Scientific Journal of the Military University of Land Forces
ISSN: 2544-7122 - print, 2545-0719 - online
2018, Volume 50, Number 2(188), Pages 19-30
DOI: 10.5604/01.3001.0012.2487

Original article

The concept of mobile, maritime system for location, assessment of technical condition, recovery and destruction of dumped chemical munitions

Jacek Fabisiak**, **Bartlomiej Paczek

Faculty of Command and Naval Operations, Polish Naval Academy, Gdynia, Poland,
j.fabisiak@amw.gdynia.pl; b.paczek@amw.gdynia.pl

INFORMATIONS

Article history:

Submited: 10 November 2017

Accepted: 12 March 2018

Published: 30 June 2018

ABSTRACT

After the World War II, acting under the terms of the Potsdam Agreement, the anti-Nazi coalition commenced destroying chemical and conventional munitions by dumping it in the seas (including in the Baltic Sea). As a result of these activities, tens of thousands of tons of ammunition were brought to the Baltic. The international project CHEMSEA has shown that dumped chemical munitions pose a threat to the environmental safety of the Baltic Sea, and that the need to collect and destroy munitions should be taken into account.

The article describes the assumptions of a pilot system to identify chemical munitions in the Baltic Sea (including selected areas of the Polish Maritime Areas), assess its technical condition and the potential for its recovery. In addition, existing technical solutions (allowing for the use of the best available techniques – BAT) provide the opportunity to collect and neutralize sunken chemical munitions.

* Corresponding author

KEYWORDS

chemical munitions, toxic warfare agents (BST), the Baltic Sea, ecological threat

1. Introduction

After the World War II, chemical weapons stocks worldwide were estimated at more than 500,000 tons [Robinson 1971]. Only about 300,000 tons of chemical munitions [Szarejko and Namiesnik 2009] containing over 100,000 tons of poisonous chemicals, including 25,000 tons of mustard gas and 20,000 tons of tabun [Makles and Sliwakowski 1997], remained in Germany alone, which at that time was the world leader in research and production of BST. Apart from Germany, intensive research programs, as well as the production of chemical weapons during the interwar period and during the war, were conducted by Italy, Japan, the United States of America, Great Britain and France. At the end of the war, about 170,000 tons of poisonous agents remained only in the United Kingdom and the United States. Significant amounts of BST, at least tens

of thousands of tons, remained in the Soviet Union. It is estimated that at the end of the Second World War, about 60 states could hold chemical weapons [Konopski 2009].

After the end of the Second World War, the United States, France, Great Britain and the Soviet Union confiscated chemical munitions from Germany, and pursuant to the Potsdam Agreement concluded in August 1945, they took responsibility for its destruction. At the same time, the process of the seized weapon utilization began. Dumping was considered the best, cheapest and fastest method of destruction. Initially, the states decided to destroy the post-war or obsolete chemical weapons and dumping areas were designated far from the mainland. Firstly, 4-km deep places were selected [Tumilowicz 2013]. However, before the destruction of the weapon began, the cost of the operation had very quick verified these plans. Eventually, chemical weapons were sunk near land, very often at low depths, and sometimes even in rivers and lakes to make the destruction process as cheap as possible [Walker 2012]. Chemical munitions were often dumped alongside conventional weapons, making these zones even more dangerous. It is estimated that this way of getting rid of post-war chemical weapons was chosen by as many as 40 states – their holders [Carton and Jagusiewicz 2011].

However, chemical weapons produced before and during the World War II were not the only things sunk in the seas and oceans. The United States, Britain, France, Japan and Russia used dumping as a primary way to utilize unused or outdated chemical weapons until the early 1970s. The USA alone sank about 350,000 pieces of extra munitions in the seas and oceans by the 1970s [Smart 1997]. The consequence of these actions is that more than a million tons of chemical ammunition produced during the World Wars I and II, as well as in the post-war period, is now located in the bottom of the oceans. As of today, 127 locations of chemical munitions are documented in detail, where the USA alone carried out drops 74 times. Unfortunately, this list is not closed. It is assumed there are over 300 chemical munitions dumping zones [James Martin Center… 2016]. Chemical weapons have been sunk in the Atlantic, the Pacific and the Indian Ocean, off the coast of northern and eastern Canada and the United States, in the Gulf of Mexico, off the coast of Australia, New Zealand, India, the Philippines, Japan, Great Britain, Iceland, the Caribbean, the Black, the Red, the Mediterranean, the North and the Baltic Seas. At present these dump sites represent a significant threat to both marine organisms inhabiting the areas and users of seas, and the countries on waters of which the drowning was carried out have a huge problem to solve. Initially it was thought that the poisons being gradually released into the environment would decompose into non-toxic products, hence not posing a serious threat. For this reason, it was often decided to leave the weapons where they had been sunk, hoping for a gradual disappearance of the problem. Unfortunately, studies have shown that certain BSTs do not decompose in the aquatic environment as soon as they are thought to, so that the risk has not diminished. In addition, research has evidenced genetic alterations in reef-dwelling organisms, the basis of which are likely to be toxic warfare agents. In addition, chemical analyzes of bottom sediments and pore waters in the dumping areas show increased arsenic content, which in turn is a threat to marine organisms and when accumulated in fish it also threatens significantly their consumers [Beldowski et al. 2016]. These facts have prompted many countries, including the

United States, Japan, Belgium and Italy, to take action aimed at clearing their waters of chemical ammunition. Technological advancement has made the methods used today so safe for the environment and humans that they are no longer an obstacle that had been formed several years before by the risk of causing greater contaminations during extraction operations than those that can potentially occur when ammunition is left at the bottom.

The paper presents Poland's position on the problem of chemical weapons buried in the Polish maritime areas and describes the assumptions for a pilot system for locating the chemical munitions dumped in the Baltic Sea, assessing its technical condition and possibilities of its recovery and destruction.

2. Chemical munitions dumped in the Baltic Sea

About 300,000 tones of chemical munitions found in Germany were gathered at the port of Wolgast on the Baltic Sea near Peenemünde. Under the decisions of the Potsdam Agreement, the anti-Nazi coalition (the USA, France, Great Britain and the Soviet Union) began developing a plan for their destruction. In order to address generally accepted principles at the time, the dumping was considered the best method of destroying the weapons. Initially, German remnants of the war were planned to carry by special means of transport and sink in one of the oceans, at a depth of at least 4 km [Tumilowicz 2013]. This place was supposed to be the Faroe Islands on the Atlantic Ocean. However, the operation was not realized, mainly due to the lack of adequate vessels for the transport of dangerous substances and the high cost of this operation. Ultimately, the lethal measures were decided to be dumped in the North Sea and the Baltic Sea. Not all the weapons were sunk, and the then-great powers used a large portion of them for their own purposes. Sinking operations were conducted in the Baltic mainly by the Soviet Army placing confiscated chemical weapons in a part of the Baltic Proper, and the United Kingdom sinking some of the confiscated chemical weapons in the Skagerrak region. It should be noted that just before the end of the war, the Germans destroyed part of their chemical weapons through sinking it in Little Belt [Knobloch et al. 2013].

Various dumping techniques were used: small amounts of ammunition were dumped, from single pieces of ammunition, drums and canisters to huge amounts of bombs, rockets, even entire ships loaded with chemical ammunition, toxic warfare agents and conventional ammunition. In the Baltic Sea, the post-war weapons dumping operation was carried out until 1947 [Fabisiak et al. 2012]. It is estimated that 360,000-385,000 tons of German ammunition were sunk at that time, of which over 40,000 tons were chemical munitions containing about 13,000 tons of BST. Chemical weapons were dropped in the south-eastern part of the Gotland Deep (about 2000 tons), in the eastern part of the Bornholm Vault (about 32,000 tons) and in the Little Belt (about 5000 tons) [Fabisiak et al. 2012]. In addition, the declassified documentation showed that chemical weapons were sunk to the east (about 8000 tons) and southwest (about 15,000 tons) of Bornholm. However, no quantity or type of chemical munitions and BST has been verified up to date [Kasperek, 1999]. Recent research has shown that BST

is also found in the Gdansk Deep, previously considered an unofficial dumping site [CHEMSEA… 2014; Beldowski et al. 2016]. It should be noted, however, that the GDR and the USSR armed forces sank the useless (outdated), withdrawn from the use of chemical weapons long after 1947. In the case of the GDR, declassified documents indicate that from 1959 to 1965 in the regions east and south of Bornholm Island approximately 60 tons and 120 tons of chemical ammunition, mainly bombs, missiles and barrels containing sulfur mustard, phosgene, adamsite and CLARK I and II [Knobloch et al. 2013] respectively, were dumped. Figure 1 shows the locations of chemical weapons in the Baltic Sea.

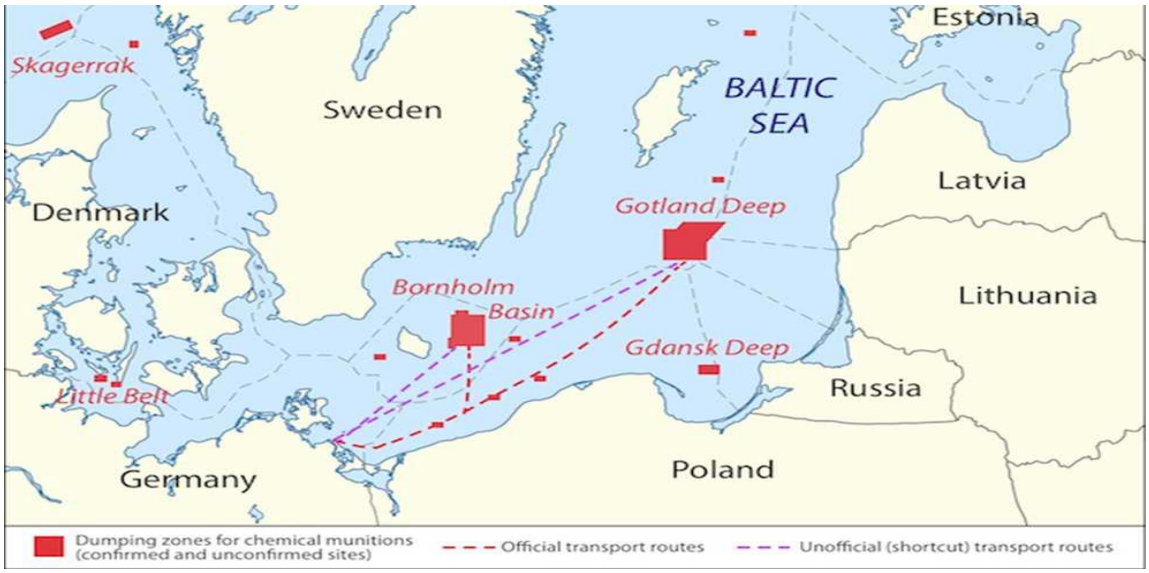

Fig. 1. Chemical munitions dumping areas in the Baltic Sea
Source: [Beldowski 2012].

There are five regions in Poland with a total area of about 440 km^2 where the risk of encountering chemical weapons exists. These include the areas of: Bornholm, i.e. the border area with the Danish Exclusive Economic Zone (220 km^2), Dziwnow where artillery shells with mustard and lewisite were dumped at the depths of 10-12 m, Kolobrzeg (at the depth of about 65 m), Darlowo (at the depth of about 90 m) and Hel (at the depth of about 105 m). It is estimated that there can be as many as 60 such places, and the amount of chemical munitions drowned there is estimated at 10,000-12,000 pieces [Beldowski et al. 2013]. These estimates, however, are not supported by research and are only conclusions based on the analysis of the facts of the past events. Table 1 depicts the marine areas in Poland where the risk of extraction of toxic warfare agents occurs. The above-mentioned Gdansk Deep constitutes the largest "Polish" chemical weapons dumping site, where 60 tons of ammunition containing mustard gas have been sunk [Knobloch et al. 2013].

Table 1. Areas near the Polish coast,
where the risk of extraction of toxic warfare agents exists

Region	Depth [m]	Type of munitions
Dziwnow	10-12	artillery shells with mustard gas and arsenic compounds
Kolobrzeg	65	bombs, artillery ammunition, mines, containers, containers with mustard gas and arsenic compounds
Darlowo	90	mustard gas bombs
Hel	up to 117	bombs, artillery ammunition, mines, containers, containers with mustard gas and arsenic compounds

Source: [A. Styczynski, based on materials of the Chief of the NBC Defense of the Polish Navy Command, 2004].

As it turns out, neither did the dumping of chemical munitions solve the problem of no longer useful weapons, nor was it a safe method of disposal. At present, the intensive use of the sea and the exploitation of its bottom have caused more and more people, especially when working underwater, to encounter ammunition filled with lethal poisons. Dumped weapons have become a problem again. More and more frequently chemical munitions or poisons released into the environment are pulled out together with fishing. The increase in the numbers of burns or poisoning from those agents is recorded among maritime professionals. It often happens that ammunition is also washed out onto beaches, causing their contamination and thus endangering tourists and residents of coastal areas. The problem of dumped munitions returned not only to the countries that had been destroying it, but also to the coastal countries in waters of which the weapons had been sunk. In the Polish maritime areas, the reported cases of pulling or washing chemical munitions or BST, mainly mustard gas, out on the beach dates back to 1950. Studies show that to date 30 incidents involving chemical munitions or toxic warfare agents have occurred, of which 7 on the beaches. The last case happened on January 9, 1997, 20 miles north of Wladyslawowo. The consequence of this incident were serious burns of at least 4 people [Fabisiak 2014].

3. Chemical munitions in the Baltic in the light of the Helsinki Convention

Signing of the "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter" in 1972 was the world's first step towards the cessation of polluting the marine environment, among others by the lethal components of chemical weapons. As from the entry of the Convention into force, i.e. since 1975, the storage of chemical weapons at the bottom of the seas and oceans has been strictly forbidden.

The issue of chemical weapons dumped in the Baltic Sea has been investigated by the Baltic Marine Environment Protection Commission (HELCOM), which coordinates the work provided for in the 1992 Convention on the Protection of the Marine Environment of the Baltic Sea. In order to address the problem of chemical munitions left in the Baltic Sea, in 1993 the Helsinki Commission set up a special working group on the dumped chemical munitions, under the name HELCOM CHEM. The group included rep-

resentatives of all signatory States to the Helsinki Convention and experts from the United Kingdom, the United States of America and Norway. The group's responsibilities included gathering and compiling data on dumped munitions, assessing the degree of threat to the marine environment and human health, and identifying the need and direction of future research on this issue. In 1994, the Group presented a report that contained information on the type and quantity of dumped chemical munitions, dumping areas, properties of toxic warfare agents and munitions status, potential hazards, as well as the results of previous investigations in the dumping area.

In 1995, the final report elaborated by the HELCOM CHEMU group contained a number of recommendations from two years of work on issues related to dumped chemical munitions. The most important ones were: searching for chemical munitions dumping sites, conducting research on chemical processes which toxic warfare agents are subject to in the marine environment and ecological consequences of these processes, developing instructions for fishermen in case of pulling out BSTs, developing guidelines for relevant institutions/authorities responsible for liquidation of effects of pulled out chemical munitions and conducting investigation on the corrosion status of dumped chemical munitions. In the course of the work of the group, it was also determined that combat measures did not pose significant risks to the environment and therefore any recovery and land-based destruction should not apply to them. Notwithstanding the in-depth work the group has put into creating the final report, it should be pointed out that its conclusions are based primarily on archival data, theoretical studies of poisons behavior in the marine environment, as well as research, extraction and disposal technologies used in the eighties. After the dissolution of the HELCOM CHEMU group in 1995, cases related to dumped chemical weapons were included in the work of the Environmental Protection Committee and the Committee for Combating Spill. The group entrusted Denmark with the function of the Lead Party in this regard and responsibility for collecting information about the research undertaken by States Parties on the Baltic Sea dumped chemical munitions and the collection of data on cases of pulling out toxic warfare agents together with fishing by fishermen.

In 2010, at the HELCOM meeting in Moscow, the decision was made to set up another expert group, similar to HELCOM CHEMU, on dumped chemical weapons, this time under the name HELCOM MUNI. The main objective of this group was to evaluate the current findings and recommendations contained in the HELCOM CHEMU report. This decision was based on the conviction that the HELCOM forum is an excellent platform for Baltic States to cooperate in evaluating threats from chemical weapons to the Baltic ecosystem. The report of the HELCOM MUNI was unanimously adopted on November 3, 2013 at the ministerial meeting of the Parties to the Helsinki Convention in Copenhagen. The analysis of new facts and scientific findings allowed for considering the current view that chemical munitions should be left at the bottom no longer unequivocal, although the report did not address the issue of recovering and destroying chemical weapons.

4. Mobile, maritime system for searching, assessment of technical condition and destruction of dumped chemical munitions

In Poland, for many years, the problem of chemical weapons dumped in the Baltic was a taboo issue that was not discussed in the public forum. The incidents of pulling out chemical munitions by fishermen, washing out poisons on the beach or even poisoning or burns were unable to stop the collusion of silence and mobilize the then government to act to assess the threat posed by sunk deadly chemicals. The breakthrough in this matter was, first and foremost, the media broadcast of the burns of fishermen from Wladyslawowo in January 1997, and the commencement of work on the construction of Nord Stream, which was intended to pass through areas where chemical weapons were dumped. These events encouraged research conducted by numerous scientific research centers in Poland: the Naval Academy, the Marine Institute, the Marine Fisheries Institute and the Military University of Technology to assess and estimate the scale of threat posed by the poisons stored at the bottom of the Baltic Sea. One of the recommendations of the investigations conducted was the development of research programs aimed at creating a system for responding to cases of exposure to contact with chemical weapons and, in the longer term, developing methods that could be used to remove chemical weapons from the bottom of the Polish maritime areas. Ultimately, mainly for financial reasons, it was limited to scientific studies on estimating the risks and monitoring the effects of BST release into the sea. Over time, however, an increasing number of scientists, representatives of maritime administrations, pro-ecological organizations and politicians have been inclined to work to clean our waters from these dangerous weapons.

Commencing work to clean the Baltic Sea from chemical sinks is supported by the fact that the area is being more and more economically exploited year by year. The scope of extracting works has been extended, new gas pipelines and power lines are being laid and new wind farms are planned to build. All this is an intervention in the seabed and at the same time poses the risk of disturbing chemical munitions, and consequently the possibility of violent release of poisons leading to serious environmental pollution exists. According to the regulations, any underwater works that encounter chemical munitions must be stopped until the hazard is removed. Inevitably, sooner or later, it will prove necessary to create a system that in such situations will enable collecting and destroying the found chemical weapons.

In the 1990s, a number of companies offered recovery of sunken chemical munitions, but such an operation involved very high costs (about $ 8 billion) [Witkiewicz 1998] and the need to destroy poisons on land. There are also proponents of the view that these munitions ought to be isolated from the surrounding water. It is considered possible to cover chemical munitions dumping sites with a layer of concrete or polymer. In the case of wrecks filled with ammunition, it is proposed to replace the water contained therein with a solution of the substance, which after polymerization would make the filled hull become a monolith. This would prevent the destructive impact of water on metal parts of the munitions and prevent the escape of poisonous substances into the water. Similarly, as in the case of munitions extraction, this solution would

not be technically easy, but on the contrary, costly, without offering complete assurance of its effectiveness. Having the above arguments taken into consideration, it is comprehensible why the view that dumped chemical munitions should be left intact in the sea is prevailing. At this point, the issue must therefore be raised whether it is appropriate to collect all the chemical weapons buried in the Baltic Sea or whether to develop an effective system to destroy them in areas where they pose a threat to fishing, beaches, new seabed investments and other commercially significant exploitation works.

In 2015, the Polish Naval Academy (AMW) in Gdynia proposed the creation of a mobile, offshore marine vessel, based on a vessel withdrawn from combat operations, equipped with a system for the safe disposal of chemical munitions. Such a vessel would also serve as an analytical laboratory, a monitoring and rescue unit, and, most importantly, there would be a system for chemical weapons safe destruction installed. Effective and above all safe methods of destroying chemical ammunition exist today. One of the most widely used systems in the world is one called DAVINCH used by Japan to destroy chemical weapons dumped at its coast. The installation consists of a high-pressure chamber in which the vacuum detonation of collected projectiles is performed, followed by burning them under the conditions of the so-called cold plasma. German companies also specialize in the safe disposal of chemical weapons in the North Sea.

The vessel proposed by AMW would be equipped with the best available technology, among which the necessary equipment would include:

- A vessel whose characteristics and equipment will allow for conducting research at high sea states, a minimum of 5. The best solution seems to be the take-over of a ship hull (minesweeper) withdrawn from the Navy and its refurbishment so that it meets the requirements of a research vessel (equipped with bow thrusters for dynamic positioning of the vessel, which is essential for precise positioning of the vessel over objects, without the use of an anchor, as well as laboratory cabins, equipment stores, human and equipment decontamination systems, docking stations for underwater vehicles, a gantry, etc.). Another option is to build a new research unit, however, this variant will be much more expensive than the previous one.
- A group of submersible vehicles of both autonomous AUVs and remote controlled ROVs, which would be equipped with appropriate dippers for sediment, water, parts of munitions, precision manipulators, and hydro-acoustic devices to accurately locate hazardous objects, identify them and assess their technical condition.
- The installation for destroying chemical munitions directly at sea. One of the most widely used systems in the world is the afore-mentioned DAVINCH system [Committee on Review… 2006]. The installation consists of a high-pressure chamber in which the vacuum detonation of collected projectiles is performed, followed by the destruction of the received products using the plasma technology. There are also German technologies specialized in the safe destruction of

sunken chemical weapons. Also in Poland, technologies for destroying chemical munitions have been developed.
– A decompression chamber for divers.
– A towed barge (without propulsion) – necessary to install DAVINCH and a decompression chamber on it.
– Equipment for hydro acoustic testing (sonars, magnetometers, para-metric depth finder, multi-beam depth finder).
– A laboratory and measuring equipment for the identification of chemical munitions.
– Satellite vessel positioning system (EGNOS-WAAS) and underwater vessel positioning (USBL).
– Special containers for lifting munitions.
– Computer hardware + satellite communication.

Provided that the hull will be obtained from the Military Property Agency free of charge, the cost of building such a unit would amount to approximately EUR 120 million. Its construction would take 3 years, followed by 3 years of cleaning up Polish maritime areas (as technology demonstrator). After that period, the research vessel would be used to "recover" chemical munitions from other areas of the Baltic Sea.

It does not seem feasible to clean up the Baltic Sea from all the chemical munitions. Nonetheless, the extraction and destruction of 5000 pieces of munitions (the chamber has the capacity for such an amount of destruction processes) should give measurable, qualitative results.

Finally, a question should be raised how to achieve funds for such a costly investment. The best solution seems to be the creation at the EC level of a special contracted design sponsored by the European Commission (for example from the Infrastructure and Environment Funds) and the Environment Ministries from the Baltic Sea States.

Conclusion

Neither did the dumping of chemical munitions solve the problem, nor was it a safe disposal method. Many poisons, despite being decomposed, continue to pose a threat, because their decomposition products contain arsenic, which lying in the bottom sediments gradually permeates into the organism, thus cumulating in them. Hydrolysis products of some toxic warfare agents are still toxic and, due to the low water solubility, a significant proportion of dumped chemical warfare remains to be toxic for many years, and when left in marine sediments, they cumulate in marine organisms. Increasingly intensive use of the seas and exploitation of the seabed caused that people more and more often encounter munitions filled with combat poisons. Dumped weapons have become a problem again, not only to the states that had destroyed them, but also to other coastal countries that had weapons dumped in their waters. Chemical warfare is an important issue for marine users, as well as for the marine environment. Bearing this in mind, states that have been affected by this problem are taking steps to eliminate this threat. Technological development has made it safer to recover chemical

ammunition and continues to improve the methods of their destruction to make these operations safe for humans and the environment.

The arsenals of dumped chemical weapons have gained recognition. According to experts the problem should not be presented in catastrophic terms, although in fact it contains many dangers. However, knowledge of this issue and awareness of threats greatly improves safety of sea users. The complete removal of deadly substances requires many years of work, but today, scientists are already preparing special rules for dealing with accidental pulling out chemical munitions, sudden poison leaks, or incidents of disturbing marine sediments contaminated with BST. Poland is strongly committed to activities aimed at initiating the purification of the Polish maritime areas of poisons left there. So far these activities have become visible in the political as well as scientific and research spheres. This effort has already resulted in the expansion of cooperation on international fora. Perhaps it is time to begin the process of purifying the Baltic Sea from the chemical weapons dumped in it.

Acknowledgement

No acknowledgement and potential founding was reported by the authors.

Conflict of interests

The author declared no conflict of interests.

Author contributions

All authors contributed to the interpretation of results and writing of the paper. All authors read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

ORCID

Jacek Fabisiak https://orcid.org/0000-0002-6342-7728

Bartlomiej Paczek – The author declared that he has no ORCID ID's

References

Beldowski, J. (2012). *All Partner Activities within the CHEMSEA project – current status*. Referat 3. Spotkanie Projektu CHEMSEA, 12-14-09-2012, Helsinki, Finlandia.

Beldowski, J., Klusek, Z., Szubska, M. et al. (2016). Chemical Munitions Search & Assessment – An evaluation of the dumped munitions problem in the Baltic Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, vol. 128, pp. 85-95.

Beldowski, J., Sosnowska, A. and Podscianski, A. (2013). Bron chemiczna zatopiona w Morzu Baltyckim. *Aura*, no. 8, pp. 19-22.

Beldowski, J., Szubska, M., Emelyanov, E. et al. (2016). Arsenic concentrations in Baltic Sea sediments close to chemical munitions dumpsites. *Deep Sea Research Part II: Topical Studies in Oceanography*, vol. 128, pp. 114-122.

Carton, G. and Jagusiewicz, A. (2011). Historic disposal of munitions in U.S. and European coastal waters, how historic information can be used in characterizing and managing risk. *Marine Technology Society Journal*, vol. 43, no. 4, pp. 16-32.

CHEMSEA findings. Results from the chemsea project – chemical munitions search and assessment. (2014). Sopot: Institute of Oceanology of the Polish Academy of Sciences.

Committee on Review and Evaluation of International Technologies for the Destruction of Non-Stockpile Chemical Materiel, Board on Army Science and Technology, Division on Engineering and Physical Sciences, National Research Council of the National Academies. (2006). *Review of international technologies for destruction of recovered chemical warfare materiel*. Washington: National Academies Press.

Fabisiak, J. (2014). Udzial i rola polskich organizacji i jednostek naukowych w miedzynarodowych dzialaniach zmierzajacych do rozwiazania problemu zatopionej w morzach i oceanach broni chemicznej. *Logistyka*, no. 6, pp. 586-596.

Fabisiak, J., Michalak, J. and Paczek, B. (2012). Wspolpraca panstw nadbaltyckich w celu przeciwdzialania skutkom zatopionej w morzach amunicji chemicznej. *Logistyka*, no. 5, pp. 273-284.

James Martin Center for Nonproliferation Studies. Combating the spread of weapons of mass destruction with training & analysis. (2016). [online]. Middlebury Institute of International Studies at Monterey. Available at: http://cns.miis.edu/stories/090806_cw_dumping.htm [Accessed: 27 June 2018].

Kasperek, T. (1999). *Chemical weapons dumped in the Baltic Sea*. Lysomice: Europejskie Centrum Edukacyjne.

Knobloch, T., Beldowski, J., Böttcher, C. et al. (2013). *Chemical Munitions Dumped in the Baltic Sea. Report of the ad hoc Expert Group to Update and Review the Existing Information on Dumped Chemical Munitions in the Baltic Sea (HELCOM MUNI)*. Helsinki: Helsinki Commission and Baltic Marine Environment Protection Commission.

Konopski, L. (2009). *Historia broni chemicznej*. Warszawa: Belleona, 2009.

Makles, A. and Sliwakowski, M. (1997). Bron chemiczna zatopiona w Polskiej strefie ekonomicznej Morza Baltyckiego, a bezpieczenstwo ludzi gospodarczo wykorzystujacych zasoby morza. *Biuletyn Informacyjny WIChiR*, vol. 27, no. 1, pp. 5-28.

Robinson, J.P. (1971). *The problem of chemical and biological warfare. A study of the historical, technical, military, legal and political aspects of CBW, and possible disarmament measures*. Vol. 1. *The rise of CB weapons*. Stockholm: Almquist & Wiksell.

Smart, J.K. (1997). *History of chemical and biological warfare. An American perspective*. In: Sidell, F.R., Takafuji, E.T. and Franz, D.R. (eds.). *Medical aspects of chemical and biological warfare*. Washington: Borden Institute, Walter Reed Army Medical Center et al.

Szarejko, A. and Namiesnik, J. (2009). The Baltic Sea as a dumping site of chemical munitions and chemical warfare agents. *Chemistry and Ecology*, vol. 25, no. 1, pp. 13-26.

Tumilowicz, B. (2013). Baltyk pelen iperytu. *Przeglad*, no. 11, pp. 44.

Walker, P.F. (2012). *Ocean-Dumped Chemical Weapons: History, Challenges, Prospects.* Materialy z International Workshop Polish Naval Academy. Gdynia, pp. 16-32.

Witkiewicz, Z. (1998). *Stan techniczny zatopionej amunicji chemicznej i przewidywane tego konsekwencje*. Materialy z Sympozjum Naukowego "Bron chemiczna zatopiona w Morzu Baltyckim" (22 kwietnia 1997 r.). Gdynia: Wydawnictwo Akademii Marynarki Wojennej, pp. 35-38.

Biographical notes

Jacek Fabisiak – Lt. Cdr. Dr. Eng. Initially he served at the Central Chemical and Radiometric Laboratory, then at the Naval Contamination Analysis Center, and finally at the Polish Naval Academy since 1998. As of this date, his scientific activities have been focusing on environmental threats related to the activities of the Armed Forces and the defense against weapons of mass destruction. Currently Director of the National Security Institute, member of CHEMSEA (Chemical Munitions Search and Assessment) and DAIMON (Decision Aid for Marine Munitions). Graduate of the Military Academy of Technology. Author of more than 40 scientific papers published in national and international journals. Co-author of the national report for HELCOM MUNI. He is a member of the National Section of the Marine Environment Protection (MEPC) and the International Center of Excellence for Dumped Chemical Munitions.

Bartlomiej Paczek – Lt. Cdr. Dr., Deputy Dean of the Faculty of Command and Naval, member of research teams of international projects CHEMSEA and DAIMON. He has served in the Navy since 1994, initially in the Naval Hydrographic Defense Squadron, on-board ORP Arctowski, in positions of the hydrologist, hydrography officer and Commander of the Hydrographic Division. He joined the Naval Academy in 2007, concentrating his scientific work around the role of naval forces in the state security system and the theory and practice of commanding these forces.

How to cite this paper

Fabisiak, J., and Paczek, B. (2018). The concept of mobile, maritime system for location, assessment of technical condition, recovery and destruction of dumped chemical munitions. *Scientific Journal of the Military University of Land Forces*, vol. 50, no. 2(188), pp. 19-30, http://dx.doi.org/10.5604/01.3001.0012.2487