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TAKING MINES SERIOUSLY

Mine Warfare in China's Near Seas

Scott C. Truver

A mine is a terrible thing that waits. The easy way is always mined. Any ship can be a minesweeper—once. Sea mines and the need to counter them have been constants for the U.S. Navy since the earliest days of the Republic. In January 1778, patriot David Bushnell used floating kegs of gunpowder fitted with contact firing mechanisms to attack a British fleet anchored in the Delaware River above Philadelphia. Four British sailors died trying to retrieve the kegs—an early example of the challenges of explosive ordnance disposal (EOD) against an unknown threat—but the ships were unscathed. Since that uncertain beginning, mines and mine countermeasures (MCM) have figured prominently in the Civil War, Spanish-American War, both world wars, Korea, Vietnam, numerous Cold War crises, and Operations DESERT STORM and IRAQI FREEDOM.¹

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In February 1991, the U.S. Navy lost command of the northern Arabian Gulf to more than 1,300 mines that had been sown by Iraqi forces virtually under the “noses” of multinational coalition naval forces constrained by their rules of engagement. Mines severely damaged two Navy warships, and commanders aborted an amphibious assault for fear of more casualties. That mirrored the Navy's experience four decades earlier, off the east coast of North Korea, when more than three thousand mines (put in place in a matter of weeks) utterly frustrated an October 1950 assault on Wonsan by a 250-ship United Nations amphibious task force. Its commander, Rear Admiral Allen E.

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Smith, lamented, “We have lost control of the seas to a nation without a navy, using pre–World War I weapons, laid by vessels that were utilized at the time of the birth of Christ.”² The initial clearance operations saw three mine countermeasures vessels sunk by mines and more than a hundred personnel dead or wounded. By the end of hostilities in July 1953, coalition MCM forces, which accounted for just 2 percent of all UN naval forces, had suffered 20 percent of all naval casualties.

The Korean War experience served as the catalyst for the U.S. Navy’s MCM renaissance in the 1950s and early 1960s, as did the Operation DESERT STORM MCM debacle for a renaissance that began in the mid-1990s and continues today (the latter revival much less extensive than the former, however). As Rear Admiral David G. Farragut wrote on 25 March 1864 to the Secretary of the Navy, “it does not do to give your enemy such a decided superiority over you.”³

Traditional navies as well as maritime terrorists can and have used mines and underwater improvised explosive devices (UWIEDs) to challenge military and commercial uses of the seas. These “weapons that wait” are the quintessential naval asymmetric threat, pitting adversaries’ strengths against what they perceive as naval and maritime weaknesses. Indeed, sea mines are key to regional navies’ anti-access/area-denial (A2/AD) and sea-control strategies and operations. Perhaps a million mines of more than three hundred types are in the inventories of more than sixty navies worldwide, not counting U.S. weapons.⁴ More than thirty countries produce mines, and twenty countries export them; highly sophisticated weapons are available in the international arms trade. Worse, these figures are for sea mines proper; they do not include UWIEDs that can be fashioned from fifty-five-gallon drums, other containers, and even discarded refrigerators.

Mines and underwater IEDs are easy to acquire or build and are cheap, but their low cost belies their potential for harm. With costs measured from a few hundred to several thousands of dollars, they are the weapons of choice for a “poor man’s navy,” providing an excellent return on investment: low cost but high effects. On 18 February 1991, for example, the billion-dollar Aegis cruiser USS *Princeton* (CG 59) suffered a “mission kill” from an Iraqi-laid Italian Manta multiple-influence bottom mine costing about \$25,000; the warship was out of service for the duration of Operation DESERT STORM and longer. Several hours earlier that same day, USS *Tripoli* (LPH 10) struck an Iraqi contact mine, which ripped a twenty-three-foot hole in the hull and came close to sinking the ship. During the 1980s “tanker war” in the Arabian Gulf, only the heroic efforts of its crew saved USS *Samuel B. Roberts* (FFG 58) from sinking on 14 April 1988 after it struck a contact mine of World War I design.⁵ The warship’s damage-repair bill came in at more than \$96 million, in fiscal year (FY) 1993 dollars. In an

accounting that usually comes as a surprise, since the end of World War II mines have seriously damaged or sunk almost four times more U.S. Navy ships than all other means of attack combined:⁶

- Mines, fifteen ships
- Missiles, one ship
- Torpedoes/aircraft, two ships
- Small-boat terrorist attack, one ship

While mines and even UWIEDs might not be naval power–projection “show-stoppers,” they could certainly be “speed bumps” in critical waterways and regions, slowing the movement of warships, military sealift, and humanitarian response in crisis and conflict.⁷

FOCUS ON CHINESE MINE WARFARE

The mine warfare experiences of America and other nations are not lost on the People's Liberation Army Navy (PLAN).⁸ Chinese naval analysts and historians understand the asymmetric potential for mine warfare to “baffle the enemy, and thus achieve exceptional combat results.”⁹ Mines provide what some have described as “affordable security via asymmetric means.”¹⁰

The Chinese note that hundreds of thousands of mines served tactical sea-denial and strategic ends in both world wars. Throughout the Great War, Russia, Germany, Turkey, Great Britain, and the United States relied on sea mines. Their mining campaigns culminated in the “North Sea Mine Barrage” of June–October 1918, when British and American ships laid more than seventy-three thousand mines, sinking thirteen U-boats and keeping more in home ports until the armistice. Mines were also used successfully in all World War II theaters. Remarkably, Nazi submarines laid 327 mines from Halifax, Nova Scotia, to the Mississippi Delta, closing several North American ports for a total of forty days and sinking or damaging eleven ships. Toward the end of the war in the Pacific, Operation STARVATION showed the strategic value of mines. From March to August 1945, U.S. Army Air Forces heavy bombers and Navy submarines laid some 12,200 mines in Japan's shipping routes and territorial waters and ports. The results were unequivocal: mines sank or severely damaged some 670 Japanese ships and strangled all maritime commerce around the home islands.

Testimony in 2007 before the U.S.-China Economic and Security Review Commission by a member of the U.S. Naval War College's China Maritime Studies Institute can serve as a prelude to this discussion:

We have recently completed a two-year-long study of over 1,000 Chinese language articles concerning naval mine warfare (MIW). Our three most important findings are:

(1) China has a large inventory of naval mines, many of which are obsolete but still deadly, and somewhat more limited numbers of sophisticated modern mines, some of which are optimized to destroy enemy submarines. (2) We think that China would rely heavily on offensive mining in any Taiwan scenario. (3) If China were able to employ these mines (and we think that they could), it would greatly hinder operations, for an extended time, in waters where the mines were thought to have been laid. The obvious means of employing mines are through submarines and surface ships. Use of civilian assets should not be discounted. But we also see signs of Chinese recognition of the fact that aircraft offer the best means of quickly laying mines in significant quantity. These aircraft would be useless, however, without air superiority.¹¹

With that as framework, this article addresses four broad areas of concern:

- What are the current and projected statuses of China's naval mine technologies and of its inventory, delivery systems, doctrine, and training?
- How might China employ naval mines in "Near Seas" scenarios?¹²
- To what extent are the U.S. Navy and allied/partner navies prepared to cope with Chinese mine warfare strategies and operations?
- How might the U.S. Navy employ mine warfare in Near Seas combat against Chinese forces?

There are broad MIW implications for U.S. strategies, plans, and programs, generally, but particularly for the nascent AirSea Battle Concept, which has captured the attention of the Secretary of Defense, the Chief of Staff of the Air Force, and the Chief of Naval Operations. As outlined in the 2010 Quadrennial Defense Review, the Air Force and Navy are formulating this concept to defeat adversaries that possess sophisticated A2/AD capabilities.¹³ The concept is meant to help guide the development of future capabilities needed for effective power projection, including our own mines to defeat our adversaries' naval forces and strategies. Before turning to these questions, however, some mine warfare terms of reference will be useful.

AN MIW "PRIMER"

Mine warfare—at sea as well as on land—comprises two broad categories of capabilities and operations: first, mines and mining, and second, mine countermeasures.

Damn, "Torpedoes"!

The fundamental goal of a minefield is to deny access, not to damage or destroy a specific ship or submarine. Mines, or simply psychological uncertainty about them (what weapons are actually in the water, and where?) can have intended effects even without firing.¹⁴

Although mines or underwater IEDs can be constructed in virtually any configuration, there are four primary types: bottom (or “ground”) mines, buoyant moored mines, floating (or drifting) mines, and limpet mines. They can be put in place by aircraft, surface ships, pleasure boats, submarines, or combat or suicide divers, even from pickup trucks crossing bridges over critical waterways. They are designed for operations anywhere from the surf and craft-landing zone (less than ten-foot water depth) to deep water (greater than two hundred feet), and their payloads can range from a few pounds to several tons of high explosive (see the figure). The same weapon can be used in offensive or defensive modes—to attack directly an adversary’s ships or submarines or to protect one’s own ships, submarines, or critical sea areas, ports, or waterways.

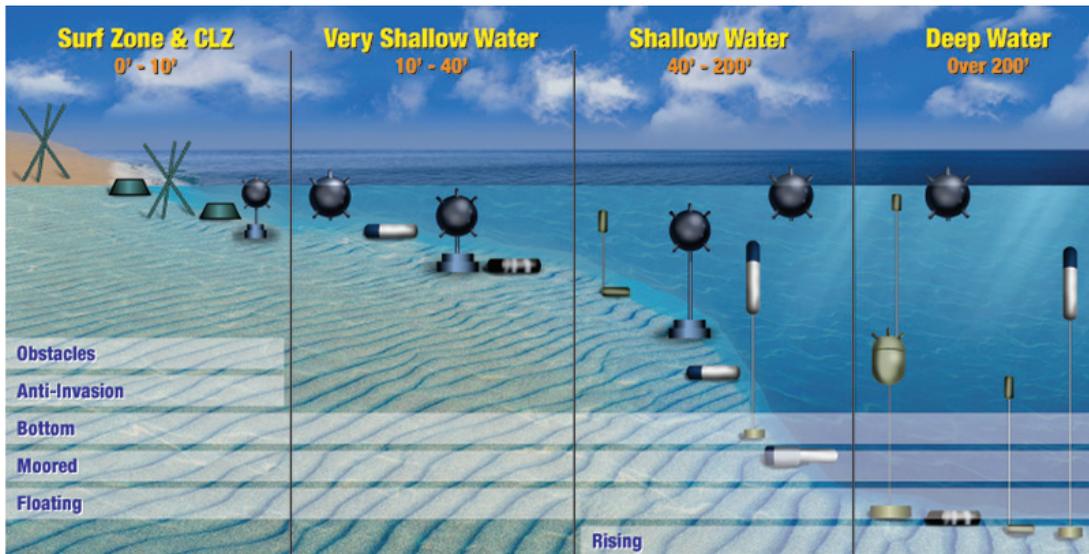
Bottom mines, resting on the seafloor (described as “proud”), are held in place by their own weight but can also be buried under sediment to confound mine hunting; strong tides and currents can result in mine “creep.” Bottom mines range from thirty-six-inch cone-shaped devices to weapons twelve feet in length. Those intended to target surface ships are most effective in relatively shallow water, less than two hundred feet, although bottom mines remain effective against submarines even in deep water.

Moored mines are buoyant cases held in place by anchors. There are three types: *close-close-tethered* and *close-tethered* mines, near the seafloor; *in-volume* mines; and *near-surface* mines. A moored mine requires a large internal air space to make its case buoyant, which limits the amount of explosives it can contain. As a result, the damage radius of a moored mine is usually less than that of a bottom mine. However, they can be fitted with influence sensors or armed with torpedoes or rockets, greatly increasing their “reach.”

Floating mines are positively buoyant and float on or near the surface, but they are generally anchored in place. If allowed to drift they are completely indiscriminate. A variant, the oscillating mine, drifts beneath the surface between two set depths or maintains a constant depth. International law requires that automatic contact mines—mines that fire themselves—must become inert within an hour after becoming free of their anchors.¹⁵ Clearly, drifting mines that are not designed to become inert are prohibited, but they continue to be used.

Finally, combat or terrorist/suicide divers can attach *limpet* mines directly to hulls of targets, set to explode minutes, days, or longer after being put in place. For example, in July 1985 two time-delay limpet mines sank the Greenpeace vessel *Rainbow Warrior* in the Auckland, New Zealand, harbor. The May 2008 sinking of the Sri Lankan logistics ship M/V *Invincible* by Tamil Sea Tigers using limpets underscored the vulnerability of military vessels to suicide-diver attack in ports and waterways.¹⁶

MINE THREAT SPECTRUM



Source: U.S. Navy.

Some mines are mobile, capable of being launched from submarines thousands of yards from intended minefields. Old mines can be refitted with modern, highly sophisticated components to improve effectiveness and confound EOD efforts, and any mine can be equipped with counter-countermeasure features—for example, “ship counts” or antiodiver sensors—to frustrate sweeping, hunting, and neutralization. They can be fabricated from fiberglass or plastic, making them extremely difficult to detect, identify, or counter once in the water. They can be designed to fire in several ways: by contact, by sensing the signatures or “influences” of a surface ship or submarine, and on command.

Contact mines are either moored or surface/drift mines that are designed to actuate when their cases or attachments come into contact with targets. This is the oldest type of mine still in use. Most contact mines use a chemical “horn” that becomes a battery to actuate the detonator when the chemical vial in the horn is broken. Others are fitted with electric switches and internal batteries to fire the detonator.

Influence mines can be bottom or moored weapons and can have sophisticated sensors and firing mechanisms that do not require contact with targets. They are fitted with combinations of magnetic, acoustic, seismic, underwater-electrical-potential, pressure, and video sensors. Modern sensors use microcomputers that can sense a target’s approach, determine whether the sensed signature is a ship or a sweep, and estimate the optimum time to detonate as the target passes.

Command-detonated mines are moored or bottom weapons that are fired on order by the miner when the target ship enters the minefield. Command-detonated

minefields are generally—but not always—limited to protective/defensive operations in harbors or restricted waterways.

Thus, mines are “tools” that can be used in peacetime as well as crisis or war. Indeed, the peacetime laying of naval mines is a legal option in a state’s own internal waters and territorial sea, even on the high seas areas (though not the high-sea regions of international straits or archipelagic waters)—so long as an explicit and effective *Notice to Mariners* is issued and other rules are followed, as the U.S. multiservice *Commander’s Handbook on the Law of Naval Operations* explains.¹⁷

Hunt If You Can—Sweep If You Must

The best MCM operations are those that prevent the minelayers from putting their weapons in place—once in the water, mines are exceedingly difficult to detect, identify, and neutralize. To keep them out of the water, aircraft, cruise missiles, naval “fires” (long-range, targeted strikes, especially by gunnery), and even special-operations forces can (assuming rules of engagement permit) attack mine depots, assembly areas, or potential minelayers.

Failing that, MCM operations can be conducted from the high-water mark on shore to water depths greater than two hundred feet. Countermeasures can be carried out in crowded ports, in narrow assault “breaching” lanes, and in fleet operating areas covering many thousands of square nautical miles. The variety of MCM operations areas and the number of mine types and characteristics, taken together, greatly complicate the mine-defense “problem.” Tactics, techniques, and procedures that apply to one water regime, area, or mine threat do not usually apply to others. No other naval warfare discipline presents such a diversity of environments and threats.

Accordingly, several critical questions must be answered if MCM is to be effective:

- What intelligence do we have about the weapons?
- Where might they be deployed?
- What is the miner’s objective?
- What are the local oceanographic, bottom, and environmental characteristics?
- What is already on the bottom?
- How can we know if something new is there?

With these questions in mind, MCM operations can be broken into two broad categories of tasks: mine hunting and minesweeping.

Mine hunting is effective against virtually all mine types. It comprises five steps: detection, classification, localization, identification, and neutralization.

Sonars are the primary means to detect and classify contacts as mine-like or not. Each contact can also be identified as a mine or a non-mine by specially trained divers, marine mammals, or such equipment as video cameras and laser systems on mine-neutralization or unmanned underwater vehicles (UUVs). Advanced sonars and electro-optical sensors on UUVs offer good promise to enhance mine-hunting capabilities and remove the “man and the marine mammal” from the minefield. Still, detection and classification/identification are slow: surface mine-hunting tactics using hull-mounted or towed sonars are usually carried out at very low speeds, on the order of three knots; mine hunting by helicopters is faster—depending on the sensor system, upward of fifteen knots or so—but less certain.

Once a contact has been detected and classified as mine-like and identified as a mine, it must be rendered safe before the commander can declare a route or area cleared. Depending on the accuracy with which the contact has been located, the characteristics of the bottom (i.e., smooth or rough), sediment type, amount of clutter, the amount of burial, and the depth of the water, among other factors, the detection-to-neutralization process of a single mine-like contact can take several hours if conducted by MCM ships, longer if by other systems.

In contrast, *minesweeping* is a matter of trawling defined swaths of water, using either mechanical or influence systems to expose or destroy any mines that might be there (along with any mine-like but non-mine objects that are there, too). *Mechanical* sweeping consists of cutting the tethers of mines moored in the water volume or physically damaging the mines themselves in other ways, such as chain drags to cut control wires. Moored mines cut loose by mechanical sweeping must then be neutralized (as by gunfire or explosive charges) or rendered safe for subsequent analysis.

Influence minesweeping consists of simulating the magnetic, electric, acoustic, seismic, or pressure signatures of a ship so that a mine fires harmlessly. Intelligence, surveillance, and reconnaissance of an adversary’s mining objectives, doctrine, tactics, and inventories are extremely important when influence sweeping, as is specific intelligence on the operation of the sensors, firing criteria, and any counter-countermeasures (e.g., ship counters or delay arming) of mines believed to be present. Minesweeping is more risky to the platform than mine hunting and, when completed, generally leaves behind a higher residual risk to ships that transit the area. To ensure as low a risk as possible, then, most mine countermeasures operational plans include both mine hunting and minesweeping.

Before sending naval and commercial traffic through a cleared channel, a low-value guinea pig ship often transits first to demonstrate that the channel is indeed safe. These low-value ships can be configured to withstand multiple hits without sinking, in an operation called “check sweeping.” During the 1980s “tanker war”

in the Arabian Gulf, for example, M/V *Bridgeton* struck a contact mine but was able to remain under way and thereafter served (inadvertently) as a guinea pig/minesweeper of sorts, leading the way for the U.S. Navy warships that had been assigned to escort it and other U.S.-flagged commercial ships.

PLAN MINES AND MINING

Chinese mine inventories total perhaps as many as a hundred thousand weapons, from relatively unsophisticated but still dangerous moored contact mines of World War I design to rocket-propelled weapons employing sophisticated signal-processing and target-detection systems. However, this figure of a hundred thousand mines is at best a guess; no one really knows for sure—at least from open sources.

U.S. Government–Published Assessments

Despite a burgeoning “cottage industry” scrutinizing virtually every aspect of the U.S./People’s Republic of China (PRC) relationship in recent years, official unclassified assessments of the PLAN MIW forces are remarkably slim. For example, a U.S. Department of Defense 2010 report to Congress gives Chinese mine-warfare capabilities virtually no mention. Its single reference, which appears in two places, is indirect, simply acknowledging that in January 2010 the Barack Obama administration announced its intent to sell to Taiwan \$6.4 billion worth of defensive arms and equipment, which included ex–U.S. Navy mine-hunting ships of the *Osprey* (MHC 51) class, as an element of a broader commitment to defend it against the use of force or coercion by Beijing.¹⁸

In its latest published assessment of the Chinese navy, the U.S. Navy’s Office of Naval Intelligence provides some pertinent details about Chinese MIW:¹⁹

- The PLAN surface force in 2009 included forty mine warfare ships (in addition to twenty-six destroyers, forty-eight frigates, more than eighty missile-armed patrol craft, fifty-eight amphibious ships, fifty major auxiliaries, and more than 250 minor auxiliaries and service/support craft).
- The Song and Yuan advanced diesel-electric submarines and the Shang nuclear-powered attack submarines (SSNs) are the PLAN’s newest indigenous submarines and the first to be designed to employ the YJ-82 antiship cruise missile in addition to traditional loadouts of torpedoes and mines.
- The Chinese-licensed copy of the French SA-321 Super Frelon helicopter, the Z-8, is a medium-lift helicopter performing troop transport, antisubmarine, antisurface, minesweeping, and minelaying tasks.
- In the last fifteen years the PLAN has moved from an obsolete mine inventory comprising primarily pre–World War II mines to a robust and modern inventory including moored, bottom, drifting, rocket-propelled,

and intelligent mines. Advanced mines feature digital microprocessors for enhanced targeting and integrated sensors to resist sweeping. The mines can be laid by submarines (primarily for covert mining of enemy ports), surface ships, aircraft, and fishing and merchant vessels.

- Although the PLAN considers its MCM capabilities to be relatively advanced—including as it does operations in complex, multiservice environments, during emission-controlled conditions, and at night—China recognizes that adversary mines could be a major impediment to its naval operations. In 1988, the PLAN launched a new minesweeper, *Wolei*, and might have developed an indigenously produced version of the French Pluto Plus mine-neutralization vehicle. The PLAN looks to be maturing into a more capable MCM force by improving its capability to protect its waters from mines, in addition to clearing minefields Chinese forces might have sown during a conflict.
- The PLAN is expanding its domestic research and development for underwater weapons, moving away from reliance on imported systems and technology. The PLAN has reportedly developed a maintenance and inspection program for the upkeep of existing mine stockpiles, necessary to ensure that the more advanced mines, using microprocessors and long-life batteries, are operational when needed.

The Congressional Research Service provides a bit more information:²⁰

- China's naval modernization effort encompasses a broad array of weapon acquisition programs, including programs for antiship ballistic missiles, antiship cruise missiles, land-attack cruise missiles, surface-to-air missiles, mines, manned aircraft, unmanned aircraft, submarines, destroyers and frigates, patrol craft, amphibious ships and craft, mine countermeasures ships, and supporting C4ISR (command and control, communications, computers, intelligence, surveillance, and reconnaissance) systems.
- Although the aging Ming-class (Type 035) submarines are based on old technology and are much less capable than its newer submarines, China may decide that they have value as minelayers or as "bait," decoy submarines that can draw out enemy submarines (such as American SSNs), which can then be attacked by other Chinese naval forces. In related areas of activity, China reportedly is developing new unmanned underwater vehicles and has modernized its substantial inventory of mines.
- China's navy exhibits limitations or weaknesses in several areas, including C4ISR systems, anti-air warfare, antisubmarine warfare, and MCM. Countering China's naval modernization might thus involve, among other things,

actions to exploit these limitations and weaknesses, such as developing and procuring electronic-warfare systems, antiship cruise missiles, *Virginia* (SSN 774)-class attack submarines, torpedoes, UUVs, and mines.

Current/Future PLAN Mines and Mining

Aside from these publications, interviews with U.S. Navy MIW operators, planners, and intelligence specialists at Navy headquarters and in field activities, augmented by additional sources, yield, in summary form, the following.

In the PLAN's mine inventory are more than thirty types of contact, magnetic, acoustic, water-pressure, and other multiple-influence (e.g., acoustic- or magnetic-sensor) mines, including remote-control, rocket-propelled rising, and mobile mines.²¹ The inventory is mostly based on older, former Soviet technology, but it also boasts newer, more sophisticated, multiple-influence types. For example, Chinese copies of Soviet AMD (or MDM) -series multiple-influence bottom mines are common, and they can have air-, ship-, or submarine-launched variants. The PLAN is augmenting with more-capable weapons its inventory of 1970s/1980s-era (and even earlier) mines. Most of these older mines, designed to defend littoral areas, can be deployed only in shallow seas; only a fraction of them can be deployed in medium depths. (Table 1 shows selected Chinese navy mines.)

The shallow-water Chen-1, -2, -3, and -6 influence mines can be placed for defense of ports and harbors; the T-5 mobile mine can be laid in deeper waters in channels and approaches to ports; and the Soviet PMK-1 and the Chinese-developed Mao-5 rocket rising mines are intended for deeper waters farther from ports and in open-ocean areas and choke points.

China's remotely controlled mines, such as the EM-53 bottom influence mine, can be deployed and deactivated by acoustic codes to allow the safe passage of friendly vessels through a mined area and then reactivated to attack adversary ships and submarines.

China likely also possesses an inventory of submarine-launched mobile mines (SLMMs), called "self-navigating mines" in Chinese. These are similar to the U.S. Navy's Mk (Mark) 67 SLMMs. Thought to be derived from Yu-type torpedoes, China's SLMM can travel along a user-determined course for a set period of time; when it arrives at its programmed destination, the torpedo's engine shuts off and the weapon sinks to the bottom.

China began to develop rocket-propelled and rising mines in 1981 and produced its first prototype in 1989. Rising-mine systems are moored, sometimes in very deep water, and release buoyant torpedoes or warhead-tipped rockets when they detect targets. The guided, rocket-propelled EM-52 reportedly can reach attack speeds of eighty meters per second, is armed with a 140-kilogram warhead, and has an operating depth of at least two hundred meters, while the Russian

**TABLE 1
SELECTED PLAN MINES**

Model	TDD	Type/Mission	Laying Platform	Case Depth (meters)	Warhead (kg)
C-1 500 1000	Acoustic, magnetic	Bottom ASW, ASUW	Surface ships, aircraft Surface ships, aircraft, submarines	6–30	300 700
EM-52	Acoustic, magnetic, pressure	Rocket-propelled straight-rising ASW, ASUW	Surface ships	200	140
EM-56	Acoustic, magnetic, pressure	Mobile (13 km) ASUW	Submarines	45	380
M-3	Contact	Moored ASUW	Surface ships, submarines	12–430	(large)
M-4	Acoustic	Moored ASW, ASUW	Surface ships, submarines	200	600
PMK-2	Acoustic (passive/active)	Rocket-propelled encapsulated torpedo ASW	Aircraft, surface ships, submarines	400 (anchor depth > 1,000)	110

Note: ASW: antisubmarine warfare; ASUW: antisurface warfare.

Sources: Erickson, Goldstein, and Murray, *Chinese Mine Warfare*, pp. 12–17; Friedman, *World Naval Weapon Systems*; Wertheim, *Combat Fleets*.

PMK-2 rising encapsulated torpedo mine can be laid in waters deeper than two thousand meters (anchor depth). (A speed of eighty meters per second means that an EM-52 in two hundred meters of water will take about three seconds from weapon launch to endgame attack—far too short a time for maneuver even if the target detects the approaching weapon.) China reportedly offers these two rising mines for export.

Minelaying platforms will likely not include dedicated MCM vessels, other than a single 3,100-ton combination minelayer/sweeper MIW command ship, *Wolei*, mentioned by the Office of Naval Intelligence. This vessel can carry as many as three hundred weapons. The MCM force is focused on near-shore defense, and the Chinese navy has several mining options among its other assets. That said, the aging T-43 minesweepers can carry from twelve to sixteen mines, and the newer *Wosao* Type 082 MCM ships are capable of carrying six mines each.

About 150 maritime patrol aircraft and naval bombers can carry mines, and the employment of aircraft-delivered mines is considered a critical element in “air blockade campaigns.”²² For example, China’s Harbin SH-5 seaplane can carry six Chinese copies of the Russian ADM-500 mine. The aging force of H-6 bombers might still be employed in mining roles, each capable of carrying up

to eighteen mines, as the aircraft apparently continues to be used in minelaying exercises. The literature seems to indicate that People's Liberation Army (PLA) Air Force bombers might also be able to deploy mines, although their availability for mining missions is another question.

PLAN surface warships are equipped to lay mines. The four *Sovremenny*-class (Project 956E/956EM) destroyers have rails for up to forty mines, and the ten of the Luda class (Types 051/051D/051Z) can each carry thirty-eight mines. The twenty-five Jianghu I/V-class (Type 053H) and three Jianghu III- and IV-class (Type 053 H2) frigates each can carry up to sixty mines. The ten Hainan-class (Type 037) coastal patrol craft are fitted with mine rails, while the thirty-five gun-armed fast attack craft of the Shanghai II (Type 062) class can be fitted with rails for ten mines. Chinese planners are well aware that most sea mines laid worldwide since 1945 have been sown by merchant ships, fishing trawlers, or junks—"vessels that were utilized at the time of the birth of Christ." China has thousands of such craft available to support a mining campaign.

Submarines have attracted particular attention as deployment platforms for deepwater rising mines and SLMMs. The Chinese navy regards submarines as ideal for long-range, clandestine operations that would sow weapons in an adversary's port or naval base. The need for high-volume mine delivery is understood as well, and submarine mine belts—external, conformal containers designed to carry and release large numbers of mines—are seen as a clandestine means to complement high-volume aircraft delivery. These belts can expand otherwise limited payloads, a method pioneered in the British E-class submarines in 1915. More recently, the Soviet navy developed a mine belt capable of deploying fifty sea mines on either side of a submarine.

Approximately fifty-five PLAN submarines can sow mines in clandestine operations: the Han-class (Type 091) nuclear-powered attack submarines each carry up to thirty-six mines; twelve Song-class (Type 039/039G) diesel/guided-missile subs also carry mines; nineteen Ming (Type 035) diesel subs, thirty-two mines; the twelve Kilo (Project 877EKM/636) diesel-powered cruise-missile boats, twenty-four mines; and the residual Romeo (Project 033) diesel boats, twenty-eight mines. In all cases, however, mine loads are carried at the expense of torpedoes.

The mine warfare school is located at Dalian, adjacent to the major surface warfare officer school. Chinese minelaying training and exercises have extensively involved air, surface, and even civilian platforms. For example, *Jane's Underwater Warfare Systems* notes, "airborne minelaying is also regularly practiced and would be a significant component of defence planning considerations." Also, in particular, the PLAN views submarine delivery of mines as a critical element

of offensive and blockade operations, and it practices this “most basic requirement of submarine warfare.” By 2002, minelaying had become one of the most common PLAN submarine tactics—a significant difference from the U.S. Navy submarine warfare “culture” that during the Cold War came to view mining as a diversion from more critical tasks. Indeed, PLAN crews train to handle submarines loaded with large quantities of mines and practice deploying them from shallow, in-port/near-port locations to choke points and deep water.

Chinese naval officers recognize the challenges inherent in “penetrating the enemy’s antisubmarine forces and laying mines behind enemy lines.” According to one PLAN assessment, “Secretly penetrating the combined mobile formation deployed by the enemy’s antisubmarine forces is a prerequisite to fulfilling the mine-laying task.” There is some evidence that China may rely on centralized control of its submarines when conducting offensive mining missions. In carrying out offensive mine blockades, for example, “if there is a shore-based submarine command post to handle command and guidance of the submarine for its entire course, it will not only ensure its concealment but also improve the strike effectiveness of the mines . . . that are laid.”

The Research, Development, Test, Evaluation, and Industrial Base

Mindful of the Russian support to the North Korean mining of coastal waters in the late summer and early fall of 1950, China has imported Russian mines, technology, and even engineers to bolster its indigenous MIW programs. As a leading reference explains:

China aggressively seeks foreign mine technology and is believed to have done considerable business acquiring advanced Russian mine technologies. The mine stock is estimated to number tens of thousands of weapons, mostly derivatives of USSR/Russian origin, including M-08, M-12, M-16 and M-26 moored contact mines; the MYaM shallow water and M-KB deep water contact mines; the PLT-3 contact mine (submarine laid); and KMD and air-launched AMD influence mines. Indigenously developed mines include the EM 52 rocket-propelled rising mine, which closely resembles the first Russian “Cluster” [NATO code name] rising mine and is believed to be powerful enough to break the keel of an aircraft carrier; the EM 55 (submarine laid); and the EM 56 rising mine. Ground mines include the EM 57 remote-control mine and the EM 11 multipurpose mine.²³

Recent data suggest that the PLAN is expanding “in-house” research on enhancing its indigenous deepwater rising mines: on methods to predict rocket-propelled-mine attack probability; analysis of launch-platform stability, underwater rocket propulsion, and launch trajectory; target detection, tracking, blast maximization, and damage to ships; and the ability of targets to react to and evade deepwater rising mines.

There has been discussion of a theoretical nature in published Chinese naval analyses concerning arming sea mines with tactical nuclear weapons, although there is no direct evidence of the existence of such naval tactical nuclear weapons programs in China. (During the Cold War, the U.S. Navy tested a mine armed with a tactical nuclear warhead in Operation CROSSROADS, but the weapon never went into production.)

Several sources offer insight regarding the Chinese mine research and development (R&D) and industry infrastructure, which, particularly compared to the U.S. mine industrial base, looks to be robust. Plant 884 in Taiyuan and a satellite facility near Houma in Shanxi Province began producing contact mines in 1958 and single/multiple-influence weapons in 1965, all based on Soviet technology. Naval civilian research facilities for demagnetization and mines center in Institute 710, in Yichang. PLAN mine warfare testing has been concentrated in Huludao; other test facilities are at Lüshun, Zhoushan Island, and Changshan Island. These mine facilities are in the North Fleet area, except for Yichang and Zhoushan.

PLAN Mining Strategies and Scenarios

In late March 2011, a U.S. Navy MIW analyst cautioned:

Do *not* “mirror-image” the PLAN. It is *not* the U.S. Navy. They will do things differently than we otherwise might expect. For example, Beijing might announce in the early, “pre-kinetic” phase of a crisis that the PLAN has laid mines in critical high sea areas for “defensive” purposes in accordance with the international legal regime—in essence daring the United States and others to attempt passage: are mines in place or not? They could even command-fire one or two weapons just to heighten the anxiety. Also, don’t discount their use of “dummy” mines in great numbers to slow down and frustrate our and our partner-navies’ naval maneuver and MCM operations. Their objective would be to convince regional navies and the U.S. Navy that the cost of engagement would be too high—in essence achieving “checkmate” on the first move.

Finally, although it’s also important not to conflate capabilities with intentions, in this case the PLAN looks to be capable of *and* intending to use mines during a crisis or conflict in both “Near” and “Far Seas” scenarios.²⁴

Another senior U.S. Navy MIW official interviewed for this article was unequivocal in his assessment that the Chinese could “seriously hamper an adversary’s ability to enter the First Island Chain. That’s a fairly significant advantage to them in a ‘Taiwan Strait’ scenario—particularly if they executed this before the ‘kinetic’ phase of a conflict. But that’s looking at the obvious.” He continued,

The open-source Chinese literature also indicates they are concerned about Guam and its strategic importance as a base for USAF [U.S. Air Force] strategic bombers and Navy attack submarines. Apra outer harbor is very narrow; outside the harbor

entrance it gets deep quickly. We need to be concerned about the Chinese Navy's ability to place covertly small numbers of advanced mines in strategic locations, like the Apra channel, even if it does no more than slow down our ability to carry out time-phased operations.²⁵

Much of the sea area and several of the choke points within the First and Second Island Chains and the approaches to Taiwan are minable, in what have been described as a "strategic interior line of defense" and a "tactical exterior line of defense," respectively. Chinese bottom mines can be deployed in water depths of approximately two hundred feet and still be effective against surface targets and shallow-running submarines, while the PLAN's rising mines can be deployed in waters some two thousand meters deep to serve as area-denial barriers—much like the U.S. Navy's Mk 60 CAPTOR (enCAPsulated TORpedo) mines in the Greenland–Iceland–United Kingdom "GIUK Gap" during the Cold War.

The United States must consider the possibility of feigned or actual deployment of Chinese sea mines in conflict arising out of a crisis over territorial claims in the South China Sea or on the Korean Peninsula. In those areas, MCM support from South Korean and Japanese naval forces will be critically important in keeping sea-lanes open.

That said, the U.S. Navy's concern seems to be focused on its ability to respond to a Taiwan crisis in which naval mines are one element of an overall, combined-arms campaign. The bathymetry of the Taiwan Strait and sea areas to the immediate north and south of the island's largest ports is sufficiently shallow for all types of PLAN mines. Although Taiwan's eastern coast has deeper waters, a multi-axis mining effort, involving primarily submarines and aircraft, could efficiently blockade Taiwan. American assessments of Chinese analyses conclude that the PLAN believes Taiwan's MCM vessels cannot effectively counter Chinese mines and that attempts by Taiwan to deploy its own mines could be defeated by PLA air forces, surface warships, and submarines.

The concept of the "air blockade campaign" looks to be critical for PLAN operations in the Taiwan scenario as well as for A2/AD efforts, particularly within the First Island Chain. According to a 2011 RAND analysis:

In conjunction with the naval and ground force elements, air forces may also implement the blockade of maritime and ground traffic. Typically, maritime blockades are conducted jointly by the air force and navy and involve blockading maritime routes and attacks on shipping. Bombers and fighter-bombers are employed in blockading maritime routes, operations that generally involve mining port entrances and critical sea-lanes to impede and eventually sever transport traffic with the outside.²⁶

This example is perhaps of most relevance for a Taiwan scenario, and aerial minelaying is regarded as one of the primary means employed in aerial blockades.

Minelaying is, according to the 2000 version of *Study of Campaigns*, one of the four important operations conducted during air blockades.

Beyond Taiwan, Chinese assessments of antisubmarine warfare suggest that mines are best employed against submarines by laying them in egress/ingress routes nearby adversaries' bases, potentially frustrating the ability of enemy submarines to reach the ocean or return for replenishment should the crisis or conflict go on for long. In view of the strategic importance to the U.S. Navy of Guam, for example, it should be expected that the PLAN would attempt to lay mines in the approaches to bases there. Guam is within the endurance limits of the more capable Chinese submarines armed with "self-navigating mines." The waters around the southern Ryukyus, including Okinawa, are also susceptible to Chinese offensive mining operations, as could be the Tsushima Strait. Offensive mining apparently has been a major impetus for Chinese research on mobile mines, and the priority would be the laying of SLMMs in each choke point of the First Island Chain, forming a blockade line and preventing U.S. nuclear and other navies' submarines—or surface forces—from entering China's Near Seas areas.

In light of the Chinese navy's intense study of historical mining campaigns and of its focus on U.S. submarine capabilities, PLAN commanders also may believe that a geographically broader "deep thrust" mining campaign—even if employing only a few weapons at each attack point—might be worth the risk. For example, sporadic mining of American West and even East Coast ports by Chinese armed forces or PRC-sponsored terrorists may join the list of options, if only as a means of diluting the U.S. Navy's constrained MCM capabilities.

Here Chinese thinking on the use of commercial vessels might come into play. Much of the Chinese merchant fleet falls under the control of the state-owned China Ocean Shipping Company (known as the COSCO Group), and COSCO container lines maintain scheduled services to several key American ports, including Los Angeles/Long Beach, San Francisco, Seattle, and Tacoma, Washington, on the West Coast, and Norfolk, Virginia, on the East Coast (as well as Kao-hsiung and Keelung in Taiwan). In addition, other, nonscheduled bulk and break-bulk vessels in COSCO's large fleet—modified into covert minelayers—might be conscripted into minelaying service in an emergency. The domestic terrorist-mining threat has become an increasing interest for the U.S. Northern Command.

Such a course of action might be difficult for the PLA should hostilities commence and key forces on both sides concentrate in the Near Seas. Prehostilities mine deployment, using time-delay or remote-control activation, could help solve the problem of laying mines without U.S. or partner navies detecting or responding to the act.

U.S. AND PARTNER NAVIES' MCM CAPABILITIES

“Brittle”—that is how several U.S. Navy mine warfare specialists described the Navy’s MCM capabilities in the spring of 2011.²⁷ This brittleness is largely due to the state of mine warfare generally in the Navy. Mines, mining, and mine countermeasures—from the laboratories and industry to Navy headquarters and systems commands, to deployed forces—historically have accounted for less than 1 percent of the service’s annual total funding for programs and operations. The vast majority of that constrained funding supports MCM, not mining, programs, or operations.²⁸

Brittleness also reflects the fact that American MCM is on the cusp of a broad transformation from an aging force of specialized surface vessels, helicopters, and diver and marine-mammal EOD systems to a highly integrated, “tailored,” modular mine-countermeasures “system of systems” embarked on the new littoral combat ships of the *Freedom* (LCS 1) and *Independence* (LCS 2) classes. The new “tailored” MCM forces are intended to provide direct, highly automated MCM support to naval maneuver forces in forward areas. However, it is proving difficult to maintain the material and operational readiness of in-service “legacy” platforms during the transition, raising concern that the Navy might be hard-pressed to respond to some crisis or conflict involving mines before the “tailored” future arrives.

U.S. MCM in Transition

The sea is a maneuver area. From the U.S. Navy’s perspective, the goal of MCM is to enable maneuver of naval forces, not to counter every mine. If a crisis involving PLAN mining of critical regions in Taiwanese waters and inside the First and perhaps even Second Island Chains erupted today, the U.S. Navy’s mine-countermeasures response would clearly be a “come as it is” force of uncertain effectiveness, due to its small numbers and increasing obsolescence. As of the spring of 2011, U.S. Navy’s dedicated MCM assets fall into three main categories.

The fourteen ships of the *Avenger* (MCM 1) class constitute the Navy’s dedicated surface mine-countermeasures capabilities. They are relatively slow, with top speeds of around fourteen knots, making their response to “away games” somewhat problematic (although they could be transported to the scene by heavy-lift ships). To enhance responsiveness, four are forward deployed to the Arabian Gulf (Manama, Bahrain), and four are homeported in Sasebo, Japan; the remaining six ships are in San Diego. The *Avengers* are fitted with several hunting and sweeping systems. The Navy is upgrading these ships—which in 2011 were well beyond the midpoints of their operational lives—but their backlogged modernization and material readiness bill, just to keep them ready in the near term, amounted to some \$500 million. The final MCM 1 will retire in

2024. But for the time being, in any PLAN mine-warfare scenario, the U.S. Navy's initial surface MCM response would be limited to the eight ships in Japan and the Arabian Gulf.

The airborne "leg" of the Navy's mine countermeasures "triad" comprises two squadrons of MH-53E Sea Dragon helicopters, a total of twenty-eight airframes—a figure that includes seven in training, as well as "pipeline" (out of service for rework, etc.) aircraft. Both squadrons (HM-14 and HM-15) are located at the Airborne Mine Countermeasures (AMCM) Center for Mine Warfare Excellence, at Naval Air Station Norfolk, Virginia. Two helicopters are deployed to South Korea and four to Bahrain. The helicopters carry out rapid-response MCM tasks—they can be airlifted anywhere in the world within seventy-two hours of the decision to deploy, assuming the availability of strategic airlift—with mine-hunting sonars and mechanical and influence sweeping systems. In service since 1986, the MH-53Es are capable of night operations and have a six-hour mission capability. In 2009, the Navy began a fatigue-life-extension program of structural upgrades to ensure that the helicopters can perform their missions until all are retired, by 2025.

The third leg of the triad is explosive ordnance disposal. The Navy's EOD detachments directly support mine-hunting and -clearance operations. They have specialized training in equipment, tactics, techniques, and procedures to locate, identify, neutralize, recover, or otherwise dispose of sea mines, torpedoes, and other undersea weapons, including underwater IEDs.

In addition, the Navy maintains several types of marine-mammal systems, bottlenose dolphins and sea lions specially trained for mine detection and neutralization, swimmer defense, and recovery of exercise mines, torpedoes, and other objects. In some situations the marine mammals are much more effective than humans or hardware now in service, and presently only they can detect buried bottom mines. Each "system" has several dolphins or sea lions that can be deployed quickly throughout the world by strategic airlift and worked from ships in forward operating areas. For example, Navy MCM dolphins deployed to the Arabian Gulf in 1988 during Operation EARNEST WILL, in 1991–92 during DESERT STORM/DESERT SWEEP, and in 2003 in support of Operation IRAQI FREEDOM.

It is apparent from this summary that the U.S. Navy's dedicated mine countermeasures force is aging while the worldwide mine threat is being modernized, particularly that of the PLAN. As a result, the Navy is making investments in a future mine-defense force. Its formal requirements call for a new capability that various Navy briefings and publications describe as "fast, light, agile, adaptable, precise, and modular, to remove the man and the marine mammals from the minefield."

The focal point of this next-generation MCM force is the modular littoral combat ship (LCS), which is to be the principal host for the MH-60S multimission helicopter (which, however, unlike the MH-53E, cannot conduct MCM at night and has about half of the MH-53E's mission endurance), unmanned aerial vehicles, and several advanced "mission module" systems. (Of the two classes, *Freedom* is a primarily all-steel monohull design, while *Independence* is a predominantly aluminum trimaran.) Modular mine-countermeasures, antisubmarine, and anti-surface packages are being developed to counter A2/AD strategies and contribute to littoral sea superiority.

The MCM mission modules include the Remote Minehunting System (RMS), AQS-20A mine-hunting sonar, Airborne Laser Mine Detection System (ALMDS), Airborne Mine Neutralization System (AMNS), Organic Airborne and Surface Influence Sweep (OASIS), Unmanned Influence Sweep System (UISS), and Coastal Battlefield Reconnaissance and Analysis (COBRA) system. The ships will also possess inherent capabilities for intelligence support, surveillance, reconnaissance, special operations, and maritime interception, regardless of the specific mission package installed. With top speeds in excess of forty-five knots, the LCS looks to be far more responsive than the Navy's legacy dedicated forces. Indeed, necessary mission modules could be staged in critical regions to allow any LCS to be reconfigured as an MCM platform, although there are growing concerns about the maturity of the MCM mission packages.²⁹

The first units of each class, LCS 1 and LCS 2, were in service in 2011, two more are under construction and will be delivered in 2012, and the Navy has awarded contracts for an additional twenty ships (ten of each design). A total of fifty-five LCSs are in the Navy's plan, and the service intends to acquire twenty-four MCM mission packages. Two packages have been delivered, and one was in production in mid-2011. However, several systems of the MCM mission modules are not yet in service—only three (AQS-20, AMNS, and ALMDS) are even in "low-rate initial production"—so it will be years before the LCS (in its MCM configuration) replaces the *Avenger* class. In the meantime, the Navy is investigating proposals to deploy MCM mission modules on other ships, such as dock transport ships (LPDs)—or to land facilities from which the MH-60S helicopters could operate.

The U.S. Navy's future, LCS-focused MCM assets are also to be the core forces dedicated to any mine-cleanup mission after crisis or hostilities. In the aftermath of DESERT STORM, for example, it took a multilateral MCM force of vessels and helicopters from Belgium, France, Germany, Italy, Japan, the Netherlands, the United Kingdom, and the United States more than two years to make the primary channels in the northern Arabian Gulf as mine-free as possible. Since then,

periodic MCM operations have continued in this strategic waterway (as noted, four of the Navy's *Avengers* are homeported there). It must be expected that MCM-tailorable LCSs will be included in any dedicated force, and concepts for how they are to perform such tasks need to be addressed before the first weapon fires in some future crisis or conflict.

Regional Partner Navies' MCM

Several regional navies have made a commitment to mine countermeasures, but all are focused on near-shore littoral operations using traditional sweeping and hunting, albeit in some instances complemented by remotely operated and unmanned systems. These resources might be available to assist U.S. Navy MCM operations in response to PLAN mining of critical waterways.

Australia. The Royal Australian Navy (RAN) operates six *Huron*-class mine hunters (MHCs) based on the Italian *Gaeta* class, acquired from 1999 to 2003.³⁰ These are modern ships, employing several types of mechanical and influence minesweeping systems and variable-depth mine-hunting sonars. In service since 1982 are the RAN's two 520-ton auxiliary minesweepers *Bandicoot* and *Wallaroo*, which also deploy reconfigurable permanent-magnet influence sweeps. The RAN has put in place a "Craft of Opportunity program" that employs fishing vessels taken up from trade and fits them with side-scan sonars and magnetic influence sweeps. The RAN also has two small (about 115 tons full-load displacement) auxiliary minesweepers—MS(S)/MSA *Bermagui* and *Koraaga*—converted from tuna boats, capable of deploying side-scan sonars and magnetic influence sweeps. Finally, the RAN operates three MCM drones employed by craft-of-opportunity vessels.

Indonesia. The Republic of Indonesia Navy operates eleven coastal mine-hunting and minesweeping ships, of which only about five are in active service.³¹ Two are modern, Tripartite-class MHCs taken from Royal Netherlands Navy production in 1988: *Pulao Rengat* (ex-*Willemstad*) and *Pulao Rupert* (ex-*Vlardinggen*). They embark remotely operated mine-hunting vehicles that can neutralize confirmed contacts, mechanical sweep equipment, and magnetic and acoustic influence sweeps. The remaining nine ships, ex-German navy Kondor II-class coastal patrol ships, have been employed primarily as patrol craft, although their original mechanical sweep gear has been retained and more modern magnetic-influence sweeps have been tested. The three (or fewer) active Kondor IIs are obsolescent, at best.

Japan. Like the RAN, the Japan Maritime Self-Defense Force (JMSDF) has modern and capable MCM forces.³² The need for robust MCM is seared in the Japanese navy's memory by the experience of Operation STARVATION, the many years

needed to clear ports, harbors, straits, and nearby seas after World War II, and the mine experiences of the Korean War and Operation DESERT STORM. Published sources show a JMSDF mine warfare order of battle comprising about thirty-five surface mine hunters and minesweepers, three drone-control ships, and six radio-controlled MCM drones. These include a mix of new acquisitions (e.g., the twelve *Sugashima*-class MHCs, which joined the fleet in the late 1990s and early 2000s) and ships that were in service in the mid-1980s—certainly not “old,” in comparison to those of other regional navies, including the PLAN. The two *Uraga*-class mine countermeasures support ships, which entered service in 1997–98, also serve in minelaying roles. The ships are fitted with mechanical and influence sweeping equipment and can operate remote mine-hunting vehicles. Since 1989, the JMSDF has also operated MH-53E Sea Dragon AMCM helicopters; a total of eleven were in service at this writing and employed minesweeping and -hunting equipment similar to that of the U.S. Navy’s MCM helicopters. These aircraft are being replaced by the MCH-10, which will operate the OASIS minesweeping system, now under development in the United States, as well as in-service systems.

Malaysia. The Royal Malaysian Navy operates four coastal mine hunters based on the Italian *Lerici* design acquired in the middle and late 1980s.³³ They are equipped with on-board and off-board mine-hunting systems and influence and mechanical sweep gear. EOD divers can be embarked.

Philippines. The Philippines Navy operates no MCM ships or craft. Several ex-U.S. minesweepers have been modified for patrol duties and are no longer capable of mine countermeasures.

Republic of China. Rather remarkably, given the potential for extensive PLAN mining during a “Taiwan scenario,” the Republic of China’s MCM capabilities are poor.³⁴ The Taiwan navy has only twelve small coastal mine hunters and sweepers, eight of which are ex-U.S. or ex-Belgian vessels built during the 1950s. The eight older ships are capable of minesweeping only; they are fitted with acoustic and magnetic systems as well as wire sweeps to cut moored mines free for subsequent destruction. The four units of the *MWW 50/Yung Feng* class were delivered in 1991 but were not commissioned until 1995. They can conduct mine-hunting as well as sweeping operations. As noted earlier, in January 2010 the Obama administration announced its intent to sell to Taiwan \$6.4 billion in defensive arms and equipment, which included *Osprey*-class mine hunters—Taiwan reportedly wants two MHCs—but the deal is still pending.

Republic of Korea. The South Korean navy understands well the value of mines and mine countermeasures, and in any contingency on the Korean Peninsula

or with China mine warfare would be pivotal for the coastal defense of both its coasts.³⁵ Critical sea lines of communication, particularly through the Tsushima Strait, are indispensable to the ability of South Korean and American forces, and perhaps Japanese forces as well, to fight and win. Despite this requirement, South Korean MCM forces are modest: a single (appropriately named) *Wonsan*-class minelayer/MCM ship, a planned ten-ship *Yangyang* class of coastal mine hunters, six SK5000-class MHCs based on the *Lerici* design, five ex-U.S. MSC 289-class coastal minesweepers (transferred between 1963 and 1975), and three ex-U.S. MSC 268-class coastal minesweepers (transferred in 1959). These last two classes, if still in service, are obsolete; the others, however, are newer (in service from 1993 on) and can operate modern minesweeping and mine-hunting systems. In July 2009 the Republic of Korea requested a Foreign Military Sales purchase of eight Seahawk multimission AMCM helicopters. (This is the same “main battery” that will operate from the U.S. LCSs, and it would employ the AQS-20A towed sonar mine countermeasures system, AES-1 ALMDS, ASQ-235 AMNS, and ALQ-220 OASIS.) Three months later, however, the deal was postponed.

Singapore. The Republic of Singapore Navy operates four *Bedok*-class MCM vessels based on the Swedish *Landsort* design.³⁶ All were placed in service in 1995. These are modern, capable MCM ships, carrying two remote-control mine-neutralization systems. A mine rail is fitted, allowing the ships to lay mines. Beginning in 2009, they received service-life extensions, which included advanced integrated MCM combat systems, new hull-mounted and towed synthetic-aperture sonars, and expendable mine-disposal systems.

Vietnam. Although its inclusion in this “partner navies” discussion might seem problematic, the Socialist Republic of Vietnam operates a small number of obsolescent coastal and inshore MCM vessels and craft, perhaps as many as eight, all ex-Soviet navy minesweepers.³⁷ They would be irrelevant in virtually any contingency involving the PLAN.

In general, the MCM assets in Pacific Rim partner navies cannot substitute for a more robust American mine-warfare capability in the region. Their technical and operational limitations and the likelihood that they would be tasked in their home waters mean that most would probably be unavailable to support Near Seas mine countermeasures. The U.S. Navy’s own MCM capability—brittle or not—will undoubtedly determine the extent to which Chinese mines can frustrate American strategies and operational plans. But whether U.S. Navy mines and minelaying capabilities are sufficiently effective, in turn, to defeat PLAN strategies, operations, and forces is uncertain.

U.S. MINES AND MINING

“I have always deemed it unworthy of a chivalrous nation,” wrote Admiral Faragut in 1864 of what we now call mine warfare, after having “damned the torpedoes” at Mobile Bay.³⁸ In that he echoed the Royal Navy’s rejection half a century earlier of “a mode of war which they who commanded the sea did not want, and which, if successful, would deprive them of it.”³⁹

The U.S. Navy has had a “love/hate” relationship with its own naval weapons that wait, from Bushnell’s screw-torpedo and floating powder kegs to advanced, autonomous, twenty-first-century, networked weapons. Since the end of World War II, Navy planners have focused on mine countermeasures to defeat adversaries’ mines rather than on sustaining our own mine inventories—perhaps with good reason, given the Navy’s post–World War II encounters with mines. There were a few exceptions, such as the advanced, deepwater Mk 60 CAPTOR mines targeting Soviet ballistic-missile and attack submarines.

The result has been the gradual atrophy of the “pillars” of America’s naval mining capabilities: the technological/industrial base, modern and effective mines, adequate mine stockpiles, minefield planners, trained specialists to ready the weapons, and the means to put them in place. If U.S. Navy MCM capabilities are brittle, so, too, are the Navy’s mines and mining capabilities. Without our own mines, we essentially give adversaries a “free pass.” Instead, they should be made to solve MCM problems of their own, posed by the mines of the United States and its maritime partners.

This is particularly important in any strategy to use American mines to deny sea areas to PLAN surface ships and submarines. But in such an attempt, if undertaken today, the U.S. Navy would—in an instance of asymmetric irony—be pitting its mining weakness against the PLAN’s mine-countermeasures weakness, with ultimately uncertain results.

Ramping Up Mining

That said, senior Navy leaders, including the Chief of Naval Operations and the commanders of the Third and Fifth Fleets, are warming to “offensive” mining. In the fall of 2010, Captain John Hardison, then deputy program manager of the Navy’s Mine Warfare Programs Office (PMS-495) in the Naval Sea Systems Command, identified remote control and improved targeting for offensive mining as among his command’s “top items of interest.”⁴⁰ He echoed Admiral John C. Harvey, Jr., Commander, Fleet Forces Command, who said the Navy needs to avoid losing its naval mining capabilities—although, the admiral also admitted, funding mine R&D was not at the top of *his* list of priorities.⁴¹

One measure of relative priorities is the fact that U.S. Navy mine inventories pale in comparison to those of other countries. The American stockpile is

significantly smaller than even North Korea's estimated fifty thousand mines, while the PLAN might have, as noted, on the order of a hundred thousand mines, and Russia has been estimated to have about 250,000. Ominously, all three (and another twenty or so mine-producing countries) actively sell their weapons to other states and nonstate actors.

The Navy's mine arsenal includes diminishing numbers of the increasingly obsolescent Mk 67 submarine-launched mobile mine, which will be out of service by the end of fiscal year 2012. The Mk 67 is a modified Mk 37 torpedo with its wire guidance removed and a thin-wall mine warhead and multiple-influence (magnetic/seismic/pressure) target detection device (TDD) installed. A shallow-water bottom mine meant for use against submarines and surface ships, the Mk 67 is launched from the torpedo tubes of a submarine and runs to a preselected location or distance, at which point the motor shuts down and the mine sinks to the bottom. Arming takes place at a preset time or distance, and the mine either "sterilizes" (i.e., shuts itself down) or self-destructs at a predetermined end of life. This is the Navy's only submarine-delivered mine, and after FY 2012 the U.S. Navy's submarine force will have no minelaying capability. There are suggestions for a modification to the Mk 48 heavyweight torpedo into a dual-purpose weapon—that is, torpedo or SLMM, at the turn of a switch. If pursued, that would be well into the future, as no funding has been programmed.

The Navy does have the dedicated, aircraft-laid, thin-walled, two-thousand-pound Mk 65 Quickstrike (QS) bottom mine, as well as low-drag bomb-conversion kits for the aircraft-laid five-hundred-pound Mk 62 and thousand-pound Mk 63 QS bottom mines. The Mk 62/63 weapons use general-purpose Mk 82 (five hundred pound) and Mk 83 (thousand pound) low-drag bombs as explosive warheads. Arming takes place at a preset time after the mine enters the water and comes to rest on the bottom, and the mines either self-destruct or sterilize at the end of life.

The in-service multiple-influence Mk 57, Mk 58, and advanced Mk 71 TDDs are used with the converted general-purpose bomb QS weapons and the Mk 65 dedicated mine. The TDD Mk 71 for the QS Mk 65 was fielded in the spring of 2011, and the Navy has one approved software algorithm for its use, with three more ready for final testing. The Mk 71 is a programmable device capable of responding to a broad spectrum of target types, from small combatant craft and quiet, diesel-electric or air-independent submarines to major warships. The Mk 71 development program dates to the early 1990s, and acquisition began in FY 2005, but it has been chronically hamstrung by low-level funding and changing priorities, as well as by a "tech refresh" to make it more producible. The development of a new Mk 75 safe and arming fuse for Mk 62 and Mk 63 QS bomb

conversions has also taken longer than anticipated, but it should enter service by 2017–18. As an example of the fragility of the American mine industrial base, only a single company produces the Mk 71/75 TDDs, and a sole subcontractor company that provided a critical component has ceased production, forcing the Navy to look for alternative sources.

There is no surface minelaying capability in the U.S. Navy, although the service might investigate rolling Mk 62 and Mk 63 Quickstrikes off virtually any available ships (e.g., the LCS) or craft—something Libya, using Soviet/East German “export” mines, did from a ferry (M/V *Ghat*) in the Red Sea during the summer of 1984.⁴²

With the demise of the Mk 67 SLMM in 2012, the nation’s sole minelaying capabilities will reside in naval aviation and the U.S. Air Force. The Navy’s P-3C Orion maritime patrol aircraft and F/A-18 Hornet/Super Hornet can drop QS mines (P-3C mine loadouts are four Mk 63 or two Mk 65 mines, and Hornets can carry all three QS variants), but the P-3Cs will start leaving service in 2013. They will be replaced by the P-8 Poseidon Multi-Mission Maritime Aircraft; it too will also have a mining capability, but its ability to lay mines in meaningful numbers is years away.

Minelaying training for F/A-18 Hornet pilots ramped up in 2011, and the Navy’s minefield planners have seen a renaissance of sorts within the aviation strike warfare community. However, the last time the U.S. Navy aircraft laid mines “in anger” was during the DESERT STORM “air war” in February–March 1991. A sortie of four A-6 Intruders from Attack Squadron 55 embarked on USS *Ranger* (CV 61) attempted to mine the Khwar 'Abd Allah waterway with Mk 36 Destructor mines (DSTs, predecessors of the Quickstrike) in January 1991, but with uncertain results. One aircraft was shot down and the crew lost, a reminder of how dangerous airborne mining can be. The Navy did employ Mk 36 DSTs against Iraqi bridges and runways (a tactic perfected against traffic along jungle trails during the Vietnam War), with better effect and no losses.⁴³

The U.S. Air Force B-52H Stratofortress, B-1B Lancer, and B-2A Spirit strategic bombers constitute the nation’s only high-volume mining capability. B-1s can carry more Quickstrike mines than the seemingly ageless B-52s (expected to remain active through 2040, the first B-52H having entered service in 1961), and the B-52s and B-1s—but not B-2s—regularly train for and practice this mission.⁴⁴ Close collaboration between the Navy and Air Force has been on the rise in recent years, and in 2011 planning began for B-52s and B-1s to deliver mines for an in-water mine test. However, in wartime, high-volume mining will be only one of several missions demanded of Air Force strategic bombers and, if the minefields are at great distances, their supporting fleet of aerial tankers.

Mining-specific training continues to be a concern for planners. The focus at the Mine Warfare Training Center in San Diego has been on MCM rather than mining, although the Naval Mine and Anti-submarine Warfare Command (NMAWC) is increasingly emphasizing training for aircrews in mining tactics, techniques, and procedures. But the Navy's institutional knowledge base for mining and minefield training largely amounts to "received wisdom" passed down by experts in the Mobile Mine Assembly Division of the Navy Munitions Command. In the late spring 2011 there were only two minefield planners in the U.S. Navy—a retired Coast Guard captain and a Limited Duty/Surface Ordnance naval officer assigned to NMAWC—in addition to a handful of enlisted rated minemen (none of whom have formal training).

Looking to an ambiguous future, in the fall of 2010 Captain Mark Rios, Resource Sponsor for Mine Warfare (N852) in the Expeditionary Warfare Directorate (N85) of the Navy Staff, observed that while the Navy has a good ability to lay indiscriminate mines, it could create mines that would more effectively and discriminately target enemy ships and could be turned on and off by remote control. "We want there to be a discussion about how we can use mines," Captain Rios noted in October 2010.⁴⁵ "Clearly some of our adversaries or potential adversaries have submarines and patrol craft that are very nimble and fast. Early on in the conflict, mining their harbors or their approaches to come in and out of port would reduce the number of ships and submarines that could come out to attack us and this reduces the threat." He also mentioned that N85 is assessing concepts for "glide mines" (fitted with global positioning system targeting, they could be launched from tactical aircraft well outside the range of adversary antiaircraft weapons) and mine-laying UUV "trucks" (that could be clandestinely deployed from the Navy's special-forces/guided-missile attack submarines).⁴⁶

That vision will likely prove optimistic. There have been only a few efforts—halfhearted and short-lived—since the Cold War ended in 1991 to develop new mines. An improved submarine-launched mine based on the Mk 48 torpedo was initiated but died in 2002, and there was the "2010 Mine," a modern air-dropped mine to complement the Quickstrike mines by 2010. That too was canceled.

Several years ago the Navy proposed a new family of mines, Sea Predator, that fell victim to the tyranny of the budget when available funds were shifted to solve the land-IED problem in Iraq and Afghanistan.⁴⁷ That said, low-level testing and proof-of-concept work have continued, and the Navy has modeled a networked-mine approach with some analytical success. The Sea Predator concept called for an advanced, remote-control, autonomous mobile mine (in some concepts more like an armed UUV than a traditional mine) that would nonetheless take advantage of the basic mine characteristics—high lethality, long endurance, "man out

of the loop” tactics, strong psychological impact, and force-multiplying features that free manned platforms for other duties. Sea Predator was to have an exceptionally large damage width. It was also to be deployable by both submarines and surface ships (the littoral combat ship was a candidate platform). Thus the distinction among smart mobile mines, torpedoes, and UUVs is becoming blurred.

Some have suggested acquiring foreign mines for American service. For example, in 2005 the Naval Research Advisory Committee concluded,

The U.S. Navy should consider employing mines in offensive operations, to create barriers to deny areas of interest/operations to hostile submarines, UUVs, and SDVs [swimmer delivery vehicles]. The current U.S. mine capability is limited and rapidly dying. It is unlikely that the planned 2020 Mine [Sea Predator] will be developed on time, at cost, and with the capabilities originally expected. Accordingly, the Panel recommends the use of existing and in-development foreign-built mines that could be fitted with advanced sensors to meet the use described above.⁴⁸

As this article was prepared, the Navy was considering a “drill down” study to get to the “ground truth” about acquiring and employing foreign mines.

Still, this nascent interest in advanced, sophisticated offensive mines has not yet translated to funding, and given increasing pressures on Defense and Navy budgets, “business as usual” will likely set in. Within the mine warfare community itself, investment in advanced new mines looks to be held hostage by resource competition. The Navy’s mine-warfare resource sponsor (that is, the requirements and funding office) has a difficult problem: balancing MCM and mines/mining while having to fund both legacy and future MCM systems as they are brought on line, with no growth in total budget. In short, while the technologies for improving mines are mature, the Navy’s will to develop, acquire, and deploy them remains uncertain.

This in turn brings into question emerging strategies to deal with the PLAN anti-access/area-denial challenges, generally, and the Chinese mine threat, specifically.

U.S. Mines in the AirSea Battle Concept

While still being refined and debated in mid-2011 (and at this writing still not formally released), an “AirSea Battle Concept” outlined in the 2010 Quadrennial Defense Review—focused largely on defeating a Chinese A2/AD strategy in both Near and Far Seas scenarios but also addressing those of Iran and North Korea—has implications for the nation’s future mines and mining capabilities:

Develop a joint air-sea battle concept. The Air Force and Navy together are developing a new joint air-sea battle concept for defeating adversaries across the range of military operations, including adversaries equipped with sophisticated anti-access and area-denial capabilities. The concept will address how air and naval forces will integrate

capabilities across all operational domains—air, sea, land, space, and cyberspace—to counter growing challenges to American freedom of action. As it matures, the concept will also help guide the development of future capabilities needed for effective power projection operations.⁴⁹

Specifically regarding U.S. mines and mining, observers have outlined several candidate AirSea Battle “future capabilities” and concepts to defeat A2/AD systems of China, Iran, North Korea, and other countries. These could include:⁵⁰

- Enhanced capabilities are needed for undersea operations generally, including submarines, submersible robotic systems, and mines.
- Offensive mining appears particularly attractive, given its comparatively low cost and the difficulty and time-consuming nature of countermine operations. Mining will generally be effective only in areas close to hostile territory, near the approaches to ports and naval bases, and in choke points.
- Significant numbers of smart mobile mines capable of autonomous movement over extended distances to programmed locations are needed. Such mines should be deployable by submarines and stealthy Air Force bombers. Smart mobile mines might prove particularly effective in attriting PLAN submarines and surface forces or blocking their access to and from their bases.
- Stealthy minelaying platforms capable of penetrating A2/AD systems are preferable. Assuming that submarine-launched weapons—armed UUVs and more traditional mines—are in the inventory, these capabilities will likely need to be deployed almost exclusively from submarines during the early stages of a conflict, as submarines represent the only highly survivable maritime asset of the United States and its maritime partners. However, they have limited payload capacity, must trade off mine loads for torpedoes, have lengthy transit times (whereas the theater is enormous), and, perhaps most important, are needed for other high-priority missions. Establishing effective minefields near all PLAN bases would require a prolonged effort if submarines alone were assigned the mission.
- The AirSea Battle Concept would also employ stealthy Navy and Air Force aircraft to lay mines, and they could prove particularly effective in that role, given their large payloads.
- The Air Force should equip its stealthy, large, long-range/long-endurance, manned and unmanned platforms with an offensive minelaying capability and then train and conduct exercises in conjunction with the Navy for offensive minelaying missions within the PLAN's A2/AD zone.

These AirSea Battle mining initiatives are years, if not longer, away from bearing fruit, and whether they ever do depends on an American commitment to

design, engineer, and acquire modern mines—problematic at best. However, if advanced U.S. mine-development programs are pursued, they promise to challenge PLAN naval forces generally, but also Chinese MCM forces, which, like those of the United States, are “brittle,” particularly when compared to China’s mines and mining capabilities.

Moreover, from a broader countermining perspective, U.S. Air Force strategic aircraft, Navy and Air Force tactical aircraft, long-range land-attack cruise missiles, and aircraft carrier-based armed unmanned aircraft systems would certainly be used to attack mine depots and warehouses, assembly areas, and minelaying platforms should intelligence be sufficiently precise and accurate. While prehostilities (“prekinetic”), preemptive destruction of PLAN mining capabilities is probably out of the question for a variety of reasons—diplomatic (it would be a significant escalation of a crisis), operational (PLAN submarines would probably be deployed and weapons laid well before bombers departed bases in Guam and Missouri), and practical (how would the United States determine whether mines were on board a given COSCO merchant ship or fishing boat—that is, solve the quintessential maritime-domain-awareness challenge?)—it is unlikely that the option to do so would not be included in operational plans.

CHINESE NAVY MCM CAPABILITIES

Compared to the PLAN’s extensive mine/mining capabilities, Chinese mine-countermeasures forces look much less impressive.⁵¹ Various sources indicate a total order of battle of about twenty-eight active MCM vessels (with another sixty-eight or so in reserve) and four “mine warfare drones” (with another forty-two in reserve), plus another seventy small, port- and harbor-focused MCM craft. PLAN minesweeping forces are strictly coastal and port/harbor vessels, except for the T-43 minesweepers and the single MCM command ship.

The first Chinese minesweepers were nine coastal ships delivered after the end of World War II: four former Japanese 222-ton units delivered in 1947 and five 350-ton former U.S. Navy yard minesweepers in 1948. The first postwar-design minesweepers, and the beginning of a credible Chinese mine warfare force, were the four T-43 minesweepers obtained from the Soviet Union in 1955. China began building copies at Wuchang Shipyard in Wuhan and at Donglang Shipyard in Canton (Guangzhou). The first two were launched in 1956, and by 1976 a total of twenty-three had been built. Wuchang ceased production in 1960, but Donglang continued until a total of forty minesweepers had been built. As many as sixteen T-43s may remain active, with the rest in reserve or modified for patrol duties, if not scrapped. Chinese MCM equipment on the T-43s includes mechanical and magnetic sweep gear.

In the late 1970s/early 1980s, the Chinese copied the German remote-control Troika minesweepers, producing more than fifty, designated the *Futi* class (Type 312). These are capable of magnetic and acoustic sweeping under remote control up to five kilometers from a shore control station. Although several PRC minesweepers have been marketed for export, the only sales were to Thailand and Pakistan.

Four steel-hulled, 320-ton *Wosao* (Type 082)-class coastal minesweepers are in service, the first of them commissioned in 1988. The second was not seen until 1997. They are equipped with mechanical, magnetic, acoustic, and low-frequency/infrasonic sweeps.

At least five *Wochi*-class mine countermeasures vessels (MCMVs) are in service and are capable of acoustic and magnetic minesweeping. The first of the class, *Zhangjiagang*, was commissioned in 2007; the second, *Jingjiang*, in November 2007; and the remaining vessels at regular intervals. Final numbers in the class are not known, but indications are that it might replace the remaining T-43s.

Only one *Wozang*-class MCMV is known to be in commission. Commissioned in July 2005, it was thought to be a successor to the T-43; however, no additional hulls have been seen. The hull seems to be built of glass-reinforced plastic to reduce its magnetic signature and to have acoustic-reduction features to reduce self-noise. It is believed to be capable of remotely operating mine-hunting/sweeping vehicles.

Wolei can serve as a command ship during mine-clearing operations. Another one-of-a-kind unit is hull 4422 of the *Wosao* class; it was designed for export, but there were no customers. In 1976, about twenty Shanghai II patrol boats were built for minesweeping and named the *Fushun* class.

China's approximately seventy smaller coastal and auxiliary minesweepers are attached to various maritime-district control roles. Examples include the four-hundred-ton *Lienyun*-class minesweepers, which are designated with district letters—such as *J-141* and *J-143*, under the Shanghai Maritime Military District—and the *Fushun* 250-ton coastal sweeper *E-303*. All of the coastal and harbor minesweepers are equipped solely with simple, mechanical sweeps that counter only moored contact mines.

The PLAN has apparently developed towed-array MCM sonars operated from helicopters. The Changhe Z-8, similar to the French Super Frelon design, is the largest helicopter yet built in China. The Z-8 carries out auxiliary roles in the PLAN, such as towing of mine-clearing systems, vertical in-flight refueling of ships, and support to the submarine fleet.

In short, the PLAN MCM force appears to be quite limited and devoted primarily to minesweeping in near-shore regions, ports, and waterways. In direct

counterpoint to the U.S. Navy’s MIW posture, PLAN attention seems to be focused on mines and mining rather than the countermeasures needed to deal with its adversaries’ mines.

AN EXCELLENT RETURN ON INVESTMENT

Mines, like the poor, will always be with us. Mines and their terrorist-counterpart underwater IEDs are easy to acquire or build and are cheap, but their low cost belies their potential to do significant damage. With costs measured from a few hundred to several thousand dollars, they are asymmetric weapons of choice for a “poor man’s navy,” providing an excellent return on investment. To summarize the discussions of this article:

- Current and projected future Chinese naval mine technologies, inventories, delivery systems, doctrine, and training are robust. The PLAN seems to take mining seriously.
- China could rather easily employ sea mines in several Near Seas as well as Far Seas scenarios, in addition to the “Taiwan scenario.” Also, given development of stealthy minelaying systems, particularly advanced submarines, the PLAN could extend mining operations to key targets beyond the First Island Chain. Indeed, mines could be employed in virtually any crisis or conflict.

**TABLE 2
PLAN/U.S. NAVY MIW COMPARATIVE ASSESSMENT**

Mine Warfare Area	PLA Navy	U.S./Partner Navies
Mines and mining	“Quantity has a quality all its own.” Mix of many older but still dangerous weapons with new, sophisticated devices supported by strong RDT&E efforts. Doctrinal foundation for mining appears to be strong. Uneven capabilities with regard to submarine, surface, and airborne mine-delivery platforms.	Limited mine capabilities and likely to worsen without significant investment in RDT&E and acquisition of modern weapons and delivery platforms. Doctrinal foundation for mining is weak. With the demise of the Mk 67 SLMM in 2012, the only U.S. minelaying capability resides in Navy tactical aircraft and Air Force strategic bombers.
Mine countermeasures	“Brittle,” obsolescent platforms and systems, mixed with small numbers of more modern technologies, systems. MCM command, control, communications, intelligence, reconnaissance, and surveillance capabilities uncertain.	“Brittle” and worsening in near term until LCS and MCM mission modules in service in numbers post-2020. Need concept of operations for post-2020 “hybrid organic/dedicated” MCM forces. Other than Australia and Japan, regional partner navies’ MCM capabilities are limited and constrained to coastal operational environments.

Note: RDT&E: research, development, testing, and evaluation.

U.S., allied, and partner navies in the region thus must be mindful of the potential that they will have to counter Chinese weapons that wait.

- The U.S. Navy and its allied and partner navies are ill prepared to cope with Chinese mine warfare strategies and operations. In addition to the eight American MCM ships in the region, only the Australian and Japanese MCM forces look up to the task of countering Chinese mines in approaches to ports and harbors, in choke points, and in the open sea. All others are likely to be held back for local or littoral operations. Assuming the eventual success of the LCS and its organic tailored-mission MCM systems, however, the balance might become more even.
- The U.S. Navy is significantly hamstrung in types and numbers of mines and in its ability to deploy them in the Near Seas with precision and in high volume. The lack of sufficient numbers of modern, sophisticated, and effective mines casts doubt on emerging concepts like the AirSea Battle, exposing the reality behind the rhetoric, at least in the mine warfare arena.

Table 2 provides a thumbnail assessment of the PLAN, U.S. Navy, and regional-partner navy mine warfare balance as of the spring of 2011.

The conclusions reached in 2009 by analysts of the U.S. Naval War College's China Maritime Studies Institute remain sound.⁵² First, China has a large inventory of naval mines, many of which are obsolete but still deadly, and somewhat more limited numbers of sophisticated modern mines, some of which are optimized to destroy enemy submarines. Second, we think that China would rely heavily on offensive mining in any Taiwan scenario. Third, were China able to employ these mines—and *all* think that it could—they would greatly hinder operations, for an extended time, in waters where the mines were even *thought* to have been laid.

In short, the U.S. Navy and its regional maritime partners damn China's "torpedoes" at their peril.

NOTES

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Although the views presented here are the author's alone, he thanks the valuable contributions of several key people: uniformed and civilian MIW analysts, planners, engineers, scientists, and operators at U.S. Navy headquarters, systems commands, laboratories, and fleet commands; Dr. Andrew Erickson; Edward Feege; Capt. George Galdorisi, USN

(Ret.); Dr. Lyle Goldstein; Capt. Robert O'Donnell, USN (Ret.); George Pollitt; Norman Polmar; and William S. Murray.

1. Tamara Moser Melia, "Damn the Torpedoes": *A Short History of U.S. Naval Mine Countermeasures, 1777–1991*, Contributions to Naval History 4 (Washington, D.C.: Naval Historical Center, 1991); Gregory K. Hartmann and Scott C. Truver, *Weapons That Wait: Mine Warfare in the U.S. Navy* (Annapolis, Md.: Naval Institute Press, 1991); National Research Council, *Naval Mine Warfare: Operational and Technical Challenges for Naval Forces* (Washington, D.C.: Naval Studies Board, 2001); U.S. Navy Dept., *Mine Warfare Plan: Meeting the Challenges of an Uncertain World* (unclassified version) (Washington, D.C.: 29 January 1992); U.S. Navy Dept., *21st Century U.S. Navy Mine Warfare: Ensuring Global Access and Commerce* (Washington, D.C.: PEO LMW/N85, June 2009); and U.S. Navy Dept., *Mine Warfare*, NWP 3-15/MCWP 3.3.1.2 (Washington, D.C.: Chief of Naval Operations and Headquarters, U.S. Marine Corps, August 1996).
2. Melia, "Damn the Torpedoes," p. 76; Hartmann and Truver, *Weapons That Wait*, pp. 78–79.
3. Melia, "Damn the Torpedoes," p. 3; Hartmann and Truver, *Weapons That Wait*, pp. 4, 35–36.
4. Adm. Gary Roughead, USN, Chief of Naval Operations, statement before the Congressional Mine Warfare Caucus, 10 June 2009.
5. Bradley Peniston, *No Higher Honor: Saving the USS Samuel B. Roberts in the Persian Gulf* (Annapolis, Md.: Naval Institute Press, 2006).
6. U.S. Navy Dept., *21st Century U.S. Navy Mine Warfare*, pp. 7–8.
7. H. Dwight Lyons, Jr., et al., *The Mine Threat: Show Stoppers or Speed Bumps?*, Occasional Paper (Alexandria, Va.: Center for Naval Analyses, July 1993). For example, in late April 2011 NATO officials announced that alliance warships had intercepted pro-Qadhafi forces trying to lay mines in the approaches to Misurata harbor, which served as a lifeline for ships ferrying the injured to hospitals in the rebel stronghold, Benghazi, and also for aid entering the city. As many as three mines had been put in place; two were rendered safe, and the third floated away but was later rendered safe. Other accounts indicate that NATO cruise-missile and tactical aircraft strikes targeted Qadhafi's mine warehouses and assembly facilities early on as a means of crippling his minelaying capabilities. Had the mines not been interdicted, they would have had a chilling effect on humanitarian missions and support to the rebels. "Libya: Nato Says Gaddafi Tried to Mine Misurata Harbour," *BBC News Africa*, 29 April 2011, www.bbc.co.uk/; and Rob Crilly, "NATO Warships Clear Misurata of Sea Mines as Gaddafi Remains Defiant," *Telegraph*, 30 April 2011. See note 42 below for a 1984 example of Libyan peacetime mining, in this instance of the Red Sea and Gulf of Aqaba.
8. This discussion of the People's Liberation Army Navy naval mine warfare capabilities and implications for the U.S. Navy draws heavily on two principal secondary sources: Andrew S. Erickson, Lyle J. Goldstein, and William S. Murray, *Chinese Mine Warfare: A PLA Navy "Assassin's Mace" Capability*, China Maritime Study 3 (Newport, R.I.: Naval War College Press, 2009), and "China's Undersea Sentries," *Undersea Warfare* (Winter 2007), pp. 10–15. Important also were background interviews conducted during February–April 2011 with U.S. Navy mine warfare personnel in the Office of the Chief of Naval Operations and the Naval Sea Systems Command in Washington, D.C.; in the Naval Surface Warfare Center, Panama City (Fla.) Division; and the Naval Mine and Anti-submarine Warfare Command, San Diego, Calif. U.S. Navy MIW operators, planners, and intelligence specialists at Navy headquarters and field activities interviewed for this article unanimously pointed to *Assassin's Mace* as the best unclassified open-source information on PLAN mines, mining, and MIW capabilities.
9. Erickson, Goldstein, and Murray, *Chinese Mine Warfare*, p. 70 note 188, citing Ren Danon, "Submarine Minelaying," *Modern Ships* (February 1998), p. 26.
10. Ambassador Chas (Charles W.) Freeman, former Assistant Secretary of Defense, remarks ("China's Strategy for the Near Seas" conference, Naval War College, 10 May 2011).

11. Dr. Andrew S. Erickson, "PLA Modernization in Traditional Warfare Capabilities," statement before the U.S.-China Economic and Security Review Commission, 29 March 2007, p. 73ff, esp. p. 74.
12. "Near Seas" is a Sino-centric concept and refers specifically to seas near China: the South China Sea, East China Sea, and Yellow Sea areas within the First Island Chain. Seas beyond the First Island Chain are generally known as the "Far Seas." China's Near Seas defense strategy requires the PLAN to develop capabilities to operate effectively in the seas within and slightly beyond the First Island Chain, which stretches from the Aleutian Islands through the Kurile Islands, the main islands of Japan, the Ryukyu Archipelago, Taiwan, and the Philippines to the Greater Sunda Islands. Far Seas operations, by contrast, would extend the range of effective PLAN operations from the First Island Chain up to the Second Island Chain, which extends from Japan's southern islands (including Iwo Jima and the Bonin Islands) to the Mariana Islands (including Guam) and Caroline Islands, and beyond. See Nan Li, "The Evolution of China's Naval Strategies and Capabilities: From 'Near Coast' and 'Near Seas' to 'Far Seas,'" *Asian Security* 5, no. 2 (2009), pp. 144–69.
13. U.S. Defense Dept., *Quadrennial Defense Review Report* (Washington, D.C.: February 2010).
14. Scott Savitz, *Psychology and the Mined: Overcoming Psychological Barriers to the Use of Statistics in Mine Warfare*, CRM D0013693.A2/ Final (Alexandria, Va.: Center for Naval Analyses, April 2006); William L. Greer and James C. Bartholomew, *Psychological Aspects of Mine Warfare*, Professional Paper 365 (Alexandria, Va.: Center for Naval Analyses, October 1982).
15. Among other provisions, the Hague Convention VIII of 1907 focuses on "The Laying of Automatic Submarine Contact Mines" (sec. VII). Relevant are articles 1–5, available at Yale Law School, *Avalon Project*, avalon.law.yale.edu/. In the late twentieth/early twenty-first centuries, the Hague mine warfare rules have been honored more in the breach than in observance, and technological advances (e.g., autonomous armed UUVs) look to outstrip the legal regime.
16. In addition to the mine threat to military operations, mines and UWIEDs are among many threats to maritime homeland security. See U.S. Homeland Security Dept., *National Maritime Terrorism Threat Assessment*, CG-HSEC-006-08 (Washington, D.C.: USCG Intelligence Coordination Center, 7 January 2008); Scott C. Truver, "Mines and Underwater IEDs in U.S. Ports and Waterways: Context, Threats, Challenges, and Solutions," *Naval War College Review* 61, no. 1 (Winter 2008), p. 106ff; and George Pollitt, *Maritime 911: A Threat and Economic Effects Analysis*, briefing JNO2:g2p (Laurel, Md.: Johns Hopkins University Applied Physics Laboratory, May 2010).
17. U.S. Navy Dept., *Commander's Handbook on the Law of Naval Operations*, NWP 1-14M (Washington, D.C.: July 2007), pp. 9-2 and 9-3, especially arts. 9.2.2 (Peacetime Mining) and 9.2.3 (Mining during Armed Conflict), available at www.usnwc.edu/. NWP 1-14M has been issued by the U.S. Marine Corps as MCWP 5-12.1 and by the Coast Guard as COMDTPUB P5800.7A.
18. U.S. Defense Dept., *Annual Report to the Congress: Military and Security Developments Involving the People's Republic of China* (Washington, D.C.: 2010), pp. 7, 49.
19. U.S. Navy Dept., *The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics* (Suitland, Md.: Office of Naval Intelligence, April 2009), pp. 18, 23–24, 29–30.
20. Ronald O'Rourke, *China Naval Modernization: Implications for U.S. Naval Capabilities—Background and Issues for Congress*, RL33153 (Washington, D.C.: Congressional Research Service, 22 April 2011), pp. 3, 4, 21, 62, 63.
21. This discussion relies heavily on Erickson, Goldstein, and Murray, *Chinese Mine Warfare and "China's Undersea Sentries"; "Mine Warfare Forces (China),"* in section Mine Warfare Platforms—Mine Warfare Forces, in *Jane's Underwater Warfare Systems*, articles.janes.com/; Bernard D. Cole, *The Great Wall at Sea: China's Navy Enters the Twenty-First Century* (Annapolis, Md.: Naval Institute Press, 2001), pp. 80, 102–103, 156–57; James C. Bussert, "Chinese Mines Pose Taiwan Blockade Threat," *AFCEA Signal*, June 2005, pp. 69–71; Norman Friedman, *The Naval Institute Guide*

- to *World Naval Weapon Systems* (Annapolis, Md.: Naval Institute Press, 2006) [hereafter Friedman, *World Naval Weapon Systems*], pp. 777–78; and Eric Wertheim, *The Naval Institute Guide to Combat Fleets of the World*, 15th ed. (Annapolis, Md.: Naval Institute Press, 2007) [hereafter Wertheim, *Combat Fleets*], pp. 109–10.
22. Roger Cliff et al., *Shaking the Heavens and Splitting the Earth: Chinese Air Force Employment Concepts in the 21st Century* (Washington, D.C.: RAND, 2011), pp. 160–62. See also Milan Vego, “China’s Naval Challenge,” U.S. Naval Institute *Proceedings* (April 2011), pp. 36–40.
 23. “Mine Warfare Forces (China).”
 24. Background interview conducted in March 2011 with U.S. Navy mine warfare analysts.
 25. *Ibid.*
 26. Cliff et al., *Shaking the Heavens and Splitting the Earth*, p. 161. RAND cites here Wang Houqing and Zhang Xingye, *Study of Campaigns* (Beijing: National Defense Univ. Press, 2000), pp. 369–70.
 27. In addition to sources cited in note 1, see Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, 18th ed. (Annapolis, Md.: Naval Institute Press, 2005) [hereafter Polmar, *Ships and Aircraft*], pp. 226–39, 457; and Wertheim, *Combat Fleets*, pp. 917–18.
 28. Capt. Mark Rios, USN, N852 Mine Warfare Branch program briefing (National Defense Industrial Association Expeditionary Warfare Conference, Panama City, Fla., 4 October 2010); Rios, N852 Mine Warfare Branch program briefing (Mine Warfare Association conference, Panama City, Fla., 11 May 2011); and U.S. Navy Dept., *21st Century U.S. Navy Mine Warfare*. For general programmatic information on the Navy’s programs, including MIW programs, see U.S. Navy Dept., *Navy Program Guide, 2011* (Washington, D.C.: Chief of Naval Operations, 2011), available at www.navy.mil/.
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 32. *Ibid.*, pp. 372, 387–90; and “CH-101 Airborne Mine Countermeasures (AMCM),” [Global Security.org](http://GlobalSecurity.org).
 33. Wertheim, *Combat Fleets*, p. 468.
 34. *Ibid.*, pp. 762–63.
 35. *Ibid.*, pp. 432–33; Yoji Koda, “The Emerging Republic of Korea Navy: A Japanese Perspective,” *Naval War College Review* 63, no. 2 (Spring 2010), pp. 13–34; Anthony H. Cordesman et al., *The Korean Military Balance: Comparative Korean Forces and the Forces of Key Neighboring States* (Washington, D.C.: Center for Strategic and International Studies, 15 February 2011).
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 37. Wertheim, *Combat Fleets*, pp. 1025, 1029.
 38. In addition to U.S. Navy materials cited, see Polmar, *Ships and Aircraft*, pp. 501–505; and Friedman, *World Naval Weapon Systems*, pp. 790–94.
 39. Melia, “*Damn the Torpedoes*,” pp. 3, 7; Hartmann and Truver, *Weapons That Wait*, pp. 4, 35–36.
 40. PMS-495, “Future Mine Warfare Business” (presentation, National Defense Industrial Association conference, 21 September 2010), slide 7. Although “offensive mining” was at the top of this list, the briefing noted that the list of priorities was “not in rank order.”
 41. Cid Standifer, “Navy Examines Improved Offensive Mine Warfare Capabilities,” *Inside the Navy*, 18 October 2010; and Rios, N852 Mine Warfare Branch program briefing, 4 October 2010.
 42. See Scott C. Truver, “The Mines of August: An International Whodunit,” U.S. Naval Institute *Proceedings* (May 1985), pp. 94–117.
 43. U.S. Navy Dept., *Mine Warfare Plan*, p. 62. See also Edward J. Marolda, *Operation End*

Sweep: A History of Minesweeping Operations in North Vietnam (Washington, D.C.: Naval Historical Center, 1993).

44. The seventy-seven active B-52s each can carry about forty-five Mk 62 QS mines, eighteen Mk 63 mines, or eighteen Mk 65 mines; the sixty-six B-1s can carry eighty-four Mk 62, twenty-four Mk 63, or eight Mk 65 mines; and the twenty B-2s carry eight Mk 62s.
45. Standifer, "Navy Examines Improved Offensive Mine Warfare Capabilities."
46. For "special-forces/guided-missile attack submarines," see Charles D. Sykora, "SSGN: A Transformation Limited by Legacy Command and Control," *Naval War College Review* 59, no. 1 (Winter 2006), pp. 41–62.
47. Ray Widmayer and Scott C. Truver, "Sea Predator: A Vision for Tomorrow's Autonomous Undersea Weapons," *Undersea Warfare*, Winter 2006, available at www.navy.mil/.
48. Naval Research Advisory Committee, *Science and Technology for Naval Warfare 2015–2020*, Report NRAC 05-3 (Washington, D.C.: August 2005), p. 32.
49. U.S. Defense Dept., *Quadrennial Defense Review Report*, p. 23.
50. Jan Van Tol, Mark Gunziger, Andrew Krepinevich, and Jim Thomas, *Air Sea Battle: A Point-of-Departure Operational Concept* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2010), pp. xiv, 43, 73, 90. See also Andrew Krepinevich, *Why AirSea Battle?* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2010); O'Rourke, *China Naval Modernization*, pp. 60–61; Jose Carreno, Thomas Culora, George Galdorisi, and Thomas Hone, "What's New about the AirSea Battle Concept?," U.S. Naval Institute *Proceedings* (August 2010); and Bill Sweetman and Richard D. Fisher, "AirSea Battle Concept Is Focused on China," *Aviation Week*, 8 April 2011.
51. In addition to the source cited in note 20, generally, this section relies on *Jane's Underwater Warfare, 2010–2011*, and Wertheim, *Combat Fleets*, pp. 125–26.
52. Erickson, Goldstein, and Murray, *Chinese Mine Warfare*. The report is available at www.usnwc.edu/Publications/Publications.aspx.