THE GLOBAL RISK OF MARINE POLLUTION FROM WWII SHIPWRECKS: EXAMPLES FROM THE SEVEN SEAS

Rean Monfils
Sea Australia
P.O. Box 938
Civic Square, ACT 2608
Australia

ABSTRACT

The world took notice and action when the oil tanker Prestige sank and leaked oil onto the coast of Spain and France. Significant resources and considerable money was allocated to locate the wreck, patch the leaks and eventually offload the remaining oil. What is not well known, is that there is a significantly larger global marine pollution threat from over 7800 sunken WWII vessels worldwide, including over 860 oil tankers, corroding for over 60 years at the bottom of the worlds oceans.

Over the past three years, in conjunction with the Pacific Regional Environment Programme (SPREP), a project has been completed by the author to compile data on WWII shipwrecks across the Asia/Pacific region. This regional risk assessment is probably the first and most complete of its type so far published.

The Geographic Information System (GIS) database created for the Asia Pacific waters details ship type, tonnage and location of over 3,800 vessels lost in WWII. This amounts to over 13 million tons of sunken vessels in the Pacific alone ranging from aircraft carriers to battleships, and including over 330 tankers and oilers.

The creation of the Asia Pacific database acted as a catalyst to the creation of the Atlantic, Mediterranean and Indian Ocean (AMIO) WWII shipwreck database. This new geographic database, although still in its initial development, highlights the significant number of WWII shipwrecks globally. The AMIO database details the location and ownership of over 3950 vessels, over 1000 tons, of which 529 are oil tankers.

This paper details the information contained within the AMIO WWII shipwreck database including the potential oil and non-oil sources of marine pollution from these vessels. WWII shipwrecks are unique from commercial and non-military shipwrecks due to sovereignty, jurisdictional and ownership issues and these differences will also be discussed. The paper concludes with a summary for future directions to address the many response and preparedness issues associated with WWII shipwrecks.

INTRODUCTION

Throughout history, ships have been lost at sea due to war, day-to-day trade and severe weather events. With our increasing need to protect our oceans health from pollution, sunken shipwrecks have recently been receiving increased attention as a potential environmental and health threat.

Over the past century the occurrence of regional and global wars has left a legacy of thousands of sunken vessels across our oceans. The international community is aware of the problem of sunken wrecks and the potential pollution threat but not the magnitude of the global problem or the scale of the threat. It was only in March 2004 that the International Maritime Organization (IMO) OPRC (Oil Pollution Preparedness, Response and Cooperation) Technical Group acknowledged this problem and encouraged "regional centres and secretariats... to assess the situation regarding WWII wrecks that may cause oil pollution on their respective sea areas" (IMO 2004).

World War II was the single, largest loss of shipping in a relatively short period of time the world has ever witnessed. The Battle of the Atlantic and the vital trade routes was said to be, by Winston Churchill, "*the dominating factor all through the war*", on which everything depended (Williams 2002). The Battle in the Pacific again saw thousands of ships sunk and scuttled in an effort to protect the valuable resources of the South East Asia region.

Now sixty years on, the global risk of marine pollution from these sunken and scuttled WWII vessels could be said to be one of the most significant risks to the global marine environment from shipping along with ballast water and marine introduced species.

THE SPREP REGIONAL SHIPWRECK STRATEGY

The Pacific Regional Environment Programme (SPREP), under its Pacific Ocean Pollution Prevention Programme (PACPOL) formulated a Regional Strategy to address the issues related to World War II wrecks in the Pacific. This regional strategy was instigated by the continued leaking of the *USS Mississinewa* in Ulithi lagoon, Yap State, Micronesia (Nawadra & Gilbert 2002).

The aim of the SPREP regional strategy completed in 2002 was to address marine pollution from World War II shipwrecks and to assess and determine the extent of pollution risk posed by these vessels to the Island nations of the Pacific and their resources (SPREP 2002). The first and main step of the strategy endorsed by the SPREP member countries in 2002 was to collect and collate data associated with naval and merchant vessels lost during WWII across the Pacific.

The SPREP WWII shipwreck database has increased three fold from that reported by Gilbert *et al* (2003) at the International Oil Spill Conference in Vancouver, Canada and currently stands at 3854 vessels with a total tonnage of 13,638,830. This includes ships from many different nations that were sunk in the Pacific during WWII including both military ships and civilian merchant vessels.

THE SEVEN SEAS AND THE AMIO DATABASE

To the ancient mariners the word "seven" was often used to imply "many", and before the fifteenth century the many seas of the world were: the Red Sea, the Mediterranean Sea, the Persian Gulf, the Black Sea, the Adriatic Sea, the Caspian Sea and the Indian Ocean. In today's world the oceans are generally divided up into four main bodies of water; the Arctic Ocean, the Atlantic, the Indian Ocean and the Pacific Ocean.

Most, if not all of the seas and oceans of the world contain the remnants of WWII shipwrecks. By combining the Pacific WWII SPREP shipwreck information and the new AMIO shipwreck geographic databases **the combined total of WWII shipwrecks stands at 7807 vessels worldwide (Figure 1), combining to over 34 million tons of shipping with 861 tankers and oilers (Figure 2)**.

Although work on the Pacific SPREP WWII shipwreck database is relatively complete, work on shipwrecks in the other oceans has only recently commenced. The Atlantic, Mediterranean and Indian Ocean (AMIO) database of WWII shipwrecks is in its initial stages. Currently, the AMIO database contains over 3953 WWII vessels over 1000 gross tons equating to over 20 million tons of shipping lying on the bottom of the ocean.

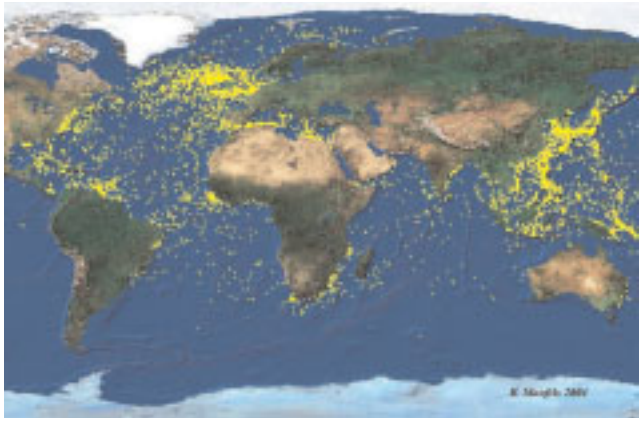

FIGURE 1: WORLD WAR II SUNKEN VESSELS COMBINING AMIO AND SPREP DATABASES

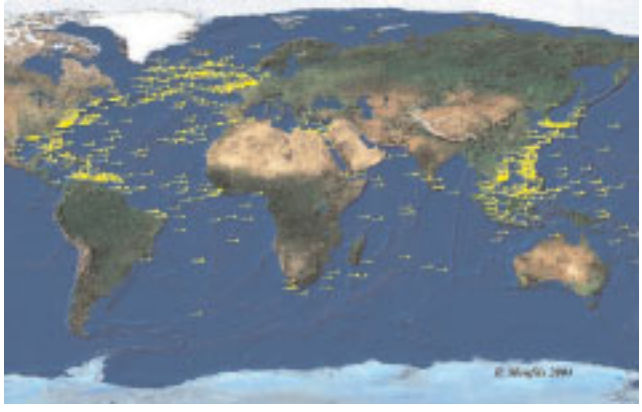

FIGURE 2: WORLD WAR II SUNKEN TANKERS COMBINING AMIO AND SPREP DATABASES

The Japanese Government has sovereignty or ownership of over 85% of the vessels sunk in the Pacific Ocean (Monfils *et al.* 2003). However, the major stakeholder for the rest of the world's WWII shipwrecks is the British Government who has sovereignty for just over half the WWII shipwrecks in the AMIO database, amounting to over 10 million tons of British WWII shipping (Table 1).

Table 1: AMIO WWII Shipwreck Database: Major ownership of vessels

COUNTRY	NUMBER OF VESSELS	% OF TOTAL
Britain	1903	51%
Germany	194	5%
Greece	142	3.70%
The Netherlands	157	4%
Norway	305	8%
Panama	88	2.30%
Sweden	106	2.80%
USA	607	16%
Total	3502	92.8%

Previous oil pollution incidents and past WWII shipwrecks (i.e. *USS Mississinewa*, Gilbert *et al.* 2003) have indicated that of particular concern should be the location of the high risk vessels sunk and the cargo they held. The location of oilers and oil tankers, both military and merchant is of prime concern. These vessels pose a higher risk due to the large quantities of oil carried on board at the time of sinking. Figure 2 provides the generalised locations of the sunken WWII oil tankers globally by combining the SPREP and AMIO datasets. These oil tankers pose a real and ever-increasing threat to the marine environment and human well-being from marine pollution leakage.

The AMIO database alone currently totals over 529 tankers outside the Pacific Ocean (Figure 2). Of these tankers a majority again have British sovereignty (Table 2).

Table 2: AMIO Database of Sunken WWII Oil Tankers: Ownership

COUNTRY	NUMBER OF VESSELS	% OF TOTAL
Britain	193	42%
Germany	4	0.80%
The Netherlands	20	4.30%
Norway	86	18.80%
Panama	26	5.70%
Sweden	5	1%
USA	122	26.70%
Total	456	99.3%

As indicated the AMIO geographic database is still under development but initial figures indicate the majority of vessel lie in the Atlantic Ocean. The Battle of the Atlantic took a significant toll on merchant vessels and left behind a legacy of over 3000 vessels in the North Atlantic alone and approximately 305 WWII vessels in the Mediterranean Sea.

Table 3: AMIO & SPREP Shipwreck Databases—Distribution of Shipwrecks Globally

OCEAN/SEAS	# OF VESSELS	TOTAL TONNAGE	# OF TANKERS
North Atlantic	3002	15108305	452
South Atlantic	198	1143374	20
Mediterranean	305	1578910	19
Indian	313	1813398	35
Arctic	124	729569	2
Pacific	3276	12158895	273

ESTIMATION OF OIL QUANTITIES FOR SUNKEN WRECKS

Liquid product tankers during WWII were carrying a variety of products including various crude oils, heavy fuel oil and/or refined fuel products, some were even carrying molasses. Of the 529 tankers logged within this database, 105 were known to be in ballast at the time of sinking and therefore pose little oil pollution risk except for that of its own fuel oil. Another 181 tankers had no information available on whether they were in ballast and what cargoes they were carrying. This leaves 243 oil tankers with accurate cargo information available with which to make an estimate of the amount of oil on board these tankers on average.

Heavy fuel oil is often seen as the most environmentally significant oil spill threat because of its persistence even after weathering at sea and very slow biodegradation rates. The *Prestige* oil spill caused significant damage because the cargo leaking was a high viscosity heavy fuel oil. Of the 243 tankers, only 79 tankers were identified as carrying fuel oil and so the attention was focused on these vessels in order to make an estimate of oil cargo on board. The 79 tankers together contained a total of over 939 million litres (>248 million gallons) of fuel oil. That is on average 11 megalitres of oil per vessel.

This calculation is based upon many assumptions but is also very conservative, as it does not include the 'no information' tankers, or tankers that had cargoes other than fuel oil (i.e. crude oil, gasoline, benzene, diesel, aviation spirit). The current AMIO database of the Atlantic, Mediterranean and Indian Ocean only contains information on vessels that were over 1000 tons. Submarines, however, were included as they played a vital role in the Battle of the Atlantic and also contain significant quantities of hazardous chemicals such as lead, acids and mercury which also pose an environmental threat.

RISK OF OIL RELEASE FROM SUNKEN WRECKS

The sea is a sacrificial and corrosive chemical environment for metal objects and wooden structures. The rates of shipwreck deterioration depends upon type of construction, length of immersion, extent of burial, chemical, physical and biological factors. Saltwater corrosion along with shifting sea-bottom sediments, marine bacteria and organisms, destructive storms and currents will reduce a sunken shipwreck back to its original basis chemical elements. Some protection of a vessels metal super structure may occur due to burial in soft silts on the seabed, and reduced oxygen and temperature in deep water. But eventually a shipwreck will deteriorate over time under the sea to the extent where it may release some or all of its oil cargo, fuels, lubricants or hazardous chemicals.

Sunken shipwrecks in shallow waters which are exposed to warm tropical water temperatures will usually deteriorate at a greater rate than cold deep water wrecks. This is primarily due to a number of environmental factors which include shallow oxygenated waters in lagoonal or near shore environments, microbial attack, the impact of storms, unstable bottom sediments and strong local hydrodynamic forces acting on the wreck (Macleod 2002).

Merchant vessels lost at sea due to storms, grounding or collision accidents, or military vessels that have been sunk during wartime are expected to have suffered extensive structural damage, fires and explosion of ammunition prior to sinking. Often during the war, explosions continued even after the vessel sank because depth charges would explode due to increased water pressure and the shifting and crushing of cargoes.

It must also be recognised that most WWII sunken shipwrecks have:

- Suffered over 60 years of continual deterioration underwater after sinking
- Weakened by the initial accident, fire or explosion that sank the vessel prior to it sinking
- Crushed and deformed by the enormous forces of the sea if sunk in deep water
- Either served in combat or associated wear & tear prior in merchant service
- Have settled over time into bottom sediments and will continue to do so placing different structural stresses and strains on the vessel over time
- Suffered the impacts of storms, typhoons and ocean currents over many decades
- Suffered slow and variable degradation of the metal structure due to general metal wasting from oxidation (rust) and electrochemical reactions
- Suffered the loss of strength of fasteners throughout the vessel superstructure and pipe-work causing possibly internal and external leaks of oil

Oil leaks from sunken WWII wrecks often occur at pipe-work and at mechanical connections, valves and joints, usually in internal parts of fuel and cargo tanks (i.e. *H.M.S. Royal Oak*, Rowlands 2001). Metal fasteners over time lose their ability to hold flanges (e.g. nuts and threads waste away), rubber seals fail and the ingress of seawater to metal components and seals causes rust and metal wastage. Iron oxide (rust) occupies a greater physical volume than iron itself, causing expansion and the forcing apart of the already weakened fasteners, leading to oil leakage and seepage or seawater ingress.

Each year that passes, the vessels lost during and after WWII deteriorate more and the risk of significant oil release becomes more likely. It is for this reason that the risk of marine pollution from sunken WWII vessels is a relatively 'new' problem and why it needs to be addressed sooner rather than later to ensure global agreement and preparedness to this world-wide problem.

CHEMICAL AND ORDNANCE

During and after WWII the majority of vessels sunk contained not only fuel oil and (tragically) human life, but many contained

large quantities of live ammunition, shells, mines, depth charges other explosives as well as some chemical warfare agents (CWA). Current estimates indicate over 300,000 tonnes of chemical warfare agents in the waters around Europe alone, mostly dumped deliberately after the war (Plunkett 2003a, Kaffka 1996). Over 4900 tonnes of CWA was dumped off Japan after instructions from the US occupation forces and over 21,000 tonnes of CWA disposed in Australian waters (Plunket 2003b). The Baltic, Barents, North and Irish Sea are said to be riddled with ammunition and CWA from WWII (Murphy 2003, Leewis 1991).

The disposal of CWA and unused armaments at sea was seen as the best disposal method at the time; as there was simply too much of it to store, incinerate or dispose of on-land. Often derelict vessels were loaded with unwanted material and scuttled in designated areas, other times unwanted bombs and containers of CWA were simply thrown overboard at will. The sea was seen by the military and governments to have unlimited absorptive capacity. CWA and armaments are coming in increasing contact with human activities such as fishing. In the 1970's, for example, trawlers would rarely trawl below 120m, now they can trawl in depths of 1500m and the dumped waste material is becoming much more than a nuisance, it has become a health hazard and a potential ecological and environmental problem.

Some of the ammunitions and CWA have already started washing ashore and includes artillery shells, phosphorous flares, mortars, incendiaries, cluster bombs, mustard gas, nerve gas (both Tabun and Sarin[1]) and phosgene-charged rockets[2]. There are numerous unfortunate examples of injuries and loss of life caused by ammunition and CWA from around the world.

Danish Authorities have reported over 400 cases of fishermen catching and lifting toxic material from the seabed onto their boats. Deaths and severe injuries have resulted from fishermen inadvertently handling the hazardous materials (DIVER 1998, Doyle 2004). As a consequence of these deaths and injuries many fishermen in the Baltic now carry chemical protective equipment and decontamination gear on board their fishing vessels.

CWA and live ordnances is a significant problem worldwide. The Baltic region, the Barents Sea, the waters around Europe and the UK, Japanese waters and Australian waters are known to have the remnants of war. In some countries the exact, or approximate location of these dump sites is well known; such as Australia (Plunkett 2003b) or the Beaufort Trench in the Irish Sea (Fisheries Research Services). Unfortunately, however sometimes the dumped chemical cargo did not sink straight to the bottom as cylinders, boxes and containers often became buoyant on the surface or in the water column and travelled great distances from the pre-approved dump site. Other times, the ammunition, explosives or toxic chemical cargo was not dumped at the approved site due to poor weather, the lack of close government supervision or cost savings in time and fuel steaming out to deep water disposal.

Of major concern to European governments is the identification of CWA dump sites near fishing grounds. For example Norway is only aware of the location of 15 of a possible 36 ships that were dumped after the war containing over 168,000 tonnes of Nazi ammunition (Doyle 2004).

Some of the Governments of the Asia Pacific region have raised concerns as to WWII ordnances from sunken shipwrecks being salvaged by locals for use in home made explosives for illegal dynamite fishing as well as for construction of home made weapons. The remnants of WWII still litter many of the small Pacific islands and lagoons and being mishandled by locals causing injuries (Trevor Gilbert, SPREP, *pers. com*).

WWII WRECK OWNERSHIP AND RESPONSIBILITY

The issue of "who is responsible" for these sunken WWII shipwrecks has become a very complicated matter and a subject of much international debate.

The jurisdictional WWII shipwreck issue has been discussed in detail in Monfils *et al.* (2003) but in summary WWII wrecks are classified as 'state owned vessels' and as such have "sovereign immunity"—i.e. they are immune to many of the maritime conventions such as MARPOL. The sovereignty of military vessels (be they warships or merchant) resides with the government that had control of that vessel at the time of its sinking. This immunity also applies to the property, cargo or content on board the vessel at the time of sinking. Could one then assume that the responsibility for any mitigation of marine pollution and environmental damage caused would then also be the responsibility of the flag-state?

The three flag states for the majority (80%) of vessels sunk during WWII world-wide are Japan, the United States and the British Governments. All three have recently published policies on the protection, sovereignty and responsibility for sunken WWII vessels[3].

The three policies cover the same principles and in summary they reinforce the conclusion that the vessels and their contents are flag state (government) property no matter where they rest, and that this sovereignty does not diminish with depth of water nor passage of time. These wrecks are also entitled to special respect as war graves and any attempt to interfere or salvage the vessel or contents without the expressed permission of the flag state would be regarded as a serious breach of sovereign immunity.

SHIPWRECK RISK ASSESSMENT

In the Pacific WWII Shipwreck study undertaken by SPREP a generalized oil pollution risk assessment methodology was published (Gilbert et al 2003 and SPREP 2002). Many countries have taken a 'passive monitoring' attitude to WWII shipwrecks and their potentially hazardous cargo, as in the case of the US oil tanker *Montebello* off the coast of California (Hunter 2002) and the ammunition ship *USS Richard Montgomery* in UK waters (Johnson 2004). The *Montebello* threatens the California coast with over 11 megalitres of crude oil (Hunter 2002) and the *SS Richard Montgomery* threatens the Thames Estuary, the Isle of Sheppey and its surroundings with over 3000 tones of explosives (Johnson 2004, Mitchell 1986).

In the future it may become necessary for decisive precautionary mitigation action to be taken in order to avert a potential marine pollution incident or loss of human life. Regional risk assessments will identify the location, tonnage and ownership of these vessels and determine the extent of risk posed by these vessels. The high risk vessels will require further investigative work such as identifying the extent of corrosion of the vessels hull such as was undertaken for the *Montebello* in Hunter (2002).

The initial risk assessment for the Pacific Island members of SPREP can be found on the SPREP website[4] and has also been published on a CD-ROM (SPREP 2003).

CONCLUSION

This paper has detailed the extent of 7807 World War II sunken vessels around the worlds oceans by combining the already mostly completed SPREP database with the new AMIO database. The world-wide total tonnage of sunken World War II vessels amounts to just over 34 million tonnes of shipping with about 20 million in the AMIO and 13 million in the SPREP database. A majority of the vessels were sunk in the Atlantic Ocean which currently hosts over 3200 vessels and over 16 million tonnes. The Pacific SPREP database indicates that the Pacific Ocean hosts over 3854 vessels with a lower total tonnage of over 13 million tonnes. In total, there are 861 sunken World War II tankers and oilers on the bottom of the world's oceans (529 in AMIO and 332 in SPREP).

When an oil spill event incident occurs from a sunken wreck it is usually handled on an ad-hoc reactive basis to solve the immediate pollution threat. Difficult issues such as jurisdiction, national

sovereignty, political sensitivity and legal responsibility can stand in the way of a timely response to the spill. Jurisdictionally there are three main owners of sunken World War II vessels around the world. Britain (1940 vessels), Japan (3322 vessels) and the US (1022 vessels) own over 80% of all the sunken World War II vessels logged within the databases to date. There is a slight discrepancy in this calculation since Allied war losses were better recorded than Axis war losses. The next stage for the AMIO database will be to further investigate the German and Italian war losses.

However, the WWII wreck issue is not a technology problem but a failure on the part of the responsible parties to accept that these vessels could possibly pose a threat to the environment. It is clear, however that the problem is too big to be ignored. Passive monitoring may only work for a while, but the nature of seawater and the effect of corrosion and structural deterioration of these vessels and the passing of over 60 years indicate that it is only a matter of time; and not if these vessels will pollute and leak but when they will pollute and leak. When they do, the extent of deterioration on the wrecks may cause a catastrophic oil spill which may pollute the environment and affect fisheries, tourism and trade.

The live ammunition and explosives is also a problem that requires immediate attention and further investigation. A mishap with one of these vessels could lead not only to pollution and environmental problems but loss of life for local residents, fishermen or salvage crews.

The problem is not unique to World War II vessels either. A United Nations Development Programme (UNDP) survey reported over 282 wrecks in Iraqi territorial waters which could pose an environmental threat if not safely removed (IRIN News 2004).

The AMIO database is in its initial stages and already shows the extent of the problem and numbers involved with sunken WWII vessels. In the coming years, the AMIO database should be further researched in order to make a more complete listing of sunken WWII vessels. Eventually, desk-top risk assessments and site risk assessments will lead to regional strategies and contingency plans being implemented in order to more successfully deal with WWII vessels and the threats they pose to both human life and the environment.

ACKNOWLEDGEMENTS

The author would like to thank Sefa Nawadra from SPREP for allowing me to use the SPREP information in this paper and Trevor Gilbert for his scientific and chemical input.

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CAPTIONS

ENDNOTES

[1] Sarin is the nerve agent used in the 1995 terrorist attack on the Tokyo subway. A 1 mg dose kills an adult in 15 minutes

[2] Phosgene is a poisonous gas that acts as a acute respiratory irritant, causing severe lung damage.

[3] For Japan: Communication from the Government of Japan, September 13, 2003 to the US State Department Public Notice 4614. 69 FR 5647 02/05/2004
For USA: Clinton, W.J. Public Papers of the President Vol III, Page 2956, Jan. 19, 2001
For UK: Communication from the UK Foreign and Commonwealth Office, July 4, 2003

[4] http://www.sprep.org.ws/publication/webpage/004ship_waste_ww2/WWII_strategy/regional.htm