SCIENCE
PLAN

BASIN-SCALE EVENTS & COASTAL IMPACTS

Uniting the North Pacific to Better Understand the Ocean We Share

PICES

NPAFC

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

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We are grateful to the North Pacific Marine Science Organization (PICES) for their collaboration and support. The BECI project, through its focus on delivering integrated, actionable knowledge products, directly addresses key recommendations from the 2024 PICES External Review, particularly the critical call for PICES to "revise its role to provide actionable science information… and facilitate actions towards science-based solutions."

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EXECUTIVE SUMMARY

The North Pacific Ocean is undergoing significant climate-driven changes that transcend national boundaries and affect marine ecosystems, fisheries, and coastal communities across the basin. Marine heatwaves are increasing in frequency and intensity, the ocean is acidifying and losing oxygen, and species are moving across political boundaries in response to changing conditions. These changes threaten fisheries valued at billions of dollars, cultural practices that have sustained communities for generations, and the ecological integrity of one of Earth's most productive marine regions.

Despite substantial investments in ocean research across the North Pacific, critical knowledge remains fragmented across sectors, disciplines, and national boundaries, with no central hub to connect and synthesize information, insights, and expertise. This fragmentation means cross-regional patterns go undetected, management stays reactive instead of proactive, and operational tools that could inform decisions remain underutilised.

The Basin-scale Events and Coastal Impacts (BECI) project aims to create a **North Pacific Ocean Knowledge Network**, an interactive platform that integrates climate, oceanographic, ecological, fisheries, management, and socioeconomic information across national and disciplinary boundaries. The **goal of the knowledge network** is to:

- **Organize** fragmented information into one accessible platform—connecting ocean monitoring, species data, ecosystem assessments, and management tools from across the North Pacific so users can find what exists and access what they need
- **Synthesize** cross-regional knowledge into actionable products—transforming scattered research and data into standardized comparisons, status assessments, and synthesis reports that reveal regional and basin-wide patterns no single nation can see alone
- **Accelerate** the path from information to decision—delivering insights through interactive dashboards, real-time alerts, and curated resources designed for the pace that climate-driven changes demand

Our Approach

The Knowledge Network will be built using two complementary strategies: **1) federated discovery** that maps and connects existing databases while respecting data ownership, and **2) strategic repositories** that enable synthesis of critical information into accessible formats for decision-making. This architecture is guided by FAIR Data Principles (Findable, Accessible, Interoperable, Reusable) and OCAP (Ownership, Control, Access, Possession) Principles for Indigenous Knowledge.

The Platform

The Knowledge Network delivers information through six integrated sections:

- **Ocean State:** Current conditions, basin-scale climate drivers, and extreme event monitoring with real-time extreme event alerts
- **Fish Dynamics:** Species-level information for transboundary species including abundance, distribution shifts, condition, and climate vulnerability
- **Ecosystem Status:** Cross-regional assessment of ecosystem health across Large Marine Ecosystems using standardized indicators
- **Knowledge Library:** Curated directory of management tools, models, data resources, ecosystem assessments, conservation tools, and published resources
- **Network Community:** Communication tools to connect researchers, working groups, and collaboration opportunities across the North Pacific
- **Human Dimensions (*under development*):** Socioeconomic and cultural impacts of changing fisheries, including community vulnerability, food security, and adaptation responses

Focus and Implementation

BECIs initial focus is on commercially and ecologically important transboundary fish species, including Pacific salmon, Pacific saury, halibut, tunas, squid, and other key forage species, and the changing ocean conditions that affect them. Our implementation follows three progressive phases, from establishing core infrastructure and collaborations (Years 1-2), through enhanced integration and synthesis (Years 2-3), to comprehensive decision-support capabilities (Years 3+).

Expected Outcomes

By developing pathways for cross-regional collaboration and knowledge synthesis, BECI aims to support:

- **Improved understanding** of climate impacts on marine ecosystems at multiple scales
- **Enhanced capacity** to detect and respond to emerging threats
- More **coordinated management** approaches for transboundary species
- More **efficient research and monitoring** investments across the basin
- **Strengthened science-policy interfaces** for climate adaptation

Through these outcomes, BECI seeks to improve how we collectively understand, prepare for, and respond to climate change in our shared North Pacific Ocean.

BACKGROUND

Current Gaps & Needs

Species distributions are shifting, ocean conditions are becoming more variable, and extreme events are disrupting ecosystems with increasing frequency. For fisheries managers, this means the fish they're responsible for may no longer be where historical data suggests, the environmental conditions underlying stock assessments are changing, and decisions must be made faster than traditional science-to-policy timelines allow. Effective response requires access to integrated, timely information that crosses the boundaries fish are moving across.

Despite substantial investments in ocean research and monitoring across the North Pacific, fragmented knowledge-sharing systems create critical bottlenecks (Hampton et al., 2013; Tenopir et al., 2020; Tanhua et al., 2021). Research remains siloed within organizations and across international boundaries, and even excellent work often doesn't reach the decision-makers who need it most. No single organization can provide the cross-regional synthesis essential for managing transboundary species, especially as environmental conditions change (Pinsky et al., 2018; Koubrak & VanderZwaag, 2020).

Through engagement with scientists, fisheries managers, and Regional Fisheries Management Organizations, we have identified consistent needs across the region:

- Integrated access to existing information across institutions and national boundaries
- Clear, standardized summaries of changing ocean conditions
- Cross-regional synthesis connecting observations and research findings across the North Pacific
- Support for understanding climate impacts on fish populations, especially transboundary species
- Knowledge products designed for practical application rather than academic outputs alone
- More effective communication channels between research and management organizations

These challenges are particularly acute in the high seas—areas beyond national jurisdictions that serve as crucial migration corridors and feeding grounds for many commercially important species, yet remain understudied (Hazen et al., 2019; Morishita, 2018).

Without coordinated approaches to addressing these knowledge access gaps, the North Pacific region will continue facing delayed recognition of emerging climate impacts, missed opportunities to learn from other regions' experiences, and inefficient use of limited resources (Lewison et al., 2016). BECI's knowledge network will directly address these challenges by creating pathways for cross-regional collaboration, information integration, and knowledge synthesis to support climate-informed decision making across the region.

What We Aim to Do

The Basin-scale Events to Coastal Impacts (BECI) project will establish a **North Pacific Ocean Knowledge Network,** an interactive platform that integrates environmental, ecological, fisheries, management, and socioeconomic information across national and disciplinary boundaries (Figure 1). This knowledge network will:

1. **Connect** diverse information sources on ocean conditions and climate impacts throughout the North Pacific basin, including oceanographic measurements, species distribution data, climate projections, ecosystem monitoring, and operational tools from research institutions, government agencies, and Indigenous knowledge systems
2. **Transform** fragmented information into synthesized, actionable knowledge products through standardized protocols, cross-disciplinary integration, and analytical tools that identify patterns, relationships, and thresholds in complex marine systems
3. **Deliver** timely, accessible insights to support climate-informed decision making through visualization platforms, status reports, forecasting products, and management-relevant frameworks

We will focus initially on commercially and ecologically important transboundary species including Pacific salmon, Pacific saury, halibut, squid, and tunas. Primary users will include fisheries managers, researchers, conservation planners, coastal communities, and resource agencies across the North Pacific Ocean.

We aim to provide practical tools that bridge the gap between scientific data and management needs, supporting more effective decisions related to climate-driven changes in North Pacific marine ecosystems.

The geographic scope of BECI is the North Pacific Ocean, from the equator up to the Chukchi Sea. It includes coastal and marine environments, as well as freshwater environments associated with anadromous fishes. This expansive area captures fisheries that operate on the high seas and/or cross-national jurisdictions, making it subject to intricate international management arrangements. We anticipate this network will also support other initiatives such as **Biodiversity Beyond National Jurisdiction (BBNJ)**, if ratified.

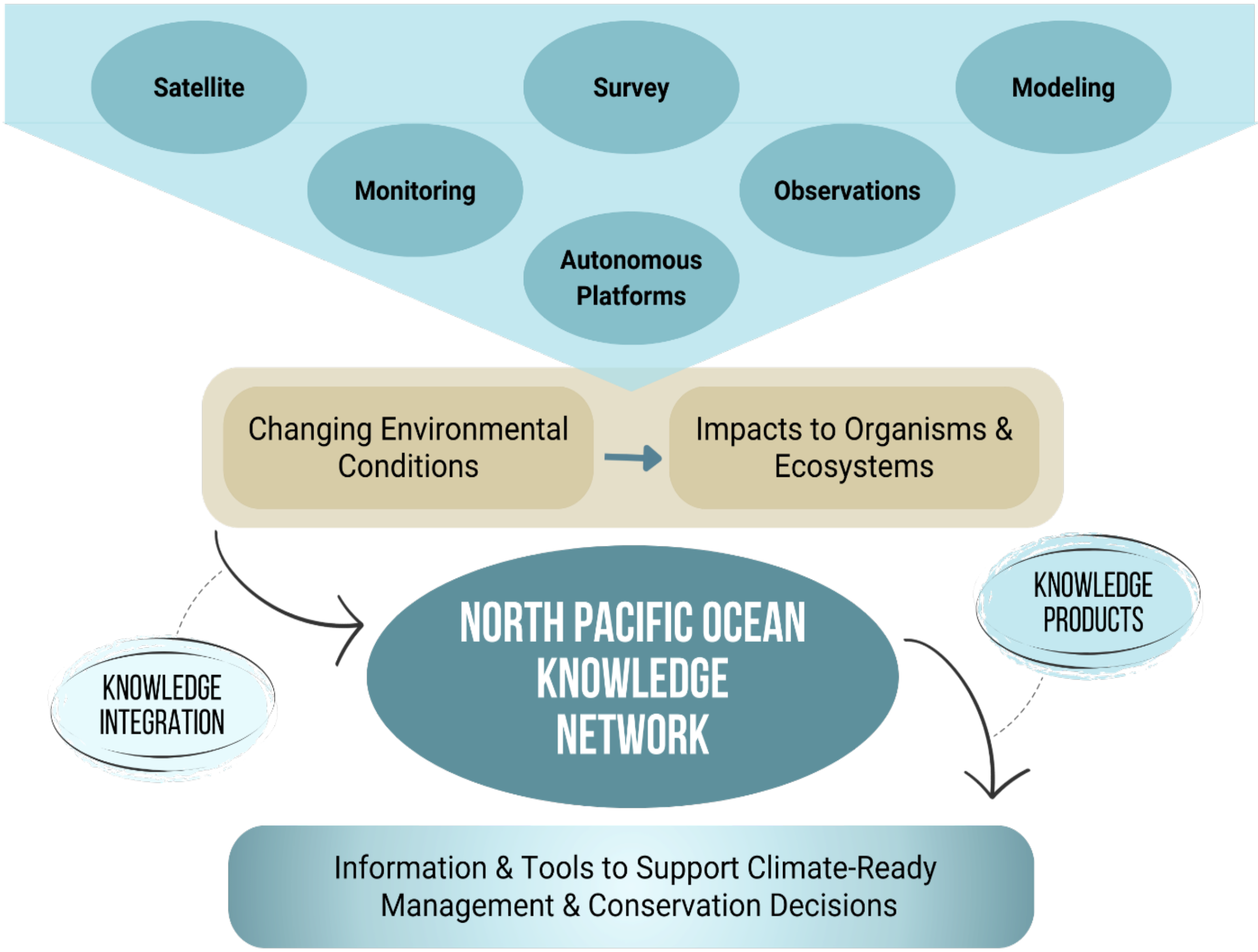


Figure 1. **The BECI North Pacific Ocean Knowledge Network** integrates diverse knowledge domains across North Pacific nations to deliver enhanced understanding, coordination, management support, and resource optimization throughout the region.

Why BECI is Critical Now & the Cost of Inaction

Scientists across the North Pacific are producing critical information to help us understand and adapt to rapid ocean change, but this knowledge remains fragmented across sectors, disciplines, and national boundaries, with no central hub to connect and synthesize information, insights, and expertise.

What does this mean for scientists and managers?

The consequences of this fragmentation are practical and immediate. Cross-regional patterns go undetected when findings remain scattered across national reports and disciplinary journals. Management stays reactive instead of proactive because decision-makers work with partial pictures of transboundary dynamics. Regional lessons and innovations such as successful adaptation strategies, effective monitoring approaches, novel analytical methods rarely reach other jurisdictions facing similar challenges. Researchers spend more time searching for relevant data than analyzing it. Operational tools and models that could inform management decisions remain undiscovered and underutilized.

This knowledge fragmentation has real consequences for marine ecosystems and fisheries:

Fish populations are shifting across borders faster than management systems can adapt. Early warning signals for emerging threats such as the conditions that preceded past stock collapses, the environmental thresholds that trigger regime shifts go undetected when monitoring data isn't connected across regions. Transboundary coordination falters when countries work from different datasets, use incompatible methods, or lack awareness of each other's findings. Protected areas risk becoming ineffective as the species they were designed to conserve move beyond designated boundaries.

BECI addresses these challenges by establishing a knowledge network that connects existing climate and ecosystem information across disciplinary and national boundaries. By organizing fragmented knowledge into accessible, integrated formats, we can help the North Pacific community identify emerging patterns earlier, learn from experiences across regions, and respond more strategically to environmental change.

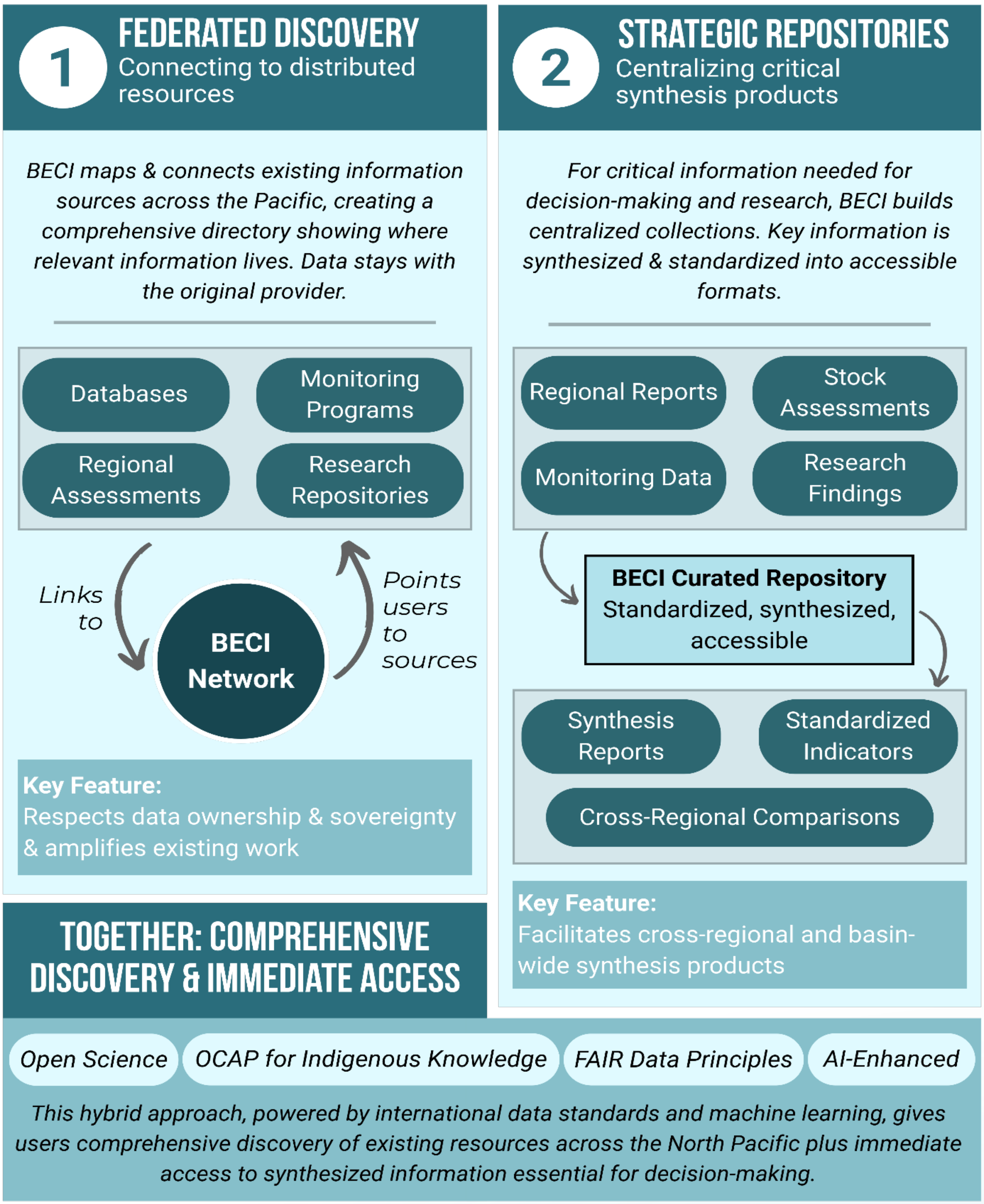
BUILDING OUR KNOWLEDGE NETWORK

Effectively addressing climate change in the North Pacific requires coordinated access to scientific information across disciplines, regions, and knowledge systems. The challenge isn't a lack of information, its that critical knowledge is scattered across hundreds of institutions, databases, and publications. Even excellent research often doesn't reach the managers who need it most, and no single organization can provide the cross-regional synthesis essential for managing transboundary species.

BECI addresses this challenge by building a **North Pacific Ocean Knowledge Network,** an interactive platform that connects, organizes, and synthesizes existing information to support climate-informed decisions at the pace ocean change demands.

Our Approach: Federated & Centralized

The Knowledge Network is being built using two complementary strategies (Figure 2) to make existing information more accessible and actionable:



Knowledge Products

The Knowledge Network delivers practical outputs that translate integrated information into actionable knowledge:

- **Interactive Dashboards**: The platform's core interface focuses on Ocean State, Fish Dynamics, Ecosystem Status, and Human Dimensions, providing timely access to organized information with filtering and visualization tools
- **Synthesis Reports**: Cross-regional analyses addressing specific decision-making needs, such as marine heatwave impact assessments or transboundary species status summaries
- **Knowledge Library**: Curated catalogues of tools, models, data resources, and publications organized by theme and management application
- **Interactive Maps**: Visualizations showing environmental conditions, species distributions, extreme events, and management boundaries across the basin
- **Network Community**: Communication hub to connect researchers, working groups, and collaboration opportunities

Our knowledge products represent the synthesis of environmental data, ecological monitoring, traditional ecological knowledge, management approaches and ecological research findings (Figure 3). They range from environmental condition assessments and synthesis reports to analytical resources and visualization platforms, providing holistic picture of ocean ecosystems and their responses to climate change.

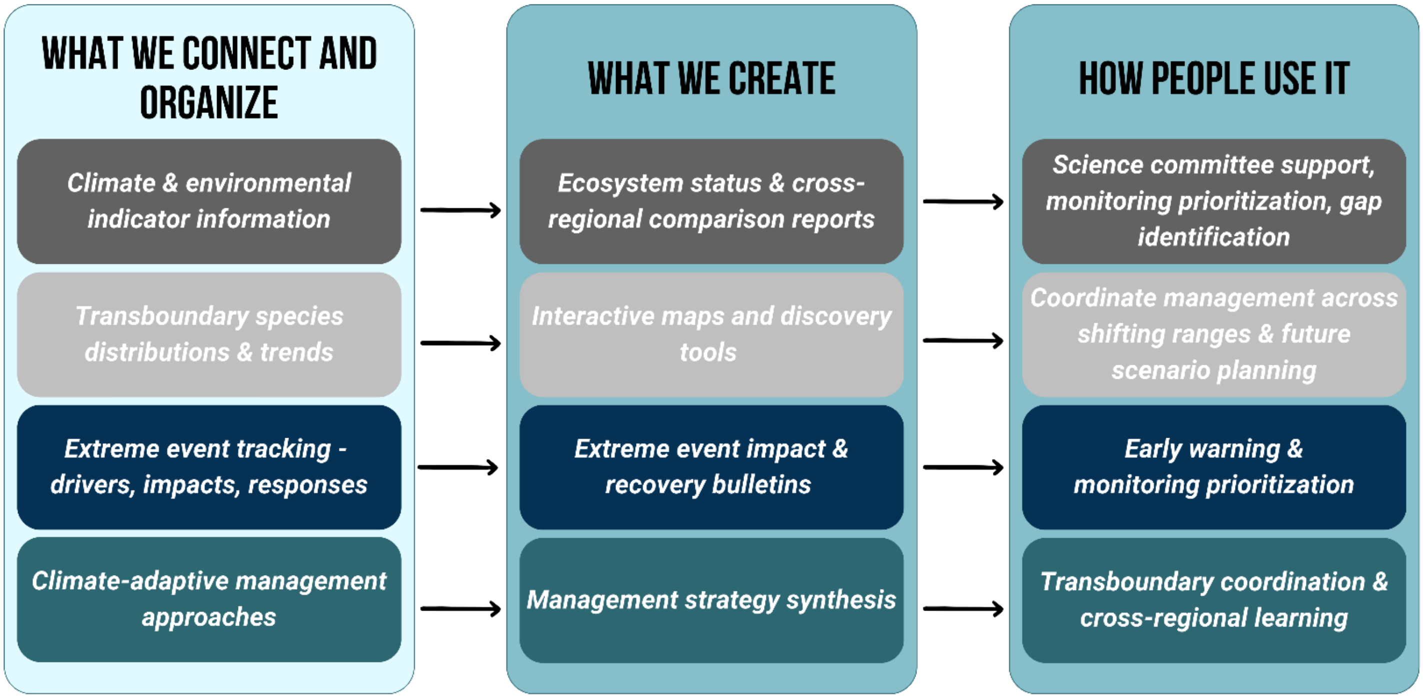


Figure 2. Knowledge Products. *This figure provides examples of knowledge products that will be created that can be used to support decision-making.*

The Knowledge Network Platform

The Knowledge Network delivers information through an integrated dashboard with five main sections. Each section is designed to answer specific questions that managers and researchers face when working with changing ocean conditions.

Ocean State

"What are current ocean conditions, and what extreme events are affecting the system?"
Ocean State provides a comprehensive picture of North Pacific environmental conditions organized around three perspectives:

- **Drivers**: Basin-scale climate patterns that influence the entire North Pacific, for example Pacific Decadal Oscillation, ENSO teleconnections, North Pacific Gyre Oscillation, and Aleutian Low patterns. Understanding these helps managers anticipate regional conditions months in advance.

- **State**: Current ocean conditions including sea surface temperature, chlorophyll-a concentration, zooplankton biomass, and stratification. These show the baseline environment that fish populations are experiencing right now.
- **Pressures**: Extreme events disrupting the system, such as marine heatwaves, harmful algal blooms, hypoxia events, and ocean acidification. These stressors often trigger the management responses that decision-makers need to act on quickly.

The platform links to real-time marine heatwave monitoring with event-specific alerts. When an event develops, managers can immediately see its designation, spatial extent, and severity ranking, enabling timely awareness, assessment and response.

Why this matters: When a marine heatwave develops, managers can immediately see its extent and severity, compare it to past events, understand which drivers are causing it, and access information about how similar events affected fisheries. This connects physical oceanography directly to management-relevant information.

Fish Dynamics

"How are key fish populations responding to changing conditions?"

Fish Dynamics provides species-level information for commercially and ecologically important transboundary species. Each species "ecocard" organizes information around the key questions and information scientists and decision-makers require:

- **Abundance & Recruitment**: Population trends, spawning success, and estimates of new individuals entering the population. Recruitment data is critical because it's highly sensitive to environmental conditions and predicts future productivity.
- **Distribution & Migration**: Current range shifts, changes in migration timing, and movement patterns. As species shift across borders, this information becomes essential for coordinated international management.
- **Condition & Health**: Body condition indices, disease prevalence, and stress indicators. These metrics reveal how environmental conditions are affecting individual fish, often before population-level impacts become apparent.
- **Food Sources & Diet**: Prey availability, zooplankton biomass, and forage fish status. Changes in food web dynamics often explain why fish populations respond to environmental change.

Priority species include Pacific salmon (multiple species), Pacific saury, Pacific halibut, Pacific cod, bluefin tuna, albacore tuna, neon flying squid, chub mackerel, and Japanese sardine, species that cross national boundaries and are managed by multiple jurisdictions.

The standardized format of the fish ecocards enables direct comparison across species and provides the specific information people need for evidence-based decisions.

Why this matters: A manager dealing with declining Pacific cod can quickly see population trends, understand how recent marine heatwaves affected the stock, compare responses across regions, and access information about management measures other jurisdictions have implemented. The ecocard format presents complex information in an accessible, standardized way.

Ecosystem Status

"How healthy are different regions, and how do they compare?"

Ecosystem Status enables cross-regional comparison of ecosystem health across Large Marine Ecosystems (LMEs) throughout the North Pacific. The platform synthesizes multiple indicators into a standardized framework that allows direct comparison between regions like the Gulf of Alaska, Bering Sea, Sea of Okhotsk, Kuroshio Current, and California Current.

Core indicators include sea surface temperature anomalies, primary production, ocean acidification rates, HAB frequency, and species-specific focal indicators. Each indicator shows current status, recent trends, and confidence level based on data quality.

A cross-regional comparison view presents all monitored LMEs in a standardized heat map, showing current status and trend direction for each core indicator. This enables people to quickly identify which regions face the greatest stress and how conditions compare across the basin.

Why this matters: Regional Fisheries Management Organizations and national agencies can see how conditions in their waters compare to other regions, see what environmental conditions transboundary species may be encountering in different life cycles stages, identify emerging patterns that may spread across the basin, and learn from how other regions have responded to similar conditions.

Knowledge Library

"What tools, data, and resources exist that I can use?"

The Knowledge Library serves as a curated catalogue of tools, data resources, models, and publications organized by theme. Rather than recreating existing databases, it helps users discover and access relevant resources efficiently.

The library is organized by six categories:

- **Climate Informed Management Tools**: Practical tools for assessing climate vulnerabilities, evaluating management options, and planning adaptive responses, including vulnerability assessment frameworks, management strategy evaluation (MSE) toolboxes, scenario planning resources, and early warning systems like NOAA's marine heatwave forecasts.
- **Ocean, Climate & Ecological Models**: Species distribution models (e.g., EcoCast, WhaleWatch), ocean circulation models (e.g., ROMS, HYCOM), ecosystem models (e.g., ACLIM, Atlantis, NEMURO), and multi-model ensemble frameworks like FishMIP are organized by model type with information on status, lead institutions, and access links.
- **Ecosystem Status & Health Assessments**: Regional ecosystem status reports, health indices, and indicator frameworks from across the North Pacific, including the Ocean Health Index, PICES North Pacific Ecosystem Status Report, Alaska Marine Ecosystem Status Reports, California Current IEA reports, and assessments from Japan, Korea, and China.
- **Data Resources**: Satellite observations, field measurements, monitoring programs, and data portals supporting climate-informed decision-making from global resources like Argo and Copernicus to regional systems like CIOOS Pacific and the Alaska Harmful Algal Bloom Network.
- **Research Publications & Knowledge Products**: International assessments (e.g., IPCC SROCC, FAO SOFIA, World Ocean Assessment), peer-reviewed literature, and BECI synthesis documents (e.g., cross-regional analyses that compile lessons learned, management responses, and ecological patterns across the North Pacific basin).
- **Conservation Approaches & Planning (under development)**: Strategies and frameworks for climate-adaptive spatial conservation, including dynamic ocean management approaches, climate-smart protected area design, connectivity planning for shifting species, and cross-jurisdictional coordination mechanisms. Resources will cover vulnerability assessment methods, climate refugia

identification, and case studies of how conservation planning is adapting to changing conditions across the North Pacific

Why this matters: A researcher developing a climate vulnerability assessment can find existing models they can build on, data sources they weren't aware of, and examples of how similar assessments were done in other regions. A decision maker can find decision-support tools used by other jurisdictions, and review how similar management challenges were addressed elsewhere. The library reduces duplication and accelerates both research and management response by making existing resources discoverable and accessible in one place.

Human Dimensions (under development)

"How are climate-driven changes affecting fisheries-dependent communities and livelihoods?"
Human Dimensions addresses the socioeconomic and cultural consequences of changing ocean conditions across the North Pacific. While other dashboard sections track physical and biological changes, this section connects those changes to their human impacts, recognizing that climate effects on fisheries are ultimately felt by people and communities.

Content under development includes:

- **Community Vulnerability**: Economic dependence on affected fisheries, employment trends, and adaptive capacity indicators for coastal communities across the North Pacific
- **Cultural & Food Security**: Traditional harvesting practices, Indigenous fisheries, and subsistence patterns affected by shifting species distributions and changing access
- **Sector Responses**: Documentation of how fishing industries and communities are adapting, including gear changes, target species shifts, geographic adjustments, and livelihood diversification
- **Policy & Management Adaptation**: Tracking how jurisdictions are incorporating climate considerations into allocation decisions, access policies, and community support programs

Why this matters: When assessing a declining fish population it is important to understand not just the biological status, but which communities depend on that fishery, how they've responded to past downturns, and what adaptation options exist. Human Dimensions connects ecological information to real-world consequences, supporting decisions that account for both ecosystem health and community wellbeing.

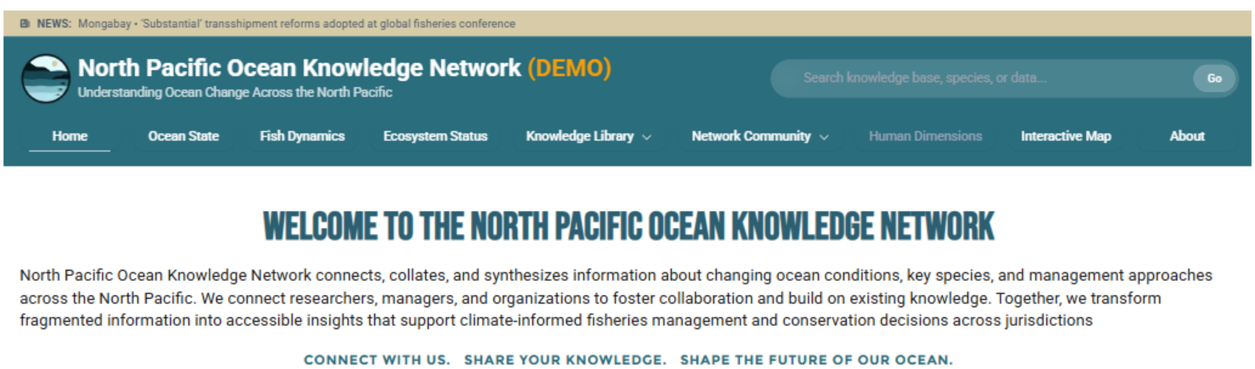
This section is being developed in partnership with social scientists, community representatives, and fisheries economists across the North Pacific.

Network Community

"Who else is working on this, and how can I connect with them?"

Network Community connects users with research programs, experts, and collaboration opportunities across the North Pacific. This includes active research initiatives, expert directories, working groups, and upcoming events relevant to climate and fisheries management.

Why this matters: Science advances through collaboration. The community section transforms the Knowledge Network from a static information source into a living platform for collaboration.



Real-World Application: Marine Heatwave Response

To illustrate how the Knowledge Network's sections work together, consider a scenario that North Pacific decision-makers increasingly face: a marine heatwave develops in the waters off Japan and begins spreading eastward across the basin.

Ocean State aggregates information from partner monitoring systems to show the event's current spatial extent, intensity classification (Category II Strong), and how it compares to recent events in the region. The Drivers tab reveals that an extreme northward meander of the Kuroshio Extension is displacing cold Oyashio water with warm subtropical water. Pressures tracking shows associated harmful algal bloom development and declining dissolved oxygen in subsurface waters as warm, lower-oxygen Kuroshio water replaces the typically oxygen-rich Oyashio.

Fish Dynamics identifies which species face immediate risk. Ecocards for Pacific saury show the stock is shifting further northward and eastward, moving away from traditional Japanese fishing grounds toward Russian waters. Japanese sardine ecocards indicate potential range expansion, while chub mackerel profiles reveal the species is concentrating in cooler waters at the edges of the thermal anomaly.

Ecosystem Status places this event in basin-wide context. The cross-regional comparison shows the Kuroshio Current LME shifting to "elevated stress" status while the adjacent Oyashio region shows significant warming as subtropical water intrudes northward. Historical trends reveal increasing frequency of thermal anomalies in this region over the past decade, with implications for the productive transition zone where cold and warm currents meet.

Knowledge Library provides immediate access to tools and evidence: marine heatwave forecast products for trajectory prediction, peer-reviewed studies documenting how previous thermal events affected saury recruitment and sardine distribution, and case studies of how fishing effort shifted during past anomalies across Japan, Korea, and Russia.

Network Community connects managers with researchers actively monitoring the event across multiple countries, identifies relevant NPFC and PICES working groups tracking Pacific saury and small pelagic dynamics, and links to colleagues in other regions who have managed similar conditions, enabling rapid knowledge exchange when decisions can't wait for formal publication cycles.

This integrated response, connecting physical conditions to species vulnerability to management options to expert networks, transforms scattered information into coordinated action. A person accessing any single data source would see only a fragment; **the Knowledge Network reveals the complete picture and provides pathways to respond.**

Development Phases & Timelines

Our implementation will follow three progressive phases (Figure 4), each building upon the achievements of previous work while expanding capabilities to meet emerging needs:

Current

Phase INITIAL — Years 1-2

Foundation & Connection

- Establish core platform infrastructure
- Connect initial data sources across regions
- Launch proof-of-concept dashboards
- Build federated discovery directory
- Develop partnership frameworks
- Complete initial use case pilots

Data Connection

Phase INTERMEDIATE — Years 2-3

Integration & Synthesis

- Standardize analysis frameworks across regions
- Expand species coverage in Fish Dynamics
- Develop cross-regional synthesis products
- Enhance ecosystem status comparisons
- Build strategic repositories
- Grow Network Community

Knowledge Synthesis

Phase ADVANCED — Years 3+

Decision Support & Expansion

- Deliver comprehensive decision-making guidance
- Expand to additional species
- Integrate climate projection tools
- Develop scenario planning capabilities
- Establish sustainable operational model
- Support RFMO climate adaptation planning

Decision Support

Each phase builds upon previous achievements while expanding capabilities to meet emerging needs. As BECI capabilities evolve, our ability to support climate-informed decision-making grows progressively more sophisticated, from basic data connection to integrated synthesis and decision support.

Use Cases

To demonstrate how our knowledge network and products deliver practical value, we have developed a series of use cases that address specific climate-related challenges identified by partners across the North Pacific. Each use case showcases how BECI transforms fragmented data and information into actionable insights that support evidence-based decision making for critical marine resource management and conservation.

List of Initial Use Cases (full use cases are provided in Appendix A)

Use Case #1: Learning From Marine Heatwave Impacts on Key Fisheries - Creating a comprehensive synthesis of marine heatwave events and impacts across the North Pacific to connect dispersed data on current and past events, identify response patterns across species and regions, and develop management strategies to improve resilience to future extreme events. Over time, this use case will expand to include other extreme events such as harmful algal bloom (HAB) outbreaks.

Use Case #2: North Pacific Ocean Ecosystem Status Report Framework - Building on the PICES North Pacific Ecosystem Status Report and Ocean Health Index processes to create a standardized framework for ecosystem status assessments that harmonizes data analysis and reporting across ecoregions, enabling timely basin-wide assessments and cross-regional analyses.

Use Case #3: Climate-Adaptive Spatial Conservation Planning - Developing frameworks and decision-support resources that enable conservation managers to design more effective protected area networks that can adapt to changing ocean conditions across jurisdictional boundaries.

The BECI Knowledge Network will generate specific knowledge products across various use cases, including:

- BECI Knowledge Network interactive map (**all use cases**)
- Comprehensive synthesis report and mapping of Marine Heatwave (MHW) impacts organized by ecological mechanism, region, and species (**UC1**)
- Comprehensive multinational ecosystem status report framework with standardized core metrics and regional adaptations (**UC2**)
- Synthesis report on the state of climate-adaptive spatial conservation planning (**UC3**)

GUIDING PRINCIPLES & TECHNICAL APPROACH

Our implementation is guided by established principles that ensure accessibility, inclusivity, and scientific integrity.

FAIR Data Principles

- **Findable** - Easily discoverable through rich metadata and persistent identifiers
- **Accessible** - Available through standardized protocols with appropriate authentication
- **Interoperable** - Using common vocabularies and formats that enable integration
- **Reusable** - Well-documented with clear usage licenses and provenance information

OCAP Principles for Indigenous Knowledge

- **Ownership** - Recognizing that communities own their knowledge and cultural data
- **Control** - Ensuring Indigenous partners maintain control over data about their communities
- **Access** - Establishing appropriate protocols for accessing Indigenous knowledge
- **Possession** - Supporting Indigenous data sovereignty and stewardship

Open Science Approaches

- Promoting transparency in methods and analyses
- Encouraging reproducible research practices
- Creating accessible knowledge products for diverse audiences
- Supporting equitable participation across regions and institutions

Technical Architecture

The Knowledge Network uses a layered technical approach that balances flexibility with interoperability:

- **Data Layer:** Connects distributed repositories while respecting data ownership and sovereignty
- **Integration Layer:** Provides standardized interfaces for cross-domain compatibility
- **Synthesis Layer:** Combines analytical capabilities with expert teams to transform integrated data into actionable insights
- **User Layer:** Delivers customized interfaces for researchers, managers, and policymakers

This architecture allows BECI to progressively expand capabilities while maintaining ethical data governance and scientific integrity.

GOVERNANCE & STRUCTURE

While BECI is currently in its early planning and strategic development phase, we are systematically building toward a comprehensive governance and operational framework that will support our ambitious vision. Figure 5 illustrates our three-pillar structure consisting of governance bodies, operational units, and functional teams that work together to ensure effective coordination across the North Pacific.

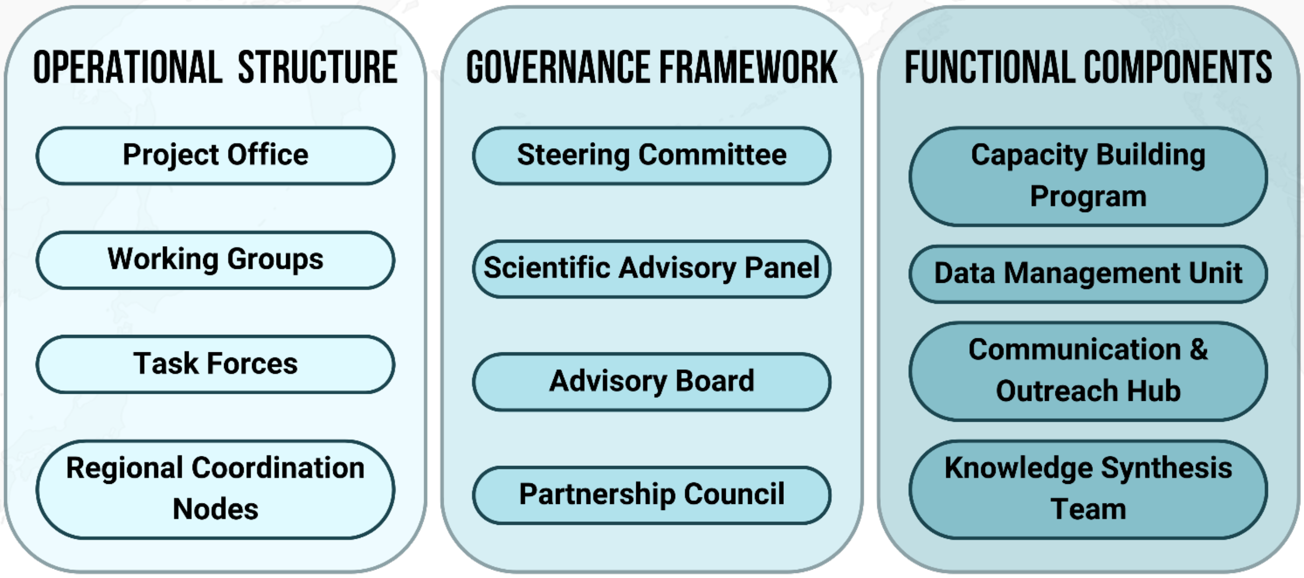


Figure 5. Planned governance structure *for the BECI Knowledge Network.*

Operational Structure

Our operational units implement the network's activities and facilitate collaboration:

- Project Office: Based at PICES, providing administrative and scientific support in addition to coordination across all network activities
- Working Groups: Standing teams of experts focused on ongoing research priorities and knowledge synthesis within specific scientific areas
- Cross-Cutting Task Forces: Time-limited teams addressing urgent emerging issues or specific methodological challenges that require rapid, focused attention across regions
- Regional Coordination Nodes: Sub-networks focused on specific regions of the North Pacific to ensure local relevance and implementation

Governance Framework

Our governance bodies provide strategic direction and ensure diverse stakeholder representation:

- Steering Committee: Representatives from PICES and key partner organizations providing strategic direction and oversight
- Advisory Board: Distinguished representatives from policy, science, industry, and conservation sectors offering high-level guidance
- Scientific Advisory Panel: International experts who ensure scientific rigor across disciplines
- Partnership Council: Representatives from Indigenous communities, industry, NGOs, and management agencies providing input on practical needs

Functional Components

Our functional teams deliver specialized capabilities:

- Data Management Unit: Coordinates data sharing, standards, and integration across the network
- Knowledge Synthesis Team: Specialists in analyzing and synthesizing information from diverse sources
- Communication and Outreach Hub: Dedicated to translating scientific findings for various audiences
- Capacity Building Program: Supporting training and participation across the network, particularly for underrepresented groups

PARTNERSHIPS & ENGAGEMENT

BECI addresses challenges that no single organization or nation can solve alone. Building on the established international partnerships of PICES and NPAFC, we connect research institutions, Regional Fisheries Management Organizations, national agencies, Indigenous knowledge holders, NGOs, coastal communities and industry stakeholders across the North Pacific basin.

Our network will include:

- **Scientific partners**: Research institutions and universities throughout the Pacific Rim contributing data, expertise, and analytical capacity
- **Management organizations**: RFMOs (NPFC, NPAFC, IPHC, IATTC, WCPFC) and national agencies responsible for fisheries and marine resource decisions
- **Indigenous communities**: Knowledge holders whose observations and expertise span generations of ocean change
- **Supporting organizations**: NGOs, industry groups, and international bodies with stakes in sustainable North Pacific fisheries

This collaborative structure ensures the Knowledge Network reflects diverse expertise and serves practical needs across the region. By creating pathways for information sharing that transcend traditional institutional and national boundaries, BECI supports climate-informed decision-making at the scale the challenges demand.

Practical Benefits for Partners

The BECI knowledge network provides tangible value to diverse stakeholders and Indigenous communities (Figure 6):

Figure 6. BECI Partner Benefits. *The network delivers specialized value to diverse user groups across the North Pacific, from management agencies and research organizations to Indigenous communities and industry partners. By bringing these diverse organizations together in a cohesive network, we create opportunities for knowledge exchange and collaboration that enhance marine research and management across the entire region.*

Engagement Approach

BECI will engage partners through:

- Regional working groups and task forces
- Workshops/ online platforms designed for collaborative exchange
- Cross-sector knowledge exchange forums
- Collaborative knowledge product development
- Regular communication and targeted outreach
- Co-designed research and monitoring initiatives

Indigenous Knowledge & Partnership

BECI recognizes the deep historical understanding of Indigenous peoples who have observed North Pacific Ocean changes since time immemorial. To ensure meaningful and ethical engagement, we have developed a dedicated Indigenous Engagement Strategy that guides our approach to working with coastal Indigenous communities.

Our approach is founded on key principles that prioritize:

- **Moving at the speed of trust:** Starting engagement early, before research agendas are finalized, and beginning with listening
- **Reciprocity and balance:** Ensuring that activities, contributions, and relationships provide mutual benefits and embody the principle of 'giving back'
- **Respect and accountability:** Creating ethical and safe spaces that honor diverse values, cultures, ways of knowing, and priorities
- **Knowledge sovereignty:** Upholding principles of Ownership, Control, Access, and Possession (OCAP) in how Indigenous knowledge is collected, stored, and shared
- **Transparency:** Providing clear, accessible, and timely communications with realistic expectations based on capacity and desired outcomes

This principled approach supports multiple forms of engagement including:

- Creating pathways for appropriate Indigenous knowledge integration
- Building community data stewardship capacity
- Developing collaborative knowledge production mechanisms

Our engagement strategy acknowledges historical challenges in research relationships and establishes processes to avoid extractive approaches. Instead, we seek to create meaningful partnerships where engagement is authentic, reciprocal, and relational, generating outcomes that advance trust and mutual benefits for all involved.

Funding & Project Support

BECI is currently funded by the British Columbia Salmon Restoration & Innovation Fund and is an endorsed project of the United Nations Decade of Ocean Science for Sustainable Development. The project was originally developed through the collaborative efforts of PICES and NPAFC, with ongoing support from multiple international research and management organizations.

Future project sustainability will be pursued through continued institutional partnerships, targeted grant applications, and the demonstration of the project's scientific value in understanding North Pacific marine ecosystem changes.

If you are interested in exploring partnership opportunities, please contact us:

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APPENDIX A:

Use Case #1: Learning From Marine Heat Waves Impacts on Key Fisheries

Background

Marine heatwaves (MHWs) have emerged as a profound and increasingly frequent consequence of climate change in the North Pacific Ocean. These extreme events, defined as periods when daily sea surface temperature (SST) exceeds the 90th percentile of historical SST observations within a given region for at least 5 consecutive days (Oliver et al. 2018; Holbrook et al. 2019), have dramatically impacted marine ecosystems and fisheries across the basin. While large-scale events like "the Blob" (2013-2016) have received significant attention, smaller-scale MHWs occur frequently throughout the North Pacific, creating a complex mosaic of thermal stressors that marine ecosystems must contend with.

The North Pacific has experienced several notable MHWs in recent years. "The Blob," an unprecedented warm water mass that persisted from 2013-2016 in the Northeast Pacific, caused widespread ecological disruptions, including mass mortality events of seabirds, shifts in species distributions, and fisheries closures (Cavole et al. 2016). In 2019-2020, another major MHW developed in the Gulf of Alaska, reinvigorating concerns about vulnerable fish stocks that had not yet recovered from previous thermal stress. Simultaneously, the Northwest Pacific has experienced its own MHWs, with significant impacts on commercially important species like Pacific cod and anchovy (Liu et al. 2024).

These events have highlighted the economic vulnerability of fisheries to thermal extremes. A single MHW can result in approximately 800 million USD in direct losses, with cascading effects generating more than 3.1 billion USD in indirect losses that persist across multiple years (Smith et al. 2021). The Gulf of Alaska Pacific cod fishery collapse following the 2014-2016 MHW stands as a stark example, with a 71% reduction in allowable catch and estimated losses exceeding $100 million (Barbeaux et al. 2020).

While valuable research has documented MHW impacts on key North Pacific commercial species—including Gulf of Alaska walleye pollock (Rogers et al. 2021), Gulf of Alaska Pacific cod (Barbeaux et al. 2020), Northeast and Northwest Pacific cod (Liu et al. 2024), Pacific sardine (Cavole et al. 2016) and Northwest Pacific anchovy (Liu et al. 2024)—these findings remain fragmented across disparate studies, regions, and fisheries. This fragmentation creates a critical knowledge gap for decision-makers who need comprehensive understanding to develop effective response strategies.

The National Oceanic and Atmospheric Administration (NOAA) has made significant advances in forecasting and monitoring marine heatwaves through initiatives like their MHW Tracker and experimental seasonal prediction systems. This use case would build upon these existing operational frameworks, focusing on connecting physical forecasts to ecological and management responses rather than duplicating prediction efforts.

The urgency of addressing this gap is underscored by climate projections indicating that MHWs will increase substantially in frequency, intensity, and duration, becoming up to 20 times more frequent even under conservative climate scenarios (RCP2.6) (Collins et al. 2019). By synthesizing existing knowledge across the North Pacific into an integrated framework, this analysis provides fisheries managers and policymakers with the comprehensive understanding needed to anticipate, prepare for, and mitigate the complex impacts of future marine heatwaves on economically and ecologically vital fisheries.

Issues of Concern

- Increasing frequency, intensity, and duration of marine heat waves in the North Pacific, with projections indicating a 20-fold increase even under conservative climate scenarios
- Fragmented understanding of marine heatwave impacts on commercially important fish species and fisheries across the North Pacific hinders effective management responses
- Insufficient integration of marine heat waves into future fisheries projections and vulnerability assessments
- Insufficient capacity for anticipating and responding strategically to future marine heatwaves, leaving critical fisheries vulnerable to potentially avoidable impacts
- Prolonged and frequent recurrence of MHWs will likely exceed recovery windows for commercially important fish species, leading to compounding impacts

Objectives

Knowledge Synthesis

- Create a comprehensive synthesis of existing knowledge on MHW impacts on key commercial species throughout the North Pacific, integrating disparate regional studies into a basin-wide understanding
- Document, evaluate, and compare management responses to past MHW events across jurisdictions to identify best practices and adaptation strategies

Develop Knowledge Products

- Develop accessible visualization tools and knowledge products to enhance understanding of MHW patterns, ecological impacts, and management implications

Outreach & Collaboration

- Establish a collaborative network of researchers, managers, and stakeholders across the North Pacific to facilitate knowledge exchange and coordinate monitoring efforts
- Identify critical knowledge gaps and research priorities to improve forecasting and management of MHW impacts on fisheries

Focal Species

- Pacific Salmon
- Pacific Halibut
- Tuna and Tuna-Like Species
- Pacific Saury
- Pacific Herring
- Pacific Hake
- Squid

Information/Data

Physical Data

- Historical and real-time temperature data (satellite, buoy, and vessel-based) to characterize MHW events
- Spatial and temporal metrics of past marine heat waves in the North Pacific
- Oceanographic parameters (salinity, dissolved oxygen, productivity) associated with MHW events

- NOAA MHW forecasting products and prediction tools to serve as foundation for impact assessments

Biological/Ecological Data

- Systematic survey or catch data of key fish species before, during, and after marine heat wave events
- Physiological data (energetics, stomach contents, growth rates) on key fish species before, during, and after marine heat wave events
- Species-specific vulnerability assessments and thermal tolerance thresholds
- Ecosystem-wide impacts including prey availability and predator-prey relationships

Management Data

- Management responses (catch quotas, closures, etc.) implemented during past MHW events
- Economic impact assessments of MHWs on fisheries and coastal communities
- Traditional and local ecological knowledge of MHW impacts and adaptation strategies
- Policy frameworks and governance mechanisms available for MHW response

Proposed Activities & Outputs

Phase	Step	Action	Product(s)
Initial	Knowledge Synthesis	Comprehensive literature review of MHW impacts on fisheries across the North Pacific	Literature database with systematic categorization of impacts by species, region, and response type
	Visualization tool	Collation of spatial and temporal data on past MHWs in the North Pacific	BECI Knowledge Network Interactive map: • Historical MHW events • Intensity • Duration • Spatial extent metrics
	Network Development	Identify and connect with scientists throughout North	Directory of ongoing MHW research and monitoring activities

		Pacific working on MHW impacts on key species	
	Management Review	Document management responses to past MHW events across jurisdictions	Database of Initial management response with preliminary assessment of effectiveness
Intermediate	Synthesis Development	Analyze patterns of species response across regions and events	Comprehensive synthesis report of MHW impacts organized by ecological mechanism, region, and species
	Visualization tool	Map species-specific impacts in relation to MHW characteristics	BECI Knowledge Network Interactive Map: Enhanced layers connecting MHW events to documented biological impacts
	Network Enhancement	Form a North Pacific working group on MHW impacts and management responses	Established working group with regular meetings and collaborative research agenda
	Management Assessment	Evaluate effectiveness of past management responses	Management response report with comparative analysis of strategies and outcomes
	Vulnerability Assessment	Develop framework to assess species and fisheries vulnerability to future MHWs	Vulnerability assessment methodology report and preliminary application to key species
	Forecast Integration	Integrate NOAA MHW forecasts with species distribution and biological response data	GIS-based decision support tool connecting predicted MHW patterns with vulnerable fisheries and ecosystems
Advanced	Stakeholder Engagement	Organize regional workshops with diverse stakeholders to develop MHW response strategies	Series of regional workshops and cross-regional knowledge exchange forums

	Best Practice Development	Synthesize lessons learned and identify effective management approaches	Best practice guidelines for proactive and reactive management responses to MHWs
	Decision Support Tool Creation	Develop tools to support management decision-making during MHW events	Web-based decision support platform with impact projection capabilities and management option evaluation
	Early Warning System Development	Create indicators to identify early biological responses to emerging MHWs and utilize NOAA's MHW forecasting systems	Early warning indicator framework integrated with existing monitoring systems
	Adaptive Management Integration	Work with RFMOs to incorporate MHW scenarios into Management Strategy Evaluations	MSE outputs and recommendations for adaptive fisheries management under MHW conditions

Expected Outcomes

This use case will produce a comprehensive understanding of marine heatwave impacts on key species across the North Pacific, leading to tangible improvements in management capacity and ecological resilience:

Scientific Outcomes

- Comprehensive synthesis of MHW impacts on commercially important species across the North Pacific
- Identification of common vulnerability factors and resilience characteristics across species and ecosystems
- Improved understanding of ecological mechanisms connecting physical MHW characteristics to biological responses
- Clear articulation of critical knowledge gaps to guide future research priorities

Management Applications

- Evidence-based best practices for management responses to MHWs at different stages (preparation, during-event, recovery)
- Enhanced capacity to incorporate MHW scenarios into fisheries forecasting and quota-setting processes

- Early warning indicators of potential fisheries impacts from emerging MHW conditions
- Decision-support tools tailored to different management contexts and jurisdictions

Collaboration Benefits

- Established Pan-Pacific network of researchers and managers focused on MHW impacts and responses
- Improved knowledge transfer between regions that have experienced severe MHWs and those preparing for future events
- Enhanced coordination of monitoring efforts across jurisdictions to capture basin-wide patterns
- Strengthened science-policy interface for addressing extreme climate events in marine systems

Stakeholder Benefits

- Improved industry understanding of potential MHW impacts and preparation strategies
- Enhanced coastal community resilience through proactive planning for MHW events
- Documented traditional and local ecological knowledge contributions to understanding and managing MHW impacts
- Clearer communication of MHW science to non-technical audiences through visualization tools and knowledge products

Key Partners

Research Organizations

- NOAA Pacific Marine Environmental Laboratory & Alaska Fisheries Science Center
- NOAA Climate Prediction Center and MHW forecasting teams
- Fisheries and Oceans Canada (DFO) Science Branch
- Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
- University research laboratories specializing in climate impacts and fisheries
- PICES Working Groups on Climate Change and Ecosystem Effects
- Climate modelling centers (global and regional)

Management Bodies

- North Pacific Fishery Management Council

- Pacific Fishery Management Council
- Regional Fisheries Management Organizations
- National and sub-national fisheries agencies
- Coastal resource management authorities

Monitoring Networks

- Integrated Ocean Observing Systems
- Distributed Biological Observatory
- Research vessel programs and surveys
- Satellite monitoring programs (NOAA, NASA, JAXA)

Industry Partners

- Commercial fishing organizations and associations
- Seafood processing companies
- Aquaculture operations in affected regions
- Marine recreation and tourism sectors

Indigenous and Community Partners

- Coastal communities affected by MHWs
- Traditional knowledge holders and Indigenous fishing organizations
- Community-based monitoring networks
- Local conservation organizations

Note: this framework will be expanded upon to include other extreme events such as Harmful Algal Bloom (HAB) outbreaks

Use Case #2: North Pacific Ocean Ecosystem Status Report Framework

Background

The North Pacific Ocean functions as an interconnected ecosystem spanning multiple national boundaries, where climate-driven changes increasingly impact marine resources and ecosystem services across the entire basin (Hazen et al., 2019; Hollowed et al., 2013). While individual country monitoring efforts provide valuable insights within national waters, true understanding of ecosystem dynamics requires coordinated transboundary approaches that can capture basin-scale patterns and processes (Pinsky et al., 2018; Bograd et al., 2019).

The North Pacific Ecosystem Status Reports (NPESR) produced by PICES (North Pacific Marine Science Organization) represent important collaborative efforts to synthesize ecosystem information across 14 distinct ecoregions spanning the North Pacific (PICES, 2010; McKinnell & Dagg, 2010). These ecoregions include the Oyashio/Kuroshio, Sea of Okhotsk, Yellow Sea, East China Sea, South China Sea, Western Bering Sea, Northern Bering–Chukchi Seas, Eastern Bering Sea, Aleutian Islands, Western Gulf of Alaska, Eastern Gulf of Alaska, Northern California Current, and Southern California Current. Each ecoregion has unique ecological characteristics, monitoring capacities, and management priorities, creating significant challenges for standardized reporting and cross-regional comparisons (Megrey et al., 2009; Zador et al., 2016).

Despite this comprehensive geographic coverage, the NPESR process is limited by voluntary, non-standardized contributions from member countries. This results in inconsistent reporting across ecoregions, with significant variations in data availability, parameter selection, and analytical approaches. There is a clear need to create a more coordinated framework for the NPESR process that will not only increase efficiency but also provide significant benefits including enhanced comparability across regions, improved detection of ecosystem-wide patterns, reduced duplication of effort, and better integration of findings into management decisions.

The Ocean Health Index (OHI), introduced by Halpern et al. (2012), offers a complementary approach that could strengthen the NPESR framework. Unlike NPESR's primarily descriptive approach focusing on ecological status and inconsistent human dimension metrics, OHI provides a quantitative, goal-oriented framework that integrates ecological, social, and economic dimensions of ocean health into standardized scores (Halpern et al., 2015; Lowndes et al., 2015). OHI uses reference points to assess status relative to targets, employs standardized scoring methodologies, and focuses on sustainability outcomes. By integrating elements of OHI with NPESR, we can create a framework that maintains NPESR's ecological depth while adding standardized scoring, human dimensions with consistent metrics, and outcome-oriented metrics (Samhouri et al., 2012; Koehn et al., 2020).

NPESR typically includes:

- Physical and oceanographic conditions (temperature, salinity, currents)
- Chemical parameters (nutrients, oxygen, acidification)
- Lower trophic level productivity (phytoplankton, zooplankton)
- Fish stock abundance and distribution
- Seabird and marine mammal populations
- Notable ecosystem events (e.g., harmful algal blooms)
- Human activities (fisheries, shipping, coastal development)
- Socioeconomic indicators (when available)

OHI's distinguishing features include:

- A consistent framework of 10 standardized goal metrics applied uniformly across regions
- Quantitative scoring against reference points (0-100 scale)
- Explicit integration of human benefits from marine ecosystems
- Calculation of both status and likely future state
- Incorporation of pressures and resilience factors into scoring
- Standardized methodology allowing direct cross-regional comparisons
- Open-source, repeatable assessment process

By combining elements of the NPESR approach with the structured goal-oriented methodology of OHI, we can create a more standardized, comparable framework that maintains essential flexibility for regional priorities while ensuring consistent core metrics.

This hybrid approach will demonstrate how standardized ecosystem monitoring, assessment, and reporting frameworks can enhance knowledge sharing, support ecosystem-based management decisions, and improve understanding of climate impacts across the North Pacific, directly supporting BECI's mission to connect knowledge and enhance science-based decision making across political boundaries.

The United States (Alaska regions), Canada (Eastern Gulf of Alaska), and Japan (Oyashio/Kuroshio systems) represent ideal partners for a multinational framework pilot project due to their strong scientific capacities, established monitoring programs, and history of successful collaboration through PICES. These countries span critical migratory corridors for shared species including Pacific salmon, albacore tuna, marine mammals, and seabirds (Sydeman et al., 2015; Woodworth-Jefcoats et al., 2017). Climate impacts occurring in one nation's waters directly affect the abundance, distribution, and health of species in another's, creating an inherent need for coordinated monitoring and assessment (Di Lorenzo et al., 2013).

The multinational framework would leverage each country's monitoring strengths while addressing their limitations. The United States offers comprehensive fisheries monitoring and ecosystem reporting systems with strong benthic and pelagic fish assessments. Canada provides sophisticated integrated ocean observing networks and salmon management expertise. Japan contributes exceptional oceanographic monitoring capabilities and long-term time series for western Pacific species. Together, they create a powerful collaborative network spanning the eastern and western reaches of the North Pacific (Murawski et al., 2010).

This multinational approach will demonstrate how standardized ecosystem monitoring, assessment, and reporting frameworks can enhance knowledge sharing across political boundaries, support coordinated ecosystem-based management for shared species and improve understanding of basin-scale climate impacts across the North Pacific. By connecting these regions through a common framework, we can better detect, understand, and respond to ecosystem-wide changes that no single nation could effectively address alone (Levin et al., 2014; Samhouri et al., 2014).

Objectives

1. Develop a multinational NPESR-OHI framework that integrates standardized monitoring across Alaska, Canada, and Japan
2. Create multilingual data submission protocols that facilitate consistent reporting while respecting national data policies
3. Demonstrate how standardized transboundary monitoring can enhance understanding of basin-scale climate impacts
4. Support coordinated ecosystem-based management approaches for shared migratory species
5. Create a scalable model that can be expanded to include additional PICES member countries

Proposed Activities & Outputs

Phase	Step	Action	Product(s)
Initial	Framework Development	Create hybrid NPESR-OHI framework specifying core and flexible parameters across USA, Canada, and Japan ecoregions	Comprehensive multilingual framework document detailing required metrics, methodologies, and reporting formats
	Multinational Working Group	Establish coordination team with representatives from each country and ecoregion	Governance structure document with clear roles, responsibilities, and decision-making protocols
	Data collation	Catalog existing monitoring programs and datasets across the three countries relevant to ecosystem status reporting	Directory of available datasets, responsible organizations, and metadata with cross-regional mapping
	Stakeholder Engagement	Convene international workshops with monitoring agencies, indigenous organizations, and management bodies from all three countries	Multinational stakeholder needs assessment and engagement report
Intermediate	Data Sharing Protocols	Develop multilingual data sharing agreements that address national regulatory constraints	Tiered data sharing framework document with metadata standards and access control specifications
	Template Creation	Create standardized multilingual data submission templates and quality control procedures	Multilingual data submission documents including templates, quality control procedures, and metadata requirements
	Digital Platform Development	Create beta version of cross-basin digital platform for collating, analyzing, and visualizing ecosystem indicators	Web-based interactive multinational ecosystem status platform
	Pilot Implementation	Implement the framework starting with core physical and biological parameters across selected ecoregions	First standardized multinational ecosystem status report using the hybrid framework

	Collaborative Analysis	Conduct joint analysis of shared climate-driven ecosystem patterns across participating ecoregions	Cross-basin synthesis identifying teleconnections and shared response patterns
Advanced	Full Integration	Incorporate complete suite of indicators including human dimensions across all participating ecoregions	Comprehensive multinational ecosystem status report with standardized core metrics and regional adaptations
	Management Translation	Develop tools for translating ecosystem status information into management-relevant formats for shared species	Decision support documents linking ecosystem indicators to management thresholds and reference points for transboundary resources
	Forecast Integration	Incorporate predictive ecosystem forecasts into the status reporting system across all participating regions	Integrated multinational forecast/status reporting system with uncertainty estimates
	Framework Expansion	Work with remaining PICES member countries to expand the framework to additional ecoregions	Expanded framework documentation with additional PICES member country-specific adaptations
	Knowledge Exchange Platform	Create permanent infrastructure for ongoing data sharing, analysis, and visualization	North Pacific Ocean Knowledge Network with sustainable governance and funding model

Implementation Strategy

Initial Phase: Foundation Building (Years 1-2)

- Investigate each countries desire to participate in NPESR-OHI framework building and develop relationships with representatives for each ecoregion
- Form a Multinational Working Group with representatives from each country
- Identify shared priority indicators across all seven ecoregions
- Create data sharing protocols that address each country's regulatory constraints
- Develop trilingual templates and metadata standards

Intermediate Phase: Pilot Implementation (Years 2-3)

- Launch initial data integration for core physical and biological parameters

- Create beta (pre-release) version of multinational data dashboard
- Produce first coordinated ecosystem status assessment report
- Identify shared climate-driven ecosystem patterns across ecoregions

Advanced Phase: Expansion & Refinement (Years 3-5+)

- Incorporate full suite of indicators including human dimensions
- Develop management-relevant products including early warning indicators
- Create coordinated forecasting capability across ecoregions
- Incorporate remaining ecoregions within Canada, USA and Japan (if we go with 1 each to start)
- Engage additional PICES countries for future expansion

Advantages of Multinational Approach

- Enhanced Scientific Value: Connecting eastern and western Pacific ecoregions allows detection of basin-scale patterns and teleconnections
- Improved Management of Shared Resources: Better coordination for species that migrate across these ecoregions
- Complementary Expertise: Each country brings unique monitoring strengths and analytical approaches
- Diplomatic Benefits: Strengthens scientific cooperation across nations with significant geopolitical importance
- Increased Efficiency: Shared data standards and analysis approaches reduce redundant efforts

Key Partners

United States

- NOAA Alaska Fisheries Science Center
- Alaska Department of Fish and Game
- University of Alaska
- North Pacific Fishery Management Council
- Alaska Observing System
- U.S. Integrated Ocean Observation System

Canada

- Fisheries and Oceans Canada (DFO)
- Ocean Networks Canada
- University of British Columbia

- Pacific Salmon Commission
- Canadian Integrated Ocean Observing System

Japan

- Japan Fisheries Research and Education Agency
- Japan Meteorological Agency
- Fisheries Technology Institute
- University of Tokyo

International Organizations

- PICES Secretariat
- North Pacific Anadromous Fish Commission
- Pacific Salmon Commission
- Ocean Health Index team
- Global Observation System

This multinational framework would provide a powerful demonstration of how standardized approaches can work across different national systems while respecting their unique characteristics. It would create a model for eventual expansion to include all PICES member countries in a truly integrated North Pacific ecosystem assessment framework.

Use Case #3: Climate-Adaptive Spatial Conservation Planning in the North Pacific Ocean

Background

The North Pacific Ocean is experiencing significant changes due to climate change, including shifting species distributions, changing productivity patterns, and altered ecosystem dynamics. These changes pose major challenges for effective conservation planning, particularly in Areas Beyond National Jurisdiction (ABNJ), which comprise approximately 64% of the global ocean surface. Traditional static spatial approaches to conservation using Marine Protected Areas (MPAs) and other Area-Based Management Tools (ABMTs) are increasingly insufficient as marine ecosystems undergo rapid transformation under climate change (Bruno et al. 2018). The fixed boundaries of conventional protected areas fail to accommodate the dynamic nature of ocean systems where species distributions are rapidly shifting poleward and into deeper waters in response to warming temperatures (Hobday 2011, Cashion et al. 2020). This spatial mismatch is exacerbated by changes in ocean chemistry, including acidification and deoxygenation, which alter habitat suitability across broad geographic ranges regardless of protection status. Marine species facing these stressors are exhibiting accelerated phenological shifts in migration timing, breeding cycles, and feeding patterns that transcend the temporal management frameworks of static reserves. This ineffectiveness is compounded by extreme climatic events, changing oceanographic conditions, and institutional barriers to adaptive management, necessitating more flexible, anticipatory conservation strategies that respond to ongoing marine ecosystem change rather than attempting to preserve historical conditions.

Frameworks are needed to make marine conservation and management more robust under the increasing pressures of global change and resource needs (Fulton et al. 2015). To date, the MPA planning process considers only a few, if any, aspects of climate change (Jones et al. 2020). Conservation planning in the North Pacific requires consideration of multiple temporal scales—from seasonal variations to multidecadal climate change impacts—and must adapt to ephemeral oceanographic features, climate oscillations, and long-term shifts in ecosystem productivity (Brown et al. 2015, Crespo et al. 2020). Forward-looking protected areas and adaptive or dynamic marine spatial management can help maintain ecological connectivity and provide critical protection and refugia from climate impacts for commercially valuable fish stocks as their ranges shift, ultimately contributing to both biodiversity protection and fisheries sustainability (Arafeh-Dalmau et al. 2023). Existing climate-adaptive MPAs that have demonstrated effectiveness include the Pacific Remote Islands Marine National Monument, which preserves pelagic habitats and migration corridors for commercially valuable tuna and other migratory fish, while safeguarding critical feeding grounds that become increasingly important as climate change alters oceanic productivity. In California, the network of MPAs along the coast was strategically designed to protect larval dispersal pathways, helping marine populations adapt as ocean conditions change (Carr et al. 2017). The integration of robust climate projections from dynamic Earth System Models, climate models, biological/ecological models, and ensemble modelling approaches like the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP) offer a promising avenue to develop more climate-adaptive spatial conservation strategies that can account for future ocean conditions when designing protected areas and other spatial conservation measures (Fulton et al. 2015). Some initial efforts have begun to progress this work, with focus on the North Atlantic oceanic regions (e.g., Palacios-Abrantes et al. 2023), but a focused initiative is needed for the North Pacific region to contribute to the BECI knowledge network.

Issues of Concern

Several key challenges hamper effective climate-adaptive conservation planning in the North Pacific:

- Knowledge gaps in climate impacts on pelagic and deep-sea habitats: Most research on climate adaptation for marine conservation has focused on coastal ecosystems, particularly coral reefs, with insufficient attention to open ocean and deep-sea environments that dominate the North Pacific (Wilson et al., 2020).
- Inadequate consideration of multiple climate stressors: Conservation planning typically considers temperature changes but often fails to address other stressors such as ocean acidification, deoxygenation, and changes in productivity regimes that will have synergistic impacts.
- Conflicting adaptation strategies: The scientific literature presents polarizing advice between protecting only climate refugia versus protecting a diversity of habitats to increase resilience, creating confusion for conservation planners.
- Limited empirical evidence for adaptation effectiveness: Few existing MPAs have incorporated climate adaptation strategies, resulting in uncertainty about which approaches will be most effective in protecting biodiversity under changing conditions.

- Governance challenges for dynamic management: Current governance structures for ABNJ lack mechanisms to implement and monitor dynamic MPAs that can shift boundaries as ocean conditions change.

Objectives

1. Develop a comprehensive framework for climate-adaptive spatial conservation planning in the North Pacific that integrates dynamic oceanographic, ecological and ensemble model projections
2. Create decision-support tools that enable conservation planners to incorporate multiple climate stressors and temporal scales into MPA network design
3. Identify potential climate refugia and high-vulnerability areas in the North Pacific based on ensemble modelling outputs
4. Establish protocols for dynamic and flexible ABMTs that can adapt to changing ocean conditions
5. Build capacity among conservation practitioners and governance bodies to implement climate-adaptive spatial planning approaches

Information/Data

The following types of data and information would contribute to this use case:

Climate Projections

FishMIP ensemble model outputs for the North Pacific under multiple emissions scenarios (SSP1-RCP2.6, SSP2-RCP4.5, SSP3-RCP6.0, SSP5-RCP8.5)

- Sources: ISIMIP, FishMIP contributors, NOMEME (North Pacific Ocean Marine Ecosystem Model Ensemble)

Oceanographic Data

Historical and current data on temperature, salinity, oxygen, pH, productivity patterns

- Sources: NOAA, World Ocean Database, Argo float program, OOI (Ocean Observatories Initiative), Earth System Models (e.g., GFDL)

Species Distribution Data

Current and projected distributions of key North Pacific species

- Sources: OBIS, GBIF, national fisheries research institutions, International Year of the Salmon datasets

Biodiversity Hotspot Information

Locations of ecologically significant areas

- Sources: CBD EBSAs, VME databases, IUCN Red List, migratory species tracking data

Ecosystem Connectivity Data

Larval dispersal pathways, animal migration corridors

- Sources: Animal tracking networks, oceanographic particle tracking models

Existing Protected Area Information

Current MPAs, fishery closures, and other spatial management measures

- Sources: World Database on Protected Areas, Regional Fisheries Management Organizations

Governance Frameworks

Institutional arrangements for ABMTs in the North Pacific

- Sources: BBNJ Treaty, RFMOs, ISA, IMO, regional seas organizations

Proposed Activities & Outputs

Phase	Step	Action	Product(s)
Initial	Data collation and integration	Compile and standardize available FishMIP and other climate model outputs for the North Pacific	BECI Dashboard interactive database of climate projections relevant to conservation planning
	Knowledge network development	Identify and connect key partners across the Pan-Pacific region working on climate-adaptive conservation	Working group on Climate-Adaptive Spatial Conservation Planning with regular webinar series
	Gap analysis	Review existing literature and practice in climate-adaptive MPAs in the North Pacific	Synthesis report on the state of climate-adaptive spatial conservation planning
Intermediate	Methodology development	Develop approaches for incorporating temporal variability at multiple scales into spatial planning	Technical guidelines for multi-scale temporal analysis in conservation planning
	Vulnerability assessment	Assess vulnerability of key ecosystems and species to multiple climate stressors	BECI Knowledge Network Interactive Map: Vulnerability layers for North Pacific ecosystems under different climate scenarios

	Decision support tool development	Create planning tools that incorporate FishMIP outputs into spatial prioritization	BECI Dashboard: Interactive conservation planning platform with climate projection layers
	Case study implementation	Apply framework to selected pilot areas in the North Pacific ABNJ	Case study reports demonstrating application of climate-adaptive planning approaches
Advanced	Dynamic MPA protocol development	Establish protocols for implementing and monitoring dynamic protected areas	Dynamic MPA implementation handbook and governance framework
	Performance evaluation	Monitor and evaluate effectiveness of different climate adaptation strategies	Report on comparative analysis of adaptation strategy effectiveness
	Policy integration	Work with governance bodies to incorporate climate-adaptive approaches into policy frameworks	Policy briefs and recommendations for North Pacific regional bodies and BBNJ process

Expected Outcomes

Implementation of this use case will lead to:

1. Enhanced understanding of climate change impacts on North Pacific marine ecosystems at multiple temporal and spatial scales
2. Improved capacity among conservation practitioners to incorporate climate projections into spatial planning processes
3. More robust and climate-adaptive MPA networks in the North Pacific, particularly in ABNJ
4. Development of innovative approaches to dynamic spatial management that can respond to changing ocean conditions
5. Strengthened science-policy interface for marine conservation governance in the region
6. Greater resilience of protected areas to climate change impacts
7. More effective conservation of biodiversity under changing climate conditions

Key Partners

Data Providers

- FishMIP contributors (global marine ecosystem models)
- PICES (North Pacific Marine Science Organization)
- NOAA (oceanographic and fisheries data)
- OBIS/GBIF (biodiversity data repositories)
- National fisheries research institutions around the North Pacific
- International Year of the Salmon program

Knowledge Contributors

- University research labs studying climate impacts on marine systems
- IPCC Working Group II contributors
- NGOs focused on marine conservation (e.g., Ocean Conservancy, WWF)
- Indigenous knowledge holders around the North Pacific

Implementation Partners

- GIS specialists and spatial conservation planning experts
- Regional Fisheries Management Organizations in the North Pacific
- UN Environment Programme Regional Seas Programme
- BBNJ Secretariat (once established)
- Software developers for conservation planning tools

End Users

- Regional Fisheries Management Organizations
- National conservation and fisheries management agencies
- BBNJ Conference of Parties (once treaty enters into force)
- Conservation NGOs implementing protected area projects
- Marine spatial planners in North Pacific nations

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