

Supplementary Table S1. Physicochemical properties of the seawater at the sampling site and the sediment sample.

Parameter	Measurement
<i>Seawater</i>	
Temperature	26.4°C
pH	8.87
Salinity	6.33 PSU
<i>Sediment sample</i>	
pH	8.82
Salinity	77.1 mg/L
Electric conductivity	164 μ S/cm
Organic matter	0.47%
Total carbon	0.273%
Total organic carbon	1.40%
Total nitrogen	690 mg/kg
Phosphorus (P)	58.2 mg/kg
Magnesium (Mg^{2+})	1300 mg/kg
Calcium (Ca^{2+})	3580 mg/kg
Potassium (K^{+})	139 mg/kg
Sodium (Na^{+})	1650 mg/kg
Cation exchange capacity (CEC)	28.697 meq/100 g
Na^{+} / CEC	0.250 C mol/ kg
K^{+} / CEC	0.012 C mol/ kg
Ca^{2+} / CEC	0.623 C mol/ kg
Mg^{2+} / CEC	0.377 C mol/ kg

Supplementary Table S2. Media used to isolate and identify the suspected actinomycetes in seabed sediment from Ain-Achir, Gulf of Annaba, Algeria.

Medium	Formulation (per L)	Seawater (%)	Reference
<i>For isolation</i>			
M1-BE ¹	18 g agar; pH 7.2	100	Becerril-Espinosa et al. (2013)
M1	10 g starch, 4 g yeast extract, 2 g peptone, 18 g agar; pH 7.2	100	Mincer et al. (2002)
M2	6 mL glycerol, 1 g arginine, 1 g K ₂ HPO ₄ , 0.5 g MgSO ₄ , 18 g agar; pH 7.2	100	Mincer et al. (2002)
Starch casein agar (SCA)	10 g soluble starch, 2 g K ₂ HPO ₄ , 2 g KNO ₃ , 2 g NaCl, 1 g casein, 0.02 g CaCO ₃ , 0.05 g MgSO ₄ .7H ₂ O, 0.01 g FeSO ₄ .7H ₂ O, 15 g agar; pH 7.2	50	Mohanraj and Sekar (2013); Mukesh (2014)
Starch casein nitrate agar (SCN)	10 g soluble starch, 2 g K ₂ HPO ₄ , 2 g KNO ₃ , 2 g NaCl, 0.3 g casein, 0.02 g CaCO ₃ , 0.05 g MgSO ₄ .7H ₂ O, 0.01 g FeSO ₄ .7H ₂ O, 18 g agar; pH 7.2	50	Duncan et al. (2015); Gulve and Deshmukh (2011); Remya and Vijayakumar (2008)
Actinomycetes isolation agar (AIA)	4 g sodium propionate 2 g sodium caseinate, 0.1 g L-asparagine, 0.5 g K ₂ HPO ₄ , 0.1 g MgSO ₄ .7H ₂ O, 0.001 g FeSO ₄ .7H ₂ O, 15 g agar; pH 8.1	50	Goodfellow (2012)
Marine Rhodococcus agar (MRA)	10 g yeast extract, 4 g malt extract, 4 g glucose, 18 g agar; pH 7.3	75	Atlas (2010)
Glycerol asparagine agar (GAA)	10 g glycerol, 1 g L-asparagine, 1 g K ₂ HPO ₄ , 1 mL trace salt solution ² , 15 g agar; pH 7.3	50	Goodfellow (2012)
Glycerol glycine agar (GGA)	20 g glycerol, 2.5 g glycine, 1 g NaCl, 1 g K ₂ HPO ₄ , 1 g CaCO ₃ , 0.1 g MgSO ₄ .7H ₂ O, 0.1 g FeSO ₄ .7H ₂ O, 20 g agar; pH 7	50	Ghanem et al. (2000)
Starch glycerol inorganic salts agar (SGIA)	10 g soluble starch, 10 mL glycerol, 1 g NaCl, CaCO ₃ 2g, (NH ₄)SO ₄ 2g, 1 g K ₂ HPO ₄ , 1 g MgSO ₄ .7H ₂ O, 1 mL trace salt solution ² , 20 g agar; pH 7.2	50	Biji (2003)

Starch nitrate agar (SNA)	20 g soluble starch, 1 g K ₂ HPO ₄ , 2 g KNO ₃ , 100 g NaCl, 3 g CaCO ₃ , 0.5 g MgSO ₄ , 1 mL trace salt solution ² , 20 g agar; pH 7.1	50	Atlas (2010)
Kuster's agar (KA)	10 g glycerol, 2 g K ₂ HPO ₄ , 3 g KNO ₃ , 2 g NaCl, 0.3 g casein, 0.02 g CaCO ₃ , 0.05 g MgSO ₄ , 0.01 g FeSO ₄ , 15 g agar; pH 7	50	Baskaran et al. (2011); Mohseni et al. (2013)
Casein starch peptone yeast extract malt extract agar (CSPY-ME)	1 g yeast extract, 1 g malt extract, 10 g maize starch, 3 g casein, 0.5 g K ₂ HPO ₄ , 1 g peptone, 20 g agar; pH 7.5	50	Biji (2003)
Raffinose-histidine agar (RHA)	10 g raffinose, 1 g L-histidine, 1 g K ₂ HPO ₄ , 0.5 g MgSO ₄ .7H ₂ O, 0.01 g FeSO ₄ .7H ₂ O, 15 g agar; pH 7.2	50	Goodfellow (2012)
<i>For identification</i>			
Yeast extract–malt extract agar (ISP 2)	4 g yeast extract, 4 g glucose, 10 g malt extract, 20 g agar; pH 7.2	0	Shirling and Gottlieb (1966)
ISP 6	20 g peptone, 0.5 g ammonium ferric citrate, 0.08 g sodium thiosulfate, 1 g K ₂ HPO ₄ , 1 g yeast extract, 20 g agar; pH 7	0	Shirling and Gottlieb (1966)
ISP 7	1 g L-asparagine, 0.5 g L-tyrosine, 0.5 g K ₂ HPO ₄ , 0.5 g NaCl, 15 g glycerol, 0.01 g FeSO ₄ .7H ₂ O, 1 mL trace salt solution ² , 20 g agar; pH 7.2	0	Shirling and Gottlieb (1966)

¹ Renamed M1-BE to distinguish from M1 as described in Becerril-Espinosa et al. (2013). ² Trace salt solution: 0.1 g FeSO₄.7H₂O, 0.1 g MnCl₂.4H₂O, 0.1 g ZnSO₄.7H₂O, 100 mL distilled water.

Supplementary Table S3. Assays used to detect various enzyme activities of the actinomycete isolates.

Enzyme activity (substrate)	Method	Positive reaction	Reference
Amylase (starch)	Isolates streaked onto Gause medium (20 g soluble starch, 1 g/L KNO ₃ , 0.5 g/L NaCl, 0.5 g/L K ₂ HPO ₄ , 0.5 g/L MgSO ₄ , 0.01 g/L FeSO ₄ and 20 g/L agar) adjusted to pH 7.4. After incubation, plates flooded with Lugol's iodine solution	Clear zone	Williams and Cross (1971)
Cellulase (cellulose)	Isolates streaked onto carboxymethylcellulose medium (0.5 g/L carboxymethylcellulose, 0.1 g/L NaNO ₃ , 0.1 g/L K ₂ HPO ₄ , 0.05 g/L MgSO ₄ , 0.05 g/L yeast extract and 15 g/L agar) adjusted to pH 7. After incubation, plates flooded with 1% aqueous Congo red solution and incubated (RT for 15 min). The Congo red solution was discarded and plates flooded with 1N NaCl and incubated (RT for 15 min).	Yellow/orange halo against the red background	Prasad et al. (2012)
Chitinase (chitin)	Isolates were spot-inoculated onto a basal medium (0.7 g/L K ₂ HPO ₄ , 0.3 g/L KH ₂ PO ₄ , 0.5 g/L MgSO ₄ .5H ₂ O, 0.01 g/L FeSO ₄ .7H ₂ O, 0.001 g/L ZnSO ₄ , 0.001 g/L MnCl and 20 g/L of agar) adjusted to pH 7, which was then supplemented with 10 g/L colloidal chitin	Clear zone	Hsu and Lockwood (1975)
Caseinase (casein)	Isolates were streaked onto skim milk agar (1% peptone, 0.5% sodium chloride, 0.3% yeast extract, 2% agar and 10% skimmed milk) adjusted to pH 7.2.	Clear zone	Roy et al. (2014)
Gelatinase (gelatin)	Isolates were streaked onto nutrient agar supplemented with 0.4% bacteriological gelatin and adjusted to pH 7. After incubation, plates were flooded with 1% mercuric chloride solution prepared in 1N HCl and incubated (RT for 15 min).	Clear zone	Williams and Cross (1971)

Tyrosinase (tyrosine)	Isolates were streaked onto tyrosine agar (0.5% peptone, 0.5% L-tyrosine, 0.3% beef extract and 2% agar) adjusted to pH 7.	Brown or black halo	Roy et al. (2014)
DNase (DNA)	Isolates were streaked onto DNase agar (Oxoid, UK) adjusted to pH 7. After incubation, plates were flooded with 1N HCl (RT for 15 min).	Clear zone	Leboffe and Pierce (2012)
Pectinase (pectin)	Isolates were spot-inoculated onto MP7 medium (500 mL mineral salts solution [2 g (NH ₄) ₂ SO ₄ , 4 g KH ₂ PO ₄ , 6 g Na ₂ HPO ₄ , 0.2 g FeSO ₄ .7H ₂ O, 1 mg CaCl ₂ , 10 µg H ₃ BO ₃ , 10 µg MnSO ₄ , 70 µg ZnSO ₄ , 50 µg CuSO ₄ and 10 µg MoO ₃ dissolved in 1L distilled water], 1 g yeast extract, 5 g pectin from citrus fruit, 15 g agar and 500 mL of distilled water) adjusted to pH 7.2. After incubation, plates were flooded with 10% copper acetate solution (RT for 15 min).	Clear zone against blue background	Hankin et al. (1971)
Esterase (Tween 80)	Isolates were streaked onto agar medium (10 g/L peptone, 5 g/L NaCl, 0.1 g/L CaCl ₂ .2H ₂ O and 18 g/L agar) adjusted to pH 7.4, which was supplemented to 10 g/L with sterilized Tween 80.	Opaque halo	Sierra (1957)
Lecithinase (lecithin)	Isolates were streaked onto egg-yolk medium (10 g/L peptone, 5 g/L yeast extract, 10 g/L NaCl and 20 g/L agar) adjusted to pH 7, and which was supplemented to 10% with egg-yolk emulsion once cooled to 50°C.	Insoluble, white, opaque, diffuse precipitate	Nitsch and Kutzner (1969)
L-glutaminase (L-glutamine)	Isolates were streaked onto minimal glutamine agar medium (0.5 g/L KCl, 0.5 g/L MgSO ₄ .7H ₂ O, 1 g/L KH ₂ PO ₄ , 0.1 g/L FeSO ₄ .7H ₂ O, 1 g/L ZnSO ₄ .7H ₂ O, 5 g/L glutamine, 20 g/L agar and 0.012 % phenol red) adjusted to pH 7.	Agar color change from yellow/orange to pink/violet	Reda (2015)
Uricase (uric acid)	Isolates were streaked onto basal medium (5 g/L uric acid, 30 g/L glycerol, 5 g/L NaCl, 1 g/L K ₂ HPO ₄ , 0.2 g/L MgSO ₄ .7H ₂ O, 0.1 g/L CaCl ₂ and 20 g/L agar) adjusted to pH 7.	Clear zone	El-Naggar (2015)

L-asparaginase (L-asparagine)	Isolates were streaked onto modified M9 medium (6 g/L Na ₂ HPO ₄ , 3 g/L KH ₂ PO ₄ , 0.5 g/L NaCl, 2 g/L MgSO ₄ , 0.5 g/L KCl, 3 g/L glucose, 10 g/L L-asparagine, 20 g/L agar and 0.009% phenol red) adjusted to pH 6.8.	Agar color change from yellow/orange to pink/violet	Varma et al. (2016)
Urease (urea)	Isolates were inoculated into 5 mL of urea-indole broth (Ferguson medium)	Medium turns deep violet or red color	Leboffe and Pierce (2012)

Supplementary Table S4. Media and methods used to isolate 35 suspected actinomycetes from marine sediment sampled at Ain-Achir, Gulf of Annaba, Algeria. Mycelium characteristics, colony sizes and production of diffusible pigments were determined after culture on the ISP 2 identification medium for 72 h at 28°C, except for ID 11, ID 15 and ID 33 that took longer to form colonies and observations in these cases were at 5 days. Production of melanoid pigment was assessed on ISP 6 and ISP 7. +: present, - absent. For isolation medium abbreviations, see Supplementary Table S2, and for isolation method, see Section 2.3.2. Other colony characteristics can be found in Supplementary Table S3.

Isolate	Isolation medium	Isolation method	Aerial mycelium	Substrate mycelium	Colony size (mm)	Colony color (RAL-code) ¹	Diffusible pigment	Melanoid pigment	Gram stain ²
ID 1	SGIA	5	-	-	1 to 2	Deep orange (2011)	-	-	+
ID 2	AIA	4	-	-	1 to 2	Pastel yellow (1034)	-	-	+
ID 3	SGIA	5	-	-	> 5	Pastel yellow (1034)	-	-	+
ID 4	GAA	2	-	-	1 to 3	Pure white (9010)	-	+	V
ID 5	RHA	1	-	-	1 to 2	Beige (1001)	-	-	V
ID 6	GGA	5	-	-	1 to 3	Light ivory (1015)	-	-	V
ID 7	GGA	5	-	-	1 to 2	Light ivory (1015)	-	-	V
ID 8	GGA	3	+ ³	-	1 to 2	Yellow orange (2000)	-	-	V
ID 9	AIA	4	-	-	1 to 2	Light ivory (1015)	-	-	V
ID 10	GGA	4	-	-	1 to 2	Pastel yellow (1034)	-	-	V
ID 11	SGIA	4	+	+	3 to 5	AM: Pure white (9010); SM: Oyster white (1013)	-	+	+
ID 12	M1	2	-	-	1 to 2	Sand yellow (1002)	-	-	+
ID 13	AIA	3	-	-	1 to 2	Pastel yellow (1034)	-	-	V
ID 14	SCN	2	-	-	2 to 3	Sulphur yellow (1016)	-	-	V
ID 15	M2	3	+	+	1 to 2	AM: Pure white (9010), then beige grey (7006); SM: Light ivory (1015)	-	-	+
ID 16	RHA	2	-	-	1 to 3	Pastel yellow (1034)	-	-	+
ID 17	KA	3	-	-	1 to 2	Oyster white (1013)	-	-	V

ID 18	GGA	2	-	-	1 to 2	Light ivory (1015)	-	-	V
ID 19	SCN	5	-	-	1 to 2	Light ivory (1015)	-	-	+
ID 20	SGIA	1	-	-	1 to 2	Sand yellow (1002)	-	+	+
ID 21	SGIA	2	-	-	1 to 3	Oyster white (1013)	-	+	V
ID 22	GAA	4	-	-	1 to 2	Light ivory (1015)	-	-	+
ID 23	M1	2	-	-	1 to 2	Oyster white (1013)	-	-	+
ID 24	AIA	3	-	-	1 to 2	Pastel yellow (1034)	-	-	V
ID 25	RHA	2	-	-	1 to 2	Light ivory (1015)	-	-	+
ID 26	AIA	4	-	-	1 to 2	Oyster white (1013)	-	-	+
ID 27	GGA	5	-	-	1 to 3	Light ivory (1015)	-	-	V
ID 28	SGIA	4	-	-	1 to 2	Beige (1001)	-	-	V
ID 29	RHA	2	-	-	1 to 2	Light ivory (1015)	-	-	V
ID 30	GGA	3	-	-	1 to 2	Oyster white (1013)	-	-	V
ID 31	GAA	4	-	-	1 to 2	Oyster white (1013)	-	-	V
ID 32	GAA	2	-	-	1 to 2	Light ivory (1015)	-	-	V
ID 33	SGIA	3	+	+	> 5	AM & SM: Silk grey (7044)	-	-	+
ID 34	RHA	1	-	-	1 to 2	Oyster white (1013)	-	-	+
ID 35	KA	4	-	-	1 to 2	Light ivory (1015)	+ (orange yellow)	-	+

¹ AM: aerial mycelium; SM: substrate mycelium.

² V: variable.

³ Observed at 7 days.

Supplementary Table S5. Descriptions of the actinomycete isolates according to colony appearance on ISP 2 agar medium and from observations made using a light microscope.

Isolate	Colony morphology (elevation; surface texture; contour)	Microscopic morphology
ID 1	Flat; rough and gelatinous; irregular	Coccobacilli
ID 2	Slightly convex; mucoid and glistening; regular	Coccobacilli
ID 3	Flat to slightly convex; wrinkled surface; regular	Coccobacilli
ID 4	Flat; dull; irregular	Short rods
ID 5	Convex; dull; irregular	Short rods and coccobacilli
ID 6	Flat; dull; irregular	Cocci and coccobacilli
ID 7	Slightly convex; smooth and creamy; irregular	Short rods
ID 8	Flat; creamy and dull; irregular	Cocci and bacilli
ID 9	Flat; rough and dull; irregular	Cocci and bacilli
ID 10	Flat; dull; irregular	Cocci and bacilli
ID 11	Raised; rough laminated surface, sticky in the agar; irregular and echinulate	Mycelium composed of very thin, branched, non-septate and non-fragmented hyphae; very long chains of non-motile spores observed
ID 12	Flat; smooth and dull; regular	Cocci and coccobacilli
ID 13	Flat; dry and rough; irregular	Bacilli and coccobacilli
ID 14	Flat; creamy, smooth and glistening; regular	Bacilli
ID 15	Slightly convex; rough, powdery and dry; irregular	Mycelium composed of very thin, branched, non-septate and non-fragmented hyphae; very long chains of non-motile spores observed
ID 16	Slightly convex; creamy, smooth and glistening; irregular	Cocci and coccobacilli
ID 17	Flat; dull, dry and rough; irregular	Short rods
ID 18	Convex; creamy, smooth and glistening; irregular	Cocci and bacilli
ID 19	Flat; creamy, smooth and glistening; irregular	Cocci and bacilli
ID 20	Flat; translucent, creamy and smooth; regular	Short rods
ID 21	Slightly convex; creamy; irregular	Cocci and coccobacilli
ID 22	Flat; dull and smooth; irregular	Cocci and bacilli
ID 23	Slightly convex; smooth and creamy; irregular	Cocci and coccobacilli

ID 24	Flat; smooth and creamy; irregular	Short rods
ID 25	Flat; dull; irregular	Cocci and coccobacilli
ID 26	Flat; creamy and glistening; irregular	Cocci and coccobacilli
ID 27	Flat; dull and smooth; irregular	Short rods
ID 28	Flat; dull and creamy; irregular	Cocci and coccobacilli
ID 29	Flat; dry; irregular	Cocci and coccobacilli
ID 30	Flat; dull and smooth; irregular	Cocci and bacilli
ID 31	Convex; creamy, smooth and glistening; regular	Coccobacilli
ID 32	Flat; creamy and dull; regular	Cocci and coccobacilli
ID 33	Flat; powdery and dry; echinulate	Mycelium composed of very thin, branched, non-septate and non-fragmented hyphae; sporangia or spherical vesicles containing non-motile spores
ID 34	Flat; creamy and smooth; irregular	Coccobacilli
ID 35	Flat; smooth and creamy; regular	Bacilli and coccobacilli

Supplementary Table S6. Species, accession number and percentage sequence similarity for the closest sequence match in BLASTn for each of the actinomycete isolates, which allows for a genus to be proposed.

Isolate	Proposed genus	Accession number	Species of closest match	Accession number of closest match	Percentage similarity (%)
ID 1	<i>Rhodococcus</i>	MK130802.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 2	<i>Rhodococcus</i>	MK130803.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 3	<i>Rhodococcus</i>	MK130804.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.66
ID 4	<i>Microbacterium</i>	MK130823.1	<i>Microbacterium resistens</i> DMMZ 1710	NR_026437.1	99.50
ID 5	<i>Rhodococcus</i>	MK130805.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 6	<i>Microbacterium</i>	MK130824.1	<i>Microbacterium resistens</i> DMMZ 1710	NR_026437.1	99.50
ID 7	<i>Rhodococcus</i>	MK130806.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 8	<i>Rhodococcus</i>	MK130807.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.66
ID 9	<i>Rhodococcus</i>	MK130808.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.83
ID 10	<i>Agromyces</i>	MK130827.1	<i>Agromyces mediolanus</i> VKM Ac-1388	NR_118453.1	99.34
ID 11	<i>Streptomyces</i>	MK130830.1	<i>Streptomyces hawaiiensis</i> ISP 5042	NR_114824.2	99.83
ID 12	<i>Rhodococcus</i>	MK130809.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.83
ID 13	<i>Rhodococcus</i>	MK130810.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.50
ID 14	<i>Microbacterium</i>	MK130825.1	<i>Microbacterium resistens</i> DMMZ 1710	NR_026437.1	99.60
ID 15	<i>Streptomyces</i>	MK130831.1	<i>Streptomyces mangrovicola</i> GY1	NR_148322.1	99.67
ID 16	<i>Agromyces</i>	MK130829.1	<i>Agromyces mediolanus</i> VKM Ac-1388	NR_118453.1	99.83
ID 17	<i>Microbacterium</i>	MK130826.1	<i>Microbacterium resistens</i> DMMZ 1710	NR_026437.1	96.84
ID 18	<i>Rhodococcus</i>	MK130811.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 19	<i>Brevibacterium</i>	MK130833.1	<i>Brevibacterium sediminis</i> CGMCC 1.15472	NR_153678.1	99.50
ID 20	<i>Rhodococcus</i>	MK130812.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.83
ID 21	<i>Rhodococcus</i>	MK130813.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 22	<i>Brevibacterium</i>	MK130834.1	<i>Brevibacterium sediminis</i> CGMCC 1.15472	NR_153678.1	99.67
ID 23	<i>Rhodococcus</i>	MK130814.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.83
ID 24	<i>Rhodococcus</i>	MK130815.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.83
ID 25	<i>Rhodococcus</i>	MK130816.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 27	<i>Microbacterium</i>	MK130828.1	<i>Microbacterium resistens</i> DMMZ 1710	NR_026437.1	99.67

ID 28	<i>Rhodococcus</i>	MK130817.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.66
ID 29	<i>Rhodococcus</i>	MK130818.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.34
ID 30	<i>Rhodococcus</i>	MK130819.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.83
ID 31	<i>Rhodococcus</i>	MK130820.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.50
ID 32	<i>Rhodococcus</i>	MK130821.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	99.67
ID 33	<i>Streptomyces</i>	MK130832.1	<i>Streptomyces euryhalinus</i> MS 3/20	NR_178847.1	99.83
ID 35	<i>Rhodococcus</i>	MK130822.1	<i>Rhodococcus qingshengii</i> CCM 4446	NR_145886.1	100.00