REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
19-05-2015	Research	7 July 2014 - 3 June 2015

4. TITLE AND SUBTITLE
Unmanned Underwater Vehicles: Resurrecting Forcible Entry From the Sea

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
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5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USMC School of Advanced Warfighting
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3070 Moreell Avenue
Quantico, VA 22134-5068

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

12. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
Amphibious operations are vulnerable to naval mines. The tactical and operational implications of a UUV that can detect and neutralize naval mines in the VSW zone provide an amphibious task force increased tempo and surprise to achieve a forcible entry. A UUV that can both detect and neutralize naval mines in the VSW zone creates an MCM force with increased minefield clearance rates, additional tactical options for the MCM commander, the ability to undermine the tactical asymmetries of naval mines and to reorder the integration of existing MCM systems. These combined tactical implications produce MCM forces that can clear boat lanes for landing craft to suitable beaches at a significantly faster rate. A more potent MCM force can increase an amphibious task force's maneuver space, speed, tempo, surprise, and erode the advantage of naval mines. It behooves the Naval Service to grasp the positive implications of UUVs in MCM and the benefits that these technologies have on the core mission of forcible entry from the sea.

15. SUBJECT TERMS
Mine counter-measures, very shallow water zone, unmanned underwater vehicles (UUVs), amphibious operations, forcible entry

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	17	Marine Corps University / School of Advanced Warfighting
Unclassified	Unclassified	Unclassified			19b. TELEPONE NUMBER *(Include area code)* (703) 432-5318 (Admin Office)

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FUTURE WAR PAPER

Unmanned Underwater Vehicles: Resurrecting Forcible Entry From the Sea

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF OPERATIONAL STUDIES

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AY 2014-15

Mentor:

Approved: Dr. Bradley J. Meyer

Date: 20 May 2015

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"We can ill afford to move 3,000 miles to theater and be stymied by mines and obstacles in the last 3,000 yards."[1]

—Maj Gen Rhodes, USMC, Marine Corps Combat Development Command

General Rhodes' comment, just after the Persian Gulf War, captures the power of naval mines in the very shallow water (VSW) zone. These weapons can frustrate the efforts of an amphibious task force as it reaches the critical point in its journey to an objective. After the Persian Gulf War, the threat of naval mines seemed to vanquish the feasibility of future forcible entry operations from the sea. The key to solving this difficult problem may be unmanned underwater vehicles (UUVs) and their application to mine countermeasure (MCM) operations in the VSW zone. The tactical and operational implications of a UUV that can detect and neutralize naval mines in the VSW zone provide an amphibious task force increased tempo and surprise to achieve a forcible entry.

A UUV that can both detect and neutralize naval mines in the VSW zone creates an MCM force with increased minefield clearance rates, additional tactical options for the MCM commander, the ability to undermine the tactical asymmetries of naval mines and to reorder the integration of existing MCM systems. First, An MCM force's minefield clearance rates would increase if UUVs could both detect and neutralize naval mines due to reduction in MCM sorties into a minefield, a UUVs longer on-station time, and low visibility characteristics. Currently, UUVs and biological systems such as marine mammals and divers are employed sequentially to detect mines in the VSW zone. These sequential layers of detection are in preparation to support the employment of a manned system to reacquire, identify, and finally neutralize the mine. This sequential employment is composed of multiple sorties over several periods of darkness. This method is time consuming. A UUV with a self-contained ability to detect and neutralize mines in a single sortie renders the sequential employment of different specialized systems to perform these separate functions unnecessary. Whereas several sorties of separate systems were required to detect and eventually neutralize mines, UUVs could perform both functions in a single sortie, making each sortie more productive and ultimately leading to fewer overall sorties to clear boat lanes for landing craft. A UUV with this ability yields more progress in clearing a minefield in less time. More capable UUVs executing fewer sorties also possess additional inherent strengths to increase overall minefield clearance rates.

For instance, UUVs have inherent strengths of longer on station time and a low visible signature. UUV's longer on-station time increases minefield clearance rates by maximizing the amount of time dedicated to detection and neutralization for each sortie. UUVs can remain on station within a minefield longer than a biological system. Just as unmanned aerial vehicles (UAVs) can remain aloft longer than manned systems with crew rest constraints, UUVs can remain underwater significantly longer than a diver.[2] UUVs can dedicate more time to detection and clearance than a manned system per sortie. An MCM force would then require fewer sorties and each sortie it executed would dedicate more time to the activity of detection and neutralization, instead of a manned system that would have to be recovered and replenished with greater frequency.

The low visibility of UUVs makes daylight MCM operations in the VSW zone feasible and can reduce the amount of time dedicated to MCM operations by an amphibious task force. Currently, MCM operations in the VSW zone are conducted exclusively during periods of darkness to reduce exposure to enemy observation. A UUV due to its ability to remain submerged longer than manned systems exposes itself less frequently to enemy observation. Due to this lower visible signature, UUVs could potentially be employed in daylight, which allows an MCM force to conduct detection and neutralization 24 hours a day. Previously, an MCM force would limit its operations to periods of darkness and halt its clearance efforts during hours of daylight. The cumulative result is progress through a minefield in the VSW zone stops during half of the time devoted to MCM operations prior to an amphibious assault. Taken together, fewer sorties, increased on-station time, and 24-hour operations significantly increases the minefield clearance rates for an MCM force.

In addition to faster clearance rates, UUVs designed to detect and neutralize give an MCM commander additional tactical options to counter naval mines in the VSW zone. One such option is to employ a UUV designed to detect and then neutralize in a "one-way" sortie. Unmanned systems are in a unique position to offer sacrificial capabilities that are acceptable and reliable as opposed to manned systems tasked to do the same. Instead of a "two-way" sortie in which the UUV is launched and recovered in a round-trip mission; the "one-way" option would involve only launching or inserting systems into a minefield. There would be no requirement to recover the system and therefore no need for forces to expose themselves to enemy observation to link up and recover the system. A one-way sortie implies that the UUV sacrifices itself to neutralize a mine. This option requires that the MCM force have one UUV for each mine it intends to clear. A dense minefield would require a large amount of UUVs and platform (air and sea based) space to deliver them.

The one-way sortie option opens the possibility of employing UUVs in mass from multiple platforms to neutralize a minefield. If using an overt means of neutralization such as explosives, the one-way sortie gives the MCM commander a one-shot opportunity to detect and neutralize. This opportunity has the potential to be a single point of failure that requires mitigation. An MCM commander can mitigate this problem and increase his chances for success by increasing the quantity of UUVs to counter mines. The more UUVs employed increases the probability of neutralizing mines within identified boat lanes. Instead of sending one UUV per mine, an MCM force could send 10 UUVs per mine to produce more desirable odds of success. Each additional UUV employed is an additional chance to neutralize the field. Instead of surgically neutralizing mines, the idea is to saturate naval mine fields by employing UUV countermeasures on a mass scale, overwhelming the mines in the boat lanes to be cleared.

Additionally, an increased ratio of UUVs to mines can allow an MCM force to forego a battle damage assessment to determine the effectiveness of clearance efforts. While a battle damage assessment can confirm clearance effectiveness and exploitable gaps in a field, it can also preclude surprise and interrupt tempo. Improving the UUV to mine ratio increases the confidence level of clearance efforts and allows an MCM force to maintain speed and tempo for the amphibious task force. UUVs, employed on a mass scale, in combination with alternate neutralization techniques present further opportunities.

A UUV with a low neutralization signature presents the possibility of rendering an enemy minefield ineffective without his knowledge. Currently, neutralizing mines involves using explosives, which have a large signature. If a UUV could neutralize or disable a mine without explosives it could potentially avoid this signature. Perhaps a UUV could neutralize a mine with a chemical reaction to degrade the mine's explosive material. Another possibility is a UUV with a system that destroys the electronic mechanisms within a mine, preventing it from detecting its target and detonating. An enemy may use his minefield as part of an economy of force mission and dedicate the minimum forces to the area of the minefield to allow him the ability to mass forces elsewhere. If an enemy operates under the assumption that his minefield is active and intact he will most likely employ his forces in accordance with this assumption. Alternatively, if an enemy is aware of our low signature neutralization capability he may increase his surveillance of his minefield. Minefields are usually under some sort of surveillance to determine their effectiveness.[3] However, with this MCM capability, an enemy will have to focus his surveillance to determine if his minefield is even still intact let alone effective. Either way the enemy assumes a risk imposed on him by this possible UUV capability.

UUVs can negate the tactical asymmetry of a naval mine. To a disadvantaged defender, naval mines provide an effective tactical asymmetry. In World War II, General Irwin Rommel relied on naval mines to help thwart the anticipated Allied amphibious assault in France. Faced with an allied foe superior in men and material and suffering an annihilated Luftwaffe and no meaningful ability to maneuver, Rommel planned to stop the invasion via an impenetrable crust of fortified shore defenses behind large naval mine fields.[4] Seeking affordable asymmetries, he relied on a mixture of deliberate and hasty minefields along the Norman coast to include shallow water mines. Plagued by disadvantage, Rommel sought advantage through mines.

The asymmetry in cost between mines and their countermeasures is another inherent strength of naval mines. In 1972, the United States mined and then subsequently cleared its own mines from Haiphong harbor during the Vietnam War. Exposing an asymmetry in its own mine force, United States Navy spent twice the amount to clear the harbor as it did to mine it.[5] Later, during operation Desert Storm, a $25,000 Iraqi mine caused $15 million dollars of damage to the USS Princeton.[6] The tactical asymmetry and advantageous return on investment to a defender show the appeal of a mine's inherent strengths. A potential way to negate this strength is to possess a low cost counter measure to equal or undercut a mine's advantage.

UUVs designed to detect and neutralize mines can provide a low cost countermeasure that can be employed on a mass scale equal to or greater than quantities of naval mines. If the valuable asymmetries of mines are negated then they lose their tactical and operational value to a defender. If defenders abandon mines and seek other ways to prevent amphibious assaults, then UUVs have provided a valuable return. This technology has friendly force implications in addition to enemy force implications just discussed.

UUVs that can detect and neutralize mines would reorder MCM systems employed in the VSW zone. Currently, divers are the supported system that ultimately neutralizes a naval mine. In the proposed possible future, a UUV becomes the supported system or main effort with other MCM systems arranged to ensure the UUV's success. UUVs would require supporting systems to increase their effectiveness. A disadvantage of a UUV is that it is specialized to perform a specific task and does not yet improvise in stride solutions to problems that interfere with its assigned mission. A large net placed around or inside a minefield to deny a UUV access to the field is an example of an obstacle that could prove difficult for a UUV to negotiate mid-mission. Ideally, UUVs would be employed in an area devoid of obstacles. Realistically, however, an enemy will defend a suitable beach for an amphibious assault with both mines and obstacles. During the Persian Gulf War, this combination contributed to the US led coalition's decision to abandon an amphibious option to liberate Kuwait.[7] A supporting system to breach unavoidable obstacles is required if tactical reasons compel a UUV to be deployed in an area with obstacles. This supporting system could be another specialized UUV but, since obstacles can be numerous in their variety, a manned system like a diver armed with tools to breach such obstacles would be required. Divers can't quickly reduce an entire obstacle, but a group of divers can breach and mark an underwater obstacle for UUVs to pass through. Technology to mark underwater obstacle breach sites would have to be developed that can be recognized by a UUV. The UUV would have to be able to pass through small breach sites and then continue with its mission to detect and neutralize mines. Breach sites could be opened and marked during one period of darkness and UUVs employed the next period or immediately.

Divers could also be prepared to emplace subsurface navigation transponders, which allow a UUV to carry out its mission completely subsurface, free of buoyed antennae or frequent trips to the surface to transmit and receive GPS signals to determine its location. UUVs could perform this function, but a manned system to execute this critical job is a reliable redundancy.

UUVs that can detect and neutralize mines would not differ from current MCM systems in their requirement for the most accurate knowledge as to the location and density of minefields. Mine reconnaissance has always been a key to success in mine countermeasures. Admiral David Farragut's legendary order to "damn the torpedoes" spawned from a detailed prior reconnaissance of the minefield in Mobile Bay in 1864 by one of his junior officers in a rowboat and not the seemingly reckless audacity we are led to believe.[8] A UUVs newfound ability to detect and neutralize does not negate the need for mine reconnaissance from other platforms prior to the employment of MCM forces. UUVs require reconnaissance of minefields to determine size, density, and composition prior to commitment of MCM forces to that field. The most effective reconnaissance would be carried out prior to hostilities before reconnaissance platforms could be targeted and destroyed. Current surveillance platforms using technologies such as wide area persistent stare[9] can be used to capture baseline conditions of sea space before it is mined for later comparison after indications and warnings of enemy mine-laying operations. Routine mine reconnaissance and stereo pairing of imagery can arm MCM forces with accurate information to employ UUVs at peak effectiveness.

These combined tactical implications produce MCM forces that can clear boat lanes for landing craft to suitable beaches at a significantly faster rate. This more potent MCM force has operational implications.

A more potent MCM force can increase an amphibious task force's maneuver space, speed, tempo, surprise, and erode the advantage of naval mines. An MCM force armed with UUVs that can detect and neutralize increases an amphibious task force's freedom of action. A more potent MCM force unlocks the sea as maneuver space for the amphibious task force to use to its advantage. Faster clearance rates allows MCM forces to dedicate assets not only to the beaches identified for the assault, but to additional suitable beaches to complicate the enemy's decision making and provide alternate landings sites to the commander of the amphibious task force. An enemy posed with MCM efforts on multiple potential landing sites would face a dilemma as to where the amphibious assault will occur. This dilemma complicates the enemy's decision to position his counter attack forces to thwart an amphibious assault. An amphibious task force could now exploit a vast maneuver space and force a higher degree of uncertainty on the enemy.

More potent MCM forces increase the speed of an amphibious task force. MCM forces armed with UUVs that significantly increase its clearance rates could carry out their mission more quickly. A commander of an amphibious task force could dedicate less time to MCM operations. As a consequence, advanced force operations would require less time to set conditions for an assault. Therefore an amphibious task force could proceed to decisive operations sooner and threaten the enemy in less time. The speed that a more potent MCM force brings to an amphibious task force reduces the enemy's time window to respond to an amphibious assault. This speed translates to a higher tempo for the amphibious task force.

Significantly increased clearance rates generate higher tempo for an amphibious task force. Tempo refers to a force's relative speed to an enemy. A naval minefield in relation to an amphibious task force is essentially an outpost zone of a defense in depth. The outpost zone provides the defender early warning of an attack in order to give the defender time to position counter attack forces to defeat the attack. If the outpost zone does not provide this early warning then the attacker has an advantage by cutting through the enemy's defenses before the enemy can determine the attacker's main effort and concentrate counter attack forces accordingly. An MCM force armed with UUVs that increase its clearance rates essentially pushes through an enemy's outpost zone more quickly, thereby reducing the reaction time the enemy has to position his counter attack forces to defeat the amphibious assault. An MCM force armed with these UUVs can render beaches accessible to a landing force before the enemy can operationally counter the amphibious assault. The tactical speed of mine clearing UUVs translates to increased tempo against an enemy relying on mines to slow the advance of an attacker. An amphibious task force with increased tempo has the potential to maintain surprise as it maneuvers in the sea.

An MCM force with increased low visibility and tactical options can provide an amphibious task force with tactical and operational surprise. Surprise refers to posing the enemy with an unexpected event for which he is unprepared. The increased low visibility of an MCM force reduces the potential for enemy observation of MCM operations. Reducing the enemy's ability to detect MCM operations degrades his opportunities to react to a follow on amphibious assault. More tactical options for a MCM force due to UUVs will greatly increase uncertainty in the enemy's mind. A more potent MCM force can increase the credibility of deception operations. Today an MCM force can support deception operations by signaling the execution of MCM operations. However, due to lack of capacity, this threat is not credible and also dilutes the effectiveness of an MCM force by diverting assets from the actual boat lanes to be cleared. An MCM force with higher clearance rates can dedicate more forces and activity to a deception operation and therefore pose a more credible threat to complicate the enemy's decision making. Additionally, the tactical option of low signature neutralization will poison an enemy minefield with ambiguity. From this increased fog of war cast by a more potent MCM force armed with UUVs, the enemy is more likely to be surprised by an amphibious task force.

A more potent MCM force erodes the advantage of naval mines. The enemy would be forced to array his forces differently to offset a more effective MCM force. The enemy would divert additional surveillance assets to attempt to detect harder to find MCM forces. The enemy would be forced to divert resources to replenish or repair a minefield more frequently as a more effective MCM force eats through his mines at a faster rate. Therefore, naval mines, a comparatively cheap weapons system, will require additional support, increasing their expense, to maintain their effectiveness. Enemy forces earmarked for a decisive counterattack would be on a shorter tether and less likely to be tasked or massed elsewhere due to lack of confidence in a minefield's ability to thwart or delay an amphibious assault. UUVs and the MCM forces they support will dissipate the once alluring advantage of naval mines and the economy of force mission they support.

The below vignette describes a possible future of the implications of an amphibious task force supported by a MCM force armed with UUVs that can detect and neutralize naval mines in the VSW zone:

In the year 2030, the United States is in the initial stages of a conflict with Country X, a coastal nation. The US military has mustered a formidable amphibious task force to conduct a forcible entry operation into Country X's territory in support of a campaign goal. The Combatant Commander of Country X's region has ensured routine mine reconnaissance over the past several years via UAVs and UUVs assigned to US air and naval forces in accordance with associated war plans. The combined information from multiple platforms provides the Combatant Commander with pre-conflict baseline conditions of all suitable beaches for amphibious landings. The Combatant Commander would like to strike Country X's mine laying assets and depots. However, since Country X has no intention to mine international waters, but only plant defensive fields in its territorial waters, the strike is denied by the National Command Authority due to a desire to de-escalate the conflict. However, due to reconnaissance efforts, the Combatant Commander has indications and warnings of enemy mining due to changes in baseline conditions around possible landing sites. The Commander is authorized to begin MCM operations as part of advanced force operations. The Commander Amphibious Task Force supported by the Mine

Warfare Commander selects the most suitable beaches for an amphibious assault and the best approach lanes. Country X, fully aware of its most vulnerable beaches, heavily mined the very shallow water zone along with various obstacles to thwart MCM efforts. The Diver companies from Clearance Teams 1 and 2 are tasked to breach the protective obstacles around the VSW zone minefields to allow the safe passage of vehicles from the UUV companies to detect and neutralize all mines within the projected boat lanes that approach the beach. The Diver companies embarked in a mixture of high speed inflatable boats and requisitioned fishing trawlers approach the breach sites from over the horizon. Armed with basic cutting tools and marking devices programmed to be recognized by the follow on UUVs, the divers breach and mark their sites in one period of darkness. The UUV companies from Clearance Teams 1 and 2, embarked on two Virginia class submarines with modified containers to hold 200 UUVs, approach their respective launch points. The MCM commander, tasked with clearing boat lanes that best support the CATF's scheme of maneuver, determines from his review of mine reconnaissance products that there are 80 mine like objects in the planned boat lanes. The UUV companies, onboard submarines, upload the mine reconnaissance and breach marking data into their vehicles. Once the submarines reach their launch sites, the UUVs are immediately launched subsurface towards the breach sites without waiting for a period of darkness. The MCM commander is confident he will have a high clearance percentage with a 4:1 ratio of UUV to mines. Meanwhile the CATF tasks the Mine Warfare Commander to airdrop UUVs against other suitable beaches as part of a deception plan targeting the enemy operational level commander to think that the American amphibious assault will land on an alternate beach. The JFACC provides multiple sorties of UUV drops from various aircraft. The UUVs detect and neutralize, via explosives, thirty very shallow water mines, which triggers the operational commander to re-orient an armored brigade to prepare for counterattack in vicinity of the alternate beach.

This short narrative describes how a reordered MCM force would operate in a future conflict and the tactical and operational effects of an amphibious task force armed with a more potent MCM capability.

In conclusion, there are multiple tactical implications of a UUV that can both detect and neutralize naval mines. An MCM force armed with this technology is faster at clearing minefields and gives an MCM commander more tactical options to achieve his mission. The combination of these tactical improvements creates a more potent MCM force. An amphibious task force supported by such an MCM force is able to pose the enemy with difficult dilemmas that complicate the enemy's decision making and ultimately creates gaps for an amphibious task force to exploit. Unmanned systems are influencing multiple domains of warfare. The field of MCM is no exception. As General

Rhodes realized over fifteen years ago, if not addressed, mines void the billions of dollars of ships, landing craft, and training that an amphibious task force transports across the globe. It behooves the Naval Service to grasp the positive implications of UUVs in MCM and the benefits that these technologies have on the core mission of forcible entry from the sea.

Endnotes

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[1] Rhodes, J. E. Lt. Gen. (USMC), Commanding General, Marine Corps Combat Development Command, to Chief of Naval Operations (N81), subject: Amphibious Counter- Mine and Counter-Obstacle Requirements in support of Operational Maneuver from the Sea, 25 Mar 99, 2.
[2] subsurface duration of divers is limited by the amount of breathable gas and CO2 emission scrubber they can carry, the current underwater breathing apparatus provides approximately three to four hours of bottom time at a depth 55 feet of seawater.
[3] Gregory Kemenyi Hartmann and Scott Truver. *Weapons That Wait: Mine Warfare and the U.S. Navy* (Annapolis, Maryland: United States Naval Institute, 1991), 195.
[4] Gordon A. Harrison, *Cross Channel Attack.* (Washington DC: Center of Military History, 1993), 250-1.
[5] Hartmann, 148-155.
[6] Office of the Chief of Naval Operations. Mine Warfare Plan: Meeting the Challenges of an Uncertain World. 1992, 28.
[7] Ibid, 10.
[8] Tamara Moser Melia. *"Damn The Torpedoes" A Short History of U.S. Naval Mine Countermeasures, 1777-1991*(Washington DC: Naval History Center, 1991), 1-4.
[9] Wide area persistent stare. https://www.youtube.com/watch?v=QGxNyaXfJsA

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