Downscaling AquaMaps

v01: blue whale, GEBCO SoCal

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## 1 Overview

**Goal**: Downscale [AquaMaps.org](https://aquamaps.org) species distributions (Kaschner et al. 2023; Ready et al. 2010) from 0.5 decimal degrees to 15 arc seconds (111.11 km to 0.46 km at the equator), using the R package [aquamapsdata](https://raquamaps.github.io/aquamapsdata/index.html) and the the General Bathymetric Chart of the Oceans [GEBCO](https://www.gebco.net/).

We start with the “Blue Whale” ([*Balaenoptera musculus*](https://aquamaps.org/preMap2.php?cache=1&SpecID=ITS-Mam-180528)) and Southern California.

Later we’ll iterate over species and expand to global, which will require large raster handling techniques using Cloud-Optimized GeoTIFFS (COGs; see [cogeo.org](https://www.cogeo.org)).

All code and files (except the large global GEBCO grid) are found in this repository:

* [github.com/marinebon/aquamaps-downscaled](https://github.com/marinebon/aquamaps-downscaled)

## 2 Species map (blue whale)

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| Figure 1: Map of blue whale (*Balaenoptera musculus*) distribution from AquaMaps. |

### 2.1 Zoom to SoCal

Notice the very large pixels, far bigger than useful for smaller planning purposes, such as for Sanctuaries or BOEM Wind Energy Areas.

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| Figure 2: Map of blue whale (*Balaenoptera musculus*) distribution from AquaMaps zoomed into Southern California. Notice the very large pixels, far bigger than useful for smaller planning purposes, such as for Sanctuaries or BOEM Wind Energy Areas. |

## 3 Environmental preferences

Here are the environmental preferences for the species in the database.

Table 1: Table of blue whale (*Balaenoptera musculus*) environmental suitability parameters from Aquamaps.

| name | value |
| --- | --- |
| SpeciesID | ITS-Mam-180528 |
| Speccode | 69007 |
| LifeStage | adults |
| FAOAreas | 18, 21, 27, 31, 34, 41, 47, 48, 51, 57, 58, 61, 67, 71, 77, 81, 87, 88 |
| FAOComplete | NA |
| NMostLat | 90 |
| SMostLat | -90 |
| WMostLong | -180 |
| EMostLong | 180 |
| DepthYN | 1 |
| DepthMin | 0 |
| DepthPrefMin | 1000 |
| DepthPrefMax | 4000 |
| DepthMax | 8000 |
| MeanDepth | 1 |
| Pelagic | 0 |
| TempYN | 1 |
| TempMin | -1.8 |
| TempPrefMin | -1.3 |
| TempPrefMax | 27.87 |
| TempMax | 32.07 |
| SalinityYN | 1 |
| SalinityMin | 3.58 |
| SalinityPrefMin | 32.57 |
| SalinityPrefMax | 35.49 |
| SalinityMax | 38.84 |
| PrimProdYN | 1 |
| PrimProdMin | 0.1 |
| PrimProdPrefMin | 1.4 |
| PrimProdPrefMax | 16.07 |
| PrimProdMax | 119.58 |
| IceConYN | 1 |
| IceConMin | -0.88 |
| IceConPrefMin | 0 |
| IceConPrefMax | 0.49 |
| IceConMax | 0.96 |
| OxyYN | 0 |
| OxyMin | 1.1 |
| OxyPrefMin | 116.82 |
| OxyPrefMax | 275.01 |
| OxyMax | 408.48 |
| LandDistYN | 0 |
| LandDistMin | 0 |
| LandDistPrefMin | 17 |
| LandDistPrefMax | 733 |
| LandDistMax | 1740 |
| Remark | FAO areas,bounding box and/or pelagic flag based on last review. |
| DateCreated | 2019-08-07 00:00:00 |
| DateModified | NA |
| expert\_id | NA |
| DateExpert | NA |
| Layer | s |
| Rank | 1 |
| MapOpt | 1 |
| ExtnRuleYN | 1 |
| Reviewed | 1 |

Now let’s convert all variables having {Var}YN == 1 into the relative environmental suitability rhomboids (Kaschner et al. 2006).

Table 2: Table environmental suitability parameters from Aquamaps that are applicable to blue whale (*Balaenoptera musculus*), i.e. {Var}YN == 1 in [Table 1](#tbl-blue_whale_env).

| var | prob\_name | var\_value | prob\_value |
| --- | --- | --- | --- |
| Depth | Min | 0.00 | 0 |
| Depth | PrefMin | 1000.00 | 1 |
| Depth | PrefMax | 4000.00 | 1 |
| Depth | Max | 8000.00 | 0 |
| Temp | Min | -1.80 | 0 |
| Temp | PrefMin | -1.30 | 1 |
| Temp | PrefMax | 27.87 | 1 |
| Temp | Max | 32.07 | 0 |
| Salinity | Min | 3.58 | 0 |
| Salinity | PrefMin | 32.57 | 1 |
| Salinity | PrefMax | 35.49 | 1 |
| Salinity | Max | 38.84 | 0 |
| PrimProd | Min | 0.10 | 0 |
| PrimProd | PrefMin | 1.40 | 1 |
| PrimProd | PrefMax | 16.07 | 1 |
| PrimProd | Max | 119.58 | 0 |
| IceCon | Min | -0.88 | 0 |
| IceCon | PrefMin | 0.00 | 1 |
| IceCon | PrefMax | 0.49 | 1 |
| IceCon | Max | 0.96 | 0 |

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| Figure 3: Plots of environmental suitability parameters from Aquamaps that are applicable to blue whale (*Balaenoptera musculus*) from [Table 2](#tbl-blue_whale_env_yes). |

## 4 Depth (GEBCO) for SoCal

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| Figure 4: Map of depth from GEBCO zoomed into Southern California. Notice the much higher resolution compared to [Figure 2](#fig-blue_whale_map_socal). |

## 5 Ramp depth with species preference

### 5.1 Create ramp\_env() function

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| Figure 5: Plot of original depth preferences for 4 points (black circles) and interpolated values (red asterisks) using new ramp\_env() function. |

### 5.2 Apply to SoCal

Apply the ramp\_env() function to the SoCal depth using blue whale preferences.

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| Figure 6: Map of depth preference for r sp\_term applied to SoCal depth with the ramp\_env() function. |

## 6 Next Steps

Goal: Downscale global AquaMaps with all env preferences

TODO:

* ☐ Gather finer resolution global data based on yes/no parameters (\*YN):
  + ☒ Depth: [GEBCO](https://www.gebco.net)
  + ☐ Temp:
  + ☐ Salinity:
  + ☐ PrimProd:
  + ☐ IceCon:
  + ☐ Oxy:
  + ☐ LandDist:
  + ☐ ExtnRule:
* ☐ Work out rest of individual species workflow
  + ☐ Apply ramp\_env() to each environmental parameter applicable to the species (ie {var}YN ==1)
  + ☐ Average all environmental parameter grids for the species
  + ☐ Clip to NMostLat, SMostLat, WMostLong, EMostLong
  + ☐ Mask to FAOAreas
  + ☐ Figure out unknown fields: ExtnRuleYN, MapOpt, …
* ☐ Repeat for workflow for ALL species
* ☐ Render maps from anywhere
  + ☐ Store in COG with each species as a separate layer; or try individual layer COGs
  + ☐ Upload COG to Google Cloud Storage
  + ☐ Install [TiTiler](https://developmentseed.org/titiler) on MarineBON.app server
  + ☐ Render map layers from COG using TiTiler in new function(s) borrowing from [offhabr](https://offshorewindhabitat.info/offhabr/index.html) functions like [oh\_map\_cog\_lyr()](https://offshorewindhabitat.info/offhabr/reference/oh_map_cog_lyr.html)
* ☐ Build Shiny app
  + ☐ Render map of selected species from dropdown
  + ☐ Summarize species from drawn area
  + ☐ Summarize species from selected area from existing:
    - ☐ EEZ
    - ☐ LME
    - ☐ Sanctuary
    - ☐ BOEM Wind Energy Area
    - ☐ …
* ☐ Calculate biodiversity metrics
  + ☐ Richness
  + ☐ Abundance
  + ☐ Extinction Risk
  + ☐ Endemism
  + ☐ Foundation Species
  + ☐ …

## 7 References

Kaschner, K., K. Kesner-Reyes, C. Garilao, J. Segschneider, J. Rius-Barile, T. Rees, and R. Froese. 2023. “AquaMaps: Predicted Range Maps for Aquatic Species. Retrieved from https://www.aquamaps.org.”

Kaschner, K., R. Watson, A. W. Trites, and D. Pauly. 2006. “Mapping World-Wide Distributions of Marine Mammal Species Using a Relative Environmental Suitability (RES) Model.” *Marine Ecology Progress Series* 316 (July): 285–310. <https://doi.org/10.3354/meps316285>.

Ready, Jonathan, Kristin Kaschner, Andy B. South, Paul D. Eastwood, Tony Rees, Josephine Rius, Eli Agbayani, Sven Kullander, and Rainer Froese. 2010. “Predicting the Distributions of Marine Organisms at the Global Scale.” *Ecological Modelling* 221 (3): 467–78. <https://doi.org/10.1016/j.ecolmodel.2009.10.025>.