FishyIPMS

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1 First meeting notes

Quarto enables you to weave together content and executable code into a finished document. To learn more about Quarto see https://quarto.org.

1.1 Objectives

- Fit a population dynamic model (IPMs) with anthropogenic drivers (human driven factors such as climate change, direct exploitation, pollution, biological invasions, sea-use change; Moullec et al., 2021).

- The IPM should be a mechanistic model (plug and play; Frost et al., 2023; Smallegange et al., 2017). The IPMs should describe how the variables affect population.

- IPMs should model temporal trends in human characteristics using variables that indicate catchment state of each year and a continuous time series data.

- Produce prediction maps (of what?)

1.2 Covariates to use

- Easily accessible variables e.g. using remote censored data

- environmental covariates

2 Example data received

The data is explained in Bærum et al. (2021).

The following data have been received:

2.1 Dataset 1: Individual data for some fish populations

- Each row = one individual fish

```
library(readr)
Example1 <- read_delim("Example1.csv", delim = ";", escape_double = FALSE, trim_ws = TRUE)


#explore data
colnames(Example1)
```

```
 [1] "Column1"       "klima"         "loknr"         "lpnr"
 [5] "dato"          "juli"          "periode"       "navn"
 [9] "kode"          "lenkenr"       "garnnr"        "m_vidde"
[13] "dyp1"          "dyp2"          "gj_dyp"        "art"
[17] "Lengde"        "vekt"          "k"             "v_gonfri"
[21] "kjonn"         "stadium"       "moden"         "moden1"
[25] "mage"          "cyst"          "gen"           "lpnr_2"
[29] "otr"           "alder_aar"     "otr_1"         "v_skaal"
[33] "v_skaalmfisk"  "vekt_diff"     "v_gonader"     "gon_kode"
[37] "v_skaal_dryw"  "wetprosent"    "v_glass"       "v_glass_prove"
[41] "l_prove"       "v_prove"       "cs137_wet"     "cs137_dry"
[45] "filet"         "s_vekting"     "moh"
```

```
#summary(Example1)
```

2.1.1 Column names and their meaning

which columns are interesting?

I would love to have the meaning of the column names to make meaning of the data. I am only guessing, but my guesses may be wrong. I think:

- `dato` - Date data was collected. The date is between 01.07.2007 to 01.08.2008.

- `Juli` - July, but it has different codes. What do they mean?

Most of the column names are abbrevations.

Looking at the dataset and the summary, is it safe to say this is a data with presence of multiple species (hopefully at a given location, but I cannot find a location name, lake name or ID). This is because I could not find the counts of the fishes at the lake. If the data is for each lake or location, the absences can also be inferred.

2.2 Dataset 2: Subsample of dataset 1

Here the ID represents and individual fish.

```
Example2 <- read_delim("Example2.csv", delim = ";",
    escape_double = FALSE, trim_ws = TRUE)
colnames(Example2)
```

```
 [1] "LengdeVvekst"   "LengdeValder"    "vekstaar"       "vekstalder"
 [5] "alder_aar"      "ID"              "tilv_lengde"    "klima"
 [9] "loknr"          "moh"             "lpnr"           "dato"
[13] "aar"            "periode"         "navn"           "alder"
[17] "lengde"         "vekt"            "kjonn"          "moden"
[21] "moden1"         "tilvekstalder"  "tilvekst"       "inst_vekst"
[25] "CPUE"           "Temp_mai"        "Temp_juni"      "Temp_juli"
[29] "nedbor_mai"     "nedbor_juni"     "nedbor_juli"    "tempratur"
[33] "nedbor"         "NaoV"            "Column1"        "_1"
[37] "_2"             "_3"              "_4"             "_5"
```

```
summary(Example2)
```

```
  LengdeVvekst    LengdeValder       vekstaar       vekstalder
 Min.   : 10.00   Min.   : 10.00   Min.   :1998   Min.   :0.000
 1st Qu.: 35.56   1st Qu.: 35.56   1st Qu.:2004   1st Qu.:1.000
 Median : 83.05   Median : 83.05   Median :2005   Median :2.000
 Mean   : 93.25   Mean   : 93.24   Mean   :2005   Mean   :2.218
 3rd Qu.:141.08   3rd Qu.:141.08   3rd Qu.:2006   3rd Qu.:3.000
 Max.   :409.49   Max.   :409.49   Max.   :2008   Max.   :9.000


   alder_aar           ID         tilv_lengde          klima
 Min.   : 1.000   Min.   :  1.0   Length:4289        Min.   :1.000
 1st Qu.: 2.000   1st Qu.:219.0   Class :character   1st Qu.:1.000
 Median : 3.000   Median :445.0   Mode  :character   Median :2.000
 Mean   : 3.218   Mean   :443.4                      Mean   :2.159
 3rd Qu.: 4.000   3rd Qu.:670.0                      3rd Qu.:3.000
 Max.   :10.000   Max.   :896.0                      Max.   :3.000


     loknr            moh             lpnr            dato
 Min.   : 1.00   Min.   : 36.0   Min.   :  1.00   Length:4289
 1st Qu.: 6.00   1st Qu.: 92.0   1st Qu.: 24.00   Class :character
```

```
   Median :10.00   Median :205.0   Median : 42.00   Mode  :character
   Mean   :11.38   Mean   :341.7   Mean   : 60.77
   3rd Qu.:18.00   3rd Qu.:600.0   3rd Qu.: 88.00
   Max.   :21.00   Max.   :800.0   Max.   :227.00

      aar          periode          navn              alder
   Min.   :2008   Min.   :0.0000   Length:4289         Min.   : 1.000
   1st Qu.:2008   1st Qu.:0.0000   Class :character    1st Qu.: 4.000
   Median :2008   Median :1.0000   Mode  :character    Median : 5.000
   Mean   :2008   Mean   :0.6706                        Mean   : 5.446
   3rd Qu.:2008   3rd Qu.:1.0000                        3rd Qu.: 7.000
   Max.   :2008   Max.   :1.0000                        Max.   :12.000

      lengde          vekt           kjonn            moden
   Min.   : 85   Min.   :   8.3   Min.   :1.000   Min.   :0.0000
   1st Qu.:180   1st Qu.:  62.1   1st Qu.:1.000   1st Qu.:0.0000
   Median :215   Median : 107.3   Median :1.000   Median :0.0000
   Mean   :223   Mean   : 154.4   Mean   :1.493   Mean   :0.2414
   3rd Qu.:259   3rd Qu.: 193.5   3rd Qu.:2.000   3rd Qu.:0.0000
   Max.   :453   Max.   :1030.8   Max.   :2.000   Max.   :1.0000
   NA's   :10                     NA's   :2        NA's   :2
      moden1         tilvekstalder       tilvekst         inst_vekst
   Min.   :0.0000   Length:4289         Min.   :  4.41   Min.   :0.3828
   1st Qu.:0.0000   Class :character    1st Qu.: 30.59   1st Qu.:1.0283
   Median :0.0000   Mode  :character    Median : 37.51   Median :1.0796
   Mean   :0.2498                       Mean   : 39.02   Mean   :1.0825
   3rd Qu.:0.0000                       3rd Qu.: 46.00   3rd Qu.:1.2088
   Max.   :1.0000                       Max.   :151.43   Max.   :2.0314
   NA's   :2                                             NA's   :1
      CPUE           Temp_mai        Temp_juni        Temp_juli
   Min.   : 0.6095   Min.   : 3.983   Min.   : 7.65   Min.   :11.51
   1st Qu.: 1.7000   1st Qu.: 5.803   1st Qu.:10.14   1st Qu.:13.98
   Median : 3.8889   Median : 7.110   Median :11.55   Median :14.93
   Mean   : 4.1464   Mean   : 7.221   Mean   :11.40   Mean   :14.75
   3rd Qu.: 5.0357   3rd Qu.: 8.510   3rd Qu.:12.45   3rd Qu.:15.96
   Max.   :16.8889   Max.   :12.343   Max.   :15.78   Max.   :17.49
```

```
  nedbor_mai         nedbor_juni        nedbor_juli         tempratur
 Min.   :  6.20    Min.   :  8.80    Min.   : 12.80    Min.   : 9.412
 1st Qu.: 48.30    1st Qu.: 44.20    1st Qu.: 54.50    1st Qu.:10.664
 Median : 70.90    Median : 67.80    Median : 71.60    Median :11.759
 Mean   : 64.31    Mean   : 63.13    Mean   : 76.29    Mean   :11.816
 3rd Qu.: 80.20    3rd Qu.: 75.60    3rd Qu.:101.00    3rd Qu.:12.847
 Max.   :106.40    Max.   :155.80    Max.   :195.80    Max.   :15.078

     nedbor            NaoV           Column1            _1
 Min.   :209.4    Min.   :-0.8200    Mode:logical    Mode:logical
 1st Qu.:315.8    1st Qu.:-0.2000    NA's:4289       NA's:4289
 Median :390.3    Median :-0.1100
 Mean   :383.6    Mean   : 0.2695
 3rd Qu.:428.7    3rd Qu.: 0.7900
 Max.   :540.2    Max.   : 1.8500

      _2                _3                _4                _5
 Min.   : 1.000    Min.   :   668    Length:4289       Min.   : 36.0
 1st Qu.: 5.000    1st Qu.: 36938    Class :character  1st Qu.: 60.0
 Median :10.000    Median : 38967    Mode  :character  Median :205.0
 Mean   : 9.529    Mean   : 41208                      Mean   :288.4
 3rd Qu.:14.000    3rd Qu.: 40445                      3rd Qu.:535.0
 Max.   :18.000    Max.   :118010                      Max.   :663.0
 NA's   :4272      NA's   :4272                        NA's   :4272
```

Do we link both datasets by their IDs?

NOTE: There is no ID in the first dataset. So do I link them by species or develop a species-specific IPM?

2.3 Dataset 3: Catchment collected per lake

- Each row represents a lake

```
catchments <- read_csv("NO_all_vars_over_catchments.csv")
colnames(catchments)
```

```
[1] "vassdragNr"
```

```
 [2] "vatnLnr"
 [3] "Land principally occupied by agriculture, with significant areas of natural vegetation"
 [4] "Broad-leaved forest"
 [5] "Moors and heathland"
 [6] "Sparsely vegetated areas"
 [7] "Peat bogs"
 [8] "Water bodies"
 [9] "Discontinuous urban fabric"
[10] "Non-irrigated arable land"
[11] "Coniferous forest"
[12] "Transitional woodland-shrub"
[13] "Complex cultivation patterns"
[14] "Water courses"
[15] "Mixed forest"
[16] "Industrial or commercial units"
[17] "Green urban areas"
[18] "Sport and leisure facilities"
[19] "Continuous urban fabric"
[20] "Road and rail networks and associated land"
[21] "Airports"
[22] "Pastures"
[23] "Bare rocks"
[24] "Mineral extraction sites"
[25] "Inland marshes"
[26] "Glaciers and perpetual snow"
[27] "Sea and ocean"
[28] "Port areas"
[29] "Natural grasslands"
[30] "Intertidal flats"
[31] "mean_ndsi"
[32] "fractional_snow_cover"
[33] "mean_ndvi"
[34] "total_road_length"
[35] "road_density"
[36] "total_ditch_length"
[37] "ditch_density"
```

```
[38] "unbuilt"

[39] "res_built"

[40] "nres_built"

[41] "total_population"

[42] "population_density"

[43] "gHM"
```

```r
summary(catchments)
```

```
  vassdragNr            vatnLnr
 Length:591        Min.   :     3
 Class :character  1st Qu.:   118
 Mode  :character  Median :  1051
                   Mean   :  5047
                   3rd Qu.:  2180
                   Max.   :209024


Land principally occupied by agriculture, with significant areas of natural vegetation
 Min.   : 0.000
 1st Qu.: 0.000
 Median : 0.000
 Mean   : 2.852
 3rd Qu.: 1.955
 Max.   :85.934


Broad-leaved forest Moors and heathland Sparsely vegetated areas
 Min.   :  0.000    Min.   : 0.000    Min.   : 0.00
 1st Qu.:  0.000    1st Qu.: 0.000    1st Qu.: 0.00
 Median :  2.167    Median : 5.172    Median :14.28
 Mean   : 17.817    Mean   :15.432    Mean   :22.90
 3rd Qu.: 30.268    3rd Qu.:25.863    3rd Qu.:41.66
 Max.   :100.000    Max.   :99.896    Max.   :99.16


   Peat bogs        Water bodies     Discontinuous urban fabric
 Min.   : 0.0000   Min.   : 0.0000   Min.   : 0.00
 1st Qu.: 0.0000   1st Qu.: 0.2035   1st Qu.: 0.00
 Median : 0.9125   Median : 0.8455   Median : 0.00
```

```
Mean    :  6.6690   Mean    : 2.0653   Mean    : 1.44
3rd Qu.:  8.5524   3rd Qu.: 2.2132   3rd Qu.: 0.00
Max.    :100.0000   Max.    :47.2630   Max.    :99.91


Non-irrigated arable land Coniferous forest Transitional woodland-shrub
Min.    : 0.000          Min.    :  0.00   Min.    : 0.000
1st Qu.: 0.000          1st Qu.:  0.00   1st Qu.: 0.000
Median : 0.000          Median :  0.00   Median : 0.000
Mean    : 3.504          Mean    : 20.05   Mean    : 2.656
3rd Qu.: 0.000          3rd Qu.: 39.61   3rd Qu.: 0.000
Max.    :96.060          Max.    :100.00   Max.    :57.443


Complex cultivation patterns Water courses     Mixed forest
Min.    : 0.0000          Min.    : 0.0000   Min.    : 0.000
1st Qu.: 0.0000          1st Qu.: 0.0000   1st Qu.: 0.000
Median : 0.0000          Median : 0.0000   Median : 0.000
Mean    : 0.3231          Mean    : 0.1315   Mean    : 1.086
3rd Qu.: 0.0000          3rd Qu.: 0.0000   3rd Qu.: 0.000
Max.    :36.0527          Max.    :16.6498   Max.    :45.713


Industrial or commercial units Green urban areas Sport and leisure facilities
Min.    : 0.00000          Min.    :0.00000   Min.    :0.00000
1st Qu.: 0.00000          1st Qu.:0.00000   1st Qu.:0.00000
Median : 0.00000          Median :0.00000   Median :0.00000
Mean    : 0.09384          Mean    :0.01138   Mean    :0.06379
3rd Qu.: 0.00000          3rd Qu.:0.00000   3rd Qu.:0.00000
Max.    :17.58435          Max.    :2.45899   Max.    :9.76409


Continuous urban fabric Road and rail networks and associated land
Min.    :0.00000          Min.    :0.00000
1st Qu.:0.00000          1st Qu.:0.00000
Median :0.00000          Median :0.00000
Mean    :0.01214          Mean    :0.01468
3rd Qu.:0.00000          3rd Qu.:0.00000
Max.    :5.71279          Max.    :8.18734

```

```
     Airports            Pastures          Bare rocks
 Min.   :0.000000   Min.    :0.000000   Min.   : 0.000
 1st Qu.:0.000000   1st Qu.:0.000000    1st Qu.: 0.000
 Median :0.000000   Median :0.000000    Median : 0.000
 Mean   :0.001873   Mean    :0.007849   Mean   : 2.468
 3rd Qu.:0.000000   3rd Qu.:0.000000    3rd Qu.: 0.000
 Max.   :0.599905   Max.    :1.924005   Max.   :53.809


 Mineral extraction sites Inland marshes    Glaciers and perpetual snow
 Min.   : 0.00000         Min.   :0.000000   Min.   :0.0000
 1st Qu.: 0.00000         1st Qu.:0.000000   1st Qu.:0.0000
 Median : 0.00000         Median :0.000000   Median :0.0000
 Mean   : 0.04256         Mean   :0.005025   Mean   :0.0442
 3rd Qu.: 0.00000         3rd Qu.:0.000000   3rd Qu.:0.0000
 Max.   :19.09487         Max.   :2.969928   Max.   :8.9945


 Sea and ocean       Port areas        Natural grasslands Intertidal flats
 Min.   : 0.0000   Min.   :0.000000   Min.   :0.000000   Min.   :0.000e+00
 1st Qu.: 0.0000   1st Qu.:0.000000   1st Qu.:0.000000   1st Qu.:0.000e+00
 Median : 0.0000   Median :0.000000   Median :0.000000   Median :0.000e+00
 Mean   : 0.3005   Mean   :0.002194   Mean   :0.001686   Mean   :1.552e-05
 3rd Qu.: 0.0000   3rd Qu.:0.000000   3rd Qu.:0.000000   3rd Qu.:0.000e+00
 Max.   :71.5460   Max.   :0.648935   Max.   :0.711776   Max.   :9.173e-03


   mean_ndsi        fractional_snow_cover   mean_ndvi      total_road_length
 Min.   :-0.2026   Min.   :0.0000        Min.   :0.1183   Min.   :     0
 1st Qu.: 0.3938   1st Qu.:0.4721        1st Qu.:0.5831   1st Qu.:     0
 Median : 0.5460   Median :0.9350        Median :0.6757   Median :  4161
 Mean   : 0.5013   Mean   :0.7263        Mean   :0.6545   Mean   : 20204
 3rd Qu.: 0.6431   3rd Qu.:0.9998        3rd Qu.:0.7545   3rd Qu.: 19618
 Max.   : 0.7740   Max.   :1.0000        Max.   :0.8530   Max.   :256730
 NA's   :4
  road_density       total_ditch_length ditch_density         unbuilt
 Min.   :0.0000000   Min.   :    0.0    Min.   :0.000e+00   Min.   :0.1520
 1st Qu.:0.0000000   1st Qu.:    0.0    1st Qu.:0.000e+00   1st Qu.:0.9974
 Median :0.0004313   Median :  151.2    Median :1.621e-05   Median :0.9998
```

```
Mean    :0.0012442   Mean    :  6761.6   Mean    :2.667e-04   Mean    :0.9869
3rd Qu.:0.0016803   3rd Qu.:  4520.9   3rd Qu.:3.100e-04   3rd Qu.:1.0000
Max.    :0.0229385   Max.    :156650.1   Max.    :4.358e-03   Max.    :1.0136


   res_built         nres_built       total_population   population_density
Min.    :0.000000   Min.    :0.0000000   Min.    :    0.00   Min.    :    0.0000
1st Qu.:0.000000   1st Qu.:0.0000000   1st Qu.:    0.00   1st Qu.:    0.0000
Median :0.000056   Median :0.0000000   Median :    1.13   Median :    0.0537
Mean    :0.011244   Mean    :0.0018676   Mean    :  516.91   Mean    :   35.9188
3rd Qu.:0.002136   3rd Qu.:0.0002885   3rd Qu.:   42.02   3rd Qu.:    3.6931
Max.    :0.739137   Max.    :0.2763020   Max.    :35542.86   Max.    :3069.6211


     gHM
Min.    :0.01147
1st Qu.:0.05810
Median :0.09409
Mean    :0.17734
3rd Qu.:0.25972
Max.    :0.75534
```

3 References

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