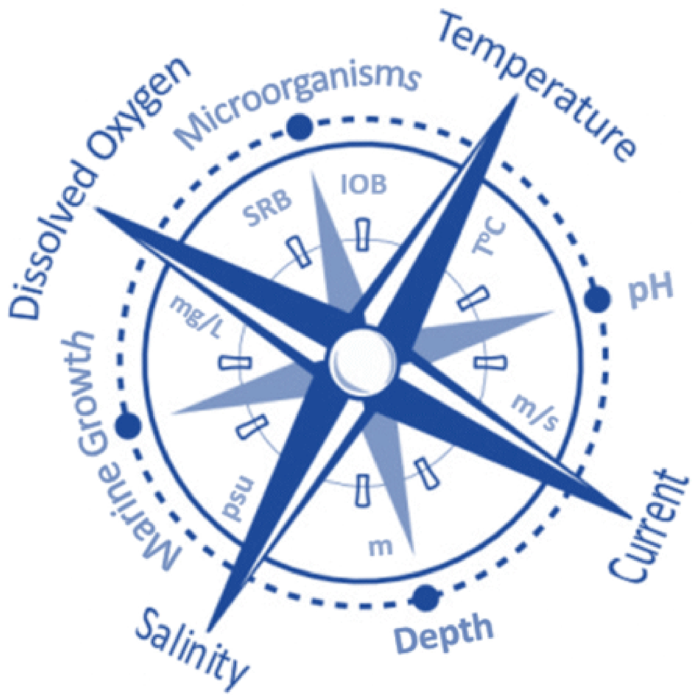


CO2Compass-SE is now renamed as Shipwreck-Compass.

Shipwreck-Compass®: Software for Shipwreck Corrosion Modeling and Shipwreck Corrosion Prediction

Version 9.18

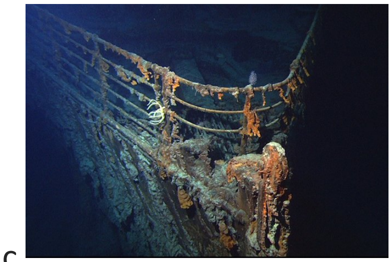
☆ **Performance** ☆ **Functionality** ☆ **Usability**

Anytime Anywhere Any Device Any OS

No USB dongles No installation No Browser Plug-ins

Contact Us for License Details

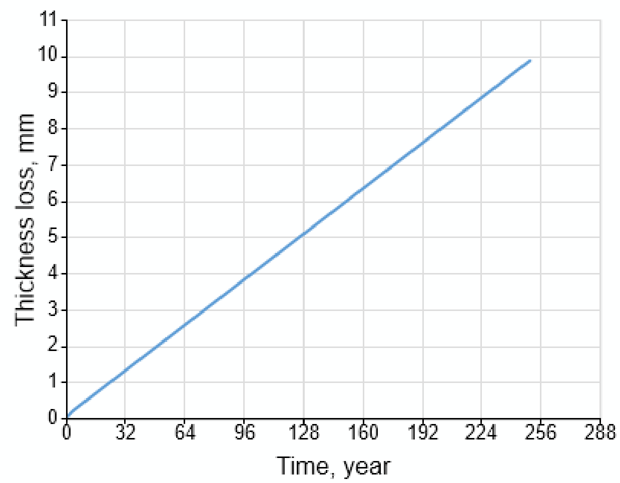
Features and Functions of Shipwreck-Compass

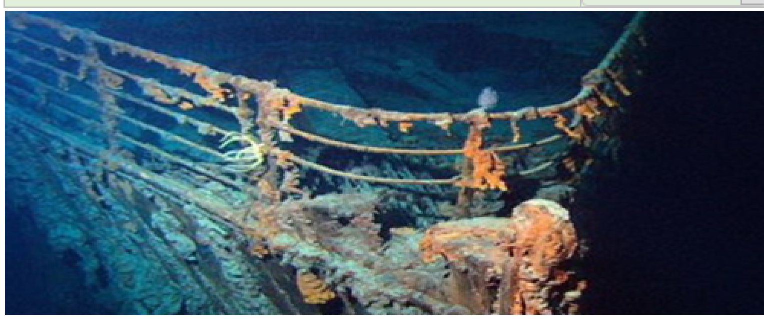


There are many shipwrecks at the bottoms of oceans around the world. Statistics shows that in the Pacific Ocean alone, there are about 3,000 WWII shipwrecks at risk of leaking oil and around 10 per cent of the wrecks are oil tankers. Some of these wreckages have cultural and historic significance while others have serious environmental concerns such as oil leaking due to corrosion of the hull plate. Accurate prediction of the corrosion rate and hence the remaining life, or the time-to-perforation is important both to the conservation of historic shipwrecks and to the environmental risk assessment of others.

Shipwreck-Compass is the only device and OS independent software tool on the market for shipwreck corrosion modeling and corrosion prediction. Its predictive engine is based on the rigorous frameworks of thermodynamics, physical chemistry, and corrosion kinetics. This software tool models the effects of dissolved oxygen, temperature, salinity, current velocity, pH, depth of water, marine growth and microorganisms including sulphate-reducing bacteria (SRB) and iron-oxidizing bacteria (IOB) on the corrosion rate, pitting rate, the thickness loss, pit depth, the remaining life, and the time-to-perforation, as shown in Figure 1 below for an oil tanker sank in the Atlantic Ocean in 2002.

Shipwreck Corrosion Modeling and Prediction		
Name of vessel	Oil Tanker (2002)	
Wreck location	North Atlantic Ocean	
Age of the wreck immersed in water	year	1.00
Water depth at wreck site	m	3800
Salinity of water at depth of wreck	‰	35.00
Temperature of water at depth of wreck	°C	3.00
Dissolved O2 in water at depth of wreck	ml/L	5.20
Current velocity at depth of wreck	m/s	0.00
pH of water at depth of wreck	pH	8.00
Biofilm and/or macro-fouling on shipwreck	with SRB/IOB	

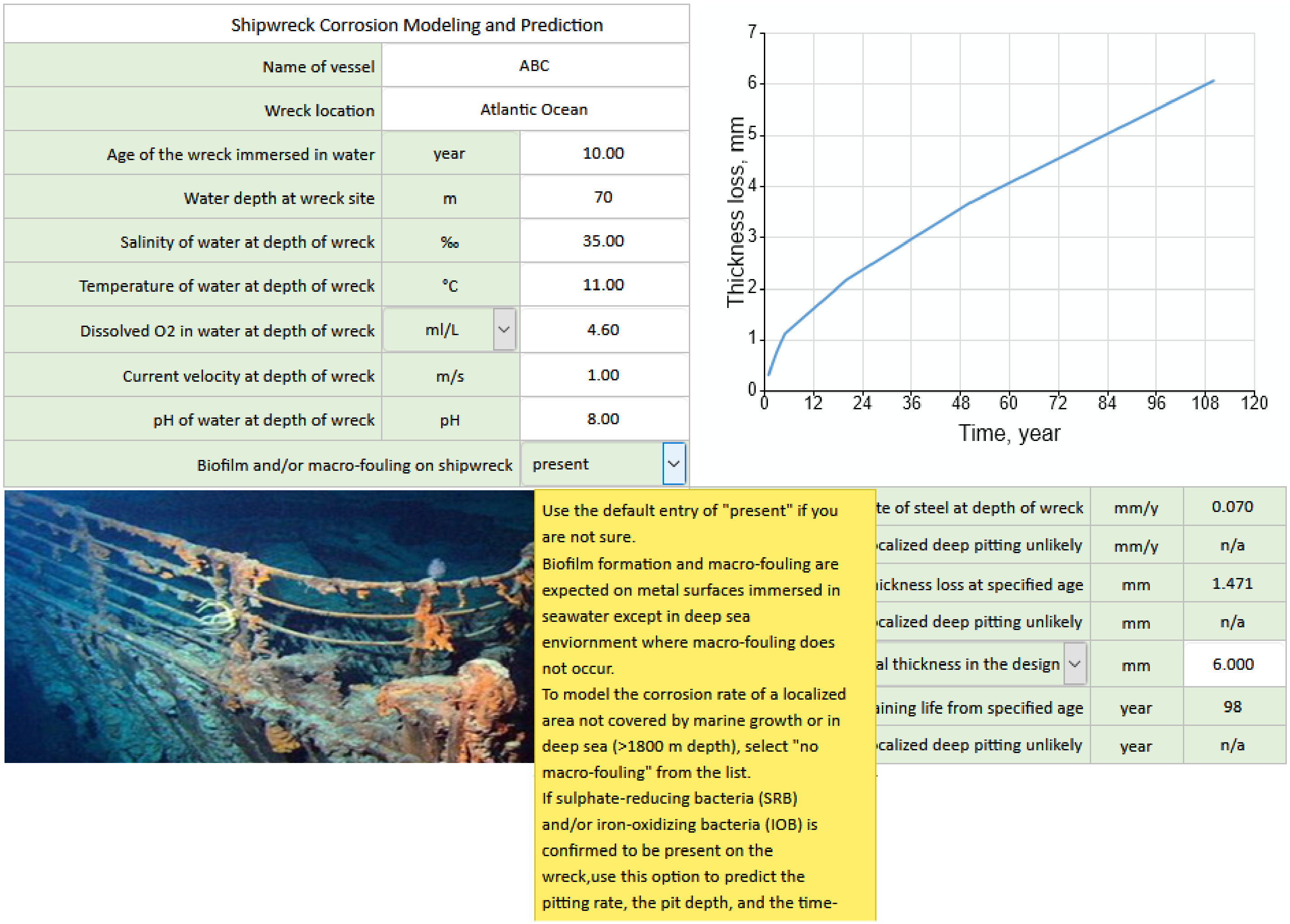




Corrosion rate of steel at depth of wreck	mm/y	0.078
Pitting at localized spots if SRB/IOB present	mm/y	0.392
Accumulated thickness loss at specified age	mm	0.078
Pit depth at localized spots if SRB/IOB present	mm	0.392
Original thickness in the design	mm	9.600
Predicted remaining life from specified age	year	242
Time-to-perforation by pitting at localized spots	year	24

Figure 1 Shipwreck-Compass Predicts Shipwreck the Corrosion Rate, the Thickness Loss, and the Remaining Life.

The predictive engine in Shipwreck-Compass also takes into account the effects of marine growth and microorganisms that are present in seawater environments (Figures 2a and 2b). The biofilms that form on the metal surface have the capability to influence the corrosion of the metal. The film itself can range from a microbiological slime film to a heavy encrustation of hard-shelled fouling organisms. This influence of biofilm derives from the ability of the organisms to change the local environmental variables important to corrosion such as dissolved oxygen, temperature, velocity, pH and others. For example, a heavy encrustation of bio-fouling organisms on steel immersed in seawater will often decrease the corrosion rate of the steel as long as the cover of organisms remains complete and relatively uniform. The heavy fouling layer acts as a barrier film in limiting the amount of dissolved oxygen reaching the metal surface, thus reducing the thickness loss of the steel. A layer of hard-shelled organisms, such as barnacles or mussels, on steel also shields the metal from the damaging effect of wave action.



Shipwreck Corrosion Modeling and Prediction		
Name of vessel	ABC	
Wreck location	Atlantic Ocean	
Age of the wreck immersed in water	year	10.00
Water depth at wreck site	m	70
Salinity of water at depth of wreck	‰	35.00
Temperature of water at depth of wreck	°C	11.00
Dissolved O2 in water at depth of wreck	ml/L	4.60
Current velocity at depth of wreck	m/s	1.00
pH of water at depth of wreck	pH	8.00
Biofilm and/or macro-fouling on shipwreck	present	

te of steel at depth of wreck	mm/y	0.070
calized deep pitting unlikely	mm/y	n/a
ickness loss at specified age	mm	1.471
calized deep pitting unlikely	mm	n/a
al thickness in the design	mm	6.000
aining life from specified age	year	98
calized deep pitting unlikely	year	n/a

Figure 2a: Modeling the effect of marine growth and microorganisms on corrosion.

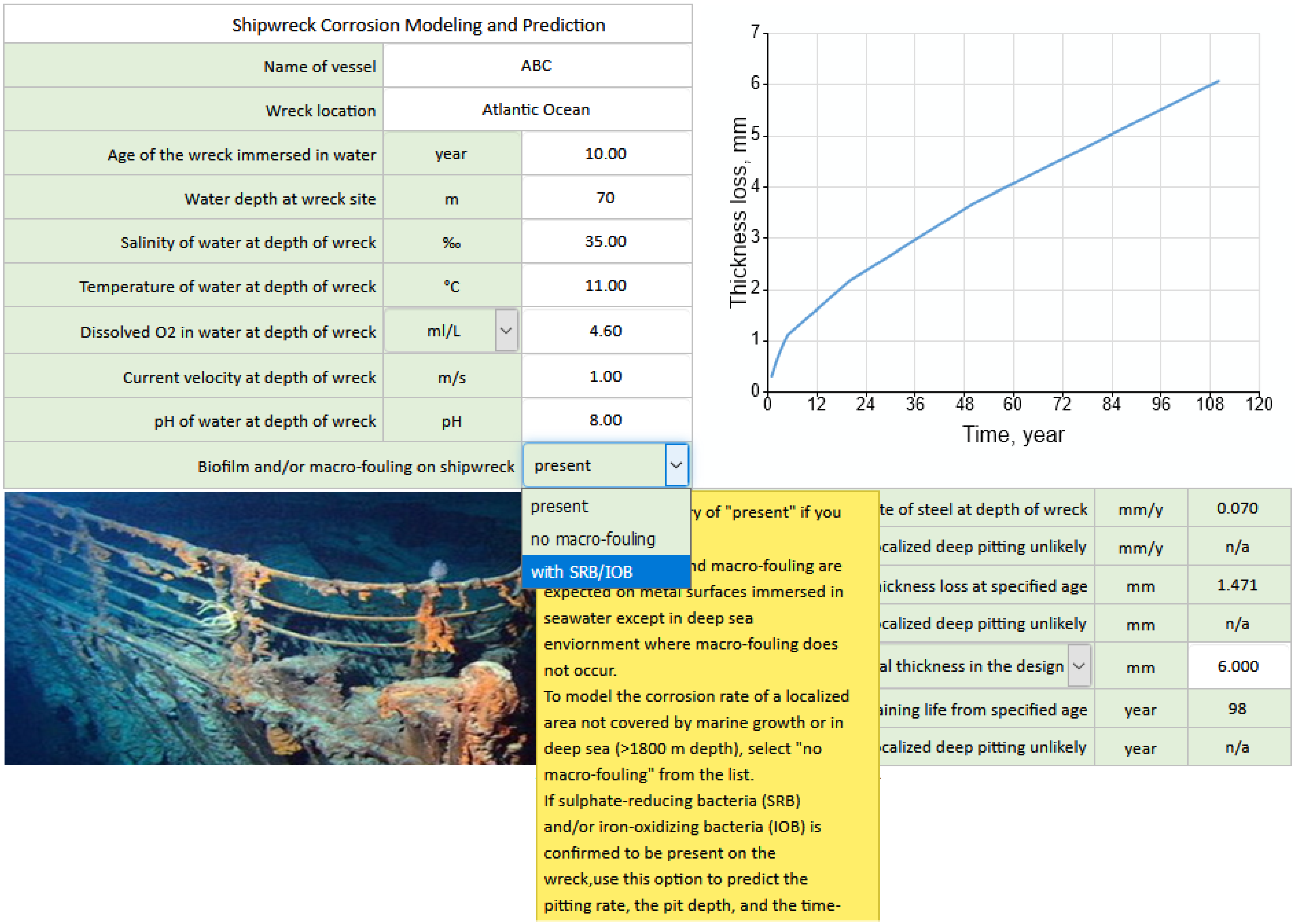
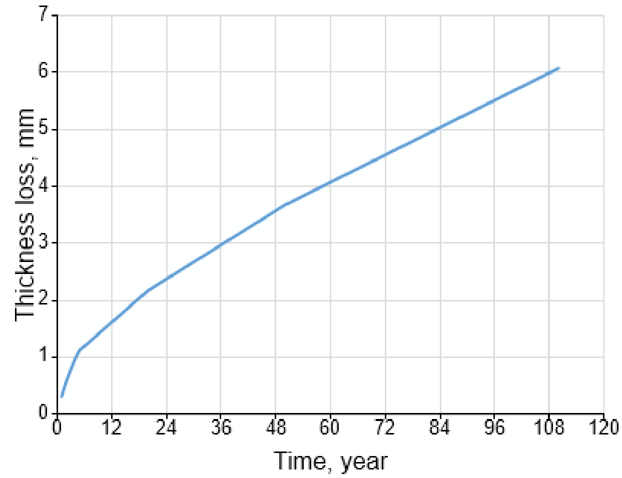


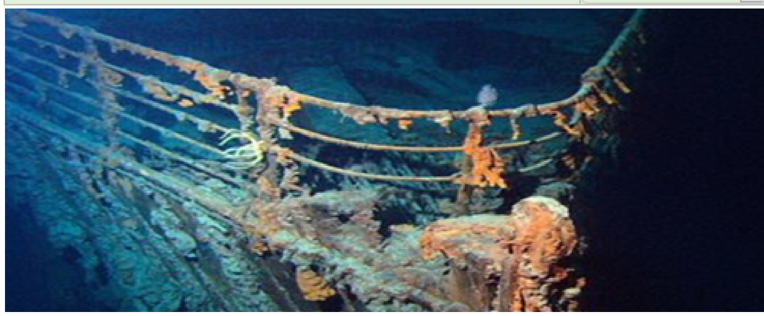
Figure 2b: Modeling the effect of marine growth and microorganisms on corrosion.

Shipwreck-Compass was designed with end users in mind. Experience the first cross-platform and device-independent Shipwreck Corrosion Modeling and Prediction application on your iPads, tablets, smart phones, notebooks and desktops, at any time and anywhere, in the office or on the sea. No installation files to download, no browser plug-ins required, no USB dongles to carry around, and no license keys to transfer from one PC to another. Shipwreck-Compass simply works on any device running any OS. All you need is an internet browser.

Users can enter the dissolved oxygen concentration in any unit without the need to do manual conversion (Figure 3). To predict the remaining life, users can either enter the original thickness in the design (if known) or the remaining thickness (if measured), as shown in Figure 4.

Shipwreck Corrosion Modeling and Prediction		
Name of vessel	ABC	
Wreck location	Atlantic Ocean	
Age of the wreck immersed in water	year	10.00
Water depth at wreck site	m	70
Salinity of water at depth of wreck	‰	35.00
Temperature of water at depth of wreck	°C	11.00
Dissolved O2 in water at depth of wreck	ml/L	4.60
Current velocity at depth of wreck	ml/L	1.00
pH of water at depth of wreck	mg/L ppm	8.00
Biofilm and/or macro-fouling on shipwreck	present	

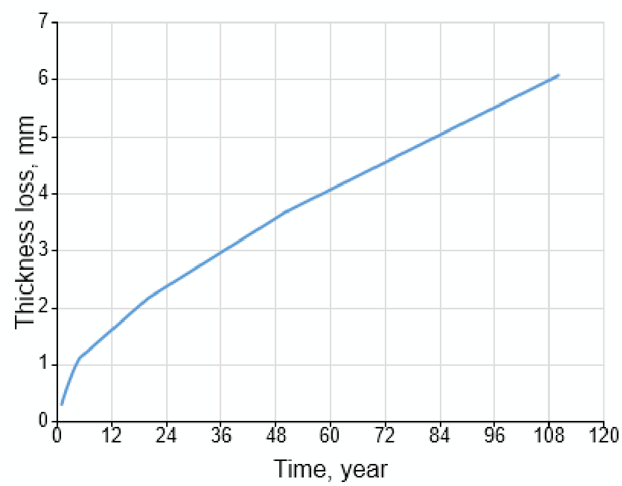


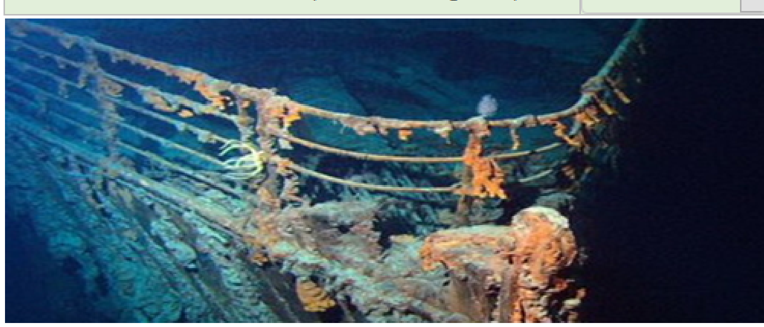


Corrosion rate of steel at depth of wreck	mm/y	0.070
No SRB/IOB, localized deep pitting unlikely	mm/y	n/a
Accumulated thickness loss at specified age	mm	1.471
No SRB/IOB, localized deep pitting unlikely	mm	n/a
Original thickness in the design	mm	6.000
Predicted remaining life from specified age	year	98
No SRB/IOB, localized deep pitting unlikely	year	n/a

Figure 3 Dissolved Oxygen Concentration and Shipwreck Corrosion Prediction

Shipwreck Corrosion Modeling and Prediction		
Name of vessel	ABC	
Wreck location	Atlantic Ocean	
Age of the wreck immersed in water	year	10.00
Water depth at wreck site	m	70
Salinity of water at depth of wreck	‰	35.00
Temperature of water at depth of wreck	°C	11.00
Dissolved O2 in water at depth of wreck	ml/L	4.60
Current velocity at depth of wreck	m/s	1.00
pH of water at depth of wreck	pH	8.00
Biofilm and/or macro-fouling on shipwreck	present	





Corrosion rate of steel at depth of wreck	mm/y	0.070
No SRB/IOB, localized deep pitting unlikely	mm/y	n/a
Accumulated thickness loss at specified age	mm	1.471
No SRB/IOB, localized deep pitting unlikely	mm	n/a
Original thickness in the design	mm	6.000
Original thickness in the design	year	98
Remaining thickness before sinking	year	n/a

Figure 4 Remaining Life Prediction of Shipwreck

Corrosion Prediction of a Warship Sank in World War I in 1915

In this application example, we have a look at the Corrosion Prediction of Submarine HMAS AE2 (1915) in the Sea of Marmara, Turkey. The Australian submarine AE2 was built in 1912 by Vickers Armstrong at Barrow-in-Furness, England, launched in 1913 and sank on 25 April 1915 at a depth of 73 m at the bottom of the Sea of Marmara, Turkey during World War I. The seawater physicochemical properties are as follows:

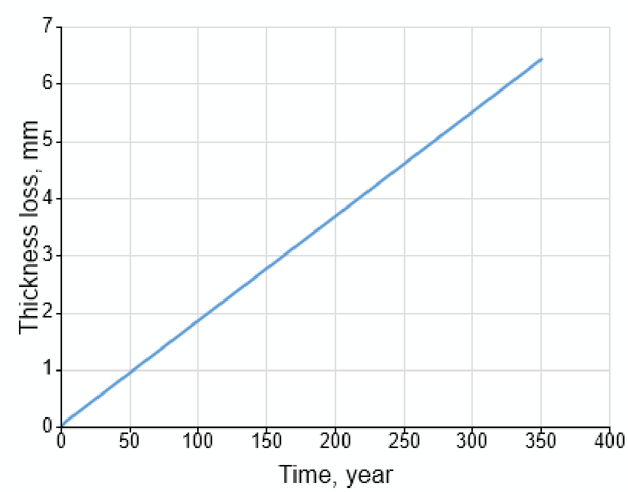
Temperature: 14.1°C

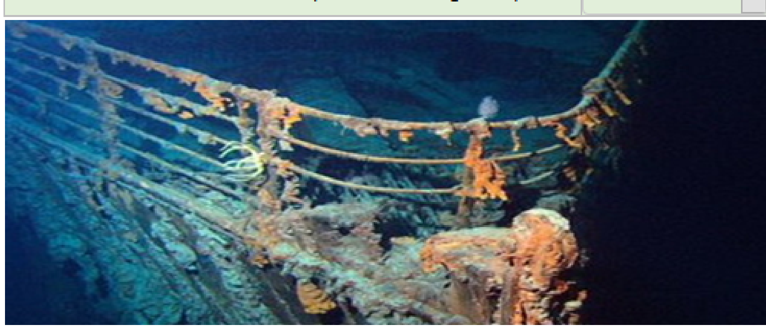
Dissolved oxygen: 2.6 ppm

Salinity: 41.3

The ballast tank with an original thickness of 6.35 mm lost 1.75 mm in 92.4 years (till 2007) based on ultrasonic thickness gauge measurement, giving a corrosion rate of 0.0189 mm/y. Figure 5 shows the prediction results from Shipwreck-Compass. Table 1 compares the measured and the predicted thickness loss and the corrosion rate. Shipwreck-Compass predicts that the remaining life of the ballast tank is 253 years.

Shipwreck Corrosion Modeling and Prediction		
Name of vessel	HMAS AE2 (1915)	
Wreck location	The Sea of Marmara, Turkey	
Age of the wreck immersed in water	year	92.40
Water depth at wreck site	m	73
Salinity of water at depth of wreck	‰	41.30
Temperature of water at depth of wreck	°C	14.10
Dissolved O2 in water at depth of wreck	ppm	2.60
Current velocity at depth of wreck	m/s	0.00
pH of water at depth of wreck	pH	8.00
Biofilm and/or macro-fouling on shipwreck	present	





Corrosion rate of steel at depth of wreck	mm/y	0.018
No SRB/IOB, localized deep pitting unlikely	mm/y	n/a
Accumulated thickness loss at specified age	mm	1.729
No SRB/IOB, localized deep pitting unlikely	mm	n/a
Original thickness in the design	mm	6.350
Predicted remaining life from specified age	year	253
No SRB/IOB, localized deep pitting unlikely	year	n/a

Figure 5 Shipwreck-Compass Prediction of shipwreck corrosion and remaining life for Submarine HMAS AE2 (1915)

Table 1 Comparison of the measured and the predicted thickness loss and the corrosion rate.

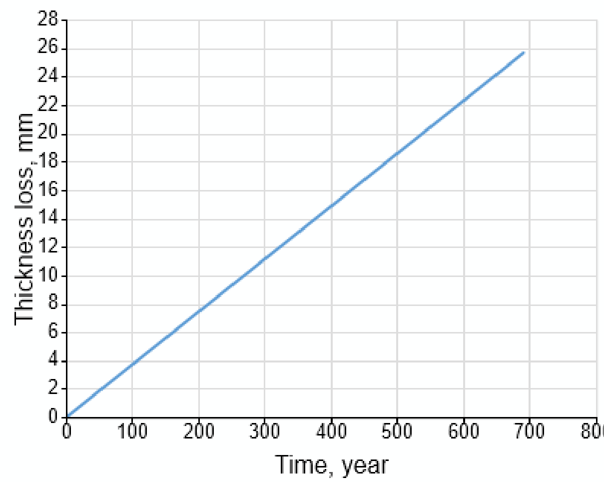
	Measured using ultrasonic thickness gauge	Predicted using Shipwreck-Compass
Thickness loss, mm	1.75	1.73
Corrosion rate, mm/y	0.0189	0.018

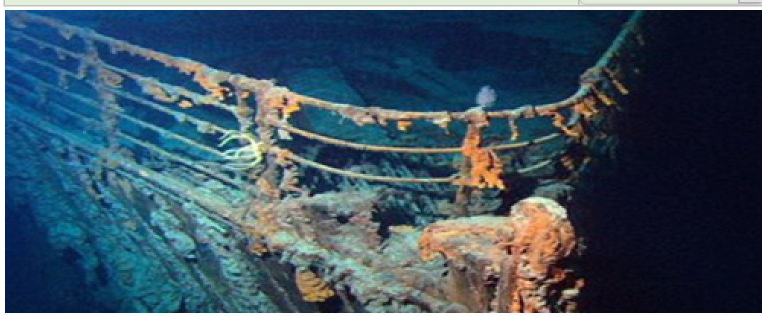
Corrosion Prediction of the USS Monitor Sank in 1862

The USS Monitor was the first iron-clad battleship equipped with a revolving gun turret constructed from 8 layers of 1-inch (2.54 cm) iron plates. It sank in a storm in December 1862 off the coast of Cape Hatteras, North Carolina, at a water depth of 70 m.

Ultrasonic thickness measurements conducted in 2007 (144 years after sinking) on the outer turret plates at eight locations near the gun openings showed a thickness loss of about 5 mm. This gives an average measured corrosion rate of 0.035 mm/y. Figure 6 shows the prediction results from Shipwreck-Compass. The predicted corrosion rate is 0.037 mm/y and the predicted thickness loss is 5.4 mm.

Shipwreck Corrosion Modeling and Prediction		
Name of vessel	USS Monitor (1862)	
Wreck location	Cape Hatteras, NC, USA	
Age of the wreck immersed in water	year	144.00
Water depth at wreck site	m	70
Salinity of water at depth of wreck	‰	35.00
Temperature of water at depth of wreck	°C	7.00
Dissolved O2 in water at depth of wreck	ppm	6.40
Current velocity at depth of wreck	m/s	0.00
pH of water at depth of wreck	pH	8.20
Biofilm and/or macro-fouling on shipwreck	present	





Corrosion rate of steel at depth of wreck	mm/y	0.037
No SRB/IOB, localized deep pitting unlikely	mm/y	n/a
Accumulated thickness loss at specified age	mm	5.431
No SRB/IOB, localized deep pitting unlikely	mm	n/a
Original thickness in the design	mm	25.400
Predicted remaining life from specified age	year	538
No SRB/IOB, localized deep pitting unlikely	year	n/a

Figure 6 Shipwreck-Compass Prediction of shipwreck corrosion and remaining life for the USS Monitor (1862)

Table 2 Comparison of the measured and the predicted thickness loss and the corrosion rate.

	Measured using ultrasonic thickness gauge	Predicted using Shipwreck-Compass
Thickness loss, mm	5 mm	5.4 mm
Corrosion rate, mm/y	0.035 mm/y	0.037 mm/y

The powerful applications of Shipwreck-Compass are truly unlimited in both the conservation of shipwrecks with cultural and historic values and the risk assessment of shipwrecks with environmental concerns.

Click here to contact us for a free trial and experience the power of Shipwreck-Compass in shipwreck corrosion modeling and corrosion prediction.

Shipwreck-Compass, giving you the right directions in Shipwreck Corrosion Modeling and Corrosion Prediction