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Executive Summary

Russia is expanding its undersea operations as part of a broader strategy of coercion aimed at its neighbors, the North Atlantic Treaty Organization (NATO), and the United States. Russia has a long history of emphasizing its maritime capabilities for the purpose of strategic signaling, including the use of targeted provocations. Suspected territorial incursions in the Baltic Sea and provocative patrols in the North Atlantic have caused alarm among NATO and partner nations, in part because they have underscored the extent to which NATO and regional partner anti-submarine warfare (ASW) capabilities have atrophied since the end of the Cold War.

The Russian Navy and its submarine force have remained somewhat insulated from the economic and personnel challenges impacting Russia's broader military modernization efforts. Moscow has demonstrated an unwavering commitment to the development and maintenance of its submarine-based strategic deterrent and has emphasized nonnuclear submarine capabilities, certain surface warfare capabilities, and long-range anti-ship missiles over carrier battle groups, for example. For this reason, Russian submarines are generally believed to be very capable vessels when properly maintained. In Northern Europe, the Russian Navy's use of submarines to signal presence, reach, and power achieves an effect that is disproportionate to the resources committed.

NATO and partner nations do not currently possess the ability to quickly counter the Russian undersea challenge in much of the North Atlantic and Baltic Sea. Declining capabilities are not only to blame, however; equally problematic is the lack of integration among relevant allies and partners. An effective ASW capability will take a federated approach that integrates national and NATO platforms, sensors, and personnel in a coordinated manner. This integrated capability needs to be undergirded by a coherent and cohesive doctrine and regularly exercised to build a true capability at both a national and alliance level.

Given competing priorities, tight defense budgets, and seam issues in the European defense community between NATO members and the vital partner countries of Sweden and Finland, organizational reforms paired with a federated approach to capability development and small posture adjustments are needed to begin rebuilding the U.S. and European ASW capability in Northern Europe.

1. *Preparing Organizational Structures:* Using exclusively NATO structures may fail to properly leverage partner capabilities and expertise. NATO together with the Nordic Defense Cooperation (NORDEFCO) may be able to serve a bridging function to drive interoperability and combined operational proficiency. An ASW-focused Center of Excellence could also usefully serve as a hub for research, planning, doctrine development, lessons learned, and rebuilding and integrating undersea warfare capabilities.
2. *Upgrading Capabilities:* In order to develop a system that is effective against new and emerging technologies, NATO and its partners need to build a multidomain, multiplatform ASW and maritime surveillance complex, ideally within a federated construct, that prioritizes payloads over platforms. The specific recommendations contained in this report bring together different sensors and strike capabilities hosted on large and small, manned and unmanned, space-based, aerial, surface, and subsurface platforms.
3. *Enhancing Posture:* NATO can optimize its ASW posture to ensure that the right capabilities are in the right places at the right time by reopening Keflavik Naval Air Station in Iceland and encouraging Norway to reclaim and reopen its submarine support facility at Olavsvern.

The organizations, relationships, intelligence, and capabilities that once supported a robust ASW network in the North Atlantic and Baltic Sea no longer exist. Building a federated approach to countering the twenty-first-century challenge posed by Russian undersea assets in this region is a critical step in preventing Russian naval coercion against the United States, NATO, and key European partners.

Introduction

Russia's aggression in Ukraine and elsewhere has rightly prompted concern in the United States and Europe about Russia's geopolitical intent and military capabilities. In addition to challenging European nations by land and air, Russia has engaged in new and worrying activities at sea, including naval exercises of increasing scope and scale, commissioning of new surface and subsurface combatants after a long hiatus, and systemic intimidation of NATO and Western European forces in the Baltic Sea and the broader North Atlantic. Vice Admiral (VADM) Clive Johnstone, Commander of Allied Maritime Command, recently observed that Russian submarine activity is reaching levels unseen since shortly after the end of the Cold War.[1]

The United States and its allies and partners in Northern Europe depend on free and safe sea navigation to support civilian, commercial, and military transit requirements; to guarantee the security of maritime borders; and to protect vital global communication cables. It is therefore both prudent and necessary for these nations to proactively build their collective ability to manage, deter, and, if necessary, counter Russia's undersea provocations.

SCOPE AND OBJECTIVES

This study focused explicitly on the nature and scope of the Russian undersea challenge in the Baltic Sea and North Atlantic. The team recognizes that similar issues exist in the Black and Mediterranean Seas, but these areas are beyond the geographic scope of this study. At the core of this study is one fact and two foundational assumptions. The fact is that Russian submarine deployments are at the highest observed levels since the end of the Cold War. The assumptions are that some of Russia's undersea activities are part of a larger coercive campaign aimed at influencing NATO's calculus in Eastern Europe and beyond and that NATO and partner capabilities to manage,

1. 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/.

deter, and, if necessary, counter Russian undersea activities in Northern Europe have atrophied, in some cases dangerously.

CSIS conducted this study from November 2015 to July 2016 and convened a series of working groups in Sweden, Finland, Poland, and Washington, DC, to discuss the range of issues surrounding Russia's naval aggression and identify ways to enhance cooperation and joint capability development between the United States and European allies and partners.

This report is broken down into four broad themes: (1) understanding Russia's increased activities in the Baltic Sea and North Atlantic; (2) renewed and evolving Russian undersea capabilities; (3) U.S., allied, and partner undersea capabilities; and (4) recommendations for building a more capable and integrated defense architecture to better address Russian undersea activity.

It is important to note that most aspects of undersea warfare are classified in nature. The sensitivities surrounding undersea capabilities and operations are evident in the carefully guarded comments from naval officials and sparse unclassified government reports on these topics. In this sense, the public statement by VADM Johnstone on current Russian activity levels is very much an exception. This study should be viewed with these constraints in mind.

Finally, this study assumes a certain baseline of knowledge with regards to operations in the undersea domains. For those readers less seeped in submarine terminology, the team has prepared a basic primer on submarine and undersea warfare, which can be found in Appendix A. This primer explains the systems and technologies at the core of modern undersea warfare.

The Russian Navy: Undersea Activities and Objectives

Russia's dissatisfaction with the post–Cold War order has manifested an increasingly antagonistic foreign policy, as witnessed most recently in Ukraine and Syria.[1] Direct military action on land has been accompanied by probing air and maritime incursions in or near the airspace and territorial waters of NATO allies and partners. The Russian military's buzzing in April 2016 of a U.S. destroyer (DDG), the USS *Donald Cook*, in the Baltic Sea is the latest in a series of increasingly reckless Russian behaviors.[2] Similar to its snap exercises on land, Russia's air and sea maneuvers serve to test the responses of allied and partner forces while simultaneously creating a numbness to such activities; demonstrate Russian capabilities by exercising risky military tactics; send a signal regarding Russian dissatisfaction with the increased U.S. and allied presence along NATO's eastern flank and intolerance of any Swedish and Finish plans to draw closer to NATO; and reinforce Russian claims to a sphere of influence.[3] Russia's current foreign policy trajectory, emphasizing an increasingly aggressive stance vis-à-vis the United States and Europe, is unlikely to change in the next decade.

Following the country's poor performance during the 2008 Russia-Georgia War, the Russian military made significant investments in the reorganization of its forces and modernization its equipment. In Ukraine and Syria, Russia featured sophisticated artillery and combined arms capabilities that had been augmented with new or repurposed technologies, such as unmanned aerial systems (UAS), to improve targeting and lethality. Russia has also demonstrated a range of effective

1. "Ukaz Prezidenta Rossiiskoi Federatsii ot 31 dekabrya 2015 goda N 683 'O Strategii Natsionalnoi bezopastnosti Rossiiskoi Federatsii," *Rossiiskaya gazeta*, December 31, 2015, http://rg.ru/2015/12/31/nac-bezopasnost-site-dok.html.

2. Sam LaGrone, "Video: Russian Fighters Buzz USS Donald Cook in Baltic Sea," *USNI News*, April 13, 2016, https://news.usni.org/2016/04/13/video-russian-fighters-buzz-uss-donald-cook-in-baltic-sea.

3. "RAF search after 'Russian submarine spotted off Scotland,'" BBC News, November 22, 2015, http://www.bbc.com/news/uk-34896956; Ben Farmer, "Britain Forced to Ask NATO to Track 'Russian Submarine' in Scottish Waters," *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; "Finland Drops Depth Charges in 'Submarine' Alert," BBC News, April 28, 2015, http://www.bbc.com/news/world-europe-32498790; LaGrone, "Video: Russian Fighters Buzz USS Donald Cook."

electronic warfare capabilities that include jamming of satellite navigational devices and communications systems and distributing propaganda en masse via cell phone messages. Such investments have increased the efficacy of Russia's military in a cost- and time-effective manner.

A number of key deficiencies and obstacles remain, however, and will continue to inhibit the Russian military's capability and capacity. Low birth rates in the early post-Soviet period, along with a decline in the prestige of military service and retention issues, has led to a personnel shortfall that is further complicated by Russian military plans to phase out conscription and shift to a fully professional force. Russia has long relied on a system of two-year conscription to fill out its military. This was shortened to one year in 2008 and has been described as the beginning of a "slow-motion disaster" for the Russian military personnel system.[4] The Russian Navy and the submarine force has been, to some extent, insulated from the issues currently facing the Russian Army. The highly technical nature of these positions means that the Russian submarine force is overwhelmingly manned by professional contract sailors and officers. The Russian officer education system has generally produced very competent commanders who are intimately familiar with the capabilities of their submarines and crews. This familiarity is coupled with a high risk tolerance in carrying out their assigned missions.

Russia's economic downturn also represents an undeniable challenge for the military. As a result of sanctions, plummeting oil prices, systemic inefficiencies, and the dramatic devaluation of the ruble, the Russian economy has weakened substantially since 2014. In turn, the Russian military is facing increasing budgetary constraints and has twice been targeted for budget reductions since 2015. Some investment areas, such as procurement, are suffering more than others, though this may not remain the case should economic difficulties persist. Submarine construction, for example, has so far been prioritized and shielded from the effects of the military's belt-tightening.[5] The State Armament Program (SAP) 2011–2020 allocates 26 percent of its 19.4 trillion rubles to the navy, totaling five trillion rubles.[6] Overall, Russia appears willing to accept some trade-offs with regard to its domestic social spending in favor of continued investments in a strong military and an activist foreign policy agenda.

Likely in recognition of these constraints, Moscow has been shrewd in how it exercises its military power, aiming to get as much "bang for the ruble" as possible and relying on its strategic nuclear deterrent to underwrite any shortcomings with its conventional forces. In Northern Europe, for example, the Russian Navy's use of submarines to signal presence, reach, and power achieves an effect that is disproportionate to the forces committed. Indeed, Russia has a long history of emphasizing its maritime capabilities for the purpose of strategic signaling and targeted provocations.

4. Kier Giles with Andrew Monaghan, *Russian Military Transformation—Goal in Sight* (Carlisle, PA: Strategic Studies Institute, 2014), 37, http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB1196.pdf.

5. Over the period 2011–2020, the Russian Navy's 26 percent share of total military funding is the greatest share of any of the service branches. See Julian Cooper, *Russia's State Armament Programme to 2020: A Quantitative Assessment of Implementation 2011–2015* (Stockholm: FOI, March 2016), http://www.foi.se/sv/Sok/Sammanfattningssida/?rNo=FOI-R--4239--SE.

6. Cooper, *Russia's State Armament Programme to 2020*, 20.

RECENT RUSSIAN UNDERSEA ACTIVITIES

A number of maritime incidents have showcased Russia's use of the undersea domain as part of a broader strategy of coercion aimed at its neighbors, NATO, and the United States. These incidents include the probable territorial violations of Swedish and Finnish waters by Russian submarines; submarine activity near the UK submarine base at Faslane, Scotland; and reported suspicious activity near undersea infrastructure in the North Atlantic.

In a highly publicized incident in 2014, the Swedish Navy spent a week searching the Stockholm archipelago in the Baltic Sea with helicopters, minesweepers, and 200 service personnel after an alleged spotting of a Russian submarine in Swedish territorial waters.[7] The Swedish government has not offered any definitive conclusions regarding the incident, but open source reporting suggests that an emergency radio call (in Russian) was detected by Sweden's intelligence service.[8] Of course, this would not be the first time Russia has breached Swedish territory, nor is it likely to be the last. Another highly publicized incident occurred in 1981—the so-called Whiskey on the Rocks affair—in which a Soviet S-363 *Whiskey*-class submarine spent 10 days stranded on a rock in Swedish waters.[9]

Russian submarine sightings in Sweden have taken on an almost Loch Ness–like mystique. While the frequency of supposed sightings likely gives too much credit to the supportable operating tempo of the Russian Navy, it is highly probable that the 2014 incident was in fact a Russian submarine. In this case, Russia could have been signaling its displeasure at Sweden's growing ties to NATO; the alleged incursion occurred just a month after Sweden signed a host-nation support agreement with NATO at the Summit in Wales. This signal fits into a broader pattern of Russian rhetoric and actions vis-à-vis Sweden. It was recently revealed, for example, that Russia conducted a mock nuclear attack on Sweden during a 2013 war game. The Russian ambassador to Sweden also ominously warned of "countermeasures" should Sweden join the alliance.[10]

A similar incident occurred off the coast of Finland in April 2015. In response to reports of a possible foreign submarine, the Finnish Navy dropped small-depth charges to issue a warning to the intruder. As in the Sweden incident, no official attribution was ever declared by the Finnish government.[11] Although this incident does not appear to have been as purposeful or egregious a violation of sovereignty as the Sweden incident, unofficial reporting has strongly suggested that the

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7. Peter Walker, "Sweden Searches for Suspected Russian Submarine off Stockholm," *Guardian*, October 19, 2014, http://www.theguardian.com/world/2014/oct/19/sweden-search-russian-submarine-stockholm.

8. Mariano Castillo and Lindsay Isaac, "Sweden Confirms Foreign Sub in Its Waters," CNN, November 14, 2014, http://www.cnn.com/2014/11/14/world/europe/sweden-russia-submarine-mystery/.

9. David Crouch, "Sweden Calls Of Hunt For Submarine," *Guardian*, October 24, 2014, http://www.theguardian.com/world/2014/oct/24/sweden-calls-off-hunt-submarine-stockholm-archipelago.

10. Roland Oliphant, "Russia 'Simulated a Nuclear Strike' against Sweden, NATO Admits," *Telegraph*, February 4, 2016, http://www.telegraph.co.uk/news/worldnews/europe/russia/12139943/Russia-simulated-a-nuclear-strike-against-Sweden-Nato-admits.html; Jeremy Bender "Russian Ambassador: If Sweden Joins NATO, There Will Be 'Consequences,'" *Business Insider*, June 18, 2015, http://www.businessinsider.com/russia-warns-sweden-over-joining-nato-2015-6.

11. "Finland Drops Depth Charges in 'Submarine' Alert."

undersea object was, in fact, a Russian submarine.[12] Reports suggest that Russia semiroutinely skirts the edges of Finnish waters as submarines transit the Gulf of Finland from their base near St. Petersburg. These patrols and deliberate skirting of Finnish waters may serve to test the Finnish Navy's undersea sensing capabilities. Increased Russian undersea activity has also been observed in the North Atlantic. Beginning in late 2014, the Royal Navy reported suspected Russian submarine activity off the coast of Faslane, Scotland, the location of the United Kingdom's only submarine base and home of the entirety of the British nuclear deterrent: *Vanguard*-class submarines equipped with Trident missiles. Due to a lack of nationally owned, land-based antisubmarine warfare (ASW) assets, the United Kingdom requested allied assistance to track the suspected incursion.[13] Such reports are especially disquieting for the British government as they reflect Russia's potential ability to hold at risk the British nuclear deterrent and underscore the fact that the UK, a historically preeminent maritime power, is currently without fixed-wing maritime patrol aircraft (MPA). The Russian Ministry of Defense has denied any involvement in the three suspected cases of undersea territorial violations in Sweden, Finland, and the United Kingdom.

Press reports indicate that Russian submarines have likewise been operating in exceptionally close proximity to undersea cables in the North Atlantic and elsewhere. This has raised concerns among U.S. officials that Russia may be planning to exploit these key transoceanic linkages through tapping or injection of cyber payloads or by severing them outright.[14] Such capabilities would also be highly damaging in the Baltic Sea, given the large number of undersea data and power cables crisscrossing the region. There have been several reported incidents of Russian naval vessels disrupting the construction of the NordBalt (formerly SwedLit) submarine power cable, resulting in diplomatic complaints from both Sweden and Lithuania.[15]

The lingering uncertainty surrounding all the incidents described only increases the deterrent effect of Russia's submarine activity. The ambiguity inherent in submarine warfare lends itself to a sense of Russian undersea omnipresence. This is sufficient to fulfill Russia's ambition to signal that it considers the Baltic Sea, North Sea, and Arctic as falling within its sphere of influence and that it possesses the capability to hold at risk key allied and partner infrastructure and sea lines of communication.

Incidents like those in Sweden, Finland, and the United Kingdom are, at minimum, provocative and are rightly perceived by NATO allies and partners as evidence of increasing Russian aggression. It would not be fair, however, to ascribe *all* Russian military activities as having directed intentions. A great deal of Russia's reported undersea aggression more accurately reflects a return to standard operating practices—exercises, sea trials, readiness drills, and transit between Kaliningrad and

12. Elias Groll, "Swedes Find Definitive Evidence of Submarine, Russians Call Them Unmanly," *Foreign Policy*, November 15, 2014, http://foreignpolicy.com/2014/11/15/swedes-find-definitive-evidence-of-submarine-russians-call-them-unmanly/.

13. Farmer, "Britain Forced to Ask NATO to Track 'Russian Submarine' in Scottish Waters."

14. 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.

15. "Russian Warships Disrupt Swedish Cable Laying," *Local*, May 2, 2015, http://www.thelocal.se/20150502/russian-warships-disrupt-swedish-cable-laying.

St. Petersburg—for submarine fleets. Certain legitimate actions may *feel* aggressive because Russia is resuming more constant activities from a very low, post–Cold War operating tempo as it begins to rebuild its submarine force after years of atrophy. Such misperceptions may be further exacerbated by the lack of muscle memory among allies and partners in dealing with the Russian undersea threat and the atrophy of their own response capabilities.

RUSSIAN NAVAL OBJECTIVES

The Russian Navy's strategy, doctrine, and structure have not radically changed since the days of the Soviet Navy. It mostly conducts the same missions with the same platforms as its Soviet predecessor, only on a dramatically reduced scale. The last major shift in Russian naval thinking took place under the direction of Admiral of the Fleet Sergei Gorshkov in the 1970s and 1980s. At this time, the Soviet Navy transformed into a global force and began to develop capabilities reminiscent of Western naval forces. In general, the Russian Navy's role can be understood as operating across three key lines of effort.

Sea-Based Deterrence

First, the navy is charged with maintaining a credible sea-based deterrent force on active patrol, with a high state of readiness, and protecting the ability of the sea-based deterrent force to carry out this mission. These tasks reflect the importance of Russia's nuclear arsenal to overall national power.

The provision and protection of Russia's nuclear fleet for strategic deterrence and denying an adversary's freedom of movement will remain the guideposts for the Russian Navy. In support of this, Russia is already in the process of modernizing its ballistic missile submarine force and replacing, albeit slowly, its oldest Soviet-era attack submarine fleet. Targeted investments in overhauling older submarines leverage the technical excellence of the late Soviet submarine designs while offsetting their deficiencies in combat weapon systems through more modern upgrades. During the Second World War, both Germany and the United States used submarines to impose outsized costs on their adversaries. It was then that the Soviet Navy recognized how potent submarine warfare could be in the face of an adversary with superior surface capabilities.

Sea Denial

Second is the defense of maritime areas of geostrategic importance to include the Arctic, Barents, Baltic, and Black Seas, which represent the "aeromarine" approaches to Russia. To achieve this end, grand naval strategy offers two competing concepts: sea control and sea denial. A navy that embarks on the strategy of sea control seeks to achieve dominance of the seas in order to achieve national aims. Historically, sea control translates into blockades, amphibious operations, or carrier strikes against inland targets. During the Cold War, NATO's maritime strategy was one of sea control. This would allow the successful resupply of forces in Europe and strikes against the Soviet flank should the Cold War turn hot.

The Soviet Navy recognized NATO's sea control strategy and surface fleet superiority. It chose to respond not through direct competition but rather through a strategy of sea denial. This strategy has often been embraced by continental, land-centric powers facing maritime powers. At its core, it aims to prevent an adversary from using the sea to its advantage. For the Soviet Union, this meant preventing the United States and NATO from conducting sea-based strikes on Soviet territory. This would be achieved by "killing the archer," or destroying U.S. and NATO vessels before they could carry out their missions. The sea denial goals of the Russian Navy are the same as their Soviet predecessors and include protection of vital military installations and assets—notably, the large complex of bases on the Kola Peninsula that house the Northern Fleet, the largest of Russia's four naval fleets.

Russia has begun to reestablish a sea denial strategy using a layered defense approach through increased operations of surface ships and submarines in the North Atlantic and moving steadily closer to Russia's territorial waters through the Barents, Arctic, and Baltic Seas. This is reflected in the estimate that Russia has increased its submarine patrols by 50 percent in the past year alone.[16] Submarine warfare has long been a key element to Russia's sea denial strategy, embodied most evidently by Russia's emphasis on the guided missile submarine (SSGN). Unlike their U.S. equivalents, the Russian variants are designed to attack surface naval group formations with long-range, antiship cruise missiles. By contrast, the U.S. equivalent, the *Ohio*-class SSGN, is exclusively used for land attack missions and does not have a substantial antiship capability. The increased activity of Russian submarines has led to renewed U.S. and NATO interest in monitoring the Greenland-Iceland-UK (GIUK) gap, a strategic choke point that represents the Russian Northern Fleet's gateway to the Atlantic Ocean.[17]

Strategic Signaling

Third, and as previously mentioned, Russia's naval power is also used to signal other nations of Russia's intent and help to achieve overarching political goals. This buttresses Russia's attempts to maintain and, where necessary, reclaim what it believes to be its traditional sphere of influence. A submarine's stealthy veil can be lifted at an opportune moment as a "tacit revelation" of both presence and capability. Such reveals of capability (and adversary weakness) can impose significant psychological and financial costs on the signaled party; recall the massive and expensive search embarked on by the Swedish Navy as a result of a simple surfacing maneuver.[18] A key attribute of Russia operations is the idea of reflexive control, or forcing your adversaries into a

16. Eric Schmitt, "Russia Bolsters Its Submarine Fleet, and Tensions With U.S. Rise," *New York Times*, April 20, 2016, http://www.nytimes.com/2016/04/21/world/europe/russia-bolsters-submarine-fleet-and-tensions-with-us-rise.html?_r=0.

17. Christopher C. Cavas, "US: Russia Building 'Arc of Steel' From Arctic to Med," *Defense News*, October 6, 2015, http://www.defensenews.com/story/defense/naval/2015/10/06/russia-military-naval-power-shipbuilding-submarine-warships-baltic-mediterranean-black-sea-arctic-syria-estonia-latvia-lithuania-crimea-ukraine/73480280/.

18. James P. Stebbins, "Broaching the Ship: Rethinking Submarines as a Signaling Tool in Naval Diplomacy" (master's thesis, Naval Postgraduate School, Monterey, CA, 2015), http://calhoun.nps.edu/bitstream/handle/10945/45261/15Mar_Stebbins_James.pdf?sequence=3&isAllowed=y.

predictable course of action by manipulating how they perceive your intent.[19] This manipulation takes many forms and is part of Russia's overarching information campaign. Due to the relative efficiency of such tactics, the low number of platforms required, and the opportunity for plausible deniability that is far greater than surface maritime or airspace violations can provide, the Russian Navy has seemingly embraced the use of submarines and "tacit revelations" as a reliable method of fear and coercion.

When applying these overarching objectives in the Baltic Sea, Russia's naval activities have included efforts to monitor NATO naval activity; conduct targeted provocations and intimidation; complicate allied contingency planning to preserve Russia's perceived sphere of influence, including by acting as a component of Russia's anti-access/area denial (A2/AD) network; deter NATO military activity on or near its border; disrupt the sea lines of communications of NATO allies and partners; and ensure Russia's territorial integrity. In the North Atlantic, Russia's Navy is additionally focused on maintaining its sea-based nuclear deterrent by ensuring access through the GIUK gap; holding at risk key NATO assets; and protecting the naval approaches to its interior in order to protect its ballistic missile submarines (SSBNs). The activities of the Russian Navy in the Baltic Sea and North Atlantic demonstrate how important naval forces can be to broader coercion campaigns.

19. Off-the-record conversation with experts on Russia and information operations.

02

Russia's Undersea Capabilities: Today and Tomorrow

Russian naval capability development has been informed by the requirements of its sea denial strategy. Rather than investing heavily in carrier battle groups, Russia has emphasized submarine capabilities, certain surface warfare capabilities, and long-range anti-ship missiles. Over and above the requirements for sea denial, Russian has also demonstrated an unwavering commitment to the development and maintenance of its submarine-based strategic deterrent. In fact, many of the sea denial capabilities Russia has developed are meant to protect its SSBNs. While a detailed discussion of the relationship between the Russian Navy and the Russian nuclear deterrent is beyond the scope of this study, it is important to remember that the relationship exists and the protection of these weapon systems is a major factor informing Russian naval planning.

RUSSIA'S CURRENT CAPABILITIES

The active Russian submarine fleet is considerably smaller than it was in the late 1980s and early 1990s. Today's Russian Navy is believed to operate approximately 56 submarines in comparison to the 240 that the Russian Navy inherited from its Soviet predecessor. Russia has been slowly overhauling and modernizing the core of its undersea fleet while retiring the vast majority of its inherited vessels.

Russian submarines are generally believed to be very capable vessels when properly maintained. While the design and layout of many Russian submarine classes may seem unorthodox or even needlessly complicated to Western designers, the end result has been quite impressive. At the end of the Cold War, Russian designers and some Western analysts believed that the Soviet Union was on the cusp of overtaking the United States in terms of acoustic quieting, which would have represented a complete reversal of the Cold War's "regular order" regarding submarine technology. Present-day U.S. admirals have publicly acknowledged the prowess of Russia's forthcoming *Severodvinsk*-class nuclear-powered attack submarines.[1] Russian submarines still trail U.S. and

1. Dave Majumdar, "U.S. Navy Impressed with New Russian Attack Boat," *USNI News*, October 28, 2014, https://news.usni.org/2014/10/28/u-s-navy-impressed-new-russian-attack-boat.

Western vessels, however, in sonar performance; that is, they carry fewer towed arrays and, until very recently, an inferior sonar array design.

Russia maintains a host of anti-submarine warfare (ASW) capabilities ranging from dedicated surface warships to long-range, fixed wing aircraft, almost all of which were inherited from the Soviet Navy. These capabilities are not discussed at length given this study's focus on Russian undersea activities. Nevertheless, it is important to acknowledge that any nation operating submarines near Russian territory will have to consider Russian ASW capabilities into their risk calculus. The U.S. and European ASW capabilities needed to counter Russian undersea activities, however, will be discussed in Chapter 3. The following section explores the current state of the Russian submarine fleet and the maintenance and shipbuilding challenges faced by the Russian Navy.

Submarines

The Russian Navy is emerging from its post–Cold War malaise. During the 1990s, its naval leadership, grappling with severe cost constraints, made hard trade-offs in order to triage and save some of the most advanced Soviet submarines. These efforts prioritized the Russian SSBN fleet. These SSBNs, in addition to a relatively small number of modernized diesel (SSK) and nuclear-powered attack submarines (SSNs), make up the core offensive capability of the Russian Navy.

The Russian Navy operates one class of SSK (the *Kilo*-class), four classes of SSNs (the *Victor III*-class, the *Sierra II*-class, the *Akula*-class, and the *Severodvinsk*-class), and one class of guided missile or SSGN submarines (the *Oscar II*-class). As with a large majority of Soviet and Russian naval systems that must typically contend with long development and production timelines, there is a high degree of variation even between single classes.[2] Table 2.1 below offers an overview of Russia's submarine force. However, it does not include several classes of submarines in advanced stages of development or Russia's fleet of auxiliary submarines used for special missions and systems development.

From an organizational perspective, the Russian Navy is divided into four fleets: Northern, Pacific, Black Sea, and Baltic. There is also one flotilla in the Caspian Sea. We focus here exclusively on the Northern and Baltic Fleets. The **Northern Fleet** is Russia's largest and most formidable. The fleet is homeported at a collection of installations in the Kola Peninsula in Murmansk Oblast. In terms of its submarine order of battle, Russia claims its Northern Fleet includes 42 submarines. Open source analysis, however, suggests that the number of operational submarines is much lower, at approximately 22 to 31.[3] The Northern Fleet also includes a number of special mission and auxiliary submarines, which will be discussed in more detail later in this section. Table 2.2

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2. For a complete description of these alternations, see Norman Palomar and Kenneth J. Moore, *Cold War Submarines: The Design and Construction of U.S. and Soviet Submarines* (Washington, DC: Potomac Books, 2004).

3. For the purposes of this study, we classify the *Yasen/Severodvinsk*-class submarine as an SSN. Many sources refer to this class as an SSGN. However, it is a hybrid design akin to a U.S. *Virginia*-class SSN with the Virginia Payload Module (VPM). Its mission is that of a multipurpose attack submarine.

Table 2.1. Current Russian SSKs, SSBNs, SSGNs, and SSNs

Class	Type	Basic Characteristics
Kilo (Project 877 and 636)	*SSK*	Successful diesel submarine design produced in large numbers for both the domestic and export market. It is unclear to what extent the older Project 877 boats have been modernized.
Delta IV (Project 667BDRM)	*SSBN*	The final evolution of the Delta design and the backbone of the Russian at-sea nuclear deterrent. When the Deltas were first introduced, they were a step change in terms of acoustic performance. All remaining vessels will be retired as the *Dolgorukiy*-class are commissioned.
Typhoon (Project 941UM)	*SSBN*	The largest submarine ever designed. A truly massive platform for ballistic missiles. One vessel remains in service and is used as a test platform for a new generation of submarine-launched ballistic missiles (SLBMs).
Dolgorukiy (Project 955)	*SSBN*	The latest Russian SSBN that is supposed to replace the entire existing fleet. This class has faced delays in construction and in the development of the primary weapon system, the *Bulava* SLBM; three are currently in service.
Oscar II (Project 949A)	*SSGN*	One of the largest submarines ever designed. Created to sink U.S. carriers and their escorts with an extremely long anti-ship cruise missile armament.
Victor III (Project 671RTM)	*SSN*	Most advanced of the second generation of Russian/Soviet SSNs. First submarines used heavily to track U.S. ballistic missile submarines.
Sierra II (Project 945A)	*SSN*	First of the 3rd generation of Russian/Soviet SSNs and first to feature a single reactor. Titanium hull.
Akula (Project 917 and 971M)	*SSN*	Follow-on to the *Sierra II* but with a steel hull, increased displacement, and an improved combat weapon system.
Severodvinsk (Project 885)	*SSN/ SSGN*	A multirole submarine designed to replace both Russia's SSN and SSGN fleets. Tremendously expensive but exceptionally quiet with a large missile armament.

represents the study team's best estimate of the Northern Fleet's current laydown based on open source material.[4]

4. Kathleen Weinberger and Andrew Metrick, "Analysis of Russian Submarine Availability" (unpublished analysis, CSIS, Washington, DC, April 2016).

Table 2.2. Estimated Northern Fleet Order of Battle

Type	Northern Fleet	
	Believed Active	Claimed by Russia
SSK	5	6
SSBN	6	8
SSGN	2	3
SSN	7–9	14
SSAN[1]	2–9[2]	9
SSA[3]	0	1[4]
Total	**22–31**	**42**

[1] Auxiliary submarine, nuclear powered (SSAN).
[2] Reporting on the status and operations of Russia's fleet of auxiliary submarines is tremendously difficult due to the secrecy that surrounds their existence. The team is relatively confident that a small handful of these vessels conduct regular operations. The exact number is unable to be discerned.
[3] Auxiliary submarine, diesel powered (SSA).
[4] The one SSA is not an operational submarine; it is a test platform for new submarine technologies. This makes it difficult to characterize in this quantitative assessment.

The **Baltic Fleet**, in contrast, contains no nuclear-powered submarines and boasts only two diesel-electric *Kilo*-class SSK attack submarines that entered service in the 1980s. One of these submarines is currently down for repairs, with no clear date defined for return to service. The fleet's one active *Kilo* was used in 2015 to exercise Russia's anti-submarine warfare capabilities in the Baltic Sea and may have been responsible for the reported territorial violations discussed in Chapter 1.[5] The size of the Baltic Fleet is restricted largely due to the extremely complex operating environment of the Baltic Sea itself. The Baltic Sea is very shallow with an average depth of 200 feet, requires navigation through an intricate archipelago and heavy sea surface traffic, is littered with what is likely the world's highest concentration of unexploded mines and ordinances (UXOs) from the two world wars, and features unforgiving acoustic conditions due to its low salinity and large

5. "Russian Baltic Sea Fleet Ships Drill Antisubmarine Warfare," TASS, September 8, 2015, http://tass.ru/en/defense/819546.

seasonal temperature variations.[6] For these reasons, most submariners agree that if you can operate in the Baltic Sea, you can operate anywhere. The Baltic Fleet's submarine force is ostensibly homeported at the Russian naval base on Kotlin Island in St. Petersburg, but often operates out of Russian naval facilities in Kaliningrad.

Russia maintains a fleet of smaller **auxiliary submarines** (SSA/SSAN) for special missions and deep sea research. The most advanced of these auxiliary submarines can be paired with converted SSBN "motherships" to help offset the key weakness of these small submarines: a lack of range and self-deployment capability beyond Russia's near seas.[7] The SSAN AS-12 Losharik, for example, is believed to be carried by a converted *Delta III* SSBN, the Orenburg, and possess an exceptionally deep diving capability greater than 8,200 feet (2,500 meters). For comparison, modern SSNs are believed to have a maximum depth of approximately 1,600 feet (500 meters). The Losharik achieves this remarkable depth through a series of spherical pressure hulls.[8] A second repurposed SSBN, the Podmoskovye, a converted *Delta IV* SSBN, is thought to also be able to serve as a mothership for auxiliary submarines.[9]

Russia's auxiliary submarines, also referred to as deep sea underwater stations, are operated by the secretive Directorate for Deep Sea Research (GUGI). The personnel that man these submarines are some of the most highly compensated in the entire Russian military, speaking to the dangerous and covert nature of their mission.[10] It is likely that Russian auxiliary vessels, including teleoperated or autonomous undersea craft, are equipped to be able to manipulate objects on the seafloor and may also carry sensitive communications intercept equipment in order to tap undersea cables or otherwise destroy or exploit seafloor infrastructure. In theory, this capability could enable collection of sensitive traffic carried on transatlantic cables and/or cyber attacks against secure computer systems, among other things. These vessels may also permit the Russian Navy to covertly place sensitive acoustic recording equipment near U.S. and European submarine installations.

The Northern Fleet is believed to have as many as nine nuclear-powered special mission submarines (SSANs) in total, but it is unclear how many of these are actually operational.[11] It also has one

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6. Carsten Holm, "Dangerous Depths: German Waters Teeming with WWII Munitions," *Spiegel*, April 11, 2013, http://www.spiegel.de/international/germany/dangers-of-unexploded-wwii-munitions-in-north-and-baltic-seas-a-893113.html.

7. A retired U.S. research submarine NR-1 is believed to be conceptually similar to the Losharik; however, it was paired with a surface tender when deployed, dramatically curtailing the stealthiness of the operation. See U.S. Navy, "NR 1 Deep Submergence Craft," U.S. Navy Fact File, May 24, 1999, https://web.archive.org/web/20030429014652/www.chinfo.navy.mil/navpalib/factfile/ships/ship-nr1.html.

8. The name Losharik is an allusion to the Russian cartoon character of the same name. It is a toy horse made by linking together a chain of balls (similar in design to the submarine).

9. Trude Pettersen, "Russian Nuclear Submarine Launched after Modernization," *Barents Observer*, August 13, 2015, http://barentsobserver.com/en/security/2015/08/russian-nuclear-submarine-launched-after-modernization-13-08.

10. Foreign Military Studies Office, "Russian Media Discuss Role of Hydronauts," *OE Watch* 3, no. 1 (August 2013), http://fmso.leavenworth.army.mil/OEWatch/201308/Russia_09.html.

11. "Submarines," Russian Ships, accessed on April 12, 2016, http://russianships.info; "Атомные подводные лодки России (2015)," Topwar.ru, April 1, 2015, http://topwar.ru/72013-atomnye-podvodnye-lodki-rossii-2015.html;

special purpose diesel-electric submarine (SSA), the Sarov, which is being used to test new submarine technologies, including acting as a mothership for unmanned underwater vehicles (UUVs).[12] While the Sarov is shrouded in secrecy, what we do know is that it is highly unusual, as it has a nuclear reactor that is not mechanically connected to the vessel's propulsion system.[13]

SHIPBUILDING AND MAINTENANCE

Russia has improved its submarine maintenance and repair capabilities since the low point of the 1990s, but it remains to be seen whether it will be able to keep up with the maintenance needs of a more active submarine force. Russia's poor shipyard infrastructure and its large variety of classes and subclasses do not inspire great confidence in this regard. Reports suggest that up to 70 percent of Russia's total shipyard equipment is in disrepair.[14] The inability to maintain and service submarines became the Achilles' heel of the Soviet Navy. Russia must do better if it hopes to maintain its enhanced operational tempo.

There are also persistent questions about the supply chain feeding Russia's shipbuilding and ship maintenance facilities. For example, the first two *Dolgorukiy*-class SSBNs incorporate hull sections from incomplete *Akula*-class and *Oscar II* submarines and steam turbines from a retiring *Oscar II* submarine.[15] The cannibalization of all available resources to build "Frankenstein" submarines demonstrates supply issues with the Russian industrial base and calls into question the acoustic performance of these initial submarines, which slips with every mistake or imperfection. New investments in existing shipyards may help offset these issues, but long build times and extended sea trials suggest that issues of quality control persist in the Russian shipbuilding industry.

Separate from the shipyards used for submarine maintenance, Russia has two primary centers used for submarine production that are in much better shape: Severodvinsk on the White Sea and St. Petersburg on the Baltic Sea. Sevmash, the primary shipyard in Severodvinsk, is the largest shipyard in Russia and presently the only one building nuclear-powered vessels. The yard took extraordinary efforts to avoid mass layoffs during the economic downturn and has managed to maintain a capable core of shipbuilders for the time being.[16]

"ПОДВОДНЫЕ ЛОДКИ ПРОЕКТА 1851 'НЕЛЬМА,'" Warfiles.ru, April 24, 2015, http://warfiles.ru/show-86648-podvodnye-lodki-proekta-1851-nelma.html.

12. "Подводных роботов испытывают на подлодке 'Саров,'" RIA Novosti, December 26, 2014, http://ria.ru/defense_safety/20141226/1040266812.html.

13. Galrahn, "Russia's Not So Super Secret Special Submarine," *Information Dissemination*, December 18, 2007, http://www.informationdissemination.net/2007/12/russias-not-so-super-secret-special.html.

14. Dmitry Gorenburg, "Shipbuilding May Limit Russian Navy's Future," *Maritime Executive*, November 27, 2015, http://www.maritime-executive.com/editorials/shipbuilding-may-limit-russian-navys-future.

15. "Dolgorukiy SSBN: The Dirty Secret Under the Hood," *7 Feet Beneath the Keel* (blog), September 24, 2014, http://7fbtk.blogspot.com/2014/09/dolgorukiy-ssbn-dirty-secret-under-hood.html.

16. Yoshiaki Sakaguchi, "Russia's Policy on Strengthening the Navy and the Defense Industry," *NIDS Journal of Defense and Security* 15 (December 2014): 64–65, http://www.nids.go.jp/english/publication/kiyo/pdf/2014/bulletin_e2014_4.pdf.

Russia's main production line for *Kilo*-class and other diesel-powered submarines is the Admiralty Shipyard in St. Petersburg. In a crisis situation, the Russian Navy could presumably add an additional submarine to its Baltic Sea Fleet by pulling a submarine in sea trials that is meant for export into the Russian Navy. St. Petersburg is linked to the White Sea and the shipyards in Severodvinsk and elsewhere by the White Sea Baltic Canal. This linkage may also permit Russia to quickly redistribute a small number of *Kilo*-class submarines from the Northern Fleet to the Baltic Fleet should the situation warrant.

RUSSIA'S FUTURE CAPABILITIES

Over the next five to 10 years, Russia is likely to continue its plans to develop several new ship classes—though, if history is any indication, it will struggle to realize its full undersea agenda on time and on budget. The most ambitious of its development programs are likely to be curtailed or delayed by Russia's current economic and geopolitical situation, which is dramatically limiting its access to key foreign technologies and equipment. The depth and targets of these cuts, however, remain an open question. The following section explores Russia's undersea development plans in greater detail and discusses the prospects for key Russian shipbuilding and maintenance facilities in the near- to mid-term.

Submarines and Undersea Capabilities

The Russian Navy aims to improve on its capabilities in the undersea domain. This includes the development of new submarines, new propulsion technologies, advanced sensors, and unmanned underwater vehicles. Current submarine procurement plans call for eight to 10 *Dolgorukiy*-class SSBNs, eight to 10 *Severodvinsk*-class SSNs, and a mix of diesel-powered SSK submarines.[17]

As mentioned, the Northern Fleet currently operates one *Dolgorukiy*-class SSBN submarine. This vessel is likely slightly quieter than the late *Akula*-class SSNs and is comparable in terms of mission to the U.S. *Ohio*-class SSBNs. After very public setbacks due to issues with its main weapon system, the Bulava submarine-launched ballistic missile (SLBM), the production line for this class seems to have turned a corner. Russia is looking to introduce a mid-production design change with either the third or fourth boat, which may carry additional SLBMs and feature a redesigned hull for improved acoustic performance.[18] Unlike the earlier boats in the class, this mid-production design change is likely to include the production of true "new build" SSBNs rather than vessels that rely on cannibalized components.

The Northern Fleet also operates a single *Severodvinsk*-class SSN, with the second boat currently under construction. The lead boat has been in sea trials since launching in 2013, and its future may

17. "МИНОБОРОНЫ УВЕЛИЧИТ ЗАКАЗ НА 'ЯСЕНИ' И 'БОРЕИ,'" *Military Paritet*, February 7, 2012, http://www.militaryparitet.com/teletype/data/ic_teletype/13815/.

18. Franz-Stefan Gady, "Putin's 'Red October': Russia's Deadliest New Submarine," *Diplomat*, March 4, 2015, http://thediplomat.com/2015/03/putins-red-october-russias-deadliest-new-submarine/.

be in doubt.[19] This vessel was under construction for almost 20 years, having been laid down in 1993.[20] Cost is an additional concern. The lead boat's cost was frozen at 47 billion rubles and the second boat was reportedly going to cost 112 billion rubles.[21] This converts into about $1.4 billion (pre-ruble crash) / $700 million (post-ruble crash) for the first boat and a staggering $3.3 billion / $1.68 billion for the second boat. To put this in perspective, the current U.S. SSN *Virginia*-class is $2.6 billion per unit, which constitutes a much smaller percent of investment from the U.S. defense budget than a *Severodvinsk*-class SSN requires of Russia. (The United States spent $595 billion on defense in 2015 while Russian spent $91 billion on defense in the same year.[22]) It is unlikely that Russia's shipbuilding budget can support SSNs costing upwards of $2 billion, given its other priorities and fiscal constraints.

Despite these issues, and as previously mentioned, the end product appears to be a technically excellent submarine that has made Western naval leaders sit up and take notice. The *Severodvinsk*-class vessels are full of firsts. They are the first Russian submarines to be equipped with superior spherical bow sonars; previous Russian and Soviet systems had used an inferior cylinder design. They are the first Russian submarines to use Western-style vertical launch tubes for cruise missiles. They are also the first to be equipped with a "life of the boat" reactor; that is, a reactor that will not require a costly and disruptive midlife refueling. Taken together, the Russians appear to have a vessel that approaches and in some cases surpasses the most recent U.S. SSNs.

Russia is already considering a more affordable follow-on to the *Severodvinsk*-class SSN. The follow-on may include two separate designs: one to protect (or "screen") surface strike groups from adversary submarines and the other to serve as a cruise missile submarine.[23] Given past trends in Russian submarine development, one or two of these vessels may serve as an advanced technology testbed. The Soviet Union was engaged in a number of research and development (R&D) projects at the end of the Cold War that had the potential to transform undersea warfare. One such research stream was the use of composites and polymers to build a submarine hull with substantially reduced hydrodynamic drag that would have dramatically increased the maximum speed of submerged vessels. Such technologies may appear on a future Russian submarine, although the likelihood of costly R&D projects may be impacted by the current Russian economic situation.

Russia's SSK ambitions are the most uncertain due to the development issues facing the *Lada*-class, the replacement for the *Kilo*-class. Problems with the initial prototype, the *St. Petersburg*, led

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19. Dmitry Gorenburg, "Russian Shipbuilding Still in Trouble," Russian Military Reform, January 19, 2016, https://russiamil.wordpress.com/2016/01/19/russian-shipbuilding-still-in-trouble/.

20. Dmitry Gorenburg, "Russian Military Shipbuilding: An Update (Part 1)," Russian Military Reform, June 26, 2013, https://russiamil.wordpress.com/2013/06/26/russian-military-shipbuilding-an-update-part-1/.

21. Dmitry Gorenburg, "Difficult Course to a Grand Fleet," Russian Military Reform, October 6, 2011, https://russiandefpolicy.wordpress.com/2011/10/06/difficult-course-to-a-grand-fleet/.

22. SIPRI Military Expenditure Database: 1988–2015, accessed May 31, 2016, https://www.sipri.org/databases/milex.

23. Dmitry Gorenburg, "Russian Naval Shipbuilding: Is It Possible to Fulfill the Kremlin's Grand Expectations?," PONARS Eurasia, October 2015, http://www.ponarseurasia.org/memo/russian-naval-shipbuilding-it-possible-fulfill-kremlins-grand-expectations.

to the suspension of the construction of the two additional *Lada*-class submarines.[24] The *St. Petersburg* has been in development since 1997 but was not commissioned until 2010. Its trials are set to continue through the end of 2016. During its development, the project has met resistance from Russian naval officials due to "shortcomings revealed during the Northern Fleet's operation of the Project 677 lead ship, *St. Petersburg*."[25] Further delays seem all but guaranteed despite a top-to-bottom overhaul of the design over the course of its 19-year development and production timeline.[26]

It appears that Russia may be moving on from the failed *Lada*-class altogether with a new design, the *Kalina*-class. These vessels may be equipped with the Russian air independent propulsion (AIP) system currently under development.[27] (Diesel submarines with AIP systems are often referred to as SSPs.) The exact timeline for these vessels is unclear and likely dependent on the completion of the new propulsion system. The introduction of AIP technology has been described as a near-term goal for the past decade with little to show in terms of end product. Current reporting suggests that Russia is investing in a hydrogen-oxygen fuel cell AIP system similar to that currently used on German submarines.[28] This system has completed shore-based testing, and Russia claims it will be ready for operation in the next five to six years.[29]

Other Russian technological developments that, at minimum, should be acknowledged are nonacoustic methods of detecting and tracking submarines. The Soviet Union was very interested in ship-based and space-based technologies that could enable adversary submarine detection and subsequent tracking without a traditional sonar. These technologies would be transformative with regards to the ASW mission and submarine activities more broadly. Nonacoustic detection may degrade or outright remove a submarine's defining characteristic, stealth. Shortly after the end of the Cold War, there was considerable debate regarding the maturity of the Soviet R&D activities and claims of operational efficacy. Any new claims regarding this technology should be met with a healthy dose of skepticism but cannot be dismissed out of hand.

Russia's development of unmanned underwater vehicles is yet another advancement shrouded in mystery. UUVs may eventually revolutionize all facets of undersea warfare should the technology mature, as many predict it will. Russia has cleverly signaled the possible existence of a long-range UUV to be used as a nuclear delivery tool by "accidently" showing a classified slide describing the system in the background of a televised briefing for President Vladimir Putin. However, many

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24. "Испытания подлодки проекта 677 'Санкт-Петербург' завершат к концу года," RIA Novosti, March 18, 2016, http://ria.ru/defense_safety/20160318/1392288077.html.

25. "ВМФ решит судьбу подлодок проекта 'Лада' после испытаний," *Lenta*, March 20, 2012, https://lenta.ru/news/2012/03/20/testdrive/.

26. Nikolai Novichkov, "Russia's Lada-Class Submarine Project Suffers Further Delays," *IHS Jane's Defence Weekly*, January 20, 2016, http://www.janes.com/article/57350/russia-s-lada-class-submarine-project-suffers-further-delays.

27. Gorenburg, "Russian Naval Shipbuilding."

28. "Russia Developing New Fuel-Cell Air Independent Propulsion System for Submarines," *Navy Recognition*, December 12, 2015, http://www.navyrecognition.com/index.php/news/defence-news/year-2015-news/december-2015-navy-naval-forces-defense-industry-technology-maritime-security-global-news/3343-russia-developing-new-fuel-cell-air-independent-propulsion-system-for-submarines.html.

29. Novichkov, "Russia's Lada-Class Submarine Project Suffers Further Delays."

Table 2.3. Future Russian SSKs, SSNs, SSBNs, SSGNs, and SSPs

Class	Type	Basic Characteristics
Dolgorukiy II (Project 955A)	*SSBN*	Reported to include major structural revisions to the prior design. Increases the SLBM payload by 4 to 20 missiles.
Severodvinsk (Project 885M)	*SSGN/SSN*	Improved design for serial production with the goal to reduce the extraordinary costs of the initial submarines.
Severodvinsk Follow-On	*SSGN/SSN*	Reports have suggested that Russia is in the design stages of either a more affordable SSN or an exceptionally advanced SSN with game-changing technologies.*
Lada (Project 677)	*SSK/SSP*	Planned successor to the *Kilo*-class submarines that was supposed to be equipped with AIP technology. This class has faced extensive delays related to design and production. Unclear if Russia will move forward with this class.
Kalina	*SSP*	Potential replacement for the *Lada*-class design. May incorporate AIP technology, although the development of Russian AIP systems has been fraught with setbacks.

* Given Russia's relatively bleak economic outlook, many will scoff at the suggestion that Russia is working on any revolutionary/transformative undersea capability. However, such advances should not be so quickly discounted. During the Cold War, the Soviet Navy invested in audacious and technically risky submarine development programs. The legendary *Alfa*-class with a titanium hull, liquid metal cooled reactor, and extreme submerged speed is the prime example.

Western experts have doubts about the ability of Russia to indigenously develop this technology. Unmanned systems require a mastery of technologies that Russia has never demonstrated a competency in developing or producing. Russia's inability to build successful, large unmanned aerial systems reflects this fact. To offset its own technological weaknesses, Russia has purchased tactical UAS from Israel, and it is possible that Russia has reverse-engineered some Israeli designs. Russia may be able to purchase some systems or subsystems on the international market but will likely be unable to match future Western-style UUVs in terms of either numbers or capabilities.

The development of Russia's future submarine fleet is likely to suffer due to a number of factors. International sanctions imposed on Russia as a result of the Ukraine crisis, coupled with the severing of all access to vital Ukrainian industries, hurt Russian shipbuilding and modernization efforts. Russia (and the Soviet Union before it) struggled to develop an indigenous microelectronics industry. Much of this technology was imported from European sources. Russia also suffers from a shortage of machine tooling, a vital component for the manufacture of heavy industrial and military equipment. This shortage is directly tied to ongoing sanctions following Russia's annexation of Crimea.

While Russia is attempting to find workarounds to this challenge, it is unclear how successful it will be, and the timelines associated with finding viable substitutions are long.[30] In September 2014, the Sevmash shipyard announced that it would no longer be importing foreign parts for submarine construction.[31] Reports of cannibalization of certain parts from retiring submarines suggests that Russia has yet to bridge the gaps in its supply chains. While submarine construction has been prioritized, the Russian Navy's set targets have not been met and delivery timetables for new equipment have consistently slipped right.[32] This will likely only become more exaggerated should Russia's economic downturn persist.

The future of Russian submarine design, construction, and maintenance may also suffer due to a looming precipitous drop-off in knowledgeable workers. The massive downsizing of the Russian Navy after the end of the Cold War included deep cuts to design houses and shipyards, which had a significant impact on human capital of the Russian shipbuilding industry. As a result of these deep cuts, there is a generational gap in many if not all Russian technical fields. Those with experience designing and building new submarines—most from the Soviet-era—are retiring without having trained qualified replacements. Consequently, while a core of highly capable submariner engineers, builders, and maintainers exist, it is unclear for how long and if it will be sufficient for the fleet expansion envisioned by the Russian Navy. These are skills that Russia has not historically imported from abroad, either through legitimate or illegitimate means, and doing so would prove challenging even if Russia chose to do so.

30. Eugene Gerden, "Russian Government Solving Machinery Shortage Problem," *Nonwovens Industry*, January 5, 2015, http://www.nonwovens-industry.com/issues/2015-01-01/view_features/russian-government-solving-machinery-shortage-problem.

31. Oleg Korotkov, "Коммерческая независимость Севмаша," Северный рабочий, July 29, 2014, http://nworker.ru/2014/07/29/2621.html.

32. Gorenburg, "Russian Naval Shipbuilding."

03

Meeting the Russian Challenge

As discussed in Chapter 1, Russia's renewed activities in the undersea domain have raised concerns among defense experts in Washington and European capitals who recognize that the West's collective capabilities to meet this challenge have decreased significantly. The following sections consider the priorities of NATO and partner nations in the undersea domain; their available capabilities; and the ability of NATO and partner nations to work together to address key capability gaps.

NATO AND PARTNERS' STRATEGIC PRIORITIES

The priorities for U.S. allies and partners in the North Atlantic and Baltic Sea, while complementary, reflect some degree of unique national interest based on the particular geographic characteristics of each nation and the specific nature of the Russian challenge in each area. Broadly speaking, however, NATO and partner maritime priorities can be defined along three lines of effort: (1) Maintain the capacity to defeat adversaries and respond to aggression, as necessary; (2) ensure that sea lines of communication remain open, allowing for the free flow of goods and security of critical undersea infrastructure; and (3) ensure military access and monitor Russian naval activity, which are foundational to all. NATO allies have the additional task of safeguarding the alliance's sea-based strategic nuclear deterrent.

In the North Atlantic, these priorities are largely achieved by monitoring and subsequently tracking Russian submarines and other naval assets. This is a mission that has remained constant since the late 1940s. During the first several decades of the Cold War, monitoring activities were driven by the need to keep an eye on Soviet ballistic missiles submarines. As ranges of SLBMs increased, monitoring activities shifted to tracking Russian attack and guided missile submarines. This task increased in complexity as Russia produced progressively quieter submarines. This increase in quieting dramatically blunted the NATO advantage in undersea sensing beginning roughly in the 1980s. Today, the need to monitor the strategic GIUK choke point is once again growing given an increased Russian operational tempo and the use of submarines as strategic signaling tools. This task remains difficult for modern-day allied and partner navies as the latest Russian submarines have reached near parity with some of their Western counterparts.

In the Baltic Sea, each nation prioritizes defense of its own territory, including several hard to defend strategic islands in the middle of the Baltic Sea. In support of ensuring their territorial integrity, Baltic Sea nations monitor Russian activities in an attempt to lessen their coercive effects and mitigate the advantage Russia gains from ambiguity. Undersea monitoring in the Baltic Sea must include key undersea infrastructure such as data and power cables that crisscross the region, as well as vital port facilities. In the Bay of Gdansk, adjacent to Kaliningrad, the main Russian threat is from submersibles and, however delivered, special operations forces. Here, guarding against "little green frogmen" will be especially challenging given the shallow depths and locations of assets on the seafloor.

NATO AND PARTNERS' CAPABILITIES

In decades past, the NATO alliance built and maintained a strong proficiency in ASW, conducting regular ASW operations in the North Atlantic and undertaking robust scientific collaboration that could be leveraged for operational advantages. Once the Cold War ended and the Russia threat diminished, the focus on capability development shifted to conflict management and stability operations mostly beyond the European continent. At the same time, defense budgets and force structure took deep and significant cuts, which led to divestment in ASW capabilities. Overall, today's platforms are undeniably more capable than those they replaced but European nations (and the United States) are able to afford far fewer than they once did. While the picture remains mixed, the ability of many Western nations to reliably detect, track, deter, and counter Russian undersea activities has atrophied given lack of investments in readiness and matériel over the past decade and a half. Of course, state-of-the-art capabilities are insufficient without the human know-how required to operate them. Successful ASW is ultimately the result of skills honed over the course of regular, repeated exercises.

Broadly speaking, the capabilities needed for undersea warfare include submarines, surface vessels, fixed wing aircraft, helicopters, and in-place sensors. In most cases, it takes all of these platforms and systems working in concert to achieve an effective ASW mission capability. This integrated capability needs to be undergirded by a coherent and cohesive doctrine and regularly exercised to build a true capability at both a national and alliance level. Table 3.1 provides an overview of regional undersea-related capabilities by nation.[1]

In general, there have been real and worrying decreases in national capability and capacity for ASW operations by the nations most needed for credible undersea deterrence and defense in the North Atlantic and Baltic Sea. Many of the platforms that are currently in inventory are aging and have questionable operational utility in certain maritime areas of operations.[2] These decreases are made

1. For the United States, these numbers reflect either estimates of available forces based on 40 percent of total force allocation or vessels homeported on the East Coast.

2. It is important to keep in mind that not all of these vessels are created equal and many, such as the French *Rubis*-class SSN submarines, are currently scheduled for replacement.

Table 3.1. Relevant ASW Assets Based in the North Atlantic and Baltic Sea

	Submarines	Fixed Wing Aircraft	ASW Helicopters	ASW-Capable Surface Vessels
Denmark	0	0	7	3 FFGs, 4 FFs, 2 AGs
Finland	0	0	0	4 PCs, 2 MLs
France	6 SSNs	12	35	1 CVN, 22 FFGs
Germany	5 SSPs	8	22	7 FFGs
Netherlands	4 SSKs	0	18	6 FFGs
Norway	6 SSKs	6	3	5 FFGs
Poland	5 SSKs	0	11	2 FFGs
Sweden	5 SSPs	0	0	5 FSs, 4 PCs
UK	6 SSNs	0	75	6 DDGs, 13 FFGs
U.S.	23 SSNs	44	95	5 CVNs, 10 CGs, 24 DDGs

Note: Auxiliary, miscellaneous (AG); aircraft carrier, nuclear-powered (CVN); destroyer, guided missile (DDG); frigate (FF); frigate, guided missile (FFG); corvette (FS); minelayer (ML); patrol craft (PC); submarine, diesel-powered (SSK); submarine, nuclear-powered (SSN); and submarine, air independent propulsion (SSP).

starker by the increasing sophistication of Russian submarines. The reality of these reinforcing trends is that barring some revolutionary breakthrough in undersea sensing technology, it will take more assets than in the current inventory to locate and then track suspected Russian activity. Table 3.2 provides a brief snapshot of how NATO and partner submarine fleets have decreased since 2000. In addition to showing a nominal downward trajectory, the figures all reveal an increasing burden on the United States. In 2000, the United States accounted for about half of submarine capabilities of the nations considered in this study; by 2016, that number has risen to 65 percent.

Denmark

The Royal Danish Navy is responsible for the defense of the Danish mainland and its considerable overseas territory, namely Greenland. It is the fifth largest exclusive economic zone (EEZ) in NATO trailing France, the United States, Canada, and the United Kingdom.[3] These factors contribute

3. According to the U.S. National Oceanic and Atmospheric Administration, an EEZ is the zone under which a coastal nation has jurisdiction of the natural resources contained therein. See "What is the EEZ?," National Oceanic and Atmospheric Administration, accessed on June 9, 2016, http://oceanservice.noaa.gov/facts/eez.html; "Exclusive

Table 3.2. Submarine Fleets (2000 and 2016)

	2000	2016
Denmark	3	0
France	7	6
Germany	14	5
Netherlands	4	4
Norway	10	6
Poland	3	5
Sweden	9	5
UK	12	7
United States	74	71
Total	**136** (62)	**109** (38)

Source: International Institute for Strategic Studies (IISS), *The Military Balance 2000–2001* (London: IISS, 2000); IISS, *The Military Balance 2016* (London: IISS, 2016).
Note: The numbers in parenthesis are the total European fleet without the United States.

greatly to the force structure of the Danish Navy, which operates a comparatively large number of ocean patrol vessels, as well as one class of frigate specifically optimized for Arctic operations.

All of the major Danish surface combatants are equipped with a unique system known as Stanflex, a modular mission payload system that allows vessels to be rapidly configured for certain missions.[4] Denmark operates three classes of frigates capable of carrying out the ASW mission for a total of nine vessels. It should be noted that these ships do not possess a towed array sonar system, instead relying on embarked helicopters to augment their hull-mounted sonar systems. One of these frigate classes is a unique hybrid vessel combining the missions of a frigate, troop transport, command ship, and minelayer into one platform. The modular nature of these vessels is what allows them to be reconfigured to meet the requirements for each of these different missions.

Economic Zones: How Some Countries Are a Lot Larger Than They Appear," *The Basement Geographer* (blog), March 10, 2011, http://basementgeographer.com/exclusive-economic-zones-how-some-countries-are-a-lot-larger-than-they-appear/.

4. Megan Eckstein, "What the U.S. Navy Could Learn from Danish Frigate Design," *USNI News*, March 5, 2015, https://news.usni.org/2015/03/05/what-the-u-s-navy-could-learn-from-danish-frigate-design.

Denmark previously operated a relatively robust submarine force but divested this capability completely in the middle of the 2000s. There are no announced plans to rebuild any form of submarine force. Denmark is in the process of replacing its ASW helicopters with new MH-60Rs purchased from the United States. The Royal Danish Navy took delivery of the first of these aircraft early in 2016.[5]

France

France is an interesting case due to the history of its relationship with NATO and the Mediterranean focus of most of its naval forces. The French Navy operates the only non-U.S. nuclear-powered aircraft carrier, maintains a fairly substantial surface fleet, has recently recapitalized its maritime patrol aircraft (MPA), and is in the early stages of procuring a new class of small SSNs. Despite France's considerable ASW capabilities and capacity, it is unclear whether the French government would be willing to employ them in the GIUK gap or in support of operations in the Baltic Sea.

The majority of the French naval fleet, which includes the SSN force, is based in Toulon on the Mediterranean coast. At 20 knots, it would take a French naval vessel approximately six days to travel from Toulon to either the GIUK gap or the Baltic Sea. Given France's core security concerns, its naval orientation toward the Mediterranean is understandable. The reality is that France is far more likely to contribute to any NATO maritime missions in the Mediterranean and broader Middle East than in the waters of the North Atlantic.

Regarding hardware, the European multi-mission frigate (FREMM), a joint development and acquisition effort between Italy and France, will form the backbone of the French surface ASW force. This vessel comes in several variants specific to each nation. The majority of the FREMM frigates that have been purchased by France are the ASW variant.[6] A previous frigate class is also being retrofitted with a towed sonar array as a stopgap method until a new class can be procured in the mid-2020s.

Additionally, the French Navy has begun the construction of a new class of SSNs, the *Barracuda*-class, which are expected to enter service in late 2017. These vessels are noteworthy for their small size when compared with their U.S. or UK counterparts and will represent a substantial upgrade for the French Navy. These submarines will have the ability to launch a long-ranged land attack cruise missile, the *Missile de Croisière Naval* (MdCN), which is comparable to the U.S. Tomahawk.[7]

France is one of the few nations in Europe that still maintains an MPA fleet, in the form of 12 Atlantique 2 aircraft. While these aircraft are quite old, their avionics and sensor suites received

5. Dominic Perry, "Denmark Receives First Three MH-60R Seahawks," *Flightglobal*, June 7, 2016, https://www.flightglobal.com/news/articles/denmark-receives-first-three-mh-60r-seahawks-426149/.

6. "Update to French Military Planning Law Means New Capabilities for Lafayette Class Frigates," *Navy Recognition*, May 21, 2015, http://www.navyrecognition.com/index.php?option=com_content&task=view&id=2747.

7. "MDCN–NCM," MBDA Missile Systems, accessed on June 1, 2016, http://www.mbda-systems.com/maritime-superiority/ncm/.

an upgrade earlier this decade.[8] Despite this, they will likely need to be replaced at some point in the coming decades.

Finland

Finland takes an interesting approach to its military. The Finnish Defense Forces total just slightly over 8,000 professional soldiers, sailors, and airmen. Finland does have compulsory military service with over 20,000 active conscripts and nearly 1 million reserve personnel who could be called up.[9] Accordingly, the Finnish Navy is quite small and does not operate any submarines. It does operate a small number of corvettes equipped for the ASW mission to include sonar systems. Finland is planning to comprehensively overhaul its surface fleet by acquiring a new class of corvettes that appear to be more capable across a wider range of missions than the previous designs. This new procurement program, called Squadron 2020, may include embarking a multirole helicopter.

Finland's surface vessels are augmented by a system of sensors that monitor the maritime approaches to the country. A unique element of the Finnish Navy is its steadfast commitment to mine warfare. The Finns maintain a robust fleet of minelayers and a stockpile of advanced sea mines. This strategy is very much in keeping with their overall defense doctrine of absolute territorial defense. In a crisis scenario, the Finnish Navy could mine the approaches to key facilities and deny access to adversary vessels.

Germany

The German Navy is representative of the ASW capabilities resident in several relevant European nations. For the past fifteen years, NATO has emphasized its operations in Afghanistan. In response, the German Navy moved away from investing in capabilities needed for territorial defense. Therefore, the latest class of German surface combatant, the F125 *Baden-Wurttenberg*-class, has little to no ASW capabilities.

This surface fleet shortfall is partially offset by the excellence of the German submarine fleet. The Type 212 submarines, the product of a joint development program with Italy, are some of the most advanced air independent propulsion (AIP) submarines in the world. Their exceptional stealth, long submerged endurance, and small size makes them ideal for shallow water and littoral operations. While they would seemingly excel in Baltic Sea operations, it is unclear to what extent the German submarine force operates in these waters.

Notably, however, these vessels have no land attack capability. In fact, the German Navy does not possess any form of long-range land attack weapon for either surface or subsurface vessels. There are understandable political sensitivities around the acquisition of such capabilities by the German

8. Amy Svitak, "Thales, Dassault Poised for Atlantique 2 Upgrade," *Aviation Week*, June 18, 2013, http://aviationweek.com/defense/thales-dassault-poised-atlantique-2-upgrade.

9. IISS, *The Military Balance 2016*, 92–94; Felicity Capon, "Finnish Military Preparing 900,000 Reservists for 'Crisis Situation,'" *Newsweek*, May 1, 2015, http://europe.newsweek.com/finish-military-preparing-900000-reservists-crisis-situation-326712.

Navy. However, given the current security environment in Europe and beyond, a limited investment into these systems may to be prudent.

Germany operates eight P-3C ASW patrol aircraft acquired from the Netherlands in 2006.[10] These secondhand aircraft are quite old, but the German Navy is funding a major overhaul of the airframes, which will hopefully extend their service life considerably. However, this service life extension program will take eight years to complete and, given past experiences with such activities, may prove costlier than originally projected. These aircraft are based near the Jutland Peninsula and could be relevant for operations both in the North Atlantic and Baltic Sea.

The Netherlands

During the Cold War, the Netherlands previously maintained a robust ASW capability to include surface vessels, submarines, and aircraft. While it still has a somewhat robust surface ASW capability that includes ship-based helicopters, the other legs of its ASW triad (submarines and aircraft) have atrophied.[11]

The Royal Netherlands Navy operates four *Walrus*-class, diesel-powered SSKs. These vessels entered the force starting in 1992 and had a midlife upgrade in 2007, but they are not equipped with AIP systems.[12] The *Walrus*-class vessels are unlikely to be effective in the deep waters of the North Atlantic against modern SSNs. They may have greater utility in the North Sea or potentially the Baltic Sea. The Dutch government understands that these vessels are getting old and announced that they will be replaced in the 2025 time frame. Reports indicate that the Netherlands may be partnering with Sweden on submarine development and production.[13]

The Netherlands previously operated a fleet of 13 P-3C MPA aircraft and was an active participant in NATO ASW missions during the Cold War.[14] During the early 2000s, all of these aircraft were divested and sold to Portugal and Germany. There are no announced plans to replace this capability.

Norway

Norway has long been a key partner in NATO ASW efforts. This is unsurprising given its proximity to both the GIUK gap and then-Soviet naval facilities in the Kola Peninsula. For these reasons, Norway's ASW competencies, especially as they relate to personnel and organization, have not

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10. Andrew Chuter, "German Navy Extends Life of P-3C With New Wing," *Defense News*, July 29, 2015, http://www.defensenews.com/story/defense/2015/07/29/germany-contracts-airbus-and-lockheed-martin--supply-new-wing--p-3cs/30822275/.

11. The surface ASW capability of the Netherlands is termed somewhat robust as the primary surface combatant, the *De Zeven Provincien*–class, does not deploy any form of towed array sonar.

12. "Netherlands Submarine Capabilities," Nuclear Threat Initiative, July 29, 2013, http://www.nti.org/analysis/articles/netherlands-submarine-capabilities/.

13. Richard Tomkins, "Swedes, Dutch Partner for Future Submarine Work," UPI, January 22, 2015, http://www.upi.com/Business_News/Security-Industry/2015/01/20/Swedes-Dutch-partner-for-future-submarine-work/2621421769173/.

14. "Dutch P-3 Orions," accessed on June 6, 2015, http://members.casema.nl/falcons/Orions.html.

atrophied as greatly as other nations. However, the Norwegian Navy still has to contend with decreasing defense spending and a shrinking pool of assets.

Norway's navy operates six *Ula*-class SSK submarines that, while relatively capable, are scheduled to reach the end of their already-expanded lifetimes in the early 2020s.[15] While these small diesel submarines can operate effectively in the Baltic Sea, they most likely operate in the North Atlantic close to Norwegian shores. Norway's geographic advantage means that its submarine force does not face a long transit time to patrol areas. It is unlikely that these diesel submarines, or a new generation of AIP vessels for that matter, would be effective at open ocean ASW missions against the new generation of exceptionally quiet nuclear submarines. This is due to their low tactical speed, smaller sonars, and decreased ability to operate towed arrays when compared with nuclear-powered vessels. Off board sensors and multiplatform integration could help offset this shortcoming, but the balance of power in undersea warfare tilts toward SSNs in the open ocean.

In addition to its submarine fleet, the Norwegian Navy operates five large multipurpose frigates with ASW capabilities, including embarking an ASW helicopter.[16] Norway is one of the few NATO nations that has maintained an MPA capability throughout the post–Cold War period in the form of four P-3C aircraft. While this is a small number of airframes, Norway again benefits from its geography as the P-3Cs are based on the eastern edge of the GIUK gap. Given the age of its fleet and an inability to fund a full replacement program, Norway is considering leasing P-8s from the United States to meet its ongoing operational need for MPAs.[17]

Poland

The Polish Navy operates a mixture of old Western and former Soviet equipment, including two frigates, formerly U.S. *Oliver Hazard Perry*–class vessels, and five aging submarines. The submarines include four very small vessels (less than 1,000 tons) acquired from the Norwegians in the early 2000s and a singular *Kilo*-class SSK submarine inherited from the former Soviet Union.[18] While this SSK is generally well suited for the Baltic environment, its overall readiness is unknown and the other four small submarines are likely not combat relevant. Reports suggest that Poland is interested in acquiring a new class of submarines with long-range land attack missiles and may be looking at a Swedish-designed vessel. This interest in new, advanced submarines suggests that the Polish armed forces may appropriately be pursuing a strategy of sea denial (vice sea control) that complements with the land-centric nature of their military.

Poland also maintains a small number of aging rotary wing ASW aircraft. These were supposed to be replaced with a new Airbus-produced helicopter; however, this deal was opposed by the

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15. Jaroslaw Adamowski and Gerard O'Dwyer, "Poland, Norway Could Team on Sub Program," *Defense News*, September 27, 2015, http://www.defensenews.com/story/defense/naval/submarines/2015/09/27/poland-norway-could-team-sub-program/32555687/.

16. "Nansen Class Anti-Submarine Warfare Frigates, Norway," Naval Technology, http://www.naval-technology.com/projects/nansen/.

17. Kjetil Bigmark, "Norge vurderer å lease overvåkningsfly fra USA," *Dagbladet*, March, 14, 2014, http://www.dagbladet.no/2014/03/14/nyheter/innenriks/overvakning/forsvaret/nord-norge/32309079/.

18. IISS, *The Military Balance 2016*, 128.

now-ruling party and may be reconsidered.[19] Regardless, it will be some time before any new ASW capabilities enter the Polish armed forces. At one point, Poland operated a network of undersea sensors in the Bay of Gdansk. If this network is still operational, it likely does not possess significant operational efficacy due to its age and mostly silent Russian SSKs.

Sweden

Like others, the Swedish Navy is less capable across the full spectrum of ASW mission requirements than it once was, despite operating several excellent platforms that could be used in this mission. This suggests that the force has not maintained its proficiency in ASW from previous highs and that Sweden may lack some capacity to cover its large and intricate coastline. In this regard, Sweden is confronted by a geographic problem. Not only is its coastline challenging to monitor, but Swedish officials must also concern themselves with the defense of Gotland, a strategic island in the middle of the Baltic Sea.

Sweden operates one of the most capable AIP submarine classes in the world, the *Gotland*-class. These three vessels are highly capable and designed for the Baltic Sea environment. The *Gotlands* are so advanced that the United States leased one from Sweden in 2005 to test U.S. ASW capabilities.[20] The Swedish Navy also operates two older *Sodermanland*-class submarines that have subsequently been updated with AIP technology. These older boats will be replaced in the near- to mid-term by two new, highly advanced AIP submarines. The new A26 vessels will be a step change in terms of multi-mission capability—a major advancement for small AIP submarines. The A26s will also use Stirling engines vice fuel cells, eliminate the days-long fueling process, and boast a flexible payload capacity with the ability to deploy everything from torpedoes to divers.

The Swedish Navy's primary surface vessel, the *Visby*-class stealth corvette, has a robust sonar suite but lacks the ability to track submarines at range, as it lacks a dedicated aviation capability. Sweden is currently acquiring a dedicated airborne ASW platform in the form of the popular NH90 helicopter.[21]

United Kingdom

The Royal Navy may be at its lowest ebb in terms of overall force capacity. The coming years should see the fleet try to reverse some of its losses and regain key capabilities. From an ASW perspective, the Royal Navy is looking to complete the acquisition of the last four of the *Astute*-class SSNs, take delivery of the first *Queen Elizabeth*–class aircraft carriers (CVs), begin construction of a new frigate class, and purchase a fleet of maritime patrol aircraft.

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19. Franek Grabowski, "Poland Debates Helicopter Requirements Again," *AINonline*, January 21, 2016, http://www.ainonline.com/aviation-news/defense/2016-01-21/poland-debates-helicopter-requirements-again.

20. Tyler Rogoway, "Sweden Has a Sub That's So Deadly the US Navy Hired It to Play Bad Guy," *Foxtrot Alpha* (blog), October 23, 2014, http://foxtrotalpha.jalopnik.com/sweden-has-a-sub-thats-so-deadly-the-us-navy-hired-it-t-1649695984.

21. Beth Stevenson, "Sweden Receives First Anti-Submarine-Variant NH90," *Flightglobal*, December 17, 2015, https://www.flightglobal.com/news/articles/sweden-receives-first-anti-submarine-variant-nh90-420159/.

The *Astute*-class SSNs, the successor to the *Trafalgar*-class, are technically excellent, with press reports suggesting that these vessels are roughly comparable to the U.S. *Virginia*-class.[22] The fleet will total seven nuclear attack submarines (a one-for-one replacement of the previous class), with three boats currently in service. While a seven-ship fleet is small, the excellence of the vessels and their crews, and their basing location in Faslane, Scotland, makes them an ideal partner for ASW operations in the GIUK gap. Additionally, the exceptionally close defense relationship between the United States and the United Kingdom means that the two navies have an unrivaled operational partnership in the undersea domain.

The flagship naval acquisition program for the Royal Navy is the two-ship carrier class, the *Queen Elizabeth*. The Royal Navy expects to take delivery of the first of two CVs in 2017. It is difficult to overstate, from both a cultural and operational perspective, the importance of the Royal Navy regaining carrier capabilities. These CVs may be used in support of some ASW operations; however, they are most likely to be used as a highly visible signal of national intent and an offensive strike platform when required. The surface vessels that play a much more direct role in the United Kingdom's ASW operations are its 13 Type 23 frigates. These vessels will begin to come out of service in the early 2020s and will be replaced by some combination of two new classes: Type 26 Global Combat Ship and Type 31 General Purpose Frigate. The initial Type 26 program was a one-to-one replacement for the Type 23s, but the program was altered in the 2015 Strategic Defence and Security Review (SDSR) to include eight Type 26 ASW frigates and at least five of a lighter class, the Type 31.[23]

The United Kingdom's biggest shortcoming in the undersea domain is the lack of any MPA capability since the Nimrod platform was retired in 2010. As discussed in Chapter 1, this shortcoming was dramatically underscored in 2015 when the United Kingdom had to request assistance from NATO allies during a suspected Russian submarine incursion near Faslane. The 2015 SDSR committed the United Kingdom to rebuilding this capability by purchasing nine U.S. P-8 aircraft, but these will not enter service for several years.[24]

United States

The U.S. Navy is the world's largest and most powerful naval force with 10 nuclear-powered carriers (CVNs), 22 cruisers (CGs), 63 destroyers (DDGs), and 53 SSNs in its total force.[25] This doesn't count numerous support vessels, amphibious warfare ships, or ballistic missile submarines. While the U.S. Navy has maintained unquestioned primacy since the end of the Cold War and is

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22. Peter D. Lawlor, "New Mexico Tests Its Capabilities During Fellowship 2012," U.S. Navy, January 31, 2012, http://www.navy.mil/submit/display.asp?story_id=65063.

23. Andrew Chuter, "New Royal Navy General Purpose Frigate to Be Known as Type 31," *Defense News*, February 12, 2016, http://www.defensenews.com/story/defense/naval/ships/2016/02/12/type-31-royal-navy-general-purpose-frigate/80281358/.

24. HM Government, *National Security Strategy and Strategic Defence and Security Review 2015: A Secure and Prosperous United Kingdom* (London: HM Government, 2015), 32, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/478933/52309_Cm_9161_NSS_SD_Review_web_only.pdf.

25. "Ship Battle Forces – 274," Naval Vessel Register, accessed on May 9, 2016, http://www.nvr.navy.mil/NVRSHIPS/SBF/FLEET.HTM.

arguably the most capable it has ever been, other actors are gaining in both size and capability. China's navy is asserting itself in the Pacific and the Russian Navy is finding its sea legs once more.

Under the "Asia-Pacific Rebalance" policy of the United States, the U.S. Navy plans to have 60 percent of its fleet homeported in the Pacific by 2020.[26] Assuming a 53 boat fleet, the number of SSNs homeported on the U.S. East Coast would need to decrease from 23 to 21 to meet stated goals. However, the total size of the U.S. SSN force is on the decline and is set to bottom out at 41 in 2029.[27] The U.S. Navy's reliance on allies and partners to respond to the Russia challenge will, therefore, only increase given other challenges to U.S. national security in the Asia Pacific and Middle East.

There are also practical issues impacting the ability of the United States to fully engage in the Baltic Sea region. Given its size, a U.S. SSN would have an extremely difficult time navigating the shallow and uneven undersea environment of the Baltic Sea. The U.S. *Virginia*-class is 377 feet long and draws approximately 30 feet of water.[28] By contrast, the Swedish *Gotland*-class has been optimized for this environment and is roughly 200 feet long and draws approximately 18 feet of water.[29] The United States can contribute aerial and possibly some surface assets in this region, but is not best placed to lead an undersea response here.

In the broader North Atlantic, the United States no longer has all of the tools it once possessed to monitor subsurface activity. The efficacy of permanent undersea acoustic sensors against modern Russian SSBNs and SSNs is questionable. To increase its collection ability in this region, the U.S. Navy has recently announced that it will operate maritime patrol aircraft from the former Keflavik Naval Air Station in Iceland on a rotational basis.[30] It will also be undertaking efforts to recoup some of the navy's lost institutional knowledge regarding ASW and build greater officer proficiencies in integrated ASW operations.

WORKING TOGETHER

NATO and partner nations do not currently possess the ability to quickly counter the Russia undersea challenge in much of the North Atlantic and Baltic Sea. Declining capabilities are not only to blame for this shortcoming; equally problematic is the lack of integration among relevant allies

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26. Michael Green, Kathleen Hicks et al., *Asia-Pacific Rebalance 2025: Capabilities, Presence, and Partnerships: An Independent Review of U.S. Defense Strategy in the Asia-Pacific* (Washington, DC: Center for Strategic and International Studies, January 2016), 123, https://csis-prod.s3.amazonaws.com/s3fs-public/publication/160119_Green_AsiaPacificRebalance2025_Web_0.pdf.

27. Ronald O'Rourke, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress* (Washington, DC: Congressional Research Service, 2016), 10, https://www.fas.org/sgp/crs/weapons/RL32418.pdf.

28. Green, Hicks et al., *Asia- Pacific Rebalance 2025*, 128.

29. "The Gotland-Class," Swedish Armed Forces, accessed on May 11, 2016, http://www.mc.nato.int/exer/Documents/DYMH14/HSwMS%20GOTLAND_new.pdf.

30. Steven Beardsley, "Navy Aircraft Returning to Former Cold War Base in Iceland," *Stars and Stripes*, February 9, 2016, http://www.stripes.com/news/navy-aircraft-returning-to-former-cold-war-base-in-iceland-1.393156.

and partners. An effective ASW capability is built on different platforms, sensors, and personnel being able to combine forces in a coordinated manner. Unfortunately, NATO allies, including the United States, and partner nations have lost the ability to work together against a peer adversary in the ASW domain. The organizations, relationships, intelligence, and capabilities that once supported a robust ASW network in the North Atlantic and Baltic Sea have not been seriously called upon since the early 1990s.

The most obvious way to approach developing an integrated, multinational ASW campaign is to leverage existing structures and multinational organizations. In this case, NATO is perhaps an obvious choice, though any format would need to be adjusted to include non-NATO partners Sweden or Finland. Sweden and Finland are, of course, key contributors to advancing joint priorities in the North Atlantic and Baltic Sea. Given that anti-submarine warfare is extremely complex and highly classified—to the point that integrating undersea maritime forces is difficult even among NATO allies—conducting unified responses with partner forces adds an extra layer of complication. Within the NATO context, the domestic political and national security concerns of Sweden and Finland must be carefully navigated, given Russia's strong aversion to the idea of these nations moving closer to NATO. So far, they have taken care to walk a fine line between ensuring their own territorial integrity and avoiding unnecessary provocation. Respecting these nations' positions outside of the NATO structure while ensuring a unified approach to common security challenges is vital.

The European Union (EU) may be an alternative structure, though European collective defense through an EU body has faced major challenges and, of course, the EU does not include the United States. The Nordic Defense Cooperation (NORDEFCO) could also potentially play a role in catalyzing enhanced cooperation and integrating ASW capabilities. This body aims to achieve defense cooperation among its member states and includes both NATO and non-NATO nations, but excludes relevant players such as Poland, Germany, the United Kingdom, and the United States. Both the EU and NORDEFCO would also be limited in how far they could take cooperative efforts as they lack a standing command and control structure akin to NATO. Regardless, they may yet prove to be useful launching points for knitting together a more unified response to Russian activity in the Baltic Sea region.

These imperfect options highlight the seam in the European defense community between full NATO members and the vital partner countries of Sweden and Finland. There are, however, promising signs of increased integration between Sweden, Finland, and key security actors. At the 2014 NATO Summit in Wales, allied leaders established a forum called the Enhanced Opportunity Partnership to ensure Sweden and Finland remain closely integrated with the alliance.[31] Both Sweden and Finland also signed a host-nation support agreement with NATO in 2014 that allows both states to request NATO forces in times of crises.[32] These are steps in the right direction, but

31. "Wales Summit Declaration," NATO, September 5, 2014, http://www.nato.int/cps/en/natohq/official_texts_112964.htm.

32. Gerard O'Dwyer, "NATO Membership Not Automatic for Nordic States, Officials Warn," *Defense News*, April, 28, 2016, http://www.defensenews.com/story/defense/international/europe/2016/04/28/nato-membership-not-automatic-nordic-states-officials-warn/83649744/.

achieving a foundational level of jointness while respecting the sovereignty of both nations will require novel solutions and dedicated U.S. leadership.

Augmenting the multilateral approach with strong bilateral relationships can help bridge the lack of alignment between existing international structures and the current threat environment. Close bilateral relationships will also be required to undergird current structures and augment these arrangements where necessary. The United States is well placed to play a key bridging role in the integration of ASW capabilities across the region and enable partnerships with key allies on very sensitive systems. The U.S. Navy and Finnish Defence Forces already enjoy a close and deepening working relationship and are partnering on some science and technology projects with real relevance to anti-submarine and undersea warfare. Likewise, the United States and Sweden recently signed an agreement that deepens their bilateral relationship and specifically calls out undersea warfare capabilities and training as a focus area. Similarly, the budding relationship between Poland and Sweden may help to bridge the gap in the Baltic Sea region. Increased cooperation between these nations could open the door for creating a host of synergies with regards to operations and acquisitions.

The United States will also need to leverage its bilateral relationships with close allies like the United Kingdom and Norway to develop and deploy a new generation of undersea sensing capabilities. In both cases, the United States has been willing to cooperate on very sensitive issues. The U.S. Navy and Royal Navy conduct tactical submarine combat exercises, for example, and the United States has helped outfit Norwegian survey ships with sophisticated electronic intelligence collection equipment. Leveraging strong bilateral relationships and NATO's enhanced partnership initiative may be the best path forward to simultaneously respect Swedish and Finnish neutrality and build a collective security system in the Baltic Sea and North Atlantic.

04

Recommendations for Countering Russian Undersea Activity

NATO along with key regional partners, Sweden and Finland, must rebuild lapsed proficiency in integrated anti-submarine warfare in order to deter and, if necessary, counter Russian undersea activities across Northern Europe. This should be pursued through (1) preparing organizational structures, (2) upgrading capabilities, and (3) enhancing posture. These steps will serve as the cornerstone for improving allied proficiency in the undersea domain. The long-term success of these efforts will ultimately depend on the alliance and its partners maintaining a unified political front in the face of Russian aggression, as Russia will exploit any fissures in European collective security.

PREPARING ORGANIZATIONAL STRUCTURES

Recommendation: Revise the Alliance Maritime Strategy (AMS)

NATO's existing AMS was published in 2011 and focuses on "over the horizon" maritime security concerns, such as piracy, that threaten commercial sea-lanes or freedom of navigation. It does not reflect the implications of a resurgent Russia or the role of maritime in defense and deterrence. The revised AMS should articulate a common view of the maritime challenge posed by Russia, with an emphasis on anti-access/area denial (A2/AD) vulnerabilities and undersea warfare activity in the North Atlantic Ocean, Baltic Sea, and Mediterranean Sea. This document must also elevate the alliance's priority on ASW and emphasize cooperation with key non-NATO partners, such as Sweden and Finland, on issues of mutual concern.

Desired Effect: Balances the NATO alliance's current emphasis on crisis management, partnerships, and maritime security with the role of maritime forces in collective defense and conventional warfighting.

Recommendation: Encourage NATO-NORDEFCO ASW Cooperation and Leverage Bilateral Relationships

As discussed in Chapter 3, Sweden and Finland are key partners in meeting the present Russian undersea challenge. Using exclusively NATO structures may fail to properly leverage their capabilities and expertise. NATO-NORDEFCO cooperation may be able to serve a bridging function to drive interoperability and combined operational proficiency. The close bilateral military relationships that both nations have with key NATO allies should also be leveraged to advance ASW cooperation. These bilateral relationships can build combined capabilities and proficiencies in the same way that NATO-NORDEFCO efforts may enable more unified military responses to global threats.

Desired Effect: Creates new avenues for furthering defense integration and better enables the participation of Swedish and Finnish partners.

Recommendation: Create an ASW NATO Center of Excellence (COE)

While the realities of undersea combat make tactical cooperation difficult, strategic and operational coordination can be the difference between success and failure in an ASW campaign. Success in this sphere may not be about calling the same plays, but rather about making sure everyone is working from the same game plan. An ASW-focused Center of Excellence for allies and partners would serve as a hub for research, planning, doctrine development, lessons learned, and rebuilding and integrating undersea warfare capabilities. This center should serve as a venue for the creation of a common NATO playbook, akin to the Maritime Tactical Signal and Maneuvering Book, for theater ASW operations. Such an effort could help drive understanding across NATO and with relevant partner nations. An ASW COE would work closely with NATO's existing Centre for Maritime Research and Experimentation (CMRE) in Italy, the COE for Operations in Confined and Shallow Waters in Germany, and the COE for Naval Mine Warfare in Belgium.

Desired Effect: Provides a venue for integration and enhancement of NATO and partner ASW capability.

Recommendation: Align the NATO Framework Nation Concept with a Refocused Standing NATO Maritime Group

The alliance should reshape and refocus at least one of the two standing NATO maritime groups (SNMGs) on high-end naval warfighting, including ASW. The force will require a combination of surface, subsurface, and aerial sensors. Synergies may be found with the existing NATO Mine Countermeasure Group 1. A nation highly competent and capable in ASW should act as the framework nation that integrates other relevant ASW nations—including Sweden and Finland. A deputy nation could alternate operational command of the group on a biannual basis. These nations could help steer area-specific networking and sensor developments through their national processes and the NATO ASW COE.

Desired Effect: Aligns and enhances the SNMG structure to the present threat environment; expands the framework nation concept to the maritime domain; and dramatically improves NATO's maritime posture and capabilities in the Baltic Sea and North Atlantic.

Recommendation: Institutionalize and Further Develop a Unified Submarine Command, Weapons, and Tactics Course

The UK's submarine pre-command school, colloquially known as "Perisher" because of its high standards and associated high failure rate, is attended by officers from several NATO nations. NATO should develop a short-form Perisher-style course for allies and partners, perhaps within the context of the ASW COE. Due to equipment differences, this course would not supplant national training for commanders (especially for those representing more advanced undersea navies), but it will help promote integration among NATO navies, improve that ability of the NATO submarine force to operate in a combined manner, alleviate some of the burden of maintaining a robust training pipeline for nations with small submarine forces, and create a common baseline among those countries with more nascent capabilities. A unified pre-command course will also be important as the navies of the various NATO member states acquire new undersea warfare capabilities.

Desired Effect: Drives common understanding and tactical interoperability and aids smaller nations in maintaining high-quality training for their submariners.

Recommendation: Improve Information Sharing to Develop a Common Undersea Operating Picture

One of the most potent attributes of Russia's undersea capabilities is the strategic ambiguity created by the submarine force. Many of the NATO and partner nations in Northern Europe already possess relevant ASW capabilities, but they are not integrated to produce a common undersea operating picture. Developing allied and partner information-sharing capabilities will help lift the veil on Russia's undersea activities and decrease its coercive power. To achieve greater integration, NATO should develop a transmission-agnostic, encrypted data standard for undersea sensing data. Data streams from static and mobile sensors could not only feed local assets but be relayed to a shore-based NATO fusion center, potentially colocated with the ASW COE and aligned with the ASW-focused SNMG, to provide analytic capability. For submarine operations, this capability should include maintaining synchronized charts of allied and partner submarine areas of operation.

Desired Effect: Decreases the strategic ambiguity created by Russian undersea capabilities. A common undersea operating picture can also help ensure the resiliency of undersea infrastructure to minimize underwater incidents and deconflict ASW operations.

Recommendation: Increase NATO ASW Training for Allies and Partners and Integration of ASW Activities into NATO Exercises

NATO and partner nations will have to demonstrate prowess in the undersea domain to achieve their collective security goals and deter Russia. Simply developing and maintaining disparate capabilities will not be sufficient. Instead, capabilities will have to be regularly exercised and employed in a combined fashion as an unequivocal signal of intent, resolve, and commitment.

When looking at training and NATO exercises in particular, there are some that are specifically focused on rebuilding ASW competencies or incorporating ASW elements. In 2015, NATO conducted a major ASW exercise named Dynamic Mongoose that included contributions of submarines and surface vessels from many NATO nations as well as Swedish submarines. This exercise allowed the

Commander of Submarine Forces NATO to gain experience in integrated ASW activities. Exercises of this scale and scope need to be conducted on a regular basis with the focus of restoring deep water ASW capabilities and providing training for SSN-operating nations in littoral combat.

BALTOPS is a U.S.-sponsored annual exercise in the Baltic Sea that focuses on a wide range of maritime missions to include ASW. This exercise is generally viewed as a forum to drive systems and operational interoperability between a wide range of NATO and partner nations in this vital region. Due to the changing threat environment, recent BALTOPS have more heavily focused on developing ASW and amphibious warfare competencies. This exercise and the U.S. role therein will be vital for creating a theater ASW capability for the Baltic Sea.

Desired Effect: Increased readiness, interoperability, and deterrent value. Creates venues for building and maintaining staff and command expertise.

UPGRADING CAPABILITIES

NATO investment in ASW capabilities has fallen across the board as the capability seemed less compelling post–Cold War. Accordingly, past excellence in ASW platforms, payloads, and personnel has atrophied in NATO and partner navies. NATO nations must recapitalize their ASW capabilities to achieve the needed proficiency with integrated theater ASW. These investments will have to be made in coordination with NATO's Nordic partners and ideally take a broader federated approach that seeks to maximize cost-savings, effectiveness, and efficiency across participating nations. Groups of nations with similar requirements would map out clear procurement priorities and divisions of labor; establish a unified maintenance and training pipeline for specialized skills; engage in joint research and development; develop common standards; and emphasize interoperability. This method would seek to leverage common platforms or mission systems to achieve greater information sharing and enhanced ASW sensor coverage of key areas. A new ASW COE, as recommended, could ostensibly be a driver and facilitator for a federated approach.

The CSIS study team acknowledges, however, that a federated approach to shipbuilding, in particular, is likely not feasible for many nations. Nations are highly protective of their national shipbuilding industries, viewing them as key national security and economic assets. The track record of past multinational shipbuilding efforts is relatively poor, though there are some exceptions. Regardless, other areas of ASW procurement and maintenance, especially MPAs and sensors, are ideal for a federated approach.

Recommendation: Create a Multidomain, Multiplatform Anti-Submarine Warfare System and Federate Where Possible

During the first phases of the Cold War undersea competition, the United States gained a significant operational advantage from its undersea surveillance system. As submarines get progressively quieter, a wider array of sensors and platforms will need to be brought to bear in order to successfully track and, if necessary, engage an adversary's submarines. To develop a system that is effective against the threats of both today and tomorrow, NATO and its partners need to adopt a multidomain, multiplatform ASW and maritime surveillance complex that prioritizes payloads over platforms. This network will bring together different sensors hosted on large and small, manned and unmanned space-based, aerial, surface, and subsurface platforms. This complex will also include austere, deployable, and potentially disposable sensors that can be widely seeded across a potential battlespace.

Achieving this vision will be difficult given national sensitivities about data sharing in this domain. Some countries may also be unwilling to share data produced by national intelligence assets with their own tactical units. The United States faced this problem at certain points during the Cold War and it has the potential to again complicate efforts to achieve the clearest possible picture of the undersea domain. These efforts will also be hindered by the physical challenges of wirelessly transmitting large quantities of data from disparate sensors to centralized processing locations. Bandwidth limitations and national sensitivities surrounding encrypted communications are well understood within certain intelligence communities, especially those that work with unmanned aerial systems (UAS), but are not uniformly understood across the policy community.

Space Systems

The use of space-based systems for ASW missions is not new. Overhead imaging has been used to track naval deployments that include submarines for at least two decades. Because of this fact, many nations have built covered bases for their submarine fleets to prevent or limit the ability of other nations to monitor their deployments from space.

Unclassified sources point to new uses for space-based monitoring systems for ASW. Such systems fall into a broader category of nonacoustic tracking of submerged vessels. These technologies generally include aerial- and space-based sensors, but almost all require the synthesis of multiple sensors in order to accurately track an adversary's submarine. This requires substantial processing and bandwidth to achieve. It is believed that the Soviet Union was investing in these technologies before the end of the Cold War. The present state of Russian research in this area is unclear to the CSIS study team. A breakthrough in this technology area could create a paradigm shift in undersea warfare.

> *Desired Effect:* In the near term, space-based systems will provide some measure of warning before submarine deployment. In the long term, space-based systems could transform undersea warfare. Any such breakthrough is likely decades in the future, but the potentially disruptive nature of these future systems along with potential Soviet/Russian research efforts in this sphere merit some amount of consideration.

Aerial Systems

This category encompasses a range of platforms from large MPAs based on commercial airliners to small UAS that can be launched by a single operator. Several European nations are looking to replace or renew their maritime patrol capability. As previously mentioned in Chapter 3, the UK is acquiring several P-8 aircraft and the Norwegians may follow suit. Both Germany and France will likely to have replace their MPA fleets in the 2020s. While a common airframe is unlikely, common payloads could help defer some costs, streamline maintenance, and dramatically improve interoperability. These aerial platforms should have the capability to serve as aerial intelligence processing and dissemination hubs for a wide range of distributed sensors above, on, and below the sea.

NATO and partner nations should also consider how UAS could augment or perhaps replace traditional manned ASW assets. With their exceptionally long loiter times and potentially high payloads, larger UAS seem to be ideal platforms for seeding a range of distributed undersea sensors on short notice. Such platforms could also serve as a networking hub for collecting data from these disturbed sensors and transmitting it to a surface vessel or other central location of processing.

From an aerial sensors perspective, NATO and partners should look beyond advanced periscope detection radars and advanced sonobuoys (or sonobuoy-esque systems). Future aerial sensors could potentially include light detection and ranging (LIDAR) systems or advanced magnetic anomaly detectors. Advances in sensor technologies will likely enable smaller systems to be employed for ASW missions, therefore bringing these capabilities to a wider array of platforms. (For example, small patrol vessels less than 100 feet in length may be able to deploy with small ASW UAS, dramatically improving the capabilities of small navies such as in Lithuania, Latvia, and Estonia.)

> *Desired Effect:* UAS have the potential to reshape the aerial ASW mission by creating an inherently networked solution, as well as bring ASW abilities to a wider range of platforms. Future sensors may also move away from the acoustic detection paradigm.

Surface Systems

Surface systems are often thought of as second-class citizens when it comes to ASW missions. However, they play an important role in the broader ASW system. They can host a wide array of sensors, embark purpose-built ASW aircraft, and may serve as a floating processing, exploitation, and dissemination (PED) center for a variety of different sensors supporting a theater-level ASW campaign.

Planned NATO investments in large surface vessels capable of performing the ASW mission and their respective sensors are likely sufficient to meet current and future threats. These vessels are often not used as the proverbial tip of the spear in ASW operations. That said, NATO and its partners should explore investments and experimentation with afloat PED systems to transform these surface ships into the "quarterbacks" of the ASW mission.

The use of unmanned surface vessels (USVs) is a potential growth area in these missions. An example of such a system is the Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV) currently being tested by the U.S. Defense Advanced Research Projects Agency (DARPA). There are also a host of commercially available options in this space. Such platforms use their nontraditional designs (the result of not having a crew) to offer unique capabilities in the ASW mission. They are also tremendously difficult for adversaries to counter due to their low acoustic and optical profiles.

> *Desired Effect:* Investments in afloat PED systems can help with the creation of a truly integrated multidomain, multiplatform ASW complex. USVs, like their cousins in other domains, may provide novel capabilities and significant capacity at lower costs than a comparable manned system. This increased capacity may be an operational necessity given advances in submarine quieting.

Subsurface Systems

As with the previous two categories, subsurface systems include both manned and unmanned platforms. Also similar is the time component to these developments, with manned platforms representing the current capabilities and advanced UUVs representing a future development goal. With regard to traditional submarines, NATO and partner nations should look to cooperate wherever possible on the development and construction of a new generation of air independent propulsion (AIP) submarines. This collaboration should also include subsystems such as propulsion, sensors, and battle management equipment.

Joint acquisition efforts would allow nations to gain savings from economies of scale and shipyard proficiency. However, differing design requirements that result from major differences in operating environments are a potential issue for any collaborative effort. For example, nations that opt for small submarines operating for short durations in coastal areas will not be able to support long-duration missions in distant waters.

In addition, all future submarines should use a modular design with regards to both sensors and combat weapon systems. This will be vital if submarines are to keep pace with rapidly evolving technologies, especially UUVs. Future submarines may serve as the mothership for a wide range of other systems operating above, on, or below the surface at various ranges.

As a first step in acquiring operational proficiency with these systems, NATO should develop an unmanned underwater vehicle capable of being launched from ship or submarine, based on a commercially available system. This UUV should be compliant with a NATO 533-millimeter torpedo tube and have a modular payload. A common NATO UUV would also have the ability for tele-operated or autonomous operations. Such a craft could be used as an additional ASW sensor to monitor vital undersea infrastructure.

As a longer-term R&D goal, NATO should consider how future large UUVs will be integrated into any theater-level ASW system. These R&D efforts will have to tackle difficult questions such as undersea networking and power generation. The development and fielding of these systems will permit greater ASW coverage without large capital investments in manned systems. When teamed with other platforms, they can be used in concert to offset individual platform shortcomings. In the Baltic Sea, unmanned platforms can be key partners to advanced submarines as they can improve the ability to operate and sense in shallow, crowded littoral waters.

Subsurface capabilities also include distributed undersea sensors of both the disposable and permanent varieties. The most pressing need in this area is the development of a new family of systems to monitor key choke points in the North Atlantic and Baltic Sea. Oceanographic and topological conditions can either help or impair the coverage of distributed sensor networks. Due to the sensitivity surrounding these systems and the intelligence they produce, the development and fielding of any such system is likely limited to the United States, United Kingdom, Norway, and possibly a Nordic partner.

> *Desired Effect:* These investments will replace aging and outdated platforms in the near- to mid-term and lay the foundation for a new generation of systems in the mid- to long term. The effective integration of UUVs will create a manned-unmanned teaming paradigm in the undersea domain and pave the way for a dramatic increase in the tracking capability and lethality of the entire system.

Data Processing and Intelligence Fusion

Sonar has remained the chief tool for tracking submarines since its inception. While the capability of automated systems has increased dramatically, they still fall short of a well-trained human sonar operator. This gap may prove difficult to completely overcome. Despite this, NATO and partner nations should direct investments that can automate portions of the acoustic intelligence exploitation process. These technologies can help limit bandwidth requirements for remote sensors and provide unmanned platforms the intelligence required to identify and track potential targets and, if necessary, cue additional platforms.

These investments will be necessary to leverage many of the systems previously described in this section. The amount of data that will be generated by increasing the number of unmanned systems will be more than can be currently processed. Onboard preprocessing will be a requirement for data transmission in bandwidth-limited environments, such as underwater, and may prove to be required for all systems given the explosive growth of data and the finite nature of the wireless spectrum.

> *Desired Effect:* These investments will reduce manpower requirements for undersea monitoring and improve the efficacy of remote, autonomous sensing platforms.

Recommendation: Integrate Interoperable Land Attack Weapons on All NATO and Partner Nations' Submarines

Several nations have been unwilling to integrate land attack cruise missiles into their naval force for political reasons. Given current gaps in precision-guided munitions across allied surface and subsurface fleets, NATO and Sweden should refit their submarine forces to be capable of employing Tomahawk (or equivalent) land attack weapons. Land attack capability should also be a key requirement for all future allied and partner submarines.

> *Desired Effect:* Allows submarines to strike targets with less counterforce risk than land-based systems, bringing powerful deterrent value.

Recommendation: Leverage Rapidly Deployable, Nonmilitary Government Assets to Improve Undersea Collection Capabilities

There is an impressive collection of militarily relevant, oceanographic survey capabilities owned directly by NATO or by individual NATO allies and partners. These vessels could be used as platforms for undersea intelligence collection. Often, they are optimized for acoustic collection with specially designed hulls, engines, and other equipment. During the Cold War, NATO's scientific committee used expertise in oceanography to gain an operationally relevant edge over the Soviet Navy. As part of a modern effort to leverage these assets and skills, the U.S. Navy should consider supplying a Surveillance Towed Array Sensor System (SURTASS) to NATO's Centre for Maritime Research and Experimentation (CMRE). NATO should also fund the installation of secured communications and signal processing equipment on appropriate vessels to ensure they can be successfully integrated into a maritime sensor network. Leveraging nonmilitary research vessels for military purposes may be considered politically sensitive among certain allies and partners.

> *Desired Effect:* Increases the number of sensors available for the ASW mission in a novel and low-cost manner. The high at-sea time of these vessels can be leveraged in the ASW mission without disrupting the core scientific mission. In a crisis scenario, these nonmilitary vessels offer an interesting option for increasing situational awareness without necessarily increasing tensions.

ENHANCING POSTURE

To maximize the impact of the recommended reinvestments in organization and capabilities, NATO should also consider some posture changes. This is an issue largely restricted to the North Atlantic, as the enclosed geography and relatively small size of the Baltic Sea make any posture challenges negligible. The changes proposed here, while not substantial, will have an outsized impact on re-optimizing the alliance for ASW operations in the North Atlantic.

Recommendation: Encourage Norway to Reclaim and Reopen Its Submarine Support Facility at Olavsvern

The former Royal Norwegian Navy base at Olavsvern is ideal for supporting submarine operations in the extreme North Atlantic and Arctic Seas. This facility was built to house the Norwegian submarine force in fully enclosed pens built into the side of a fjord and is strategically located at the confluence of the Barents Sea and extreme North Atlantic. During the Cold War, NATO submarines used this strategically important base as a resupply hub when conducting long ASW patrols of the region. It was closed in 2009, a move that has been criticized by retired members of the Royal Norwegian Navy. This criticism intensified when the private investors who purchased the facility went on to lease it to Russian firms with links to Gazprom. These linkages have caused some angst among many in the security community both in Norway and abroad. While reopening the entire facility may be cost-prohibitive, it may be possible for Norway to nationalize and reopen a portion of the facility to support the rotational presence of U.S., UK, French, and Norwegian submarines. Such an arrangement may be particularly useful for the French, as their SSN fleet is homeported in the Mediterranean.

Desired Effect: Offers NATO nations a secure facility from which to base patrols in the North Atlantic and Arctic, with very limited transit times from home port to station.

Recommendation: Reopen Keflavik as a Support Facility for Rotational NATO and Partner ASW Activities

As part of the fiscal year 2017 budget request, the Department of Defense intends to restart ASW aircraft patrols from the former Keflavik Naval Air Station in Iceland on a rotational basis. Keflavik was a key hub for NATO MPAs during the Cold War. Its proximity to the GIUK gap meant that aircraft wasted little time in transit and could therefore patrol for much longer periods. The United States closed the base in the 2000s. While overall MPA capacity in Europe has significantly declined, NATO should consider ways in which allies could join the United States in Keflavik on a similar rotational basis. Any NATO footprint is likely to be small as Keflavik is also Iceland's primary international airport.

Desired Effect: Increases the patrol aircraft coverage of the GIUK gap by creating a nearby basing hub. Keflavik operations would be easily conducted in concert with existing MPA bases in the United Kingdom and Norway.

Appendix A. Key Submarine Technologies: A Primer

This study is full of technical concepts related to submarine warfare and design that can seem impenetrable for those unfamiliar with the foundational terminology used by submariners. The following section offers a brief primer on key submarine technologies and serves as a useful reference document for those wishing to better understand the discussion and recommendations contained in this report.

PROPULSION SYSTEMS

Air Independent Propulsion (AIP) systems are a relatively recent invention that attempts to correct for some of the deficiencies of conventional diesel-electric systems. AIP adds electric-generation capabilities that can be operated underwater, dramatically increasing the submerged endurance time of a submarine. AIP submarines still have lower submerged speeds than their nuclear cousins, but are lethal combatants in littoral waters due to their extreme stealth. Current AIP systems generally use one of two technologies: Stirling engines or fuel cells. These may be augmented by advanced lithium-ion battery technologies to further improve submerged endurance.

Diesel-Electric Propulsion systems have been around since the advent of the modern submarine. While the capabilities of these systems have improved dramatically over time, the design principles have remained roughly the same. Submarines equipped with a diesel-electric drive have three major components: a diesel-powered electrical generator, an electric motor, and a large bank of batteries. The diesel generator can be used to either recharge the batteries or propel the submarine. The batteries are used to power the submarine when submerged. The benefit of this system is the extreme quietness of the electric drive when submerged. The drawbacks include a submerged endurance limited by battery life; a low speed when operating on battery power; and a vulnerability when recharging the batteries, which is a relatively noisy operation that must be performed either on or near the surface.

Nuclear Propulsion systems have long been the gold standard of submarine propulsion as they simultaneously offer theoretically unlimited submerged endurance and high speeds. However, development and maintenance of submarine nuclear power plants is very expensive. These systems, generally speaking, can be thought of as miniature models of land-based nuclear power plants, heating steam to drive turbines that generate electrical and propulsion power. Key differences are that modern submarine nuclear plants do not require refueling and can operate at a significant percentage of maximum power without running coolant pumps. The latter helps limit the primary drawback of this technology—noise—when compared to other propulsion systems. In the past, nuclear power plants have needed to continuously run coolant pumps in order to cool the reactor; this is a source of noise and was the Achilles' heel of older nuclear-powered submarines in comparison to their diesel-electric counterparts. The major noise sources on modern nuclear submarines are steam turbines, reduction gears, and propellers.

Pump-Jet Propulsors are a somewhat recent addition to modern submarines. These systems replace the traditional screw (the propeller) and are akin to a massive jet-ski engine. They are heavier and more complex than traditional screws but have one vital and offsetting advantage: they can operate at higher speeds than traditional screws without producing cavitation. Cavitation refers to the small bubbles that form when rapidly moving a solid object through a liquid. As these bubbles collapse, the give-off noise that can be detected by other submarines' passive sonar. The lack of cavitation gives pump-jet-equipped submarines a key tactical advantage.

SENSORS

Magnetic Anomaly Detectors (MAD) are systems generally employed by aircraft to detect submerged submarines. Using sensitive equipment, they can detect the magnetic field of a submarine and alter other sensors to more accurately track the target vessel. These systems have fallen out of favor due to the widespread introduction of degaussing, a process that reduces a submarine's magnetic field and lack of fidelity in deep water operations. However, advances in signal processing and quantum mechanics may create low-power MAD systems with extremely high fidelities.

Other Nonacoustic Sensors encompass a wide array of emerging technologies that may augment more traditional undersea sensors in the coming years. Most of these sensors would be deployed on aircraft. For example, advances in laser and light emitting diode (LED) technology may permit the detection of submarines in a manner akin to active sonar except with light.[1] These systems all attempt to create a greater degree of "transparency" in the world's oceans. In other words, they aim to lift the traditional veil of secrecy afforded to submarines operating underwater. If breakthroughs occur in these technologies, navies will have to invest in countermeasures for their existing and future submarine fleets.

1. Bryan Clark, *The Emerging Era in Undersea Warfare* (Washington, DC: Center for Strategic and Budgetary Assessments, 2015), 10, http://csbaonline.org/publications/2015/01/undersea-warfare/.

Sonar comes in two primary forms: active and passive. Active sonar systems generate a pulse of noise and then listen for the return. This generates an accurate picture of the underwater environment but gives away the exact location of the active sonar system. As such, it is rarely used by submarines outside of specialty systems for under-ice and countermine operations. Active sonar is often used by surface vessels and anti-submarine aircraft. Passive sonar uses hydrophones, or sophisticated underwater microphones, to listen to the surrounding environment and detect other submarines and surface vessels. Broadly speaking, modern submarines deploy three types of passive sonar generally described by their location: bow, flank, or towed. These systems work in concert to detect and track targets. Passive sonar performance is affected by numerous oceanographic factors such as temperature, salinity, and background noise. Passive sonar may be augmented by other sensor technologies as submarines become increasingly quiet, decreasing the detection ranges of passive sonar.

WEAPONS

Cruise Missiles are the most recent additions to submarine arsenals and include anti-ship and land attack variants. There are two ways in which a submarine can launch cruise missiles. The first method is through existing torpedo tubes. The cruise missile is encapsulated in a special container, fired from a torpedo tube, and upon surfacing, lifted into the air by a booster rocket. The benefit to this system is that it can be retrofitted to a large number of existing submarines. The downside is that missile diameter is constrained by that of the torpedo tube. The second launch option uses purpose-built vertical launch system (VLS). A powerful blast of compressed air is used to propel the missile to the surface where a booster rocket takes over. The benefit to this system is that this cruise missile capacity does not come at the expense of torpedoes. The downside is that VLS tubes require a specially designed hull and cannot be retrofitted onto older submarines.

Mines are the oldest form of undersea warfare. The concept behind the most basic mines dates back hundreds of years. Modern mines can be deployed from submarines, ships, and airplanes. The most advanced systems can discriminate between military and civilian vessels to create “smart” minefields. Older mines without these features are still stockpiled by numerous countries around the globe.

Torpedoes are the weapon system most associated with submarine warfare. Most torpedoes can be wire-guided, home-in on their target using onboard sensors, or use some combination of the two. Wire-guidance gives submarine commanders a broader array of options for engaging targets, but limits their ability to maneuver the submarine. The Russian Navy possesses at least two classes of torpedoes with wake-homing capability for use against surface vessels, primarily U.S. carriers. In addition to the heavy torpedoes used by submarines, there are a number of lighter torpedoes for use by anti-submarine aircraft and some surface combatants.

Torpedo Countermeasures are designed to deceive an enemy torpedo through some form of deception. Some systems generate a powerful sonar signal to distract an incoming torpedo. Others attempt to mimic a targeted vessel’s sonar profile to confuse the incoming torpedo. The most advanced active decoys are able to present a plausible decoy to both an adversary's active and passive sonar systems.

GENERAL TECHNOLOGIES

Submarine or Acoustic Quieting refers to a host of technologies and processes that are employed to reduce to the greatest extent possible a submarine's acoustic profile. The first steps to achieving a quiet submarine are in the vessel's design and exceptionally stringent quality controls implemented during construction. Shoddy workmanship during construction will result in a noisy submarine. Additional quieting steps involve the installation of low noise mechanical equipment combined with additional dampening and isolation efforts. The design and construction of the submarine's screw is also of vital importance as a poorly designed screw can create significant noise even at low speeds. Lastly, modern submarines are covered in specially designed tiles to further dampen the acoustic signature of the vessel.

Unmanned Underwater Vehicles (UUVs) encompass a large family of systems ranging in size from tens of pounds to hundreds of tons and even larger. UUVs may have a transformative effect on undersea warfare by creating new missions/capabilities and augmenting traditional submarines. These systems can operate more freely in littoral and contested spaces as well as in close proximity to the seabed due to their extreme stealth and potentially small size. A promising future role for UUVs is to act as a distributed, networked detection system in support of anti-submarine and surface naval warfare. Advances in UUV autonomy, networking, and power generation will be required in order for these systems to reach their considerable promise.

Appendix B. Capability Recommendation Matrix

Capabilities	Platforms	Relevant					
		U.S.	UK	SWE	FIN	NOR	
Space Systems: In the near term, space-based systems will provide some measure of warning before submarine deployment. In the long term, space-based systems could transform undersea warfare. The long-term effects of such a breakthrough are manifold and beyond the scope of this study.		X	X	X	X	X	
Aerial Systems: Aging platforms will need replacement in the coming decades. Several nations are considering U.S. P-8. While capable, not all platforms have been outfitted with the full ASW suite. UAS have the potential to reshape the aerial ASW mission by creating an inherently networked solution, while providing ASW abilities to a wider range of surface platforms.	*Manned*	X	X			X	
	Large UAS	X	X			X	
	Small UAS	X	X	X	X	X	
Surface Systems: Investments in afloat PED systems can help with the creation of a truly integrated multidomain, multi-platform ASW complex. USVs, like their cousins in the other domains, may provide novel capabilities and significant capacity at lower costs than a comparable manned system.	*Manned*		X		X		
	USVs	X	X	X	X		
Subsurface Systems: These investments will replace aging and outdated platforms in the near- to mid-term and lay the foundation for a new generation of systems in the mid- to long-term. The effective integration of UUVs will create a manned-unmanned teaming paradigm in the undersea domain and pave the way for a dramatic increase in the tracking capability and lethality of the entire system.	*Manned*			X		X	
	Large UUVs	X	X			X	
	Small UUVs	X	X	X	X		
	Distributed Sensors	X	X	X	X	X	
Automated Acoustic Intelligence Processing: Improvements to sensors and increased sensor density will dramatically increase collection of acoustic intelligence data. Some form of automated processing will be required to both ease the strain on human analysts and minimize bandwidth requirements for wireless transmission.		X	X	X	X	X	

**Individual country priorities vary.*

Nations						Overall Capability Priorities*
DNK	POL	FRA	GER	NLD	NATO	
		X			X	Conduct baisc research on perspective sensing technologies. Work with commercial industry and small littoral states to explore how microsatellites may be used in this role.
		X	X	X	X	Recapitalize/replace aging platforms. Consider common sensor architectures for modular aerial ASW.
		X		X	X	Deploy systems that offer dramatic increases to dwell times with common aerial sensor packages.
X	X	X	X	X		Enable aerial ASW systems to be acquired and employed by a wider array of nations including those with limited naval forces.
X		X	X			Fully integrate surface vessels into ASW sensor networks and explore the potential for creating afloat PED hubs for distributed sensors.
X		X				Replace manned vessels for some missions and increase capacity at lower costs.
	X			X		Increase submerged endurance and multi-mission capabilities.
		X				Replace manned vessels for some missions and increase capacity at lower costs.
X	X		X			Improve the coverage and lethality of manned platforms through man-machine teaming.
	X				X	Deploy enhanced sensor networks and maintain a deployable surge capability.
X					X	Reduce the workload on human operators, maximize capabilities of distributed sensing networks, enable intelligence queuing of manned and unmanned assets.

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