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Introducing *pacea*

An R package of Pacific ecosystem information to help facilitate an ecosystem approach to fisheries management

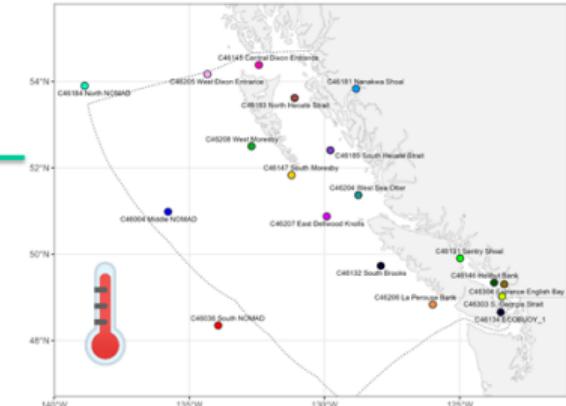
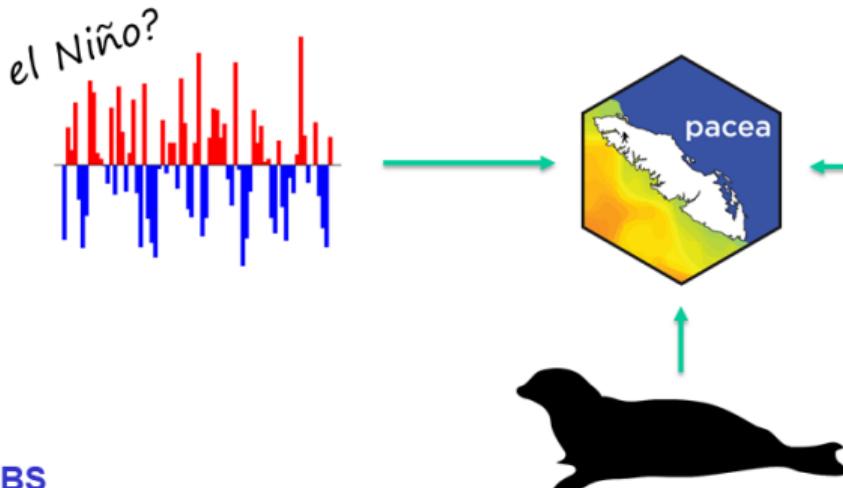
Andrew Edwards and Travis Tai



Introducing pacea: an R package of ecosystem information to help facilitate an ecosystem approach to fisheries management

Andrew Edwards & Travis Tai

Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC.



Acknowledgments

- Co-authors: Joe Watson, Angelica Peña, Andrea Hilborn, Charles Hannah, and Chris Rooper.
- Kelsey Flynn, Jessica Nephin, Lindsay Davidson, Strahan Tucker, Brianna Wright, Patrick Thompson, Matt Grinnell, Sean Anderson, Philina English, Chris Grandin, Jennifer Boldt, and others.
- Carley Colclough for designing the logo.
- DFO's Competitive Science Research Fund for funding (project 21-FS-03-13).

Motivation

- Revised Fisheries Act: “... the Minister shall take into account the environmental conditions affecting a fish stock.”
- Yet <50% of DFO’s stock assessments currently use environmental data.
- Only 28% of assessments in Pacific Region use environmental data.
- Leading cause of not using environmental data is availability of the data.

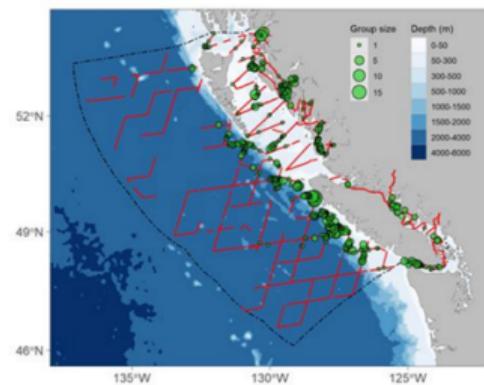
Kulka DW, Thompson S, Cogliati K, Olmstead M, Austin D, Pepin D. (2022). An Accounting of Integration of Environmental Variables in Fishery Stock Assessments in Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3473: viii + 79 p.

https://publications.gc.ca/collections/collection_2022/mpo-dfo/Fs97-6-3473-eng.pdf



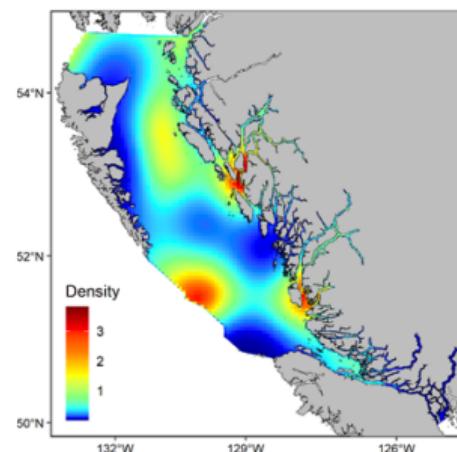
Motivation (based on a true story)

Survey sightings of Humpback Whales



Modelling

Estimated densities

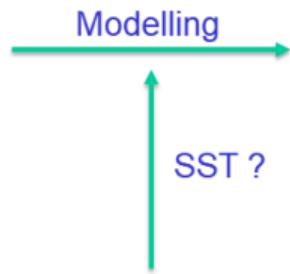
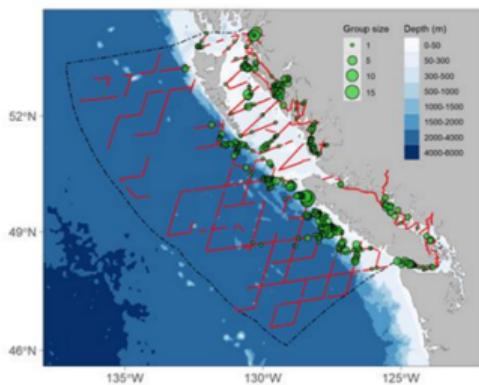


See Doniol-Valcroze et al. (2022) in last year's SOPO report.
Density plot courtesy Brianna Wright.

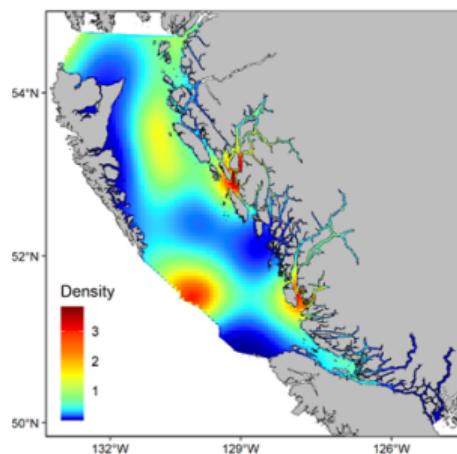


Motivation (based on a true story)

Survey sightings of Humpback Whales



Estimated densities



Motivation (based on a true story)

A search for sea surface temperature yields an overwhelming number (341) of choices:



Grid DAP Data	Sub- set	Table DAP Data	Make A Graph	W M S	Source Data Files	Acces- sible ?	Title	Sum- mary	FGDC, ISO, Metadata	Back- ground Info	RSS	E mail	Institution
data			graph	M		public	Sea-Surface Temperature, NOAA ACSPO Daily Global 0.02° Gridded Super-collated SST and Thermal Fronts Reanalysis, 2012-present, Daily (L3S-LEO degrees C)	?	F I M	background ↗			NOAA/NESDIS/STAR
data			graph	M		public	Sea-Surface Temperature, NOAA ACSPO NOAA-20 VIIRS CoastWatch Co-gridded 4km Daily (degrees C)	?	F I M	background ↗			NOAA/NESDIS/OSPO
data			graph	M		public	Sea-Surface Temperature, NOAA ACSPO S-NPP VIIRS CoastWatch Co-gridded 4km Daily (degrees C)	?	F I M	background ↗			NOAA/NESDIS/OSPO
data			graph	M	files	public	Sea-Surface Temperature, NOAA Geo-polar Blended Analysis Day+Night, GHRSST, Near Real-Time, Global 5km, 2019-Present, Daily	?	F I M	background ↗			NOAA NESDIS Coast... ?
data			graph	M	files	public	Sea-Surface Temperature, NOAA Geo-polar Blended Analysis Diurnal Correction (Day+Night), GHRSST, Near Real-Time, Global 5km, 2019-Present, Daily	?	F I M	background ↗			NOAA NESDIS Coast... ?

Likely requires extensive data wrangling to be usable, which usually takes way, way, longer than anticipated.

So the SST analysis did not happen.

Motivation

- Motivated by Dan Duplisea's `gslea` package for the Gulf of St. Lawrence.
- Outputs from a BC physical biogeochemical model have been shared by Angelica Peña.
- But the netCDF format may be unfamiliar to non-oceanographers – we take care of the wrangling into R
- Open Data is great, but can be hard to **convert raw data into usable information**.
- Primary audience is DFO stock assessment scientists, but usable by anyone (with a minimal working knowledge of R).

Duplisea et al. (2020). `gslea`: the Gulf of St Lawrence ecosystem approach data matrix R-package. R package version 0.1 <https://github.com/duplisea/gslea>

Why an R package?

- R is the programming language most widely used by stock assessment scientists.
- An R package is the standard way to share code (and data).
- Easy installation:

```
remotes::install_github("pbs-assess/pacea")
```

- Ensures proper documentation of data objects and functions (helps users).
- Include vignettes which walk users through various features.
- All data (except one type) is saved within the package, no further downloading required.

Why an R package on GitHub?

- Can host freely on GitHub: <https://github.com/pbs-assess/pacea>
- Standard way to collaborate on code.
- Code is completely open source: transparent, traceable, and transferable.

:≡ README.md

pacea 



- 'Passing' badge: ensures package can build in R.
- 'codecov' is the amount of the code that is covered by unit tests, which help weed out bugs.

pacea objects

Currently, pacea contains:

- 202,927 calculations of daily sea surface temperature based on data from 19 buoys
- outputs from the spatial British Columbia continental margin (BCCM) model
- NOAA's spatial Optimum Interpolation Sea Surface Temperature (OISST) record
- 9 climatic and oceanographic indices, such as the Pacific Decadal Oscillation and those related to El Niño
- estimates of abundances for Harbour Seals and Pacific Hake

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Sea surface temperature

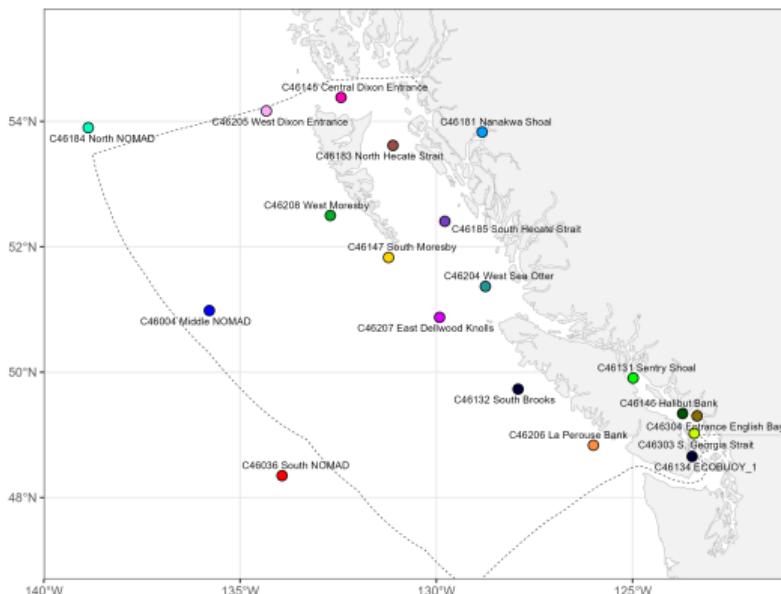
Andrea Hilborn (IOS) maintains

https://github.com/IOS-OSD-DPG/Pacific_SST_Monitoring which is updated weekly to show recent SST from various sources for the Northeast Pacific (and anomalies and marine heatwave information).

The screenshot shows the GitHub repository page for 'Pacific_SST_Monitoring'. At the top, there's a header with the repository name, a search bar, and navigation links for Code, Issues (3), Pull requests, Actions, Projects, Security, and Insights. Below the header, the repository details are shown: 'Pacific_SST_Monitoring' (Public), 1 branch, 0 tags, Watch 1, Fork 1, Star 2. Underneath, there's a main navigation bar with 'main', 1 branch, 0 tags, Go to file, Add file, and a green 'Code' button. A commit history section shows a recent commit by 'schckngs' titled 'Updating plots' made 9 hours ago with 448 commits. To the right, there's an 'About' section describing the repository as 'Recent SST and buoy temperature data for monitoring current conditions'.

Sea surface temperature data from buoys

Data from 19 buoys maintained by DFO/ECCC (Environment and Climate Change Canada), hosted through CIOOS (Canadian Integrated Ocean Observing System).



Sea surface temperature data from buoys

Extensive data processing to calculate daily mean SST:

- Resolution is every 10 minutes or every hour
- Come with quality control flags (mostly)
- We decided a daily mean calculations requires:
 - at least one measurement every 2 hours
 - ≥ 10 2-hour measurements every day
- Switch from DFO data stream to ECCC data stream when appropriate
- Still working on fixing a few outliers in the high-resolution data (hard to automate)

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Sea surface temperature data from buoys

The data are saved as a tibble in pacea:

```
buoy_sst
# A tibble: 202,927 x 3
  date      stn_id    sst
  <date>    <fct>   <dbl>
1 1988-08-05 C46004  12.8
2 1988-08-06 C46004  12.7
3 1988-08-07 C46004  12.5
4 1988-08-08 C46004  12.5
5 1988-08-09 C46004  12.6
6 1988-08-10 C46004  12.6
# i 202,921 more rows
```

Sea surface temperature data from buoys

The data are saved as a tibble in pacea:

```
buoy_sst
# A tibble: 202,927 x 3
  date      stn_id    sst
  <date>    <fct>   <dbl>
1 1988-08-05 C46004  12.8
2 1988-08-06 C46004  12.7
3 1988-08-07 C46004  12.5
4 1988-08-08 C46004  12.5
5 1988-08-09 C46004  12.6
6 1988-08-10 C46004  12.6
# i 202,921 more rows
```

```
tail(buoy_sst)
# A tibble: 6 x 3
  date      stn_id    sst
  <date>    <fct>   <dbl>
1 2023-11-03 C46304  10.3
2 2023-11-04 C46304  10.6
3 2023-11-05 C46304  10.6
4 2023-11-06 C46304  10.3
5 2023-11-07 C46304  10.3
6 2023-11-08 C46304  9.87
```

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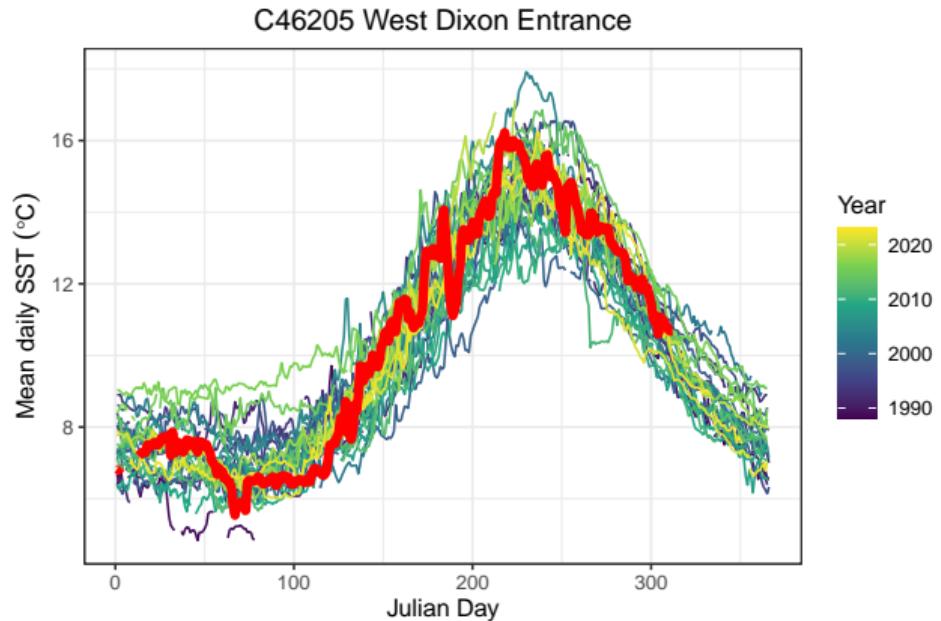
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Sea surface temperature data from buoys

Plot data from a single buoy for all years, the default is for buoy C46205:

```
plot(buoy_sst)
```



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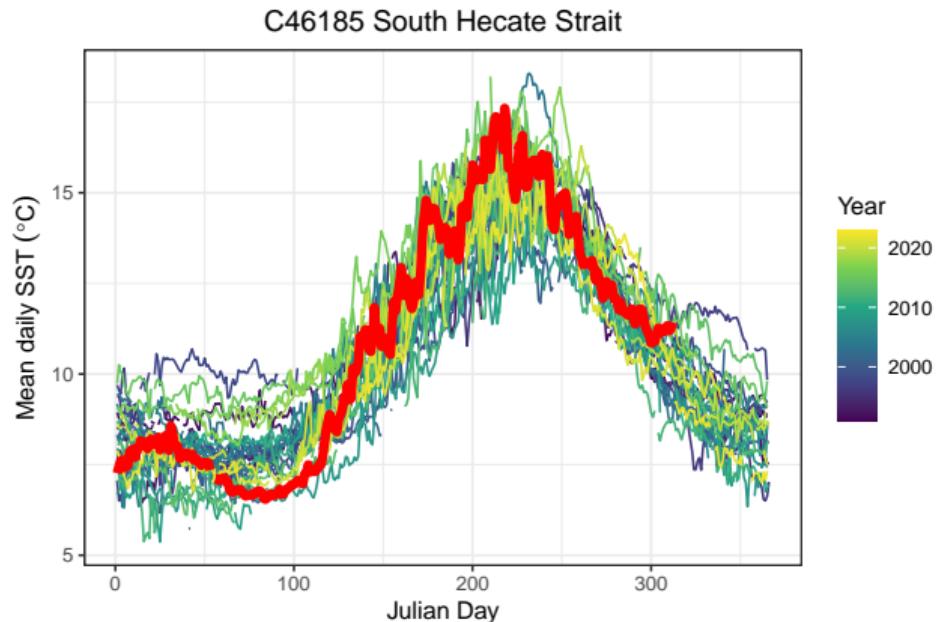
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Sea surface temperature data from buoys

Easy to look at values for any buoy

```
plot(buoy_sst,  
     stn_id = "C46185")
```



Help file for every object

```
?buoy_sst
```

Daily average sea surface temperatures for 19 buoys (yielding over 200,000 values) calculated with data from Environment and Climate Change Canada (ECCC) and DFO.

Description:

A tibble of daily average calculations of sea surface temperature in coastal Canadian Pacific waters. The earliest data are from September 1987, and 14 buoys were still providing data as of May 2023. See the example code below to see the start and end dates for each buoy.

Usage:

```
buoy_sst
```

Format:

A tibble with columns:

date: date (of class `Date`) used to calculate the `sst`, based on UTC -8 hours (i.e. Pacific Standard Time, not changing due to daylight savings)

...

Vignettes for each type of data

We have written vignettes for each type of data. Viewable directly on GitHub site (see the README).

Buoy Sea Surface Temperature Data

Andrew Edwards

Daily average sea surface temperature from buoys

```
library(pacea)
library(dplyr)
library(tibble) # Else prints all of a tibble
```

In pacea we include daily average sea surface temperature (SST) from 19 buoys in Canadian Pacific waters, yielding over 170,000 values. Data are from Environment and Climate Change Canada, and Fisheries and Oceans Canada. The earliest data are from September 1987, and 14 buoys were still providing data as of May 2023.

Metadata for the buoys is given by

```
buoy_metadata
#> # A tibble: 19 × 9
#>   wmo_id name    type  latitude longitude water_depth_m col_key stn_id name_key
#>   <fct>  <fct>  <fct>  <dbl>    <dbl>        <dbl> <fct>  <fct>
#> 1 46004  Middle... NOMAD  51.0     -136.      3600 #0000FF C46004 C46004 ...
#> 2 46036  South ... NOMAD  48.4     -134.      3500 #FF0000 C46036 C46036 ...
#> 3 46131  Sentry... 3 me... 49.9     -125.      18 #00FF00 C46131 C46131 ...
#> 4 46132  South ... 3 me... 49.7     -128.      2040 #000033 C46132 C46132 ...
#> 5 46134  ECOBUO... 3 me... 48.7     -123.       65 #000033 C46134 C46134 ...
#> 6 46145  Centra... 3 me... 54.4     -132.      257 #FF0086 C46145 C46145 ...
```

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Climatic and oceanographic indices

Various climate and oceanographic indices are currently included in pacea:

Object	Description	Resolution	Start year	End year
pdo	Pacific Decadal Oscillation	monthly	1854	2023
npi_monthly	North Pacific Index (monthly)	monthly	1899	2023
npi_annual	North Pacific Index (annual)	annual	1899	2023
alpi	Aleutian Low Pressure Index	annual	1900	2015
oni	Oceanic Niño Index	monthly	1950	2023
npg0	North Pacific Gyre Oscillation	monthly	1950	2023
ao	Arctic Oscillation	monthly	1950	2023
soi	Southern Oscillation Index	monthly	1951	2023
mei	Multivariate El Niño Southern Oscillation Index	monthly	1979	2023

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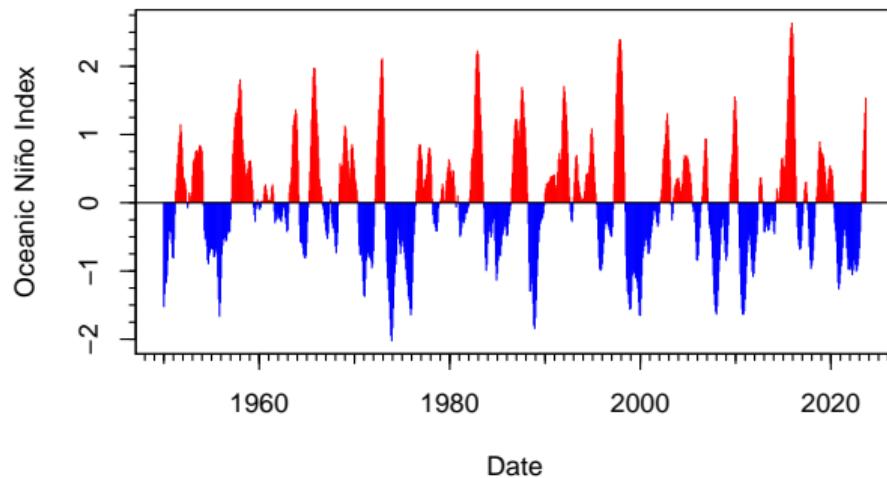
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Climatic and oceanographic indices

For example, to see a plot of the Oceanic Niño Index (ONI) anomaly, simply type

```
plot(oni)
```



This shows the onset of El Niño (positive index) conditions in April 2023.

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Climatic and oceanographic indices

The values are readily available for doing your own analyses:

```
oni
# A tibble: 885 x 4
  year month value anomaly
  <dbl> <dbl> <dbl>   <dbl>
1 1950     1  24.7   -1.53
2 1950     2  25.2   -1.34
3 1950     3  25.8   -1.16
4 1950     4  26.1   -1.18
5 1950     5  26.3   -1.07
6 1950     6  26.3   -0.85
# i 879 more rows
tail(oni)
# A tibble: 6 x 4
  year month value anomaly
  <dbl> <dbl> <dbl>   <dbl>
1 2023     4  27.8    0.16
2 2023     5  28.3    0.48
3 2023     6  28.4    0.77
4 2023     7  28.4    1.07
5 2023     8  28.3    1.32
6 2023     9  28.3    1.54
```

Climatic and oceanographic indices

Each climatic and oceanographic index is saved as a data object, and properly documented, described, and referenced in its help file, for example:

```
?oni
```

ONI - Oceanographic Niño Index

Description:

The Oceanic Niño Index is a monthly index which is one measure of the El Niño-Southern Oscillation.

Usage:

```
oni
```

Format:

A tibble also of class `pacea_index` with columns:

year: year of value

month: month (1 to 12) of value

val: absolute values of three-month averages (preceding, current, and next month), deg C; note that recent values may change in subsequent updates - see details

anom: anomalies based on 30-year base periods that are updated

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Climatic and oceanographic indices

Continuing the help...

The Oceanic Niño Index (ONI) is a 3-month running mean of sea surface temperature (SST) anomalies in the Niño 3.4 region (5 deg N to 5 deg S, 120 deg W to 170 deg W) plotted on the center month. The SST anomalies are calculated based on 30-year base periods that are updated every 5 years, which accounts for global warming and some of the decadal-scale SST variability (as seen in the Pacific Decadal Oscillation index). The ONI is provided by the NOAA's National Weather Service National Centers for Environmental Prediction CPC:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

...

Because of the high frequency filter applied to the ERSSTv5 data, `ONI values may change up to two months after the initial real time value is posted`. Therefore, the most recent ONI values should be considered an estimate.

Climatic and oceanographic indices

So for some analyses you may want to restrict values to a specified time period (for which values should not change in future pacea updates), for example

```
oni_fix <- dplyr::filter(oni,
                          year < 2023 | year == 2023 & month < 3)
tail(oni_fix)      # Will always end with February 2023
# A tibble: 6 x 4
  year month value anomaly
  <dbl> <dbl> <dbl>   <dbl>
1 2022     9  25.8   -1.01
2 2022    10  25.7   -0.99
3 2022    11  25.8   -0.92
4 2022    12  25.8   -0.82
5 2023     1  26.0   -0.67
6 2023     2  26.4   -0.43
```

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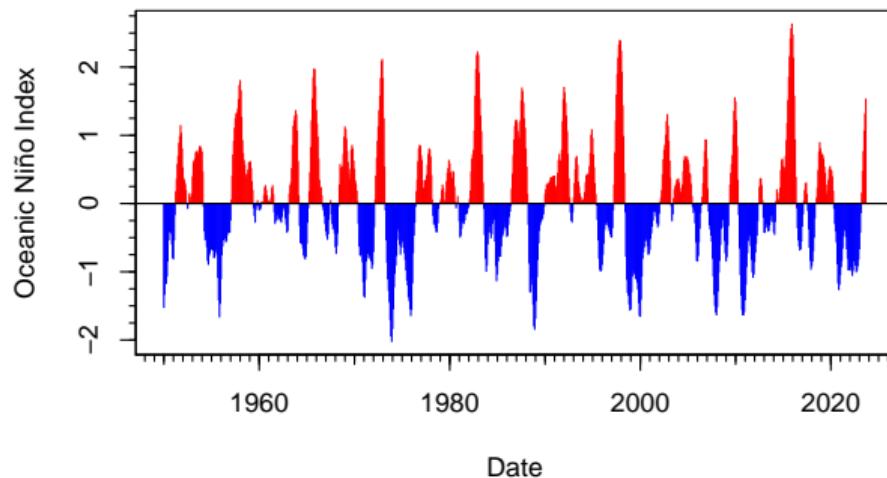
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Further plotting options and styles

Each index has a default plotting style (which you can override). For oni it shows the monthly anomalies as colour-code bars:

```
plot(oni)
```



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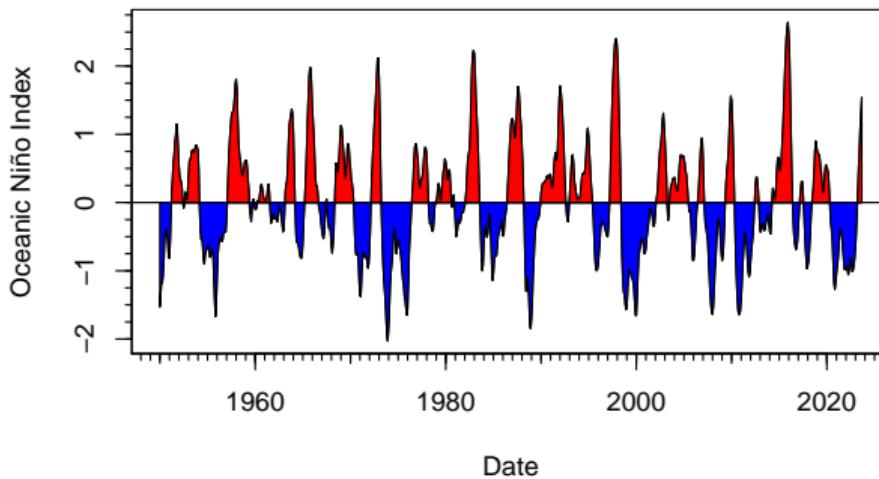
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Further plotting options and styles

Another option is as a black line with filled-in colouring:

```
plot(oni,  
     style = "red_blue")
```



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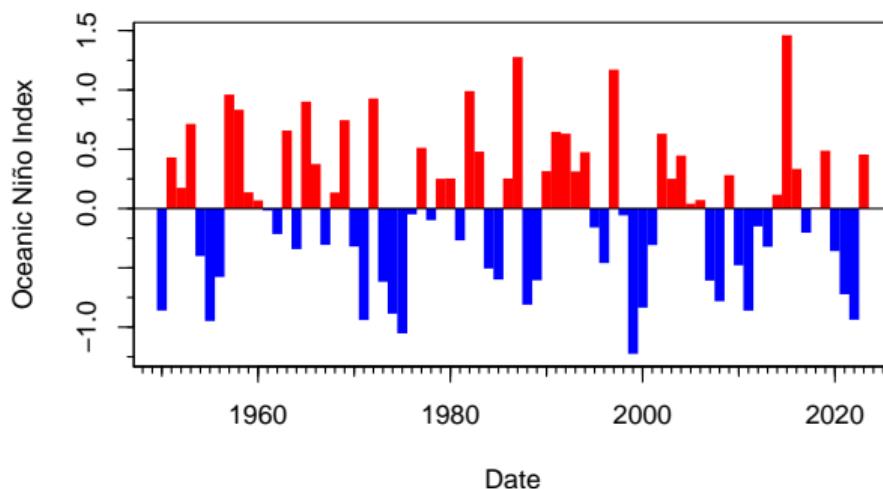
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Further plotting options and styles

To see oni as an annual (not monthly index):

```
plot(oni,  
     smooth_over_year = TRUE,  
     lwd = 6)
```



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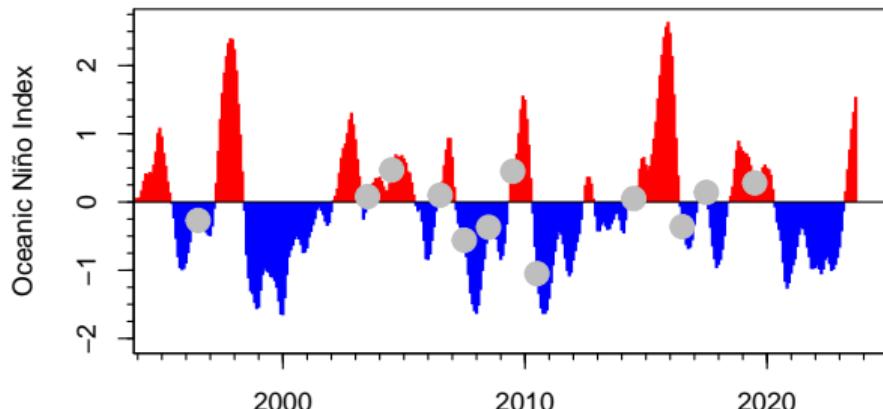
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Further plotting options and styles

And say you want to see if specific events coincide with El Niño (based on a true story, see help for details):

```
plot(oni,
  event_years = c(1996, 2003, 2004, 2006, 2007, 2008, 2009, 2010, 2014, 2016, 2017, 2019),
  xlim = c(lubridate::dmy("01011995"),
            lubridate::dmy("01012024")),
  lwd = 2)
```



Technical aside regarding plot()

The object oni has the class pacea_index:

```
class(oni)
[1] "pacea_index" "tbl_df"      "tbl"        "data.frame"
```

which ensures that `plot(oni)` automatically uses our specialised function `plot.pacea_index(oni)`, giving the red and blue colours, tickmarks, axis labelling, etc.

So see `?plot.pacea_index` for further options. Similarly, check the class of other objects saved in `pacea`.

Estimates of animal populations

In pacea we include estimates of populations, with measures of uncertainty, as calculated from recent stock assessments.

Currently, we have estimates of:

- Pacific Hake (the coastwide stock off Canada and United States)
- Pacific Harbour Seals (most abundant pinniped species in the Northeast Pacific)
- Pacific Herring (coming soon)

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Hake biomass

The hake biomass time series is saved as a tibble object in pacea:

```
hake_biomass
# A tibble: 58 x 4
  year   low median  high
  <dbl> <dbl>  <dbl> <dbl>
1 1966  0.510  0.877  1.66
2 1967  0.534  0.876  1.65
3 1968  0.534  0.874  1.68
4 1969  0.609  0.972  1.90
5 1970  0.723  1.15   2.30
6 1971  0.737  1.19   2.42
# i 52 more rows

tail(hake_biomass)
# A tibble: 6 x 4
  year   low median  high
  <dbl> <dbl>  <dbl> <dbl>
1 2018  1.08   1.58   2.77
2 2019  1.06   1.62   2.98
3 2020  0.910  1.48   2.85
4 2021  0.724  1.29   2.63
5 2022  0.716  1.42   3.08
6 2023  0.757  1.91   5.61
```

Hake biomass

?hake_biomass

Pacific Hake annual spawning stock biomass (females only) as estimated by the [2023](#) stock assessment.

Description:

The Pacific Hake stock is managed and assessed through an Agreement between Canada and the United States. The spawning stock biomass (mature females) estimates come from the most recent joint stock assessment, and, importantly, are [for](#) the coastwide stock from California to British Columbia.

Usage:

```
hake_biomass
```

Format:

A tibble also of class `pacea_biomass` with columns:

year: year of the estimate of spawning stock biomass (mature females), where the estimate is [for](#) the start of the year

low: low end ([2.5](#)th percentile) of the [95](#)% credible interval [for](#) biomass, units as [for](#) `median`

median: median estimate of biomass, [in](#) millions of tonnes of female spawning biomass at the start of the year

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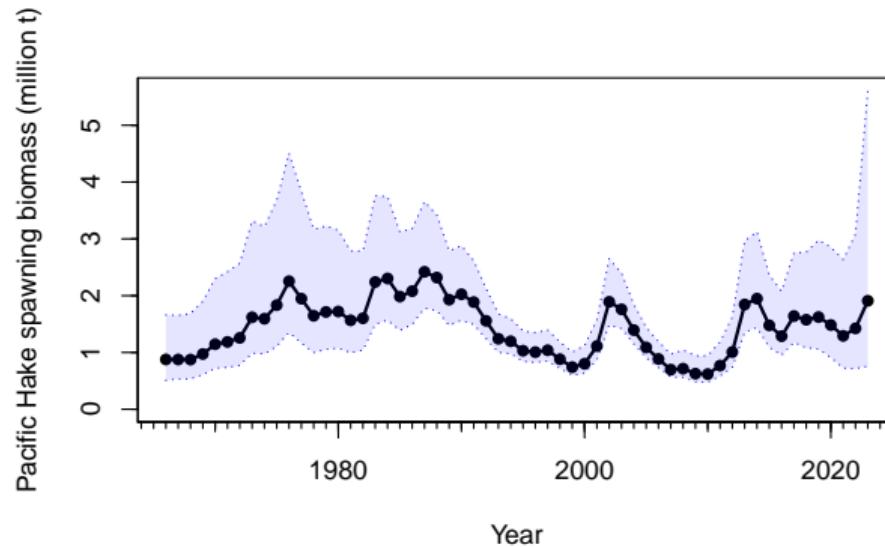
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Hake biomass

Time series of spawning biomass:

```
plot(hake_biomass)
```



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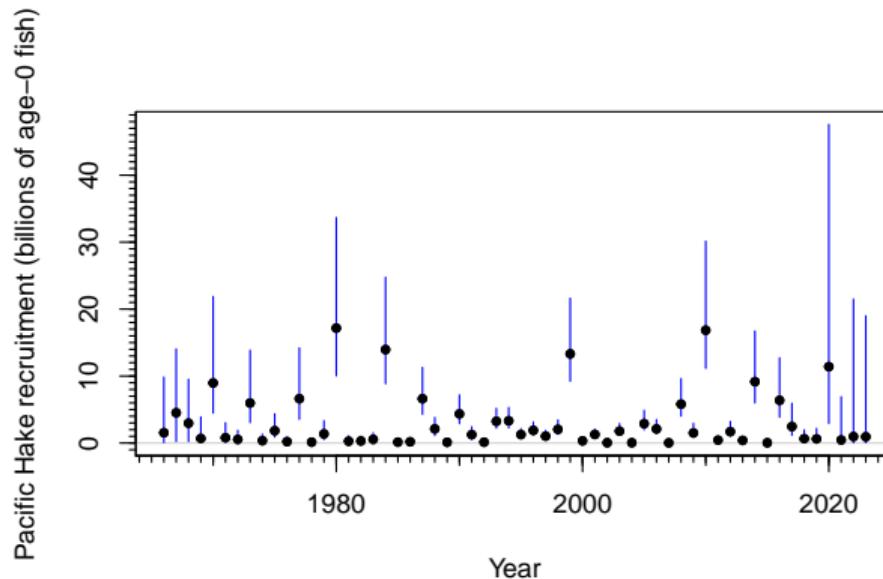
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Hake recruitment

Estimates of annual recruitment (exclude recent years for any analyses since not greatly informed by data; see ?hake_recruitment):

```
plot(hake_recruitment)
```



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Pacific Harbour Seals

Estimated abundances for seven regions (and coastwide) were calculated by DFO (2022; SAR 2022/034), and included here:

```
harbour_seals
# A tibble: 640 x 5
  date      region    low   mean   high
  <date>    <fct>    <dbl>  <dbl>  <dbl>
1 1965-01-01 SOG     593. 1384. 3231.
2 1965-09-07 SOG     669. 1488. 3307.
3 1966-05-14 SOG     755. 1599. 3387.
4 1967-01-19 SOG     851. 1719. 3471.
5 1967-09-25 SOG     959. 1848. 3562.
6 1968-06-01 SOG    1080. 1988. 3661.
# i 634 more rows

tail(harbour_seals)
# A tibble: 6 x 5
  date      region    low   mean   high
  <date>    <fct>    <dbl>  <dbl>  <dbl>
1 2015-08-01 Coastwide 75072. 92401. 118166.
2 2016-04-07 Coastwide 73146. 91001. 117663.
3 2016-12-13 Coastwide 71189. 89638. 117317.
4 2017-08-20 Coastwide 69222. 88313. 117113.
5 2018-04-26 Coastwide 67259. 87026. 117031.
6 2019-01-01 Coastwide 65316. 85774. 117053.
```

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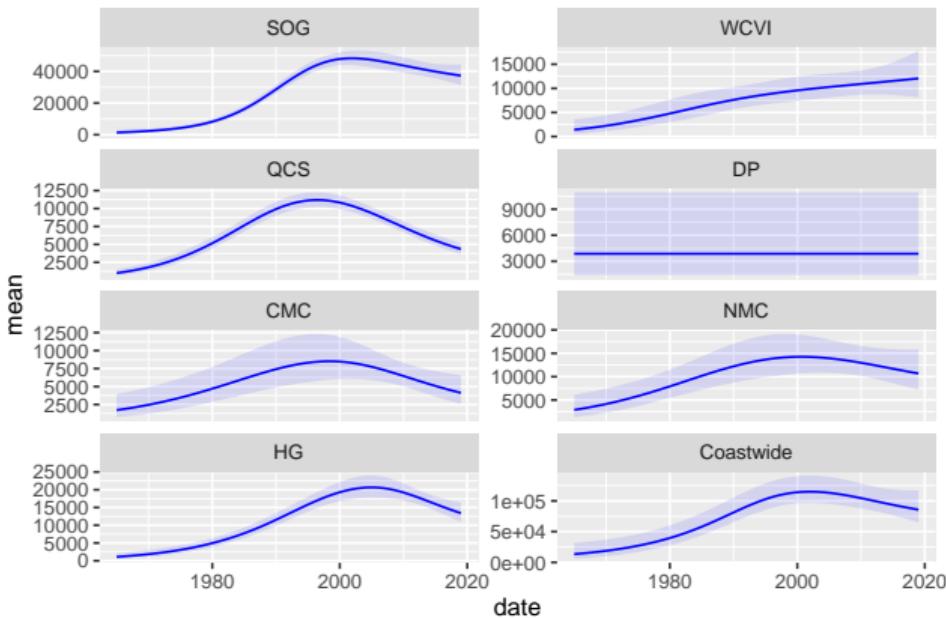
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Pacific Harbour Seals

Estimates for each region and coastwide, reproducing Figure 3 of DFO (2022):

```
plot(harbour_seals)
```



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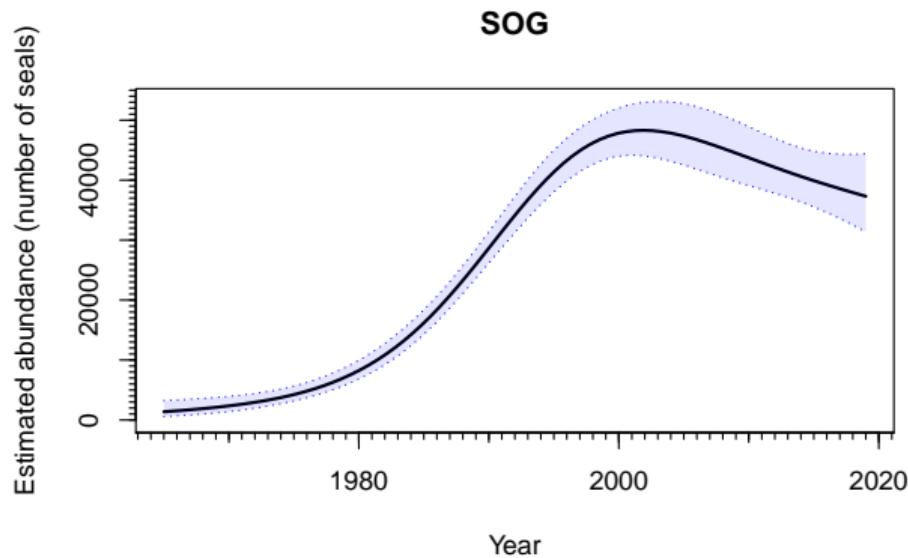
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Pacific Harbour Seals

Or just plot estimates for a single region:

```
plot(harbour_seals,  
     region = "SOG")
```



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NOAA's Optimal Interpolation Sea Surface Temperature

NOAA's Optimal Interpolation Sea Surface Temperature

OISST - long term gridded climate data record

- 1/4° longitude x latitude
- Interpolated to fill gaps
- Canada's Pacific EEZ
- 925 gridded cells
- September, 1981 to (relatively) present
 - Updated ~monthly

2 data products: weekly and monthly mean SST

- oisst_7day and oisst_month

R erddap - <https://www.ncei.noaa.gov/products/optimum-interpolation-sst>

Huang, B., C. Liu, V. Banzon, E. Freeman, G. Graham, B. Hankins, T. Smith, and H. Zhang, 2021: Improvements of the Daily Optimum Interpolation Sea Surface Temperature (DOISST) Version 2.1. J. Climate, 34, 2923–2939, <https://doi.org/10.1175/JCLI-D-20-0166.1>.

OISST – monthly mean

The data are saved as a sf (simple feature) tibble object in pacea:

```
oisst_month

Simple feature collection with 467125 features and 7 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: -138.625 ymin: 46.625 xmax: -123.125 ymax: 54.625
Geodetic CRS:  WGS 84
# A tibble: 467,125 x 8
  year month   sst sst_sd sst_n start_date end_date
* <dbl> <dbl> <dbl> <dbl> <int> <date>    <date>
1 1981     9 16.4  0.830    30 1981-09-01 1981-09-30
2 1981    10 14.3  0.838    31 1981-10-01 1981-10-31
3 1981    11 12.7  1.38     30 1981-11-01 1981-11-30
4 1981    12 10.2  0.549    31 1981-12-01 1981-12-31
5 1981     9 16.4  1.05     30 1981-09-01 1981-09-30
6 1981    10 14.2  0.697    31 1981-10-01 1981-10-31
# i 467,119 more rows
# i 1 more variable: geometry <POINT [BO]>
# i Use `print(n = ...)` to see more rows
```

Help file

```
?oisst_month
```

Description

Simple features objects of NOAAs Optimal Interpolation SST

oisst_7day

7-day mean sea surface temperature (deg C)

oisst_month

Monthly mean sea surface temperature `in` (deg C)

Usage

```
oisst_7day
oisst_month
```

Format

`year` Year

`week` Calendar week

`month` Calendar month

`sst` Mean sea surface temperature, SST (deg C)

...

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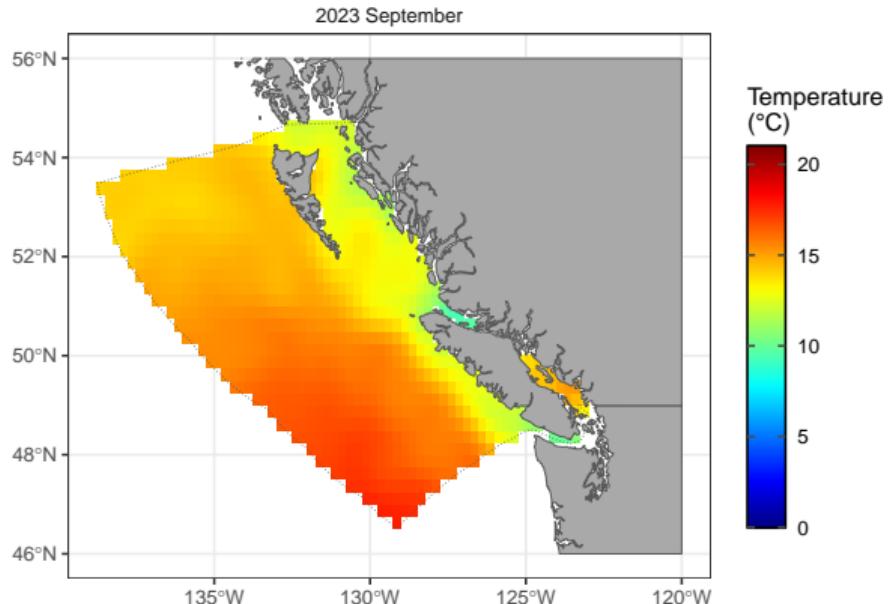
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Built in plots – default

```
plot(oisst_month)
```



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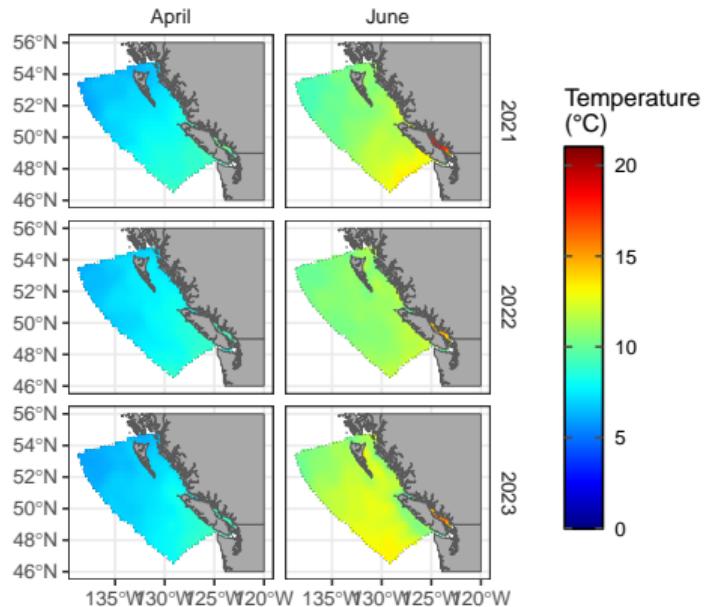
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Built in plots – select years and months

```
plot(oisst_month, months.plot = c("April", "June"), years.plot = c(2021:2023))
```



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British Columbia Continental Margin (BCCM) model

British Columbia Continental Margin (BCCM) model

Physical biogeochemical oceanographic model

- Regional Ocean Modelling System (ROMS)
- Curvilinear grid at 3km x 3km resolution
- Interpolated to regular grid
- Clipped to Canada's Pacific EEZ

Model output provided by Angelica Peña at the Institute of Ocean Sciences (Fisheries and Oceans Canada).

Peña, M.A., Fine, I. and Callendar, W. 2019. Interannual variability in primary production and shelf-offshore transport of nutrients along the northeast Pacific Ocean margin. Deep-Sea Research II, [doi:10.1016/j.dsr2.2019.104637](https://doi.org/10.1016/j.dsr2.2019.104637).

Nearest neighbour linear interpolation

Curvilinear → regular grid

- Inshore ($2 \times 2\text{km}$) and offshore ($6 \times 6\text{km}$)
- Nearest neighbour interpolation
 - Performance = RMSE error
- **40,480 cells**
- **Monthly from 1993-2019**

List of available layers

bccm_data for available variables

```
bccm_data
          data_name
1      bccm_surface_oxygen
2      bccm_surface_ph
3      bccm_surface_salinity
4      bccm_surface_temperature
5      bccm_avg0to40m_oxygen
6      bccm_avg0to40m_ph
7      bccm_avg0to40m_salinity
8      bccm_avg0to40m_temperature
9      bccm_avg40to100m_oxygen
10     bccm_avg40to100m_ph
11     bccm_avg40to100m_salinity
12    bccm_avg40to100m_temperature
13    bccm_avg100mtоБot_oxygen
14    bccm_avg100mtоБot_ph
15    bccm_avg100mtоБot_salinity
16   bccm_avg100mtоБot_temperature
17   bccm_bottom_oxygen
18   bccm_bottom_ph
19   bccm_bottom_salinity
20   bccm_bottom_temperature
21   bccm_phytoplankton
22   bccm_primaryproduction
```

Downloading data locally

The data are saved as a `sf` (simple feature) in a separate GitHub repository `pacea-data` (<https://github.com/pbs-assess/pacea-data>).

There are built in functions to download specific variables:

```
bccm_avg100mtoBot_ph()

pacea would like to download and store these data in the directory:
C:\Users\TAIT\AppData\Local\pacea\Cache
Is that okay?
1: Yes
2: No
```

Selection:

```
Simple feature collection with 33642 features and 324 fields
Geometry type: POLYGON
Dimension: XY
Bounding box: xmin: 164671.6 ymin: 163875 xmax: 1097612 ymax: 1103653
Projected CRS: NAD83 / BC Albers
# A tibble: 33,642 × 325
  `1993_1` `1993_2` `1993_3` `1993_4` ...           geometry
    <dbl>    <dbl>    <dbl>    <dbl> ...           <POLYGON [m]>
 1     7.83     7.87     7.88     7.90 ... ((575612.5 1103653, 577612.5 ~
 2     7.83     7.87     7.88     7.90 ... ((577612.5 1103653, 579612.5 ~
 3     7.83     7.87     7.88     7.90 ... ((579612.5 1103653, 581612.5 ~
 4     7.83     7.87     7.88     7.90 ... ((581612.5 1103653, 583612.5 ~
```

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Downloading data locally

Or all variables (will take several minutes):

```
bccm_all_variables()
```

Downloading all BCCM data may take many minutes. Files will be downloaded to pacea_cache directory:

C:\Users\TAIT\AppData\Local/pacea/Cache

Would you like to continue?

1: Yes

2: No

Selection:

Help file

?bccm_surface_oxygen

BCCM environmental variable data

Description

Loading and/or downloading British Columbia continental margin (BCCM) model data [for](#) the BC Pacific region to local drive.

To download all BCCM data, use the function `'bccm_all_variables()'`. See help page [for](#) details (`'?bccm_all_variables'`).

Usage

```
bccm_bottom_oxygen(update = FALSE, ask = interactive(), force = FALSE)
```

```
bccm_bottom_ph(update = FALSE, ask = interactive(), force = FALSE)
```

```
bccm_bottom_salinity(update = FALSE, ask = interactive(), force = FALSE)
```

...

Arguments

update Logical. Would you like to check [for](#) a newer version of the layer?

ask Logical. Should the user be asked before downloading the data to local cache? Defaults to the value of `interactive()`.

force Logical. Should download of data be forced? Overrides '`ask`' argument [if](#) TRUE.

Format

A simple features dataframe.

...

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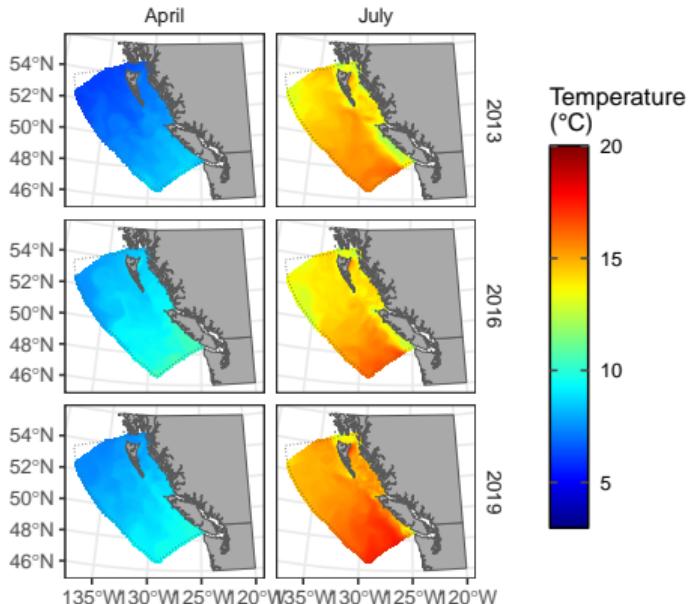
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Built in plotting

```
plot(bccm_surface_temperature(), months.plot = c("April", "July"), years.plot = c(2013, 2016, 2019))
```



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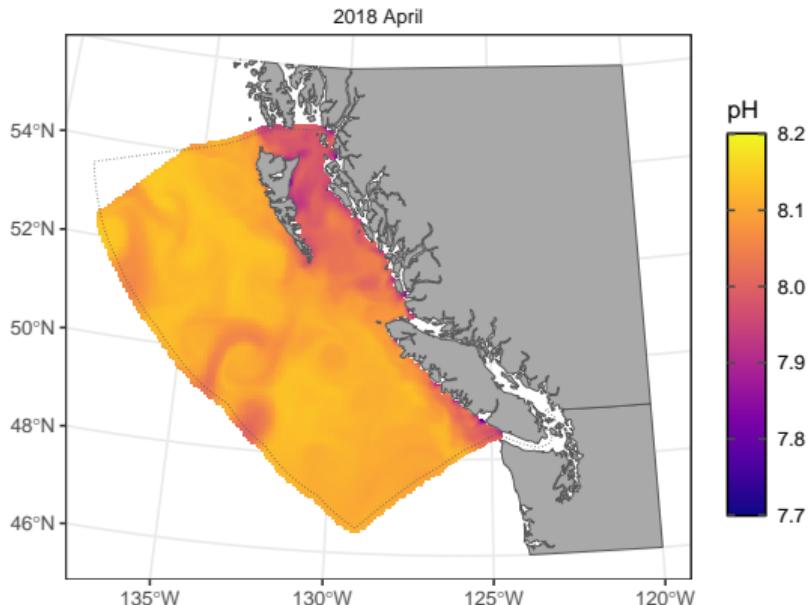
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Built in plotting

```
plot(bccm_surface_ph())
```



Extras – climatology function

Built in functions to calculate 30-year climatology

```
?calc_clim
```

Description

Function **for** calculating climatology of a pacea data object.

Usage

```
calc_clim(  
  data,  
  clim_years = c(1991:2020),  
  clim_time = "month",  
  time_period_return = "all"  
)
```

Arguments

data pacea data object: BCCM, OISST, buoy_sst data only

clim_years climatology period years

clim_time time units (e.g. month) to summarize climatologies

time_period_return vector of value(s) **for** the specific time units to estimate climatologies (e.g. '4' **for** week 4 or April). Set

...

Extras – climatology function

Output with each climatology time unit (e.g. week, month)

```
calc_clim(bccm_surface_temperature())  
  
Simple feature collection with 486960 features and 4 fields  
Geometry type: POLYGON  
Dimension: XY  
Bounding box: xmin: 164671.6 ymin: 163875 xmax: 1097612 ymax: 1103653  
Projected CRS: NAD83 / BC Albers  
# A tibble: 486,960 x 5  
  month clim_value clim_sd clim_n      geometry  
  <dbl>     <dbl>   <dbl>   <int>      <POLYGON [m]>  
1     1      5.80    0.721     27 ((575612.5 1103653, 5776~  
2     2      5.47    0.610     27 ((575612.5 1103653, 5776~  
3     3      5.64    0.627     27 ((575612.5 1103653, 5776~  
4     4      6.61    0.623     27 ((575612.5 1103653, 5776~  
5     5      8.49    0.732     27 ((575612.5 1103653, 5776~  
6     6     10.5     0.662     27 ((575612.5 1103653, 5776~  
# i 486,954 more rows  
# i Use `print(n = ...)` to see more rows
```

And we can also use this with the OISST and buoy data

```
calc_clim(oisst_7day)  
calc_clim(buoy_sst)
```

Extras – anomaly function

Built in functions to calculate anomaly to the 30 year climatology

```
?calc_anom
```

Description

Function `for` calculating climatology of a pacea data object.

Usage

```
calc_anom(  
  data,  
  clim_years = c(1991:2020),  
  clim_time = "month",  
  time_period_return = "all",  
  years_return  
)
```

Arguments

`data` pacea data object: BCCM, OISST, buoy_sst data only

`clim_year` climatology period years

`clim_time` time units (e.g. month) to summarize climatologies

`time_period_return` vector of value(s) `for` the specific time units to estimate climatologies (e.g. '`4`' `for` week `4` or April). Set to

`years_return` vector of value(s) to return the years of interest. Defaults to all years `in` input data

...

Extras – anomaly function

Specify year(s) and time period (e.g. week, month) to return – otherwise all.

```
anom_dat <- calc_anom(bccm_surface_temperature(), time_period_return = "April", years_return = c(2010, 2015))

Simple feature collection with 40580 features and 2 fields
Geometry type: POLYGON
Dimension:      XY
Bounding box:   xmin: 164671.6 ymin: 163875 xmax: 1097612 ymax: 1103653
Projected CRS: NAD83 / BC Albers
# A tibble: 40,580 x 3
`2010_4` `2015_4`          geometry
<dbl>   <dbl> <POLYGON [m]>
1  0.114    1.09 ((575612.5 1103653, 577612.5 1103653, 577612.5 1101653, 575612.5 1101653, 575-
2  0.124    1.08 ((577612.5 1103653, 579612.5 1103653, 579612.5 1101653, 577612.5 1101653, 577-
3  0.150    1.07 ((579612.5 1103653, 581612.5 1103653, 581612.5 1101653, 579612.5 1101653, 579-
4  0.204    1.08 ((581612.5 1103653, 583612.5 1103653, 583612.5 1101653, 581612.5 1101653, 581-
5  0.204    1.07 ((583612.5 1103653, 585612.5 1103653, 585612.5 1101653, 583612.5 1101653, 583-
6  0.244    1.08 ((585612.5 1103653, 587612.5 1103653, 587612.5 1101653, 585612.5 1101653, 585-
# i 40,574 more rows
# i Use `print(n = ...)` to see more rows
```

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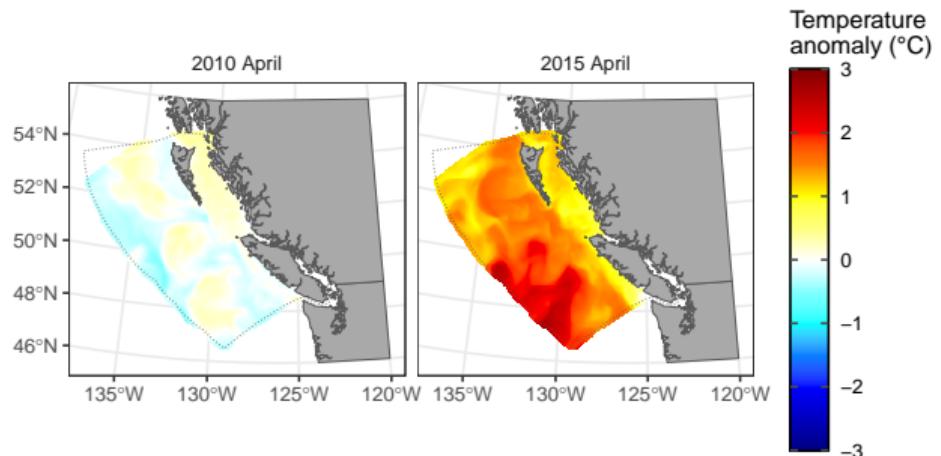
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Extras – anomaly plot

```
plot(anom_dat, months.plot = "April", years.plot = c(2010, 2015))
```



Extras – other tidbits in vignettes

Geospatial functions in vignettes

- `area_mean()` estimates inshore and offshore spatial mean (200m isobath)
- Masking/clipping specific areas (e.g. fishing regions of interest)
- Various other data visualisation examples

Commitments from package authors

We will:

- (try to) not break the package, by working on branches on GitHub before merging.
- ensure any improvements are back compatible.
- update the NEWS as we add/update data and make improvements.
- ideally update the following **on the 20th of every month (or soon after)** to get the latest raw data:
 - climatic and oceanographic indices
 - buoy sst
 - OISST

Commitments from package authors

- update other data as appropriate:
 - hake assessment output: February each year
 - harbour seals: next time assessment is updated
 - herring assessment output: when SAR published each year
 - BCCM model output: in early 2024 the model may be run into 2020 (boundary conditions come from a global model currently only available to Jan 2021).
 - note that BCCM is a research model (not an operational model) so updates depend on projects and access to High Performance Computing.

Recommended guidelines for users

Please:

- read the README!!
- check the help files and vignettes
- check the NEWS (for updates to data, useful additions, new data, etc.)
- understand the limitations of the data

Recommended guidelines for users

To check when you last installed pacea

```
pacea_installed()
```

You last locally installed pacea on **2023-11-01** which is **8** days ago.

Compare that with the updates [in](#) the NEWS file (and you can also check dates of the latest commits at <https://github.com/pbs-assess/pacea/commits/main>)

Commits

The screenshot shows a GitHub commit history for the 'main' branch. It displays two groups of commits:

- Commits on Nov 9, 2023:**
 - Add test and slide for pacea_installed(). (andrew-edwards committed 14 minutes ago) ✓
 - Tweak talk, add new pacea_installed() function. (andrew-edwards committed 2 hours ago) ✘
 - Rename talk file. (andrew-edwards committed 3 hours ago) ✓
 - Improve summary, remove un-needed section. (andrew-edwards committed 3 hours ago)
 - Add NEWS.md (travistai2 committed 4 hours ago) ✓
- Commits on Nov 8, 2023:**
 - (No commits shown)

Recommended guidelines for users

- any problems, make a minimum working example (usually makes you figure it out yourself)
 - check the Issues on GitHub in case someone else has asked or we are already working on it
 - simple quick question just ask us
 - more detailed questions or bug reports post a new Issue (allows others to see, and maybe answer, your question)

Recommended guidelines for users

- cite pacea and the original sources for any data you use
- let us know of any applications (so we understand the uptake and how much effort to devote to maintaining it)
 - you could be out on a survey and wondering how warm the water is compared to previous years
 - Chris Rooper: looking at Pacific Saury process errors from a stock assessment using the indices (PDO etc.). "It made my life easier today."



We wrangle the data so you don't have to

```
citation("pacea")
```

Edwards AM, Tai TC, Watson J, Peña MA, Hilborn A, Hannah CG, Rooper CN

(2023). "pacea: An R package of Pacific ecosystem information to help facilitate an ecosystem approach to fisheries management."
<https://github.com/pbs-assess/pacea>.