ASAM Metadata 2021 Krill Biomass Estimate

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11/06/2021

Set up document, files and packages

Packages used:

```
Matt Dowle and Arun Srinivasan (2020). data.table: Extension of `data.frame`. R package version 1.13.4.
https://CRAN.R-project.org/package=data.table

Hadley Wickham (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Yihui Xie (2020). knitr: A General-Purpose Package for Dynamic Report Generation in R. R package version 1.30.
```

This script reads in **ASAM_metadata_2021_v2_tidy.csv** - This is the same as ASAM-metadata_2021_V2 spreadsheet but

a. 'notes' that were on otherwise empty rows have been moved into the 'notes' or newly named 'ASAM_NOTES' column on the row that the comment relates to

b. empty rows area then deleted

Read in data

Set filepath using "filepath <-"

file name = "ASAM_metadata_2021_v2_tidy.csv"

Tidy and inspect file structure

1. Checking structure (most data is currently character type)
2. Renaming columns to be R friendly
3. Inspect individual column contents for unusual formats or notes prior to type conversion

Names of Data:

Set names to be more R Friendly

Metadata Table Names	R Names
Year (yyyy)	Year_yyyy
Month (MON)	Month_MON
Vessel	Vessel
Contributor	Contributor
Subarea	Subarea
Survey name	Survey_name
Density estimate (g m-2)	Density_gm2
CV of density estimate (%)	CV_of_density_Perc
CV estimation method	CV_method
Survey area (km2)	Survey_area_km2
Echosounder model	Echosounder
Frequency used for biomass estimate (kHz)	Freq_for_biomass_est_kHz
Other frequencies available	Frequencies_avail
Method used for target identification	TS_Id_Method
dB-difference window	dB_diff_window
TS model used	TS_model
Depth range integrated (m)	Depth_range_integrated_m

Metadata Table Names	R Names
Time of day sampled	Time_sampled
Stratum name	Stratum_name
Survey design description	Survey_design_description
Reference	Reference
Note	Note
empty1	empty1
sourceexl	sourceexl
Net	Net
Tow design	Towdesign
ASAM_NOTES	ASAM_NOTES

Years & Months available:

```
##  [1] 1982 1986 1989 1990 1991 1992 1993 1994 1996 1997 1998 1999 2000 2001 2002
## [16] 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
## [31] 2018 2019 2020
```

```
##  [1] "Dec"             "Jan"             "Oct"             "Mar"
##  [5] "Nov"             "May"             "Feb"             "Apr"
##  [9] "Aug"             "Feb-Mar"         "Dec,Jan,Feb,Mar" "Jan, Feb"
```

Vessels and contributors

```
##  [1] "RRS James Clark Ross" "Atlantida*"           "RRS Discovery"
##  [4] "RRS John Biscoe"      ""                     "F/V Fu Rong Hai"
##  [7] "Yuzhmorgeologia"      "Moana Wave"           "Nathaniel B. Palmer"
## [10] "Polarstern"           "Saga Sea"             "Juvel"
## [13] "Kronprins Haakon"     "Cariboo"              "Italica"
## [16] "F/V Kwang Ja"         "RV Tangaroa"          "several"
## [19] "RV Atlantida"
```

```
##  [1] "UK"
##  [2] "China"
##  [3] "USA"
##  [4] "Germany, China, Australia"
##  [5] "IMR"
##  [6] "IMR, YSFRI, BAS"
##  [7] "IMR, YSFRI"
##  [8] "Italy (CNR IRBIM)"
##  [9] "Korea"
## [10] "New Zealand"
## [11] "ARK,China,Korea,Norway,Ukraine,United Kingdom"
## [12] "CCAMLR2000"
## [13] "Russia"
```

Subarea codes

Area “48” is the ccamlr 2000 survey

```
## [1] "48.3"       "48.1"       "48.2"       "88.1"       "48.2, 48.3"
## [6] "48.4"       "48"         "48.1/48.2"
```

CV method

```
## [1] "Jolly and Hampton"
## [2] ""
## [3] "Here, the CV were simply calculated as the S.E/Mean x 100% for each stratum or entire survey area"
## [4] "Bootstrapping"
```

There is an unusual entry of CV method:

“Here, the CV were simply calculated as the S.E/Mean x 100% for each stratum or entire survey area”

A note has been added to the “Note” column indicating that “CV calculated as the S.E/Mean x 100% for each stratum or entire survey area”

Data where CV calculated as the S.E/Mean x 100% for each stratum or entire survey area

Year_yyyy	Month_MON	Vessel	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2
2018	Apr	Polarstern	Germany, China, Australia	48.1	Germany, China, Australia	108.9	12.3	115526
2018	Apr	Polarstern	Germany, China, Australia	48.1	Germany, China, Australia	64	22.1	24479
2018	Apr	Polarstern	Germany, China, Australia	48.1	Germany, China, Australia	125.9	42.7	29031
2018	Apr	Polarstern	Germany, China, Australia	48.1	Germany, China, Australia	65	21.7	43865
2018	Apr	Polarstern	Germany, China, Australia	48.1	Germany, China, Australia	213.7	10.4	18151

Echosounder used:

```
##  [1] "EK500"               "EK60"                "EKS120 QM"
##  [4] "EK400 QD"            "EK400 ESP"           "Simrad EK60"
##  [7] "ES60"                "EK80"                "BioSonics 102"
## [10] "EK60,ES70,ES80,EK80"
```

Frequency used for biomass estimation, TS method and TS model

```
## [1] 120  70  38
```

```
##  [1] "dB difference (120-38 & 200-120)"
##  [2] "dB difference (120-38)"
##  [3] "All signal"
##  [4] "Visual"
##  [5] "Swarms identification"
##  [6] "dB difference (120-70)"
##  [7] "dB difference (120-70)***"
##  [8] "dB difference (120-38, 200-38, 200-120)"
##  [9] "acoustic fingerprint at 38, 120, 200"
## [10] "dB difference"
## [11] "Multifrequency response, swarms idenification"
```

```
##  [1] "full SDWBA (ASAM 2010 parameterisation)"
##  [2] "Greene et al. 1991"
##  [3] "Fluid sphere model. TS equation: Greene et al. 1991"
##  [4] "Fluid sphere model. TS equation: Greene et al. 1992"
##  [5] "Fluid sphere model. TS equation: Greene et al. 1993"
##  [6] "Fluid sphere model. TS equation: Greene et al. 1994"
##  [7] "Fluid sphere model. TS equation: Greene et al. 1995"
##  [8] "Fluid sphere model. TS equation: Greene et al. 1996"
##  [9] "Fluid sphere model. TS equation: Greene et al. 1997"
## [10] "Fluid sphere model. TS equation: Greene et al. 1998"
## [11] "Fluid sphere model. TS equation: Greene et al. 1999"
```

Depth range integrated

```
## [1] "250"  ""     "500m" "200"
```

Time of samples

```
## [1] "daylight only" "day and night" "day"
```

Stratum names and codes

To ease coding new strata codes were set up for Area 48.1 data under col ‘strata’.

Strata that were assigned a code based on the area they matched best.

Surveys which overlapped multiple areas were assigned combined codes.

Survey design

```
## [1] "Parallel transects"        "Radial transects"
## [3] ""                          "Transect"
## [5] "zig-zag transects"         "O'Driscoll et al (2010)"
## [7] "As per CCAMLR 2000 survey"
```

Notes/Comments

```
##  [1] "See map"
##  [2] ""
##  [3] "* my understanding that Atlantida did the WCB during the CCAMLR 2000 survey"
##  [4] "Greene and two frequency fixed window presented in Reid et al. 2010"
##  [5] "Brierley AS, Goss C, Grant SA, Watkins JA, Reid K, Belchier M, Everson I, Jessop MJ, Afanasyev V, Robst J. 2002 CCA
MLR Science 9: 71-82"
##  [6] "dB-difference window was applied to the detected aggregations  following the swarm-based identification method temp
late by SG-ASAM 2017"
##  [7] "As a contribution to the joint effort on the large-scale krill survey in Area 48, 2019"
##  [8] "see inset map for schematic display of sampling strata -- Joinville stratum includes the tracklines and stations th
at are not included in the other three strata"
##  [9] "200kHz is questionable for 2015, due to calibration. It wasn't used in 2016"
## [10] "CV calculated as the S.E/Mean x 100% for each stratum or entire survey area"
```

```
## [1] ""
## [2] "Reid K, Watkins JA, Murphy EJ, Trathan PN, Fielding S, Enderlein P. 2010 Marine Ecology Progress Series 399: 243-25
2"
## [3] "Fielding S., Watkins, J.L., Trathan, P., Enderlein, P., Waluda, C., Stowasser G., Tarling G.A., Murphy E.J. (2014) I
nter-annual variability in Antarctic krill (Euphausia superba) density at South Georgia, Southern Ocean: 1997 â\200“ 2012. I
CES Journal of Marine Sciences. doi:10.1093/icesjms/fsu104"
## [4] "Fielding S. (2018) Comparing two and three frequency dB window identification techniques for estimating Antarctic kr
ill density. SG-ASAM-18/01"
## [5] "Brierley, A.S., Watkins, J.L., Goss, C., Wilkinson, M.T. and Everson, I. (1999) Acoustic estimates of krill density
at South Georgia, 1981 to 1998. CCAMLR Science, 6: 47-57."
```

```
## [1] ""
## [2] "Same surveys as above, but done with Greene model"
## [3] "*No density estimate due to low proportion of survey area covered_**Reduced coverage due to ice"
## [4] "**Reduced coverage due to ice_***This frequency combination does not work well for discrimination"
## [5] "*Reduced spatial extent due to ice cover"
## [6] "**reduced coverage due to time constraints"
```

Survey details

Tow design. Nets. Source exl.

```
## [1] ""                                "Non-targeted Oblique"
## [3] "Non-targeted Oblique haul to 250 m"
```

```
## [1] ""         "1.8m IKMT" "6m2 IMKT"
```

```
##  [1] "GBR"      "CHN"      "USA"      "GER"      "NOR"      "ITA"
##  [7] "KOR"      "NZL"      "synoptic" ""
```

Remove Duplicate and Bad data

As analysis requires Density CV and Area for weighted density calculations:

1. Remove rows which do not have complete records for ‘Density’ and/or ‘CV’
2. Remove anything with a comment in the ‘ASAM_NOTES’ because this was either a. the same AMLR data but run with the Greene algorithm so DUPLICATED b. incomplete/the area wasn’t covered properly so difficult to weight appropriately

Removed data is being saved in a table named remdat

Before converting column classes, check numeric columns look numeric

Density

```
##   [1] "31.7"         "96.3"         "38.9"         "427.4"        "9.7"
##   [6] "23.7"         "2.7"          "1.6"          "36.7"         "5.7"
##  [11] "2.2"          "137"          "13.6"         "44.3"         "84.6"
##  [16] "168.9"        "12.9"         "26.1"         "93.2"         "55.6"
##  [21] "89.4"         "30.4"         "67"           "119.1"        "144.4"
##  [26] "38.7"         "61.1"         "17.2"         "6.2"          "25.9"
##  [31] "28.8"         "15"           "59"           "90.1"         "61.8"
##  [36] "31.2"         "25.4"         "45.2"         "29.2"         "24.8"
##  [41] "21.2"         "11.7"         "29.7"         "45.1"         "75.1"
##  [46] "6.4"          "95"           "65.8"         "7.4"          "1.9"
##  [51] "26.7"         "40.6"         "25.2"         "54.7"         "21.4"
##  [56] "151"          "3.5"          "34.7"         "51.6"         "47.2"
##  [61] "80.4"         "32.1"         "7.8"          "20.22"        "20.57"
##  [66] "41.47"        "55.16"        "80.74"        "89.2"         "94.7"
##  [71] "202.1"        "86.1"         "39.8"         "25"           "35.7"
##  [76] "86.4"         "41.4"         "12.1"         "13.9"         "54.2"
##  [81] "10"           "18.1"         "23"           "16.8"         "38.6"
##  [86] "103.4"        "81.1"         "22.6"         "117.07"       "20.1"
##  [91] "84.1"         "141.9"        "109.9"        "126.2"        "29.1"
##  [96] "20.7"         "107.6"        "1.4"          "3.6"          "2.4"
## [101] "0.4"          "67.3"         "72.2"         "21.7"         "17.3"
## [106] "5.1"          "54"           "30.9"         "136.7"        "70.3"
## [111] "51.028"       "15.57"        "49.5"         "37.3"         "26.2"
## [116] "41.5"         "16.5"         "80.7"         "25.6"         "5.6"
## [121] "7.1"          "50.3"         "50.2"         "1.2"          "2"
## [126] "17.085"       "20.5"         "15.2"         "50.7"         "43"
## [131] "19.7"         "20.8"         "6.1"          "55"           "14.6"
## [136] "3.2"          "13.4"         "0.5"          "18.7"         "4.8"
## [141] "68.8"         "30.6"         "17.1"         "76.7"         "229.9"
## [146] "95.3"         "1.58"         "1.5"          "0.15"         "1.5676"
## [151] "3.8"          "1.3"          "13.55"        "117.8"        "121"
## [156] "0.3"          "108.9"        "64"           "125.9"        "65"
## [161] "213.7"        "108.69"       "86.93"        "148.29"       "57.19"
## [166] "42.23"        "71.09"        "69.87"        "8.278307498" "9.146525297"
## [171] "21.77390952" "16.30624753" "5.922502164" "5.259348377" "13.64"
## [176] "24.57"        "14.48"        "0.93"         "5.58"         "40.47688092"
## [181] "25.89848421" "23.857455"    "67.72112684" "77.83964515" "9.092878215"
## [186] "25.9440078"   "56.03156687" "9.888204883" "102.4346965" "83.01170926"
## [191] "58.99355769" "170.5593277" "22.33682075" "19.6"         "31.47"
## [196] "1.8"          "136"          "319.4"        "33.8"         "4"
## [201] "58.48"        "73.06"        "82.05"        "114.93"       "557.81"
## [206] "17.95"        "19.57"        "38.47"        "76.99"        "62.85"
## [211] "25.13"        "17.62"        "46.15"        "35.6"         "77.17"
```

CV

Some CV values are 95% CI range rather than actual CV.

Remove from analysis data set (store in remdat).

```
##   [1] "26"              "14.3"            "28"
##   [4] "20.1"            "19.8"            "57.8"
##   [7] "35.5"            "18.3"            "27.5"
##  [10] "61.4"            "88.6"            "30.1"
##  [13] "37.8"            "57.9"            "43.1"
##  [16] "44.4"            "9.8"             "62.1"
##  [19] "40.6"            "60.6"            "38.9"
##  [22] "57.4"            "44.9"            "25.6"
##  [25] "47"              "26.2"            "70"
##  [28] "57"              "44.7"            "11.8"
##  [31] "46.6"            "46.2"            "39.1"
##  [34] "29.8"            "41.7"            "18.5"
##  [37] "86.1"            "26.1"            "9.5"
##  [40] "47.2"            "44"              "21"
##  [43] "53.2"            "15"              "34.6"
##  [46] "15.5"            "20.3"            "28.8"
##  [49] "9"               "17.1"            "11.1"
##  [52] "19.6"            "65.6"            "30.7"
##  [55] "33.5"            "26.5"            "43.6"
##  [58] "63.6"            "68.1"            "22.91"
##  [61] "28.53"           "18.9"            "17.68"
##  [64] "13.07"           "21.8"            "30"
##  [67] "29.7"            "13.9"            "24.2"
##  [70] "36.1"            "25"              "21.5"
##  [73] "16.95"           "21.6"            "39.6"
##  [76] "37.1"            "10.6"            "17.8"
##  [79] "20.2"            "48"              "30.2"
##  [82] "41.3"            "42.8"            "31.8"
##  [85] "48.9"            "16"              "9.1"
##  [88] "23.5"            "23.3"            "17.6"
##  [91] "23.1"            "37.2"            "27.9"
##  [94] "54.7"            "58.3"            "64.5"
##  [97] "68.6"            "19"              "40.1"
## [100] "20.6"            "41.5"            "60.2"
## [103] "80.5"            "55.2"            "16.7"
## [106] "41.9"            "11.3"            "14.1"
## [109] "18.2"            "56.2"            "49.5"
## [112] "9.6"             "80.9"            "30.6"
## [115] "96.1"            "32.1"            "26.8"
## [118] "58.5"            "99.6"            "16.04"
## [121] "53.1"            "33"              "48.8"
## [124] "63.2"            "25.57"           "53.9"
## [127] "43.3"            "8.6"             "54.5"
## [130] "115"             "44.5"            "55.9"
## [133] "52.1"            "40"              "59.3"
## [136] "58.7"            "46.8"            "33.6"
## [139] "51"              "29.1"            "30.4"
## [142] "51.78"           "51.9"            "60.7"
## [145] "71.85"           "37.4"            "27.6"
## [148] "55.28"           "52.2"            "62.7"
## [151] "12.3"            "22.1"            "42.7"
## [154] "21.7"            "10.4"            "18"
## [157] "32"              "41"              "45"
## [160] ""                "46.13"           "39.83"
## [163] "44.45"           "95%CI 0-6.42"    "95%CI 0.21-11.29"
## [166] "10.98898388"     "26.19352013"     "16.24168617"
## [169] "23.91574601"     "30.53981024"     "22.2208224"
## [172] "16.16530256"     "36.89290425"     "18.22463023"
## [175] "18.29492378"     "32.39759521"     "65.16650117"
## [178] "27.54752975"     "19.5615218"      "31.91"
## [181] "38.2"            "16.32"           "55"
## [184] "35.7"            "10.91"           "25.62"
## [187] "7.73"            "34.87"           "42.84"
## [190] "26.16"           "19.05"           "26.65"
## [193] "24.13"           "46.02"           "32.89"
## [196] "32.65"           "19.65"
```

Year_yyyy	Month_MON	Vessel	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	CV_method	Survey_area_km

Year_yyyy	Month_MON	Vessel	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	CV_method	Survey_area_km
2008	Feb-Mar	RV Tangaroa	New Zealand	88.1	NZ IPY-CAML	0.93	95%CI 0-6.42	Bootstrapping	35818
2008	Feb-Mar	RV Tangaroa	New Zealand	88.1	NZ IPY-CAML	5.58	95%CI 0.21-11.29	Bootstrapping	179283

Area

Some data sets do not have an area associated with them. See table below.

Area is required for weighting and calculating CV of combined metadata.

Rows without Areas associated are removed from analysis (stored in remdat).

```
##  [1] "8000"        "10640"       ""            "5332.8"      "7066.4"
##  [6] "48231"       "41673"       "43865"       "34149"       "38524"
## [11] "29031"       "8102"        "24479"       "18034.03"    "18162.17"
## [16] "17056.53"    "18016.4"     "18172.22"    "18322.1"     "18140.77"
## [21] "18153.26"    "18112.24"    "18156"       "10840.55"    "21198.39"
## [26] "43853"       "43915.886"   "42572.22267" "43863.75021" "18151"
## [31] "115526"      "27000"       "15000"       "37200"       "39600"
## [36] "60600"       "58800"       "473318"      "1109789"     "321800"
## [41] "48654"       "24409"       "25000"       "62274"       "0"
## [46] "214195"      "120980"      "77707"       "53921"       "9943"
## [51] "23302"       "20437"       "18870"       "22416"
```

No area available in Metadata - Required for CV!

Year_yyyy	Month_MON	Vessel	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2
1982	Nov	RRS John Biscoe	UK	48.3	JB03	11.7	9.5	
1986	Dec	RRS John Biscoe	UK	48.3	JB06	29.7	47.2	
1990	Jan	RRS John Biscoe	UK	48.3	JB10	45.1	44	
1990	Feb	RRS John Biscoe	UK	48.3	JB10	75.1	21	
1991	Jan	RRS John Biscoe	UK	48.3	JB11	6.4	53.2	
1992	Jan		UK	48.3	Fish survey	95	15	
1993	Jan	RRS James Clark Ross	UK	48.3	JR03	65.8	34.6	
1994	Jan	RRS James Clark Ross	UK	48.3	JR06	7.4	15.5	
1994	Jan	RRS James Clark Ross	UK	48.3	JR06	1.9	20.3	
2013	Dec	F/V Fu Rong Hai	China	48.1	S481FRH2013-14	20.22	22.91	
2015	Mar	F/V Fu Rong Hai	China	48.1	S481FRH2014-15	20.57	28.53	
2016	Jan	F/V Fu Rong Hai	China	48.1	S481FRH2015-16	41.47	18.9	
2018	Feb	F/V Fu Rong Hai	China	48.1	S481FRH2017-18	55.16	17.68	
2019	Feb	F/V Fu Rong Hai	China	48.1	S481FRH2018-19	80.74	13.07	
2016	Apr	F/V Kwang Ja	Korea	48.1		13.64	46.13	

Year_yyyy	Month_MON	Vessel	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2
2019	Mar	F/V Kwang Ja	Korea	48.1		24.57	39.83	
2019	Mar	F/V Kwang Ja	Korea	48.1		14.48	44.45	

Summary of data cleaning:

This cleaning process has removed 84 data entries from an original 286.

60 of these were duplicated AMLR studies using the Greene method.

Other data either had incomplete records for Density, CV and or Area or reduced coverage.

Data removed:

Year_yyyy	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2	ASAM_NOTES	strata
1996	USA	48.1	U.S. AMLR 96A	29.93	28.98	48231	Same surveys as above, but done with Greene model	E
1996	USA	48.1	U.S. AMLR 96D	14	28.89	48231	Same surveys as above, but done with Greene model	E
1997	USA	48.1	U.S. AMLR 97A	58.84	21.29	48231	Same surveys as above, but done with Greene model	E
1998	USA	48.1	U.S. AMLR 98A	47.56	14.43	41673	Same surveys as above, but done with Greene model	E
1998	USA	48.1	U.S. AMLR 98D	25.26	15.47	41673	Same surveys as above, but done with Greene model	E
1999	USA	48.1	U.S. AMLR 99A	14.09	40.63	41673	Same surveys as above, but done with Greene model	E
1999	USA	48.1	U.S. AMLR 99D	16.37	37.58	41673	Same surveys as above, but done with Greene model	E
2000	USA	48.1	U.S. AMLR 00D	38.71	25.62	41673	Same surveys as above, but done with Greene model	E
2001	USA	48.1	U.S. AMLR 01A	5.47	20.61	41673	Same surveys as above, but done with Greene model	E
2001	USA	48.1	U.S. AMLR 01D	6.91	10.83	41673	Same surveys as above, but done with Greene model	E
2002	USA	48.1	U.S. AMLR 02A	4	42.05	43865	Same surveys as above, but done with Greene model	E
2002	USA	48.1	U.S. AMLR 02D	3.11	21.71	43865	Same surveys as above, but done with Greene model	E
2003	USA	48.1	U.S. AMLR 03A	25.6	8.44	43865	Same surveys as above, but done with Greene model	E
2003	USA	48.1	U.S. AMLR 03D	18.22	20.23	43865	Same surveys as above, but done with Greene model	E

Year_yyyy	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2	ASAM_NOTES	strata
2004	USA	48.1	U.S. AMLR 04A	12.24	17.18	43865	Same surveys as above, but done with Greene model	E
2004	USA	48.1	U.S. AMLR 04D	11.9	23.76	43865	Same surveys as above, but done with Greene model	E
2005	USA	48.1	U.S. AMLR 05A	42.8	17.81	43865	Same surveys as above, but done with Greene model	E
2005	USA	48.1	U.S. AMLR 05D	1.86	20.96	43865	Same surveys as above, but done with Greene model	E
2006	USA	48.1	U.S. AMLR 06A	6.83	32.08	43865	Same surveys as above, but done with Greene model	E
2007	USA	48.1	U.S. AMLR 07A	8.41	36.5	43865	Same surveys as above, but done with Greene model	E
2008	USA	48.1	U.S. AMLR 08A	43	32.7	43865	Same surveys as above, but done with Greene model	E
2008	USA	48.1	U.S. AMLR 08D	22.6	47.5	43865	Same surveys as above, but done with Greene model	E
1997	USA	48.1	U.S. AMLR 97A	49.68	69.19	8102	Same surveys as above, but done with Greene model	S
1998	USA	48.1	U.S. AMLR 98A	36.97	17.22	8102	Same surveys as above, but done with Greene model	S
1998	USA	48.1	U.S. AMLR 98D	42.11	12.63	8102	Same surveys as above, but done with Greene model	S
1999	USA	48.1	U.S. AMLR 99A	15.55	13.47	8102	Same surveys as above, but done with Greene model	S
2000	USA	48.1	U.S. AMLR 00D	32.87	32.11	8102	Same surveys as above, but done with Greene model	S
2001	USA	48.1	U.S. AMLR 01A	27.19	60.24	8102	Same surveys as above, but done with Greene model	S
2001	USA	48.1	U.S. AMLR 01D	2.16	52.7	8102	Same surveys as above, but done with Greene model	S
2002	USA	48.1	U.S. AMLR 02A	2.23	44.88	24479	Same surveys as above, but done with Greene model	S
2002	USA	48.1	U.S. AMLR 02D	1.38	40.67	24479	Same surveys as above, but done with Greene model	S

Year_yyyy	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2	ASAM_NOTES	strata
2003	USA	48.1	U.S. AMLR 03A	14.45	23.9	24479	Same surveys as above, but done with Greene model	S
2003	USA	48.1	U.S. AMLR 03D	18.73	25.06	24479	Same surveys as above, but done with Greene model	S
2004	USA	48.1	U.S. AMLR 04A	9.51	26.21	24479	Same surveys as above, but done with Greene model	S
2004	USA	48.1	U.S. AMLR 04D	4.59	88.82	24479	Same surveys as above, but done with Greene model	S
2005	USA	48.1	U.S. AMLR 05A	16.38	14.08	24479	Same surveys as above, but done with Greene model	S
2005	USA	48.1	U.S. AMLR 05D	4.52	39.01	24479	Same surveys as above, but done with Greene model	S
2006	USA	48.1	U.S. AMLR 06A	45.72	15.95	24479	Same surveys as above, but done with Greene model	S
2007	USA	48.1	U.S. AMLR 07A	8.65	42.56	24479	Same surveys as above, but done with Greene model	S
2008	USA	48.1	U.S. AMLR 08A	20.46	50.9	24479	Same surveys as above, but done with Greene model	S
2008	USA	48.1	U.S. AMLR 08D	10.3	62.2	24479	Same surveys as above, but done with Greene model	S
1997	USA	48.1	U.S. AMLR 97A	45.5	28.04	34149	Same surveys as above, but done with Greene model	W
1998	USA	48.1	U.S. AMLR 98A	55.24	19.24	34149	Same surveys as above, but done with Greene model	W
1998	USA	48.1	U.S. AMLR 98D	53.19	23.57	34149	Same surveys as above, but done with Greene model	W
1999	USA	48.1	U.S. AMLR 99A	16.49	31.22	34149	Same surveys as above, but done with Greene model	W
1999	USA	48.1	U.S. AMLR 99D	16.29	33.35	34149	Same surveys as above, but done with Greene model	W
2000	USA	48.1	U.S. AMLR 00D	36.62	33.15	34149	Same surveys as above, but done with Greene model	W
2001	USA	48.1	U.S. AMLR 01A	5.43	19.95	34149	Same surveys as above, but done with Greene model	W

Year_yyyy	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2	ASAM_NOTES	strata
2001	USA	48.1	U.S. AMLR 01D	8.46	38.92	34149	Same surveys as above, but done with Greene model	W
2002	USA	48.1	U.S. AMLR 02A	0.86	30.1	38524	Same surveys as above, but done with Greene model	W
2002	USA	48.1	U.S. AMLR 02D	1.39	54.25	38524	Same surveys as above, but done with Greene model	W
2003	USA	48.1	U.S. AMLR 03A	29.89	16.5	38524	Same surveys as above, but done with Greene model	W
2003	USA	48.1	U.S. AMLR 03D	38.7	21.25	38524	Same surveys as above, but done with Greene model	W
2004	USA	48.1	U.S. AMLR 04A	18.36	9.26	38524	Same surveys as above, but done with Greene model	W
2004	USA	48.1	U.S. AMLR 04D	10.78	43.25	38524	Same surveys as above, but done with Greene model	W
2005	USA	48.1	U.S. AMLR 05A	25.5	18.47	38524	Same surveys as above, but done with Greene model	W
2005	USA	48.1	U.S. AMLR 05D	9.95	62.81	38524	Same surveys as above, but done with Greene model	W
2006	USA	48.1	U.S. AMLR 06A	2.53	22.85	38524	Same surveys as above, but done with Greene model	W
2007	USA	48.1	U.S. AMLR 07A	11.43	21.44	38524	Same surveys as above, but done with Greene model	W
2008	USA	48.1	U.S. AMLR 08A	32.1	40.1	38524	Same surveys as above, but done with Greene model	W
2013	IMR, YSFRI, BAS	48.2	S482_SS_2011	*		27000**	*No density estimate due to low proportion of survey area covered_**Reduced coverage due to ice	NA
2015	IMR	48.2	S482_J_2011	7.1	49	27000**	**Reduced coverage due to ice_***This frequency combination does not work well for discrimination	NA
1994	Italy (CNR IRBIM)	88.1		21.85394976		31800*	*Reduced spatial extent due to ice cover	NA
2014	Italy (CNR IRBIM)	88.1		26.48023705		16800**	**reduced coverage due to time constraints	NA

Year_yyyy	Contributor	Subarea	Survey_name	Density_gm2	CV_of_density_Perc	Survey_area_km2	ASAM_NOTES	strata
2016	Italy (CNR IRBIM)	88.1		5.38226619		12000**	**reduced coverage due to time constraints	NA
2008	New Zealand	88.1	NZ IPY-CAML	0.93	95%CI 0-6.42	35818	NA	NA
2008	New Zealand	88.1	NZ IPY-CAML	5.58	95%CI 0.21-11.29	179283	NA	NA
1982	UK	48.3	JB03	11.7	9.5		NA	NA
1986	UK	48.3	JB06	29.7	47.2		NA	NA
1990	UK	48.3	JB10	45.1	44		NA	NA
1990	UK	48.3	JB10	75.1	21		NA	NA
1991	UK	48.3	JB11	6.4	53.2		NA	NA
1992	UK	48.3	Fish survey	95	15		NA	NA
1993	UK	48.3	JR03	65.8	34.6		NA	NA
1994	UK	48.3	JR06	7.4	15.5		NA	NA
1994	UK	48.3	JR06	1.9	20.3		NA	NA
2013	China	48.1	S481FRH2013-14	20.22	22.91		NA	WS
2015	China	48.1	S481FRH2014-15	20.57	28.53		NA	WS
2016	China	48.1	S481FRH2015-16	41.47	18.9		NA	WS
2018	China	48.1	S481FRH2017-18	55.16	17.68		NA	WS
2019	China	48.1	S481FRH2018-19	80.74	13.07		NA	WS
2016	Korea	48.1		13.64	46.13		NA	WS
2019	Korea	48.1		24.57	39.83		NA	WS
2019	Korea	48.1		14.48	44.45		NA	WS

Format data classes

Density, CV and Survey area all assigned numeric

Stratum_name, Subarea, strata - assigned as factor

Save reduced data set to file

“ASAM_metadata_2021_v3_reduced.csv” = retained
“ASAM_metadata_2021_v3_REMOVED.csv” = removed

Krill biomass estimates from ASAM 2021 metadata

This Rmarkdown scripts works with a reduced version of the ASAM 2021 metadata spreadsheet, generated by code above. In summary, the original metadata spreadsheet was:

1. formatted to be R friendly
2. cleaned of duplicated data
3. cleaned of data with missing values of Density, CV or Area required in calculations

This script works with the data in *“ASAM_metadata_2021_v3_reduced.csv”*. Some plots of data for all area sampled are produced before restricting data to area 48.1 only.

Prepare data for plottng

Data Summary

Area by contributor

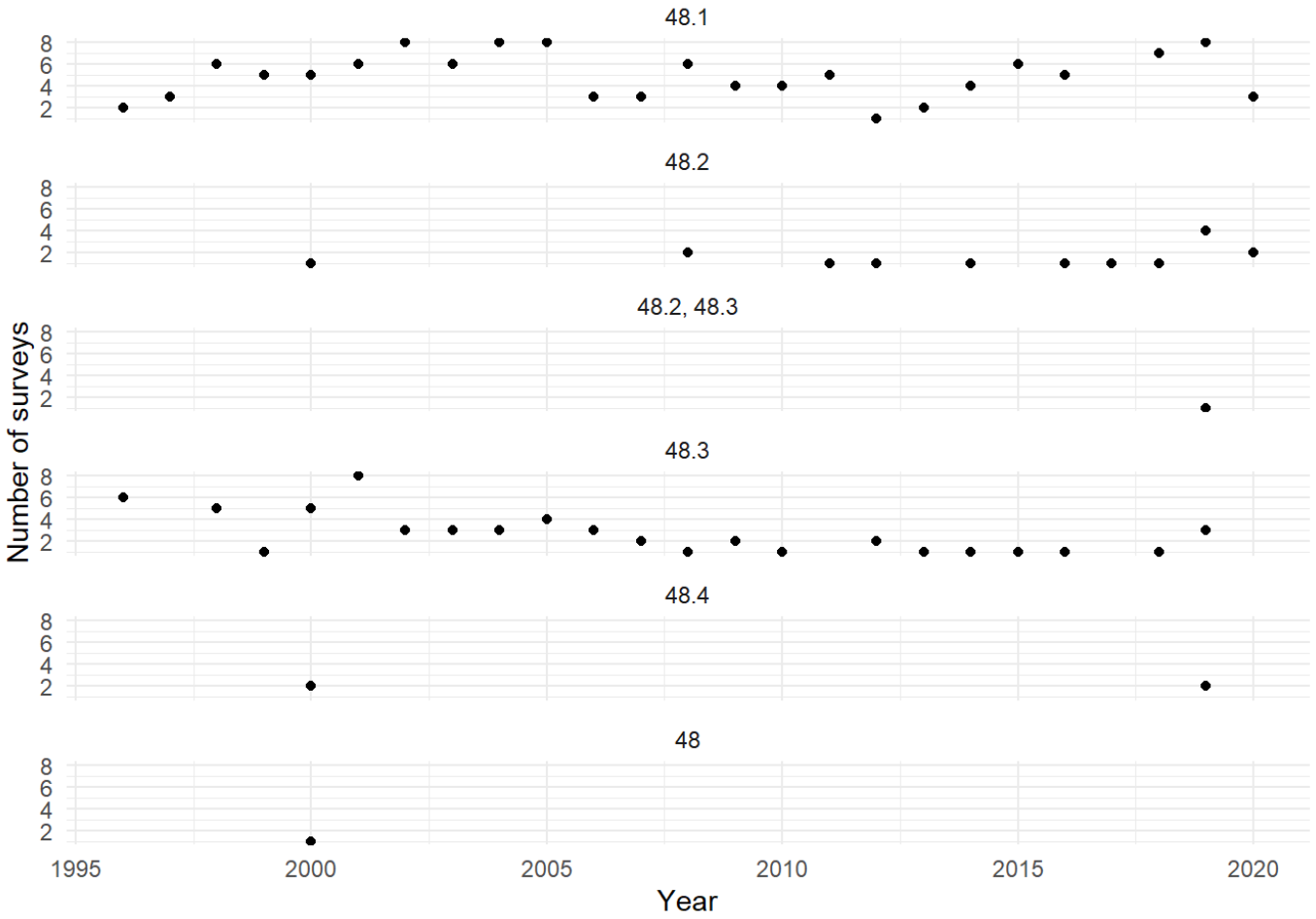
	ARK,China,Korea,Norway,Ukraine,United Kingdom	CCAMLR2000	China	Germany, China, Australia	IMR	IMR, YSFRI	IMR, YSFRI, BAS	Russia	UK	USA
48	0	1	0	0	0	0	0	0	0	0
48.1	6	2	10	5	0	0	0	2	0	92
48.1/48.2	0	0	0	0	0	0	0	1	0	0
48.2	3	1	0	0	5	1	1	2	0	2
48.2, 48.3	1	0	0	0	0	0	0	0	0	0
48.3	2	1	0	0	0	0	0	0	54	0
48.4	2	2	0	0	0	0	0	0	0	0
88.1	0	0	0	0	0	0	0	0	0	0

Time series plots

Number of surveys for each year by subarea

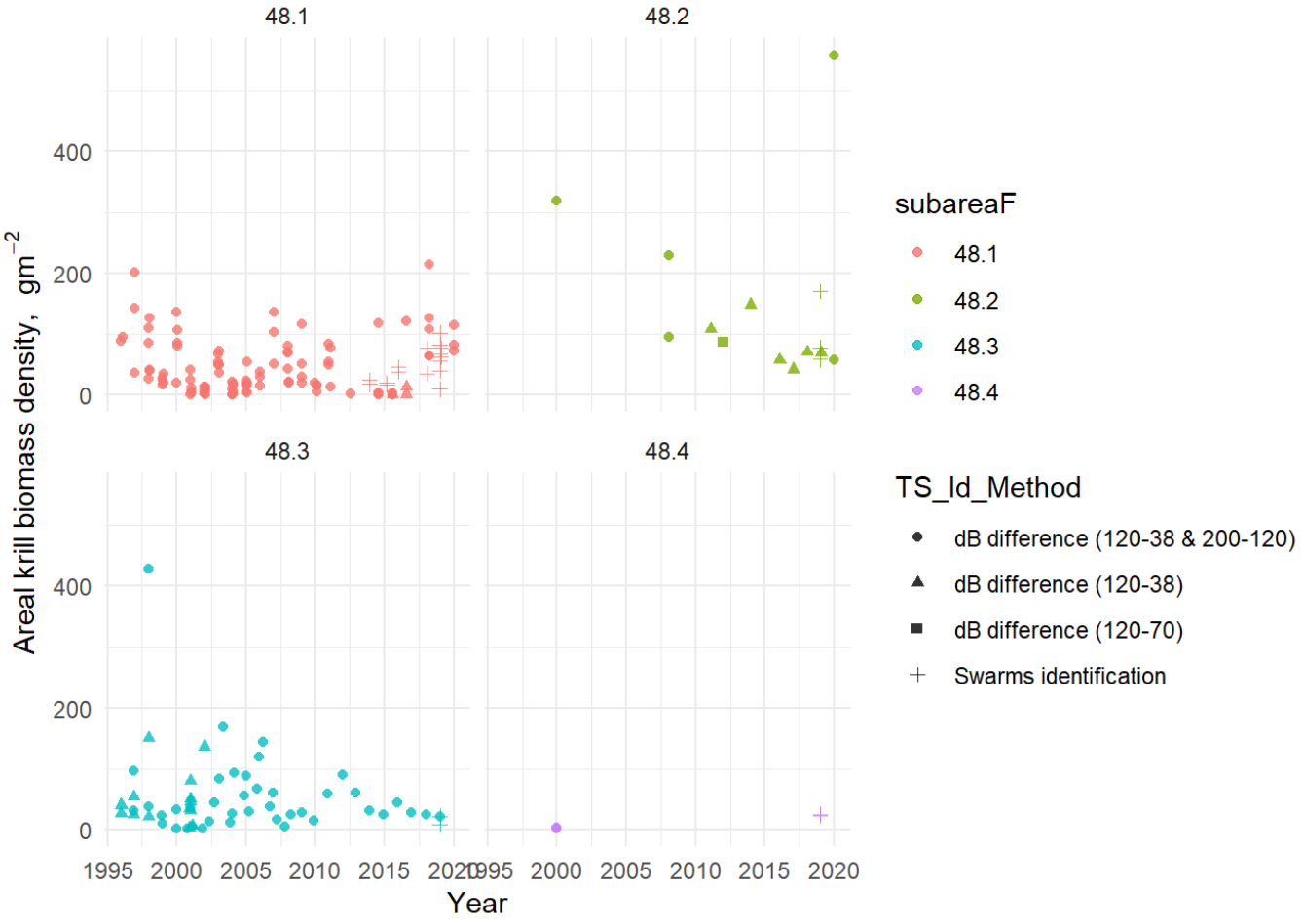
subareaF	Year_yyyy	n
48.3	1996	6
48.3	1998	5
48.3	1999	1
48.3	2000	5
48.3	2001	8
48.3	2002	3
48.3	2003	3
48.3	2004	3
48.3	2005	4
48.3	2006	3
48.3	2007	2
48.3	2008	1
48.3	2009	2
48.3	2010	1
48.3	2012	2
48.3	2013	1
48.3	2014	1
48.3	2015	1
48.3	2016	1
48.3	2018	1
48.3	2019	3
48.1	1996	2
48.1	1997	3
48.1	1998	6
48.1	1999	5
48.1	2000	5
48.1	2001	6
48.1	2002	8
48.1	2003	6
48.1	2004	8
48.1	2005	8
48.1	2006	3
48.1	2007	3
48.1	2008	6
48.1	2009	4
48.1	2010	4
48.1	2011	5

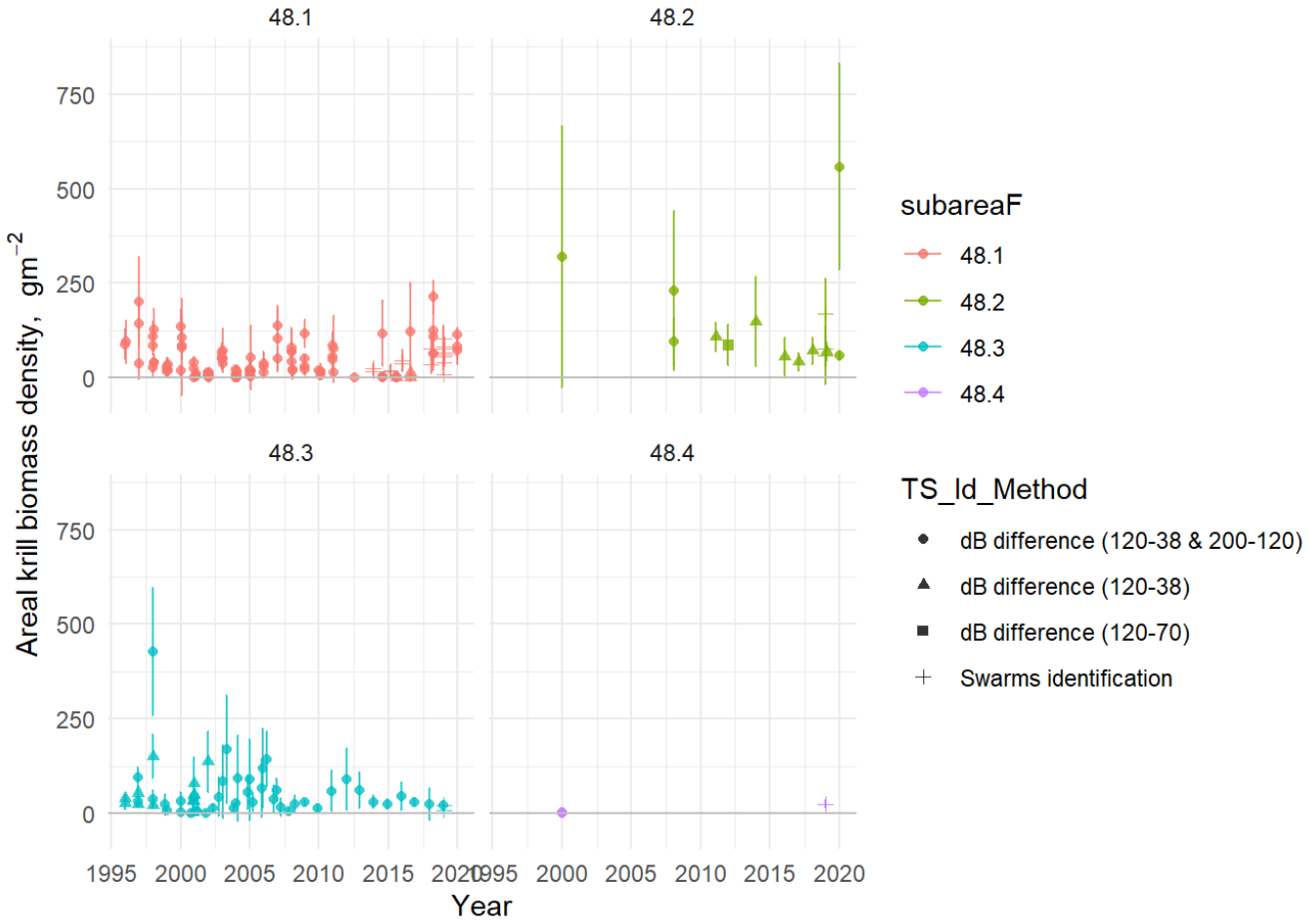
subareaF	Year_yyyy	n
48.2	2008	2
48.1	2012	1
48.1	2014	4
48.1	2015	6
48.1	2016	5
48.1	2018	7
48.2	2011	1
48.2	2012	1
48.2	2014	1
48.2	2016	1
48.2	2017	1
48.2	2018	1
48.2	2019	4
48.1	2019	8
48.2, 48.3	2019	1
48.4	2019	2
48	2000	1
48.4	2000	2
48.2	2000	1
48.2	2020	2
48.1	2020	3
48.1	2013	2



Number of surveys carried outduring each year by subarea.

NOTE: Areas labeled with “48.2, 48.3” and “48” are not plotted below to ease visualisation





Focus on Area 48.1

Years & Months available for 48.1 data:

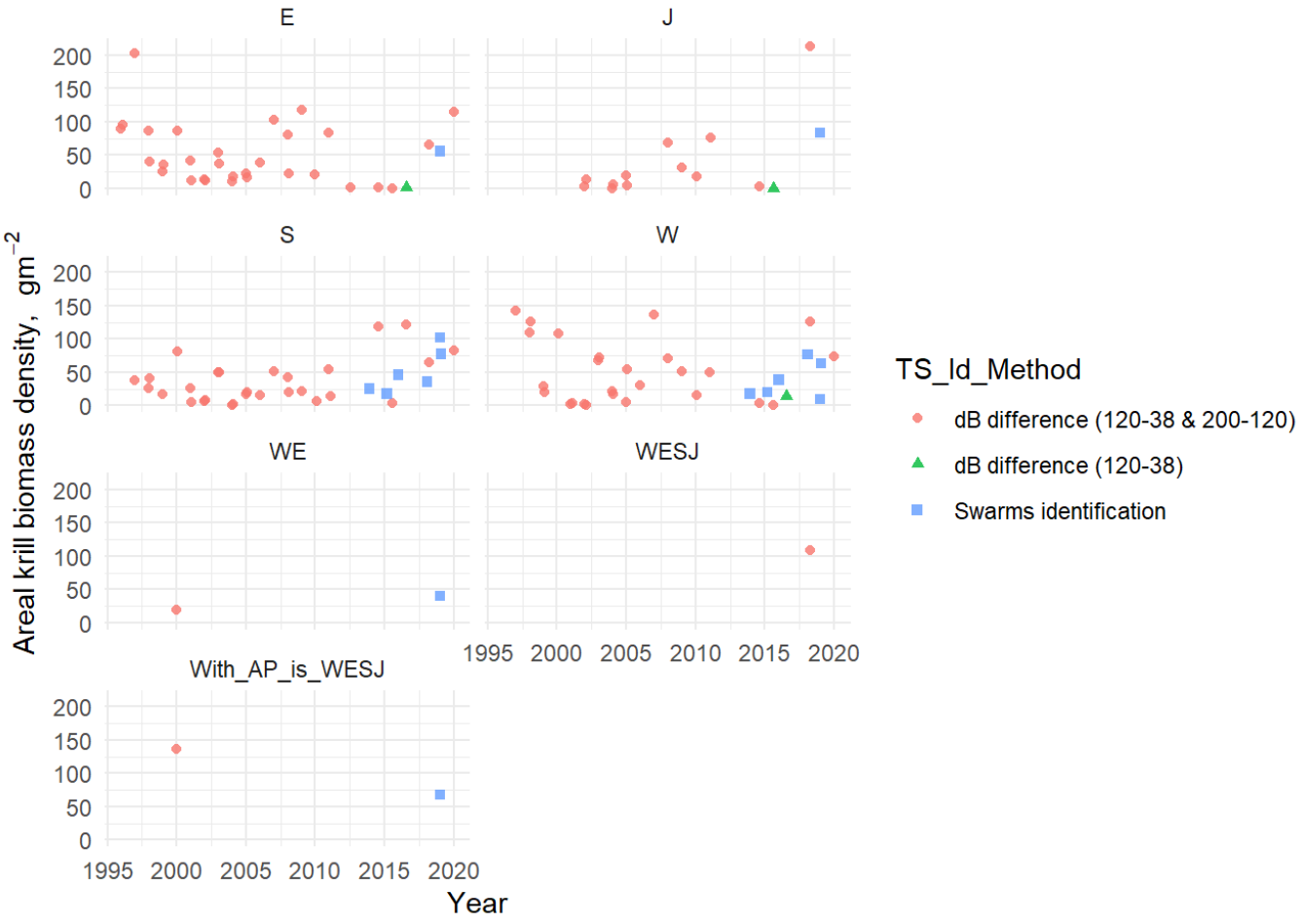
```
##  [1] 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
## [16] 2011 2012 2013 2014 2015 2016 2018 2019 2020
```

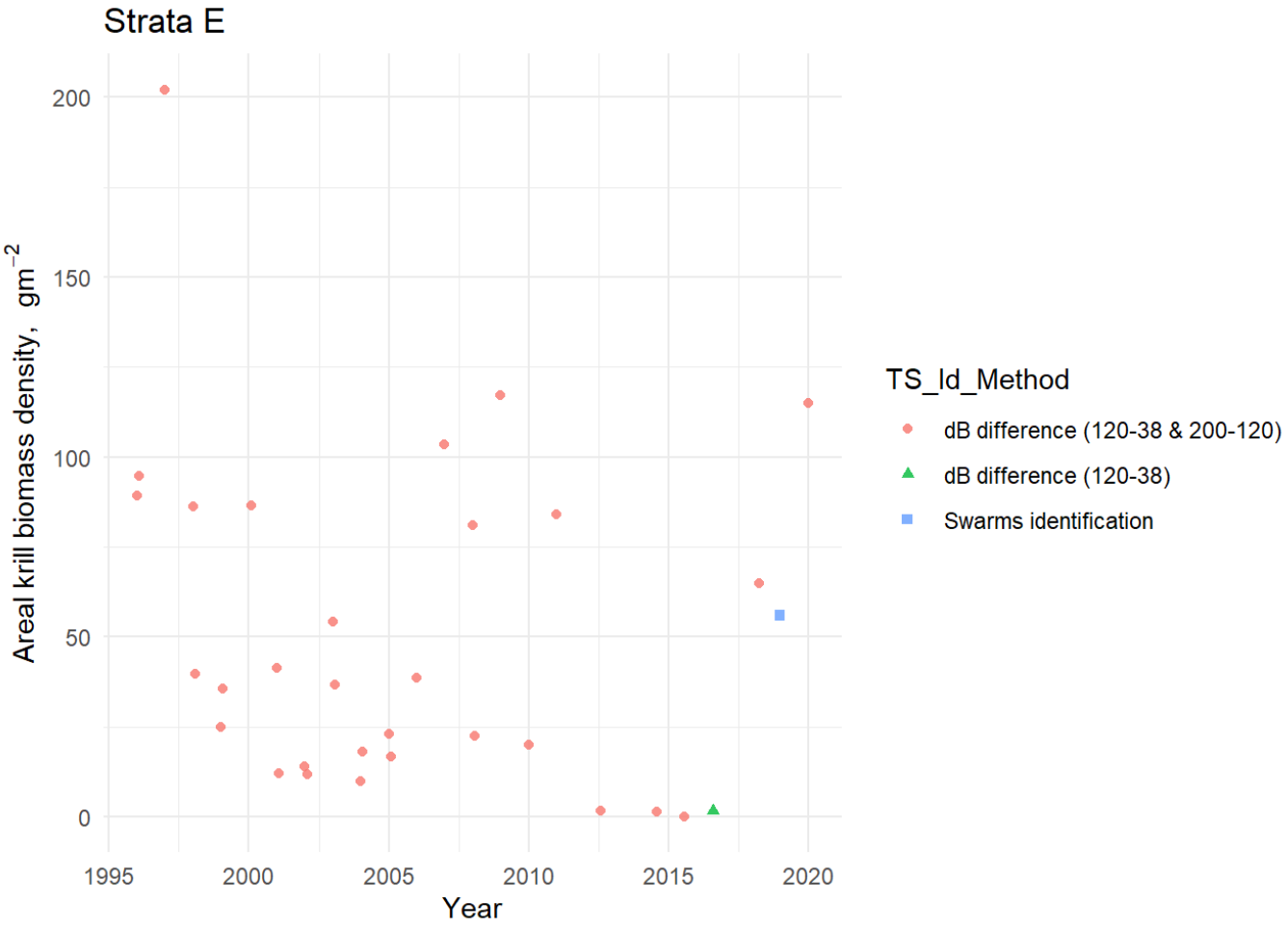
```
## [1] "Apr"           "Aug"           "Dec"           "Dec,Jan,Feb,Mar"
## [5] "Feb"           "Jan"           "Jan, Feb"      "Mar"
```

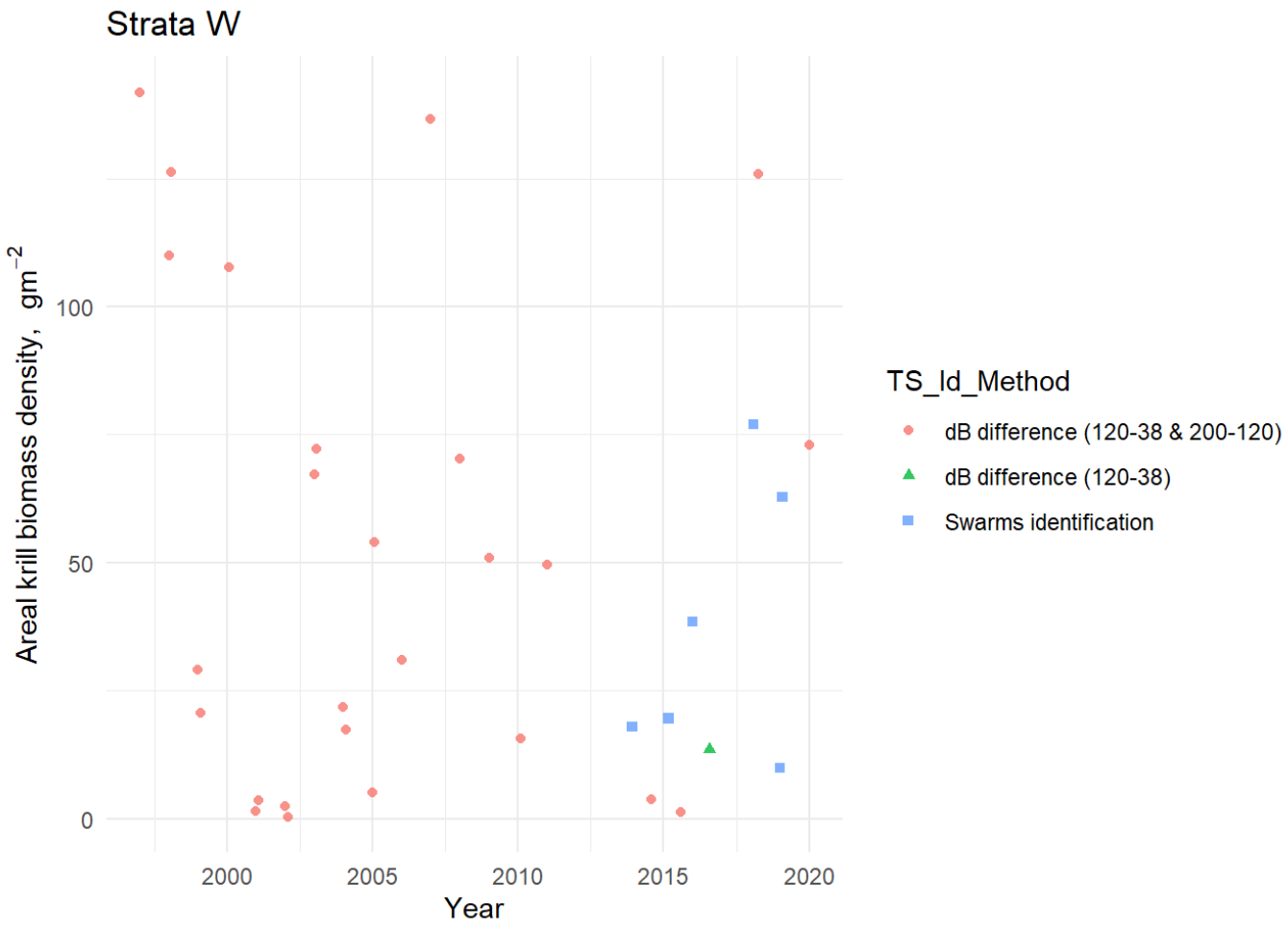
Strata available

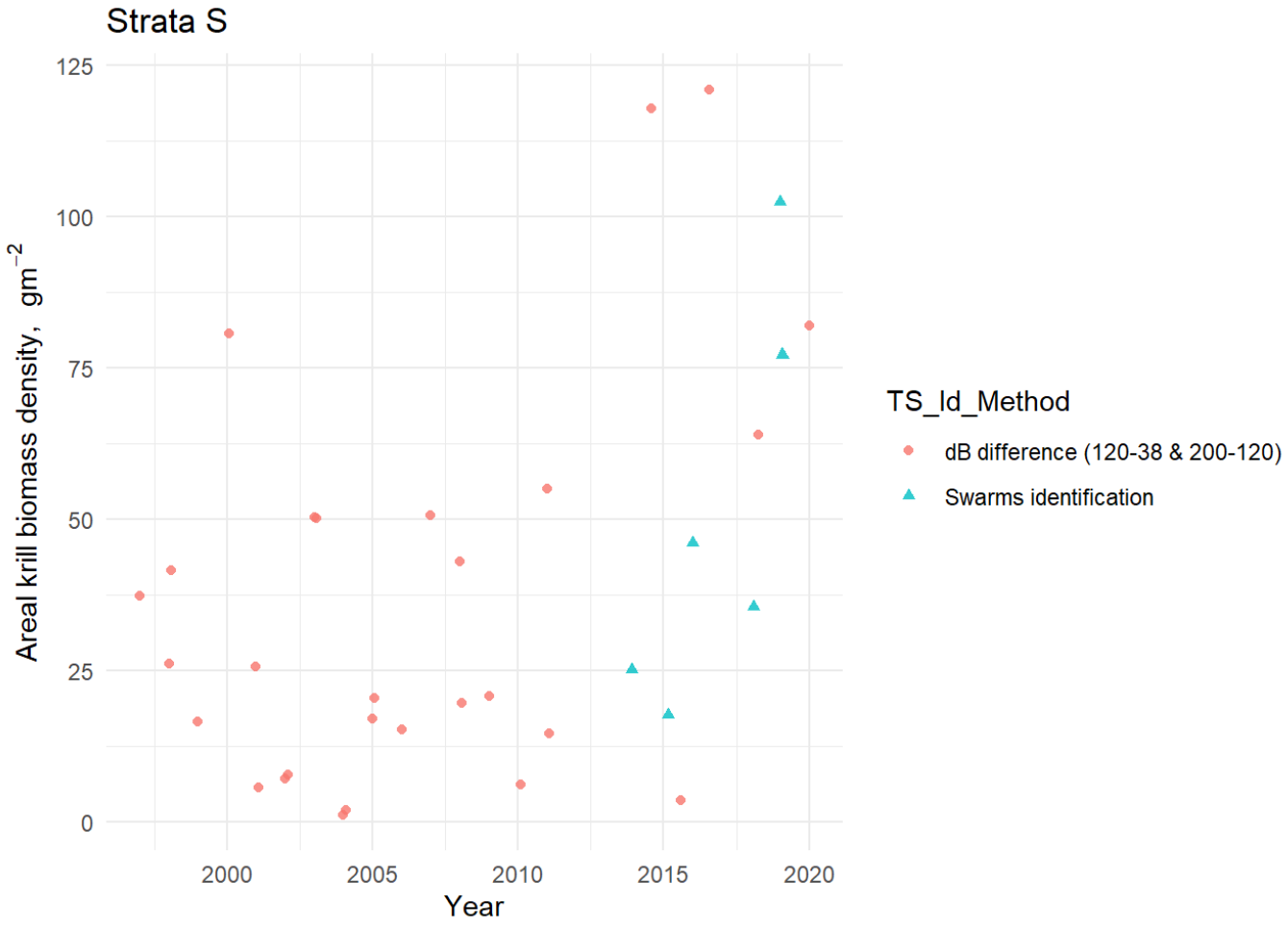
Stratum_name	Number_surveys	strata_code	Min_Area	Max_Area	Mean_Area
Elephant Island	31	E	41673	48231	43752
West	31	W	18870	38524	34398
South	26	S	8102	24479	20070
Joinville	14	J	17057	18322	18066
entire survey area	1	WESJ	115526	115526	115526
Bransfield	2	S	24479	24479	24479
South Shetland Islands North	1	W	29031	29031	29031
AP	2	WE	473318	473318	473318
SSI	2	With_AP_is_WESJ	48654	48654	48654
South Shetland Island (SSI)	1	W	120980	120980	120980
Bransfield Strait (BS)	6	S	22416	77707	31631
Elephant Island (EL)	1	E	53921	53921	53921

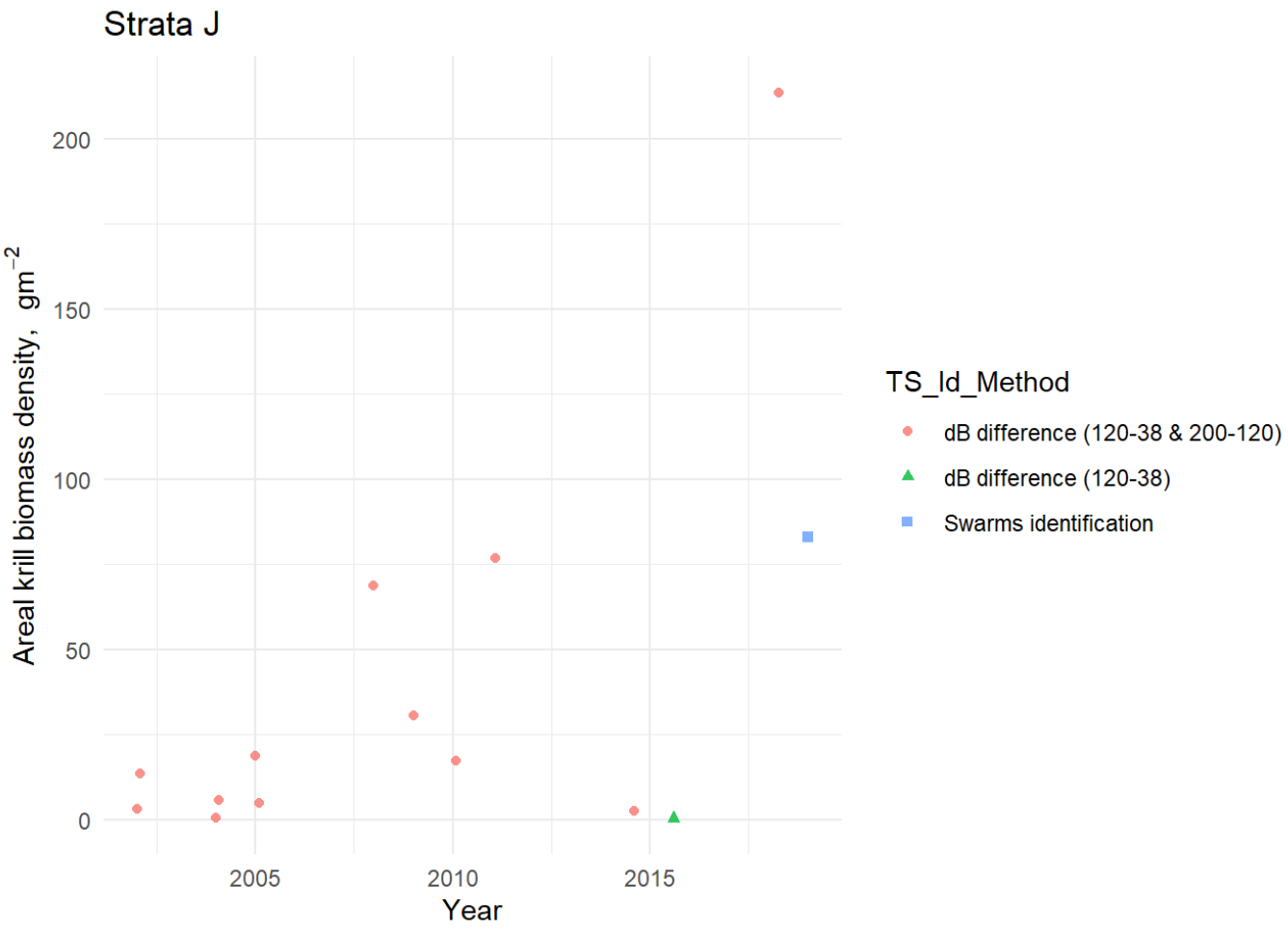
Area 48.1 Strata plots


E
J
S
W
WE
WESJ
With_AP_is_WESJ
Areal krill biomass density, gm^{-2}
Year
TS_Id_Method
dB difference (120-38 & 200-120)
dB difference (120-38)
Swarms identification


Strata E
Areal krill biomass density, gm^{-2}
Year
TS_Id_Method
dB difference (120-38 & 200-120)
dB difference (120-38)
Swarms identification


Strata W
Areal krill biomass density, gm^{-2}
0
50
100
2000
2005
2010
2015
2020
Year
TS_Id_Method
dB difference (120-38 & 200-120)
dB difference (120-38)
Swarms identification


Strata S
Areal krill biomass density, gm^{-2}
0
25
50
75
100
125
2000
2005
2010
2015
2020
Year
TS_Id_Method
dB difference (120-38 & 200-120)
Swarms identification


Strata J
Areal krill biomass density, gm^{-2}
200
150
100
50
0
2005
2010
2015
Year
TS_Id_Method
dB difference (120-38 & 200-120)
dB difference (120-38)
Swarms identification

Biomass calculations

Strategy

The data will be assessed sequentially starting at the smallest strata combining all data within each of “E”, “W”, “S”, “J” .

Then combining all data with “WE” codes and finally combining all in the large scale full area “WESJ”.

NOTE: the 2019 synoptic survey was aggregated over “Dec,Jan,Feb,Mar” & data available broadly spans months of Dec-Mar.

April is represented by a single 2018 survey carried out on *Polarstern*. In addition the CV were simply calculated as the S.E/Mean x 100% for each stratum or entire survey area, which covered: * South Shetland Islands North - W * Elephant Island - E * Bransfield - S * Joinville - J * entire survey area - WESJ

August data was all collected by the *Nathaniel B. Palmer* in 2012, 2014, 2015, 2016

Given the available data, summary stats are initially being calculated for the combined months of “December, January, February and March” data only.

Methodology

1) identify the various surveys that will be included in computing an average

2) compute weighted mean density using the survey areas as weights

- TotalArea <- sum(Survey_area_km2)
- AreaWeighting := Survey_area_km2/TotalArea
- Mean_Wt_Density_gm2 <- weighted.mean(x =Density_gm2, w = AreaWeighting)

since CVs are reported in the metadata spreadsheet these need to be converted to variances for use in the next step as
variance of survey density = (reported CV * reported density)^2

- Var_Density := (Density_gm2 * (CV_of_density_Perc / 100))^2

3) compute the variance of the weighted mean density using equation 3 in Jolly and Hampton (1990)

$$\mathrm{Var}(\hat{\bar{\rho}}) = \frac{\sum_i A_i^2 \, \mathrm{Var}(\hat{\bar{\rho}}_i)}{\left(\sum_i A_i\right)^2}$$

- JH_Numerator := (Survey_area_km2^2 * Var_Density)
- Var_WtMeanDensity <- (sum(tmpdt$JH_Numerator)) / (TotalArea)^2

4) CV = sqrt of variance from step 3 / mean from step 2

- CV <- (sqrt(Var_WtMeanDensity) / Mean_Wt_Density_gm2)*100

5) compute extrapolated biomass estimate as mean from step 2 * area to which extrapolation applies

(in Tonnes Per Square Kilometer (t/km2))

- biomass_extra <- Mean_Wt_Density_gm2 * Area_of_Extrapolation

6) compute variance of estimate from step 5 as variance from step 3 * (area to which extrapolation applies)^2

- var_biomass_extra <- Var_WtMeanDensity *(Area_of_Extrapolation^2)

7) CV = sqrt of variance from step 6 / biomass estimate from step 5

- CV_of_TotalBiomass <- (sqrt(var_biomass_extra) / biomass_extra)*100

Notes: • Steps 2-3 of this pseudocode can be applied to multiple surveys within a single stratum, surveys that cover multiple strata, or any combination of both. • Steps 3 and 6 aren’t necessary but the results of those two should be equal and provide a nice double-check that everything is working OK. • For those interested in application to the Grym later on - the outcome from Step 7 (or Step 4) might yield a useful estimate of the parameter “B0logSD,” where B0logSD = sqrt(log(1+CV^2))

Strata Areas for extrapolation

Strata areas are the maximum area recorded in the metadata from each of the strata.

AMLR areas are smaller than maximum Strata area, and the areas AMLR traditionally used to survey.

48.1 area is 640583 km^2 as taken from Table 1. WG-ASAM-21/14

PLEASE NOTE: I do not have WG-ASAM-21/14 so if someone can check that this is copied correctly that would be excellent!

strata	n	Strata_Area	AMLR_Area
E	32	53921	43865
W	33	120980	38524
S	34	77707	24479
J	14	18322	18151
WESJ	1	115526	NA
WE	2	473318	NA
With_AP_is_WESJ	2	48654	NA
CCAMLR_48_1	NA	640583	NA

Step 1 - working by area

Year codes

```
y3 =  2020 2019 2018

y5 = 2020 2019 2018 2016 2015

y5107 = 2020 2019 2018 2016 2015 2014 2013 2012 2011 2010 2009

yall = All available =  2020 2019 2018 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007 2006 2005 2004 2003 2002 2001 2000
1999 1998 1997 1996
```

Joinville

Years available: 2002, 2004, 2005, 2008, 2009, 2010, 2011, 2014, 2015, 2018, 2019

Mean Joinville survey area from all data in analysis: 18066km^2 for extrapolation

```
## [1] "Joinville"
```

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
Joinville	1	83.01	723.28	32.4	18322	1520941	32.4	18151	1506746	32.4	y3
Joinville	1	83.01	723.28	32.4	18322	1520941	32.4	18151	1506746	32.4	y5
Joinville	4	51.87	187.89	26.43	18322	950409	26.43	18151	941538	26.43	y5107
Joinville	11	29.48	28.19	18.01	18322	540112	18.01	18151	535071	18.01	yall

Elephant

Years available: 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2018, 2019, 2020

Mean Elephant survey area from all data in analysis: 44070km^2

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
Elephant	1	56.03	427.32	36.89	53921	3021278	36.89	43865	2457825	36.89	y3
Elephant	1	56.03	427.32	36.89	53921	3021278	36.89	43865	2457825	36.89	y5
Elephant	4	69.33	73.26	12.35	53921	3738094	12.35	43865	3040958	12.35	y5107
Elephant	26	55.57	16.32	7.27	53921	2996454	7.27	43865	2437630	7.27	yall

Bransfield

Years available: 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2014, 2015, 2016, 2018, 2019, 2020, 2013

Mean Bransfield survey area from all data in analysis: 22369km^2

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
Bransfield	3	72.65	81.99	12.46	77707	5645309	12.46	24479	1778367	12.46	y3
Bransfield	5	56.64	41.65	11.4	77707	4401161	11.4	24479	1386439	11.4	y5
Bransfield	10	40.05	17.01	10.3	77707	3112044	10.3	24479	980346	10.3	y5107
Bransfield	29	31.2	6.43	8.13	77707	2424801	8.13	24479	763853	8.13	yall

West

Years available: 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2014, 2015, 2016, 2018, 2019, 2020, 2013

Mean West survey area from all data in analysis: 36859km^2

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
West	3	41.65	34.02	14	120980	5038735	14	38524	1604498	14	y3
West	5	37.43	19.75	11.87	120980	4528001	11.87	38524	1441864	11.87	y5

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
West	9	37.04	7.78	7.53	120980	4480619	7.53	38524	1426776	7.53	y5107
West	28	48.68	12.59	7.29	120980	5888913	7.29	38524	1875223	7.29	yall

All strata together

Years available: 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2018, 2019, 2020, 2013

The strategy for combining all data is as before. All data is weighted by the survey area, however it is then extrapolated to a biomass for the entire survey area by summing the previous AMLR survey areas.

The sum of the AMLR areas were used for a region wide survey biomass estimate as some of the surveys were already combined over large areas and there was considerable overlap.

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
All 48.1	10	47.43	12.49	7.45	NA	NA	NA	125019	5929790	7.45	y3
All 48.1	14	45.64	10.29	7.03	NA	NA	NA	125019	5705583	7.03	y5
All 48.1	29	45.44	6.15	5.46	NA	NA	NA	125019	5680410	5.46	y5107
All 48.1	98	43.91	3.31	4.14	NA	NA	NA	125019	5490124	4.14	yall

Table of strata area biomass estimates

“N” = Number of surveys
“Density gm2” = Weighted mean density gm^{-2} across all surveys contributing (weighted by original survey area)
“Var Wt Density” = Variance of weighted mean density “CV Wt Density %” = Coefficient of Variation (percent) of weighted mean density
“Strata Area” = Maximum Area (km^2) of any survey contributing to the calculation of Weighted mean density
“Strata Area AMLR” = Previous AMLR survey areas (km^2) covering “Joinville”, “Elephant Island”, “Bransfield” and “West”
“Strata Biomass T km-2” = Biomass (Tones per km^2) extrapolated to Maximum Strata area surveyed
“CV Strata Biomass %” = Coefficient of Variation (percent) of Biomass extrapolated to Maximum Strata area surveyed “AMLR Biomass T km-2” = Biomass (Tones per km^2) extrapolated to AMLR defined area surveyed - in the case of combined data this is the sum of areas covering “Joinville”, “Elephant Island”, “Bransfield” and “West” “CV AMLR Biomass %” = Coefficient of Variation (percent) of Biomass extrapolated to AMLR survey areas “Years” = see “Year codes” above

Strata	N	Density gm2	Var Wt Density	CV Wt Density %	Strata Area	Strata Biomass T km-2	CV Strata Biomass %	Strata Area AMLR	AMLR Biomass T km-2	CV AMLR Biomass %	Years_included
Joinville	1	83.01	723.28	32.40	18322	1520941	32.40	18151	1506746	32.40	y3
Joinville	1	83.01	723.28	32.40	18322	1520941	32.40	18151	1506746	32.40	y5
Joinville	4	51.87	187.89	26.43	18322	950409	26.43	18151	941538	26.43	y5107
Joinville	11	29.48	28.19	18.01	18322	540112	18.01	18151	535071	18.01	yall
Elephant	1	56.03	427.32	36.89	53921	3021278	36.89	43865	2457825	36.89	y3
Elephant	1	56.03	427.32	36.89	53921	3021278	36.89	43865	2457825	36.89	y5
Elephant	4	69.33	73.26	12.35	53921	3738094	12.35	43865	3040958	12.35	y5107
Elephant	26	55.57	16.32	7.27	53921	2996454	7.27	43865	2437630	7.27	yall
Bransfield	3	72.65	81.99	12.46	77707	5645309	12.46	24479	1778367	12.46	y3
Bransfield	5	56.64	41.65	11.40	77707	4401161	11.40	24479	1386439	11.40	y5
Bransfield	10	40.05	17.01	10.30	77707	3112044	10.30	24479	980346	10.30	y5107
Bransfield	29	31.20	6.43	8.13	77707	2424801	8.13	24479	763853	8.13	yall
West	3	41.65	34.02	14.00	120980	5038735	14.00	38524	1604498	14.00	y3
West	5	37.43	19.75	11.87	120980	4528001	11.87	38524	1441864	11.87	y5
West	9	37.04	7.78	7.53	120980	4480619	7.53	38524	1426776	7.53	y5107
West	28	48.68	12.59	7.29	120980	5888913	7.29	38524	1875223	7.29	yall
All 48.1	10	47.43	12.49	7.45	NA	NA	NA	125019	5929790	7.45	y3
All 48.1	14	45.64	10.29	7.03	NA	NA	NA	125019	5705583	7.03	y5
All 48.1	29	45.44	6.15	5.46	NA	NA	NA	125019	5680410	5.46	y5107
All 48.1	98	43.91	3.31	4.14	NA	NA	NA	125019	5490124	4.14	yall

CCAMLR subarea 48.1

This data has not been extrapolated to the entire CCAMLR sub area 48.1 as some decisions need to be made around how to do that given that some of the areas that are not sampled are likely to be low density.

To extrapolate to the Entire subarea as is would involve running code chunk 756 - 830 but replacing

```
Area_of_Extrapolation_AMLR <- sum(AreaExtra[strata %in% c("W", "E", "S", "J")]$AMLR_Area)

with:

 Area_of_Extrapolation_AMLR <- 640583
```

In the interests of completion I have set up the code to run in the R markdown script BUT not included it in the final table.

This is unwise as all of this area has not been sampled

Strata 2019

Setting up codes to match the strata from 2019 synoptic survey.

One that was unclear was a Stratum name of ‘South’ which has been coded as “Bransfield”.

Areas need to be defined for these and then code can be looped through the unique strata2019 codes to produce biomass estimates as above.

```
s2019 <- mdat

knitr::kable(s2019[, .(n=.N,
                       strata = unique(strata)),
                   by=Stratum_name])
```

Stratum_name	n	strata
WCB	46	NA
ECB	7	NA
South Georgia	2	NA
Elephant Island	31	E
West	31	W
South	26	S
Joinville	14	J
South Orkneys	2	NA
entire survey area	1	WESJ
Bransfield	2	S
South Shetland Islands North	1	W
SOI	9	NA
AP	2	WE
SS	2	NA
ESS	2	WESJ
SSI	2	With_AP_is_WESJ
SG	2	NA
Sand	2	NA
SOF	1	NA
SOC	1	NA
Scotia Sea (SS)	1	NA
South Shetland Island (SSI)	1	W
Bransfield Strait (BS)	6	S
Elephant Island (EL)	1	E
South Orkney Island (SOI)	1	NA

```
s2019 <- s2019[Stratum_name=="WCB", strata19 := "WCB"][Stratum_name=="ECB", strata19 := "ECB"][Stratum_name %in% c("South Ge
orgia", "SG") , strata19 := "SG"][Stratum_name %in% c("Elephant Island", "Elephant Island (EL)") , strata19 := "Elephant"][S
tratum_name %in% c("West", "South Shetland Islands North"), strata19 := "West"][Stratum_name=="South", strata19 := "Bransfie
ld"][Stratum_name=="Joinville", strata19 := "Joinville"][Stratum_name %in% c("ESS", "entire survey area"), strata19 := "ESS"
][Stratum_name %in% c("South Orkney Island (SOI)", "South Orkneys", "SOI"), strata19 := "SOI"][Stratum_name %in% c("Bransfie
ld","Bransfield Strait (BS)"), strata19 := "Bransfield"][Stratum_name=="AP", strata19 := "AP"][Stratum_name=="SS", strata19
 := "SS"][Stratum_name %in% c("SSI","South Shetland Island (SSI)"), strata19 := "SSI"][Stratum_name=="Sand", strata19 := "Sa
nd"][Stratum_name=="SOF", strata19 := "SOF"][Stratum_name=="SOC", strata19 := "SOC"][Stratum_name=="Scotia Sea (SS)", strata
19 := "SS"]


knitr::kable(s2019[, .(n=.N,
                       strata = unique(strata),
                       strata19 = unique(strata19)),
                   by=Stratum_name])
```

Stratum_name	n	strata	strata19
WCB	46	NA	WCB
ECB	7	NA	ECB
South Georgia	2	NA	SG
Elephant Island	31	E	Elephant
West	31	W	West
South	26	S	Bransfield
Joinville	14	J	Joinville
South Orkneys	2	NA	SOI
entire survey area	1	WESJ	ESS
Bransfield	2	S	Bransfield
South Shetland Islands North	1	W	West
SOI	9	NA	SOI
AP	2	WE	AP
SS	2	NA	SS
ESS	2	WESJ	ESS
SSI	2	With_AP_is_WESJ	SSI
SG	2	NA	SG
Sand	2	NA	Sand
SOF	1	NA	SOF
SOC	1	NA	SOC
Scotia Sea (SS)	1	NA	SS
South Shetland Island (SSI)	1	W	SSI
Bransfield Strait (BS)	6	S	Bransfield
Elephant Island (EL)	1	E	Elephant
South Orkney Island (SOI)	1	NA	SOI

```
# unique strata to assess biomass
strata_id <- unique(s2019$strata19)
```