1. Spatial Generalized additive model (GAMs)

1.1. Descriptive results on the continental shelf delivered by the GAMs

On the continental shelf, the spatial GAM results (Tables S1 and S2) showed that the environmental parameters influence the SSL descriptors (thickness and depth) more during nighttime and sunrise than during daytime for all frequencies.

Local depth affects SSL thickness at night (negative effect on SSL thickness at 70 kHz and positive effect on SSL thickness of the other three frequencies) and at sunrise (positive effect for SSL thickness at 38 kHz and negative effect for SSL thickness for the other three frequencies) at all frequencies. The sea temperature also has an effect on thickness at nighttime (negative effect on SSL thickness for all frequencies) and sunrise for all frequencies except at 38 kHz where it was not significant during sunrise (negative effect on SSL thickness at 120 and 200 kHz and positive effect for SSL thickness at 70 kHz), salinity affects thickness at night except at 200 kHz (positive effect on SSL thickness at 38 and 70 kHz and negative effect at 120 kHz), during sunrise it only affects the 70 kHz SSL thickness (positive effect), and salinity during the day only affects thickness at 38 kHz (negative effect). Fluorescence affects thickness at nighttime at all frequencies (negative effect) and during sunrise, fluorescence only affects SSL thickness at 38 kHz (positive effect). Turbidity affects thickness at night for all frequencies except 120 kHz (negative effect on SSL thickness at 70 kHz and positive for the SSL thickness of the two others), while sunrise turbidity only affects 70 kHz thickness (positive effect). Geographical coordinates have a negative effect on SSL thickness for all frequencies.
For SSL depth, bottom depth had an effect at 38 and 70 kHz during the night (negative effect), while during sunrise an effect is observed only the 120 and 200 kHz (negative effect). Temperature affects SSL depth during sunrise at all frequencies except 38 kHz (positive effect on SSL depth at 120 kHz and negative effect for the two others), while nighttime sea temperature only affects the SSL depth at 70 and 38 kHz (negative effect) and daytime temperature only at 38 kHz (negative effect). Salinity only affects depth during sunrise at 120 (negative effect) and 200 kHz (positive effect). Turbidity affects the SSL depth at all frequencies except at 200 kHz during sunrise (positive effect). Geographical coordinates have a negative effect on SSL depth for all frequencies. For SSL density (Sa), the goodness of fit obtained is not satisfactory.

1.2. Descriptive results in the southern Senegalese high sea delivered by the GAMs

In the southern Senegalese high sea, bottom depth influences the SSL thickness at all frequencies during sunset (positive effect for SSL thickness at 38 and 200 kHz and negative effect for the SSL thickness of the two others) while at night SSL thickness is only influenced at 70 kHz (negative effect). Temperature influences SSL thickness during nighttime at all frequencies (positive effect only in SSL thickness at 200 kHz), whereas during sunset it only affects SSL thickness at 38 and 70 kHz (negative effect). Salinity affects SSL thickness for all frequencies at night except 200 kHz (negative effect) and during sunset, it only affects the thickness at 70 kHz (positive effect). Fluorescence affects thickness during sunset (negative effect on SSL thickness at 120 kHz and positive effect on SSL thickness at 38 and 200 kHz) and night (negative effect on SSL thickness at 200 kHz and positive effect on SSL thickness at 38 and 120 kHz) for all frequencies except 70 kHz while turbidity has no effect at 200 kHz (positive effect on SSL thickness at the three frequencies during sunset and only positive effect at 70 kHz during night). Geographical coordinates have an effect on SSL thickness for all frequencies (positive effect of latitude on SSL thickness and positive effect of longitude on only SSL thickness at 120 kHz).

For the SSL depths, bottom depth affects 38 and 70 kHz at night (negative effect), while during sunset bottom depth affects the SSL depth at 120 and 200 kHz (positive effect). The sea temperature is highly significant at all frequencies (positive effect only on SSL depth at 200 kHz during sunset and negative for the three others) and also fluorescence is significant for all frequencies (positive effect on SSL depth during the night for all frequencies except at 120 kHz where we have a negative effect. During sunset, negative effects were recorded on SSL depth for all frequencies) while salinity has no effect at 70 kHz at night (negative effects were recorded on SSL depth for the three frequencies during the night and negative effect only at SSL depth of 120 kHz during sunset). Turbidity has an effect on all SSL depths during these two period except at 200 kHz during sunset (positive effect on SSL depth at 38, 70, and 120 kHz during sunset and negative effect on SSL depth for all frequencies during the night). Latitude has a positive effect on SSL depth for all frequencies while longitude has a positive effect only at SSL depth at 120kHz.

1.3. Descriptive results in the the northern Senegal delivered by the GAMs

In the northern Senegal shelf, bottom depth affects the SSL thickness at 38 and 200 kHz during sunrise (positive effect) while the daytime bottom depth increase only the thickness at 70 kHz. Temperature is significant for all frequencies during sunrise (positive effects were recorded on SSL thickness at 38 and 120 kHz while negative effects were recorded on SSL thickness at 70 and 200 kHz), while at night it does not affect the SSL thickness at 38 kHz (negative effect). Salinity only affects the SSL thickness at 70, 120, and 200 kHz during sunrise (positive effect). Fluorescence affects the 38, 70, and 120 kHz SSL thickness at night (negative effect only on SSL thickness at 38 kHz contrary to the two others) and sunrise (negative effect on SSL thickness for these three frequencies), while turbidity at sunrise has significant effects on all frequencies (positive effect), and turbidity at night affects only the 38 and 70 kHz SSL thickness (positive effect). Geographic coordinates have positive effects on the thickness at 38 and 200 kHz and negative effects on the thickness at the other frequencies.

Bottom depth affects the SSL depth at all frequencies during the day, except 200 kHz (positive effect) and sunrise (positive effect). Temperature affects SSL depth at all frequencies during sunrise (positive effect only on SSL depth at 120 kHz compared to the others) while at nighttime temperature did not affect the 70 and 120 kHz depth SSL (negative effect on SSL depth at 38 kHz and positive effect on SSL depth at 200 kHz) and daytime temperature affects only SSL depth at 200 kHz (positive effect). Salinity affects the SSL depth at 38, 70, and 120 kHz during sunrise. During daytime sea salinity affects SSL depth at 38 and 70 kHz (positive effect), and salinity only affects the 38 and 120 kHz SSL depth during nighttime (positive effect on SSL depth at 38 kHz and negative effect on SSL depth at 120 kHz). Turbidity affects SSL depth during sunrise for all frequencies (positive effect) and fluorescence affects SSL depth during sunrise for all frequencies (negative effect). Turbidity affects only SSL depth at 38 kHz during the night (positive effect). Fluorescence did not affect the 200 kHz SSL depth during daytime (negative effect on SSL depth at 38, 70, and 120 kHz) while at nighttime fluorescence does not affect the 120 kHz SSL depth (positive effects were recorded only on SSL depth at 70 kHz compared to the 38 and 200 kHz). Geographic coordinates have negative effects on the SSL depth for all frequencies. For the SSL density (Sa), their fit qualities were low.

2. Multivariate Functional Principal Component analysis (MFPCA)

2.1. MFPCA results on the continental shelf of southern Senegal

On the continental shelf of southern Senegal (Figure S4), sea temperature data obtained at 38 kHz revealed a low peak between 20 and 30 meters, and a high peak between 40 and 50 meters in the first component. Similar observations were recorded for the second component. The salinity data showed a high peak between 40 and 50 meters in the first component, followed by a low peak between 50 and 60 meters. The second component exhibited a low peak between 20 and 30 meters, followed by a high peak between 40 and 50 meters. Fluorescence data at 38 kHz revealed a low peak between 10 and 20 meters in the first component, followed by a high peak at 30 meters. The second component displayed a low peak between 20 and 30 meters. Turbidity data at 38 kHz showed a weak peak between 10 and 20 meters in the first component, followed by a high peak at 30 meters. The second component was characterized by a high peak between 30 and 40 meters.

At 70 kHz frequency, the first component of sea temperature showed a low peak between 20 and 30 meters, and a high peak between 35 and 40 meters. The second component exhibited similar observations. The salinity data displayed a weak peak at 25 meters in the first component, and a weak peak between 20 and 25 meters in the second component. Fluorescence data showed a high peak between 10 and 15 meters in the first component, followed by a low peak between 25 and 30 meters. The second component displayed a low peak between 15 and 20 meters. Turbidity data in the first component was characterized by a high peak between 10 and 15 meters, followed by a low peak at 20 meters. The second component exhibited a low peak between 15 and 20 meters, followed by a high peak between 20 and 25 meters.

At 120 kHz frequency, sea temperature data displayed a low peak at 25-30 meters in the first component and a high peak at 40 meters. The second component exhibited a low peak at 25 meters, and a high peak at 40-45 meters. The salinity data showed a low peak at 25 meters in the first component and a high peak at 35 meters. The second component displayed a low peak at 25 meters. Fluorescence data revealed a low peak between 25 and 30 meters in the first component, and a low peak at 25 meters in the second component. Turbidity data exhibited a high peak between 15 and 20 meters in the first component, followed by a low peak between 40 and 45 meters. The second component displayed a high peak at 20 meters.

At 200 kHz frequency, sea temperature data displayed a high peak between 20 and 25 meters in the first component, and a low peak at 35 meters. The second component showed a low peak between 20 and 25 meters. The salinity data exhibited a high peak between 15 and 20 meters in the first component, followed by a low peak between 30 and 35 meters. The second component displayed a low peak between 20 and 25 meters. Fluorescence data showed a high peak at 40 meters in the first component, and a low peak between 20 and 25 meters in the second component. Turbidity data displayed a low peak at 20 meters in the first component, followed by a high peak between 30 and 35 meters. The second component exhibited a low peak at 20 meters.

2.2. MFPCA results on the southern Senegalese high sea

The paragraph describes how different variables are grouped at different depth levels on the southern Senegalese high sea, using different frequencies. At 38 kHz, temperature ESUs with low values between 25 and 50 m are grouped in the first component, while those with high values at 50 m are grouped in the second component. Salinity ESUs with higher values at 25 m are grouped in the first component, while those with higher values between 50 and 62 m are grouped in the second component. Fluorescence ESUs with low values between 25 and 50 m are grouped in the first component, while those with higher values at 50 m are grouped in the second component. Turbidity showed similar variations.

At 70 kHz, temperature ESUs with higher values between 25 and 50 m are grouped in the first component, while those with high values at 50 m and low values between 25 and 37 m are grouped in the second component. Salinity ESUs with higher values between 50 and 62 m are grouped in the first component, with a similar peak in the second component. Fluorescence ESUs with higher values at 37 m are grouped in the first component, while those with higher values at 50 m are grouped in the second component. Turbidity ESUs with higher values at 37 m are grouped in the first component, while those with lower values between 25 and 37 m and higher values at 50 m are grouped in the second component.

At 120 kHz, temperature ESUs with higher values between 30 and 40 m are grouped in the first component, while those with higher values between 40 and 50 m are grouped in the second component. Salinity ESUs with low values between 20 and 30 m are grouped in the first component, while those with high values in the same range are grouped in the second component. Fluorescence ESUs with higher values between 30 and 40 m are grouped in the first component, while those with lower values between 20 and 30 m are grouped in the second component. Turbidity shows similar observations.

At 200 kHz, temperature ESUs with lower values at 50 m and higher values between 75 and 87 m are grouped in the first component, while those with low values between 25 and 37 m and high values at 62 m are grouped in the second component. Salinity ESUs with high values at 25 m are grouped in the first component, while those with higher values between 25 and 37 m are grouped in the second component. Fluorescence ESUs with low values between 37 and 50 m are grouped in the first component, while those with high values at 75 m are grouped in the second component. Turbidity ESUs with low values at 37 m are grouped in the first component, while those with low values between 25 and 37 m and high values at 50 m are grouped in the second component.

2.3. MFPCA results in the northern Senegalese shelf

The study conducted over the northern Senegalese shelf (Figure S2), revealed distinct patterns in the acoustic response of the ecosystem at different frequencies. At 38 kHz, the first component of temperature grouped ESUs with low values between 50 and 62 m, with similar observations made on the second component. The first component of salinity grouped ESUs with low values between 50 and 75 m, while the second component grouped those with low values at 75 m. The first component of fluorescence grouped ESUs with low values between 12 and 25 m, while the second component grouped those with high values between 25 and 50 m. The first component of turbidity grouped ESUs with high values between 37 and 50 m, while the second component grouped those with high values between 25 and 50 m.

At 70 kHz, the first component of temperature grouped ESUs with high values between 25 and 75 m, while the second component grouped those with low values between 50 and 62 m. The first component of salinity grouped ESUs with high values between 50 and 62 m, while the second component grouped those with low values at 62 m. The first component of fluorescence grouped ESUs with high values between 25 and 37 m, while the second component grouped those with high values between 37 and 50 m. The first component of turbidity grouped ESUs with high values at 87 m, while the second component grouped those with low values at this depth.
At 120 kHz, the first component of temperature grouped ESUs with low values between 25 and 37 m, while the second component grouped those with low values at 50 m. For salinity, the first component grouped ESUs with low values between 62 and 75 m, while the second component grouped those with low values between 50 and 62 m. The first component of fluorescence grouped ESUs with low values at 25 m, while the second component grouped those with high values between 25 and 37 m. The first component of turbidity grouped ESUs with high values at 37 m, while the second component grouped those with high values between 25 and 37 m.
Finally, at 200 kHz, the first component of temperature grouped ESUs with high values at 37 m, while the second component grouped those with low values between 50 and 62 m. For salinity, the first component grouped ESUs with high values at 62 m, while the second component grouped those with low values between 50 and 62 m. The first component of fluorescence grouped ESUs with high values between 12 and 25 m, while the second component grouped those with high values at 25 m. The first component of turbidity grouped ESUs with low values at 37 m, while the second component grouped those with high values at this depth.

3. Spatial functional generalized spectral additive model (FGSAMs)

3.1. Descriptive results on the southern continental shelf delivered by the FGSAMs

On the southern continental shelf (Figure S7 and Table S3), at 38 kHz, fluorescence has a positive effect on SSL thickness between 10 and 30m and a negative effect beyond. Temperature has an overall negative effect while turbidity has a negative effect between 10 and 30 and a positive effect beyond that. The same observations are done for salinity.

For SSL thickness, at 70 kHz fluorescence has a negative effect between 10 and 20, positive between 20 and 35, and negative beyond. The temperature has a positive effect between 10 and 20m, negative between 20 and 30, and positive beyond, while turbidity has a negative effect between 10 and 20m, positive between 20 and 30, and negative beyond. Salinity has a negative effect between 10 and 20 m, a positive between 20 and 30, and a negative beyond.

On the 120 kHz SSL thickness, fluorescence has a negative effect between 10 and 20m and positive beyond, while temperature has a positive effect between 10 and 35 and negative beyond. Turbidity has a negative effect between 10 and 25 and a positive effect beyond. Salinity has a positive effect between 10 and 25 and negative between 25 and 35 and a positive one beyond.

Fluorescence has a negative effect on the 200 kHz SSL thickness at depths below 15 and a positive effect between 15 and 25 and a negative effect beyond. The temperature has a positive effect between 10 and 25, a negative between 25 and 40, and a positive beyond. Turbidity has a positive effect between 10 and 25, a negative between 25 and 35, and a positive beyond. Salinity has a negative effect between 10 and 25, a positive between 25 and 40, and a negative beyond.

For SSL depth, on the 38 kHz frequency, fluorescence has a positive effect between 10 and 30, negative between 30 and 45, and positive beyond. The temperature has a positive effect between 10 and 35, a negative between 35 and 55, and a positive beyond, while turbidity has an overall positive effect. Salinity has a positive effect between 10 and 30 and a negative effect beyond.

For the 70 kHz depth, fluorescence has a negative effect between 10 and 20, a positive between 20 and 35, and a negative beyond. The temperature has a negative effect below 12m, positive between 12 and 35, and negative beyond. Turbidity has a negative effect between 10 and 30m, positive between 30 and 37m, and negative beyond. Salinity has a positive effect at depths below 12m, negative between 12 and 30, and positive beyond.

At 120 kHz, fluorescence has a negative effect between 10 and 20 m, positive between 20 and 40, and negative beyond. The temperature has a negative effect between 10 and 25, a positive between 25 and 40, and a negative beyond. Turbidity has a positive effect between 10 and 25 and a negative beyond. Salinity has a negative effect between 10 and 25, a positive between 25 and 40, and a negative beyond.

Fluorescence has an overall negative effect on the depth of the 200 kHz SSL. The temperature has a positive effect at depths below 20m, a negative effect between 20 and 35, and a positive effect beyond. Turbidity has a positive effect between 10 and 25, a negative between 25 and 35, and a positive beyond. Salinity has a negative effect between 10 and 35, a positive between 35 and 47, and a negative beyond.

3.2. Descriptive results in the southern Senegal high sea delivered by the FGSAMs

In the southern Senegal high sea, at 38 kHz, fluorescence has a positive effect on SSL thickness, between 10 and 70 m and negative beyond. The Sea temperature has a positive effect between 10 and 50 m and a negative beyond. The water turbidity has a negative effect between 10 and 90 m and positive beyond while salinity has a negative effect between 10 and 50 m and positive beyond.

At 70 kHz, fluorescence has a positive effect, temperature has a negative effect between 10 and 40 m and positive beyond, turbidity has a negative effect beyond 10 m while salinity has a positive effect between 10 and 40 m and negative beyond.

At 120 kHz, fluorescence has an overall positive effect on thickness, the temperature has a negative effect between 10 and 50 m and a positive effect beyond, turbidity has a positive effect between 10 and about 37 m and then a negative effect between 37 and 80 m and a positive effect beyond while salinity has a negative effect between 10 and 50 m and a positive effect beyond.

At 200 kHz, fluorescence has a negative effect between 10 and 40 m, positive between 40 and 120 m and negative beyond, the temperature has a negative effect at 10 m and positive beyond, turbidity has a negative effect between 10 and 80 m and positive beyond and salinity has a negative effect between 10 and 110 m and positive beyond.

For the 38 kHz fluorescence has a positive effect between 10 and 80 m on SSL depth and negative thereafter, temperature has a negative effect between 10 and 20 m and positive between 20 and 80 m and negative thereafter, turbidity has a negative effect between 10 and 90 m and positive thereafter while salinity has a negative effect between 10 and 50 m and positive thereafter.

On the 70 kHz, fluorescence has a positive effect on SSL depth between 10 and 70 m then slightly negative between 70 and 90 m then positive beyond, temperature has a negative effect between 10 and 50 m then positive between 50 and 90 m, and negative beyond, turbidity has an overall negative effect while salinity has a positive effect between 10 and 50 m and negative beyond.

At 120 kHz, fluorescence has a positive effect between 10 and 60 m and negative thereafter, temperature has a negative effect between 10 and 50 m, positive between 50 and 80 m, and negative thereafter, turbidity has a negative effect at depths below 20 m, positive between 20 and 50 m and negative thereafter, while salinity has a negative effect between 10 and 50 m and positive to 80 m and negative thereafter.

At 200 kHz, fluorescence has an overall negative effect on depth, the temperature has a negative effect between 10 and 50 m and a positive effect beyond that, turbidity has a negative effect between 10 and 80 m and a positive effect beyond that, while salinity has a negative effect between 20 and 110 m and a positive effect beyond that.

3.3. Descriptive results in northern Senegalese shelf sea delivered by the FGSAMs

In northern Senegalese shelf, at 38 kHz, fluorescence has a negative effect on SSL thickness between 10 and about 80 m and positive beyond, the temperature has a positive effect between 10 and 30 m, negative between 30 and 90 m and positive beyond, turbidity has a positive effect between 10 and 30 m, negative between 30 and 90 m and positive beyond, while salinity has a positive effect at depths less than 20 m, negative between 20 and 60 m and positive beyond.

At 70 kHz, fluorescence has a negative effect between 10 and 90 m and a positive effect beyond, temperature has a positive effect between 10 and 50 m and a negative effect beyond, turbidity has a positive effect between 10 and 30 m, a negative effect between 30 and 110 m and a positive effect beyond while salinity has a positive effect between 10 and 30 m, a negative effect between 30 and 110 m and a positive effect beyond.

At 120 kHz, fluorescence has a negative effect between 10 and 90 m and a positive effect beyond, temperature has a positive effect between 10 and 50 m and a negative effect beyond, turbidity has a negative effect between 10 and 20 m, a positive effect between 20 and 110 m and a negative effect beyond and salinity has a positive effect between 10 and 40 m, a negative effect between 40 and 90 m and a positive effect beyond.

At 200 kHz, fluorescence has a negative effect between 10 and 30 m, positive between 30 and about 120 m, and negative beyond, temperature has a positive effect between 10 and 30 m, negative between 30 and 50 m, positive between 50 and 120 m and negative beyond, turbidity has a positive effect between 10 and 20 m, negative between 20 and about 60 m, positive between 60 and 120 m and negative beyond while salinity has a negative effect between 10 and 80 m and positive beyond.

For SSL depth at 38 kHz, fluorescence has a negative effect between 10 and 90 m and a positive effect beyond, temperature has a negative effect between 10 and 50 m and a positive effect beyond, turbidity has a positive effect between 10 and 30 m, a negative effect between 30 and 90 m and a positive effect beyond and salinity has a positive effect between 10 and 120 m and a negative effect beyond.

At 70 kHz, fluorescence has a negative effect between 10 and 60 m, positive between 60 and 100 m and negative thereafter, temperature has a positive effect between 10 and 50 m, negative between 50 and 110 m and positive thereafter, turbidity has a positive effect between 10 and 30 m, negative between 30 and 80 m and positive thereafter while salinity has a negative effect between 10 and 90 m and positive thereafter.

At 120 kHz, fluorescence has negative and zero effects between 10 and 90 m and then positive beyond, the temperature has a positive effect between 10 and 20 m, negative between 20 and 110 m and then positive beyond, turbidity has a positive effect between 10 and 20 m, negative between 20 and 70 m, positive between 70 and 120 m and then negative beyond while salinity has a positive effect between 10 and about 37 m, negative between 37 and 57 m, positive between 57 m and 120 m and then negative beyond.

At 200 kHz, fluorescence has a negative effect between 10 and about 22 m, positive between 22 and 117 m and negative thereafter, temperature has a positive effect between 10 and 60 m, negative between 60 and 120 m and positive thereafter, turbidity has a negative effect between 10 and 60 m, positive between 60 and 120 m and negative thereafter, while salinity has a negative effect between 10 and 22 m, positive between 22 and 100 m and negative thereafter.

4. Matlatb code: association of Scanfish Data with echosunder echointegration cell

Matlatb code for averaging in for each echointegration cell (allowing them to be matched with the SSL descriptors), the environmental variables, i.e., seawater temperature (Temp in °C), fluorescence (Fluo in mll^{-1}), turbidity (Turb in NTU), and salinity (Sal in psu; obtained from conductivity measurement), acquired every second using the Scanfish along the path of the vessel.

```
Idfreq=2;
load('DataScanFishEcho_RadialXX.mat');
IdEsu=dataek(Idfreq).EIIndexEsu;
IdDepth=dataek(Idfreq).EIIndexDepth;
ei=matfile('Echointegration');
EI_sf=ei.Sv_surface(IdDepth, IdEsu,Idfreq);
MeanEsuDuration=mean(diff(dataek(Idfreq).EITime));
MeanPingDuration=(diff(dataek(Idfreq).Time));


%Temperature
PingTime=dataek(Idfreq).Time; EsuTime=dataek(Idfreq).EITime; MeanEsuDuration=mean(diff(EsuTime));
PingDepth=dataek(Idfreq).Depth; EsuDepth=dataek(Idfreq).EIDepth; EIHeight=mean(diff(EsuDepth));
for kesu=1:length(EsuTime)
    idesu=find(PingTime>=EsuTime(kesu)-MeanEsuDuration/2 & PingTime<=EsuTime(kesu)+MeanEsuDuration/2);
    for kdep=1:length(EsuDepth)
        iddep=find(PingDepth>=EsuDepth(kdep)-EIHeight/2 & PingDepth<EsuDepth(kdep)+EIHeight/2);
        TemperatureforEI(kdep,kesu)=nanmean(nanmean(Temperature(iddep,idesu)));
    end
end

%Fluorescence
PingTime=dataek(Idfreq).Time; EsuTime=dataek(Idfreq).EITime; MeanEsuDuration=mean(diff(EsuTime));
```

```
PingDepth=dataek(Idfreq).Depth; EsuDepth=dataek(Idfreq).EIDepth; EIHeight=mean(diff(EsuDepth));
for kesu=1:length(EsuTime)
    idesu=find(PingTime>=EsuTime(kesu)-MeanEsuDuration/2 & PingTime<=EsuTime(kesu)+MeanEsuDuration/2);
    for kdep=1:length(EsuDepth)
        iddep=find(PingDepth>=EsuDepth(kdep)-EIHeight/2 & PingDepth<EsuDepth(kdep)+EIHeight/2);
        FluorescenceforEI(kdep,kesu)=nanmean(nanmean(Fluorescence(iddep,idesu)));
    end
end

%Turbidity

PingTime=dataek(Idfreq).Time; EsuTime=dataek(Idfreq).EITime; MeanEsuDuration=mean(diff(EsuTime));
PingDepth=dataek(Idfreq).Depth; EsuDepth=dataek(Idfreq).EIDepth; EIHeight=mean(diff(EsuDepth));
for kesu=1:length(EsuTime)
    idesu=find(PingTime>=EsuTime(kesu)-MeanEsuDuration/2 & PingTime<=EsuTime(kesu)+MeanEsuDuration/2);
    for kdep=1:length(EsuDepth)
        iddep=find(PingDepth>=EsuDepth(kdep)-EIHeight/2 & PingDepth<EsuDepth(kdep)+EIHeight/2);
        TurbiditeforEI(kdep,kesu)=nanmean(nanmean(Turbidity(iddep,idesu)));
    end
end

%Salinity
PingTime=dataek(Idfreq).Time; EsuTime=dataek(Idfreq).EITime; MeanEsuDuration=mean(diff(EsuTime));
PingDepth=dataek(Idfreq).Depth; EsuDepth=dataek(Idfreq).EIDepth; EIHeight=mean(diff(EsuDepth));
for kesu=1:length(EsuTime)
    idesu=find(PingTime>=EsuTime(kesu)-MeanEsuDuration/2 & PingTime<=EsuTime(kesu)+MeanEsuDuration/2);
    for kdep=1:length(EsuDepth)
        iddep=find(PingDepth>=EsuDepth(kdep)-EIHeight/2 & PingDepth<EsuDepth(kdep)+EIHeight/2);
        SaliniteforEI(kdep,kesu)=nanmean(nanmean(Salinity(iddep,idesu)));
    end
end
```

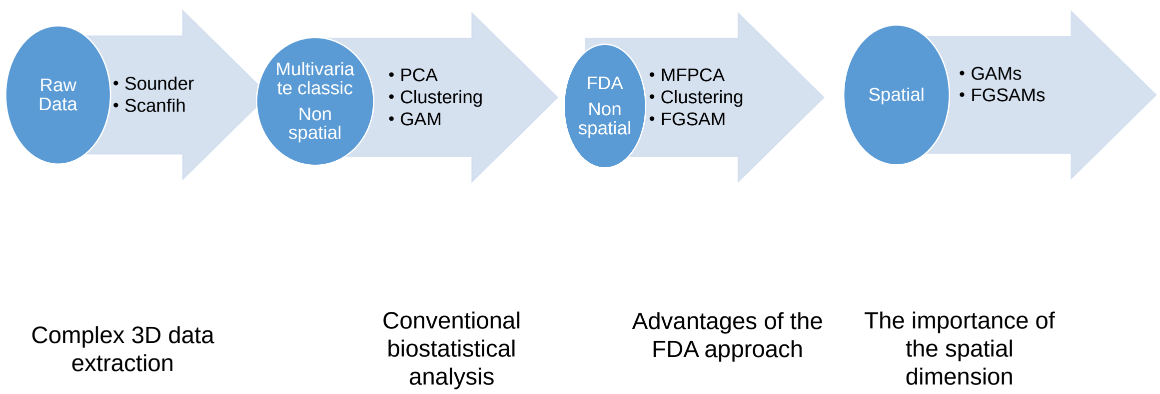


Fig. S1: A flowchart outlining the main research process

Table S1

Results of Generalized additive model (GAM) between sound scattering layers (SSLs) and oceanographic conditions (sea temperature (Temp), salinity (Sal), turbidity (Turb), fluorescence (Fluo)), diel period (day, sunset, night and sunrise), bottom depth (Bottom) and geographical positions (latitude (Lat) and longitude (Lon)) to predict (1) SSL thickness and (2) SSL Depth and (3) SSL density, spread over three geographical areas (A: southern continental shelf; B: southern high sea and C: northern continental shelf) as observed during the AWA sea survey. AIC (Akaike's Information Criterion); BIC (Bayesian Information Criterion); Log Likelihood (log-likelihood value of a model); Deviance (goodness-of-fit metric for statistical model); Deviance explained (proportion of the total deviance explained by the current model); R^2 (Adjusted R-Squared); GCV score (Generalised Cross-Validation score); Num.obs. (number of observations); Num. smooth terms (Number of smooth terms).

① (A)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	**13.48*****	4.32	3.17	6.86	**14.33*****	5.45	4.27	**5.93****
	(1.23)	(3.35)	(6.27)	(8.78)	(2.24)	(3.44)	(3.43)	(2.16)
s(Bottom):Night	**3.15****	**2.51****	**4.86*****	**3.39*****	**3.86*****	**2.63***	**4.41*****	**5.09*****
	(3.27)	(2.95)	(5.34)	(3.85)	(3.98)	(3.09)	(4.91)	(5.46)
s(Bottom):Sunrise	**2.88*****	**5.76*****	**1.00*****	**4.04*****	**3.11*****	**3.90***	**3.28***	**4.14***
	(3.07)	(6.14)	(1.00)	(4.79)	(3.31)	(4.53)	(3.92)	(4.78)
s(Bottom):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Temp):Night	**3.84*****	**3.97****	**1.00***	**1.00***	**3.89*****	**4.74*****	**1.00****	**2.14*****
	(3.97)	(4.50)	(1.00)	(1.00)	(3.99)	(5.12)	(1.00)	(2.62)
s(Temp):Sunrise	2.18	**3.29****	**6.55*****	**2.78*****	1.00	**5.10*****	**1.00***	**1.00*****
	(2.63)	(4.07)	(7.40)	(3.44)	(1.00)	(6.07)	(1.00)	(1.00)
s(Temp):Day	**1.00*****	1.00	1.00	1.00	**1.00***	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Night	**3.52*****	2.00	2.66	2.41	**3.60*****	**2.54****	**3.69****	2.63
	(3.85)	(2.41)	(3.22)	(2.92)	(3.89)	(3.01)	(4.26)	(3.16)
s(Sal):Sunrise	1.12	2.29	**1.00***	1.00	1.00	**2.10****	1.00	1.00
	(1.24)	(2.89)	(1.00)	(1.00)	(1.00)	(2.66)	(1.00)	(1.00)
s(Sal):Day	1.00	1.00	1.00	1.00	**1.00***	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Night	**1.78*****	**3.04*****	**3.20***	**2.29****	**1.80*****	**3.08*****	**4.31*****	**1.00****
	(1.98)	(3.54)	(3.82)	(2.74)	(2.00)	(3.57)	(4.91)	(1.00)
s(Fluo):Sunrise	1.22	**1.00****	**4.40*****	**4.14*****	**1.36***	2.31	2.10	1.00
	(1.40)	(1.00)	(4.95)	(4.65)	(1.58)	(2.76)	(2.54)	(1.00)
s(Fluo):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Night	1.65	1.82	1.00	**1.84***	**1.00*****	**1.95*****	1.00	**1.00*****
	(1.71)	(1.92)	(1.00)	(1.92)	(1.00)	(1.98)	(1.00)	(1.00)
s(Turb):Sunrise	**1.00****	**2.37****	1.00	**4.60*****	2.39	**3.65****	3.63	2.75
	(1.00)	(2.95)	(1.00)	(5.14)	(2.70)	(4.28)	(4.31)	(3.43)
s(Turb):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Lon,Lat)					**2.66*****	**24.90*****	**24.85*****	**25.48*****
					(2.85)	(27.28)	(27.32)	(27.82)
AIC	999.93	1001.16	909.55	1049.94	890.68	706.41	804.57	853.40
BIC	1105.99	1135.30	1034.71	1180.98	1007.53	949.49	1019.80	1055.34
Log Likelihood	−468.84	−461.21	−418.04	−486.51	−411.05	−281.86	−339.11	−367.43
Deviance	874.91	817.07	554.76	1025.20	521.04	163.56	273.33	352.35
Deviance explained	0.98	0.93	0.87	0.75	0.99	0.99	0.94	0.91
Dispersion	4.49	4.32	2.91	5.41	2.72	1.02	1.64	2.08
R^2	0.97	0.91	0.85	0.70	0.98	0.98	0.92	0.89
GCV score	494.03	492.90	452.39	513.97	441.06	385.69	421.92	444.04
Num. obs.	223	223	223	223	223	223	223	223
Num. smooth terms	15	15	15	15	16	16	16	16

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

(B)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	**64.04*****	**49.68*****	**34.41*****	**31.70*****	**65.53*****	**48.90*****	**29.44*****	**28.75*****
	(0.55)	(0.88)	(0.61)	(0.52)	(1.00)	(0.96)	(0.98)	(0.71)
s(Bottom):Night	**8.57*****	**8.36*****	**8.76*****	**8.66*****	5.57	**4.98*****	1.01	1.00
	(8.93)	(8.85)	(8.96)	(8.94)	(6.55)	(6.00)	(1.01)	(1.00)
s(Bottom):Sunset	1.00	**1.85*****	**1.99*****	**1.94*****	**1.00*****	**1.95*****	**1.92****	**1.00*****
	(1.00)	(1.96)	(2.01)	(2.00)	(1.00)	(1.99)	(1.99)	(1.00)
s(Temp):Night	**1.00*****	**4.53*****	**1.96*****	**4.59***	**3.73*****	**5.32*****	**3.00*****	**6.95*****
	(1.01)	(5.46)	(2.56)	(5.72)	(4.63)	(6.25)	(3.93)	(8.00)
s(Temp):Sunset	**3.70*****	**4.00*****	**1.00****	**3.88*****	**2.69*****	**5.11*****	3.08	3.69
	(4.53)	(4.94)	(1.00)	(4.75)	(3.34)	(6.16)	(3.88)	(4.55)
s(Sal):Night	**3.63*****	**3.08*****	**2.04****	**6.77*****	**1.00*****	**1.00****	**1.00*****	4.78
	(4.51)	(3.88)	(2.64)	(7.63)	(1.00)	(1.00)	(1.00)	(5.86)
s(Sal):Sunset	1.49	2.22	3.87	1.00	3.18	**3.76***	1.10	1.00
	(1.82)	(2.84)	(4.71)	(1.00)	(3.93)	(4.65)	(1.18)	(1.00)
s(Fluo):Night	**6.40*****	**5.68*****	**7.51*****	**6.54*****	**3.63****	1.01	**6.16*****	**4.24****
	(7.37)	(6.57)	(8.48)	(7.68)	(4.59)	(1.02)	(7.47)	(5.36)
s(Fluo):Sunset	1.00	**5.16*****	**2.97*****	**5.08*****	**4.24***	4.51	**4.46*****	**4.16*****
	(1.00)	(6.15)	(3.71)	(6.05)	(5.09)	(5.39)	(5.44)	(5.04)
s(Turb):Night	**4.26*****	3.75	**7.15*****	3.04	**4.03****	**5.03****	**7.57*****	2.82
	(5.31)	(4.70)	(8.19)	(3.99)	(5.01)	(5.98)	(8.47)	(3.70)
s(Turb):Sunset	4.27	1.00	**1.00*****	1.01	**6.53*****	**4.65*****	**1.00***	1.00
	(5.35)	(1.00)	(1.00)	(1.01)	(7.41)	(5.60)	(1.00)	(1.00)
s(Lon,Lat)					**25.96*****	**25.31*****	**26.73*****	**26.99*****
					(27.96)	(27.63)	(28.54)	(28.61)
AIC	3811.84	3820.00	3822.70	3776.45	3471.41	3459.43	3479.46	3397.44
Deviance explained	0.79	0.86	0.83	0.82	0.89	0.93	0.91	0.91
R^2	0.77	0.85	0.82	0.81	0.88	0.92	0.90	0.90
Num. obs.	602	602	602	602	602	602	602	602
Num. smooth terms	10	10	10	10	11	11	11	11

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

(C)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	−5.44	**22.09*****	**18.21*****	**13.32*****	**18.62***	**23.48*****	**23.50*****	4.30
	(8.22)	(6.15)	(2.38)	(3.70)	(8.66)	(4.10)	(4.55)	(6.23)
s(Bottom):Night	**4.48*****	**6.68*****	**6.38*****	**6.14*****	2.19	1.00	1.00	1.00
	(5.28)	(7.13)	(6.93)	(6.76)	(2.59)	(1.00)	(1.00)	(1.00)
s(Bottom):Sunrise	1.00	**3.70***	1.00	1.00	**4.57*****	1.00	1.00	**4.10*****
	(1.00)	(4.34)	(1.00)	(1.00)	(5.18)	(1.00)	(1.00)	(4.80)
s(Bottom):Day	1.00	**2.89*****	**3.12*****	1.12	1.00	**3.02*****	1.00	1.71
	(1.00)	(3.45)	(3.69)	(1.22)	(1.00)	(3.67)	(1.00)	(2.01)
s(Temp):Night	1.65	**4.43*****	**6.14*****	**4.82***	2.08	**4.20*****	**6.28*****	**4.75*****
	(1.98)	(5.23)	(6.90)	(5.65)	(2.57)	(5.09)	(7.02)	(5.72)
s(Temp):Sunrise	**7.39*****	**6.62*****	**5.96*****	**7.86*****	**2.12****	**7.64*****	**6.54*****	**8.57*****
	(7.78)	(7.58)	(6.91)	(8.51)	(2.60)	(8.35)	(7.38)	(8.90)
s(Temp):Day	1.41	1.00	1.00	1.00	1.00	1.00	2.21	1.00
	(1.64)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(2.76)	(1.00)
s(Sal):Night	2.78	1.00	1.00	1.00	3.19	1.00	1.44	1.00
	(3.41)	(1.00)	(1.00)	(1.00)	(3.86)	(1.00)	(1.73)	(1.00)
s(Sal):Sunrise	**4.91*****	**6.77*****	**6.67*****	**8.16*****	1.00	**6.51*****	**7.00*****	**8.41*****
	(5.91)	(7.60)	(7.35)	(8.58)	(1.00)	(7.43)	(7.71)	(8.84)
s(Sal):Day	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.01)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Night	**1.00***	**6.07*****	**5.39***	2.98	**3.76*****	**4.45***	**4.33***	1.00
	(1.00)	(7.15)	(6.47)	(3.77)	(4.64)	(5.49)	(5.38)	(1.00)
s(Fluo):Sunrise	**6.63*****	**3.72***	**2.91*****	**7.16*****	**2.61*****	**5.49*****	**4.35****	1.00
	(7.01)	(4.57)	(3.62)	(7.86)	(3.16)	(6.47)	(5.23)	(1.00)
s(Fluo):Day	1.00	1.50	1.00	**1.99***	1.00	1.00	1.00	1.00
	(1.00)	(1.68)	(1.00)	(2.15)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Night	**4.33*****	2.56	2.08	2.96	**4.75***	**3.38****	1.00	1.67
	(5.29)	(3.13)	(2.56)	(3.67)	(5.75)	(4.07)	(1.00)	(2.08)
s(Turb):Sunrise	**5.50*****	**5.94*****	**5.67*****	**4.28*****	**4.51*****	**5.67*****	**4.35*****	**4.31*****
	(5.99)	(6.41)	(6.45)	(4.90)	(5.09)	(6.20)	(5.22)	(4.96)
s(Turb):Day	1.06	**1.00****	**1.00*****	**3.16*****	1.63	1.00	1.00	**3.15***
	(1.10)	(1.00)	(1.00)	(3.63)	(1.98)	(1.00)	(1.00)	(3.67)
s(Lon,Lat)					**26.08*****	**25.28*****	**23.23*****	**26.73*****
					(27.96)	(27.65)	(26.31)	(28.43)
AIC	2934.35	2537.17	2502.36	2527.95	2605.35	2373.69	2394.55	2315.45
Deviance explained	0.76	0.84	0.85	0.84	0.91	0.91	0.90	0.92
R^2	0.73	0.81	0.82	0.82	0.89	0.88	0.87	0.90
Num. obs.	371	371	371	371	371	371	371	371
Num. smooth terms	15	15	15	15	16	16	16	16

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

② (A)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	**20.91****	9.64	12.11	22.52	**25.55****	**19.14****	**20.50***	**21.94*****
	(6.97)	(12.70)	(11.64)	(13.38)	(7.88)	(6.16)	(9.09)	(6.15)
s(Bottom):Night	2.28	1.00	1.00	1.00	**1.00***	**1.00***	1.00	1.00
	(2.67)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Bottom):Sunrise	**3.07*****	**2.85*****	**3.80*****	1.00	1.00	2.34	**3.65***	**4.04***
	(3.82)	(3.57)	(4.54)	(1.00)	(1.01)	(2.82)	(4.20)	(4.58)
s(Bottom):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.39
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.55)
s(Temp):Night	**3.06***	1.00	1.00	1.00	**2.69****	**1.00***	1.00	1.00
	(3.72)	(1.00)	(1.00)	(1.00)	(3.28)	(1.00)	(1.00)	(1.00)
s(Temp):Sunrise	1.00	**1.00*****	**7.41*****	**4.57*****	1.00	**3.68*****	**6.87*****	**4.22*****
	(1.00)	(1.00)	(7.90)	(5.49)	(1.00)	(4.53)	(7.44)	(5.01)
s(Temp):Day	**1.34***	1.00	1.00	1.00	**1.00****	1.00	1.00	1.00
	(1.54)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Night	1.77	1.00	1.00	1.00	1.67	1.47	1.00	1.00
	(2.20)	(1.00)	(1.00)	(1.00)	(2.07)	(1.79)	(1.00)	(1.00)
s(Sal):Sunrise	1.00	1.00	**1.00****	**3.80****	1.00	1.00	**1.08****	**3.80***
	(1.00)	(1.00)	(1.00)	(4.70)	(1.00)	(1.00)	(1.15)	(4.67)
s(Sal):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Night	**2.02****	1.73	1.26	1.27	1.00	1.00	1.00	1.00
	(2.42)	(2.11)	(1.47)	(1.48)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Sunrise	1.00	**4.14*****	**3.42****	**4.11*****	1.00	1.00	1.28	1.00
	(1.00)	(4.62)	(3.98)	(4.70)	(1.00)	(1.00)	(1.45)	(1.00)
s(Fluo):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Night	1.18	1.00	1.00	1.00	1.71	1.65	1.00	1.00
	(1.30)	(1.00)	(1.00)	(1.00)	(1.90)	(1.86)	(1.00)	(1.00)
s(Turb):Sunrise	**4.65*****	**4.11****	**4.02***	1.00	**4.53*****	**4.12*****	**4.33****	3.74
	(5.24)	(4.71)	(4.68)	(1.00)	(5.13)	(4.72)	(4.91)	(4.40)
s(Turb):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Lon,Lat)					**20.04*****	**23.72*****	**20.60*****	**21.66*****
					(24.37)	(26.87)	(24.53)	(25.31)
AIC	1122.71	1266.56	1290.21	1320.44	1054.94	972.39	1132.36	1209.56
BIC	1231.44	1361.97	1407.97	1420.49	1224.48	1158.40	1322.09	1405.56
Log Likelihood	−529.45	−605.28	−610.54	−630.85	−477.71	−431.60	−510.49	−547.25
Deviance	1506.72	2974.34	3118.14	3741.18	947.34	626.49	1271.20	1767.63
Deviance explained	0.93	0.84	0.86	0.69	0.96	0.97	0.94	0.85
Dispersion	7.70	15.01	16.23	18.97	5.25	3.58	7.30	10.21
R^2	0.92	0.82	0.84	0.65	0.95	0.96	0.93	0.81
GCV score	539.71	607.98	628.73	633.21	511.06	484.72	559.92	592.63
Num. obs.	223	223	223	223	223	223	223	223
Num. smooth terms	15	15	15	15	16	16	16	16

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

(B)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	**42.89*****	**36.84*****	**30.92*****	**31.64*****	**43.53*****	**36.20*****	**30.94*****	**32.09*****
	(0.27)	(0.47)	(0.28)	(0.27)	(0.48)	(0.47)	(0.63)	(0.56)
s(Bottom):Night	**8.62*****	**8.49*****	**8.11*****	**8.40*****	**5.09***	**6.46****	4.84	5.62
	(8.94)	(8.90)	(8.68)	(8.85)	(6.14)	(7.31)	(5.82)	(6.63)
s(Bottom):Sunset	**1.00*****	**1.90*****	**1.29*****	**1.89*****	1.00	1.00	**1.86*****	**1.89***
	(1.00)	(1.97)	(1.48)	(1.99)	(1.00)	(1.00)	(1.96)	(1.97)
s(Temp):Night	**1.00*****	**4.82*****	**2.14*****	**5.52*****	**3.11*****	**5.98*****	**4.83*****	**6.41*****
	(1.00)	(5.76)	(2.80)	(6.69)	(3.91)	(6.82)	(5.97)	(7.53)
s(Temp):Sunset	**5.27*****	**5.12****	**8.00*****	**6.45*****	**4.77*****	**6.05*****	**7.70*****	**6.11*****
	(6.27)	(6.28)	(8.66)	(7.35)	(5.73)	(7.16)	(8.45)	(7.06)
s(Sal):Night	**3.64*****	**3.30*****	**3.94*****	**6.10*****	**1.00*****	1.00	**3.74*****	**1.01***
	(4.53)	(4.14)	(4.87)	(7.11)	(1.00)	(1.00)	(4.66)	(1.01)
s(Sal):Sunset	**4.63*****	**4.27*****	**3.73*****	**8.03*****	**4.18****	**5.22*****	**3.68*****	**8.38*****
	(5.57)	(5.20)	(4.58)	(8.54)	(5.04)	(6.21)	(4.51)	(8.77)
s(Fluo):Night	**6.52*****	**5.73*****	**6.45*****	**6.96*****	**4.42*****	**3.97***	**5.74*****	**4.70*****
	(7.48)	(6.60)	(7.64)	(8.03)	(5.48)	(4.90)	(7.01)	(5.86)
s(Fluo):Sunset	**5.05*****	**6.67*****	2.29	1.00	**5.70*****	**6.54*****	**3.50***	**2.65*****
	(5.98)	(7.44)	(2.89)	(1.00)	(6.49)	(7.34)	(4.33)	(3.27)
s(Turb):Night	**3.75*****	**4.71***	**5.00***	4.01	**3.09****	**3.89****	**6.11*****	**3.23*****
	(4.76)	(5.67)	(6.20)	(5.15)	(3.94)	(4.83)	(7.29)	(4.18)
s(Turb):Sunset	**1.00****	**6.26*****	**4.71****	**7.58*****	**5.09*****	**6.27*****	**4.85****	5.04
	(1.00)	(7.16)	(5.68)	(8.38)	(6.06)	(7.16)	(5.85)	(6.11)
s(Lon,Lat)					**26.58*****	**25.69*****	**25.51*****	**26.57*****
					(28.23)	(27.86)	(27.79)	(28.29)
AIC	2941.41	2945.36	3065.03	3030.08	2548.67	2542.51	2830.61	2723.37
Deviance explained	0.89	0.92	0.91	0.93	0.95	0.96	0.95	0.96
R^2	0.88	0.91	0.90	0.93	0.94	0.96	0.94	0.96
Num. obs.	602	602	602	602	602	602	602	602
Num. smooth terms	10	10	10	10	11	11	11	11

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

(C)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	**63.15****	**19.35***	**25.49*****	14.29	**92.97*****	**43.44*****	**26.50*****	**39.40*****
	(21.65)	(9.68)	(7.47)	(10.01)	(20.62)	(8.98)	(7.37)	(10.33)
s(Bottom):Night	**4.40*****	**5.84*****	**5.81*****	**6.12*****	2.82	1.00	1.00	1.00
	(5.21)	(6.55)	(6.50)	(6.74)	(3.30)	(1.00)	(1.00)	(1.00)
s(Bottom):Sunrise	**5.08*****	**4.99*****	**5.38*****	**5.19*****	**4.58****	**4.27*****	**5.06*****	**4.19*****
	(5.50)	(5.53)	(5.89)	(5.64)	(5.05)	(4.88)	(5.62)	(4.76)
s(Bottom):Day	**1.44***	**1.00*****	**2.49*****	**3.35***	**1.00****	**1.00*****	**1.00****	3.10
	(1.73)	(1.00)	(2.94)	(3.90)	(1.00)	(1.00)	(1.00)	(3.62)
s(Temp):Night	**6.11*****	**1.00*****	2.61	**4.20***	**6.43*****	3.97	2.02	**4.72*****
	(6.73)	(1.00)	(3.21)	(4.94)	(7.00)	(4.83)	(2.54)	(5.54)
s(Temp):Sunrise	**7.68*****	**6.99*****	**7.92*****	**6.03****	**7.10*****	**8.09*****	**7.69*****	**8.05*****
	(7.94)	(7.88)	(8.60)	(6.95)	(7.56)	(8.62)	(8.38)	(8.54)
s(Temp):Day	1.00	1.00	1.00	2.94	1.00	1.00	1.00	**3.62*****
	(1.00)	(1.00)	(1.00)	(3.34)	(1.00)	(1.00)	(1.00)	(3.89)
s(Sal):Night	**5.40*****	**4.21****	**5.09***	2.18	**5.03*****	1.00	**5.26*****	2.86
	(6.05)	(5.00)	(5.91)	(2.72)	(5.74)	(1.00)	(6.13)	(3.56)
s(Sal):Sunrise	**5.08*****	**6.85*****	**8.60*****	**6.95*****	**4.93****	**7.40*****	**8.53*****	4.87
	(6.08)	(7.70)	(8.89)	(7.54)	(5.87)	(8.16)	(8.84)	(5.79)
s(Sal):Day	2.58	1.00	1.32	1.00	**2.89****	**2.66*****	1.00	1.00
	(2.98)	(1.00)	(1.50)	(1.00)	(3.31)	(2.96)	(1.00)	(1.00)
s(Fluo):Night	**4.87*****	**2.22*****	3.88	3.92	**5.29*****	**5.13*****	1.00	**6.19****
	(5.91)	(2.80)	(4.82)	(4.88)	(6.36)	(6.21)	(1.00)	(7.17)
s(Fluo):Sunrise	**6.43*****	**4.70*****	**8.40*****	**6.64*****	**6.27*****	**8.32*****	**7.44*****	**7.42*****
	(6.77)	(5.68)	(8.84)	(7.43)	(6.64)	(8.74)	(8.20)	(8.07)
s(Fluo):Day	**1.00*****	**2.16*****	**5.00*****	1.00	**1.00****	**1.00***	**5.11*****	1.00
	(1.00)	(2.36)	(5.56)	(1.00)	(1.00)	(1.00)	(5.67)	(1.00)
s(Turb):Night	**1.56***	2.27	1.00	1.00	**1.00***	1.56	1.00	1.20
	(1.92)	(2.79)	(1.00)	(1.00)	(1.01)	(1.92)	(1.00)	(1.36)
s(Turb):Sunrise	**3.83*****	**6.00*****	**6.23*****	**5.74*****	**6.87*****	**6.34*****	**3.34*****	**6.35*****
	(4.50)	(6.44)	(6.82)	(6.19)	(7.17)	(6.74)	(4.19)	(6.77)
s(Turb):Day	1.00	1.00	1.47	2.43	1.00	1.00	1.79	2.82
	(1.00)	(1.00)	(1.76)	(2.96)	(1.00)	(1.00)	(2.19)	(3.30)
s(Lon,Lat)					**24.04*****	**24.83*****	**25.14*****	**22.28*****
					(26.66)	(27.38)	(27.49)	(25.59)
AIC	2689.73	2673.54	2451.26	2580.09	2465.45	2412.89	2323.17	2319.48
Deviance explained	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99
R^2	0.95	0.96	0.98	0.97	0.97	0.98	0.99	0.99
Num. obs.	371	371	371	371	371	371	371	371
Num. smooth terms	15	15	15	15	16	16	16	16

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

③ (A)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	−355.57	62.86	−12.24	−773.82	330.45	694.83	886.00	380.21
	(1215.52)	(1112.02)	(951.35)	(1108.95)	(1257.77)	(1383.81)	(971.35)	(1086.23)
(Bottom):Night	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Bottom):Sunrise	1.01	4.13	**4.43***	**3.86***	1.00	2.27	**2.15***	**1.97***
	(1.01)	(4.91)	(5.21)	(4.67)	(1.00)	(2.75)	(2.77)	(2.54)
s(Bottom):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Temp):Night	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Temp):Sunrise	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Temp):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Night	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Sunrise	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Night	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Sunrise	**4.53*****	**4.86*****	**4.83*****	**4.52*****	**4.50*****	**4.58*****	**4.83*****	**4.54*****
	(4.85)	(5.18)	(5.16)	(4.96)	(4.83)	(4.90)	(5.19)	(5.01)
s(Fluo):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Night	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Sunrise	**6.42*****	**5.14*****	**5.48*****	**5.40*****	**6.41*****	**4.80*****	**5.31*****	**5.05*****
	(6.67)	(5.48)	(5.82)	(5.84)	(6.67)	(5.20)	(5.67)	(5.53)
s(Turb):Day	1.00	1.00	1.00	1.25	1.00	1.00	1.00	1.58
	(1.00)	(1.00)	(1.00)	(1.46)	(1.00)	(1.00)	(1.00)	(1.96)
s(Lon,Lat)					2.00	10.12	**2.00****	**2.00*****
					(2.00)	(13.90)	(2.00)	(2.01)
AIC	3053.96	3138.70	3022.89	3132.03	3052.99	3133.92	3021.19	3124.12
BIC	3144.37	3239.50	3125.73	3233.99	3150.10	3272.77	3122.16	3226.50
Log Likelihood	−1500.44	−1539.77	−1481.26	−1536.09	−1498.00	−1526.20	−1480.96	−1532.01
Deviance	9121706.49	12979044.80	7680023.36	12558234.92	8923868.89	11492746.05	7659412.69	12107392.14
Deviance explained	0.66	0.52	0.56	0.43	0.66	0.58	0.56	0.46
Dispersion	46058.95	66266.42	39333.02	64087.13	45510.36	61056.24	39138.43	61820.40
R^2	0.61	0.46	0.50	0.36	0.62	0.50	0.51	0.38
GCV score	1448.39	1485.52	1432.51	1479.85	1431.56	1463.47	1412.05	1456.46
Num. obs.	223	223	223	223	223	223	223	223
Num. smooth terms	15	15	15	15	16	16	16	16

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

(B)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	**28.90*****	**19.25*****	**15.57*****	**15.00*****	**27.99*****	**18.00*****	**14.58*****	**14.39*****
	(0.81)	(0.68)	(0.69)	(0.50)	(1.69)	(1.21)	(1.15)	(0.80)
s(Bottom):Night	**8.50*****	**8.35*****	**7.83*****	**7.62*****	**1.00***	**1.57****	1.00	1.00
	(8.91)	(8.85)	(8.54)	(8.46)	(1.00)	(1.95)	(1.00)	(1.00)
s(Bottom):Sunset	**1.00*****	**1.00****	**1.15*****	**1.62*****	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.27)	(1.81)	(1.00)	(1.00)	(1.00)	(1.00)
s(Temp):Night	1.00	**1.84***	1.00	1.01	2.16	1.12	1.00	1.00
	(1.00)	(2.33)	(1.00)	(1.01)	(2.76)	(1.24)	(1.00)	(1.00)
s(Temp):Sunset	1.00	1.00	1.00	1.92	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(2.38)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Night	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.01)	(1.00)	(1.01)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Sunset	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.01)	(1.01)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Night	**1.00***	**1.00****	**2.17****	**1.04*****	1.96	1.00	1.00	2.60
	(1.00)	(1.00)	(2.75)	(1.07)	(2.55)	(1.00)	(1.00)	(3.29)
s(Fluo):Sunset	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(2.48)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Night	**1.51***	**1.28****	**4.29*****	**4.98*****	1.00	1.00	1.32	3.05
	(1.89)	(1.50)	(5.30)	(6.09)	(1.00)	(1.00)	(1.57)	(3.85)
s(Turb):Sunset	1.00	1.92	1.00	1.00	1.89	1.00	1.00	1.00
	(1.00)	(2.39)	(1.00)	(1.00)	(2.40)	(1.00)	(1.00)	(1.00)
s(Lon,Lat)					**25.50*****	**26.21*****	**25.53*****	**24.50*****
					(28.05)	(28.35)	(28.10)	(27.53)
AIC	4453.14	4311.72	4235.92	3972.48	4354.37	4192.21	4132.82	3887.44
Deviance explained	0.39	0.36	0.33	0.40	0.52	0.51	0.46	0.51
R^2	0.38	0.34	0.31	0.38	0.49	0.47	0.43	0.48
Num. obs.	602	602	602	602	602	602	602	602
Num. smooth terms	10	10	10	10	11	11	11	11

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

(C)

	Non-Spatial				Spatial			
	38 kHz	70 kHz	120 kHz	200 kHz	38 kHz	70 kHz	120 kHz	200 kHz
(Intercept)	20.58	26.64	13.41	**40.78*****	29.02	346.35	520.74	**59.44*****
	(11.23)	(82.38)	(96.24)	(11.80)	(16.44)	(229.78)	(279.30)	(17.66)
s(Bottom):Night	2.72	1.00	1.01	**4.99*****	1.00	1.00	**1.00***	1.00
	(3.30)	(1.00)	(1.02)	(5.88)	(1.00)	(1.00)	(1.00)	(1.00)
s(Bottom):Sunrise	1.54	1.00	1.00	1.52	1.00	1.00	1.00	1.00
	(1.89)	(1.00)	(1.00)	(1.84)	(1.00)	(1.00)	(1.00)	(1.00)
s(Bottom):Day	**1.44*****	1.00	1.00	1.00	**1.98****	1.00	1.00	1.00
	(1.75)	(1.00)	(1.00)	(1.00)	(2.39)	(1.00)	(1.00)	(1.00)
s(Temp):Night	**1.00***	1.00	1.00	1.00	1.92	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(2.44)	(1.00)	(1.00)	(1.00)
s(Temp):Sunrise	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Temp):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Night	1.00	**7.95*****	**8.82*****	1.00	1.00	**7.95*****	**8.83*****	1.00
	(1.00)	(8.05)	(8.97)	(1.00)	(1.00)	(8.05)	(8.97)	(1.00)
s(Sal):Sunrise	1.00	1.00	1.00	**4.19****	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(5.12)	(1.00)	(1.00)	(1.00)	(1.00)
s(Sal):Day	**1.00***	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Night	1.04	1.00	1.00	3.85	1.00	1.00	1.00	4.19
	(1.08)	(1.00)	(1.00)	(4.75)	(1.00)	(1.00)	(1.00)	(5.12)
s(Fluo):Sunrise	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Fluo):Day	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**1.97***
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(2.20)
s(Turb):Night	**4.59****	1.00	1.00	**2.74***	**4.71****	1.00	1.00	2.67
	(5.60)	(1.00)	(1.00)	(3.38)	(5.73)	(1.00)	(1.00)	(3.27)
s(Turb):Sunrise	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
s(Turb):Day	2.33	1.00	1.00	2.94	2.91	1.00	1.00	3.43
	(2.85)	(1.00)	(1.00)	(3.51)	(3.51)	(1.00)	(1.00)	(3.88)
s(Lon,Lat)					5.17	2.00	2.00	**16.70*****
					(6.93)	(2.00)	(2.00)	(20.98)
AIC	4189.26	5667.89	5779.16	4136.79	4183.99	5669.16	5778.41	4106.43
Deviance explained	0.30	0.39	0.43	0.34	0.33	0.39	0.44	0.43
R^2	0.25	0.35	0.40	0.28	0.27	0.35	0.40	0.36
Num. obs.	371	371	371	371	371	371	371	371
Num. smooth terms	15	15	15	15	16	16	16	16

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table S2

Results of Generalized additive model (GAM) and spatial Generalized additive model(GAMs) showing the effect (blue: Positive; red: Negative; gray : Not significant) of oceanographic conditions (sea temperature, salinity, turbidity and fluorescence), diel period (day, sunset, night and sunrise), bottom depth (Bottom) and geographical positions (latitude (Lat) and longitude (Lon)) on sound-scattering layers (SSLs) (1) thickness and (2) depth, detected by echosounders (38, 70, 120 and 200 kHz), according to three Senegalese geographical areas (A: southern continental shelf; B: southern high sea and C: northern continental shelf).

① (A)

Thickness																								
Frequencies	38 kHz						70 kHz						120 kHz						200 kHz					
Diel period	Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day	
Model	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs
Temperature	red	red	gray	gray	red	red	red	red	red	blue	gray	gray	red	red	red	red	gray	gray	red	red	red	red	gray	gray
Fluorescence	red	red	gray	blue	gray	gray	red	red	blue	gray	gray	gray	red	red	red	gray	gray	gray	red	red	blue	gray	gray	gray
Salinity	blue	blue	gray	gray	gray	red	gray	blue	gray	blue	gray	gray	gray	red	red	gray	gray	gray	gray	gray	gray	gray	gray	gray
Turbidity	gray	blue	red	gray	gray	gray	gray	red	red	blue	gray	gray	gray	gray	gray	gray	gray	gray	red	blue	red	gray	gray	gray
Bottom	red	blue	blue	blue	gray	gray	red	red	red	red	gray	gray	blue	blue	blue	red	gray	gray	red	blue	blue	red	gray	gray
Lat	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red
Lon	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red	-	red

(B)

Thickness																
Frequencies	38 kHz				70 kHz				120 kHz				200 kHz			
Diel period	Night		Sunset		Night		Sunset		Night		Sunset		Night		Sunset	
Model	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs
Temperature	red	red	red	red	red	red	red	red	red	red	red	gray	red	blue	red	gray
Fluorescence	blue	blue	gray	blue	blue	gray	blue	gray	red	blue	red	red	red	red	blue	blue
Salinity	red	red	gray	gray	red	red	gray	blue	red	red	gray	gray	red	gray	gray	gray
Turbidity	red	red	gray	blue	gray	blue	gray	blue	red	red	blue	blue	gray	gray	gray	gray
Bottom	blue	gray	gray	blue	blue	red	red	red	blue	gray	blue	blue	blue	gray	blue	red
Lat	-	blue	-	blue	-	blue	-	blue	-	blue	-	blue	-	blue	-	blue
Lon	-	red	-	red	-	red	-	red	-	blue	-	blue	-	red	-	red

(C)

Thickness																								
Frequencies	38 kHz						70 kHz						120 kHz						200 kHz					
Diel period	Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day	
Model	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs
Temperature																								
Fluorescence																								
Salinity																								
Turbidity																								
Bottom																								
Lat+Lon	-		-		-		-		-		-		-		-		-		-		-		-	

② (A)

Depth																								
Frequencies	38 kHz						70 kHz						120 kHz						200 kHz					
Diel period	Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day	
Model	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs
Temperature																								
Fluorescence																								
Salinity																								
Turbidity																								
Bottom																								
Lat	-		-		-		-		-		-		-		-		-		-		-		-	
Lon	-		-		-		-		-		-		-		-		-		-		-		-	

(B)

	Depth															
Frequencies	38 kHz				70 kHz				120 kHz				200 kHz			
Diel period	Night		Sunset		Night		Sunset		Night		Sunset		Night		Sunset	
Model	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs
Temperature																
Fluorescence																
Salinity																
Turbidity																
Bottom																
Lat	-		-		-		-		-		-		-		-	
Lon	-		-		-		-		-		-		-		-	

(C)

	Depth																							
Frequencies	38 kHz						70 kHz						120 kHz						200 kHz					
Diel period	Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day		Night		Sunrise		Day	
Model	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs	GAM	GAMs
Temperature																								
Fluorescence																								
Salinity																								
Turbidity																								
Bottom																								
Lat+Lon	-		-		-		-		-		-		-		-		-		-		-		-	

Table S3

Results of Functional Generalized Additive Spectral Model (FGSAM) and spatial Functional Generalized Additive Spectral Model (FGSAMs) showing the effect (blue: Positive; red: Negative; gray: Not significant; values in intervals (m) represent ranges of variation; + represents beyond this value (m) and Night represents the reference modality (by default, coefficients are calculated compared to this modality)) of oceanographic conditions (sea temperature, salinity, turbidity, fluorescence), diel period (day, sunset, night and sunrise), bottom depth (Bottom) and geographical positions (latitude (Lat) and longitude (Lon)) on sound-scattering layers (SSLs) (1) thickness and (2) depth, detected by echosounders (38, 70, 120 and 200 kHz), according to three geographical areas (A: southern continental shelf; B: southern high sea and C: northern continental shelf).

① (A)

Thickness								
Frequencies	38 kHz		70 kHz		120 kHz		200 kHz	
Model	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs
Temperature	[red]	[red]	[blue]	10-20 [blue]; 20-30 [red]; 30+ [blue]	10-35 [blue]; 35+ [red]	10-35 [blue]; 35+ [red]	10-30 [blue]; 30-55 [red]; 55+ [blue]	10-25 [blue]; 25-40 [red]; 40+ [blue]
Fluorescence	10-30 [blue]; 30+ [red]	10-30 [blue]; 30+ [red]	10-20 [blue]; 20-35 [red]; 35+ [blue]	10-20 [red]; 20-35 [blue]; 35+ [red]	[blue]	10-20 [red]; 20+ [blue]	10-30 [red]; 30+ [blue]	<15 [red]; 15-25 [blue]; 25+ [red]
Salinity	10-30 [red]; 30+ [blue]	10-30 [red]; 30+ [blue]	10-20 [red]; 20-30 [blue]; 30+ [red]	10-20 [red]; 20-30 [blue]; 30+ [red]	10-25 [blue]; 25-35 [red]; 35+ [blue]	10-25 [blue]; 25-35 [red]; 35+ [blue]	10-30 [red]; 30-50 [blue]; 50+ [red]	10-25 [red]; 25-40 [blue]; 40+ [red]
Turbidity	10-30 [red]; 30+ [blue]	10-30 [red]; 30+ [blue]	10-20 [red]; 20-30 [blue]; 30+ [red]	10-20 [blue]; 20-30 [red]; 30+ [blue]	10-25 [red]; 25+ [blue]	10-25 [red]; 25+ [blue]	10-30 [red]; 30-55 [blue]; 55+ [red]	10-25 [blue]; 25-35 [red]; 35+ [blue]
Bottom	[blue]	[blue]	[blue]	[red]	[blue]	[blue]	[gray]	[gray]
Night								
Sunrise	[blue]	[blue]	[blue]	[gray]	[gray]	[gray]	[red]	[gray]
Day	[blue]	[blue]	[blue]	[gray]	[gray]	[gray]	[gray]	[gray]
Lat	-	[red]	-	[gray]	-	[gray]	-	[red]
Lon	-	[gray]	-	[gray]	-	[gray]	-	[gray]

(B)

Thickness								
Frequencies	38 kHz		70 kHz		120 kHz		200 kHz	
Model	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs
Temperature	10-45 [red]; 45+ [blue]	10-50 [blue]; 50+ [red]	10-42 [red]; 42+ [blue]	10-40 [red]; 40+ [blue]	<10 [blue]; 10-45 [red]; 45+ [blue]	10-50 [red]; 50+ [blue]	<20 [red]; 20-60 [blue]; 60-118 [red]; 118+ [blue]	<10 [red]; 10+ [blue]
Fluorescence	10-45 [blue]; 45+ [red]	10-70 [blue]; 70+ [red]	[blue]	[blue]	10-80 [blue]; 80+ [red]	[blue]	10-40 [red]; 40-120 [blue]; 120+ [red]	10-40 [red]; 40-120 [blue]; 120+ [red]
Salinity	[blue]	10-50 [red]; 50+ [blue]	10-40 [blue]; 40+ [red]	10-40 [blue]; 40+ [red]	10-45 [red]; 45+ [blue]	10-50 [red]; 50+ [blue]	10-115 [red]; 115+ [blue]	10-110 [red]; 110+ [blue]
Turbidity	10-80 [red]; 80+ [blue]	10-90 [red]; 90+ [blue]	<25 [red]; 25-80 [blue]; 80+ [red]	10+ [red]	10-80 [red]; 80+ [blue]	10-37 [blue]; 37-80 [red]; 80+ [blue]	10-80 [red]; 80+ [blue]	10-80 [red]; 80+ [blue]
Bottom	[red]	[red]	[blue]	[blue]	[red]	[red]	[red]	[red]
Night								
Sunset	[blue]	[gray]	[red]	[red]	[blue]	[gray]	[gray]	[red]
Lat	-	[blue]	-	[gray]	-	[red]	-	[gray]
Lon	-	[blue]	-	[red]	-	[gray]	-	[blue]

(C)

Thickness								
Frequencies	38 kHz		70 kHz		120 kHz		200 kHz	
Model	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs
Temperature	10-50; 50-80; 80+	10-30; 30-90; 90 +	10-40; 40+	10-50; 50+	10-50; 50+	10-50; 50+	10-50; 50+	10-30; 30-50; 50-120; 120+
Fluorescence	10-90; 90+	10-80; 80 +	10-80; 80+	10-90; 90 +	10-80, 80-110; 110+	10-90; 90 +	10-80, 80-110; 110+	10-30; 30-120; 120+
Salinity	10-20; 20-90; 90+	<20; 20-60; 60 +	20-40; 40-110; 110+	10-30; 30-110; 110 +	10-90; 90 +	10-40; 40-90; 90 +		10-80; 80+
Turbidity	20-80; 80+	10-30; 30-90; 90 +	10-100; 100+	10-30; 30-110; 110+	20-60; 60+	10-20; 20-110; 110+	10-60; 60-120	10-20; 20-62; 62-120; 120 +
Bottom								
Night								
Sunrise								
Day								
Lat	-				-		-	
Lon	-		-		-		-	

② (A)

Depth								
Frequencies	38 kHz		70 kHz		120 kHz		200 kHz	
Model	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs
Temperature	10-45; 45+	10-35; 35-55; 55+	10-20; 20-30; 30+	<12; 12-35; 35+	10-30; 30+	10-25; 25-40; 40+		<20; 20-35; 35+
Fluorescence	10-30; 30-45; 45+	10-30; 30-45; 45+		10-20; 20-35; 35+		10-20; 20-40; 40+		
Salinity	10-30; 30+	10-30; 30+	10-30; 30+	<12; 12-30; 30+	10-35; 35+	10-25; 25-40; 40+	10-25; 25+	10-35; 35-47; 47+
Turbidity			10-30; 30+	10-30; 30-37; 37+	10-25; 25+	10-25; 25+	10-25; 25-40; 40+	10-25; 25-35; 35+
Bottom								
Night								
Sunrise								
Day								
Lat	-		-		-		-	
Lon	-		-		-		-	

(B)

Depth								
Frequencies	38 kHz		70 kHz		120 kHz		200 kHz	
Model	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs
Temperature	<10 ; 10-60 ; 60-110 ; 110+	10-20 ; 20-80 ; 80+	10-50 ; 50-90 ; 90+	10-50 ; 50-90 ; 90+	<10 ; 10-50 ; 50+	10-50 ; 50-80 ; 80+	10-50 ; 50+	10-50 ; 50+
Fluorescence	10-40 ; 40-70 ; 70-110 ; 110+	10-80 ; 80+	<10 ; 10+	10-70 ; 70-90 ; 90+	10-90 ; 90+	10-60 ; 60+		
Salinity	<30 ; 30+	10-50 ; 50+	10-50 ; 50+	10-50 ; 50+	10-50 ; 50+	10-50 ; 50-80 ; 80+	<20 ; 20-80 ; 80-120 ; 120+	20-110 ; 110+
Turbidity	<20 ; 20-70 ; 70+	10-90 ; 90+	<20 ; 20+		<10 ; 10-50 ; 50-80 ; 80+	<20 ; 20-50 ; 50+	10-50 ; 50+	10-80 ; 80+
Bottom								
Night								
Sunset								
Lat	-		-		-		-	
Lon	-		-		-		-	

(C)

Depth								
Frequencies	38 kHz		70 kHz		120 kHz		200 kHz	
Model	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs	FGSAM	FGSAMs
Temperature	10-20 ; 20-90 ; 90+	10-50 ; 50+	10-30 ; 30-50 ; 50+	10-50 ; 50-110 ; 110+	10-20 ; 20-110 ; 110+	10-20 ; 20-110 ; 110+	10-110 ; 110+	10-60 ; 60-120 ; 120+
Fluorescence		10-90 ; 90+	10-60 ; 60-100 ; 100+ ;	10-60 ; 60-100	10-60 ; 60-90 ; 90+	10-90 ; 90+	10-80 ; 80-100 ; 100+	10-22 ; 22-117 ; 117+
Salinity	10-20 ; 20-60 ; 60+	10-120 ; 120+	10-90 ; 90+	10-90 ; 90+	10-30 ; 30-60 ; 60-120 ; 120+ ;	10-37 ; 37-57 ; 57-120 ; 120+	10-30 ; 30-100 ; 100+	10-22 ; 22-100 ; 100+
Turbidity	10-90 ; 90+	10-30 ; 30-90 ; 90+	10-30 ; 30-80 ; 80-110 ; 110+	10-30 ; 30-80 ; 80+		10-20 ; 20-70 ; 70-120 ; 120+	10-80 ; 80+	10-60 ; 60-120 ; 120+
Bottom								
Night								
Sunrise								
Day								
Lat	-		-		-		-	
Lon	-		-		-		-	

Table S4

Comparison of non-spatial (GAM and FGSAM) and spatial models (GAMs and FGSAMs) for (1) SSL thickness and (2) SSL depth, as detected using four different echosounder frequencies (in kHz; denoted as suffix after statistical model abbreviations) and spread over three Senegalese geographical areas (A) southern continental shelf, (B): southern high sea and (C): northern continental shelf (during the AWA fisheries acoustics sea survey). R^2_ajusted (Adjusted R-Squared); R^2 (R-Squared); RMSE_Train (Root Mean Square Error in training set); MAE_Train (Mean Absolute Error in training set); RMSE_Test (Root Mean Square Error in test set); MAE_Test (Mean Absolute Error in test set).

① (A)

	R^2_ajusted	R^2	RMSE_Train	MAE_Train	RMSE_Test	MAE_Test
GAM38	0.97	0.98	1.98	1.36	3.37	2.26
GAMs38	0.98	0.99	1.53	1.01	2.77	1.61
FGSAM38	0.98	0.99	1.46	1.00	2.46	1.58
FGSAMs38	0.99	0.99	1.01	0.69	1.82	1.19
GAM70	0.91	0.93	1.91	1.25	2.41	1.59
GAMs70	0.98	0.99	0.86	0.54	1.88	1.08
FGSAM70	0.88	0.89	2.31	1.62	2.74	1.86
FGSAMs70	0.97	0.97	1.17	0.77	1.89	1.20
GAM120	0.85	0.87	1.58	1.03	2.41	1.53
GAMs120	0.92	0.94	1.11	0.68	1.64	0.99
FGSAM120	0.90	0.92	1.28	0.77	2.27	1.31
FGSAMs120	0.90	0.92	1.25	0.75	2.24	1.28
GAM200	0.70	0.75	2.14	1.55	3.10	2.28
GAMs200	0.89	0.91	1.26	0.94	1.75	1.24
FGSAM200	0.72	0.75	2.12	1.52	3.30	2.33
FGSAMs200	0.82	0.85	1.64	1.11	2.67	1.72

(B)

	R^2_ajusted	R^2	RMSE_Train	MAE_Train	RMSE_Test	MAE_Test
GAM38	0.77	0.79	5.34	4.20	5.50	4.33
GAMs38	0.88	0.89	3.83	3.03	4.21	3.39
FGSAM38	0.70	0.74	5.92	4.39	6.20	4.68
FGSAMs38	0.88	0.90	3.63	2.88	4.19	3.24
GAM70	0.85	0.86	5.34	4.25	5.51	4.35
GAMs70	0.92	0.93	3.79	2.95	4.39	3.47
FGSAM 70	0.81	0.84	5.77	4.19	7.21	5.22
FGSAMs70	0.85	0.88	5.11	3.83	6.77	5.03
GAM120	0.82	0.83	5.37	4.29	5.33	4.09
GAMs120	0.90	0.91	3.90	3.11	4.53	3.57
FGSAM120	0.87	0.89	4.36	3.38	5.47	4.20
FGSAMs120	0.89	0.91	3.92	3.09	4.97	3.70
GAM200	0.81	0.82	5.13	3.97	4.86	3.81
GAMs200	0.90	0.91	3.64	2.75	4.12	3.03
FGSAM200	0.85	0.87	4.37	3.30	5.08	3.96
FGSAMs200	0.90	0.92	3.53	2.65	4.43	3.33

(C)

	R²_ajusted	R²	RMSE_Train	MAE_Train	RMSE_Test	MAE_Test
GAM38	0.73	0.76	10.96	7.80	13.41	9.19
GAMs38	0.89	0.91	6.67	4.62	7.16	5.02
FGSAM38	0.80	0.84	8.99	6.56	12.12	8.99
FGSAMs38	0.90	0.92	6.44	4.65	8.23	6.05
GAM70	0.81	0.84	6.22	4.30	9.96	6.02
GAMs70	0.88	0.91	4.75	3.42	8.24	4.97
FGSAM70	0.83	0.86	5.81	3.80	11.90	7.30
FGSAMs70	0.84	0.87	5.50	3.78	10.38	6.45
GAM120	0.82	0.85	6.02	3.93	6.94	4.11
GAMs120	0.87	0.90	4.95	3.12	5.70	3.35
FGSAM120	0.85	0.87	5.52	3.93	7.62	5.16
FGSAMs120	0.91	0.93	4.02	2.81	5.51	3.38
GAM200	0.82	0.84	6.17	4.03	11.25	6.29
GAMs200	0.90	0.92	4.44	2.98	6.25	3.96
FGSAM200	0.79	0.83	6.49	4.52	7.33	5.48
FGSAMs200	0.90	0.93	4.24	2.72	4.93	3.60

② (A)

	R²_ajusted	R²	RMSE_Train	MAE_Train	RMSE_Test	MAE_Test
GAM38	0.92	0.93	2.60	1.44	3.97	2.19
GAMs38	0.95	0.96	2.06	1.03	3.09	1.63
FGSAM38	0.92	0.93	2.53	1.73	4.09	2.43
FGSAMs38	0.95	0.96	1.88	1.22	3.05	1.86
GAM70	0.82	0.84	3.65	2.33	4.10	2.62
GAMs70	0.96	0.97	1.68	5.08	2.52	1.32
FGSAM70	0.84	0.87	3.35	2.42	3.55	2.66
FGSAMs70	0.96	0.97	1.60	1.07	2.37	1.67
GAM120	0.84	0.86	3.74	2.44	4.08	2.57
GAMs120	0.93	0.94	2.39	1.43	3.35	1.82
FGSAM120	0.90	0.92	2.86	1.89	3.37	2.26
FGSAMs120	0.93	0.94	2.46	1.52	3.20	1.89
GAM200	0.65	0.69	4.10	2.72	6.06	4.22
GAMs200	0.81	0.85	2.82	1.86	4.23	2.78
FGSAM200	0.70	0.75	3.68	2.77	5.25	3.74
FGSAMs200	0.79	0.82	3.10	2.07	4.53	2.85

(B)

	R²_ajusted	R²	RMSE_Train	MAE_Train	RMSE_Test	MAE_Test
GAM38	0.88	0.89	2.58	2.05	2.44	1.93
GAMs38	0.94	0.95	1.78	1.43	1.91	1.54
FGSAM38	0.83	0.86	2.86	2.17	3.40	2.47
FGSAMs38	0.92	0.93	1.96	1.51	2.33	1.84
GAM70	0.91	0.92	2.53	1.95	2.79	2.20
GAMs70	0.96	0.96	1.75	1.39	2.08	1.65
FGSAM70	0.84	0.86	3.35	2.41	3.79	2.58
FGSAMs70	0.86	0.89	3.01	2.16	3.50	2.47
GAM120	0.90	0.91	2.81	2.13	3.16	2.32
GAMs120	0.94	0.95	2.21	1.72	2.80	2.16
FGSAM120	0.89	0.91	2.88	2.06	3.70	2.66
FGSAMs120	0.91	0.93	2.54	1.86	3.48	2.50
GAM200	0.93	0.93	2.70	2.08	2.63	2.07
GAMs200	0.96	0.96	2.03	1.58	2.35	1.79
FGSAM200	0.70	0.75	5.18	3.30	6.47	4.19
FGSAMs200	0.73	0.77	4.96	3.22	6.23	4.02

(C)

	R^2_ajusted	R^2	RMSE_Train	MAE_Train	RMSE_Test	MAE_Test
GAM38	0.95	0.96	7.59	5.53	9.09	6.40
GAMs38	0.97	0.98	5.24	3.90	6.42	4.87
FGSAM38	0.77	0.80	16.40	11.16	17.43	11.90
FGSAMs38	0.84	0.86	13.74	8.96	14.72	10.61
GAM70	0.81	0.84	6.22	4.30	50.66	35.05
GAMs70	0.98	0.99	4.93	3.24	11.30	5.65
FGSAM70	0.91	0.93	11.58	8.21	20.01	12.94
FGSAMs70	0.97	0.97	6.86	4.37	15.74	8.39
GAM120	0.98	0.98	5.38	3.13	18.38	6.64
GAMs120	0.99	0.99	4.38	2.44	8.06	4.09
FGSAM120	0.91	0.93	10.71	7.76	15.86	11.21
FGSAMs120	0.97	0.98	6.07	4.36	8.89	6.16
GAM200	0.97	0.98	6.52	4.08	9.97	5.76
GAMs200	0.99	0.99	4.29	2.72	8.66	4.78
FGSAM200	0.92	0.94	10.69	7.79	16.63	11.63
FGSAMs200	0.99	0.99	3.89	2.88	8.84	6.07

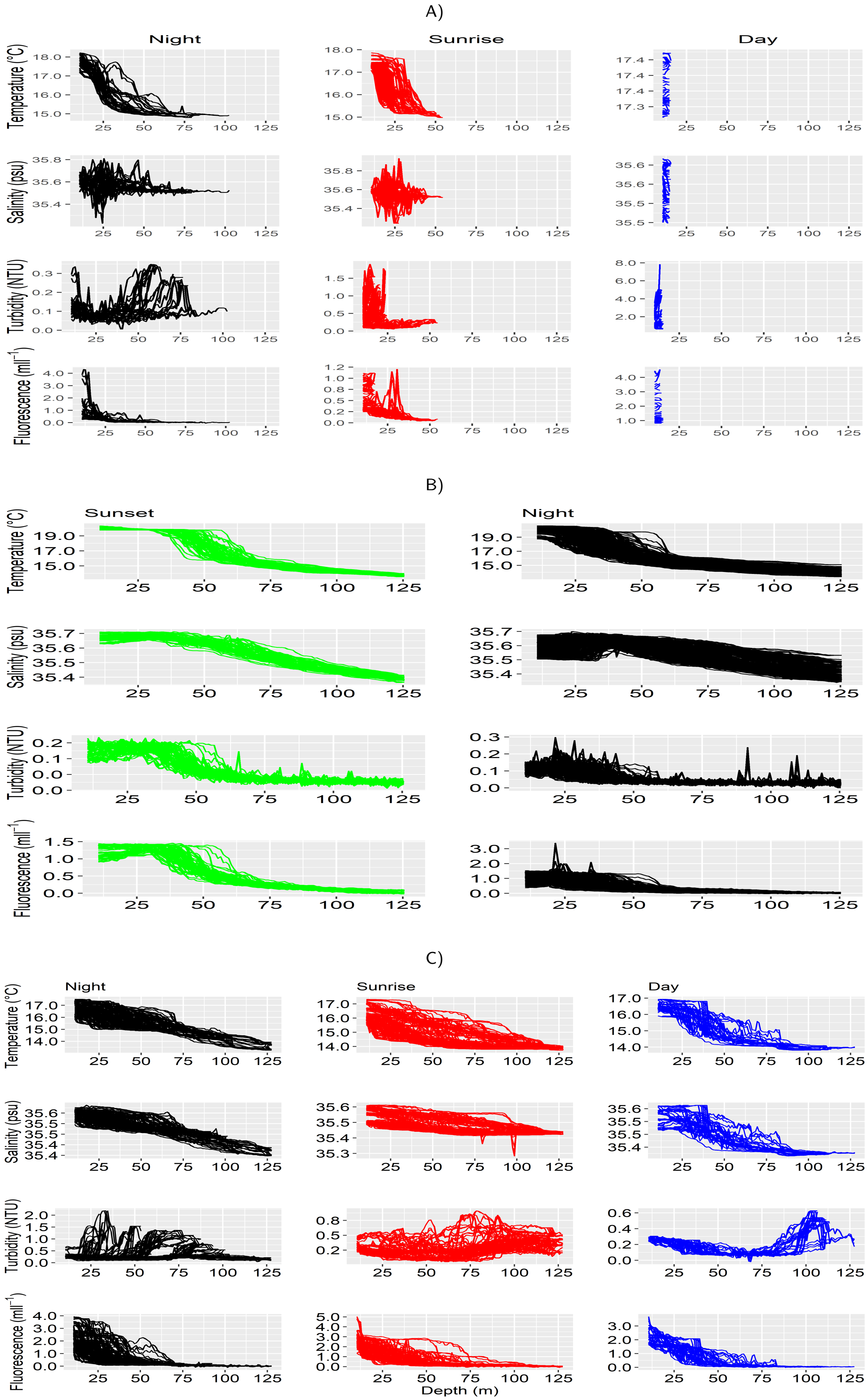
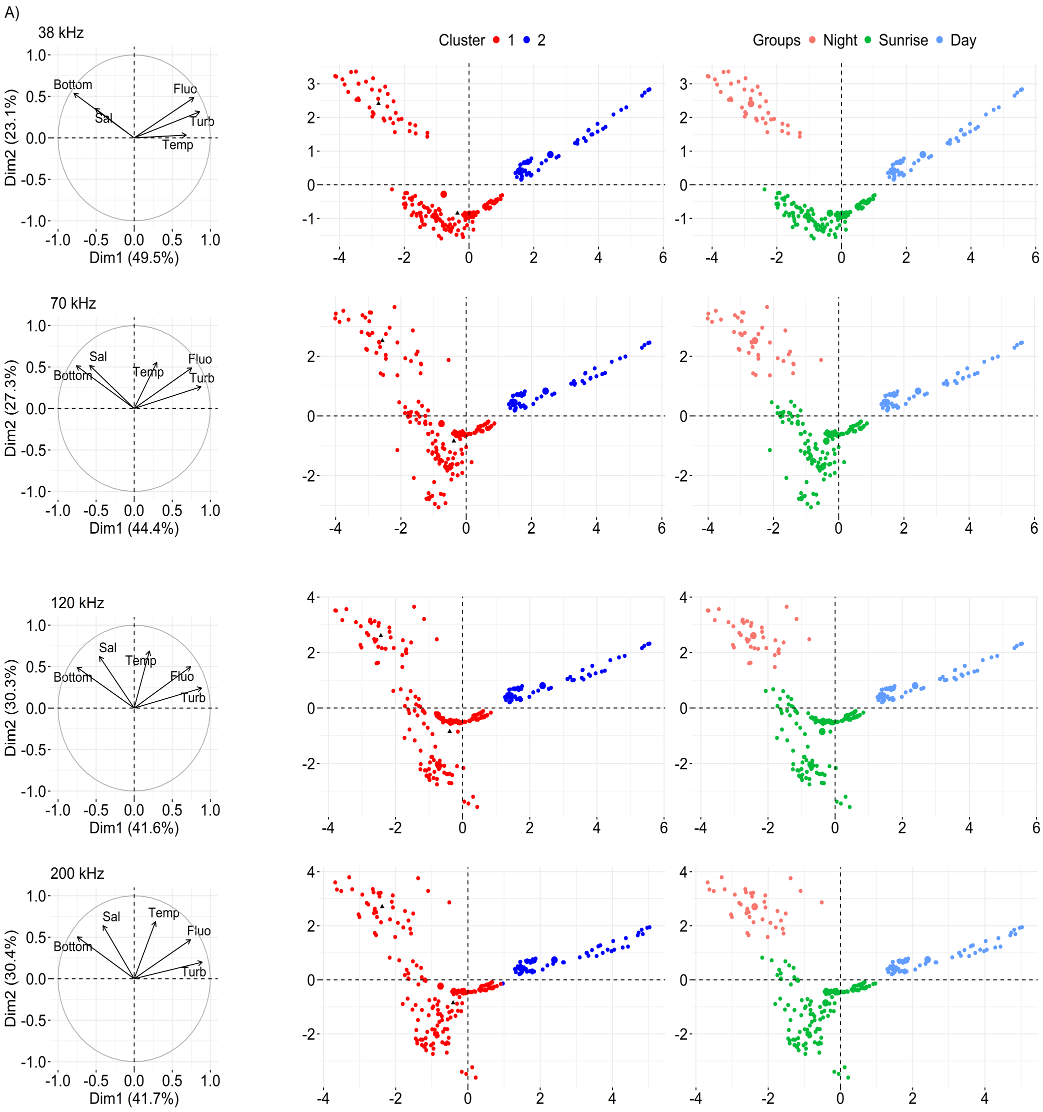
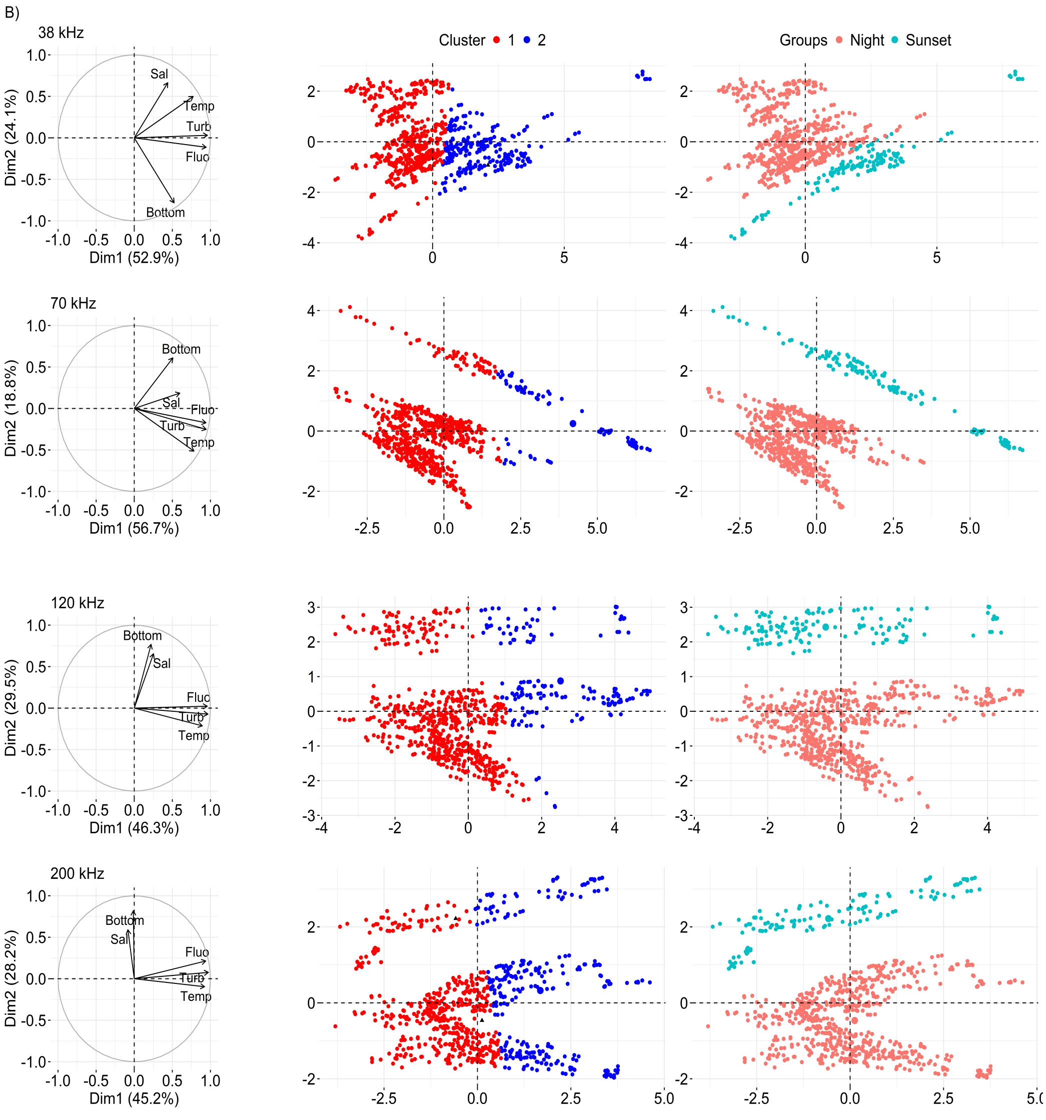


Fig. S2: Variation of physical parameters along depths over three contrasted Senegalese areas: (A) southern continental shelf; (B) southern high sea and (C) northern continental shelf) during the AWA sea survey.


A)
38 kHz
70 kHz
120 kHz
200 kHz
Cluster 1 2
Groups Night Sunrise Day
Dim1 (49.5%)
Dim2 (23.1%)
Dim1 (44.4%)
Dim2 (27.3%)
Dim1 (41.6%)
Dim2 (30.3%)
Dim1 (41.7%)
Dim2 (30.4%)
Bottom
Sal
Temp
Fluo
Turb


B)
38 kHz
Cluster 1 2
Groups Night Sunset
Sal
Temp
Turb
Fluo
Bottom
Dim1 (52.9%)
Dim2 (24.1%)
70 kHz
Dim1 (56.7%)
Dim2 (18.8%)
120 kHz
Dim1 (46.3%)
Dim2 (29.5%)
200 kHz
Dim1 (45.2%)
Dim2 (28.2%)

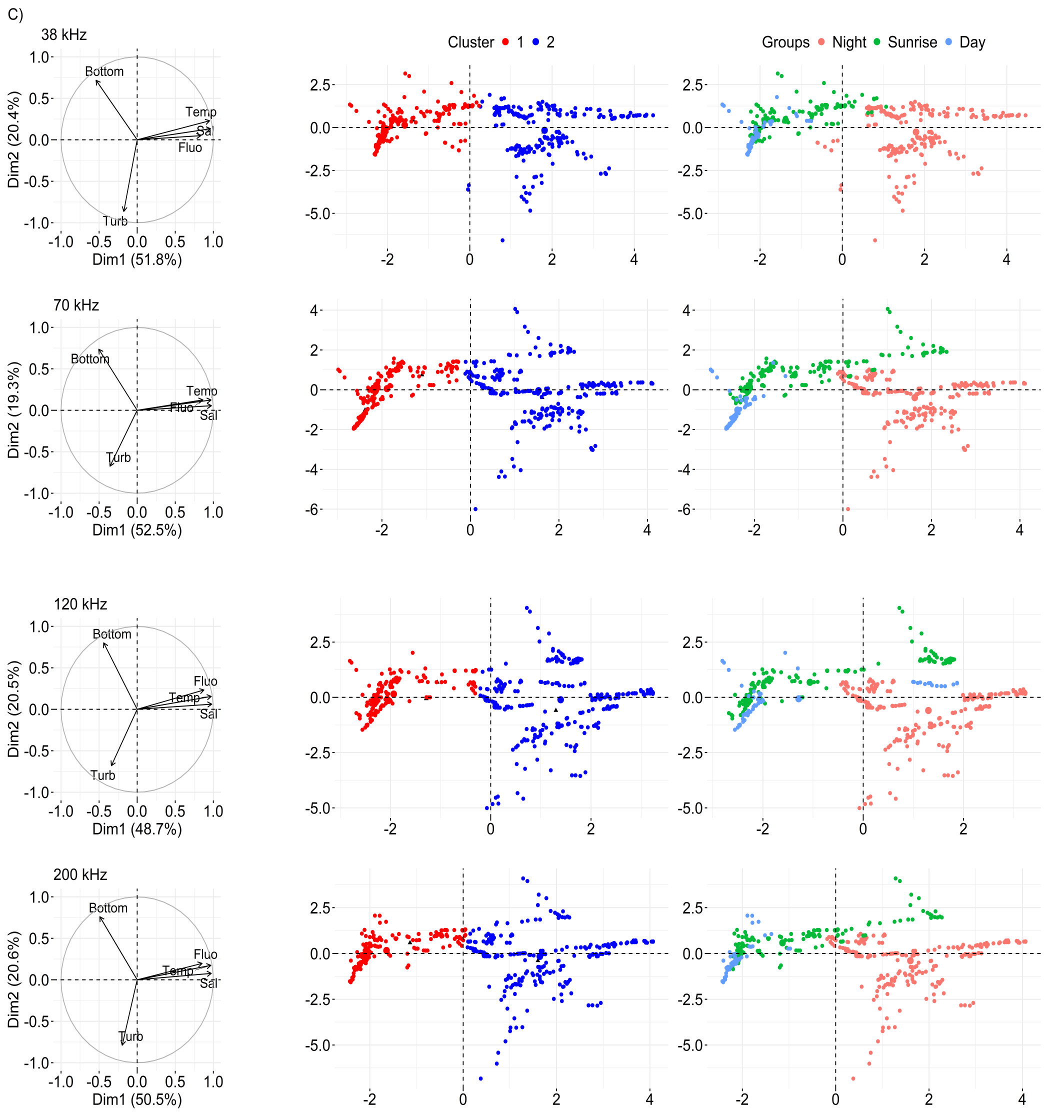
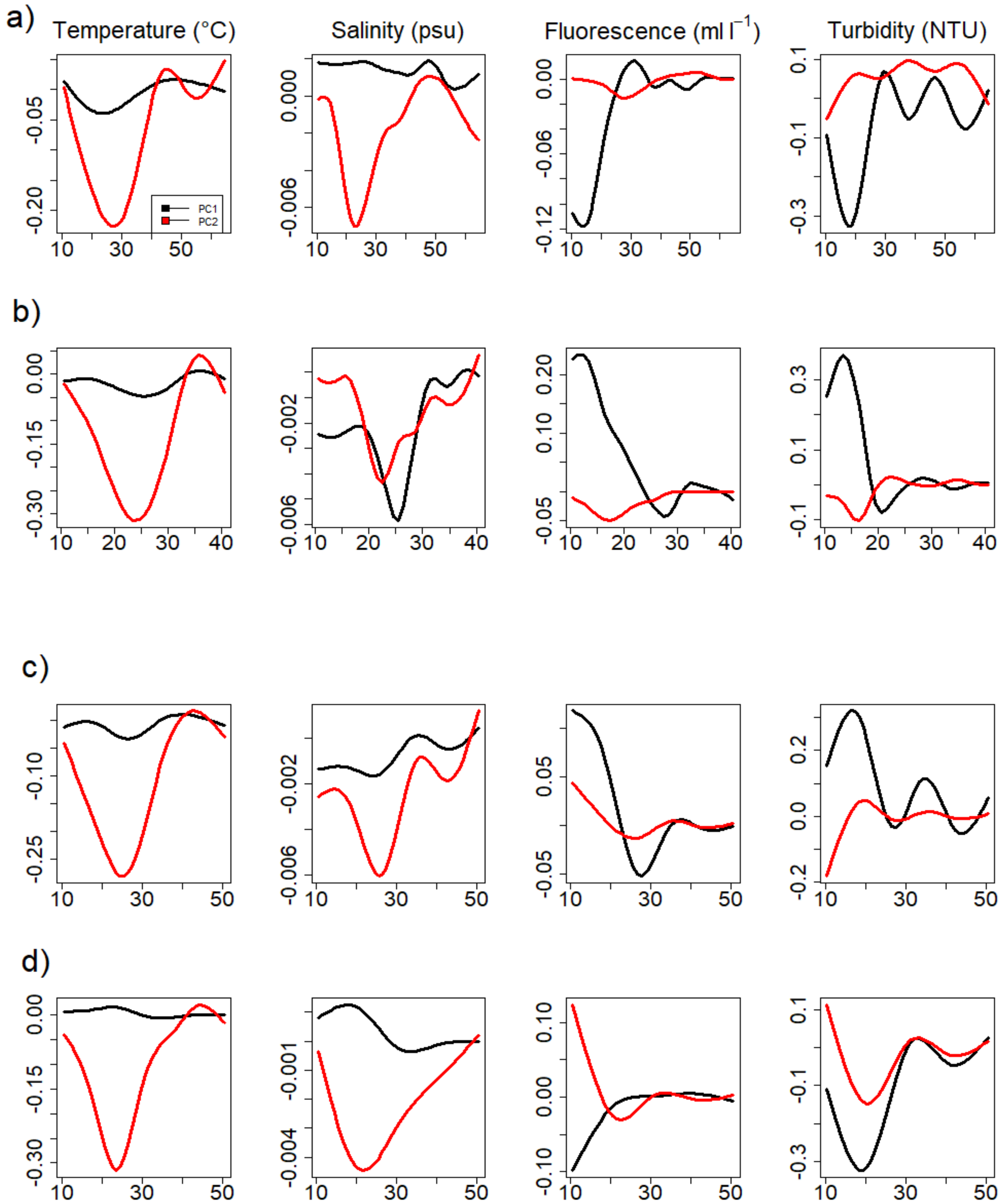
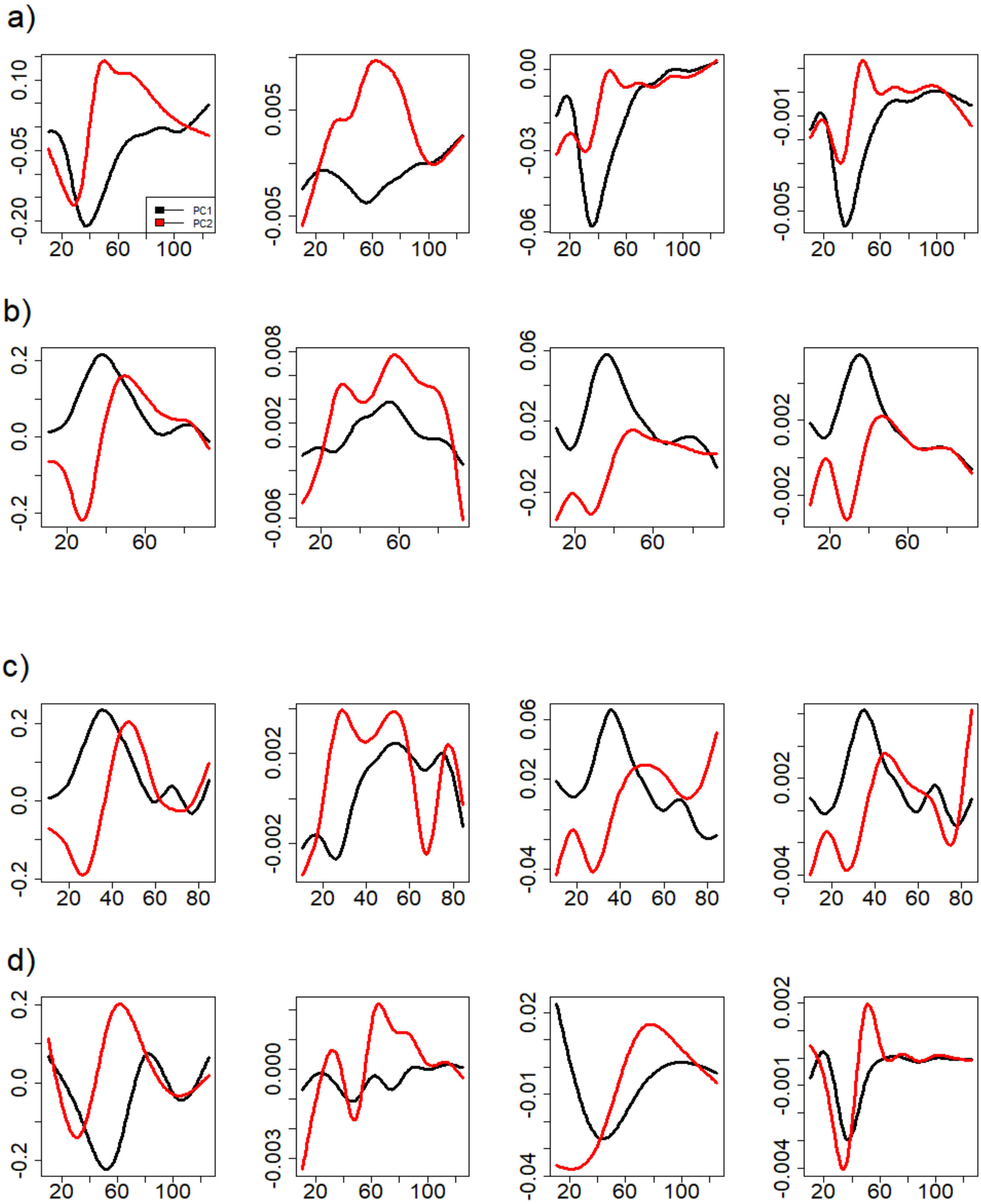


Fig. S3: Principal Component Analysis (PCA: PC1 on x-axis and PC2 on y-axis) followed by classification (CAH) (red: Cluster 1; blue: Cluster 2) of the mean environmental parameters (sea temperature, fluorescence, turbidity, and salinity) measured within the minimum and maximum depths of the sound scattering layer (SSL) at different frequencies; 38, 70, 120, and 200 kHz and bottom depth, grouped by diel period (day, sunset, night and sunrise) over Senegalese waters (A: southern continental shelf; B: southern high sea and C: northern continental shelf) during the AWA sea survey.

A)


a)
Temperature (°C)
Salinity (psu)
Fluorescence (ml l^{-1})
Turbidity (NTU)
PC1
PC2
b)
c)
d)

B)



C)

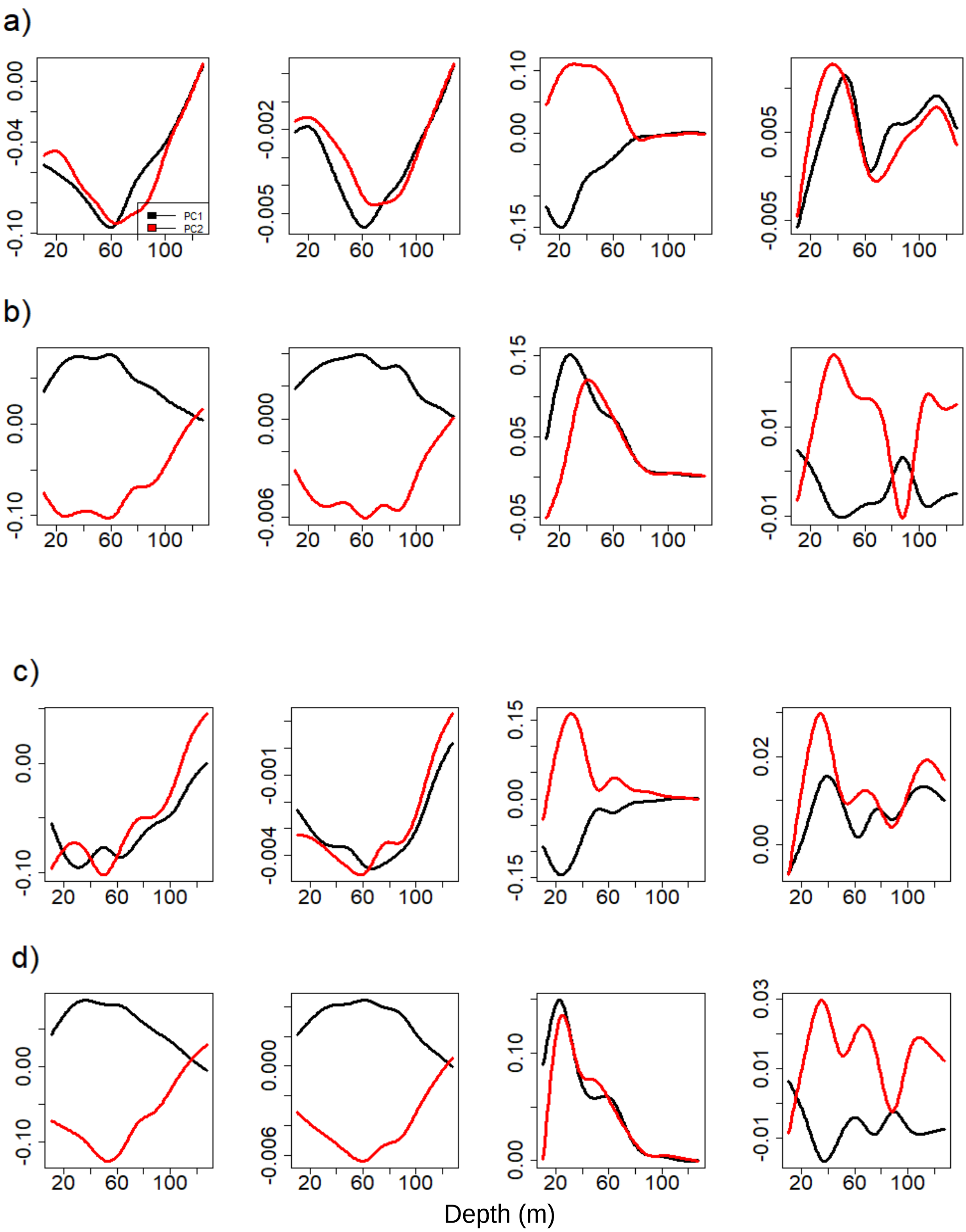
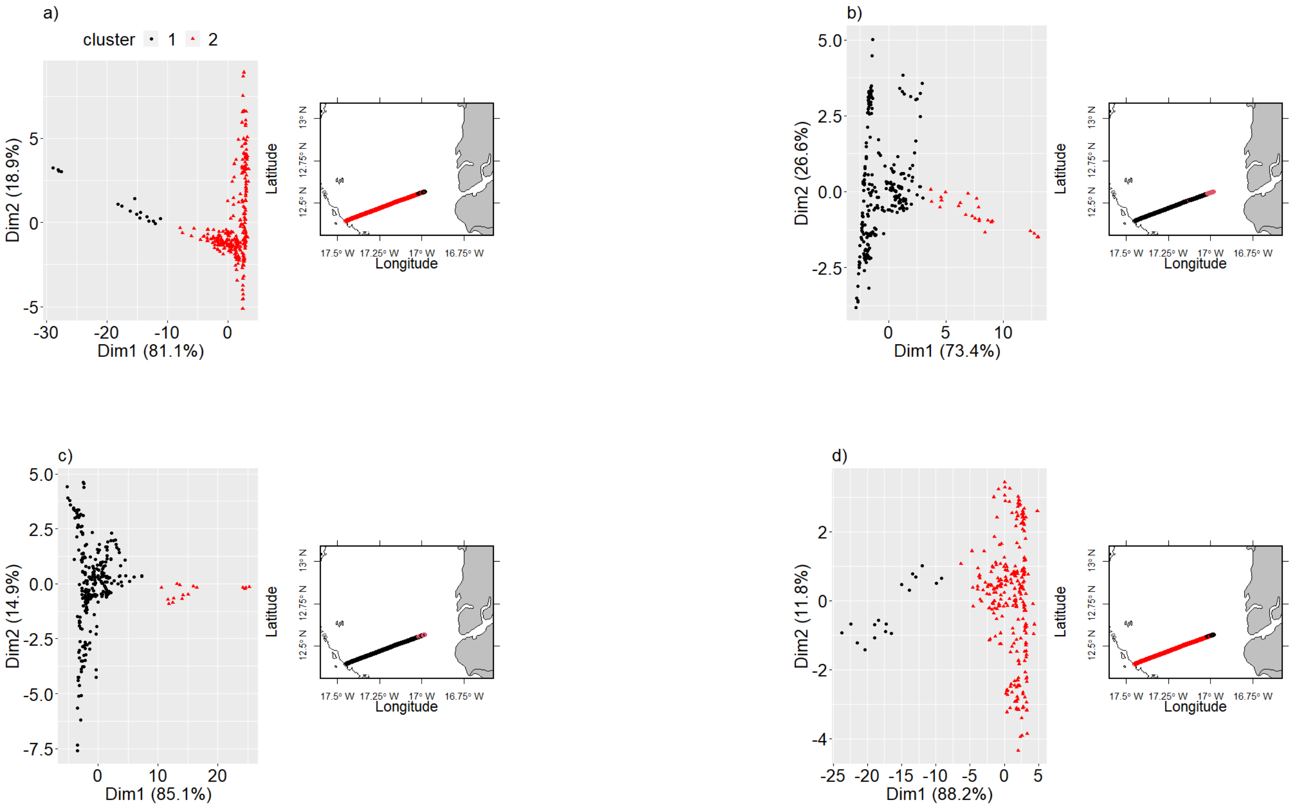
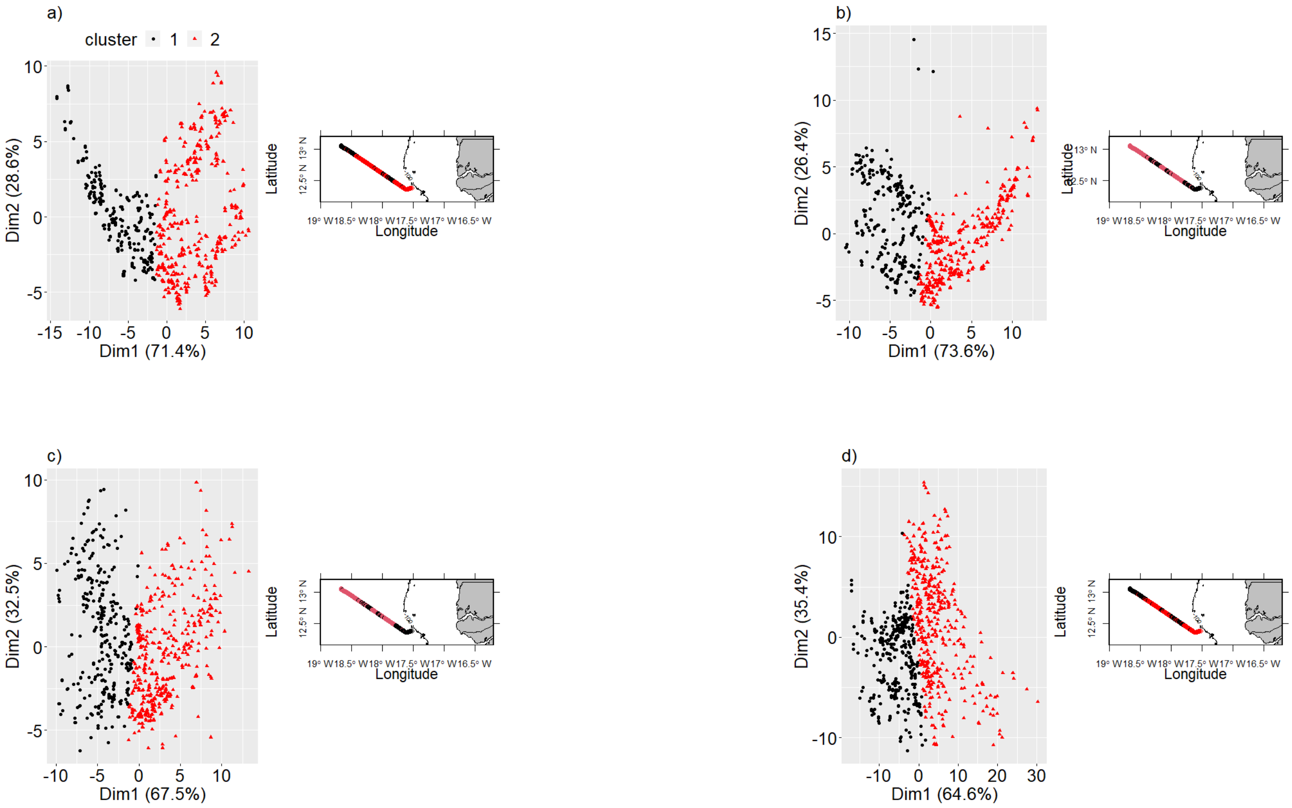


Fig. S4: Multivariate Functional Principal Component Analysis (MFPCA) of oceanographic condition (sea temperature (in °C), salinity (in psu), fluorescence (in ml l^{-1}), turbidity (in NTU)) along the depths) measured between the minimum and maximum depths of the layers at four frequencies. Representation of the two main functional components (black : first component (PC1); red : second component (PC2)) over Senegalese waters (A: south continental shelf; B: south high sea and C: north continental shelf of the AWA sea survey), observed at various frequencies: (a) 38 , (b) 70 ,(c) 120 and (d) 200 kHz.

A)


a)
cluster • 1 ▲ 2
Dim2 (18.9%)
Dim1 (81.1%)
Latitude
Longitude
b)
Dim2 (26.6%)
Dim1 (73.4%)
Latitude
Longitude
c)
Dim2 (14.9%)
Dim1 (85.1%)
Latitude
Longitude
d)
Dim2 (11.8%)
Dim1 (88.2%)
Latitude
Longitude

B)


a)
cluster • 1 ▲ 2
Dim2 (28.6%)
Dim1 (71.4%)
Latitude
Longitude
b)
Dim2 (26.4%)
Dim1 (73.6%)
Latitude
Longitude
c)
Dim2 (32.5%)
Dim1 (67.5%)
Latitude
Longitude
d)
Dim2 (35.4%)
Dim1 (64.6%)
Latitude
Longitude

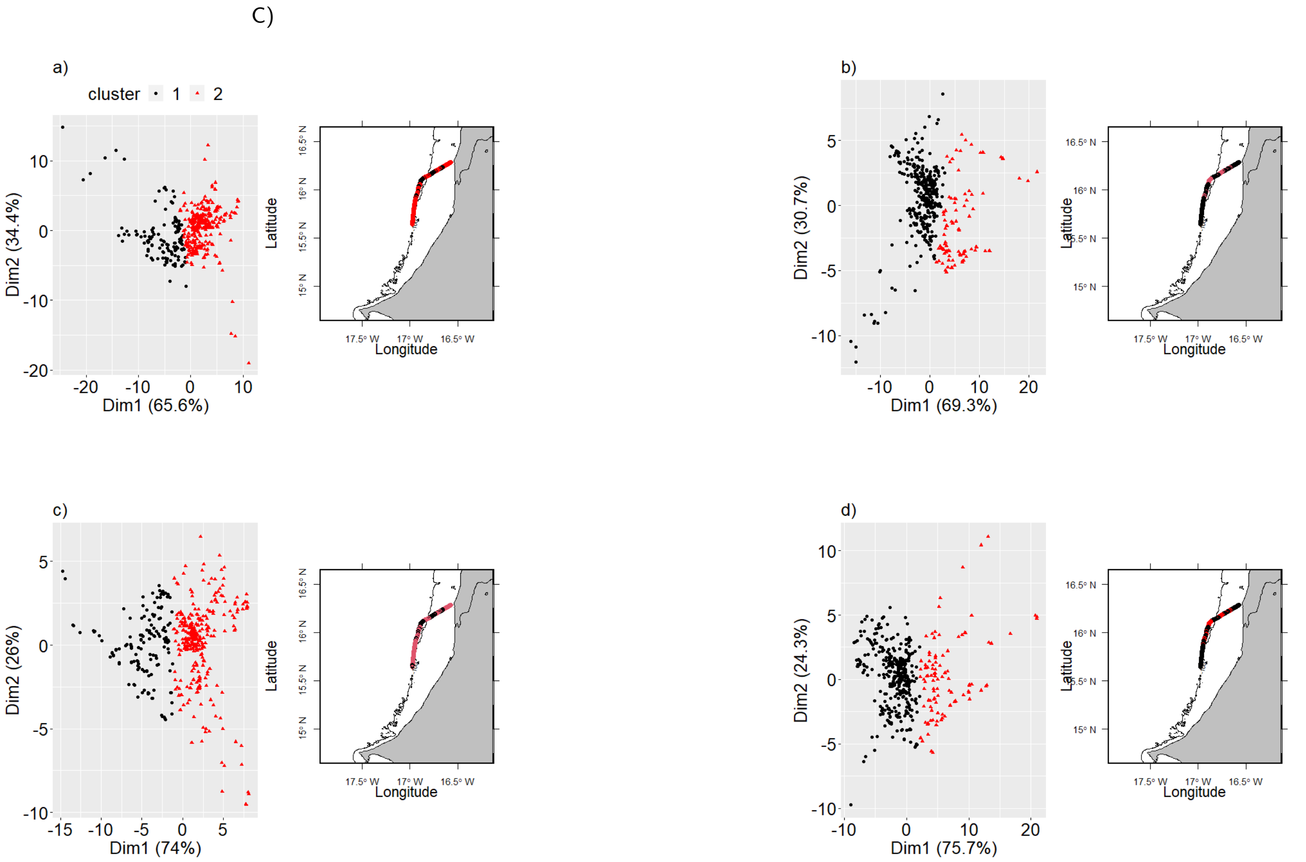
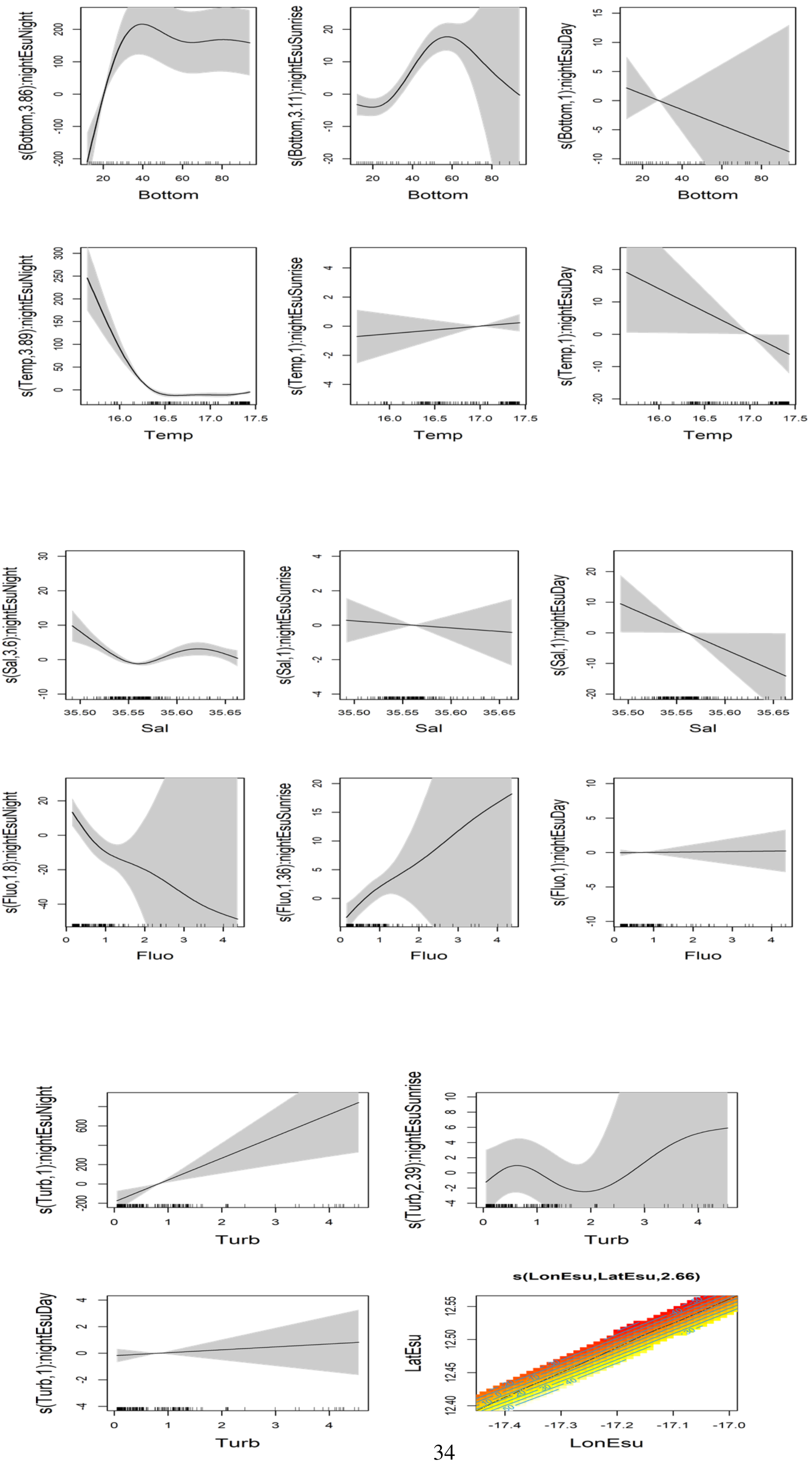


Fig. S5: Classification of functional principal component scores (derived from Multivariate functional principal component analysis MFPCA) (black: Cluster 1; red: Cluster 2) over Senegalese waters (A: south continental shelf; B: south high sea and C: north continental shelf of the AWA sea survey), observed at various frequencies: (a) 38, (b) 70, (c) 120 and (d) 200 kHz.

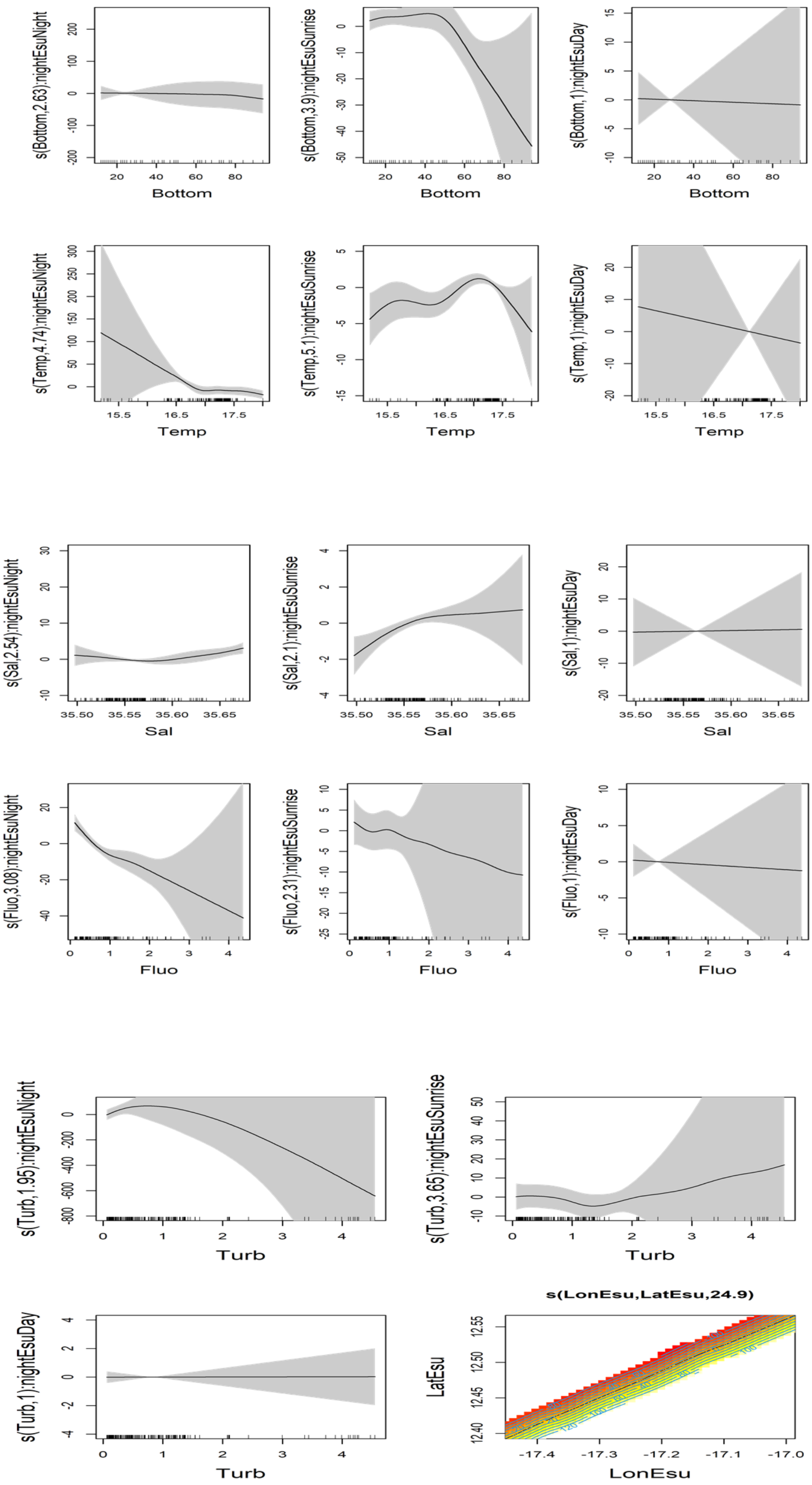
①

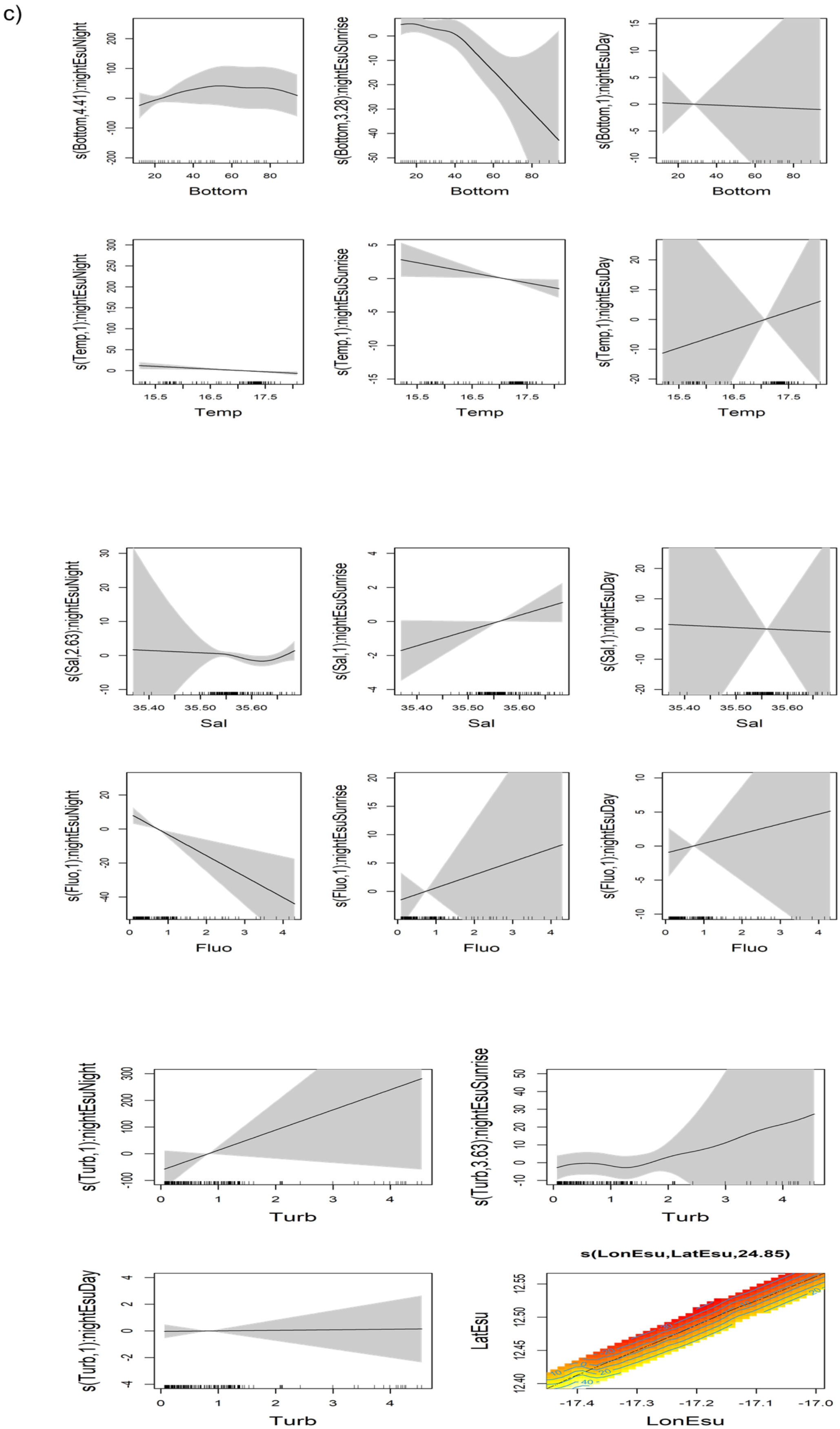
A)

a)

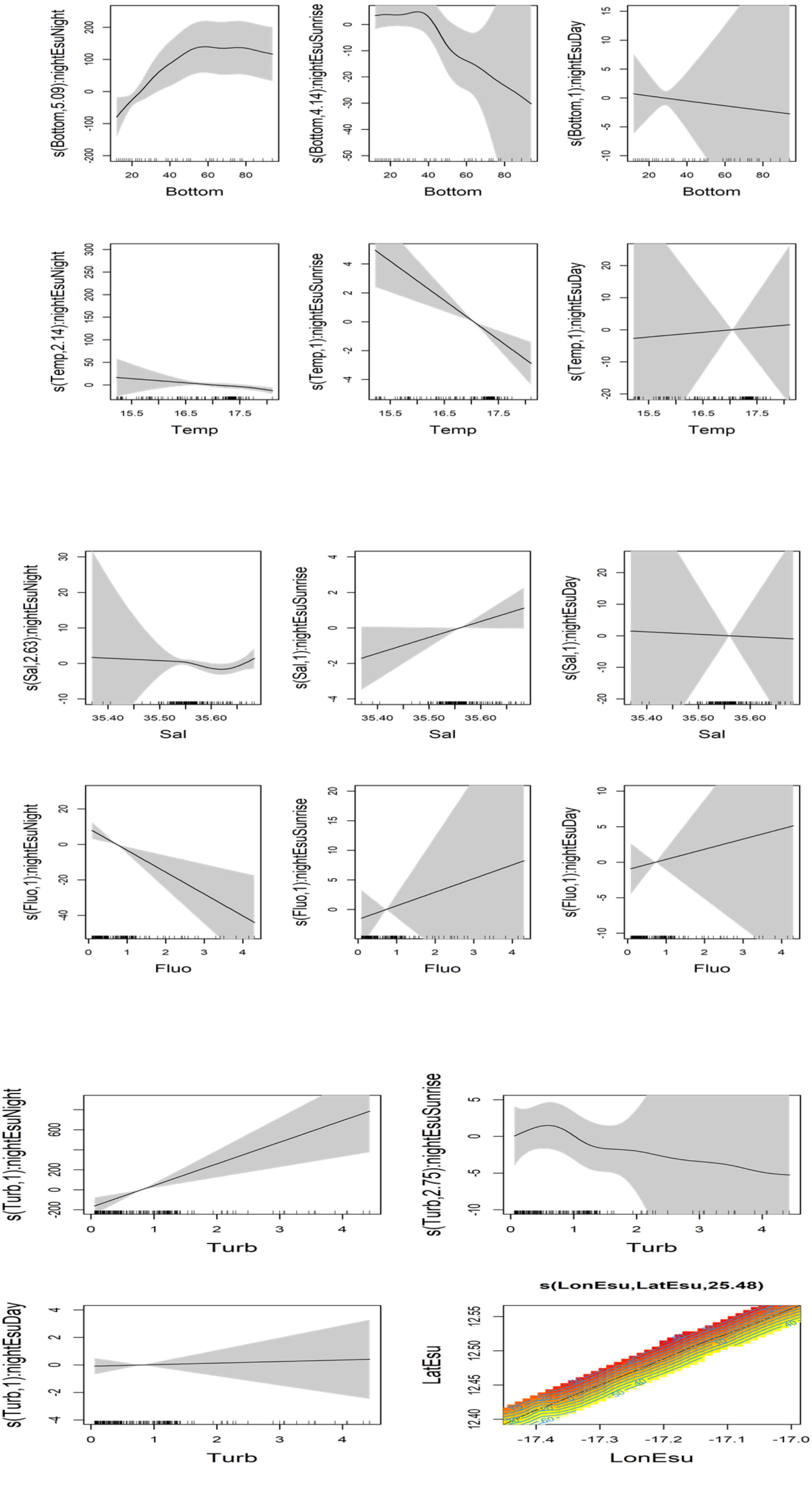

s(Bottom,3.86):nightEsuNight
s(Bottom,3.11):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,3.89):nightEsuNight
s(Temp,1):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,3.6):nightEsuNight
s(Sal,1):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1.8):nightEsuNight
s(Fluo,1.36):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,2.39):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,2.66)
LatEsu
LonEsu

b)


s(Bottom,2.63):nightEsuNight
s(Bottom,3.9):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,4.74):nightEsuNight
s(Temp,5.1):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,2.54):nightEsuNight
s(Sal,2.1):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,3.08):nightEsuNight
s(Fluo,2.31):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1.95):nightEsuNight
s(Turb,3.65):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,24.9)
LatEsu
LonEsu

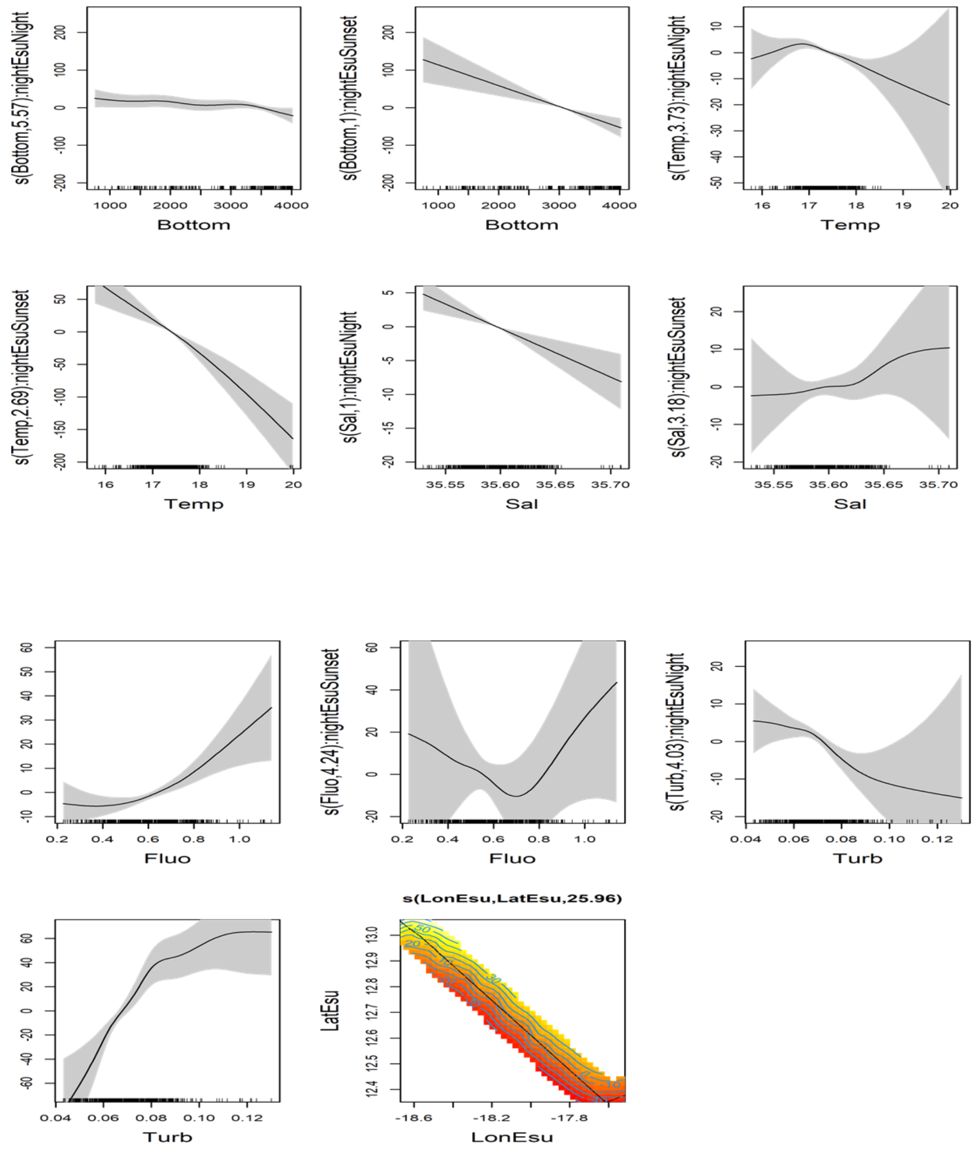

c)
s(Bottom,4.41):nightEsuNight
s(Bottom,3.28):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,1):nightEsuNight
s(Temp,1):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,2.63):nightEsuNight
s(Sal,1):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,1):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,3.63):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,24.85)
LatEsu
LonEsu

d)

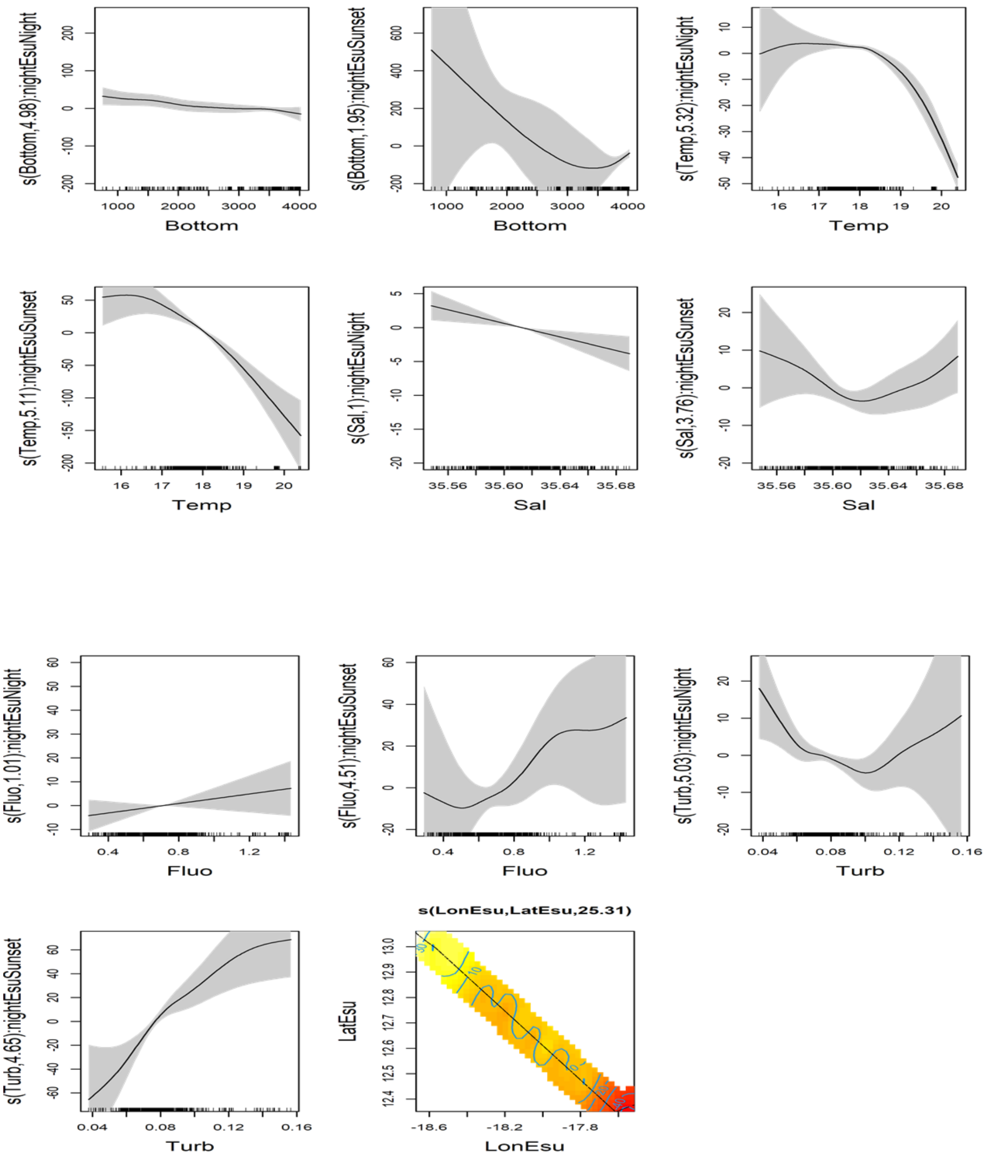

s(Bottom,5.09):nightEsuNight
s(Bottom,4.14):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,2.14):nightEsuNight
s(Temp,1):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,2.63):nightEsuNight
s(Sal,1):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,1):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,2.75):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,25.48)
LatEsu
LonEsu

B)

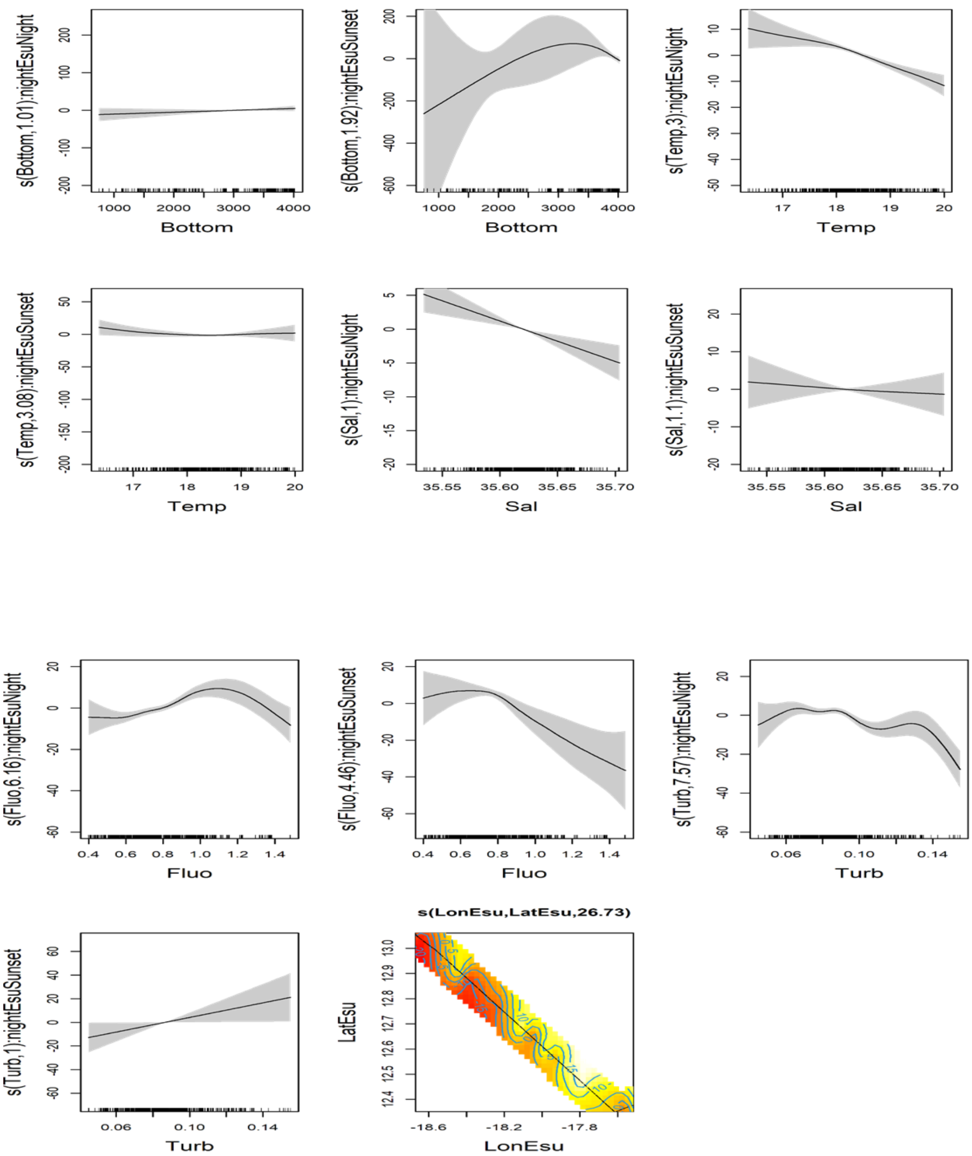
a)


s(Bottom,5.57):nightEsuNight
Bottom
s(Bottom,1):nightEsuSunset
Bottom
s(Temp,3.73):nightEsuNight
Temp
s(Temp,2.69):nightEsuSunset
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,3.18):nightEsuSunset
Sal
s(Fluo,3.63):nightEsuNight
Fluo
s(Fluo,4.24):nightEsuSunset
Fluo
s(Turb,4.03):nightEsuNight
Turb
s(Turb,6.53):nightEsuSunset
Turb
s(LonEsu,LatEsu,25.96)
LatEsu
LonEsu

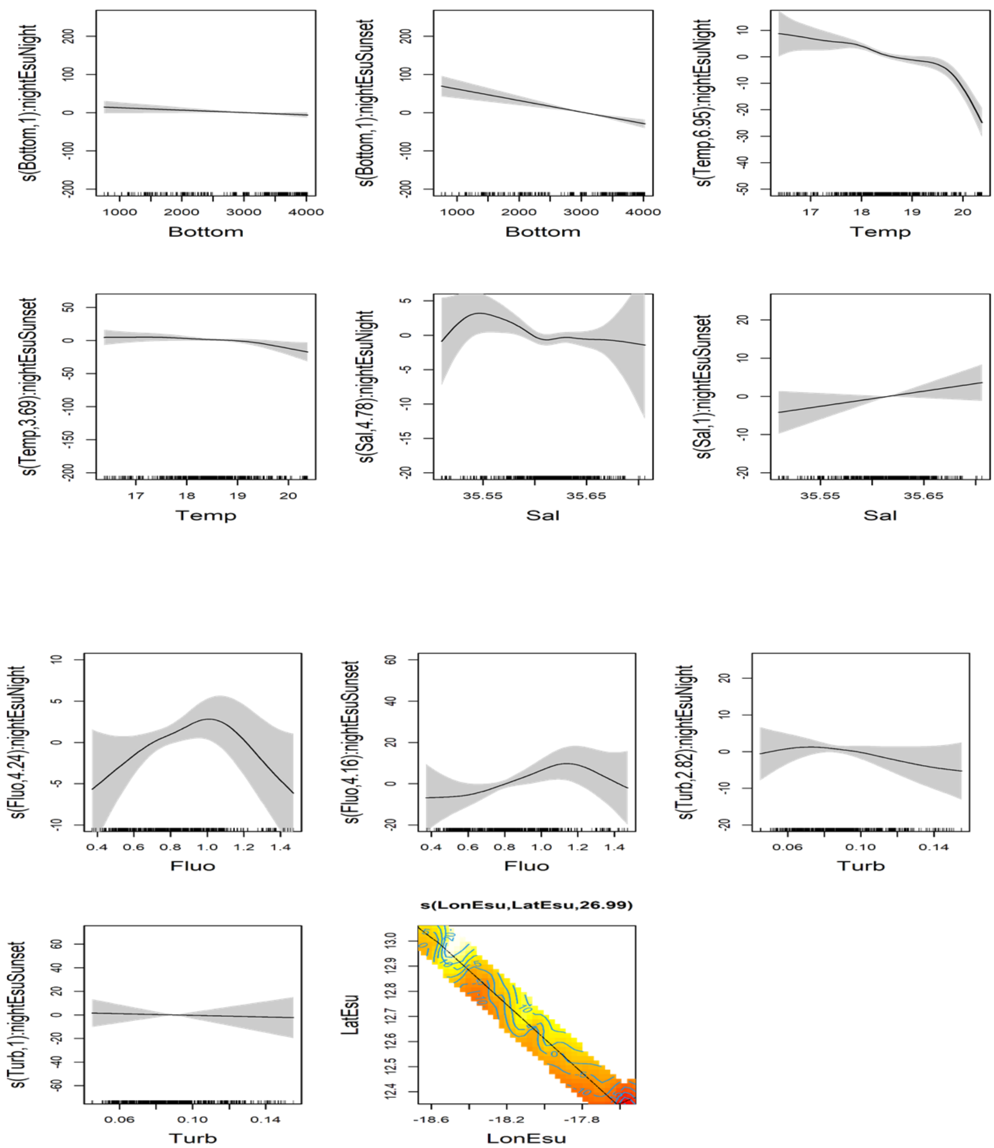
b)


s(Bottom,4.98):nightEsuNight
Bottom
s(Bottom,1.95):nightEsuSunset
Bottom
s(Temp,5.32):nightEsuNight
Temp
s(Temp,5.11):nightEsuSunset
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,3.76):nightEsuSunset
Sal
s(Fluo,1.01):nightEsuNight
Fluo
s(Fluo,4.51):nightEsuSunset
Fluo
s(Turb,5.03):nightEsuNight
Turb
s(Turb,4.65):nightEsuSunset
Turb
s(LonEsu,LatEsu,25.31)
LatEsu
LonEsu

c)

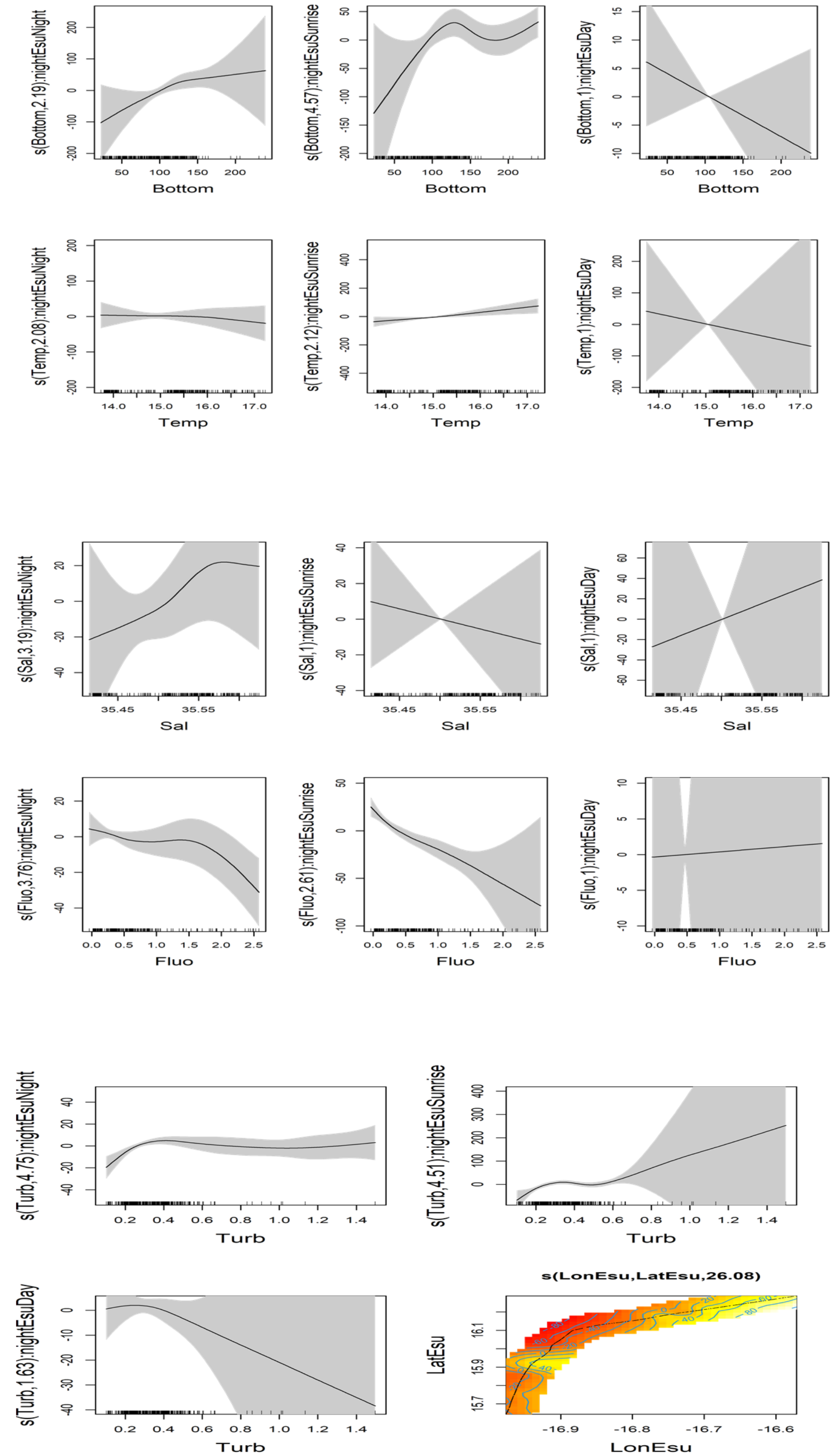

s(Bottom,1.01):nightEsuNight
Bottom
s(Bottom,1.92):nightEsuSunset
Bottom
s(Temp,3):nightEsuNight
Temp
s(Temp,3.08):nightEsuSunset
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,1.1):nightEsuSunset
Sal
s(Fluo,6.16):nightEsuNight
Fluo
s(Fluo,4.46):nightEsuSunset
Fluo
s(Turb,7.57):nightEsuNight
Turb
s(Turb,1):nightEsuSunset
Turb
s(LonEsu,LatEsu,26.73)
LatEsu
LonEsu

d)

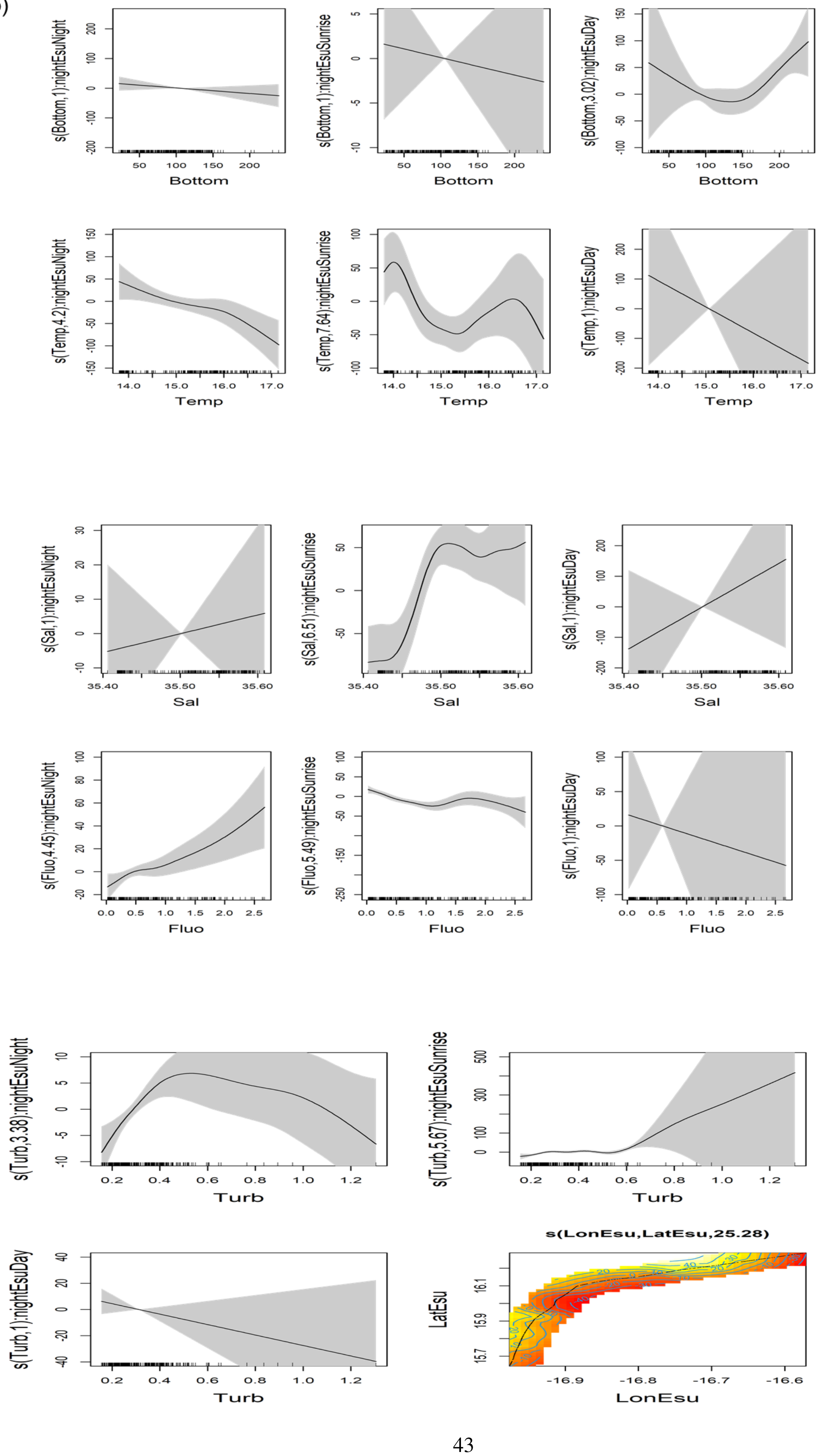

s(Bottom,1):nightEsuNight
Bottom
s(Bottom,1):nightEsuSunset
Bottom
s(Temp,6.95):nightEsuNight
Temp
s(Temp,3.69):nightEsuSunset
Temp
s(Sal,4.78):nightEsuNight
Sal
s(Sal,1):nightEsuSunset
Sal
s(Fluo,4.24):nightEsuNight
Fluo
s(Fluo,4.16):nightEsuSunset
Fluo
s(Turb,2.82):nightEsuNight
Turb
s(Turb,1):nightEsuSunset
Turb
s(LonEsu,LatEsu,26.99)
LatEsu
LonEsu

C)

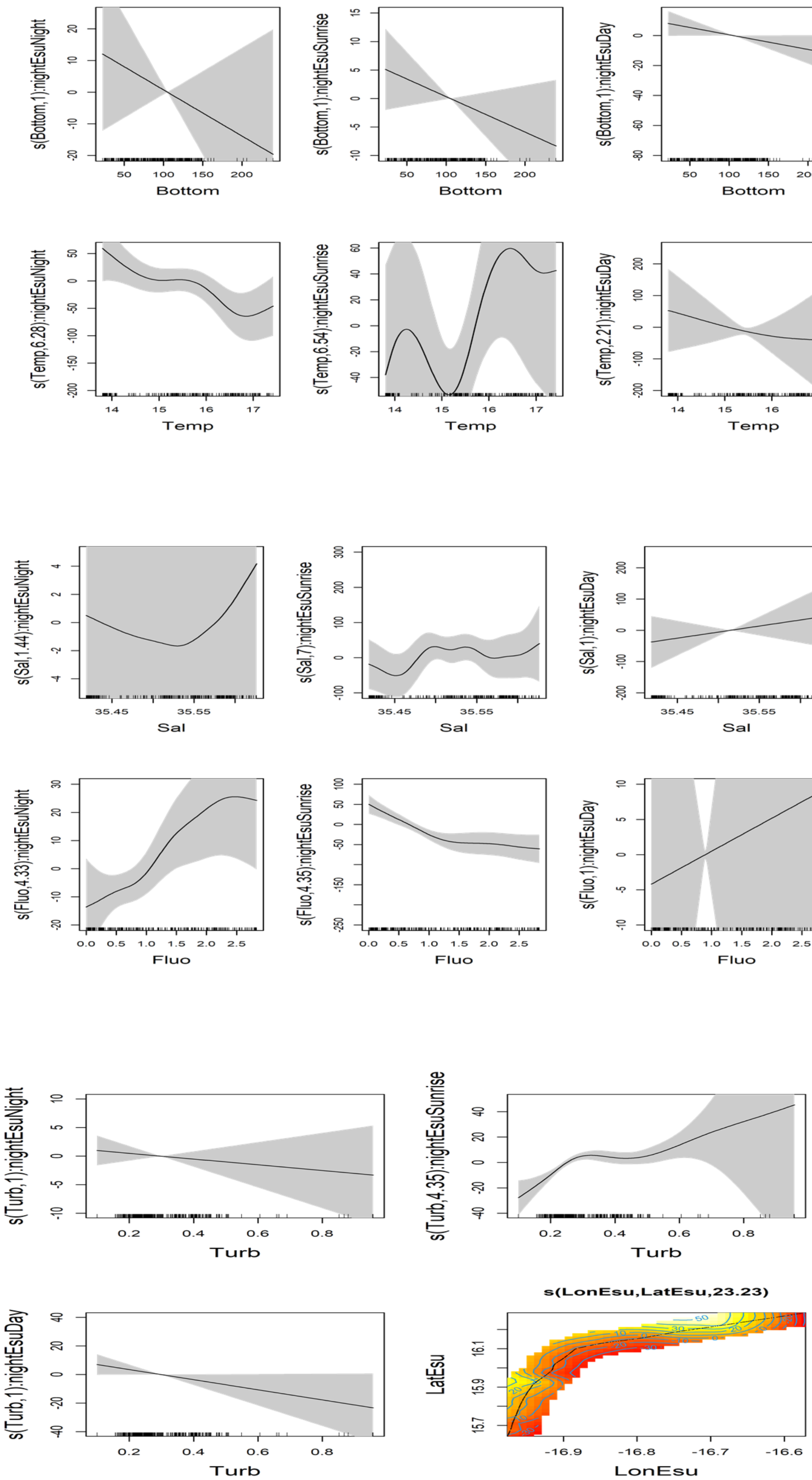
a)


s(Bottom,2.19):nightEsuNight
s(Bottom,4.57):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,2.08):nightEsuNight
s(Temp,2.12):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,3.19):nightEsuNight
s(Sal,1):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,3.76):nightEsuNight
s(Fluo,2.61):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,4.75):nightEsuNight
s(Turb,4.51):nightEsuSunrise
s(Turb,1.63):nightEsuDay
Turb
s(LonEsu,LatEsu,26.08)
LatEsu
LonEsu

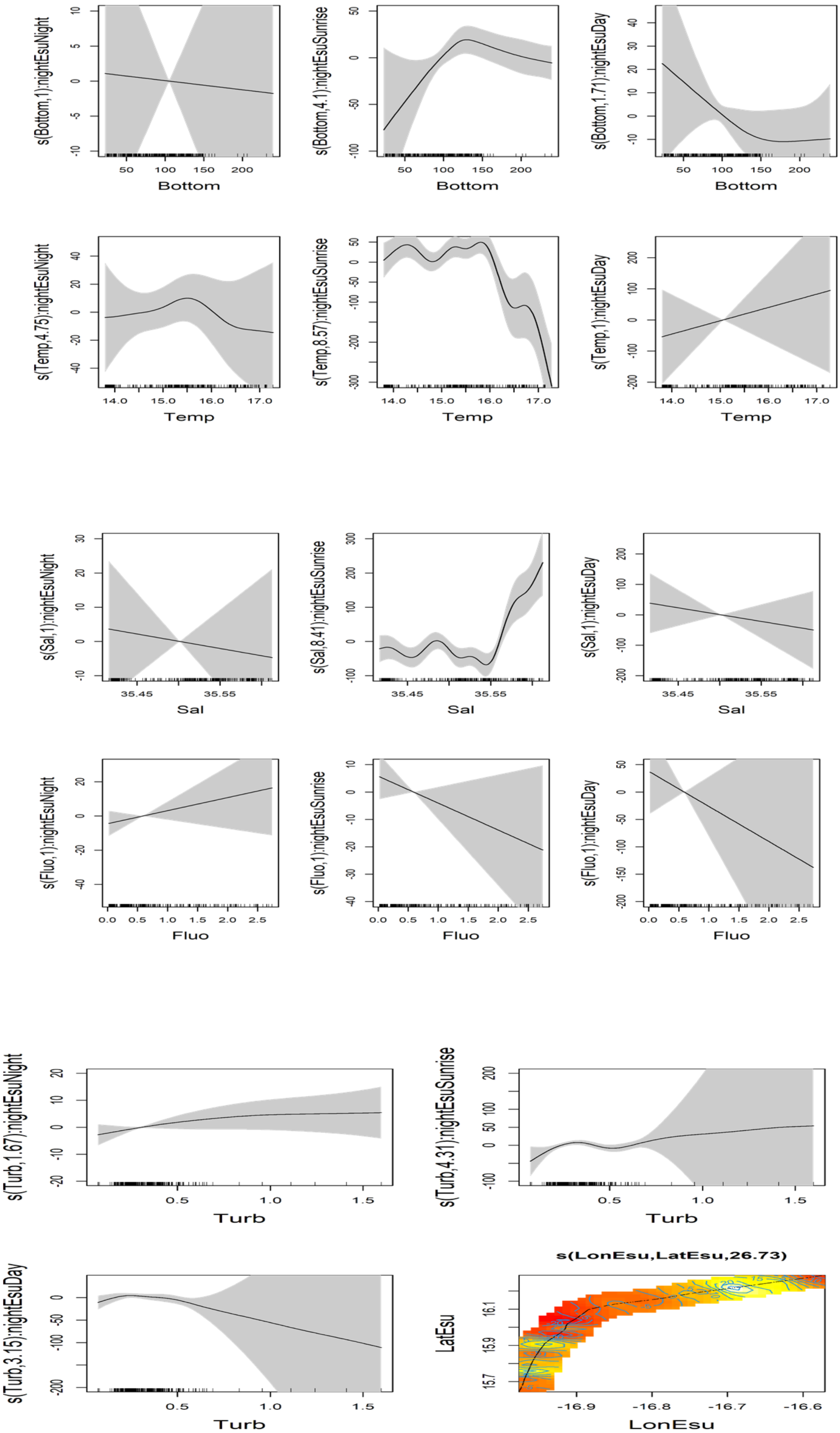
b)


s(Bottom,1):nightEsuNight
Bottom
s(Bottom,1):nightEsuSunrise
Bottom
s(Bottom,3.02):nightEsuDay
Bottom
s(Temp,4.2):nightEsuNight
Temp
s(Temp,7.64):nightEsuSunrise
Temp
s(Temp,1):nightEsuDay
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,6.51):nightEsuSunrise
Sal
s(Sal,1):nightEsuDay
Sal
s(Fluo,4.45):nightEsuNight
Fluo
s(Fluo,5.49):nightEsuSunrise
Fluo
s(Fluo,1):nightEsuDay
Fluo
s(Turb,3.38):nightEsuNight
Turb
s(Turb,5.67):nightEsuSunrise
Turb
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,25.28)
LatEsu
LonEsu

c)


s(Bottom,1):nightEsuNight
s(Bottom,1):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,6.28):nightEsuNight
s(Temp,6.54):nightEsuSunrise
s(Temp,2.21):nightEsuDay
Temp
s(Sal,1.44):nightEsuNight
s(Sal,7):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,4.33):nightEsuNight
s(Fluo,4.35):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,4.35):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,23.23)
LatEsu
LonEsu

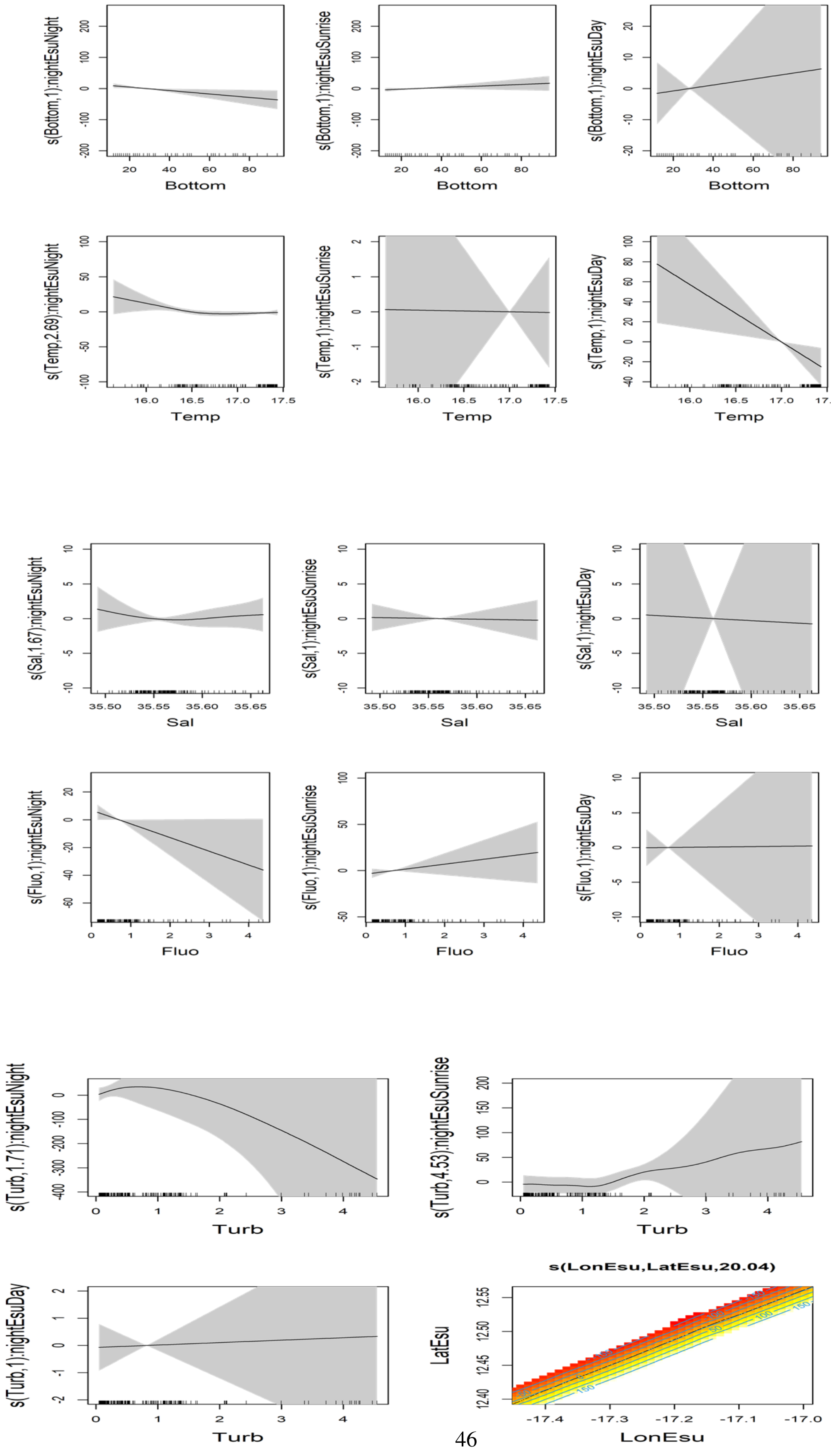
d)


s(Bottom,1):nightEsuNight
s(Bottom,4.1):nightEsuSunrise
s(Bottom,1.71):nightEsuDay
Bottom
s(Temp,4.75):nightEsuNight
s(Temp,8.57):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,1):nightEsuNight
s(Sal,8.41):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,1):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1.67):nightEsuNight
s(Turb,4.31):nightEsuSunrise
s(Turb,3.15):nightEsuDay
Turb
s(LonEsu,LatEsu,26.73)
LatEsu
LonEsu

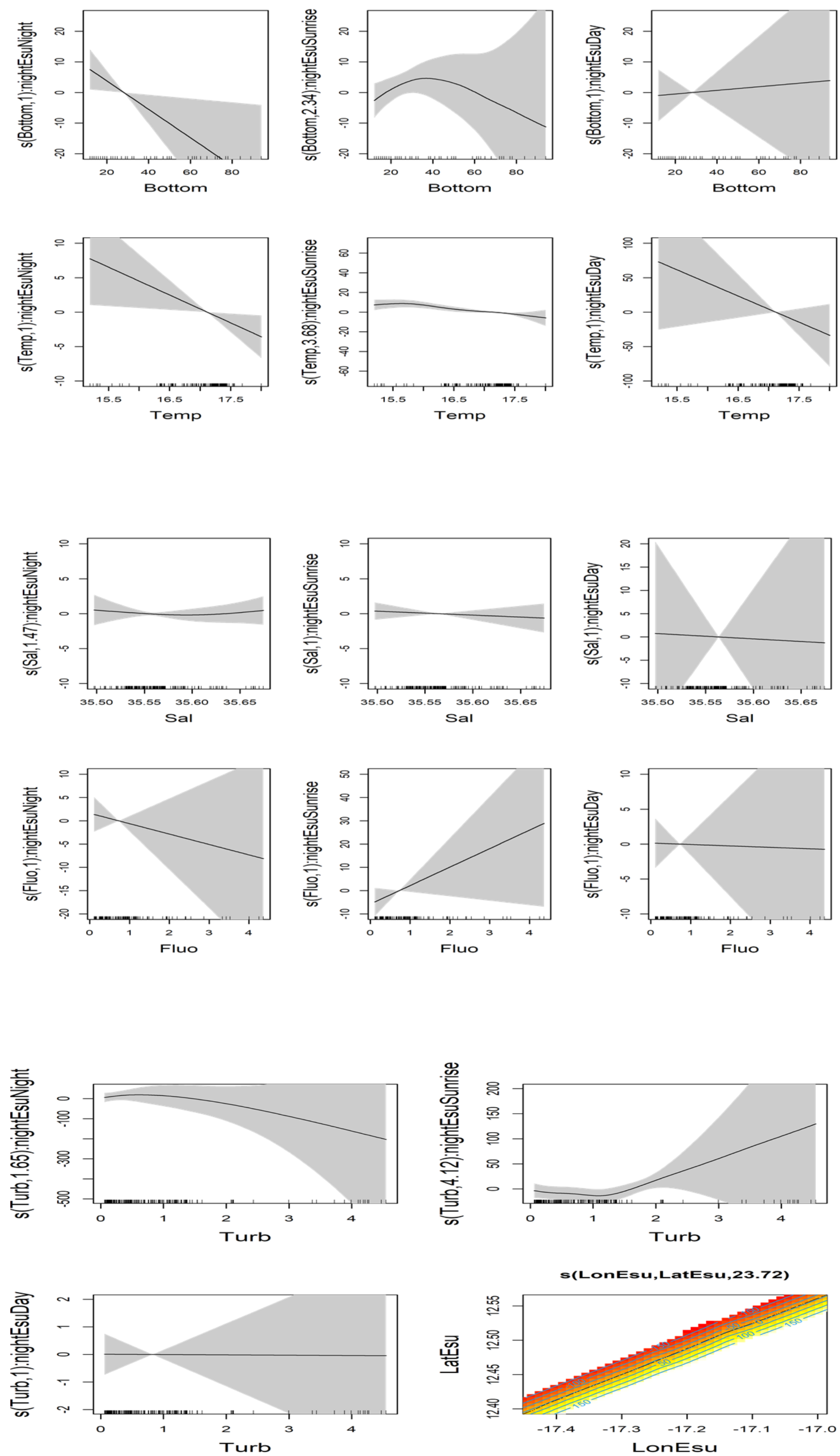
②

A)

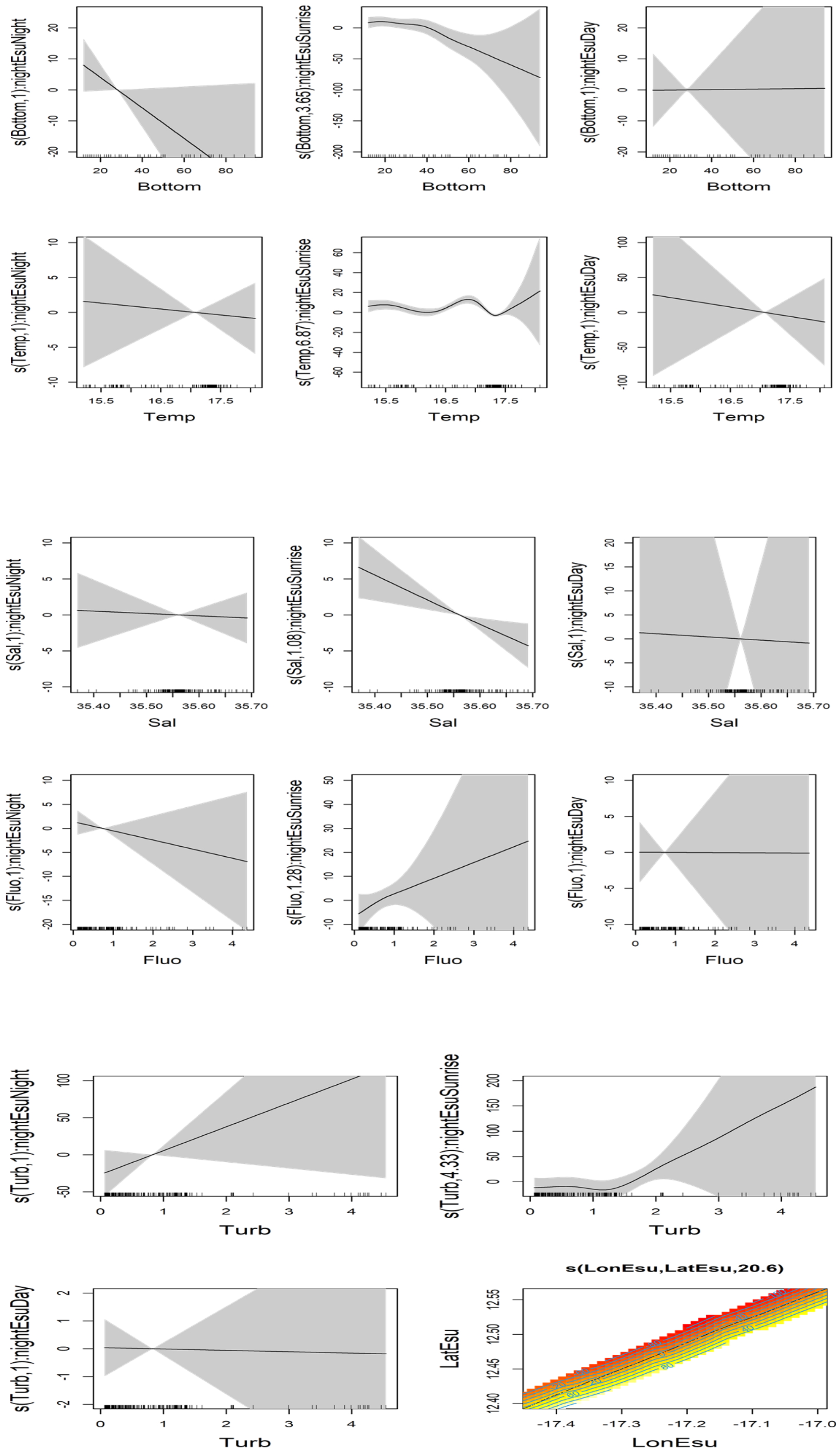
a)


s(Bottom,1):nightEsuNight
Bottom
s(Bottom,1):nightEsuSunrise
Bottom
s(Bottom,1):nightEsuDay
Bottom
s(Temp,2.69):nightEsuNight
Temp
s(Temp,1):nightEsuSunrise
Temp
s(Temp,1):nightEsuDay
Temp
s(Sal,1.67):nightEsuNight
Sal
s(Sal,1):nightEsuSunrise
Sal
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
Fluo
s(Fluo,1):nightEsuSunrise
Fluo
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1.71):nightEsuNight
Turb
s(Turb,4.53):nightEsuSunrise
Turb
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,20.04)
LatEsu
LonEsu

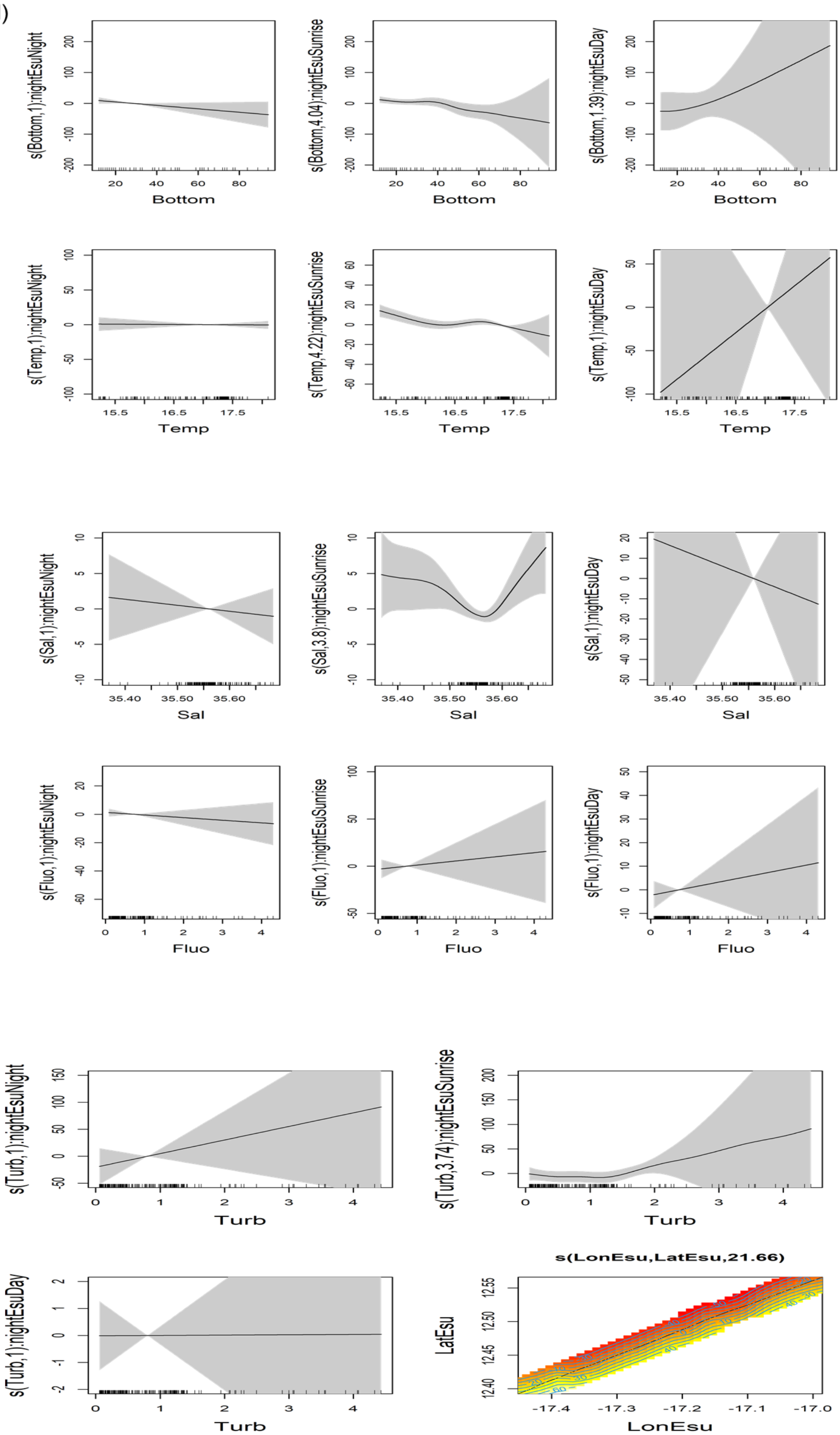
b)


s(Bottom,1):nightEsuNight
s(Bottom,2.34):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,1):nightEsuNight
s(Temp,3.68):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,1.47):nightEsuNight
s(Sal,1):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,1):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1.65):nightEsuNight
s(Turb,4.12):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,23.72)
LatEsu
LonEsu

c)

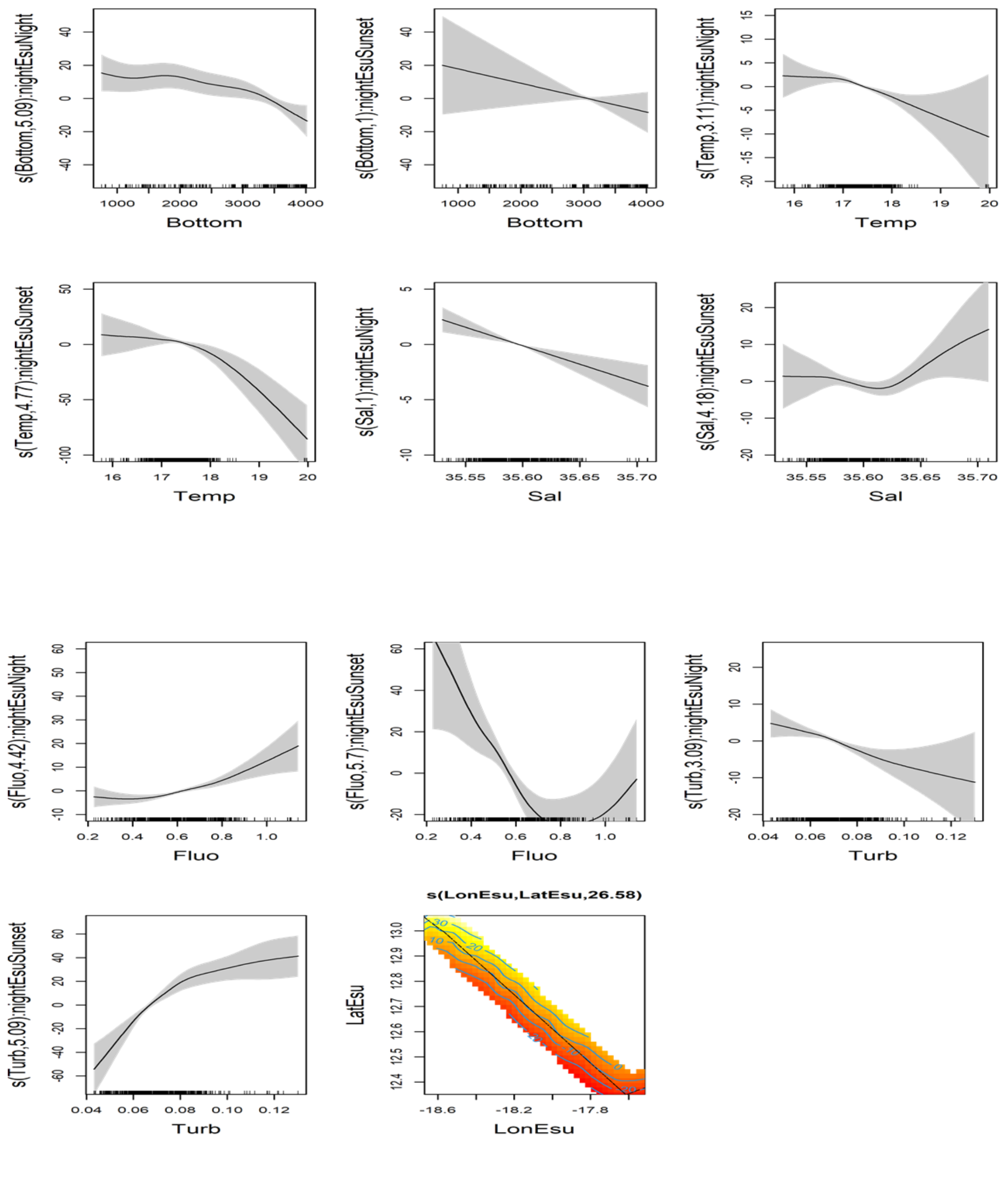

s(Bottom,1):nightEsuNight
s(Bottom,3.65):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,1):nightEsuNight
s(Temp,6.87):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,1):nightEsuNight
s(Sal,1.08):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,1.28):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,4.33):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,20.6)
LatEsu
LonEsu

d)

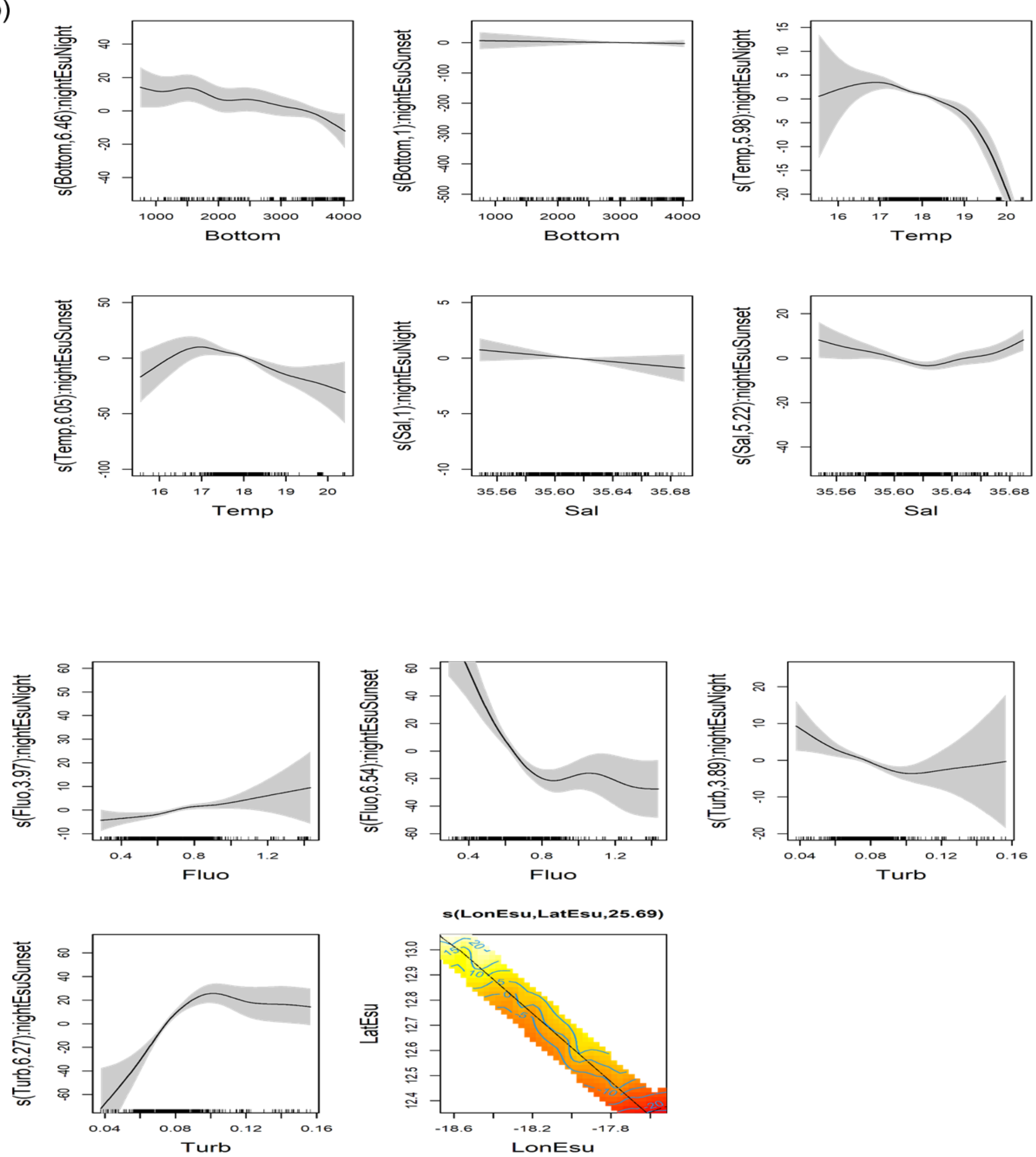

s(Bottom,1):nightEsuNight
s(Bottom,4.04):nightEsuSunrise
s(Bottom,1.39):nightEsuDay
Bottom
s(Temp,1):nightEsuNight
s(Temp,4.22):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,1):nightEsuNight
s(Sal,3.8):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,1):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,3.74):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,21.66)
LatEsu
LonEsu

B)

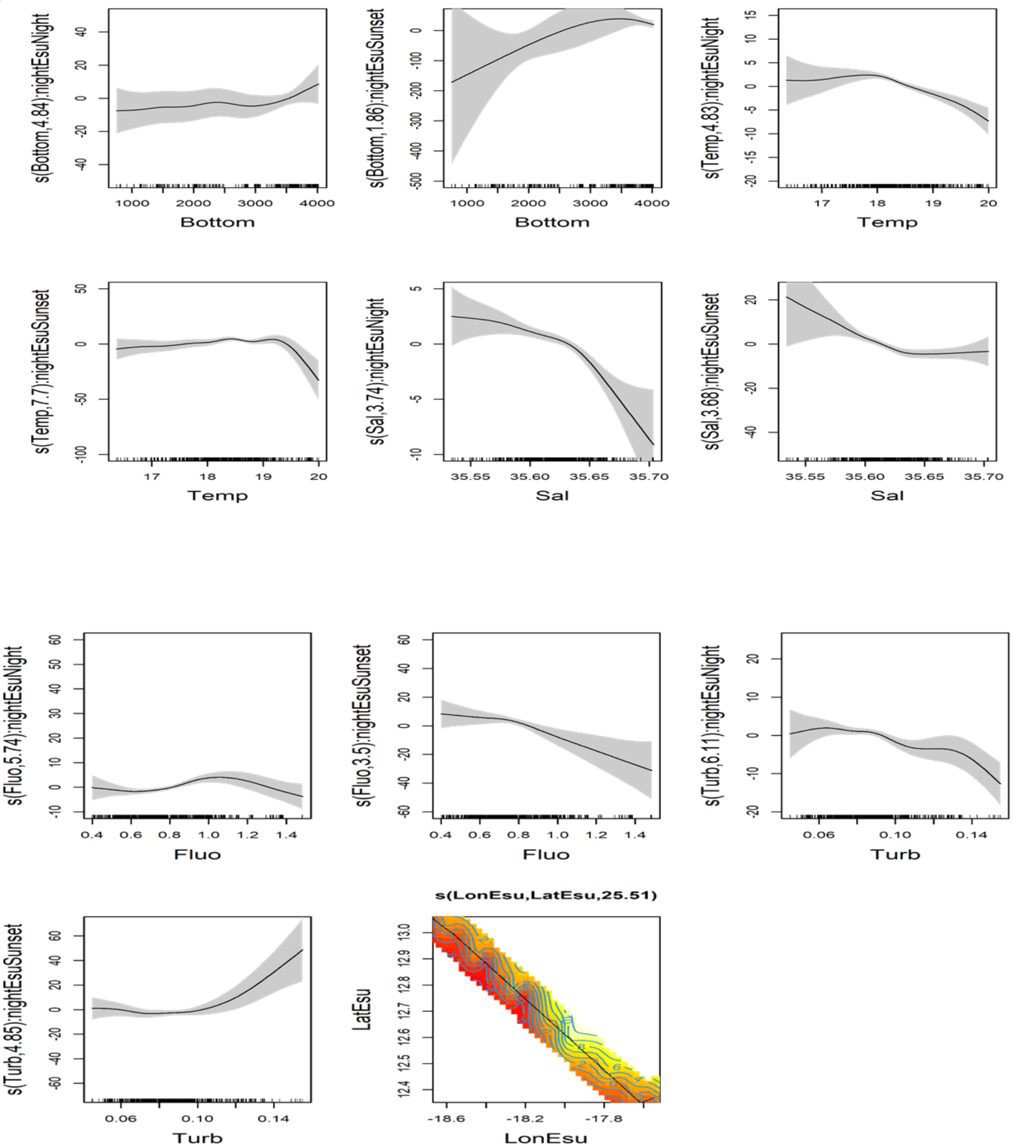
a)


s(Bottom,5.09):nightEsuNight
Bottom
s(Bottom,1):nightEsuSunset
Bottom
s(Temp,3.11):nightEsuNight
Temp
s(Temp,4.77):nightEsuSunset
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,4.18):nightEsuSunset
Sal
s(Fluo,4.42):nightEsuNight
Fluo
s(Fluo,5.7):nightEsuSunset
Fluo
s(Turb,3.09):nightEsuNight
Turb
s(Turb,5.09):nightEsuSunset
Turb
s(LonEsu,LatEsu,26.58)
LatEsu
LonEsu

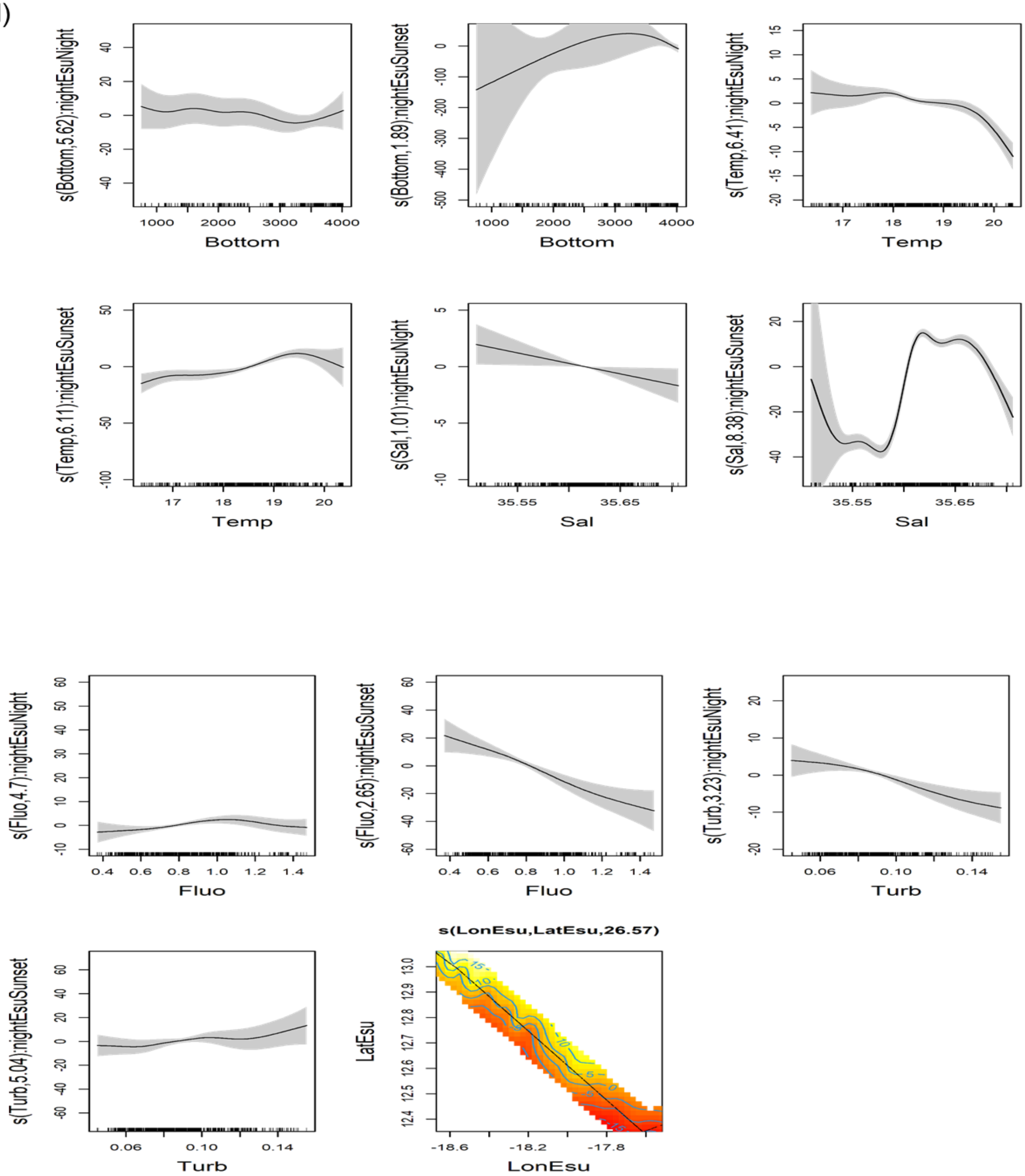
b)


s(Bottom,6.46):nightEsuNight
Bottom
s(Bottom,1):nightEsuSunset
Bottom
s(Temp,5.98):nightEsuNight
Temp
s(Temp,6.05):nightEsuSunset
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,5.22):nightEsuSunset
Sal
s(Fluo,3.97):nightEsuNight
Fluo
s(Fluo,6.54):nightEsuSunset
Fluo
s(Turb,3.89):nightEsuNight
Turb
s(Turb,6.27):nightEsuSunset
Turb
s(LonEsu,LatEsu,25.69)
LatEsu
LonEsu

c)

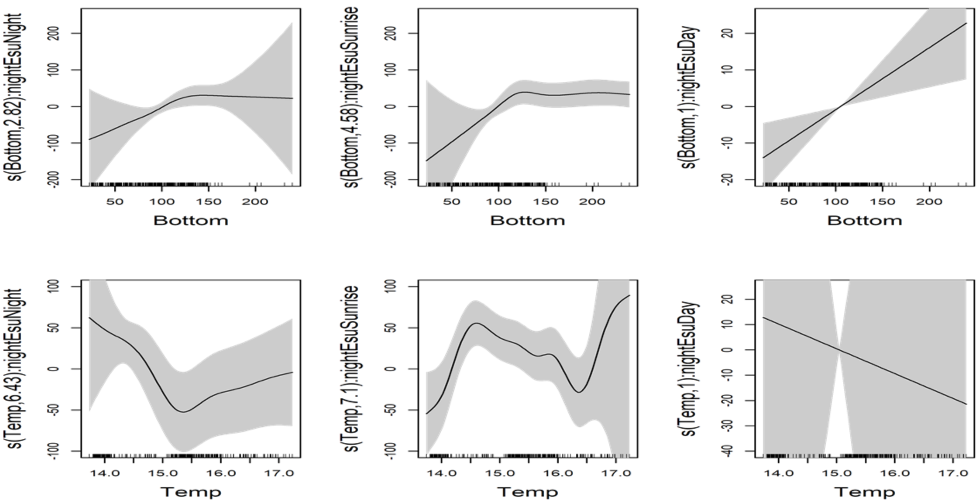

s(Bottom,4.84):nightEsuNight
Bottom
s(Bottom,1.86):nightEsuSunset
Bottom
s(Temp,4.83):nightEsuNight
Temp
s(Temp,7.7):nightEsuSunset
Temp
s(Sal,3.74):nightEsuNight
Sal
s(Sal,3.68):nightEsuSunset
Sal
s(Fluo,5.74):nightEsuNight
Fluo
s(Fluo,3.5):nightEsuSunset
Fluo
s(Turb,6.11):nightEsuNight
Turb
s(Turb,4.85):nightEsuSunset
Turb
s(LonEsu,LatEsu,25.51)
LatEsu
LonEsu

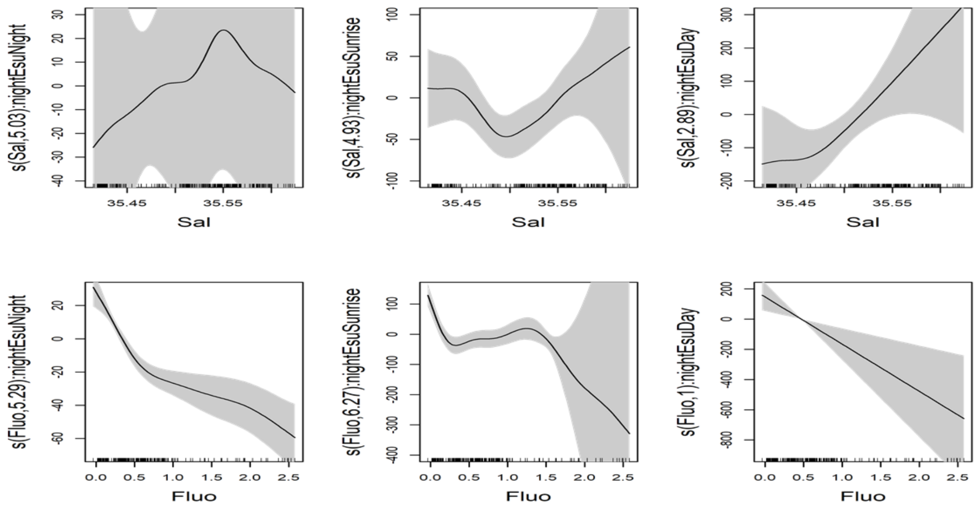
d)

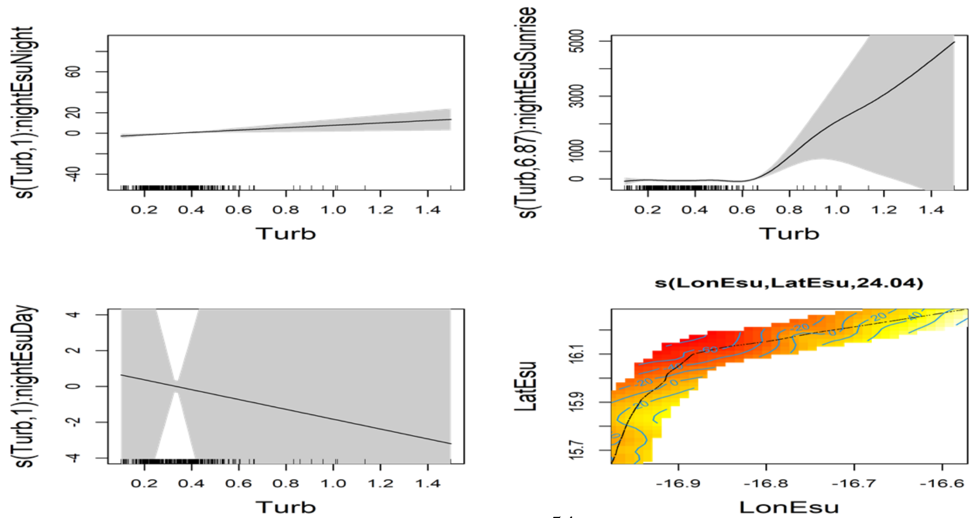

s(Bottom,5.62):nightEsuNight
Bottom
s(Bottom,1.89):nightEsuSunset
Bottom
s(Temp,6.41):nightEsuNight
Temp
s(Temp,6.11):nightEsuSunset
Temp
s(Sal,1.01):nightEsuNight
Sal
s(Sal,8.38):nightEsuSunset
Sal
s(Fluo,4.7):nightEsuNight
Fluo
s(Fluo,2.65):nightEsuSunset
Fluo
s(Turb,3.23):nightEsuNight
Turb
s(Turb,5.04):nightEsuSunset
Turb
s(LonEsu,LatEsu,26.57)
LatEsu
LonEsu

C)

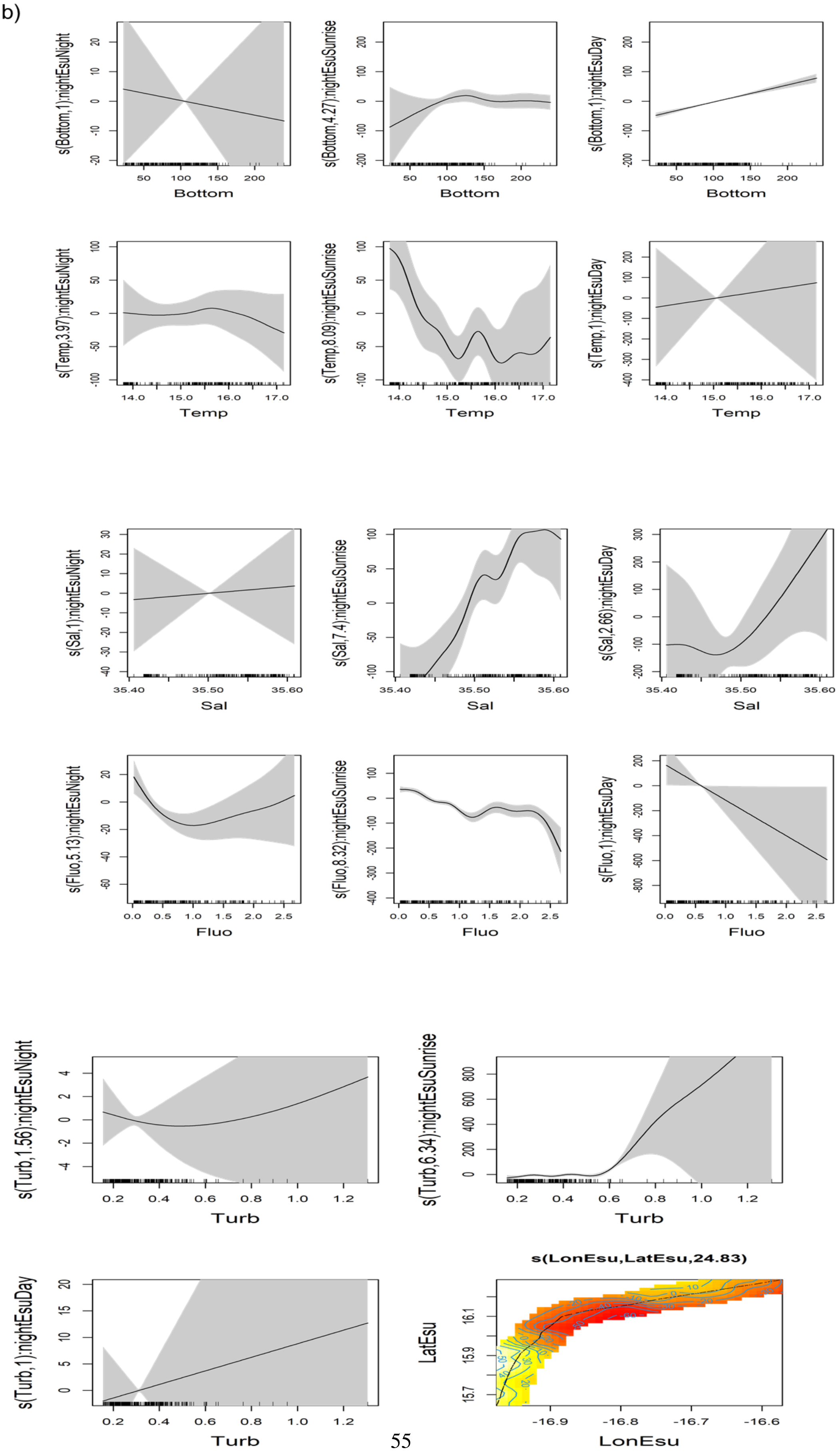
a)


s(Bottom,2.82):nightEsuNight
s(Bottom,4.58):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,6.43):nightEsuNight
s(Temp,7.1):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp

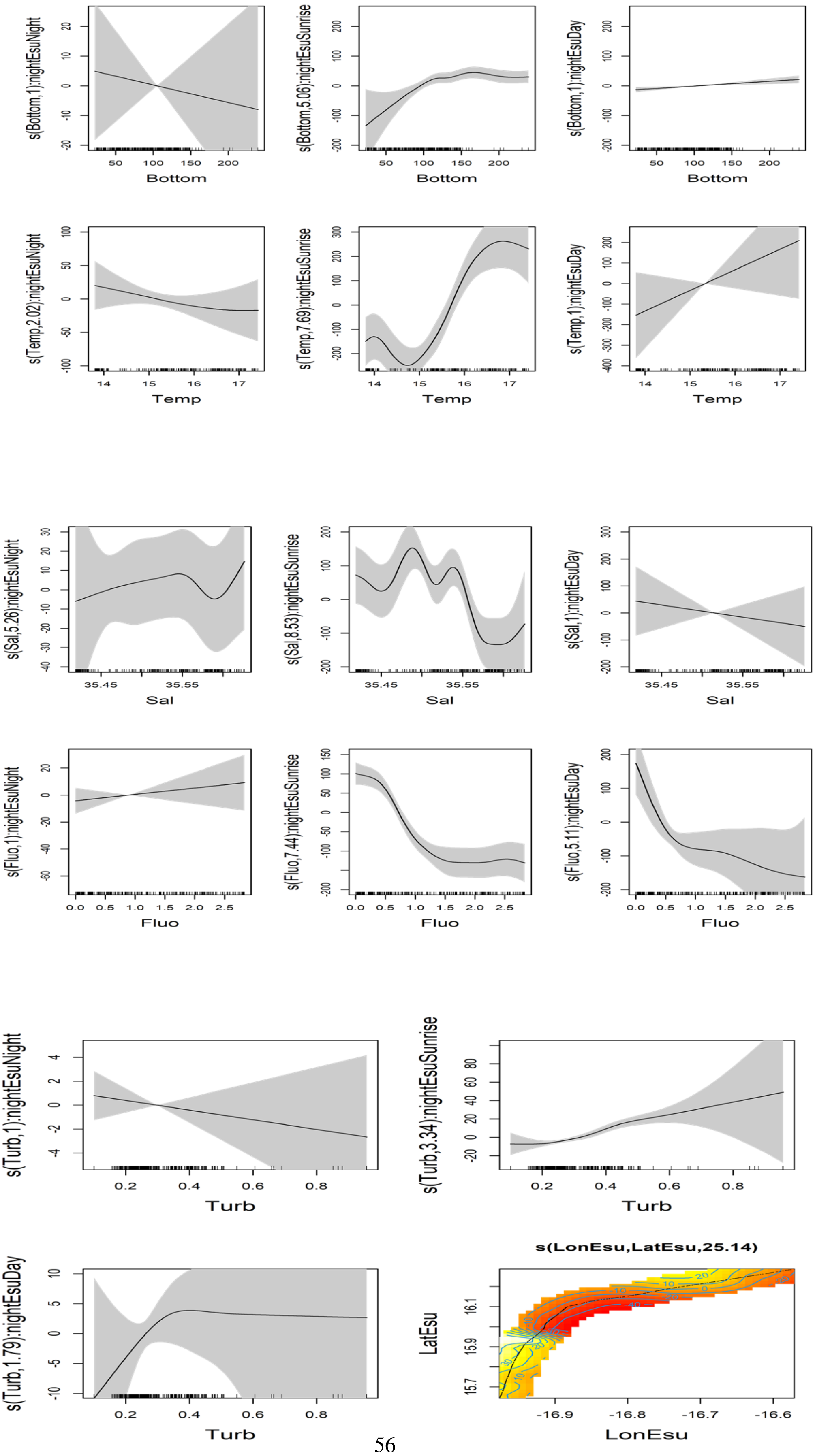

s(Sal,5.03):nightEsuNight
s(Sal,4.93):nightEsuSunrise
s(Sal,2.89):nightEsuDay
Sal
s(Fluo,5.29):nightEsuNight
s(Fluo,6.27):nightEsuSunrise
s(Fluo,1):nightEsuDay
Fluo


s(Turb,1):nightEsuNight
s(Turb,6.87):nightEsuSunrise
s(Turb,1):nightEsuDay
Turb
s(LonEsu,LatEsu,24.04)
LatEsu
LonEsu

b)


s(Bottom,1):nightEsuNight
Bottom
s(Bottom,4.27):nightEsuSunrise
Bottom
s(Bottom,1):nightEsuDay
Bottom
s(Temp,3.97):nightEsuNight
Temp
s(Temp,8.09):nightEsuSunrise
Temp
s(Temp,1):nightEsuDay
Temp
s(Sal,1):nightEsuNight
Sal
s(Sal,7.4):nightEsuSunrise
Sal
s(Sal,2.66):nightEsuDay
Sal
s(Fluo,5.13):nightEsuNight
Fluo
s(Fluo,8.32):nightEsuSunrise
Fluo
s(Fluo,1):nightEsuDay
Fluo
s(Turb,1.56):nightEsuNight
Turb
s(Turb,6.34):nightEsuSunrise
Turb
s(LonEsu,LatEsu,24.83)
LatEsu
LonEsu
s(Turb,1):nightEsuDay
Turb

c)


s(Bottom,1):nightEsuNight
s(Bottom,5.06):nightEsuSunrise
s(Bottom,1):nightEsuDay
Bottom
s(Temp,2.02):nightEsuNight
s(Temp,7.69):nightEsuSunrise
s(Temp,1):nightEsuDay
Temp
s(Sal,5.26):nightEsuNight
s(Sal,8.53):nightEsuSunrise
s(Sal,1):nightEsuDay
Sal
s(Fluo,1):nightEsuNight
s(Fluo,7.44):nightEsuSunrise
s(Fluo,5.11):nightEsuDay
Fluo
s(Turb,1):nightEsuNight
s(Turb,3.34):nightEsuSunrise
s(Turb,1.79):nightEsuDay
Turb
s(LonEsu,LatEsu,25.14)
LatEsu
LonEsu

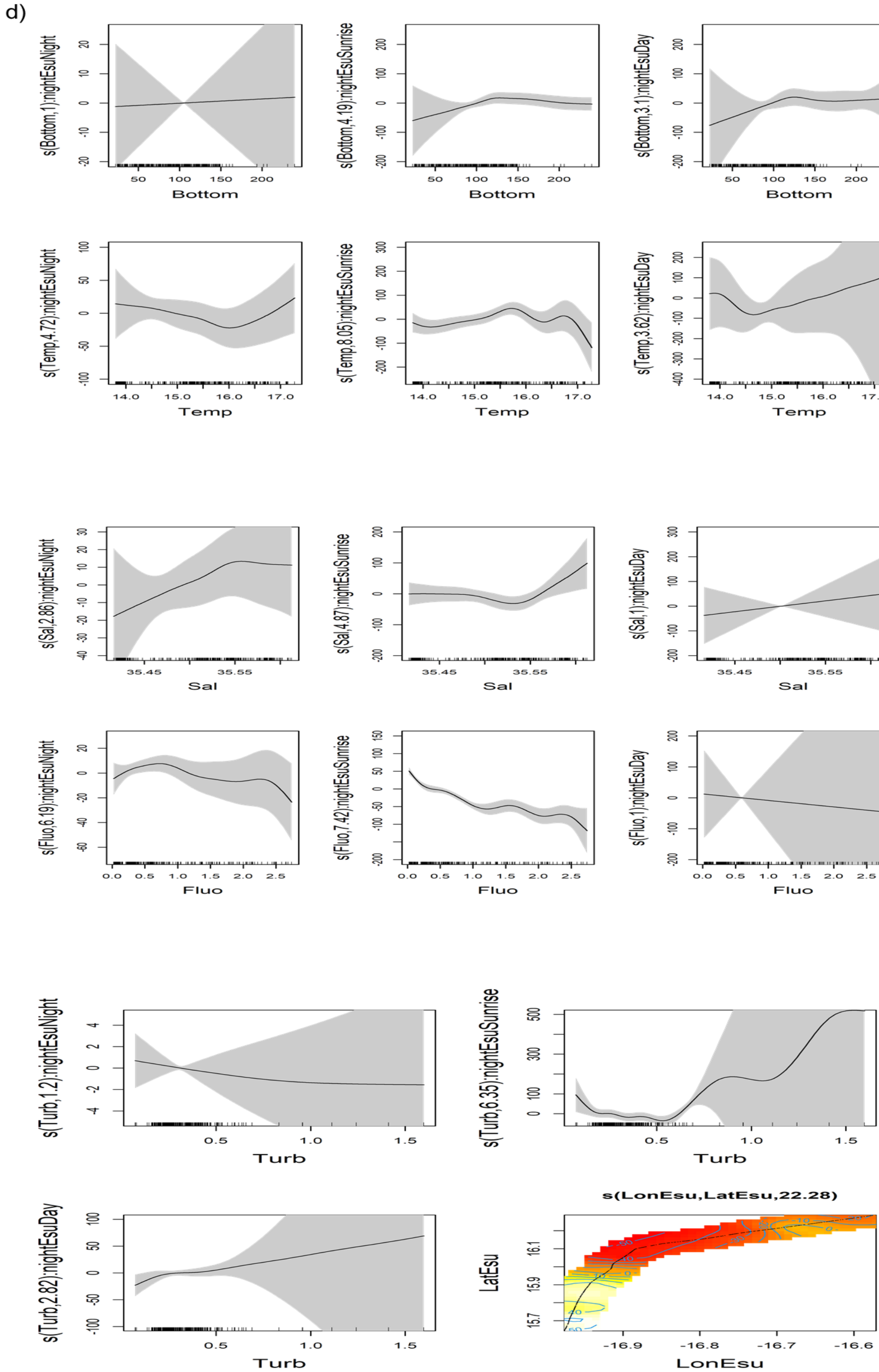
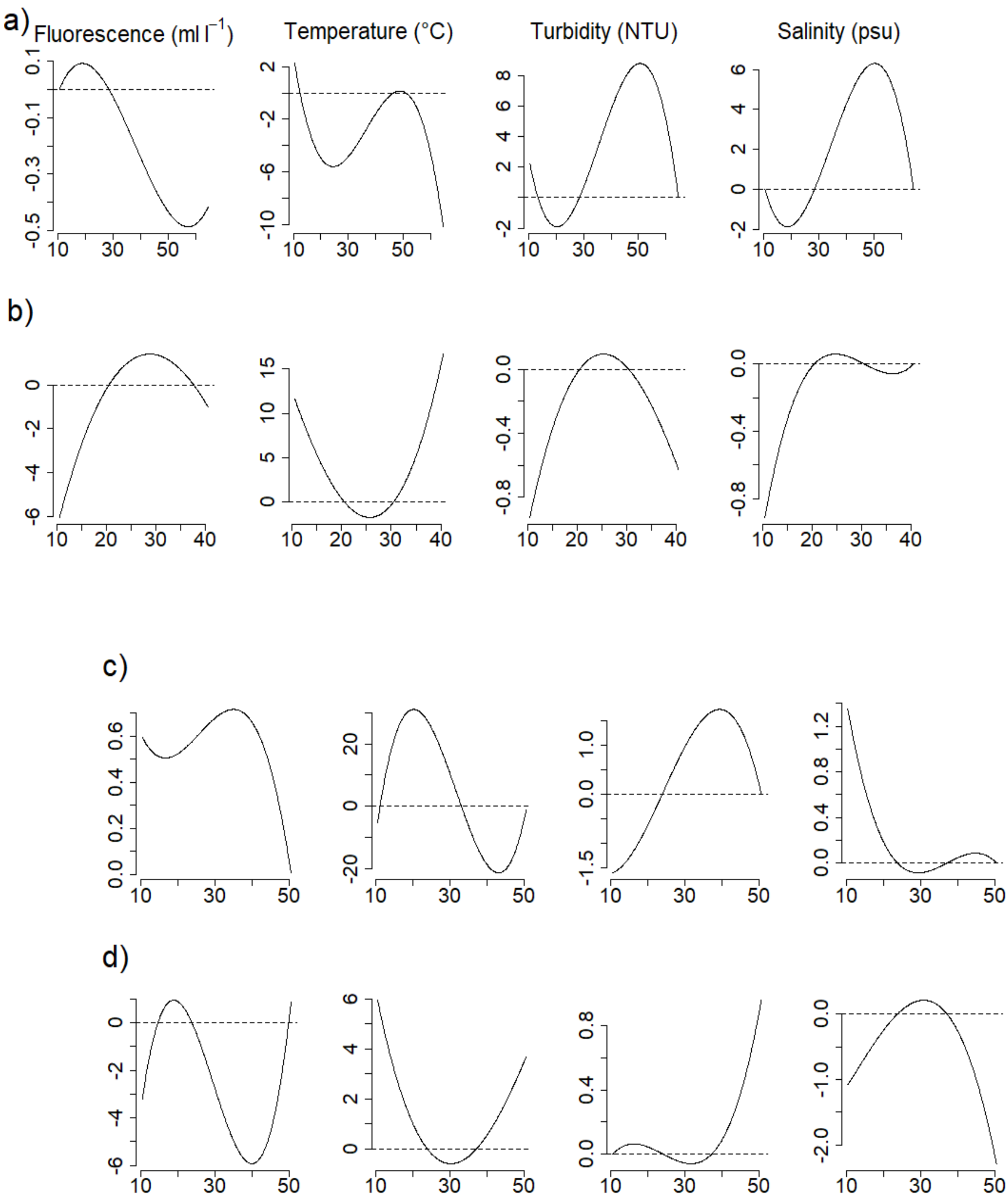


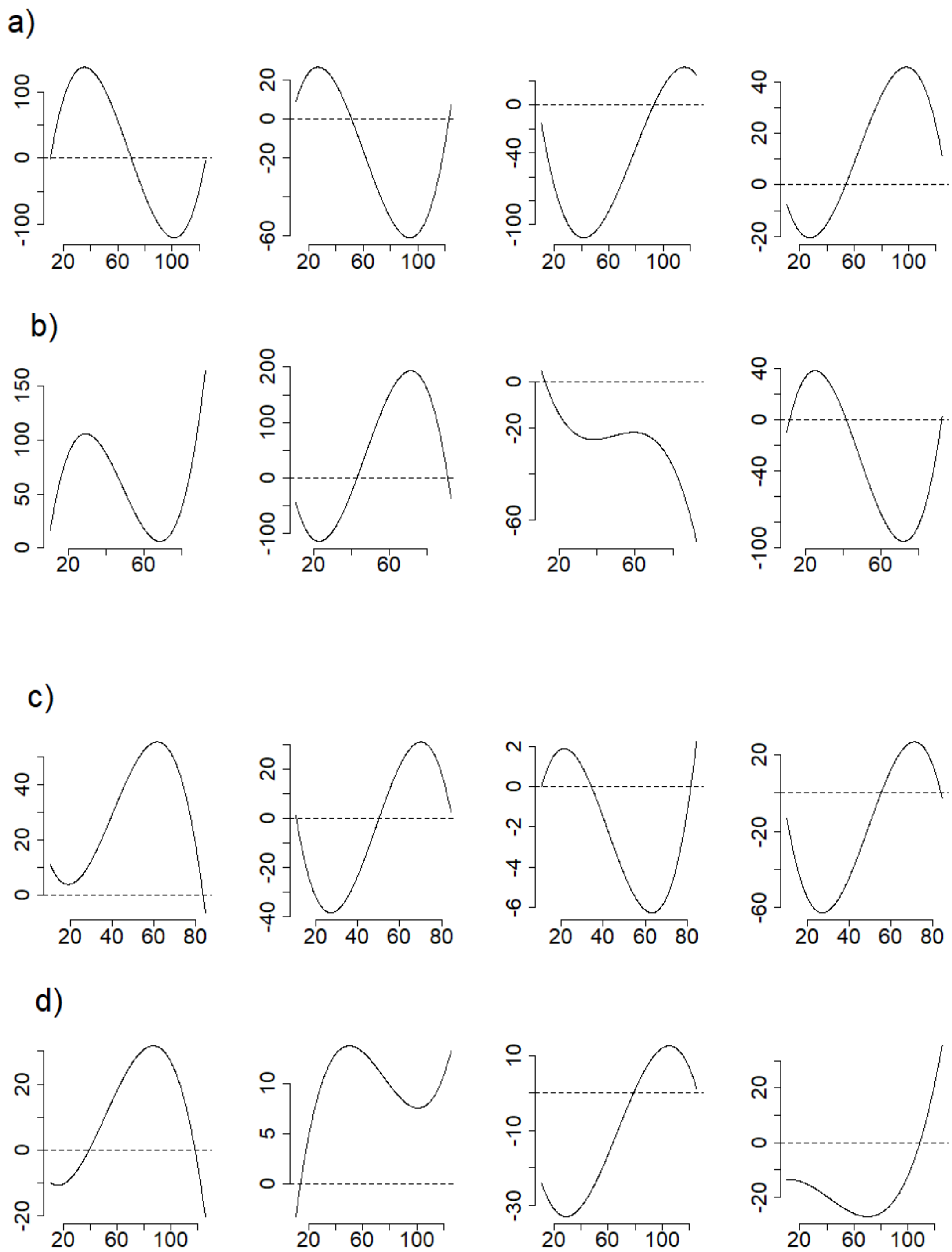
Fig. S6: The smooth terms resulting from the spatial GAM (GAMs) model between oceanographic condition parameters (sea temperature, fluorescence, salinity and turbidity) grouped by diel period (the variable is called nightEsu in the model) (day, sunset, night and sunrise) and SSL descriptors: (1) SSL thickness and (2) SSL depth over three different areas (A: southern continental shelf of Senegal; B: southern high sea of Senegal; C: northern Senegal) and as expect at various echosounder frequencies (a) 38, (b) 70, (c) 120 and (d) 200 kHz. The tick marks on the x-axis are observed data points. The y-axis represents the partial effect of each variable. The shaded areas indicate the 95% confidence intervals.

①

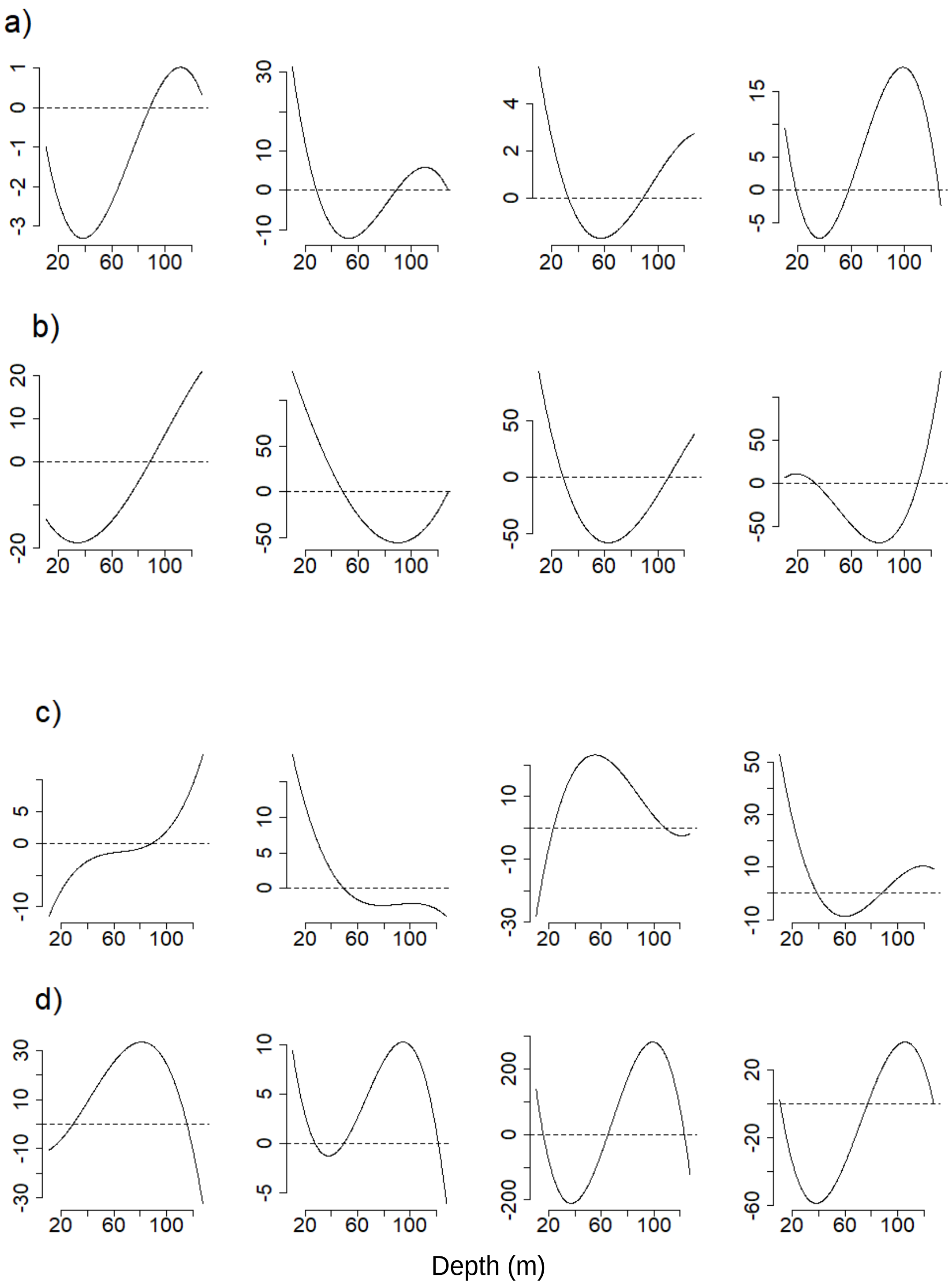
A)


a)
Fluorescence (ml l^{-1})
Temperature (°C)
Turbidity (NTU)
Salinity (psu)
b)
c)
d)

B)

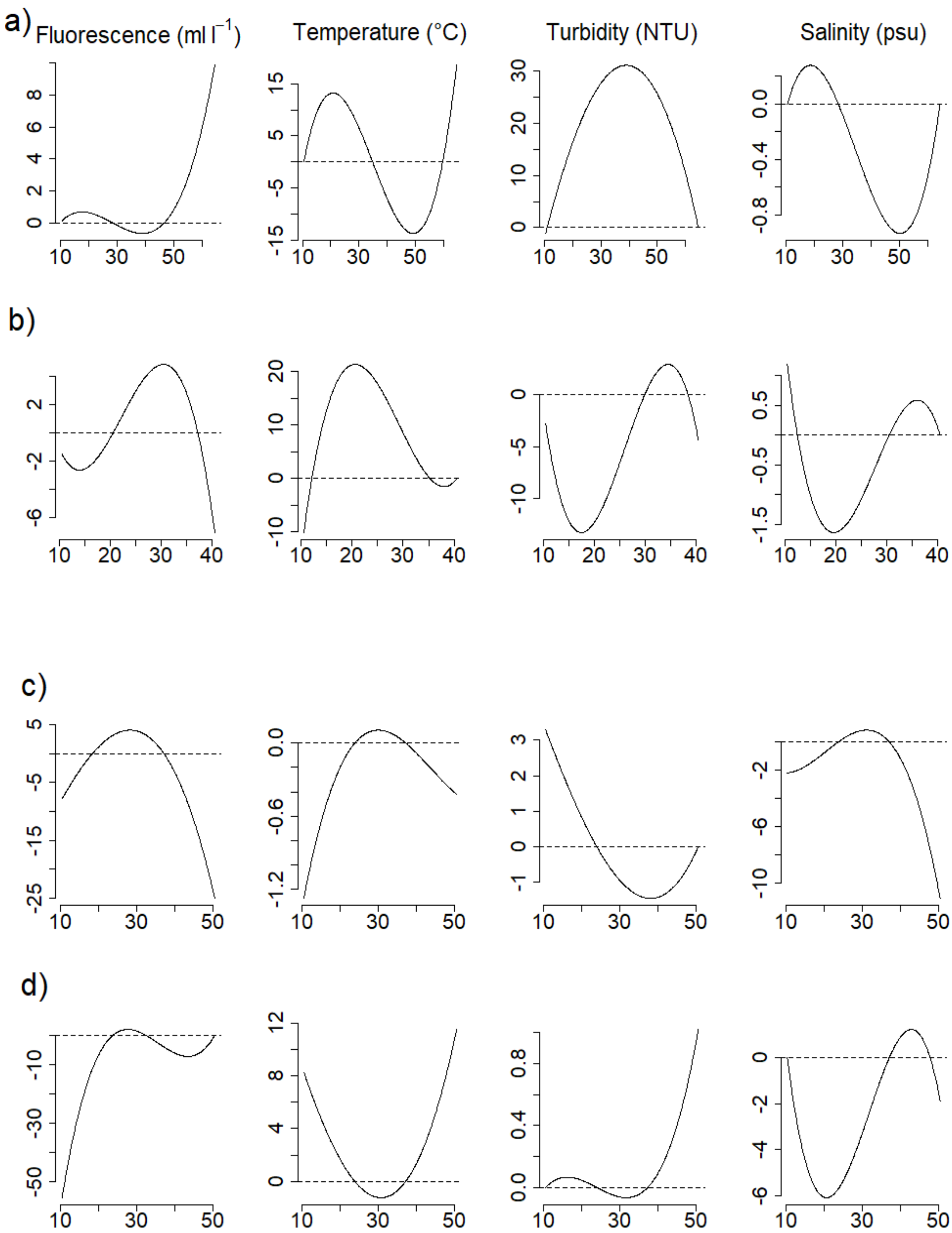


C)

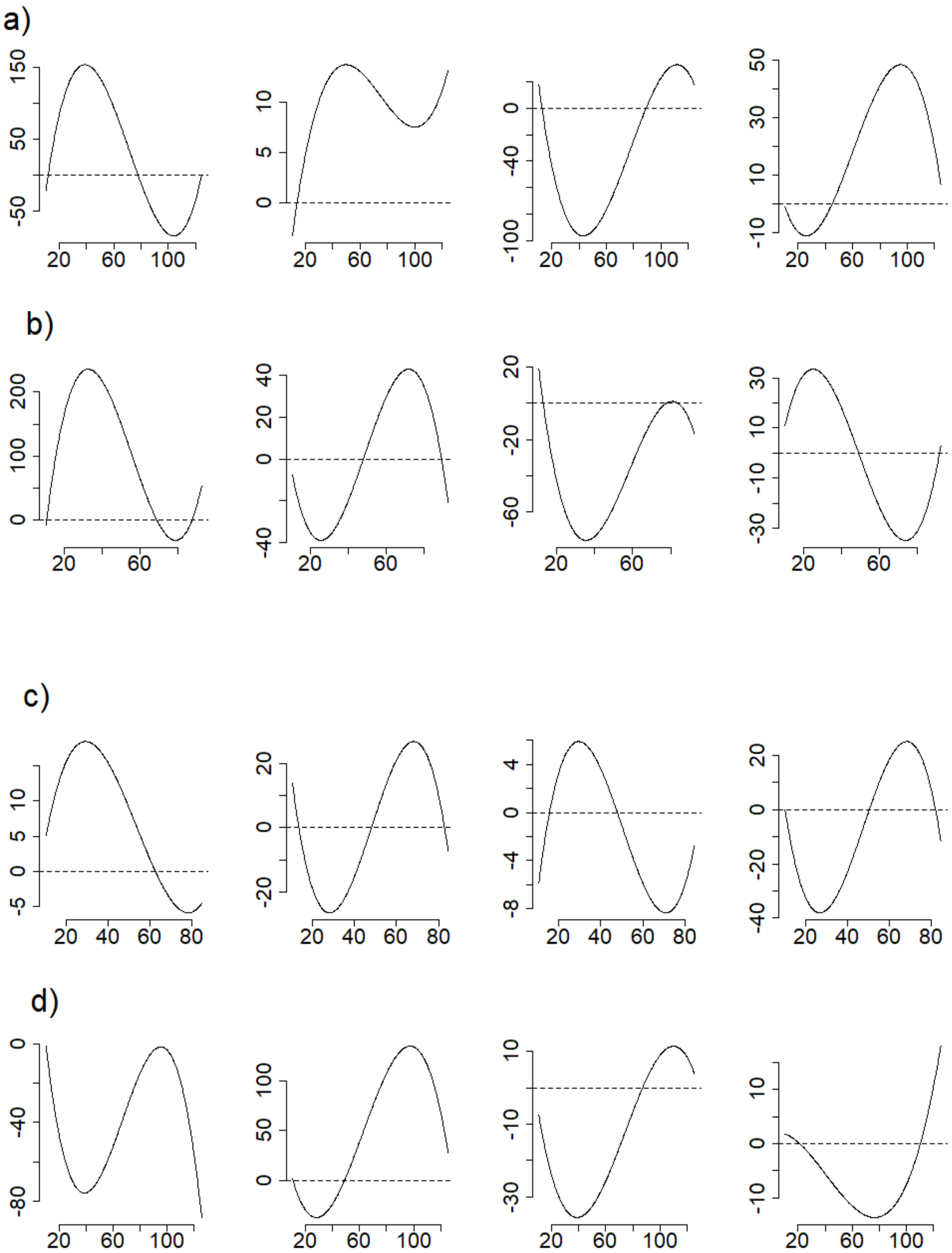


②

A)


a)
Fluorescence (ml l^{-1})
Temperature (°C)
Turbidity (NTU)
Salinity (psu)
b)
c)
d)

B)



C)

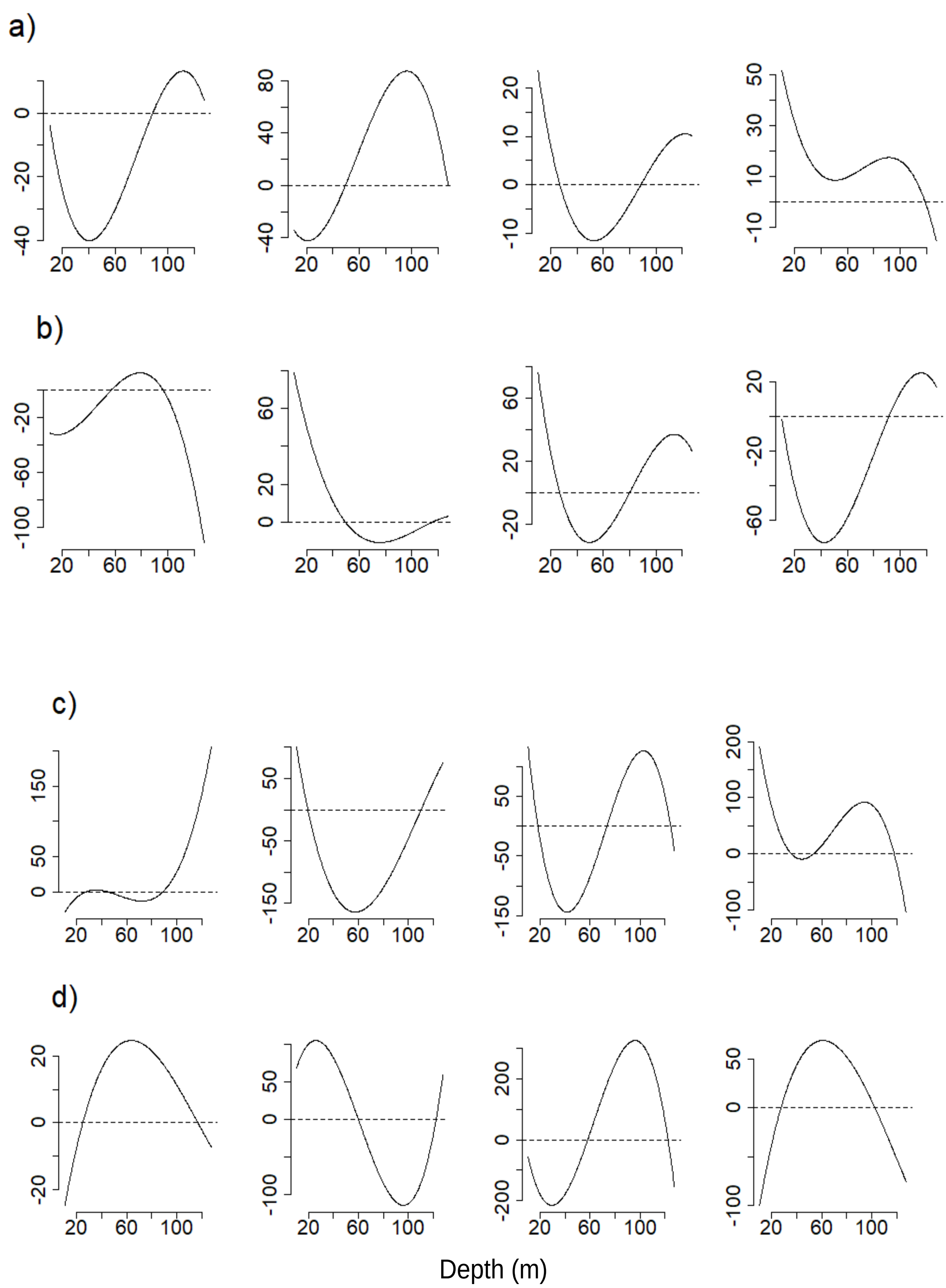


Fig. S7: Estimated oceanographic condition parameters (sea temperature, fluorescence, salinity and turbidity) resulting from the functional model for (1) SSL thickness and (2) SSL depth with the spatial dimension (spatial Functionnal Generalized Spectral Additive Model (FGSAMs)) over three different areas (A: southern continental shelf of Senegal; B: southern high sea of Senegal; C: northern Senegal) and as expect at various echosounder frequencies (a) 38, (b) 70, (c) 120 and (d) 200 kHz.