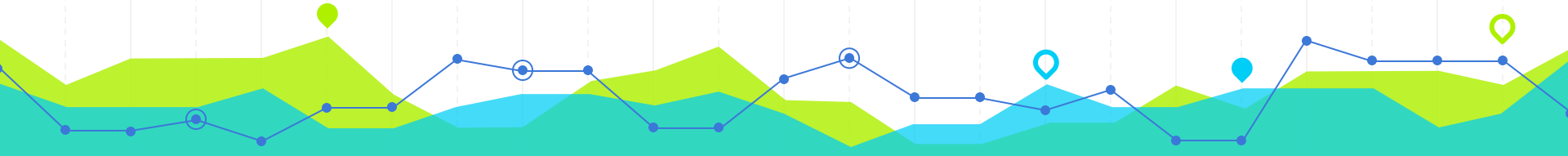


Halophiles and Biogeography

By Bex Kemp, Adam Wolford and Bonnie Baxter

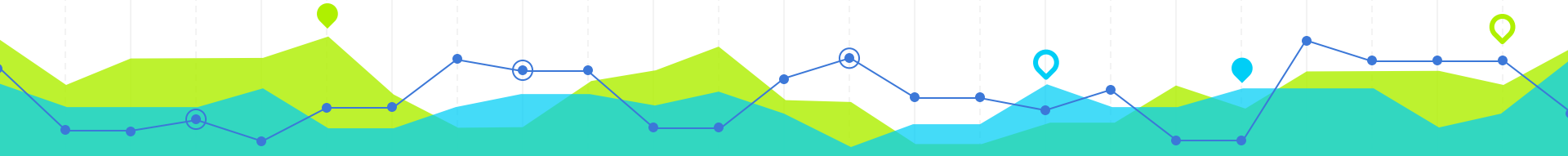
HALOPHILIC ARCHAEA

- ◉ Halophilic archaea dominate the Earth's many hypersaline environments such as Great Salt Lake (GSL)
- ◉ They are multi-extremophiles, tolerating not only salinity, but also desiccation and high levels of UV irradiation
- ◉ *Halorubrum* is a genus of Halophilic archaea with wide distribution around the Earth
- ◉ The distribution of *Halorubrum* across space and time begs the question of the mechanism behind the biogeography.



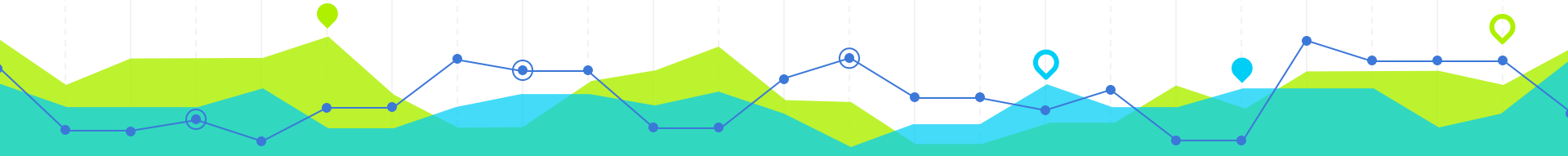
BIOGEOGRAPHY

- Baas Becking famously postulated that “everything is everywhere; but, the environment selects” to explain the vast diversity of microorganisms and their overlapping geographic distributions
- Recent studies have disputed this idea and suggest other mechanisms of distribution
- Our study investigated bird migration as a mechanism for distributing genetically similar *Halorubrum* strains



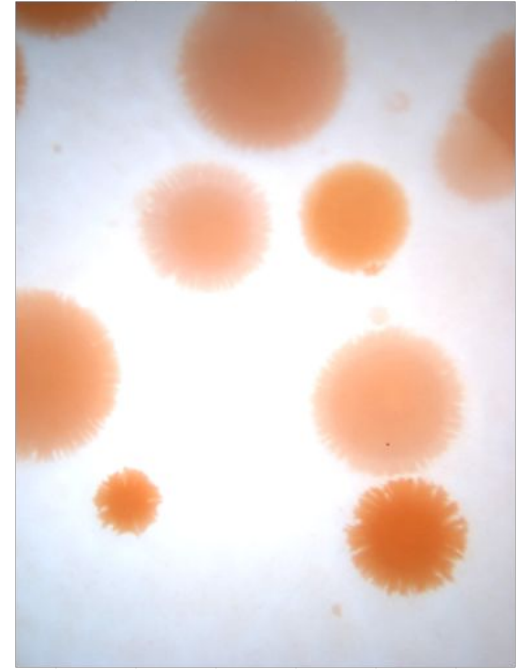
HYPOTHESIS

We predict that through that bird migration patterns can explain their genetic diversity and biogeography of the location of similar strains

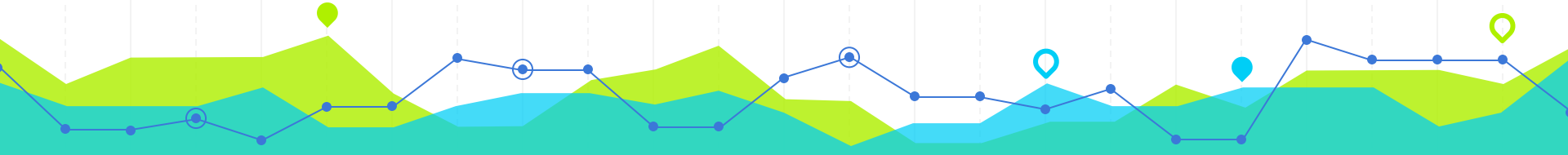


METHODS

- Halite (salt) was collected from the north arm of GSL
- This halite was added to growth media and incubated for three weeks
- Halophilic archaea from the liquid cultures were plated and grown on solid media for isolation
- Strains were isolated
- The 16S rRNA gene was amplified and sequenced
- GenBank was used to compare sequences of GSL strains to other strains in the genetic database



RESULTS

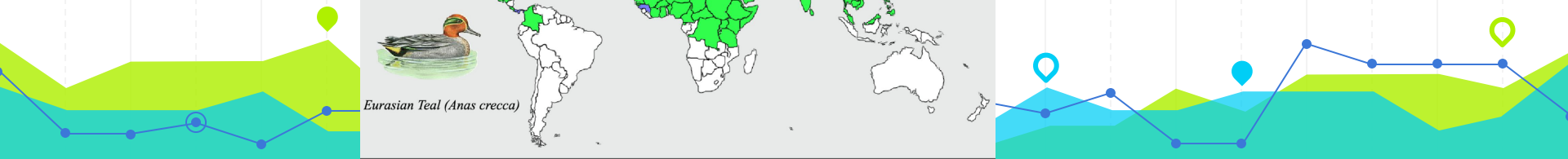
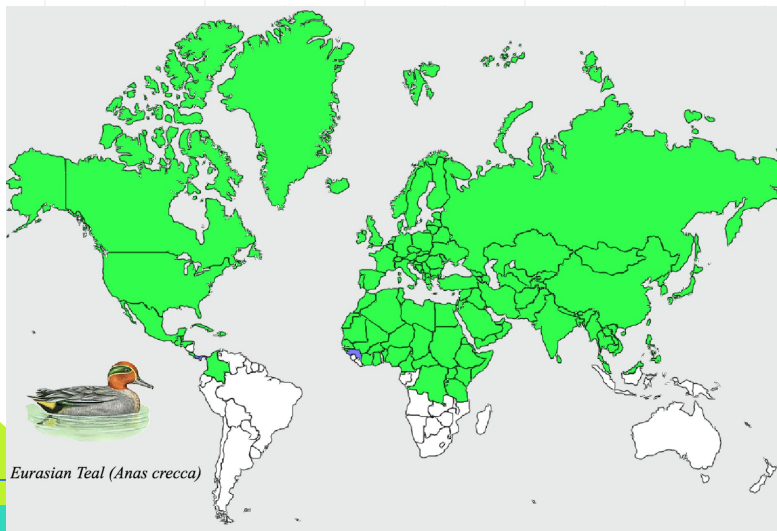
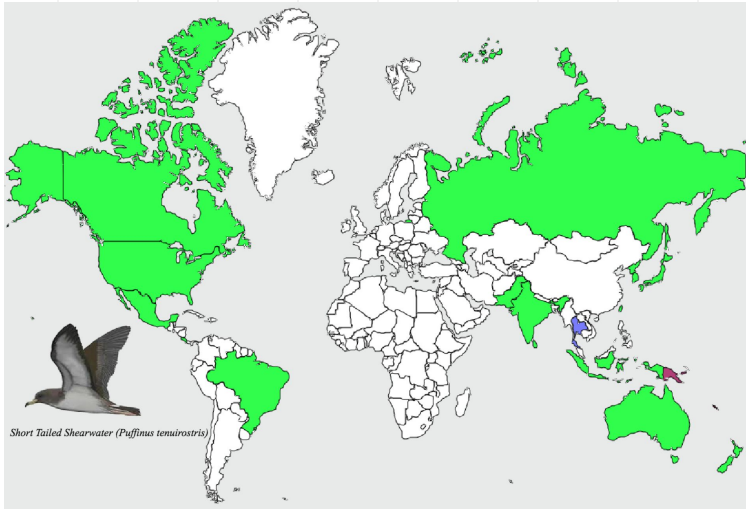


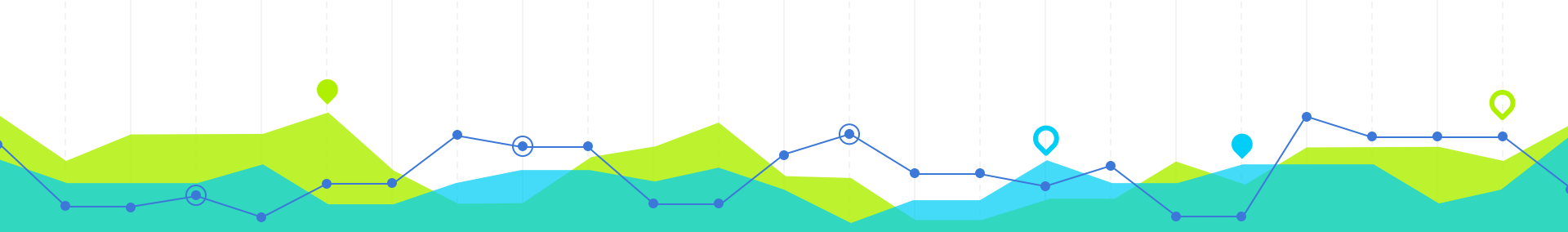
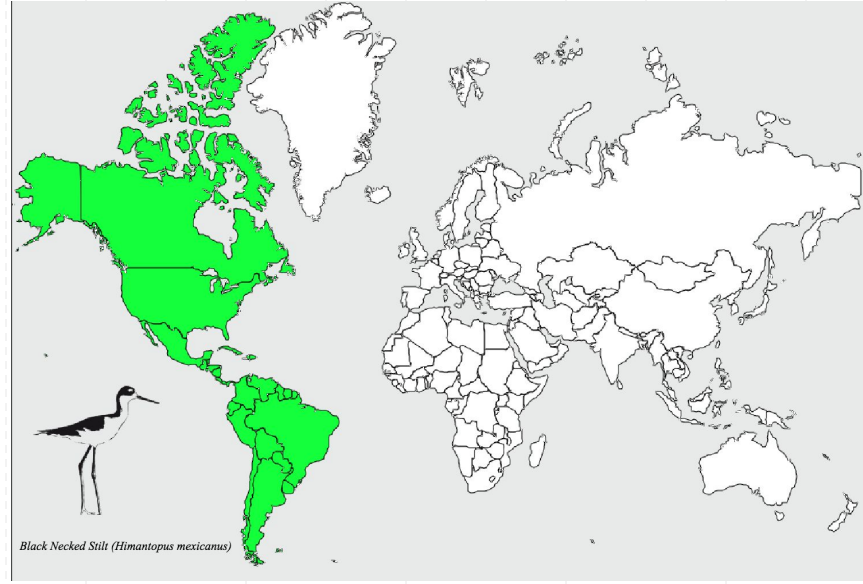
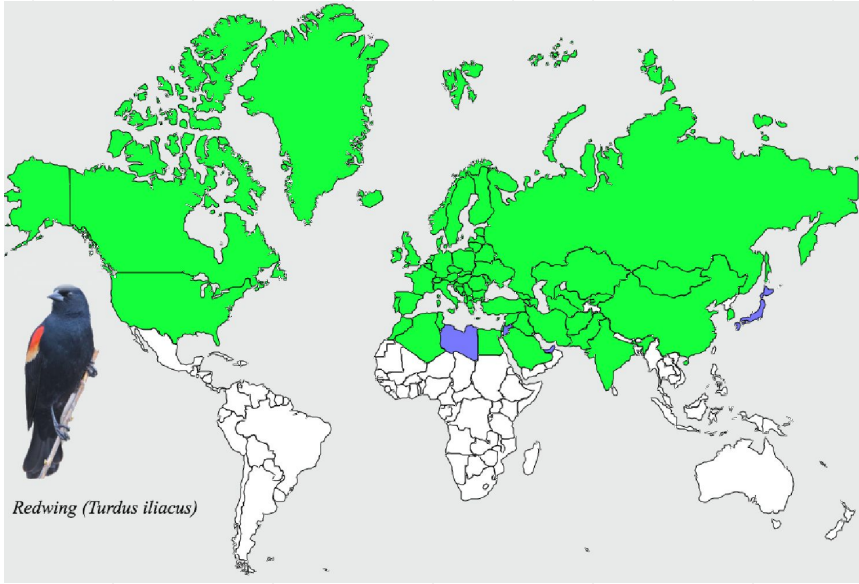
CONCLUSION

- ◉ *Halorubrum*, as a representative halophilic archaea genus, can survive desiccation in salt crystals
 - ◉ More than 5 million migrating birds visit GSL per year
 - ◉ Salt encrusted in their feathers could contain *Halorubrum* species
- [[[Discuss overlap in migration patterns and biogeog of *Halorubrum*]]]



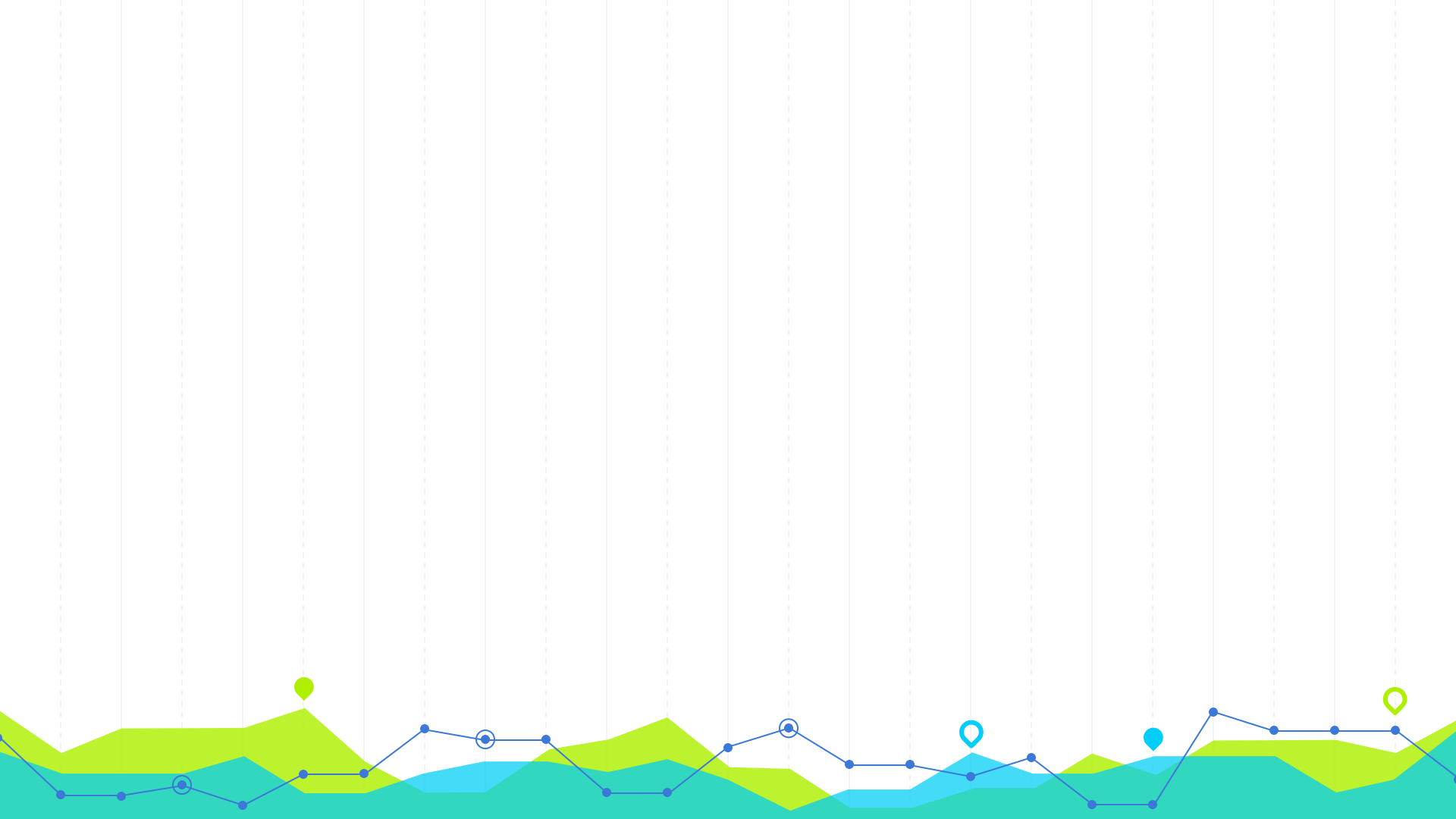
BIRD MIGRATION



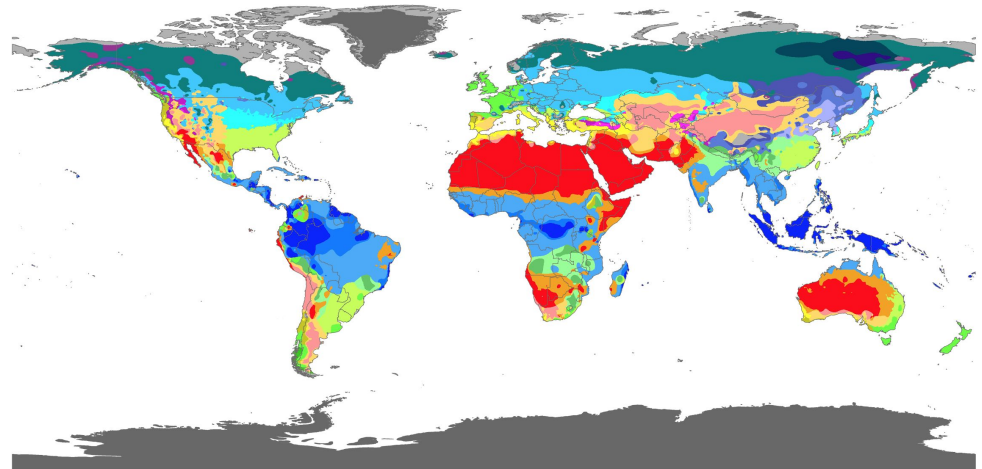


Americas	Eurasian	Long Distance Travelers	Main Suspects
American Avocet (<i>Recurvirostra americana</i>)	Amur falcon (<i>Falco amurensis</i>)	Arctic Tern (<i>Sterna paradisaea</i>)	Black Necked Stilt (<i>Himantopus mexicanus</i>)
Bald Eagle (<i>Haliaeetus leucocephalus</i>)	Barn swallow (<i>Hirundo rustica</i>)	Black Noddy (<i>Anous minutus</i>)	Eurasian Teal (<i>Anas crecca</i>)
Bank Swallow (<i>Riparia riparia</i>)	Common Crane (<i>Grus grus</i>)	Short Tailed Shearwater (<i>Puffinus tenuirostris</i>)	Redwing (<i>Turdus iliacus</i>)
Black Necked Stilt (<i>Himantopus mexicanus</i>)	Common Pochard (<i>Aythya ferina</i>)	Sooty Shearwater (<i>Puffinus griseus</i>)	Short Tailed Shearwater (<i>Puffinus tenuirostris</i>)
Common Teal (<i>Anas crecca</i>)	Eurasian Teal (<i>Anas crecca</i>)	Sooty Tern (<i>Onychoprion fuscatus</i>)	
Eared Grebe (<i>Podiceps nigricollis</i>)	Northern Wheatears (<i>Oenanthe oenanthe</i>)	Tundra Swan (<i>Cygnus columbianus</i>)	
Green-winged teal (<i>Anas carolinensis</i>)	Redwing (<i>Turdus iliacus</i>)	Wedge Tailed Shearwater (<i>Puffinus pacificus</i>)	
Peregrine Falcon (<i>Falco peregrinus</i>)			
Snowy Plover (<i>Charadrius nivosus</i>)			
White faced Ibis (<i>Plegadis chihi</i>)			
White Pelican (<i>Pelecanus erythrorhynchos</i>)			
Wilson’s Phalarope (<i>Phalaropus tricolor</i>)			

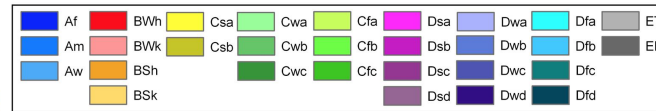
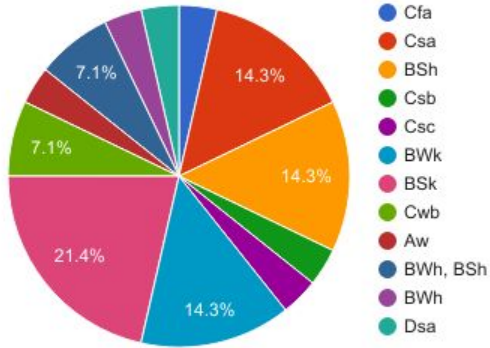
Matching Strains							
GenBank Sequence Matches	Similarity to GSL Sequences	Collection Site	Site Location	Climate category	Rainfall	Temp Range	Elevation
Halorubrum chaoviator strain CDZI43 16S ribosomal RNA gene, partial sequence	100, 98, 100	Rozel Bay, GSL, UT, USA Southern Tunisia	41°26'15.2"N 112°40'08.7"W 33° 42' 0" N, 8° 25' 48" E	Cfa Csa	453mm 100 mm	10.4°C 20.0°C	4400 above -10-25m
Halorubrum chaoviator strain CDW118.2(3A) 16S ribosomal RNA gene, partial sequence	100	Southern Tunisia ,Zarzis Tunisia	33°24'55.2"N 11°03'42.1"E	BSh	200mm	19.9°C	0m
Halorubrum chaoviator strain CDRi04 16S ribosomal RNA gene, partial sequence	100	Southern Tunisia, Zarzis Tunisia	33°24'55.2"N 11°03'42.1"E	BSh	200mm	19.9°C	0m
Halorubrum chaoviator strain CDRi36 16S ribosomal RNA gene, partial sequence	100	Southern Tunisia, Zarzis Tunisia	33°24'55.2"N 11°03'42.1"E	BSh	200mm	19.9°C	0m
Halorubrum chaoviator strain DSM 19316 16S ribosomal RNA gene, complete sequence	100, 100, 100	Baja California	29 29N ,114 21W	Csb	116.8 mm	18.2°C	+660m
Halorubrum californiense strain JCM 14715 16S ribosomal RNA gene, complete sequence	100, 100	Newark, California	37° 32' 0" N, 122° 2' 0" W	Csc	368 mm	15.0 °C	+6m
Halorubrum arcis strain JCM 13916 16S ribosomal RNA gene, complete sequence	100, 100	Qinghai-Tibet Plateau	33° 0' 0" N, 88° 0' 0" E	BWk	43 mm	4.8°C	+4,500m
Halorubrum ezzemoulense strain CECT 7099 16S ribosomal RNA gene, partial sequence	100, 100	Ez zemoul sabkha, Algeria	35°53.137'N, 06°30.200'E	BSk	382 mm	14.5 °C.	+850 m
Halorubrum tebenquichense strain CGF3 16S ribosomal RNA gene, partial sequence	100, 100	La Colorada Grande, Argentina	38 15 0 S, 63 45 0 W,	BSk	685.8mm	12-15°C	+175m
Halorubrum ejinorensis strain JCM 14265 16S ribosomal RNA gene, partial sequence	100, 100, 100, 100	Lake Ejnor China	41°4' N, 113°2' E	BSk	391mm	6.4 °C	+1,065 m
Halorubrum distributum strain JCM 9100 16S ribosomal RNA gene, complete sequence	100, 100, 100, 100, 100	Golden Age Lake, Turkmenistan	40° 44' 0" N, 56° 47' 0" E	BWk	124mm	14.8 °C	+252m
Halorubrum terrestre strain JCM 10247 16S ribosomal RNA gene, complete sequence	100, 100, 99, 100, 100	Ashgabat, Turkmenistan	37° 56' 0" N, 58° 22' 0" E	BSk	228mm	15.4°C	+219m
Halorubrum chaoviator partial 16S rRNA gene, isolate SP_13S37	100, 99, 100, 100	Santa Pola Alicante, Spain	38° 11' 23" N, 0° 33' 20" W	BSh	317mm	18.2°C	+ 6m
Halolubrum sp. strain Y122 16S ribosomal RNA gene	99, 99, 100	Kunming, Yunnan salt mine, China	25° 4' 0" N, 102° 41' 0" E	Cwb	999mm	15.2°C	+1,892 m
Halolubrum sp. strain Y62 16S ribosomal RNA gene	99, 99, 100	Kunming, Yunnan salt mine, China	25° 4' 0" N, 102° 41' 0" E	Cwb	999mm	15.2°C	+1,892 m
Halorubrum sp. SP9-2 16S ribosomal RNA gene, partial sequence	98	Sedom ponds, Israel	31.23531 N 35.38234 E	Csa	41.9mm	26.1°C	-400m
Halorubrum sp. SS13-13 16S ribosomal RNA gene, partial sequence	98	Samut Sakhon, Thailand,	13° 32' 55" N, 100° 16' 39" E	Aw	1330mm	27.8°C	+7m
Halorubrum sp. YC-11 16S ribosomal RNA gene, partial sequence	98	Yuncheng salt lake, Shanxi, China	34.95517 N 110.96122 E	BSk	74.7mm	14.05 °C	+353m
Halorubrum californiense partial 16S rRNA gene, isolate AV_23B86	100	Balearic Island, Spain	39° 30' 0" N, 3° 0' 0" E	BSk	449mm	18.2°C	+ 13m
Halolubrum sp. ADMK104 16s ribosomal RNA gene	99	Rann of Kachchh	24° 5' 11" N, 70° 38' 16" E	BWh, BSh	406 mm	27.0 °C	+15m
Halolubrum sp. ADMK100 16s ribosomal RNA gene	99	Rann of Kachchh	24° 5' 11" N, 70° 38' 16" E	BWh, BSh	406 mm	27.0 °C	+15m
Halorubrum ezzemoulense strain C41 16S ribosomal RNA gene, partial sequence	98	Camalti Saltern, Izmir, Turkey	38°28.47' N 26° 56.11' E	Csa	687 mm	16.7 °C.	0m
Halorubrum ezzemoulense strain ETR14 16S ribosomal RNA gene, partial sequence	100	Sfax saltern, Tunisia	34°39'N 10°42'E	BWh	212 mm.	19.0 °C	0m
Halorubrum tebenquichense strain JCM 12290 16S ribosomal RNA gene, complete sequence	100, 100	Lake Tebenquiche, Atacama Saltern, Chile	23°08'09.2"S 68°15'31.9"W	BWk	7mm	17°C	+2339m
Halorubrum trapanicum strain JCM 10477 16S ribosomal RNA gene, partial sequence	99, 99	Golden Age Lake, Turkmenistan	40°43'43.0"N 56°46'49.8"E	BWk	124mm	14.8°C	+281m
Halorubrum sp. spIB11 parital 16S rRNA gene, strain LB11	98	Isla Bacuta and Isla Cristina, Huelva Spain	37°14'56 N, 6°58'3 W	Csa	467 mm	17.8 °C	+8m
Halorubrum xinjiangense strain MLW86 16S ribosomal RNA gene, partial sequence	99	Lake Meyghan, Iran	34°11'52.2"N 49°52'58.1"E	Dsa	316 mm.	11.8 °C	+1659m



World map of Köppen-Geiger climate classification



Climate Category



DATA SOURCE : GHCN v2.0 station data
 Temperature (N = 4,844) and
 Precipitation (N = 12,396)

PERIOD OF RECORD : All available

MIN LENGTH : ≥30 for each month.

RESOLUTION : 0.1 degree lat/long

Contact : Murray C. Peel (mpeel@unimelb.edu.au) for further information



368.8
mm

Average Rainfall

17.3
°C

Average Temperature

720.9
m

Average Elevation

