Climate Change and the Olympic Coast: Interpreting Potential Futures

A presentation to the OCNMS Sanctuary Advisory Council
23 Sept 2011

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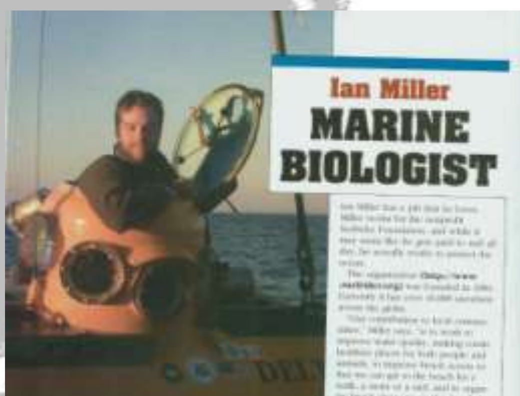
Motivation and Background



- At the request of the Office of National Marine Sanctuaries (ONMS), develop a *Climate Change Site Scenario* that describes what the site and its environs will likely look like in 50 to 100 years

- Guidance from the ONMS Climate-Smart Sanctuaries program states that the draft *Climate Change Site Scenario* should:

  - Be based on best available information, in-cluding historic baseline information, recent resources assessment(s), and any climatologies, models, or forecasts available for the site and its surrounding region;

  - Use the best local expertise;

  - Provide for the involvement of stakeholders, including an advisory group if present;

  - Provide for other public review; and

  - Undergo a rigorous peer review process.

OCNMS Draft Management Plan

D2. Climate Change Action Plan

Desired Outcomes:

1) OCNMS is a sentinel site in the Pacific Northwest for climate change monitoring,
2) OCNMS is a go-to source for climate change information on Washington's outer coast marine ecosystems, and
3) OCNMS understands and is prepared for likely climate change impacts in the sanctuary region.

Strategy CLIM1: CLIMATE-SMART SANCTUARY PROGRAM

Participate in the Office of National Marine Sanctuaries Climate-Smart Sanctuaries program in order to become certified as a climate-smart sanctuary.

- **Activity B:** Develop a Climate Change Site Scenario for OCNMS that synthesizes the best available information on climate change impacts to present a picture of what the sanctuary might look like in 50 to 100 years.

Strategy CLIM4: COMMUNICATING CLIMATE CHANGE

Communicate information about climate change and its potential effects on the sanctuary and Washington's outer coast to OCNMS partners and the public.

- **Activity B:** Provide local communities and the public with information about potential climate change impacts on the Olympic Coast and local, tribal, state and regional efforts to plan for climate change.

http://olympiccoast.noaa.gov/protection/mpr/33-118_draftplan.pdf

Proposed Outline

- Abstract (including a summary of key issues and a list of recommendation)
- Introduction (defining the need)
- Physical Effects of Climate Change
  - Precipitation and Land Run-off
  - Atmosphere
  - Ocean Currents (e.g. upwelling)
  - Waves
  - Sea Level Rise
  - Coastal Erosion and Shoreline Change
  - Changing Ocean Properties (e.g. Acidification, Oxygen)
- Expected Response of Biological Communities
  - Marine Organisms
  - Range Shifts
  - Responses in Marine Habitats
- Human and Biological Vulnerability to Coastal Change
- A Review of Relevant Adaptation Strategies
- Needs Assessment: Priority Research Areas

Sea Grant Washington

CLIMATE IMPACTS GROUP
Climate Science in the Public Interest

Goals

Expertise in outreach and communication of marine science

Coastal processes

Benthic Ecology

Fisheries/Water Quality

Local Knowledge

Expertise in outreach and communication of climate science

Ecosystem Modeling

Global Climate Model Down-scaling

Vulnerability Assessment and Adaptation Planning

http://cses.washington.edu/cig/

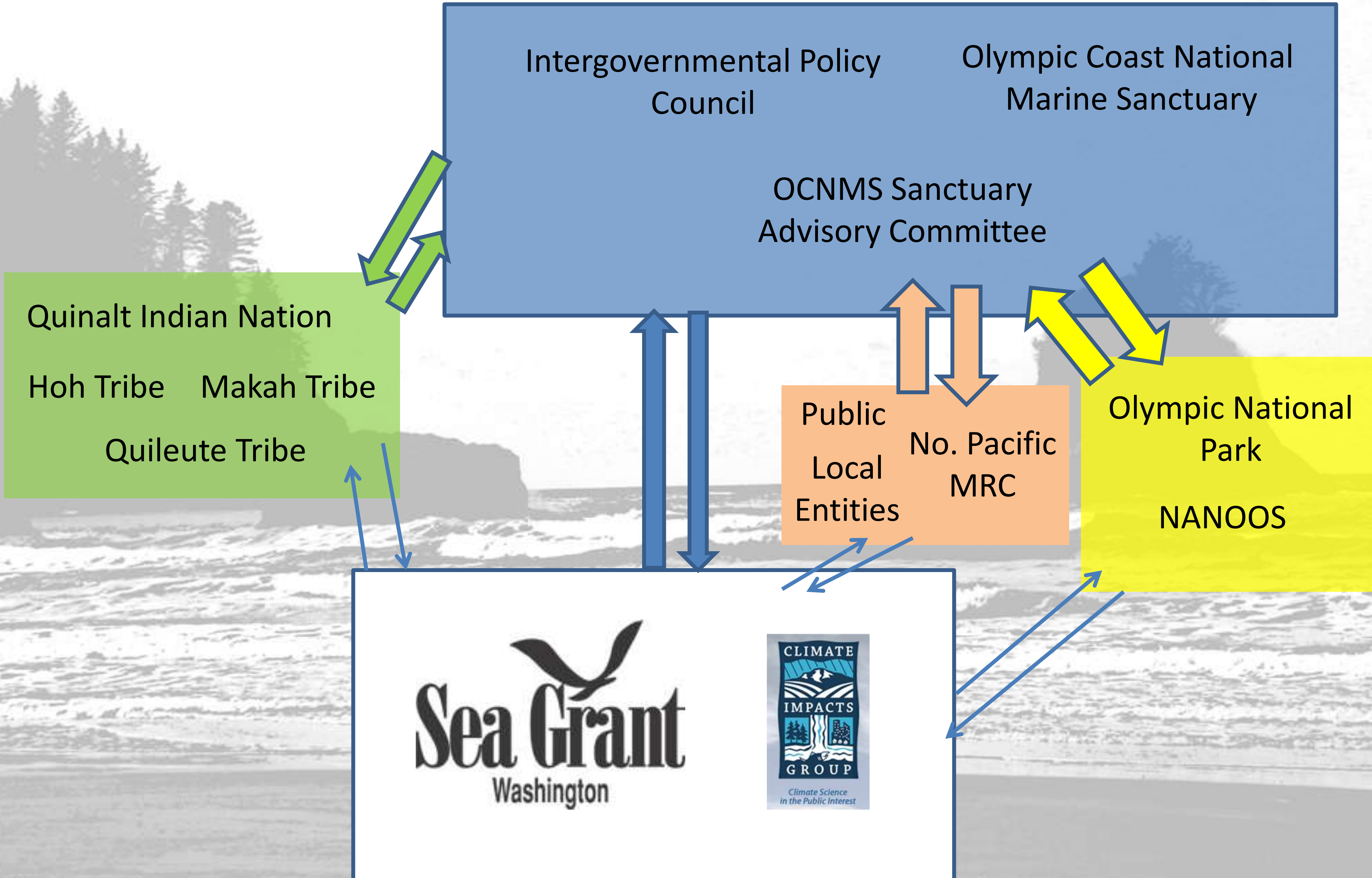
Attempt to answer the question, "What do we know?"

- Using the peer-review as the threshold
- Don't have the resources for a full examination of perceptions of climate change
- In essence, a "literature review", a gathering of information

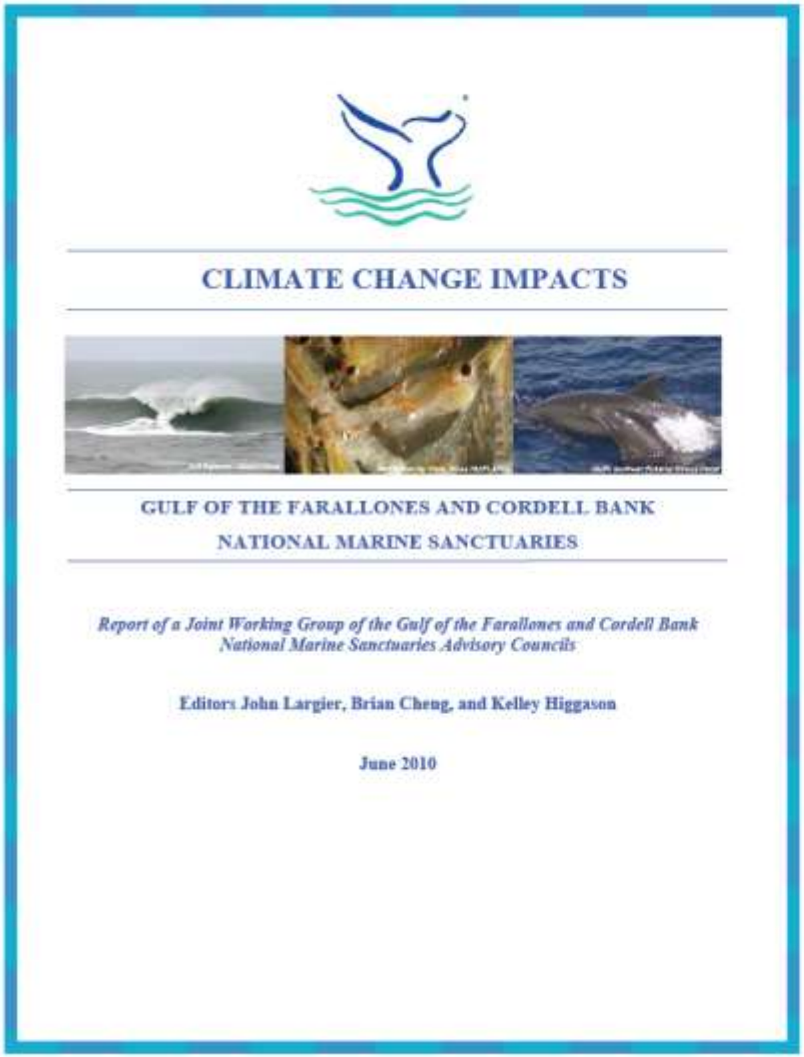
NOT comprehensive, we likely won't be able to cover all of the ground

BUT anticipate providing a basis from which to start planning

Proposed Communication Model



Templates


CLIMATE CHANGE IMPACTS

GULF OF THE FARALLONES AND CORDELL BANK
NATIONAL MARINE SANCTUARIES

Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils

Editors John Largier, Brian Cheng, and Kelley Higgason

June 2010

http://cordellbank.noaa.gov/science/climate_imp_0610.pdf

17 Working Group Members
2 Staff
39 contributors

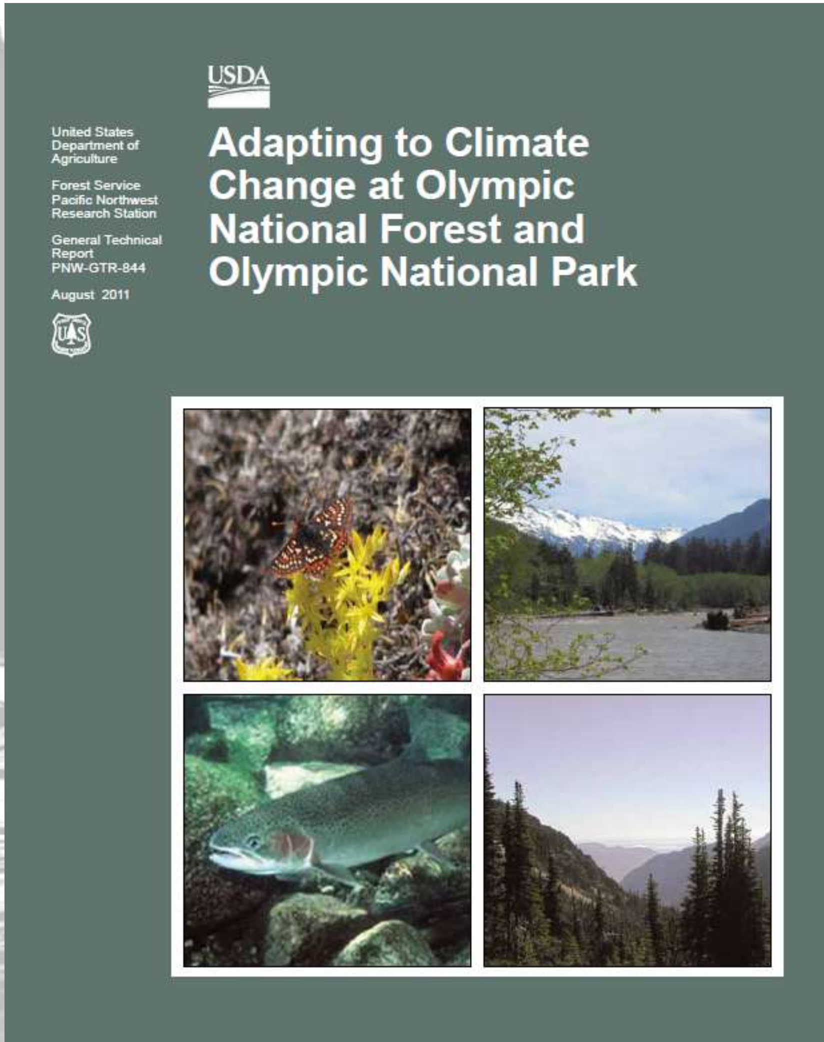
Priority Issues:

- Upwelling
- Ocean Temperature
- Sea Level
- Ocean pH
- Surprise!

Sample Recommendations

- Promote Stewardship
- Outreach
- Direct Monitoring Towards Expected Change
- Assess Stressors that constrain “breathing room”
- Adapt Management to Minimize Future Impacts

Templates

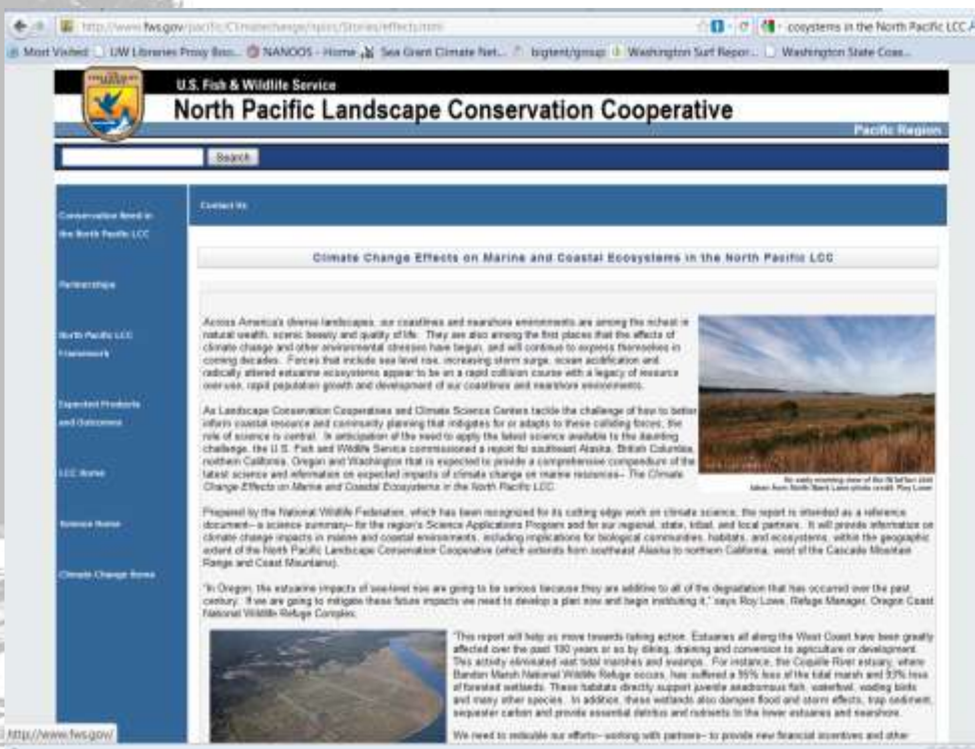


http://www.treesearch.fs.fed.us/pubs/38702

Nice Analysis of Potential Terrestrial Impacts

But, no Coast Specific Scenario Analysis

Templates



Regional Scale Compilation of Impacts on Marine and Coastal Ecosystems – DUE OUT SOON

Also, a regional synthesis of Sea Level Rise for the West Coast of the U.S. by the National Research Council also due out soon.

http://www.fws.gov/pacific/Climatechange/nplcc/Stories/effects.html

Templates

8: Coasts

Impacts of Climate Change on the Coasts of Washington State

Daniel D. Huppert[1], Amber Moore[1], Karen Dyson[1]

Abstract

Climate change on the Washington coast will trigger significant physical and chemical stressors: (a) inundation of low-lying areas by high tides as sea level rises; (b) flooding of coasts during major storm events, especially near river mouths; (c) accelerated erosion of coastal bluffs; (d) shifting of beach profiles, moving the position of the Mean High Water line landward; (e) saltwater intrusion into coastal freshwater aquifers; and (f) increased ocean temperature and acidity. Similar forces will be working everywhere, but shore areas will respond differently depending upon substrate (sand versus bedrock), slope (shallow versus steep cliffs), and the surrounding conditions (exposed versus sheltered from storms). We expect substantial impacts on coastal systems from bluff erosion, shifting beach berms, shoreline armoring, and inundation of coastal lands. Further, increased ocean temperatures and acidity will negatively impact shellfish aquaculture. As beaches adjust to sea level rise, coastal property lines and intertidal aquaculture leases will need to be carefully defined through modified property laws. We anticipate relatively minor impacts on coastal freshwater aquifers. Additional research is needed to develop a more comprehensive assessment of climate impacts on all coastal features in the state.

[1] School of Marine Affairs College of Ocean and Fishery Sciences, University of Washington, Seattle, Washington

http://cses.washington.edu/cig/res/ia/waccia.shtml

Washington Climate Change Impacts Assessment

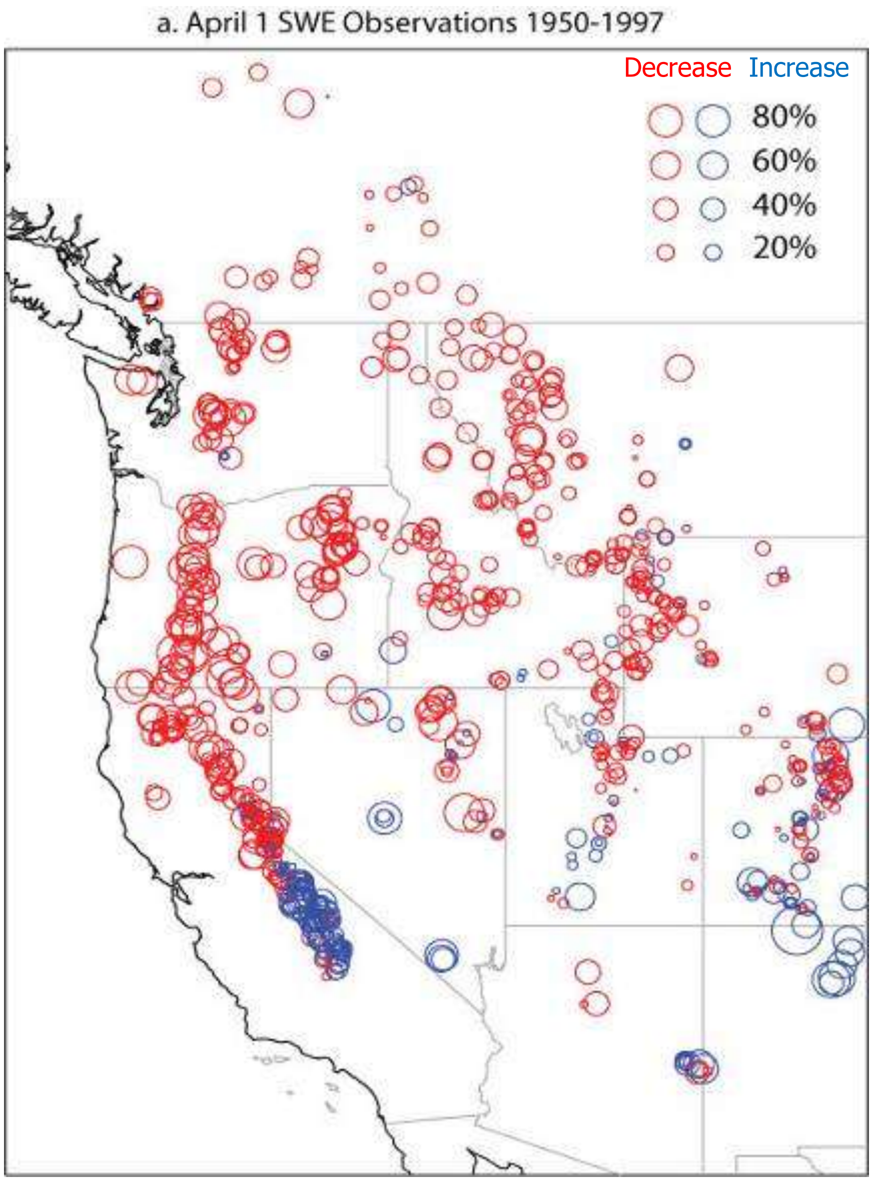
Coastal Chapter a brief survey of impacts and responses, mostly with a focus on economic response (i.e. impact to the shellfish industry)

Key Trends in PNW Climate

Average annual temperature increased **+1.5°F** in the PNW during the 20th century

April 1 snowpack has decreased throughout the PNW with losses of 30-60% at many individual stations (1950-2000)

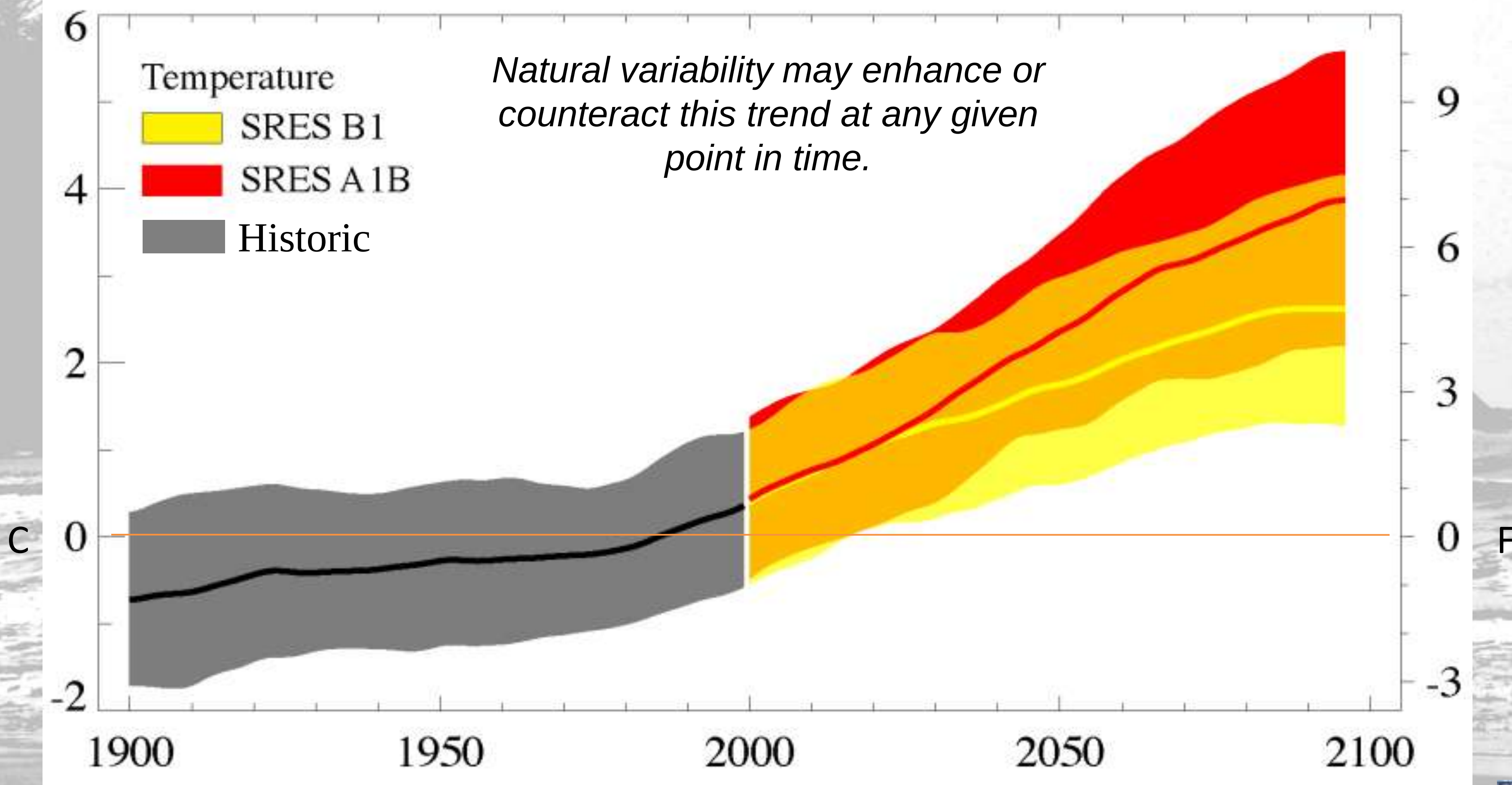
Similar snowpack declines are seen throughout the western United States



Projected Increases in Annual PNW Temperature

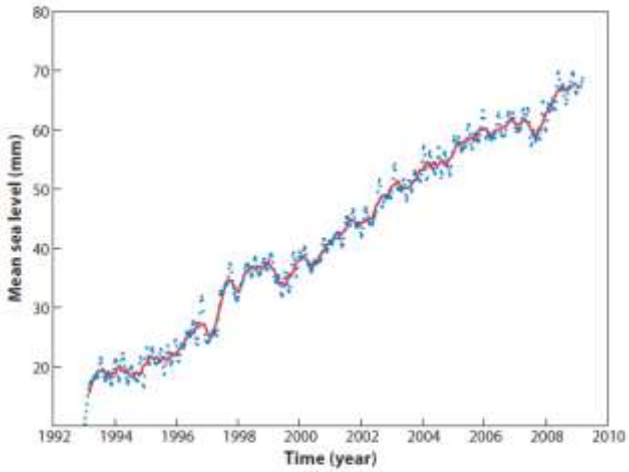
** Relative to 1970-1999 average*

2020s	+2.0°F *(1.1-3.4°F)*
2040s	+3.2°F *(1.6-5.2°F)*
2080s	+5.3°F *(2.8-9.7°F)*

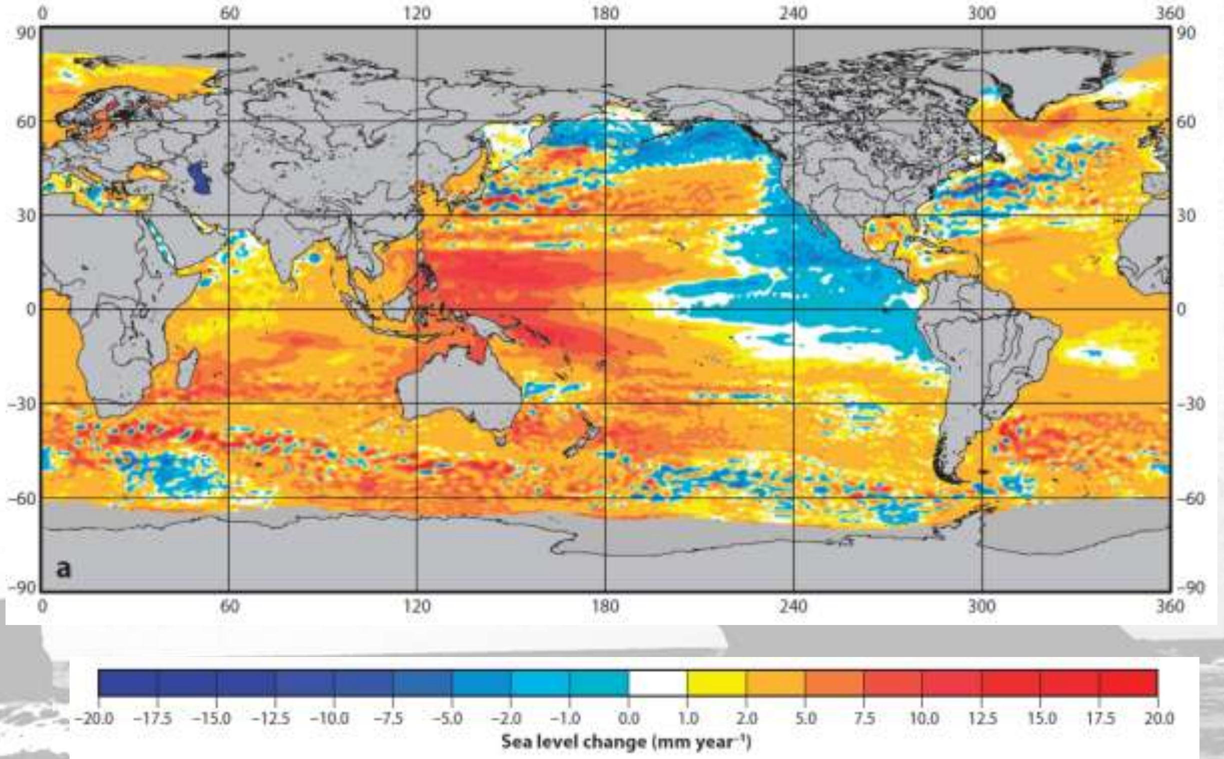


Mote and Salathé, 2009

Sea Level



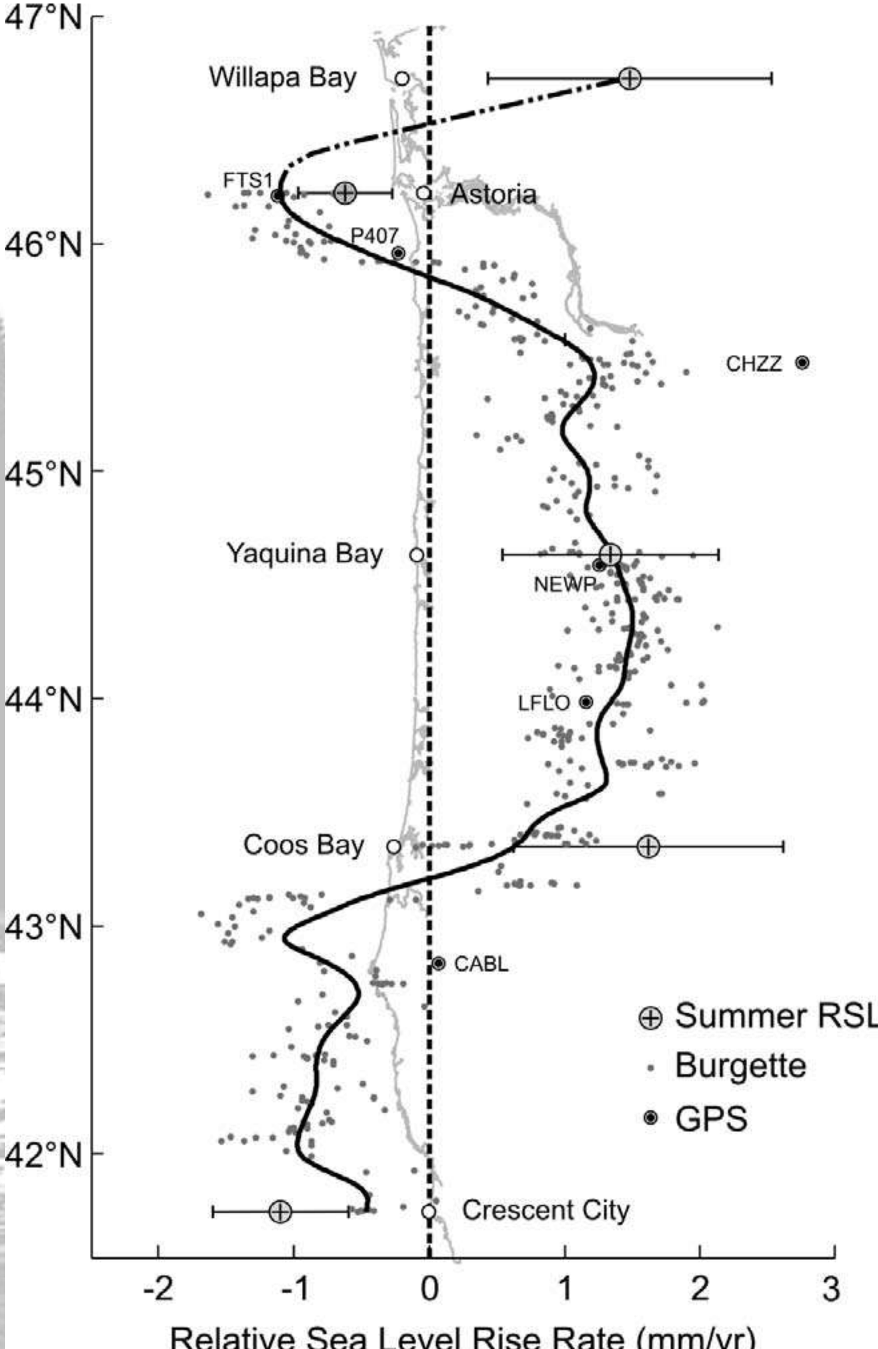
Cazenave and Llovel, 2010



But, wind stress patterns associated with the PDO cycle may be responsible for this low regional sea level – and an acceleration may be in the future

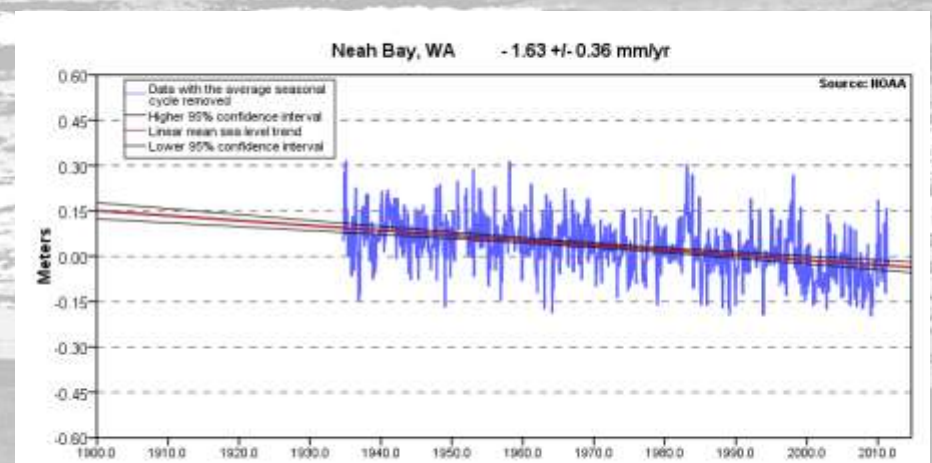
Bromirski et al., 2011

Regional Sea Level Trends



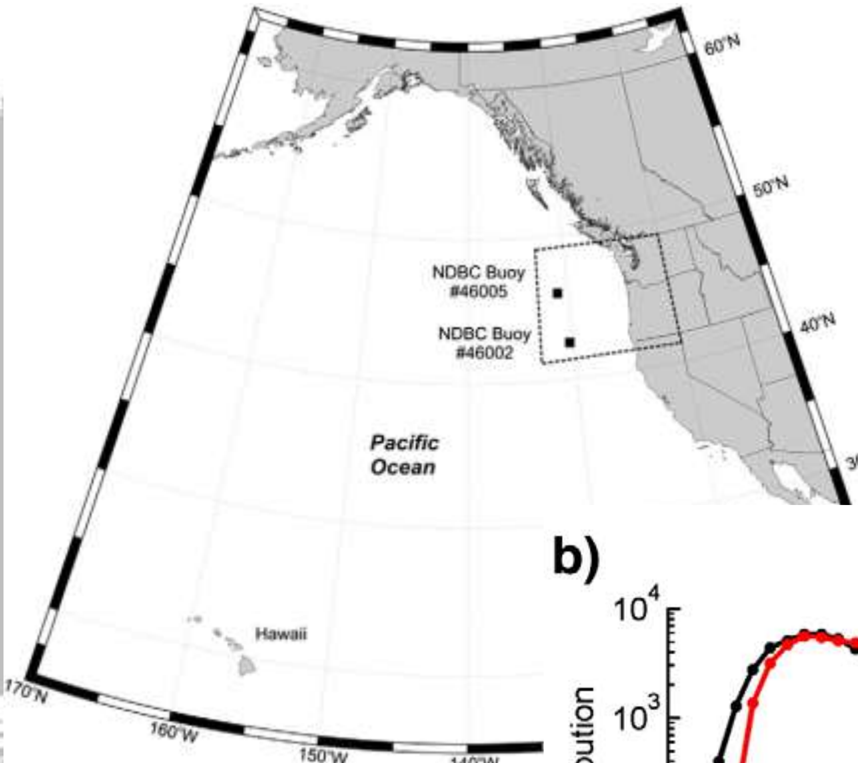
The Alignment of Tide Gauge Data (Relative Sea Level Rise) and GPS Data (Land Movement) works, IF ~2.28m/yr Of "true" sea level rise is added in.

2.28 m/yr previously estimated by Burgette, Weldon and Schmidt (2009) for the last half of the 20th Century

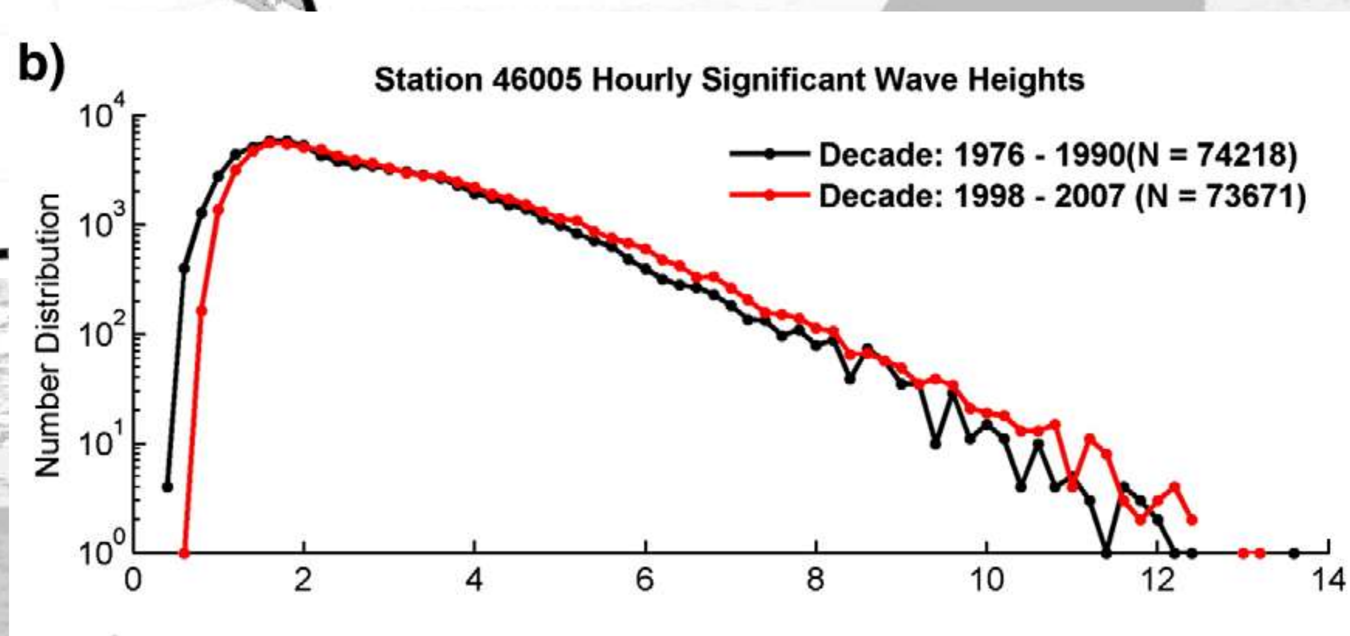


Komar et al., 2011

Wave Climate

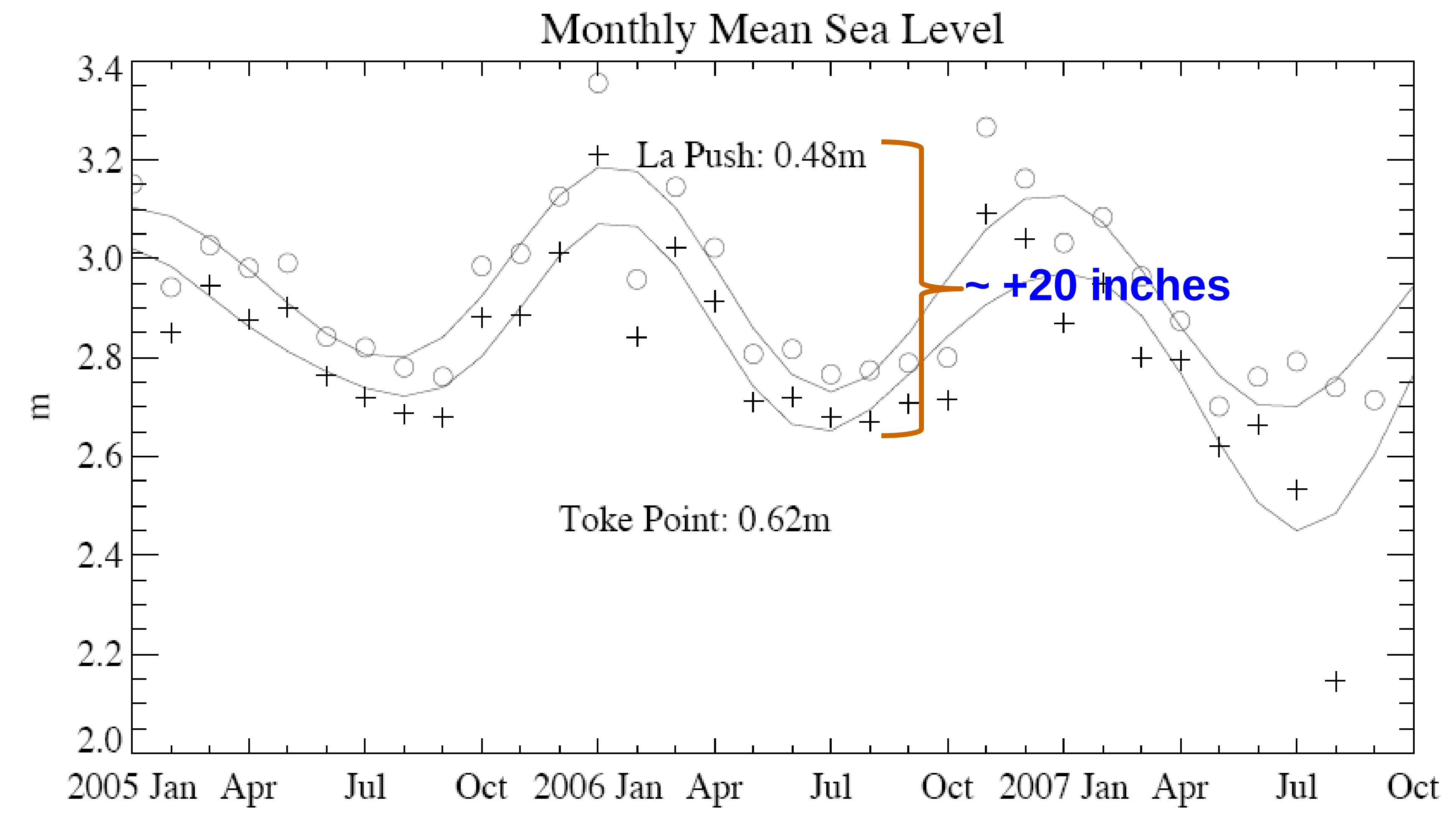


"uncertainty remains as to whether [these increases] are the product of human-induced greenhouse warming or represent variations related to natural multi-decadal climate cycles. Whatever the cause, the increases are important in their impacts ranging from ship safety to enhanced coastal hazards"

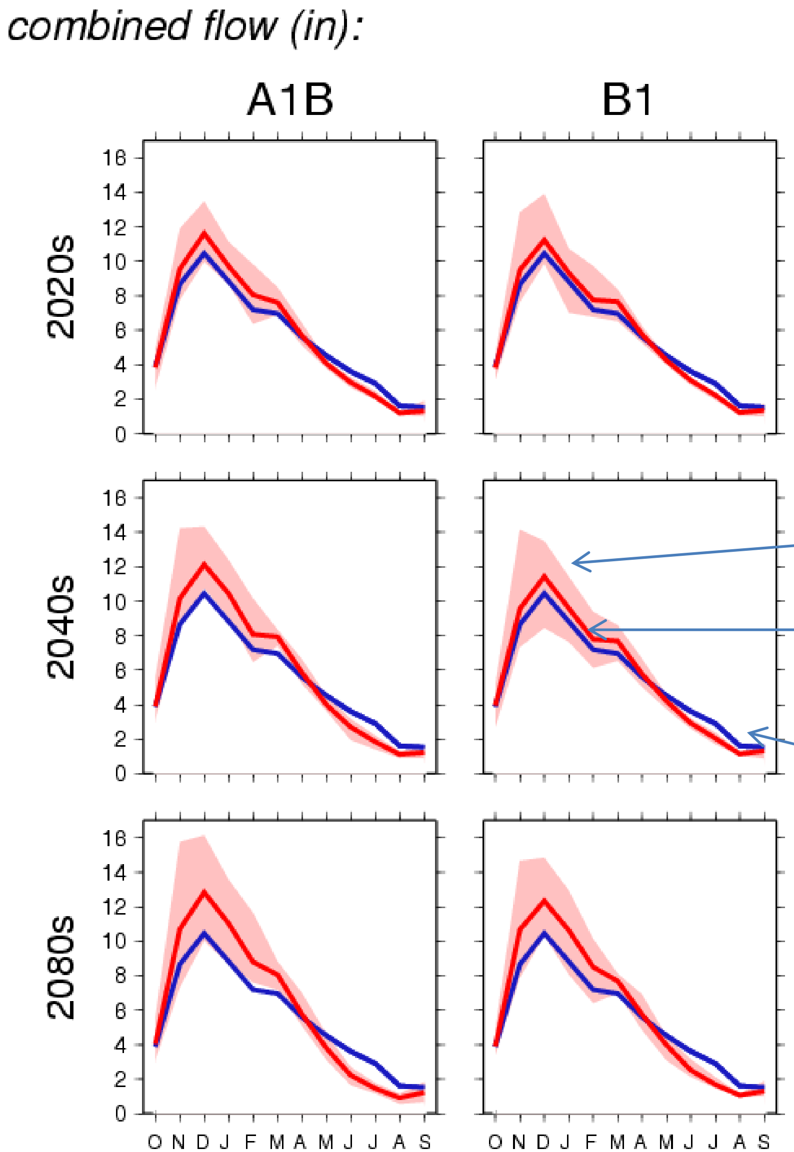


Ruggiero et al, 2010

Storm Impacts



Water Flux, Hoh River



A1B Scenario = Medium High Emissions

B1 Scenario = Low Emissions

Range of Outcomes from Multiple Runs

Mean of Outcomes from Multiple Runs

Estimated Historical Baseline (1916-2006)

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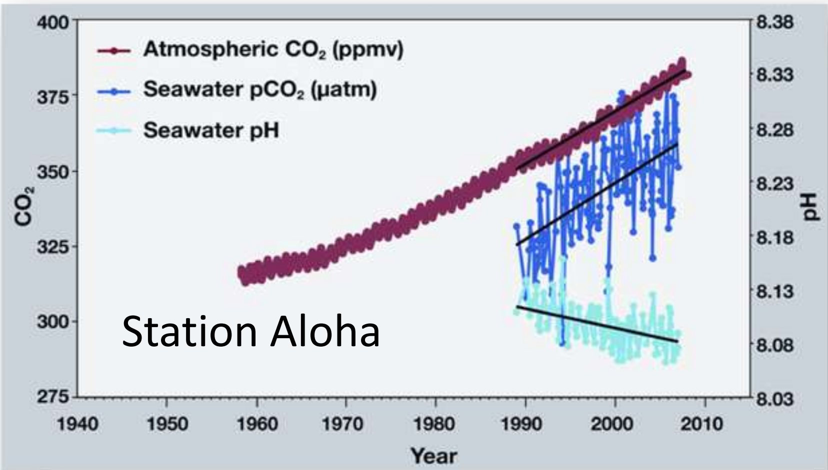
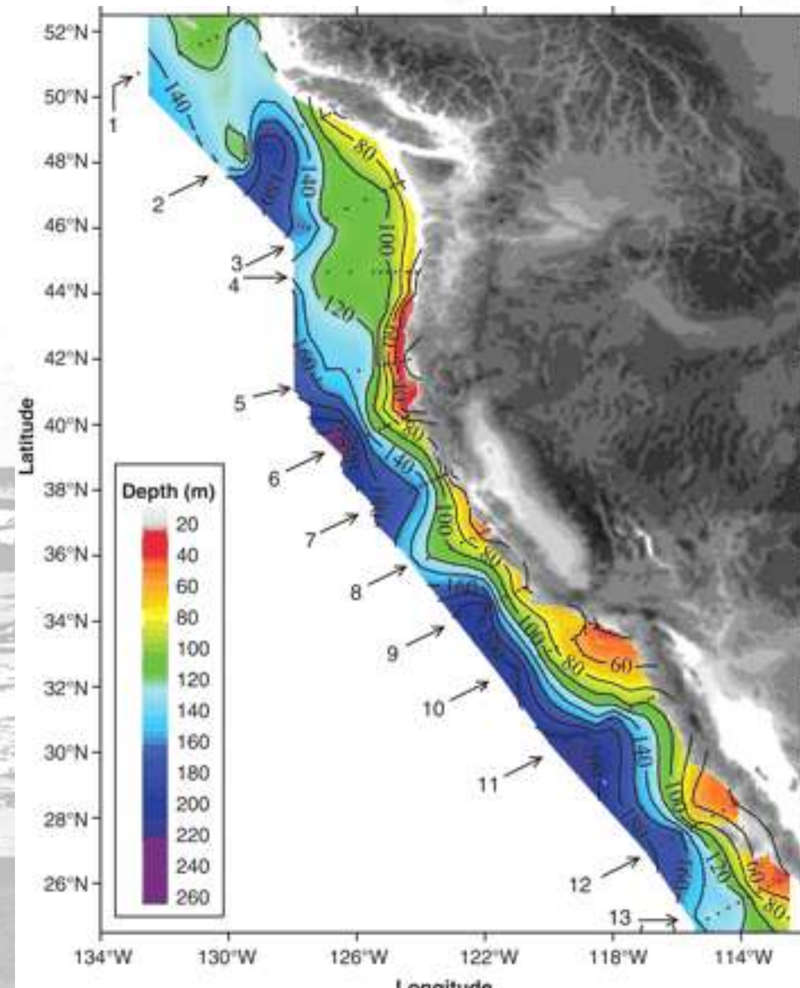
Ocean Acidification



Aragonite Saturation Horizon Shoaling
At 1-2 m/yr

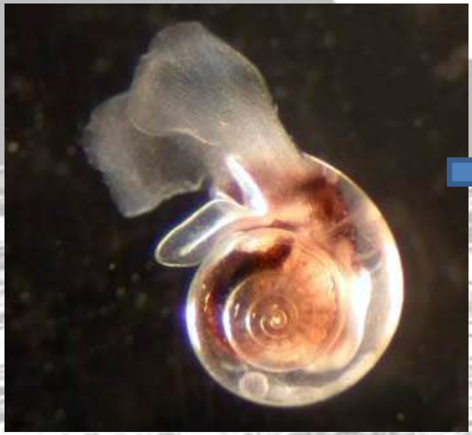


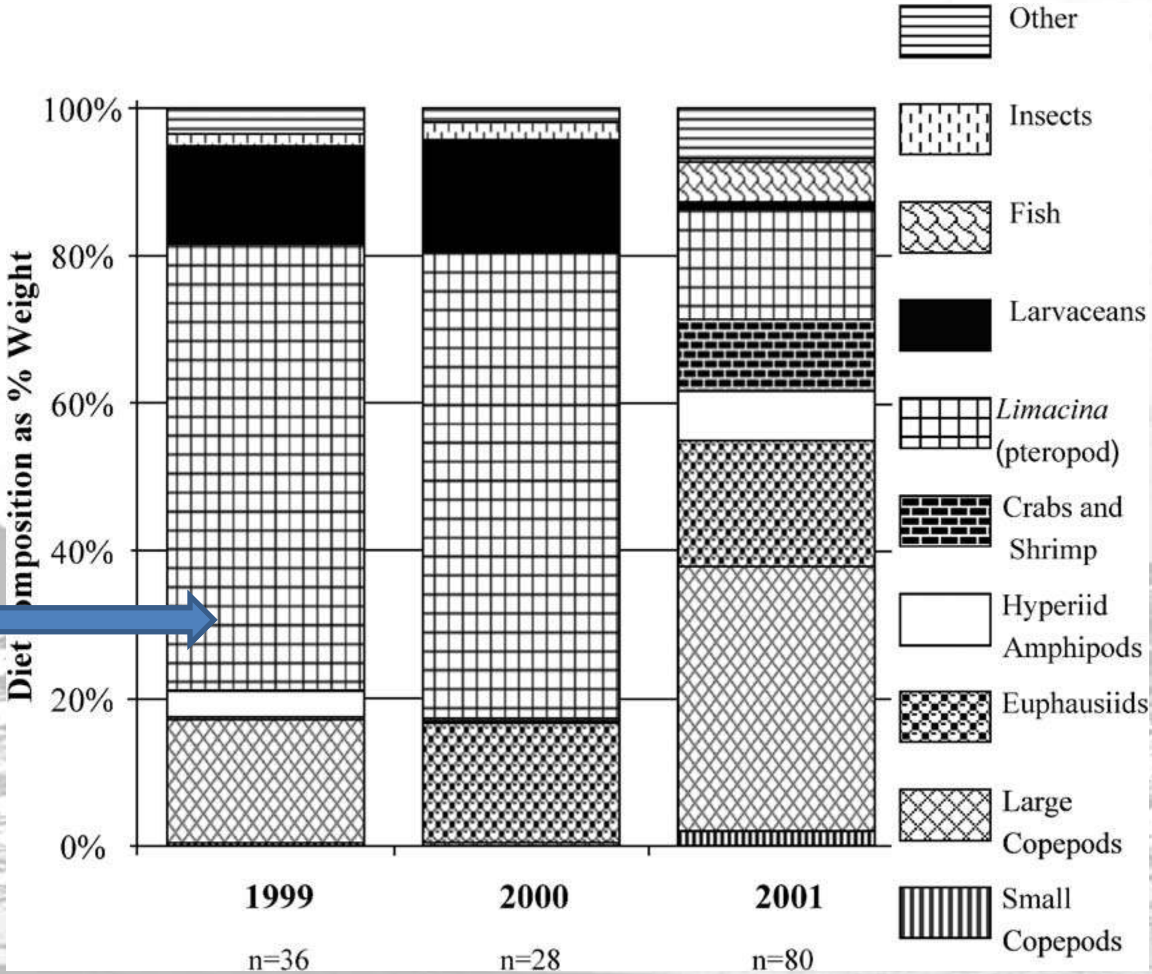
Distribution of the depths of undersaturated water (aragonite saturation < 1.0; pH < 7.75) on the continental shelf of western North America from Queen Charlotte Sound, Canada, to San Gregorio Baja California Sur, Mexico.

Feely et al., 2008

Biological Communities

Gulf of Alaska Juvenile Pink Salmon Prey Distribution





Armstrong et al. 2005

Questions?

Other Angles or Directions?

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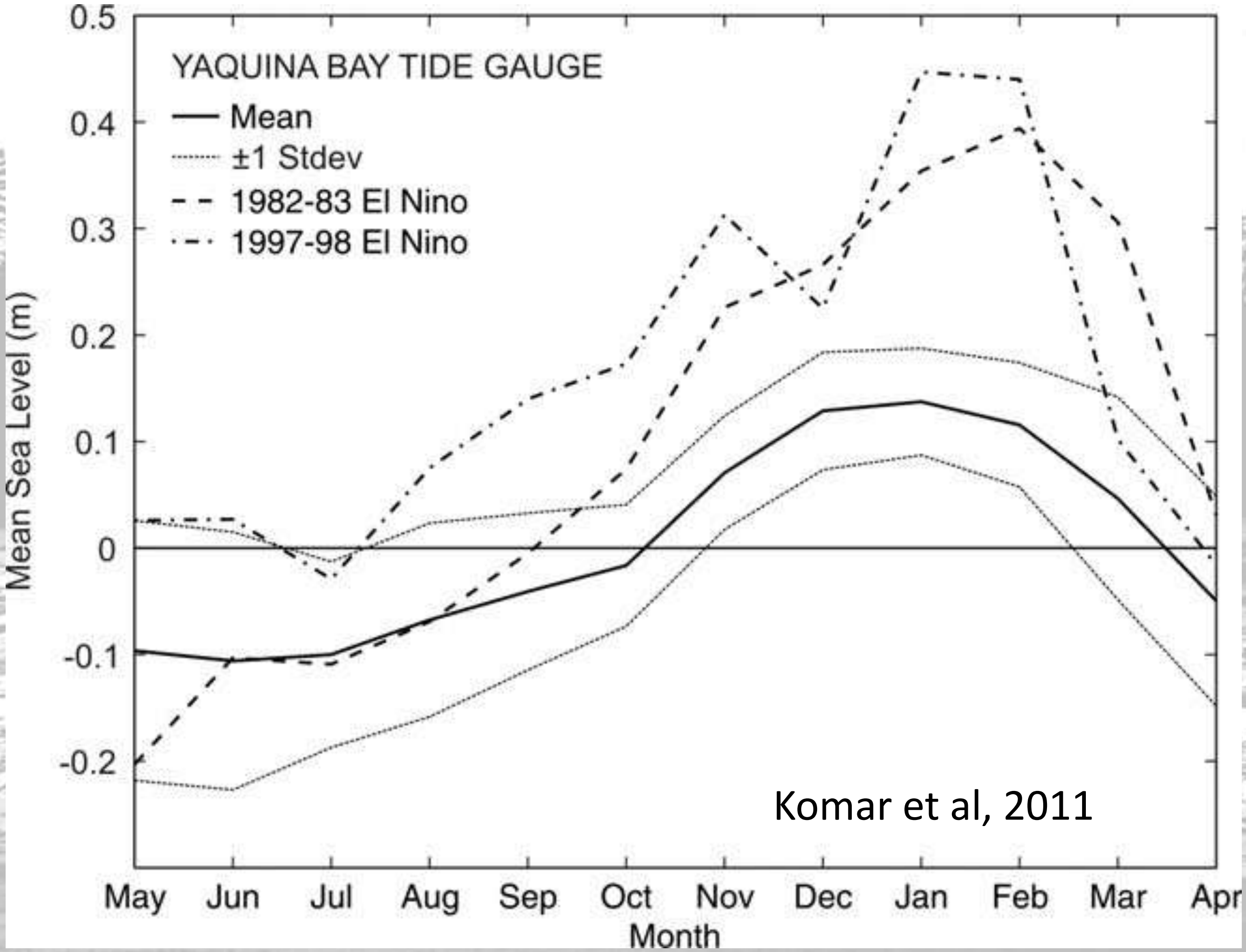
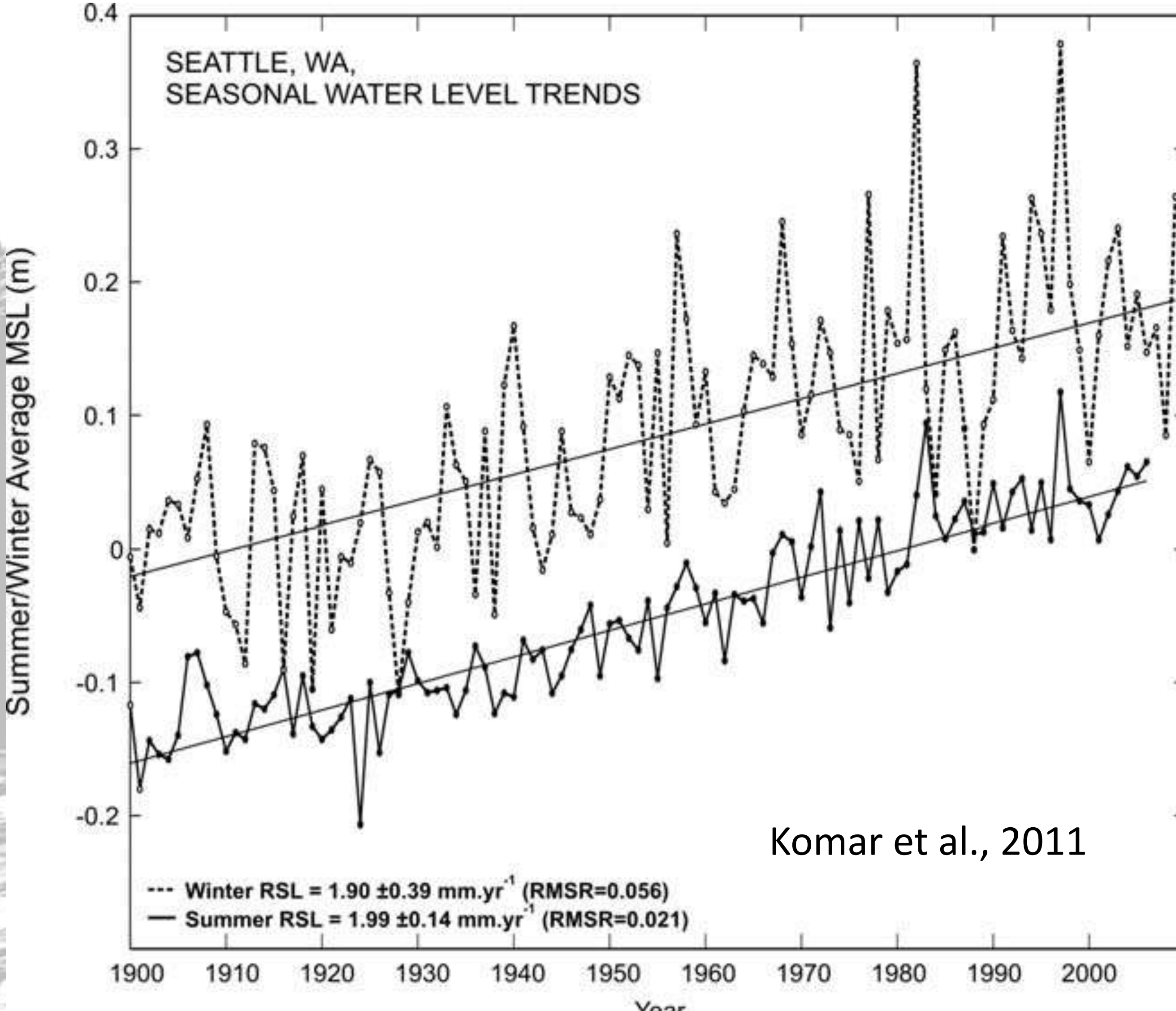
Extra Slides

Climate Cycles

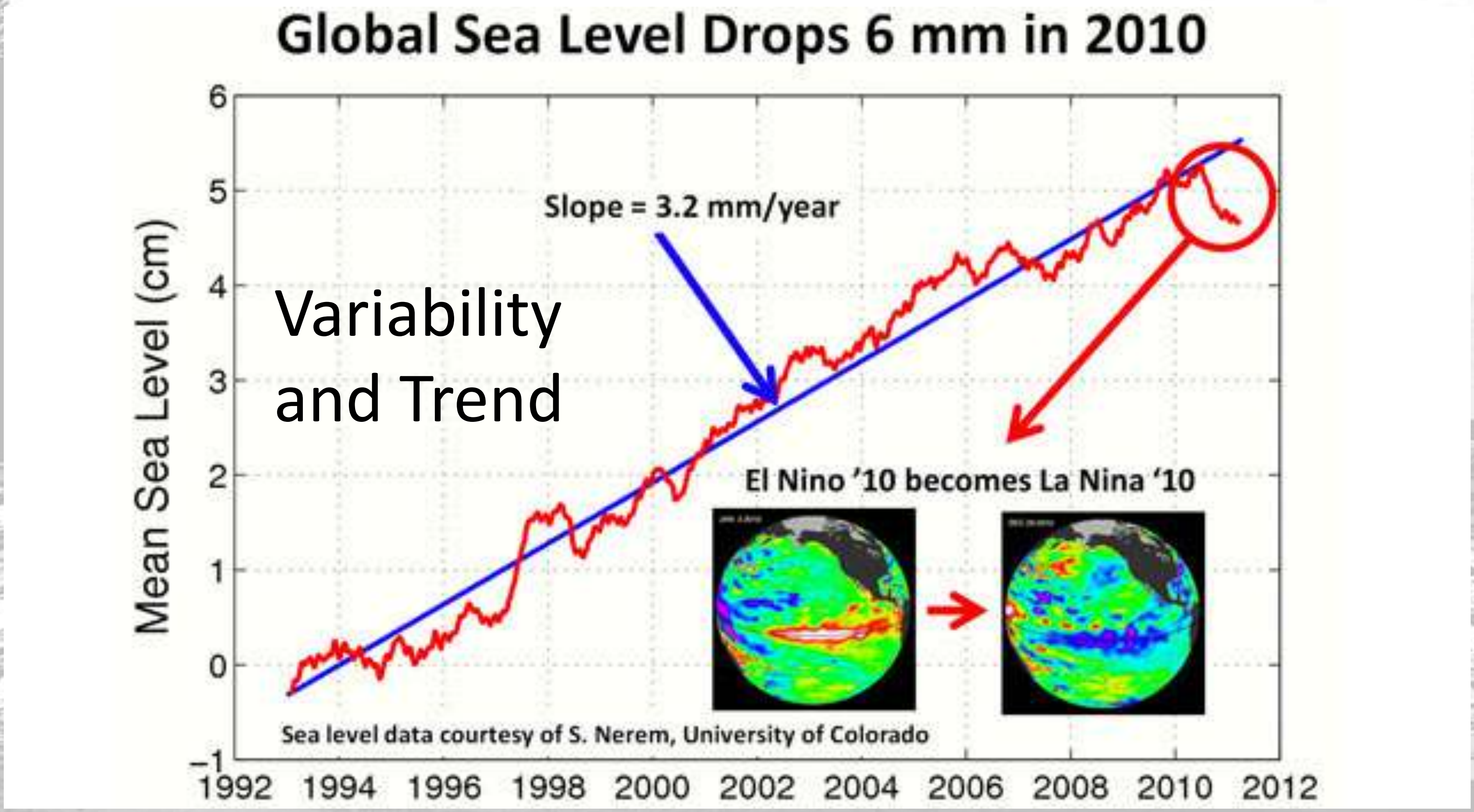


Komar et al, 2011

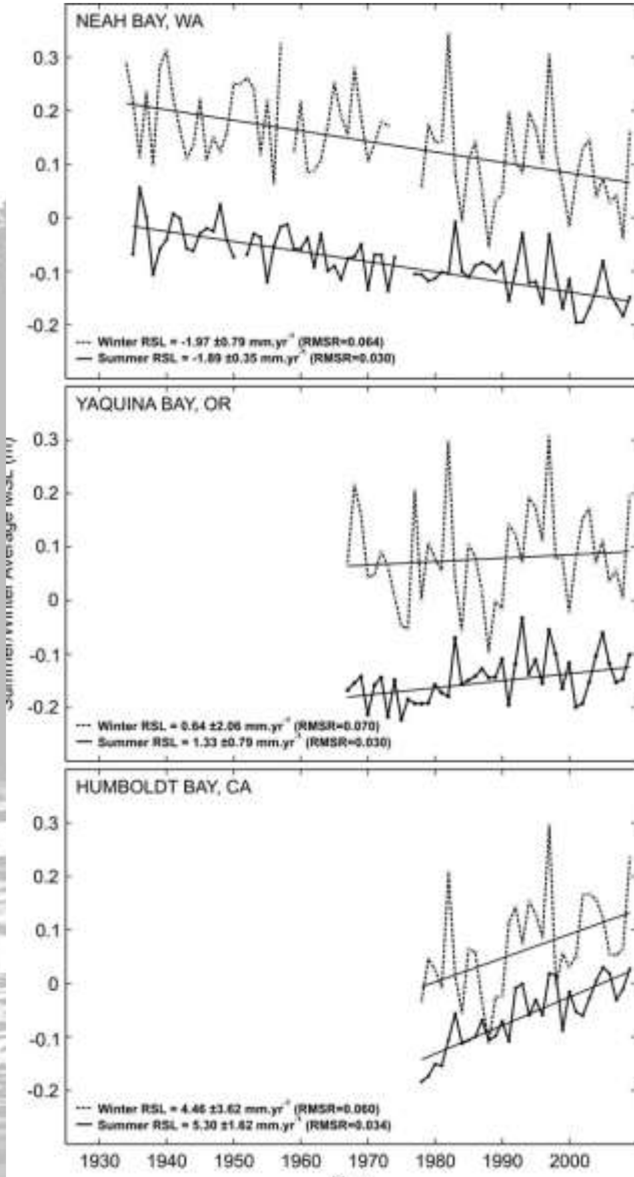


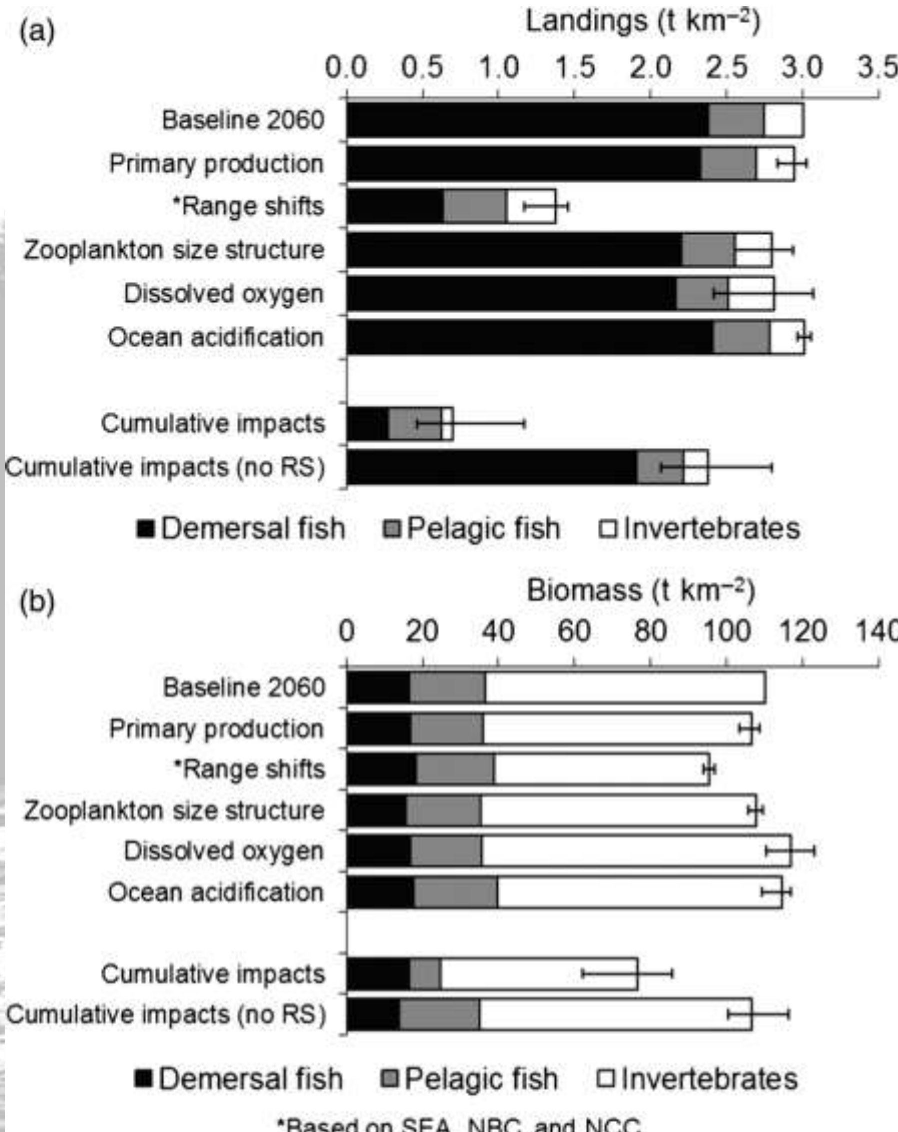
Komar et al., 2011

A Few Examples



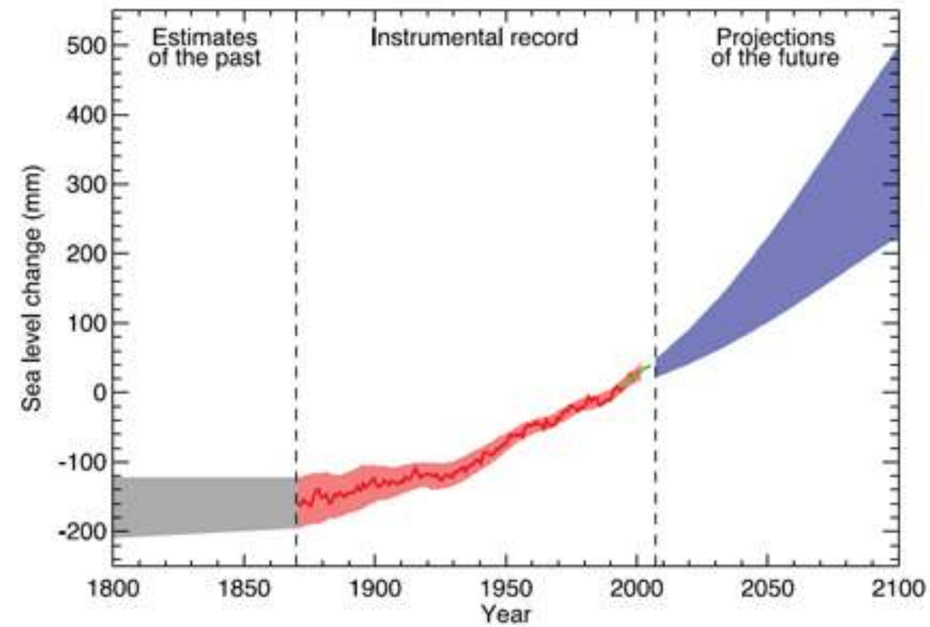
http://www.jpl.nasa.gov/news/news.cfm?release=2011-262


NEAH BAY, WA
Winter RSL = -1.97 ±0.79 mm.yr⁻¹ (RMSR=0.064)
Summer RSL = -1.89 ±0.35 mm.yr⁻¹ (RMSR=0.030)
YAQUINA BAY, OR
Winter RSL = 0.64 ±2.06 mm.yr⁻¹ (RMSR=0.070)
Summer RSL = 1.33 ±0.79 mm.yr⁻¹ (RMSR=0.030)
HUMBOLDT BAY, CA
Winter RSL = 4.46 ±3.62 mm.yr⁻¹ (RMSR=0.060)
Summer RSL = 5.30 ±1.62 mm.yr⁻¹ (RMSR=0.034)
0.3
0.2
0.1
0
-0.1
-0.2
1930
1940
1950
1960
1970
1980
1990
2000
Year

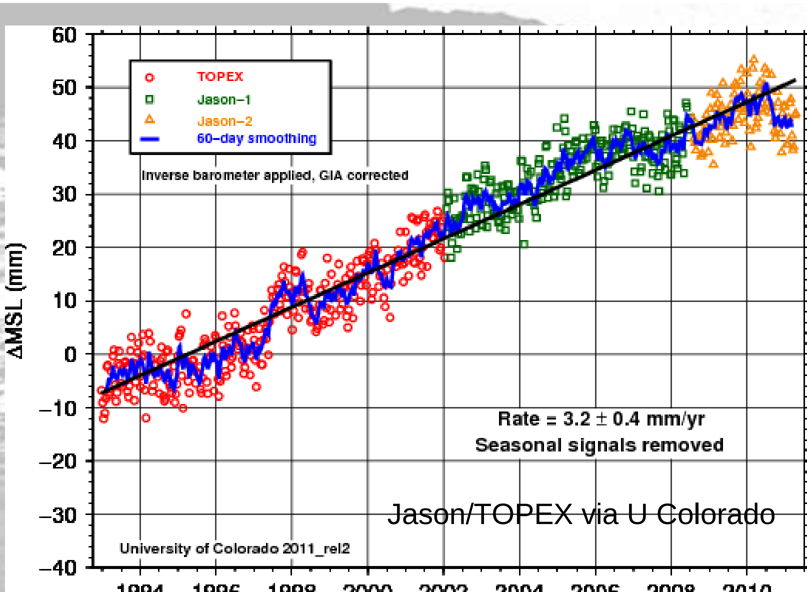


(a)
Landings (t km⁻²)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
Baseline 2060
Primary production
*Range shifts
Zooplankton size structure
Dissolved oxygen
Ocean acidification
Cumulative impacts
Cumulative impacts (no RS)
Demersal fish
Pelagic fish
Invertebrates
(b)
Biomass (t km⁻²)
0 20 40 60 80 100 120 140
Baseline 2060
Primary production
*Range shifts
Zooplankton size structure
Dissolved oxygen
Ocean acidification
Cumulative impacts
Cumulative impacts (no RS)
Demersal fish
Pelagic fish
Invertebrates
*Based on SEA, NBC, and NCC

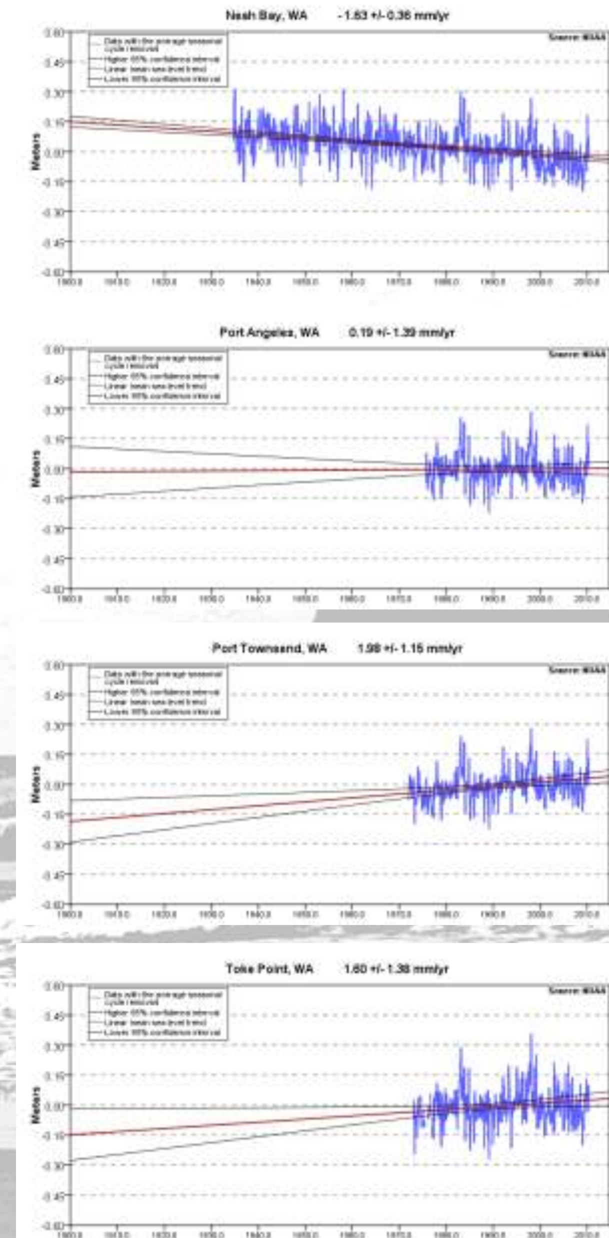
Sea Level



Estimates of the past
Instrumental record
Projections of the future
Sea level change (mm)
500
400
300
200
100
0
-100
-200
1800
1850
1900
1950
2000
2050
2100
Year



TOPEX
Jason−1
Jason−2
60−day smoothing
Inverse barometer applied, GIA corrected
Rate = 3.2 ± 0.4 mm/yr
Seasonal signals removed
Jason/TOPEX via U Colorado
University of Colorado 2011_rel2
ΔMSL (mm)
60
50
40
30
20
10
0
−10
−20
−30
−40
1994
1996
1998
2000
2002
2004
2006
2008
2010



Neah Bay, WA -1.63 +/- 0.36 mm/yr
Port Angeles, WA 0.19 +/- 1.39 mm/yr
Port Townsend, WA 1.98 +/- 1.15 mm/yr
Toke Point, WA 1.60 +/- 1.38 mm/yr

Storm Frequency/Intensity