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Newport, RI**

**BLUE WATER NAVY – LITTORAL THREAT**

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**A paper submitted to the faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.**

**The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.**

**Signature: \_\_\_\_\_**

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## **Abstract**

The United States spent the latter half of the twentieth century designing and building a Navy to operate in Blue Water, prepared for eventual conflict with the Soviet Union fleet. With the end of the Cold War, the Soviet fleet is gone and there exists no other Blue Water threat; other nations have focused their resources towards areas which had previously been avoided by the US Navy, the littorals. Inside these waters, the capabilities which ensured the supremacy of the US Navy in Blue Water are ill-matched to locate and operate against the threats in these littoral regions.

The existing gap between the Blue Water and the Littoral Navy is substantial; however, recent strategic decisions will ensure the conversion of the US fleet over the next twenty years. Should conflict rise before the building process is complete, a Blue Water navy will be employed in the littoral, against forces specifically designed for operations in those waters.

During the next two decades the Navy requires changes in operational planning and tactical doctrine to even the bar with the littoral threat in order to ensure local sea control at any desired time for national tasking.

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## INTRODUCTION

The current US Navy was designed, tested, and built to combat the threat of the Soviet Navy, best described as a Blue Water threat, a threat on the high seas, hundreds of miles from coastal waters. These Blue Water fleets had been planned to execute Mahanian-type massive fleet engagement tactically deployed by commanders in a head to head engagement which never came to fruition<sup>1</sup>. Concurrent with the dissolution of the Soviet Union and the slow erosion of both the Soviet Navy and their power projection capabilities, the US Navy has awoken to find itself undisputedly the most powerful navy in the world, without a Blue Water peer. This position does not suggest unlimited power, control, or access throughout the globe, it simply suggests a force without significant threats while operating in Blue Water. With the realities of the shipbuilding process taking up to two decades to design and produce a single new ship of the line, no competitor has an opportunity to threaten this dominance for over the next decade; however, this does not suggest these competitors will remain dormant. It should be expected that competitors will focus their resources not in building fleets for Blue Water engagements against the US, but rather in areas where the US would have difficulty in leveraging Blue Water capabilities, which is exactly what is occurring. The naval landscape today does not reflect a pre-World War II (WWII) naval build-up of dozens of carriers or scores of battleships by neighboring nations, but rather a focus in warfare areas located in the gaps of the US Navy's capabilities: anti-submarine warfare and mine warfare, specifically in the littorals. By focusing a fraction of the resources towards acquisition of the assets required for these fringe warfare areas, sea denial and sea control can be effectively achieved at marginal costs by foreign competitors. The nature of the threat location, the littorals, requires significant change in current fleet tactics, as well as

refocused application of research and development program spending by the US Navy. The gap in the littorals will be narrowed and closed in coming years as new systems are designed and built, but that does not help the operational commander today. In the current circumstance, an untouchable Blue Water navy must be operated in the marginalizing littoral environment to ensure sea control for US power projection efforts in nearly every current conflict. The loss of single major fleet asset would reflect poorly on US power and dominance, as well as publicly reveal the true nature of these fleet shortcomings; even “a heavily damaged ship better serves an opponent’s desire for adverse media exposure as it is towed home instead of being sunk<sup>2</sup>.” It is only through an awareness of these near-term force weaknesses that the operational commander can minimize risk through changes in operational planning and tactical utilization of these resources.

## **TWO FLEETS – THE SHORTFALLS**

Suggesting the most powerful navy in the world is ill-prepared for today’s threats and conflict requires a historical discussion to understand why the current operational forces available have been designed and built without the correct composition or capabilities to fight in today’s battlespace. Throughout the Cold War, the US Navy sustained a procurement and building program to contain and defeat the great bear, the Soviet Navy. During the height of its build-up, the Navy numbered as many as 600 ships<sup>3</sup>. These 600 ships were organized into battle divisions, centered about the high value unit (HVU), the aircraft carrier. In a historical context, the carrier is the centerpiece of the Navy and had been since 7 December 1941. Pearl Harbor was the conclusion of twenty years of Naval War College debates between the supremacy of the battleship over the untested merits of the carrier, each system a capable force in a battle, each with an equally capable lobby of senior

officers attempting to optimally shape the Navy to be best prepared for the “next” war. Time and again, war games demonstrated the shortcomings of the battleship battle group when threatened by a solitary carrier, but while the conclusions of the war games did not change the opinions of the battleship admirals, they did inspire the rising generation of admirals, Nimitz, Halsey, and Mitscher, to train and study for both areas of future combat operations, surface and air. In preparation for combat operations against Japan, the battleships were strategically moved to Honolulu, Hawaii to provide a visual force deterrent to the aggressive Japanese war machine. Though war games throughout the 1930s did include a surprise attack by the Japanese Navy on the US fleet in Honolulu, the risk of this operation was assessed as very unlikely, outweighed by the preponderance of the battleship force recently staged in Pearl Harbor; the Japanese would never risk their fleet against the monumental force arrayed in Hawaii. In the absence of any operational planning, it was merely good fortune that allowed the US Navy to escape December 7<sup>th</sup> with all of her active carriers patrolling the Pacific, while the strategies of her battleship fleet, as well as the ships, sank at the piers; ending conclusively any discussion and debate as to the operational centerpiece in future naval operations. This background portrays the institutional inertia resident inside the Navy organization which exists when major force structure changes are required, despite the overwhelming evidence that a threat’s systems and capabilities had evolved or surpassed US naval capabilities. Over two decades have passed following the fall of the Soviet Union, yet the current fleet composition, while very capable of defeating a Soviet Blue Water fleet, is still ill-equipped for any engagement in the littorals. It will require at least another decade before the fleet begins to fill with the emergent technologies required to balance or regain the initiative in the littorals. Today the operational commander

must weigh heavily the significant risk of the loss of major fleet assets in order to gain and maintain local sea control in any future littoral operation.

Throughout WWII, the carrier battle group (CVBG) cemented its place in history and operational planning. When involved in a contest between navies, the CVBG would be the power and punch of the US Navy. All missions of the battle group in one way or another were tied to the protection of the carrier, which would carry the main weight of any engagement with an enemy, through the offensive arm, the air wing. For seventy years, in every operational plan, it was always the carrier which defined the roles and missions of naval planning. With the collapse of the Soviet Union and the emergence of asymmetric threats, any future engagement will not include a Battle of Jutland or a Battle of Midway; no major at-sea battle between two huge combined fleets will occur, wrestling the control of the sea to the victor. Instead the future battle will likely be waged within sight of land, with an actual combined fleet of Navy and Marine Corps assets, with a cadre of Air Force resources leveraged to counter the defenses of the future opponent. The current and future fight is in this littoral region, in an area no carrier will venture, where every other naval vessel must operate to execute current missions. This fight will force planners to take a navy designed for Blue Water operations and plan for operations in areas of the globe which marginalize their primary defensive weapons and systems.

The CVBG is an awesome instrument of national power. During the Cold War the CVBG was composed of approximately 20 ships: the included the carrier, submarines, amphibious ships, support ships and a squadron of cruiser/destroyer ships (crudes), which could be composed of as many as ten cruisers, destroyers and frigates. Each element of the CVBG played a role in protecting the carrier, or providing USMC forces ashore. The crudes

element was broken down into three primary warfare areas: anti-air (AW), anti-surface (SUW), and anti-submarine (USW). Each warfare area was focused against the capabilities of specific Soviet ships and weapon systems. Upon the collapse of the Soviet Union in the late 1980's, the US Navy's mission has become jeopardized. The Navy's force structure built over a period of forty years had been specifically honed to defeat a very specific threat in a very specific place, Blue Water. As a result of the force that had been planned and built by threat-based planning, there are a number of "secondary" warfare areas which had been placed lower on the priority lists of the Navy. The focus of the threats that had been excluded in Navy planning included most threats in the littoral area, the zone or area within approximately 20 miles of the beach, or shoal water.

Over the previous few decades, while not defined as a revolution in military affairs (RMA), the US Navy has undergone significant change in the composition, as well as the capabilities, of the CVBG. Since the dissolution of the Soviet Navy, the CVBG has been divided with the amphibious ships separating into an independent fighting force, causing a change in title from CVBG into carrier strike group (CSG) and expeditionary strike group (ESG). This division demonstrates the two very different operational missions of each group of ships; the CSG will provide power projection through cruise missiles and fixed wing attack aircraft, using these long range systems to remain in Blue Water, while the ESG will provide power projection via the marine expeditionary unit (MEU), in the littoral. The CSG retains an escort group of approximately seven ships, assembled more for their specific system capabilities than for the sheer numbers of ships for layered defense; it is composed of carrier with associated air wing, three AEGIS capable cruisers or destroyers, four VLS-Tomahawk capable ships, ten LAMPS helicopters, two attack submarines and one multi-

purpose supply ship. As the carrier is more easily defended, and thus safer, if maintained in Blue Water, it will whenever feasible remain in Blue Water. Without a peer competitor, the defensive screen of ships to defend the HVU can actually be smaller. This allows the freedom to operate the rest of the assets assigned to the CSG more optimally when physically separated from the carrier and as required in the littoral regions, providing power projection, fire support, or additional duties to either an ESG or forces ashore. The administrative definition of the CSG composition must not be viewed as operationally restrictive, but rather as a group of assets available for individual tasking from the CSG construct, allowing the operational planner much more flexibility with Naval assets than during any previous period in history.

### **CURRENT AND FUTURE THREAT**

The areas of future conflict, while not clearly defined in the New York Times, can be inferred by studying current foreign policy debates. From President Bush's 2006 State of the Union Address, the US is either currently engaged or concerned with the actions of a variety of countries: Afghanistan, Iraq, Iran, North Korea, Syria, Burma, and Zimbabwe,<sup>4</sup> are but a few. A threat assessment of any of these countries does not reflect an overwhelming Blue Water naval threat, and in the case of Zimbabwe, US interests will include countries without ocean coast lines. In order to be able to support, cooperate, or interdict in situations in these areas, a naval force will require access to their areas of the globe and at some point a port is likely to be involved in any insertion of significant levels of resources or forces. To ensure the security of these ports and sea lines of communications (SLOCs), the Navy will need to enter the littoral area in those regions.

The littoral represent a fundamental and radically different operating area for the Navy. In Blue Water the types of threats are such to preclude close quarter operations, rather all engagements would be expected to occur outside of 50 miles of the carrier and at least 15 miles of any combatant, by the use of surface launched or air launched missiles and torpedoes. The CSG created an impregnable circumference, or vital zone, well away from the HVU, defended by a layered defense of submarines, ships and aircraft. The littoral, by nature of its very definition, immediately penetrates the vital zone of the CSG. As such the detection, identification and weapon systems of the Cold War CVBG, can not provide adequate protection for the carrier in this environment. The littorals provide significant change of environment when considering the operational factors of force, space and time. The space consideration of the littorals has been defined as the vital area of the CSG, something inside 20 miles; however, along with a limiting distance is the limiting characteristics of water depth. Blue Water suggests deep water, greater than 100 fathoms of water, and is directly related to the characteristics of sound in the water.

As a primary detection medium for underwater threats, sound provides the most difficult source of propagation to exploit. While radar systems use the electromagnetic spectrum to locate and track contacts in the atmosphere with great accuracy, the use of sound by sonar systems is not remotely as precise a process. Using a basic sonar range model, the following parameters can effect detection of a target: source level of the object (how quiet a ship is) or active sensor (how much power a sonar system radiates), transmission loss to and from the target, the noise level of the ocean in the area of interest (background noise), the directivity index of the sensor involved, the reverberation level of the area (reflected sound losses), self noise of the sensor's ship, and the target strength of the object. In Blue Water, a

number of these variables can be minimized, while in the littoral the same variables are of great effect and result in shorter detection ranges, or non-detection, of a threat. Sound propagation underwater travels in a variety of manners: direct path, bottom bounce, deep sea channel, and convergence zone. The variety of paths sound may take from an object to a detection system on a ship adds an element of ambiguity of determining where the object may be located, which translates into a loss of time for the operational planner.

While Navy sonar systems are unrivaled in Blue Waters, the technology required to master the littoral area was not a recipient of the Navy procurement budget during the Cold War. As operational factors limited fleet engagements in the littoral, the focus of R&D also avoided the littoral challenge. In the littoral, the detection and identification problem is markedly different from any other area of warfare. Additionally, the environmental and sound characteristics of the littoral region overwhelmingly favor a defensive position, another obstacle to overcome in the likely scenario of the US Navy entering the littoral waters of a potential threat.

While effective warfare against a CSG in Blue Water would require a similar battle group structure, the threat required to repulse or threaten a CSG in littoral waters is of much different character. In the littoral, there are three threats of fundamentally different character than in Blue Water operations: the diesel submarine, the mine, and the small boat. These threats are asymmetric to Cold War threats and the Blue Water fleets; as a result, their capabilities run counter to current Navy capabilities. Of these three the diesel submarine and the mine threat, due to similarities in their operational characteristics, will be the focus of this discussion. In an engagement in the littoral, the un-located submarine must be defined as the enemy operational center of gravity, regardless of all other assets, “the existence of one

single un-located diesel submarine is a traumatizing reality for naval commanders<sup>5</sup>.” The diesel submarine due to its need for oxygen and therefore regular visits to the ocean surface, long ago was replaced in the US Navy by the nuclear submarine, which acts independent of the ocean surface requirements for propulsion and sustenance. Similarly, most countries with Blue Water navies evolved from diesel to nuclear submarines. As the threat evolved towards nuclear technology, so did US submarine detection technology, ignoring those peripheral nations which still maintained the “antiquated” diesel technology. However, by focusing on the Cold War threat, US Navy detection technology did not focus on the characteristics of the ever-evolving diesel submarines, which while operating on battery power is nearly impossible to detect. “The technologies available today to submarine-operating nations allow them to deploy fewer, but far more lethal submarine designs in littoral waters<sup>6</sup>.” While the nuclear submarine threats provided “noisy” systems which US Navy detection systems could exploit, the need to detect the diesel was ignored. To successfully counter a diesel submarine threat, US Navy assets must use active sonar, though active sonar incurs significant operational vulnerabilities compared to the passive sonar tactics. Passive sonar operations allow the searching unit’s position to remain unknown, while successfully locating, tracking and targeting the opponent; the predominant method of USW in Blue Water. As a result of water characteristics and sound propagation in the littorals, passive operations are not reliable or dependable. Thus, the use of active sonar is required to detect threats in the littoral. The operation of active sonar, as with any active system, provides enemy location data on friendly forces at over double the detection ranges of those of the active sonar transmitting force. Operational surprise is lost as both identification and location of friendly forces is literally propagated for all opposing forces to target. While

active sonar may detect an object, the next element of tactical concern is identification. This step of the engagement process is equally challenging, or rather time consuming, allowing the opponent time to marshal the principles of war while friendly forces are dispersed and less prepared for changes in the battle space. The very nature of submarine warfare allows maneuver, mass, economy of force, security, offense and surprise to converge and favor the force lying in wait in the littoral waters. The diesel submarine appropriately trained and operating in enemy littoral water maintains an extremely unwarranted advantage over friendly forces in the same waters. When dealing with littoral waters in the Pacific Ocean, while not a current threat, the Chinese Navy has nearly 70 diesel submarines in commission, half of which have been built within the last ten years, reflecting advanced technology, design and capabilities<sup>7</sup>. The ability to field and potentially lose a handful of “older” diesels, would be an adept method of locating the more limited and valuable quarry, the US nuclear submarine assets, while not adversely affecting their own capabilities.

Analogous to the submarine, mines located in the littoral also represents a difficult obstacle for US Naval forces. When operating in littoral waters, there are three possibilities of a mine threat: the waters are known to be mined, known not to be mined, or it is unknown. Only in the possibility of known not to be mined can friendly forces be employed without consideration to this threat. In either of the other cases, the operational factor of time will significantly impact any proposed operation. US Navy mine detection and neutralization systems have been a focus of US Congressional concern since Desert Storm and the damage of three Navy ships, a significant loss of forces during Desert Storm operations<sup>8</sup>. However, despite Congressional interest, mine warfare (MIW) has remained a secondary warfare in the Navy. The assets available can given a significant amount of time, and freedom of action,

locate mines and effectively create an insertion zone for sea lines of communication; the ability to conduct the mine neutralization requires an element of local sea control over a significant period of time. However, the combination of time to detect and locate mines, the time to create a sea route and the ease of reseeding mines into a previously laid minefield represents significant operational risk and will require the prudent delay of Navy forces or repositioning of such forces to prevent losses as demonstrated in 1991. The combination of a mine threat with a robust diesel submarine force adds an incalculable amount of time to operational planning considerations, with friendly courses of action likely to include reselection of sea lanes and amphibious landings sites, or a significant operational pause for sanitization operations of the area or marginalization of enemy forces.

A complicating factor of these threats is the comparable ease in acquisition and affordable costs when compared to other major navy assets. Two subsets of threat nations can be established with respect to these three major threats in the littorals: low tech and high tech. The low tech threat can purchase mine and small boats, which are extremely affordable and available for every nation interested in such defensive armament, suggesting the proliferation may be expected to be world wide. The high tech nation threat will include the diesel submarine in its inventory; however, as it is much more costly and requires substantially more infrastructure, this is much easier to maintain surveillance and intelligence of the threat.

The area of operations for current and future operations is in the littorals, and the threats which will be the weapons of choice in future engagements are asymmetric to current US Navy capabilities. Additionally, while the mine threat and the small boat threat are quite affordable, they can yield substantial results both in battle damage and influencing the

development of courses of action, as well as tactical decision making on the battlefield. Today, the Navy is vulnerable in those waters, at a level of risk higher than at any time during the Cold War.

### **CONCLUSIONS – THE WAY AHEAD**

In an example of “the emperor has no clothes,” “the Navy’s ASW Assessment did not contain the rigorous analysis of ASW shortfall<sup>9</sup>.” The Navy continues to attempt to minimize capability shortfalls, while simultaneously failing to adapt training or tactics to correct the issue, “Top defense leaders continue to look for a singular (technical) solution instead of developing widespread anti-sub and mine capabilities through coordinated training<sup>10</sup>.” As the US Navy fleet has been designed and built for Blue Navy warfare, today the quandary lies in how it must be operated to maximize success probabilities and minimize risk to personnel and equipment. This will require changes in how the fleet is used to fight the war. A variety of efforts must be employed to exploit operational factors of force, space and time. Intelligence gathering and preparation of the battle space must be an essential element of planning. The consideration of coalition assets and capabilities will and must be a force multiplier in the littoral fight. While the US Navy has shrunk to half its size since the end of the Cold War, the application of the forces can still be maximized by deviating from traditional CVBG or CSG HVU defense structures. Scheduling and timing of an operation must be balanced against the conditions of the environment in a manner quite unlike historical operations, as a result of the overwhelming advantage in the littorals of the defending forces. From a tactical perspective, active sonar operations must be the predominant method of threat detection and localization, a significant change from Blue Water operations; this method leads to loss of surprise and early identification of friendly

force location and identification for enemy prosecution. Finally, a red team cell must thoroughly scrutinize all operational branches and sequels, specifically in this area of warfare where the Navy has so little threat based operational experience.

To overcome the likely threats in the littoral, operational planners will need to use current Navy forces in a manner completely foreign to the methods pursued during the Cold War. The division of the CVBG, into the CSG and ESG, represents the first significant change in current operational utilization of the naval force assets. This creation of the CSG and ESG dramatically changes the operational landscape of naval planning, since instead of a high of 15 CVBG available at the height of the Navy build-up in the 1980s, today with half the ships commissioned there are 23 strike groups of varying power projection capabilities. Future operations need to blur the difference between the two strike groups and recognize the need for a strike group presence, either CSG or ESG. While these strike groups provide an extremely different air capability, during peace time each provides a stabilizing presence in an AOR. By easing GNFP strike group requirement it provides greater flexibility for contingency operations and additional assets for secondary or tertiary areas of operation, better supporting the 2001 1-4-2-1 QDR construct, and at the same time, gaining greater intelligence and experience into areas of potential future conflict.

While the division of the CVBG into CSG and ESG represent a method of multiplying the forces available in a region, a further division of the CSG must be a common operational practice. To defend a carrier, the pre-dominant step is remaining in Blue Waters, optimizing current defensive capabilities and limiting the threats opportunities. By remaining in Blue Water and due to advances in capabilities in current crudes platforms, the carrier no longer requires the layered defenses of a squadron of crudes ships. This allows a

further division in forces available for operations in the littoral. By this simple multiplication of friendly forces operating in the littoral, the threat's tactical picture is disrupted and their operational plans will require alteration. While never constrained by Navy doctrine, by maintaining the carrier in distant Blue Water and deviating from standard carrier defense tactics, the threat's operational plan will be complicated and thus cause a reduction in their decision cycle.

A reliance on active sonar detection systems will be a deciding factor in littoral warfare. When the littoral has been designated for operations, either for SLOCs, power projection, or amphibious landings, local sea control must be achieved. This local sea control will include sanitization of both underwater threats, which will require an aggressive active search by a multitude of sensors. Currently, this would be the host of crudes, submarine, and fixed and rotor wing assets. Each of these units must be integrated in succinct maritime awareness picture, through the use of Link 11 or Link 16. The opportunity cost of this sanitization operation will be the inability of the operational commander to plan for or conduct additional concurrent operations. While an area, or space, of sanitization is achievable it directly relates to time and force in operational planning. It is not a short time framed element of the operation, but a significant facet in resource allocation of ships, aircraft and time. The reduction of the CSG layered defense assets is a fundamental piece to expediting this aspect of achieving local area sea control.

As in many aspects of operational planning, red team cells dramatically assist in identifying enemy courses of action and branches and sequels. Clausewitz remarks that in general, "defense is a stronger form of fighting than attack<sup>11</sup>." This is an understatement of the situation in the littoral environment; as such the process of red teaming must be

adequately applied to the threat's defensive actions and tactics in the littoral in order to shift the advantage to the attacking force.

Sun Tzu spends two of his thirteen chapters focusing on the importance of environment in the Art of War<sup>12</sup>, this element of littoral sea control is fundamental in any operation in the littoral. As detection of diesel submarines and mines will be predominantly achieved by active sonar systems, a study and utilization of the environment is critical in any littoral operation. As essential to the success of the Allied landings in Normandy on D-Day, 6 June 1944, the environmental elements of weather, sea state and tides are more critical for today's USW operations in the littoral. While atmospheric weather prediction remains firmly in the realm of chance, underwater predictions are more predicable. No other element of planning may be as critical in the preparation of the battle space as a complete understanding of the local environmental effects in the battle in the littorals.

## **RECOMMENDATIONS**

The US Navy is in the unenviable position of being unprepared for the current threat and though a rapid building program is addressing these shortcomings, specific systems will take time to populate the fleet in an operational mode (DDX, LCS, SSN 774). To bridge the gap between what can be done and what must be done requires changing or refocusing of operational planning resources.

1. Detection and identification of enemy mines and diesel submarines are extremely difficult problems in the littoral battle space; identifying and tracking these threats is a prerequisite for entry of friendly forces; the allocation of intelligence assets must be planned and executed months earlier than any other element of the operational plan.

2. Force multiplier – non-US. As a factor of intelligence, coalition or non-hostile assets must be woven into the fabric of a tactical data system. The concepts of the maritime domain awareness system and the 1000 ship navy must be exploited to ensure threat movements are known and tracked.

3. Force multiplier – US. OPTEMPO and operational schedule clearly delineate the number of naval forces available in any area at any time. The division of the CVBG into CSG and ESG has allowed a greater coverage area and time to be created with the same reduced force structure. A second step is the stripping of the CSG of her layered defense system leaving the HVU with one or two ships to provide a capable but minimally layered defense. Reliance on open ocean separation, the carrier's speed, and the increased capabilities of aegis cruises ships, will limit risk to the HVU while providing increased assets to search for the real threat in the littoral. This separation of forces will maximize forces in the littoral while minimizing the unnecessary allocation of forces in the wrong location.

4. Aggressive Active Operations. Operationally plan for the use of all force assets in an aggressive, active saturation technique, massed to quickly overload the threat's decision cycle. By massing all forces, submarine, surface and aircraft into the littoral area it would mark a definitive change in risk adverse methods currently used in the fleet. While the active sonar has the significant drawback of identifying friendly force location and identification, a lightning strike with all pooled forces changes the calculus of the opposing force's plans and timelines.

5. Red Teaming. As in many applications, red teams are invaluable for demonstrating short falls in blue planning; identifying possible branches and sequels is not adequately performed today in current Navy operations. As there are few areas in which the

opposing force would hold such an advantage over the US Navy, red team efforts would be invaluable prior to entering into conflict in the littorals.

6. Exploit the Environment. The littoral presents a unique challenge in underwater sound propagation and sonar detection. Both the threat and the US Navy must be intimately aware of the sonar conditions and take advantage of the conditions when best suited for operational success; the more diligent of the adversaries will gain the advantage.

## Notes

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