Agenda Item 7.3

New Program
on
Predictions of Marine Ecosystem Changes in the Northwest Pacific Ocean

I. Title of proposal, and its timeframe

(Please identify if the proposal will be a program with a timeframe of no longer than eight years, or a project of no longer than four years, or a working group of no longer than four years. In the case of a working group, please refer to the Guidelines for the establishment of WESTPAC Working Groups. The extension of programs/projects/working groups could be made, subject to their deliverables, performance and evaluation results.)

Title: Predictions of Marine Ecosystem Changes in the Northwest Pacific Ocean
The program is scheduled to begin on 1 April 2025 and end on 31 December 2030, with a duration of 5 years and 8 months.

II. Program/project proposer (or working group chair), and recommended members for the program/project steering group (working group), if available

(The Program/Project Steering Group and Working Group shall consist of **ACTIVE members**. Once the new program/project/working group is established, National Focal Points in Member States can recommend additional qualified experts. As soon as the Sub-Commission establishes the new programs/projects/working groups, WESTPAC designated Principal Investigators (PIs)/WG Chairs shall play an important role in the development and implementation, as they are entrusted to coordinate the development of respective WESTPAC programs/projects/WGs, engage relevant stakeholders, and deliver knowledge, tools and results needed to address priority needs of Member States in the region.)

The proposer of the program is Toshio Suga from the Advanced Institute for Marine Ecosystem Change (WPI-AIMEC), located at 6-3 Aoba, Aramaki, Aoba-ku, Sendai, Miyagi 980-8578, Japan.
The recommended members of the steering team are Sayaka Yasunaka, Michio Kondoh, and Takeshi Obayashi from Tohoku University; Michio Kawamiya, Shinya Kouketsu, Sherwood Lan Smith, and Yoichi Ishikawa from JAMSTEC; Niklas Shchenider from University of Hawaii; and Shangping Xie from Scripps Institute of Oceanography.

III. Justifications for this program/project/working group

(Note: This part is extremely important. Please provide detailed justifications as much as possible.)

Global warming has been driving severe and accelerating changes in marine ecosystems, with marine heatwaves, ocean acidification, and deoxygenation among the most intensifying impacts. These changes are already causing widespread ecosystem shifts, threatening biodiversity, fisheries, and coastal communities that depend on ocean resources for their livelihoods. This proposed program titled ‘Predictions of Marine Ecosystem Changes in the Northwest Pacific Ocean’ is not just timely, it is an emergency response to the pressing need for scientific understanding of marine ecosystem’s resilience and adaptive mechanisms amid accelerating changes in marine ecosystems across the Northwest Pacific Ocean. The initiatives directly support the visions and themes of IOC/WESTPAC and the mission of the UN Decade of Ocean Science for Sustainable Development (2021-2030) by addressing the critical knowledge gaps that are essential for immediate and informed decision-making in ocean management.

Through interdisciplinary research approaches, integrating ocean physics, ecology, and data science, this programme will rapidly advance our understanding of climate, ocean, and ecosystem interactions. This knowledge is critical to formulate timely approaches and

sustainable strategies to protect marine environments under climate change and human impact.

With contributions from researchers in the WESTPAC member states, which have densely populated coastlines and significant anthropogenic influences on marine ecosystems, this program will provide valuable scientific insights. Given the Northwest Pacific Ocean's role as a dynamic and highly impacted region (which are in the WESTPAC coverage), this collaborative effort is not just necessary but again urgent to address environmental challenges and support evidence-based marine policies and resource management strategies.
Details are described in the draft Science Action Plan (INF-***).

IV. S.M.A.R.T objectives and expected outputs/outcomes

(Note: The objectives of WESTPAC program/projects/working groups shall be specific, measurable, attainable/achievable, relevant, and time-bound.)

S (Specific): Focus on the predictability of the marine ecosystem change in the Northwestern Pacific from coast to open ocean.
M (Measurable): Number of publications in international scientific journals.
A (Achievable): 50 publications per year in relevant scientific journals.
R (Realistic): Outputs from developments of marine ecosystem modeling and AI techniques.
T (Time Frame): Completion by the end of the program (31 December 2030).

V. Terms of reference of the program/project steering group (or working group)

(For the purpose of guidance and management, WESTPAC encourages each program/project to set up its Steering Group with ACTIVE members. A draft TORs for this Group shall be developed, and submitted for considerations.)

The International Steering Team (IST) for this program will provide guidance and oversight, and make recommendations and report to the IOC Sub-Commission for the Western Pacific (WESTPAC), on the development and implementation of this program.

1. Functions

i. Review and provide inputs to the development of the Science Action Plan and relevant documents and guidelines;
ii. Monitor the progress of the program development, and recommend actions for engagement and resource mobilization to support the program development and implementation;
iii. Facilitate coordination and collaboration among relevant countries and their institutions in the developments and implementation of the program;
iv. Promote the development of new research actions and ensure their outputs/outcomes to be in line with the objectives and relevant operational guidelines;
v. Review and recommend endorsements of new action(s);
vi. Promote and raise awareness of the program, and engage its stakeholders into the development and implementation;
vii. Plan and organize annual IST meetings, workshops, and other relevant events;
viii. Support communications, and provide information to the WESTPAC Office to enable its posting to the WESTPAC Website and reporting or dissemination to IOC and other organizations; and
ix. Submit reports and, if needed, make recommendations to the Sub-Commission and/or its advisory group.

2. Composition and terms

The IST will consist of national representatives nominated by the WESTPAC Member States willing to participate in the program. No more than three representatives could be

nominated from each country with one preferably from national agency closely related to the program, and 1-2 from the research or other relevant communities. Individual experts or other stakeholders could also be invited, if deemed necessary. The WESTPAC officers and the Head of Office will serve as ex-officio members.

The Sub-Commission will seek the nomination once every two years. A member of IST shall serve a two-year term and may be renominated again. The IST will select two co-chairs for a term of two years, with a maximum of three consecutive terms. In case of resignation, inactivity or other issues affecting the work of IST, his/her replacement (substitute) could be recommended by her/his country, and the substitute shall perform the required functions for the rest of the term.

VI. Engagement of relevant stakeholders outside academia

(Please endeavor to outline and engage potential stakeholders of this program/project, if possible. The list of stakeholders could be continuously expanded as the program/project enhances its impacts.)

At present, “None”, however we plan to engage the stakeholders from the governments of member states, such as fishery agencies and other operational agencies as members of the IST for this programmme. Also, citizens supporting this action will also be considered stakeholders.

VII. Main activities to be carried out during its timeframe

- Regular scientific meetings with participating members focused on their regional issues and solutions;
- Publish research findings in leading scientific journals;
- Conduct initiatives to raise awareness about “a healthy and resilient ocean” and engage citizens in activities such as sampling eDNA to establish marine ecosystem mapping;
- Submit the obtained data to the Ocean Data Information System (ODIS) and/or appropriate data systems;
- Provide capacity building opportunities for Early-Career Ocean Professionals (ECOPs); and
- Develop advanced climate-ocean-ecosystem and/or Earth System models for “Predictable Marine Ecosystems”.

VIII. Proposed work plan and budget for 2025 - 2027

(Provide, in tabular form, the action items that should be included in the work plan and budget)

Program/ Project/Working Group	Objectives	Activities	Expected outputs/outcomes	Date and Place	Funding required	
					IOC	Other sources (i.e., from national/international sources)
Predictions of Marine Ecosystem Changes in the Northwest Pacific Ocean	1) Scientific understanding based on marine ecosystem observation data and quantification and formulation required to develop numerical models 2) Develop ESMs that include marine ecosystem processes and provide predictive information	1st IST	Discuss Science Plan	2025 and Sendai	N/A	20K US Dollars from WPI-AIMEC
		Intersessional meetings	Call for New Initiatives	Remote	N/A	
		Symposium and workshop	Science Plan: Identify the Challenges and Solutions	2026 and Yokohama	N/A	40K US Dollars from WPI-AIMEC
		2nd IST	Endorsement of intitives	2026 and Yokohama	N/A	20K US Dollars from WPI-AIMEC
		Intersessional meetings	2nd Call for New Initiatives	Remote	N/A	
		3rd IST	Review of Actions	2027 and somewhere	N/A	20K US Dollars from WPI-AIMEC
		4th IST and workshop	Review of Actions	2028 and somewhere	N/A	20K US Dollars from AIMEC
		5th IST and workshop	Review of Actions	2029/2030 and somewhere	N/A	20K US Dollars from WPI-AIMEC

(DRAFT)

Science Action Plan for Predictions of Marine Ecosystem Changes in the Northwest Pacific Ocean

(Version of February 28, 2025)

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Part 1. Why MECNP?

The marine ecosystem is facing an unprecedented crisis due to climate change and human-induced activities. The urgency of addressing this issue cannot be overstated, as marine biodiversity is under severe threat, with consequences spanning from declining fish stocks to the degradation of coral reefs. The Northwest Pacific Ocean, characterized by significant ecological variability and high biodiversity, is particularly vulnerable. Climate change, ocean acidification, marine heat waves, deoxygenation, and pollution are exacerbating ecosystem degradation at an alarming rate.

The Northwest Pacific Ocean, positioned at the confluence of diverse climatic zones, is one of the most ecologically rich marine environments in the world. However, this region is experiencing substantial environmental fluctuations due to interactions between Arctic, subarctic, subtropical, and tropical oceanic influences. These changes are not only of scientific interest but also have far-reaching societal impacts, affecting fisheries, coastal economies, and global climate dynamics.

International bodies such as the United Nations Framework Convention on Climate Change (UNFCCC), the Conference of the Parties (COP), and the Intergovernmental Panel on Climate Change (IPCC) have emphasized the severe consequences of climate change on marine biodiversity. Already, in regions such as Japan's coastal waters, increasing sea surface temperatures have disrupted nutrient cycling, leading to decreased phytoplankton productivity. Such disruptions have cascading effects, including shifts in fish migration patterns, reduced aquaculture viability, and the loss of critical marine habitats such as coral reefs.

Given these pressing concerns, there is an immediate need for international cooperation to enhance our understanding and prediction of marine ecosystem changes. While science-driven initiatives are crucial, the involvement of multiple nations is essential for achieving meaningful impact. The Marine Ecosystem Changes in the Northwest Pacific Ocean (MECNP) initiative provides an intergovernmental framework that enables various member states to collaborate in predicting and mitigating marine ecosystem disruptions. Through this platform, scientific

advancements will be integrated into a cooperative structure, ensuring that global efforts align towards sustainable ocean management.

Recognizing the growing need for not only marine conservation but also active restoration efforts, MECNP aims to advance scientific understanding and predictive capabilities of marine ecosystem changes. High-accuracy predictions will enable global stakeholders to implement both adaptive and mitigative strategies to protect marine biodiversity and ecosystem services.

Despite recent technological advancements, predictive models for marine ecosystems remain underdeveloped. Current oceanographic observations predominantly focus on physical parameters such as temperature and salinity, while biological indicators, including chlorophyll concentration, dissolved oxygen levels, and biodiversity assessments, require further refinement. To bridge this gap, MECNP will integrate high-precision marine ecosystem observation data into numerical models, ultimately enhancing forecasting capabilities.

By strengthening international scientific collaboration, MECNP will facilitate interdisciplinary research, ecosystem modeling, and data assimilation efforts. Initially, leading marine laboratories will contribute to cross-sectoral studies and marine ecosystem observations in the Northwest Pacific Ocean. As MECNP progresses, researchers from various nations will be invited to participate, ensuring a diverse and comprehensive approach to marine ecosystem prediction. Through this intergovernmental platform, WESTPAC member states can collectively advance scientific knowledge, drive policy-relevant research, and take proactive measures to restore and sustain marine ecosystems for future generations.

Part 2. Objectives, Possible Approaches, and Expected Outcomes

MECNP sets two high-level objectives and envisions outcomes using data and information in the process of achieving the objective or at its endpoint.

<u>Objective 1: Scientific understanding based on marine ecosystem observation data and quantification and formulation required to develop numerical models</u>

Potential approach: The Argo float, a self-supporting automatic observation robot, will be improved to support ecosystem observations while maintaining traditional oceanographic observation methods using ships and moored buoys that have been used up to now. This improvement will enable the acquisition of novel data that has never been obtained before, for e.g., Biogeochemical (BGC) Argo. These data include nutrient and light environment data linking ocean physics and marine ecosystems, as well as data on the abundance of zooplankton and phytoplankton that make up lower-order marine ecosystems. These floats will be deployed to the Northwest Pacific Ocean to elucidate the ocean stratification structure, nutrient supply to the ocean surface, and ocean responses. In addition, we will assess ecosystem responses using spatio-temporal variation analyses of environmental analysis (e.g., eDNA) to understand the diversity, abundance, and migration pathways of higher organisms in the ecosystem food chain, and the biological response at the genetic level. This kind of sampling will be expanded from riverine and coastal areas to the North Pacific surface layer to accelerate the collection of data on ecosystems in both quantity and quality. The development of these instruments and methods will provide accurate and abundant data for climate-ocean-ecosystem model and/or Earth System Model (ESM) development. These approaches are not exhaustive, and MECNP remains open to adopting and integrating additional methodologies to enhance its scientific and predictive capabilities.

<u>Objective 2: Develop ESMs that include marine ecosystem processes and provide predictive information</u>

One approach: Develop an advanced ESM that integrates a marine ecosystem model to represent the adaptive capacity of plankton communities in the Northwest Pacific. Based on the understanding that the biodiversity and adaptive capacity of plankton communities have co-evolved, MECNP challenges to model the interactions of plankton communities and their responses to environmental changes. The approach is not limited to the previously mentioned method, as MECNP continues to explore additional innovative methods.

Expected Outcomes:
Several kinds of outcomes are expected from the provision of observational data and predictive models. These will include, for example, the development of the BGC Argo and the observation data to reveal heretofore unknown aspects of marine ecosystems in the Northwest Pacific Ocean using the Argo, eDNA data for the coastal regions of Japan and the Northwest Pacific Ocean, the creation and publication of an advanced numerical models that includes marine ecosystem processes, and numerical model data. The expected outcomes will lead to some practical applications, such as enabling fishermen to use the predictions for more efficient fishing practices, facilitating fisheries management at local, national, and regional levels to realize sustainable fisheries, and enhancing the integration of marine ecosystem mechanisms into the ESMs to provide more reliable projections of future climate change, with more detailed information about likely impacts (e.g., to fisheries) at finer resolution, and thus contribute to global warming countermeasures. As MECNP continues to adopt open approaches and explore innovative methods, additional outcomes are expected, further advancing our ability to predict and manage marine ecosystem changes effectively.

Part 3. Knowledge Gaps in MECNP

3.1 Understanding marine life and the biogeoscience field in the Northwest Pacific - Resolving data shortage on marine ecosystem

To effectively predict marine ecosystem changes, it is critical to address the significant shortage of biological data, particularly from deeper ocean regions. While physical-chemical data are well-documented, data on marine organisms remain scarce. MECNP will prioritize the collection of high-quality biological data in the Northwest Pacific to fill this gap and support robust ecosystem modeling.

The collection of biological data will be carried out, e.g., through the expansion of Biogeochemical (BGC) Argo float deployments, focusing on surface layers while extending to deeper waters. For ecological data such as eDNA, sampling will begin in coastal areas and gradually expand into deeper oceanic layers. Additionally, physical oceanographic observations will be enhanced, for instance, by integrating OneArgo program to collect critical biological and environmental data. These efforts will improve our understanding of marine biodiversity dynamics and their variability in response to environmental changes.

There is a wide range of gaps for WESTPAC member states to collaborate by contributing their expertise and resources in biological data collection, sharing regional datasets, and participating in joint expeditions for marine sampling. Countries with advanced marine observation capabilities can support developing nations through capacity-building programs, ensuring that all members benefit from the collective effort.

3.2 Understanding the interactions between ocean physics and marine ecosystems - A new approach to understanding the interactions between complex ecosystems and physical processes

The limited availability of marine ecosystem data has hindered the ability to fully understand the interactions between ocean physics and marine ecosystems. MECNP aims to advance

research into how environmental changes impact biodiversity, species abundance, and migration patterns at multiple biological levels, from communities to genetics.

One possible method for this purpose is the inverse estimation of marine ecosystem variability. The correlation between short-term cyclic fluctuation patterns with numerical oceanographic data and dynamic stability indices of biodiversity and functionality will be analyzed using mathematical and data science techniques that incorporate machine learning to enable inverse estimation of ocean ecosystem fluctuations. The development of isotope measurement techniques for biopolymer constituent elements will also be an important method. In laboratory settings, a culturomics approach will be applied to nucleic acid molecules from eukaryotic and prokaryotic organisms, viruses, and residual DNA to reveal the periodic behavior modes of the marine physical environment and the potential responses/adaptations of marine ecosystems to deviating events at the gene expression and metabolite levels. By focusing on genomic plasticity related to horizontal gene dissemination through extracellular DNA and vesicle-cell-virus interactions, along with isotope fractionation effects and elemental conversion rates generated by organisms' respiratory metabolism, we will use environmental genomics, proteomics, biogeochemistry, and isotope geochemistry analytical approaches to investigate the ocean. These will help elucidate the stability and adaptability of the ecosystem as a whole, and potential feedback functions on the global environment that act from the ecosystem side.

Furthermore, as a correlation analysis between short-period fluctuation patterns, numerical data, and dynamic stability indices of biodiversity and functionality, it is necessary to understand how variability in the physical environment affects marine ecosystems and leads to maintenance and changes in productivity in order to predict the future with a quantitative understanding of the relationship between environmental changes and productivity. Achieving this requires a thorough understanding of the mechanisms by which physical environmental disturbances affect marine ecosystems and result in shifts in productivity. For this objective, we will utilize spatiotemporally dense oceanographic data and culturomics experimental data that account for biological response processes. Through linear and nonlinear systems analysis, we aim to elucidate the stability and adaptability of the marine ecosystem as a whole, as well as potential feedback functions on the global environment acting on the ecosystem side.

There are a wide variety of gaps for WESTPAC member states to collaborate by conducting regional studies that analyze the effects of oceanographic changes on marine biodiversity from coastal to open ocean region. Joint research initiatives can be developed to assess how different climate conditions influence marine species across various regions, strengthening a more comprehensive understanding of ecosystem dynamics on a global scale.

3.3 Assimilation into the EMS model and formulation for implementation into the model

Regarding the development of marine ecosystem change models, an advanced marine ecosystem module will be installed in the ocean general circulation model through international collaboration. Using oceanographic and experimental data, we will reproduce observed environmental fields and validate the model system to quantitatively understand the causal relationships between ocean environmental changes and ecological changes over decadal time scales. To further predict nonlinear phenomena (e.g., sudden blooming, occurrence of mutant species of rare species that can adapt to the environment), we will employ AI and machine learning techniques to conduct prediction and reproduction experiments. AI application methods for these purposes will be developed through collaborative efforts. Ultimately, the project aims to make future projections of variables related to human well-being, such as fishing activities and carbon dioxide emission control, understand the interactions of environmental and societal factors, and make projections of how those coupled, complex systems are likely to evolve in the future.

WESTPAC will play a crucial role in the development and validation of these models by contributing regional climate and oceanographic data, engaging in cross-national modeling efforts, and ensuring that the predictive tools are applicable across diverse marine environments. Additionally, collaborative AI and machine learning research will be conducted to improve prediction accuracy and model reliability.

Part 4. Action Framework

4.1 International Framework

The MECNP will stimulate, harness, facilitate, and coordinate the development of inter- and multi-disciplinary ocean research to generate data, information, and knowledge essential for achieving its objectives and societal outcomes. It will establish an international cooperative framework for participating countries, ocean research institutions, and other stakeholders to advance ocean science and technological innovations, leverage resources and research infrastructures, and strengthen partnerships.

The program will invite research institutions and universities to actively participate in this initiative from its inception. Leveraging the strengths of the institutions and universities will enable pioneering interdisciplinary research on rapidly changing climate-ocean-ecosystems, including the acquisition of data at the global scale (e.g., Northwest Pacific, Northwest Atlantic, and polar oceans), not limited to the Northwest Pacific Ocean, and drive global-level studies. The ultimate goal of the project is to scientifically elucidate the mechanisms governing marine ecosystem responses and adaptations and develop informative projections of their likely changes in the future.

After this program is launched, together with the WESTPAC Office, a broader call for participation will be issued to various countries, including WESTPAC member states, to involve a wider range of researchers, research institutions, universities, relevant stakeholders, communities, and the public in order to establish an international joint research framework for ecosystem change forecasting with a focus on the Northwest Pacific.

Participants and stakeholders of this project will be invited to workshop meetings in 2026 and 2028. These workshops will report on research activities, identify problems, discuss ways to improve, and determine the direction of activities for the remainder of the year (2027), with a final presentation and discussion scheduled for 2030. Member states will collaborate by contributing expertise, resources, and research infrastructure. The MECNP will focus on the Northwest Pacific Ocean as its main research area and will promote international research collaboration by sharing findings globally and obtaining input on analyses from leading international research institutions and universities that have participated in this program since its inception. This will promote international research cooperation and establish a more robust international research collaboration system. The actual research areas to be covered will be expanded along with the activities of the UN decade program.

Given its large geographic coverage and ambitious objectives, MECNP will embody a number of initiatives-MECNP Actions. The MECNP Actions will cover a wide range of marine ecosystem research, such as ocean observations, remote sensing, modeling, data analysis, and predictability studies. To achieve its societal outcomes, MECNP has been and will be continuously co-developed with various stakeholders interested in and/or benefiting from the study of understanding the response and adaptation mechanisms of marine ecosystems.

4.2 Engagement of MECNP Initiatives/Projects

To achieve its objectives and societal outcomes, MECNP will be underpinned by a number of initiatives addressing different aspects of the response and adaptation mechanisms of marine ecosystems. These initiatives will be developed and carried out by a wide range of stakeholders, including but not limited to governmental agencies, research institutions, international organizations/programs, and the education sector.

The request for endorsement of MECNP initiatives will be made via periodic calls for MECNP initiatives to ensure alignment of the proposed initiatives with the MECNP objectives and societal outcomes.

4.3 Implementations and Collaborations of MECNP Initiatives/Projects

The MECNP workshops, which will be held in 2026, 2028 and 2030, serve as one key means of implementation. It provides opportunities for discussions among, but not limited to, various MECNP initiatives to share generated knowledge, review progress, and explore synergies and possible areas of collaboration and partnerships. It will also be open to any partners interested in contributing to the MECNP.

4.4 Collaborations with Stakeholders

The success of MECNP hinges on its ability to address the needs of the stakeholders. The MECNP key stakeholder groups cover a diverse range of communities, including academia and scientific communities; national government agencies responsible for meteorology, fisheries, aquaculture, and disaster risk reduction; business and private sectors; local communities, education sectors, and the general public. Therefore, it is essential to get them engaged in the development process of MECNP. Information and knowledge generated through MECNP should be shared and discussed with relevant stakeholders and translated into accessible formats that could be used to serve their purposes.

4.5 Data and Information Management

Data and information generated from MECNP will be the cornerstones to achieving its objectives and societal outcomes. The MECNP will adopt the IOC Oceanographic Data Exchange Policy (see Annex I) and further formulate its data and information management plan in line with the FAIR data principles.

4.6 Capacity Development

Capacity development forms an integral part of the MECNP, given the disparity in research capacity across generations, genders, and countries in the region. Having a multinational collaborative program provides a perfect opportunity for students and early career researchers to advance their knowledge and spirit of cooperation. Participation in the research activities across different research groups will provide exposure to diverse cultures, technologies, and operating procedures. Regular scientific symposia to exchange results and ideas will be scheduled. Opportunities for student scholarships and exchange visits will be explored with member states and institutions.

Part 5. Coordination and Governance

Achieving the MECNP objectives and societal outcomes requires coordination at regional and international levels among member states and their institutions. It also necessitates a co-design and co-delivery process with ocean stakeholders such as government agencies, private companies, educators, and citizens.

After this program will be registered a the UN Decade Action Programm, a Support Office for the Programme will be established as a MECNP Support Office. This office will have experts who, in collaboration with the WESTPAC Office, will coordinate the research and administrative works of stakeholders in each participating country and play a central role in organizing the MECNP workshops meetings and the other important meetings such as international symposia.

An International Steering Team (IST) for the UN decade program MECNP will be established with a mandate to provide guidance and oversight, make recommendations, and report to the IOC Sub-Commission for the WESTPAC on the development and implementation of MECNP. The IST will consist of national representatives and experts from national agencies closely related to research or other relevant communities. The IST will conduct their business in accordance with the Terms of Reference attached as Annex III.

The WESTPAC Office as the Decade Coordination Unit will act as the primary coordination unit for MECNP and as the Secretariat for the IST. The establishment of MECNP Support Offices will be explored with participating countries and/or their institutions. The Support Offices are legally separated from the UNESCO and its IOC, and operated under the responsibility of the host countries or entities. They will provide scientific and administrative support to relevant MECNP action(s) in cooperation with the WESTPAC Office.

As the MECNP will be continuously developed to accommodate emerging needs and changes over its timespan of nearly five years, a reporting and monitoring process will allow rapid identification of and response to those needs and changes. Each MECNP action will be required to submit annual reports, in a succinct manner, on its progress, outputs, and achievements. The IST will review, from time to time, the progress of all MECNP actions, provide recommendations for further development, conduct comprehensive evaluations of MECNP development, and eventually make necessary revisions or adjustments to the Science Action Plan.

ANNEX I to IV (To Be Attached)

Annex I: Endorsement Criteria for MECNP Actionss (Draft)
Annex II: Proposed MECNP Actions (But Not Limited to)
Annex III: Draft Terms of Reference for the International Steering Team on MECNP
Annex IV: Data and Information Management Plan for MECNP (To Be Developed Later)

Annex I: Endorsement Criteria for MECNP Actions

1. Accelerate the generation of knowledge regarding the adaptation mechanisms of marine ecosystems and development of ocean-climate-ecosystem model and advanced ESM for marine ecosystem changes, and contribute to fulfilling the UN Ocean Decade Challenges,
2. Contribute to the achievements of MECNP objectives: (1) Scientific understanding based on marine ecosystem observation data and quantification and formulation required to develop numerical models and (2) develop numerical models that include marine ecosystem processes and provide predictive information,
3. Strive to "co-design and co-deliver" the project with relevant stakeholders to facilitate the uptake of MECNP science and knowledge for societal needs,
4. Provide a feasible implementation plan, including a list of project implementation partners, liaise with IST, and communicate about the project progress, and
5. Ensure that data and resulting knowledge are shared and stored in alignment with the MECNP data and information management plan.

Annex II: Proposed MECNP Actions (But Not Limited to)

There are four actions/activities within a five-year period that could compose the substances of the MECNP (but not just these). All information provided is as of January 2025 and subject to change. The Principal Investigators (PIs) and contributors for each MECNP action are listed in the respective sections and just candidates.

1. Climate-Ocean-Ecosystem Interactions

The North Pacific is one of the most advanced regions in the world in terms of research on the variability of the ocean environmental field, ranging from decadal scales to seasonal cycles, thanks to observation projects over the past 30 years. In this research and development, detailed information on environmental change processes over this broad spatio-temporal scale will be integrated with environmental genome (eDNA) information, biogeochemical data, and genome-level plasticity and adaptive evolutionary process data. We will extract hierarchical patterns of temporal and spatial variability in daily to decadal-scale changes and elucidate the linkages among spatio-temporal scales and variables using statistical methods and machine learning.
PIs: Sayaka Yasunaka, Niklas Schenider, and Shang-ping Xie

2. Assessment of Marine Ecosystem Dynamics and Adaptation/Response

Marine microbial ecosystems, which are responsible for basic surface production, have a direct impact on the diversity, abundance, and translocation pathways of higher organisms within the ecosystem food chain. In ecological theory, changes in interactions between species in an ecosystem occur on much shorter time scales than between generations, and the aggregation of these changes influences large-scale community-level ecosystem change. Tohoku University has conducted eDNA monitoring (ANEMONE) along the coast of Japan for more than 10 years, established ecosystem dynamic stability indices, and successfully assessed community- and interspecies-level ecosystem responses to seasonal environmental variables. In this study, we

will expand the applications of eDNA spatio-temporal variability analysis to the North Pacific Ocean. This expansion will maximize the use of the fixed station at the University of Hawaii, oceanographic survey opportunities provided by JAMSTEC, and on-site eDNA collection and analysis devices developed in collaboration with private companies. The scope of application of eDNA spatio-temporal variability analysis will extend from the riverine and coastal areas to the North Pacific Ocean, with ecosystem dynamic stability indices applied to assess community- and interspecies-level ecosystem responses to seasonal environmental variables. The correlation between short-period fluctuation patterns with numerical oceanographic data and dynamic stability indices of biodiversity and functionality will be analyzed using mathematical and data science methods incorporating machine learning. These analyses aim to enable inverse estimation of ocean ecosystem fluctuations and provide advanced prediction of such fluctuations.
PIs: Michio Kondo and Takeshi Obayashi

3. Development of AI Applications for the Prediction of Nonlinear Phenomena

Significant unknowns remain regarding the occurrence and propagation of rare and mutant species that can adapt to the environment, the mechanism of sudden blooming at the community, individual, and molecular levels, and the potential plasticity of ecosystems due to changes in genome and protein functionality. To efficiently link information from sparse ecological data according to high-density physical observations and the processes in the model, we will develop a model that simulates the dynamic response of interactions between biodiversity and the physical and chemical environment. Prediction and reproduction experiments will also be conducted using AI, including machine learning. In these experiments, in addition to the forecasting dataset that includes an evaluation of forecasting accuracy, variables related to human activities, such as fishing activities, will also be forecasted, aiming for dynamic forecasting of a system where the environment and society interact and evolve.
PIs: Shinya Kouketsu and Yoichi Ishikawa

4. Advanced Marine Ecosystem Change Modeling

The ocean general circulation model developed by JAMSTEC covers the entire ocean and can reproduce the ocean's physical environment with a horizontal resolution of 0.1° (about 10 km) with a certain degree of representation of medium-scale eddies. By incorporating into this model the latest marine ecosystem module, which captures the dynamic eco-physiology of phytoplankton and thereby better reproduces observed distributions of chlorophyll and carbon-based primary production, as well as the composition (carbon:nutrient ratios) of organic matter, this research and development effort aims to comprehensively understand the material cycles that emerge from the interactions between the ocean's physical environment and its ecosystems. Methods to translate marine biodistributions into functions for material cycling and climate formation will be developed to understand and predict changes in ocean material cycling and productivity and feedback mechanisms to climate. Furthermore, to quantitatively understand the causal relationship between real decadal-scale ocean environmental and ecological changes, we will reproduce environmental fields and validate the system by assimilating actual observed data and experimental data. Advanced time-series analysis (Empirical Dynamic Modeling) will also be applied to observations and model outputs in order to identify causal relationships and assess the predictability of observable model outputs such as chlorophyll concentrations and rates of primary production in terms of carbon. Initial analyses will examine seasonal variations, and then be expanded to inter-annual time scales. The decadal-scale variability is important for predicting the near future of the ocean, and we aim to deepen the integrated understanding of uncertainties and improve the accuracy of predictions.
PIs: Sherwood Lan Smith and Michio Kawamiya

Annex III: Draft Terms of Reference for the International Steering Team on MECNP

The International Steering Team (IST) of MECNP will provide guidance and oversight, make recommendations, and report to the IOC Sub-Commission for the Western Pacific (IOC/WESTPAC) on the development and implementation of the MECNP program.

Functions

i. Review and provide inputs to the development of the Science Action Plan and relevant documents and guidelines;
ii. Monitor the progress of the program development and recommend actions for engagement and resource mobilization to support the program development and implementation;
iii. Facilitate coordination and collaboration among relevant countries and their institutions in the development and implementation of the program;
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vii. Plan and organize annual IST meetings, workshops, and other relevant events;
viii. Support communications and provide information to the WESTPAC Office to enable its posting to the WESTPAC Website and reporting or dissemination to IOC and other organizations; and
ix. Submit reports and, if needed, make recommendations to the Sub-Commission and/or its advisory group.

Composition and Terms

The IST will consist of national representatives nominated by the WESTPAC Member States willing to participate in MECNP. No more than three representatives could be nominated from each country, with one preferably from a national agency closely related to MECNP activities and 1-2 from MECNP research or other relevant communities. Individual experts or other stakeholders could also be invited as deemed necessary. The WESTPAC officers and the Head of the WESTPAC Office will serve as ex-officio members.

The WESTPAC will seek the nomination once every two years. A member of IST shall serve a two-year term and may be renominated for no more than three consecutive terms. The IST will select two co-chairs for a term of two years, with a maximum of three consecutive terms. In case of resignation, inactivity, or other issues affecting the work of IST, his/her replacement (substitute) could be recommended by her/his country, and the substitute shall perform the required functions for the rest of the term.

Meetings

The IST will meet at least once per year to fulfill its functions. Specific sub-groups may be established and mandated for conducting technical tasks as decided by the IST. These technical working groups may meet as often as required by their members.

Secretariat Support

The WESTPAC Office will assume the secretariat function at the regional level, acting as the primary coordination unit for MECNP and as the Secretariat for the IST. Decentralized secretariat support at the project level will be encouraged. These structures shall have well-defined mandates which are developed in close consultation with the WESTPAC Office.

Annex IV: Data and Information Management Plan for MECNP

(To Be Developed Later)