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经过将近六世纪之后，中国再度以海事强权的角色出现，此次重视的焦点在于其水下作战能力。1996 年到 2006 年间，解放军取得了 30 艘以上潜舰 [1]。这些舰艇包含两种新型核能潜舰-改良型宋级柴油潜舰及元级柴油潜舰(根据某些报导，此为美国情报单位预期外的新型潜舰 [2]。除了上述野心勃勃的海军建军计划外，在 2005 到 06 年间，人民解放军接收了八艘强大的基洛级潜舰(及武器系统)。这几艘在 2002 年时购买的潜舰，加上原有的四艘同型潜舰后更如虎添翼。以海南岛为驻地的新型核能潜舰基地，可能更进一步地宣告了解放军海洋作战新纪元的到来。

东亚安全分析家间现多专注于北京潜在的航空母舰建军及部署之议题。然而这项说法，至少就近期而言，可说是一个转移注意力的作法。在可预见的未来里，解放军并非把重点完全置于「掌控海权」，而是追求东亚近海制海权：此一范围较小，且更易理解的目标。在解放军的第一艘航母照片流出后，毫无疑问地增添了此议题的讨论空间，然而其海军在近期更着重于有效，且较少受到关注的海战类型-水雷作战。这个议题及其他非对称类型的海战，对于东亚的军事平衡有举足轻重的影响。

解放军的海军战略家宣称水雷战具有「易布难扫、隐匿效果强、破坏力高及长期威胁价值」等特色 [3]。解放军对于水雷攻击策略的关键目的在于「封锁敌人基地、港口及航道、摧毁敌人海上运输能力、攻击或限制敌舰行动、削弱或耗尽敌人战力」[4] ，就未来沿海作战而言，普遍地认为「水雷是各国海军的主要威胁，对于航母作战群及潜舰更加为甚」[5]。且这点更加呼应解放军在作战评估上认为「相对于其他种类作战，(美国海军)水雷战能力极弱」[6]。中国海军战略家认为二次世界大战以来，遭击沉或严重损害的 18 艘战舰中就有 14 艘是被水雷所破坏 [7]。如同解放军报所称「当军事专家放眼于开阔海域作战时…隐匿的潜舰鱼雷攻击及水雷的巧妙部署依然是现代海军的主要作战工具」[8]。当代解放军准则中「布雷」这个名词 ，在 2008 年的中国国防白皮书中使用了不下 3 次，由此可见被重视的程度 [9]。正当多数国家投入于研究水雷反制时，仍有少数国家枉顾普世价值而追求攻势水雷作战 [10]。例如 2006 年出版的战役学(着重于解放军准则作战及战略的研究)中，提到「(我们必须)全面地运用(水雷)…前进至敌港及经济航道，以进行大规模地布雷」[11]。

联合潜舰作战能力后，中国似乎正努力地提升其水雷作战的技术。相较之下，潜舰体积大更难隐匿，加上其他军事强权的情报机构磨刀霍霍般掌控解放军潜舰发展的状况。相对地，水雷作战的能力较易隐藏，因此可称为军事手段上的「杀手锏」[12]。美国的说法中，就是解放军的「银弹」(silver bullet)。这个术语在某些中国消息来源，包含解放军本身 [13] 都明确地使用于水雷作战中 [14]。目前的解放军仅靠水雷就已经能够将台湾及西太

平洋海域重要的海运航线完全封锁。如 Thomas Christensen (柯庆生)曾发表「台湾海域邻近中国大陆…台湾在贸易上对海运的依赖…扫雷本身的困难性，及美国极弱的扫雷能力，特别在(太平洋)作战区…等等因素，让水雷封锁..对于中国来说…是一个极具诱惑的策略」[15]。水雷作战除强化其他作战能量之外，的确对于美国海军在东亚军事版图上是一个致命的重大挑战。 依上述论点，此报告中对其他近期发表的研究报告，例如：中国的水雷作战能力被过度夸大，在对台作战想定中不具决定性因素之说法提出质疑[16]。该研究报告的结论可能在过去某段时间内成立，但此说法现在已过时，并轻忽了水雷战对部署于亚太区域的美国海军造成严重威胁的可能性。

这份报告分为 10 个部分。首先是讨论波湾战争促进了中国发展现代水雷作战。第二阶段将以此脉络，讨论中国水雷作战鲜为人知的历史。接下来的两个阶段将详述中国海军的水雷储备及各种布雷的方式。第五阶段将讨论中国水雷作战发展中的人员因素，简述近期训练及操演的特色。接着说明解放军海军发展中的水雷作战准则的现阶段轮廓。第七阶段将讨论未来水雷反制扮演的战略因素；第八阶段则讨论可能的想定场景，特别是台湾海域的封锁，并着重于未来亚太海域安全环境中，水雷战可能形成的全面性评估。接着从另一个角度来切入中国的水雷战发展。最后阶段将讨论美国国防及外交政策与此相关的议题。

促进中国水雷战发展的历史转折点

除了 1895 年中日甲午战争中遭受大败的清朝舰队外，中国在近代海军史舞台中并非主要角色。中国的军事理论家因此深感中国海战经验及实战知识的不足。最明显的是二次世界大战时，中国并无能力迎战横越太平洋到中国沿海的大型舰队。难怪国防分析家习惯将中国叙述为「大陆强权」(continental power)。

1978 年以来，因中国的开放政策，中国专家有系统地吸收外国经验，并提供政策家(planners)海军发展的研究分析。这些研究树立了水雷战的重要性。根据中国水雷战教材，二次世界大战期间约布署了 81 万枚水雷，击沉了约 2,700 艘舰艇[17]。 此外中国海军战略家更是赞叹在单次战役中，德国就因同盟军的水雷而丧失了 27 艘 U 型潜舰[18]。中国海军战略家也对 1945 年美国对日本的水雷战有极大兴趣[19]，认为这项策略对日本无条件投降有极大影响。他们认为美军共部署了 12,053 枚水雷，击沉了 670 艘日本舰艇[20]。中国海军战略家认为了福克兰战役中，阿根廷因未使用水雷对抗英国皇家海军，是其战败的主因[21]。

中国战略家所分析的许多军事战役中，波湾战争(1990-91 年)特别的重要。此战震惊了经历邓小平时代下国防预算削减、军事技术低、战备贫乏阶段的人民解放军。根据 David Shambaugh(沈大伟)所说「在人民解放军 70 年历史中，只有韩战让人经历了如此全面性的再思考」[22]。这个冲击「对人民解放军有如当头棒喝」。Shambaugh 解释：「(解

放军的)政策家从未想象美国所发展的新型高科技可如此运用…几乎任何军事观念都提醒着解放军高层其未逮之处」[23]。这些研究中有个值得注意的现象被忽略，但却暗自影响了中国海军之后发展；因此，中国分析家详细的分析了 1990-91 年的军事冲突中的海军战役。[24] 中国军事著作引用此战役中水雷破坏了两艘美军战舰的例子，认为水雷战几乎是全面的 [25]。

以众多水雷战及水雷反制著作闻名的中国军事专家傅金祝，在 1992 年 3 月中国船舶重工集团公司(CSIC)的「现代舰船」期刊上，发表了一篇关于波湾战争在水雷战的全面性分析 [26]。傅认为水雷战非预期性地扮演了一个重大的角色，突显出水雷是小国能对抗大国最有效的方法之一，但傅也小心地指出大国亦可有效地部署水雷 [27]。傅认为成功地让黎坡里号(USS Tripoli) 及普林斯顿号(USS Princeton)触雷，说明了美军在水雷反制上「相对地势弱」。他认为此论点在伊拉克水雷战失败中特别明显，傅列出了在作战规划及整备上的不足，例如未布署足够数量的水雷(伊拉克「仅」布署了 1,100 枚水雷)，错用了系留雷，不够巧妙地隐匿水雷作战或实施长距离水雷作战等因素。虽然认同伊拉克在水雷战中善用了民船，但同盟军的空优则是阻碍伊拉克从空中布雷的主因，并消耗了大量伊拉克水雷数量。此外，傅更加确认此历史事件本质上显示出「反水雷艰巨性」。

在波湾战争的海军作战中亦有篇研究报告呼应上述论点 [28]。此分析报告强调，其讽刺之处在于波湾战争普遍地被认为是「高科技作战」，然而传统武器(如水雷)却扮演了重要的角色。作者认为水雷战具惊人的经济效益，并以「价廉物美」来形容它。认为水雷对中国来说为特别适切的武器，不仅在守势作为上，更因中国具有长且复杂的海岸线，因此也适用于攻势作为，可制造封锁敌港、破坏海上交通线的机会 [29]。如同傅金祝，此分析家强调可师法伊拉克经验，因为「水雷也应该运用高科技」。在改善的方法及技术当中，以反水雷反制装备为先、接续为「智能化水雷」、快速布雷、及「多载台布雷手段」等。如前所述，第二份研究分析也相当地不赞赏同盟军的水雷反制作为：「虽然四个国家共布署了 13 艘舰艇，结果仍未达期望，这批联军受制于各舰艇作业能力不同，因此(在对抗伊拉克水雷上)只有缓慢的进展」。

傅金祝于 2004 年时，在中国造船工程学会(CSNAME)期刊-「舰船知识」中的发表，暗示关于前述及相关分析观点已成为解放军的海军战略家间普遍的看法。开头便说「我们都知道在 1991 年的海湾战争中，伊拉克的水雷发挥了重要的作用，重创美海军的 2 艘大型战斗舰和 1 艘改装的猎雷舰」[30]。这篇研究中分析了 2003 年伊拉克战争中水雷战及水雷反制，并检讨为何此次同盟军在水雷反制作为上明显优于 1991 年。傅认为伊拉克水雷并未造成同盟军的伤亡，因此 2003 年的水雷反制作为是成功的。然而，他认为即使运用了许多新型系统(例如 AN/AQS-24 猎雷声纳)，同盟军水雷反制上还是有许多问题。据他观察，在水雷反制作战开始的 36 小时内，只搜获了 6 枚水雷(相对于约 90 枚布雷)，且当时最先进的水雷反制系统仍受到海底杂迹(例如假目标)的影响 [31]。再回到本段主题-波湾战争分析上，傅强调伊拉克水雷战的失败，在于同盟军掌握了相关空域

及海域完全掌控权。傅认同水雷战的效果，但也说明水雷反制本质上的困难，他引用了伊拉克战争中负责水雷反制战的美海军官员说法：「即使在最佳的海象及作战环境下，猎雷及扫雷作业仍是缓慢的，带给人员挫折感及威胁」[32]。

在水雷战的历史中，1991 年波湾战争显然对于解放军的海军发展上有显著的影响。西方的国防分析家很明白地表示波湾战争对整体解放军来说是一个转折点，暴露出中国弱于美国军力上的显著差距，而驱使中国急起直追的欲望。然而，中国对于波湾战争水雷战及水雷反制上的评估，进而注意到美国在此类作战能力上的致命点。正如一位中国分析家在2004年中国海军官方报-人民海军上发表在中美军事冲突时水雷战可能扮演的角色：

美军需要从海上移动补给品。但中国不是伊拉克，中国具有先进的水雷...这对美国的海上运输来说是个致命的威胁...当台湾海峡爆发冲突时，，解放军海军可以布署水雷。美军舰艇在反潜战前，需先执行区域扫雷。美国在波湾战争时，花了超过半年时间才将所有伊拉克水雷扫除。因此，美军在扫除解放军水雷时必不轻松[33]。

除了对于外国水雷战经验的详细分析外，中国亦运用某些自身经验。

中国水雷战的发展史

虽然波湾战争及其他国水雷战的分析可能促进中国发展水雷战，但无视中国本身在这个领域下鲜为人知的努力却是错误认知。中国的水雷发展等同于其海军的盛衰史-从古代的强盛而转衰颓到近期的复苏[34]。

值得注意的是中国宣称发明了水雷，[35]在明朝(16 世纪中期)发明及生产，[36]之后亦广泛地运用[37]。早在 1363 年，据传明朝就在战役中使用分壳布雷船作战[38]。在 1558 年，唐顺编撰的「武编」一书就详细记载了沉雷的设计，从 14 世纪到 16 世纪时，就用作攻击中国沿海倭寇的布雷方法[39]。清朝时设立了天津水雷学堂[40]，并期望恢复中国的制海权并防御领土的完整性。

几世纪后，在中日战争期间，共军与国民党合作布雷，抵抗日本在长江上的运输[41]。在中华人民共和国于 1949 年建立后，「海军军官发现水雷武器的独特作战性：威胁时间长、攻击隐匿、难以预料等」[42]。人民解放军在 1949 年时，使用渔船清除汕头港的水雷[43]，解放军必须建立一支扫雷部队以扫除国民党在长江所布下的水雷。在俄国专家的指导下，四艘登陆舰改装成扫雷舰，于当年 10 月成功地完成扫雷任务[44]。

西方及中国战略家都同样熟悉在元山战役时的联军扫雷作战[45]。中国消息明确指出北朝鲜成功布下了 3 千枚水雷，并暂时延缓了美军攻进沿海的时间[46]。联军成功地扫雷

或摧毁了225枚水雷，但也付出了惨痛的代价。4艘美军扫雷舰及1艘舰队拖船被击沉，五艘驱逐舰受到严重的损害。水雷也击沉了南韩的扫雷舰YMS-516，并伤害了几艘南韩舰艇[47]。在此役中带领前进兵力的美海军准将Allan Smith，这样叙述此事件：「这个国家在没有海军，仅靠一次大战前的武器及过时的船只的状况下，就让我们丧失了制海权」[48]。

人民解放军在韩战期间初次进行了水雷战，这是一个被西方广泛忽略的事实。在1953年2月，北京海军司令部派遣了一只派遣队布署水雷屏障，预防美国两栖渗透兵力进入共产党领土。4月6日，5艘舰艇组成的分遣队抵达清川江口，并根据俄国准则试图布雷(因环境参数影响而适时调整，并革新战术)。[49] 经此开端后，共产党在韩战的作战经验成了中国近代水雷战的滥觞。解放军海军引进俄国水雷同时也决定开始仿制。

在韩战期间制定的国家政策决定，在此战役结束后购买不同型的外国扫雷舰。1951年制定的政策，对于解放军海军的发展有着长久的影响，让中国决定「从苏联获得技术转移权利并自制军舰」到「从仿制(舰艇)到半本国自制」，而最后「一步一步地从半本国自制到完全自制」。[50] 中国因此购买并改装了二次大战的扫雷舰，以及苏联在1948年造的数艘扫雷舰。在此动机下，中国同时将渔船改装成扫雷舰，并开始制造首艘专用猎雷舰。根据1953年中俄协议[51]，莫斯科将6605及6610型扫雷舰的造舰计划及装具交付中国，而后于武昌造船厂组建。在1960年代起开始量产。[52]

在1950年代中期，根据1956-67年的国防科学及技术开发计划的指导[53]，中国开始发展水雷建设。北京当局设立了水雷专业委员会，负责指导水雷研发。以及水中武器研究机构，负责相关资料收集及分析。[54] 于1958年，山西省汾西机器厂开始自制中国第一枚水雷：型号M1-3型，为仿制俄国原型之水雷。

在1956年，中国开始设计第一艘自制猎雷舰：057K型，由第一机械制造工业部下的造船工业管理局的第一产品设计室负责[55]。第一代的港区扫雷舰是由中船重工(CSIC)下的708研究所负责监造，主要的船厂有江南、中华、江西等[56]。1965年经过海上测试后，首艘猎雷舰便交给解放军。中国在日后会将此舰跟058型舰艇布署到越南。058型舰设计始于1967年，解放军于1972年时接收。此型舰采低磁性特征钢，并使用消磁装备(用以降低磁性特征)[57]。在1970年代时[58]，依照东德“Troikas”型舰研发了约50艘312型无人扫雷舰执行河川的扫雷作业；这批舰艇后来也在越南使用。[59]

水雷发展在文化大革命期间(1966–76)仍持续进行着，也许是因为跟毛泽东的人民战争准则路线相近的关系而保留着。为了建立能抵抗俄国核子攻击下的偏远「第三线」国防建设，打击了中国的军事产业也丧失极大的效率，影响甚至延续到今日[60]。当时研发许多模块化、简单构造的浅水雷，例如C-4及C-5型沉底雷等[61]。这个时期的水雷普遍具有开发时间长的问题；后续也多需要升级引信才可延续可用性。现在仍不清楚这些

浅水雷在今日中国的战斗序列中能扮演何种角色。

在 1972 年 5 月 9 日，美国海军在越南海防港布雷。中国立即回应河内的求助，并于 5 月 12 日时正式地谴责封锁行动[62]。中国接下来在研讨后，不寻常地派兵至战区，注意当时中国在水雷反制上是缺乏经验的。而且他们亦坦率地承认文化大革命折损了中国原有的实力[63]。当月稍后中国水雷调查工作队抵达了海防港，并开始分析寻获的美军水雷。在当年 7 月到 1973 年 8 月之间，解放军派遣了 12 艘扫雷舰、4 艘支持舰及 318 名官兵到越南。[64] 在多名伤员及至少一人死亡的状况下，中国的扫雷舰航行了 27,700 海浬，运用了音响触发、水下作业员及其他方式等，清除了 46 枚美军水雷。[65]这些清除水雷的经验让解放军在越战后期已经相当熟悉美军水雷战的工法及硬件架构。中国在美国对北越的水雷战中学到的经验还包含了：夜间时空中布雷的战术，以求出人意料的效果。并在心理战上以「布多说少、布少说多」的手段取得上风[66]。中国后来也在 1974 到 75 年间，利用这项水雷反制的经验帮助柬埔寨的赤柬[67]。

在 1970 年代，解放军固化了其生产基本型、俄式装备的能力。这是一个(军事)起飞的时代；到 1980 年代时解放军在研发上的能力已大有进展。许多从前构想的设施也成功地开发并生产。早期生产的设施亦能以新科技改良。中国第一型国制水雷 M-4 型系留雷，在 1974 年起服役；其改良型水雷后续于 1982 年及 1985 年问世。C-3 型水雷是中国第一个具抗扫能力的国制水雷，自 1974 年起服役。后续引信的改良，于 1986 年产生了改良型 C-3B 型水雷。在 1975 年，中国决定了第一个使用晶体管科技设计的水雷：C-2 型深水沉底雷。其后续的改良型将改善引信的感应。新型的水雷反制舰，编号 082 型港区扫雷舰于 1976 年时建案，在 1984 年开始兴建，于 1987 年起服役。[68]

邓小平于 1978 年崛起后，降低国防预算以促进经济发展，但「改革开放」政策也鼓励解放军在几十年里，第一次全面地引进外国科技及构想。在 1980 年代中期，作为「战略转变」的一环，将部分过时的人民战争教范转换为高科技下进行有限、本地的战争，另将大陆作战重心转移到海洋领土防卫，解放军海军将专业布雷舰的发展列为其优先考虑。延续先前的俄国经验，中国开始研发专用布雷舰艇。在 1988 年，经过从 1981 年开始的漫长设计及测试阶段，918 型布雷舰-舷号 814 开始加入舰队服勤。[69]经报导，814 号可利用多向吊臂实施无码头补雷，为一机械式的运雷系统，并配有先进射控雷达，可携带 300 枚水雷。但其航速慢、易被侦测等性质似乎欠缺了作战上的优势；可能是被当作技术测试平台了。也许就是为何到现在也仅造了 1 艘 918 型舰的原因吧。[70]

照片 1 (涡池级水雷反制舰。詹氏年鉴内列有六艘，由两个船厂兴建。设计上与先前中国建造的俄国型式扫雷舰相似，但舰长多出 5 米。)

在此议题上不应忽略解放军扫雷舰的发展，据报导于 2004 年 4 月 20 日时，求新船厂生产了新型的六百吨扫雷舰[71]。解放军广州军区政治部门所发行的日报中报导 2005 年时，海军成功地「开发了新型扫雷舰之新装备训练及作战战法」[72]。2005 年后，解放军接收了两种型式的国造新制水雷反制舰：六艘涡池级，及目前仅一艘的涡藏级[73]。央视的军事频道 CCTV-7 基于某种目的，于 2007 年上半年播放了中国水雷反制操演的特集中，播出涡藏级使用线传遥控载具(ROV)进行水下猎雷作业的画面，此举显然是解放军海军的第一次。[74] 根据一名水雷战专家指出这个遥控载具可能没有声纳，但似乎能施放引爆炸药，且可能具备扫雷刀，可割断水雷的锚炼。与美军水雷处理系统相当类似。然而就外观而言，它并不像是直接从西方水雷反制系统中仿制而来。[75] 东海舰队的一支扫雷支队[76] 在 2008 年时以型式相似的遥控载具支持了水雷反制。[77] 放大标准来看，使用猎雷无人水下载具(UUVs)虽表示中国在水雷反制能力上是新的进展，但相对于当世水平上来说，复杂程度不高。

照片 2 东海舰队扫雷战队指挥官张建明与猎雷遥控载具。此型遥控线接式猎雷载具在外观上像意大利的冥王(PLUTO)系统，在前端的「泡泡」处有扫雷刀装置，可用于割断水雷炼，在「泡泡」内有摄影镜头，也可能在其下方的黑色金属壳处运用炸药引爆沉底雷。

邓(小平)时代现代化所遗留的资产在于加速了海军水下战技术发展。努力积极地引进外国经验当中，较特别的是源自美国的鱼雷科技。而在水雷反制的领域内，据说中国已从以色列获得了先进的扫雷技术。[78]

特别是中国自 1981 年开始发展火箭水雷，于 1989 年时初次生产。[79] 在后天安门时代，这项研究更获得大笔军事经费、强势经济抬头及稳定国家科技建设等因素支持。美国国防大学 [80] 在 2002 年出版的 21 世纪海战主要专题论文与一般看法不同，文中认为火箭水雷及其改良型式，在这 20 年来势必已在解放军弹药库占有一席之地了。

中国水雷储备

中国目前的水雷储备包含许多致命性武器。公开、不保密的水雷存量总数约五万到十万之间。[81] 然而值得注意的是水雷可轻易隐匿储放位置。因此上述估计量因谨慎视之。

战斗序列

一篇中国近期的文章宣称中国握有超过五万枚水雷，其中「有超过 30 种触发感应、磁性感应、声响感应、水压感应、复合感应、遥控水雷、火箭上升水雷及移动水雷等各式水雷。」[82] 在表 1 列出的是目前公开的中国水雷清单。其范围从较旧型的系留雷、精密的沉底雷到火箭水雷等都有。

系留雷：典型水雷，从一次世界大战开始使用在军事上。1991 年及 1988 年时分别破坏了美军黎坡里号(USS Tripoli)及山姆罗勃号(USS Samuel B. Roberts)可证明其杀伤力依旧。[83] 系留雷漂浮在海平面下，透过锚固定于定点。通常用直接接触舰艇或旧式的引爆机制来实施引爆。系留雷中，例如中国的 EM 31 型及 EM 32 型受限于锚炼(缆)长度及水深不超过两百米。[84] 水雷锚炼及引爆简单等特征，让此类水雷在获知布放情报后，即便以一般扫雷舰也可轻易扫除。[85]

漂雷：是一种「自由漂浮」的水雷，解放军海军已大量研发及生产。根据报导，解放军在枉顾国际法规下，至少制造了 3 种漂雷，占其传统水雷类的大宗之一。但目前在生产、存量、布署等信息均不明。

漂雷主要被认为用以攻击水面舰。由中船重工(CSIC)在湖北省宜昌的 710 研究所研发 [86]，大连起重机厂生产，漂-1 型这种自动、稳定、深漂雷有大型及小型两种。用于攻击中小型舰艇，可由军舰或一般民船布放。漂-1 型据报于 1974 年起服役。其施放深度为 2 到 25 米、作战寿命为 2 年、爆炸半径为 10 米。根据报导，漂-1 型具隐匿佳、生产价格低、难扫且可设定漂浮深度。

漂-2 型这种小型、自动、稳定、深浮水雷是由 710 研究所开发，由大连起重机厂生产。漂-2 型水雷的外观为长型火箭体，容量相对较小、净重 125 到 150 公斤、可漂浮于固定深度，主要用于攻击中小型水面舰艇。漂-2 型可实施分解，俾利人工布雷，可利用小艇或渔船之类简单的载台作业。漂-2 型原设计用于沿海作战及封锁海上航道。有迹象显示中国已经开发了第三代漂雷。漂-3 型：漂浮深度在 2 到 7 米间。[87] 此型漂雷可能将特别用在封锁台湾东部海域的水面舰艇航道，因其深度太深而不适用上升水雷。

型式	引信	类型	布放载台	攻击深度(米)	任务目标	尺寸/弹头	寿限(年)	开发历史	改良型式	开发技术	开发单位
C-1 500 1000	音响频率 磁感信号	沉底雷	水面舰 飞机 水面舰 潜舰鱼雷	6–30 6–60	攻击水面舰及潜舰	495 公斤；300 公斤炸药；直径 533 MM 1080 公斤；700 公斤炸药；直径 533 MM	4	1965 年起服役		仿制俄国非接触深沉底音响诱发雷	710 研究所；西安东风仪表厂;汾西机械厂
C-2 500 1000	磁感信号 低音波(<20Hz)	沉底雷	水面舰 潜舰	6–50 6–100	攻击中大型沿海舰艇	直径 533 MM	2	1965 年起开发；1966 年海上实测；1975 年研发计划终了	针对因淤泥沙掩盖而降低灵敏度进行多种改良	中国第一个使用晶体管技术的水雷	由 710 研究所设计，先锋(Vanguard)电器厂；汾西机械厂
C-3 500 1000	音响频率 磁感信号	沉底雷	水面舰 潜舰 飞机	6–50 6–100	攻击中大型水面舰、潜舰	直径 533 MM	2	1974 年 11 月起服役	1982 年改良引信；1986 年 12 月的 C-3B 型改良施放最大深度到 200 米	中国的第一个国制研发的水雷，具抗扫及抗干扰功能	由 710 研究所设计；上海先锋电器厂生产
C-4	磁感信号 低音波 (<20Hz) 水压感应	沉底雷	海军舰艇 民船 人工	5–15	攻击中小型舰艇,「人民的海上战争」	小型、轻型模块化设计	4	1976 年研发计划终了		具强大的抗扫及抗干扰功能	由 710 研究所设计；东风仪表厂制造
C-5	超音波感应 水压感应	沉底雷		5–15	攻击中小型舰艇	小型、模块化、下半部为短筒状、上半部为半球体：210 公斤	4	1973 年继续开发计划；1975 年服役		因 1974-75 年间协助赤柬夺取柬浦寨政权而在 1978 年获得国家科技成就奖	由 710 研究所设计；东风仪表厂制造
C-6	磁感信号 水压感应 低音波 (<20Hz) 音响频率			10–300						仿制意大利 MR-80 系列	
EM-52	超音波(>20kHz) 磁感信号 使用三种引信： 待机 战斗(音响) 爆炸(水压)	火箭推进直接上升	水面舰艇	2–200	反水面及反潜作战	短粗鱼雷外型，长度 3.7 米、直径 0.45 米、629 公斤、140 公斤炸药	1	1981 年开始研发，1987 年积极测试及修改原型，1989 年继续研发	改良施放深度(目标 500 米)，1994 年起持续改良炸药	从计划深度 200 米到水面时间 5 秒，对周围舰艇达 80% 打击率，中国产销	由 710 研究所管理研发。

型式	引信	类型	布放载台	攻击深度(米)	任务目标	尺寸/弹头	寿限(年)	开发历史	改良型式	开发技术	开发单位
EM-53	音响/磁性， 磁性影响	沉底雷 遥控		6–60	防御水雷战斗数组，封锁海湾、海峡及航道等			1978 年起开发；军方于 1986 年接收原型		三种功能： -解除启动 -战斗 -最大战略弹性引爆	
EM-54					选择目标：飞机或合适排水量的航母						中国舰船研究室研发
EM-55	主动、音响、被动								EM-52 的改良型	中国产销	
EM-56	音响、震动、压力	自走	潜舰 可能由岸基单位发射	从 13 公里到最大 45 公里，可漂浮发射	反水面作战	380 公斤				中国产销	
EM-57 500 1000	音响/磁性	沉底雷 遥控 改良距离至 730 公里	空中 水面舰	6–100	反水面及反潜作战	300 公斤炸药 700 公斤炸药			500 公斤 1000 公斤	中国产销	
MAFOS-1		自动搜寻及判别型式									
M-1	接触引爆	大型系留雷	水面舰 潜舰	12–263	大型水面舰艇		1	1962 年起服役;停产	M-1B，新增非接触引信	仿制俄国水雷	汾西机械厂
M-2	接触引爆	中型系留雷	水面舰 潜舰	15–110	航道及 港口封锁		1	1964 年起服役;停产	新增 非接触引信	仿制俄国水雷	汾西机械厂
M-3	接触引爆	大型系留雷	水面舰 潜舰	12–430	攻击潜舰		1	1965 年起服役;停产	新增 非接触引信	仿制俄国水雷	汾西机械厂
M-4	音响信号 超音波（>20kHz)	系留雷	水面舰 潜舰	200	深水封锁 攻击中型舰艇、潜舰	600 公斤	2	1973 年 11 月研发计划终了；1974 年服役	1982 年 M-4A 增加浮力及引信稳定度；1985 年 11 月 M-4B 型改良引信电路整合	中国第一个国产水雷；第一个非接触深水超音波水雷	710 研究所研发；汾西机械厂制造
M-5	接触、计时、音频	上升水雷		200							

型式	引信	类型	布放载台	攻击深度(米)	任务目标	尺寸/弹头	寿限(年)	开发历史	改良型式	开发技术	开发单位
漂-1/2	接触	漂浮、中型自动定深	人工 小艇 渔船	2–8+	攻击中小型船舰	长型火箭体 低容量 125–150 公斤	2		中国的漂-1 原型缺乏辨别敌我的功能。难以使用，可能已停产		710 研究所研发；大连起重机厂生产
漂-3	音响、接触	漂浮	潜舰 水面舰	2–7 上下 (+/-1 米)	反水面作战	130 公斤	受限于水中最大寿命				
PMK-1	感应、计时、音频	(火箭?) 推进鱼雷	水面舰 潜舰	200–400 (1000 米锚深)	反水面及反潜作战	350 公斤				俄国制造	
PMK-2	被动、主动、音响	(火箭?) 推进鱼雷内装弹头	空中 潜舰 水面舰	400 米 (锚深 100–1000 米) 可联机	反潜作战	相当于 110 公斤 TNT 炸药				俄国制造，以 MPT-1M 热感鱼雷为原型	
T5	音响、磁感、水压	自航									
特 2-1	遥控「安全/战斗/引爆」等功能	遥控		6–65				1978 年开始研发		上海交通大学及海军工程学院协助	上海先锋仪表厂、上海电子装备自动化研究所、海军测试基地
500 型		深训水雷	飞机 (特指海军航空部队)		练习海上布雷			1987 年 12 月设计计划终了	可回收		710 研究所、汾西机械厂、海军航空部队
训-1	可选择 C-1、-2 及 -3 等引信	沉底雷 训雷	潜舰		潜舰布雷练习用			1982 年 11 月后继续开发	操演后浮至水面		710 研究所、汾西机械厂

表 1. 中国水雷一览表

来源包含：林长盛「潜龙在渊-解放军水雷兵器的现况与发展」第 22-33 页；Ling Xiang (凌翔)「Raise Mighty Chinese Sea Mine Warfare Ships on the Sea」第 152–61 页；詹氏年鉴-水下作战系统，参考网址 www.janes.com ；Wayne Mason 着「Naval Mine Technologies」等。

照片 3 「漂型」漂雷。中国海军已生产了大量的自由漂雷，但目前生产的状况、存量及部署等都不明。

根据某些中国消息来源，解放军因漂雷难以控制的特性，已经停止开发。[88] 但 2007 年的某中国水雷战教材中讨论了大量漂雷的内容。[89] 而且近期在 CCTV-7 频道中亦出现了似乎为近代水雷，且「标示为漂雷」的影像。[90]

关于漂雷的研发，中国的实际处置及盘算仍不明确。然而上海国际研究机构的报刊「国际展望」的编辑表示「漂雷…能在桥及港口等设施，用以攻击航行舰及锚泊舰。漂雷并不受限于水深或海上，很可能会漂出海上战区，并伤及非交战国的船只。因此国际条约禁止使用漂雷。当然实际状况下不会如此理想化。」[91] 漂雷的确在广泛认知的军事冲突法律下是不合法的，主要在于其无差别攻击的特性：它们可以轻易地将民船误认为合法的军事目标般摧毁。而且几乎无法追踪位置。海珊(Saddam Hussein)因在波湾战争(1990–91)中使用漂雷而受世人谴责。只有在施放后不久即成为惰性的漂雷才有可能合法，即便如此，漂雷中仍有危险的化学物质并持续漂流，也让人质疑其正当性。[92]

相当于中国最新的作战法手册中，说明 1907 年海牙第 8 公约「关于敷设自动触发水雷公约」限定水雷使用，但是缔约国在二次大战期间仍多有违反此限制。「因而严重地破坏此协议的规则」[93] 最后，这群中国分析家总结国家利益无可避免地高于法律协议。不难想象中国在台湾冲突时，使用「维护领土完整」的理由自外于此类国际公约吧。[94]

沉底雷：顾名思义可知此型雷直接布于海底，感应经过船只的磁场、电场、音响或水压的变化，在满足其触发条件时引爆。[95] 是一种危险且有效的武器，1991 年沙漠风暴时普林斯顿号(USS Princeton)触雷事件可应证。解放军某些旧式沉底雷，例如 500 及

1000型等，被评估具有计算通过船只的功能，在引爆之前最多可感应到15次船只造成的环境变化。它们也具有启动延迟的机制，在实际布署前最多停滞250日，其自毁定时器可设定最多达500天。[96]中国的C系列沉底雷从1960年中期时的浅水沉底雷开始改良，到1975年后加强深水布署及多重引信等复杂度。[97] 中国的沉底雷EM-11及EM-53型较系留雷更难侦测及从水里扫除。[98] 在1991年时，某位水雷专家写过：「依目前状况，满足磁场、音响及水压等条件顺序下，进行扫雷作业几乎是不可能的。」[99]，710研究所根据报导，在近期已与巴基斯坦共同开发新世代的灵敏引信沉底雷。[100] 受限于感应范围及炸药等条件，沉底雷被限制布署在水深200米或更浅的深度。[101]

遥控雷：某些水雷可透过传输编码音响信号而解除，让友舰安全通过后可重新启动，限制敌舰通行。在中国技术文件中明显有许多关于此功能的研究。[102] 中国被认为可依此方式控制EM-53及-57型沉底雷。[103] 遥控雷虽符合守势水雷的目的，在攻势作战中一样有用。

潜射自走雷：中国具有一定存量，例如EM-56型。可自行移动至最终目标区域。[104] 中文称「自航水雷」。 这型水雷可到其他方式无法到达的地点，单纯就鱼雷壳体装填弹药后航至该区。一般使用废弃的鱼雷改制(例如中国YU型系列的早期模型)，从潜舰发射。将沿着使用者规划的航线航行一段时间。当抵达预设的终点时(可能是某港口的中心)，鱼雷的引擎停机，而雷体就沉到海底。而弹头就由类似其他沉底雷的引信所控制。如大部分的水雷，这型水雷也限用于浅水区。

上升水雷：另一种型式的水雷，以「上升水雷」得名，可被用于深水区。西北工业大学有关火箭上升水雷的一篇学术论文中提到：「它们可用于深水区以扩大制海范围，并适用于中国的海洋环境。」[105] 这型雷以系留方式固定，但其漂浮炸药的部分-鱼雷或弹头火箭，将在系统侦测到符合的通行船只时释放。而鱼雷或火箭从该深度升起后，导向并摧毁其目标，一般目标为潜舰。某消息指出：所谓的「指向性火箭上升水雷」就是一种具有精准控制、导引及主动攻击能力的高科技水雷…攻击速率(例如攻击潜舰目标)可达每秒80米。[106] 例如中国从俄国进口的PMK-2型上升鱼雷水雷，据说能在水深2千米的深度施放。[107] 而系留缆材质的改良可能加深最大的锚深。中国已获得俄国早期的PMK-1型，并可能反向开发出自制型式。中国也已开发出，并出口至少两种上升水雷。[108] 伊朗于1994年购买了数量不明的中共EM-52型火箭上升水雷，[109]据报导至少有两百米的作战深度。[110]

近期对上升水雷研发的关注，显示出中国「对水雷战的新认知」：有必要开发有效的广大深海区域水雷战，并研发并配备能够执行…机动攻击的火箭水雷。[111] 解放军正扩储1970及80年代时，原用以对抗冷战强权攻击，防御沿海区域的水雷存量；这些武器多数「仅能布署于浅水区」，仅有少数能布署于略深水域中。解放军已经「开始筹购垂直火箭上升水雷，并积极研发指向性火箭水雷、火箭上深导引飞弹水雷及火箭助推水

雷。」[112]

俄国的影响

无效率的国防产业氛围不太可能限制中国的水雷开发，因为其国家无法本地开发的部分可能已从俄国获得。中国已获得俄国的水雷、技术，很有可能包含俄国工程师，以强化其本身的自制水雷计划。[113] 自从冷战结束后，水雷战技术「因前苏联水雷专家出走及世界市场等因素而快速地扩散」。[114] 一份中国主要海军刊物中的文章引述俄国为「世界的水雷王国」。[115] 傅金祝相信俄国在水雷上的成就甚至超过英美。[116] 中国分析家举证三大因素说明俄国的水雷战特色：天然(地理)屏障因素利于水雷战、击溃优势海军的能力、以便宜价格大量生产的能力。[117] 很明显地，这个分析结果壮盛了中国水雷战的论点。再者，中国战略家已经对俄国及苏联时期的水雷战役有相当透彻的研究。[118] 这些分析检视了土(耳其)俄战争及日俄战争中水雷的角色。有众多研究检视苏联在二次世界大战时，所设下的约 8 万枚水雷所扮演的重要角色。[119] 延续这个主题，近期在「国际展望」于一篇极详细的研究中，附上了 1941 年时在芬兰海湾所布署的俄、德及芬兰雷区图。[120]

中国在新的硬件架构中整合了对俄国水雷发展史及准则的认知。中国分析家认为在俄国总理赫鲁晓夫执政期间，俄国在水雷企图上稍有减弱，但于 1960 年代后期又再次复兴，并认为传统战争想定中的水雷将扮演更吃重的角色。[121] 另有中国消息来源强调俄国「持续开发高速水下火箭科技」。[122] 根据此消息及其他中国研究显示，俄国火箭水雷(例如 PMK-1)为理想的对抗美国核子潜舰用武器。这些武器具每秒五十米的追杀力，可高速攻击核动力潜舰 (SSNs)，使其无法及时反制。它们也被认为是对抗美制的单船体潜舰的有效武器。据说藉由部署此型武器，即使相对旧型的柴油潜舰也能抗衡核能潜舰，此为传统的俄国战略。

而解放军明显在训练中使用 R 级或明级潜舰，于敌港布放 EM-52 型火箭上升水雷，暗示这些潜舰的战时任务，并说明了中国保存这些潜舰的理由。[123] 据报有俄国科学家参与中国的水雷计划。[124] 在此作战领域中，俄国广泛的支持正符合解放军军事上的优先发展需求，但其合作的规模仍不可知。

研究方向

解放军持续地寻求外国装备、科技及专业人才等，支持其快速的水雷发展。但中国并不单纯满足于获得先进的俄国及他国水雷。受其科学及科技革命上的影响，中国已取得了丰富的水雷研究成效。从中国持续的研究焦点，可知她正专注于发展并加强深水上升水雷的效果。[125] 中国于 1981 年开始研发火箭上升水雷，1989 年生产第一型。青岛潜舰学院的学者已于近期计算出，在某特定海域中，需多少自走雷可完成封锁。[126] 而实际上，在潜射机动水雷(SLMM)领域上亦有广泛的研究[127]，特别是其障碍或反制作为。

[128] 中国海军航空工程及大连海军学院的科学家已发展出预测火箭推进水雷攻击可能性的方法。[129] 另外有许多研究分析发射载台稳定性[130]、水下火箭推进[131]、及发射轨迹路径[132]等。如其他国家，中国也广泛地测试水雷战模型。测试领域有「水雷封锁战」[133]、水雷反制(MCM)[134]及军舰磁场等。[135] 某些关键的数学模型证实了中国水雷战及水雷反制是「基于五十年来解放军自身及研究他国海军的成果」。[136]

中国 710 研究所作为水雷研发中心已有多年。近几年来，研究人员研发了引信触发[137]及影像等议题。[138] 并帮水雷设计出了 USB 型式的「高容量内部记录器」。[139] 在与大学及多国机构合作下，开发出「水雷深度量测及控制系统」。[140]值得注意到，他们推崇在水雷软件开发中采用「国家军事标准」。[141] 同样地，哈尔滨工程大学的某个学生提倡发展可靠的「军用自动测试系统」，以确认武器战备。[142] 其他水雷研究则针对目标追踪[143]、爆炸半径[144]、最大化[145]及对舰损害程度[146]等研究。某中国顶尖的科技大学研究人员则分析在何种程度下，目标能反应并回避深水上升水雷。[147] 且他们建议使用目标舰艇的被动特性来瞄准水雷。[148]

另有某些观点认为潜舰适合作为上升水雷的发射载台；在大连海军学院的一篇文章中建议解放军将兴趣放在潜射机动水雷上。[149] 某位 705 研究所研究员提倡获得封装鱼雷式水雷，类似美国冷战期间使用的卡普托水雷(Captor)。此型水雷可部署在深水区域，攻击经过的潜舰。[150] 技术上的需求可经由实地测试确认：

特定新型水雷的潜舰测试曾于中国南海执行。此测试领域的资深工程师 Zhang Zhaokui 及 Jin Shujun 在狭隘的鱼雷发射舱间内工作超过 2 个月，并精确地收集到每个群组资料。之后由海军的军事训练部将这些及珍贵的技术参考数据纳进作战手册内，提供新装备使用上的科学基础。[151]

引信是中国研究的另一个主题。水雷设计师设计出较精密的引信系统，来解决早期水雷易扫的问题。中国正将其旧型水雷翻新为现代化、高性能，实际上不可能扫除的型式。[152] 这解决了中国大批库存濒临汰除的水雷问题。其成效就是「聪明」或「智能型」水雷，更能抵抗水雷反制外，亦可具选择特定舰型目标。[153] 其中一个重要的研究方向就是数字引信，[154] 这是使用神经网络作为强化抗扫性的一种方法。[155] 在 710 研究所及海军工程大学的研究员研讨改良水雷引信压力感应的方法。[156] 其他研究包含侦测舰艇弱磁场的改良方法。[157] 中国的 M 型系留雷系列就展示了这个开发过程：早期在 1960 年代的最先两种旧式雷，据推测是因容易扫除而不再使用，而 M-4A 及-B 型在 1980 年代升级时引进了更新、更精密的引信。改良后的引信造就了更加强大的沉底雷。使用这种方法，搭配其他措施，解放军持续与时俱进，抗衡外国更加精密的水雷反制作为。[158] 如解放军报所报导：

实测不仅要验证对目标的射击，同样仰赖它们收集到大量的科学研究资料。新型

水雷的设计最终阶段的测试中，施放后的水雷并没有如默认目标作动，且其测量及记录相关的「黑盒子」也无所获。然而使用同样接口的目标射距测量仪具却清楚地记录了各种数据。从目标射距的科学分析可得知水雷的「脑」在电子系统的设计上有瑕疵。因此目标射距分析数据将让此水雷「脱胎换骨」。一年后，此高效能智能型水雷在评估后已达标准。[159]

从空中布雷亦是一个日益重要的主题。举例来说，值得注意在 2007 年发行的有关水雷战教材发展的共同计划中，参与的五所大学其中两所就有附属的航天研究机构，分别是西北工业大学及北京航空航天大学。[160] 无人飞行器的研究所已进行水雷降落伞轨迹参数的研究。[161] 太空科技也投入降落伞设计中。[162] 西北工业大学及中北大学的研究者已于近期发表数篇研究报告，以空投水雷撞击水后的影响为模型。[163] 某位中国专家已设计出精密的数学模型，可决定空中布雷的最佳参数。[164] 因此，如同其他研究领域，也已透过实测来决定最佳的施放方法：

实测中与参与测试的研发机构及单位紧密的接洽及合作，使用了一系列的措施。经过努力后的新装备大型科学研究模型，是一个三维、研发、测试及运用的模型。某个空投鱼雷已具有完善，达世界先进等级的技术文献。但遗憾总有几个小零件容易勾到降落伞，在发生时，水雷就会直接落水并破裂。根据这个缺陷，参与实测的科学研究机构及工业机构共同合作解决了这个困难的问题。[165]

中国分析家细心地跟随美国海军发展的脚步，持续研究美军的弱点。[166] 广泛的中国水雷侦测研究中，[167] 包含青岛潜舰学院的概率论水雷反制决策研究[168]、海军工程大学的压力与水雷触发参数研究[169]等，都可适用于此领域上。令人不安的是海军分析中有些假设性研讨，考虑在水雷中使用战略性核子武器。例如在 2007 年的水雷战教材中就触及了上述议题。[170] 在论及俄国水雷战的某篇类似分析报告中就谈及了核子水雷可将敌核动力潜舰于 2 千米外距离击沉，而核子水雷亦可从 7 百米外距离将航空母舰或其他大型舰船摧毁。[171] 第二篇研究中发现核子弹药在逻辑上是个增加水雷破坏力的方式。[172] 而第三篇研究中则认为核能水雷战特别有望运用在未来深水反潜战中。其结论为「许多国家在此时正积极研究这类极强大的核能水雷」。[173] 在 2006 年 7 月的解放军海军期刊-「当代海军」中有篇文章，讨论解放军海军在水雷运用的未来发展，也提及到核子水雷的潜在性战斗价值。[174] 尚有其他证据显示相关的基础研究，像是某篇水下大爆炸的研究报告。[175] 这种武器除了违反 1971 年的海床公约外，也抵触了中国不先动武政策，并削弱其历史性的核子武器中央集权管控力量。虽无直接证据显示中国存有这样的海军战略核子武器计划，仍有必要紧密监控她是否有任何朝此方向发展的迹象。

中国的研发者显然进行破坏力较低，但更具作战潜力的航空器攻击水雷-特别是反直升机的水雷开发。[176] 某位中国分析师解释，直升机因其明显的优势，使其成为水雷反制的理想工具。然而文中更一步说明，在实施水雷反制时，直升机通常以 8 到 25 节

飞行速度，并维持在 80 到 100 米的高度，这正提供了反直升机火箭上浮水雷的攻击机会。[177] 此型水雷会受直升机的音响特性触发。[178] 根据消息来源指出，「现已知 710 研究所已进入『火箭上浮导引飞弹水雷』研发的进阶阶段」[179] 在 2007 年水雷战教材中也论及此型「导弹式水雷」，可以新方式攻击水面舰。[180] 此型水雷似乎比反直升机水雷更加复杂，且可能攻击水面舰艇及海上巡逻艇及其他飞行器。根据这个观念，飞弹透过水雷发射到空中，然后靠降落伞在空中保持位置直到可锁定目标。作者宣称此型先进水雷尚未进入到工程研发阶段，但解放军「仍坚定执行此型水雷的计划…因此问题就在于什么时候会开发成功了」。[181]

关于这些计划，值得注意的是在 2002 年中国海军百科全书中，已描绘出上述两种对空水雷观念图。[182] 另一个潜在的水雷战发明，则是据报中国正研发「火箭助投水雷」，希望在 380 公里的距离外，在大约几小时内将此种水雷布署到敌港外。[183] 综合上述观点，这些论调实质上暗示着中国目前已走在水雷科技发展的尖端。

水雷布放载台

中国能藉由水面舰、潜舰、飞机及改装的民商船或渔船布放水雷。解放军已经使用过上述载台实施布放演练。[184]

水面舰

解放军的许多水面舰艇都配有布雷的装备，包含四艘现代级驱逐舰(可配载最多 40 枚水雷)、12 艘旅大级驱逐舰(38 枚水雷)，及约 27 艘的江湖级护卫舰(最多 6 枚水雷)。中国并不使用其最先进的江凯 II 级护卫舰，或旅洋 II/旅洲级驱逐舰实施布雷。而她们似乎确未配有执行此类任务的装备。解放军中数百艘「汰除」、老旧及小型炮舰(例如上海级及海南级)、扫雷舰及鱼雷舰等，每艘都能携带并布放少量水雷。解放军的专用水雷舰(舷号 814)据报导能携带最多 300 枚水雷。[185] 使用水面舰布雷的优点在于她们的携行量大、人员受过训练及指挥管制上较单纯等。缺点则是缺乏隐匿、速度受限及易受攻击等。[186]

照片 4. 施放训练用沉底雷。如同照片中的沉底雷操演的环境因素一样，施放水雷的条件包含了吊架、合适的甲板空间、全球定位系

统及海象等条件。

舰型	载台型式	水雷携行量	现存量	备考
海岸扫雷舰 082 型	水面舰艇	10 枚 M-1 型或 8 枚 C 1000 型	2 艘	布雷轨道
舰队扫雷舰 5、10 型 (T43)	水面舰艇	10 枚 M-1 型或 8 枚 C 1000 型	37 艘	布雷轨道
海珠级驱潜艇 037 I 型	水面舰艇	12 枚 M-1 型或 C 500 型	2 艘	布雷轨道
沪新级驱潜艇 037 型	水面舰艇	12 枚 M-1 型或 8 枚 C 1000 型	?	布雷轨道
黄河级 (Huanghe)登陆舰 037 型	水面舰艇	60 枚 M-1 型或 51 枚 C 1000 型	?	布雷轨道
江湖级 1 型 053-H 型号	水面舰艇	最多 60 枚	12 艘	布雷轨道
江湖级 2 型 053-HI 型号	水面舰艇	最多 60 枚	7 艘	布雷轨道
江湖级 3 型 053-HG 型号	水面舰艇	最多 60 枚	3 艘	
江湖级 5 型 053-H II 型号	水面舰艇	最多 60 枚	3 艘	布雷轨道
旅大级 1 型 051 型号	水面舰艇	38 枚	10 艘	布雷轨道
旅大级 2 型	水面舰艇	12 枚 M-1 型或 20 枚 C 1000 型	4 艘	
旅海级 167	水面舰艇	18 枚 M-1 型或 30 枚 C 1000 型	2 艘	
旅沪级 112、113	水面舰艇	18 枚 M-1 型或 30 枚 C 1000 型	2 艘	
海巡艇 037 IS 型	水面舰艇	12 枚 M-1 型或 C 500 型	2 艘	?
汕头级炮艇 101 型	水面舰艇	8 枚 M-1 型或 6 枚 C 1000 型	?	布雷轨道
现代级导弹驱逐舰	水面舰艇	24 枚 M-1 型或 40 C 1000 型	2 艘	布雷轨道

舰型	载台型式	水雷携行量	现存量	备考
沃雷级布雷舰	水面舰艇	200 枚 M 型	1 艘	布雷轨道
G 级潜舰	潜舰	40 枚	1 艘	
汉级核潜舰	潜舰	28 枚	4 艘	
基洛级 636 型	潜舰	24 枚 AM-1 型	10 艘	
基洛级 877 型	潜舰	24 枚 AM-1 型	2 艘	
明级潜舰 035 型	潜舰	28–32 枚	11 艘	
明级潜舰(改良型)035 G 型	潜舰	28–32 枚	8 艘	
R 级潜舰 SS33 型	潜舰	28 枚	8 艘	
商级核潜舰	潜舰	28 枚(?)	2 艘	携行量应类似汉级
宋级潜舰	潜舰	24–30 枚	13 艘	携行量应类似基洛级
元级潜舰	潜舰	24–30 枚	3 艘 (持续建造中)	携行量应类似基洛级
H-6 轰 6 轰炸机	飞机	最多到 18 枚(?)	估算可能为 100 架	
JH-7/7A 战斗轰炸机	飞机	最多到 12 枚 250 公斤等重型式(?)	估算可能为 100 架	

表 2. 解放军海军布雷载台一览表。
来源包含：海林「岛内军事利物利载防务专家预测」页次 17、18；詹氏年鉴战斗舰艇数据库，参考网址 www.janes.com 及 Sinodefense.com。

潜舰

中国海军战略家似乎相当看重潜舰布雷。例如某位分析家表示「在两次世界大战中，所有国家的潜舰兵力都进行了潜舰布雷，而且成效显然相当卓越」。[187] 该分析家进一步说明「在敌方控制下的海域及防卫区内作业的潜舰能够实施攻势布雷，进而制造奇袭及长期威慑的效果」。[18] 解放军的所有潜舰都能够携带水雷，包含约 20 艘的汰除及噪音大的 R 级潜舰也能携带 28 枚水雷。而约为 19 艘型式类似，但更新、更安静的明级潜舰可携带最大量到 32 枚水雷；约 10 到 12 艘现代化宋级潜舰则可携带到约 30 枚水雷。中国拥有的 12 艘基洛级潜舰能够携带 24 枚水雷。目前 3 艘或以上数量的新型元级潜舰可携带约最多 30 枚潜舰，剩余的四艘核动力汉级潜舰携行量为 28 枚。[189]

据说解放军潜舰使用的感应水雷沉-1、-2、-3 及-6 型，适合部署在近港口外海。T-5 型自走雷则适合布于港外海域及港口航道上。而俄制 PMK-1 型及中国制的锚-5 型火箭上升水雷适用于港外，水深可高达 15 公里范围内。[190] 如下图所示，改良的 PMK-2 型水雷也加入潜用水雷系列。潜艇外挂布雷舱：是一种外挂式的舱间，设计于携带并施放大量水雷，能装挂于潜舰上。据某消息来源表示「过去几年来，相关的解放军专家均明确地表示出对于潜艇外挂布雷舱的兴趣…解放军很有可能已发展出潜艇外挂布雷舱」。[191]

照片 5.潜舰水雷：正在装载 PMK-2 推进水雷到宋级柴油潜舰上，摄于青岛。

经过系统化分析各种布雷载台的优缺点后，中国分析家们的结论看来，特别在长距离上，潜舰布雷是攻势水雷的最佳方式。利用潜舰布雷的优点包含了她们的隐匿性、精确布雷的能力，以及她们穿越困难目标的能力(可能是透过自走水雷来达成)。另外应注意的是，潜舰布雷的高准确率及成效能以较少量的水雷来达到(其他方式)一样的效果。[192] 根据一则分析报告指出「空中及海上兵力对于潜舰(活动)的限制相对较小，所以进入敌后布雷比较容易」。[193] 而根据另一篇报告，此载台(潜舰)「具有最高的隐匿性及奇袭能力…因为潜舰停在距港口外 10-15 公里、水深约 40 米处，就能发射一枚有战力的自走雷并突破该港」。[194] 由中国国防大学学者所著作的「战役理论学习指南」中，设想使用潜舰并利用「水雷的定时功能及隐匿的手段，将水雷布署在敌主要港口及重要航道。它们将在进行封锁后开始发挥作用…可在进行封锁约 10 天前开始实施(布雷)…1-2 天前较合适」。并可在敌反潜兵力遭遇恶劣天候，或在离开警戒区域的空隙时，暗中进行水雷补放。[195]

潜舰布雷的缺点包含雷管弹药有限、运送速度较慢、代价较高(此型水雷需以鱼雷或巡弋飞弹的成本考虑)。另一个缺点与水面舰相同，就是敌人监测舰艇大举出港的能力。一份近期的中国分析报告宣称中国的潜舰布雷操演量及复杂度都在上升。[196] 此主题稍后详述。

飞机

北京拥有超过百架轰-6 轰炸机，即使其中有因太多任务而需汰除，但每架都可以携载 12 到 18 枚 500 公斤水雷。[197] 虽无法得知轰-6 机是否会被赋予这样的任务，但近期此机型常被用于许多布雷操演中。[198] 中国数量有限的轰-5 轰炸机也可能扮演对台湾进行布雷的角色。中国超过百架的 JH-7/7A 战斗轰炸机，每架都可携载最多到 20 枚 250 公斤炸弹。[199] 根据解放军海军称，此型机可在「近海」执行布雷，意指第一岛链，也就是从日本岛屿经台湾到菲律宾。[200] 这些机型以及其他机型都可轻易地携带水雷，其不外乎是将重力炸弹装上磁感应或其他引信。[201] 根据某消息来源指出「解放军目前沉-1 到沉-6 型感应水雷，及锚-1 到锚-5 型系留雷的备储量适用于飞机布雷」。[202] 在这个类别中，亦可以加进精密的 PMK-2 型水雷。空中布雷的优点，如同美国军队从 1944 年就了解到，就是可以快速地施放大量水雷并设立雷区。主要的缺点则是需先建立空优的难度，以及使用现代化战机执行布雷任务的机会成本。

虽然较早的分析家曾检视中国利用水面舰及潜舰布雷的能力，但没有分析家认真地考虑中国是否会透过飞机来布雷。自解放军海军在 1949 年 4 月起成立了一支布雷轰炸机分队起，空中布雷就已享有其专属的作业载台。[203] 中国的某份主要海事期刊中，详细地解析美国如何在二次大战时使用空投水雷加速日本的战败，并在之后以相同手段瘫痪北越的运输。[204] 某位解放军空军指挥学院的教授，在中国最具声望的军事刊物-「中国军事科学」中发表的一篇文章，对于空中布雷的价值也提出类似的论点。[205] 几篇中

国技术论文中，非常细腻地论述实际飞机布雷较艰涩难懂的面向。[206] 在一场解放军海军航空能力的讨论中，北海舰队的副军团司令员朱光宏(英译：Zhu Guanghong)在最近指出「海军军机具极低高度飞行的优越能力。他们能够执行…港口布雷任务」。[207] 一支北海舰队航空部队的舰载机部队甚至因「首次直升机使用操雷打声靶」而得到「创造解放军空中反潜历史」美誉的表扬。[208] Gidropribor.com 网站及詹氏年鉴目前讨论了从飞机布放中国及俄国类似水雷的内容。[209] 在近期中国海军刊物中有一篇相当详细的文章，讨论中国水雷库储中，哪些可用于空中布雷。[210] 最后，战役理论学习指南主张「从空中集中布雷」，特别是在「潜舰难以潜入的区域」。[211] 它认定「布雷封锁兵力」通常包含「海军及空军轰炸航空部队」。[212] 很清楚可知，中国掌握着空布水雷战的效用，且正在思索如何将它具体地运用在作战中。

民间船舶

在上述强大的能力上锦上添花的是可强征使用的数千艘中国渔船及商船。2003 年，烟台警备区副司令员荣森芝在一篇军事科学学院附属刊物中，主张使用民船进行扫布雷作业。[213] 中国 2008 年国防白皮书中将「扫雷及猎雷」列为解放军海军四大后备部队之一。[214] 根据一篇文章指出「中国目前有 3 万艘铁壳机械拖渔船(每艘可携载 10 枚水雷)，以及 5 万艘渔帆船(每艘可携载 2 到 5 枚水雷)」。[215]「战争科学(Science of Campaigns 2006 年)」中就相当明确地指出这一点：「布雷任务通常指派具相对良好隐匿性的潜舰及航空部队执行，但民间船只也可以执行…布雷任务」。[216] 中国的文章中经常提到将民用运输船纳入例如水雷战之类的军事用途中。[217] 一篇 2005 年的文章中用照片描述在许多解放军海军基地内，经常举行的大型「民兵」操演中，使用渔船作为布雷艇。[218]

照片 6. 民兵(船)布雷。两艘在中国海上常见的民间渔船正在施放水雷，这是 2004 年 12 月解放军三亚基地的大型「民兵」操演的一部分。此类操演定期的在不同的解放军海军基地实施。在中国港口的周围建立守势雷区时，将使用全球定位系统协助准确布雷，即使是民兵也能实施。

某中国消息来源指出「约 100-200 吨位间的渔船」适用实施水雷战，因为他们符合数量充足、「小型目标」、机动性及掩护性佳等特征。[219] 此大小之渔船可轻易作业于整个东亚沿海区域，亦可涵盖整个台湾的周遭海域。只需要「稍微改装」就能够「安装简易的布雷装备…且渔民非常熟悉海域」，因此能够善用「地形、海势及天黑」等优点。[220] 另一中国消息来源则认为「解放军已经有效地组织，并指挥机动拖渔船，在战时能架设布雷轨道，并利用绝佳的伪装实施水雷作战」。此消息来源的结论是「这种非传统型式的水雷布放载台，虽然布放数量不多，但在派出大量船只或再补雷时，仍可建立一个广大的雷区」。[221] 或许在看到这位中国出色的海军策略家-解放军海军军事学术研究所的李杰大校，近期于 2008 年 5 月时解放军赞助的期刊「中国民兵」中所发表的「水下武器的新发展」之主题论文时无需太过讶异。[222] 此外，(中国)于法律基础上也已经建立战时动员民船之依据，包含 1995 年所公布的国防运输法，及 1997 年的中华人民共和国国防法等。此项立法措施根据解放军海军条款，显然已于 2003 年时就再次修订了。[223] 水雷战因此能够支持终极的「海上人民战争」。[224] 中国也因此具备所有实施侵略性水雷作战的实际需求要素，包含持续改良的大量水雷存量、充足的布雷载台等等条件。但这并非事物全貌，毕竟硬件若无人员及经验因素也是枉然，而此条件只能透过训练及操演来加强。

中国越发拟真的水雷作战操演

解放军支持操演内容涵盖水雷。[225] 解放军海军专家柯尔教授(Bernard Cole)注意到解放军不像其他国家，中国水面舰艇年年都实施布雷演练，但无法确定其操演实际的规模。[226] 近期公开的数据显示解放军实际上正积极地扩大此类操演，并让此类操演逼近真实状况。[227] 中国近期的水雷操演更纳入潜舰、空中、水面等兵力，甚至民船等载台。此类操演详细地记录在解放军的海军官方报纸-人民海军报中。

中国海军认为潜舰布雷为「潜舰作战最基本的要求」。[228] 布雷已成为近期加强的中国潜舰兵力训练的一环[229]，官兵们努力进行的训练具多样化且益发复杂，并与当地环境、水文地理及天气状况相结合。[230] 在中国海军的观念中，认为潜舰布放水雷是未来水雷封锁作战的关键。[231] 2002 年时，水雷布放已成为最普遍的解放军潜舰战斗手段之一，并让官兵透过训练操控载有大量水雷的潜舰。[232] 操演的变化中，包含了「隐匿行踪并于深水中布雷」[233] 并配合鱼雷发射等类型作战。[234] 对抗港口目标的纵深布雷也是重点[235]，以假设突破敌人防卫为先决条件。[236]

解放军海军官员认同「突破敌人的反潜兵力及敌后布雷」的固有难度。根据某位舰长的说法「隐密地潜入敌人布署的联合机动数组，是完成布雷任务的先决条件」。[237] 某些证据显示，中国可能对执行攻势布雷的潜舰采取集中管控。一位中国分析家指出，在执行攻势水雷封锁中，「大部分的潜舰兵力主要以单舰、独立作战模式，若有一个陆岸潜舰指挥所来执行潜舰整体航向的指挥及导引，则不仅将确保其隐匿性，并可改善…所布的水雷之攻击效率」。[238]

中国海军正努力加强其潜舰官兵的本质，包含他们对于水雷作战的熟练度。青岛潜舰学院的指参学官密集地学习布雷。[239] 潜舰队已演练「高难度的新战略，例如于极深水中布雷」，[240] 并藉由如「大深度隐匿布雷战法」[241] 等技术持续破新深度纪录。中国官方电台宣称解放军潜舰特遣队的鱼水雷官赵忠义(英译：Chao Chunyi)在水下布雷训练中达成了 16 项研究成果、将水雷搭载时间减半、并开发出水雷移动控制装置。[242] 宋级潜舰 314 号舰长马立新是中国海军官媒的名人，近期带领一支东海舰队潜舰特遣队「发展革新战略」。马立新在前年已研究并开发出超过 10 项新战法，「包含如何执行封锁，以及如何使用传统潜舰布雷」。在 2005 年初，马立新「带领他的部队参与海上实操…他(们)抵达预定区域…(布放)水雷」。[243] 2005 年初的水雷操演中，马立新负责回避「敌」反潜机、雷区，以及最困难的-敌潜舰，以遂行近海区域布雷的任务。他成功掌握当地环境、使用最低杂音航行速度、避开「敌」潜舰及岸基雷达，在规定时间内完成了布雷任务。[244] 在潜舰上安全地处理水雷，很自然地成为青岛潜舰学院一个重要的研究领域。[245] 另有研究报告讨论现代潜舰中常见的「舰首鱼雷管布放水雷」等安全议题。[246] 目前为止在某些极有意思的文章当中，某篇详细地记录 2006 年 3 月 12 日，似乎南海舰队的某艘「新型潜艇」透过潜射机动水雷(SLMM)实施了「水雷试射」。虽然这是此型潜舰的

初次测试，可容许一些犯错空间，但根据报导试射成效相当地准确。[247]

中国空中兵力透过益增频繁、规模及多样化等方式实施水雷作战。1997 年美国国防部的解放军发展报告中提到，中国的军机实施空投水雷。[248] 东海及南海舰队航空军团的训练计划已于近期内涵盖了布雷[249]战法，包含采用不同的机种[250]，以及敌空中封锁等手段。[251] 在 2002 年 8 月的一次南海舰队操演中，演练了「真实」状况下对抗敌军，并于不熟悉的地点使用轰炸机投放水雷。此操演所包含的战斗机群由 3 架轰炸机分队、1 架电子干扰机及护卫战斗机等组成。使用电战机干扰敌方雷达，当战斗机群采最低飞行高度战法时，快速投放数十枚水雷及鱼雷。[252] 另一篇很有可能针对相同操演的报导中指出，「红军」轰炸机于中国南海域执行布雷任务时，遭「蓝军」战斗机拦截及攻击。[253] 从 2006 年 3 月起，南海舰队轰炸机军团便开始演练「远海布雷封锁」。[254] 在 2006 年 6 月 6 日，作为「复杂气象条件下远海岛礁导弹打击模拟演练」的一部分，一支南海舰队海军航空部队实施「海上布雷」。其飞行员也受过「雾天远海布雷」训练。[255] 同样于 2006 年时，一支南海舰队海军航空部队演练「雨天海上布雷」。[256] 在 2008 年 8 月下旬，4 架近期翻新的南海舰队航空战斗机模拟「在复杂的电磁环境下」，及不同的天气应变时「于港口及航道实施攻势布雷」。[257] 在 2009 年 1 月初，根据军事训练及评估新纲要，一支东海舰队轰-6 轰炸机部队「实施新战法训练：突破远海深层防御，并完成低空攻势布雷任务」。该部队「探索出一些新的战法，例如…夜间大机群攻势布雷」。[258] 同年(2009 年) CCTV-7 台报导解放军海军航空部队的「水上飞机能够执行…布雷」。[259]

解放军布雷手段中有一个令人不安的因素，就是利用民间协助来补强军事资产的概念。在过去几年，每个海军基地都将民兵单位(视为「未来海战的重要兵力」组成)编入训练装备、管理、运用及保安部队运用，给予经验并发展新战法，「以完成任务上的需求」。 中国的 2008 年国防白皮书中，明确地提出后备部队有可能用于水雷战中(包含布雷及扫雷)。[260] 在某次使用民船的东海舰队操演中，其中一项重点是清除不同种类的水雷。[261] 某本中国海事期刊可能披露了第一张于水雷战中使用民船的照片。在 2004 年 12 月，三亚海军民兵的紧急维修及布雷特遣队[262] 动员了 6 艘民船，执行了一项包含(在许多活动外)侦搜、「渔船布雷」、及战斗中军舰不靠港而于海上补给等操演项目。[263] 解放军于 2005 年 9 月[264]设立在浙江省宁波的第一个后备扫雷支队，在 2006 年 7 月初时在东中国海执行了一个月的训练。在紧急征召命令下达后，两百位海军后备军士官兵在半日内就整备了 16 艘征用渔船。由两位主要军官领军训练了七个项目，包含「指挥所转移」、「防空疏散」、「扫雷」、及「反特种作战」等。透过东海舰队党委员会协调，此实验性质的操演由不同的当地组织支持，并征召「当地渔民中的后备士官兵及退伍军人」。并在经济现实下给予补助：「一艘高马力渔船绑在码头一天要几千块人民币(约几百元美金) 」。少一次出海捕鱼损失的价值超过 10 万人民币($12,500 美元)。[265] 在 2006 年后期，蓬莱市(山东省)透过渔业协会及公司，成立了布雷民兵战斗特遣队。这是根据解放军总参谋部「关于调整民兵组织的意见」。[266] 在 2007 年 3 月，某东海舰队扫雷部队与加装扫雷装置的渔船，共同执行了联合水雷反制作战操演。[267] 循此步调，在 2008 年 12 月

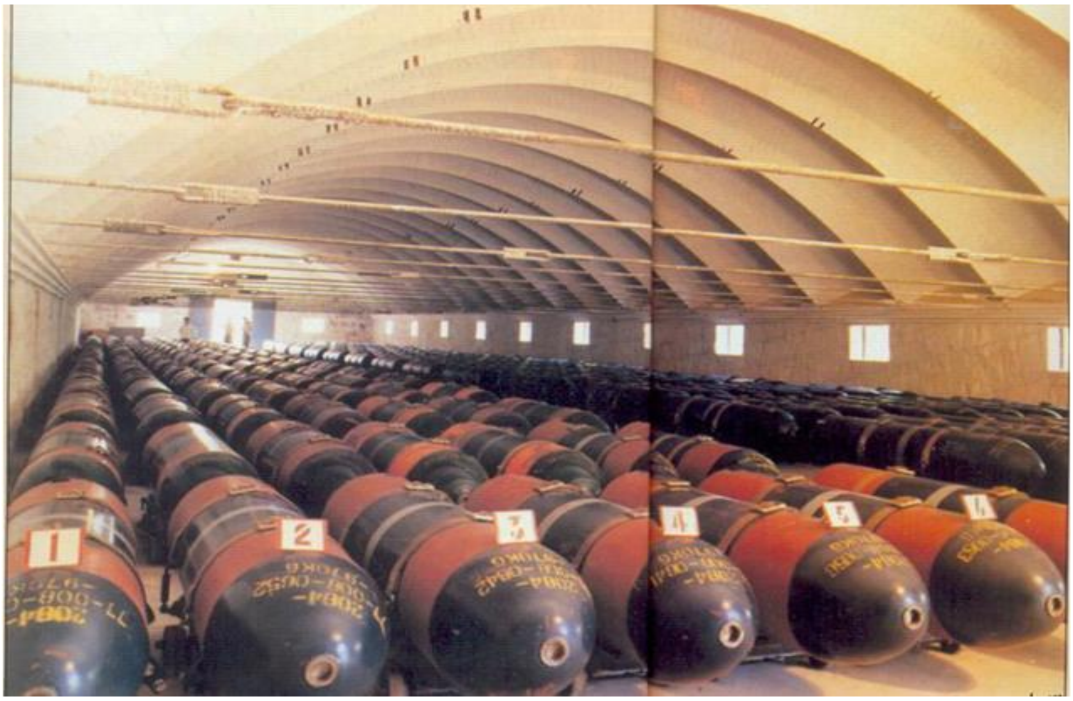
时，一个海军后备支队演练在困难状况下快速布雷的操演项目。[268]

另一项报告中详列出远港水雷移载时的装备需求(例如：吊架)，这是假设在军事冲突时，主要军港可能因敌精准导引弹药攻击而无法使用。[269] 在许多刊物中都提及此训练要务，例如「无码头」操演。根据「人民海军」报导，2006 年 8 月 15 日，某北海舰队潜舰队开始使用新开发的「潜艇装雷浮筏专用车」。此型机动(可能用拖的)载具可将水雷载入到鱼雷管中，拥有强大的储放及吊载能力。相信它被改良了加载速度达六倍，并加强隐匿性，可与潜舰在离标准码头位置外的沿海区域会合。[270]

水雷仓库官员也在近期实施了突发性操演。[271] 某南海舰队鱼水雷仓库下达新的任务，实施「四种变革」以改善高速、长程机雷的运输。[272] 某东海舰队鱼水雷仓库执行了独立、机动全天候操演，其目标在于遭空袭时仍能确保水雷的高速运输。官员们协助发展合适的侦测系统及测试仪具。他们利用地势、天气及夜间来实施伪装。[273] 某北海舰队后勤支持基地成立了一支潜舰水雷的「技术服务团队」，专精于「无船坞时当地紧急加油」。[274] 在 2006 年 3 月 16 日，某北海舰队鱼水雷仓库的「新号手」们进行了「夜间鱼雷应急保障训练」，显示此单位的这项作业在实际状况中属于常态。2006 年 11 月下旬，某行政官员报告，广州支持基地(南海舰队)从基地外超过 5 百公里的某个「临时补给阵地」实施了水雷机动紧急再补给。[275] 海军工程大学已于近期提供，改善水雷管理、技术支持及备料等相当大的帮助。[276]

水雷战是水面舰队的主要任务。解放军海军已加强提升速度、[277] 自动化及电子化[278]、及「全天候」布雷能力。[279] 江湖级护卫舰已执行过布雷任务，作为其反潜战训练的一部分。[280] 扫雷舰的舰长们在旅顺海军基地的特训中心接受训练。[281] 扫雷单位已于近期演练布放不同型式的系留雷及深水沉底雷作为快节奏、对抗操演中的一环。某个南海舰队扫雷部队已于近期参与超过 10 次类似的操演，并于操演中「取得了 26 项科学研究成果」。这是为了与「新全球军事革命」并肩同行，当中包含「网络集中训练」及「水雷的思维」。[282] 的确，解放军很明显地视装载「鱼雷」(机动)水雷的扫雷舰为一个可行的反潜载台。此想法亦勾勒出「旧装备 + 网络 + 才能」的潜力，并可「完全说服」那些相信「不可能以旧装备配置载台执行信息化操演」的人。[283] 在 2002 年，北海舰队下辖 813 及 811 扫雷舰的某部队，并用「国产及外国鱼雷水雷」并在「百分百成功率」下攻击了潜舰。[284] 中国的三大舰队更于近期使用了疑似先进机动水雷施训。在 2005 年 12 月北海舰队官兵被拍到吊起「新型水雷」，很有可能要配载到潜舰上。[285] 此水雷类似美国的 Mark 25 Mod 2 型水雷，反映出美国及俄国科技对解放军水雷发展的影响。[286]

照片 7. 水雷仓库内含实弹及训雷。在图片左侧的 98 枚水雷的条纹显示为训练弹，可支持高强度的操演。在右侧数量相仿的水雷固定的颜色显示为实弹。



照片 8. 解放军扫雷舰。

中国水雷战仍留有相当的改进空间。水雷操演中有时依然会发生故障。[287] 装备支持教材有时只有外国语文(例如俄文)，而且需透过翻译或研析。[288] 而政治工作也消耗了一些时间，尽管比起以往可能较少。[289] 但很明显地对于解放军模拟真实战斗状况的操演政策仍有些阻力。[290] 甚至在水雷战操演中有证据显示，解放军持续经历转移到现代化、专业化组织时的挑战。[291] 但解放军海军的领导人清楚地了解，硬件的进步在没

有相关的人力改善下是不完整的。[292] 解放军海军官员决心要改善水雷作战能力[293]，设计新训练方式[294]，并练习更有弹性的程序。[295] 在 2001 年初，南海舰队 814 号扫雷舰改变了其未任命官员的职前准备方式，藉由「不同阶级及水平的训练」，配合先前的经验，避免不必要的重复训练。[296] 扫雷舰 852 号则透过竞争及考试来改进官兵评比。[297] 在 2005 年 4 月底，某解放军的扫雷舰设定了「未来作战环境的训练」，在「不熟悉的海域」的全天候状况下，演练了扫雷及布雷。[298]

某些单位因训练的革新而受到奖励。某南海舰队扫雷舰单位「旗舰」，舷号 809 就连续达成解放军海军楷模而受奖。[299] 该单位建立了「带领小部队的夜间训练」以增加训练挑战。该单位的官员使用全球定位系统、雷达及手持式定位系统(包含罗盘及六分仪)等，在不熟悉的海域下抵达了指定地点的 2 米内。[300] 利用多种航海系统(装备)，似乎是应用战斗时任一系统无法使用时的手段。在 2000 年，为了因应现代化高科技战争，809 号扫雷舰设立了「战争及训练方式讨论小组」，此小组研习电子干扰反制、高性能敌水雷、视距外飞弹攻击、假想敌的观念，以及现有及未来中国装备的使用等。从 2001 年起，809 号扫雷舰已经发展出 12 种「抗电子干扰」、抵抗先进敌水雷及视距外飞弹攻击的新战法。[301] 在 2003 年，「人民海军」报导 809 号舰已执行了解放军的初次实布实扫水雷操演，包含对抗敌军部队及非战时等状况，扫除了比其他解放军舰更多的水雷。到了 2003 年，809 号扫雷舰已常规性并成功地于日夜间、各种天候下扫除了各型式的水雷，可在许多不确定及真实状况下当机立策。[302] 根据媒体报导，另一艘同样出色的扫雷舰- 804 号舰；该舰已有与被称为「新型扫雷装置」的遥控猎雷水下无人载具操演的经验，似乎配有精密、高频、主动数位声纳。[303]

解放军科学家也对水雷战操演中，使用新仿真系统进行了可能性评估。[304] 在 2006 年，某东海舰队扫雷支队颁发出色的单位及个人奖励金。[305] 解放军海军专家已发表数篇学术报告，并参与外国水雷反制操演。(例如 2007 年的新加坡)[306]

照片 9. 解放军 804 号反水雷舰。为中国最现代化的反水雷舰艇之一，此舰曾使用遥控猎雷水下无人载具进行操演，并配有精密、高频、主动数位声纳。

依上述的扫雷舰作业可以了解，有战力的水雷战需要有效的水雷反制。特别是中国在水雷反制科技上仍落后西方国家，研究者仍在研析先前西方国家的(反制)手段，包含水下火箭炸弹(RBUs)等。[307] 解放军知道这个缺点并因应整备。[308] 因此虽然海军底下有才能的反水雷/水雷战年轻军官可能无法潜舰(官员)的战力相比，但他们也同样受到栽培。[309] 基于未来战争中不可避免受损的前提之下，解放军在紧急应变上做缜密的安排。[310] 或许这就是官兵接受不同的武器系统训练，并让副舰长练习舰长职务的原因。[311] 在 2005 年 4 月 10 日一场北海舰队反潜操演中，据报导有一组「水雷小组」，演练从「潜猎舰」上发射火箭及深水炸弹。[312] 在一场 2005 年 6 月东海舰队扫雷舰数组操演的描述中，分析家援用中国的越南扫雷经验强调，『扫雷舰被认为是海战中的「敢死队」；它的角色极重要』。[313] 水雷在解放军海军的相对新领域-红蓝军对抗训练中，正扮演着逐渐重要的角色。在 2002 年中国南海，某「水下护卫艇」对抗反潜舰、飞机及一场水下雷区封锁。该艇在发射「一种新中国制鱼雷」后成功逃脱。[314]

某些操演中假设『「敌舰艇」已在特定海域布下水雷，以封锁我战舰通行』。[315] 水雷反制及水雷战舰艇角色上似乎可互相交换，因此解放军的扫雷舰亦经常演练布雷。[316] 扫雷舰训练已于近期纳入「白天深水扫雷」、「夜间扫雷」及单一船团「通过复合式雷区」等项目。[317]

照片 10. 反潜舰上的操控台。这部操控台很可能来自 804 号反水雷舰，具有游戏杆及遥控观测摄影机的功能。它可观察来自猎雷无人载具所回传的影像。

解放军水雷战准则的初步构想

综合中国水雷战的历史发展、目前的能力及先前所述的各项训练作为，可藉此勾绘出当代解放军海军水雷战准则大致上的轮廓。中国的水雷战/反水雷期刊「水雷战与舰船防护」，可能作为宣传此准则的平台。[318] 这类专业刊物的存在本身就暗示了对于此型战争专业的某种决策。此段之后的准则大纲只是从朦胧难解的中国军事计划(包含水雷战)中描绘出其大致样貌。下列 13 点是从许多中国水雷战论文中撷取出来，具重复出现性质的句子，在其节录出的论文中被认为具有主要策略及战略性等重要性质。[319]

1.「易布难扫」。 这个简单的攻势布雷优点公式，普遍地使用于中国水雷战著作中。反映出一个强大的信念，基于历史性分析及海军战争的趋势，中国水雷战的发展已远超越水雷反制发展，并将持续下去。[320] 这是中国水雷战中的核心驱动原则，但此原则也同时建立在认定了美国海军水雷反制上的弱点。但美国海军在水雷反制技术上仍优于解放军，而且水雷反制在各国海军中仍属困难，及资源集中的基本立场并不会改变。

2. 「不惹人注意」。水雷战及水雷反制是现代海军战争中最不精彩的部分。向舷外抛下水雷很难与从航空母舰发射战斗机的兴奋度相比。而且其载台舰艇通常不引起人们的注

意。全世界的海军中，水雷战事业亦是较少人选择的道路。除此之外，这些武器基于其易隐匿性，本质上难以监控；中国海军战略家意识到其独特性，并巧妙地利用这些对于水雷战的世俗观念，投注于它们强大的攻击能力将难受到反制，因此可善加运用在战争中。[321] 也不像发展航空母舰，其间最明显的差异在于，发展水雷并不与中国宣称的「和平发展」策略相冲突，或是引发假想敌(例如日本)间的军武竞赛。

3.「四两可拨千斤」。这个中国水雷战分析中常用的说法可反映出水雷战的不对称特性。[322] 这个谚语也暗示，水雷战能够造成的战略性影响远大于敌人实际上的战斗损失。[323] 某中国海军分析家认为，水雷战可造成敌人的「巨大心理压力」。[324] 此结论呼应美国海军的观念：「(水雷是)高效率的心理武器，怀疑水雷的存在，通常将可能造成港口或运输航道管制，搅乱战斗计划，或迫使人员、武器及补给采取其他路线」。[325] 同此观点，「战争科学」中讨论利用「假布雷」手段混淆敌人，造成敌人浪费其有限的水雷反制资源。[326]

4.「控在一定时间一定海域」。解放军的海军领导者了解，他们无法在绝对制海权上以对称作战方式挑战美国海军。某位南京海军指参学院学者在中国军事科学中发表的一篇2005年的文章中指出，中国对「制海权」观念上与美国的差异：「在中国的军事圈中，海权的掌控代表冲突中的一方，在一定的时间内对一定海域有控制权」。[327] 美国海军寻求对于海域的完全掌控；解放军海军的观念则较为狭窄。水雷战在这种策略上，依据其阻碍敌人势力的巨大潜能，并将敌人导入到特定海域的能力，逻辑上可扮演一个决策性角色。

5.「巨大数量」。 巨大的水雷数量提供解放军许多作战上的可能性，特别是相对老旧的水雷若摆在对的位置时，仍可能造成的巨大心理战因素。依先前引用的解放军海军战略家对于波湾战争的分析指出，布雷数量(1,100枚)相对低的状况下，限制了伊拉克的水雷战果。[328] 记住这个分析也引起了对于开发「水雷高载舰艇」的注意。[329] 再者，我们已在之前引用了某篇中国的报告，讨论潜艇外挂布雷舱。[330]中国对于1945年美国以水雷封锁日本的某篇分析结论，认为「大量的水雷」是关键因素。[331] 目前封锁台湾所需的水雷数量估计为7千到1万4千枚间，[332] 相对低于解放军海军的水雷存量总数。「战争科学」强调拥有足够水雷数量的重要性，因此在「联合封锁战争」时，才可储有充足的数量对于雷区再补给。[333]

6.「先制」。「先发制人」的观念遍布在解放军的准则中，特别是与水雷战相关的部分。这个说法经常出现在中国的水雷战文章中，暗示(中国)强烈的先发制人倾向。秘密布雷有造成奇袭的优势。根据「舰船知识」中的一篇文章，『水雷已成为「第一步控制」…战斗的重要因素』。[334] 在该期刊中的另一篇文章则认为，「改装后的民船特别适合在敌人了解到我战略意图前，实施攻势布雷作战」。[335] 中国水雷专家傅金祝在评估台湾水雷战时，便赤裸裸地暗示先制的议题，他宣称「既然已知台湾的布雷能力，就应该能够轻

易地扫除」。[336] 而「舰船知识」的另一篇 2005 年的文章中，则更直接地暗示：「如果布雷无法快速的实施，则在战争爆发之前将可能无法完成水雷战任务」。[337]

7.「高低技术」。解放军的海军论文中经常提到水雷战的成本效益性质。某张在 2004 年「舰船知识」文章中的图，将伊拉克在波湾战争中使用的水雷成本(1 千 5 百元到 1 万元美金)与受雷损的美军舰艇修复成本(高达 9 千 6 百万元美金)相列。[338] 同样重要的是 2004 年中「人民海军」的论述，「中国并非伊拉克…她具有先进的水雷」。[339] 如前所述，中国已获得也开始生产世界上最先进且致命的水雷。综合运用这种高低技术后，水雷战将让任何假想敌在水雷反制上更加复杂并棘手。[340] 解放军寻求透过引信改装，并将最先进的水雷用于最困难的任务等方式，来最大化其水雷战能力。

8.「潜载雷为隐蔽，空载雷为多快」。 中国战略家已细心地考虑到，不同布雷载台相对的优势。他们对于波湾战争中伊拉克水雷战的分析强调，水面舰艇实施布雷所面临的弱势。[341] 就潜舰无可比拟的隐匿性而言，潜舰布放被认为是水雷打击硬件目标，例如港口及基地等的最理想方式。[342] 「潜舰最出名的特色就是其高度隐匿性，可确保(潜舰布放的)雷区比起由飞机或水面舰投放的(雷区)对敌人来说更加的危险。」[343] 本文先前提及潜舰水雷战需要高水平的训练。虽然潜舰能够相当精确布放水雷，然而其承载量并不大，且出动率低。相对之下，飞机能以更大的速度及效率投放水雷，也可到达潜舰无法进入的浅水区。[344] 中国分析家也了解，布放特定型式水雷在特定位置功效上的影响因素。[345] 大连海军学院专家举例这些因素，有「水深、海床地质、海床形式、潮、流、风、波浪、海水能见度、水温、海水盐分、海洋生物、噪音、地震(及)磁暴等」。[346]

9.「军民联合」。中国的历史分析从二次世界大战到波湾战争中，找到许多战时使用民船执行水雷战及水雷反制的例子。中国分析家更举出国共内战期间实际使用民船清除河道水雷的例子。[347] 根据 2004 年在「当代海军」中的一篇文章，「组织快速且有效的民船参与战争是海军战役中胜利的重要保证」。 接着说「中国沿岸(民用)船只现在有丰富的资源…(因此组成)巨大的海战兵力」。文中最后认为水雷/反水雷任务，应作为将民船改装升级做战斗用时的第一优先考虑。[348] 本文之前举出的演习操演说明了这些想法并非单纯理论。此外，水雷/反水雷中的军民结合与中国贯有的战略文化一致。[349]

10.「水下卫士」。 虽然中国不敢轻忽美国航空母舰，[350] 但有证据显示解放军的海军战略家也同样或更重视美国核子潜舰。[351] 虽然解放军潜舰在与美军潜舰交锋时可能不占优势，但水雷战被视为具有对抗此威胁的潜在功效。[352] 即使海军民兵团的布雷也被视有同样能力，虽然其范围可能局限于沿海区域。[353] 中国分析家注意到俄国在冷战后期复兴水雷战领域，某种程度上是为了对抗美国核子潜舰。某篇中国反潜战研究解释新型水雷兴起于 1980 年代，是因为「更加符合现代反潜战的需求」。[354] 一篇中国对于俄国火箭水雷的详细分析的结论，「这型武器将快速攻击核子潜舰而对方无法实时反制，并且视为能有效对抗美国舰艇的单体船壳构造」。[355] 中国战略家提出「潜舰特别易受水雷

伤害，因为被动声纳无法有效定位水雷，而且潜舰本身具非常有限的反水雷能力」。[356] 再者，水雷威胁出奇不意的效果可能降低潜舰反制作为的效果。[357] 在 2007 年出版的中国水雷战教材中，重复地强调反潜战为一项任务，[358] 并已经在红蓝军对抗操演中演练过。[359] 「战役理论学习指南」明确地要求「反潜雷区」的建立。[360] 如此一来，中国便可动用先进的俄国水雷，例如 PMK-2 水雷及中国制的其他型式水雷，就是特别针对美国潜舰而设计的。因此水雷便暗中给予解放军无法以其他形式获得的「穷人的」反潜能力，并作为北京在获得更坚强的反潜实力前的一个权宜之计。美国潜舰生存力极强，但敌方的战略家可以让其无法遂行任务(mission-kill)，透过破坏潜舰也等于是消灭它了。[361]

11.「水雷管理的信息化」。信息技术的整合已成为当代中国军队改革的一个主要目标，此目标也适用于水雷作战。[362] 后勤管理作法是解放军从韩战起的一项优先事项，其影响特别的突出。中国海军分析家强调有效运送大量不同型式水雷的重要性。[363] 其他报告指出解放军海军特别重视水雷作战后勤，例如革新仓库领导者，[364] 改善信息流 [365] 及后勤管理，[366] 定期从水雷库存中汰除废弃的武器，[367] 训练军士官技术检查及部署整备等。[368] 中国认定后勤在水雷作战中的重要角色，在 1994 年海军后勤部的「海军后勤库储职业管理规定」中规定，从事水雷技术任何工作的干部及士官兵，包含库存管理、维修及处理废弃武器者都需受高等训练。[369] 解放军的海军弹药支持部(Ordnance Support Department)已公布实施进一步的规定，可让「一个水雷战备等级转换到另一个的时间减少」。[370] 从 2008 年起，对于某南海舰队水雷储库的电子「管家」来说，仅仅知道储库中的水雷确切存量已不符需求，他们应该能在不同的复杂状况下，设计出精心构思且详细的备援计划。事实上，由系统自动产生的精确备援计划，不仅能显示出弹药任何零件的特定规格，也可以告知需支持的地点的环境、天候、潮流等信息。[371]

照片 11. 运用信息技术。中国技术员使用计算机，链接后方的训练用雷。计算机可大大增加水雷分配、放置及设定特色(例如启动延迟、舰船计数器及其他功能)的准确性，因而优化其功效。

据传某个青岛后勤基地「已与军队内外约 20 个学校、30 个研究机构及 40 个装备生产工厂建立了良好的工作关系」，在信息化下支持实际训练，并且于解决装备开发及维持上取得了极大的进步。且因此『开发出「自动化水雷检查系统」及「海军舰艇装备自动化维保系统」…赢得了全海军的后勤装备技术模范第一级与第二级奖』。[372] 解放军也已开发出「扫雷艇仿真训练系统」。[373] 在中国期刊「水雷战与舰船防护」中，许多文章展现强烈的中国信念，认为在武器无法可靠的工作下，水雷战无法达成效果。[374]

12.「布扫雷互相支持」。中国海军战略家了解，在水雷反制上中国传统的弱点，以及其所造成的漏洞。据观察「敌人将极容易…沿着中国东南沿海，沿着众多岛屿及港口，布下大量的水雷」。[375] 中国水雷反制在近期的未来，仍无法达到西方国家水雷反制的技术水准。虽然现在新的载台及技术已引进到中国的水雷反制范畴，但基本的手段很可能仍维持与西方国家的差异性。[376] 但先前所提到的操演例子确实显示出复兴水雷反制的决心，例如近几年(参考前文)解放军已接收了数艘新型扫雷舰。另外对于水雷反制研究，似乎也正进行中。[377] 这项研究包含运用先进的技术，例如直升机[378] 及无人载具[379] 执行水雷反制。「战争科学」观察，中国海军基地有可能成为敌人水雷攻击的目标。[380] 而水雷反制及水雷作战之间所存在的互补关系，似乎也成为了一个基本信仰，中国的水雷反制基本上将支持扎实的水雷作战。某篇人民海军的文章便替这个观念背书，将其能力视为「双面刃」。[381] 实际上，为了支持 2005 年 3 月到 9 月的扫雷及布雷操演，解放军「对于舰船执行扫雷及猎雷的整体作业上，进行系统化训练编组、观察并交换角色」。[382] 反映出他们在中国水雷作战的重要性，也征用了民船参与水雷反制的操演。[383]

13.「卫星航海」。知道水雷的确切地点，对于建立安全航道并维持安全通过雷区，以及未来扫雷或再布雷来说都是很重要的。过去的水雷作战有个很大的问题就是误袭友军。战时在通信或航行上的失误亦经常导致水雷作战舰艇破坏自己的舰艇。[384] 值得省思的是全球定位系统科技的问世，能够如何影响水雷战的未来功效，例如此项科技能够更加准确地布署雷区(或是降低实施水雷战的老手人力需求)，或将这些雷区的参数透过信息传输给我方单位等。[385] 关于解放军报告中与全球定位系统相关的训练操演，包含夜间及恶劣天候的水雷战及水雷反制操演等，可能表示这项新科技能够成为水雷战的关键角色。[386] 某扫雷大队发展可以「提高准确度及扫布雷的作战能力的水雷内部记录仪」也可作为此论点的左证。[387]

照片 12. 扫雷操演。2008 年 5 月时，解放军东海舰队反水雷舰的船员操作噪音器的拖体，此拖体用于扫除音响触发雷。水中的是标示浮标。甲板吊架的右边可见水雷轨道。

威胁及反应?西方对太平洋水雷反制作为的趋势分析

整份研究的重点为中国水雷战的能力、训练及准则等。但是完整的战略分析需配合其他面向检讨，也就是可能对抗中国水雷战威胁的水雷反制兵力。

当前局势看来，以美国的水雷反制兵力迅速打击中国水雷作战的前景并不乐观。大部分的美国海军水雷反制部队离战场较远。最近的反制部队为驻地在日本佐世保的两艘(不久后将增编为四艘)扫雷舰。他们离台湾只有一天半的航程。但即使他们抵达也无法稍微改变这不安的情况。美国海军的大部分猎雷部队，最近才将驻地从德州移至加州圣地亚哥基地。[388] 而可较快抵达战区的水雷反制直升机，若在争夺制空权的环境下作业，则将面临严重的威胁。[389] 如「战役理论学习指南」中倡导，战场指挥官「组织海上及空中机动兵力，并离岛及沿海火力发动多轮、多向攻击，以求绝对粉碎敌人扫雷及屏卫企图」。[390]

可以肯定的是，美国海军目前正处于水雷反制计划的历史上，最激进的过渡期中。这次的过渡期将在未来十年内，将所有专业美军反水雷舰艇除役，并以滨海战斗舰(LCS)取代。此型舰是透过「模块」工程的设计来强化战斗力，能力在于不同的作战任务套件(mission packages)下可接受不同的模块。滨海战斗舰的原型舰-自由号(LCS 1)于 2008 年 11 月服役，具备改良的「有机化」水雷定位及处理能力，配有先进的声纳系统，及可执行水雷定位任务的无人水下及水上载具。滨海战斗舰搭载配有空中雷射水雷侦雷系统的 MH-60S 直升机，可搜索水雷。在侦测后，可从专门直升机载机枪发射超空泡射弹(supercavitating projectile)，或是透过光纤导引的可抛式炸药 UUV 摧毁水雷。[391] 其他水面舰级潜舰也将配载强化的声纳系统，可让他们更有效地侦测及回避水雷。

从专业水雷反制舰改变为「有机」水雷反制，这个过渡期在设计上反应出(水雷反制)领域的主要趋势。水雷反制最传统形式是使用简单的装置切断系留雷的锚炼。然而就沉底雷而言，则需要更进步的方法，像是模拟通过的船只所产生的触发信号。因此直升机拖曳橇(tow sleds)及扫雷舰拖行之扫雷器(tow drogue)，产生可满足引爆标准的磁感及音响信号，并将水雷无害引爆。但如先前所述，这种除雷法因沉底雷的逻辑电路及软件日趋精密及难以欺骗，因此难有功效。所以当前的作法是透过高分辨率声纳搜索沉底雷后，以炸药摧毁之。这种方法被称为「猎雷」，是一种费时及艰巨的过程，不仅需要及准确的测深定位，在可疑海域的海床上每个似雷的物体都代表辛苦的调查过程。需要先进、昂贵的科技，专业训练及高水平的准确定位能力。[392]

美国海军正依规划于 2010 会计年时筹购至 7 艘滨海战斗舰，并达最终 55 艘舰艇的目标前进，[393] 这是美国国防部长盖兹强烈背书的一个计划。[394] 依此看来，对滨海战斗舰的承诺可认为是对水雷反制作为的强烈保证。毕竟滨海战斗舰将纳入目前最先进的水雷反制科技，此型舰的最后部署数量应超过专业反水雷舰的现有数量。再者，滨海战斗舰的观念是建造一个相对价廉的舰艇，可强行进入高强度战斗浅滩区，一般有利于水雷反制任务。[395] 但滨海战斗舰的实验性质及整体「模块」的概念，确实对于官兵熟练度及训练、舰艇及模块的真实任务上带来一定程度风险。很不幸地，即使这个过渡期达到最佳预期成效后，美国海军仍难以有效抗衡这份研究中所提出的威胁。预期的滨海战斗舰数量确实可应付另一场沙漠风暴，甚至可在伊朗军事冲突中开启霍尔木兹海峡。但是这个预想的战斗部队在对抗解放军数以百计，甚至千计的布放载台，以及大量水雷时也将力有未逮。可靠的因应作为可能意味着大幅增加滨海战斗舰的预算，用以建立一支发生军事冲突时，可替打击群在进入潜在重度布雷西太平洋海域前开路的兵力。但依目前的财政限制，这样的部队不太可能实现。

台湾在对抗中国水雷战的前景则更加严峻，她的反水雷兵力弱，且极易受战机及飞弹攻击。与受战壕保护的中华民国空军(ROCAF)战斗机不同(虽然其飞行跑道很容易破坏)，台湾的水雷反制部队暴露在外，很可能成为解放军的优先目标。台湾只有 12 艘水雷作战舰艇。其中四艘为翻修过的永阳级扫雷舰，原于 1950 年代中期在美国建造。某中国消息来源评估，这四艘舰艇具有「侦测磁场、磁感、音响及传统水雷的其他引爆装置的能力。这型舰的 USQS-1 声纳…具侦测系留雷的能力，但无法侦测(沉底)雷」。[396] 台湾的水雷作战兵力中也包含了四艘较小，但较现代化的德制 MWV 50 (永丰级)猎雷舰。[397] 同一个中国消息来源宣称，这些舰艇的猎雷声纳功效不佳，但认为他们的遥控操作炸药-水雷引爆装备具有某种程度的能力。[398] 最后，台湾的四艘老旧的美国制大鹳级扫雷舰，詹氏年鉴在 1996 年评估为「多少已到达使用年限了」。[399]

简而言之，台湾最多有八艘扫雷舰可用来对抗中国水雷。但这些舰艇非常可能均不专精于引爆沉底雷，特别是配有现代化引信的水雷。所以台湾在通过水雷区，开拓安全

航道的能力上非常令人存疑。某中国期刊所出版的一篇评估论文就认为，如果台湾的水雷反制部队参战，也只会暴露出它「虚有其表」的能力。这篇分析报告也认为「若台湾海军丧失制空及制海权，接着就不可能使用飞机或军舰布雷」，因此若其(尝试)运用「渔船…布下防御性雷区，此过程等于是这些渔船的自杀行为」。该分析补充台湾海军「没有办法扫除可能用于封锁东部沿海之某些专用水雷」。[400]

综合美国和台湾在反制能力上的限制，无疑地将促使华盛顿及台北寻求其他可协助之同盟。很明显的支持就是日本与其 26 艘反水雷舰，这些舰艇作为东京对于水雷反制上的坚定承诺，都是 1980 年代或较新的旧型舰。[401] 在 2005 年 2 月时，美国与日本的联合声明中「(持续)支持台湾海峡议题透过和平对话解决」，此「普遍战略性目标」在某种程度上，可以相信东京可能考虑于某些想定中，有限的军事支持如扫雷类(的协助)。[402] 然而日本与中国间持续成长的经济互赖，日本政策中的永续和平主义(伴随日本领导者没有处理军事政治危机上的经验)，更不用说中国潜在的报复行为等(可能包含水雷的使用)，上述因素都是日本起而对抗中国水雷战的窒碍。但很明显的中国海军战略家了解日本在整体太平洋水雷作战平衡上的重要立场。举例来说，「舰船知识」最近便用了一篇 9 页的专文单独分析日本水雷反制的发展。[403]

另外值得注意的是，中国研究家紧紧地盯着美国海军[404]及其他西方国家[405]的水雷反制趋势及能力。解放军的海军研究家便努力地了解最先进的美国研究机构下之研究计划，例如罗得岛的海军水下作战中心。[406] 中国分析家亦紧迫地观察美国海军从专业到有机水雷反制载台之过渡期，试着解析其策略性弱点。[407] 中国研究家也密切地随着不同的外国无人水下载具(UUV)设计及发展的脚步。[408] 他们对于无人水下载具的战斗能力特感兴趣，例如长期潜伏在敌港附近实施侦搜，并可接战目标的能力。[409] 他们也敏锐地察觉出反水雷直升机在美军准则中的重要性，因而紧迫盯人地注目着新系统研发及测试的各项细节。[410] 他们对于维吉尼亚级潜舰也非常有兴趣，特别是其水雷反制能力。[411]

在分析解放军水雷作战发展上直接反制的形势后，便有可能评估出中国水雷作战的战略意义。

想定场景

在想定设想的目的上，我们现在转而检讨中国水雷作战在东亚军事冲突中，最重要的想定内所可能扮演的角色。很自然地，这个想定将偏向关注于台湾议题。然而，以北京在海权领域上持续成长的地缘战略分量看来，中国国防政策的分析家必需分析各种可能的场景。

很少人注意在未来朝鲜半岛军事冲突时，中国对于海事情势的潜在影响。然而，鉴

于朝鲜邻近于中国北部，这种冲突将直接冲击到中国的安全利益。如果北京在危机发展的初期并没有立即诉诸大规模使用武力，并试图释出其主导意图时，则水雷战在逻辑上是符合其目标的。[412] 解放军可从山东半岛尖端到北朝鲜，布出离 38 度线不远的小型雷区。[413] 若以较具野心的方式也在解放军的能力范围内，则是将此水雷区从中国最大的海军基地之一的青岛，直接往东延伸到南韩沿海。任何一种方式都将在程度上表现出保护平壤的决心，且都将不只严重限制美海军在黄海的作战任务，也将给首尔带来极大压力。此区域的浅水深度也显示出此类战役相对上的简便性。

第二种想定中考虑中国与东南亚的策略性互动，特别是与中国南海接壤的国家。在此再次说明，当前其外交倾向虽仍相当正面，但潜在的冲突依然存在。越南、菲律宾、马来西亚及印度尼西亚等国，重度仰赖海上浅水区或航道的贸易行为。因此上述国家不管何种想定下，均无法对付中国的水雷。[414] 而「战争科学」中亦曾假定，使用水雷对「珊瑚礁岛屿进行攻势作战」。[415] 在面对南沙群岛的冲突时，北京可选择在某些特定岛屿周遭布下限制水雷区，以加强宣称其主权；并将之作为派出时间长、昂贵且具潜在挑衅意味的军舰外另一种选择。在东南亚的所有国家当中，越南绝对是最易感受到中国水雷作战压力的国家。[416]

第三种也是最可能的想定，则是中国与台湾之间的军事冲突。虽然从 2008 年 3 月台北方面新的领导人上台后，两岸关系有令人印象深刻的改善；很遗憾地，(两岸)微妙关系间的军事冲突(可能)，在可预见的未来内仍无法排除。为了解中国水雷作战在这些想定中可能扮演的角色，可以就解放军「最小化」及「最大化」军事场景来考虑。在政治及策略上有许多理由可解释，为何北京可能降低(最小化)动武的意图。其中最主要的就是降低台湾(人民)的伤亡及物资上的破坏，因而不加深台湾人民的抵抗。这方面，水雷战比起可造成许多台湾人民伤亡的大型飞弹攻击来说更有用。这种展现敌意却不造成大量伤亡的「灰色地带」，不至于催化成宣战的理由或引发与论的作法，可能会让华盛顿(甚至东京)对响应其侵略行为感到进退两难。

在这个想定场景中，最主要的目标将是台湾的港口；鉴于围绕台湾的海域多为浅水区，故多数港口皆易受水雷攻击。[417] 主要的战斗大致上将受限于台湾海空军兵力受敌抑制。「战役理论学习指南」中叙述，台湾的军队假定下列场景：「海空军封锁将是不可避免的战斗阶段，而使用水雷抵抗封锁将会是最符经济效率的手段。第一阶段的 4 到 6 天内，台湾将面临 5 千到 7 千枚水雷的封锁；在第二阶段，7 千枚以上水雷将加入封锁中；两个阶段将布署低于 1 万 5 千枚水雷，已足够切断台湾的国内及国际海上运输及补给航线」。[418] 大约在两天后，高雄、基隆、台中及花莲港之系统被空投水雷切断。[419] 某台湾分析家认为「藉由 100 枚空投非接触型水雷来封锁一个军港或中型港口是可能的，且其价格与一枚反舰飞弹相仿」。[420] 在同时间或甚至不久之前使用延迟起动型水雷，透过中国的潜舰、水面舰及改装民船，都可在台湾附近布下许多水雷。这个想定中，解放军可以保留其最先进的载台及火箭上升水雷来攻击台湾东部港口。同时，北京将吓阻外

国势力介入，藉由宣称台湾东部海域，一个作为美国及其同盟军集结海军兵力的合理位置，已用漂雷，或甚至火箭上升水雷等「大量地布雷」。鉴于台湾社会早已呈现的分裂感，经济上对封锁的脆弱性，中国政治目标的复杂及弹性(例如：大陆无需派兵驻扎台湾)等，这个想定将有合理的成功机会。综合下列各种因素，这对于北京是相当富有吸引力的：包含其所牵涉的广大实际距离、水雷本质上无法缩短的排除作业时间、[421] 中国水雷的精密性、中国再次补设雷区，以及美国可用的水雷反制兵力限制等。

从北京角度来看上述想定的最大缺点，在于它不仅依赖台北方面意志迅速崩溃，并提供美国及其同盟军一个在解放军泄漏明显意图后，抢占先机的机会。「最大化」的解放军策略，为透过两栖部队入侵，使用侵略性及大范围先发制人兵力对抗美国(可能含日本)部队，在另外一方面则排除上述之可能性，或许采用攻击之前先发动台湾领导人斩首行动。

如果北京判断华盛顿将干预台湾事务，则中国可能攻击美国在太平洋的部队。可能的作法，包含使用潜舰在冲绳的美军基地外海、日本其他地区、关岛或甚至夏威夷等海域布雷。某篇中国的反潜作战研究提倡，对敌潜舰的水雷作战最好的方式为「将水雷布在靠近敌基地的出口航线…进而限制敌潜舰出海的能力」[422] 这些海域范围都在解放军潜舰的航程限制内，并可用自走雷布在有用航道上，利用自走雷难以侦测、自抵目标的能力。[423] 至于长程攻势水雷作战方面，或许值得注意到中国海军分析家们曾评估二次世界大战时，德国潜舰沿美国海岸布雷的「成功」。日本南琉球群岛周遭海域也易受中国攻势水雷作战。另一篇文章叙述：「在大量的研究基础上，解放军相信美国核子潜舰非常的安静，难以…反击…(而)必须受到牵制」。[424] 根据该分析，这个考虑一直是中国在自走雷研究的主要动力；并主张在关岛附近实施水雷作战，其优先等级为「在太平洋第一岛链的每个航道布下(自走)水雷，连结后形成(一条)封锁线，(并)防止美国核子潜舰进入到中国周围海域」。[425]

中国研究家特别研究过水雷如何用于支持两栖作战，[426] 以及如何使用反登陆水雷对抗敌人。[427] 根据「战争科学」，反水雷作战是假定中两栖作战的关键。[428] 例如台湾的西边、北边及南边水域，以及南琉球群岛周遭水域等，皆易受中国攻势水雷攻击。[429] 在这些水域布雷，能限制美国水面舰及快攻潜舰在台湾东部海域活动；而中国可集中较强大的武器系统于此区域，包含中国先进的柴油潜舰。解放军分析家明显地考虑使用水雷建立出一个在第一岛链内的避难所，在内解放军舰艇及潜舰可以无惧美国潜舰的攻击。[430] 所以在第二个场景中(最大化军事手段)，水雷作战的焦点将置于拦截敌海军兵力；而第一个场景中(最小化军事手段)则是封锁台湾的港口。

从不同的观点切入

检视中国水雷战在东亚军事冲突想定中的角色的研究极少。有一篇值得探讨的研究，学者 Michael Glosny 在 2004 年春天发表在国际安全议题(后续以 IS 标示)中的论文，他与本文的结论上有极大的差异。Glosny 的研究极为有益，因为它点出台湾海峡想定中水下作战的重要。同样值得称赞的是，他以严谨的方法工具来处理这些复杂的问题。但很遗憾地，论文的结论认为对台封锁威胁为「言过其实」，是基于令人质疑的假设，而且至今已显然不合时宜。

最重要的是 2004 年的国际安全议题(IS)研究，大多低估了中国水雷作战的量及快速(成长)。其作者在评估时，忽略了中国大部分的水雷战可用载台，只留下了特定百分比的东海舰队潜舰。并指称中国广大的空中兵力(解放军的海军航空部队及空军部队本身)与此无关，因为他们无法取得「制空权」。[431] 同样地，解放军的海军舰艇也从水雷作战的方程式中除去，因为「他们在没有制空权的状态下，非常容易受到攻击」。中国巨大的商船及渔船团也不列入考虑因素，因为「他们无法布放先进水雷，而且(部署商船进行水雷战)极为复杂」。在将数以千计的水雷布放可能载台，缩小到少于 1 百艘解放军潜舰之后，国际安全议题(IS)的作者更进一步减低此数量，并主张只有东海舰队的舰艇将涉入(而不含其他两个主要舰队的舰艇)，而最后再次修改这个数值，以反映各潜舰部队的通常妥善率。最后他的结论是超过六个月时间下，解放军海军能够布放水雷最多为 1,768 枚，大致上应在 858 枚到 1,248 枚水雷之间。[432] 这些数值与伊拉克在 1991 年波湾战争中布下约 1 千枚的数量相仿，大大低于北朝鲜在元山布下的约 3 千枚的数量；在两个数值都远不对称的状况下，可说明 2004 年国际安全议题(IS)的研究非常不准确。本文充分证明中国水雷作战能力是坚强的，而且在其范围或广度上绝不亚于伊拉克或北朝鲜。

其实，2004 年国际安全议题研究报告的结论，在它受人质疑的制空权论点上便已垮台。我们主张解放军若不是在几个小时内，也可以在几天内就将台湾全部的空中兵力摧毁，或使其无法使用。[433] 即使「大胆假设」中华民国空军有残存兵力，这项假设还是在解放军海军航空部队(及空军部队)，在战斗空域中执行空投水雷任务的可能范围内，且为假设中国兵力在承受敌火攻击丧失某种程度时之状况。[434] 本文中指出可观的证据显示中国对于动员民船执行水雷作战是很慎重的。2004 年国际安全议题研究报告认为这个说法将会「很复杂」，虽然理论上合理，但却忽视了中国领导者们已考虑这个想定将近 60 年的事实。与几乎同时在世界各个角落进行复杂作战的美国军队所面临的挑战相比，特别是在全球定位系统及相关航海科技问世后，中国于沿海遂行水雷作战、于民船上加装装备及组织大型舰队等议题则相对地单纯。最后，我们预想在对台想定当中，解放军的各大舰队(实际上也包含解放军空军部队)会全面性的参战。

在 2004 年国际安全议题研究报告的其他主要瑕疵，则是台湾抵抗中国水雷作战的

能力。该作者不认同航向台湾的商船在中国片面宣布封锁海域后，就会停止运输的传统看法，他提出历史资料左证：「船运公司在战时藉由进入危险区域制造巨大利益…船货主会持续运输」。然而他所提供的历史案例(克罗地亚、黎巴嫩及两伊战争)与中国封锁台湾时致命的战斗环境迥然不同。[435] 如果认为世界大战是这方面更好的指针，则 2004 年国际安全议题的作者就严重误解了商船及货主的动机。[436] 某些货主在利益趋使下，可能会说服其船长铤而走险穿越中国封锁区，但认为海运频率将与平时相似的想法是站不住脚的。2004 年国际安全议题研究报告定量模型的另一个问题，是他们并没有考虑到台湾的水雷反制(或反潜)能力不强。很明显地在弹道飞弹、巡弋飞弹及其他精准武器之下，中国民国空军兵力的存活率令人质疑，这个原则同样地适用台湾海军部队；特别在奇袭攻击下，奇袭的效果可令中华民国空军更措手不及。在与世界大战时的英国或德国各种面向比较后，对 2004 年国际安全议题研究报告的最后一点质疑是，台湾反击的意志。[437] 即使台北方面拥有某些主权的外在形象，但英国或德国都不会有军官团公开地赞同敌人的某些目标，这个奇怪的现象是 2004 年国际安全议题的作者所承认的。[438]

也许在 2004 年国际安全议题研究中最遗憾的方面，是它仅限制在中国与台湾间的军事冲突，并没有评估美国或其它盟军的参与。虽然其作者并没有直接说明，但似乎暗示如果台湾可以应对中国的水雷作战(及潜舰)威胁，那么美国海军更能够轻易地击败中国水雷作战。事实上，依本文详细的研究显示，中国水雷战实质上已作为迎击优势敌人的主要作战方式，也就是美国海军及其同盟军。漠视面前这明确的危机是毫无意义的。

对于政策上的影响

本文阐明了中国海军发展鲜为人知的一面。它揭示了中国水雷战代表解放军海军雄心勃勃及充满野心的一面，并以快速的步伐迈向现代化。[439] 显示出中国在水雷战上广泛地吸收外国经验，并佐以自身惊人的丰富及相关的历史。

中国的水雷存量不仅多，而且可能包含某些世界上最致命的水雷作战系统。实际上，中国已走在水雷战科技及观念发展的尖端，她的军火库中已经拥有先进国家(例如美国)都没有的系统。解放军策略家了解现代战争中人的面向，在中国水雷战中特别明显。事实上，中国海军期刊中显示人员培训方案上惊人的增加，已超出以往死记硬背、照本宣科的演练型态。本文指出中国水雷战准则的初步纲要，强调速度、心理、欺骗、新旧技术混用、不同的布署手段等，另外其主要目标就是针对美国海军及其准则。

北京的军事现代化计划是全面性的，同样注重广度及集中并行。中国水雷战值得注意的地方在于，它是少数能够配合其他作战能力，出其不意并完全颠覆西太平洋权力平衡的作战类型。台湾的水雷反制部队战力小，且可能在第一击时被摧毁。日本的水雷反制舰队实力坚强，但在两岸冲突中，东京在政治上仍「难以预料」。最基本上，美国及其盟国的水雷反制兵力在编队或编制上，并非于争取制空及制海权的作战环境下「打入

战场」。即使在优势水域中，水雷反制部队在作战显著改变上只是缓不应急。因此中国水雷战所代表的是北京在中国攻击及美国防御能力不对称上的一个主要施力点，甚至比起反舰巡弋飞弹、潜舰及信息战等其他类型战争更加的有利。

鉴于上述对于美国海权的重大挑战，提供海军及国际政策制定者下列的建议：

- 在战术层级上，所有美国海军舰艇应该完全作好在可能布雷水域下航行的准备。海军持续从专业水雷反制兵力转换到各舰有机作战能力，表示这个需求是被认可的。这对于潜舰兵力特别的重要，因快攻潜舰无疑将于战斗中担任先发。强烈的证据显示中国正以部署先进、深水水雷为主，遂行反潜作战。但美国海军如果在没有适当地判断水雷战的威胁之前，迅速地投入战斗部署是充满风险的作法，而这样作则需在痛苦的资源与训练优先中取舍。对水面舰队来说，滨海战斗舰代表的是美海军水雷反制的未来，支持此战斗技术的模块的筹购应该列为最优先等级。但藉由模块化所获得的载台弹性不可与较低的训练标准妥协，或甚至将水雷反制任务边缘化。最后，中国的技术似乎将美海军的直升机及海巡舰艇作为水雷战的可行目标。为了对抗新兴且前所未有的威胁，现在将战略调整还不算太晚。

- 在作战层级上，美国太平洋指挥部很明显地缺乏适当的水雷反制兵力，这个弱点在过去十年间很可能鼓励了中国的水雷战计划。在 2005 年「基地调整及关闭委员会」决议将水雷反制中心从德州英格赛基地迁移到加州圣地亚哥基地，就是走向修正此缺点，且值得称赞的第一步。而从中再将几个分队移防到珍珠港或甚至关岛，将会是合理的第二步骤，并对于中国冒险主义起有效威慑作用。在新型有机系统舰船完建并验收之前，将这些「老」船好好保存，并维持高战备等级是很重要的。此外，将美国攻势水雷计划重启，包含再次重视透过空军进行空投水雷的手段。为了让中国领导人了解对抗美国的联合(all-out)水雷战可能为中国带来的毁灭性后果，此计划应被考虑作为威慑敌人的手段。大大小小的演习及兵推都应该纳入相当的水雷战元素，包含一个在质与量上强大的敌人、广阔的地理参数、军事或非正规部队目标，及在中国熟练的水雷战攻击下，美国海军潜在的高伤亡数。简而言之，他们应该面对中国的不对称海上挑战之事实。

- 在战略层级上，美国军队及外交领袖必须要了解中国在封台能力上已绰绰有余。[440] 此外在过去十年间，中国惩罚在台湾冲突中介入的美国军队的能力已激进地上扬，部分是因中国发展中的海军水雷威胁，但也包含其他的战力。伴随着中国军事挑战上的诸多面向，地理因素似乎是其中的王牌。这个情形下，美国或其潜在的盟友根本就没有办法部署适当的兵力，有效地拦截全面的中国水雷战攻击，一如本文所示，在规模上可能极为浩大。一旦水雷被布放后，对作战区中的美军部队可能造成极大危险。面对这项威胁，特别再加上全球反恐战争，及持续进行的大中东地区军事作战等主要军事承诺，华盛顿似乎已无选择余地，而只能在台湾议题上采取谨慎的策

略，并面对一个难以接受的事实，就是它无法长期地在军事上捍卫台湾。台北及北京从 2008 年起便开始重新进入新的对谈阶段，在台湾军事上的脆弱事实暴露在战斗之前，这个对谈过程绝对符合美国的战略性利益。在支持这种外交方案的同时，华盛顿应该帮助台北强化其水雷反制能力，并鼓励东京及其他地区的盟军维持有效的反水雷部队，以抵抗最坏的打算。不管怎样，在水雷反制的竞技场上，盟军的协助并不是万灵丹，且绝不能成为依赖，如此反而抑制了广泛的美国海军能力在这个领域下的重要发展。

关于中国海军的扩张，特别针对水雷作战领域的议题就此打住。我们面前的挑战应是掌握北京快速的海事发展中带来的严峻挑战，同时也要在这个重要的关系中，整备我们海军战力以应付意料之外的动荡不安。

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23. Ibid., p. 69. See also Paul H. B. Godwin, "Change and Continuity in Chinese Military Doctrine," in Chinese Warfighting: The PLA Experience since

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24. See, for example, 茹呈瑶,夏银山 [Ru Chenyao and Xia Yin Shan], "海湾战争中的水雷和反水雷" [Mine and Counter-mine in the Gulf War], 现代舰船 [Modern Ships], no. 64 (April 1991), pp. 51–58; and 陈书海,陈颖涛 [Chen Shuhai and Chen Yingtao], "水雷:多国部队海上的唯一障碍" [Sea Mines: The Coalition Forces' Single Naval Obstacle],舰船知识 [Naval and Merchant Ships], no. 141 (June

1991), pp. 28–29.

25. This holds true for articles of scientific nature—for example,田路,陈伏虎,钟铁城 [Tian Lu, Chen Fuhu, and Zhong Tiecheng], "反水雷技术的发展概况和声系统实现构想" [A Survey of MCM Technology and Sonar Development],声学与电子工程[Acoustic and Electrical Engineering] (April 2004), p. 17; and 刘忠 [Liu Zhong], "网络雷阵及其被动定位员李" [Mine Array Networks and Passive Location Principles], 海军工程大学学报[Journal of Naval University of Engineering] 13, no. 6 (December 2001), p. 20. It holds true also for naval reference materials,
such as in 陆建勋[Lu Jianxun], ed., 海军武器装备[Naval Weaponry and Equipment] (Beijing: Weapons Industry, 2003), p. 108, as well as in the conventional military press—for example, "对付航母战斗群的九个招数" [Nine Tactics for Coping with Aircraft Carrier Battle Groups], 当代海军[Modern Navy] 3, no. 90 (March 2001), p. 33.

26. Unless otherwise indicated, material in this paragraph
is derived from 傅金祝[Fu Jinzhu], "海湾战争中的水雷战" [Mine Warfare in the Gulf War], 现代舰船[Modern Ships], no. 75 (March 1992), pp. 30–33.

27. The statement as written is somewhat ambiguous. This could be interpreted as Fu's suggestion that China, as a "strong country," should also engage in mine warfare. Another possible interpretation is that Fu is emphasizing that strong states—the United States, for example—have employed mine warfare extensively and could do so against China in the future.

28. Unless otherwise indicated, material in this paragraph is derived from 沈游 [Shen You], "海湾战争中舰船装备'十思'" [Ten Reflections on Naval Equipment Deployed in the Gulf War], 现代舰船[Modern Ships], no. 67 (July 1991), p. 10.

29. For doctrinal statements that embody this bifurcation, see "172. How Does One Determine the Main Cover Targets in a Naval Base Defense Campaign?" and "191. How to Attack and Block the Enemy's Unloading Harbors in a Maritime Traffic Sabotage Campaign?" in 薛兴林 [Bi Xinglin], ed.,战役理论学习指南 [Campaign Theory Study Guide] (Beijing: National Defense Univ. Press, 2002). For a discussion of offensive and defensive uses of mines, see 傅金祝[Fu Jinzhu], "防御布雷和攻势布雷" [Defensive and Offensive Mining], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 4 (2008).

30. 傅金祝[Fu Jinzhu], "伊拉克水雷失效的哪般" [What Explains the Failure of Iraq's Mines?], 舰船知识[Naval and Merchant Ships] (August 2004), p. 45. A similar article that highlights U.S. MCM weaknesses is 大鹏 [Da Peng], "难说谁胜谁负" [It Is Difficult to Say Who Won and Who Lost], 当代海军[Modern Navy] (June 2003), pp. 14–15.

31. Fu Jinzhu, "What Explains the Failure of Iraq's Mines?" p. 45.

32. Ibid.

33.刘夏森 [Liu Xiasen], "台海战争一旦爆发:美国真敢出兵吗?" [If a Taiwan Strait War Erupted: Would the U.S. Really Dare to Dispatch Troops?], 人民海军 [People's Navy], 21 August 2004, p. 3.

34. “八,中国海军援越水雷战” [China’s Navy Assists Vietnam with Sea Mine Warfare], in 金玮 李杰 [Jin Wei and Li Jie, eds.], 水雷战舰艇 [Modern Sea Mine Warships], 舰船知识丛书 [Naval Ship Series] (Beijing: 中国人民公安大学出版社 [Chinese People’s Public Security Univ. Press], 1999), chap. 8, p. 117.

35. Han Peng and Li Yucai, eds., Outline of Undersea Weaponry, p. 1; Joseph Needham and Robert Temple, The Genius of China: 3,000 Years of Science, Discovery and Invention (New York: Prion, 1998).

36. “水底龙王炮” [The Underwater Dragon King Cannon], in 军事大辞海·上 [Great Military Dictionary], 熊武一,周家法 总编 [Xiong Wuyi and Zhou Jiafa, chief eds.] (Beijing: 长城出版社 [Great Wall], 2000), vol. 1, p. 564; “混江龙” [The All-Capable River Dragon], in Xiong Wuyi and Zhou Jiafa, chief eds., Great Military Dictionary (Beijing: Great Wall, 2000), vol. 2, p. 2787; “水雷” [Sea Mine], in 刘秋霖, 刘健,王亚新等编[Liu Qiulin, Liu Jian, Wang Yaxin et al., eds.], 中国古代兵器图说 [Illustrations of China’s Ancient Weapons], (Tianjin: 天津古籍出版社 [Tianjin Ancient Book], 2003), p. 408; “China’s Navy Assists Vietnam with Sea Mine Warfare,” in Jin Wei and Li Jie, eds., Modern Sea Mine Warships, p. 116.

37. Srikanth Kondapalli, China’s Naval Power (New Delhi: Institute for Defence Studies and Analyses, 2001), p. xvii.

38. Stephen Turnbull, Fighting Ships of the Far East: China and Southeast Asia 202 BC–AD 1419 (Oxford: Osprey, 2002), pp. 33–35.

39. 林长盛 [Lin Changsheng], “潜龙在渊:解放军水雷兵器的现况与发展” [The Hidden Dragon in the Deep: The Present Situation and Development of PLA Mine Weaponry],国际展望 [World Outlook], no. 9 (May 2005), p. 22. This article is perhaps the most comprehensive analysis to date of PRC sea-mine capabilities. Although this is a PRC source, Lin is actually a former Taiwanese military officer who recently spent time in the United States on a research fellowship. While Lin includes frank analysis of continued PRC weakness in such areas as ASW, he also offers more recent details unavailable in other publications. Some are currently impossible to confirm and will be referred to accordingly in this article. For Lin’s background, see William Chien, “U.S. Military—Iraq,” VOA News Report, 22 April 2003, available at www.globalsecurity.org/ and www.1n0.net/2004/12-22/0442319087-7.html. Lin’s other publications include “Counting China’s ICBMs,” Studies on Chinese Communism 37, no. 7 (July 2003), pp. 80–90.

40. 王广仁 [Wang Guangren], “东局子史话” [A History of the Eastern Bureau, Part 4], 汽车运用 [Automobile Applications] 102, no. 4 (2001), p. 49.

41. 胡胜利 [Hu Shengli], “国共两党军队合作布水雷考” [Kuomintang–Chinese Communist Cooperation in Inspecting the Laying of Sea Mines],江淮文史 [Jianghuai Literature & History], 2001, no. 2.

42. Unless otherwise specified, material in the PRC sea-mine history, development, and research sections to follow is derived from 凌翔 [Ling Xiang], 第六章 “扬威海上的中国水雷战舰艇” [Chapter 6: Raise Mighty Chinese Sea Mine Warfare Ships on the Sea], in 当代水雷战舰艇大观 [Modern Sea Mine Warships Spectacle], 当代水雷战舰艇大观丛书之五[Modern Warship Spectacle Book Series, vol. 5] (Beijing: World Knowledge, 1995), pp. 152–61 (p. 152 for this reference).

43. 汪光鑫,陈逸静 [Wang Guangxin and Chen Yijing], “东海目击:军民联合海上扫雷演练” [On the Scene in the East China Sea: A Joint Military-Civilian Mine Sweeping Exercise], 舰船知识[Naval and Merchant Ships] (January 2001), pp. 5–6.

44. For the Yangtze and Shantou operations, see also “China’s Navy Assists Vietnam with Sea Mine Warfare,” p. 92.

45. Han Peng and Li Yucai, eds., Outline of Undersea Weaponry, p. 1; 曾筱晓,董爱群 [Zeng Xiaoxiao and Dong Aiqun], “日本曾在朝鲜战争中出兵” [Japan Dispatched Troops to the Korean War], 环球军事[Global Military], no. 20 (2002), p. 29.

46. 张宝善 [Zhang Baoshan], “水雷封锁—打击‘台独’图谋的一种选择” [Mine Blockade: An Option to Foil the Conspiracy of “Taiwan Independence”], 现代舰船[Modern Ships], no. 149 (April 1998), p. 10; 王维广 [Wang Weiguang], “‘水中伏兵’—水雷” [‘Underwater Ambush’: Sea Mine], 国防 [National Defense], no. 4 (1996), pp. 36–37.

47. Gregory K. Hartmann with Scott C. Truver, Weapons That Wait: Mine Warfare in the U.S. Navy (Annapolis, Md.: Naval Institute Press, 1991), pp. 80, 106.

48. Edward J. Marolda, “Mine Warfare,” Naval History and Heritage Command, www.history.navy.mil/wars/korea/minewar.htm.

49. Unless otherwise indicated, information in this paragraph is derived from 林有成 [Lin Youcheng], “亿赴朝鲜西海岸清川江口布设水雷” [Recollection of Laying Sea Mines at the Qingquan River’s Mouth on Korea’s Western Seacoast], 军事历史 [Military History], no. 5 (2003), pp. 65–66. The seventeen soldiers from China’s Huadong Military Region were unsure of the depth at which their Soviet-manufactured moored buoyant mines should be laid and found that the methods suggested by their Soviet navy adviser were “inappropriate for immediate mission conditions.” They were forced to improvise, and in the process learned the value of basing their methods on actual conditions.

50. Srikanth Kondapalli, “China’s Naval Equipment Acquisition,” Strategic Analysis 23, no. 9 (December 1999).

51. Soviet guidance and assistance were secured by the February 1950 Treaty of Friendship, Alliance, and Mutual Assistance. The Chinese Communist Party launched its first Five-Year Plan for industrial and agricultural development and production in 1953. By soliciting extensive Soviet aid and focusing on the development of heavy industrial plants and equipment, China doubled its industrial capacity within five years and established a comprehensive, if rudimentary, military-industrial base. Soviet advisers were withdrawn in September 1960 following deterioration of the bilateral relationship.

52. Ling Xiang, “Raise Mighty Chinese Sea Mine Warfare Ships on the Sea,” p. 158.

53. Deng Liqun et al., eds., China Today: Defense Science and Technology (Beijing: National Defense Industry, 1993), vol. 1, p. 32.

54. 海林 [Hai Lin], “岛内军事利物利载防务专家预测—2010 台岛困死水雷阵:解放军水雷战战力评估” [Taiwan’s Own Military

Affairs Experts' Forecast: In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array: An Evaluation of the People's Liberation Army's Sea Mine Warfare Combat Strength],国际展望 [World Outlook], no. 9 (May 2005), p. 16.

55. Kondapalli, China's Naval Power, pp. 98–99.

56. Kondapalli, "China's Naval Equipment Acquisition."

57. Ling Xiang, "Raise Mighty Chinese Sea Mine Warfare Ships on the Sea," p. 159.

58. Kondapalli, China's Naval Power, pp. 98–99.

59.竹繁[Zhu Fan], "中国海军出国扫水雷" [China's Navy Goes Abroad to Sweep Mines], 炎黄春秋 [Yanhuang Chunqiu], no. 4 (1997), p. 35.

60. Preparation for "early war, big war, and all-out nuclear war" caused Mao to order roughly half of military production dispersed among a "Third Line" network in China's vast interior. This process, which occupied much of the 1960s and '70s and may have consumed as much as half of defense expenditures, dispersed scarce human and material resources and further challenged China's then-limited transportation infrastructure. The Cultural Revolution threw all but the most highly prioritized weapons programs into disarray, dividing bureaus into rival factions and even threatening rail links critical to the development of advanced weapons systems.

61. Ling Xiang, "Raise Mighty Chinese Sea Mine Warfare Ships on the Sea," pp. 154–55.

62. Qiang Zhai, China & the Vietnam Wars, 1950–1975 (Chapel Hill: Univ. of North Carolina Press, 2000), p. 203.

63. 蔡朋岑 [Cai Pengcen], "人民海军援越扫雷始末" [The People's Navy's Minesweeping Operations in Support of Vietnam from Beginning to End], 舰载武器[Shipborne Weapons] (March 2007), p. 34.

64. Zhu Fan, "China's Navy Goes Abroad to Sweep Mines," p. 35.

65. 雷冬 [Lei Dong], "中国海军扫雷纪实 (二):援越扫雷扬军威" [A Record of PLAN Minesweepers (Part 2): Helping Vietnam Raise Impressive Military Minesweeping Strength], 现代舰船[Modern Ships] (October 2004), pp. 32–34.

66. Cai Pengcen, "People's Navy's Minesweeping Operations in Support of Vietnam from Beginning to End," p. 34.

67. Zhu Fan, "China's Navy Goes Abroad to Sweep Mines," p. 37; Ling Xiang, "Raise Mighty Chinese Sea Mine Warfare Ships on the Sea," p. 155.

68. Information in this paragraph from Ling Xiang, "Raise Mighty Chinese Sea Mine Warfare Ships on the Sea," pp. 153–54, 160.

69. Ibid., p. 160.

70. Observations concerning hull 814 are derived from Lin Changsheng, “Hidden Dragon in the Deep,” p. 32.

71. Mikhail Barabanov, “Contemporary Military Shipbuilding in China,” Eksport Vooruzheniy, 1 August 2005, OSC CEP20050811949014.

72. “Chronicle of Events of Military Training,” Guangzhou Zhanshi Bao, 27 December 2005, pp. 1, 3, OSC CPP20060224318002.

73. Jane’s Fighting Ships, 9 February 2009, www.janes.com.

74. See post 38 of 1 March 2007 by “Xinhui” in the “PLAN Mine Warfare Threat” section of the China-Defense.com Forum, at www.china-defense.com.

75. George Pollitt, Johns Hopkins Applied Physics Laboratory mine warfare expert, e-mail exchange with authors, February 2009.

76. A zhidui (支队) is a division-leader level organization (using the PLA’s fifteen-grade structure, which is based on army terminology). The best English translation is “flotilla.” A dadui (..) is a regiment-leader level organization; the best English translation is “squadron” for naval vessels and “group” for PLAN aviation, coastal defense, marine corps, and maintenance troops. For a detailed explanation of these and related terms, see Office of Naval Intelligence, China’s Navy 2007, pp. 4–5.

77. 郑振麒,方立华 [Zheng Zhenqi and Fang Lihua], “反水雷作战淌出实战化训练新路—东海舰队某扫雷舰大队创造 4 项海军记录” [Anti-Mine Operations Set Out on a New Path of Training Made Realistic to Actual War: A Certain East Sea Fleet Minesweeper Squadron Sets Four Navy Records], 人民海军 [People’s Navy], 31 October 2008, p. 1.

78. Hai Lin, “In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array,” p. 18.

79. Lin Changsheng, “Hidden Dragon in the Deep,” p. 26.

80. Thomas R. Bernitt and Sam J. Tangredi, “Mine Warfare and Globalization: Low-Tech Warfare in a High-Tech World,” in Sam J. Tangredi, ed. Globalization and Maritime Power, (Washington, D.C.: National Defense Univ. Press, 2002), p. 395. The authors do not recognize that China has this weaponry.

81. See Bernard D. Cole, The Great Wall at Sea: China’s Navy Enters the Twenty-first Century (Annapolis, Md.: Naval Institute Press, 2001), p. 103, for the high estimate and “Naval Mine-Hunting Unit Featured,” Lien-Ho Pao, 20 April 1997, OSC FTS19970716000491, for the low. Both these guesses are now roughly a decade old.

82. Hai Lin, “In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array,” p. 16. For PRC research on remote-control sea mines, see

龙兴祖 [Long Xingzu], “遥控水雷及其在未来海战中的特殊作用” [Remote-Control Sea Mines and Their Use in Future Special Sea Warfare], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 1 (2000); 陈川 [Chen Chuan], “激光致声在水雷遥控中的应用研究” [The Sound-Sending Laser in Remote-Control Sea Mine Applied Research], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (1999).

83. 茹呈瑶 [Ru Chengyao], “水雷” [Sea Mine], in 陈德第, 李轴, 库桂生主编 [Chen Dedi, Li Zhou, and Ku Guisheng, chief eds.] 国防经济大辞典 [National Defense Economy Dictionary], (Beijing: 军事科学出版社 [Military Science], 2001), p. 906.

84. The depth limitations of Chinese mines are not known but are probably quite similar to those of Russian mines. The deepest waters in which most Russian bottom mines can be effectively laid range from fifty to two hundred meters. See Anthony Watts, “Russian Federation Underwater Weapons,” Jane’s Underwater Warfare Systems, 21 January 2005, www.janes.com.

85. Minesweepers can tow submerged cables with cutting devices attached. This apparatus, dragged through a suspected minefield, snags and severs the cables that attach the mines to their anchors. The Russian mine-manufacturing firm Gidropribor offers such sweeping mechanisms for sale; see its website, www.gidropribor.ru/eng/products/91/index.php4.

86. Chinese sources, including Lin Changsheng, “Hidden Dragon in the Deep,” also refer to a “701 Research Institute” (中国舰船研究院 701 研究所), likewise located in Yichang. Confusing the matter further, the most detailed article available on the Institute’s location calls it the “701 Research Institute” in English and the “710 Research Institute” in Chinese. See 刘见,张玮,齐小丹 [Liu Jian, Zhang Wei, and Qi Xiaodan], “中国船舶重工集团公司七一 O 研究院” [Plan and Building Design of CSIC-No.701] (original English title), 华中建筑 [Huazhong Architecture], no. 4 (2006). For an earlier reference to a “701 Institute,” see “七 O 一研究院引进计算器辅助设计系统” [701 Research Institute Introduces Computer-Aided Design System], 船海工程 [Ship and Ocean Engineering], no. 4 (1985). For purposes of clarity, this study uses the term “710 Research Institute” throughout.

87. The paragraphs on Piao-1 and -2 are derived primarily from Lin Changsheng, “Hidden Dragon in the Deep,” p. 24; and Wayne Mason, “Naval Mine Technologies,” (briefing, Mine Warfare Association Spring 2009 Regional Conference, Panama City, Fla., 19 May 2009).

88. Ibid.

89. Han Peng and Li Yucai, eds., Outline of Undersea Weaponry, pp. 137–42.

90. The video clip, originally at web.search.cctv.com, has been removed from the CCTV website. An image from the television footage has been posted on China Defense Forum at www.china-defense.com/forum/index .php?showtopic=160&st=75.

91. See Lin Changsheng, “Hidden Dragon in the Deep,” pp. 24–25.

92. The authors thank Professor Peter Dutton for these legal insights.

93. The following text is excerpted from 赵培英 [Zhao Peiying, ed.], 当代军人国际法基础 [Basis of International Law for Modern Soldiers], "全军军事科研工作'八五'计划列项课题" [Armywide Military Affairs Research Work Eighth Five-Year Plan Study Subject] (Beijing:解放军出版社 [PLA Press], 1996), pp. 258–59. "(2) Rules Regarding the Usage of Sea Mines and Torpedoes"At the beginning of the 20th century sea mines were widely used in naval warfare, posing an enormous threat to international shipping and the interests of neutral nations. Consequently, their use had come under the regulation of international law. According to the 1907 Hague Convention (VIII) relative to the Laying of Automatic Submarine Contact Mines, although it is impossible to forbid the employment of sea mines, it is nevertheless desirable to restrict and regulate their employment in order to mitigate the severity of war and to ensure the security of peaceful navigation in times of war. The Convention prohibited the laying of unanchored automatic contact mines, except when they were so constructed as to become harmless one hour at most after the person who laid them ceases to control them. It prohibited the laying of anchored automatic contact mines which did not become harmless as soon as they have broken loose from their moorings; or the use of torpedoes which did not become harmless when they have missed their mark. Likewise it was forbidden to lay automatic contact mines off the coast and ports of the enemy, with the sole object of intercepting commercial shipping. When anchored automatic contact mines were employed, every possible precaution must be taken for the security of peaceful shipping. Neutral Powers which laid automatic contact mines off their coasts must observe the same rules as were imposed on belligerents, and they must inform ship owners and the Governments where mines have been laid through the diplomatic channel. The belligerents were likewise obliged to notify ship owners of the danger zones should their mines cease to be under surveillance, as soon as military exigencies permitted. At the close of the war, the Contracting Powers were obliged to remove the mines which they have laid, each Power removing its own mines. At the time a total of 44 nations became signatories to the Convention, although during the two World Wars both sides employed sea mines on a massive scale, declaring danger zones all around the world, thereby seriously undermining the rules of the Convention."

94. See ibid. See also 刘进 [Liu Jin], "水雷使用中涉及的国际法" [The Involvement of International Law in Sea Mine Use], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 1 (2000); 夏立新 [Xia Lixin], "水雷和军备控制" [Sea Mines and Arms Control], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (2000).

95. Lin Changsheng, "Hidden Dragon in the Deep," pp. 22–23.

96. Rob Hewson, "Type 500 and 1000 Mines,Underwater Weapons," Jane's Air-Launched Weapons, www.janes.com. According to this source, these mines also have "eight operating modes, which are believed to be mixtures of fuze and logic settings to meet different operational or environmental conditions."

97. Ling Xiang, "Raise Mighty Chinese Sea Mine Warfare Ships on the Sea," pp. 154–55.

98. This has not always been the case. The first U.S. Destructor mines laid in Haiphong Harbor (simply converted gravity bombs detonated by magnetic signature change) were so sensitive, having been adjusted to destroy passing trucks when used against land targets, that a solar magnetic storm detonated the entire field prematurely. Hartmann with Truver, Weapons That Wait, pp. 72–80, 244.

99. Ibid., pp. 72–80, 129.

100. Lin Changsheng, “Hidden Dragon in the Deep,” p. 24.

101. As implied in note 84 above, the very deepest that any of the very large Russian bottom influence mines can be laid is two hundred meters. Seventy meters is the maximum depth for the smaller Russian bottom mines. See Watts, “Russian Federation Underwater Weapons.”

102. See, for example, 王伟,郭大江 [Wang Wei and Guo Dajiang], “基底频摇控 水雷全向数字接收机的研究” [Research on All-Around Digital Receiver for Very Low Frequency Remote-Controlled Naval Mines], 现代电子技术 [Modern Electronics Technology] (December 2007), pp. 1–3.

103. See U.S. Defense Dept., Future Military Capabilities and Strategy of the People’s Republic of China (Washington, D.C.: November 1998), p. 14, available at www.fas.org/news/china/.

104. U.S. Defense Dept., Annual Report on the Military Power of the People’s Republic of China (Washington, D.C.: June 2000), p. 16, available at www.defenselink.mil/.

105. 肖敏 [Xiao Min],西北工业大学,交通运输规划与管理[Northwest Polytechnic University, Communications and Transportation Planning and Management], “主动攻击水雷鲁棒控制和仿真研究” [Research on Robust Control for Initiative Attack Mine and Simulation] (master’s thesis, 9 June 2006); 肖敏,史忠科 [Xiao Min and Shi Zhongke], 三峡大学, 西北工业大学[Three Gorges University, Northwest Polytechnic University], “主动攻击水雷鲁棒跟踪控制研究” [Research on the Tracking and Robust Control of Initiative Attack Sea Mines], in 中国航空学会控制与应用第十二届学术年会论文集, 2006 . [The Collected Works of the China Aviation Institute’s Twelfth Annual Academic Meeting on Control and Applications, 2006].

106. Lin Changsheng, “Hidden Dragon in the Deep,” p. 27.

107. Watts, “Russian Federation Underwater Weapons.” Gidropribor more modestly claims a maximum depth of one thousand meters for its PMR-2 rising torpedo mine and for its PMR-2E rising rocket mine. See www.gidropribor.ru/eng/products.php4.

108. See Richard Fisher, “Chinese Notes from AeroIndia and IDEX,” International Assessment and Strategy Center, 28 February 2005, www.strategycenter.net/.

109. Samuel Morison, Guide to Naval Mine Warfare (Arlington, Va.: Pasha, 1995), pp. 88–89.

110. Rob Hewson, “EM 52 Mine, Underwater Weapons,” Jane’s Air-Launched Weapons, 14 April 2005, www.janes.com. This depth is probably a significant understatement of the true maximum operating depth, since a two-hundred-meter depth would severely limit its versatility and usefulness.

111. Lin Changsheng, “Hidden Dragon in the Deep,” p. 26.

112. Ibid.

113. Ibid., p. 28.

114. U.S. Navy Dept., U.S. Naval Mine Warfare Plan, 4th ed. (Washington, D.C.: 2000). See also 李宝祥 [Li Baoxiang], “俄罗斯水雷武器的现状和未来” [The Present Situation and Future of Russian Sea Mine Weapons], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 1 (1999).

115. “俄罗斯:世界上的‘水雷王国’” [Russia: The World’s Sea Mine Kingdom], “外国海军纵横” [Foreign Navy Crisscross], 当代海军 [Modern Navy], no. 6 (2003).

116. 傅金祝[Fu Jinzhu], “俄罗斯的火箭上浮水雷” [Russia’s Rocket Rising Sea Mines], 舰载武器[Shipborne Weapons] (April 2004), p. 65.

117. 焦方金 [Jiao Fangjin], “双头鹰的水中伏兵” [The Double-Headed Eagle’s Ambush at Sea], 国防科技 [Defense Science] (July 2003), p. 90.

118. Ibid.

119. See, for example, ibid.

120. 郑宇 [Zou Zi], “芬兰潜艇:装备与作战历史” [Finnish Submarines: Equipment and Fighting History],国际展望 [World Outlook], no. 490 (May 2004), p. 56.

121. Jiao Fangjin, “Double-Headed Eagle’s Ambush at Sea,” p. 91.

122. This quote and the remainder of this paragraph are drawn from 李克峰 [Li Kefeng], “俄罗斯火箭上浮水雷” [Russian Rocket Rising Sea Mines], 舰船知识[Naval and Merchant Ships] (October 2002), pp. 34–36.

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167. See, for example, 郑洋 [Zou Yang], 哈尔滨工程大学, 信号与信息处理[Harbin Engineering University, Signals and Information Processing], “水雷目标识别信号融合方法研究” [Research on Methods of Information Fusing for Mine Recognition] (master’s thesis, 21 August 2007); 陈萍 [Chen Ping], 哈尔滨工程大学,信号与信息处理 [Harbin Engineering University, Signals and Information Processing], “分数阶 Fourier 变换在水雷目标特征提取中的应用” [The Application of the Fractional Fourier Transform in the Extraction of Mine Characteristics] (master’s thesis, 21 August 2007); 迟慧广 [Chi Huiguang], 哈尔滨工程大学,水声工程 [Harbin Engineering University, Acoustical Engineering], “希尔伯特—黄变换在水雷目标特征提取中的应用” [The Application of the Hilbert-Huang Transform in the Extraction of Mine Characteristics] (master’s thesis, 21 August 2007); 于妮娜 [Yu Ninuo], 哈尔滨工程大学,通信与信息系统[Harbin Engineering University, Communication and Information Systems], “基于支持向量机的水雷目标识别研究” [Research on the Mine Target Recognition Based on Support Vector Machines] (master’s thesis, 2007); 郭丽华,王大成,丁士祈 [Guo Lihua, Wang Dacheng, and Ding Shiqi], “水下目标特征提取方法研究” [Research Concerning the Extraction of Underwater Targets’ Features], 声学技术 [Technical Acoustics] 24, no. 3 (September 2005), pp. 148–51, 156; 郭丽华,王大成,丁士祈[Guo Lihua, Wang Dacheng, and Ding Shiqi], “水雷目标识别中的数据融合技术” [Data Fusion Technology for Recognition of Mine Characteristics], 海洋技术 [Ocean Technology] 24, no. 2 (June 2005), pp. 36–38, 45.

168. 赵祚德 [Zhao Zuode], “基于概率推断网的水雷战专家系统” [An Expert System for Mine Warfare Based on a Probabilistic Inference Network], 情报指挥控制系统与仿真技术 [Information Command Control Systems and Simulation Technology] 27, no. 2 (April 2005), pp. 52–56.

169. 缪涛,张志宏 ,顾建农 [Miao Tao, Zhang Zhihong, and Gu Jiannong],海军工程大学理学院[College of Science, Naval University of Engineering, Wuhan], “浅水低速舰船通过雷区危险航速的预报模型” [Forecast Model of Dangerous Speed When Ships Pass a Mine Area in Shallow Water at Low Speed], 舰船科学技术 [Ship Science and Technology], no. 5 (2008).

170. Han Peng and Li Yucai, eds., Outline of Undersea Weaponry, p. 4.

171. Jiao Fangjin, “Double-Headed Eagle’s Ambush at Sea,” p. 91.

172. Wang Wei, “Enduring and Yet Fully Relevant,” p. 58.

173. Chen Dongyuan, “The Mysterious Underwater Sentry,” p. 45.

174.刘衍中,李祥 [Liu Yanzhong and Li Xiang], “实施智能攻击的现代水雷” [Carrying Out Intelligent Attacks with Modern Mines], 当代海军[Modern Navy] (July 2006), p. 29.

175. 沈国光,李德袀,李润珊,王继红 [Shen Guoguang, Li Deyun, and Wang Jihong], "大当量爆炸兴波的数值模拟" [A Mathematical Simulation of a Wave from a Large Explosion],海洋学报 [Acta Oceanologica Sinica] (September 1996), pp. 128–33.

176. Some European countries have reportedly fielded sea mines with antiaircraft capabilities, and the United States has apparently conducted research in this area as well.

177. Wang Wei, "Enduring and Yet Fully Relevant," p. 59. This capability is also hinted at in the introduction of Han Peng and Li Yucai, eds., Outline of Undersea Weaponry, p. 1.

178. Wang Wei, "Enduring and Yet Fully Relevant," p. 59.

179. Lin Changsheng, "Hidden Dragon in the Deep," p. 28.

180. Han Peng and Li Yucai, eds., Outline of Undersea Weaponry, p. 155.

181. Ibid., p. 29.

182. 李宝祥, 董大群[Li Baoxiang and Dong Daqun], "导弹水雷" [Guided Missile Sea Mines], in 荣恩杰 [Luan Enjie, chief ed.],国防科技名词辞典:船舶 [National Defense Science & Technology Phrase Dictionary: Shipping] (Beijing: 航空工业出版社/兵器工业出版社/原子能出版社 [Aviation Industry Press/Weapons Industry/Atomic Energy], 2002), p. 78.

183. One article states that the system would use a thousand bottom mines—with sonar, magnetic, or pressure fuses—in six salvoes from twenty-eight launchers to blockade a port in three hours. Hai Lin, "In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array," p. 18. China has over three decades of experience with relatively simple, shorter-range rocket deployment of the smaller types of land mines and has developed advanced multiple-launch rocket systems (MLRSs).沙兆军 [Sha Zhaojun],炮兵学院南京分院[Nanjing Artillery Academy], "火箭布雷弹抛撒均匀性评定模型及仿真研究" [Rocket Minelaying Bomb Distribution Assessment Model and Simulation Study], in ed. 陈宗海 [Chen Zonghai], 2007 系统仿真技术及其应用学术会议论文集 [The Collected Works of the 2007 Systems Emulation Technology and Applications Science Conference], 高云飞,李小燕 ,王宁 [Gao Yunfei, Li Xiaoyan, and Wang Ning],解放军理工大学工程兵工程学院 [Engineering Corps Institute, PLA University of Science and Technology, Nanjing], "蒙特卡罗法在火箭布雷中的应用" [The Application of the Monte Carlo Method in Rocket Minelaying], in 陈光亚 [Chen Guangya, ed.],科学发展观与系统工程—中国系统工程学会第十四届学术年会论文集, 2006 . [Scientific Outlook on Development and Systems Engineering: Proceedings of the 14th Annual Conference of Systems Engineering Society of China, 2006],兰宁远[Lan Ningyuan], "'现代雷神'李创 " [Li Zhao, "The Modern Mine God"], 海内与海外[At Home and Overseas], no. 11 (2004); "中国 74 式布雷火箭系统" [China's Type 74 Minelaying Rocket System], 现代兵器 [Modern Weapons], no. 11 (1998); 田思明,申小健 ,陈振有 [Tian Siming, Shen Xiaojian, and Chen Zhenyou; Resident Military Representative Roon in 743 Factory, Taiyuan], "122 mm 火箭布雷系统训练仿真弹结构设计" [Structure Design of 122 mm Rocket Minelaying System Practice Simulation Projectile], 弹箭技术 [Rocket Technology], no. 2 (1997); "火箭布雷车" [Rocket Minelaying Truck], "火箭布雷" [Rocket Minelaying], in Modern Soldier Dictionary, chief ed. Xiong Wuyi, pp. 379, 383–84. Chinese MLRSs include the China Academy of Launch Vehicle Technology's A-100 300 mm, ten-tube variant, which is similar to Russia's Smerch 9K58 300 mm

rocket system. For recent research, see 王锋 [Wang Feng],南京理工大学,兵器发射理论与技术 [Nanjing University of Technology and Engineering, Weapons Launch Theory and Technology], "舰载多功能火箭炮系统分析与研究" [Systems Analysis and Research on Shipborne Multifunction Rocket Launchers] (PhD dissertation, 21 November 2007). A student at Nanjing University of Science and Technology, who has received guidance from a PLA unit and an expert on missiles and submunitions, has conducted research and testing of a rudimentary canister holding two mine-sized objects, which are released one at a time so their trajectories can be observed.江宏寿 [Jiang Hongshou], 南京理工大学[Nanjing University of Science and Technology], 兵器发射理论与技术 [Weapons Launch Theory and Technology Discipline], "空投水雷抛撒过程数值仿真与实验研究" [Numerical Simulation and Experiment Study of Mine Throwing] (master's thesis, 6 December 2006). For an article that "puts forward two rocket launchers, a firing switchimplementation mechanism, and technical means" (提出了两座火箭发射装置实现调转发射的机理与技术途径), see 燕飞,周晓明 [Yan Fei and Zhou Xiaoming], 中国船舶重工集团公司第七一 O 研究所[710 Research Institute, CSIC], "火箭炮交替调转发射的机理与实现" [Alternating Reverse Rocket-Launch Mechanism and Implementation], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 1 (2006).

184. A major flaw in Michael Glosny's analysis is his dismissal of the use of all but East Sea Fleet submarines in a Taiwan-blockade MIW scenario. Why would China invest time and resources in practicing with platforms that it did not intend to use?

185. Lin Changsheng, "Hidden Dragon in the Deep," p. 32.

186. As a textbook elaborates, "When employing surface vessels to lay mines, they maneuver slowly, passage requires a long time, and they tend to expose the goal of the operations. . . . Only beyond the range of the opponent's main coastal firepower and with cover from strong naval and airborne forces is it possible to fully utilize [their] advantages . . . such as the ability to carry large quantities of mines, the ability to lay out a long string of mines, accurate positioning of mines, the ability to deploy a tight, large area of mines and obstructions, and the ability to deploy multiple types of mines." "174. How Does One Determine the Main Attack Targets in a Naval Base Defense Campaign?" in Bi Xinglin, ed., Campaign Theory Study Guide.

187. Ren Daonan, "Submarine Minelaying," p. 26. See also 刘定平[Liu Dingping], "水雷在战场上的运用" [The Use of Sea Mines in Battle], 现代兵器[Modern Weapons], no. 3 (2002).

188. Ren Daonan, "Submarine Minelaying," p. 26. Ren adds that submarine-laid mines can "baffle the enemy, and thus achieve exceptional combat results."

189. Unless otherwise specified, information in this paragraph is from Hai Lin, "In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array," pp. 17, 18.

190. Ibid., p. 16.

191. Lin Changsheng, "Hidden Dragon in the Deep," p. 33. Another source notes, however, that "submarines built after World War II rarely carry mines externally." See "潜艇布雷" [Submarine Minelaying], 现代舰船[Modern Ships] (July 2002), p. 44.

192. Ying Nan, “Goals of Offensive Minelaying Discussed,” Jianchuan Zhishi [Naval Merchant Ships], no. 241 (September 1999), pp. 10–11, OSC FTS19991022001765.

193. Lin Changsheng, “Hidden Dragon in the Deep,” p. 33.

194. Hai Lin, “In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array,” p. 16.

195. “32. How to Conduct Barrier Blockade Combat?” in “II. Blockade Campaign,” in Bi Xinglin, ed., Campaign Theory Study Guide.

196. Ibid., p. 16; Lin Changsheng, “Hidden Dragon in the Deep,” p. 33.

197. This estimate is based on the nine-thousand-kilogram internal payload capacity of the H-6 as reported in “H-6 Bomber,” Sinodefence.com. The estimate of one hundred H-6 aircraft is from “China, Armed Forces,” Jane’s Sentinel Security Assessment: China and Northeast Asia, 12 July 2005, www.janes.com.

198. “Military Report,” CCTV-7, 12 January 2009, OSC CPM20090304013025.

199. The payload capacity is based on study of Internet photos.

200. 计生文,姜毅,王松涛 [Ji Shengwen, Jiang Yi, and Wang Songtao], “金戈铁甲啸海疆—回眸改革开放以来海军装备建设成就” [Steel Weapons, Armor Roar through the Coastal Areas and Territorial Seas: Looking Back at the Achievements in the PLA Navy’s Equipment Effort since the Beginning of Reforms and Opening Up], 人民海军 [People’s Navy], 6 October 2008, p. 1.

201. China’s seventy-six SU-30MKK fighters could conceivably carry several mines, since they are designed to carry Russian free-fall bombs. However, it is unlikely that such a high-value platform (e.g., fourth-generation aircraft) would be used in this role when less sophisticated aircraft would suffice. PLA Navy aviation force J-8s (numbering approximately fifty) and Q-5s (approximately thirty) could also conceivably perform the MIW mission, as could the two hundred obsolete, and even expendable, PLA Navy aviation force J-6s. If the PLA Air Force (PLAAF) assumes the MIW mission, it will have many more candidate platforms, including J-7s (620), J-8s (184), Q-5s (300), and J-6s (350). But if the objective of aerial mining is the quick placement of large numbers of weapons, platforms that carry significant numbers of mines make much more sense than larger numbers of planes that carry only one or two each.

202. Hai Lin, “In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array,” p. 17.

203. Yao Jun, ed.,中国航空史 [A History of China’s Aviation] (Zhengzhou: Dajia, September 1998), pp. 183–89.

204. See Ying Nan, “Goals of Offensive Minelaying Discussed.”

205. Min Zengfu, “A Glimpse at 21st-Century Air Combat,” Zhongguo Junshi Kexue [China Military Science], 20 February 1995, OSC

FTS19950220000008.

206. See, for example, the detailed operational parameters suggested in Yu Hanyu, “An Evaluation of Minelaying by Aircraft.” See also the analysis of the effects of parachute drag on the trajectory of a mine dropped from a plane in He Jieying, “Study on the Flight Path of Mine Parachutes,” pp. 545–50, and Gao Daquan, “The Application of ‘Space Recovery Technology’ in Armaments,” pp. 16–20.

207. “Report on Role of China’s Naval Air Force,” “China Today” program, CCTV-9, 2300 GMT, 22 April 2009, OSC CPM20090423017042.

208. 刘文平,孙樱,李斌富[Liu Wenping, Sun Ying, and Li Binfu], “叱咤海天 30 载与满清武报国志;填补空白 18 项痴心反潜为打赢;北航某舰载机团反潜战术主任赵树民—堪称‘航空反潜先锋’” [Thirty Years of Commanding the Sea and the Sky Filled with a Determination of Serving the Country with Superb Military Skills; Filling in Eighteen Voids by Focusing Whole-Heartedly on Winning in Antisubmarine Warfare; Zhao Shumin, Antisubmarine Tactical Director of an Unidentified Ship-Board Aircraft Regiment of North Sea Fleet Aviation Force: Worthy of Being Called an “Aviation Antisubmarine Pioneer”], 人民海军 [People’s Navy], 16 December 2008, p. 1.

209. The Russian series of AMD bottom mines, in production since the late 1950s, is designed to be delivered by air and is believed to have been exported to, and copied by, China. See Watts, “Russian Federation Underwater Weapons,” and Hewson, “Type 500 and 1000 Mines.” Gidropribor’s MDM-2 bottom influence mine and PMR-2 rising influence mine are both designed to be delivered by aircraft. See www.gidropribor.ru/eng/products.php4.

210. Lin Changsheng, “Hidden Dragon in the Deep,” p. 32.

211. “32. How to Conduct Barrier Blockade Combat?”

212. “182. What Force Groups are Usually Assembled in a Naval Blockade Campaign?” in “XI. Naval Blockade Campaign,” in Bi Xinglin, ed., Campaign Theory Study Guide.

213.荣森芝,烟台警备区副司令员[Rong Senzhi, Deputy Commander, Yantai Garrison District], “构筑海上民兵民船,建用分级保障体系 ” [Construct a Civilian-Ship-Based Sea Militia, Build and Employ Support System with Different Levels],”国防[National Defense], 15 September 2003, p. 42.

214. Information Office of the State Council, People’s Republic of China, “China’s National Defense in 2008,” pp. 50–51. This is introduced by Chen Zhou, one of the drafters, as new information. Bai Ruixue, Wang Jingguo, and Xiong Zhengyan, “(Interpreting White Paper on National Defense) Focus the First Time in the New White Paper on National Defense,” Xinhua, 20 January 2009, **OSC CPP20090120172004.**

215. Hai Lin, “In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array,” p. 18.

216. Zhang Yuliang, Yu Shusheng, and Zhou Xiaopeng, Science of Campaigns, chap. 13. More forceful advocacy appears in "148. During a Sea Transportation Defense Campaign, How Does One Rely on Island Shores and Comprehensively Employ Various Forces to Ensure the Safety of Transportation Lines on Nearby Shores?" "VI. Naval Shipping Protection Campaigns," in Bi Xinglin, ed., Campaign Theory Study Guide.

217. "Military Report," CCTV-7, 1130 GMT, 19 October 2008, OSC CPP20081019091002.

218.查春明,王秋阳[Zha Chunming and Wang Qiuyang], "海军某基地 民兵海上训练纪实" [An On-the-Spot Report of a People's Militia Sea Drill at a Certain Navy Base],舰船知识 [Naval and Merchant Ships], no. 3 (5 February 2005), p. 4.

219. Ying Nan, "Goals of Offensive Minelaying Discussed," pp. 10–11.

220. Ibid.

221. Hai Lin, "In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array," p. 18.

222.李杰[Li Jie], "新秀闪亮水下战场" [A New Harvest of Weapons for the Undersea Battlefield],中国民兵 [China Militia] (May 2008).

223. Jia Yeliang and Guo Yike, "A Para-Naval Force from among the People: Civilian Ships," Dangdai Haijun [Modern Navy] (February 2004), pp. 46–47, OSC CPP20041102000199.

224. The concept of "People's War at Sea" has been endorsed by recently retired Major General Peng Guangqian—who has served as a research fellow at China's Academy of Military Sciences and who, as an adviser to China's powerful Central Military Commission (CMC) and Politburo Standing Committee, has enjoyed significant influence in the shaping of PLA strategy. See Peng Guangqian and Yao Youzhi, eds., The Science of Military Strategy (Beijing: Military Science, 2005), p. 456.

225. Indeed, the PLA has outfitted sea mines for use in sub-laying and air-dropping training. These include the Xun-1 submarine-laid deep-bottom sea mine and the Model 500 air-laid deep-bottom sea mine. Xun-1's distinguishing feature is its ability to utilize a fuse from either C-1, C-2, or C-3 to mimic those mines in exercises. Ling Xiang, "Raise Mighty Chinese Sea Mine Warfare Ships on the Sea," p. 156.

226. Cole, Great Wall at Sea, p. 156.

227. See, for example, 李建生[Li Jiansheng], "考核内容,海域,程序不,予提前通报:某扫雷舰大队训练考核从严从难" [The Content, Sea Area, and Procedures of the Proficiency Assessment Will Not Be Revealed in Advance: A Certain Minesweeper Squadron's Exercises Assesses Training in a Strict and Difficult Manner], 人民海军 [People's Navy], 10 November 2006, p. 1; 张建,李德,张军红 [Zhang Jian, Li De, and Zhang Hongjun], "突围,不按'规则'出牌—北海舰队某型舰艇布雷演练目击记" [To Break Out of Encirclement, Don't Play Cards according to the "Rules": An Eyewitness Report of a Minelaying Drill by a Certain Type of North Sea Fleet Submarine], 人民海军 [People's Navy], 18 October 2006, p. 1; and 曹明,陈建族 [Cao Ming and Chen Jianzu], "某扫雷舰大队:战场逼真火药味浓," [A

Certain Minesweeping Unit: A Realistic Battlefield with a Strong Smell of Gunpowder], 人民海军 [People's Navy], 18 February 2003, p. 2.

228.奏泗敬,徐红明,余子富 [Zou Qinjing, Xu Hongming, and Yu Zifu], "马立新:大洋深处走蛟龙" [Ma Lixin: The Dragon Cruises the Ocean Depths], 人民海军 [People's Navy], 5 February 2005, pp. 1, 3.

229. Kondapalli, China's Naval Power, p. 142;张罗山,向延波,彭赳 [Zhang Luocan, Xiang Yanbo, and Peng Jiu], "某支队新艇首射水雷 3 发 3 中" [A Certain Flotilla's New (Submarine) Boat Launched Sea Mines for the First Time: Three Shots, Three Bullseyes], 人民海军 [People's Navy], 17 April 2006, p. 1.

230.徐红明,刘新民,邱智勇[Xu Hongming, Liu Xinmin, and Qiu Zhiyong], "既练 '攻击术'又训'隐身法':东海舰队某潜艇支队能打能藏设有'软肋'" [Train in Both "Attack Techniques" and "Concealment Methods": A Certain East Fleet Submarine Detachment Can Attack and Hide without "Weak Spots"], 人民海军 [People's Navy], 9 November 2002, p. 3; 李兵,向延波[Li Bing, Xiang Yanbo], "3 月下旬,南海舰队某潜艇支队军港保障大队利用潜艇训练时机. . ." [During the Last 10 Days of March, A Certain South Sea Fleet Submarine Flotilla Port Support Squadron Seized an Opportune Moment to Carry Out Exercises . . .], 人民海军 [People's Navy], 21 April 2006, p. 1.

231.刘荣华,龙运河,钟魁润 [Liu Ronghua, Long Yunhe, and Zhong Kuirun], "中华第一是官方阵" [China's First Petty Officers Take Position], 人民海军 [People's Navy], 9 April 2002, p. 2.

232. 特约通讯员 闾勇政[Lu Yongzheng], "某潜艇支队 临战处置能力大幅跃升" [A Certain Submarine Detachment Makes a Great Leap in Battle Management Capability], 人民海军 [People's Navy], 31 October 2002, p. 2.

233.张罗山 [Zhang Luocan], "案港教练室攻难关:某潜艇支队长魏学义" [Littoral Port Training Room Attacks Difficulty: A Certain Submarine Detachment Exercises], 人民海军 [People's Navy], 23 March 2002, p. 1.

234.桂平电,吴中秋,唐幸芳,郝跃民 [Gui Pingdian, Wu Zhongqiu, Tang Xingfang, and He Yuemin], "海军航空兵:高难科目励新招" [Navy Airmen: High, Difficult Subjects Sharpen New Recruits], 人民海军 [People's Navy], 8 August 2002, p. 2.

235.孙施伟,金伟,张罗山 [Sun Shiwei, Jin Wei, and Zhang Luocan], "既能'一剑封喉'又能'金蝉脱壳,'某潜艇支队训练讲求攻防兼备" [Can Already Both "Seal the Throat with One Sword" and "Escape by Cunning Maneuvering": A Certain Submarine Unit's Training Stressing Both Attack and Defense], 人民海军 [People's Navy], 20 July 2002, p. 1. Col. Lo Ch'eng-lieh, Air Force Academy, "The Chinese Communist Military Revolution and Inherent Threat," Kuo Hun, 1 April 1999, pp. 42–45, OSC FTS19990627000936.

236.虞章才[Yu Zhangcai et al.], "怒海练剑—探寻某潜艇支队 315 艇艇长蔡一清谋打赢之路" [Forge Swordsmanship in the Raging Sea: A Look at How Captain Cai Yiqing of Submarine 315, Subordinate to a Certain Submarine Flotilla of the North Sea Fleet, Sought the Path to Winning Victory], 人民海军 [People's Navy], 22 February 2008, p. 1; 魏垂高,李德,闾勇政 [Wei Chuigao, Li De, and Lu Yongzheng], "358 艇艇长代胜杰—胸怀韬略,驾艇淌过封锁线" [Dai Shengjie, Captain of Submarine 358: A Strategy That Is Hidden Within; Driving a Submarine through a Blockade], 人民海军 [People's Navy], 24 August 2007, p. 2; 江山, 闾勇政[Jiang Shan and Lu Yongzheng], "走出

浅滩浅入远海练蛟龙—某潜艇支队坚持训战一致苦练真打本领" [Away from Shallow Waters and into the Distant Sea to Train the Dragon: A Certain Submarine Flotilla Persists in Training-Operation Integration to Practice and Cast Real Capabilities Painstakingly], 人民海军 [People's Navy], 1 May 2006, p. 1.

237. 徐红明, 刘新民[Xu Hongming and Liu Xinmin], "'敌后'布雷—中国海军某潜艇突破反潜编队训练目击记" [Lay Mines "in the Enemy's Rear Area": An Eyewitness Account of a Certain PLAN Submarine Exercise involving Breaking Through Antisubmarine Formations], 当代海军[Modern Navy], no. 4 (2003), p. 38; Liu Xinmin and Xu Hongming, "Firsthand Experience with Submarine Minelaying," pp. 6–7.

238. Ying Nan, "Goals of Offensive Minelaying Discussed," pp. 10–11.

239.刘剑 [Liu Jian], "潜艇学院突出复杂和应急条件下的教学训练—课堂项训练场靠拢,教员向战斗员转换" [Submarine Academy Emphasizes Teaching and Training under Complex and Emergency Conditions: Classroom Moves to the Training Ground; Instructors Switch with Warriors], 人民海军 [People's Navy], 15 December 2006, p. 1.

240. Ch'i Le-yi, "Chinese Communists Conspicuously Increase Military Intelligence Gathering on Taiwan," Chung-Kuo Shih-Pao, 28 May 2002, OSC CPP20030528000033; Zhang Luocan, "Littoral Port Training Room Attacks Difficulty," p. 1.

241. Lu Yongzheng and Zhang Qingzhou, "A Certain North Sea Fleet Submarine Flotilla Discards 12 Impractical Combat Methods," p. 3.

242. Kondapalli, China's Naval Power, p. 143.

243. "PLA Navy Captain Ma Lixin Leads Drill Using New-Type Submarine," CCTV-1, 27 February 2005, OSC CPP20050302000014.

244. Zou Qinjing, Xu Hongming, and Yu Zifu, "Ma Lixin," pp. 1, 3.

245. See, for example,李伟,钱学东,王桂芹[Li Wei, Qian Xuedong, and Wang Guiqin], "面向多对象的水雷保险器综合参数测试仪研究与设计" [Study and Design on Multi-Objective-Oriented Mine Safety Device Comprehensive Parameter Testing Instrument], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (2008); and 秦锋,逄洪照 [Qin Feng and Pang Hongzhao], "基于第二类拉格朗日方程的水雷内未弹道仿真" [Simulation of Interior Trajectory Termina for Sea Mines Based on the Second Lagrange Formulation], 鱼雷技术 [Torpedo Technology] (May 2008).

246. "Submarine Minelaying" (July 2002), p. 44. A translation of this article has been produced by Gabriel Collins.

247. Zhang Luocan, Xiang Yanbo, and Peng Jiu, "A Certain Flotilla's New (Submarine) Boat Launched Sea Mines for the First Time: Three Shots, Three Bullseyes," p. 1. Three mines reached the "furthest distance" (最远航行距离) and their "dispersion error" (散步误差) was "completely within the pre-determined scope" (预设范围之内). Because this type of mine was "very technical" (科技含量高), because the mines were to be "fired a long distance" (射程远), and because it was the new type of submarine's first time carrying out the "furthest

distance test launch" (最远距离试射), the crew members had to meet very high requirements. Also on submarine mine testing, see 高春占, 肖德伦 [Gao Chunzhan and Xiao Delun], "试验场腾起烽火硝烟—海军某试验区瞄准未来战场鉴定某新型装备纪实;科学发展现在海疆:使命,责任"[Flames of War and Smoke of Gunpowder Erupt on Testing Ground: A Certain Navy Test Base Evaluates New Armaments with View to Future Battlefield; Scientific Development Concept on the Coastal Seas and Territorial Waters: Mission and Duty], 人民海军 [People's Navy], 30 January 2008, p. 1.

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261. Wang Guangxin and Chen Yijing, "On the Scene in the East China Sea," pp. 5–6.

262. As identified in Du Wenlong, "Look for Militia around You," Bingqi Zhishi [Weapons Knowledge] (April 2008), pp. 26–27, OSC CPP20080728436001.

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264. "Military Report," CCTV-7, 1130 GMT, 26 July 2008, OSC CPP20080727091001.

265.汪鲁迅,李建生[Wang Luxun and Li Jiansheng],"海军预备役部队首次成建制海上训练" [The Navy Prepares the First Reserve Unit to Conduct At-Sea Training as an Organization], 人民海军 [People's Navy], 17 July 2006, p. 1. According to the reserve minesweeper squadron's Political Commisar, Dong Huasen (董华森), more than 95 percent of the reserve officers participating in the training "came from Party and government organizations" (来自党政机关), 30 percent were former "military members converted to cadre status" (军转干部), and 80 percent were party members. The East Sea Fleet party committee assigned a full quota of "active duty cadres/officers" (现役干部). Responsible organizations, including the "city Party Committee Organization Department and the transportation and fisheries departments in the city where [the unit] was stationed" (驻地市委组织,交通,渔业部门), along with the "Military Sub-District" (军分区) and a "ship squadron(s)" (舰艇大队), adopted the "area of jurisdiction authorization and allocation method" (属地编配方法) to requisition ships in advance. Funding came from the public finance budgets of the city and the "county" (县) and "district" (区). To create at-sea operational capability as quickly as possible and manage the contradiction between production and training, in early 2006, the reserve squadron's party committee decided to conduct training at the same time as fishing. It developed a full understanding of fishing status before the reserve unit was formed. Itpaid attention to each boat's fishing goals and set training activities rationally. It used the time when the fishing boats were going out to sea and returning as opportunities to conduct training in driving the vessel and in mechanical and electrical maintenance. It used times when fishing boats were assembling and putting to sea as opportunities to conduct training in assembling, forming up for a voyage, and changing formation. In 2006, the squadron arranged for more than two hundred reserve officers and enlisted personnel to go aboard a minesweeper in groups for training. Standardized training corrected the reservists' peacetime tendency to rely on their senses and experience and got them in the habit of plotting courses as required, keeping a voyage log, and plotting course-change points.

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322. See, for example, Shen You, “Ten Reflections on Naval Equipment Deployed in the Gulf War,” p. 10.

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337. Niu Rong and Sun Fei, “Chinese Navy’s Type 918 Minelaying Ship,” p. 11.

338. Fu Jinzhu, “What Explains the Failure of Iraq’s Mines?” p. 45.

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340. Zhang Yuliang, Yu Shusheng, and Zhou Xiaopeng, Science of Campaigns, chap. 12.

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342. Ying Nan, “Goals of Offensive Minelaying Discussed,” pp. 10–11.

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347. Wang Guangxin and Chen Yijing, “On the Scene in the East China Sea,” pp. 5–6.

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381.王冰川,王亚军 [Wang Bingchuan and Wang Yajun], "贴近实战演练,盯着问题完善—北海舰队某保障基地 30 余种新战法推向演兵场" [Conducting Exercises That Closely Approximate to Actual Combat, Perfecting Combat Methods by Focusing on Problems—A North Sea Fleet Support Base Puts Some 30 New Combat Methods to Use on the Exercise Field], 人民海军 [People's Navy], 3 June 2008, p. 2.

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384. See, for example, Arnold S. Lott, Most Dangerous Sea (Annapolis, Md.: Naval Institute Press, 1959), p. 77. Zhang Yuliang, Yu Shusheng, and Zhou Xiaopeng, Science of Campaigns, chap. 12, demonstrate an understanding of this crucial problem, noting that "one must conduct close monitoring of our own mine obstacles that have been dispositioned."

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387.孙涛[Sun Tao], "某大队研制水雷内部记录仪" [A Certain Unit Develops a Sea Mine Interior Recording Instrument], 人民海军 [People's Navy], 4 December 2004, p. 1.

388. See Fifi Kieschnick, Naval Station Ingleside Public Affairs, "Mine Warfare 'Shifts Colors' to Southern California," Pentagon Brief, pentagonbrief.wordpress.com/2008/12/28/mine-warfare-shifts -colors-to-southern-california/. Four U.S. mine countermeasure ships are now based in Bahrain. See MCM and MSC links at the new Naval Mine and Anti-Submarine Warfare Command, http://www.nmawc.navy.mil.

389. These two mine countermeasures helicopter squadrons, located in Virginia Beach, Virginia, and in Ingleside, Texas, each have ten aircraft.

390. The textbook adds: "When the enemy unfolds minesweeping and barrier clearing forces, campaign commanders shall organize mobile forces from the Navy and Air Force operating groups, coastal missile and coastal artillery forces, and far-range artillery troops to seize the favorable opportunity to resolutely launch attack when the enemy ships towing minesweeping tools are blocked by barriers and are not easy to maneuver. The best time to attack the enemy minesweeping helicopter carrier and minesweeping hovercraft carrier is when the enemy enters our inshore sea and when the minesweeping helicopters and minesweeping hovercraft have not yet left the carrier." Bi Xinglin, ed., Campaign Theory Study Guide, pp. 448–49.

391. See U.S. Navy Mine Warfare Plan, 4th ed., www.exwar.org/Htm/ConceptDocs/Navy_USMC/MWP4thEd/contents.htm. For a cogent description of the future of U.S. mine countermeasures, see Paul Ryan, RADM, U.S. Navy (Ret.), "LCS Will Transform Mine Warfare," U.S. Naval Institute Proceedings (December 2004), pp. 37–39.

392. The requirement to map or survey an area suspected of containing mines suggests that the vehicle performing the mapping must itself have sufficiently small signatures that it can operate in the presence of sensitive mines without causing their detonation. Furthermore, the vehicle must know its location precisely, so that if it detects a minelike object, the suspected object can be accurately located to later be identified and reported. The mapping vehicle must also have sufficient endurance and speed to map the desired waters in an operationally useful length of time. These requirements tend to increase the size, complexity, and costs of candidate systems, making them difficult to develop.

393. Ron O'Rourke, "Navy Littoral Combat Ship (LCS) Program: Background, Oversight Issues, and Options for Congress," CRS Report for Congress, Order Code RL3741, updated 17 November 2008, p. 1.

394. Bettina H. Chavanne, "DDG-51 and LCS Winners in Gates Budget," Aviation Week and Space Technology, 7 April 2009, http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=defense&id=news/PROG04079.xml.

395. According to the consultant described in an earlier footnote, the initial LCS ships will both cost between $700 and $900 million each. As the program enters serial production, the unit cost is expected to become as low as $350 million.

396. Fu Jinzhu, "Taiwan's Problematic Mine Warfare Capability," pp. 33–34.

397. Taiwan purchased the Yung Fung vessels from Germany in the early 1990s as "offshore oil support vessels." Taipei subsequently converted the ships into mine hunters by installing remotely operated underwater vehicles and advanced high-frequency sonar systems. See Commodore Stephen Saunders, RN (Ret.), "Yung Feng (MWV 50) Class Minehunters-Coastal (MHC)," Jane's Fighting Ships, 17 February 2005, www.janes.com.

398. Fu Jinzhu, "Taiwan's Problematic Mine Warfare Capability," pp. 33–34. See also 岩文 [Yan Wen], "台湾水中兵器研制揭密" [Taiwan's Undersea Weapons Development Revealed], 舰船知识[Naval and Merchant Ships] 295, no. 4 (April 2004), p. 9.

399. Raymond Cheung, "Fleet Review, Standing Guard across the Taiwan Strait," Jane's Navy International 101, no. 8 (October 1996), p. 48. The intervening decade has not improved these vessels' condition or Western appraisals of them. "All are in very poor condition," states Stephen Saunders, Commodore, RN (Ret.), in "Adjutant and MSC 268 Classes," Jane's Fighting Ships, 17 February 2005, www.janes.com.

400. Hai Lin, "In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array," pp. 19–21.

401. This inventory includes twelve of the Sugashima- class coastal minesweepers, three of the Yaeyama- class ocean mine hunter/sweepers,

and eleven Hatsushima/Uwajima-class mine hunter/sweepers. Jane's Fighting Ships, 28 February 2008, www.janes.com.

402. See U.S. Department of State, "Joint Statement of U.S.-Japan Security Consultative Committee," 19 February 2005, www.mofa.go.jp/region/n-america/us/security/scc/joint0502.html.

403. See, for example, 陶爱月 [Tao Aiyue], "日本水雷战舰艇综览" [A Survey of Japanese Mine Warfare Ships],舰船知识 [Naval and Merchant Ships], no. 312 (September 2005), pp.44–47; 傅金祝[Fu Jinzhu], "数量最多,更新最快:日本海上自卫队的反水雷实力" [Greatest Quantity, Fastest Renewal: The JMSDF's MCM Strength], 舰船知识[Naval and Merchant Ships], no. 312 (September 2005), pp. 48–49;侯建军[Hou Jianjun], "挑战智能水雷的 570 吨级新型猎扫雷艇" [A New Type of 570 Ton Mine Hunter/Sweeper to Challenge Intelligent Sea Mines], 舰船知识[Naval and Merchant Ships], no. 312 (September 2005), pp. 50–51; 傅金祝[Fu Jinzhu], "体现反水雷装备发展方向的日本新型 S-10 猎雷据" [Japan's New Type of S-10 Mine Hunting Tool Reflects the Development Direction of MCM Equipment],舰船知识 [Naval and Merchant Ships], no. 312 (September 2005), pp. 52–53.

404. See, for example, 侯建军[Hou Jianjun], "美国海军水雷战装备" [United States Navy Mine Warfare Equipment], 当代海军[Modern Navy], no. 6 (2003);张云广 [Zhang Yunqing], "航空激光水雷监测系统的进展" [The Development of an Aviation Laser Sea Mine Monitoring System], 光电子技术与信息[Optoelectronic Technology & Information], no. 4 (2002); 夏立新 [Xia Lixin], "掩埋水雷探测研究" [Buried Sea Mine Detection Research], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 4 (2001); 傅金祝[Fu Jinzhu], "美海军的中等深度滨海水雷开发" [U.S. Navy Medium-Depth Surf-Zone (Shallow Water) Mine Development], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (1999); 夏立新[Xia Lixin], "美国的反水雷,水雷和特种战计划" [American Mine Countermeasures, Sea Mines and Special Operations Plans], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 1 (1999); 刘平,杨洋,王青 [Liu Ping, Yang Yang, and Wang Qing], "国外反水雷舰艇装备现况及发展趋势" [The State-of-the Art and Development Trends of Equipment of Foreign Mine Countermeasures Ships], 舰船工程[Ship Engineering] 26, no. 6 (2004), pp. 1–3; and 张豪娟[Zhang Haojuan], "美国海军对电池的需要及研制" [U.S. Navy Battery Requirement and Development Efforts], 电池工业[Battery Industry] 4, no. 2, April 1999, pp. 71–74.

405. For analyses of other Western MCM developments, see 王晓娟[Wang Xiaojuan], "最新水雷对抗系统" [The Latest Counter–Sea Mine Systems],情报指挥控制系统与仿真技术 [Information Command Control System and Simulation Technology], no. 10 (2001); 张宝善[Zhang Baoshan], "多国部队未来水雷对抗作战研究" [The Future Sea Mine Opposition Warfare Research of Various Countries' Militaries], 情报指挥控制系统与仿真技术[Information Command Control System and Simulation Technology], no. 7 (2001); 夏立新 [Xia Lixin], "英国的水雷全仿真系统" [England's Complete Sea Mine Simulation System], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (2001);赵祚德 [Zhao Zuode], "澳大利亚的三维声水雷成像声纳" [Australia's Three-Dimensional Acoustic Sea Mine AMI Sonar], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 2 (2000); 赵祚德[Zhao Zuode], "英国的'铺路者'综合水雷战武器系统" [British Comprehensive Mine Warfare Weapon System], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 2 (2000); 傅金祝[Fu Jinzhu], "探测混水中水雷的声成像系统" [The Turbid Water Sea Mine Sound Imaging System], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 1 (1999); 付伟[Fu Wei], "国外激光水下侦察设备发展综述" [A Survey of the Development of Foreign Underwater Laser Surveillance Equipment],舰船电子对抗[Ship Electronic Resistance], no. 6 (2001), pp. 21–23;周智超[Zhou Zhichao et al.], "水面舰艇对水雷防御训练评估的 AHP-Fuzzy 方法" [The AHP-Fuzzy Evaluation Method of Training on Surface Ship Anti-mine Defense],系统工程与电子技术[Systems Engineering & Electronics] 23, no. 9 (September 2001), pp.

56–59; 范军,万琳,汤渭霖[Fan Jun, Wan Lin, and Tang Weilin], "沉底水雷目强度预报" [Predicting Target Strength of Mines Lying on the Seabed], 声学技术 [Technical Acoustics] 20, no. 4 (2001), pp. 145–48; and 张晓兵, 周穗华[Zhang Xiaobing and Zhou Suihua], "一种基于模糊理论和神经网络的水雷状态识别方法" [A Method of Mine State Classification Based on Fuzzy Sets and Artificial Neural Networks], 海军工程大学学报[Journal of Naval University of Engineering] 92, no. 3 (2000), pp. 77–80.

406.钱东[Qian Dong], "美国海军水下战中心 NUWC" [The U.S. Naval Undersea Warfare Center], 鱼雷技术[Torpedo Technology] 11, no. 2 (June 2003), pp. 50–51; 钱东[Qian Dong], "美国未来的大型 UUV—MANTA" [The Future U.S. Large-Scale Unmanned Undersea Vehicle—MANTA], 鱼雷技术 [Torpedo Technology] 11, no. 1 (March 2003), pp. 47–50; 傅金祝[Fu Jinzhu], "利用敌方水雷开发有效的反水雷方法" [Using an Effective Anti-mine Method from Enemy Sea Mine Development], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 4 (1999).

407.周丽萍[Zhou Liping], "水下'猎雷者'—美国 AN/WLD-1 型遥控猎雷系统" [Underwater 'Mine Hunter'—The U.S. AN/WLD-1 Remote Control Mine Hunting System], 环球军事[Global Military], pp. 26–27; 黄江飞[Huang Jiangfei], "AN/WLD-1 型遥控猎雷系统" [The AN/WLD-1 Remote Control Mine Hunting System], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (2000).

408. 乔迥超, 张旭;海军大连舰艇学院研究生队,海军大连舰艇学院水武与防化系 [Qiao Changchao, Graduate Student Team; Zhang Xu, Department of Underwater Weapons and Chemical Defense Systems; Dalian Naval Vessel Academy], "AUV 探查水雷搜索模式仿真比较研究" [Research on Comparison and Simulation of Mine Detection Search Mode by AUVs], 水雷战与舰船防护[Sea Mine Warfare and Ship Self-Defense], no. 4 (2008); 傅金祝[Fu Jinzhu], "反水雷自主式水下航行器" [Anti-mine Independent AUVs],舰船知识 [Naval and Merchant Ships] 292, no. 2 (2004), p. 39.

409. 李杰[Li Jie], "新型无人潜艇的战力" [The Battle Power of a New Type of Unmanned Submarine], 当代海军[Modern Navy], no. 10 (2004), pp. 48–50; 孙云利 [Sun Yunli], "美国海军的水下无人潜水器展望" [The Prospects for Future U.S. Navy Submarine UUVs], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 4 (2003).

410. See 杨毅[Yang Yi], "美国海军航空反水雷的发展趋势" [The Development Trend of U.S. Navy Aviation MCM], 航海[Navigation], no. 2 (2003), pp. 41–42; 夏立新 [Xia Lixin], "美国直升机反水雷的研究和开发" [The Research & Development of U.S. Helicopter MCM], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 2 (1999).

411. He Shan, "Can the Virginia Class Become the New Century's Maritime Hegemon?" pp. 18–21.

412. At the moment, Beijing is playing a relatively positive role in the Six-Party Talks. However, a future return to a more belligerent posture that involves siding explicitly with Pyongyang cannot be ruled out at this time.

413. This would be consistent with the PLA's Cold War effort to defend the Bohai Sea by fortifying the Miaodao and Changdao islands between the Shandong and Liaodong peninsulas. Interview, Beijing, 2007.

414. For a Chinese analysis of Southeast Asia's vulnerability to sea mines, see 夏立新 [Xia Lixin], "水雷对东南亚地区的潜在威胁"

[The Potential Sea Mine Threat to Southeast Asia], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 2 (2001).

415. Zhang Yuliang, Yu Shusheng, and Zhou Xiaopeng, Science of Campaigns, chap. 14.

416. This is determined by the shallow littoral waters, for example, in the Gulf of Tonkin, and also, of course, by Vietnam's proximity to Chinese bases, particularly on Hainan Island. Japan might also become a target of a limited Chinese MIW campaign under worst-case circumstances. Clearly, submarines (and perhaps civilian vessels) would have to lead such operations given the potentially high-intensity battle environment and the distances involved. However, one-third of the Chinese submarine force (approximately twenty vessels) fully loaded could deliver almost 500 sophisticated mines, enough to close several ports or sea lines of communication for at least a week or two, causing substantial damage, possibly in the form of psychological-strategic effects.

417. The bathymetry of the waters proximate to Taiwan immediately reveals that the Taiwan Strait itself, as well as waters to the immediate north and south (adjacent to the island's largest ports), are shallow enough to create a wholly appropriate environment for the use of all types of mines. Although Taiwan's eastern coast has deeper waters, the authors nevertheless believe that by relying on a combination method of deployment (air, surface, submarine, and civilian) a major Chinese MIW campaign could efficiently blockade Taiwan, especially if working in concert with the PLA Navy's submarine force. Chinese analysts, moreover, assess that Taiwan's MCM are inadequate to this challenge and that efforts by Taiwan to deploy its own mines could be dealt with by the PLA.

418. "16. How Is Sea Mine Warfare and Anti-blockade Combat Carried Out?" in "One. The Basic Combat Theory of the Taiwanese Army," in Bi Xinglin, ed., Campaign Theory Study Guide. Another source states that "the PLA can execute offensive mining against any of Taiwan's ports [naval, commercial, oil off-loading areas], sea channels or adjoining sea areas, cutting off Taiwan's sea lines of communication, destroying its economy and energy lifeblood." Hai Lin, "In 2010 Taiwan Will Be Surrounded with a Sea Mine Battle Array," p. 16.

419. A discussion of how Taiwan's air force could be rendered ineffective by current Chinese weapons is included in William S. Murray, "Revisiting Taiwan's Defense Strategy," Naval War College Review 61, no. 3 (Summer 2008), pp. 13–38.

420. Mei Lin, "Analysis of the CPC Armed Forces' Development of New Methods of Operations," Taipei Chung Kung Yen Chiu, 15 November 1997, pp. 50–60, OSC FTIS19980310000807.

421. Technology does not appear to ameliorate this enduring reality, according to one practitioner. See Lt. Cdr. Patrick Molenda, U.S. Navy, "Don't Forget Dedicated Mine Countermeasures," U.S. Navy Institute Proceedings (October 2001), p. 41.

422.丁信成[Ding Xincheng], "高技术战争中的反潜战" [Anti-submarine Warfare under Circumstances of High-Tech War], 中国民兵 [China Militia], (December 1996), p. 37.

423. In WWII, Germany successfully mined several U.S. ports via submarine, and closed the ports to traffic for periods of roughly two weeks. See Hartmann with Truver, Weapons That Wait, pp. 69–70. Special MIW operations of this nature—limited, but high-profile

strikes—could have important psychological effects early in a Sino-American military crisis, for example dramatically shifting U.S. Navy resources toward protecting sea areas closer to home, and thus enabling China's swift conquest of Taiwan. As the recent 2003 Iraq War (not to mention Hurricane Katrina) so powerfully demonstrates, strategists and military planners must work with worst-case, not best-case, assumptions for planning purposes.

424. Lin Changsheng, "Hidden Dragon in the Deep," p. 32.

425. Ibid., p. 30.

426. 周洪光,徐维川,曾松林 [Zhou Hongguang, Xu Weichuan, and Zeng Songlin], "浅析登陆作战中水雷武器的使用" [Simple Study on the Use of Sea Mine Weapons in Landing Operations], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 2 (2007).

427.杨掠[Yang Qiong], "抗登陆水雷" [Anti-landing Mines], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 3 (2007). A detailed survey of Taiwan's sea-mine capabilities is reviewed in the PRC article 邓又辉 [Deng Youhui], "水雷—'台独'幻想的救命稻草," [Sea Mines—The Illusory Lifesaving Sustenance of "Taiwan Independence"], 环球军事[Global Military] (2005), pp. 22–23.

428. Zhang Yuliang, Yu Shusheng, and Zhou Xiaopeng, Science of Campaigns, chap. 13.

429. The continental shelf extends from China about 250 miles out into the East China Sea (more than halfway to Japan) enabling the use of relatively primitive (shallow water) minefields.

430. Lin Changsheng, "Hidden Dragon in the Deep," p. 31. For PLAN Submarine Academy research on this topic, see 赵祚德 [Zhao Zuode], "水雷障碍封潜作战的效率评定模型" [An Assessment Model for the Effectiveness of Sea Mine Barriers in Antisubmarine Warfare], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 4 (2002).

431. Quotations in this paragraph from Glosny, "Strangulation from the Sea?" pp. 133, 140, 143.

432. See figures in "Total Mines Laid" in Table 4, "Results of Mine-Laying Analysis (after 6 months)," p. 144. These figures are for "scenarios one and two." In footnote 81, Glosny rejects the maximum finding of 10,166 mines for scenario 3, "[a] situation that looks worse for Taiwan," because this scenario involves "heroic assumptions." Glosny, "Strangulation from the Sea?" p. 145.

433. Murray, "Revisiting Taiwan's Defense Strategy," pp. 13–38.

434. USAF doctrine has long promulgated the notion that all missions are secondary to achieving "air dominance." This was not the case in World War II (before 1944) when massive raids were undertaken under dangerous circumstances. If the ROCAF survives the initial attack, moreover, its aircraft will be preoccupied with defending high-priority targets (leadership, air bases, missile defense sites, population centers) rather than chasing Chinese aircraft sowing mines at sea.

435. Glosny, “Strangulation from the Sea?” p. 148.

436. Sailors of the U.S. merchant marine had a higher proportion of deaths in combat than any other service in the Second World War. See www.usmm.org/men_ships.html.

437. See, for example, Glosny, “Strangulation from the Sea?” p. 145.

438. Glosny, “Strangulation from the Sea?” p. 150.

439. On the imperative of accelerating PLAN MIW development, see 张光法,黄江华 [Zhang Guangfa and Huang Jianghua], “充分利用研制资源 促进在研水雷尽快形成战斗力” [Make Full Use of Development Resources, Accelerate Existing Sea Mine Research to Form Fighting Capacity as Quickly as Possible], 水雷战与舰船防护 [Sea Mine Warfare and Ship Self-Defense], no. 4 (2001).

440. “Blockade,” defined narrowly, simply means a very significant reduction in sea borne trade, because of the closing of ports by adversary forces.