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Six Years of Kuroshio-Related Studies among Japan, Taiwan and the Philippines: Special reference to the study achievements of the Kochi Survey Team

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Abstract
In Kochi Prefecture, which has around 800 km of coastline facing the Pacific Ocean, the results of our various surveys thus far have indicated that the marine ecosystem is rapidly deteriorating due to factors that reach beyond country borders. These include, for example, internal factors such as population fluctuation, industrial development, and daily life activities, and external factors such as climate change and global warming. In order to address these problems, we have established a network linking Japan, Taiwan and the Philippines, countries that are connected by the Kuroshio current, in which we have strengthened mutual understanding, and promoted the exchange of academic information. Collaborative studies have been conducted within the framework of this network since 2004. At present, National Sun Yat-sen University (NSYSU) in Taiwan, and Bicol University (BU), the University of the Philippines (UP), and the Bureau of Fisheries and Aquatic Resouces (BFAR) under the Department of Agriculture in the Philippines, are jointly conducting diverse Kuroshio-related surveys in cooperation with Kochi University. In this paper, we summarize the achievements of our study project thus far, which has mainly focused on seaweed beds in coastal waters.

Key words: Kuroshio, Marine Protected Area (MPA), seaweed ecosystem, socio-economics

Introduction

Under the theme "Comparative Assessment of Sustainable Development of Coastal Environments in Areas facing the Kuroshio among Japan, Taiwan and the Philippines –An Integrated Analysis of Conservation Status and Countermeasures", we carried out joint surveys at selected survey sites, and conducted yearly reviews of the results. The results of the two previous symposiums have been published as a series in *Kuroshio Science* 2-1(2008) and 3-1(2009). Although the manner in which the Kuroshio is regarded differs among countries, our collaborative studies relating to the sustainable use of the waters are important and useful in consideration of the geographical linkage and various other effects that the Current produces in each country. In addition, we described how most of the problems occurring in seaweed/grass ecosystems and the resultant effects on the local fish populations are rather similar in the three countries.

With an eye towards protecting and conserving the "seaweed beds," the communities of algae that have been deteriorating more and more without generally being noticed, with the cooperation of Japan, Taiwan and the Philippines, which have the Kuroshio in common, we examine two aspects of the problem of the deteriorating coastal environment in the study project.

One of these aspects is to compare the ecosystem of seaweed beds off the coast of Kochi with that of the coastal waters of the neighboring countries where the Kuroshio also runs, closely investigate the ecosystem and examine environmental changes and the ability to restore it by, among other means, identifying the species observed. For this purpose, we identify the species of sea grasses and seaweeds, investigate the interrelations between aquatic organisms and their habitats and examine the changes and deteriorations of seaweed beds.

The other aspect of the project is to examine the interest in seaweed beds, awareness of environmental changes and activities for conservation of local people in different coastal areas. To that end, we study local peoples' relation with and awareness of seaweed beds, paying attention to the importance of the marine protected areas and no-fishing areas, and we examine a

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method for protecting seaweed beds more effectively by utilizing the wisdom of local residents. In particular, we review protection mechanisms which involve the participation of local people and examine the ecosystem of seaweed beds in the Kuroshio waters and the steps needed to protect the ecosystem.

In this paper, we summarize the achievements of our study project thus far, which has mainly focused on seaweed beds in coastal waters.

1. Methods of the study project

1) Selection of the study sites

To conduct regular monitoring of sites as fixed-point, we consulted with related organizations and selected six study sites along the Kuroshio curent (Figure 1). At these study sites, we are conducting a joint survey twice a year (February to March, and August to September) in principle of the ecosystem of seaweed beds in the coastal area and fishing villages having close relations with the protection and conservation of seaweed beds.

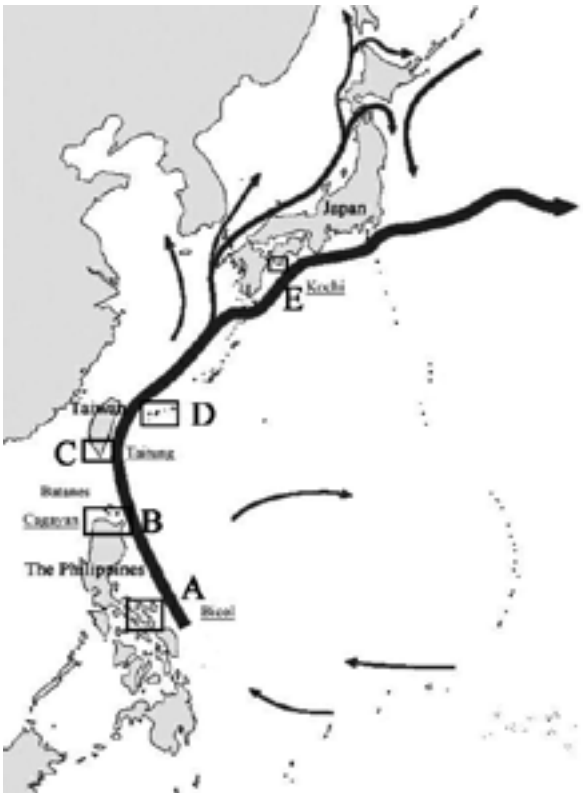

Fig. 1 Location of the joint research sites along the Kuroshio Current
A: Lagonoy Gulf, B: Claveria Lagoon, C: Green Is., D: Ryukyu Is. & E: Tosa Bay

2) Survey method

(1) Survey of algae and fishes

Submersible surveys of the habitat environments of seaweed beds are conducted, so that the state of seaweeds, coral reeves and fishes can be closely studied and the process of changes to the ecosystem can be compared across sites. In areas where studies have not been carried out in the past, efforts are made to collect the basic data to make future periodical comparisons possible. In addition, whenever needed, additional study sites for comparison are established, where we use the same method to study, among other things, the species composition of algal communities, dominance rates of sea grasses and seaweeds, interrelations and identification of the country of origin. Thus we build a database using the results of these studies together with related information on the coverage of coral reeves and the fish ecosystems.

(2) Study of marine protected activities

We collect and analyze socioeconomic information, including the relationship between the economy and occupation in the fishing villages close to the seaweed beds in the Marine Protected Area(MPA), as well as the process of consensus building for MPA establishment, residents' interest before and after the process, their participation in the conservation of the coastal environment, friction among residents, the length of the conservation and protection period for the seaweed beds and changes in fish catches, together with technical information. Here, to measure the intentions of residents, we make statistical analyses using such methods as the participatory approach and conjoint analysis, studied the intentions and views of residents and examined perceptions of how protections incorporating the wisdom of local people should be organized.

We combine the natural and social scientific findings collected by the two methods mentioned above, study the future direction of marine conservation and summarize and publish our opinions regarding the protection of coastal environments.

2. Outlines of selected study results

1) Joint study project among three countries

To report the progress of the joint study project and to summarize outstanding problems, we hold a joint symposium of the three universities every year to examine the study achievements changing the venue each year. Three symposiums held in the past three years were:

① "First Joint Kuroshio Workshop of Japan,

Taiwan and the Philippines in Kochi": held at Kochi University from November 21-23, 2007; the theme of the workshop was: Recent Changes in the Seaweed Ecosystem -Towards Collaborative Rehabilitaiton of the Cradle of Fishes-, (refer to *Kuroshio Science*, 2-1, March 2008).

② "Second Joint Kuroshio Symposium of Japan, Taiwan and the Philippines (the name changed from 'workshop' into 'symposium')": held at National Sun Yat-sen University from December 1-3, 2008; the theme of the symposium was: Biodiversity in Kuroshio Waters -A Perspective of Joint Study among Japan, Taiwan and the Philippines-, (*Kuroshio Science*, 3-1, March 2009).

③ "Third Joint Kuroshio Symposium of Japan, Taiwan and the Philippines": held at Bicol University from December 1-4, 2009; the theme of the symposium was: Investigating Benefits and Balance along the Kuroshio -Challenges to Marine Biodiversity and Resource Management-, (*Kuroshio Science*, 4-1 [this issue]).

Since we started the joint study project in 2006, we have conducted various studies mainly at the study sites mentioned above. The current state of Kuroshio-related studies in three countries is as follows:

2) Angles for the study

Bicol University in southern Luzon, the Philippines, near the source of the Kuroshio, conducted comparative studies of the coastal environment of Lagonoy Gulf in 1994 and in 2004. A period-to-period comparison of the deterioration of the coastal environment was made, its causes were studied and rates of changing were compared. To protect the coastal environment from deterioration, several MPAs were established in the gulf where measures to conserve the marine ecosystem of seaweed beds and coral reeves have now been taken. Remarkable achievements have been produced by the socio-economic analysis of conditions in fishing villages as well as by the study of the ecology of fishes living around seaweed beds.

Taiwan has also established protective areas similar to Japanese marine parks; it has recently carried out large-scale marine research projects, including those on the Kuroshio Current, in a systematic way, and has reported on the valuable scientific information collected by these studies. But what is important going forward is who should take part in the conservation and restoration of the seaweed beds that have been deteriorating internationally and how such efforts should be made. Thus it is urgently required that Japan, Taiwan and the Philippines, which have the Kuroshio in common, exchange information to compare the interests and awareness of local people and to take the necessary steps together.

To act to conserve marine resources and to promote regional development, it is important to identify those who could play a major role in the future among local residents and educate and train them, and to work together with these people. While physical infrastructure, knowledge and information are undoubtedly important for environmental conservation and international exchange, these alone are not sufficient. What is also important is the existence of good community leadership that could lead residents and help the unified community to work effectively.

Kochi University is engaging in fieldwork on the promotion of ecotourism, and additionally pursuing study of the artificial impact caused by it. As well, we also continue to consider the issue of protection of the coastal environment. These studies mainly take place on Kashiwajima Island in the west of Kochi Prefecture. In this area, the Kuroshio Zikkan Center (a NPO), the Kuroshio Biological Research Foundation, and other private groups are actively undertaking scientific research.

In addition, from the viewpoint of the "theory of the commons", we are also examining what the utilization of common resources should look like. For example, we are interested in how social friction among local people arises, and how measures to deal with such friction have been developed in connection with activities for protecting the coastal environment. How can mechanisms of cooperation in the community be used effectively towards the common objective of environmental conservation? How can Japanese scientists work together with the local people in other countries in order to achieve these goals?

To answer these questions, we must understand not only the mechanisms of cooperation in local communities, but also endeavor to be aware of differences in the intentions and awareness of local people while considering the social environment of the country in question. Case studies incorporating resident participation, for example, surveys and conjoint analyses that attempt to examine the intentions of local residents taking part in rural development, and similar group work projects, have been increasing in number in recent years. In this light, the effectiveness of these methods of analysis should also be measured.

3. Recent changes in the ecosystem of seaweed beds

① *Sargassum* species are brown algae belonging to Fucales, Phaeophyceae and form one of the main algal communities of seaweed beds(Haraguchi *et al*., 2010). It has been pointed out recently that tropical species of *Sargassum* became abundant in the coastal waters of Kochi whereas temperate species of *Sargassum* declined. We studied the distribution of *Sargassum* species in Kochi and their seasonal changes by field survey also and their growth characteristics in relatin to temperatures in both temperate and tropical species of *Sargassum* by culture experiments.

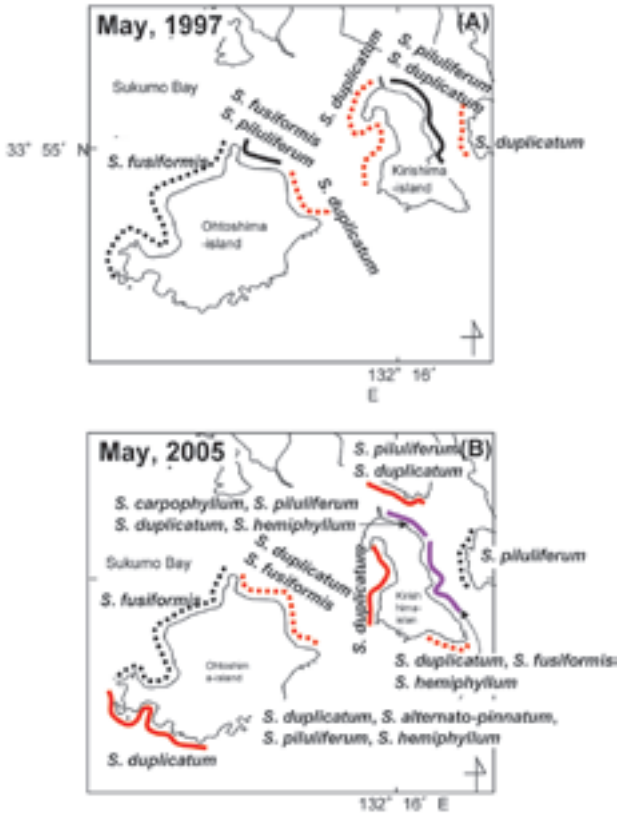

Fig. 2 Distribution and the dominant species of *Sargassum* beds in the western coast of Kochi Prefecture in May 1997 (A) and May 2005 (B)
(Haraguchi, 2010)
—— rich, ····· poor, ⋯⋯ temperate species,
—— *S.duplicatum*, —— tropical *Sargassum* species (except *S. duplicatum*)

② From the 1970s to the 1980s, *Sargassum* beds were composed mostly of temperate species including *S. okamurae* (Hiranejimoku) and *S. micracanthum* (Togemoku). During the 2007-2009 period, tropical species such as *S. duplicatum* appeared and tended to increase in distribution (Figure 2). In the 1990s, the distribution of temperate species started to decline, while *S. duplicatum* remarkably extended their habitats. In the 1990s and after, offshore seawater temperatures in Kochi rose especially in winter, concomitant with a conversion from temperate to tropical species in *Sargassum* beds. This suggested that a rise in seawater temperatures was one of the factors bringing about the decline of temperate species and the higher distribution of tropical species.

③ In recent studies of temperate species, the time when they reach their greatest total length and the time when they mature changed as compared with previously reported times. *S. okamurae* (Hiranejimoku) in recent years reached its greatest total length one month earlier than it did in 20 years before, which suggested some connection to the fact that the period of highest seawaters temperature was also earlier than in the past also by one month. In the case of *S. micracanthus* (Togemoku), the period of the release occurred later than in the past by one month. Growth was actually inhibited during the time of highest seawater temperature. Therefore, it was supposed that the high temperature conditions delayed the time when *S. micracanthus* reached its greatest total length, resulting in the delay in the time of maturity. The results from culture experiments showed that growth rates of these temperate species decreased at temperatures more than 20°C. However, the optimum growth temperature for thalli collected in March was higher than that for thalli collected in October. This suggested that effects of temperatures on growth differed depending on season, i.e., water temperatures where the thalli were living in natural habitats.

④ Recent tropical species continued to form their algal communities yearly. The maturity period was from late June to mid-July for *S. duplicatum* (Futaemoku) and *S. carpophyllum* (Majirimoku) and from late July to late August for *S. alternato-pinnatum* (Kirebamoku). The optimum growth temperature for the juvenile thalli in those tropical species corresponded with the seawater temperature when the parent thalli matured. When tropical and temperate species were cultured at temperatures of 10-20°C, the growth rate of tropical species was the same as that of temperate species at the ranges of 10-13°C but was higher than temperate species at 14°C or above. Based on the fact that seawater temperatures off Kochi in winter for the past 10 years have been higher than in the past and are at 14°C higher, it is considered that the coastal waters of Kochi are temperature environments where tropical *Sargassum fulvellum* can

survive and grow even in winter.

⑤ In the coastal waters of Kochi, rises in seawater temperatures have caused changes in the species composing *Sargassum* beds, and consequently the distribution of tropical *Sargassum* species is growing higher as temperate *Sargassum fulvellum* is declining. It has been found that this phenomenon has occurred due to conversion from temperate to tropical species, which are distinct in terms of growth characteristics in response to temperatures. The results of this study is useful for the forecasting of future changes in the species composing seaweed beds and provides basic data for the construction of eco-friendly artificial seaweed beds.

⑥ *Monostroma* species, an important edible green algae in Japan, were also investigated by Bast and coworkers(Bast *et al.,* 2009). Sexually reproducing and asexually reproducing ecotypes of monostromatic green alga from Tosa Bay, Japan were discovered through culture-based methods such as mating tests and microscopic investigations of life cycle and ontogeny, and both ecotypes were identified as *Monostroma latissimum* (Kützing) Wittrock. Patterns of seasonal fluctuations in its thallus lengths were habitat specific and recur annually, and both appearance and decay of thalli were earlier at high saline habitats, suggesting that salinity positively influences either maturation of sporophytes or senescence of gametophytes. Biogeographic isolates of *Monostroma* sp. distributed along Kuroshio Coast of Japan were panmictic and had similar sequences for the conserved nucleoribosomal DNA (nrDNA) 18S gene, however, a substantial variance was observed in the highly variable first internal transcribed spacer (ITS1) sequences that are suggestive of an emerging sympatric speciation.

⑦ On the other hand, Camaya carried out field surveys in the San Miguel Island Marine Fishery Reserve and Sanctuary (SMI-MFR/S) in Tabaco City, Lagonoy Gulf, Bicol Region, Philippines and examined species composition and biomass of seagrass beds and seaweed beds (Camaya *et al.,* 2009). Among tropical algae distributed in SMI-MFR/S, *Valonia* sp. was chosen for further culture studies because of its peculiar mode of cell division, lenticular cell formation (Figure 3). Indirect immunofluorescence microscopy using an anti-tubulin anti-body revealed that cortical microtubules changed in arrangement from paralell to radial when the protoplasm of a *Valonia* cell aggregated locally. Radial microtubules became short to be arranged randomly, concomitant with a disc-shaped aggregation of protoplasm, which was subsequently divided by a septum from the mother cell. Such a lenticular cell divided expanded to develop into a new cell or a rhizoid, where paralell microtubules were arranged longitudinally to the cell axis.

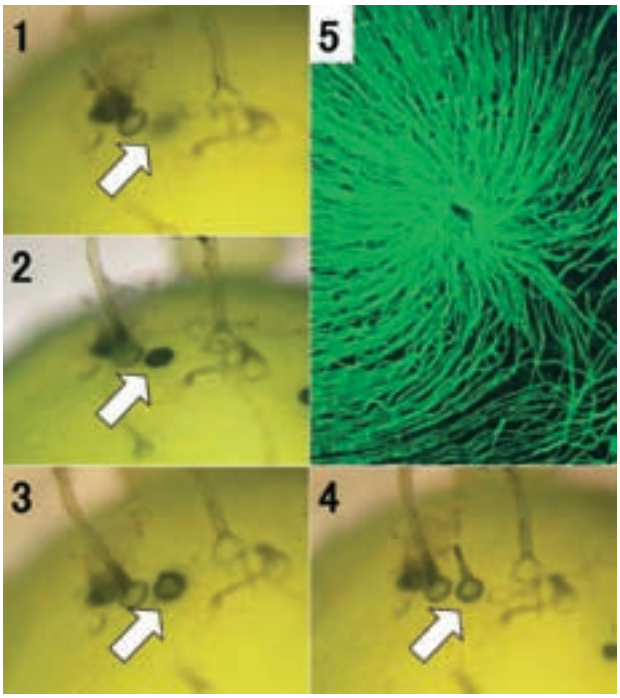

Fig. 3 A process of rhizoid formation (1-4), photos taken in intervals of a day (Photo by A. Camaya)
Note: Cortical microtubles arranged radially (5) from the center of an incipient rhizoid (1).

4. Characteristics of seaweed beds associated fishes

① Kochi is situated at the northern limits of a large coral reef. In the strict sense of the word, coral reeves are more often referred to as a "coral communities". However, with the recent phenomenon of global warming, various fish species that originate in subtropical and tropical zones have gradually enlarged their areas of habitation, and have even been found in temperate zones such as Kochi. For this reason, temperate fish species have been seen to be decreasing the scope of areas which they inhabit; it is not well understood how this phenomenon is related to global warming, or how a particular species of fish adapts to its new environment. It is therefore of importance to elucidate whether new competitive relationships emerge when a fish species enters into a different habitation site, whether such new habitats become entrenched, and how the already-deteriorating seaweed beds are affected. This has been a main focus of survey work in our collaborative research.

② In the sea area adjacent to Kochi University's Yokonami Rinkai Experimental Station, located in Suzaki, Kochi, we investigated the recruitment mechanisms of juveniles of *Chaetodon speculum* belonging to the family Chaetodontidae (Oguri *et al*., 2008). Scuba diving was conducted in the coral community of this area to investigate. Juvenile of *C. speculum* were mainly recruited in the warm months from June to September, and the age in days of the recruited individuals was measured by analyzing the number of daily otolith rings between 23 days and 43 days. We selected the corals, *Acropora formosa* and *A.solitaryensis* as the settling media for the juveniles. During the recruitment period, it was found that the number of recruits was largest when there was a new moon or a young moon, with no or almost no moonlight.

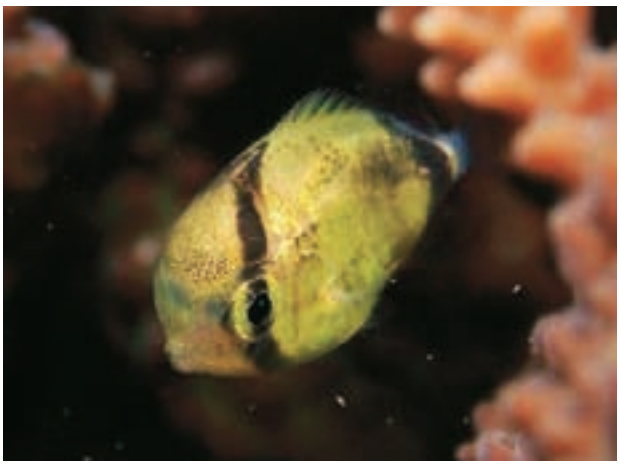

Fig. 4 ***Chaetodon speculum*** **feeding on the polyps of corals** (Photo by S. Hirata)

③ In the seaweed beds off San Miguel Island in Tabaco, Bicol in the southeastern part of Luzon, we investigated the habitats of fishes appearing mainly in *Zostera* beds. The 400m line census and quadrat methods were employed in the investigation. In 2008, while eight families and 10 species of fish were observed in the *Zostera* beds, the density of individual fish was very low, being 0.175 individuals per square meter. In contrast, at the small patch reefs around the *Zostera* beds, 15 families and 31 species of fish were found, and the density was 11.67 individuals per square meter, i.e., 67-times greater than that at the *Zostera* beds. We also considered the ecological significance of small patch reefs scattered in the *Zostera* beds.

④ In the Philippines, fisheries resources have been on the decline due to over-harvesting(Soliman *et al.,* 2009) . Going forward, in order to achieve sustainable usage of such resources, it is necessary to track the number of individuals in a particular habitat, as well as that of the stem population of each relevant species. In this regard, the link between age and physiology is crucial in defining studies on early life ecology and the population dynamics of fishes. This is because the determination of growth and mortality, which are fundamental parameters in fish biology, relies on accurate age information, from which the increase or decrease of a fish population is quantified. One of the most important challenges in such a study is to be able to sample wild larvae and juveniles in sufficient numbers to yield representative data. The study of the ecology and population dynamics of siganids, also known as rabbitfishes or "Aigo" in Japanese, presents opportunities to explore methods on how the age-physiology link can be established.

Thus, we have aimed to highlight important research gaps and related developmental areas, with the aim of sustaining resources and enhancing productivity.

⑤ The shapes and sizes of otoliths vary among species, as well as between stocks of the same species. Differences in otolith structure depend not only on differential growth rates, but also on the consistency of the environmental conditions (temperature, nutrition, etc.) encountered during their life histories (Figure 5). Geographical and environmental conditions are most often the cause of variation in otolith nucleus and shape within a species. Siganids are primarily herbivorous; they progress from feeding on zoo- and phytoplankton

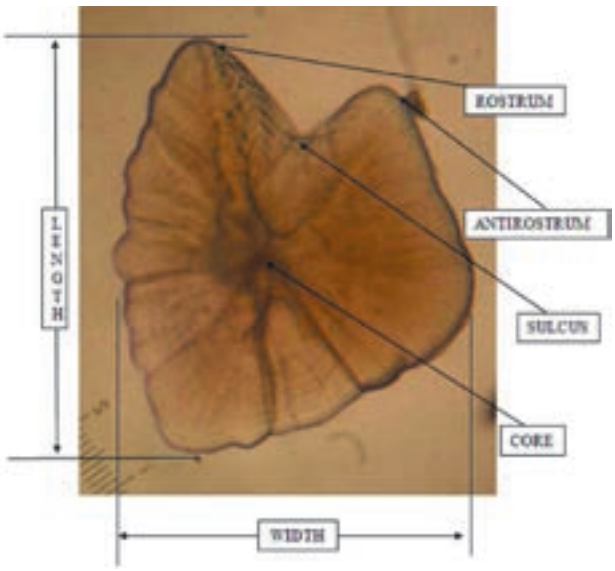

Fig. 5 Typical sagittal otolith of a siganid showing its parts (Photo by R.U. Bobiles)

as larvae, to finer algae as small juveniles, and to coarser seaweeds and encrusting algae, and occasionally sea grasses as adults. Our study is an attempt to address the relationship of settlement of larvae to otolith shape. Specifically, it aims to: (a) define the gross morphology of *Siganus canaliculatus* otoliths, and (b) discriminate between the pre-settled and post-settled juvenile seagrass siganids based on an examination of sagittal shape.

⑥ The sea area off the Batan Islands located in the Bashi Channel, near Taiwan and the Yaeyama Islands, is directly affected by the Kuroshio Current. We studied the fish fauna in this area and measured the density of the individuals present using the line census method. In the MPA west of the Batan Islands, 46 families and 170 species of fish were observed. In the 100m ($200m^2$) line census section established at a depth of 3-5 m, we found 248 individuals (103 adult and 145 juvenile individuals) of 15 families and 26 species. Because the bottom of the census survey area consisted of shore reeves, both the number of species and that of the corresponding individuals were not very large.

5. Socio-economical analyses for the MPAs

① Our socio-economic study group has conducted various surveys at 6 selected sites along the Kuroshio Current in order to investigate the real circumstances of fishing villages where the marine ecosystem tends to be deteriorated. In these studies, (a)in three countries comparative analyses were carried out focusing mainly on the present state of maritime policy, outlooks for the protection or conservation of the coastal environment, methods of implementation etc. and in particular (b) the value of MPA environments was evaluated, as an example of the participatory approach, by using socio-economic census data collected by the group. In the Philippines, although MPAs were established at various places along the coastal areas, it has been pointed out that most of them have not yet been well-implemented by the respective fishing village communities. We attempted to clarify the major problems from the residents'point of view focusing on their intentions and attitudes toward MPAs and we examined the outlook for the future including problem-solving steps which might be taken.

② In the two fishing villages, one of which is situated on Lagonoy Gulf in southern Luzon, the Philippines, where the Kuroshio has its origin, and the other on Claveria Bay in Cagayan in northern Luzon, where the current leaves the coast and starts to go north, we analyzed and evaluated the economic value of the coastal environment, focusing the MPAs, from the standpoint of local interest in the problems of the coastal environment and the intentions of residents regarding the protection of the ecosystem. We examined, when making our economic analyses, the way that the MPAs should be taking account of the degree of fishers' awareness of environmental issues, their feelings (approval, discontent, dissatisfaction) about the restriction of their fishing grounds resulting from the establishment of the MPAs and the effect on their family budget due to changes in fishing income.

③ Using a census survey based on the choice model method used in environmental economics, we examined the socioeconomic characteristics (population, household economics, degree of poverty, fishing implements and methods, interest in the protection of the ocean, awareness of the MPAs and intentions regarding protection, attributes affecting attitude, etc.) of the two study villages and analyzed their social structures. Conjoint analysis using the combined charts of the area (size) of the MPAs, expected fish catches and labor for monitoring the MPAs showed that while fishers had a strong interest in the size of the MPAs and expressed some approval of monitoring work, they displayed a strong resistance to uncertain elements, such as expected fish catches (Launio *et al.,* 2009). Thus when establishing an MPA, we should carefully consider the fact that residents diplay a strong resistance to the size of the fishing grounds restricted by the MPA's establishment and that their resistance reflects the low and stagnant economic conditions of fishing villages.

④ We analyzed and evaluated the economic value of the MPA using the contingent valuation method (CVM). However, CVM does have a weakness: when we directly ask the subjects about their willingness to pay (WTP) for a certain contingent situation, they are generally inexperienced in pricing the changes in their utility and expressing them in monetary terms. Thus to measure the values local people had in mind, we adopted a method of comparing the evaluation of the willingness to work (WTW) and the WTP by dividing the samples according to the study villages (Shinbo *et al.,* in press). The various advantages of MPA management work done mainly by local residents were seen in terms of information and monitoring costs. But in larger communities, many difficult problems arise since consensus among the stakeholders is a prerequisite. We closely investigated the data in such cases using household surveys and the focus group method, and obtained highly accurate empir-

ical analysis results (Table 1).

Table 1 Median, Mean of WTW/WTP, Aggregated WTW/WTP, and Converted WTW to Monetary Term

Items	WTW		WTP	
	All	Sagurong	Rawis	Sagurong
Median	2.75	4.60	1.55	29.4
Mean	4.00	4.64	3.22	33.2
Number of households	773	518	255	518
Aggregated WTW/WTP	3,090	2,403	820	17,194
Average daily income	76.7	100.1	51.6	-
Converted WTW(Median)	211.2	460.6	79.9	-
Converted WTW(Mean)	306.8	464.6	165.8	-

Units: WTW (days), WTP & Converted WTW (Peso)
Note: WTW x Average daily income = Converted WTW

⑤ Based on the analysis results, we summarized the policy targets for the two villages aiming to increase MPA effectiveness. In the village on Claveria Bay, in order to put the MPA into action steps must be taken to improve fishing methods in the sea areas outside the MPA, including aquaculture, and long-term investment in education that would help realize the sustainable use of resources. In the village on Lagonoy Gulf, it is urgently necessary to identify the fishers who will suffer as a result of the creation of an MPA, and to take measures to compensate such fishers disadvantages, as well as to educate under 15s, especially regarding environmental protection, and to create employment opportunities, including supplementary sources of income.

Conclusion

So far, through our joint studies, the following points have become clear:

1) In Kochi Prefecture, which is situated in the downstream Kuroshio, the area occupied by tropical and subtropical algal species is rapidly expanding, even more than in temperate zones. Through our network, we exchanged research information on the various algae-related studies that have been conducted by the corresponding universities in respective countries. Studies on seaweeds (eg. *Sargassum* species and *Ecklonia cava*) have been extensively conducted at KU, while seagrass (eg. *Thalassia hemprichii*) has been well-studied at NSYSU, and commercial algae (eg. *Eucheuma*) at BU. Based on the results of these respective algae-related studies, we now understand that it is necessary to implement a comparative study focusing on how to conserve seaweed/grass ecosystems as a whole.

2) Similar problems are also widely observed in coral reef and coral communities in the Kuroshio triangle. As with algae, through further studies we are compelled to answer the following questions in the context of climate change: “What are the consequences of shifting species composition?”, “Will the new migrants out-compete the endemic species?”, and finally, “What about the response of *Symbiodinium*?” (Chen *et al*., 2009).

3) With regard to fish ecology: fish behavior and reproductive mechanisms are being clarified based on intensive marine observation and experimentation. As social indicators for the measurement of speed and/or the degree of deterioration in the Kuroshio area, flying fish, siganids(eg. Teleostei: *Siganidae*), and triple fin species are proposed as appropriate targets of study. We have preliminary information, but more data is required, especially relating to the role of plankton and other species that could serve as environmental indicators.

4) Changes in a marine ecosystem are closely related to artificial factors caused by inhabitants of that particular coastal area. In Japan and Taiwan, marine ecosystems are less intensively managed due to conditions such as labor shortage, especially in more remote areas. At the same time, although seasonal, the effects of rural tourism on these environments cannot be disregarded. It has thus become necessary to urgently resolve problems on how to harmonize conflicts between, for example, inhabitants of these areas including fishers, and also tourists including divers and the related tour operators. Fisherfolk in Japan and Taiwan tend to worry about the damage caused to marine ecosystems by diving-related activities. In contrast, the Philippines is faced with problems of overfishing by fishers who are showing an increasing tendency to migrate to fishing villages that seemingly have a great deal of resources. As it is still very difficult to compare socio-economic conditions among the three countries, we need more basic information relating to fishing communities and how they conduct their activities, including fishing gear, methods, and types of fishing boats employed.

5) We are now very much concerned about the socio-economic conditions on San Miguel Island where a MPA has been established and managed using community-based approach for more than 10 years. This MPA is an appropriate site for considering the linkage between daily activities and coastal environmental conditions. Following the preparatory survey already conducted, we have now reached an analytical stage in which it is possible to evaluate perceptions and attitudes towards pro-

tecting marine ecosystems at an MPA. The methodology of environmental economics such as the contingent value method and related analytical tools will be employed.

We will now progress to the next stage based on our previous joint studies, in order to protect and preserve marine ecosystems in the Kuroshio Triangle which ties Japan, Taiwan, and the Philippines together.

References

Bast, F., Shimada, S, Hiraoka, M. and Okuda, K. 2009. Seasonality and thallus ontogeny of edible seaweed *Monostroma latissimum* (Kützing) Wittrock. (Chlorophyta, Monostromataceae) from Tosa Bay, Kochi, Japan, *Hydrobiologia*, 630, pp.161-167.

Camaya, A.P. and Okuda, K.2009. Cellular morphogenesis in *Valonia* sp.: with emphasis on the formation of lenticular and rhizoid cells. *Kuroshio Science*, 2-2, pp.151-159.

Chen, C.A. and Shashank, K. 2009. Taiwan as a connective stepping-stone in the Kuroshio Traiangle and conservation of coral ecosystems under the impacts of climate change, *Kuroshio Science*, 3-1, pp.15-22.

Haraguchi, H., Hiraoka, M., Murase, N., Imoto, Z. and Okuda K. 2010. Field and culture study of the temperature related growth rates of the temperate *Sargassum* species, *Sargassum okamurae* Yoshida and *S. micracanthum* (Kützing) Endlicher (Fucales, Phaeophyceae) in Tosa Bay, southern Japan, *Algal Resources*, 2, pp.27-38.

Launio, C.C., Aizaki, H. and Morooka, Y. 2009. Understanding factors considered by fishermen in marine protected area planning and management: case study of Claveria, Philippines, *J. Applied Sciences*, 9-21, pp. 3850-3856.

Oguri, S., Hirata, T., Hirata, S., Ichiba, Y., Yamada, H. and Yamaoka,K. Settlement pattern and habitat selection of chaetodontid juveniles in Tosa Bay, western Japan. Paper presented at the International Symposium on Systematics and Diversity of Fishes, March 2008, Tokyo.

Shinbo, T., Launio, C. C. and Morooka, Y. Economic evaluation for Marine Protected Area of San Miguel Island in Bico Region, Philippines: Comparison between WTW(Willingness to Work) and WTP(Willingness to Pay). *J. Rural Economics*, Agricultural Economics Society of Japan. (in press)

Soliman, V.S., Yamada, H. and Yamaoka, K. 2009. Validation of daily sagittal increments in the golden spotted rabbitfish *Siganus guttatus* (Bloch) using known-age larvae and juveniles. *J. Applied Ichthyology*, 25, pp. 438-441.

Proceedings

Morooka, Y. and Okuda K, eds. 2008. Recent changes in the seaweed ecosystem along the Kuroshio Current: Towards collaborative rehabilitation of the cradle of fishes, *Kuroshio Science*, 2-1 pp.1-117.

Morooka Y., Mok, H.K. and Okuda K, eds. 2009. Biodiversity in Kuroshio Waters: A perspecitve of joint study among Japan, Taiwan and the Philippines, *Kuroshio Science*, 3-1 pp.1-123.