
SSN	3	0	2	5
SSK	25	18	16	59
Totals	28	18	22	68

Source: Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century*, September 2015 (http://www.oni.navy.mil/Portals/12/Intel%20agencies/China_Media/2015_PLA_NAVY_PUB_Print.pdf?ver=2015-12-02-081247-687), p. 14.[90]

Shang SSN

Jin SSBN

Yuan SSK

Figures 10-12. Representative Chinese submarine types. (Images courtesy of the Office of Naval Intelligence.)

The small but growing nuclear fleet has also made noteworthy progress. After delivering just two *Shang*-class SSNs by 2003, it is now building four improved hulls. This portion of the fleet is

** For convenience, the term SSK is used here broadly to include both standard and AIP diesel-electric variants.

comparatively better suited to prolonged deep-water operations and is designed for a spectrum of antisurface warfare, antisubmarine warfare, and intelligence, surveillance, and reconnaissance missions. The improved *Shang* SSNs are reportedly configured to launch the long-range YJ-18 multirole system with antiship, land-attack, and antisubmarine variants.[91] Moreover, this year witnessed the first known operational patrol of the *Jin*-class SSBN, deployment of which affords China a long-range sea-based nuclear deterrence capability. In order to maintain a continuous peacetime presence, the current inventory of four SSBNs will likely increase to five by 2017.[92] Over the next decade, China may seek to develop both a successor SSBN and a new SSGN.[93]

Chinese diesel-electric and nuclear submarine force structure improvements over the past two decades are striking. Figure 13 conveys a comparative Office of Naval Intelligence estimate from 2009—and both Russian and Chinese designs have progressed since then. While China has evidently not yet achieved acoustic parity on the nuclear front, the *Shang* and *Jin* vessels represent a significant improvement over previous nuclear submarines. Jerry Hendrix estimates that the improved *Shang* (not reflected in figure 1) is roughly analogous to the improved *Los Angeles* or *Akula II* SSNs with respect to acoustic performance.[94] It is possible that the more recent *Jin* vessels have also benefited from derivative or related acoustic performance improvements. Should China proceed as anticipated with development of a next-generation type-095 SSN and/or type-096 SSGN, it will probably continue down the acoustic learning curve. On the diesel-electric front the more recent *Kilo* and *Yuan* vessels appear generally comparable to the Russian *Lada* (St. Petersburg)-class SSK, while the older *Romeo*, *Kilo*, and *Ming* SSKs exit the active inventory. Acoustically, at 105-110 decibels the modern 636 *Kilo* has reportedly achieved general equivalence with that of the improved *Los Angeles* SSNs. (By comparison, the *Virginia* operates at about 95 decibels and ocean background at 90.[95]) Said differently, the improved *Shangs* and *Kilos* in the Chinese inventory have achieved acoustic parity with mid-1980s American SSN technology, while Russia's new *Yasen* has an acoustic signature closer to the current-generation American SSN fleet.

Enabled by an improving submarine fleet, China's conventional and nuclear fleet is continuing its gradual shift from "near-seas defense" to "far-seas protection." Its nuclear and AIP-equipped submarines are capable of conducting operations beyond the so-called first island chain, with the former able to deploy for an extended period of time. While the Chinese navy still lacks either a "robust coastal or deep-water antisubmarine warfare capability," their submarines have proven their ability to conduct patrols in the Indian Ocean, in the Bering Sea, and elsewhere.[96] In 2006, for instance, a *Song* reportedly surfaced in close proximity to the *USS Kitty Hawk* carrier battle group operating in international waters near Okinawa.[97]

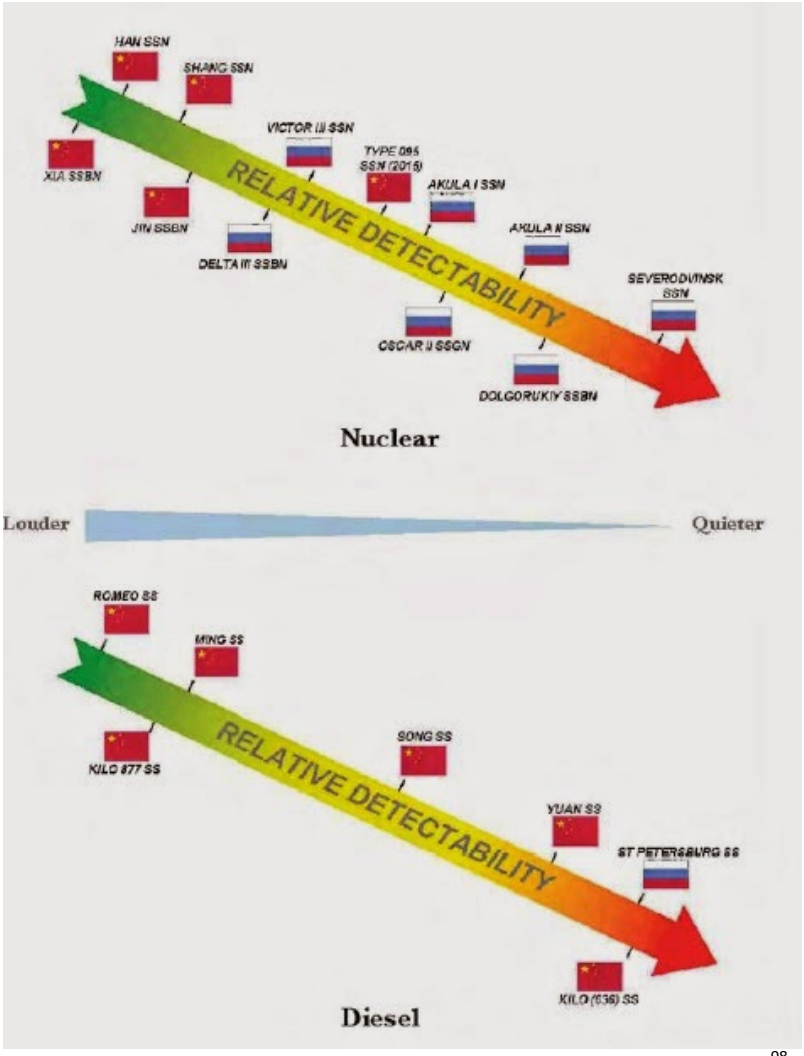


Figure 13. Relative detectability of Chinese and Russian SSKs and SSNs.[98]

While analysts such as Owen Cote have argued in the past that China's ability to deny access to U.S. nuclear attack and guided-missile submarines is "very limited," the aggregate pattern of Chinese investment suggests a future that may differ considerably.[99] China's emergent force structure is a far cry from the low-capability submarines fielded two decades ago, and they are making tangible progress toward becoming the maritime power envisioned by Chinese political leaders. While it is too early to declare victory in their sea-denial and counter-intervention goals, the United States and its regional friends and allies face the growing specter of a contested undersea domain in the years ahead. Already, Elias Groll and Dan de Luce detect a developing "submarine arms race" in the Asia-Pacific as China's neighbors "spend heavily" to counter its growing military capabilities.[100] The silver lining in these developing storm clouds: the United States has an opportunity to leverage the growing capabilities of its regional friends and allies as part of a broader regional strategy to counter China's expansionist designs.

REGIONAL SECURITY AND UNDERSEA DOMINANCE—CONTESTED

The emerging security environment of Eastern Europe and the Asia-Pacific regions are characterized by both latent and acute challenges to the *status quo*. Manifest Russian aggression in Georgia, Crimea, and the Donbas region of Ukraine, together with its coercive tactics toward the Baltic states and elsewhere, underscore a willingness to use military force to achieve revisionist objectives. Similarly, China's ongoing low-intensity engagements and coercive diplomacy in the South and East China Seas, together with its substantial and continuing development of advanced military capabilities, call into question the credibility of its claims to a peaceful rise. For its part, the U.S. ability to project power despite adversary fielding of anti-access and area-denial capabilities depends on both a robust theater military posture and active regional security partnerships. While the United States has consistently sought to uphold the principled international order established in the wake of World War II, the extent to which the international system will ultimately prove able to concurrently accommodate the respective *revisionist* and *status quo* objectives currently in play is not yet clear.[101]

Taken together, the warfighting approaches and military postures of Russia, China, and the United States appear to set the stage for armed conflict and increase the prospects for deliberate, accidental, or inadvertent escalation. Russia's hybrid warfare strategy is both aggressive and backstopped by a permissive nuclear doctrine. China's quest to become a great maritime power, coupled with its counter-intervention military posture and active efforts to establish "new great power diplomacy with Chinese characteristics," underscores hegemonic ambitions that ill-coexist with the existing regional security architecture.[102] In their respective areas, Russia and China are indirectly pressuring the United States to choose between abandoning its regional friends and allies or facing potential armed conflict. In this context, the continued success of a U.S. strategy of conventional deterrence enabled through qualitative military superiority, global power projection, and theater security cooperation is in question. Indeed, in an era where, as then-Secretary of Defense Chuck Hagel noted, "American dominance on the seas, in the skies, and in space—not to mention cyberspace—can no longer be taken for granted," the prospects for deterrence failures are real and arguably growing and the corresponding need to develop robust escalation-control strategies is acute.[103]

Maintaining U.S. undersea dominance

While American dominance *under* the seas is being challenged, it does not *yet* appear to have lapsed. In each case, Russian and Chinese undersea capabilities fit within the broader A2/AD strategies they have developed to advance their respective political and security goals. Don McCormack, director of the Naval Undersea Warfare Center, observes that Chinese and Russian undersea investments are eroding the asymmetric advantage the United States has enjoyed for several decades. An eroding competitive edge enables adversaries to, among other things:

- Deter the flow of U.S. assets to a theater of operation by surfacing an out-of-area submarine off a U.S. forward base, an allied coast, or the continental United States;

- Dissuade U.S. or partner force involvement through preemptive undersea strikes on a U.S. forward base or on allied sovereign territory;

- Weaken U.S. and partner forces by disrupting sustainment and antisubmarine warfare resources through undersea attacks on logistics ships and/or surface combatants; and

- Disrupt the United States or its allies through attacks on critical undersea international information infrastructure, on critical energy ports, or on other operational nodes.[104]

Bryan Clark's sobering conclusion: "Unless U.S. forces adapt to and lead the new competition, the era of unrivaled U.S. undersea dominance could draw to a surprisingly abrupt close."[105] The Chief of Naval Operations underscores that continuing domestic fiscal pressures mean that the Navy will not be able to "buy its way out" of the challenges it faces.[106] DoD's planned commitment of more than $40 billion over the next five years—an average of $8 billion per year—"to ensure we have the most lethal undersea and antisubmarine force in the world" is a sizable resource commitment in a context of worthwhile but competing defense priorities.[107] Understandably, the Navy's undersea leadership seeks to own the best, beat the adversary's systems, grow longer arms, protect our strategic assets, and threaten theirs.[108] And the substantial investments programmed for *Columbia* SSBNs, *Virginia* SSNs, unmanned undersea systems, Virginia Payload Modules, and other activities are critical to the nation's undersea posture. But neither the planned resource base nor current spending priorities may close the most urgent combat capability gaps resulting from Russian and Chinese force structure investments.

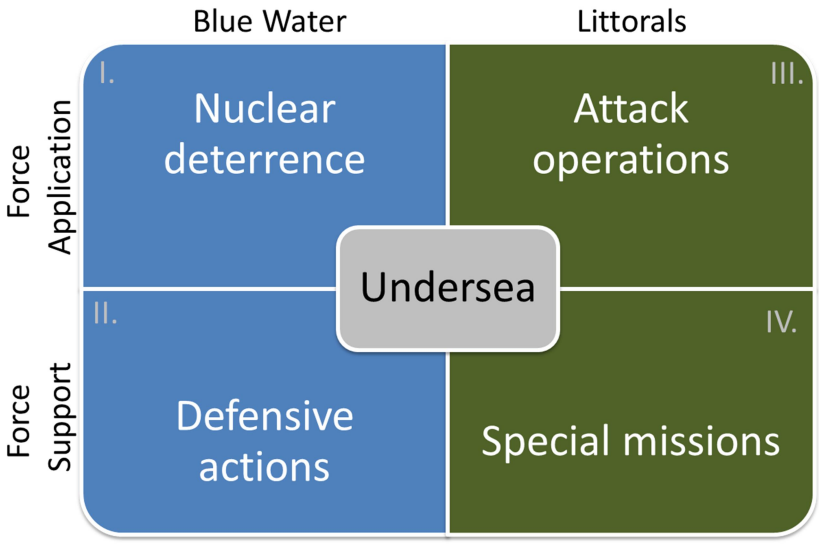


Figure 14. Undersea mission typology.

Figure 14 highlights four undersea mission areas that operational forces will need to be able to execute effectively in the emerging security environment. Navy leadership prioritizes the first of

these, nuclear deterrence, from a resource allocation standpoint. Designed for prolonged, independent, blue-water operations, the credible second-strike capability provided by the *Ohio* and future *Columbia* SSBNs is integral to the U.S. deterrence posture. While their respective force structures, investment priorities, and operating concepts vary, Russia and China have also put significant capital against the *Borei* and *Jin* SSBNs that provide a sea-based nuclear deterrence capability.

The second mission category, defensive actions, captures a broader set of operational tasks for the undersea force operating in blue-water environments. Forces should be capable of conducting antisurface warfare strike missions, as well as defensive antisubmarine warfare and other "fleet asset" duties. In this area, the Russian and Chinese submarine forces appear to have a growing advantage over their U.S. counterparts. While the United States fields a comparatively larger total blue-water SSN force, the portion of the fleet available at any given time for operations in the Asia-Pacific or European theaters is more limited. More importantly, the long-range Kalibr and YJ-18 antiship cruise missile capabilities fielded onboard the *Yasen*, improved *Shang*, *Kilo*, and *Yuan* attack platforms provide a significant standoff attack option for operations in environments such as the Atlantic Ocean or the Mediterranean, Philippine, East or South China Seas. For Harry Kazianis, a combination of "super-stealthy" diesel boats with air-independent propulsion systems and long-range antiship weapons presents a "one-two punch that can't be ignored."[109]

This challenge is arguably even more acute with respect to operations in littoral settings,[110] the third mission category highlighted above. In China's case, a large inventory of diesel-electrics armed for antisurface warfare operations plays a significant anti-access role. In Russia's case, they afford both a potent antiship and growing land-attack capability. In contrast, while U.S. attack and guided-missile submarines have for many years played a critical land-attack role, existing strike capacity will be halved with SSGN retirements. Moreover, the absence of a long-range submarine-launched antiship missile puts the United States at a tactical disadvantage. By the same token, U.S. attack submarines are optimized for, and may have a comparative advantage in, antisubmarine warfare; but this advantage erodes in shallower waters. Moreover, the demonstrated ability of both Russian and Chinese vessels to surface within striking distance of deployed or land-based assets suggests that the United States does not maintain the density of air, surface, and undersea assets needed to perform robust antisubmarine warfare operations. Other potential offensive missions in contested littoral settings, such as strategic mining, appear to favor forces most capable of operating in shallow waters. This may be an area where smaller submersibles, whether manned or unmanned, will provide a unique mission contribution.

This finding may also hold for the fourth mission area, special missions, highlighted above. Both mine countermeasures and offensive mining might ultimately prove well-suited to unmanned undersea vehicles. Depending on how various technologies progress, other shallow-water missions, such as electronic force support or intelligence, surveillance, and reconnaissance, may also be achievable with unmanned systems.[111] Larger UUVs or manned submarines will likely be

preferred for special operations forces insertion, and for some intelligence and support operations. For the United States, the key question in this area is the speed with which usable unmanned systems can be developed and acquired at scale, entering the active inventory with well-considered employment doctrine. Impending SSGN retirements make this is a time-urgent consideration, as they play an important role with respect to special operations delivery today.

Within the context of the four-mission typology described above, it appears that the U.S. undersea posture faces its most substantial gaps with respect to attack operations in littoral settings. In particular, U.S. forces should consider the following measures to strengthen their posture vis-à-vis growing Russian and Chinese A2/AD capabilities:

- *Develop a mixed submarine force structure*. In an ideal world, the Navy would procure a larger SSN fleet to support its expanding undersea requirements. And should the incoming Trump Administration successfully increase the Defense Department top-line, this should become an unambiguous acquisition priority. The *Virginia* attack boats are quiet, fast, and capable; the gold standard. But at $2.7 billion per boat, in the absence of surplus domestic shipyard capacity, and without substantially greater naval procurement resources, this is not a feasible option.[112] Not surprisingly, the Chief of Naval Operations underscores the need to "explore alternative fleet designs," including varied payloads and both manned and unmanned platforms.[113] But the Navy's longstanding preference for nuclear attack submarines overlooks another available—and increasingly capable—option: the use of modern diesel-electrics as a near-term force multiplier.

  The last U.S. diesel, USS *Blueback*, retired from the active inventory in 1990. Yet, diesel-electric technology has progressed substantially over the past quarter-century. Over the past decade, Australia's *Collins*, Sweden's *Gotland*, India's *Kilo*, and other SSK types appear to have shown well in partner antisurface and antisubmarine warfare exercises.[114] They are capable of multirole operations or can specialize in a given mission area, with the potential to carry antiship or land attack missiles, torpedoes, mines, surveillance, or other combat systems. Current-generation hull designs offer the prospect of submerged endurance exceeding 30 days, total unrefueled endurance of up to 90 days, and quiet transit of several thousand nautical miles at greater than 20 knots. While vessels such as the German HDW *Type 212A* are optimized for shallow waters, with keel depths of just 30-40 feet, others such as the French DCNS *SMX-Ocean* concept are larger vessels geared toward endurance. Not only are SSKs proven in exercises and in demand by other navies, but they are also affordable at price points ranging from about $250 million to $750 million per copy.[115] Said differently, it may be possible to procure three or four high-end SSKs for about the same price as a single *Virginia* SSN or *Zumwalt*-class destroyer.

  Should Navy leadership treat this as a priority, the Navy could in principle field a new SSK squadron within a decade. While the gold-standard SSNs should remain the backbone of the undersea fleet, silver-standard SSKs could provide a cost-effective and

time-efficient way to bridge known and growing U.S. submarine force structure gaps. Such a course of action would likely prove challenging across the spectrum of doctrine, organization, training, materiel, leadership and education, personnel, facilities and policy (DOTMLPF-P) actions required. But the concept should nonetheless be explored more fully; at minimum, it should be dismissed with malice of forethought. This may be a case where playing the role of fast-follower in a commoditizing hull market, while retaining first-mover combat systems technology advantages, can help the United States maintain a powerful undersea warfighting advantage. It is consistent with the vision of both current Chief of Naval Operations Admiral John Richardson that the Navy "explore alternative fleet designs" and that of his predecessor, Admiral Jonathan Greenert, who highlighted the growing need for modular payloads conveyed by "dependable trucks" rather than "luxury-car" platforms.[116]

- *Build a combined undersea presence*. The most credible U.S. SSK operational employment concept begins with the premise of forward basing. To maximize time-on-station, SSKs will most effectively deploy from U.S. or allied bases in a forward operating theater rather than from the continental United States. They may have utility in the North Atlantic, Baltic Sea, Mediterranean Sea or other European settings; or in the Persian Gulf, Arabian Sea, Bay of Bengal, or other Near Eastern or South Asian sea lanes. But in a context of substantial and continuing Chinese naval enhancements, their greatest near- to mid-term utility is likely in the Pacific Command area of responsibility. Looking ahead to 2030, China intends to newly build 32 diesel-electric and nuclear submarines, and Russia 11. India and South Korea plan to acquire 10 and 9, respectively. Eleven other regional states plan to build or acquire an additional 36. All told, the greater Asia-Pacific region is becoming more crowded undersea, with clusters of activity in key regional waterways.[117]

  In principle, U.S. diesel-electrics could be home-ported in Honolulu or Guam, conduct patrols in theater and resupply through regional U.S. friends and allies.[118] More effective, however, would be to home-port an SSK squadron in Japan and possibly a second squadron in Australia, the Philippines, or Thailand. Such an arrangement would provide enhanced coverage of both the East and South China Seas and neighboring waterways. James Holmes takes the idea one step further, noting that Japan's *Soryu*-class SSK could serve as a "logical common platform around which to build a combined SSK squadron."[119] A combined squadron would help build partner capacity while enhancing the U.S. undersea theater posture. It would raise the operational risks to China's A2/AD posture, affording greater allied access options and strengthening conventional deterrence prospects.

- *Accelerate fielding of unmanned systems*. At the same time, the Navy should continue to push development of unmanned systems. In its 2009 review of the Navy's UUV plan, RAND found, among other things, that mine countermeasures would probably be "the best match between warfighter needs and UUV capabilities," that the technical

challenges for complex intelligence, surveillance, and reconnaissance missions "are daunting," and that the goal of using UUVs for time-critical strike "appears unrealistic."[120] Over the past decade, the state of critical enabling technologies has improved considerably and particular UUV mission prospects may now be stronger.[121] The Navy has established a new Unmanned Systems Directorate (N99), refined its concept for a family of unmanned systems, used a UUV to meet a theater operational need,[122] and committed to delivering two large-diameter UUV prototypes by 2019.[123] It has budgeted roughly $3 billion over the next several years for the Office of Naval Research to build an "Eisenhower highway network" of UUV undersea infrastructure,[124] and more than $600 million between fiscal years 2017-21 for UUV "distributed lethality" research and development.[125] While the Navy's ultimate ability to realize its ambitious vision is not yet clear, it is clear that the Secretary of the Navy views widespread use of unmanned vehicles—undersea, air, surface—as a strategic goal.[126]

Arguably, the Navy has embraced a vision in which *undersea* transcends *submarines*; and a $3B infrastructure commitment will help it realize its ambitious vision in the outyears. But a resource base of just $120 million per year for distributed lethality over the next five suggests more in the way of continued experimentation than deployment of robust capabilities. And there clearly are some intriguing concepts and approaches that probably warrant further consideration. Rear Admiral Jabaley invokes the imagery of sharks and remoras for manned submarines and unmanned systems, while Peter Singer observes that "we're just now scratching the surface in terms of what kind of robotics we can use, how many we might have, and how we can use them . . . particularly in undersea weapons."[127]

But it is important to calibrate expectations carefully. While UUVs could ultimately become a potent force multiplier for surface and undersea naval systems, neither the defense nor the commercial markets are substantial enough to suggest that UUVs will play more than a niche or stop-gap role for the next several years. Growth is likely, with the global commercial market forecast to rise from about $2.29 billion in 2015 to $4 billion by 2020.[128] At the same time, Fred Byus observes that while relevant technology is ready to transition from the laboratory to the fleet, the Department of Defense continues to buy technology in "onesies and twosies" which risks it "getting stuck in limbo."[129] Needed is a concerted effort to prioritize unmanned undersea investments in a manner that best resolves identified theater warfighting gaps. Among the leading areas where unmanned systems may ultimately play a significant role: mine countermeasures, where capacity shortfalls loom larg; and intelligence, surveillance, and reconnaissance, an area of growing consumer demand in multiple operational theaters.

- *Develop and field an improved submarine-launched antiship missile*. The Navy seeks to extend its ability to hold adversary targets at risk from greater range—to "grow longer arms." The current submarine-launched UGM-84 Harpoon, a subsonic sea-skimming

cruise missile, carries a 488-pound warhead an estimated 134 nautical miles.[130] While this inventory weapon probably suffices for some operational taskings, it does not compare favorably to China's YJ-18 or to Russia's Kalibr supersonic cruise missiles, which carry a 660-pound warhead up to 290 nautical miles and a 440-pound warhead up to 410 nautical miles, respectively.[131] The Kalibr can also be used as an antisubmarine missile, which provides an asymmetric attack option. While the AGM-158C Long-Range Anti-Ship Missile provides an improved long-range strike option for Navy surface and aviation assets,[132] the submarine force relies on shorter-range systems—the Harpoon and Mk-48 torpedo—for antisurface warfare.[133] For American submarines to play a stronger antiship role, they must find a way to extend their reach.

Fortunately, the Navy has options to fill this growing need. As a starting point, it could rediscover the RGM/UGM-109B Tomahawk Anti-Ship Missile, a subsonic cruise missile which carried a 1,000-pound warhead more than 900 nautical miles when retired from the active inventory in 1990.[134] While this version of the Tomahawk is no longer in production, the Navy remains a customer for the land-attack variant; and Navy officials have expressed support for a modern Maritime Tomahawk Strike weapon.[135] Moreover, Raytheon has signaled that it will probably compete in the next-generation offensive antisurface warfare missile contest slated for fiscal year 2017.[136] Alternatively, should the Navy seek other option, it could seek to leverage the Army's ongoing efforts to modernize the MGM-168 Army Tactical Missile System, pursue a range-extension option for the Harpoon, or develop a new supersonic cruise missile.[137]

- *Offset the coming submarine-launched land-attack capability gap*. Submarines have played an important land-attack role over the past four decades, so the impending decline in SSGN force structure will hamper Joint operations. The Virginia Payload Module is a welcome addition to the mix, but more can and should be done to retain the existing conventional long-range strike capacity. One option to consider is permanent forward-basing of the SSGN fleet at U.S. naval installations in the Pacific, Central, and/or European theaters of operation. In principle, even as SSGNs and improved *Los Angeles* SSNs are decommissioned from active service, they could remain viable for an extended period as pier-side launch platforms at forward operating bases in, for example, Bahrain or Saudi Arabia, Singapore or South Korea, Greece or Norway. Treating these platforms as sea-based silos housing long-range conventional cruise missiles would go a long way toward bridging the looming force structure gap and continue to provide U.S. and allied theater commanders an important force multiplier.

  The Joint force could address the precipitous decline in available long-range strike capacity in other ways as well. For example, the Navy could take a page from the Russian playbook and augment its capacity through containerized surface-launch options.[138] Moreover, the Army's emergent "multi-domain battle" concept reportedly calls for use of land-based antiship missiles, an idea that could also feature a land-attack capability.[139] Similarly, the "arsenal plane" and related concepts proposed by the

Strategic Capabilities Office and Air Force could provide a long-range conventional air option in the years ahead.[140] But at the end of the day, a mobile, forward-deployable, covert option is both a necessary and preferred ingredient for theater plans. A robust undersea capability would avoid the use-it-or-lose-it challenges associated with raid-density scenarios, would be more difficult for an adversary to preempt, and would provide theater commanders maximum operational flexibility.

- *Rediscover the warfighting utility of strategic mining*. Russia, China, North Korea, Iran, and other states have embraced mine warfare in naval settings, a potentially powerful area-denial capability.[141] For example, Chinese analysts have reportedly considered favorably the lessons of *Operation Starvation*, a late-World War II aerial mining campaign designed to curtail Japan's wartime supply effort.[142] According to Andrew Erickson, Lyle Goldstein, and William Murray, Chinese naval strategists contend that sea mines are "easy to lay and difficult to sweep; their concealment potential is strong; their destructive power is high; and the threat value is long-lasting."[143] Among other things, they see warfighting utility in placing as many as 10,000-14,000 mines in a Taiwan blockade scenario. At the same time, only a small portion of the U.S. fleet is dedicated to mine countermeasures and the United States "took its eye off the ball" with respect to the "technological backwater" of maritime mine warfare.[144]

  As a result, the fleet has only recently begun to rediscover the potential utility of and emerging need for a strategic mining capability. During the Cold War, the United States maintained an active inventory of mines designed for offensive and defensive employment. Yet by the late-2000s, the Navy planned to phase-out the Mk-67 Submarine-Launched Mobile Mine, together with other offensive mine warfare capabilities. The Chief of Naval Operations intervened, however, preserving the residual Mk-67 inventory and the sole-remaining submarine employment option.[145] It is time for the Navy to embrace its longstanding role in mine warfare, both through manned and unmanned undersea systems. Strategic mining has the potential to become a valuable area-denial capability that complicates adversary planning, raises the risks and costs of military operations to the adversary, and increases the chances that U.S. and allied forces will be able to deny the adversary a quick victory on the modern battlefield. Said differently, it is time to re-learn an old lesson: that by strengthening the nation's warfighting posture, such capabilities enhance conventional deterrence.

- *Fill the gap in theater special operations undersea delivery.* While the 2020s-era retirement of SSGNs from active duty will leave a significant hole in the Navy's forward-deployable land-attack capability, it will also curtail its ability to support special operations missions. Their current ability to provide clandestine insertion and retrieval of up to 66 special forces personnel is an important capacity loss in this area.[146] Against this backdrop, the Chairman of the Joint Chiefs of Staff calls on the Joint force to "pioneer new ways to combine and employ emergent capabilities such as special forces."[147] While they have been integral to a prolonged global counterterrorism fight

for a decade-and-a-half, this 56,000-strong element of the Joint force will be equally critical in the emergent era of great power competition.

Should the Navy proceed with the proposed forward-deployed SSK squadrons, it may be possible to configure one or more of the new vessels for this mission need. Alternatively, the *Virginia* SSNs can take advantage of a reconfigurable torpedo room to covertly transport a smaller set of special forces personnel to maritime forward operating locations.[148] In either case, the Special Operations Command seeks to acquire two new types of mini-submersible for close-in littoral maneuvers. The Shallow Water Combat Submersible, designed to replace the legacy Mk-8 Seal Delivery Vehicle, can reportedly carry six or more special operators across relatively short distances. The Dry Combat Submersible, designed to travel up to 60 nautical miles while submerged up to 190 feet, extends the range and operating depth of the Shallow Water vessel.[149] The commander of the Special Operations Command, General Joseph Votel, views these as "critical procurement programs."[150] But their utility is predicated on the ability of fleet forces—and submarines in particular—to execute clandestine delivery and recovery from forward operating areas. Providing sufficient capacity is therefore a critical enabler for Joint warfighting success in contested environments.

- *Enhance the U.S. antisubmarine warfare posture*. Even as the Navy seeks to augment its offensive undersea capacity, it must ramp-up its defensive posture. Reviewing NATO's antisubmarine warfare posture in Europe, the Center for Strategic and International Studies sees "real and worrying decreases" in the group's collective ability to reliably track, deter, and counter Russia's undersea forces due to a "lack of investments in readiness and materiel over the past decade and a half."[151] The bad news, of course, is that the antisubmarine capabilities afforded through NATO's common defense posture is probably stronger than those available through the web of U.S. bilateral alliances that characterizes East Asian security architecture—even as the Chinese undersea threat is growing more quickly. It is here where the rapid rise of quiet diesel-electric attack boats is of critical importance. Says former antisubmarine warfare operations officer Jerry Hendrix, "How loud is your flashlight?"[152]

  This is a modern twist on the century-old hinder/finder competition. While antisubmarine operations in deep-water allow for the full-range of air, surface, and undersea capabilities, those in littoral settings generally are more limited. American antisubmarine warfare conducted in, for example, the Yellow or Baltic Seas will be comparatively constrained by amassed Chinese or Russian A2/AD systems. Moreover, shallow-water operations limit acoustic propagation and the resulting performance of active and passive sonars.[153] While UUVs can serve as force multipliers, also important are surface capabilities such as the antisubmarine warfare module designed for the Littoral Combat Ship and developmental programs such as DARPA's Sea Hunter, a continuous trail unmanned surface vessel, and airborne patrols by P-8, MH-60, and other aircraft.[154] At the same time, enhanced onboard computation and other

capabilities may enable improvements to both acoustic and non-acoustic detection.[155] While prolonged under-investment in this mission area was understandable in light of competing defense priorities over the past two decades, it should become a greater investment priority in light of growing undersea competition. For Captain Charlie Williams, deputy for weapons and sensors in the Navy Surface Warfare Directorate, "we must reclaim the [antisubmarine warfare] battlespace if we are going to be successful in this new era . . . we must adapt."[156] To do so, the Navy requires a more robust ASW force complement and a stepped-up training and exercise regimen.

- *Finally, full-speed ahead on an operating concept for the "anti-A2/AD force*." Over the past five years, Department of Defense components have developed various operating concepts and doctrinal approaches calibrated to the emerging A2/AD threat landscape. The *Joint Operational Access Concept* establishes the broad set of capabilities required, while the *Joint Concept for Access and Maneuver in the Global Commons* and the *Joint Concept for Entry Operations* address how the Joint force is positioning to address anti-access and area-denial challenges, respectively.[157] The Navy and Marine Corps are currently developing a concept for operations to address how "an integrated force operating from dispersed locations both ashore and afloat will achieve local sea control and power projection into contested littoral areas."[158]

  Taken together, this body of work provides a reasonable foundation for systematic development of an operating concept for what Submarine Forces Commander Tofalo calls the "anti-A2/AD force." The proposed concept would flesh out in greater detail the undersea community's specific contributions in the emergent context of Joint and combined theater operations. These might include, for example: intelligence collection, electronic force support, precision strike of land targets, maritime interdiction, surface fleet protection, strategic mining, and/or other operational support activities. Treating this as a "living" concept is important in light of continuing budgetary pressures and expanding mission needs set against a backdrop of evolving U.S. and adversary undersea capabilities. Moreover, as Under Secretary of the Navy Janine Davidson observes, different theaters present different challenges; so a one-size-fits-all approach is insufficient.[159] Because theater A2/AD operating environments and associated command priorities will vary, the concept should look across the Pacific, Central, and European theaters of operation. At the same time, theater-specific experimentation campaigns can help shape a commander's warfighting options, theater security engagement priorities, operational risk calculus, and deliberate planning activities, as well as the Navy's out-years undersea investment portfolio.

While progress in these nine areas will enhance the nation's undersea posture, continued vigilance is required as adversary forces continue to improve. The century-old hider/finder competition is thriving. As with challenges in the air, land, sea, space, cyber and broader electromagnetic domains, America's continued undersea dominance is neither an entitlement nor a given. But it is achievable, and represents one of the more important investments the

nation can make to advance its deterrence and warfighting strategies for operations in contested security environments. Said differently, the silent service's unique capabilities are integral to the nation's ability to project power; and their robustness will determine whether the United States can continue to succeed in this quest despite adversary anti-access and area-denial capability advances.

America's innate ability to cultivate novel technologies and develop outside-the-box operational concepts is not in question. But in the current budget-constrained and mission-expansive landscape, it must prioritize its efforts and resource to effect. The silver lining in today's resource crunch: senior leaders have an opportunity to chart a new course forward, to think differently about how the nation should reconfigure its operational posture for emerging security challenges. While not a panacea, the recommendations above will help the Navy navigate the choppy waters ahead—and prolong U.S. undersea superiority.

NOTES

[1] Statement of Rear Admiral Charles Richard and Rear Admiral Michael Jabaley on Naval Dominance in Undersea Warfare before the House Armed Services Committee, Seapower and Projection Forces Subcommittee, July 14, 2016 (http://docs.house.gov/meetings/AS/AS28/20160714/105204/HHRG-114-AS28-Wstate-JabaleyUSNM-20160714.pdf), p. 3.
[2] Deputy Secretary of Defense speech, "The Third U.S. Offset Strategy and Its Implications for Partners and Allies," event hosted by the Center for a New American Security, Washington, D.C., January 28, 2015 (http://www.defense.gov/News/Speeches/Speech-View/Article/606641/the-third-us-offset-strategy-and-its-implications-for-partners-and-allies).
[3] Dave Majumdar, "Chief of Naval Operations Richardson: US Navy is Focusing on Enemy Submarine Threat," *The National Interest*, August 30, 2016 (http://nationalinterest.org/blog/the-buzz/chief-naval-operations-richardson-us-navy-focusing-enemy-17522).
[4] Dave Majumdar, "Russia's Submarine Force is Back: How Worried Should America Be?" *The National Interest*, July 5, 2016 (http://nationalinterest.org/blog/the-buzz/russias-submarine-force-back-how-worried-should-america-be-16858).
[5] Under Reagan, the number of U.S. SSNs peaked at 98 against a planning requirement of 100. See Ronald O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress*, Congressional Research Service report RL32418, May 27, 2016 (https://www.fas.org/sgp/crs/weapons/RL32418.pdf), p. 2.
[6] Majumdar, "Chief of Naval Operations Richardson: US Navy is Focusing on Enemy Submarine Threat."
[7] Vice Admiral Michelle Howard, then Vice Chief of Naval Operations, suggested in March 2016 that "China building an undersea fleet and Russia modernizing a fleet" made it "quite likely that this requirement of 48 SSNs might also go up." See Justin Doubleday, "Navy will complete updated Force Structure Assessment this month," *Inside the Navy*, September 19, 2016 (http://insidedefense.com/inside-navy/navy-will-complete-updated-force-structure-assessment-month); and Dave Majumdar, "The Verdict is In: The U.S. Navy Needs to Get Bigger (and Needs More Submarines," *The National Interest*, October 27, 2016 (http://nationalinterest.org/blog/the-buzz/the-verdict-the-us-navy-needs-get-bigger-needs-more-18200).
[8] Department of Defense, *2017 Defense Posture Statement: Taking the Long View, Investing for the Future*, February 2016, p. 3. (http://www.defense.gov/Portals/1/Documents/pubs/2017DODPOSTURE_FINAL_MAR17UpdatePage4_WEB.PDF).
[9] Sydney Freedberg Jr., "Navy Seeks 2nd Attack Sub in 2021," *Breaking Defense*, July 8, 2016 (http://breakingdefense.com/2016/07/navy-seeks-2nd-attack-sub-in-2021/); and https://www.youtube.com/watch?v=yfrrYcphFBo.
[10] Rob Siltanen, "The Real Story Behind Apple's 'Think Different' Campaign," *Forbes*, December 14, 2011 (http://www.forbes.com/sites/onmarketing/2011/12/14/the-real-story-behind-apples-think-different-campaign/#a42730855c22).
[11] Statement of Bryan Clark on "Game Changers—Undersea Warfare" before the House Armed Services Seapower and Projection Forces Subcommittee, October 27, 2015 (http://csbaonline.org/publications/2015/10/undersea-warfare-game-changers/). Chief of Naval Operations Admiral Jonathan Greenert warned in 2014 that while "the undersea environment is the one domain in which the United States has clear maritime superiority," this superiority "will not go unchallenged" (http://www.ndia.org/Divisions/Divisions/UnderseaWarfare/Documents/newsletter%20-%20fall%202014.pdf).
[12] Department of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense*, January 2012 (http://archive.defense.gov/news/Defense_Strategic_Guidance.pdf), pp. 4-5. See also Joint Chiefs of Staff, *The National Military Strategy of the United States of America*, June 2015 (http://www.jcs.mil/Portals/36/Documents/Publications/2015_National_Military_Strategy.pdf), pp. 7, 10-11.
[13] Department of Defense, *2017 Defense Posture Statement*, pp. 3, 5.
[14] Joint Chiefs of Staff, *Joint Operating Environment 2035: The Joint Force in a Contested and Disordered World*, July 14, 2016, pp. 27-29 (http://www.dtic.mil/doctrine/concepts/joe/joe_2035_july16.pdf).

[15] Department of Defense, *Joint Operational Access Concept*, v1.0, January 17, 2012 (http://www.defense.gov/Portals/1/Documents/pubs/JOAC_Jan%202012_Signed.pdf), pp. i-ii

[16] Department of Defense, *Joint Operational Access Concept*, pp. 34-36. See also Department of Defense Air-Sea Battle Office, *Air-Sea Battle*, May 2013 (http://archive.defense.gov/pubs/ASB-ConceptImplementation-Summary-May-2013.pdf); and Joint Chiefs of Staff, *Joint Concept for Entry Operations*, 7 April 2014 (http://www.dtic.mil/doctrine/concepts/joint_concepts/jceo.pdf).

[17] Statement of Rear Admiral Charles Richard and Rear Admiral Michael Jabaley on Naval Dominance in Undersea Warfare, p. 3.

[18] U.S. Navy, *Commander's Intent for the United States Submarine Force and Supporting Organizations*, December 2015, p. 2 (http://www.public.navy.mil/subfor/hq/Documents/Commander's%20Intent%20DEC%202015.pdf).

[19] COMSUBFOR Change of Command, VADM Joseph Tofalo, Norfolk, VA, September 11, 2015 (http://www.navalsubleague.com/assets/tsrnovember2015webfinal.pdf).

[20] Department of Defense, *Nuclear Posture Review Report*, April 2010 (http://www.defense.gov/Portals/1/features/defenseReviews/NPR/2010_Nuclear_Posture_Review_Report.pdf), p. 22. See also Ronald O'Rourke, *Navy Columbia-Class (Ohio Replacement) Ballistic Missile Submarine (SSBN[X]) Program: Background and Issues for Congress*, Congressional Research Service report R41129, August 18, 2016 (https://www.fas.org/sgp/crs/weapons/R41129.pdf).

[21] O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement*, pp. 1-2.

[22] O'Rourke, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, Congressional Research Service report RS21007, May 22, 2008 (https://www.fas.org/sgp/crs/weapons/RS21007.pdf).

[23] U.S. 6th Fleet Public Affairs, "Navy Accomplishes Several Firsts During Operation Odyssey Dawn," April 11, 2011 (http://www.navy.mil/Submit/display.asp?story_id=59476).

[24] Statement of Rear Admiral Charles Richard and Rear Admiral Michael Jabaley on Naval Dominance in Undersea Warfare, p. 8.

[25] Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, Congressional Research Service report RL32665, May 27, 2016 (https://www.fas.org/sgp/crs/weapons/RL32665.pdf), p. 55

[26] Assistant Secretary of the Navy for Research, Development, and Acquisition Sean Stackley estimates that the Navy meets between 40-45 percent of current combatant commander demand for submarine services. Vice Admiral Joseph Malloy, Deputy Chief of Naval Operations for Integration of Capabilities and Resources, estimates that the requests from the commanders of the U.S. Pacific and European Commands are 55-60 percent met. See Naval Submarine League, *The Submarine Review*, June 2016 (http://www.navalsubleague.com/assets/tsrjunewebfinal6.2016.pdf), pp. 16, 32.

[27] Statement of Rear Admiral Charles Richard and Rear Admiral Michael Jabaley on Naval Dominance in Undersea Warfare, pp. 6-7, 9.

[28] SSGN elimination and SSN force reductions will essentially halve the existing submarine cruise missile capacity by 2028. Even with planned Virginia Payload Module enhancements to the *Virginia*-class SSNs, total cruise missile strike capacity will be roughly 17 percent lower in 2045 than today. See presentation of Rear Admiral Charles Richard to the Naval Submarine League, *The Submarine Review*, June 2016, p. 91.

[29] In contrast, the task force convened at the request of Rep. Barney Frank (D-MA) called in 2010 for a 230-ship Navy with 7 SSBNs and 37 SSNs. See Sustainable Defense Task Force, *Debt, Deficits, and Defense: A Way Forward*, June 11, 2010 (http://www.comw.org/pda/fulltext/1006SDTFreport.pdf).

[30] Stephen J. Hadley and William J. Perry, co-chairmen, *The QDR in Perspective: Meeting America's National Security Needs in the 21st Century*, U.S. Institute of Peace, 2010 (http://www.usip.org/sites/default/files/qdr/qdrreport.pdf), pp. 58-59

[31] Jacob Cohn and Ryan Boone, eds., *How Much is Enough? Alternative Defense Strategies*, Center for Strategic and Budgetary Assessments, 2016 (http://csbaonline.org/uploads/documents/CSBA6218_%28How_Much_is_Enough%29Final4-web.pdf), p. 29.

[32] Dave Majumdar, "Danger: America's Great Submarine Shortage in the Pacific," *The National Interest*, February 25, 2016 (http://nationalinterest.org/blog/the-buzz/danger-americas-great-submarine-shortage-the-pacific-15318).
[33] Patrick Tucker, "Navy Plans to Deploy a Submarine Drone Squadron by 2020," *Defense One*, October 27, 2015 (http://www.defenseone.com/technology/2015/10/navy-plans-deploy-submarine-drone-squadron-2020/123179/).
[34] Department of the Navy, *The Navy Unmanned Undersea Vehicle (UUV) Master Plan*, November 9, 2004 (http://www.navy.mil/navydata/technology/uuvmp.pdf), pp. 19-53
[35] Mark Pomerleau, "Navy outlines a path forward on unmanned systems," C4ISR, October 26, 2016 (http://www.c4isrnet.com/articles/navy-outlines-a-path-forward-on-unmanned-systems?utm_source=Sailthru&utm_medium=email&utm_campaign=DFN%20EBB%2010.27.16&utm_term=Editorial%20-%20Early%20Bird%20Brief).
[36] O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement*, pp. 10-11.
[37] "Military Doctrine of the Russian Federation," December 26, 2014, section 13b, at http://static.kremlin.ru/media/events/files/41d527556bec8deb3530.pdf.
[38] "Edict of the Russian Federation President on the Russian Federation's National Security Strategy," Moscow, December 31, 2015 (translation at http://www.ieee.ed/Galerias/fichero/OtrasPublicaciones/Internacional/2016/Russian-National-Security-Strategy-31Dec2015.pdf), clause 15.
[39] "Hybrid warfare" is the Western term of art. Russian literature uses the terms "new generation warfare" or "strategic deterrence" in this context. See Kristin Ven Bruusgaard, "Russian strategic deterrence," *Survival* 58, no. 4 (August-September 2016): 7-26.
[40] Jeffrey Mankoff and Andrew Kuchins, "Russia, Ukraine, and U.S. Policy Options: A Briefing Memo," Center for Strategic and International Studies, January 2015 (http://csis.org/files/publication/150129_Mankoff_RussiaUkraineUSOptions_Web.pdf), p. 2. In January 2016, at a market price of about $30 per barrel of oil, Finance Minister Anton Siluanov estimated that the 2016 Russian budget would balance at roughly an $82 per barrel price. See Daniel Schearf, "Medvedev: Russia's Economy Must Prepare for the Worst-Case Scenario," Voice of America news, January 13, 2016 (http://www.voanews.com/content/medvedew-russia-economy-must-prepare-for-worst-case-scenario/3143417.html).
[41] Sam LaGrone, "Russian Navy Chief: Submarine Patrols Up 50 Percent Over Last Year," USNI News, March 19, 2015 (http://news.usni.org/2015/03/19/russian-navy-chief-submarine-patrols-up-50-percent-over-last-year).
[42] Sam LaGrone, "CNO Greenert: Russian Navy 'Very Busy in the Undersea Domain," USNI News, November 4, 2014 (https://news.usni.org/2014/11/04/cno-greenert-russian-navy-busy-undersea-domain); BBC News, "Finland Drops Depth Charges in 'Submarine' Alert," April 28, 2015 (http://www.bbc.com/news/world-europe-32498790); Peter Walker, "Sweden Searches for Suspected Russian Submarine off Stockholm," *The Guardian*, October 19, 2014 (http://www.theguardian.com/world/2014/oct/19/sweden-search-russian-submarine-stockholm); Ben Farmer, "Britain Forced to Ask NATO to Track 'Russian Submarine' in Scottish Waters," *The Telegraph*, December 9, 2015 (http://www.telegraph.co.uk/news/uknews/defence/11283926/Britain-forced-to-ask-Nato-to-track-Russian-submarine-in-Scottish-waters.html); David E. Sanger and Eric Schmitt, "Russian Ships Near Data Cables Are Too Close for U.S. Comfort," *New York Times*, October 25, 2015 (http://www.nytimes.com/2015/10/26/world/europe/russian-presence-near-undersea-cables-concerns-us.html); and BBC News, "Russia hits targets in Syria from Mediterranean submarine," December 8, 2015 (http://www.bbc.com/news/world-middle-east-35041656).
[43] Thomas Gibbons-Neff, "Report: Russian sub activity returns to Cold War levels," *Washington Post*, February 4, 2016 (https://www.washingtonpost.com/news/checkpoint/wp/2016/02/04/report-russian-sub-activity-returns-to-cold-war-levels).
[44] Dave Majumdar, "Russia's Submarine Force is Back: How Worried Should America Be?" *The National Interest*, July 5, 2016 (http://nationalinterest.org/blog/the-buzz-russias-submarine-force-back-how-worried-should-america-be-16858).

[45] Lieutenant Commander Tom Spahn, "The Russian Submarine Fleet Reborn," U.S. Naval Institute *Proceedings*139, June 2013 (http://www.usni.org/magazines/proceedings/2013-06).
[46] Kathleen Hicks, Andrew Metrick, Lisa Sawyer Samp, and Kathleen Weinberger, *Undersea Warfare in Northern Europe*, Center for Strategic and International Studies, July 2016 (https://www.csis.org/analysis/undersea-warfare-northern-europe), pp. v, 2.
[47] LaGrone, "Russian Navy Chief."
[48] Vice Admiral James Foggo III, "The Fourth Battle of the Atlantic," U.S. Naval Institute, *Proceedings* 142, June 2016 (http://www.usni.org/print/87164).
[49] Sydney J. Freedberg, Jr., "Red Atlantic: Russia Could Choke Air, Sea Lanes to Europe," *Breaking Defense*, September 20, 2016 (http://breakingdefense.com/2016/09/red-atlantic-russia-could-choke-air-sea-lanes-to-europe/).
[50] Office of Naval Intelligence, *The Russian Navy: A Historic Transition*, December 2015 (http://oni.navy.mil/Intelligence-Community/Russia/), pp. ix-x.
[51] Office of Naval Intelligence, *The Russian Navy*, p. 17.
[52] Dave Majumdar, "Russia's Next Super Submarine is Almost Ready for War," *The National Interest*, March 27, 2016 (http://nationalinterest.org/blog/the-buzz/russias-next-super-submarine-almost-ready-war-15610).
[53] Bill Gertz, "Russia Tests Nuclear-Capable Drone Sub," *Free Beacon*, December 8, 2015 (http://freebeacon.com/national-security/russia-tests-nuclear-capable-drone-sub/?utm_source=RealClearDefense+Morning+Recon&utm_campaign=81e33330d0-EMAIL_CAMPAIGN_2016_12_07&utm_medium=email&utm_term=0_694f73a8dc-81e33330d0-84044145).
[54] Office of Naval Intelligence, *The Russian Navy*, pp. 17-19.
[55] Dave Majumdar, "Russia's Next Submarines Will Be Small, Super Stealthy, and Multirole?" The National Interest, October 7, 2016 (http://nationalinterest.org/print/blog/the-buzz/russias-next-submarines-will-be-small-super-stealthy-17964).
[56] TASS Defense, "Rebuilding Capabilities of Russian Navy to Be Long Process," Defense-Aerospace, September 6, 2016 (http://www.defense-aerospace.com/articles-view/feature/5/176765/rebuilding-russian-navy-capabilities-is-long-and-expensive.html).
[57] Hicks, Metrick, Samp, and Weinberger, *Undersea Warfare in Northern Europe*, pp. 2. At the same time, Russian leaders are reportedly considering as much as a 30 percent cut to the defense budget in 2017; so it is not clear how long the submarine force will continue to be insulated from downward pressure on defense spending. See Derek Bisaccio, "Russia Contemplates Large Defense Budget Cut," Forecast International, November 7, 2016 (http://www.defense-aerospace.com/articles-view/release/3/178580/russia-mulls-30-cut-to-defense-budget.html).
[58] Zachary Keck, "Russia's New Nuclear Submarines to Target U.S. Aircraft Carriers," *The National Interest*, July 6, 2015 (http://nationalinterest.org/blog/the-buzz/russia-building-aircraft-carrier-killer-nuclear-submarines-13266).
[59] Spahn, "The Russian Submarine Fleet Reborn"; Franz-Stefan Gady, "Putin's 'Red October': Russia's Deadliest New Submarine," *The Diplomat*, March 4, 2015 (http://thediplomat.com/2015/03/putins/red-october-russias-deadliest-new-submarine).
[60] Sam LaGrone, "Russian Mystery Submarine Likely Deployment Vehicle for New Nuclear Torpedo," USNI News, December 4, 2015 (https://news.usni.org/2015/12/04/russian-mystery-submarine-likely-deployment-vehicle-for-new-nuclear-torpedo).
[61] See Mark Schneider, *The Nuclear Forces and Policy of the Russian Federation* (Washington, D.C.: National Institute for Public Policy, 2006); and Jacek Durkalec, *Nuclear-Backed 'Little Green Men': Nuclear Messaging in the Ukrainian Crisis* (Warsaw: Polish Institute of International Affairs, July 2015).
[62] Dave Majumdar, "Russia's New Attack Submarines: Menace or Simply a Mirage?" *The National Interest*, August 5, 2016 (http://nationalinterest.org/blog/the-buzz/russias-new-attack-submarines-menace-or-simply-mirage-17256).
[63] Robert Beckhusen, "Russia's Got Deadly New Submarines," War Is Boring, June 6, 2013 (https://warisboring.com/russias-got-deadly-new-submarines-16ad17f45e60a#.wpu2sscjd).
[64] Hicks, et al., *Undersea Warfare in Northern Europe*, p. 11.
[65] Hicks, et al., *Undersea Warfare in Northern Europe*, p. 4.

[66] Remarks as delivered by Admiral Mark Ferguson at the Atlantic Council, October 6, 2015 (www.c6f.navy.mil/speech/remarks-delivered-adm-mark-ferguson-atlantic-council); Dave Majumdar, "Biggest Threat US Navy and NATO Face: Russian Subs and A2/AD," *The National Interest*, June 30, 2016 (http://nationalinterest.org/blog/the-buzz/biggest-threat-us-navy-nato-face-russian-subs-a2-ad-bastions-16808).
[67] Foggo, "The Fourth Battle of the Atlantic."
[68] John Schaus, Lauren Dickey, and Andrew Metrick, "Asia's Looming Subsurface Challenge," WarOnTheRocks, August 11, 2016 (http://warontherocks.com/2016/08/asias-looming-subsurface-challenge/). Grace Jean similarly finds that an "undersea arms race" has already begun in the Western Pacific. See idem., "Diesel-Electric Submarines, the U.S. Navy's Latest Annoyance," *National Defense*, April 2008 (http://www.nationaldefensemagazine.org/archive/2008/April/Pages/AntiSub2301.aspx).
[69] Franz-Stefan Gady, "PLAN Naval Drill: China Practices for 'Cruel and Short' War in East China Sea," *The Diplomat*, August 3, 2016 (http://thediplomat.com/2016/08/plan-naval-drill-china-practices-for-cruel-and-short-war-in-east-china-sea/); L. Todd Wood, "China wants to 'bloody nose' of U.S. in South China Sea," *Washington Times*, August 1, 2016 (http://www.washingtontimes.com/news/2016/aug/1/china-wants-bloody-nose-us-south-china-sea/). See also Nathan Beuchamp-Mustafaga, et al., "China Signals Resolve With Bomber Flights Over the South China Sea," WarOnTheRocks, August 2, 2016 (http://warontherocks.com/2016/08/china-signals-resolve-with-bomber-flights-over-the-south-china-sea/); David Axe, "China Launches a Stealth Invasion in the South China Sea," The Daily Beast, August 8, 2016 (http://www.thedailybeast.com/articles/2016/08/09/china-launches-a-stealth-invasion-in-the-south-china-sea.html); David E. Sanger and Rick Gladstone, "New Photos Cast Doubt on China's Vow Not to Militarize Disputed Islands," *New York Times*, August 8, 2016 (http://www.nytimes.com/2016/08/09/world/asia/china-spratly-islands-south-china-sea.html?_r=0).
[70] Due to a lack of government transparency, there are significant error bars in any such estimate for Chinese military spending. In actual terms, China's official defense budget for 2014 was $136.3B. Noting that this excludes several major categories of expenditure, such as foreign equipment and weapons procurement or research and development, the U.S. Department of Defense estimates $165B, or approximately 1.59 percent of gross domestic product. Other estimates generally range from Richard Bitzinger's 1.5 percent of gross domestic product to the Stockholm International Peace Research Institute's more than 2 percent over the last several years. See the SIPRI Military Expenditure Database, http://milexdata.sipri.org/result.php4; Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China, 2015*, p. 49; Richard A. Bitzinger, "China's Double-Digit Defense Growth," *Foreign Affairs*, March 19, 2015 (http://www.foreignaffairs.com/articles/143275/richard-a-bitzinger/chinas-double-digit-defense-growth).
[71] Director of National Intelligence James R. Clapper, Statement for the Record on the Worldwide Threat Assessment of the Intelligence Community before the Senate Armed Services Committee, February 26, 2015 (http://www.dni.gov/files/documents/Unclassified_2015_ATA_SFR_-_SASC_FINAL.pdf), p. 19.
[72] Office of the Secretary of Defense, *Annual Report to Congress* (http://www.defense.gov/Portals/1/Documents/pubs/2015_China_Military_Power_Report.pdf), p. i.
[73] Eric Heginbotham, et al., *U.S.-China Military Scorecard: Forces, Geography, and the Evolving Balance of Power, 1996-2017* (Santa Monica, CA: RAND, 2015), passim.
[74] Michael McDevitt, "Becoming a Great 'Maritime Power': A Chinese Dream," Center for International Maritime Security, July 19, 2016 (http://cimsec.org/becoming-great-maritime-power-chinese-dream/26671).
[75] Cited in Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century*, September 2015 (http://www.andrewerickson.com/wp-content/uploads/2016/02/ONI_PLAN_2015_Report_Interactive_Searchable.pdf).
[76] Dean Cheng, "China and Asian Maritime Security," testimony before the U.S. House of Representatives Committee on Foreign Affairs, Subcommittee on Asia and the Pacific, September 22, 2016 (http://docs.house.gov/meetings/FA/FA05/20160922/105354/HHRG-114-FA05-Wstate-ChengD-20160922.pdf).
[77] U.S.-China Economic and Security Review Commission, *2015 Report to Congress*, November 2015 (http://www.uscc.gov/Annual_Reports/2015-annual-report-congress), pp. 231-32.
[78] Keith Zhai and David Tweed, "China is Planning a Massive Sea Lab 10,000 Feet Underwater," *Bloomberg*, June 7, 2016 (http://www.bloomberg.com/news/articles/2016-06-07/china-pushes-plan-for-oceanic-space-station-in-south-china-sea).

[79] Ishaan Tharoor, "China may build an undersea train to America," *Washington Post*, May 9, 2014 (https://www.washingtonpost.com/news/worldviews/wp/2014/05/09/china-may-build-an-undersea-train-to-america/).
[80] Jeffrey Lin and P.W. Singer, "The Great Underwater Wall of Robots," *Popular Science*, June 22, 2016 (http://www.popsci.com/great-underwater-wall-robots-chinese-exhibit-shows-off-sea-drones).
[81] Lyle J. Goldstein, "A Frightening Thought: China Erodes America's Submarine Advantage," The National Interest, August 17, 2015 (http://nationalinterest.org/feature/frightening-thought-china-erodes-americas-submarine-13592?page=show). See also Elmi Ekmektsioglou and Matthew Hallex, "Chinese Submarines and U.S. Anti-Submarine Warfare Capabilities," August 27, 2011 (http://www.e-ir.info/2011/08/27/the-undersea-balance-in-the-western-pacific-chinese-submarines-and-u-s-anti-submarine-warfare-capabilities/).
[82] Lyle J. Goldstein, "China's 'Undersea Great Wall'," *The National Interest*, May 16, 2016 (http://nationalinterest.org/feature/chinas-undersea-great-wall-16222). See also David Axe, "China Has Begun Listening for American Submarines," War is Boring, April 13, 2014 (https://warisboring.com/china-has-begun-listening-for-american-submarines-448f7e04bbe1#.d65prael6).
[83] For example, on the role of sea mines in this context see Lyle J. Goldstein, "Old-School Killers: Fear China's Sea Mines," *The National Interest*, October 14, 2015 (http://nationalinterest.org/feature/old-school-killers-fear-chinas-sea-mines-14069); and idem., "Japan's Folly Could Be China's Gain in a War Against America," *The National Interest*, July 17, 2015 (http://nationalinterest.org/feature/japans-folly-could-be-chinas-gain-war-against-america-13356).
[84] Dave Majumdar, "Undersea Crisis: China Will Have Nearly Twice as Many Subs as the U.S.," *The National Interest*, February 26, 2016 (http://nationalinterest.org/blog/the-buzz/undersea-crisis-china-will-have-nearly-twice-many-subs-the-15335).
[85] Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2016*, April 2016 (http://www.defense.gov/Portals/1/Documents/pubs/2016%20China%20Military%20Power%20Report.pdf), p. 26.
[86] Andrew S. Erickson and Lyle J. Goldstein, "China's Future Nuclear Submarine Force: Insights from Chinese Writings," *Naval War College Review*, vol. 60, no. 1 (Winter 2007): 55; Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, Congressional Research Service report RL33153, June 17, 2016 (https://www.fas.org/sgp/crs/row/RL33153.pdf), p. 16.
[87] O'Rourke, *China Naval Modernization*, pp. 17, 85.
[88] Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century*, pp. 18-19; O'Rourke, *China Naval Modernization*, p. 17. Owen Cote assesses that Chinese SSKs will be used for coastal defense, offensive mine warfare, as a local source of communication and intelligence missions. See idem., "Assessing the Undersea Balance Between the United States and China," in Thomas G. Mahnken, ed., *Competitive Strategies for the 21st Century* (Stanford, CA: Stanford University Press, 2012), p. 184.
[89] Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century*, p. 19.
[90] Office of the Secretary of Defense estimates of the size and disposition of China's submarine fleet differs slightly from those of the Office of Naval Intelligence referenced in this table: 3 SSNs and 19 SSKs for the North Sea Fleet; and 4 SSBNs, 2 SSNs, and 20 SSKs for the South Sea Fleet. See OSD, *Annual Report to Congress*, p. 29.
[91] U.S.-China Economic and Security Review Commission, *2015 Report to Congress*, p. 242; O'Rourke, *China Naval Modernization*, p. 15.
[92] Office of Naval Intelligence, *The PLA Navy: New Capabilities and Missions for the 21st Century*, p. 20.
[93] Office of the Secretary of Defense, *Annual Report to Congress*, p. 26.
[94] Dave Majumdar, "Why the US Navy Should Fear China's New 093B Nuclear Attack Submarine," *The National Interest*, June 27, 2016 (http://nationalinterest.org/blog/the-buzz/why-the-us-navy-should-fear-chinas-new-093b-nuclear-attack-16741).
[95] https://manglermuldoon.blogspot.com/2015/02/sea-denial-analysis-of-csbas-proposal.html.
[96] Office of the Secretary of Defense, *Annual Report to Congress*, pp. 61, 69.
[97] Erickson and Goldstein, "China's Future Nuclear Submarine Force": 55.

[98] Office of Naval Intelligence (2009) graphic, excerpted from O'Rourke, *China Naval Modernization*, pp. 14-15. Acoustic propagation discussed at https://manglermuldoon.blogspot.com/2015/02/sea-denial-analysis-of-csbas-proposal.html.
[99] Cote, "Assessing the Undersea Balance," p. 185.
[100] Elias Groll and Dan de Luce, "China Is Fueling a Submarine Arms Race in the Asia-Pacific," *Foreign Policy*, August 26, 2016 (http://foreignpolicy.com/2016/08/26/china-is-fueling-a-submarine-arms-race-in-the-asia-pacific/). See also Schaus, Dickey, and Metrick, "Asia's Looming Subsurface Challenge," who estimate that 16 states in the Asia-Pacific region will field a total of 119 new diesel-electric and nuclear attack submarines by 2030.
[101] Jason D. Ellis, "Competitive Strategies and Modern U.S. Defense Policy," Lawrence Livermore National Laboratory, January 2016 (https://cgsr.llnl.gov/content/assets/docs/J_Ellis_Seizing_the_Initiative_1_16.pdf).
[102] President Xi Jinpeng, cited in Kevin Rudd, *U.S.-China 21: The Future of U.S.-China Relations Under Xi Jinping*, summary report, Belfer Center for Science and International Affairs, Harvard University, April 2015 (http://belfercenter.ksg.harvard.edu/files/Summary%20Report%20US--China%2021.pdf), p. 11.
[103] Secretary of Defense Chuck Hagel, "Defense Innovation Days," Opening Keynote, September 3, 2014 (http://www.defense.gov/Speeches/Speech.aspx?SpeechID=1877).
[104] "NUWC's Role in the Undersea Domain Operating Concept: Question & Answer with Don McCormack," *Undersea Warfare* 53, Winter 2014 (http://www.public.navy.mil/subfor/underseawarfaremagazine/Issues/Archives/issue_53/McCormack_QA.html).
[105] Bryan Clark, *The Emerging Era in Undersea Warfare* (Washington, D.C.: Center for Strategic and Budgetary Assessments, January 2015), p. 15 (http://csbaonline.org/publications/2015/01/undersea-warfare/).
[106] Chief of Naval Operations, *A Design for Maintaining Maritime Superiority*, v1.0, January 2016 (http://www.navy.mil/cno/docs/cno_stg.pdf), p. 4.
[107] Remarks of Secretary of Defense Ash Carter on "The Future of the Rebalance: Enabling Security in the Vital & Dynamic Asia-Pacific," delivered aboard the *USS Carl Vinson*, September 29, 2016 (http://www.defense.gov/News/Speeches/Speech-View/Article/959937/remarks-on-the-future-of-the-rebalance-enabling-security-in-the-vital-dynamic-a).
[108] Department of the Navy, *Undersea Warfare Science & Technology Strategy 2016*, September 2016 (http://defenseinnovationmarketplace.mil/resources/2016_USW_Strategy_Distro%20A.PDF), p. 7. See also Department of the Navy, *Undersea Warfare Science & Technology Objectives 2016*, September 2016 (http://defenseinnovationmarketplace.mil/resources/2016_USW_STOs_Distro%20A.PDF).
[109] Harry J. Kazianis, "This Could 'Sink' the U.S. Navy: Lethal Stealth Submarines," *The National Interest*, January 27, 2016 (http://nationalinterest.org/blog/the-buzz/could-sink-the-us-navy-lethal-stealth-submarines-15034).
[110] Roughly 95 percent of the world's population lives within 600 miles of a coastline, 70 percent within 300 miles; 60 percent of the world's most politically significant urban areas are located within 60 miles. See Milan Vego, "On Littoral Warfare," *Naval War College Review*, vol. 68, no. 2 (Spring 2015): 31.
[111] Reportedly, almost all voice and Internet traffic, including military transmissions and more than $4 trillion per year in financial transactions, travel through more than 300 transoceanic fiber-optic cables placed along the seabed. See Brian Fung and Andrea Peterson, "America uses stealthy submarines to hack other counties' systems," *Washington Post*, July 29, 2016 (https://www.washingtonpost.com/news/the-switch/wp/2016/07/29/america-is-hacking-other-countries-with-stealthy-submarines/); and Bryan Clark, "Undersea cables and the future of submarine competition," *Bulletin of the Atomic Scientists*, vol. 72, no. 4, 2016 (http://csbaonline.org/2016/06/15/undersea-cables-and-the-future-of-submarine-competition).
[112] The $2.7 billion estimate represents the average price of the two *Virginia*-class boats requested in fiscal year 2017. See O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement*, executive summary. On infrastructure limitations, see Richard R. Burgess, "Delivering on the Vision," *Seapower Magazine*, September 2016 (http://www.seapower-digital.com/seapower/september_2016?pg=44#pg44): 42-44; and Sydney J. Freedberg Jr., "Sub Builders Face Triple Threat: Ohio, Virginia, & VPM," *Breaking Defense*, February 26, 2015 (http://breakingdefense.com/2015/02/sub-builders-face-triple-threat-ohio-virginia-vpm/).
[113] Chief of Naval Operations, *A Design for Maintaining Maritime Superiority*, p. 6.
[114] Dave Majumdar, "Revealed: Russian-Built Kilo Submarine 'Kills' American Nuclear Sub," *The National Interest*, December 1, 2015 (http://nationalinterest.org/blog/the-buzz/revealed-russian-built-kilo-submarine-kills-american-

nuclear-14473); Winslow Wheeler, "More Than the Navy's Numbers Could Be Sinking," *Time*, December 4, 2010 (http://nation.time.com/2012/12/04/more-than-the-navys-numbers-could-be-sinking/); Tyler Rogoway, "Sweden Has a Sub That's So Deadly the US Navy Hired It to Play Bad Guy," Foxtrot Alpha, October 23, 2014 (http://foxtrotalpha.jalopnik.com/sweden-has-a-sub-thats-so-deadly-the-us-navy-hired-it-t-1649695984).

[115] https://defenseissues.wordpress.com/2013/03/03/aip-vs-nuclear-submarines/; Jonathan O'Callaghan, "Death of the nuclear submarine? Huge diesel-electric could replace other subs thanks to its stealth and efficiency," *Daily Mail*, November 4, 2014 (http://www.dailymail.co.uk/sciencetech/article-2820348/The-death-nuclear-submarines-Huge-diesel-electric-vessel-used-replace-subs-stealthy.html); Tyler Rogoway, "Is This Jumbo Diesel Electric Submarine a True Nuclear Alternative?" Foxtrot Alpha, November 3, 2014 (http://foxtrotalpha.jalopnik.com/is-this-jumbo-diesel-electric-submarine-a-true-nuclear-1652659060); Milan Vego, "The Right Submarine for Lurking in the Littorals," *Proceedings*, June 2010 (https://www.usnwc.edu/getattachment/2ef40db5-8e8e-4773-b382-ef19ab2849cd/VEGO--THE-RIGHT-SUBMARINE-FOR-LURKING-IN-THE-LITTO.aspx).

[116] Admiral Jonathan Greenert, "Payloads over Platforms: Charting a New Course" *Proceedings*, July 2012 (http://www.usni.org/magazines/proceedings/2012-07/payloads-over-platforms-charting-new-course).

[117] Schaus, et al., "Asia's Looming Subsurface Challenge."

[118] Another possibility would be to acquire additional submarine tenders, which enable the prospect of temporary forward resupply bases. See Mackenzie Eaglen and Jon Rodeback, "Submarine Arms Race in the Pacific: The Chinese Challenge to U.S. Undersea Supremacy," The Heritage Foundation, *Backgrounder* no. 2367, February 2, 2010 (http://www.heritage.org/research/reports/2010/02/submarine-arms-race-in-the-pacific-the-chinese-challenge-to-us-undersea-supremacy).

[119] James Holmes, "U.S. Submarines: Run Silent, Run Deep…On Diesel Engines?" *The National Interest*, September 18, 2016 (http://nationalinterest.org/feature/us-submarines-run-silent-run-deepon-diesel-engines-11306). See also Kyle Mizokami, "Why Japan's Soryu-Class Submarines Are so Good," The National Interest, October 1, 2016 (http://nationalinterest.org/blog/the-buzz/why-japans-soryu-class-submarines-are-so-good-17898).

[120] Robert W. Button, John Kamp, Thomas B. Curtin, and James Dryden, *A Survey of Missions for Unmanned Undersea Vehicles*, RAND report MG808, 2009 (http://www.rand.org/content/dam/rand/pubs/monographs/2009/RAND_MG808.pdf), pp. xxvi, 73, and 97.

[121] Marjorie Greene, "Unmanned Systems: a New Era for the U.S. Navy?" Center for International Maritime Security, July 18, 2016 (http://cimsec.org/unmanned-systems-new-era-u-s-navy/26256); and Kris Osborn, "New Evolving Navy Drone Strategy Envisions More Autonomy, Faster Processing," Scout Warrior, June 7, 2016 (http://www.scout.com/military/warrior/story/1676543-navy-discusses-new-attack-drone-strategy).

[122] While details are not publicly available, Project 1319 entailed the "first operational employment of a UUV from a submarine in a tactical situation real-world mission for a combatant commander." See presentation of Rear Admiral Michael Jabaley to the Naval Submarine League, *The Submarine Review*, June 2016, p. 109.

[123] Lee Hudson, "Navy to use phased rapid prototyping approach for LDUUV," *Inside the Navy*, September 12, 2016 (https://insidedefense.com/inside-navy/navy-use-phased-rapid-prototyping-approach-lduuv).

[124] Jane Edwards, "Report: DoD Eyes $3B Investment for Underwater Drone Development," ExecutiveGov, November 28, 2016 (http://www.executivegov.com/2016/11/report-dod-eyes-3b-investment-for-underwater-drone-development/); Christian Davenport, "Drone warfare heads under the seas as U.S. seeks advantage over rivals," *The Washington Post*, November 24, 2016 (https://www.washingtonpost.com/business/economy/drone-warfare-heads-under-the-seas-as-us-seeks-advantage-over-rivals/2016/11/24/9f756572-9c61-11e6-b3c9-f662adaa0048_story.html?utm_term=.89461a6b65e3).

[125] Mark Pomerleau, "DOD plans to invest $600M in unmanned underwater vehicles," Defense Systems, February 4, 2016 (https://defensesystems.com/articles/2016/02/04/dod-navy-uuv-investments.aspx).

[126] Department of the Navy, "Use and Acquisition of Unmanned Systems in the Department of the Navy," terms of reference for the Naval Research Advisory Committee, July 7, 2016 (https://insidedefense.com/document/nrac-terms-reference-memo-unmanned-systems-study).

[127] Caroline Houck, "The Navy's Future Submarines May Go to Sea with Robot Remoras," DefenseOne, July 17, 2016 (http://www.defenseone.com/technology/2016/07/navys-future-submarines-may-go-sea-robot-remoras/129966/). See also Patrick Tucker, "Why Eel Drones Are the Future of Naval Warfare," DefenseOne,

December 4, 2014 (http://www.defenseone.com/technology/2014/12/why-eel-drones-are-future-naval-warfare/100500/).
[128] http://www.marketsandmarkets.com/PressReleases/unmanned-underwater-vehicles.asp.
[129] Sandra I. Erwin, "Underwater Robots: Will the Pentagon Miss the Boat?" *National Defense*, September 27, 2016 (http://www.nationaldefensemagazine.org/blog/Lists/Posts/Post.aspx?ID=2316).
[130] https://en.wikipedia.org/wiki/Harpoon_%28missile%29.
[131] https://en.wikipedia.org/wiki/YJ-18; https://en.wikipedia.org/wiki/3M-54_Klub.
[132] https://en.wikipedia.org/wiki/AGM-158C_LRASM.
[133] The estimated effective firing range of the Mk-84 is between 21 and 27 nautical miles. See https://en.wikipedia.org/wiki/Mark_48_torpedo.
[134] https://en.wikipedia.org/wiki/Tomahawk_%28missile%29.
[135] Kris Osborn, "Navy Accelerates New Active Seeker Attack Tomahawk," Scout Warrior, November 2, 2016 (http://www.scout.com/military/warrior/story/1723865-navy-accelerates-new-active-seeker-tomahawk?utm_source=RealClearDefense+Morning+Recon&utm_campaign=2bd93e1039-EMAIL_CAMPAIGN_2016_11_02&utm_medium=email&utm_term=0_694f73a8dc-2bd93e1039-84044145); Justin Doubleday, "Navy begins surveying industry for Tomahawk missile replacement," *Inside Defense*, November 7, 2016 (http://insidedefense.com/daily-news/navy-begins-surveying-industry-tomahawk-missile-replacement).
[136] Sam LaGrone, "Navy: Raytheon Tomahawk Likely to Compete in Next Generation Anti-Ship Missile Contest," USNI, August 5, 2015 (https://news.usni.org/2015/08/05/navy-raytheon-tomahawk-likely-to-compete-in-next-generation-anti-ship-missile-contest).
[137] http://www.ibtimes.com/lockheed-martin-wins-174m-contract-atacms-missiles-us-army-uae-1921778; https://en.wikipedia.org/wiki/MGM-140_ATACMS.
[138] https://www.youtube.com/watch?v=ATHhsrH16VQ.
[139] Sydney J. Freedberg Jr., "What Lessons Do China's Island Bases Offer the US Army?" *Breaking Defense*, May 5, 2016 (http://breakingdefense.com/2016/05/chinese-island-bases-show-the-way-for-us-army/); Sydney J. Freedberg Jr., "DepSecDef Work Offers Dough for Army Multi-Domain Battle," *Breaking Defense*, October 4, 2016 (http://breakingdefense.com/2016/10/depsecdef-work-offers-dough-for-army-multi-domain-battle/); Sydney J. Freedberg Jr., "Army's 'Multi-Domain Battle': Jamming, Hacking & Long-Range Missiles," *Breaking Defense*, September 27, 2016 (http://breakingdefense.com/2016/09/armys-multi-domain-battle-jamming-hacking-long-range-missiles/).
[140] Colin Clark and Sydney J. Freedberg Jr., "Robot Boats, Smart Guns & Super B-52s: Carter's Strategic Capabilities Office," *Breaking Defense*, February 5, 2016 (http://breakingdefense.com/2016/02/carters-strategic-capabilities-office-arsenal-plane-missile-defense-gun/); Valerie Insinna, "As Air Force Shrinks, Officials Look for New Ways to Amass Firepower," *Defense News*, July 10, 2016 (http://www.defensenews.com/story/defense/show-daily/farnborough/2016/07/10/air-force-arsenal-plane-uas-firepower-hypersonics/86524792/); T.J. May and Mike Pietrucha, "We Already Have an Arsenal Plane: It's Called the B-52," WarOnTheRocks, June 22, 2016 (http://warontherocks.com/2016/06/we-already-have-an-arsenal-plane-its-called-the-b-52/).
[141] Sydney J. Freedberg Jr., "Sowing the Sea with Fire: The Threat of Sea Mines," *Breaking Defense*, March 30, 2015 (http://breakingdefense.com/2015/03/sowing-the-sea-with-fire-how-russia-china-iran-lay-mines-and-how-to-stop-them/).
[142] On *Operation Starvation*, see Frederick M. Sallagar, *Lessons From an Aerial Mining Campaign (Operation "Starvation")*, R-1322-PR (Santa Monica, CA: RAND, April 1974). On Chinese analyst interpretations, see Goldstein, "Old-School Killers"; and Goldstein, "Japan's Folly Could Be China's Gain in a War Against America."
[143] Andrew S. Erickson, Lyle J. Goldstein, and William S. Murray, *Chinese Mine Warfare: A PLA Navy "Assassin's Mace" Capability* (Newport, RI: Naval War College, June 2009), p. 1.
[144] Col. Michael W. Pietrucha, "Essay: Navy, Air Force Reviving Offensive Mining With New Quickstrikes," USNI, April 26, 2016 (https://news.usni.org/2016/04/26/essay-navy-air-force-reviving-offensive-mining-with-new-quickstrikes).
[145] Scott C. Truver, "Wanted: U.S. Navy Mine Warfare Champion," Naval War College Review, Spring 2015 (https://www.usnwc.edu/getattachment/a0288f05-f88d-4c5e-a162-d99a0e1d676f/Wanted--U-S--Navy-Mine-Warfare-Champion.aspx). See also http://navy-matters.blogspot.com/2015/07/offensive-mine-warfare.html.

[146] Naval Sea Systems Command, "Guided Missile Submarines—SSGN," November 9, 2015 (http://www.navy.mil/navydata/fact_display.asp?cid=4100&tid=300&ct=4).
[147] United States Special Operations Command, "SOCOM 2020: Forging the Tip of the Spear," n.d. (http://www.defenseinnovationmarketplace.mil/resources/SOCOM2020Strategy.pdf), p. 5.
[148] Naval Sea Systems Command, "Attack Submarines—SSN," March 8, 2016 (http://www.navy.mil/navydata/fact_display.asp?cid=4100&ct=4&tid=100).
[149] Joe Trevithick, "U.S. Navy SEALs Are Getting New Mini-Subs," War Is Boring, August 5, 2014 (https://warisboring.com/u-s-navy-seals-are-getting-new-mini-subs-273770fac0a3#.5kyaxp6mm).
[150] Statement of General Joseph L. Votel before the House Armed Services Committee, Subcommittee on Emerging Threats and Capabilities, March 1, 2016 (http://docs.house.gov/meetings/AS/AS26/20160301/104552/HHRG-114-AS26-Wstate-VotelJ-20160301.pdf), p. 15.
[151] Hicks, et al., *Undersea Warfare in Northern Europe*, p. 20. See also Dave Majumdar, "Could the US Navy Really Hunt Down Russian or Chinese Submarines?" *The National Interest*, August 12, 2016 (http://nationalinterest.org/blog/the-buzz/could-the-us-navy-really-hunt-down-russian-or-chinese-17346); and Dave Majumdar, "The US Navy is Preparing to Take On an Old Foe: Stealthy Enemy Submarines," *The National Interest*, August 24, 2016 (http://nationalinterest.org/blog/the-us-navy-preparing-take-old-foe-stealthy-enemy-submarines-17467).
[152] "Seek, but yet shall find?" *The Economist*, August 6, 2016 (http://www.economist.com/news/science-and-technology/21703360-proliferation-quieter-submarines-pushing-navies-concoct-better-ways).
[153] Owen Cote, "Assessing the Undersea Balance Between the U.S. and China," Massachusetts Institute of Technology, SSP Working Paper, February 2011 (http://web.mit.edu/ssp/publications/working_papers/Undersea%20Balance%20WP11-1.pdf). See also Brian Wang, "Undersea warfare gamechangers—China building upgraded SOSUS and US upgrading sensor and fielding network of undersea robots," Next BIG Future, May 18, 2016 (http://www.nextbigfuture.com/2016/05/undersea-warfare-gamechangers-china.html).
[154] http://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=412&ct=2; http://www.darpa.mil/program/anti-submarine-warfare-continuous-trail-unmanned-vessel; http://www.navair.navy.mil/index.cfm?fuseaction=home.display&key=cfd01141-cd4e-4db8-a6b2-7e8fbfb31b86; and http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=230E736F-D36A-4FB8-BDD3-372CD723D22C.
[155] Clark, *The Emerging Era in Undersea Warfare*, pp. 8-10, 15.
[156] J.R. Wilson, "Sonar technology comes to grips with dangerous new era," Military & Aerospace, January 14, 2015 (http://www.militaryaerospace.com/articles/print/volume-26/issue-1/special-report/sonar-technology-comes-to-grips-with-dangerous-new-era.html).
[157] Department of Defense, *Joint Operational Access Concept*, January 17, 2012 (http://www.defense.gov/Portals/1/Documents/pubs/JOAC_Jan%202012_Signed.pdf); DoD's *Joint Concept for Access and Maneuver in the Global Commons* was originally called *AirSea Battle* in May 2013 (http://archive.defense.gov/pubs/ASB-ConceptImplementation-Summary-May-2013.pdf); and DoD, *Joint Concept for Entry Operations*, April 7, 2014 (http://www.dtic.mil/doctrine/concepts/joint_concepts/jceo.pdf).
[158] http://www.mccdc.marines.mil/Portals/172/Docs/MCCDC/young/MCCDC-YH/updated%20document/naval-e.pdf?ver=2016-09-23-103727-170. See also Megan Eckstein, "Navy, Marines Developing New CONOPs for Contested Littoral Operations," USNI News, April 8, 2016 (https://news.usni.org/2016/04/08/navy-marines-developing-new-conops-for-contested-littoral-operations).
[159] Under Secretary of the Navy Janine Davidson, "U.S. Naval Forces Before and Beyond Battle," WarOnTheRocks, October 7, 2016 (http://warontherocks.com/2016/10/u-s-naval-forces-before-and-beyond-battle/).