Managing Corrosion Risks in Underwater Cultural Heritage: A Preventive Conservation Strategy for the Belinho I Shipwreck Pewter Assemblage (Esposende, Portugal)

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2. Contextualization

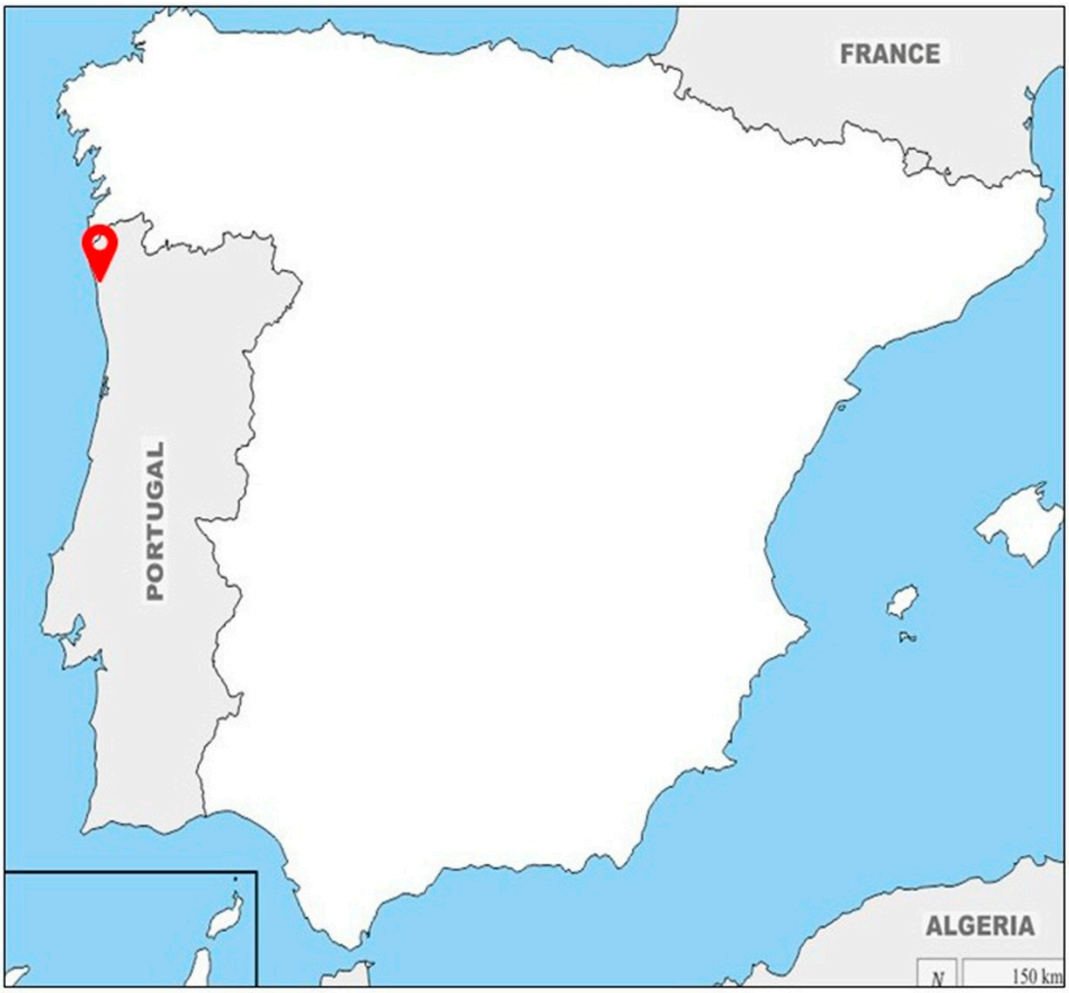

Figure S1. Location of the *Belinho I* shipwreck on Belinho beach (Esposende), Northern Coast of Portugal.

3. Materials and Methods

3.2 Laboratory preventive conservation protocol

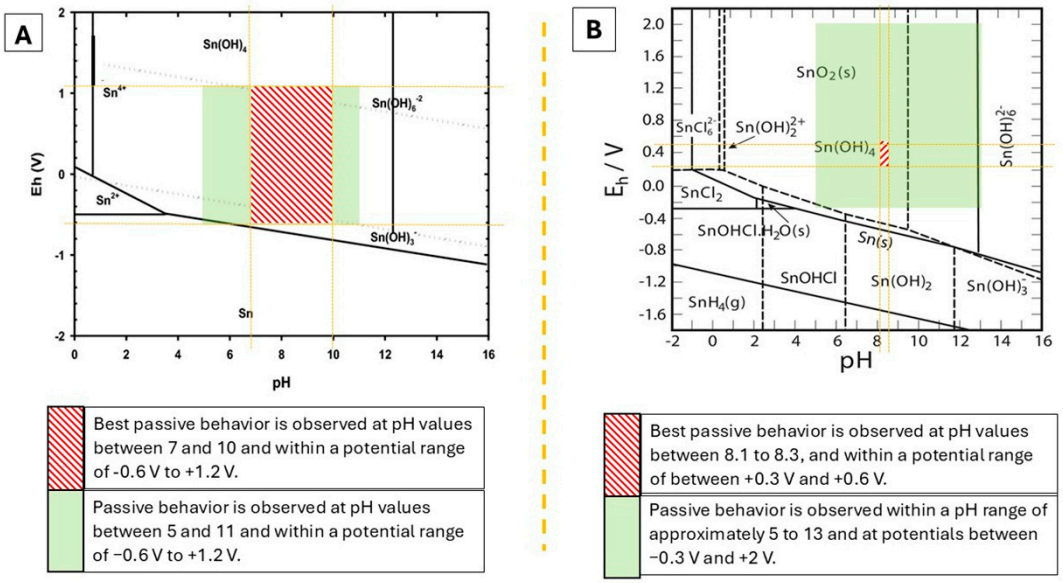

Figure S2. (**A**) Pourbaix diagram (Eh–pH) for the Sn–H_2O system at 25 °C [27]; (**B**) Pourbaix diagram for tin in a chloride medium [40], adapted from House & Kelsall (1984). Highlighted areas (red-hatched and green) are overlaid by the authors of the present work to represent the E_h–pH ranges of passive behavior as reported by MacLeod & Wozniak (1995) [28] and Zohdy et al. (2021) [42].

4. Results

4.1 Field-based Community Preventive Conservation Protocol

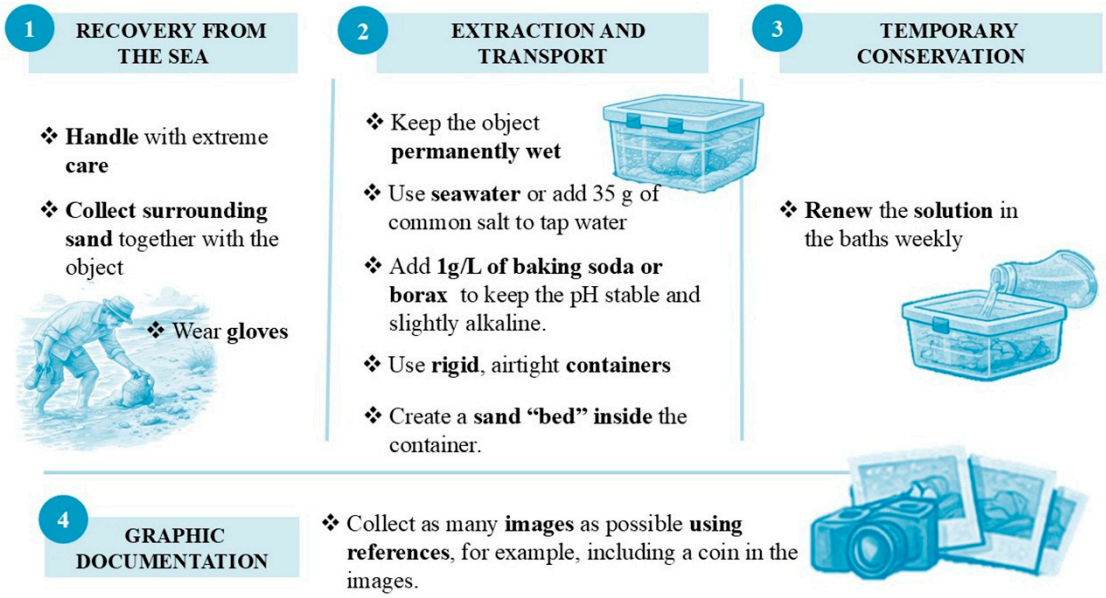

Figure S3. Schematic overview of the Field-Based Community Preventive Conservation Protocol. The illustrations in the figure were generated with generative artificial intelligence.

4.2 Implementation of the preventive conservation protocol at the laboratory: passivation baths

Table S1. Conductivity (mS/cm), Temperature (°C), and pH values measured over the full monitoring period of each passivation bath.

	Monitoring period	Conductivity (mS/cm)	Temperature (°C)	pH
1st bath	27/05/2025	31.54	20.3	9.26
	29/05/2025	32.24	20.9	9.02
	30/05/2025	32.98	21.4	8.99
	03/06/2025	33.20	21.3	8.88
2nd bath	03/06/2025	17.26	22.0	6.66
	04/06/2025	17.59	21.4	9.11
	05/06/2025	17.77	21.5	9.05
	11/06/2025	18.00	22.0	9.04
3rd bath	11/06/2025	10.41	22.5	8.33
	13/06/2025	10.60	22.4	8.27
	16/06/2025	11.18	22.2	9.22
	19/06/2025	11.61	23.0	9.10
4th bath	19/06/2025	16.70	22.8	8.86
	23/06/2025	19.50	22.0	8.83
	25/06/2025	45.70	22.3	8.86

	27/06/2025	49.80	22.3	8.56
	30/06/2025	65.50	22.2	8.43

Table S2. Redox potential (E_h, V) values measured over the full monitoring period for each pewter (ME.ARQ.SUB.1114, 1115, and 1116), and the corresponding mean ($\bar{x}$) and standard deviation (σ).

	Monitoring period	**E_h (V)**		
		ME.ARQ.SUB.1114	**ME.ARQ.SUB.1115**	**ME.ARQ.SUB.1116**
1st bath	27/05/2025	-0.033	-0.103	-0.053
	29/05/2025	-0.023	0.000	-0.093
	30/05/2025	0.097	0.057	0.067
	03/06/2025	-0.133	-0.003	0.017
2nd bath	03/06/2025	-	-	-
	04/06/2025	-0.013	-0.003	0.017
	05/06/2025	-	-	-
	11/06/2025	-0.033	-0.033	-0.043
3rd bath	11/06/2025	-0.043	0.047	-0.003
	13/06/2025	-0.003	-0.013	-0.043
	16/06/2025	-0.003	-0.003	-0.013
	19/06/2025	0.037	0.027	0.007
4th bath	19/06/2025	-0.013	0.037	0.037
	23/06/2025	0.067	0.047	0.047
	25/06/2025	0.037	0.067	0.067
	27/06/2025	0.067	0.027	0.027
	30/06/2025	0.017	0.067	0.067
$\bar{x}$		0.025	0.218	0.105
σ		0.051	0.063	0.050

4.3 Sample characterization

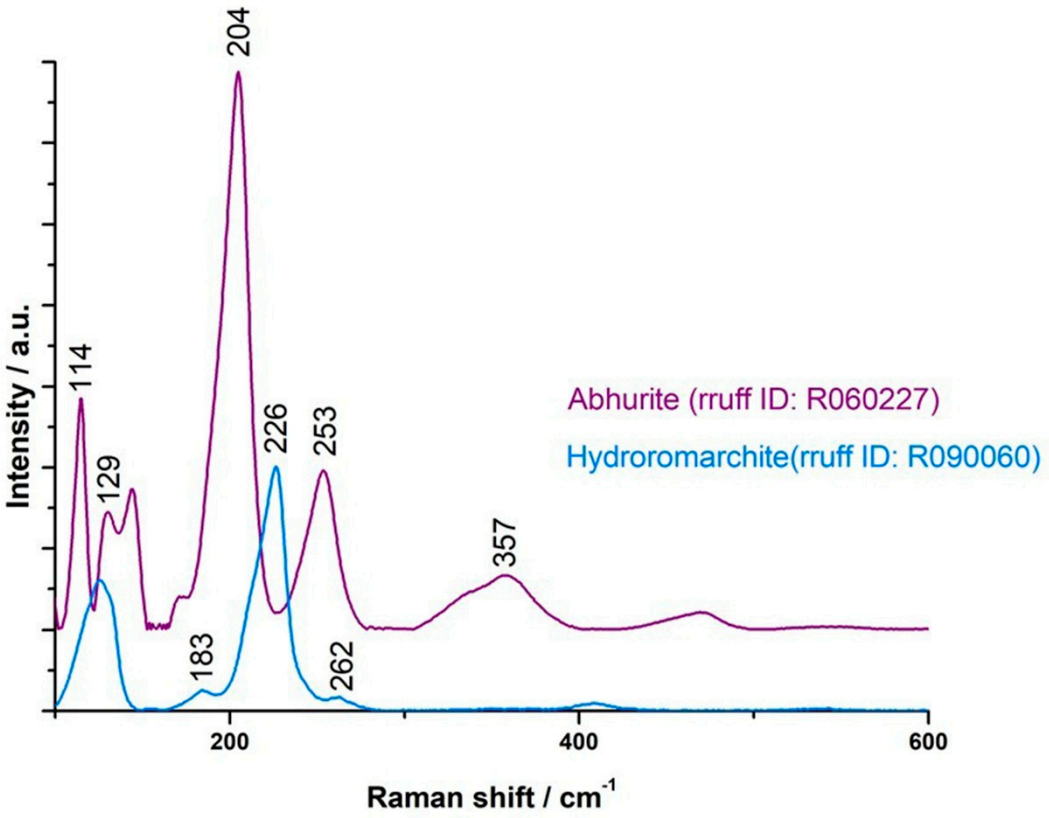

Figure S4. Raman reference spectra of Abhurite (rruff ID: R060227) and hydroromarchite (rruff ID: R090060) in violet and blue, respectively. The spectra are vertically offset for clarity.