Naval War College Review

Volume 75
Number 1 *Winter 2022*

Article 6

2022

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AN OFFENSIVE MINELAYING CAMPAIGN AGAINST CHINA

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This article explores the feasibility of a limited minelaying action against China to provide a crisis-response option more forceful than diplomacy but less risky than kinetic operations.[1] Using existing assets, it is feasible to lay minefields in the Taiwan Strait, which would both disrupt intra-Chinese trade and delay any Chinese military movement against Taiwan. Such a plan must be developed in peacetime to be available as an option to U.S. leaders in a crisis. Although offensive minelaying often is overlooked, the United States has a history of successful minelaying operations.

While mines can be weapons of the weak, they also can be tools of the strong. During World War I, Great Britain and the United States, despite possessing the strongest fleets in the world, laid seventy thousand mines to hinder German submarines.[2] During World War II, the United States, after achieving naval dominance over Japan, launched an offensive minelaying campaign that sank or damaged two million tons of shipping in the last five months of the war.[3] Most germane to this article, the 1972–73 U.S. mining of Haiphong and other harbors over the course of a few days during the Vietnam War shut down those harbors for almost a year.[4]

Although this article focuses solely on the military feasibility and not on the political advisability of such a mission, minelaying has several advantages over other responses to crises with China. In the event of a China-Taiwan conflict, minelaying could be portrayed as "separating the combatants," like a UN peacekeeping force arrayed between two rival armies. Thus, other states might be more willing to accept such an action as an aid to diplomacy. The pause in Chinese operations

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Naval War College Review, *Winter 2022, Vol. 75, No. 1*

that a minefield likely would cause might provide enough time to defuse a crisis. The economic pain caused by reduced or inconvenienced shipping also might influence Chinese decision-making positively.

Minelaying's greatest advantage is that it does not cause immediate harm but threatens harm if the other side does not yield. It transfers the burden of decision and action onto the other side; as Thomas C. Schelling points out, offering the other side the "last clear chance" to avoid disaster can be a great advantage.[5] As the U.S. Navy did with its "quarantine" during the Cuban missile crisis, passing the onus for action onto decision makers on the other side forces them to choose between highly risky escalation and backing down.[6] To avoid this painful choice, the Chinese would try to clear any minefield.

The key question, then, is how quickly could China remove a minefield and return the situation to the status quo ante? On the basis of minesweeping history, it would take China about two to three months to clear completely even a small minefield. The duration of this minesweeping operation would depend on the number of mines laid and the effectiveness of Chinese minesweepers. Analysis of the American bomber arsenal shows that it could lay between 840 and 3,880 mines at one time. Historical cases show that each of China's twenty available minesweepers could clear an average of between 0.8 and 2 mines per day. Therefore, even the smallest minefield would take between twenty-one and fifty-three days to clear. This estimate draws on analogies from historical minesweeping operations, the geography of the strait, U.S. capabilities, and Chinese capabilities. While it is reliant on open-source data, the data are extensive and sufficient to provide a rough estimate.

China could clear a limited route for military use within one to two weeks; however, the United States could reseed the minefield faster than the Chinese could clear it. The American capability to conduct constant reseeding of the field is increasing as the United States acquires more extended-range, aerial-dropped mines. Thus, assuming that the United States has sufficient stockpiles, mines could provide an enduring obstacle to Chinese cross-strait movement.

This article proceeds in five parts, examining the following subjects: past offensive minelaying operations, the minelaying mission within the hydrography of the Taiwan Strait, U.S. capabilities to plant a minefield, Chinese minesweeping capabilities, and U.S. responses to Chinese minesweeping efforts.

U.S. MINE WARFARE

While naval mining has ancient roots, the mine only came of age as a weapon of modern war during the Russo-Japanese War of 1904–1905. In the Far East, the Russians laid more than four thousand mines, which sank thirteen Japanese ships.[7] On the opposite side, the Russians lost two predreadnoughts and the energetic vice admiral Stepan O. Makarov to Japanese mines. While mines helped

to tie up the Imperial Japanese Navy, they also proved a double-edged sword, by restricting Russian movement, according to Sir Julian S. Corbett.[8] Their use in this conflict demonstrated that naval mines could have dramatic operational and strategic effects, but their risks and benefits had to be evaluated carefully.

Why Offensive Minelaying Is Neglected

The risks involved might be one reason why naval mines have been neglected in contemporary American thought. Failures in mine countermeasures and the dictates of naval doctrine also have caused U.S. planners to forget their own past successes with naval mines. Thus, any offensive mine campaign would need to overcome internal, cultural barriers.

Defensive versus Offensive Minefields. Because the U.S. Navy generally has operated forward and offensively since the Civil War, it operates in the waters of adversaries and must contend with their defensive minefields. This has not always gone well. At Wonsan, the United States tried to make an amphibious landing on the North Korean east coast, intending to cut off retreating North Korean forces, as in the Inchon landings several months earlier. However, North Korean mines frustrated the attempt, and coalition forces moving by land arrived at the port first. As the senior naval officer put it, "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."[9] In the Persian Gulf during Operation DESERT STORM, Iraqi minefields—mostly using obsolete contact mines—severely damaged two ships and limited coalition naval maneuvers during the war.[10]

These failures have spawned endless (and justified) hand-wringing over the U.S. Navy's unpreparedness for operations in mined waters. Thus, the literature on mine warfare focuses on shortfalls in mine countermeasures and what the Navy might do to remedy those shortfalls, rather than on offensive mine warfare.[11]

Naval Doctrine. Doctrine also has contributed to the neglect of offensive mine warfare—it traditionally has focused on the clash of fleets. Alfred Thayer Mahan, a U.S. naval theorist writing at the end of the nineteenth century, argued that control of the sea meant control of commerce, which drove the outcome of conflicts. He believed that this "overbearing power can only be exercised by great navies." Thus, the focus of naval operations should be on the adversary's fleet, and this required capital ships.[12]

Fleet action still dominates U.S. naval thinking. In contemporary terms, fleet action involves missile exchanges rather than battleship broadsides, but the analysis is the same. What counts is ordnance delivered. Such ordnance inflicts damage on an adversary's fleet according to physical laws established by Frederick W. Lanchester at the beginning of the twentieth century. Mass is critical, giving priority to the construction of fleet combatants.[13]

Since World War II, naval doctrine also has focused on *power projection:* the ability of naval forces to influence operations ashore. This influence is exerted mainly via aircraft and amphibious forces. Mine countermeasures have a role here because fleets often need to approach close to an adversary's shore; however, offensive mine warfare has played only a small role.

Naval officers also might hesitate to use minelaying because of legal complications. According to *The Commander's Handbook on the Law of Naval Operations,* naval mining during armed conflict requires international notification and the recording of mine location for future removal, and mines cannot be placed solely to intercept commercial shipping.[14] Any prospective naval mining by the United States could be subjected to complex legal debates. Of course, "in times of war, the law falls silent"; whether naval mining was legal or not in the particular context, the exigencies of conflict might compel the United States to practice it again, as it has in the past.[15]

Use against Japan in World War II

The most extensive and successful minelaying campaign the United States has conducted was against Japan in World War II. Although overshadowed by the strategic bombing offensive, the submarine campaign, and amphibious assaults on Japanese-held islands, the 1945 offensive minelaying campaign succeeded in paralyzing Japanese shipping and crippling the Japanese economy.

Called Operation STARVATION, the campaign ran for only five months, from late March to early August 1945. But it entailed emplacing twelve thousand mines (mainly by B-29 bombers), and the resultant minefields sank or damaged two million tons of shipping. The most dramatic effect was that shipping in Japanese home waters effectively ceased. As the summary report noted, "[S]hip losses are but incidental to the primary objects of mining which are to delay and disrupt the enemy's shipping, disorganize his maritime supply system, and thereby deprive him of essential military and economic materials."[16]

Because the Japanese swept mines aggressively, the minefields did require periodic reseeding. Reseeding with a few mines frequently was better than doing so with large numbers infrequently; the former approach forced the adversary to clear continuously. The minelaying campaign also required good intelligence (to understand the hydrography and shipping patterns), effective preparation (to have mines and aircraft in place), and experienced planners (to use assets optimally). The summary report emphasized the importance of the surprise introduction and large-scale use of mines to overwhelm defenses before the adversary could develop effective countermeasures. The report also noted that operations followed capabilities—that is, as better mines became available, the results improved, and the use of mines increased.[17]

The campaign was highly cost-effective. Of the aircraft participating, only fifteen were lost, amounting to less than 1 percent—a far lower loss rate than from the strategic bombing of cities. Further, the minelaying effort inflicted these high losses on Japan while constituting only 5.7 percent of the bomber sorties conducted over the country. One ship was damaged or sunk for every eighteen mines.[18] One calculation estimated that the mining of Japanese home waters was nine times more cost-effective than the submarine campaign.[19]

Use against North Vietnam

A smaller minelaying campaign against North Vietnam is relevant to this discussion because it both contributed directly to the political goal—bringing the North Vietnamese to negotiations—and involved more-modern mines. The minelaying occurred in reaction to the North Vietnamese Easter offensive against northern South Vietnam. Eighty-five percent of North Vietnam's imports came through the port of Haiphong, so the country was quite vulnerable to naval mining.[20]

The campaign began in May 1972. Ultimately eight thousand mines were placed, all by air.[21] The operation used modern influence mines, both magnetic and acoustic. Thirty-one ships, mostly foreign, were trapped in the harbor, and none tried to depart after the mines activated, indicating that the North Vietnamese had confidence in the effectiveness of U.S. mines. The ships were stuck in port for three hundred days, until the United States cleared the mines in 1973.[22]

The United States removed the mines as part of the overall peace agreement. Performing the sweeping after the political settlement was concluded—that is, not during active hostilities—should have been easy, because the location, types, and settings of the mines were known. In addition, the minesweeping force had been training for seven months in preparation for the operation. A large task force was employed, with thirty-three heavy helicopters, ten mine-countermeasures vessels, an LPH (landing platform, helicopter), and an LPD (landing platform, dock). Yet even given these ideal conditions, the process took forty-eight days to be sure that all the mines had been either removed or inactivated, as the treaty required. As a final proofing of the sweep, an old ship specially configured to withstand mine explosions sailed up the channel. As the officer in charge concluded, "[S]weeping of any sort is difficult, tedious, [and] lengthy."[23]

The Modern Situation

Offensive mine warfare today may be even more effective than history indicates. Contemporary mines are smart (able to distinguish a ship from a simulator), have multiple sensors (acoustic, pressure, magnetic), and typically sit on the bottom. Often, they cannot be swept by ships passing above them simulating signatures but must be hunted individually. That involves finding metal objects on the bottom, investigating them, identifying them as mines,

and neutralizing them. Since the world's oceans are full of trash, this can be time-consuming.[24]

Further, it has been seventy years since great powers engaged in mine-countermine competition. Both sides have made technological advances whose effectiveness cannot be known fully until they are deployed in a wartime environment. However, because only a few mines must work for a minefield to be successful in deterring shipping, the advantage likely rests with the minelayers, not the mine clearers. While contemporary adversaries might not be as helpless as the North Vietnamese, these historical cases suggest that the offensive use of mines deserves deeper analysis.

CRISES THAT MIGHT DEMAND A U.S. RESPONSE

While this article focuses on the military feasibility rather than the political wisdom of minelaying, it is necessary to establish that minelaying might be a useful tool in certain scenarios. China's assertive actions in the South China Sea and its recent crackdown on Hong Kong's autonomy show a willingness to take risks to enhance regional hegemony. China's claims on Taiwan and its extensive claims in the South China Sea could lead to a future crisis. The following paragraphs explore some of these scenarios.

If China decided to use military force against Taiwan and its outlying islands, it would not be the first time. When the Chinese Nationalist forces were driven off the mainland in 1949, they settled in Taiwan, but they also were able to hang on to a few islands just off the coast; Quemoy and Mazu are the closest to the mainland. In the 1950s, China periodically shelled the islands and appeared ready to assault them. The crises abated when the United States demonstrated support for the Nationalists.[25] Suppose the Chinese resumed shelling today, now with precision munitions, and appeared ready to jump the narrow straits and assault the islands?

Taiwan could make a Chinese attack more likely by declaring formal independence. The Taiwan government occupies an ambiguous position in international diplomacy. It never has announced its independence formally, instead maintaining for many decades the fiction that it is the rightful government of *all* China, but fewer and fewer nations continue to adhere to that formula. The Chinese Communist government has stated emphatically that Taiwan is a province of China and that it would react forcefully to any declaration of independence. Suppose a future Taiwan government declared formal independence and the mainland Chinese government took actions that looked like preparations for a cross-strait invasion?

China could use force to pursue its claims in the South China Sea. China has claimed that its manmade "islands" in the South China Sea establish territorial rights; other states dispute this. Currently China claims twelve-nautical-mile

exclusion zones around the island formations and seeks to require that ships and aircraft request permission to transit the area. Although states mostly ignore this, in the future China could try to enforce such a claim, either within the twelve-nautical-mile band or farther out. China established an air-defense identification zone (ADIZ) in the East China Sea in 2013; recently, Taiwan's defense minister expressed his belief that China would set up a similar zone in the larger and more contested South China Sea.[26] Suppose China started shooting at aircraft and ships that did not comply?

Minelaying might be an appropriate response in any of these scenarios. Other current options might not satisfy U.S. politicians. Diplomatic action certainly would be called for, but that might not be strong enough. Kinetic strikes have a high likelihood of leading to a high-intensity conflict. Even shows of force in the contested areas might set off a shooting war without achieving the political goal. A minelaying campaign, on the other hand, would constitute a forceful response without causing any immediate casualties. Depending on the nature of the crisis, the minefields could be configured to impede hostile naval action by the Chinese or to bottle up commerce so the Chinese would pay an economic price for their actions.

THE MISSION: MINE THE TAIWAN STRAIT

If American politicians chose to respond to a crisis with minelaying, the nature of the minefield necessarily would depend on the particular crisis. Chinese aggression in the South China Sea might entail minefields that block ports, whereas a threat against Taiwan's islands might entail minefields that block the intervening bodies of water. Nevertheless, the different operations share many characteristics.

This article analyzes a limited minelaying mission to block Chinese access to the Taiwan Strait, assuming the following:

- There is no ongoing exchange of fire.
- The mission is to lay enough mines to deter civilian and military use of the strait.
- The mines are laid in one mission, after which the United States announces the presence of the minefield and its desire to resolve the crisis peacefully.

The purpose here is not to explore what reaction this minelaying would provoke or how such a crisis might play out, but rather to analyze its feasibility as an option.

The Taiwan Strait is shallow and narrow, making the area an effective one to mine. It is about three hundred kilometers (km) long; the width averages 180 km, but measures only 130 km at the narrowest. The average depth is sixty meters (m); even at its deepest (100 m), the depth does not exceed the maximum usable depth of America's most numerous mine, the Quickstrike.[27] However, maritime

traffic in the strait is centered on an 8 km wide band of water of 20 m depth, making civilian traffic particularly vulnerable.[28] The 1945 offensive minelaying campaign against Japan provides a historical analogy. Granted that the Shimonoseki Strait between Honshu and Kyushu is shorter, narrower, and shallower than the Taiwan Strait, that campaign did block the passage effectively.[29]

Besides any military effects, a mining campaign would cause significant economic disruption to China. Sixty percent of Chinese trade travels by sea, and maritime imports into China account for a quarter of global maritime trade; a campaign aimed at ports would disrupt this trade severely.[30] However, minelaying in the Taiwan Strait mostly would disrupt Chinese internal trade, although the ports of Xiamen, Quanzhou, and Fuzhou also would be affected. Internally, China moved 5.5 million ton-kilometers of freight by ship in 2018 (compared with 2.7 million ton-kilometers by rail).[31] Approximately 39,000 vessel trips were made through the Taiwan Strait during a twelve-month period in 2011–12.[32] This means that the pain inflicted by the blockage of the strait would be focused on the Chinese themselves—an added benefit in the political calculus.

Given the mission and geography of an offensive minelaying campaign in the Taiwan Strait, the question then becomes: Does the United States have the capability to do it?

U.S. Ability to Mine the Taiwan Strait

The United States could not block the Taiwan Strait using mines laid by surface ships or submarines; the Navy currently has no surface minelaying capability, and submarine minelaying capabilities are limited. The only currently available submarine mine is the Mk 67 mobile mine. While it does offer clandestine delivery, it relies on technology from the 1960s, has a small inventory, and cannot be launched by *Virginia*-class submarines.[33] (A replacement is being developed, but it is not yet in service.)[34]

Given the geography and current capabilities, aerial-delivered mines would be used. The Quickstrike family of mines is built around five-hundred-, one-thousand-, and two-thousand-pound bombs of the Mk 80 series.[35] As noted above, these mines can function in all depths of the strait, using variable-influence sensors to detect submarines and surface ships.

Using the smallest-charge version of the Quickstrike, the Mk 62, makes sense, for three reasons. First, Iran demonstrated in the 1980s that even 250-pound-charge mines can cause significant damage.[36] Second, actually sinking ships and inflicting casualties might be counterproductive to the political goal of coercion; the loss of life created by large-charge mines striking Chinese ships that "damn the torpedoes" could create among the Chinese a perceived need to retaliate that would make a beneficial political settlement less likely.[37] Third, smaller mines

can be laid in greater quantities, which is helpful to the mission of blocking the strait.

Before the first mines are dropped, China will be uncertain what the aircraft in question are doing in the strait. After the first mines are laid and China knows what is afoot, it might target follow-on missions and escalate the situation in a context in which its actions would appear to be more justified. The first flight of aircraft could fly along the strait without going over Chinese land. While this would violate the ADIZ the Chinese have declared over the East China Sea, the United States has flown bombers through the ADIZ previously without their being shot at.[38] China would have to decide whether to shoot at American aircraft whose intentions it would not know; if it chose to shoot at such aircraft, the United States could abort the minelaying mission and seize on the Chinese action as a casus belli to gain international support. However, the more likely scenario would have China not shooting at U.S. aircraft on the first mission. Therefore, the number of mines laid would be determined by the inventory of aircraft available for a single mission and the resultant payload capacity.

B-1, B-2, and B-52 bombers all can deliver the Mk 62 Quickstrike mine.[39] Open-source information indicates that these bombers can fit the same amount of mines as their base munition—that is to say, the extra detection devices on the Quickstrikes do not reduce bomber payload.[40] With payloads of seventy thousand pounds for both B-52s and B-1s, each of those airframes could carry 140 mines. The forty-thousand-pound payload for the B-2 bomber means that each of those planes could carry eighty mines. As the mission does not require immediate action, the United States could spend some time marshaling aircraft to participate in the strike. The strait is comfortably within range of air bases in Japan and Guam for all bombers, even without refueling; with the high air-base capacity in the area and with B-2s taking off from the continental United States, air-base space would not be a constraint.

For a major operation, the United States could launch a strike force of six B-1B, three B-2, and twenty B-52H bombers, laying 3,880 mines. For comparison, eleven B-1s, four B-2s, and twenty-eight B-52s deployed for the 2003 invasion of Iraq.[41] However, open-source data suggest that readiness may have decreased since then; in 2019, only six B-1B bombers were ready to deploy.[42] It has been estimated that only three of the twenty active B-2s are ready for a mission at any time.[43] Fifty-eight B-52s are active and eighteen are in reserve, and the readiness of the simpler airframe is likely higher; thus, the conservative estimate of twenty available B-52s is reasonable.[44]

The planes' available payloads yield the maximum figure of 3,880 mines. However, use of an air armada of this scope likely would be unnecessary, its capacity

might exceed American mine stockpiles, and using it might increase the risk of a catastrophic Chinese reaction.

In a more conservative scenario, six B-1B bombers could lay 840 mines. Because B-52 and B-2 bombers are nuclear capable, their use might cause the Chinese to conclude that a nuclear strike was incoming, which could precipitate hostile countermeasures. Using only B-1B bombers flying on a north–south axis along the Chinese coast would reduce the likelihood of a Chinese reaction. As noted above, U.S. bombers have flown through the Chinese ADIZ in the Taiwan Strait previously without provoking hostile counteraction. The Chinese likely would assume that the bombers again were performing a show of force—until the bomb bays had opened, the payload had been delivered, and the bombers already had turned away.

The degree of risk to the bombers would vary only slightly with the orientation and location of the minefield. Because Quemoy Island is only two kilometers from the Chinese mainland, a minefield to protect the island would require bombers to get closer to Chinese air-defense assets. An east–west-oriented minefield to interdict trade through the Taiwan Strait would be less risky, although some aircraft still would have to get within a few miles of the Chinese coast. The stealth technology of the B-2 bomber would make those aircraft more survivable and thus preferred for seeding the areas closest to the Chinese coast, but their nuclear capabilities and lower payloads make them less attractive.

Much of the risk to the bombers would be eliminated by using extended-range variants of the Quickstrikes that currently are in development. These variants use Joint Direct Attack Munition kits to increase their range and precision. Although sufficient stockpiles likely do not exist for a mission of this magnitude at this time, they could be developed and amassed in coming years. The new, extended-range Quickstrikes have a range of about 64 km, so they could be launched from outside the Chinese-claimed 22 km ADIZ. While this is not outside the envelope of modern antiair systems, it would decrease the threat the Chinese would perceive from the bombers, and increase their survivability even if the Chinese chose to engage. In an east–west minefield to block the strait, extended-range Quickstrikes could seed the 64 km closest to the Chinese shoreline while basic Quickstrikes seeded the other half of the strait. The extended-range variants have completed operational testing and offer the added benefit of being GPS guided, which would aid in their eventual removal following a political settlement.[45]

But could the Chinese simply sweep the mines themselves, without making concessions and receiving American help?

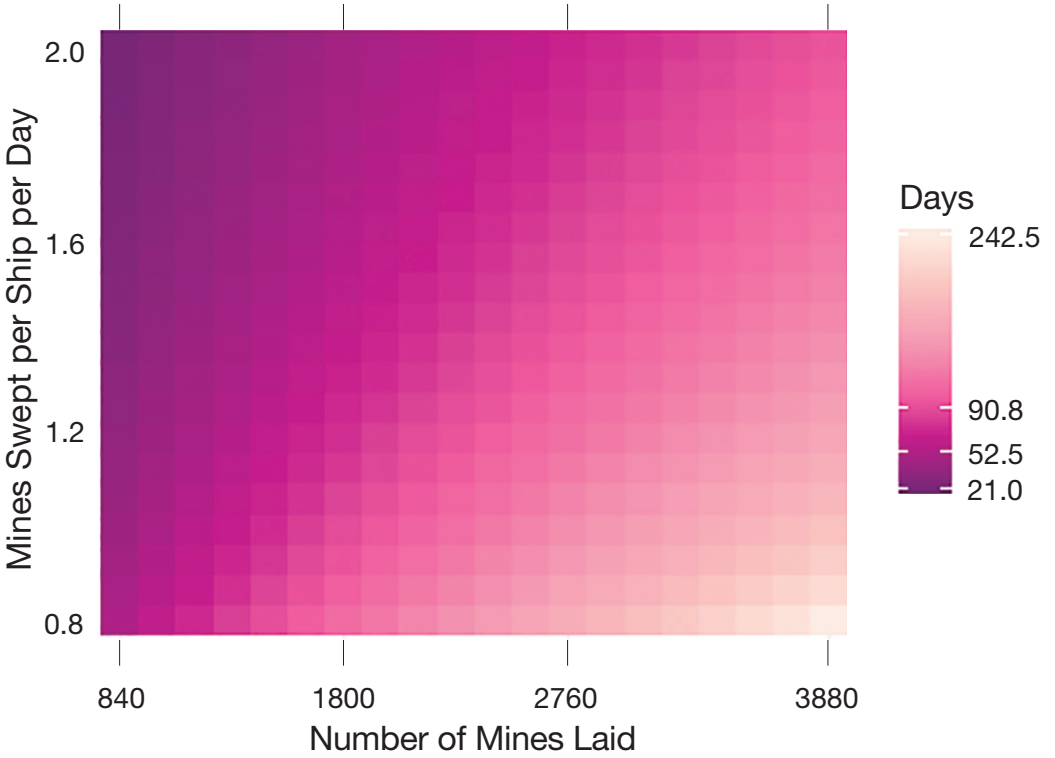
Chinese Ability to Sweep Mines

If the United States took no further measures, how long would it take China to clear the minefield? In addition to the number of mines laid, the answer depends on the number and effectiveness of Chinese minesweepers.

China could field around twenty minesweepers. It has fourteen active Type 81 minesweepers and sixteen smaller Type 82 minesweepers.[46] While China possesses a variety of other coastal and harbor minesweepers, they can counter only moored contact mines, which are less sophisticated than the Quickstrikes.[47] Assuming that a third of ships are unavailable owing to maintenance, as is typically the case with U.S. military vessels, then around twenty Chinese minesweepers would be available.[48]

Past campaigns indicate that minesweepers can clear an average of between 0.8 mines and 2 mines per minesweeper per day. U.S. minesweepers in Wonsan cleared 225 mines over fifteen days using eighteen minesweepers, for a rate of

LENGTH OF TIME REQUIRED FOR THE CHINESE TO CLEAR THE MINEFIELD



Note the range from 21 days (assuming the smallest U.S. field and the most efficient sweepers) to 242.5 days at the other extreme.

Source: Based on multiple runs of author simulation.

0.83 mines swept per day.[49] To counter Iraqi mines during the 2003 invasion of Iraq, ten minesweepers were active.[50] Talmadge calculated that together they cleared 19.5 mines per day, making 1.95 mines per minesweeper per day.[51] Talmadge also calculated that coalition minesweepers in 1991 swept 1.18 mines per day.[52] Therefore, in historic cases of similar minefield sizes and number of minesweeping vessels, each minesweeper has removed between 0.8 and 2 mines per day.

In this simplified scenario, it likely would take the Chinese between fifty and ninety days to remove an American minefield. The figure shows the duration of the minefield, depending on the per-ship minesweeping efficiency of the Chinese and the number of mines the United States laid. All scenarios assume that the Chinese can muster their twenty minesweeping ships on the day the minefield is laid. The duration ranges from twenty-one days, assuming the smallest minefield and the most optimistic per-ship sweeping efficiency for the Chinese, to a longest duration of 242.5 days. The average estimated duration of the Chinese efforts is 90.8 days. Perhaps the most likely scenario is 52.5 days, which uses the smallest minefield and the least efficient Chinese sweeping efforts. The smallest minefield is likely because the risk in laying mines will push planners to keep the number of aircraft exposed to danger low. The least efficient minesweeping efforts are likely because the United States would use influence mines more technologically sophisticated than the mines the North Koreans and Iraqis used, which mostly were contact mines.

An additional variable is whether any minesweepers themselves are lost to or damaged by the mines. At Wonsan, the United States lost two out of eighteen minesweepers over the course of fifteen days while clearing 225 mines. In 1991, two American ships were struck by mines; although they themselves were not minesweepers, they were escorting a flotilla of ten minesweepers in an operation that removed 250 mines over forty-two days.[53] However, no ships were lost in the 2003 clearing of mines from the Umm Qasr waterway.

Therefore, this article relies on a simulation of the results of a Chinese minesweeping operation in which the minesweepers suffer attrition. The simulation assumes that every day the surviving Chinese minesweepers clear a certain number of mines; this reduces the number of active mines. The most likely scenario has 840 mines being cleared at a rate of 0.8 mines per minesweeper per day. Every day, the Chinese have a two-in-fifteen chance of losing a minesweeper (as the United States lost two minesweepers over the course of fifteen days at Wonsan). Even though Wonsan is the case with the highest historical attrition rate, it probably is the most realistic, given the technological balance between America and China. If the Chinese were reduced to five minesweepers, the projection is that they would abort the mission. Minesweeper attrition thus not only extends the

duration of the Chinese operation but also makes it possible for the Chinese to fail entirely. The simulation continues until either all the mines are cleared or the Chinese have five minesweepers remaining.

Introducing minesweeper attrition to the calculation increases the duration of Chinese minesweeping to sixty-nine days in the most likely scenario, with a 6 percent chance that the Chinese are unable to sweep the field at all. Simulating the clearance operation a thousand times, the durations ranged from forty-eight to 106 days, with an average duration of sixty-nine days; nine minesweepers were lost on average. In 6 percent of trials, the Chinese minesweepers were reduced to five, and they aborted the mission. A fair summary of the results is that it likely would take the Chinese between two and three months to clear all the mines.

But do they need to clear all the mines, or just a portion thereof? Clearing a passage for military traffic might take only one or two weeks. In minefield parlance, a *Q-route* is an initial passage in which the chance of hitting a mine is believed to be 10 percent or less. How many mines this requires sweeping depends on the density of the minefield and other characteristics. In the case of Wonsan, the clearing of 225 mines out of three thousand laid by the North Koreans was sufficient for military operations. This means that clearing about 10 percent of mines would suffice for military traffic, which would reduce the duration of minesweeping proportionately. Minesweeper attrition would be lower because of the reduced number of mines to be cleared. In this scenario, the Chinese probably would require only one or two weeks to clear a Q-route through the minefield (two to nine days of actual sweeping, preceded by a few days to marshal the minesweepers to the area).

While a cleared route would defeat a U.S. mission of area denial, it would not be sufficient to allow civilian traffic to resume. A Q-route probably would not instill enough confidence to restore merchant traffic, meaning that China would continue to suffer economic pain. If the mission were defined as complete denial of the strait to the Chinese military, then an undefended minefield would afford the United States only enough time to rush assets into the theater; the minefield itself would not prevent Chinese military traffic for longer than two weeks. However, this calculus changes if the United States or Taiwan targets Chinese minesweeping assets.

RESPONSES TO CHINESE MINESWEEPING

Depending on the political situation, the United States or Taiwan or both could disrupt minesweeping efforts or could reseed the minefield. Attacking Chinese minesweeping assets would subtract one of the positive aspects of the minelaying option—namely, that laying mines can be portrayed as a relatively passive

response. However, if China were attacking Taiwan or some portion thereof (such as Quemoy), then destruction of Chinese minesweepers might be justifiable. Taiwan's expanding antiship-missile capability could allow it to disrupt minesweeping operations without involving the United States.[54] While it is beyond the scope of this article to analyze such an expanded engagement, the loss of or damage to only a few minesweepers would delay significantly or even halt Chinese minesweeping.

Reseeding the minefield is a less escalatory option that could extend the time required for Chinese minesweeping. Reseeding a minefield not only increases the number of mines; it also potentially makes previously swept zones unsafe, which usually requires minesweeping operations to start over. However, once the initial minefield has been laid, the Chinese would be justified in engaging the bombers doing the reseeding. Therefore, reseeding efforts would need to be more limited and rely on stealthier options than the initial minelaying.

The simulation used above can be expanded to see how reseeding affects the Chinese minesweeping. The B-2 bomber's forty-thousand-pound payload means it can carry eighty Mk 62 mines. The B-2 bomber's stealth makes it more survivable than other platforms, particularly when coupled with the 64 km standoff range that the extended-range Quickstrike variants provide. In the simulation, every x days eighty mines are added to the field, representing the payload of one B-2. At the end, the simulation reports the percentage of times the Chinese minesweeping failed for each value of x. This tells us the likely outcomes of American reseeding at various frequencies.

Reseeding the minefield with one B-2 bomber per week likely would be enough to prevent the Chinese from ever clearing all the mines without American aid. Reseeding the minefield as infrequently as once every thirteen days with one B-2's payload results in a 92 percent chance that the Chinese will lose fifteen minesweepers, and thus abort their mission, before they sweep every American mine. Assuming the less costly attrition rate of 1991 (two ships lost in forty-two days), reseeding the field once a week results in a 98 percent chance of Chinese failure.

Reseeding the minefield with one B-2 bomber every five days likely would be enough to prevent the Chinese from clearing a route for military use. Again, this assumes that 10 percent of the mines need to be cleared to create such a lane. Under the assumptions of the most realistic scenario, the Chinese need only a little over five days to clear 10 percent of the 840 mines ((10 percent of 840 mines) ÷ (20 minesweepers × 0.8 mines per minesweeper per day)). However, reseeding the minefield once every five days with one B-2's payload is likely enough to thwart the Chinese continuously. The issue of minesweeper attrition does not enter these calculations—so long as America has sufficient stockpiles and the Chinese minesweepers operate at expected efficiency, there never will be a cleared route.

Furthermore, it is unlikely the Chinese minesweepers would be particularly efficient in this scenario, as the B-2 could lay mines in areas the Chinese had designated previously as swept. But what if, despite this, the Chinese operate at the same efficiency as the coalition in 1991 (two mines per minesweeper per day)? In this case, one B-2 every other day would be required. Thus, with sufficient stockpiles of the extended-range Quickstrike mines, the prospects are good of preventing the clearance of a lane even under conservative assumptions.

For Navy programmers, the analysis presented here shows the importance of acquiring sufficient stockpiles of naval mines and conducting training in their employment. In the most conservative scenario depicted, six B-1B bombers lay 840 mines. Even this conservative scenario assumes that enough mines exist, they are available for a mission within days, and the bomber pilots are trained in their employment; procurement and training programs might have to be established to ensure that these factors are not stumbling blocks in the future. The new, extended-range version of the Quickstrike also should be procured in large quantities, as use of these mines would reduce dramatically the risk to bomber crews. Assuming the unit cost for Quickstrike mines is similar to that for guided bombs (around thirty thousand dollars per unit), the mines also represent a much cheaper option than other tools (for example, the AGM-158C long-range antiship missile costs $3.96 million per unit).[55] Finally, using other mines in conjunction with Quickstrikes would make the minefield much more difficult to sweep. The Mk 68 Clandestine Delivered Mine and the Hammerhead are two such systems under development.[56]

For strategists, this article shows how the exploration of unorthodox lines of action can expand the Navy's tool kit. Mines represent a historically effective weapon about which the United States thinks too little. Developing plans and capabilities now not only would make the Navy more potentially useful; it also would set up China for a measure of surprise, likely creating an advantage for the United States and the Navy during a time of great danger. Although the exact circumstances of a real crisis will be different from those of the stylized one depicted here, the effort put into thinking about options ahead of time will produce better information and plans during an actual event. As General Dwight D. Eisenhower put it maximally, "Plans are worthless, but planning is everything."[57]

Finally, for decision makers, having a minelaying option would provide a valuable additional rung on the escalation ladder between diplomatic initiatives and kinetic strikes. When faced with a crisis to which the United States must respond, American decision makers will start with diplomatic efforts, but these may prove insufficient. Escalating directly to kinetic strikes poses great risks and might not be supported by U.S. allies, even those most vulnerable to Chinese aggression. Thus,

having an intermediate option might strike the right balance between doing too little and doing too much. On the other hand, the initial seeding of the minefield could spark a larger conflict, or the Chinese could respond by laying their own minefield against U.S. bases or allies. While the operational feasibility of this operation is clear, the political and legal ramifications bear further scrutiny from other scholars.

NOTES

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