Spatial Variability in Bigeye Vertical Behaviour: Environmental Influences and Impacts on Fisheries

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Objectives:

Are there spatial variations in fish depth distributions?

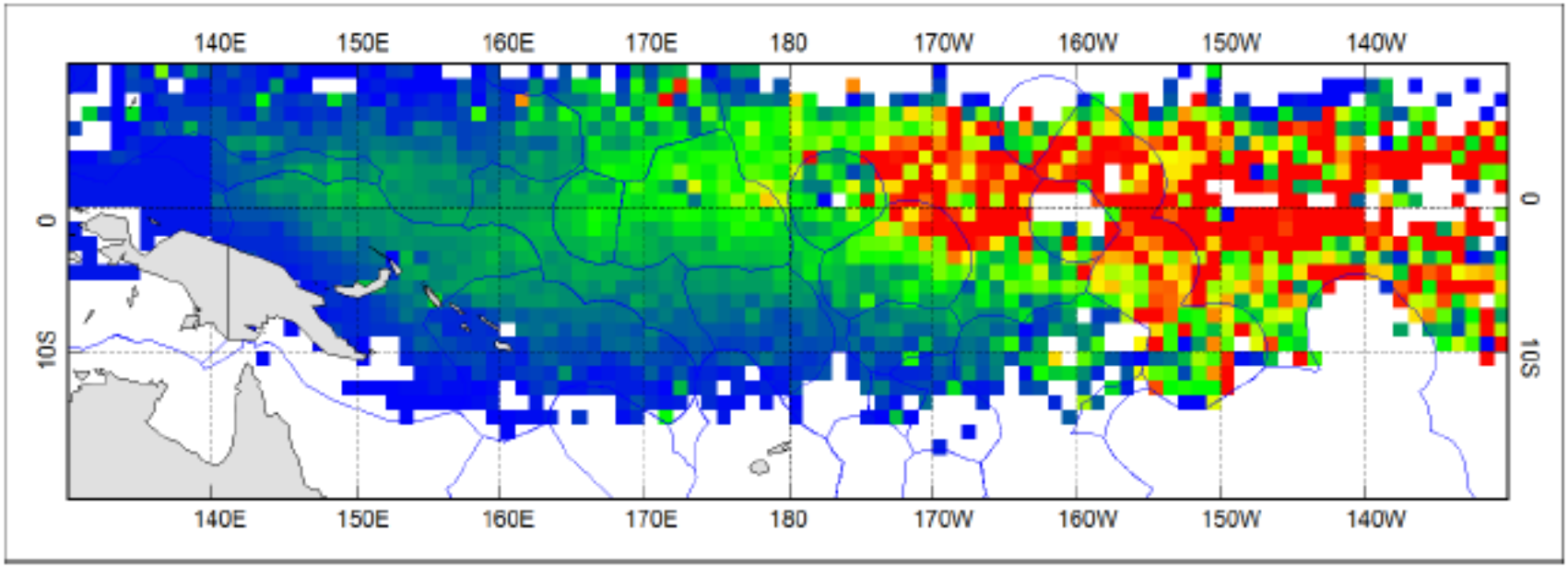
Can we link that variations with the environment?

What are the factors affecting the probability of association to FADs?

Can we use the information provided from electronic tags to improve stock assessment and management?

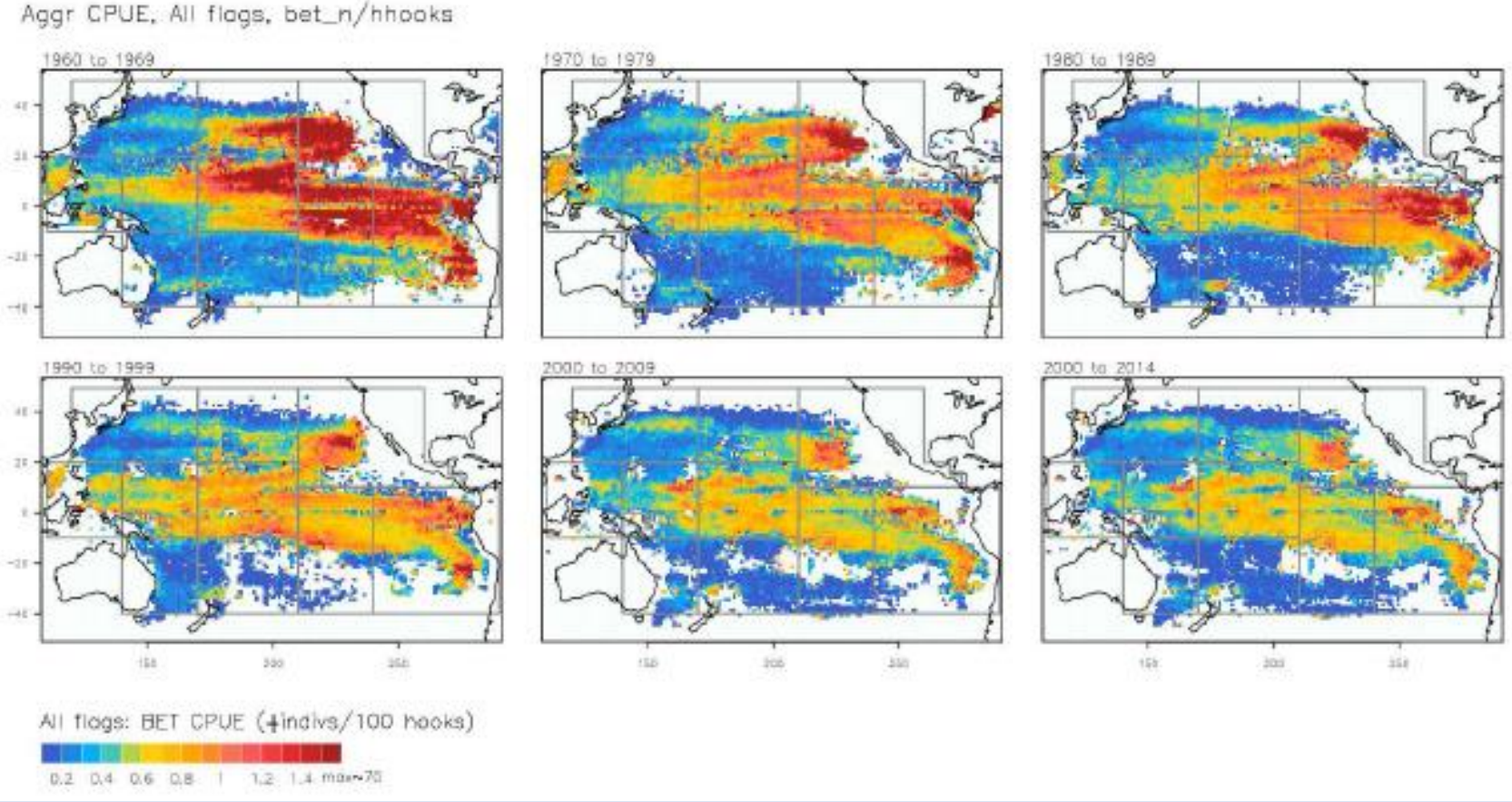
Spatial Observations of Bigeye CPUE

Purse Seine



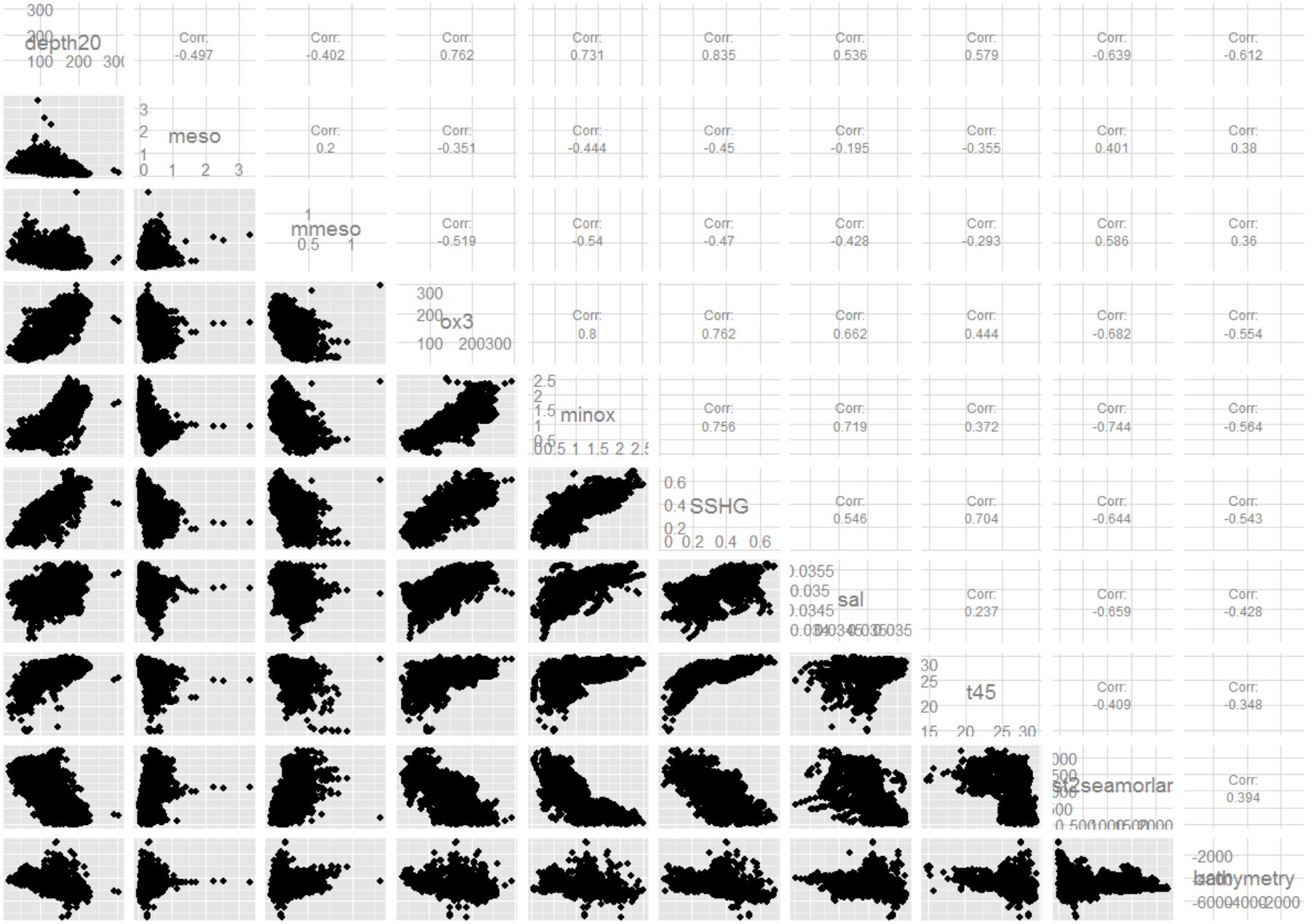
Spatial Observations of Bigeye CPUE

Longline

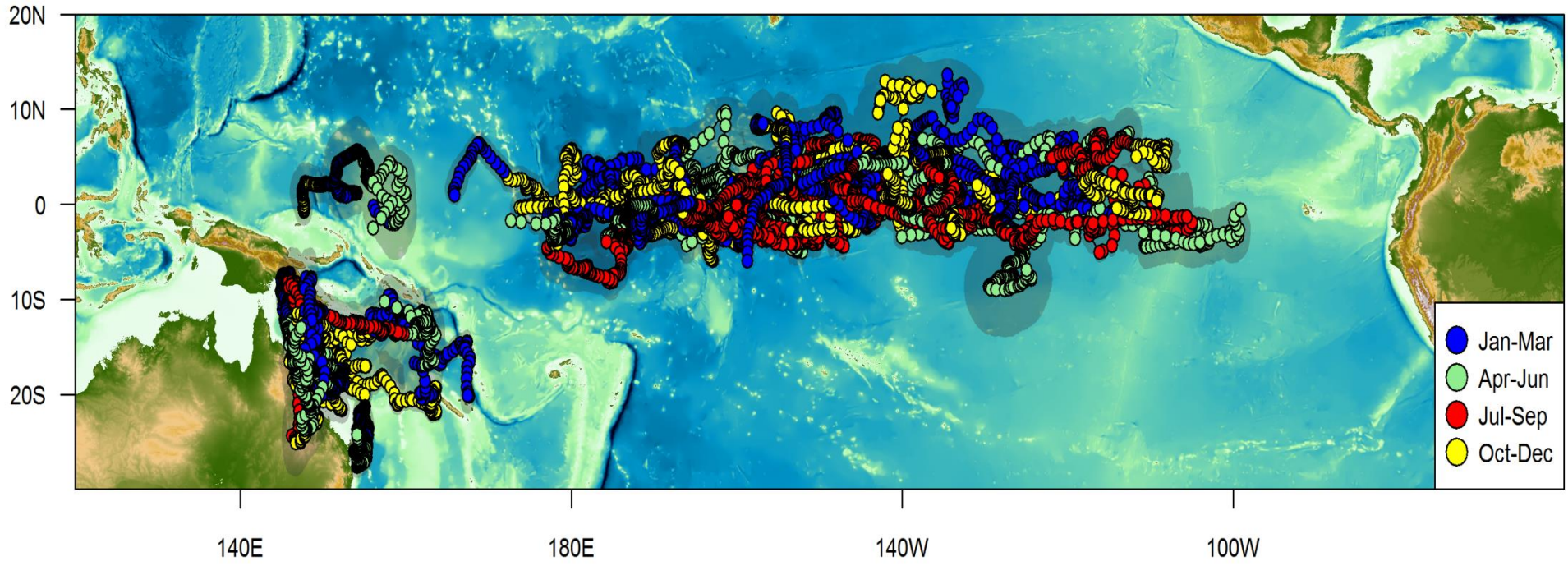


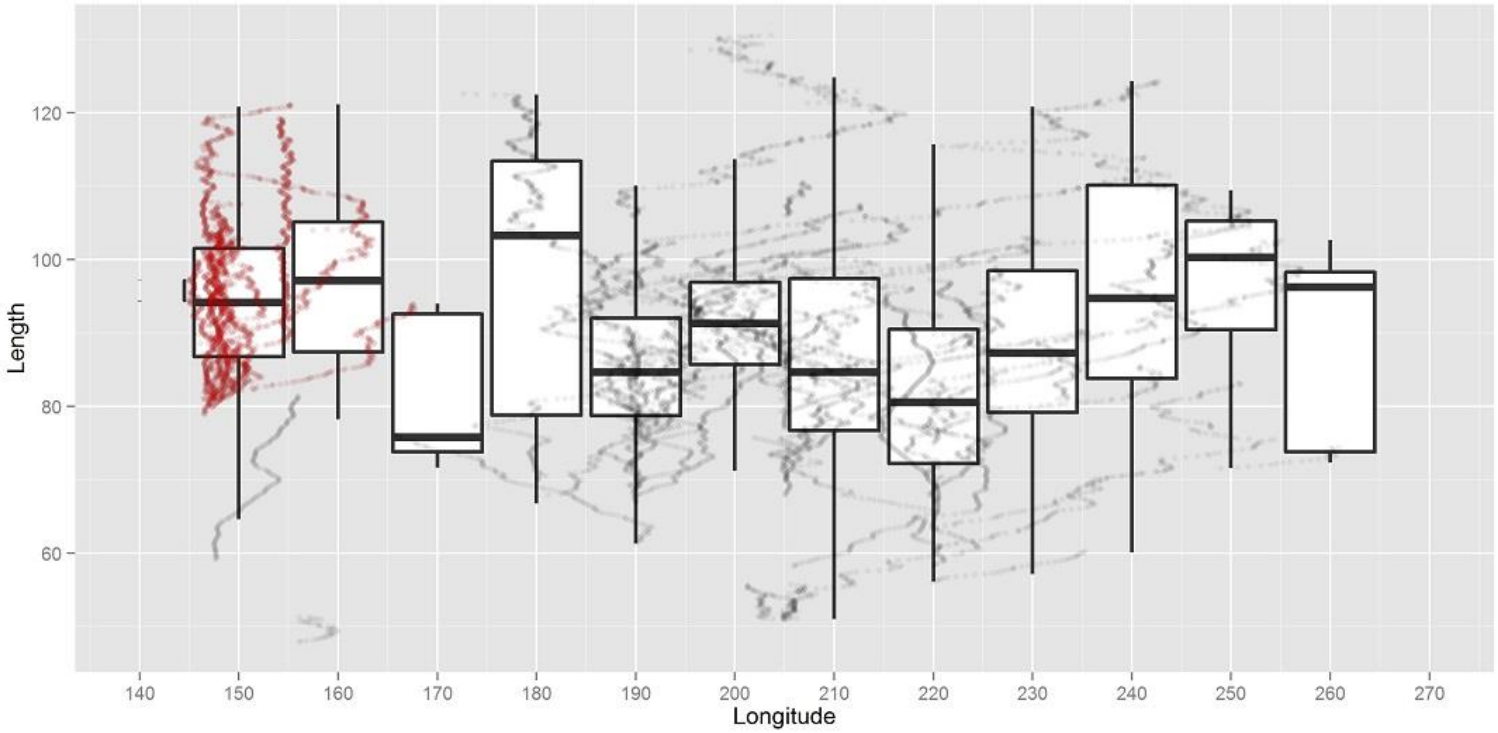
Data sources

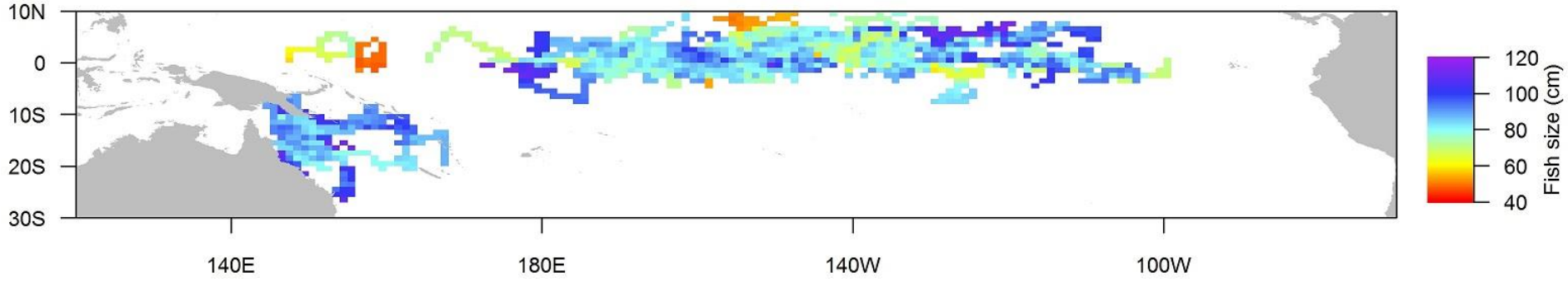
- Archival tag data: used for depth, thermocline depth, attenuation coefficients…
- Moonphase (US naval observatory)
- Forage: Tuna forage model-Seapodym
- Oxygen: Climatological data from the WOA
- Chla and PP: Oregon State University.
- Cloud cover to correct moon illumination and explain night depth (OMI-Aura-L3 product)
- IRD model data
- DSL depth (based in attenuation coefficient and solar irradiation)
- Solar elevation (proxy for season)
- sea surface height, surface currents, salinity and temperature at 45 m from GODAS
- Land, seamounts, bathymetry
- Thermal gradient from REMSS.
- Fish length


depth20
meso
mmeso
ox3
minox
SSHG
sal
t45
st2seamorlar
bathymetry
Corr: -0.497
Corr: -0.402
Corr: 0.762
Corr: 0.731
Corr: 0.835
Corr: 0.536
Corr: 0.579
Corr: -0.639
Corr: -0.612
Corr: 0.2
Corr: -0.351
Corr: -0.444
Corr: -0.45
Corr: -0.195
Corr: -0.355
Corr: 0.401
Corr: 0.38
Corr: -0.519
Corr: -0.54
Corr: -0.47
Corr: -0.428
Corr: -0.293
Corr: 0.586
Corr: 0.36
Corr: 0.8
Corr: 0.762
Corr: 0.662
Corr: 0.444
Corr: -0.682
Corr: -0.554
Corr: 0.756
Corr: 0.719
Corr: 0.372
Corr: -0.744
Corr: -0.564
Corr: 0.546
Corr: 0.704
Corr: -0.644
Corr: -0.543
Corr: 0.237
Corr: -0.659
Corr: -0.428
Corr: -0.409
Corr: -0.348
Corr: 0.394

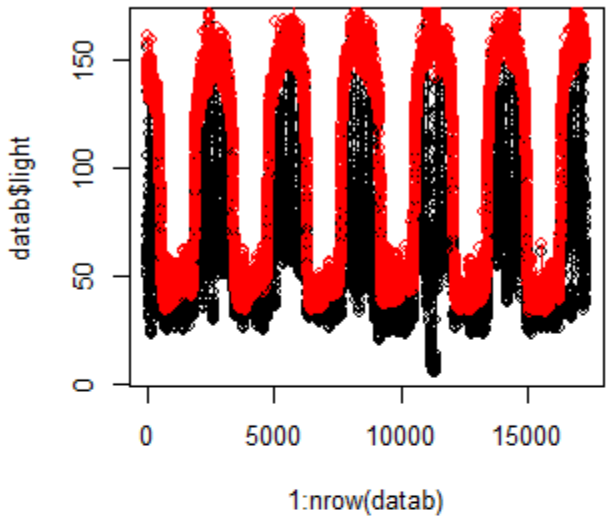
Archival data

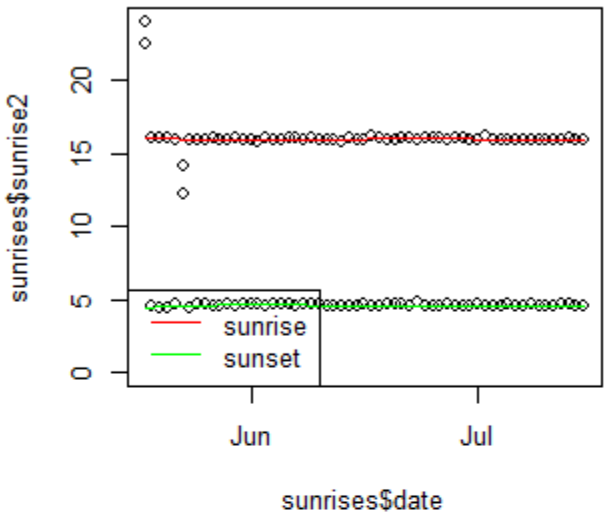


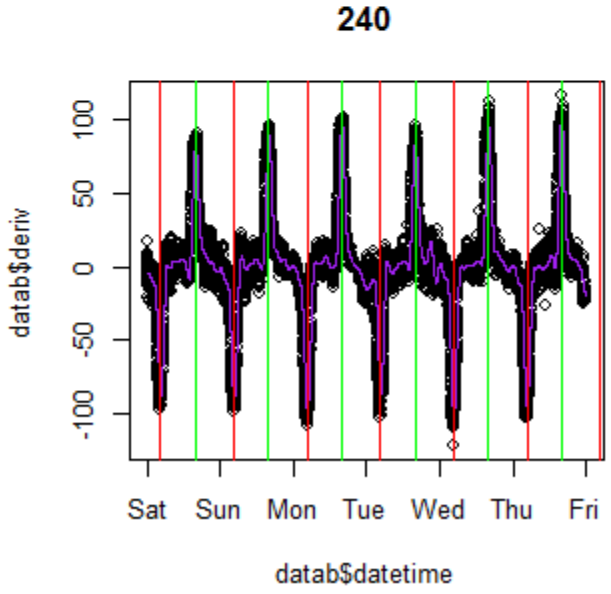

Length
120
100
80
60
140
150
160
170
180
190
200
210
220
230
240
250
260
270
Longitude

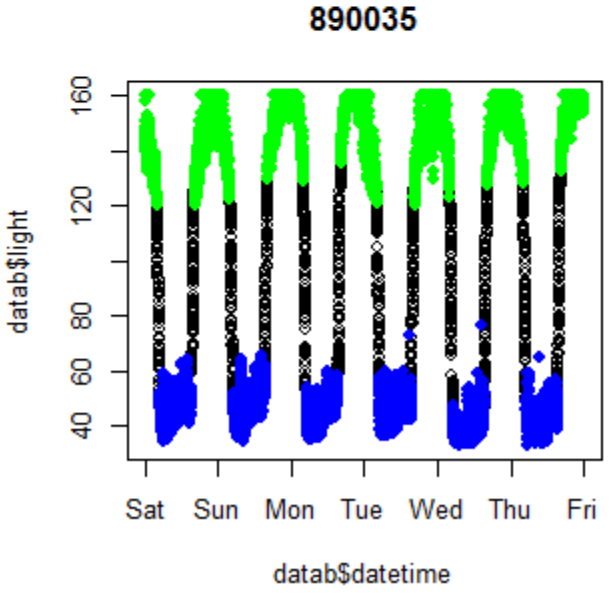

10N
0
10S
20S
30S
140E
180E
140W
100W
Fish size (cm)
120
100
80
60
40

Phase of day

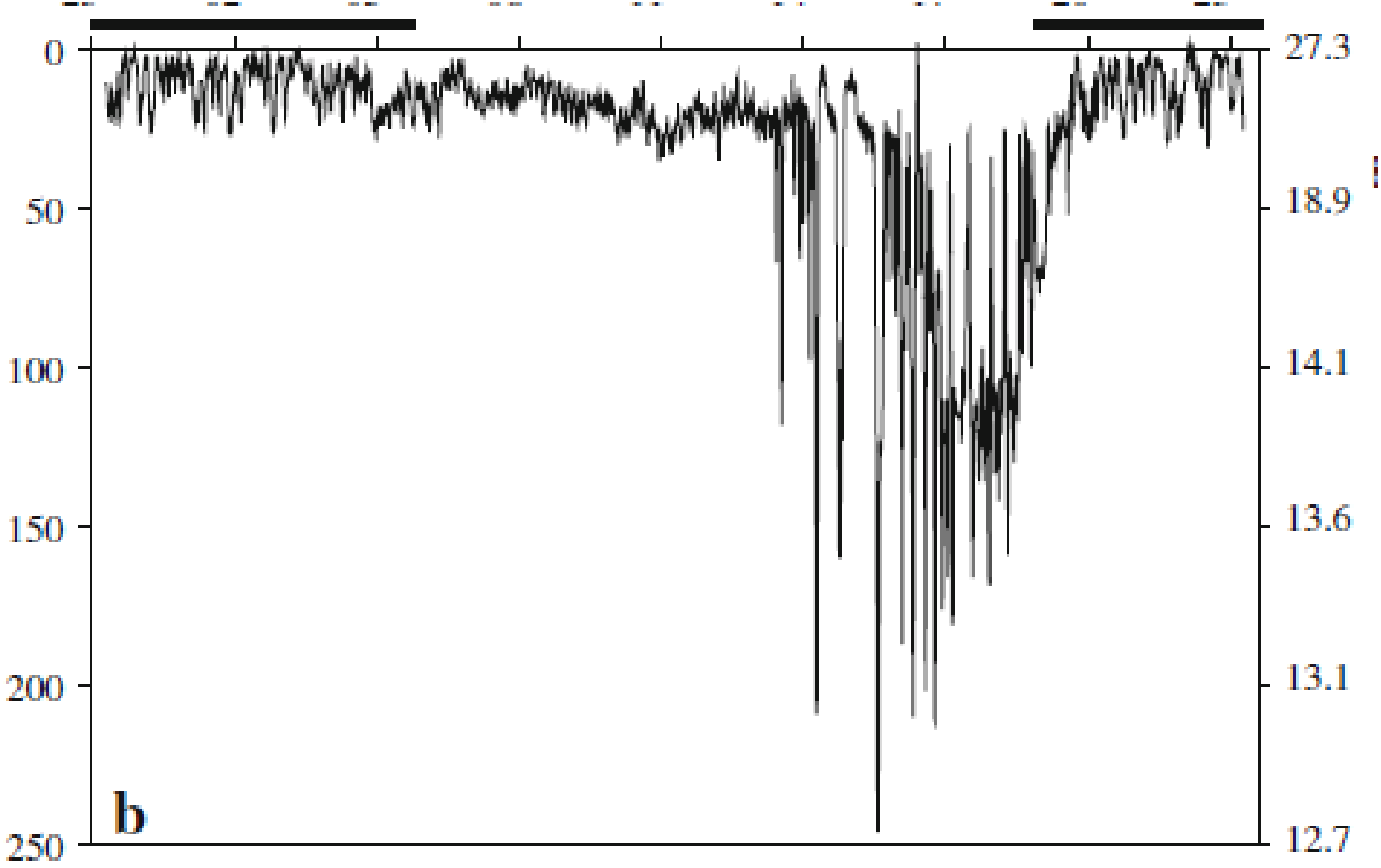

datab$light
0
50
100
150
0
5000
10000
15000
1:nrow(datab)

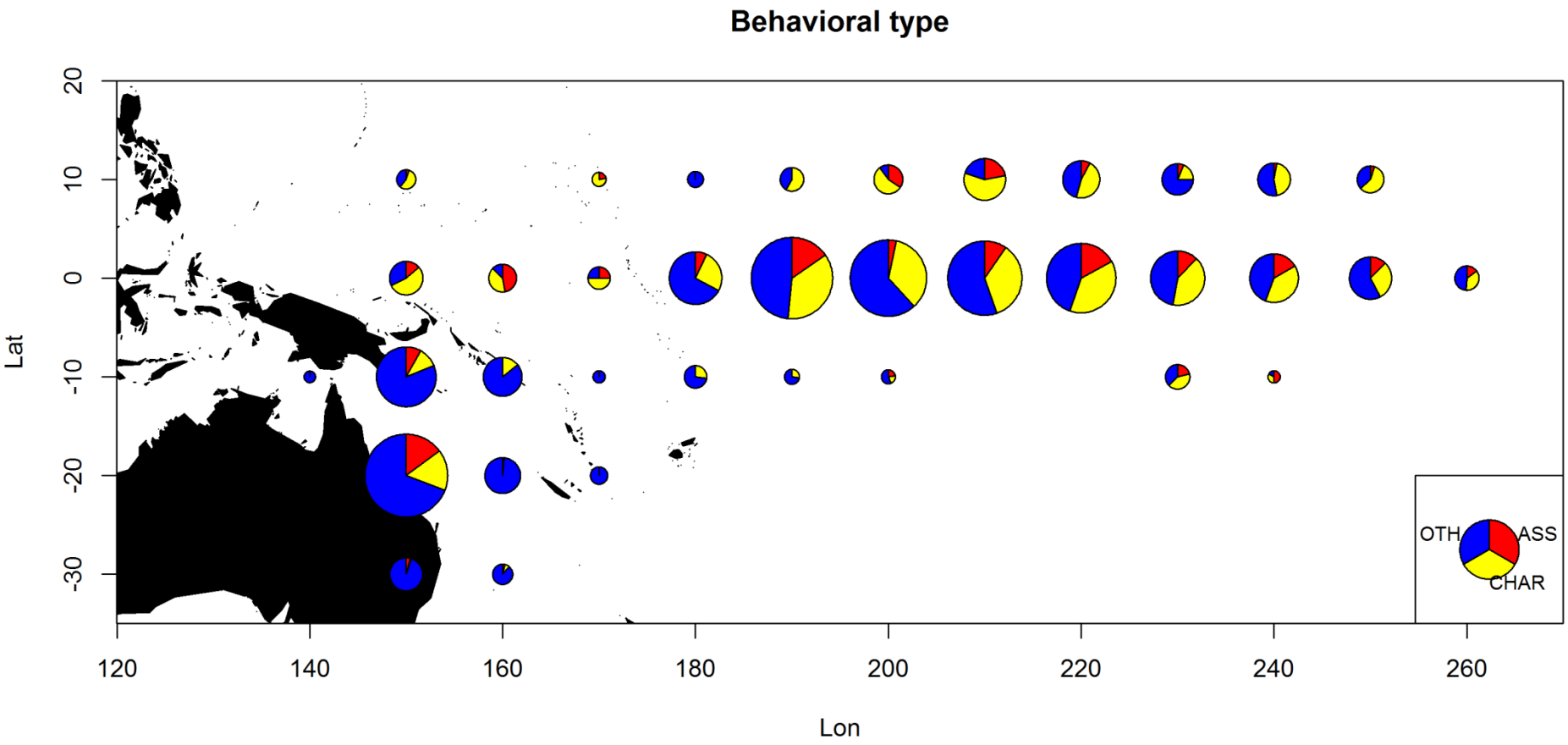

sunrises$sunrise2
0
5
10
15
20
sunrise
sunset
Jun
Jul
sunrises$date


240
datab$deriv
-100
-50
0
50
100
Sat
Sun
Mon
Tue
Wed
Thu
Fri
datab$datetime

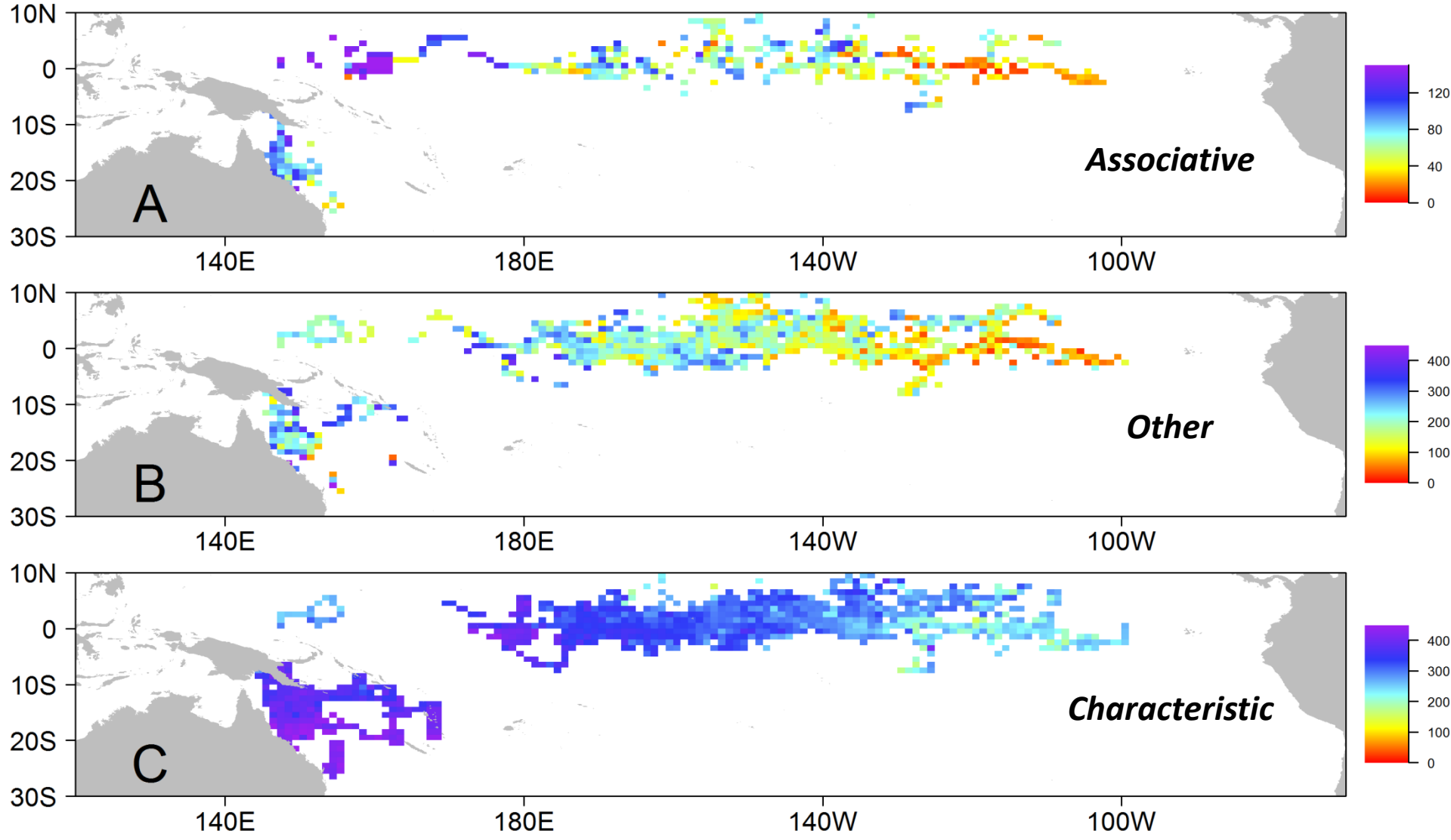

890035
datab$light
40
60
80
120
160
Sat
Sun
Mon
Tue
Wed
Thu
Fri
datab$datetime

Behavioral classification (Schaefer & Fuller, 2010)

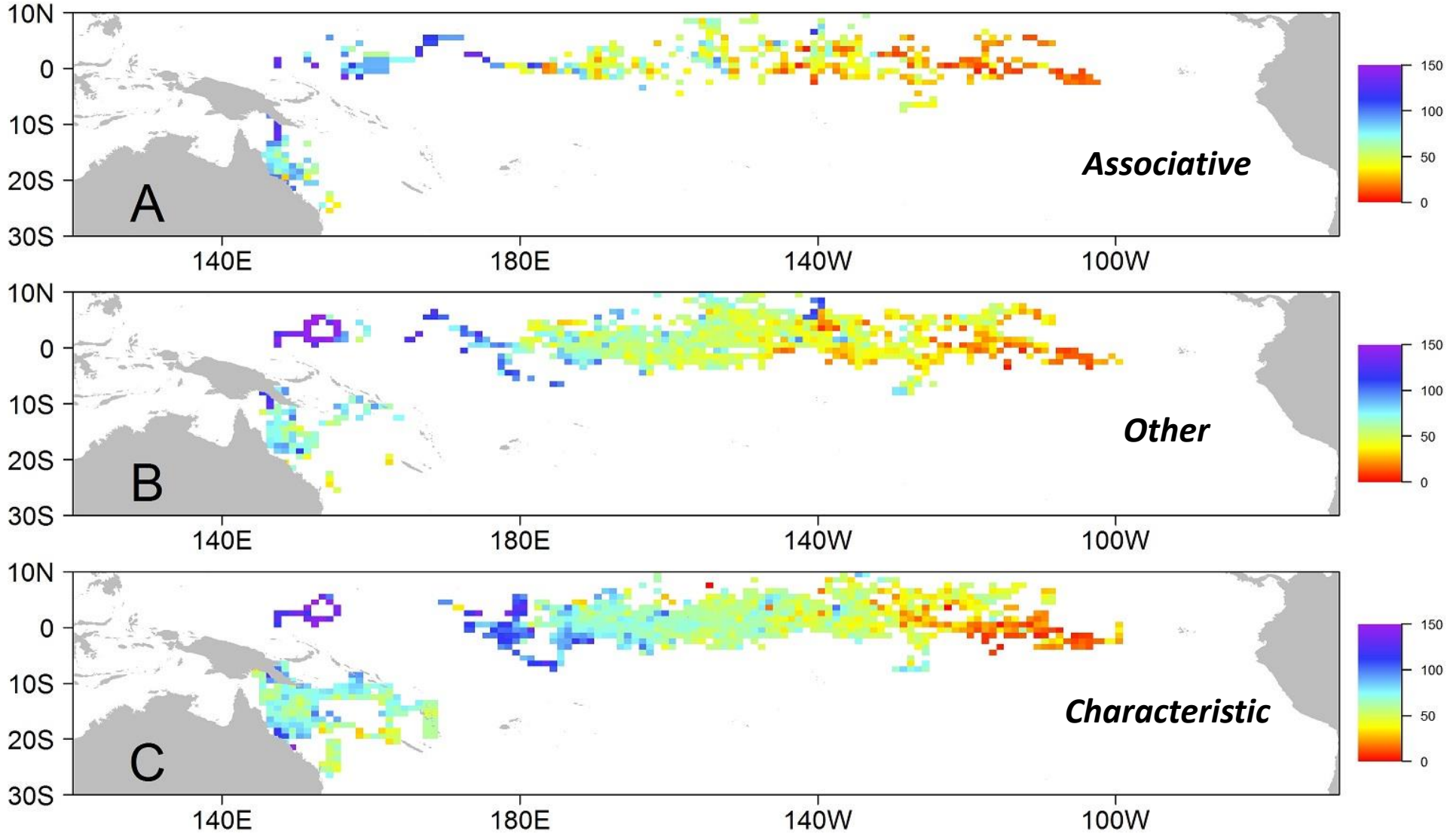


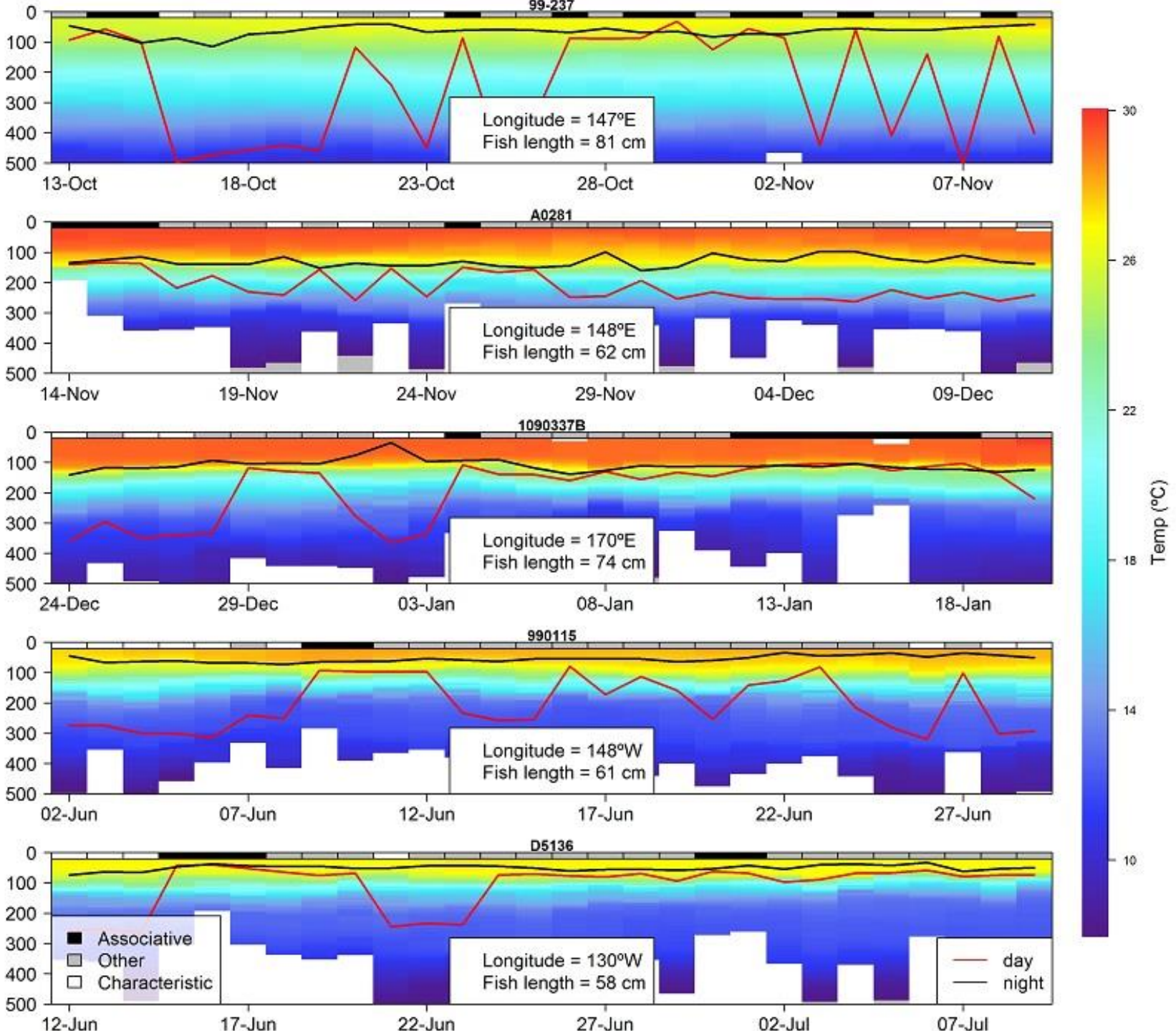

Behavioral type
Lat
Lon
20
10
0
-10
-20
-30
120
140
160
180
200
220
240
260
OTH
ASS
CHAR

Daytime. Nominal depths



Nighttime. Nominal depths

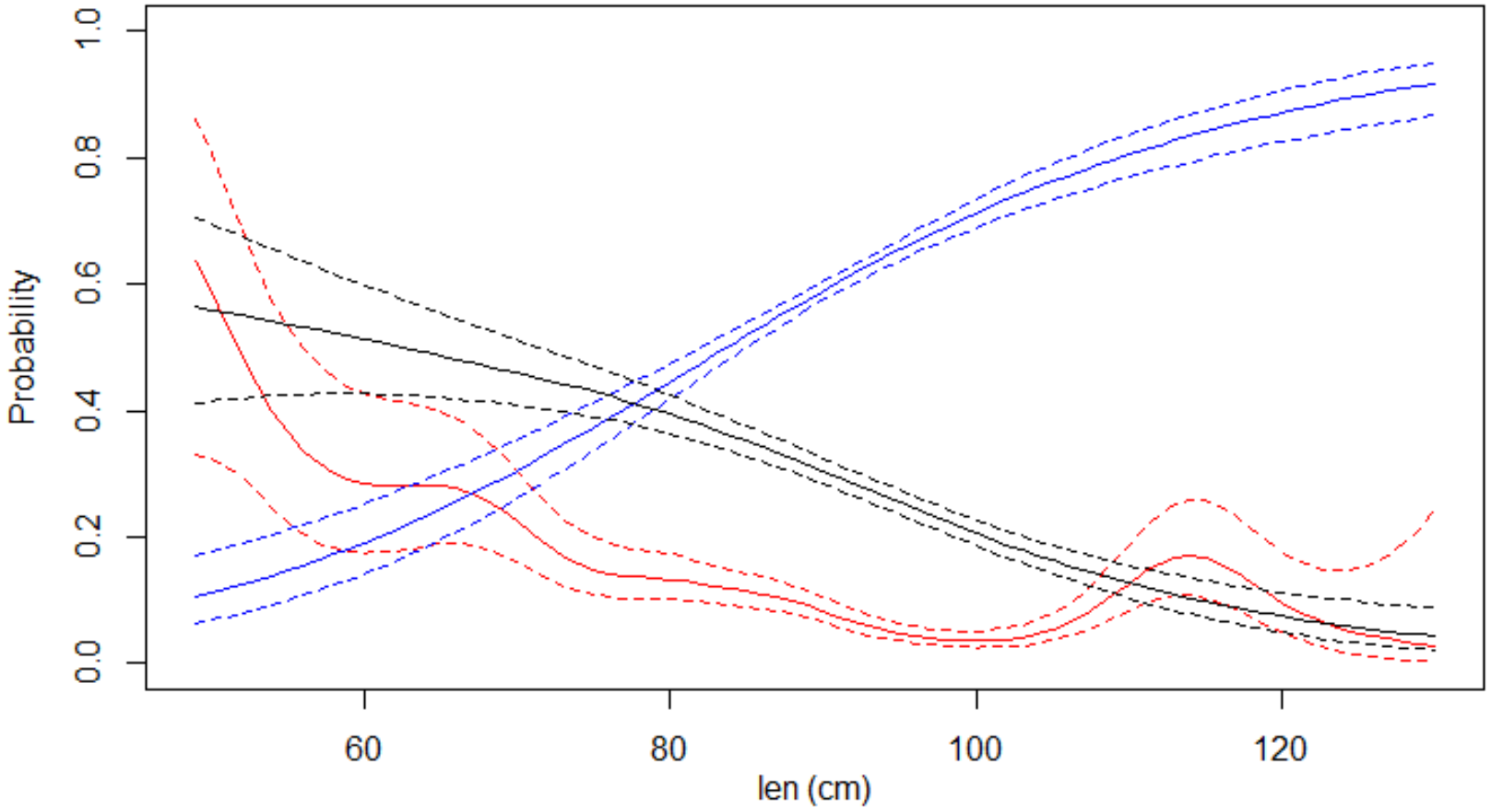



99-237
Longitude = 147°E
Fish length = 81 cm
13-Oct
18-Oct
23-Oct
28-Oct
02-Nov
07-Nov
A0281
Longitude = 148°E
Fish length = 62 cm
14-Nov
19-Nov
24-Nov
29-Nov
04-Dec
09-Dec
1090337B
Longitude = 170°E
Fish length = 74 cm
24-Dec
29-Dec
03-Jan
08-Jan
13-Jan
18-Jan
990115
Longitude = 148°W
Fish length = 61 cm
02-Jun
07-Jun
12-Jun
17-Jun
22-Jun
27-Jun
D5136
Longitude = 130°W
Fish length = 58 cm
12-Jun
17-Jun
22-Jun
27-Jun
02-Jul
07-Jul
Associative
Other
Characteristic
day
night
0
100
200
300
400
500
Temp (°C)
10
14
18
22
26
30

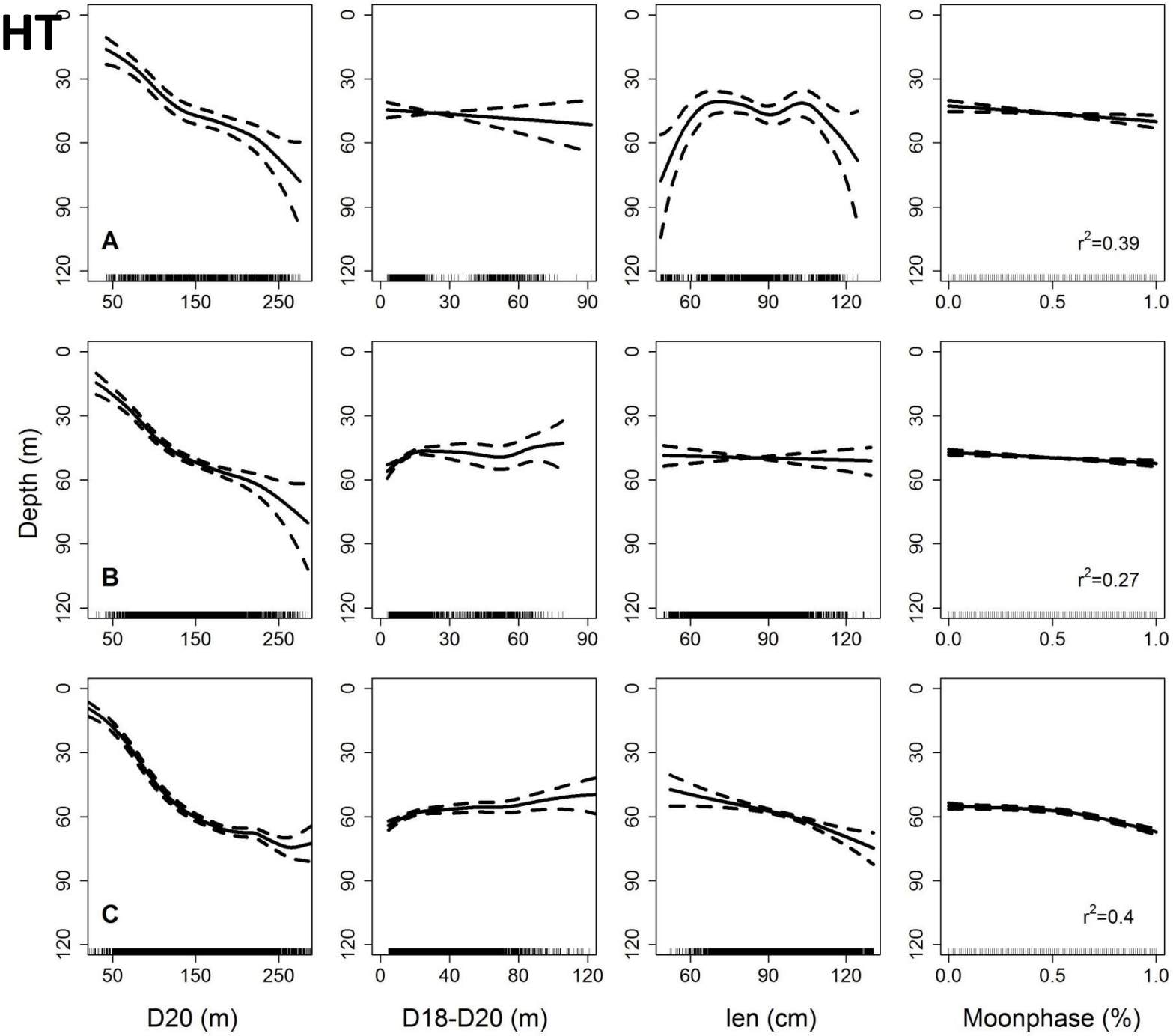
Modelling

- Split data into daytime and nighttime
- Classify according to three behavioral types: Associated, Characteristic, Other
- Model with GAMMs using tag as random effect.
- Data sources:
  - Fish length: length at release and time at liberty
  - Thermocline depth (D20): Tag data
  - Temperature stratification (D18-D20): Tag data
  - Moon phase: US Naval observatory
  - Rest: interpolation based on geolocation estimates of satellite/model products

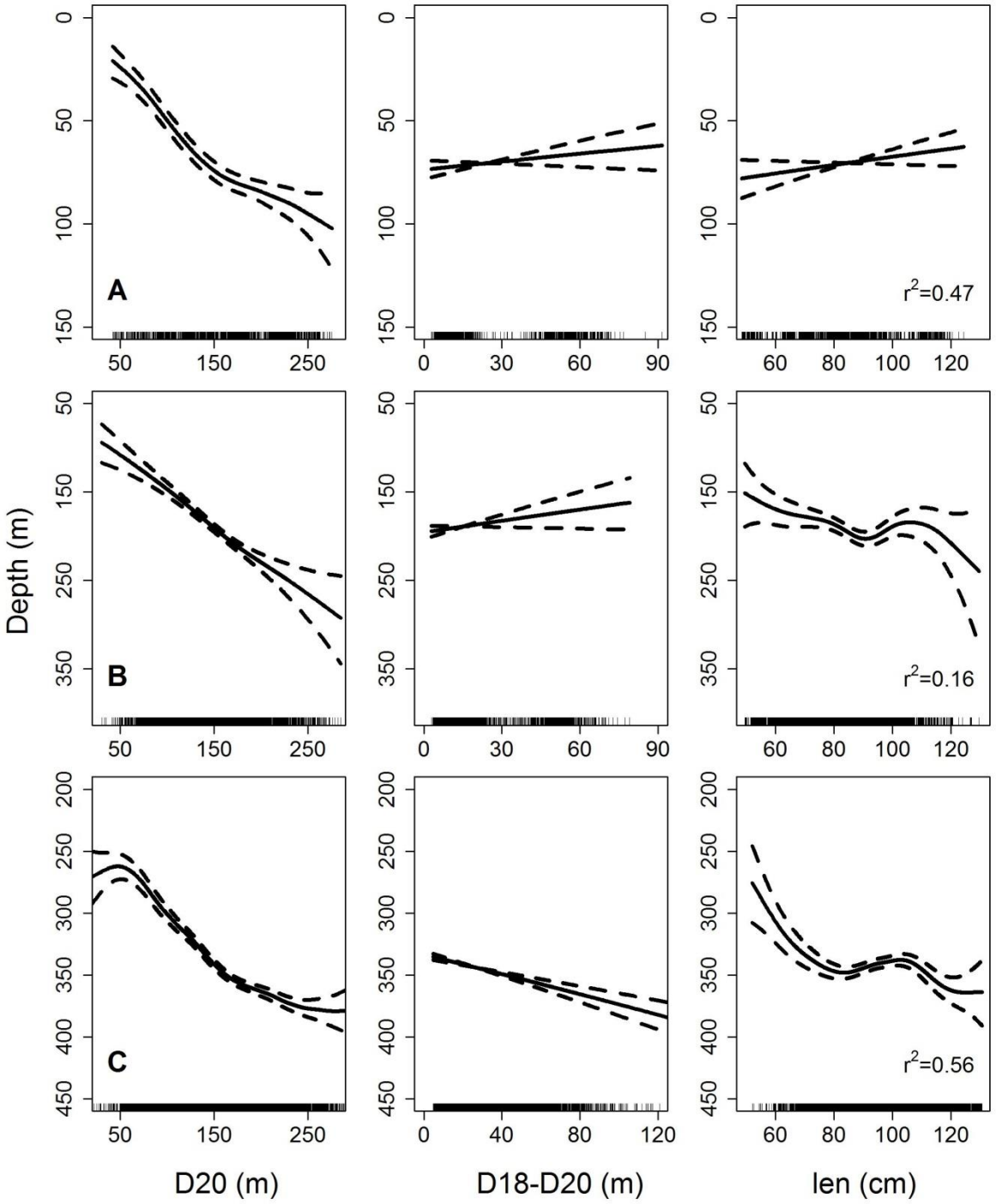
What influences the behavioral type?



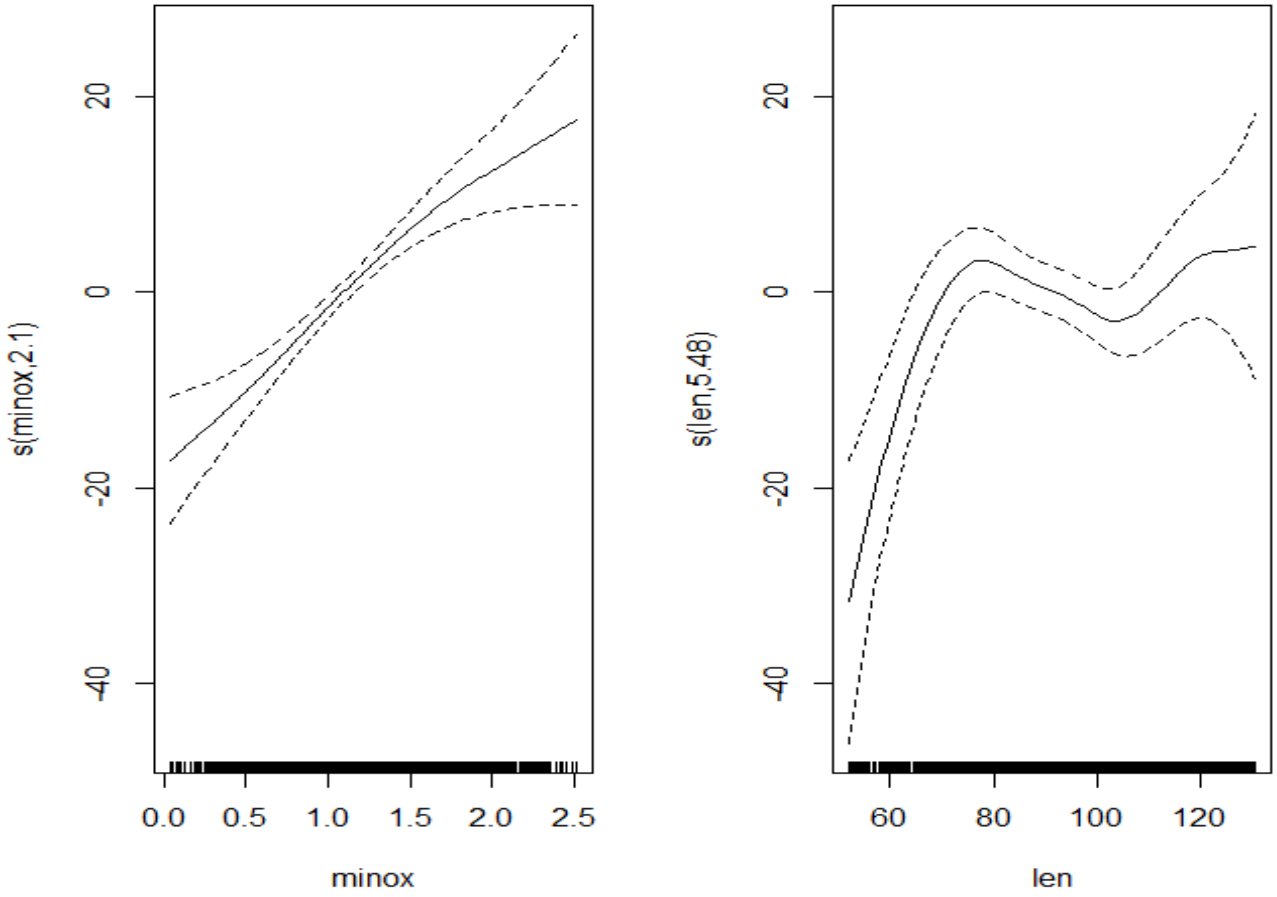
NIGHT


Assoc.
Other
Char.
Depth (m)
A
B
C
r²=0.39
r²=0.27
r²=0.4
D20 (m)
D18-D20 (m)
len (cm)
Moonphase (%)

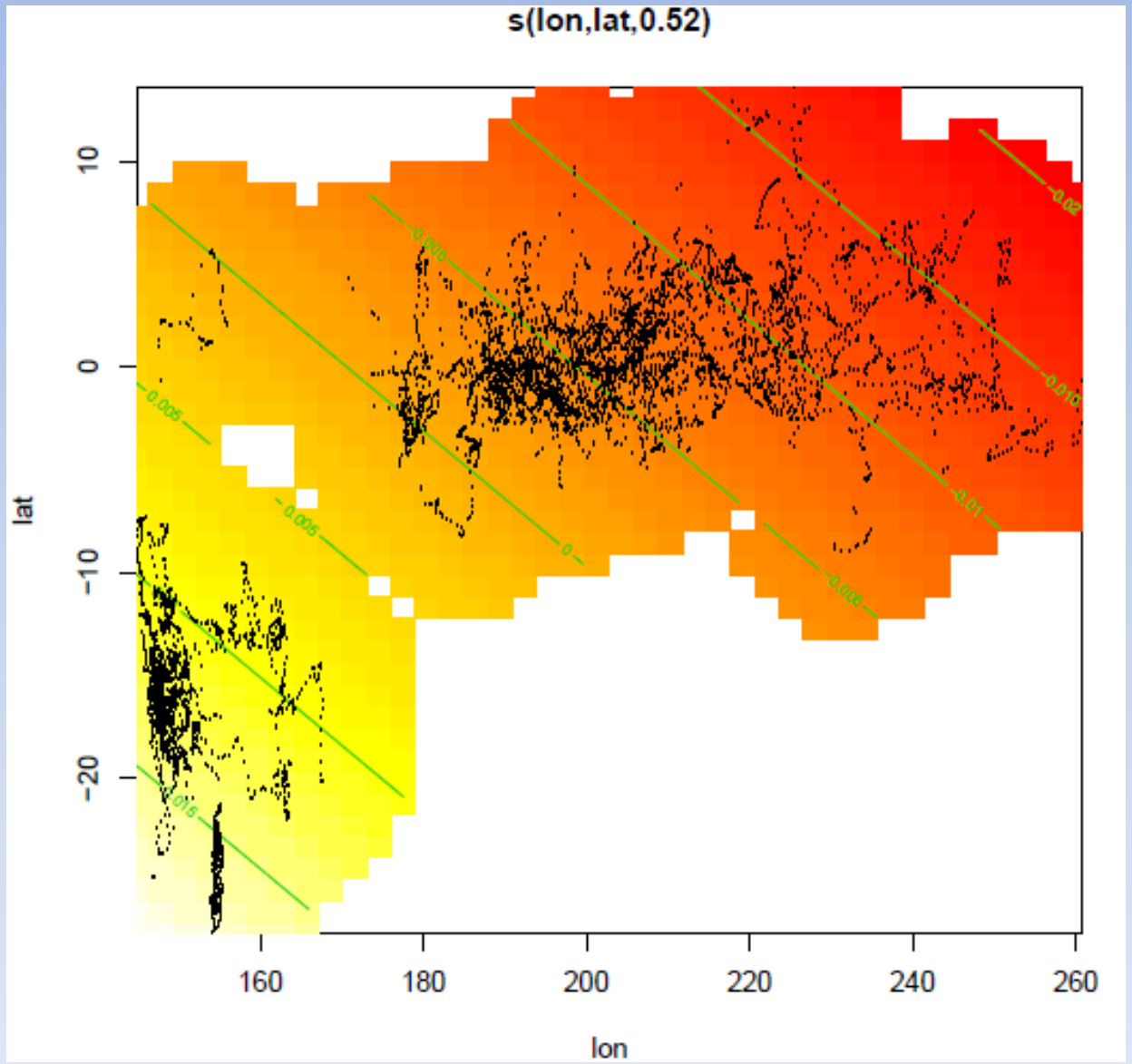
DAY


Assoc.
Other
Char.
Depth (m)
A
B
C
r2=0.47
r2=0.16
r2=0.56
D20 (m)
D18-D20 (m)
len (cm)

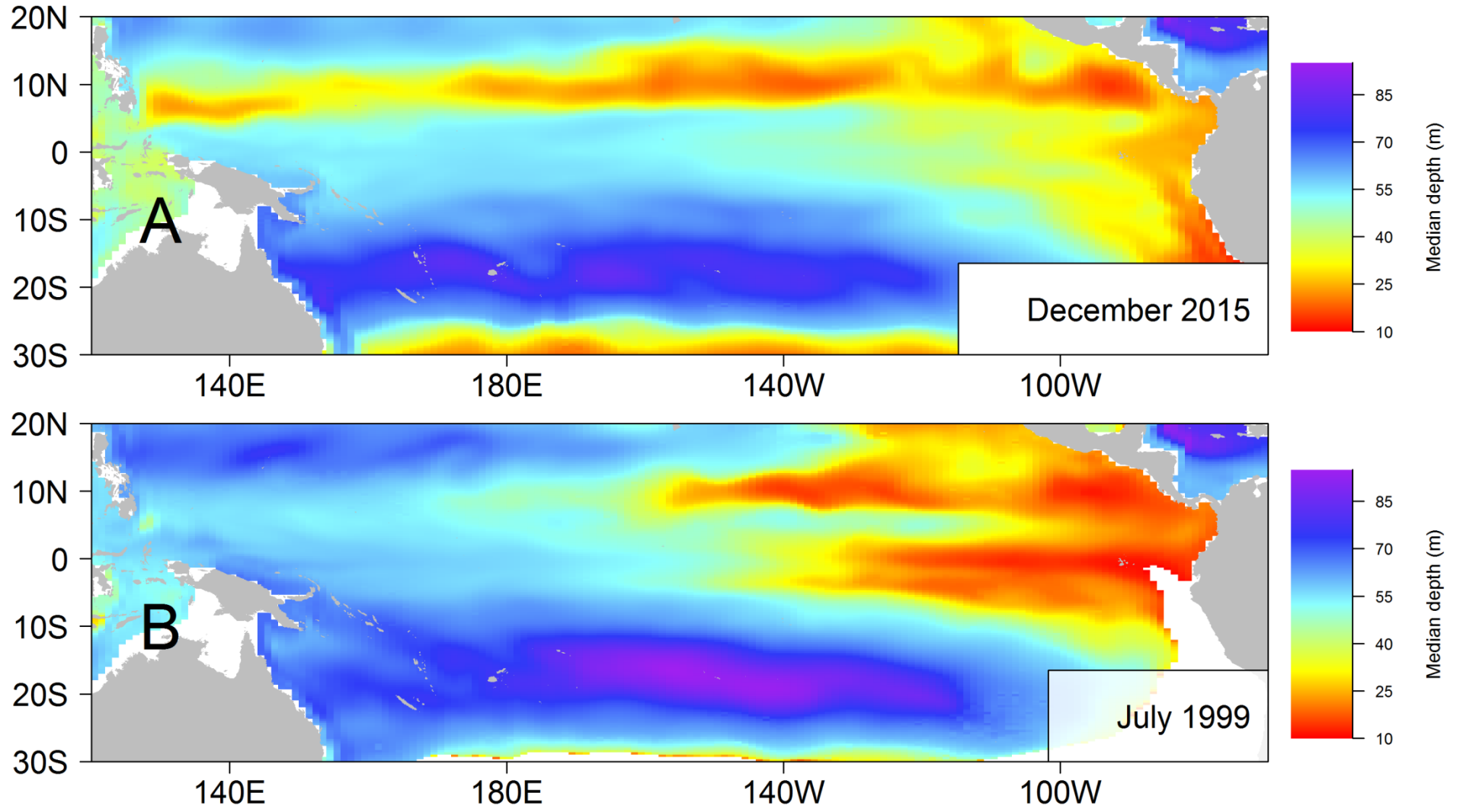
Daytime characteristic depth vs oxygen



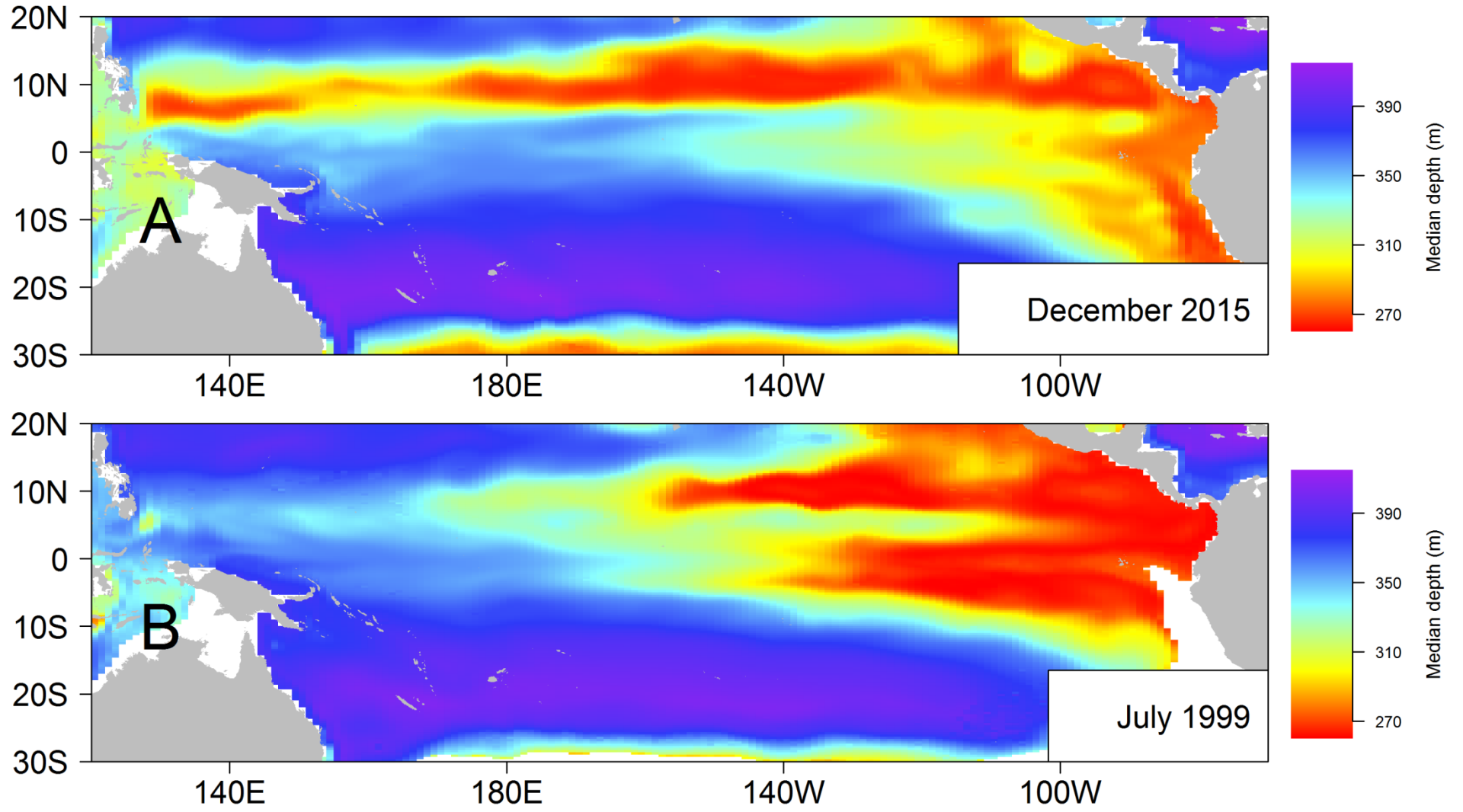
Residual distribution daytime characteristic model

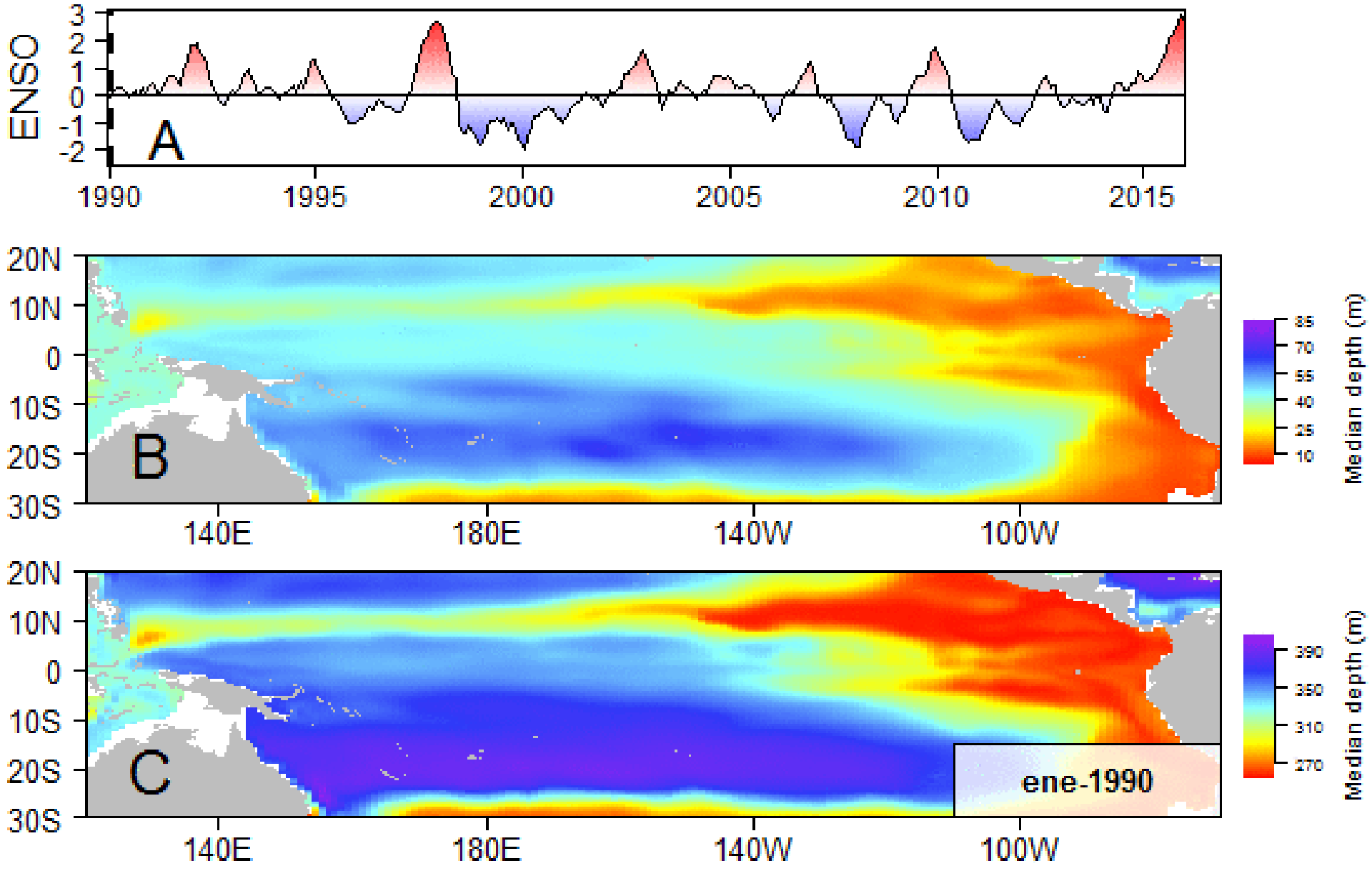


E.g, nighttime associated, 70 cm fish



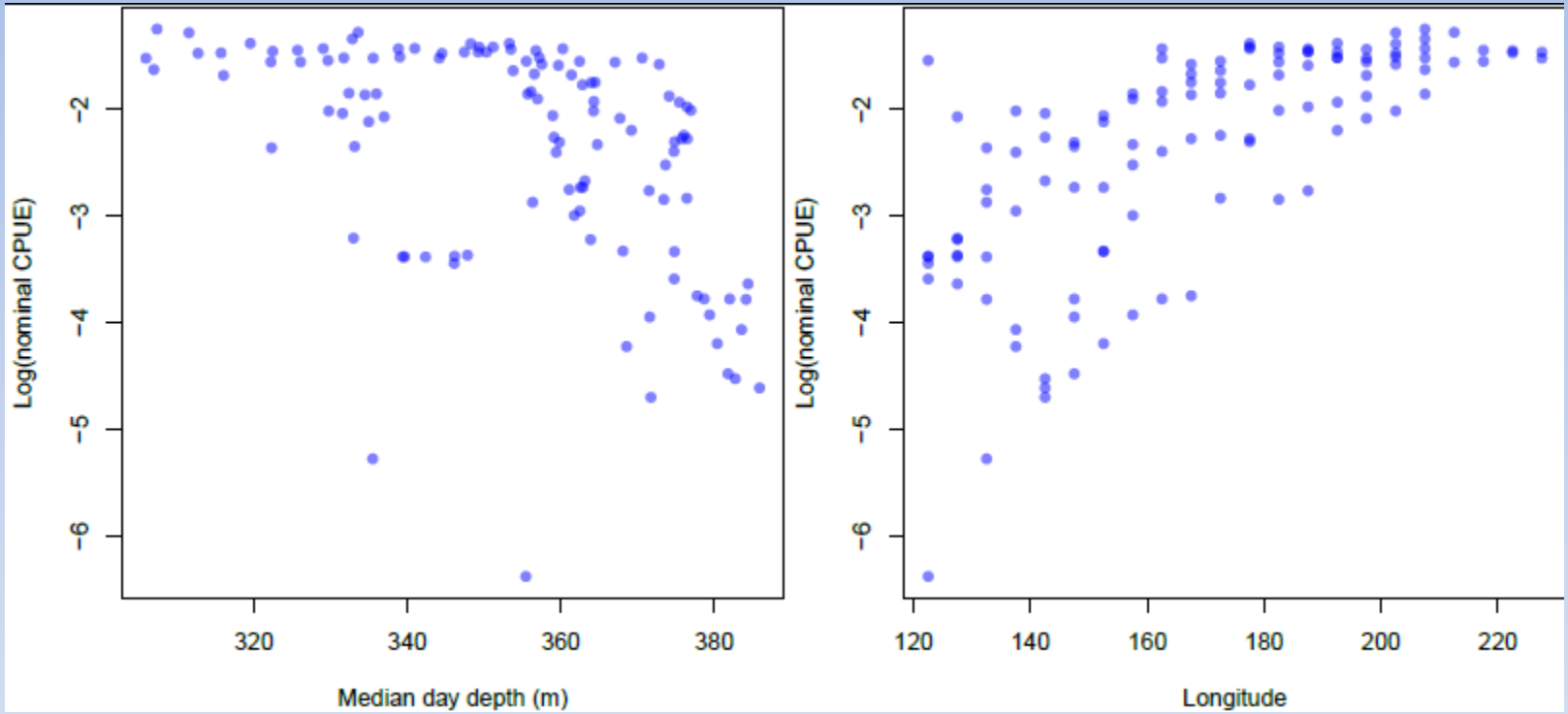
E.g, daytime characteristic, 120 cm fish




ENSO
3
2
1
0
-1
-2
A
1990
1995
2000
2005
2010
2015
20N
10N
0
10S
20S
30S
B
140E
180E
140W
100W
85
70
55
40
25
10
Median depth (m)
C
390
350
310
270
ene-1990

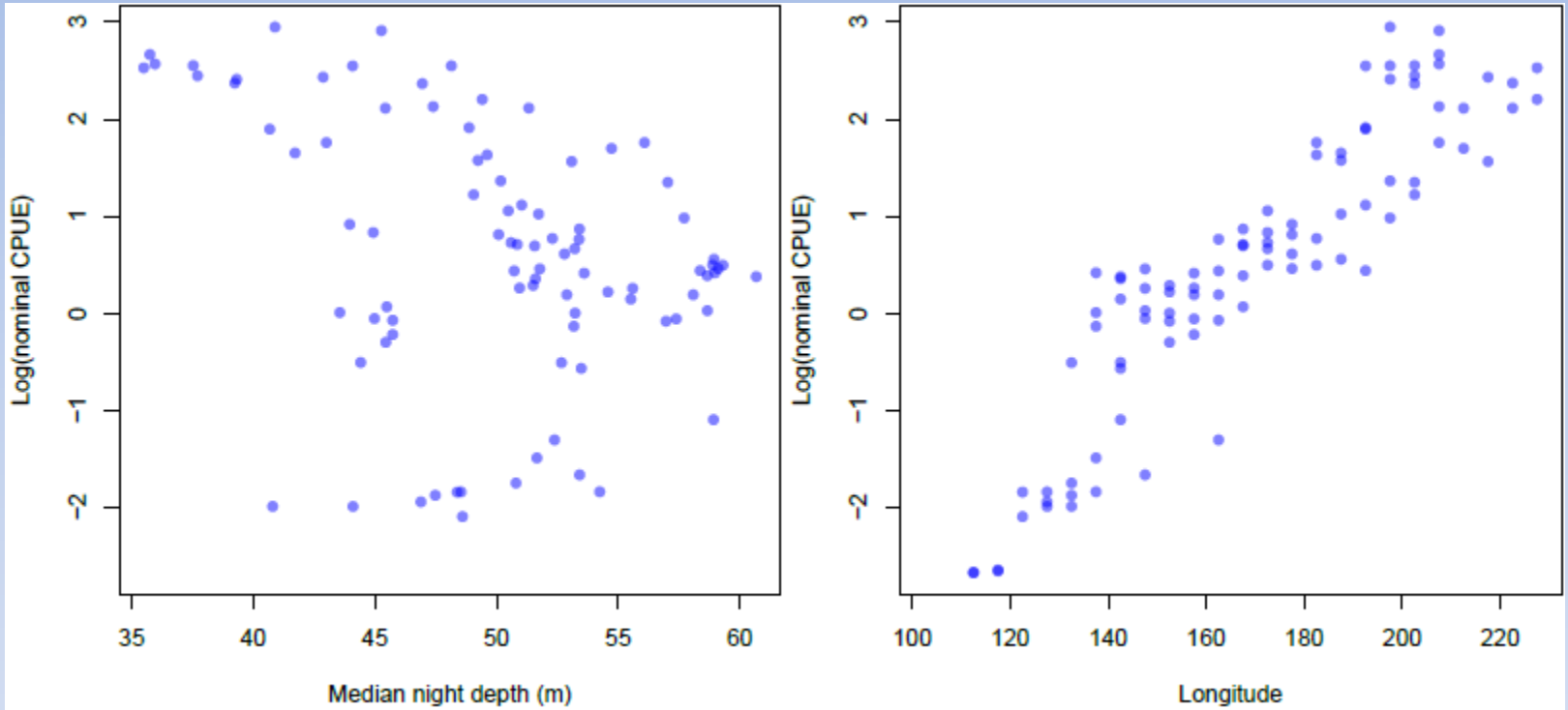
Nominal CPUE vs predicted depths

Longline

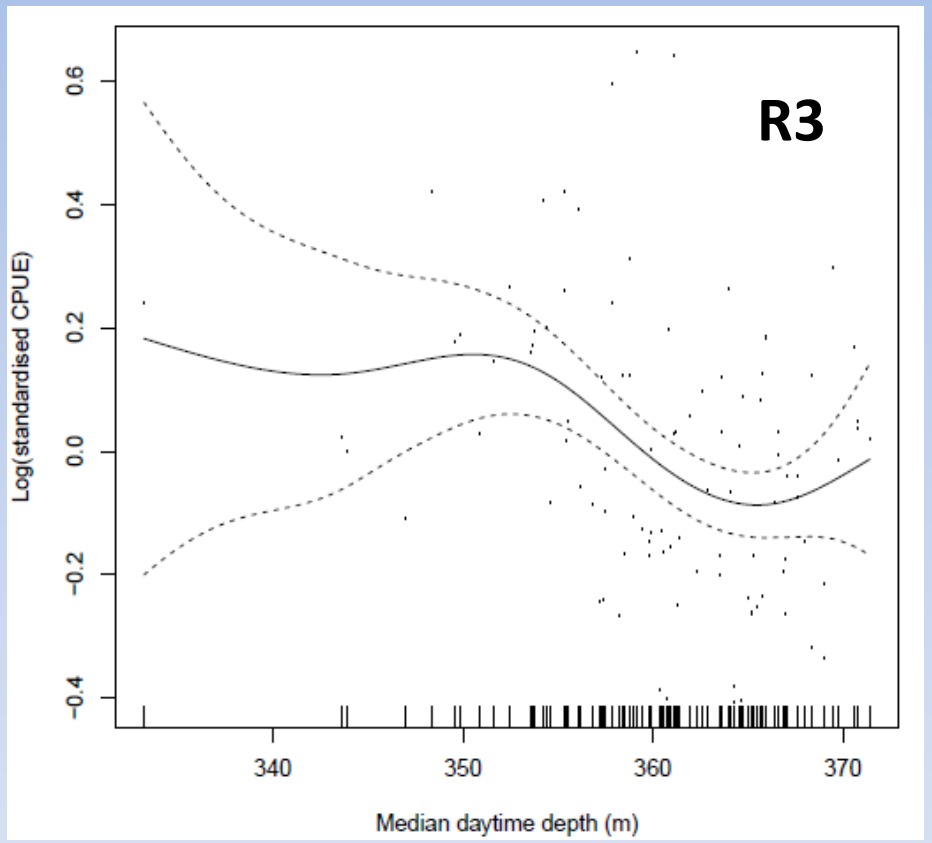


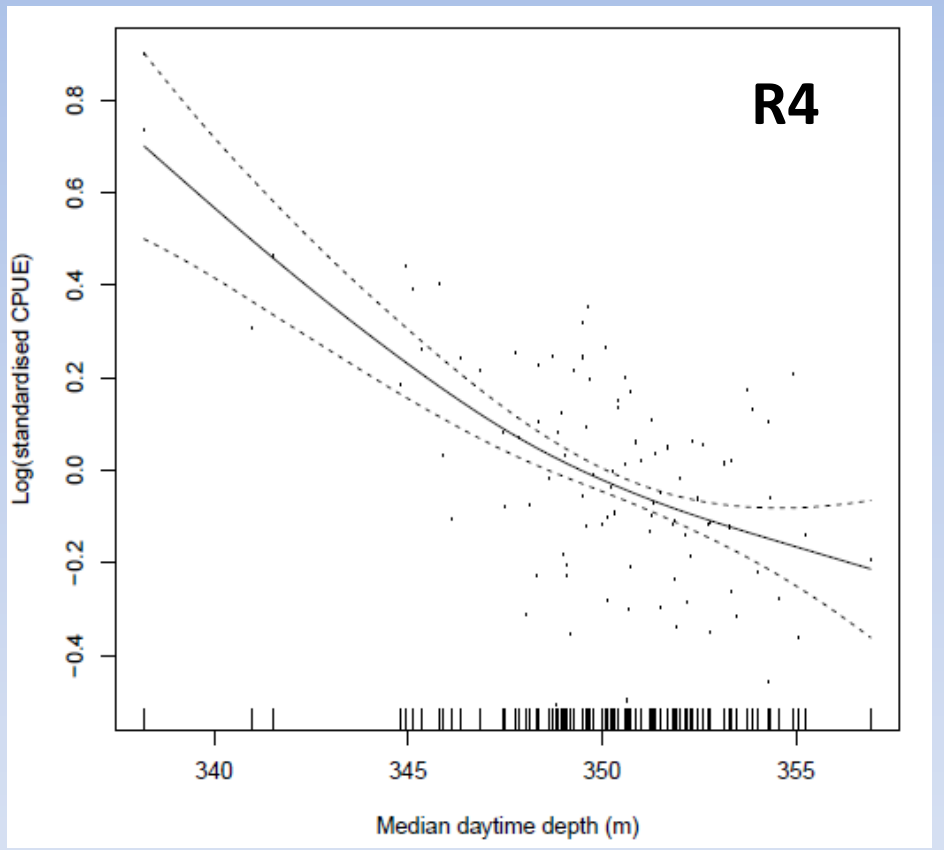
Nominal CPUE vs predicted depths

Purse seine



LL Standardized CPUE





Some potential discussions:

Are the spatial trends in the species composition in PS and LL CPUE driven by catchability?.

Can the patterns observed in 2015 in LL and PS CPUE be explained with these results?

Can it be used, and how, in future stock assessments?

Can this be a tool for the management of the species?

THANK YOU