

Review

25 years of PICES - A trajectory of the international cooperation on marine science in the North Pacific Ocean

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Introduction

PICES, the North Pacific Marine Science Organization, is an intergovernmental scientific organization. It was established in 1992 to promote and coordinate marine science in the northern North Pacific and adjacent seas. The current PICES member countries are Canada, China, Japan, Korea, Russia, and the United States.

Since its establishment, PICES has conducted studies to understand the influence of environmental variability on marine ecosystems and fishery resources, and has been a leader in fisheries oceanography in the North Pacific Ocean. On the North Atlantic side, ICES, the International Council for the Exploration of the Sea, founded in 1902, was used as the template in creating PICES. PICES is the nickname of Pacific ICES [1,2].

In this report, we will review the role of PICES for the past 25 years and look at its future direction.

Role and function

Objectives and scientific activities

The objective of PICES upon its establishment was to promote the development of cooperative research and exchange of information concerning (1) the North Pacific marine environment and its interactions with land and atmosphere, (2) uses of the North Pacific and its living and non-living resources, and (3) the effects of human activities on the quality of the marine environment [1].

To deal with this objective, PICES has formed four scientific committees on physical oceanography and climate (POC), biological oceanography (BIO), fisheries science (FIS), and marine environmental quality (MEQ), and two technical committees on data exchange (TCODE) and monitoring (MONITOR). The organization promotes collaboration between its member countries through scientific sessions and committee meetings at annual meetings, and through inter-sessional symposia and workshops.

The Carrying Capacity and Climate Change

(CCCC) program was the first integrative scientific program of PICES implemented from 1995 to 2009. CCCC's aim was to forecast the influence of interannual and decadal variability in ocean conditions on the species dominance, biomass, and productivity of the key zooplankton and fish species in the North Pacific Ocean [3]. CCCC greatly encouraged comparative studies on ecosystem structure and function between the sub-regions of the PICES area shown in Fig. 1 [4]. The results were published in 2004 as "Marine Ecosystems of the North Pacific" for reporting the ecosystems' status and trends, and this assessment is expected to continue.

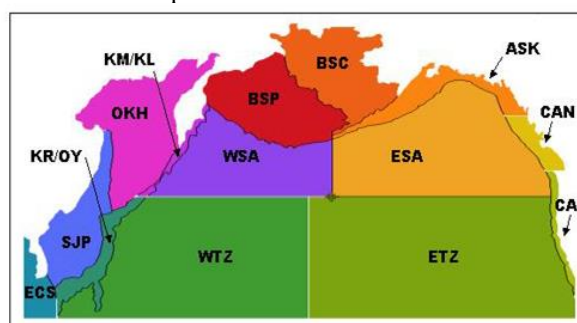


Fig. 1. Sub-regions in the PICES area (north of 30°N and including the marginal seas of the North Pacific Ocean): ASK - Gulf of Alaska Continental Shelf; BSC - Bering Sea Continental Shelf; BSP - Bering Sea Pelagic; CAN - California Current North; CAS - California Current South; ECS - East China Sea; ESA - Eastern Subarctic; ETZ - Eastern Tropical Zone; KM/KL - Kurile Islands Region; KR/OY - Kuroshio/Oyashio Region; OKH - Sea of Okhotsk; SJP - Sea of Japan; WSA - Western Subarctic; WTZ - Western Tropical Zone.

Cooperation and capacity building

To promote marine science, PICES actively cooperates with global (such as Intergovernmental Oceanographic Commission (IOC)) or regional (such as ICES) scientific organizations and programs beyond the PICES area. PICES also works with fisheries management organizations in the Pacific region such as the North Pacific Anadromous Fish Commission (NPAFC), to support their scientific activities. In addition, PICES stimulates capacity building to help

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developing Pacific Rim countries to improve their ability to deal with marine environmental issues [5].

Supporting university students and early career scientists is also an important capacity building role of PICES. The organization finances their participation to its annual meetings and symposia sponsored by PICES, holds regular PICES summer schools and early career scientist conferences with ICES, and co-sponsors training programs with other organizations, programs and member countries [5].

The major activities of PICES associated with Japan for the past 25 years are summarized in Table 1.

Table 1. Major activities of PICES associated with Japan 1992 to 2016

Year	Major activities
1992	PICES is established with Canada, China, Japan, USA 1 st Annual Meeting (Victoria, Canada)
1994	3 rd Annual Meeting (Nemuro, Japan), Russia joins PICES-GLOBEC Workshop (Nemuro, Japan)
1995	Korea joins. CCCC starts. TCODE is established 9 th Annual Meeting (Hakodate, Japan)
2000	PICES/NPAFC Joint Workshop on “Factors affecting production of juvenile salmon and climate” (Tokyo, Japan) 10 th Anniversary (Victoria, Canada)
2001	Science Board Symposium on “Ten years of PICES science: Decadal-scale scientific progress and prognosis for a regime shift in scientific approach”
2004	MONITOR is established
2006	15 th Annual Meeting (Yokohama, Japan)
2007	PICES/ICES First Conference for Early Career Scientists (Baltimore, USA)
2008	PICES Summer School on “Biomass-based management” (Hakodate, Japan)
2010	PICES/ICES/FAO Symposium on “Climate Change Effects on Fish and Fisheries” (Sendai, Japan) PICES/MAFF - IOC/WESTPAC Workshop on “Rapid Assessment Survey methodologies for detecting marine non-indigenous species” (Phuket, Thailand)
2011	21 th Annual Meeting (Hiroshima, Japan)
2012	PICES/ICES Second Conference for Early Career Scientists (La Palma, Spain) NPAFC Symposium on “Pacific salmon and steelhead production in a changing climate: Past, present, and future” (Kobe, Japan/PICES, FRA, more)
2015	25 th Anniversary (San Diego, USA)
2016	Science Board Symposium “25 Years of PICES: Celebrating the Past, Imagining the Future”

Relation with Japan

Since the establishment of PICES, Japanese scientists from agencies and academia have enthusiastically participated in its various activities, including the CCCC program, and have contributed to many PICES accomplishments, including the development of the NEMURO family of models. In addition, since 2007, the Japanese government has contributed financially to the PICES projects on capacity building in Pacific Rim developing countries.

In particular, the project “Marine Ecosystem Health and Human Well-Being” (2012-2017) has aimed to improve the capacity of sustainable fisheries management in the Asian region where small but diverse fisheries coexist.

Immediately after the Great East Japan Earthquake in 2011, PICES and ICES provided a donation to support the researches in the disaster area. At the PICES annual meeting in 2012, a special session was convened and extensive discussion took place on the diffusion of radioactive chemicals, radioactive contamination in marine organisms, and impact of the tsunami on fisheries and ecosystems. In addition, PICES conducted the project “Assessing the Debris - Related Impact From Tsunami” (2014-2016), with financial support from Japan. The project’s aim has been to examine the behavior and potential impact of the tsunami debris on the ecosystems of the North Pacific [5].

Future perspective

Global environmental changes such as global warming and ocean acidification are definitely proceeding even in the North Pacific Ocean [6]. In addition, new threats to marine ecosystems such as pollution by marine litter, including microplastics, are becoming obvious [7]. In order to ensure the sustainability of marine ecosystem services in the future, it is necessary to establish a mutual support relationship between the marine ecosystem and human socioeconomic activities.

Since 2009, PICES has been implementing a new integrative scientific program called FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystem). This program is particularly focusing on human dimensions in ecosystem conservation and fisheries management [5]. Traditional approaches in Japan, such as the co-management system by fishermen and “*Sato-umi*” concept in coastal communities are good examples of human activities harmonized with marine ecosystems, and are expected to contribute greatly to the future discussions in PICES.

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