Glider sampling simulation figures 2 to 7

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Load the database of acoustic backscatter coefficients (s[a])

'NASC_leg1.RData' (dimensions 100 x 199772) contains the krill acoustic backscatter values (s[a]) binned into 100 m horizontal by 5 m vertical cells (transposed in the simulation functions for easier visualization).

```
Sys.time()
```

```
## [1] "2021-10-01 07:23:23 PDT"
```

```
load('NASC_leg1.RData')
```

Figure 2: Sample paths of 3 yos to maximum depth of 150 m, and 1000 m

```
source('Fig2.r')
Fig2()

Fig2(yo.depths.m=rep(1000,3),max.z.m=1005)
```

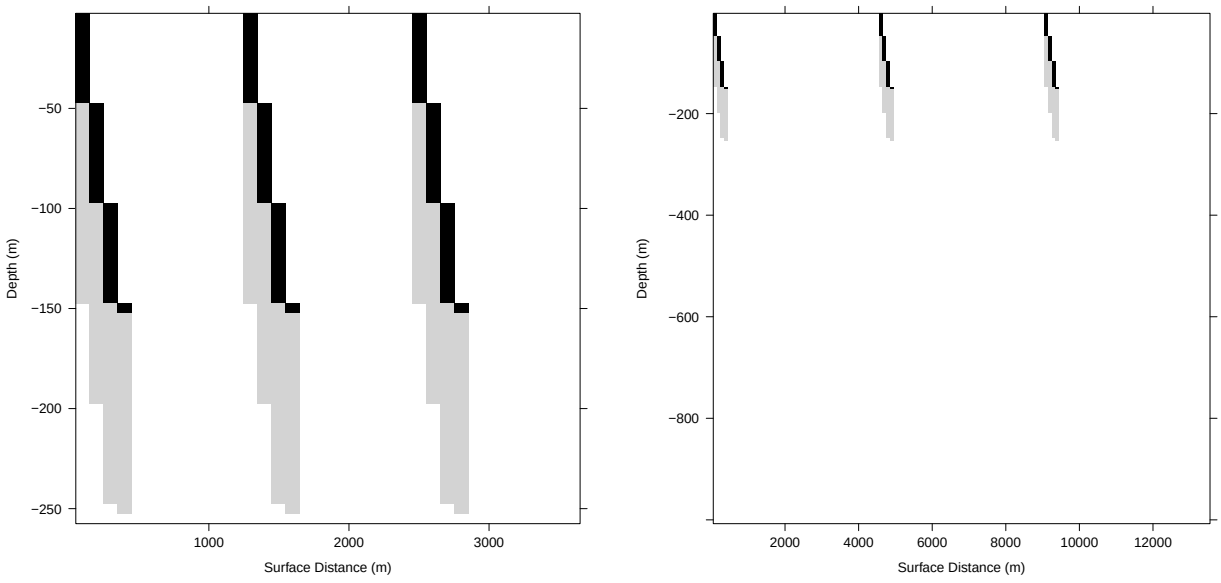


Figure 2. Schematic sample path of a glider completing 3 dives at with a maximum depth of (a) 150 m and (b) 1000 m. In each case the echosounder is shut off at 150 m, but the water column is ensonified to 250 m. Black cells indicate when the echosounder is recording and light gray represents the 100 m sampled below the glider. We computed a mean backscatter across the cells within each depth bin sampled during a dive and then summed vertically to produce glider samples of depth-integrated backscatter.

Figure 3: Plot the summed s[a] at each 5m depth in the database

'Fig3.r' calculates a plot of the summed s[a] values at each depth, illustrating the overall relationship of krill density with depth.

```
source('Fig3.r')
```

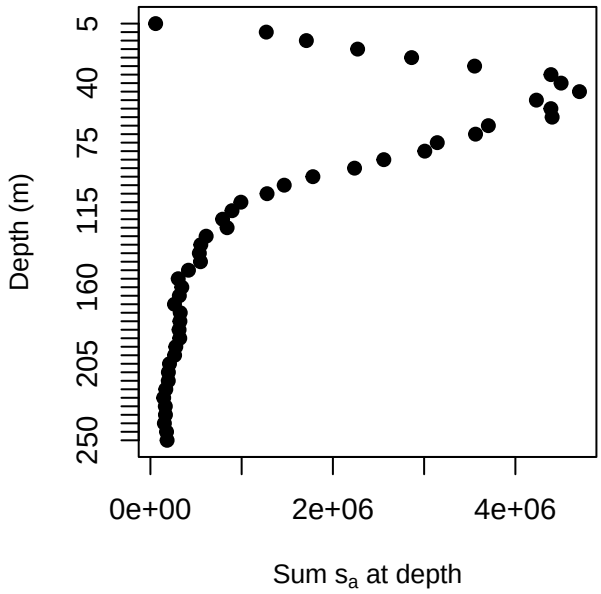


Figure 3. Mean acoustic backscatter coefficients (sa) in 5 m depth bins of the population being sampled by simulated gliders for both strata and all years combined.

Figure 4: Plot the CV of s[a] and the proportion of zero density bins at each 5m depth in the database

```
source('Fig4.r')
```

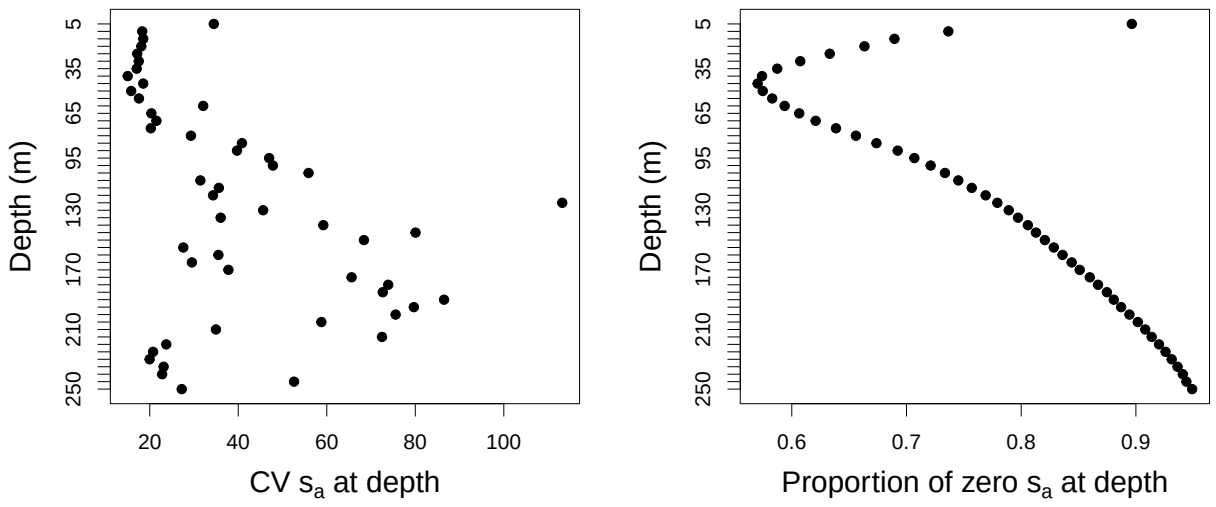
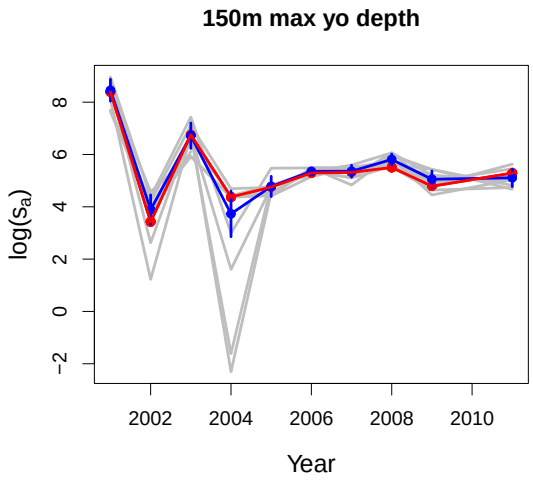


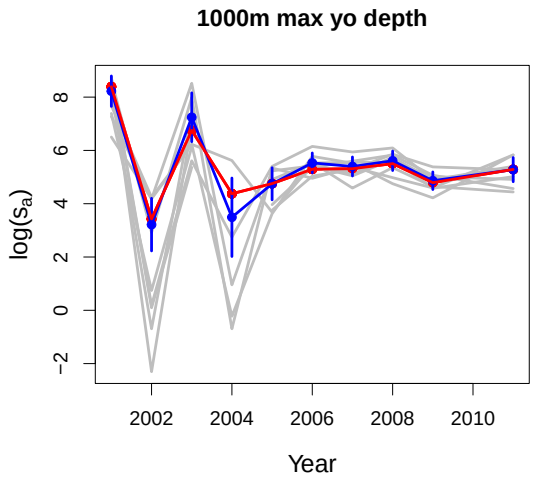
Figure 4. CVs of acoustic backscatter (left) and proportions of bins with zero acoustic energy (right) at depth in the combined database sampled by the simulated gliders.

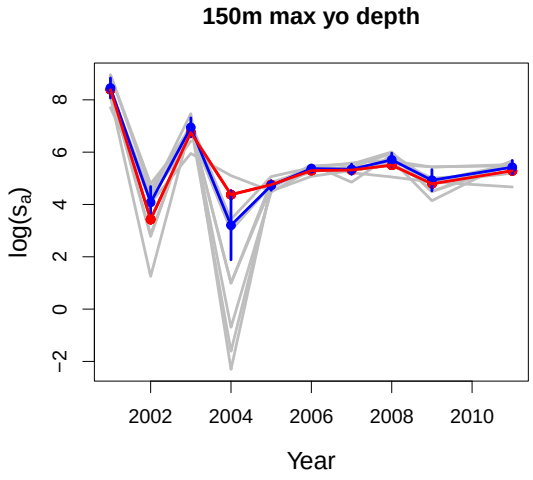
Figure 5

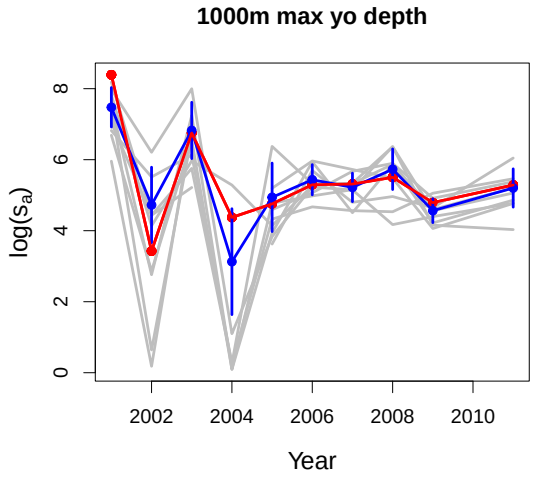
Figure 5 shows the fit of the glider samples ('gldr.smpls.yrs') of acoustic density (s[a]) to the operating model values ('ship.sums') for each strata and year. 'plot_Sa_fits.r' plots the fits of the glider samples (grey) to the operating model (red). Figure 5 requires 'Glider_simulation.rmd' to have been already rendered to provide the data. The example shows 9 replicates. More replicates can be sampled using the 'n.reps' argument to 'Fig5.r'.

```
source('Fig5.r')
Fig5(n.gldr=c(1,2,3))
```


150m max yo depth
log(sa)
−2
0
2
4
6
8
2002
2004
2006
2008
2010
Year


1000m max yo depth
log(sa)
−2
0
2
4
6
8
2002
2004
2006
2008
2010
Year


150m max yo depth
log(sa)
−2
0
2
4
6
8
2002
2004
2006
2008
2010
Year


1000m max yo depth
log(sa)
0
2
4
6
8
2002
2004
2006
2008
2010
Year

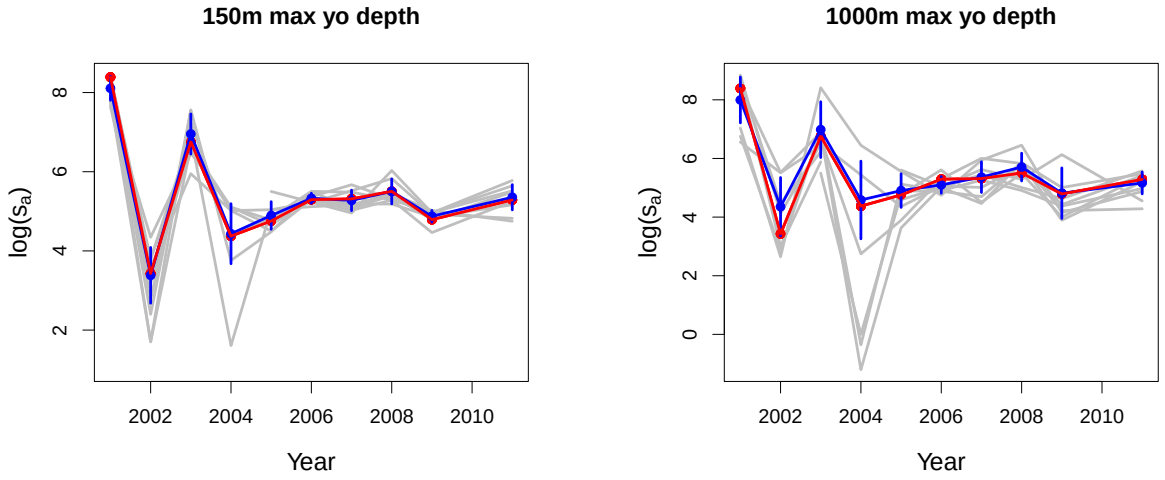


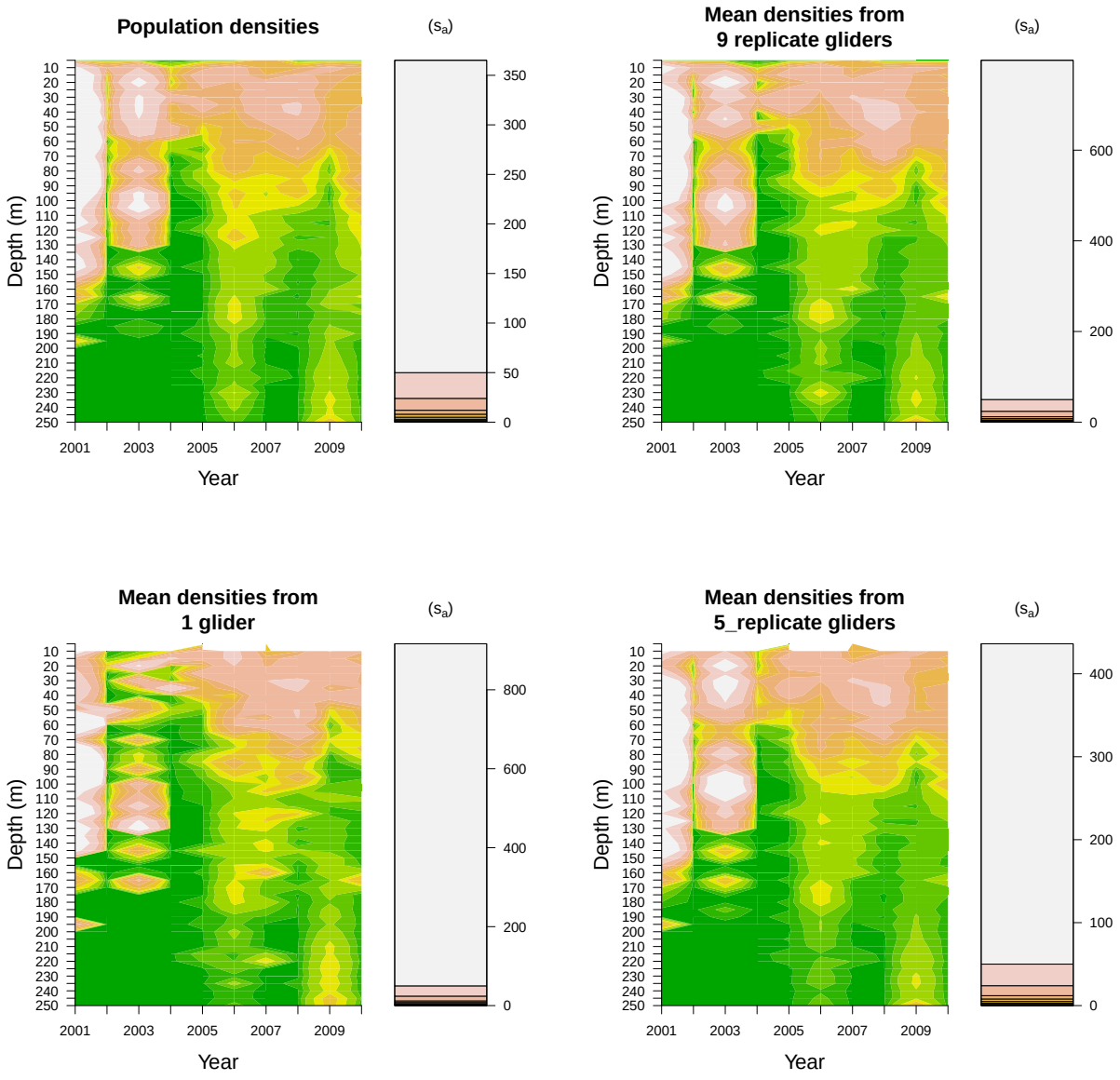
Figure 5. Annual glider logged sample means and SDs (blue) from 500 individual replicates (gray) of 1 glider with a maximum yo depth of 150 m sampling acoustic energy (sa) with individual yos as sampling units in Bransfield Strait (a), Cape Shirreff (b). In all plots, the population means (from the original ship surveys) are in red.

Figure 6

The acoustic densities at depth from the ship surveys (the 'operating model') and the sampled densities from all replicate gliders, from one glider, and from five gliders at depth.

```
source('Fig6.r')
Fig6(n.gldr=c(1))
```

```
## [1] "2021-10-01 07:25:06 PDT"
```




```
paste('Figure 6. Acoustic energy contours with depth for gliders with maximum yo depths/n',
'of 150 m. The true energies ("population"), the mean of all glider/n',
'replicates, the mean of 5 glider replicates ("5 random gliders") and one glider/n',
'("1 random glider") are shown.',sep='')
```

```
## [1] "Figure 6. Acoustic energy contours with depth for gliders with maximum yo depths/nof 150 m. The
```

Figure 7

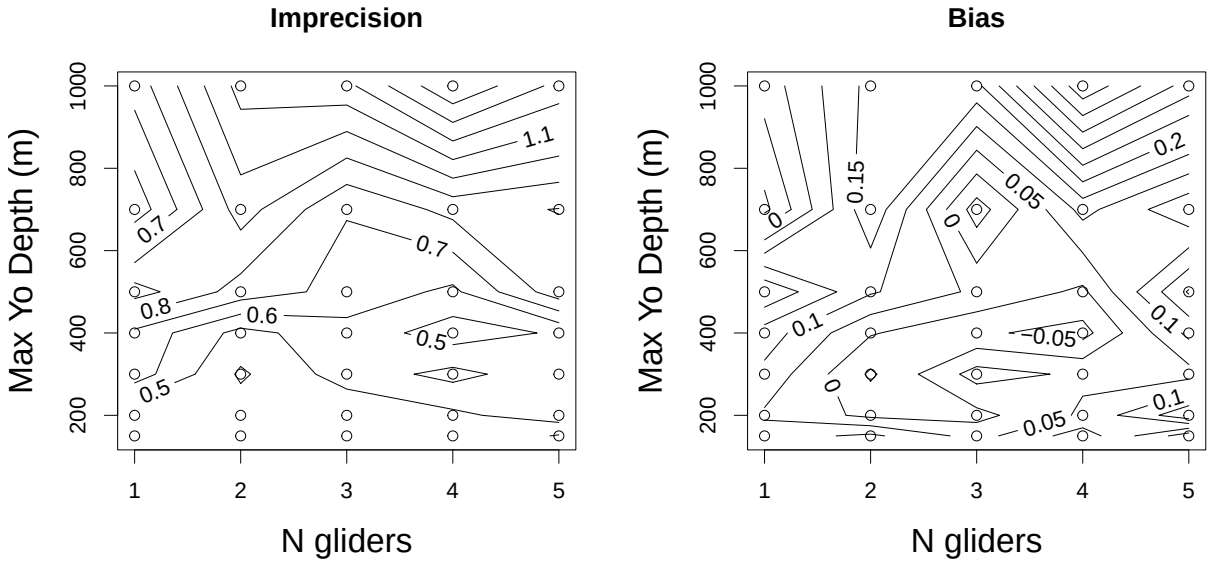
These example contour plots are based on 9 replicate samples of from 1 to 5 gliders sampling the database of acoustic densities. More replicates (i.e., 500) illustrate the statistical fits more accurately, but require many days of run time.

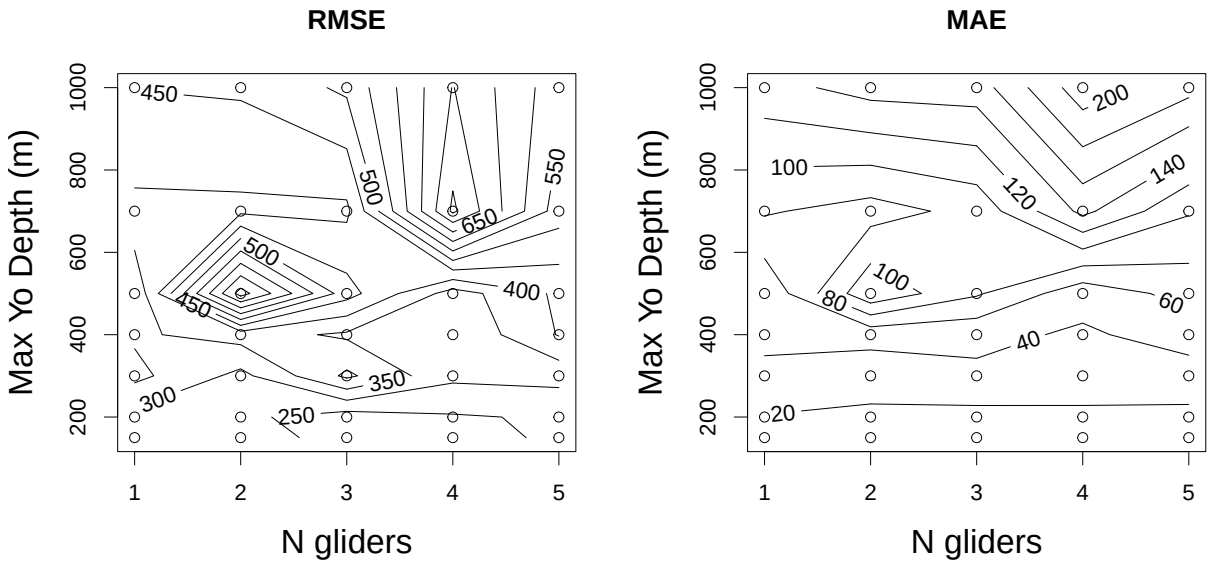
```
source('Fig7.r')
Fig7(gldr.pths = c(1))
Fig7(gldr.pths = c(2))
Fig7(gldr.pths = c(3))
Fig7(gldr.pths = c(4))
Fig7(gldr.pths = c(5))
```

Contour plots of numbers of glider combinations X maximum depth X year require at least 3 maximum yo depths and at least 3 glider combinations (i.e., 1 to 5 gliders per replicate).

```
source('Fig7_contours.r')
Fig7_contours(n.gldr.pth = c(1,2,3,4,5))
Sys.time()
```

```
## [1] "2021-10-01 07:25:11 PDT"
```




RMSE
Max Yo Depth (m)
200
400
600
800
1000
450
500
550
650
500
450
400
350
300
250
1
2
3
4
5
N gliders
MAE
Max Yo Depth (m)
200
400
600
800
1000
200
100
120
140
100
80
60
40
20
1
2
3
4
5
N gliders