Reply to referees for the manuscript "Fine-scale vertical structure of sound scattering layers over an east border upwelling system and its relationship to pelagic habitat characteristics" by Diogoul *et al.*

We would like to thank the referee for the detailed report, his comments were very useful for improving our manuscript. Below we provide the answers to all comments.

Our reply to the referee 1 comments are written in blue.

The authors present an interesting data set on coastal hydroacoustics in an African upwelling area. However, despite CTD measurements, additional measurements have not been undertaken. Thus no information on zooplankton or fish composition is made, and additional frequencies to 38kHz that could be used for a relative frequency response analysis to indicate the differential contributions of the main hydroacoustic compartments fluid-like species, fishes with swim-bladder etc. have not be sampled. One such paper is mentioned in the ref list (Behagle et al 2017).

Answer : This is absolutely right. In this study, we used the acoustic monofrequency approach (using 38 kHz, one of the most current frequencies used in fisheries surveys) to study the spatio-temporal SSLs structuration in relation to the environment at generic level, i.e., without species identification. One limitation was the lack of taxonomic information about the species composition of SSLs but that will case of most part of the acoustic sea surveys available worldwide. We do not present information on species composition, because our study focus on ecosystem organisation (as often described by ecosystem modellers who unfortunately do not consider species level communities) aiming to describe the spatio-temporal SSLs structuration using only 38 kHz. The 38 kHz frequency offers the advantages of depth-penetration covering the whole vertical range of SSLs. Lastly, even without species composition operation (which remain in any case very punctual, subject to several bias (avoidance, differential catchability per species, etc.) and difficult to extrapolate to all the area sampled)) the understanding of the relationship between SSLs and pelagic habitat characteristics is a substantial step to understand ecosystem dynamics, e.g., such results increase the understanding of migration patterns of zooplankton and micronekton as well as will improve dispersal models for organisms in upwelling regions.

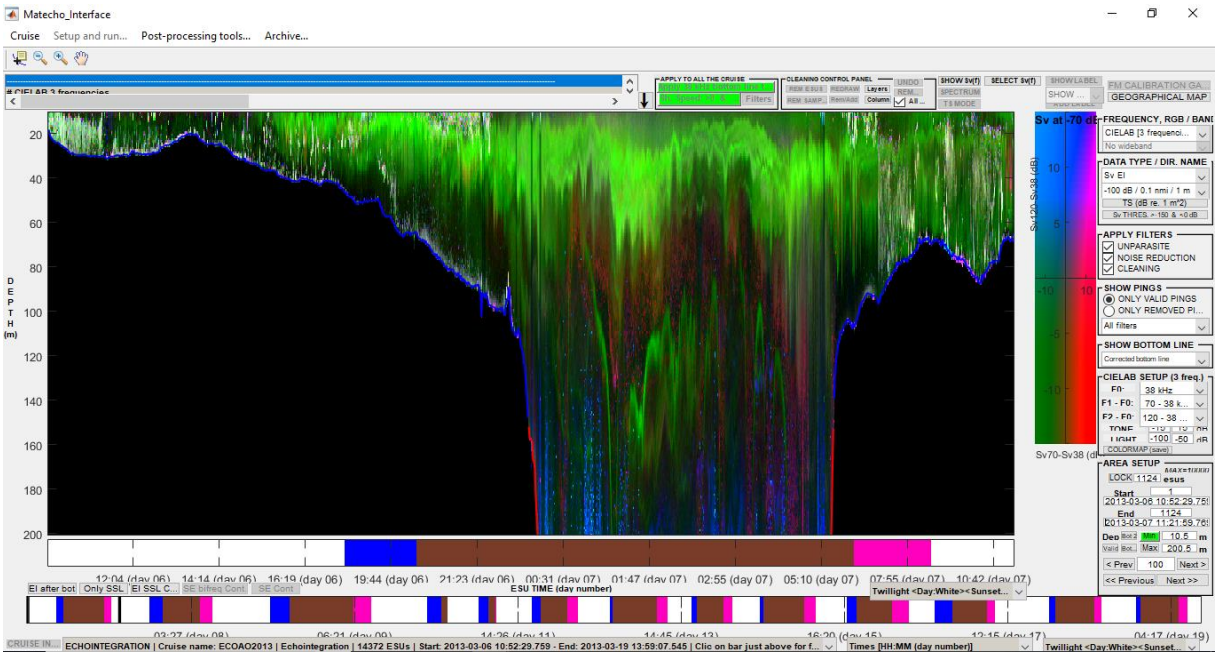


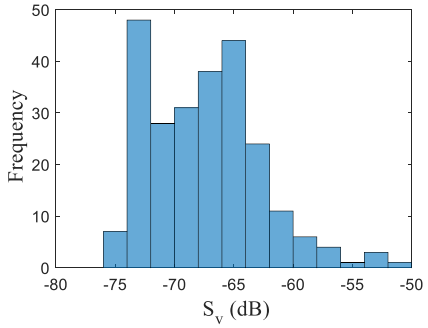
Figure 1 revision: [only for referee] ; representation of an ECOAO echogram (from 06th -07th) at three frequencies. Each frequency (here 38, 70 and 120 kHz) was scaled from 0--255

and assigned a colour RGB value based on its frequency. This method allow to clearly observe that the signal is mainly associated to 38 kHz and allow to find the same SSL shape than combined frequency.

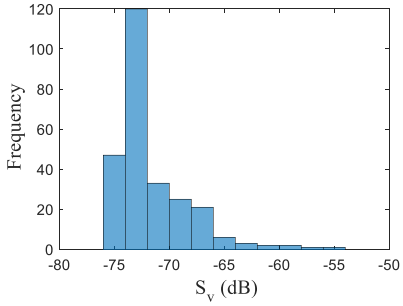
At least, the authors should consider presenting S_v histograms where possible. Altogether, this imposes some limitations on the overall scope of the analysis.

Answer : Yes, it is possible and of course more relevant to add histograms of mean S_v distribution (see below) of SSLs. According to your remark these figures will be added as a new Appendix in the revised version (see below).

Appendix H a: Mean distribution S_v of SSLs during daytimes in the study area.



Appendix H b: Mean distribution S_v of SSLs during night-times in the study area.



Significant clarifications should be done. In line 126, the authors indicate some relationship to ichthyoplankton, eggs and larvae, which needs some clarification given the properties of this features: Larvae with or without swim bladders, and how do the authors suggest fish eggs to be detected in an echogram.

Answer : Although we did do not carry out biological sampling, we assume that the backscattering was due to zooplankton and micronekton. Indeed, literature indicate the presence of zooplankton (mostly copepods), fish larvae and eggs (Ndour et al., 2018; Tiedemann and Brehmer, 2017) in our study area. Moreover, few studies have shown that fish larvae can be investigated using acoustic techniques (e.g., Castro and Bonecker, 2017; García Seoane et al., 2016). Then, when they are present in abundance, fish larvae can contribute to backscatter (García Seoane et al., 2016). For us there is no doubt that ichtchyoplankton contribute to backscatter as they fill their swim bladder with air pretty early in their life (nevertheless there was no checking for this during the larval fish identification process but the fish larvae still were only a small fraction of the whole plankton community). Therefore, we can state that backscattering was mainly due to micronekton, and zooplankton (especially fish larvae, and copepod). In line 124-125 we do not state that the backscatter come from egg and fish larvae only but by zooplankton and micronekton. Then in the next sentence line 126 we underline the fact that high abundance of egg and fish larvae have been reported during the sea survey in this area. To avoid confusion we delete fish egg in former line 126 of the MS.

I know that one of the authors has undertaken significant research in indicating fish schools by shape in echograms, no mention of this work is indicated here.

Answer : Yes, theses references (Brehmer et al., 2007, 2018) will be added on the manuscript as suggested by the referee. In the MS we add this reference as follow in the section "2.2. Data analysis":
"The output included meta information [station ID, station date, station time, latitude and longitude, diel phase (day, night), and local shelf depth (bottom depth)], all of which we associated with SSLs descriptors [SSL thickness, maximum SSL depth, mean volume backscattering strength (S_v, dB) and the mean nautical area backscattering coefficient (s_A, NASC); based on classic fish school descriptors (Brehmer et al., 2007, 2019) and physico-chemical parameters associated with each SSL."
The authors should please consider the following 4 points in detail and improve the English:
- The whole manuscript polished and corrected for English.
1. Physico-chemical properties and analysis of water masses (line 135) Dissolved oxygen was measured with a sensor - was this sensor calibrated by chemical measurements?

Answer : The CTD have been sent to seabird (USA) a couple of months before the survey to be calibrated. During the survey data delivered by the Seabird SBE43 sensor for DO, data have been checked by Winkler test by a marine chemistry scientist on board, a member of the Ecoao survey crew (Francois Baurand, IRD, US-Imago). We add inside the methodological section: "The CTD have been calibrated before the survey. During the survey data delivered by the SBE43 for DO have been corrected by Winkler test."

It is further mentioned, that DO concentrations did not satisfy criteria for hypoxia (line 392) as defined as 1.42 ml l^{-1}. However, looking at pages 24/25 the DO profiles clearly indicate layers with DO concentrations of 1 ml l^{-1} and below, which indicate local hypoxia.
Accordingly, the vertical variability of water mass properties with regards to DO and others questions the approach to cluster stations only based on their properties at 10 m water depth.
Answer : We agree with the referee regarding his remark (at line 392, where we have mentioned that DO concentrations did not satisfy criteria for hypoxia) and thanks for this. Indeed, we were wrong with the mean value of DO in the SSL with the minimum DO value at the station. We have considered this remark and have modified this part in the text MS as reported by the referee.
"Previous studies (Bertrand et al., 2010; Bianchi et al., 2013; Netburn and Koslow, 2015) have suggested that vertical distributions of SSLs organisms are limited by mid-water DO concentrations which constraint SSLs depth. These authors found a relationship between SSLs depths and hypoxia. However, in our study, we found correlation between SSLs (depth, thickness) and DO as expected, but vertical distribution of SSLs was not constrained by DO. Despite hypoxia local condition found in some stations (DO <1.42 ml l^{-1}), SSLs appeared; Consequently, DO was not a limiting factor".
Physico-chemical characterization of water masses by clustering approach is only based on their properties at 10 m water corresponding to the Mixed Layer Depth (MLD). This choice has been made to homogenise the data due the variability depth of each station done in shallow part of the shelf and deeper ones.

2. Definition of terms and surrogate variables and correlations with physicochemical properties (line 147) SSL thickness and maximum depth are returned by the algorithm "layer" - however, it is not mentioned, what criteria are applied to measure this or how thickness is defined in terms of s_A vertical distribution. The pseudo code at least should be shown in the appendix, and the respective analytical equations/definitions should be part of Material&Methods (see negative statement in line 457).
Answer : To define the descriptors (Thickness, Depth, s_A, S_v) of the SSLs, we used a threshold of -75dB, which were indicated in the algorithm "contourf.m" of Matlab (Matlab code can be

found at https://ch.mathworks.com/help/matlab/ref/contourf.html). This allowed to contour (by calculation of iso-lines according to the selected S_v threshold) the attached echo groups that formed the SSLs. The echoes within each SSL were extracted, and the associated descriptors were calculated from Matecho (code already available on web see MS see section 6 "software and code availability).
The pseudo code "Layer" allows to recover echointegrated echogram and SL descriptors calculated from Matecho, showed below and added on Appendix A in the revised version. The pseudo code "ComparEchoProfil" allow to calculate mean S_v and s_A profiles associated to each CTD profiles and to compare them (see below equations 1 to 3) and to extract station meta information (see code below for details).
We clarify inside the revised text of the MS:
"After extracting SSLs with Matecho, we developed an *ad hoc* Matlab extension of Matecho named "Layer" (**Erreur ! Source du renvoi introuvable.**) to recover SL thickness, minimum and maximum SL depths ($D_{min.}$ and $D_{max.}$, respectively) and echointergrated echogram from Matecho output files and to provide it to another Matlab program "ComparEchoProfil" (**Erreur ! Source du renvoi introuvable.**). ComparEchoProfil allows to fit in time and depth echointegrated echograms to the associated CTD vertical profiles. We used the equation below to calculate thickness:

$$\text{Thickness} = D_{max.} - D_{min.} \quad (1)$$

and also mean s_A and S_v profiles based on the average of three ESUs: the ESU nearest to the CTD position (ESU_{ctd}) and previous and following in correspondence with CTD depths (d_n) :

$$\overline{s_A(d_n)} = \sum_{i=ESU_{ctd}-1}^{i=ESU_{ctd}+1} s_A(i,d_n) \Big/ 3 \quad (2)$$

$$\overline{S_v(d_n)} = 10\times\log_{10}\left(\sum_{i=ESU_{ctd}-1}^{i=ESU_{ctd}+1} 10^{(S_v(i,d_n)/10)} \Big/ 3\right) \quad (3)$$

".

%% Layer

```
clear all; %close all;
%************************************************************************
*
% CHOIX PARAMETRES
% adresse du répertoire contenant les fichiers Echointegration.mat et Layer.mat
adress_acou='E:\ECOAO2013\Cruise_ECOAO2013\Treatment20171021_120009\CleanResu
lts\Echointegration\';

% adresse du répertoire où sauver les résultats
adress_save='C:\Users\perroty\Documents\DEVELOPPEMENTS\TOOLS_IRD\Profil_statio
n_ECOAOetAWA\ComparEchoProfil_Matecho\';

% indice de la frequence qui sont rangées dans l'ordre croissant de fréquence (le 38kHz est
kfreq=1 pour ECOAO et kfreq=2 pour Awa)
kfreq=1;

%************************************************************************
*
```

```
load([adress_acou,'Echointegration.mat'],'Time','Sv_surface','Sa_surface','depth_surface','dept
h_bottom','TransducerDepth','Night1Sunrise2Day3Sunset4','FrequencySort','BottomShift');
load([adress_acou,'Layer.mat'],'CleanLayMask','LayDescription38','LayDescriptionHeader');
LayDescription=LayDescription38;

nbcouche=size(LayDescription,1);  % LayDescription38 --> nb couche * nbre descripteur
nbesu=size(Time,2);
IdCouche=LayDescription(:,1);
IdStartCouche=LayDescription(:,5); IdEndCouche=LayDescription(:,6);
TimeStartCouche=LayDescription(:,9); TimeEndCouche=LayDescription(:,10);
DepStartCouche=LayDescription(:,11); DepEndCouche=LayDescription(:,12);
Zone=LayDescription(:,2);
EpCouche=DepEndCouche-DepStartCouche;
d=depth_surface;
nbzone=max(Zone);
EpAllZone=zeros(1,nbesu); SvAllZone=NaN(1,nbesu); SaAllZone=NaN(1,nbesu);
IndiceCoucheAllZone=NaN(1,nbesu);
DepthDebutAllZone=NaN(1,nbesu); DepthFinAllZone=NaN(1,nbesu);
IdDepthDebutAllZone=NaN(1,nbesu); IdDepthFinAllZone=NaN(1,nbesu);
for izone=1:nbzone
   tmp0=find(Zone==izone);
   if(~isempty(tmp0))

      tmp0=tmp0(1); ZoneId=[IdStartCouche(tmp0):IdEndCouche(tmp0)];

      layer=CleanLayMask(:,ZoneId,kfreq); Sv0=Sv_surface(:,ZoneId,kfreq);
Sa0=Sa_surface(:,ZoneId,kfreq); Id0=NaN(1,length(ZoneId));

      Ep=zeros(1,length(ZoneId)); Sv=NaN(1,length(ZoneId)); Sa=NaN(1,length(ZoneId));
      DepthDebut=NaN(1,length(ZoneId)); DepthFin=NaN(1,length(ZoneId));
IdDepthDebut=NaN(1,length(ZoneId)); IdDepthFin=NaN(1,length(ZoneId));
      for k=1:length(ZoneId)
         tmp=find(layer(:,k)~=0);
         if(~isempty(tmp))
            IdDebut=min(tmp); IdFin=max(tmp); Id0(k)=layer(IdDebut,k);
            if(layer(IdDebut,k)==layer(IdFin,k))
               Sv(1,k)=10.*log10(nanmean(10.^(Sv0(IdDebut:IdFin,k)./10)));
               Sa(1,k)=nanmean(Sa0(IdDebut:IdFin,k));
               Ep(1,k)=d(IdFin)-d(IdDebut);
               DepthDebut(1,k)=d(IdDebut); DepthFin(1,k)=d(IdFin);
IdDepthDebut(1,k)=IdDebut; IdDepthFin(1,k)=IdFin;
               if(Sv(1,k)==0)
                  Sv(1,k)=NaN; Sa(1,k)=NaN;
               end
            else
               tmp2=find(layer(:,k)~=layer(IdDebut,k)); layer2=layer(:,k); layer2(tmp2)=0;
clear tmp2;
               clear tmp; tmp=find(layer2~=0);
               if(~isempty(tmp))
                  Sv(1,k)=10.*log10(nanmean(10.^(Sv0(IdDebut:IdFin,k)./10)));
```

```
                Sa(1,k)=nanmean(Sa0(IdDebut:IdFin,k));
                Ep(1,k)=d(max(tmp))-d(min(tmp));
                DepthDebut(1,k)=d(IdDebut); DepthFin(1,k)=d(IdFin);
IdDepthDebut(1,k)=IdDebut; IdDepthFin(1,k)=IdFin;
                if(Sv(1,k)==0)
                    Sv(1,k)=NaN; Sa(1,k)=NaN;
                end
            end
            clear layer2;
        end
    end
    clear tmp;
  end
  IndiceCoucheAllZone(1,ZoneId(1):ZoneId(end))=Id0;
  EpAllZone(1,ZoneId(1):ZoneId(end))=Ep;
  SvAllZone(1,ZoneId(1):ZoneId(end))=Sv;
  SaAllZone(1,ZoneId(1):ZoneId(end))=Sa;
  DepthDebutAllZone(1,ZoneId(1):ZoneId(end))=DepthDebut;
  DepthFinAllZone(1,ZoneId(1):ZoneId(end))=DepthFin;
  IdDepthDebutAllZone(1,ZoneId(1):ZoneId(end))=IdDepthDebut;
  IdDepthFinAllZone(1,ZoneId(1):ZoneId(end))=IdDepthFin;

  clear ZoneId layer Ep Sv Sa Id0 DepthDebut DepthFin IdDepthDebut IdDepthFin;
 end
 clear tmp0;
end
save([adress_save,'EpSvSa.mat'],'IndiceCoucheAllZone','EpAllZone','SvAllZone','SaAllZone'
,'DepthDebutAllZone','DepthFinAllZone','IdDepthDebutAllZone','IdDepthFinAllZone')
hf=figure; subplot(6,1,1); plot(IndiceCoucheAllZone); title('Indice de la couche sur laquelle
epaisseur est estime');
subplot(6,1,2); plot(DepthDebutAllZone); title('Profondeur minimale');
subplot(6,1,3); plot(DepthFinAllZone); title('Profondeur maximale');
subplot(6,1,4); plot(EpAllZone); title('Epaisseur');
subplot(6,1,5); plot(SvAllZone); title ('Sv'); ylim([-80 -20]);
subplot(6,1,6); plot(SaAllZone); title('Sa'); ylim([0 800]);
```

```
%% ComparEchoProfil

clear all; close all; fclose all; warning('off');

%=================================================================
=========
% ECOAO : type de profils
% # name 1 = prDM: Pressure, Digiquartz [db]
% # name 2 = t090C: Temperature [ITS-90, deg C]
% # name 3 = t190C: Temperature, 2 [ITS-90, deg C]
% # name 4 = c0S/m: Conductivity [S/m]
% # name 5 = c1S/m: Conductivity, 2 [S/m]
% # name 6 = sbeox0V: Oxygen raw, SBE 43 [V]
% # name 7 = sbeox1V: Oxygen raw, SBE 43, 2 [V]
% # name 8 = par: PAR/Irradiance, Biospherical/Licor
% # name 9 = spar: SPAR/Surface Irradiance
% # name 10 = flC: Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
% # name 11 = 100-CStarTr0: Beam Transmission, WET Labs C-Star [%]
% # name 12 = altM: Altimeter [m]
% # name 13 = sbeox0ML/L: Oxygen, SBE 43 [ml/l], WS = 2
% # name 14 = sbeox0Mm/Kg: Oxygen, SBE 43 [umol/Kg], WS = 2
% # name 15 = sbeox1ML/L: Oxygen, SBE 43, 2 [ml/l], WS = 2
% # name 16 = sbeox1Mm/Kg: Oxygen, SBE 43, 2 [umol/Kg], WS = 2
% # name 17 = nbin: number of scans per bin
% # name 18 = sal00: Salinity, Practical [PSU]
% # name 19 = sal11: Salinity, Practical, 2 [PSU]
% # name 20 = sigma-é00: Density [sigma-theta, Kg/m^3]
% # name 21 = svCM: Sound Velocity [Chen-Millero, m/s]
%=================================================================
=========
% AWA2014 : DESCRPITION OF THE PARAMETERS IN MATRIX "PROF", SAVED IN
EACH MATRIX profil_d_**.mat FOR DOWN PROFILS and profil_u_**.mat FOR UP
PROFILS
% # name 1 = timeJ: Julian Days
% # name 2 = prDM: Pressure, Digiquartz [db]
% # name 3 = t090C: Temperature [ITS-90, deg C]
% # name 4 = t190C: Temperature, 2 [ITS-90, deg C]
% # name 5 = c0S/m: Conductivity [S/m]
% # name 6 = c1S/m: Conductivity, 2 [S/m]
% # name 7 = sbeox0V: Oxygen raw, SBE 43 [V]
% # name 8 = sbeox1V: Oxygen raw, SBE 43, 2 [V]
% # name 9 = flC: Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]
% # name 10 = CStarTr0: Beam Transmission, WET Labs C-Star [%]
% # name 11 = nbf: Bottles Fired
% # name 12 = sbeox0Mm/Kg: Oxygen, SBE 43 [umol/kg]
% # name 13 = sbeox1Mm/Kg: Oxygen, SBE 43, 2 [umol/kg]
% # name 14 = sal00: Salinity, Practical [PSU]
% # name 15 = sal11: Salinity, Practical, 2 [PSU]
% # name 16 = sigma-é00: Density [sigma-theta, kg/m^3]
% # name 17 = sigma-é11: Density, 2 [sigma-theta, kg/m^3]
```

```
% # name 18 = density00: Density [density, kg/m^3]
% # name 19 = density11: Density, 2 [density, kg/m^3]
% # name 20 = svCM: Sound Velocity [Chen-Millero, m/s]
% # name 21 = svCM1: Sound Velocity, 2 [Chen-Millero, m/s]
% # name 22 = nbin: Scans Per Bin
%=================================================================
=========
prompt = {'CAMPAGNE (taper ECOAO ou AWA)','CHOIX DE LA FREQUENCE A
ANALYSER (ECOAO--> 38, 70, 120 ou 200 kHz - AWA--> 18, 38, 70, 120, 200 ou 333
kHz)'};
dlg_title = 'Comparaison profils CTD et Echogrammes'; num_lines = 1; def={'ECOAO','38'};
answer = inputdlg(prompt,dlg_title,num_lines,def,'on');
if(strcmp(char(answer(1)),'ECOAO'))
   camp=1;
else
   camp=2;
end
FREQUENCES=str2num(char(answer(2)));
%=================================================================
=========
% PARAMETRES AVANCEES

% adresse du répertoire où se trouve les données acoustiques de la campagne ECOAO et
AWA (contenant tous les fichiers du type AWA2014__Y2014M02-the16at154403-
the01at075520.mat)
%adress_acou_ECOAO='C:\Users\USER\Desktop\HacTest\N058-S014-
S1999404\Cruise_1999404\Treatment20170818_124508\CleanResults\Echointegration\';
adress_acou_ECOAO='E:\ECOAO2013\Cruise_ECOAO2013\Treatment20171021_120009\
CleanResults\Echointegration\';
adress_acou_AWA='E:\AWA2014\Cruise_AWA2014\Treatment20170615_133808\CleanRe
sults\Echointegration\';

% adresse du répertoire où se trouve les fichiers des profils (qui doit être different de
adress_acou)
adress_profil='E:\CEprofil\Station_ECOAO-AWA\';

% adresse du fichier où sont enregistrées les épaisseurs (sortie du programme "couche.m")
adress_EpSvSa='C:\Users\perroty\Documents\DEVELOPPEMENTS\TOOLS_IRD\Profil_sta
tion_ECOAOetAWA\ComparEchoProfil_Matecho\EpSvSa.mat';

NbESUVisu=10;  % nombre d'esu à visualiser autour de la station (moyenne echogramme fait
sur ce nombre d'ESU)

if(camp==1)
   TrialName='ECOAO';
   ProfilType=[2,10,14,20];
   FileNameProfil='CTD_stations_ECOAO';
   adress_acou=adress_acou_ECOAO;
else
   TrialName='AWA';
```

```
    ProfilType=[3,9,12,16];
    FileNameProfil='CTD_stations_AWA';
    adress_acou=adress_acou_AWA;
end
TypeEi='v';                                          % ='v' pour analyser l'échogramme des Sv, ='a'
pour les echogrammes Sa
ProfName={'Temperature','Fluorescence','Oxygen','Density'};
ProfUnit= {'°C','µg/l','µmol/kg','kg/m^3'};
ProfilUpDown='d';                                    % ='d' pour analyser le profil descendant ou
='u' pour le profil montant

% Sauvegarde des figures
SaveFIG=1;       % =1 pour sauver les figures au format matlab (il suffit de cliquer dessus
ensuite pour les ouvrir, faire des zooms, etc..)
SaveFIGppt=1;    % =1 pour sauver toutes les figures produites dans un powerpoint (très
utile)
LabelFigHH=1;    % =1 pour afficher les numéros d'ESU en heure minute (HH:MN), =0
sinon


%**************************************************************************
*
% Debut du programme
%**************************************************************************
*
temp=pwd;
if(~exist([temp,'\RESULTATS\'],'dir'))
    mkdir(temp,'RESULTATS');
end
pathSaveFig=[temp,'\','RESULTATS\']; clear temp;

% chargement profils
load('EK500_colourmap.dat'); ek5=EK500_colourmap; clear EK500_colourmap;
load([adress_profil,FileNameProfil,'.mat']); month=char(monthtr);

% chargement des sorties de couche.m (début et fin de couche)
load(adress_EpSvSa);

%for k=12:12
for k=1:length(hourtr)
    if(month(k,1)=='F')
        m=2;
    else
        m=3;
    end
    hh=str2num(hourtr(k,1:2)); mn=str2num(hourtr(k,4:5)); ss=str2num(hourtr(k,7:8));
    timep(k)=datenum([str2num(char(yeartr(k))),m,daytr(k),hh,mn,ss]); clear hh mn ss;
    timep70(k)=(timep(k)-datenum('1970-01-01 00:00'))*60*60*24;
    timpstr(k,:)=datestr(datenum([1970 1 1 00 00 timep70(k)]),'yyyy-mm-dd HH:MM:SS');
    if(camp==1)
```

```
        temp=char(lattr(k)); ii=strfind(temp,'°'); dd=str2num(temp(1:ii-1));
mn=str2num(temp(ii+1:end-1)); lat(k)=dd + mn/60;
        if(temp(end)=='S')
            lat(k)=-lat(k);
        end
        clear temp ii dd mn;
        temp=char(lontr(k)); ii=strfind(temp,'°'); dd=str2num(temp(1:ii-1));
mn=str2num(temp(ii+1:end-1)); lon(k)=dd + mn/60;
        if(temp(end)=='W')
            lon(k)=-lon(k);
        end
        clear temp ii dd mn;
    else
        lat=lattr; lon=lontr;
    end
end
DateStation=timpstr;

filemat='Echointegration.mat';
str_fr0='000'; str_fr0(end-
length(num2str(FREQUENCES))+1:end)=num2str(FREQUENCES);
repsave=[str_fr0,'kHz_',TrialName,'_',datestr(clock,'dd-mm-yyyy_HH-MM-SS')];
mkdir([pathSaveFig,repsave]);
save([pathSaveFig,repsave,'\ParametresDeTraitement.mat'],'DateStation','TrialName','adress_
acou','adress_profil','TypeEi','FREQUENCES','FileNameProfil','ProfilType','ProfilUpDown','
ProfName');

Kstation=0; Station=[]; kfile=1; load([adress_acou,filemat(kfile,:)],'Time');
nbesutot=size(Time,2); crit=0;
NbEsuBloc=1000; IdP=[1:NbEsuBloc];
while(crit==0)
    if(IdP(end)>=nbesutot)
        IdP=[IdP(1):nbesutot];
        crit=1;
    end


load([adress_acou,filemat(kfile,:)],'Sv_surface','Sa_surface','Time','depth_surface','depth_bott
om','TransducerDepth','Night1Sunrise2Day3Sunset4','FrequencySort','BottomShift');
    load([adress_acou,'Layer.mat'],'CleanLayMask');

    fprintf('OK\n');
    Sv_surface=Sv_surface(:,IdP,:); Sa_surface=Sa_surface(:,IdP,:); Time=Time(1,IdP);
depth_bottom=depth_bottom(1,IdP);
    day_night_twilight=Night1Sunrise2Day3Sunset4(1,IdP);

    % mettre la ligne ci-dessous en commentaire (%) pour mettre tout l'échograme
    CleanLayMask=CleanLayMask(:,IdP,:); tmp=find(CleanLayMask~=0);
CleanLayMask(tmp)=1; clear tmp; tmp=find(CleanLayMask==0);
```

```
CleanLayMask(tmp)=NaN; clear tmp; Sv_surface=Sv_surface.*CleanLayMask;
Sa_surface=Sa_surface.*CleanLayMask;

   transFreq=FrequencySort;
   ind=find(timep70>=Time(1) & timep70<=Time(end));
   if(~isempty(ind))

      for kp=1:length(ind)

         Kstation=Kstation+1;  % compteur de stations

         tmp=find(Time>=timep70(ind(kp))); IndStation=tmp(1);
         if(day_night_twilight(IndStation)==1)
            JourNuitStation(Kstation,:)='Nuit  ';
         elseif(day_night_twilight(IndStation)==2)
            JourNuitStation(Kstation,:)='Levé  ';
         elseif(day_night_twilight(IndStation)==3)
            JourNuitStation(Kstation,:)='Jour  ';
         elseif(day_night_twilight(IndStation)==4)
            JourNuitStation(Kstation,:)='Couché';
         end

         tempek=[IndStation-NbESUVisu:1:IndStation+NbESUVisu]; clear tmp;
         if(tempek(1)<1)
            tempek=1:1:2*NbESUVisu;
         end
         if(tempek(end)>length(Time))
            tempek=length(Time)-2*NbESUVisu:1:length(Time);
         end

         dtim=Time(tempek);
         for k=1:length(Time)
            timtot(k,:)=datestr(datenum([1970 1 1 00 00 Time(k)]),'yyyy-mm-dd HH:MM:SS');
         end
         tim=timtot(tempek,:); DateESU=timtot;
         pingdeb=find(dtim>=timep70(ind(kp)));
         if(isempty(pingdeb))
            pingdeb=find(abs(dtim-timep70(ind(kp)))==min(abs(dtim-timep70(ind(kp)))));
         end
         pingdeb=pingdeb(1);
         pingdebtot=find(Time>=timep70(ind(kp))); pingdebtot=pingdebtot(1);

         if(ProfilUpDown(1)=='d')
            Name=['profil_d_',num2str(ind(kp))]; proftot=eval(Name); clear Name;
Name=['profildepth_d_',num2str(ind(kp))]; D=eval(Name); clear Name;
         else
            Name=['profil_u_',num2str(ind(kp))]; proftot=eval(Name); clear Name;
Name=['profildepth_u_',num2str(ind(kp))]; D=eval(Name); clear Name;
         end
         prof=proftot(:,ProfilType);
```

```
for Kfreq=1:length(FREQUENCES)

    kfreq=find(transFreq==FREQUENCES(Kfreq)*1000);

    Sv=Sv_surface(:,tempek,kfreq); Svtot=Sv_surface(:,:,kfreq);
Sa=Sa_surface(:,tempek,kfreq);

    % suppression des NaNs
    Ks=1;
    for ks=1:size(Svtot,2)
       tmp=find(~isnan(Svtot(:,ks)));
       if(~isempty(tmp))
          maxind(Ks)=tmp(end)+1; Ks=Ks+1;
       end
       clear tmp;
    end
    clear Ks; maxind=max(maxind); if(maxind>size(Svtot,1)); maxind=size(Svtot,1);
end; Svtot=Svtot(1:maxind,:);

    depth=depth_surface(1,1:maxind);
    bottomtot=depth_bottom(1,:,kfreq);
    tmp=find(bottomtot>max(depth)); if(~isempty(tmp));
bottomtot(tmp)=max(depth).*ones(length(tmp),1); end; clear tmp;
    bottom=bottomtot(tempek);

    % calcul profil acoustic moyen
    Saprof=nanmean(Sa.'); Svprof=10.*log10(nanmean(10.^(Sv.'/10)));

    %=========================================================
    % FIGURE
    SupTitle='';%['PRESSE "ESC" pour faire des zooms - PRESSE "Y" pour revenir à
toute l''image - ECHELLE DE COULEUR: PRESSE "A" ou "Q" pour augmenter ou diminuer
la valeur minimale des couleurs (PRESSE "Z" ou "S" pour augmenter ou diminuer sa valeur
maximale)' ];
    limax=[1 size(Svtot,2) min(depth) max(bottomtot)]; col=[-100 -40];
zoomcurrent=limax; ClimCurrent=col; DClim=10;
    tit={''};
    titcurrent=tit; Val=0; kcount=1; X=[]; Y=[]; aff=0;

   % while(Val==0)% | Val==3)

       close all; figure('units','normalized','outerposition',[0 0 1
1],'Name',SupTitle,'NumberTitle','off');
       Y(1)=DepthDebutAllZone(IdP(1)+IndStation-1);
       Y(2)=DepthFinAllZone(IdP(1)+IndStation-1);
       X(1)=IndStation;
       X(2)=IndStation;
       Val=1;
```

```
            FigManage;

          % end  %while(Val==0 | Val==3)

           if(~isnan(Y(1)))
              tmp=find(D>=Y(1) & D<=Y(2));
              if(isempty(tmp))
                 Temp=NaN; Fluo=NaN; Oxy=NaN; Dens=NaN; Pc=0;
              else
                 Temp=nanmean(prof(tmp,1)); Fluo=nanmean(prof(tmp,2));
Oxy=nanmean(prof(tmp,3)); Dens=nanmean(prof(tmp,4)); Pc=length(tmp)/length(D)*100;
              end
              clear tmp;

              tmp=find(depth>=Y(1) & depth<=Y(2)); Samoy=nanmean(Saprof(tmp));
tmp2=nanmean(10.^(Svprof(tmp)/10));
              if(~isnan(tmp2) & tmp2>0)
                 Smoy=10.*log10(tmp2);
              else
                 Smoy=NaN;
              end
              clear tmp tmp2;


Station(Kstation,:)=[X(1),X(2),D(1),D(end),depth(1),bottomtot(IndStation),Time(X(1)),Y(1),
bottomtot(X(1)),Time(X(2)),Y(2),bottomtot(X(2)),abs(Y(2)-
Y(1)),Temp,Fluo,Oxy,Dens,Smoy,Samoy,Pc];
           else % si pas de couche
              Temp=nanmean(prof(:,1)); Fluo=nanmean(prof(:,2)); Oxy=nanmean(prof(:,3));
Dens=nanmean(prof(:,4)); Smoy=10.*log10(nanmean(10.^(Svprof/10)));
Samoy=nanmean(Saprof);

Station(Kstation,:)=[NaN,NaN,D(1),D(end),depth(1),bottomtot(IndStation),NaN,NaN,NaN,N
aN,NaN,NaN,NaN,NaN,Temp,Fluo,Oxy,Dens,Smoy,Samoy,NaN];
           end
           SvMoyStation(Kstation).Sv=Svprof; SvMoyStation(Kstation).Sa=Saprof;

           %=========================================================
           % SAUVEGARDES

           ClimCurrent=col; zoomcurrent=limax; aff=1; FigManage; aff=0;
           if(SaveFIG==1)
              str_st='000'; str_st(end-length(num2str(ind(kp)))+1:end)=num2str(ind(kp));
str_fr='000'; str_fr(end-
length(num2str(transFreq(kfreq)/1000))+1:end)=num2str(transFreq(kfreq)/1000);
              saveas(gcf,[pathSaveFig,repsave,'\',TrialName,'_Station',str_st,'-
',str_fr,'kHz'],'fig');
           end
           if(SaveFIGppt==1)
              saveppt([pathSaveFig,repsave,'\',TrialName,'_AllStations.ppt']);
```

```
            end

            close all; pause(0.01); clear Sv depth bottom Svtot depth bottomtot;

        end %for kfreq=1:length(transFreq)
        clear Temperature Fluorescence Oxygene Density Smoy X Y Pc; clear tempek dtim
tim proftot prof D Svprof Saprof pingdeb pingdebtot IndStation;

    end %for kp=1:length(ind)

  end % if(~isempty(ind))
  clear ind;
  IdP=IdP+NbEsuBloc;

end % for kfile=1:size(filemat,1)

if(~isempty(Station))
  LatitudeStation=lat; LongitudeStation=lon;

save([pathSaveFig,repsave,'\Stations_',TrialName,'_',str_fr0,'kHz.mat'],'JourNuitStation','Date
ESU','LatitudeStation','LongitudeStation','Station','SvMoyStation');

  % ecriture du fichier excel de résultats
  fid=fopen([pathSaveFig,repsave,'\Stations_',TrialName,'_',str_fr0,'kHz.xls'],'wt');
  fprintf(fid,'N°station \t Date station \t Latitude station (deg) \t Longitude station (deg) \t
Ephéméride à la station \t Profondeur minimale station (m) \t Profondeur maximale station
(m) \t Profondeur minimale echogramme sur station (m) \t Profondeur maximale echogramme
sur station (m) \t Date point1 (seconde depuis 1970) \t Profondeur point1 (m) \t Fond au
point1 (m) \t Date point2 (seconde depuis 1970) \t Profondeur point2 (m) \t Fond au point2
(m) \t Epaisseur couche (m) \t Temperature moyenne dans la couche (°C) \t Fluorescence
moyenne dans la couche (µg/l) \t Oxygène moyen dans la couche (µmol/kg) \t Densité
moyenne dans la couche (kg/m3) \t Sv moyen dans la couche (dB) \t Sa moyen dans la couche
(NASC) \t Pourcentage de recouvrement des profils de station par la couche\n');
  for k=1:size(Station,1)
    fprintf(fid,'%i \t %s \t %4.4f \t %4.4f \t %s \t %4.2f \t %4.2f \t %4.2f \t %4.2f \t %4.4f \t
%4.2f \t %4.2f \t %4.4f \t %4.2f \t %4.2f \t %4.2f \t %4.2f \t %4.2f \t %4.2f \t %4.2f \t %4.2f
\t %4.2f \t %4.2f
\n',k,char(timpstr(k,:)),lat(k),lon(k),char(JourNuitStation(k,:)),Station(k,3:end));
  end
  fclose all;
  fprintf('\n'); fprintf('Les resultats sont sauvegardés dans le répertoire:\n');
fprintf('%s\n',[pathSaveFig,repsave]);
  cd([pathSaveFig,repsave]);
else
  fprintf('Aucune station n''a été traitée !!!\n');
end
warning('on')"
```

For "ComparEchoProfil", one 0.1 nmi unit is used for calculation around the CTD cast position, but in the figures several units are shown (normally 5). Since these are not averaged in "ComparEchoProfil", so I would leave that out so that the reader is not confused by the variability.

Answer : As the referee noticed, it look like we displayed 5 units of ESU on CTD graph, but in fact there is three with the first and the last (ESU 1 and 5) are cut in the middle and are not taken into account in the average (it is just for full illustration “graphic output of ComparEchoProfil” of the three ESUs averaged i.e. without ESU cut). These 5 ESU are not averaged in "ComparEchoProfil", only three. Our aim was to do a fine scale analysis. This is why we have choose 0.1 nmi for ESU, the idea to display the other ESU around the CTD one is to get an idea of the variability when it is possible (this is also the reason why we put time on the x-axis and not nmi). Following referee's recommendations, we have removed the zoomed echogram (see below) to avoid the reader to be confused by variability in Figure 2 and former Appendix D. We have also improved the figure by adding a distance scale showing showing diel period as requested by the referee #2.

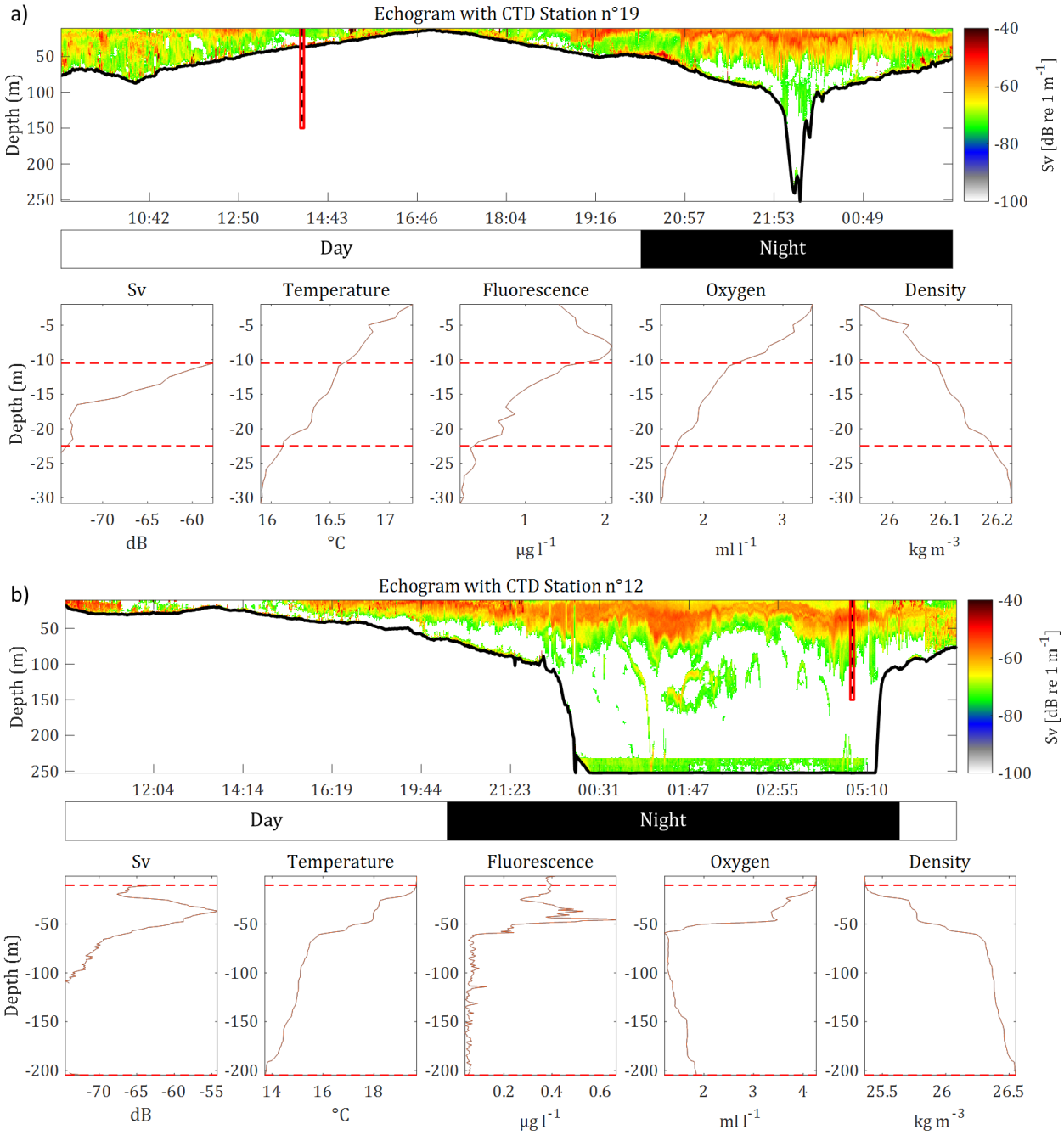


Figure legends on echogram pages 22-25 contains strong statements like "The peak of S_v match the CHL…", which need some clarification, since already in the figure for station 12 the S_v peak is < 40 m and the CHL peak is > 40 m depth, so they do not match.

Answer : That is true. We agree that the peak of S_v don't match accurately the CHL peak at station 12 even if it almost match (e.g. station $\Delta \cong 5$ m) for station 13, 16 and 25. However, to avoid such claims, we will just say that: "the peak CHL is near the S_v peak (above or in the middle)".

We correct the legend of the former Appendix D deleting "Match" as follow:

"Appendix D: Vertical profile from CTD stations associated to acoustic volume backscattering strength (S_v, in dB) integrated per elementary sampling unit (ESU) of 0.1 nmi for 4 stations: station 12, 13, 16 and 25. The peak of S_v is close to the fluorescence peak (proxy chlorophyll-*a* concentration, in µg l^{-1}) and are related to strong gradients of water temperature, itself related

to water density and dissolved oxygen. From the top left to bottom right (i) vertical profile S_v (dB) in the sound scattering layers (SSLs) ; (ii) Profile of mean temperature in SSLs (°C) ; (iii) profile of fluorescence in SSLs; (iv) profile of dissolved oxygen in SSLs (µmol kg^{-1}); (v) and profile of water density in SSLs (kg m^{-3})."

3. Model building. It is unclear, how the ANCOVA models were developed - are the calculations been carried out bin-wise or averaged over station - the residual plots indicate the latter. This needs justification, line 177 indicates some kind of 'profile coupling'.
Answer : The ANCOVA model were developed on averaged data over station. At line n° 144, we refer to the Echogram- profiles CTD coupling, i.e., the Echogram-profiles comparison approach used in this study. We clarify inside the text as follow "An ANCOVA test (analysis of covariance) (Wilcox, 2017) was implemented for SSLs characteristics (thickness, depth, and density). This ANCOVA model were developed on averaged data over station. "

4. Features of relevance In the abstract (line 34) no significant relationship to DO is indicated, however, considerable emphasis is attributed to this feature despite being non-significant. In the first place, models for G2 indeed indicate significance of DO, so the statement in the abstract is not clear. Secondly, if non-significant terms are discussed broadly, this needs better justification.
Answer : In the abstract (line 34), we discuss CHL and not DO. We believe there is a confusion between Chlorophyll and Dissolved Oxygen. Indeed, we wrote: « chlorophyll-*a* has statistically no effect on SSLs structure, we report that the chlorophyll-*a* peak was always located above or in the middle of the SSLs ». Chlorophyll-*a* was insignificant in all model while DO was significant in the offshore area (G2). Nevertheless, according to previous referee comments we have modified the end of the abstract as follow "Lastly, over the Senegalese continental shelf the level of dissolved oxygen was not always a limiting factor, despite local hypoxia reported below 30 m depth, for SSLs marine pelagic organisms during upwelling event".
In the context of climate change it is important to check carefully the impact of DO on marine pelagic spatial organisation. Tropical Atlantic minimum oxygen zone (OMZ) already expend (see, Stramma et al works) and study on the shelf is of primary importance due to fishing activity which is particularly high in our study area and there is for instance report only from one sea survey cruise lead in 2013 (Ecoao within AwA project).