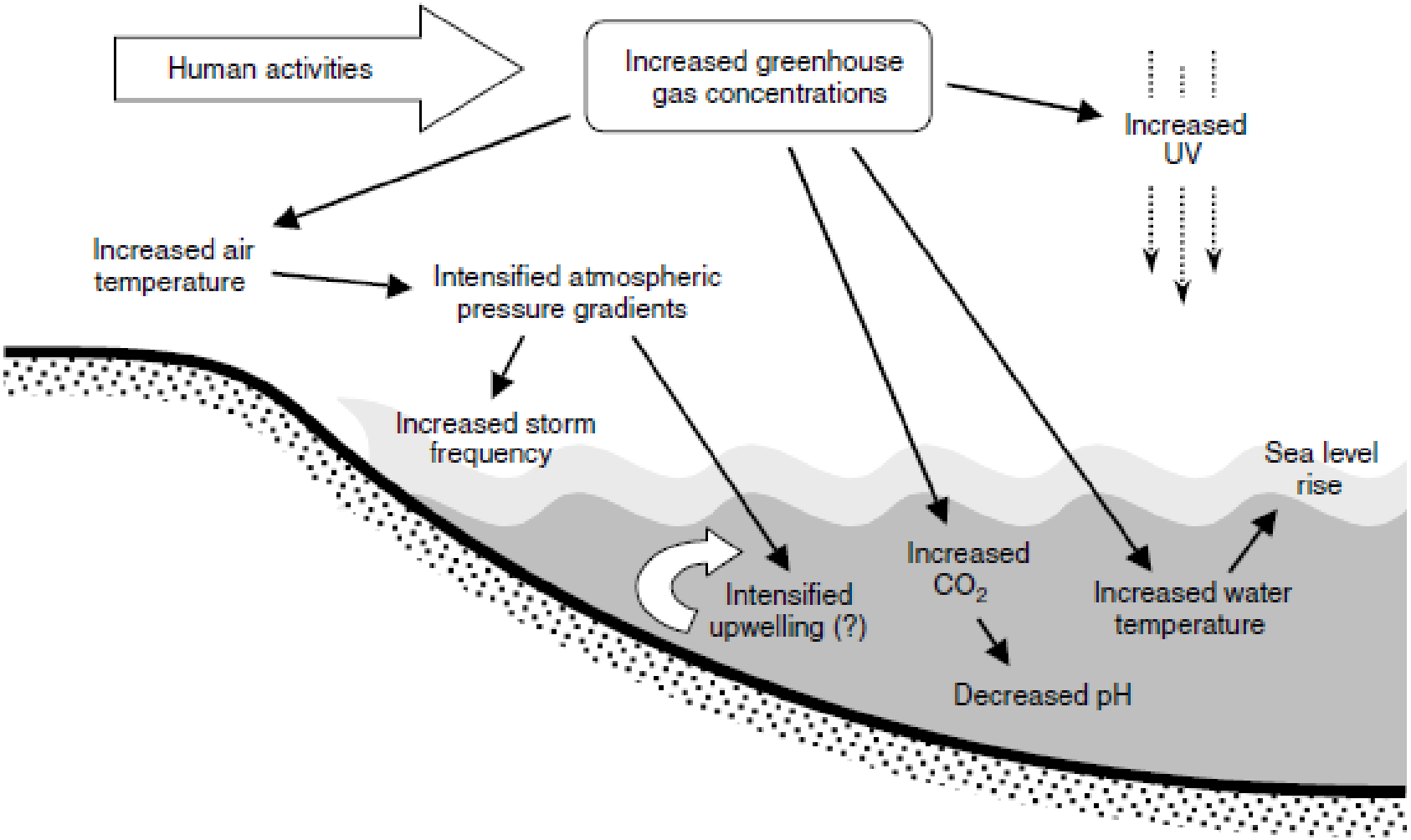
# Anthropogenic change & hypotheses

1. What are MAJOR elements of anthropogenic change over past 80 years?
2. How does hypothesizing fit with an observational study?
3. What obvious hypotheses might be associated w/ these changes (relevant to intertidal)?
4. Where should you go to get physical data?

# Climate change major impacts?

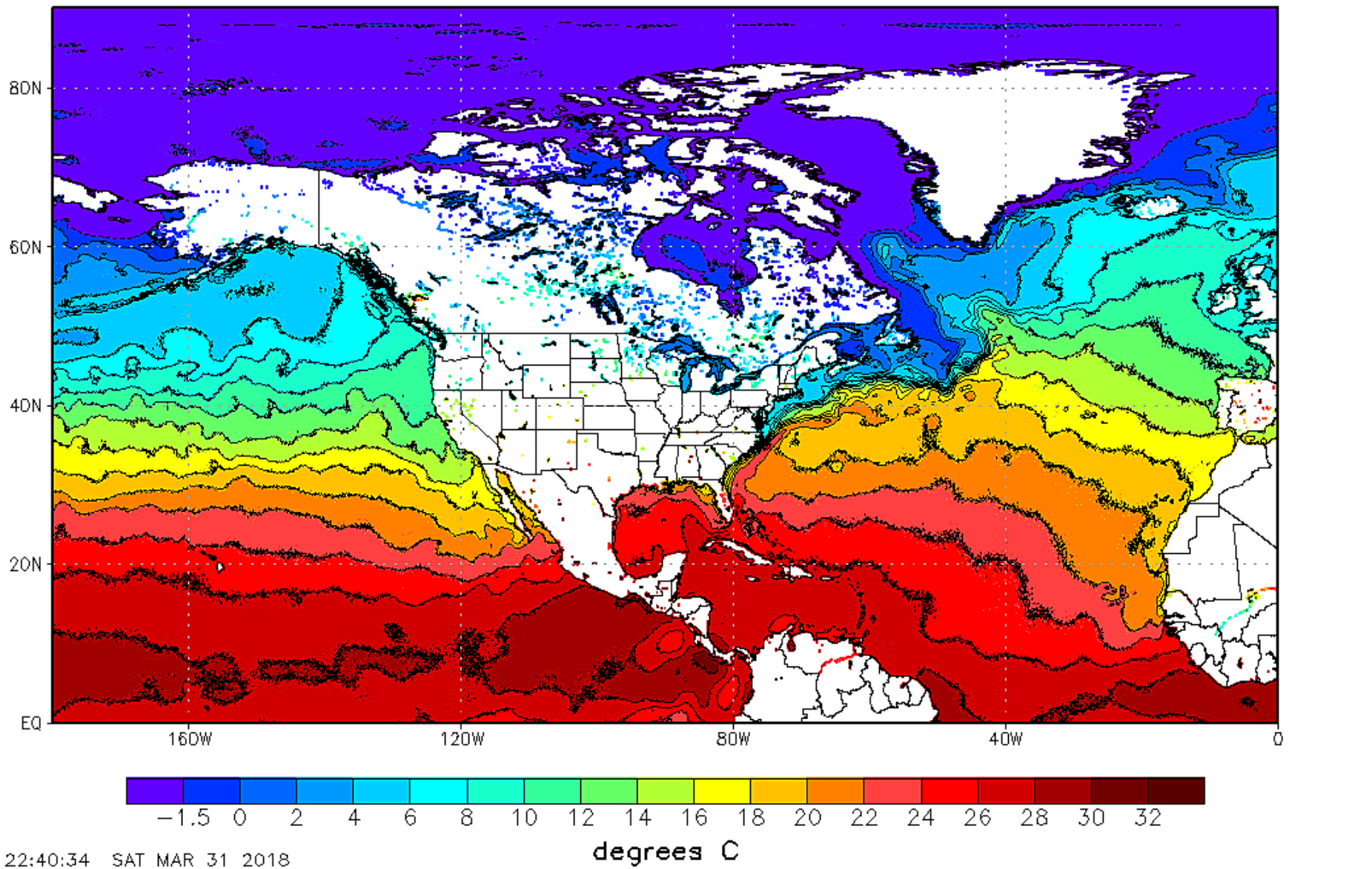
# Climate change summary



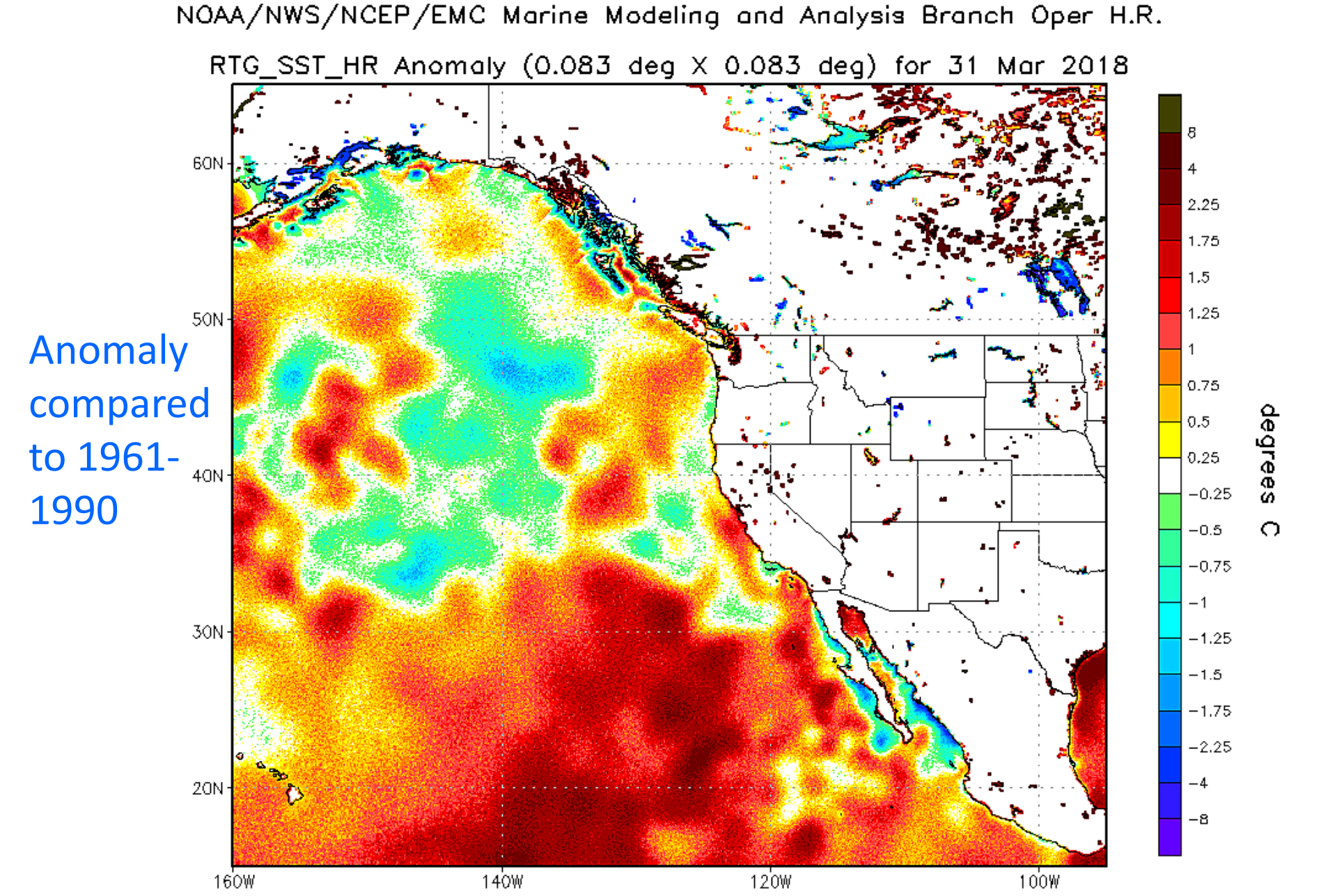

Harley et al. *Ecology Letters* 2006

# Climate change marine effects

- Warming
- Ocean acidification
- Sea level rise




http://polar.ncep.noaa.gov/sst/ophi/color_sst_NW_ophi0.png

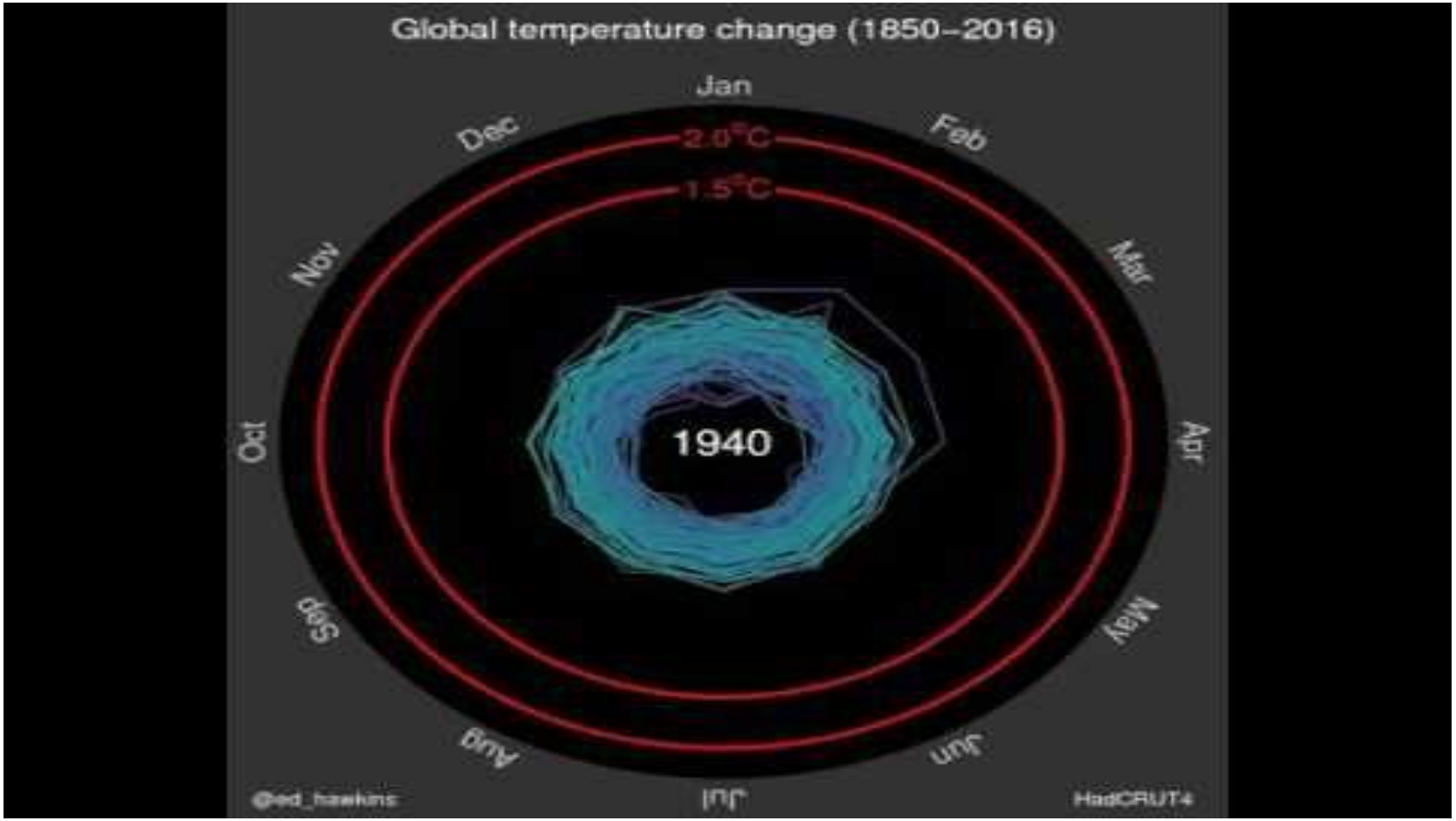



Anomaly compared to 1961-1990

http://polar.ncep.noaa.gov/sst/ophi/

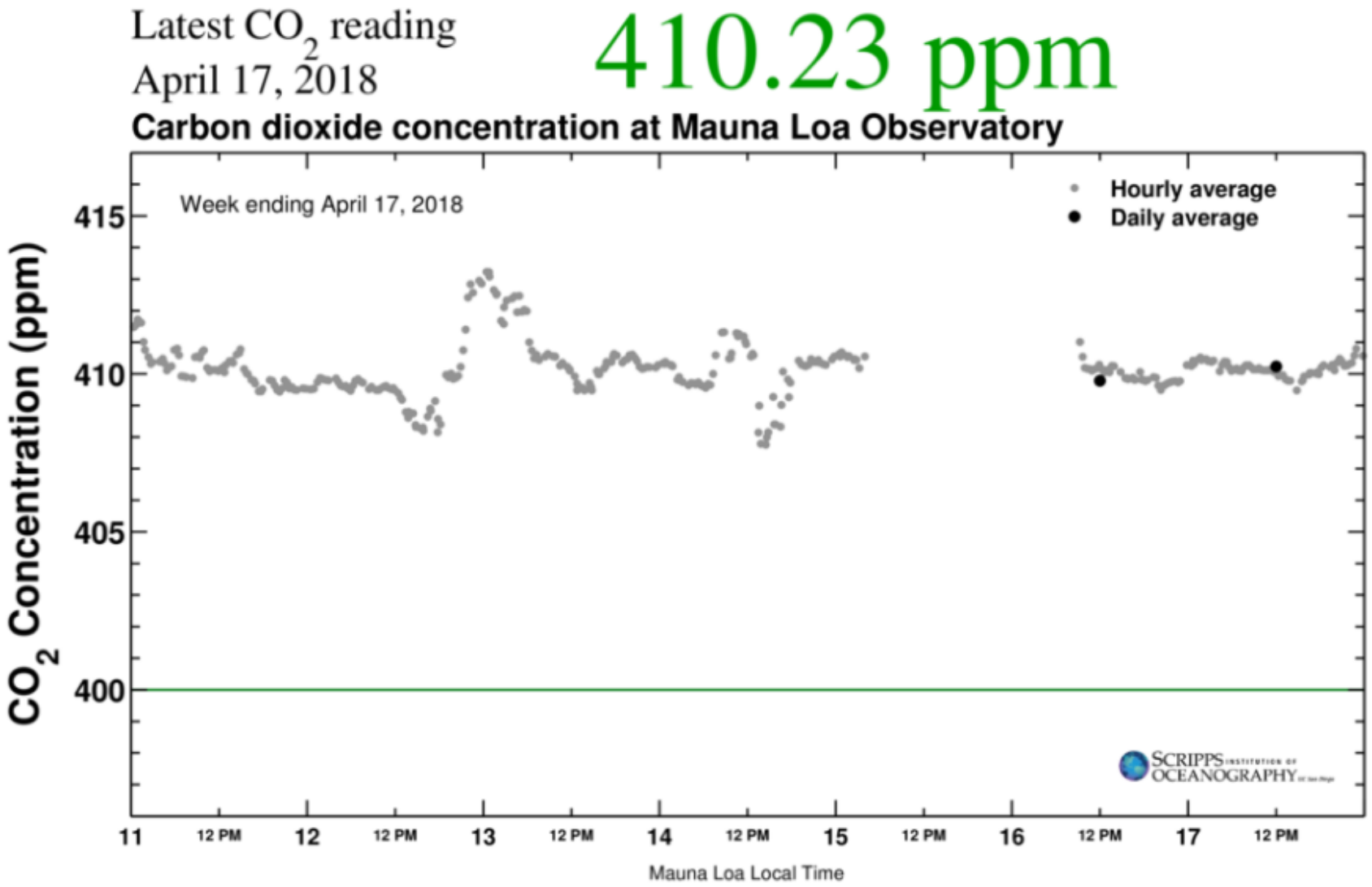
# Global temperature change since 1850

https://www.youtube.com/watch?v=wXrYvd-LBu0

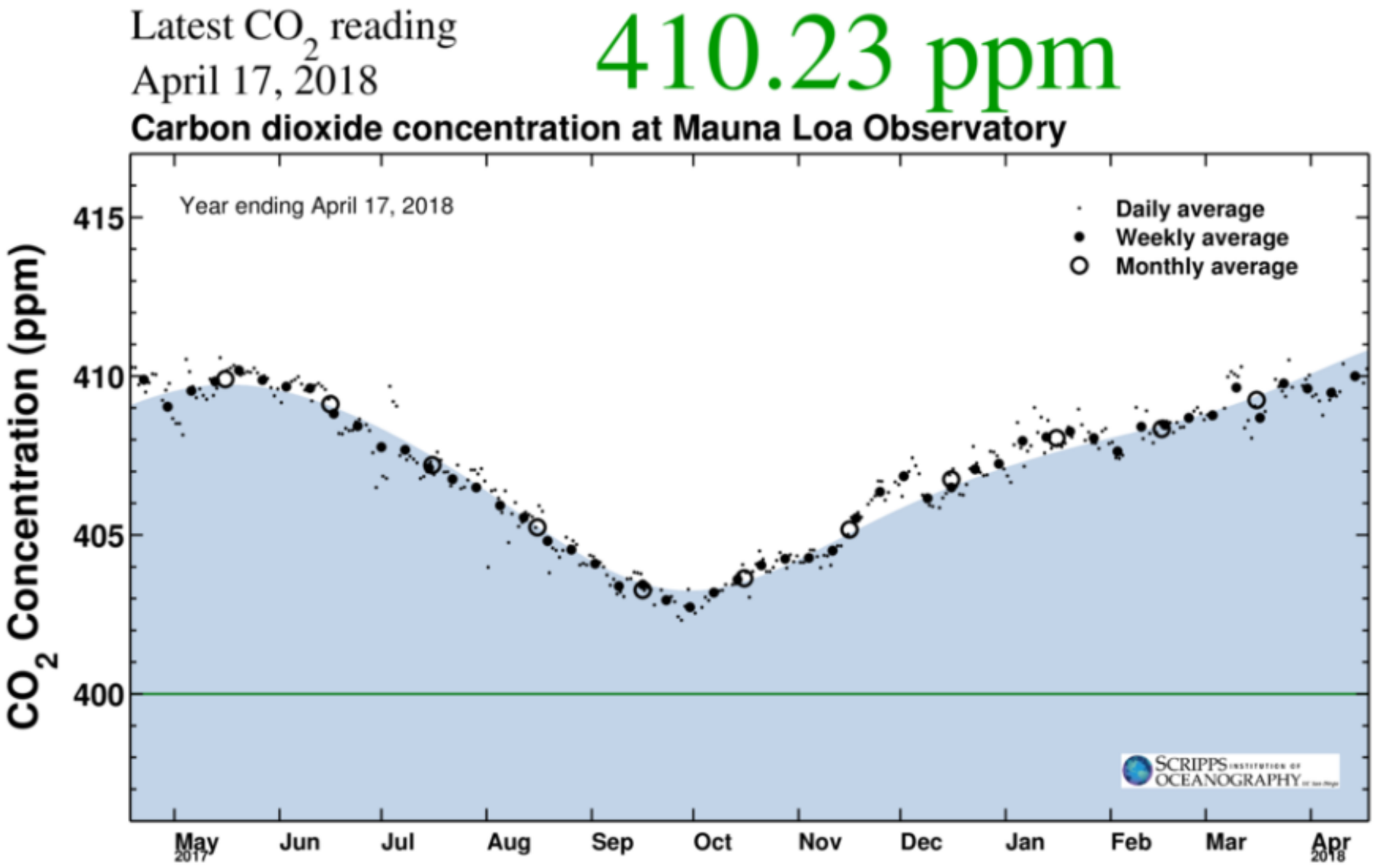


# Keeling curve

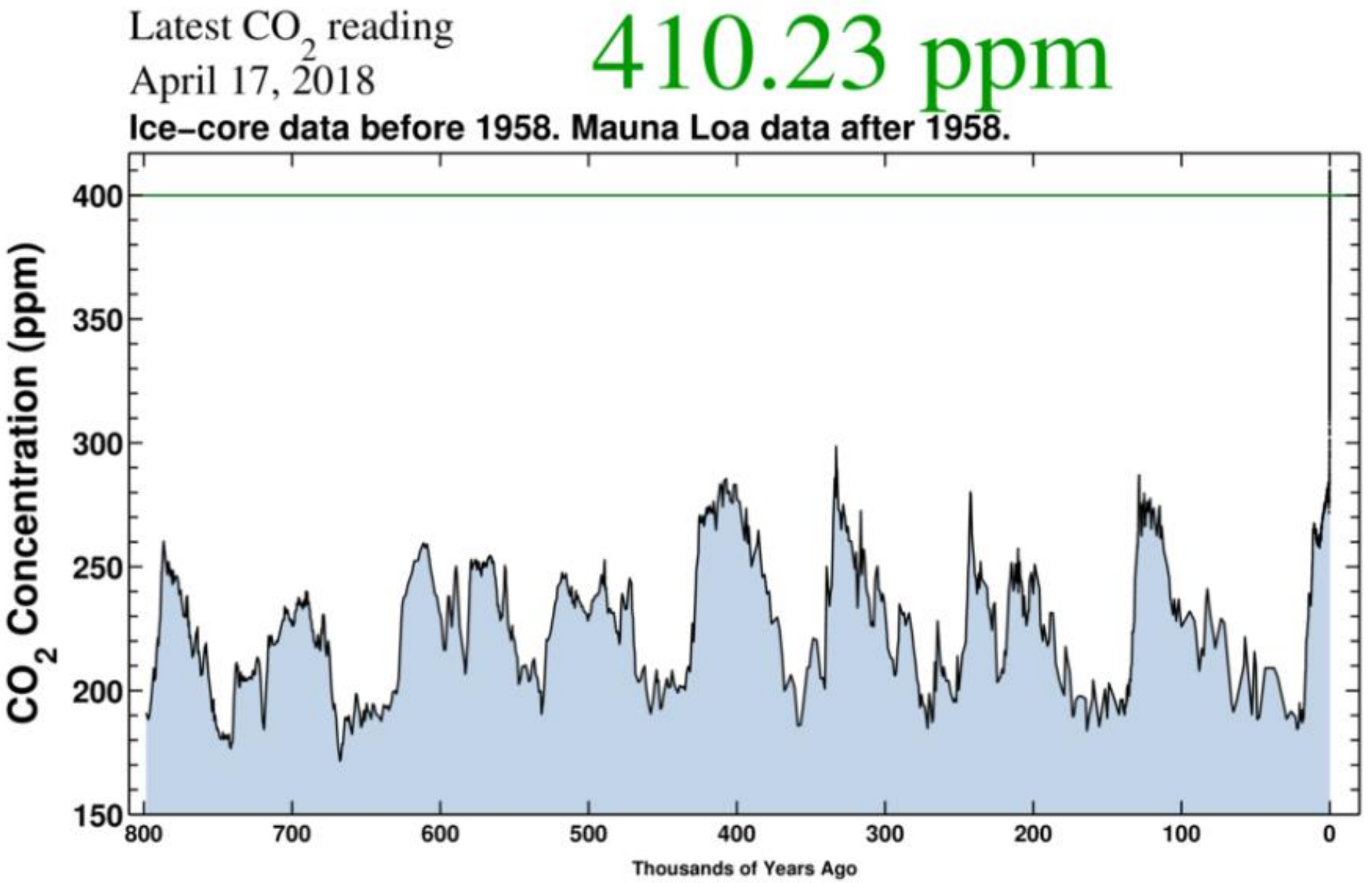
- https://scripps.ucsd.edu/programs/keelingcurve/



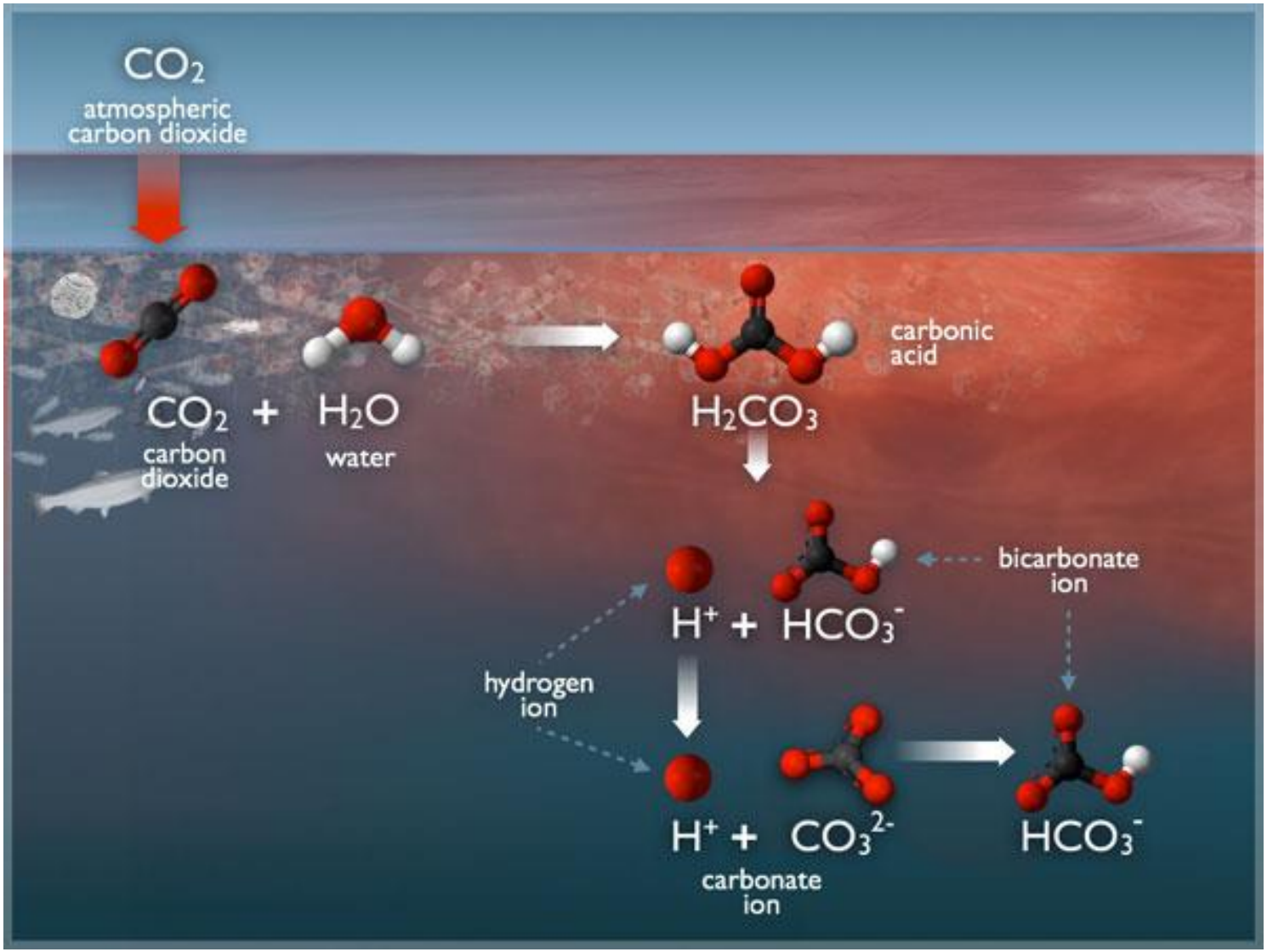
# 1 year


Latest $CO_2$ reading
April 17, 2018
410.23 ppm
Carbon dioxide concentration at Mauna Loa Observatory
Year ending April 17, 2018
Daily average
Weekly average
Monthly average
$CO_2$ Concentration (ppm)
415
410
405
400
May 2017
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr 2018
SCRIPPS INSTITUTION OF OCEANOGRAPHY

# 800,000 years

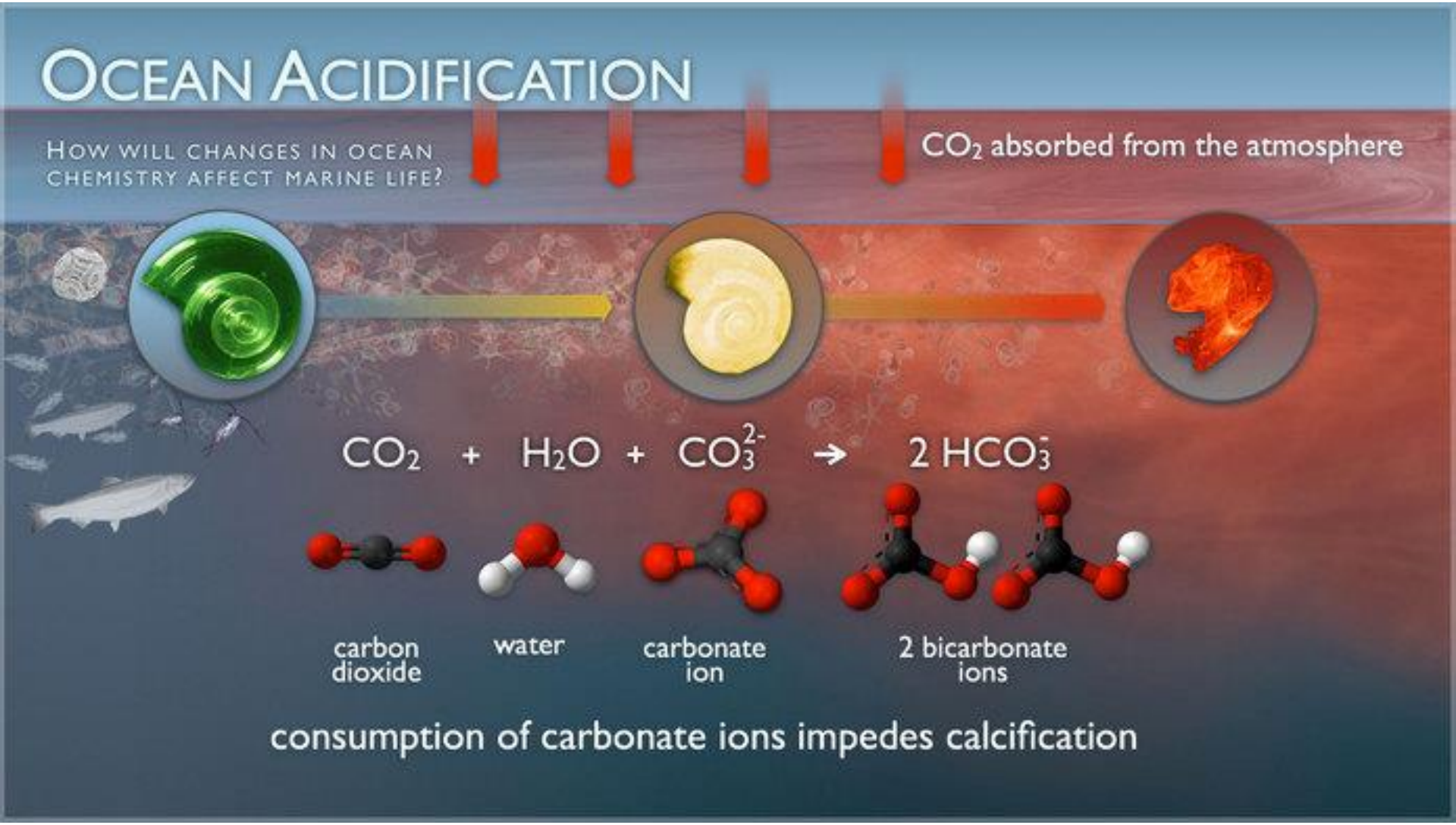


# Ocean acidification




whoi.edu

# Ocean acidification




NOAA PMEL

# Today's ocean pH values

Open ocean/global average: 8.1

Puget Sound: 7.8-7.9

Range in tidepools: 7.09-8.91 (Silbiger & Sorte 2017)

# Cause of sea level rise?

1.

2.

# Other anthropogenic effects

# Other anthropogenic effects

- water use/boating
- pollution
- land-use
  - sea walls
  - sedimentation
- fishing/harvesting

# Other anthropogenic effects

- **fishing/harvesting**
- **pollution**
- land-use
  - sea walls
  - sedimentation
- water use/boating

# Anthropogenic change & hypotheses

1. What are MAJOR elements of anthropogenic change over past 80 years?
2. How does hypothesizing fit with an observational study?
3. What obvious hypotheses might be associated w/ these changes (relevant to intertidal)?
4. Where should you go to get physical data?

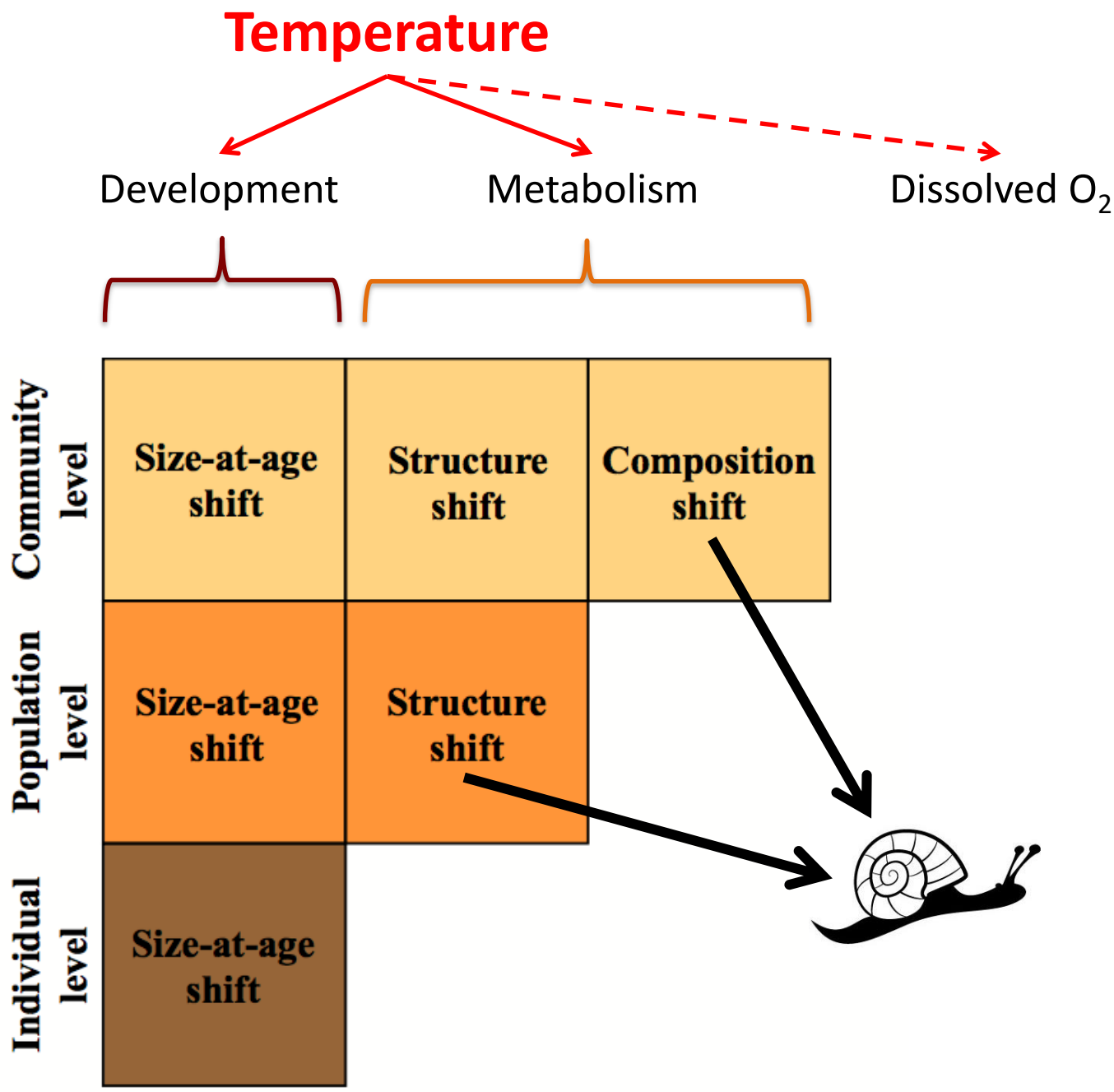
# Discuss purpose v. limits

# Anthropogenic change & hypotheses

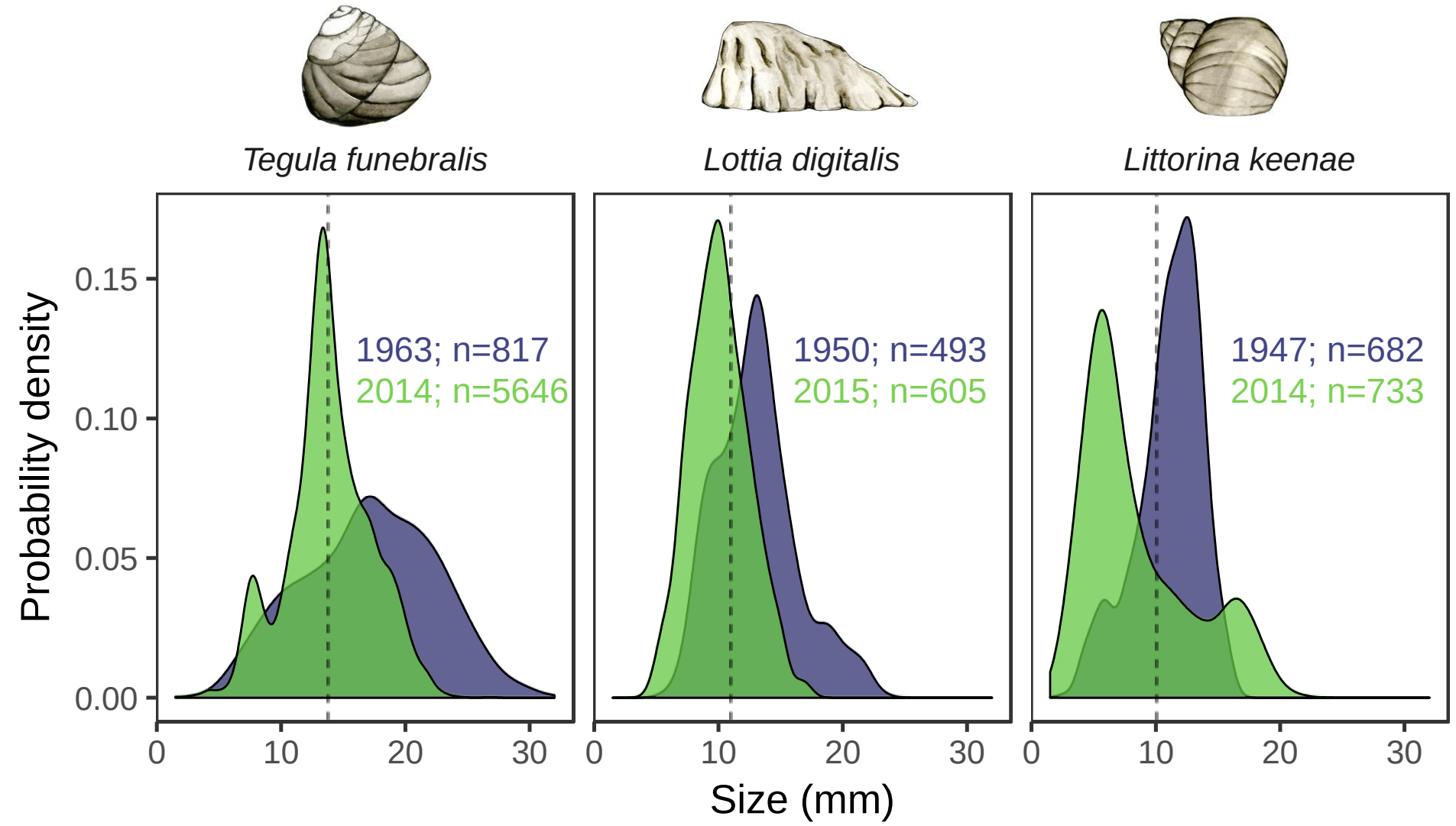
1. What are MAJOR elements of anthropogenic change over past 80 years?
2. How does hypothesizing fit with an observational study?
3. What obvious hypotheses might be associated w/ these changes (relevant to intertidal)?
4. Where should you go to get physical data?

# Some hypotheses

- body size change
- population size change (direct)
- population size change of predator/prey (indirect)
- disease prevalence change

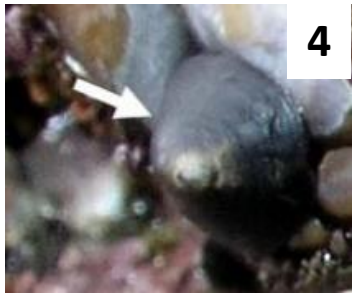



*Sheridan and Bickford 2011; Ohlberger 2013*

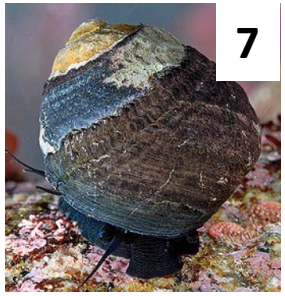

Tegula funebralis
Lottia digitalis
Littorina keenae
Probability density
0.15
0.10
0.05
0.00
1963; n=817
2014; n=5646
1950; n=493
2015; n=605
1947; n=682
2014; n=733
0
10
20
30
Size (mm)

1. *Lacuna marmorata* (7)
2. *Homalopoma luridum* (9)
3. *Tectura paleacea* (10)
4. *Lottia asmi* (11)
5. *Lottia paradigitalis* (20)
6. *Tegula brunnea* (30)
7. *Tegula funebralis* (30)
8. *Acmaea mitra* (35)
9. *Lottia pelta* (40)
10. *Lottia limatula* (45)
11. *Lottia scutum* (63)





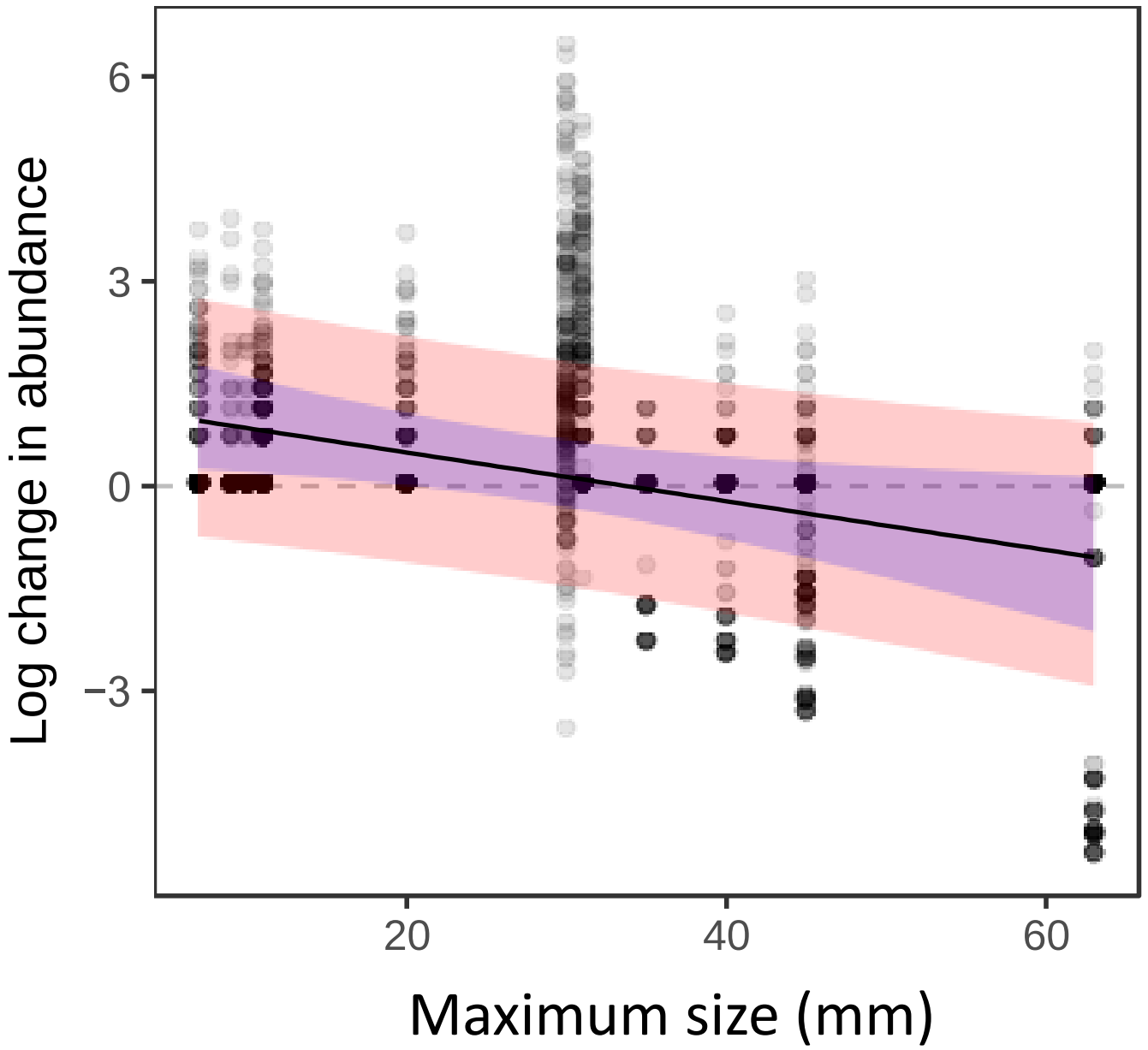








*Morris et al. 1980; https://seanet.stanford.edu/*

# Larger bodied snails are less abundant now



# Anthropogenic change & hypotheses

1. What are MAJOR elements of anthropogenic change over past 80 years?
2. How does hypothesizing fit with an observational study?
3. What obvious hypotheses might be associated w/ these changes (relevant to intertidal)?
4. Where should you go to get physical data?

# Information you may need

- Site selection
  - access
- Tides, air & water exposure
- Weather, climate, temperature
- Water chemistry
- Harvest records

# Resources – site images

https://fortress.wa.gov/ecy/shorephotoviewer/

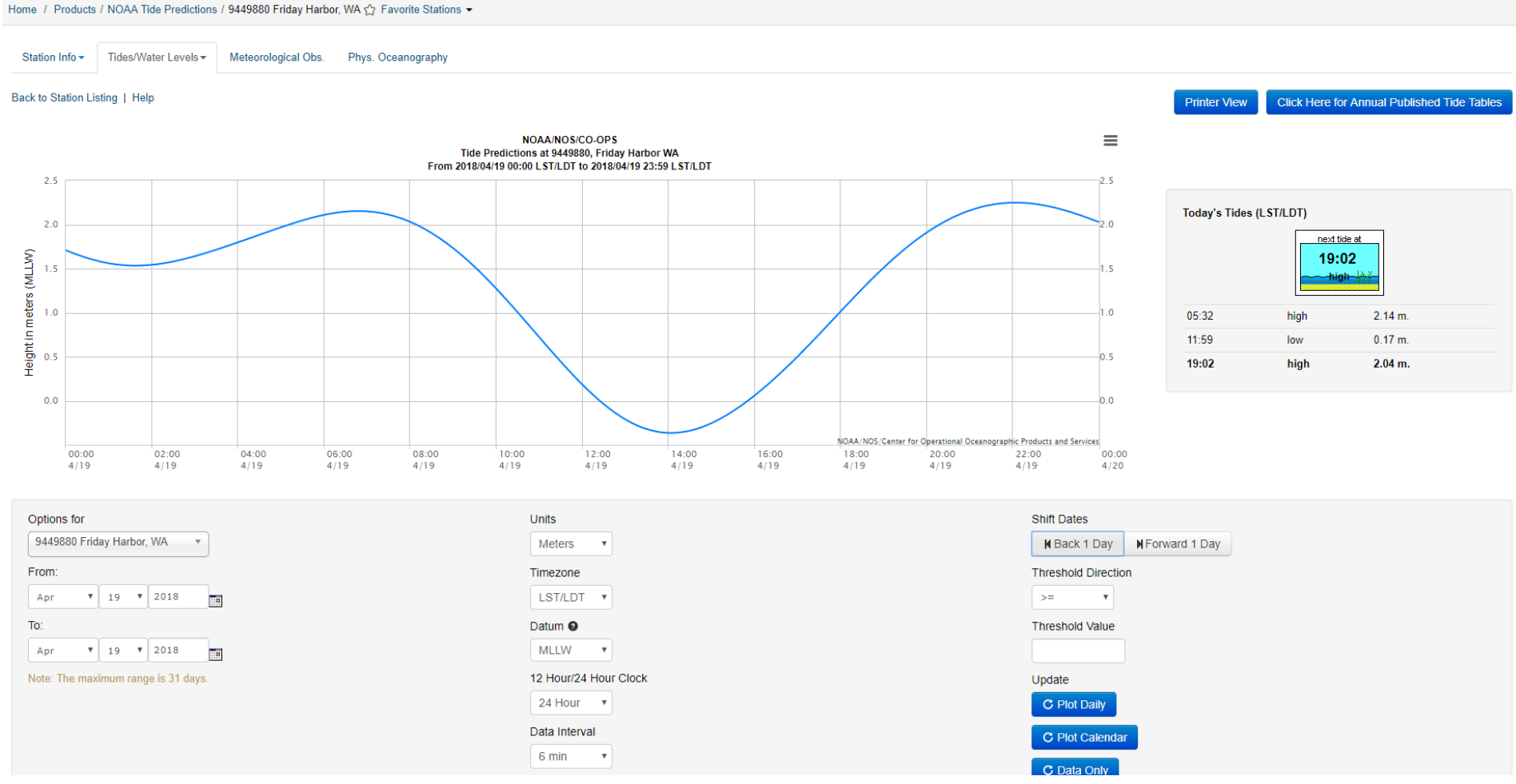
# Resources – tides

https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1415

East side → choose Friday Harbor

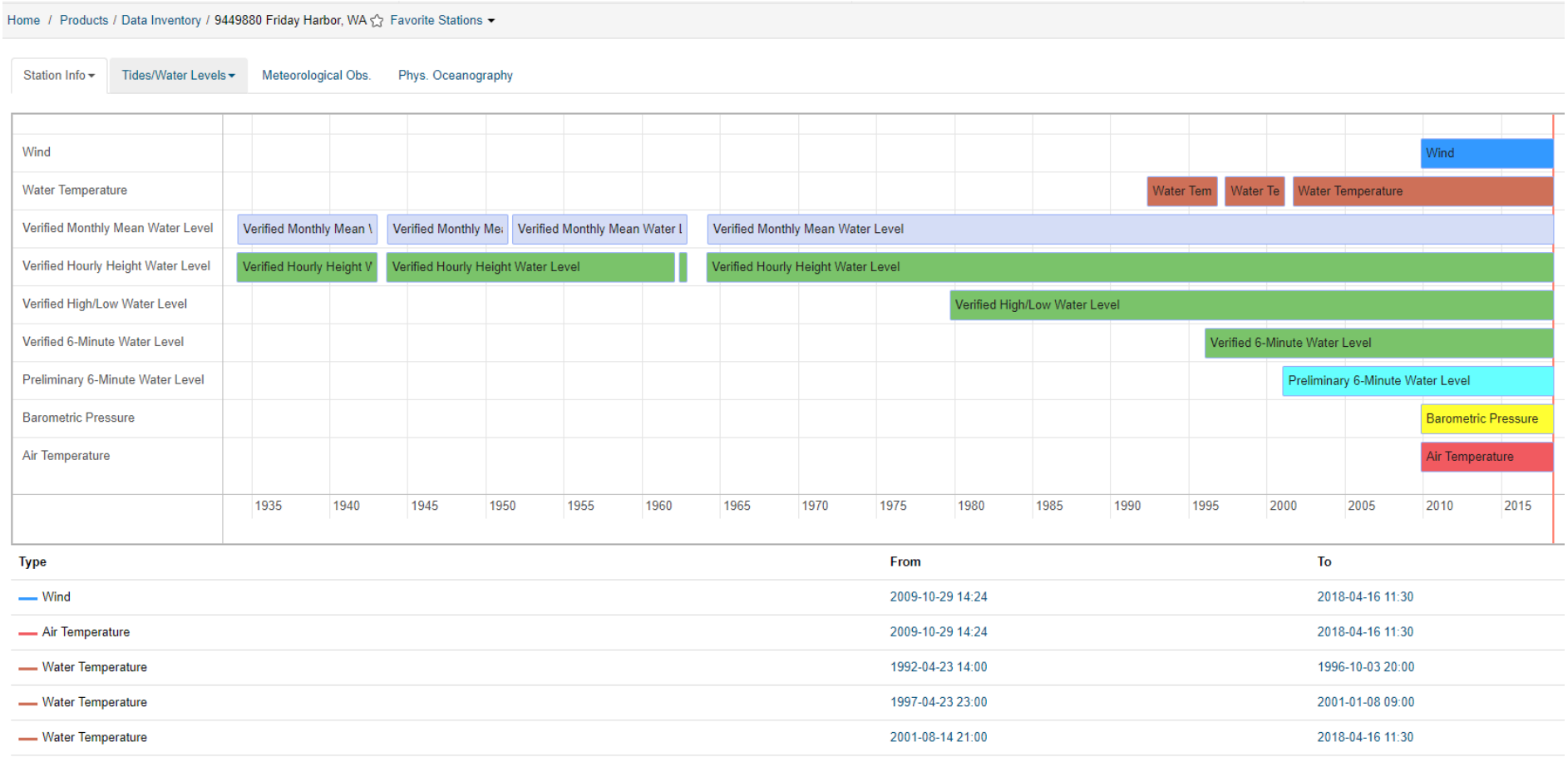
West side → choose Kanaka Bay

Cattle Pt. → choose Richardson (Lopez Island)



# Resources – historic tides

https://tidesandcurrents.noaa.gov/stations.html?type=Historic+Water+Levels



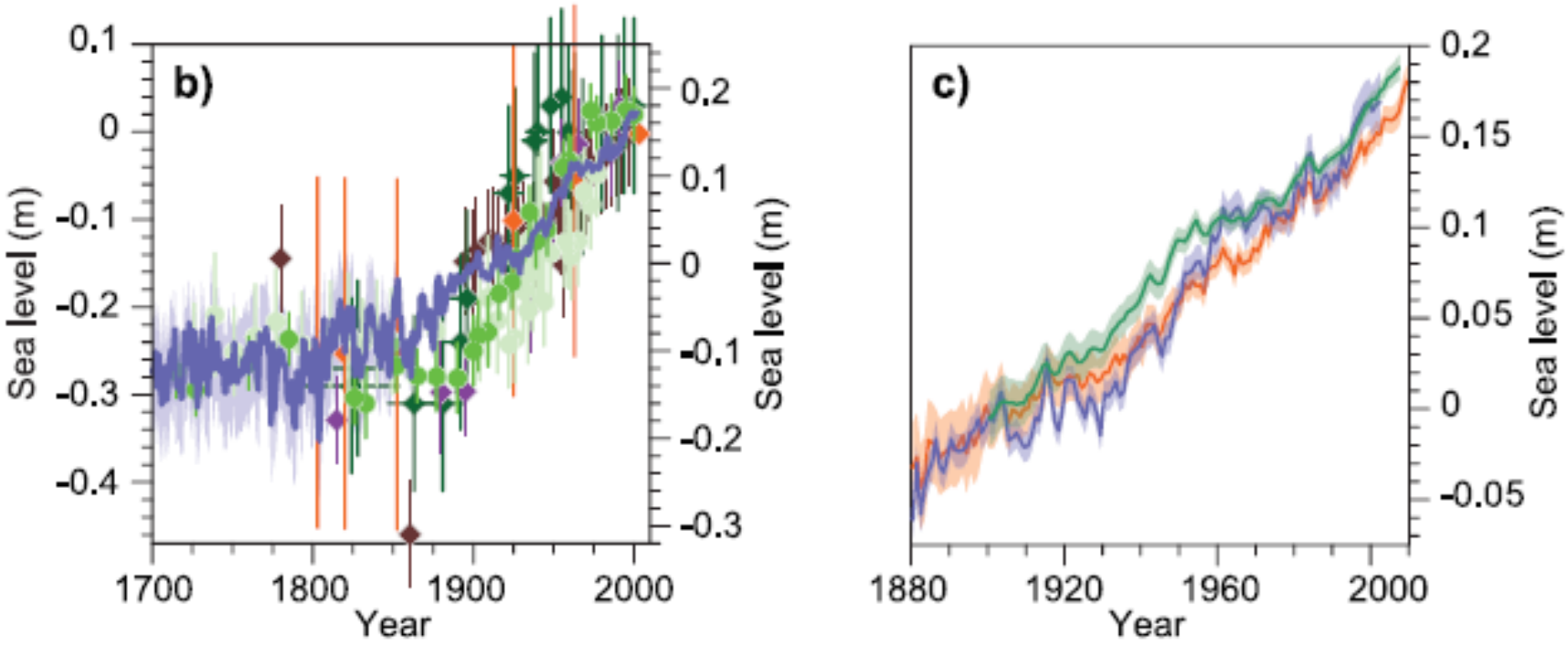

| Type | From | To |
|---|---|---|
| Wind | 2009-10-29 14:24 | 2018-04-16 11:30 |
| Air Temperature | 2009-10-29 14:24 | 2018-04-16 11:30 |
| Water Temperature | 1992-04-23 14:00 | 1996-10-03 20:00 |
| Water Temperature | 1997-04-23 23:00 | 2001-01-08 09:00 |
| Water Temperature | 2001-08-14 21:00 | 2018-04-16 11:30 |

# Resources – global sea level

- IPCC = Intergovernmental Panel on Climate Change

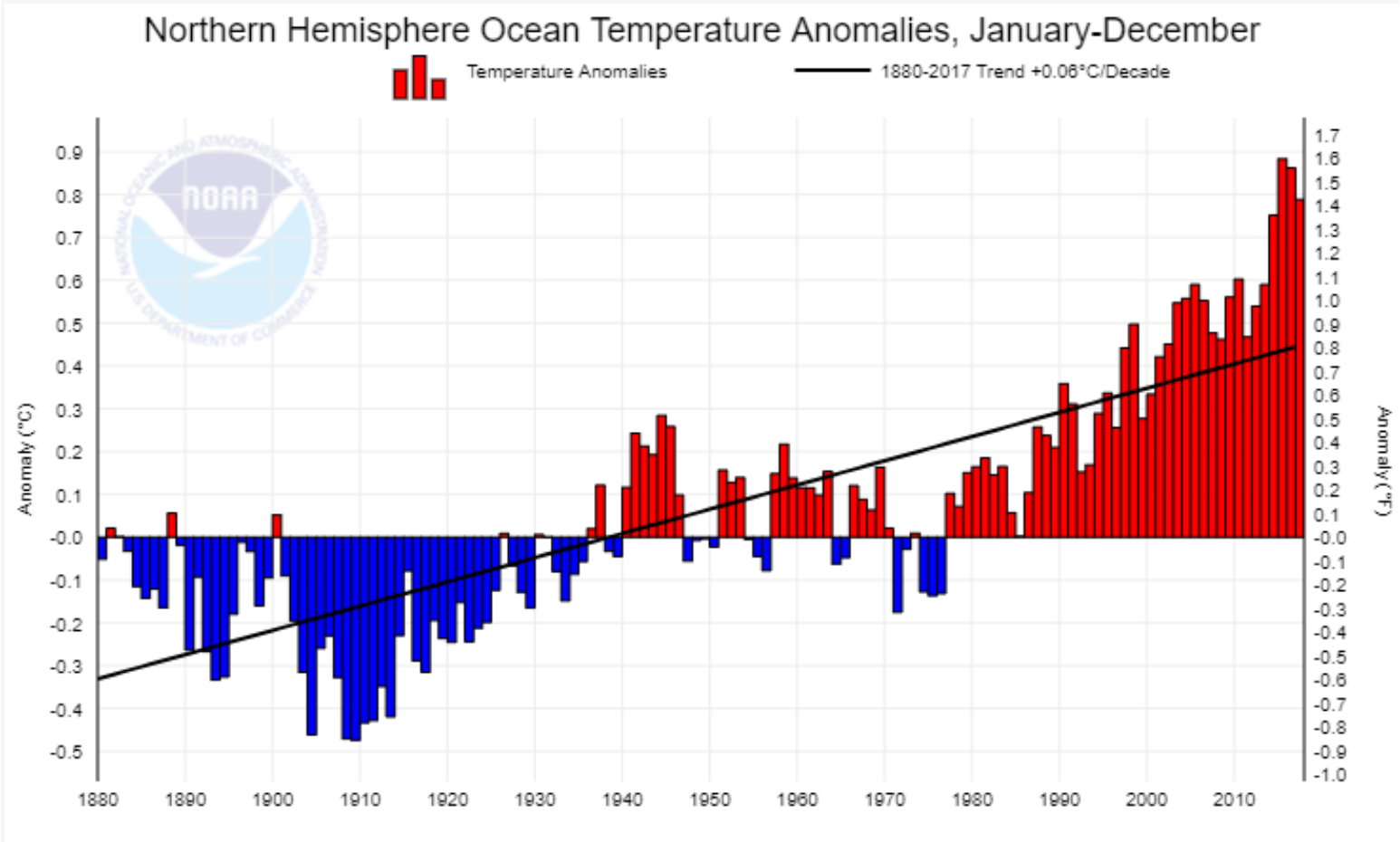
http://www.ipcc.ch/

[check here for all global climate data types]



# Resources – big trends in temp

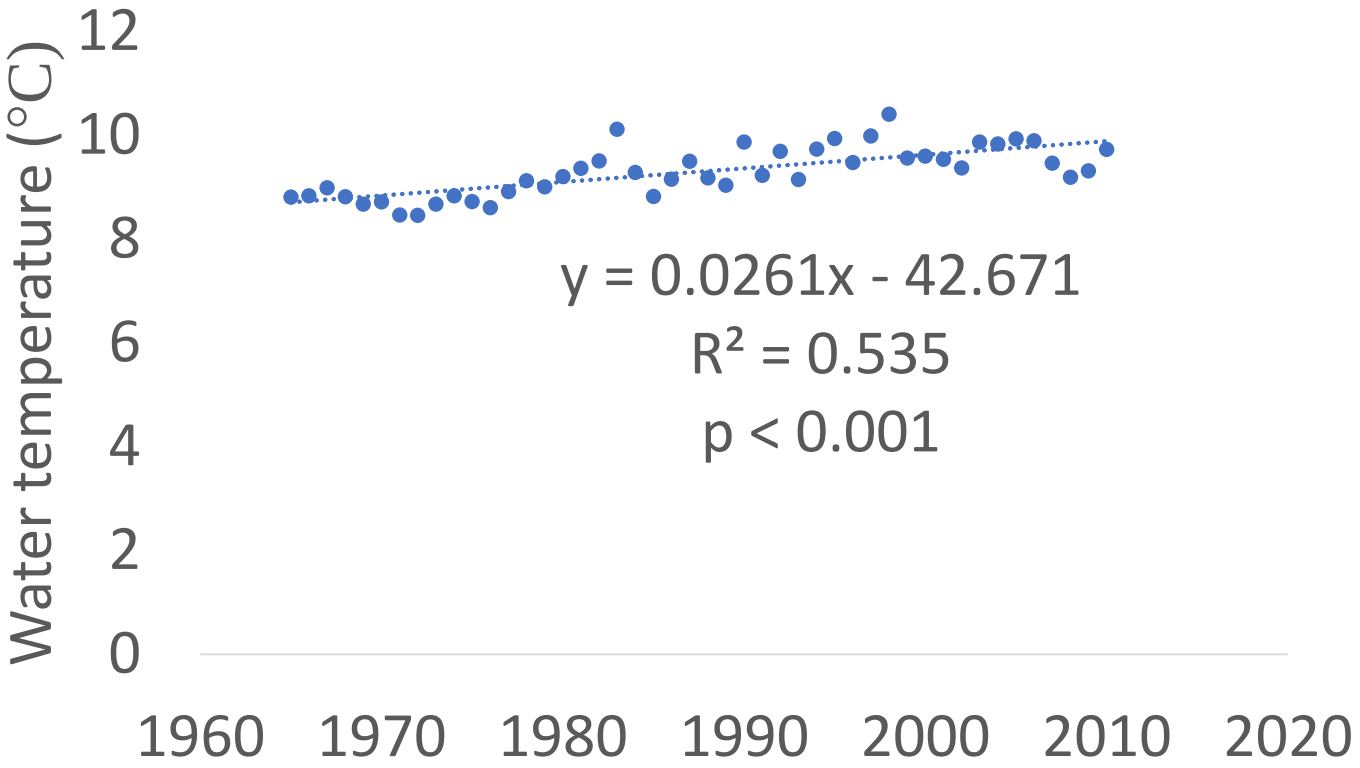
https://www.ncdc.noaa.gov/cag/global/time-series/globe/land/ytd/12/1880-2018?trend=true&trend_base=10&firsttrendyear=1880&lasttrendyear=2018



# Resources – local trends in temp

Race Rocks Lighthouse (near Victoria, BC) water temperature

http://www.racerocks.com/racerock/data/seatemp/seatemppast.htm



# Resources – local trends in temp

FHL weather station air temperature + more archive

2006-2017

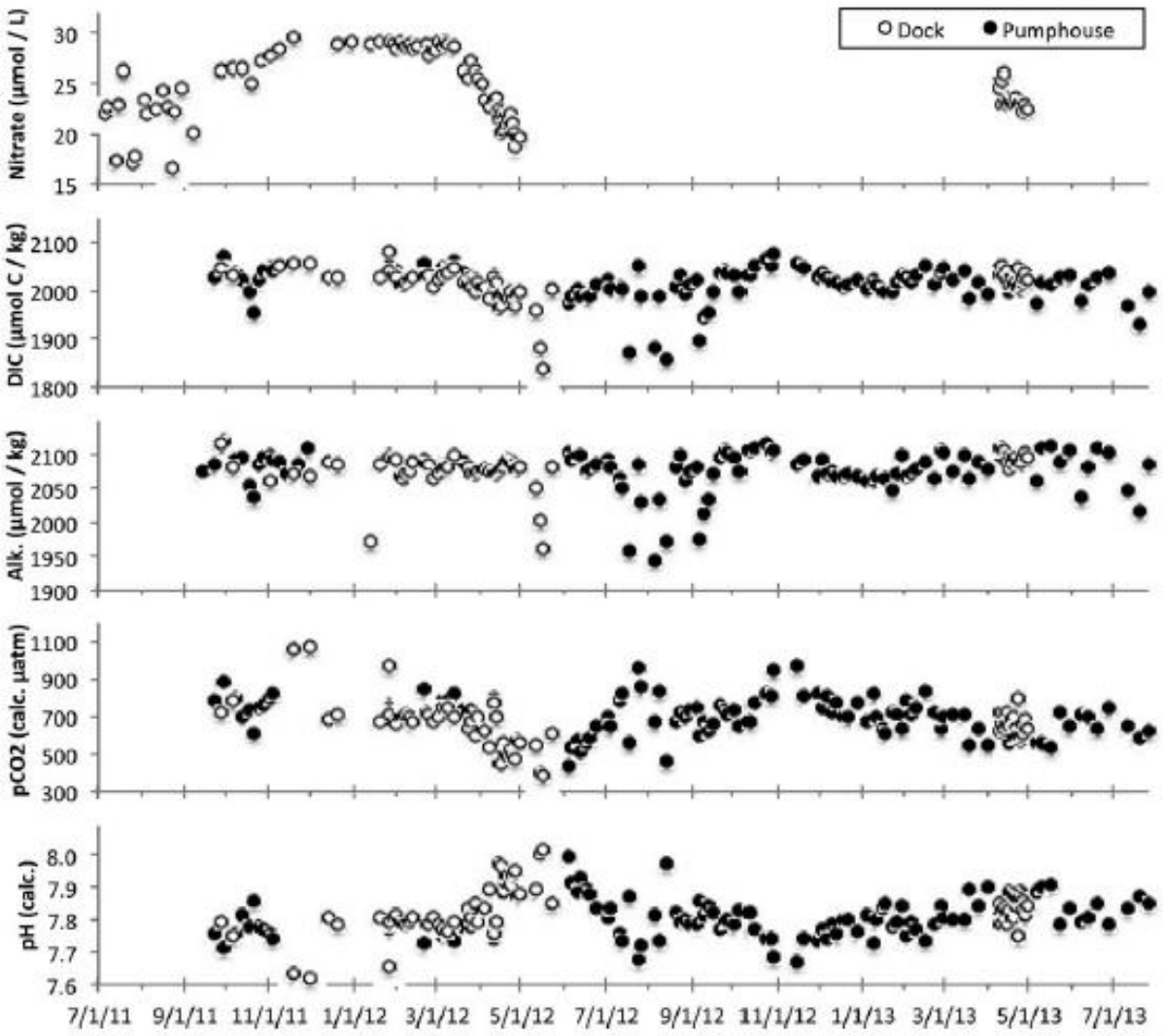
http://data.bco-dmo.org/jg/serv/BCO/IntertidalTempEffects/FHL_Weather_All.brev1%7Bdir=data.bco-dmo.org/jg/dir/BCO/IntertidalTempEffects/,info=data.bco-dmo.org/jg/info/BCO/IntertidalTempEffects/FHL_Weather_All%7D?Platform_Id%20eq%20FHL_Weather_Station

```
#  Intertidal Temperature Effects
#  Friday Harbor Labs - Weather Data
#  PI: Carrington
#  Version History:
#  2017-08-30 - (current version) Updated with data from 2015-01-01 through 2017-06-30.
#  2014-03-04 - original Version
=========================
Platform_Id          Lat      Lon
-------------------------
FHL_Weather_Station  48.5461  -123.0070
=========================
Data_Start_End
-------------------------
01Apr2009-30Jun2009
=========================
```

| Date | Time | Air_Temp | RH | Rad_PAR | Rad_Energy | Rad_tot | Rain | Wind_speed | Wind_direction | Wind_Chill |
|---|---|---|---|---|---|---|---|---|---|---|
| 20090401 | 000000 | 5.355 | 72.40 | 0.180 | nd | 13.02 | 0.000 | 3.404 | 260.60 | 2.676 |
| 20090401 | 001500 | 5.464 | 72.40 | 0.210 | nd | 15.72 | 0.000 | 3.797 | 255.50 | 2.575 |
| 20090401 | 003000 | 5.474 | 71.32 | 0.300 | nd | 15.23 | 0.000 | 3.724 | 260.30 | 2.622 |
| 20090401 | 004500 | 5.498 | 70.03 | 0.180 | nd | 18.74 | 0.000 | 4.358 | 257.40 | 2.299 |
| 20090401 | 010000 | 5.450 | 71.62 | 0.120 | nd | 16.57 | 0.000 | 4.065 | 254.50 | 2.398 |
| 20090401 | 011500 | 5.430 | 70.40 | 0.000 | nd | 14.24 | 0.000 | 3.602 | 255.60 | 2.650 |

# Resources – water chemistry

Murray et al. *Limnol. & Oceano.* 2015




data taken at FHL

# Resources – harvesting records

- Difficult to get because proprietary
- State records

  https://wdfw.wa.gov/fishing/reports_plants.html

**Table 2. Number of Sport Salmon Catch Record Cards Issued 1965-1995.**

| Year | Number of Catch Record Cards Issued |
|---|---|
| 1965 | 387,875 |
| 1966 | 392,850 |
| 1967 | 472,225 |
| 1968 | 456,675 |
| 1969 | 471,525 |
| 1970 | 591,025 |
| 1971 | 541,600 |
| 1972 | 536,750 |
| 1973 | 568,825 |
| 1974 | 562,375 |
| 1975 | 576,075 |
| 1976 | 660,150 |
| 1977 | 641,050 |
| 1978 | 580,375 |
| 1979 | 487,875 |
| 1980 | 433,700 |
| 1981 | 463,561 |
| 1982 | 481,915 |
| 1983 | 481,025 |
| 1984 | 364,286 |
| 1985 | 403,523 |
| 1986 | 431,898 |
| 1987 | 475,459 |
| 1988 | 486,356 |
| 1989 | 509,534 |
| 1990 | 497,215 |
| 1991 | 489,394 |
| 1992 | 419,986 |
| 1993 | 447,986 |
| 1994 | 244,629 |
| 1995 | 416,707 |