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# 1. Kuroshio Science as a Multi-Disciplinary Science and its Network in the Kuroshio Region

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## 1. Kochi and Kuroshio Region as our Field for Research and Education

Kochi Prefecture, the old name of “Tosa”, is located at the south of Shikoku Island and has a spatial expanse of 190 km from east to west and 166 km from north to south (Figure 1). The coastline extends over 700 km. Because of its geographic features represented by the complicated topography and the warm Kuroshio Current, Kochi is blessed with a variety of natural recourses and environments under the warm climate.

Regarding to the topography of Kochi, the difference in elevation reaches to six to seven kilometers from the bottom of Nankai Trough to the top of the Shikoku Mountains within a horizontal distance of some 200 km. The south of the prefecture faces the Tosa Bay and the Pacific Ocean. Toward the ocean, the submarine topography descends sharply from a continental shelf (100 to 150 m in depth) to an oceanic basin (800 to 1100 m), and finally down to Nankai Trough (4000 to 5000 m). The latter is a subduction zone of the Philippine Sea Plate beneath the Eurasian plate. The terrains of the ocean floor are complicated by the formation of canons, banks and hills. Meanwhile, the north of Kochi is surrounded by the Shikoku Mountains, extending west and east. It has been formed by the upheaval of the accretionary prism due to the subduction of the Philippine Sea Plate beneath the continental Eurasian Plate. The elevation reaches to 1000 to 1900 m above sea level. As a result, 89% of Kochi Prefecture is mountainous with steep and undulating topography while flat lowlands are limited in the south. Many rivers originate from the mountains and rapidly flow down into Tosa Bay.

The Kuroshio Current is a warm current which succeeds the North Equatorial Current flowing westward. The Kuroshio Current changes its course to the north at the eastern sea area of the Philippine Islands and “runs” along Taiwan and then the south coast of Japanese Islands. The word “run” suits the Kuroshio Currents because the “flow” velocity reaches four knots (about 2.1 m/s) at the maximum. The sea surface temperature of the current is around 30°C in the summer and almost 20°C even in the winter, bringing a warm climate to Kochi.

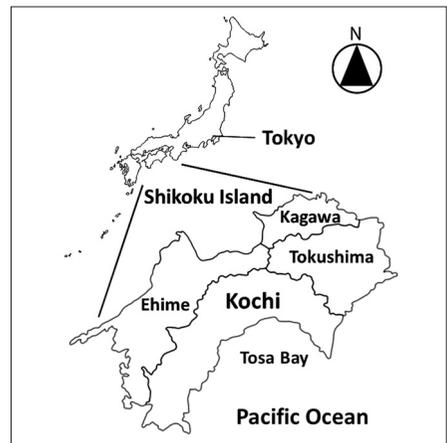


Figure 1 Location of Kochi Prefecture.

Owing to diverse environments with a warm climate, Kochi is really rich in natural resources and has been prosperous for agriculture, forestry and fishery. In addition to a variety of fish, the important components of the marine resources are coral reefs and migratory fish from the tropics and subtropics as well as whales (mainly *Balaenoptera brydei*). The representative in fishery is bonito (*Katsuwonus pelamis*; Katsuo in Japanese). Its seared slice is quite famous as *Katsuo no Tataki*, a traditional food of Kochi. Terrestrial ecosystems are also diverse with vegetation shifting from warm-temperate forest up to subarctic forest with increasing elevation. Despite the current depression, forestry used to be one of the core industry until 1960, of which vestige still remains in the current statistics: the forested land accounts for 84% of total land, for which 65% is artificial. Both figures are the highest in Japan. In terms of agriculture, because of its warm climate with abundant precipitation and long daylight hours, Kochi used to be famous for double cropping of rice and is currently for year-round greenhouse horticulture of vegetables and flowers.

Steep and undulating Shikoku Mountains is the natural boundary with the other prefectures in Shikoku Island (Ehime, Kagawa and Tokushima in Figure 1). Historically, the mountains and a lot of rapid streams have been traffic barriers not only to the outside but also the inside of Kochi, resulting in the formation of unique and colorful communities, societies and cultures throughout Kochi. This is true even in today despite the development of infrastructure and transportation network. Upon typhoon and heavy rains, Kochi often comes to an inaccessible land due to closing highway and suspending railway and airway.

Nowadays, because of its unfavorable location remote from metropolitan and industry areas and the difficulties in daily life in the mountainous areas, Kochi suffers from the current issues related to depopulation and aging population, causing increasing abandoned farmlands and poorly-managed artificial forest patches. These issues have become serious in Kochi, especially among mountainous areas, prior to urban prefectures.

## 2. Birth of Kuroshio Science and Kuroshio Region

While Kochi possesses the peculiar geographical characteristics with diverse, rich environments and resources, it has been regarded as the “advanced” region of the current social issues as mentioned above. In this context, a new study concept and methodology should be required to understand and deal with the entangled issues involving sustainable usage, management and conservation of natural resources and environments which can be compatible with the security of daily life, society and culture for us and for the future generation. Thus, in 2004, Kochi University established a three-years doctoral course of Graduate School of Kuroshio Science and this was the birth of a multi-disciplinary science “Kuroshio Science”. In 2008, the graduate school was reorganized into Kuroshio Science Program upon the integration of six master and three doctor postgraduate schools into one Graduate School of Integrated Arts and Sciences.

Thus, the Kuroshio Science is defined as a new type of a multi-disciplinary science in which various scientists from social

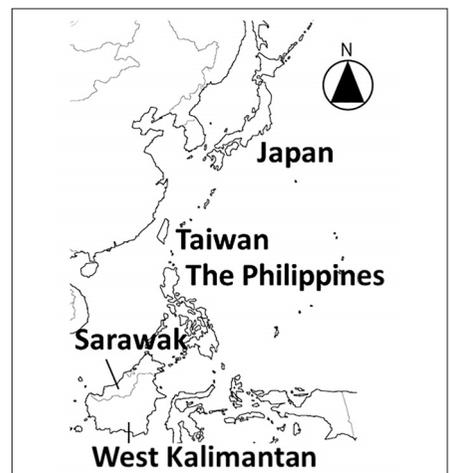


Figure 2 “Kuroshio Region” and the research network for “Kuroshio Science”.

sciences to natural sciences cooperate closely to analyze and solve various issues from natural resources to human societies and from marine to terrestrial ecosystems, which are often combined together to come out. In the linkage of Kuroshio Current, Southeast and East Asian regions, especially the Philippines, Taiwan and Japan, can share or contrast their own issues. There are also various kinds of issues arising across national borders to be challenged or tackled. Thus, this region is defined as “Kuroshio Region” which “Kuroshio Science” would be mainly concerned with and applied to (Figure 2).

### 3. Research Network in the “Kuroshio Region”

Being “Super Regional University”, Kochi University has been playing a prominent role in regional development in Kochi Prefecture. The university emphasizes on nurturing human resources who not only contribute to regional societies but also can be the linking bridge between the region and the world, advocating “From the Region to the World, From the World to the Region”. This policy is reflected by 94 Memorandum of Understandings (MOUs) with overseas universities and institutions for international exchanges in education and research. Since the establishment, the Graduate School of Kuroshio Science and the present Kuroshio Science Program have been keen to international exchanges and collaborations with the universities and institutes in the Kuroshio Region. We concluded the first MOU with University of the Philippines in 2005, followed by the MOUs with four universities and one institute in the Philippines (Table 1). The partnerships with MOU have been extending to two universities in Taiwan, one in Malaysia and one in Indonesia.

Table 1 The universities and institute having MOU with Kuroshio Science Program

Year	Name of university or institute	Location
The Philippines		
2005	University of the Philippines	Quezon City, Metro Manila
2006	Bicol University	Province of Albay
2007	Bureau of Fisheries and Aquatic Resources 2 (BFAR2)	Province of Cagayan
2017	Partido State University	Province of Camarines Sur
2019	Catanduanes State University	Province of Catanduanes
2020	Batangas State University	Province of Batangas
Taiwan		
2007	National Sun Yat-sen University	Kaohsiung City
2013	National Dong Hwa University	Hualien County
Malaysia		
2009	University of Malaysia, Sarawak	Kota Samarahan, Sarawak
Indonesia		
2010	Tanjungpura University	Pontianak, West Kalimantan

In order to establish and develop the “Kuroshio Science”, we launched a journal “Kuroshio Science” in 2007 and continue to publish one volume with two issues (twice a year). The latest is Vol. 15 (1) in October, 2021 (Figure 3). Although all articles in the first volume were written in Japanese, the subsequent volume was separated as the issue 1 in English and the issue 2 in Japanese or English. The researchers of the overseas universities and institutes with the MOU (MOU partners) participate to the editorial board. Meanwhile, in 2007, the same year of the journal publication, we started “International Kuroshio Science Symposium” to

provide the place for research presentation and direct discussion and argument (Figure 3 and Table 2). The symposium has been held every year on a rotating basis among the countries, setting one major theme with several sessions for specific subjects such as ecosystems, managements and conservation as keywords. Furthermore, an important topic, that is, the creation and formation of a cross-border network among the participating countries, is going to be discussed to facilitate the international research and educational collaboration.

In relation to facilitating the network formation, our research projects have been supported generously by research budgets founded by Kochi University and the



Figure 3 Front covers of the “Kuroshio Science” journal and the proceedings of International Kuroshio Science Symposium.

Table 2 International Kuroshio Science Symposium since 2007

	Theme	Host country
1st	Recent Changes on the Seeweed Ecosystem along the Kuroshio Current: Towards Collaborative Rehabilitation of the ‘Cradle of Fishes’	Japan
2nd	Biodiversity in Kuroshio Waters: A Perspective of Joint Study among Japan, Taiwan and the Philippines	Taiwan
3rd	Investigating Benefits and Balance along the Kuroshio Current: Challenges to Marine Biodiversity and Resource Management	The Philippines
4th	Effects of Recent Societal Changes on the Natural Environment in the Kuroshio-Related S-Shaped Zone	Japan
5th	Adaptation to Climate and Socio-Economic Changes	Taiwan
6th	Ecosystem Management and Conservation towards Sustainability in the Kuroshio Region	The Philippines
7th	Enhancing Management and Conservation in the Kuroshio Region through Harmony between People and Environment	Indonesia
8th	Kuroshio University League Network Formation Toward the Establishment of a Sustainable Society in the Kuroshio Region through Cross-Border Education	Japan
9th	Cross-Border Education and Network Formation	Taiwan
10th	Addressing Coastal Resources Conservation and Food Security thru Science-based Solution and Innovations	The Philippines
11th	Future Perspective on Cross-Border Network for Research and Education of “Kuroshio Science”	Japan
12th*	The Joint Symposium for the 12th International Kuroshio Sciences & South China Sea Marine Stations	Taiwan
13th	Climate Change Adaptation and Mitigation towards Sustainable Fisheries Recourses along Kuroshio Region	The Philippines
14th	How Does Regional Revitalization Confront Aging and Declining Populations? ~The Challenge of the Regional University~	Japan

\*No particular theme was given because of the circumstances of the organizer.

Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT). The major research projects supported by the MEXT were “Creation of Multidisciplinary Kuroshio Science (2006 to 2008)”, “Adaptation of Regional Societies toward Global Warming based on Kuroshio Science (2009 to 2011)”, and “Creation of Four-Dimensional Integrated Kuroshio Resource Science (2016 to 2021)”. These research projects considerably contribute to strengthening our collaboration with overseas researchers not only at individual levels but also at institutional levels. The following chapters will present some of the fruitful results obtained from such research activities.

#### 4. Education Network in the “Kuroshio Region”

Graduate School of Kuroshio Science and Kuroshio Science Program have granted 78 students the doctor degree so far (Table 3). Noteworthy is a high proportion of non-Japanese, especially Filipinos, who is owing largely to the special scholarship program by the MEXT. This scholarship program was approved in 2013, entitled as “Program of Nurturing Talented People to Establish a Sustainable Society

in the Kuroshio Region” and allowed us to accept two or three Filipino scholarship-students every year during 2014 to 2018. Private-expense overseas students and Japanese students could also participate in this program. Compared with the regular program, the curriculum was specialized for the purpose of the program so that the

Table 3 The number of the doctor degree conferment until September 2020

Japanese	non-Japanese	
	scholarship*	private-expense
39	21	18

\* Japanese government scholarship

Table 4 Common, compulsory subjects for the regular program (1 or 2 credits)

**DC seminar:** An aggregate of lectures in various fields to gain knowledge from different fields

**Advanced Study on Kuroshio Science:** An omnibus lecture series given by faculty from a number of fields from which students gain broad knowledge and points of view about issues of the Kuroshio Region.

**Kuroshio Seminar:** A seminar to develop presentation and discussion skills through research presentations. As well as improving self-expression, students enhance their ability to participate in discussions and arguments on research presentations in other fields.

**Special Exercise:** Interim presentations of dissertation research. Through presentations and discussion of research progress, students organize their references and bring into focus the direction of research, as well as improve presentation and discussion skills.

Table 5 Common, compulsory subjects for the “Program of Nurturing Talented People to Establish a Sustainable Society in the Kuroshio Region” (1 or 2 credits)

**DC Seminar:** The same as Kuroshio Seminar in Table 4

**Special Exercise:** The same as that in Table 4

**Advanced Study of Socioeconomic and Ecological Research:** A special exercise to learn the basic viewpoint and methodology for field surveys both in natural science and socioeconomic science

**Advanced Study of Functional Analyses of Bioresources on Human Health:** A special exercise to learn the background of a lifestyle-related disease and the functional analyses of bioresources on human health in the Kuroshio Region

**Advanced Study of Food Processing and Utilization:** A special exercise to learn proper utilization of bioresources, in particular, the techniques for food processing, especially for marine bioresources.

students could learn the concept, schemes and methodologies to develop sustainable management of the Kuroshio environments and ecosystem through the exploration of indigenous bioresources and their effective usage (Tables 4 and 5). Thirteen Filipinos have already graduated under this program with the scholarship.

In 2019, new special scholarship program was approved by the MEXT, entitled as “Leader Nurturing Program to Create Sustainable Regional Society in Kuroshio Region” (three Filipinos each year from 2020 to 2022), although the schedule has been severely influenced due to the occurrence of Covid 19. With the emphasis on regional development, this new program aims at developing students who have the skills to promote interdisciplinary research and insights into the local community, and are capable of balancing and driving environmental conservation and local community development as leaders who will lead the creation of a sustainable society that harmonizes human society and the environment. For this program, the curriculum has been largely improved based on the advises and suggestions given from the graduates in the former special program as well as the oversea researches in the MOU partners (Table 6).

Table 6 Common, compulsory subjects for the “Leader Nurturing Program to Create Sustainable Regional Society in Kuroshio Region” (1 or 2 credits)

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**DC Seminar:** The same as Kuroshio Seminar in Table 4

**Special Exercise:** The same as that in Table 4

**Scientific Literacy:** A lecture, as the first step for the expertness, to learn research ethics, information security, the importance of appropriate data analysis, and the significance transmission of information based on scientific evidences

**Kuroshio Science Special Exercise:** A exercise to build up skills and capacities as an independent researcher though consecutive processes for Ph.D. thesis from research planning until the completion.

**Advanced Study of Ecological and Environmental Field Surveys:** A special exercise to learn the basic viewpoint and methodology required for field sciences on natural resources, environments and ecosystems, taking coastal area, cropland and forest of Kochi Prefecture for example

**Advanced Study of Socioeconomic Research:** A special exercise to learn the basic viewpoint and methodology required for socioecological survey on sustainable usage of natural and environmental resources, taking the mountainous communities in Kochi Prefecture for example

**Advanced Study of Material Analysis Techniques:** A special exercise to learn the basic methodology required for laboratory analysis with scientific equipment and machine, taking natural resources and agricultural, forest and fishery products in Kochi Prefecture

**Advanced Study of Future Co-creation:** A special exercise to learn the way of thinking and needs of societies and enterprises in the real world and pursue the measure to compatibleness of appropriate resource management and environmental conservation with regional developments

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In all of the programs, we assign one supervisor and two or more co-supervisors to each student. While one of co-supervisor is from the similar research field to the supervisor or a closely-related field, the other is from a different field to provide advice and guidance from an alternative perspective. This arrangement helps students develop the competence to be highly skilled professionals and technologists who possess knowledge and skills which enables them after graduation to respond flexibly to a broad range of challenges on a number of fronts.

In addition to the formal education, we have conducted the short-term student exchange program, supported

by “Sakura Science Plan” from Japan Science and Technology Agency (JST). In the Sakura Science Plan, we have invited 10 young researchers including postgraduate students every year since 2014 mainly from the Philippines and Taiwan. They come not only from our MOU partners but also from the other universities and institutes which our graduates work at or we collaborate with for research and education. Some of our graduates participate to the program as the accompanying teachers. Despite a short duration of 10 days, the participants can take several exercises to learn advanced scientific technologies as well as they can visit local societies to have real experiences and observations about the usage and conservation of regional resources and environments.

We encourage not only our students but also the participants of the Sakura Science Plan as junior researchers to present a research paper to the Kuroshio Science journal as well as to have a research presentation at International the Kuroshio Science Symposium among senior researchers. In addition, during the Sakura Science Plan and the symposium since 2015, we have held a discussion seminar for students and young researchers in different study fields, so that they can gain broad knowledge and develop the capacity for multidisciplinary argument. We call this educational system “Cross-Border Education”, implying both across national borders and across research-field borders.

## 5. Establishment of Filipino Graduate’s Alumni Association

Upon the completion of the new scholarship program, about 30 Filipinos would be granted the doctor degree from Kochi University. Filipino Alumni Association was inaugurated during the 14th Kuroshio Science International Symposium in 2021. This is the fourth alumni of oversea graduates of Kochi University, following Chinese in 2009, Thai in 2010 and North European in 2015. At the same time, the Philippines-Japan Association for the Kuroshio Science Promotion, Inc. or PHILJAPKUS, Inc. was established with the aim at forging collaboration in both countries on research and development in socio-economic, agriculture, aquatic and natural resources and other associated fields along with the Kuroshio Region (Figure 4). We expect the Filipino Alumni Association to be the keystone to strengthen the collaboration network in the Kuroshio Region and, furthermore, the international exchange activities of Kochi University because of the following reasons. First, because the graduates profoundly understand the significance of the multidisciplinary Kuroshio Science, the alumni can play the role as the strong linking bridge for research and education between the Kuroshio Science Program and the universities and institutes of the Philippines, creating the bidirectional international-collaboration cluster connecting the ocean to terrestrial areas from the viewpoint of field sciences, basic sciences to applied sciences in the Kuroshio Region. Second, Kochi University encourage Japanese students to study abroad irrespective of a short-term or long-term study. Because English is the official language as well as the Filipino and, therefore, most Filipinos are good English speaker, the Philippines can be the prepotent destination being located close to Japan. The alumni can support the Japanese students of Kochi University, taking the necessary arrangements for the



Figure 4 PHILJAPKUS inaugurated in 2021

education in the host university so that a various needs and purposes of each student who want to study abroad can be satisfied. Lastly, during their study for three years in Kochi, not only Filipino students but also all of oversea students have many opportunities to learn and experience Japanese language, societies and culture at their Japanese-language class as well as in their daily life. This means that they are the best sympathetic supporters of Kochi and Japan among the Filipinos. Thus, we expect that our graduates and alumni can be the keystone to connect and develop human and social network between Kochi and the Kuroshio Region. We believe that this would be the goal of “multidisciplinary Kuroshio Science” and “From the Region to the World, From the World to the Region” of Kochi University.