Workshop W5:

Basin-scale processes linking western and eastern Pacific dynamics and biogeochemistry.

Conveners: Charles Hannah (Canada)
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Moderator: Cisco Werner (USA; retired)

Goals

1) a set of schematics showing how basin-scale processes drive variability for specific biogeochemical variables (e.g. dissolved oxygen, nitrate, phosphate, silicate, and iron) across the Pacific. We have now added anthropogenic carbon to the list of potential variables.

2) a proposal for a PICES Working Group to test the validity of the hypotheses represented by the schematics.

2 sessions

- Sunday November 9 at 2 pm
- Tuesday November 11 at 9 am

Agenda – Day 1

- **14:00-14:15 Introductions and goals (15 minutes)**
- **14:15-15:30 1 or 2 slides from each participant (75 minutes)**
- **15:30-15:50 Coffee break (20 minutes)**
- **15:40-16:30 Plenary Discussion – which processes should we focus on? (50 minutes)**
- **16:30-17:00 Choose Breakout Group themes (30 minutes)**
- **17:00-17:45 Breakout Group Discussion. Part 1. (45 minutes)**

Day 2 Tuesday November 11. 0900-1225

- 09:00 – 09:10 Review Day 1 (10 minutes)
- 09:10 – 10:20 Breakout Group Discussion: Part 2. (70 minutes)
  - See next slide
- 10-20-10:35 Plenary report (15 minutes)
- 10:35-10:55 Coffee Break
- 10:55-11:55 Plenary Discussion (60 minutes)
- 11:55-12:25 Draft Highlights for Workshop Report (30 minutes)
  - Report due December 1 for PICES Press.

Possible topics for Day 2

- Quantify the oxygen transport pathways from west to easr.
- What are the main sources of variability for oxygen and nutrients?
- What do we know is changing and what we suspect is changing (it has a trend in time)?

Preparing for next year

- Deadline for Workshop and Science Session proposals: 21 Nov (or 24 Nov?)
  - Need a workshop title
  - Need conveners.

- Deadline for Working Group proposals: to Committee for approval before intersessional Science Board meeting in the spring.
  - Need a WG title.

Drivers

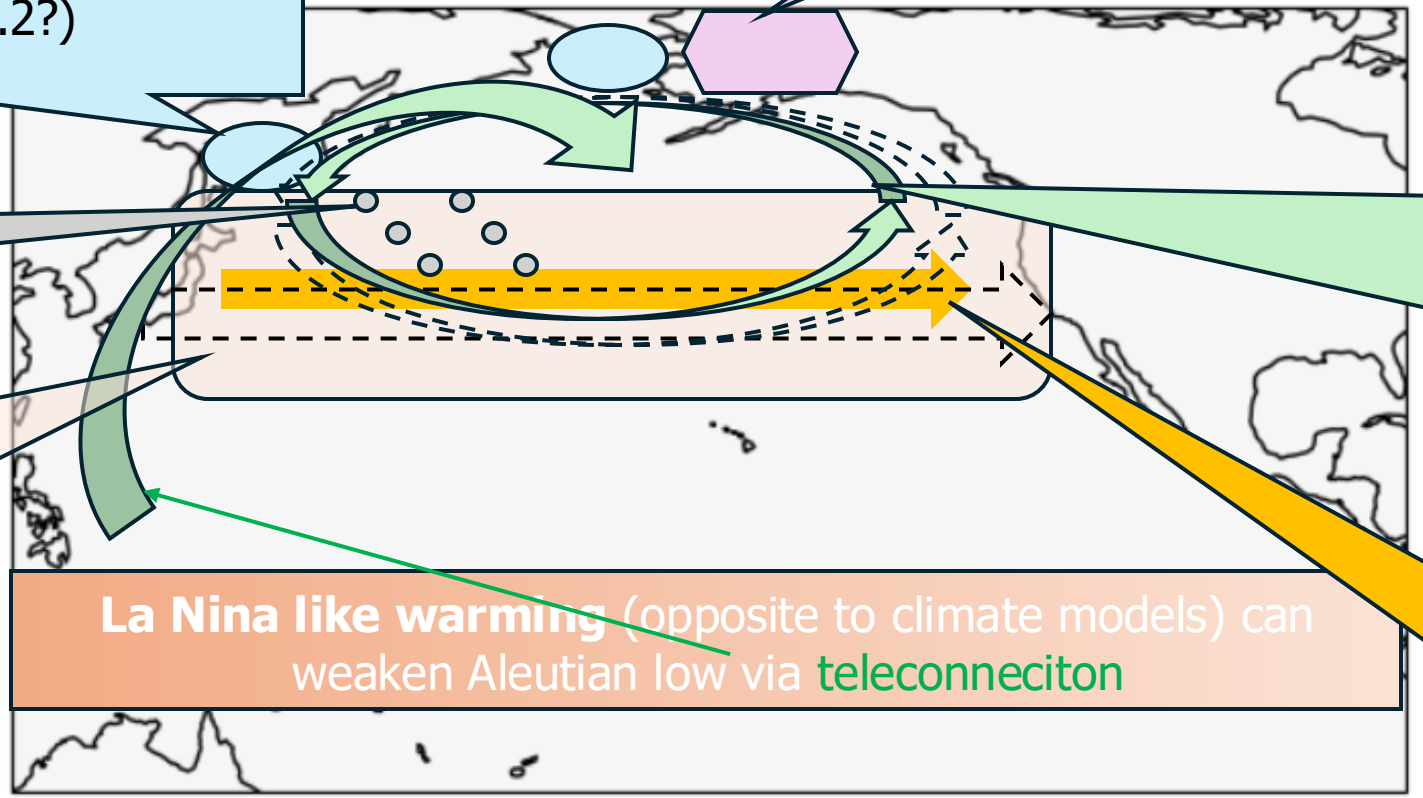
Okhotsk sea-ice decline have weakened the ventilation associated with a series of processes:
sea-ice formation
→Okhotsk Sea deep water formation
→ tidal mixing (with 18.6-year cycle)
→ outflowing to the North Pacific
→ influence NPIW (26.8-27.2?)

Bering sea-ice decline can weakened the ventilation to deeper levels than NPIW (>27.4?)

Alaska glacier melting should have weakened the ventilation with enhancing the stratification

Deposition changes of N or Fe

Warming should decrease the O2sat and weakened the ventilation (incl. mixing)



Aleutian Low has been weakened and shrink in the last 40-years. Natural variability or climate change is under debate.

Closely Related.

La Nina like warming (opposite to climate models) can weaken Aleutian low via teleconneciton

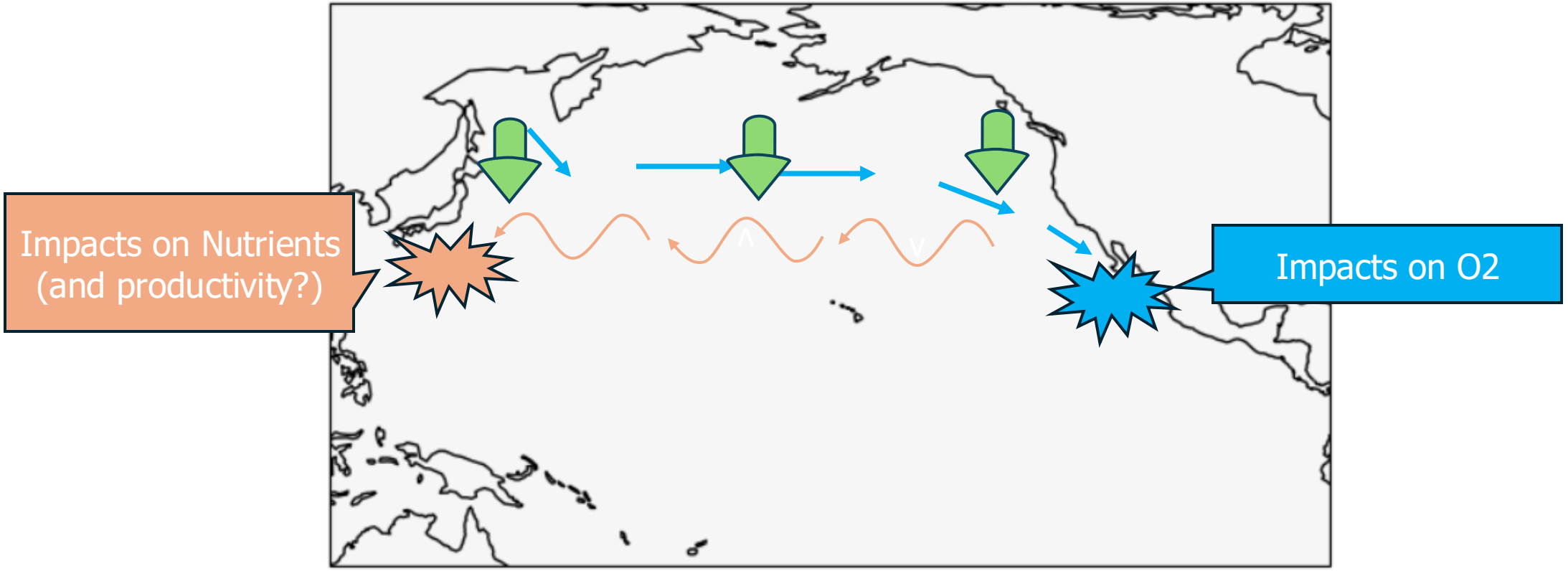
Westerly winds has been weakened and northward shifted

Processes connecting eastern and western side of basins

Advections: effective subsurface for O2, CO2, and temp, which are strongly influenced by surface fluxes, but less so for nutrients and salinity

Rossby wave propagations, clearly observed south of the Kuroshio Extension.
Also, along the Kuroshio extension itself acts as a wave guide for "jet-trapped Rossby waves"

Atmospheric forcings, if acts simultaneously in both basin, the local response can be synchronized



Data issue (this is not a summary but my thoughts)

Observed biogeo data are too sparse to track advection or propagation across the Pacific basin.

Biogeo data, estimated by using AI/Machine-learning, can fill the gap, but accuracy in data sparse area are not well identified.

Numerical models or model outputs (e.g., CMIP6 and coming CMIP7) will be useful, but it is necessary to keep people who can work on model(s) or model outputs. Please note that analysis of CMIP6 data can becomes too difficult for most of researchers due to too-big data size.

Summary Oxygen budget view

- Inputs (ventilation)
- Export
- Consumption

Inputs to subpolar gyre 1/6

1. Okhotsk Sea ventilation
   - Transport and mixing across Kuril Islands determines how the oxygen gets imprinted on density field.
   - Tidal mixing imprints an 18.6 year Lunar Nodal Modulation signal
   - Which density levels: 26.6 to 27.x
   - Also provides surface nutrients for NW Pacific
   - Decadal Variability?
   - Reduced sea ice formation in Okhotsk Sea is leading to less deep water formation and less oxygen to dense isoypcnals

Inputs to subpolar gyre 2 and 3

2. **East Kamchatka Current**
    - low DO, high nutrients
    - Where does DO from Bering Sea ventilation go?
    - In winter a branch goes into Okhotsk Sea and gains oxygen.
    - What do we know about variability and trends?

- 3. **Ventilation in the western North Pacific**.
    - Isopycnals: 26.4 – 26.6 (I think) Mecking and Drushka
    - Declining ventilation – likely due to freshening of North Pacific.
    - A 20 ish year variability in outcropping area.
    - How big is this term compared to Okhotsk Sea ventilation?
    - Does this oxygen follow same pathway to North America?

Inputs to subpolar gyre 4 and 5

4. Aleutian Islands

- Tidal mxing in the Aleutian Island chain
- Is it important for subpolar gyre?
- Which isopycnals?
- Does it go directly south around Alaska gyre

5. Winter mixing in Alaska gyre

- Has it ever been an important source of oxygen to subsurface?
- Is winter mixed layer depth declining?

Inputs to subpolar gyre 6

6. California Undercurrent

- Source: Pacific Equatorial Water
- Density levels: ??
- Low oxygen but not zero.
- Is oxygen connected to Okhotsk Sea via NPIW?
- Mixing with California Current
- Where does PDO signal get imprinted?
  - One result says PDO get imprinted due to PDO related circulation changes in subtropics.
- Trend: not sure

Export

- Export to Subtropical gyre
- Creation of North Pacific Intermediate Water
- Is there important variability in the creation and export?
- Is there a trend
- Is there a tractable problem to address?
  - Should be able to use T and S in circulation models to estimate

Consumption

- Are there systematic changes in respiration in mesopelagic zone?
- Does Marine Heatwave induced changes in plankton community composition change respiration see by subsurface oxygen? One paper says it happens sometimes in NE Pacific.
- Does atmospheric nitrogen input alter production and respiration in subpolar gyre?
- Out of scope for now?