R COURSE

Data wrangling

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R - Session 02

- Data frames
- Concept of tidy data
- Reading data
- Manipulating data
- Columns
- Rows

Data frames

R objects

- List
- Matrix
- Factors
- **Data frames**

Data frames

What is it ?

- Table mixing different types of columns (an Excel table…)
- However within a column all values are similar, e.g. numeric, logical, character

```
df <- data.frame(label = letters[1:6],
                 id = 1:6,
                 value = rnorm(6, mean = 0, sd = 1),
                 flag=c(TRUE, FALSE),                    # re
                 stringsAsFactors = FALSE)
df
```

```
  label id       value  flag
1     a  1 -0.81120779  TRUE
2     b  2 -0.74986331 FALSE
3     c  3 -0.07044145  TRUE
4     d  4 -0.19749931 FALSE
5     e  5  0.80307129  TRUE
6     f  6 -0.08003410 FALSE
```

* We will NOT use factors: `stringsAsFactors = FALSE` (default in R > 4.0)

Useful functions

```
dim(df)   # returns the dimensions of data frame
nrow(df)  # number of rows
ncol(df)  # number of columns
```

```
[1] 6 4
[1] 6
[1] 4
```

```
str(df)   # structure of data frame - name, type and preview o
colnames(df) # columns names
```

```
'data.frame':   6 obs. of  4 variables:
 $ label: chr  "a" "b" "c" "d" ...
 $ id   : int  1 2 3 4 5 6
 $ value: num  -0.8112 -0.7499 -0.0704 -0.1975 0.8031 ...
 $ flag : logi  TRUE FALSE TRUE FALSE TRUE FALSE
[1] "label" "id"    "value" "flag"
```

Access specific value

- Use the `df[i,j]` notation, first index corresponds to row, second index to column

```
df[5,3]
```

```
[1] 0.8030713
```

- Specify the name of the column

```
df[5,"value"]
```

```
[1] 0.8030713
```

The result is a **vector**

Access specific column

- Use the `df[i,j]` notation

```
df[,3]
df[,"value"]
```

```
[1] -0.81120779 -0.74986331 -0.07044145 -0.19749931  0.80307129 -0.08003410
[1] -0.81120779 -0.74986331 -0.07044145 -0.19749931  0.80307129 -0.08003410
```

The result is a **vector**

- Use $notation

```
df$value
```

```
[1] -0.81120779 -0.74986331 -0.07044145 -0.19749931  0.80307129 -0.08003410
```

- This can be used to access a specific value
- $ for the column, `[i]` for the row

```
df$value[5]
```

```
[1] 0.8030713
```

Access row

- Use the `df[i,j]` notation

```
df[1,]
```

```
  label id      value flag
1     a  1 -0.8112078 TRUE
```

The result is a **data frame**

Access specific rows

- e.g. Rows for which the value of id <= 3

```
df[df$id <= 3,]
```

```
  label id       value  flag
1     a  1 -0.81120779  TRUE
2     b  2 -0.74986331 FALSE
3     c  3 -0.07044145  TRUE
```

Select lines for which the label is c

```
df[df$label ==  "c",]
```

```
  label id       value flag
3     c  3 -0.07044145 TRUE
```

This syntax is complicated - tidyverse packages make it much more easy to manipulate and remember

Tidy data

Installation

Packages

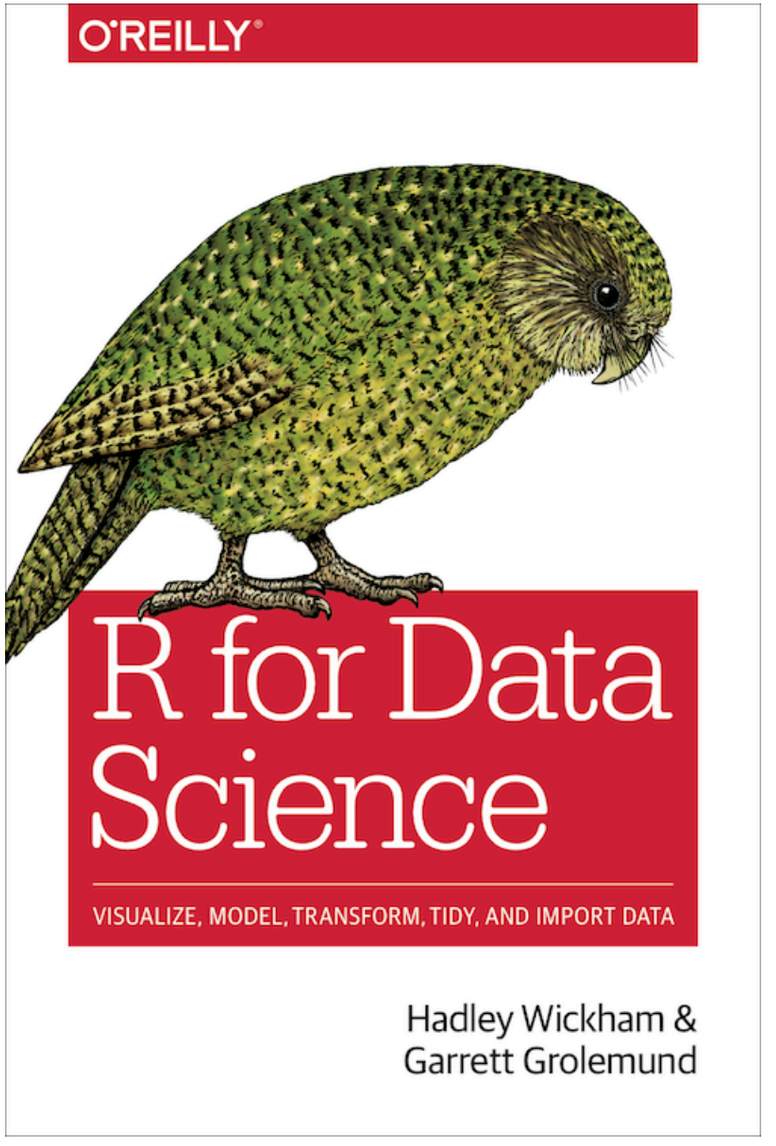
- readxl : Reading Excel files
- readr : Reading and writing Text files
- dplyr : Filter and reformat data frames
- tidyr : Make data “tidy”
- stringr : Manipulating strings
- lubridate : Manipulate date

Data and script

- unzip `data.zip`
- Open in R `scripts/script_wrangling.R`

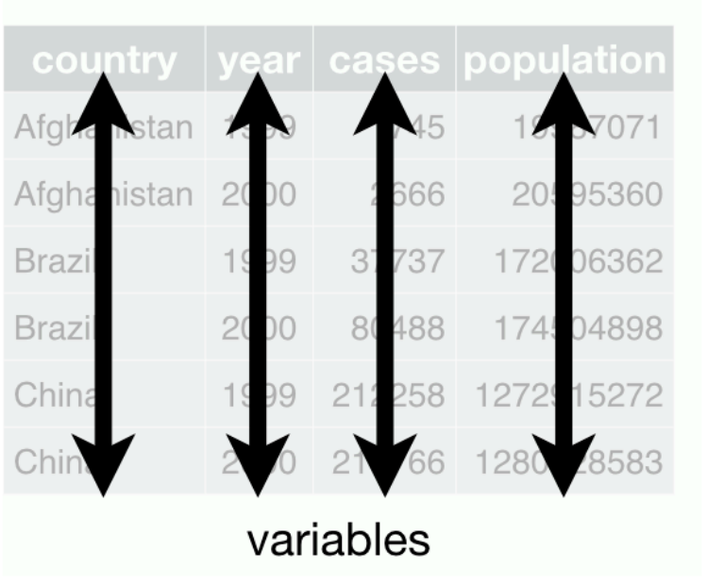
Resources

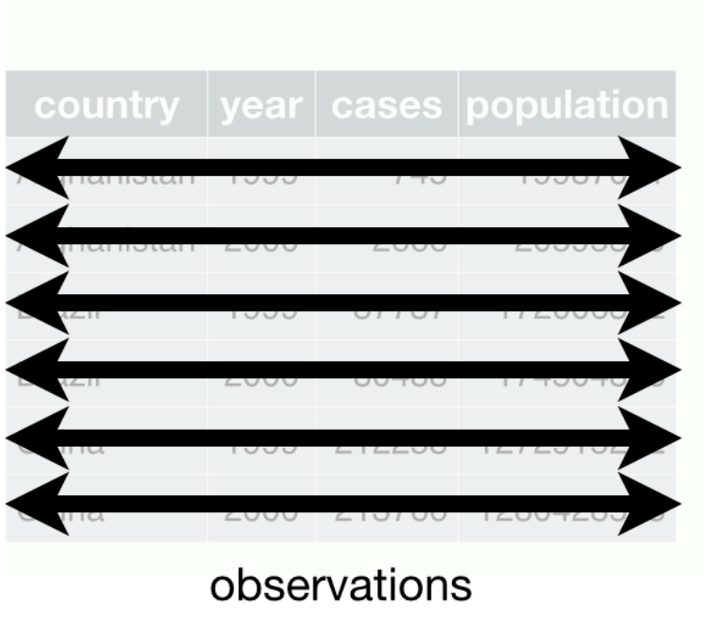
- R for data science: (Chapter 5)
- Cheat sheets
  - Importing data
  - Cleaning up data
  - Manipulating strings



Basic concepts

1. Each variable must have its own column.
2. Each observation must have its own row.
3. Each value must have its own cell.





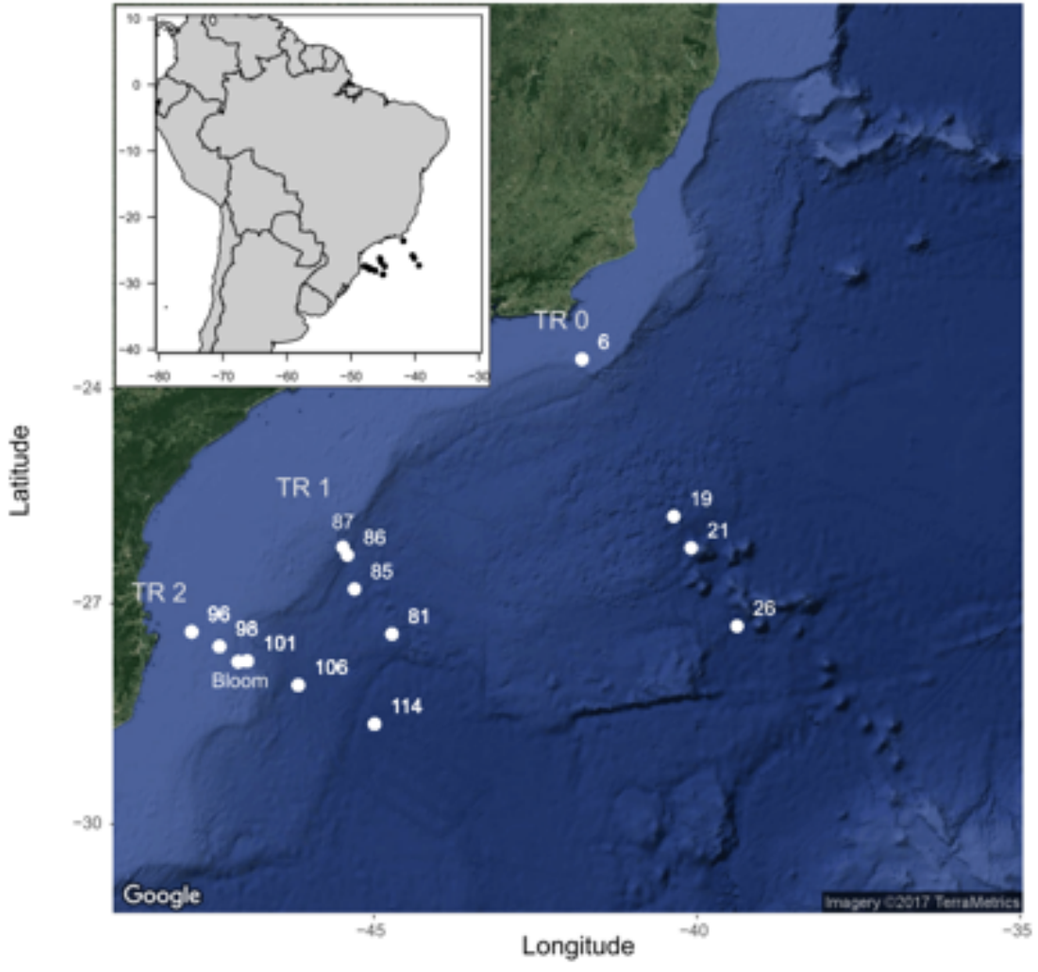
Load necessary libraries

```
library("readxl") # Import the data from Excel file
library("readr")  # Import the data from Excel file

library("dplyr")  # filter and reformat data frames
library("tidyr")  # make data tidy

library("stringr") # manipulate strings
library("lubridate") # manipulate date

library("ggplot2") # graphics
```

Read and Write data

Oceanographic data

CARBOM cruise off Brazil



- Stations
- Depth
- Coordinates
- Temperature, Salinity
- Nitrates, Phosphates

The ISME Journal
https://doi.org/10.1038/s41396-018-0050-z

ARTICLE

Small eukaryotic phytoplankton communities in tropical waters off Brazil are dominated by symbioses between Haptophyta and nitrogen-fixing cyanobacteria

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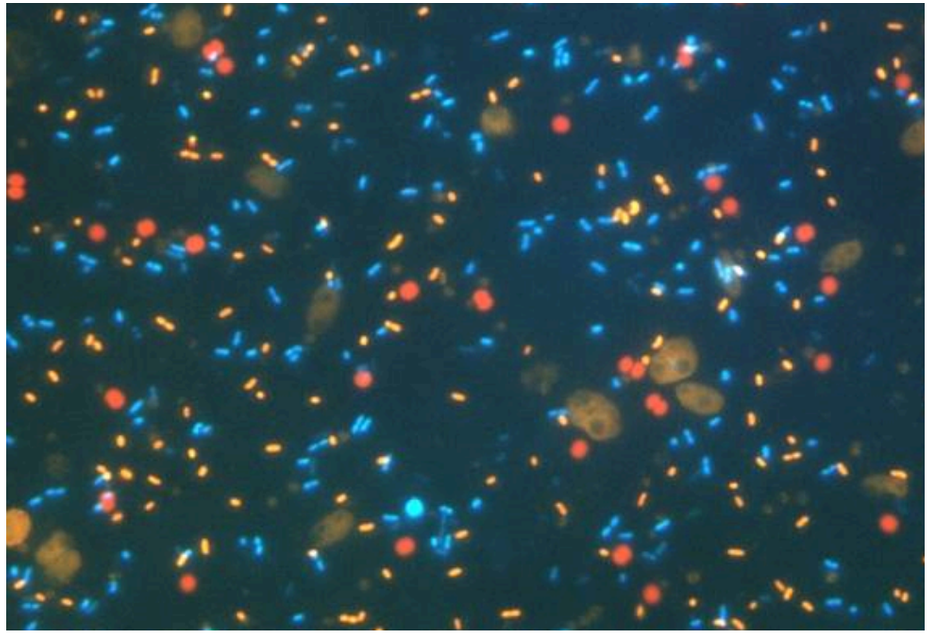
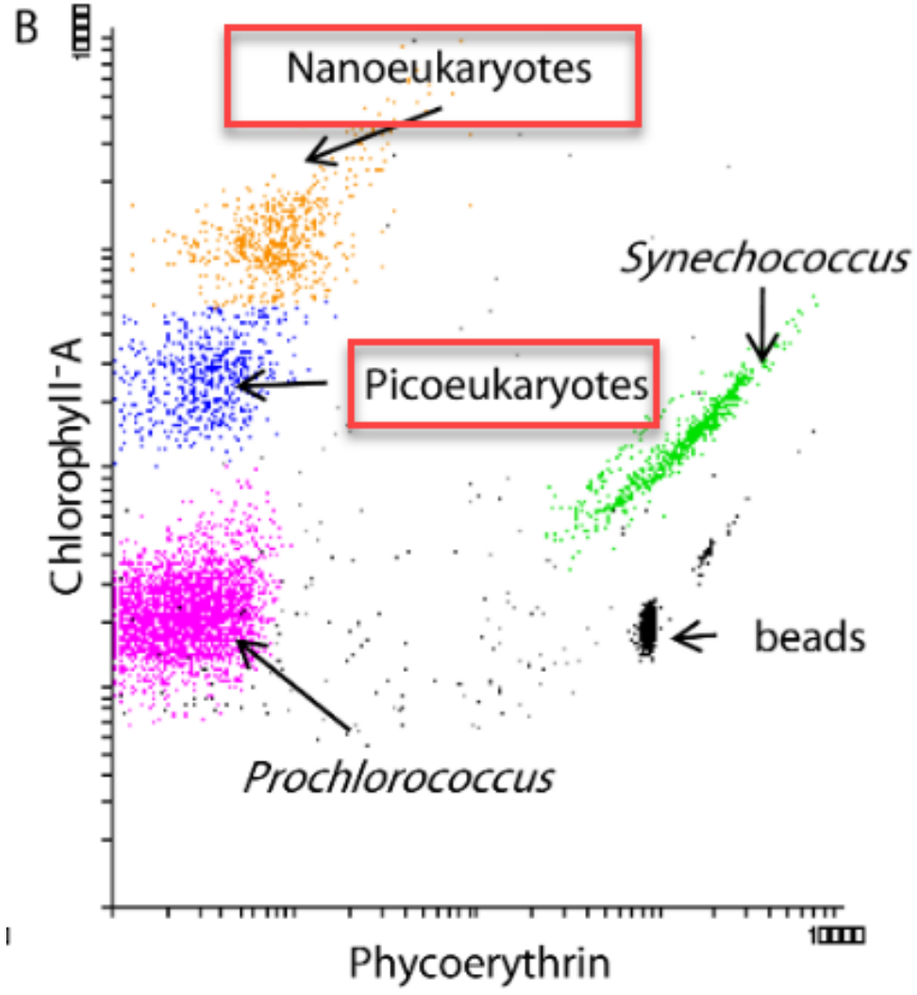
Microbial populations



- Flow cytometry :
  - pico-eukaryotes
  - nano-eukaryotes



Read data

Text file - TAB delimited

CARBOM data.txt

```
sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
10	1	81	13/11/2013	01:00	140	Deep	-27.42	-44.72	3278	1232	0.2	0.26	17.3	35.9
11	1	85	13/11/2013	13:30	110	Deep	-26.8	-45.3	16312	1615	0.29	0.22	21.3	36.5
120	2	96	18/11/2013	23:50	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
121	2		18/11/2013	23:50	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
122	2		18/11/2013	23:50	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
125	2	98	18/11/2013	05:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
126	2		18/11/2013	05:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.2	23.7	37.2
127	2		18/11/2013	05:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37
13	1	86	13/11/2013	17:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
140	2	101	18/11/2013	12:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5
141	2		18/11/2013	12:00	60	Deep	-27.79	-46.96	1046	485	0.25	0.22	23.7	37.2
142	2		18/11/2013	12:00	110	Deep	-27.79	-46.96	641	159	0.29	0.84	23.3	37.1
155	2	106	19/11/2013	02:30	5	Surf	-28.12	-46.17	355	18	0.25	0.37	23	36.9
156	2		19/11/2013	02:30	60	Deep	-28.12	-46.17	1800	300	0.25	0.34	22.9	36.9
157	2		19/11/2013	02:30	100	Deep	-28.12	-46.17	6910	1152	0.29	0.4	21.5	36.7
15	1	87	13/11/2013	19:30	105	Deep	-26.22	-45.48	6189	622	0.47	1.51	19.5	36.1
165	2	114	19/11/2013	21:40	5	Surf	-28.65	-44.99	728	226	0.29	0.28	22.4	36.4
166	2		19/11/2013	21:40	60	Deep	-28.65	-44.99	660	578	0.16	0.25	21.4	36.6
167	2		19/11/2013	21:40	80	Deep	-28.65	-44.99	722	390	0.2	0.21	21	36.6
1	0	6	31/10/2013	05:20	45	Deep	-23.58	-41.78	7651	4845	0.47	1.07	19.7	36.3
2	0		31/10/2013	05:20	45	Deep	-23.58	-41.78	7343	3258	0.47	1.07	19.7	36.3
3	0	19	02/11/2013	13:30	5	Surf	-25.79	-40.36	1005	898	0.29	0.48	22.7	36.9
5	0	21	02/11/2013	00:00	5	Surf	-26.23	-40.09	793	660	0.16	0.9	22.8	36.9
7	0	26	03/11/2013	19:30	5	Surf	-27.31	-39.38	907	856	0.2	0.5	21.2	36.4
9	1	81	13/11/2013	01:00	140	Deep	-27.42	-44.72	3181	1235	0.2	0.26	17.3	35.9
```

Reading a text file

```
samples <- readr::read_tsv("data/CARBOM data.txt")
```

sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
10	1	81	13/11/2013	01:00:00	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9
11	1	85	13/11/2013	13:30:00	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5
120	2	96	18/11/2013	23:50:00	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
121	2		18/11/2013	23:50:00	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
122	2		18/11/2013	23:50:00	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
125	2	98	18/11/2013	05:00:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
126	2		18/11/2013	05:00:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2
127	2		18/11/2013	05:00:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0
13	1	86	13/11/2013	17:00:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
140	2	101	18/11/2013	12:00:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5

- **readr::read_tsv()** : read tab delimited files
- **readr::read_csv()** : read comma delimited files
- **readr::write_tsv()** : write tab delimited files

Excel sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
4	120	2	96	18/11/2013	23:50	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
5	121	2		18/11/2013	23:50	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
6	122	2		18/11/2013	23:50	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
7	125	2	98	18/11/2013	05:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
8	126	2		18/11/2013	05:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.2	23.7	37.2
9	127	2		18/11/2013	05:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37
10	13	1	86	13/11/2013	17:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
11	140	2	101	18/11/2013	12:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5
12	141	2		18/11/2013	12:00	60	Deep	-27.79	-46.96	1046	485	0.25	0.22	23.7	37.2
13	142	2		18/11/2013	12:00	110	Deep	-27.79	-46.96	641	159	0.29	0.84	23.3	37.1
14	155	2	106	19/11/2013	02:30	5	Surf	-28.12	-46.17	355	18	0.25	0.37	23	36.9
15	156	2		19/11/2013	02:30	60	Deep	-28.12	-46.17	1800	300	0.25	0.34	22.9	36.9
16	157	2		19/11/2013	02:30	100	Deep	-28.12	-46.17	6910	1152	0.29	0.4	21.5	36.7
17	15	1	87	13/11/2013	19:30	105	Deep	-26.22	-45.48	6189	622	0.47	1.51	19.5	36.1
18	165	2	114	19/11/2013	21:40	5	Surf	-28.65	-44.99	728	226	0.29	0.28	22.4	36.4
19	166	2		19/11/2013	21:40	60	Deep	-28.65	-44.99	660	578	0.16	0.25	21.4	36.6
20	167	2		19/11/2013	21:40	80	Deep	-28.65	-44.99	722	390	0.2	0.21	21	36.6
21	1	0	6	31/10/2013	05:20	45	Deep	-23.58	-41.78	7651	4845	0.47	1.07	19.7	36.3
22	2	0		31/10/2013	05:20	45	Deep	-23.58	-41.78	7343	3258	0.47	1.07	19.7	36.3
23	3	0	19	02/11/2013	13:30	5	Surf	-25.79	-40.36	1005	898	0.29	0.48	22.7	36.9
24	5	0	21	02/11/2013	00:00	5	Surf	-26.23	-40.09	793	660	0.16	0.9	22.8	36.9
25	7	0	26	03/11/2013	19:30	5	Surf	-27.31	-39.38	907	856	0.2	0.5	21.2	36.4
26	9	1	81	13/11/2013	01:00	140	Deep	-27.42	-44.72	3181	1235	0.2	0.26	17.3	35.9
27	Trichod.1	2	Bloom	0			Surf	-27.8	-47.1	1002	194				
28	Trichod.2	2	Bloom	0			Surf	-27.8	-47.1	744	206				
29	Trichod.3	2	Bloom	0			Surf	-27.8	-47.1	600	218				

Read the data - read_excel

```
samples <- readxl::read_excel("data/CARBOM data.xlsx",
                              sheet = "Samples_boat")
```

sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
121	2		2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
122	2		2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
126	2		2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2
127	2		2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5

- Can also select a range : e.g. A1:Q26
- Can skip lines

Bad data input under Excel

sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
121	2		2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
122	2		2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
126	2		2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2
127	2		2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5

- There are missing values in the column **station** because only recorded when changed

Filling missing values - fill

```
samples <- tidyr::fill(samples, station)
```

sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
121	2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
122	2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
126	2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2
127	2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5

- All missing values have been filled in.

Write data

Text file

- **readr::write_tsv()** : write tab delimited files

```
readr::write_tsv(samples, "data/CARBOM data fixed.tsv")
```

Excel file

- **openxlsx::write.xlsx** : write tab delimited files
- Many options: specific sheet, formatting etc…

```
openxlsx::write.xlsx(samples, "data/CARBOM data fixed.xlsx")
```

Write data

Library rio

- Many output formats
- import() / export()

Import, Export, and Convert Data Files

2024-09-25

Import, Export, and Convert Data Files

The idea behind **rio** is to simplify the process of importing data into R and exporting data from R. This process is, probably unnecessarily, extremely complex for beginning R users. Indeed, R supplies an entire manual (https://cran.r-project.org/doc/manuals/r-release/R-data.html) describing the process of data import/export. And, despite all of that text, most of the packages described are (to varying degrees) out-of-date. Faster, simpler, packages with fewer dependencies have been created for many of the file types described in that document. **rio** aims to unify data I/O (importing and exporting) into two simple functions: `import()` and `export()` so that beginners (and experienced R users) never have to think twice (or even once) about the best way to read and write R data.

The core advantage of **rio** is that it makes assumptions that the user is probably willing to make. Specifically, **rio** uses the file extension of a file name to determine what kind of file it is. This is the same logic used by Windows OS, for example, in determining what application is associated with a given file type. By taking away the need to manually match a file type (which a beginner may not recognize) to a particular import or export function, **rio** allows almost all common data formats to be read with the same function

dplyr - Manipulate tables


dplyr : go wrangling
dplyr
data
horst '18

Manipulate columns

List and Summarize columns

List columns

```
colnames(samples)
```

```
 [1] "sample number" "transect"      "station"       "date"
 [5] "time"          "depth"         "level"         "latitude"
 [9] "longitude"     "picoeuks"      "nanoeuks"      "phosphates"
[13] "nitrates"      "temperature"   "salinity"
```

Summarize columns

```
summary(samples$depth)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
    5.0     5.0    50.0    56.6   100.0   140.0       3
```

Select specific columns - select

```
samples_select <- dplyr::select(samples, transect, `sample num
                                station, depth, latitude, lon
                                picoeuks, nanoeuks)
```

transect	sample number	station	depth	latitude	longitude	picoeuks	nanoeuks
1	10	81	140	-27.42	-44.72	3278	1232
1	11	85	110	-26.80	-45.30	16312	1615
2	120	96	5	-27.39	-47.82	1150	75
2	121	96	30	-27.39	-47.82	1737	218
2	122	96	50	-27.39	-47.82	853	234
2	125	98	5	-27.59	-47.39	3086	1300
2	126	98	50	-27.59	-47.39	1217	782
2	127	98	85	-27.59	-47.39	3420	226
1	13	86	105	-26.33	-45.41	6366	1007
2	140	101	5	-27.79	-46.96	500	366

* Column names are not “quoted” (in base R you need to “quote” the column names)

* Better not to put space in column header because then must enclose column name with ` (back-quote)

Select a range of columns - select

```
samples_select <- dplyr::select(samples, transect:nanoeuks)
```

transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks
1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232
1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615
2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75
2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218
2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234
2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300
2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782
2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226
1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007
2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366

Unselect columns - select

```
samples_select <- dplyr::select (samples, -nitrates, -phosph
```

sample number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	temperature	salinity
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	17.3	35.9
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	21.3	36.5
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	23.1	33.5
121	2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	22.6	33.7
122	2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	20.3	35.9
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	23.1	35.7
126	2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	23.7	37.2
127	2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	22.9	37.0
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	20.9	36.3
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	23.5	36.5

Using the pipe operator - %>%

```
samples_select <- samples %>% dplyr::select(transect:nanoeuk
```

transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks
1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232
1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615
2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75
2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218
2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234
2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300
2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782
2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226
1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007
2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366

- It is cleaner to write on 2 lines

```
samples_select <- samples %>%
  dplyr::select(transect:nanoeuks)
```

Renaming variables - rename

```
samples <- samples %>%
  dplyr::rename(sample_number = `sample number`)
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5
121	2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7
122	2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7
126	2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2
127	2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5

Creating new variables - mutate

```
samples <- samples %>%
  dplyr::mutate(pico_pct = picoeuks/(picoeuks+nanoeuks)*100)
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity	pico_pct
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9	**72.68293**
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5	**90.99124**
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5	**93.87755**
121	2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7	**88.84910**
122	2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9	**78.47286**
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7	**70.36024**
126	2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2	**60.88044**
127	2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0	**93.80143**
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3	**86.34206**
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5	**57.73672**

- You can also use **transmute()** but then it will drop all the other columns.
- It is much much better to compute new variables in R than in Excel, because you can easily track and correct errors.

Using the pipe operator you can chain operations

```
samples_select <- samples  %>%
  dplyr::select(sample_number:nanoeuks, level) %>%
  dplyr::mutate(pico_pct = picoeuks/(picoeuks+nanoeuks)*100)
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	pico_pct
10	1	81	2013-11-13	1899-12-31 01:00:00	140	Deep	-27.42	-44.72	3278	1232	**72.68293**
11	1	85	2013-11-13	1899-12-31 13:30:00	110	Deep	-26.80	-45.30	16312	1615	**90.99124**
120	2	96	2013-11-18	1899-12-31 23:50:00	5	Surf	-27.39	-47.82	1150	75	**93.87755**
121	2	96	2013-11-18	1899-12-31 23:50:00	30	Deep	-27.39	-47.82	1737	218	**88.84910**
122	2	96	2013-11-18	1899-12-31 23:50:00	50	Deep	-27.39	-47.82	853	234	**78.47286**
125	2	98	2013-11-18	1899-12-31 05:00:00	5	Surf	-27.59	-47.39	3086	1300	**70.36024**
126	2	98	2013-11-18	1899-12-31 05:00:00	50	Deep	-27.59	-47.39	1217	782	**60.88044**
127	2	98	2013-11-18	1899-12-31 05:00:00	85	Deep	-27.59	-47.39	3420	226	**93.80143**
13	1	86	2013-11-13	1899-12-31 17:00:00	105	Deep	-26.33	-45.41	6366	1007	**86.34206**
140	2	101	2013-11-18	1899-12-31 12:00:00	5	Surf	-27.79	-46.96	500	366	**57.73672**

Creating labels with mutate and stringr functions

```
samples <- samples %>%
  dplyr::mutate(sample_label = str_c("TR",transect,"St",stat
```

sample_number	transect	station	date	time	sample_label
10	1	81	2013-11-13	1899-12-31 01:00:00	**TR_1_St_81**
11	1	85	2013-11-13	1899-12-31 13:30:00	**TR_1_St_85**
120	2	96	2013-11-18	1899-12-31 23:50:00	**TR_2_St_96**
121	2	96	2013-11-18	1899-12-31 23:50:00	**TR_2_St_96**
122	2	96	2013-11-18	1899-12-31 23:50:00	**TR_2_St_96**
125	2	98	2013-11-18	1899-12-31 05:00:00	**TR_2_St_98**
126	2	98	2013-11-18	1899-12-31 05:00:00	**TR_2_St_98**
127	2	98	2013-11-18	1899-12-31 05:00:00	**TR_2_St_98**
13	1	86	2013-11-13	1899-12-31 17:00:00	**TR_1_St_86**
140	2	101	2013-11-18	1899-12-31 12:00:00	**TR_2_St_101**

Changing type of some columns - mutate

- Use the `lubridate` package to manipulate dates

```
samples <- samples %>%
  dplyr::mutate(time = str_c(lubridate::hour(time),
                             lubridate::minute(time), sep=":
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity	pico_pct
10	1	81	2013-11-13	**1:0**	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9	72.68293
11	1	85	2013-11-13	**13:30**	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5	90.99124
120	2	96	2013-11-18	**23:50**	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5	93.87755
121	2	96	2013-11-18	**23:50**	30	Deep	-27.39	-47.82	1737	218	0.43	0.23	22.6	33.7	88.84910
122	2	96	2013-11-18	**23:50**	50	Deep	-27.39	-47.82	853	234	0.56	0.21	20.3	35.9	78.47286
125	2	98	2013-11-18	**5:0**	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7	70.36024
126	2	98	2013-11-18	**5:0**	50	Deep	-27.59	-47.39	1217	782	0.25	0.20	23.7	37.2	60.88044
127	2	98	2013-11-18	**5:0**	85	Deep	-27.59	-47.39	3420	226	0.25	0.47	22.9	37.0	93.80143
13	1	86	2013-11-13	**17:0**	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3	86.34206
140	2	101	2013-11-18	**12:0**	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5	57.73672

Manipulating rows

Order rows - arrange

```
samples <- samples %>%
  dplyr::arrange(transect, station)
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity	pico_pct
3	0	**19**	2013-11-02	13:30	5	Surf	-25.79	-40.36	1005	898	0.29	0.48	22.7	36.9	52.81135
5	0	**21**	2013-11-02	0:0	5	Surf	-26.23	-40.09	793	660	0.16	0.90	22.8	36.9	54.57674
7	0	**26**	2013-11-03	19:30	5	Surf	-27.31	-39.38	907	856	0.20	0.50	21.2	36.4	51.44640
1	0	**6**	2013-10-31	5:20	45	Deep	-23.58	-41.78	7651	4845	0.47	1.07	19.7	36.3	61.22759
2	0	**6**	2013-10-31	5:20	45	Deep	-23.58	-41.78	7343	3258	0.47	1.07	19.7	36.3	69.26705
10	1	**81**	2013-11-13	1:0	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9	72.68293
9	1	**81**	2013-11-13	1:0	140	Deep	-27.42	-44.72	3181	1235	0.20	0.26	17.3	35.9	72.03351
11	1	**85**	2013-11-13	13:30	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5	90.99124
13	1	**86**	2013-11-13	17:0	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3	86.34206
15	1	**87**	2013-11-13	19:30	105	Deep	-26.22	-45.48	6189	622	0.47	1.51	19.5	36.1	90.86771

- Station 6 is not ordered numerically. It is because **station** is a character column.

Order rows - transform to numeric

```
samples <- samples %>%
  dplyr::mutate(station = as.numeric(station)) %>%
  dplyr::arrange(transect, station)
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity	pico_pct
1	0	**6**	2013-10-31	5:20	45	Deep	-23.58	-41.78	7651	4845	0.47	1.07	19.7	36.3	61.22759
2	0	**6**	2013-10-31	5:20	45	Deep	-23.58	-41.78	7343	3258	0.47	1.07	19.7	36.3	69.26705
3	0	**19**	2013-11-02	13:30	5	Surf	-25.79	-40.36	1005	898	0.29	0.48	22.7	36.9	52.81135
5	0	**21**	2013-11-02	0:0	5	Surf	-26.23	-40.09	793	660	0.16	0.90	22.8	36.9	54.57674
7	0	**26**	2013-11-03	19:30	5	Surf	-27.31	-39.38	907	856	0.20	0.50	21.2	36.4	51.44640
10	1	**81**	2013-11-13	1:0	140	Deep	-27.42	-44.72	3278	1232	0.20	0.26	17.3	35.9	72.68293
9	1	**81**	2013-11-13	1:0	140	Deep	-27.42	-44.72	3181	1235	0.20	0.26	17.3	35.9	72.03351
11	1	**85**	2013-11-13	13:30	110	Deep	-26.80	-45.30	16312	1615	0.29	0.22	21.3	36.5	90.99124
13	1	**86**	2013-11-13	17:0	105	Deep	-26.33	-45.41	6366	1007	0.34	0.15	20.9	36.3	86.34206
15	1	**87**	2013-11-13	19:30	105	Deep	-26.22	-45.48	6189	622	0.47	1.51	19.5	36.1	90.86771

- One station named “Bloom” could not be converted to numerical (-> NA)

Summarize rows - count

- Compute number of stations per transect

```
stations_count <- samples %>%
  dplyr::count(transect)
```

transect	n
0	**5**
1	**5**
2	**18**

Summarize rows - group_by / summarize

- Group by transect and station
- Compute mean of the percent picoplankton

```
samples_mean <- samples %>%
  dplyr::group_by(transect, station) %>%
  dplyr::summarise(n_samples = n(),
                   mean_pico_percent = mean(pico_pct, na.rm=TRUE))
```

transect	station	n_samples	mean_pico_percent
0	6	**2**	**65.24732**
0	19	**1**	**52.81135**
0	21	**1**	**54.57674**
0	26	**1**	**51.44640**
1	81	**2**	**72.35822**
1	85	**1**	**90.99124**
1	86	**1**	**86.34206**
1	87	**1**	**90.86771**
2	96	**3**	**87.06651**
2	98	**3**	**75.01403**

Filtering rows - filter

- Get only the surface samples

```
samples_surf <- samples %>%
  dplyr::filter(level == "Surf" )
```

sample_number	transect	station	date	time	depth	level	latitude	longitude	picoeuks	nanoeuks	phosphates	nitrates	temperature	salinity	pico_pct
3	0	19	2013-11-02	13:30	5	Surf	-25.79	-40.36	1005	898	0.29	0.48	22.7	36.9	52.81135
5	0	21	2013-11-02	0:0	5	Surf	-26.23	-40.09	793	660	0.16	0.90	22.8	36.9	54.57674
7	0	26	2013-11-03	19:30	5	Surf	-27.31	-39.38	907	856	0.20	0.50	21.2	36.4	51.44640
120	2	96	2013-11-18	23:50	5	Surf	-27.39	-47.82	1150	75	0.43	0.19	23.1	33.5	93.87755
125	2	98	2013-11-18	5:0	5	Surf	-27.59	-47.39	3086	1300	0.29	0.25	23.1	35.7	70.36024
140	2	101	2013-11-18	12:0	5	Surf	-27.79	-46.96	500	366	0.29	0.14	23.5	36.5	57.73672
155	2	106	2013-11-19	2:30	5	Surf	-28.12	-46.17	355	18	0.25	0.37	23.0	36.9	95.17426
165	2	114	2013-11-19	21:40	5	Surf	-28.65	-44.99	728	226	0.29	0.28	22.4	36.4	76.31027
Trichod.1	2					Surf	-27.80	-47.10	1002	194					83.77926
Trichod.2	2					Surf	-27.80	-47.10	744	206					78.31579

- ! Use the logical operators **==** != > >= < <= is.na()

Recap

- Import and Export data
- Select and create columns
- Summarize data
- *Joining*
- *Long vs. Wide format*
- *Displaying tables*

Next time: Data visualization (ggplot2)

- Understand the “grammar” of graphics
- Create exploratory graphics

Reading list

- Chapter 28 of R for data science
- *Fundamental of data visualization*
- *Data visualization: practical introduction*