2024 Report of Working Group on Climate Extremes and Coastal Impacts in the North Pacific (WG-49)

WG-49 held seven virtual co-chair meetings (Jan 22-23, Mar 4-5, May 27-28, June 19-20, June 27-28, July 2-3, and Aug 20-21) before the virtual working member interim business meeting on September 23-24, 2024. During the meeting, the 12 participants reviewed our Terms of Reference (ToR) and discussed the launching of new project teams to tackle some of the ToR for the upcoming in-person meeting in Honolulu. WG-49 held its third in-person business meeting at PICES-2024 on October 27, 2024 in Honolulu (*WG-49 Endnotes 1-5*). The primary objective of this meeting was to review progress, gather feedback from the broader group, and plan activities to meet the ToR and evaluate progress. Changes in membership were discussed and resulted in the addition of three new members: Dr. Peng Lian (China), Dr. Nima Farchadi (USA), and Dr. Youngji Joh (USA). Dr. Vera Trainer left WG-49 at the end of this year.

AGENDA ITEM 1
Review September 2024 Interim Meeting

Participants briefly discussed the WG49 virtual meeting held in September 2024. The agenda for this meeting was to review our ToR and prepare our agenda for the in-person meeting at PICES-2024. (See *WG-49 Endnotes 1 and 2*.)

AGENDA ITEM 2
Presentations from member country representatives

Representatives from member countries presented recent research and developments related to working group activities and ToR.

AGENDA ITEM 3
Overview of new and ongoing activities

We presented the objectives, overview, and implementation plan for two project teams, referred to as the bibliometric team and the physical driver team.

The bibliometric team will respond to the ToR by conducting systematic reviews, collecting relevant scientific literature, and organizing this information in order to cover several important climatic extremes events (CEEs) that have occurred in the North Pacific and to determine their classification and contributing factors to CEEs. A workshop has been proposed (see *WG-49 Endnote 4*) for the PICES meeting 2025 to discuss bibliometric team results and case studies that could form the focus of further investigation (ToR 2).

The physical drivers team will address some of the ToR not addressed in-depth by the bibliometric team, and in particular contribute to improved understanding of the predictability of CEEs, especially marine heat waves (MHW). Details of the physical drivers project team scope are provided in *WG-49 Endnote 5*. PICES committee members alone will not be sufficient to contribute to the discussions on predictability, therefore, the group will try to involve external researchers in related fields and to create a forum for research and information sharing.

AGENDA ITEM 4
Breakout group sessions: How can we develop/progress activities?

During these breakout sessions, we discussed how to overcome the tasks assigned to each project team. In-person participants included Helen Killeen, Dan Lew, and Hiroki Wakamatsu. The bibliometric team reviewed the keywords for the literature search, which had been discussed from the previous meeting, modified the search terms to yield a tractable body of literature for review, and reconciled what the team wanted to do with what was feasible in the R language for bibliometric analysis. Additional details of this breakout session team's discussion are available in *WG-49 Endnote 6*.

The physical drivers team discussed the goals of this activity and feasible action plans. In-person participants included Antonietta Capotondi, Jennifer Jackson, Saranya J.S., and Sung Yong Kim. Charles Hannah, Hiroshi Kuroda, and Shoshiro Minobe attended the breakout group online. The group discussed scientific questions of primary relevance to this activity, including differences and similarities between MHWs that have occurred in the eastern and western parts of the basin, and possible influences of western North Pacific processes on eastern North Pacific extreme conditions. It was agreed that the group may need to involve more researchers outside of PICES to meet the targeted ToR. Specific action items being considered are:

- Recruit additional participants with expertise relevant to the chosen regions of interest.
- Develop a bibliography on more relevant events in the study regions and the biological and biogeochemical impacts of those events.
- Organize quarterly (approximately) meetings to discuss scientific issues, interpret results from members and from literature, and advance the preparation of a synthesis paper.
- Liaise with AP-NPCOOS through common members Sung Yong Kim, Charles Hannah, and Jen Jackson to utilize data compiled by AP-NPCOOS for MHW studies.
- Plan a workshop for PICES 2026.

Additional details of this breakout session team's discussion are available in *WG-49 Endnote 7***.**

AGENDA ITEM 5
Summary of meeting activities and concluding remarks

Participants summarized the discussions from the in-person meeting and identified items that need to be addressed in the future and necessary tasks to accomplish the Terms of Reference.

WG-49 Endnote 1

WG-49 participation list

September 2024 Virtual Meeting

Members

Hiroki Wakamatsu (Japan, Co-Chair)
Chan Joo Jang (Korea, Co-Chair)
Antonietta Capotondi (USA, Co-Chair)
Helen Killeen (USA, Co-Chair)
Charles Hannah (Canada)
Jennifer Jackson (Canada)
Hiroshi Kuroda (Japan)
Shoshiro Minobe (Japan)
Sukgeun Jung (Korea)
Sung Yong Kim (Korea)
Vera Trainer (USA)
Steven Bograd (USA)

October 2024 In-person Meeting

Members
Hiroki Wakamatsu (Japan, Co-Chair)
Antonietta Capotondi (USA, Co-Chair, CLIVER)
Helen Killeen (USA, Co-Chair)
Charles Hannah [*virtual*] (Canada)
Jennifer Jackson (Canada)
Hiroshi Kuroda [*virtual*] (Japan)
Shoshiro Minobe [*virtual*] (Japan, WCRP)
Changsin Kim (Korea)
Sung Yong Kim (Korea)
Dan Lew (USA)
Steven Bograd (USA)

Members unable to attend
Canada: Karen Hunter (Co-Chair)
China: Changming Dong, Jian Tony Ma, Song Yajuan
Japan: Haruka Nishikawa
Korea: Chan Joo Jang (Co-Chair), Chun Ok Jo, Sukgeun Jung, Minho Kwan, Hyoeun Oh, Jonseong Ryu
USA: Emmanuele di Lorenz, Rob Suryan, Vera Trainer

Observers
Peng Lian (China)
Saraya Js (Korea)
Nima Farchadi (USA)

WG-49 Endnote 2

Agenda(s) for the 2024 WG-49 Meetings

September 2024 Virtual Meeting Agenda

1. Review the achievements of the WG against the terms of reference (ToR) | Helen Killeen
2. Any travel support, membership, capacity development needs that may require requests of the Secretariat | Hiroki Wakamatsu
3. Provide an overview of WG-49 events at the 2024 annual meeting | Chan Joo Jang
4. The formation of a new sub-committee or team to initiate activities focused on assessing the predictability of climate extremes (ToR 3) | Antonietta Capatondi
5. Plans for workshops and sessions during the 2025 PICES annual meeting (Yokohama, Japan). Proposals for workshops and sessions will be open October 1-November 1 | Hiroki Wakamatsu
6. PICES Working Group Fact Sheet | Helen & Vera

WG49 PICES-2024 meeting agenda
October 28th, 0900-1740

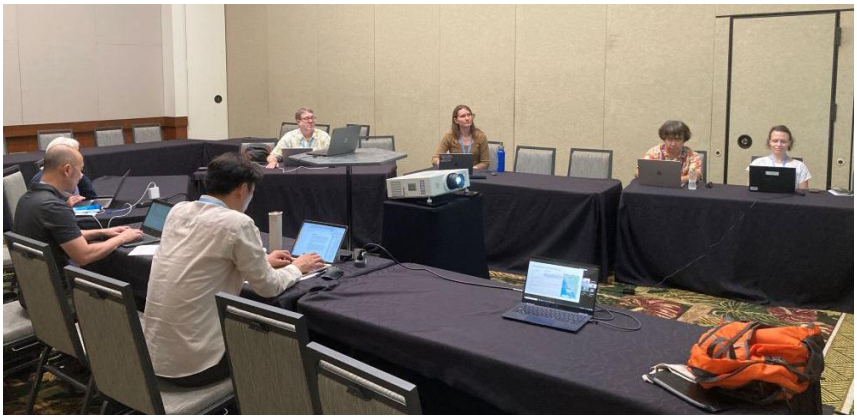
0900-0915 Introductory remarks
0915-0930 Review September 2024 Interim Meeting
0930-1040 Presentations from member country representatives
Canada – **Dr. Charles Hannah,** Fisheries and Oceans Canada, (virtual presentation)
Japan – **Dr. Hiroshi Kuroda**, Japan Fisheries Research and Education Agency (virtual presentation)
Korea – **Dr. Changsin Kim**, National Institute of Fisheries Science (virtual presentation)
United States – Dr. **Helen Killeen**, Farallon Institute CLIVAR (Climate and Ocean: Variability, Predictability and Change) – Dr. **Antonietta Capotondi,** National Oceanic Atmospheric Administration (NOAA)
1040-1100 Coffee Break
1100-1230 Overview of new and ongoing activities
Bibliographic analysis team
Physical drivers team
1230-1400 Lunch Break
1415-1520 Breakout group sessions: How can we develop/progress activities?
Bibliographic analysis breakout (leads: Hiroki & Helen)
Physical drivers breakout (lead: Antonietta)
1520-1540 Coffee Break
1540-1700 Breakout groups document discussion using Miro

1700-1730 Reconvene, group presentations, discussion. Review proposed fact sheet requested by Communications working group

1730-1740 Summary of meeting activities and concluding remarks

WG-49 Endnote 3

WG-49 participants at the first in-person meeting in October 2024



WG-49 Endnote 4

Proposal for a Workshop at PICES-2025

Workshop Title: Applying social-ecological frameworks to explore actionable solutions for climate extreme events across the North Pacific

Duration: 1.5 days

Convenors (all Co-Chairs of WG-49)
Karen Hunter (corresponding)
Helen Killeen
Hiroki Wakamatsu
Chan Joo Jang
Antonietta Capotondi

Abstract

Climate extreme events (CEC) occur with regularity across the North Pacific. Physical ocean and atmospheric events cascade into ecological anomalies such as harmful algal blooms, marine species die offs, and changes in the distribution and abundance of species. These physical and ecological dynamics often have direct consequences for social systems requiring management such as fishery closures or expansion, damage to infrastructure and property, and health problems. Currently, many resource management and policy frameworks do not yet handle the impacts of CECs efficiently. In this workshop, participants will explore CEC case studies in the North Pacific to outline drivers, and their ecological and societal impacts using the DSPIR (drivers, pressures, states, impacts, responses) framework. The DSPIR framework has been broadly applied to identify management and policy actions related to environmental

problems. It draws out interactions between state changes and human impacts to identify where the system experiences shifts in ecosystem services and societal benefits and starts to identify suitable responses to control the adverse effects of the drivers and pressures. Participants will also link knowledge generated in the workshop to the PICES-specific SEES (social-ecological environmental system) framework. The SEES framework can help identify how PICES can streamline CEC science activities and solutions for the North Pacific. The workshop will aim to generate information for researchers and decision-makers to enable actionable solutions and build understanding of the similarities and differences in outcomes across different CECs.

Sponsoring PICES Expert Groups: FUTURE

AGENDA

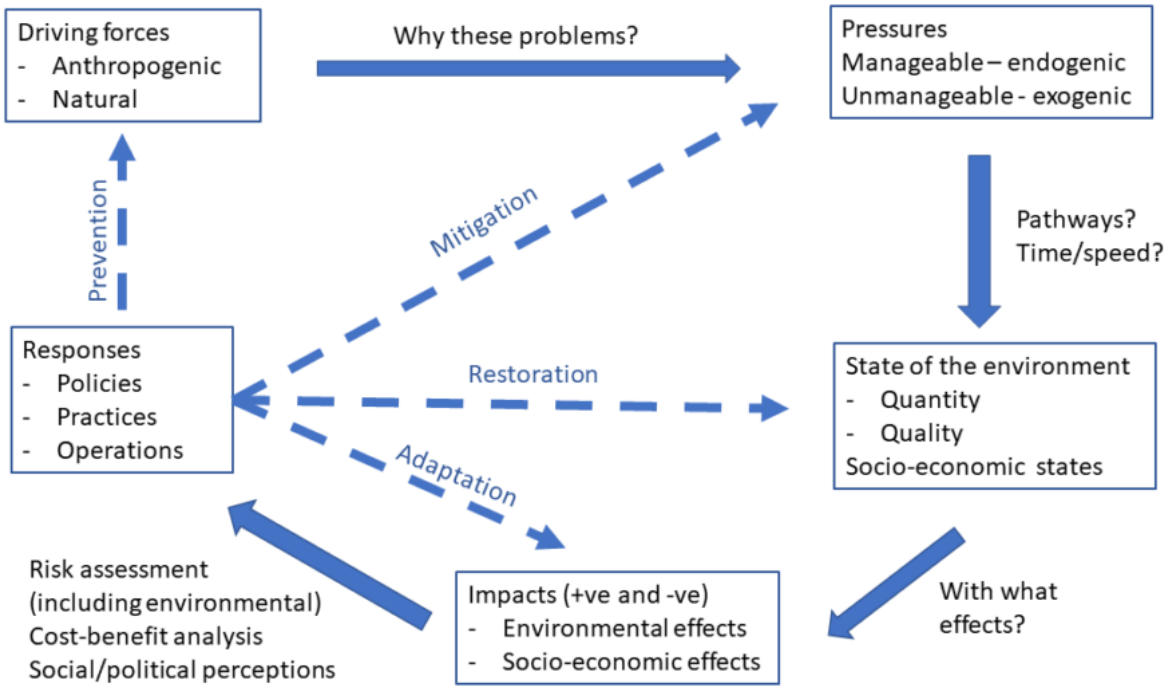
Activity 1 30 mins
Welcome and Introductions

Activity 2 1.5 hours
Case study review and discussion (possibly also share survey summary depending on whether we have any outputs by next year)
Need speakers to go through CECs and known impacts and responses for each case study. (This is where we can establish what management systems/components and policies have been used, and to what effect.)

(break).

Activity 3 1 hour
Speaker to introduce DSPIR and why WG-49 needs this framework to achieve ToR

Using a DPSIR framework to support good natural resource management and policy
A DPSIR framework highlights the key relationships between society and the environment and can be used as a communication tool between researchers from different disciplines (social and natural) as well as between researchers, on the one hand, and policy makers and stakeholders on the other. The DPSIR framework can be used to more closely link the social and natural sciences to help policy makers address complex problem situations that require just and equitable solutions.
*Need to consider temporal factors associated with various CECs



LUNCH 1 hour

Activity 4 2-4 hours
Frontiers | DPSIR—Two Decades of Trying to Develop a Unifying Framework for Marine Environmental Management? (frontiersin.org)

- Working through DPSIR for each case study in small groups to generate information that would lead to follow on discussions (Activity 5) about solutions for adaptation, restoration, mitigation, prevention.
- Important for "actionable solutions" that we focus on the management and policy angles as well by including managers/stakeholders in creative ways (as they likely won't be able to attend in person, nor would 3-4 perspectives likely be sufficient). Technical solutions, science-driven warning systems, emergency management systems are all things that could be explored

Activity 5 2-3 hours (or the next day)
Review and discussion of framework outcomes
Review and discussion of actionable solutions
*As an idea for a workshop product, imagine developing some sort of graphic that shows "state of knowledge" and gaps in knowledge across DSPIR categories across CECs. This graphic could be used as a tool to explain where we have good information that could be transposed and streamlined across possible CEC responses.

Activity 6 45 mins
Workshop product development tasking and timeline
Close workshop

WG-49 Endnote 5

Physical Drivers Project Team Proposal

Physical drivers of North Pacific marine heatwaves, and implication for predictability

The North Pacific has experienced several prominent marine heatwaves (MHWs) in recent years, with devastating ecological consequences. These events have occurred in several regions along the North Pacific Rim, both in the open ocean and at the coast. Some of these events have already been extensively studied (e.g., the Northeast Pacific MHW of 2014-16, known as the "Blob"), while others more recent events have only preliminarily been examined.

MHWs are driven by local processes (e.g., surface heat fluxes, oceanic advection), which can be modulated by large scale climate modes of variability. Both local drivers and large-scale climate influences may differ in different parts of the basin. For example, ocean advection may be more pronounced in the western North Pacific than in the eastern part of the basin. On the other hand, the Northeast Pacific may be more directly influenced by the El Nino Southern Oscillation (ENSO) than the west Pacific. While the Pacific Decadal Oscillation (PDO) may affect the entire North Pacific, it can be expected to exert different regional influences.

Despite the large and rapidly increasing literature on MHWs, our understanding of their development and predictability is still in its infancy. Even events heavily studied like the Blob remain incompletely understood in terms of their most effective drivers and sources of predictability. For example, recent studies have advocated for anthropogenic aerosol forcing and/or teleconnections from other ocean basins to explain the exceptional intensity of this MHW.

Additionally, the subsurface structure of MHWs is generally less well observed, and the regionally varying effects of vertical stratification and circulation are poorly understood. Understanding the vertical structure of MHWs, however, is critical for assessing biological impacts. Similarly, the fate of the subsurface anomalies and their possible influence on other regions has not been carefully considered.

Finally, as our oceans continue to warm, identifying the relative contributions of climate change and internal variability to extreme ocean conditions in each region is critical for understanding the leading underlying physical processes and their predictability. Studies have shown, indeed, that the trend signal may be more predictable than internal variations. In addition, interactions between secular warming and internal climate variability (e.g., PDO) can result in the regional amplification or mitigation of extreme events (Cluett et al., in review).

To address the above knowledge gaps, we propose to create a new activity within WG-49 to:

- Select a few case studies of extreme events (e.g., marine heatwaves and associated biogeochemical extremes) that have occurred (or are occurring) at different locations along the Pacific rim for in-depth analysis of the above scientific aspects.

- Assess their leading local drivers (e.g., surface fluxes, horizontal/vertical advection) and remote influences (e.g., ENSO, PDO, MJO)

- Assess the relative role of global warming vs. internal variability in the development and persistence of these extreme conditions.

- Consider both surface and subsurface conditions, and the full evolution (onset, development, peak, demise) of each event. In particular, examine the fate of the subsurface anomalies and whether they can influence event persistence or affect remote regions.

- Examine the presence of concurrent MHW and biogeochemical extremes, and their potential mechanistic connection.

- Compare and contrast results obtained in different regions to detect possible connections among regional drivers.

The above analyses can provide guidance to understand the degree of predictability of these events, which could be further examined in the context of existing prediction systems at various North Pacific institutions.

Assessment of the key features of these events could also help identify suitable indicators to characterize these extreme ocean conditions.

This activity will directly address ToR 2 and 3:

2. **Focus on case studies (e.g., MHWs) for full exploration: drivers, predictability, ecological and societal impacts, and dissemination of information for actionable solutions.**
3. **Assess the predictability of climate extremes and establish leading indicators to mitigate impacts on coastal communities.**

This activity can be viewed as a complement to the bibliometric analysis that the WG is undertaking by providing physical understanding of the drivers and predictability of some particularly significant events, while the bibliometric analysis can also more extensively document their economic and societal impacts.

Participants to date:

WG-49 co-chairs, Shoshiro Minobe, Jennifer Jackson, Charles Hannah, Steven Bograd, Youngji Joh

WG-49 Endnote 6

Bibliometric Analysis Breakout Group Notes

1. We discussed our ability to use all the tools in our planned workflow, particularly Covidence and quanteda (R package).
2. We explored some of the initial steps in creating a *corpus* through quanteda (R package).
3. We revised our search terms to be as useful as possible.
4. We planned a timeline for the coming year (GANNT).
5. We determined some alternative pathways and offramps for analysis depending on personnel needs, etc.

Decisions Taken:

1. We have decided not to proceed with analyzing storms as a standalone term

Action Items:

1. Provide a list of up to three Action Items.
2. Helen will figure out how to gain access to Covidence (a tool for screening text records for review relevance).
3. Hiroki will re-run our final searches with revised search terms, save resulting searches and files for import into Covidence.
4. We will run two internal surveys: 1) confirm search terms (Hiroki); and 2) develop initial topic dictionary (keyword list associated with the ECEs) Dan or Helen.
5. Create guidelines for initial screening that can be shared with the Covidence team (Helen will start a google doc and share with team leads).

WG-49 Endnote 7

Physical Drivers Breakout Group Notes

Provide a list of up to five items that were discussed during the meeting.

Decisions Taken:

- Extend participant group with experts from different countries as needed
- Regions:
    - Northeast Pacific, including 2014/2016, 2019 (consider heatwaves that killed the snow crabs), etc. Considering different events in the same region can help understand differing impacts of different events, e.g., which events are more effective on the coast.
    - Northwest Pacific. Some MHWs are atmospherically-driven, while others are oceanographically driven. Predictability may be different.
- Kuroshio has exhibited a different behavior in recent years, with a non-typical large meander, and an axis of the Kuroshio Extension overshoots further north than before. This shift in the Kuroshio Extension may be related to a northward shift of the westerly jet (hypothesis investigated by Hiroshi).
- Eddy-induced MHWs on broader shelves (example with South Africa and Eastern Australia). Eddies induced by Kuroshio Extension movements can create MHWs themselves.

Action Items:

1. Recruit additional participants with expertise relevant to the chosen regions of interest. All current members (WG-49 co-chairs, Jen Jackson, Charles Hanna, Steven Bograd, Hiroshi Kuroda, Shoshiro Minobe, Sung Yong Kim, Saranya J.S.) will contribute.
2. Develop a bibliography on events in the study regions, and their biological and biogeochemical impacts. All.
3. Organize approximately quarterly meeting to discuss scientific issues, interpret results from members and from literature, and advance the preparation of a synthesis paper.
4. AP-NPCOOS (Sung Yong Kim, Charles Hannah, Jen Jackson) will be compiling a time series of coastal moored observations from member countries. These data can be used to examine marine heat waves. AP-NPCOOS are interested in writing a paper that compliments this work and is happy to work with WG-49 on it.
5. Organize workshop at PICES 2026 (all members).