SCIENTIFIC PROGRESS REPORT FOR YEAR 2 (ENDING MARCH 31, 2019)

1. BACKGROUND

Natural and anthropogenic pressures are generating changes in the marine ecological system, and the effects of these changes on the well-being of people living in coastal areas are difficult to predict because of the lack of understanding and many uncertainties in social and ecological systems. Therefore, one of the most important tasks for marine researchers is to scientifically assist coastal communities in adapting to social and ecological changes for their sustainable livelihood and better well-being. This was the rationale for a PICES project entitled "*Building capacity for coastal monitoring by local small-scale fishers* (acronym FishGIS; https://meetings.pices.int/projects/FishGIS) and funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA), from the Official Development Assistance (ODA) Fund.

PICES member countries have significant resources for monitoring environmental conditions and fisheries in coastal waters, while developing nations are far more limited in their capacity for collecting these essential data to advance their management practices. Citizen-based monitoring is an approach designed to improve the efficiency and effectiveness of monitoring efforts when technical and financial resources are not sufficient. There are successful examples of citizen-based monitoring in developed countries; however, this approach has not been widely applied yet to the collection of environmental and fisheries data in developing nations.

The overall goal of the FishGIS project is to enhance the capacity of local small-scale fishers in Pacific Rim developing countries to monitor their local coastal ecosystems and coastal fisheries. The extensive use of smartphones in these countries offers a creative potential for implementing the project through a smartphone-based monitoring system to be used by local fishers and fish farmers.

Indonesia was chosen as a developing Pacific Rim country to implement the project. The importance of having more effective fisheries management practices is widely recognized in Indonesia. This has led to support by the Indonesian government and the willingness of local communities and stakeholders to consider new approaches, such as development and implementation of a citizen (fisher)-based observation system, linked with fisheries scientists and managers.

The key questions of the project are:

- How do global changes in climate and economy affect coastal ecosystems? and
- How can enhanced capacity for monitoring activities by local fishers help to improve fisheries management in coastal areas?

The major initiatives of the project include:

1. Coastal ecosystem monitoring activities by local small-scale fishers to detect ecosystems changes (*e.g.*, changes in water quality and in plankton community composition);
2. Coastal fisheries monitoring activities by local small-scale fishers to improve coastal fisheries management (*e.g.*, information about fishing operations or species composition in the market);
3. Coastal and estuarine water monitoring activities by local small-scale aquaculture farmers to measure the effects of government clean water initiatives on water quality for aquaculture operations.

These initiatives are to be supported by a series of training/capacity building workshops led by scientists from PICES member countries.

2. PROJECT ORGANIZATION AND MANAGEMENT

The request to undertake the project was accepted by PICES Governing Council in November 2017, and the ending date of the project was set as March 31, 2020. Within PICES, Science Board takes the responsibility for reporting to Governing Council on the progress and achievements of the project, and the Finance and Administration Committee takes the responsibility for reporting to Governing Council on the financial and management aspects of the project.

In accordance with the organizational and financial principles (Project Principles 3 and 4) agreed to by MAFF/JFA and PICES:

- The project is expected to interact with, and support the relevant activities of, PICES Scientific Committees on Human Dimension (HD) and Fishery Science (FIS), PICES Technical Committees on Data Exchange (TCODE) and on Monitoring (MONITOR), and PICES FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific **E**cosystems) Science Program (specifically, Research Theme 3 on "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*").
- The project is being directed by a Project Science Team (PST), co-chaired by Dr. Mitsutaku Makino (earlier at the Japan Fisheries Research and Education Agency, mmakino@affrc.go.jp; now at the Atmosphere and Ocean Research Institute, The University of Tokyo, mmakino@aori.u-tokyo.ac.jp) and Dr. Mark Wells (University of Maine, USA, mlwells@marine.edu). The PST Co-Chairmen are responsible for the detailed planning and execution of the project, and annual reporting on scientific progress to MAFF/JFA and to PICES Science Board through the HD Committee.
- Dr. Alexander Bychkov (bychkov@pices.int) is serving as the Project Coordinator and is responsible for the management of the fund and annual reporting on its disposition to MAFF/JFA and to PICES Finance and Administration Committee.
- Annual reports to MAFF/JFA should be submitted within 90 days after the close of each project year ending March 31. The Year 1 financial report was submitted on June 18, 2018, and the Year 1 progress scientific report was provided on June 29, 2018. Both reports are posted on the project website.

This progress report summarizes the activities carried out for Year 2 (ended March 31, 2019) and includes a workplan for Year 3 (April 1, 2019 to March 31, 2020), which is the final year of the project.

3. ACTIVITIES AND PROGRESS DURING PROJECT YEAR 2

<u>Project Science Team</u>

The PST was formed in December 2017 based on principles and procedures detailed in *PICES Policy for approval and management of special projects* (Decision 2017/A/7). The initial PST membership was drawn from PICES Committees and expert groups, and all Contracting Parties and all groups mentioned in Project Principle 3 (see also Section 2 above) are represented on the PST (Fig. 1). Following a request from the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) and the Indonesian Institute of Sciences (LIPI) for assistance in developing an automated harmful algal bloom (HAB) species identification system to augment the foldscope component of the project, the PST was expanded in Year 2 to include Dr. Vera Trainer (USA) who has expertise in HAB species identification and direct contacts with NOAA-based automated phytoplankton identification efforts. The current PST membership is shown in Table 1 and contact information for PST members is provided in Appendix 1.

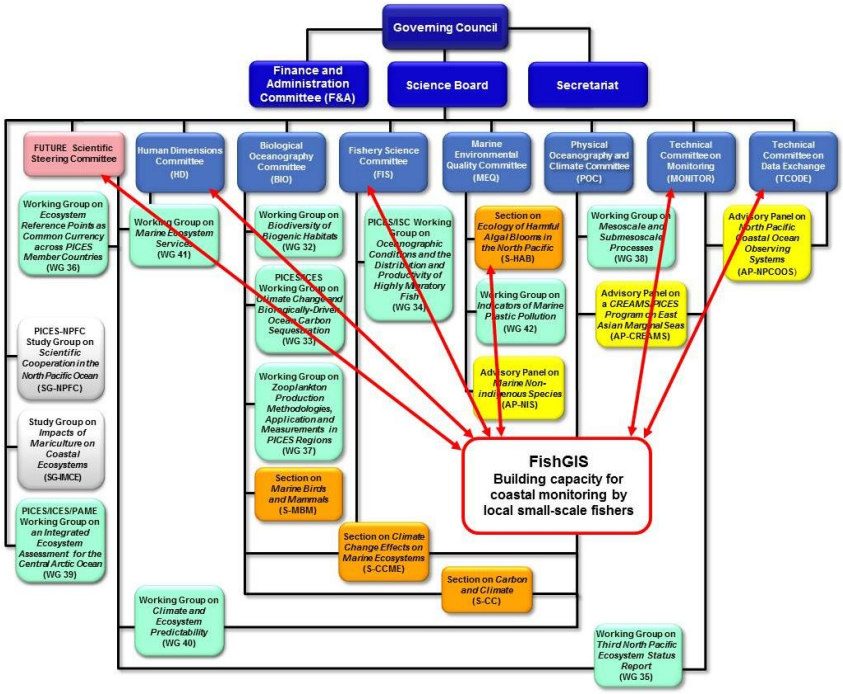

Fig. 1 PICES (North Pacific Marine Science Organization) structure for 2018–2019 showing links between the FishGIS project and PICES expert groups and committees.

Table 1 Membership of the Project Science Team (*as of June 21, 2019*)

Name	Affiliation	Country/Group
Vladimir Kulik	TINRO	Russia/MONITOR
Joon-Soo Lee	KODC, National Institute of Fisheries Science	Korea/TCODE
Mitsutaku Makino	AORI, The University of Tokyo	Japan/HD/FUTURE SSC
Shion Takemura	Japan Fisheries Research and Education Agency	Japan/HD
Vera Trainer	Northwest Fisheries Science Center, NOAA	USA/S-HAB
Naoki Tojo	Hokkaido University	Japan/FIS
Charles Trick	Western University	Canada/S-HAB
Mark Wells	University of Maine	USA/S-HAB
Chang-an Xu	Third Institute of Oceanography, SOA	China

The first PST meeting (Fig. 2, left) was convened January 17–19, 2018, in Yokohama, Japan, to (1) discuss the overall strategy and general directions for the project and develop timelines for project activities and deliverables, (2) review and refine the Year 1 workplan, and (3) identify the main elements of the Year 2 workplan.

The second PST meeting (Fig. 2, right) was held November 2, 2018, also in Yokohama, in conjunction with the PICES Annual Meeting (PICES-2018). The main objectives of the meeting were to (1) discuss the overall project strategy and timelines for project activities and products, (2) review the outcomes of the July 2018 training workshop and other activities carried out to date in Year 2, (3) examine on-going data collection and reporting activities for the two initially selected case studies (Muara Gembong and Indramayu), (4) discuss options for an additional case study site, and (5) draft the Year 3 workplan.

Fig. 2 (left) Participants of the first PST meeting held January 17–19, 2018, in Yokohama, Japan (l to r): Mitsutaku Makino, Naoki Tojo, Mark Wells, Shigeharu Kogushi (lead for the development of a GIS-based fisheries data smartphone application, GFL, Japan), Vladimir Kulik, Chang-an Xu, Alexander Bychkov (PICES), Shion Takemura, Charles Trick and Tomowo Watanabe (MAFF/JFA, Japan).

Fig. 2 (right) Participants of the second PST meeting held November 2, 2018, in Yokohama, Japan (l to r): Takaaki Mori (Hokkaido University student, Japan), Naoki Tojo, Mark Wells, Chang-an Xu, Shion Takemura, Suhendar Sachoemar (BPTT, Indonesia), Alexander Bychkov (PICES), Ayumi Kanaya (Hokkaido University student, Japan), Mitsutaku Makino, Charles Trick, Shigeharu Kogushi and Vladimir Kulik; missing from photo: Joon-Soo Lee.

Identifying partners in Indonesia and case study sites selection

One of the first, and strongest, lessons learned from the previous PICES/MAFF projects is the importance of connecting with organizations in a developing country which can facilitate and advance the project. This organization and the key people are needed to understand the project and to translate it into the local context. From the start of this project, the Indonesian Agency for the Assessment and Application of Technology (BPPT) was identified as the leading partner for two main reasons: (1) BPPT is responsible for leveraging advances in technology to study environmental systems to enhance Indonesian economic and societal development, and (2) a productive working relationship with BPPT was developed during the previous PICES/MAFF project on "*Marine ecosystem health and human well-being*" (2012–2017), and the current project can build upon this strong collaborative foundation. On March 19, 2018, during a visit by PST members to Indonesia, a Letter of Intent (LOI) between BPTT and PICES was signed as a basis for collaboration on the FishGIS project.

Linkages with other Indonesian agencies, such as LIPI and MMAF, were also determined to be beneficial for the project. The first PICES/MAFF project on "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*" (2007–2012) included HAB training for LIPI scientists, and the intention is to use this existing local expertise to help identify phytoplankton community composition changes and the appearance of HAB species in the case study sites.

In Year 1, the project was introduced to colleagues at BPPT to seek their advice on the locations for the case studies. The three potential sites initially recommended by Indonesian partners and visited by PST members and BPPT staff in March 2018 were Muara Gembong, Indramayu and Cilincing (Fig. 3). Joint meetings and small group interviews were held in each community in order to learn from the locals about the state of their fisheries, their environment, and their primary concerns for fisheries in the future. On completion of these community forums, the three proposed sites were ranked in terms of the project goals using several criteria relevant for the success of the project, including the presence of a strong local coordinator (considered vital), ecosystem changes that could be recognized by the people, evaluation of

their understanding of the relationship between environment and fisheries (wild- and aquaculture-based), and the overall interest of the community for education and training. After evaluation, Muara Gembong and Indramayu were selected as the case study sites for the project. Cilincing was reluctantly ruled out for several reasons, with the main ones being the close proximity to high-level pollution from Jakarta, and knowledge that the community and its fishing operations are likely to be in transition over the next 5 years due to local commercial development (for details see PICES Press, 2018, Vol. 26, No. 2, pp. 20–24; and FishGIS Year 1 progress scientific report).

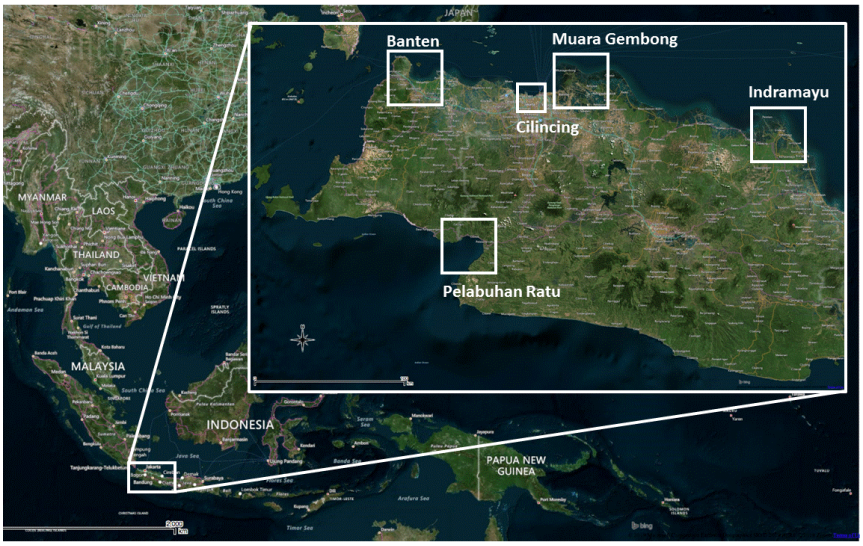

Fig. 3 Location of selected case study sites in Java, Indonesia.

Fig. 4 Visit by the PICES Team and BPPT staff to Indonesian communities considered as potential case study sites in February 2019: Welcome (top) and introduction of the FishGIS project (bottom) at the meeting in Karangantu Port of Banten on February 4 (left column); and welcome (top) and demonstration of smartphone applications (bottom) in Sukabumi of Pelabuhan Ratu on February 6 (right column).

Muara Gembong and Indramayu were ideal locations to begin the project, but both had similar challenges and marine environmental conditions. PST members felt that it would be valuable to expand the project to include communities having a more diverse portfolio of local fisheries. In consultation with BPPT, two potential sites were identified in western Java, Banten in the northwest and Pelabuhan Ratu in the southwest (Fig. 3), and visited by PST members and BPPT staff in February 2019. After holding joint meetings with fishers and local authorities (Fig. 4), both these communities were selected as additional sites for the project based on their very different fishery characteristics, their keen enthusiasm to participate in the project, and their logistically feasible travelling distance by car from Jakarta.

Analytical tools – development and modification of the smartphone applications

Based on discussions during the March 2018 visit to Indonesia, and in line with the project's major initiatives, the PST decided to introduce several easy-to-use technologies to monitor: (1) some aspects of water quality, (2) phytoplankton community composition, with emphasis on HAB species, and (3) fish landings accompanied by information on fishing operations (for details see PICES Press, 2019, Vol. 27, No. 1, pp. 16–18). These items are expected to be monitored by the locals (mainly fishers) in close collaboration with Indonesian scientists.

The water quality assessment application HydroColor is available for both Android (down to version 5) and iPhone products, and employs a methodology similar to precision radiometers and ocean color satellites to estimate three key water quality parameters: turbidity, suspended particulate matter, and chlorophyll concentration (when calibrated). The application provides a high technology but simple methodology for accurate measurements – three images are to be collected using the smartphone camera for calculating the remote sensing reflectance: an 18% photographer's grey card to calibrate the camera, the incoming (sky) radiation, and the light leaving the water surface (Fig. 5 and 6). HydroColor was tested at the July 2018 training workshop and was found to work well – no significant modification was necessary. To simplify operations, the application has been translated into the main Indonesian language, Bahasa, and is being automated for data upload. These changes are expected to be completed before the Year 3 training workshop.

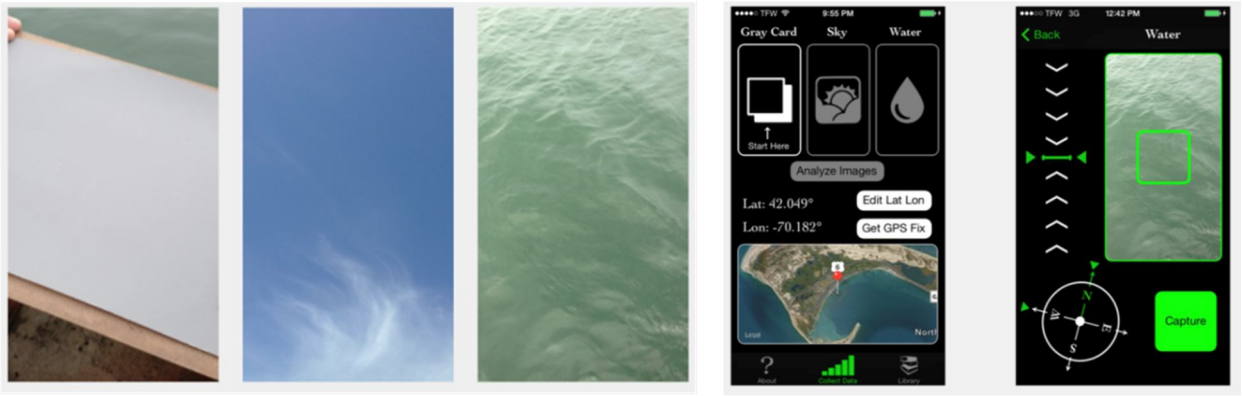

Fig. 5 (left) Example images of the 18% photographer's grey card (left), the sky (middle) and the water surface (right) collected by a HydroColor application user for calculating the remote sensing reflectance (http://misclab.umeoce.maine.edu/research/HydroColor.php).

Fig. 6 (right) The HydroColor application user interface showing the prompts for the three images: grey card, sky, and water (left). On selecting the image, the screen changes to display the inclinometer and compass to guide the user to the correct smartphone angle to capture the image (right). When the green elements of the compass and inclinometer are properly aligned with the green triangles the capture button turns green, enabling the photo to be taken.

The technology for collecting phytoplankton community composition data and, in particular, data on the presence of toxin-producing dinoflagellates, utilizes foldscopes –affordable origami-based microscopes for the masses (https://www.foldscope.com). Foldscopes provide optical magnifications of 140× with resolutions down to 2 µm, and can be attached to any smartphone. Still images or videos of swimming phytoplankton can then be collected for taxonomic identification. The foldscope component of the project is vital for helping LIPI, which is the central organization responsible for HAB monitoring in Indonesian waters, to provide this service to the participating communities.

For monitoring fish landings, the project, through a contract with Dr. Shigeharu Kogushi (Green Front Laboratory, Japan) has developed a new smartphone GIS-based application named "FishGIS" (Fig. 7). The software allows fishers to take photos of their catch and add information such as location, fishing gear, species, and catch trends (size and amount). These data can be used for preliminary stock assessment by local fisheries researchers, and then shared with the community. The FishGIS application also permits users to record and share with the local community and governmental authorities information on illegal or unregulated vessels or on operations with illegal gears. In addition, the application can be used to record the abundance and location of floating garbage – another serious problem for coastal communities, to enable clean-up actions as well as to follow changing community practices. All the monitoring results, from water quality (data view from the HydroColor application was integrated into the FishGIS platform) to garbage, are displayed on a map provided by the FishGIS application (Fig. 8).

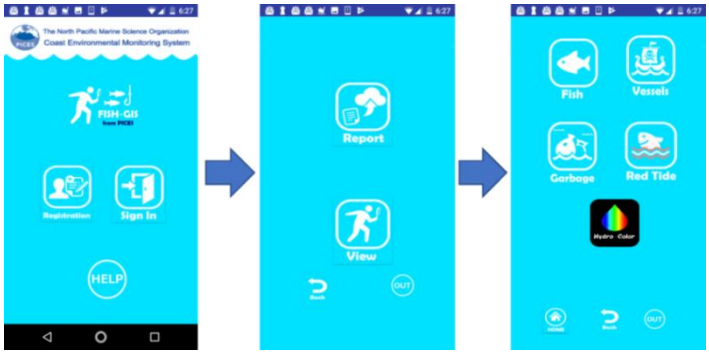

Fig. 7 The FishGIS application user interfaces: user registration (left), top menu (center), and monitoring items (right).

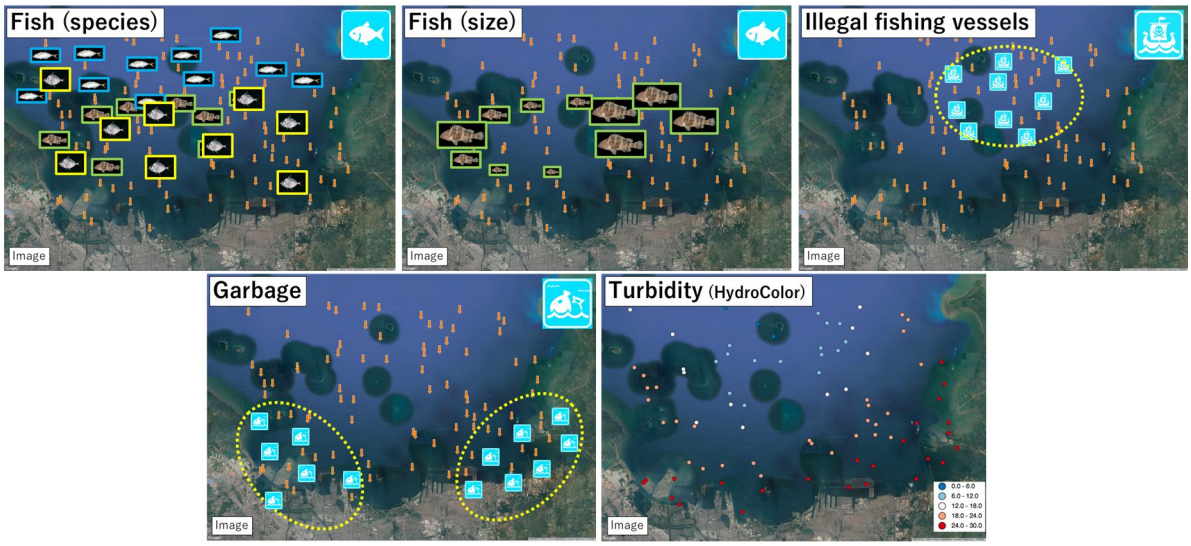

Fig. 8 Maps of the FishGIS application: fish species, catch trends (size and amount), illegal fishing vessels, floating garbage, and turbidity by the HydroColor application.

The prototype FishGIS application (Ver. 0) was extensively tested at the July 2018 training workshop, where several difficulties were identified, mainly related to how straightforward it was for fishers and fish farmers to use. The most serious limitation was that a significant number of community members are still using phones with the older Android version 4 or version 5 operating systems, which did not work with the application. The decision was made to revise the application to work with Android version 5 and later, as revising to version 4 would require a total rewriting of the application, which is beyond the financial scope of the project. Work has been also done to modify the user interfaces, simplify the steps for recording data, and remove inconsistencies between the application and fish species on site (pointed out by local fishers) and between the application and the list of illegal fishing gears, as determined by the Indonesian government (indicated by local government officers). An important step forward, taken with assistance from Indonesian colleagues, was the development of the guidelines for using the FishGIS application in Bahasa (Fig. 9). The intermediate versions of the application were tested during the last two visits of PICES experts to Indonesia: in December 2018 (Ver. 1) and February 2019 (Ver. 2). The current version will be distributed and tested under real-world conditions in July 2019 during the Year 3 training workshop.

Fig. 9 The guidelines for using the FishGIS application translated to the main Indonesian language, Bahasa.

July 2018 training/capacity building workshop

On July 10–12, 2018, PICES and BPPT, with support from MMAF and LIPI, organized a training workshop in Jakarta (Fig. 10) on the new technologies described above. Overall, more than 100 people (fishers, fish farmers, community leaders, and local government officers from Maura Gembong, Indramayu and Banten, as well as Indonesian researchers, central government officers and PICES experts) were involved in this effort.

A day prior to the workshop, an orientation training session took place for members of the Center for Development, Education and Training of BPPT, the Bureau of Legal, Cooperation and Public Relations of BPPT, the Research Centre for Oceanography of LIPI, the Ministry of Marine Affairs and Fisheries, and the Public Service Agency for Culture-Based Fishery Production of Karawang Regency. This "training of the trainers" was designed not only to increase awareness of the MAFF project and its goals, but also to prepare BPPT and LIPI staff to lead training in the future.

The workshop was held at BPPT and LIPI Headquarters. At BPPT, and then during the field session, the participants learned how to download, install and operate the FishGIS and HydroColor applications. The PST members provided the initial instructions, but training was quickly transitioned to BPPT staff, with PICES experts serving in a support role. At LIPI, the participants were presented with a practical overview

of HABs in Indonesia, including the potential implications for human health. They were then taught how to assemble and use foldscopes and their phones to observe and capture images of HAB species from LIPI's sample archives. Some participants also took additional training on the use of plankton nets.

Fig. 10 Training workshop held July 10–12, 2018, in Jakarta, Indonesia; first row: Opening the workshop by Prof. Suhendar Sachoemar (left) and Dr. Mitsutaku Makino (right); second row: Participants investigate smartphone applications (left) and the foldscopes (right); third row: Participants take part in very productive discussions (left) led by Dr. Charles Trick (right); bottom row: PICES Team members, BPPT staff and participants posing after the Closing Ceremony.

In general, the workshop was a success. The participants expressed deep interest in the topics and tools, understood what the project was trying to accomplish and demonstrated their enthusiasm and willingness to learn from training and to contribute to the project in the hope of improving their environment. Such strong interest during the entire 3-day workshop was due, in part, to the PST laying the groundwork by holding community meetings in March 2018 to clarify the local needs and issues (see PICES Press, Vol. 26, No. 2, pp. 20–24), and then developing a training course based on those.

Nevertheless, some community members remained uncertain how the data they are going to collect would be used, what kind of feedback they would be getting from these data, and how such feedback would contribute to their daily life and well-being. Fisheries management does not exist in these local communities, and PST members found that the concept was too novel to be well-communicated to the fishers using "standard" explanations. It was agreed that a deeper understanding of the fishers' livelihoods was necessary to better describe the underlying purpose of these data collections and how they would benefit the communities – creating a collective understanding would be essential for the project activities to be sustainable over the longer term.

Another shortfall was that the connection between the FishGIS and HydroColor applications and HAB monitoring with foldscopes was not demonstrated well enough – the participants were uncertain on what they would get from the foldscope data. This aspect is expected to be dealt with in a follow-up training program, where new PST member, Dr. Vera Trainer, who has expertise in how to approach this topic, will provide instructions.

Dissemination of project results/outcomes

Some results from the early stages of the project were summarized in three posters presented at PICES-2018. Though all PST members and the major BPPT counterpart, Dr. Suhendar I. Sachoemar, contributed to these papers, the lead was taken by two Hokkaido University students, Ayumi Kanaya and Takaaki Mori, and their mentor Dr. Naoki Tojo (Fig. 11):

- Ayumi Kanaya *et al*. "Participatory research in resource production for sustainable fisheries and estimation of option value in Indramayu, Indonesia" (FIS Paper Session);
- Takaaki Mori *et al*. "Economic value of ecosystem services and utility of coastal fisheries in Indramayu, Indonesia" (W8: Taking stock of marine ecosystem services in the North Pacific — Exploring examples and examining methods);
- Naoki Tojo *et al*. "Interactions within fisheries eco-/econo-system and impact of participatory research in a coastal community: in the model area of Indonesia" (FIS Paper Session).

It is expected that this project will continue functioning not only as a scientific platform but also as an educational platform for early-career scientists.

Fig. 11 After the PICES-2018 Poster Session: Hokkaido University student presenters, Ayumi Kanaya and Takaaki Mori (in the center, with a poster), posing with PST members, Shion Takemura (second from the left) and Mitsutaku Makino (second from the right) and early-career scientists from the Japan Fisheries Research and Education Agency.

Post-workshop community training: December 2018 and February 2019

At its second meeting (November 2, 2018), the PST learned that data uploads from the communities were sparse, signalling difficulties in using the smartphone applications. This problem was confirmed by BPPT staff and by direct communications between community members from Muara Gembong and Indramayu and PST member Dr. Naoki Tojo, who is leading the human dimension assessment. Because of initial technical problems with the applications and the lack of understanding how the data they collect would be used and contribute to their daily life and well-being, the project tools were slow to be adopted by the two communities. To help re-establish the initial enthusiasm for the project, and to clarify the benefits to the communities, a two-pronged post-workshop community training program was designed and began near the end of Year 2. First, Dr. Tojo led an effort in Indramayu in December 2018, which emphasized the value of management for fisheries sustainability and allowed the collection of supplemental information important from the perspective of fisheries science to better understand the target communities. Second, BPPT staff began working with one or two community members in both communities to establish consistent data collection with the intention that these lead members will serve as in-community resources for other fishers and fish farmers, thereby building a network of data-reporters.

Fig. 12 Visit of the Hokkaido University team (December 11–13, 2018) to Pabean Ilir village in Indramayu, Java, Indonesia: Local fishers discuss FishGIS application manual development (top left), investigate the foldscopes (top right), pose prior to field observations (bottom left), and sail to collect fisheries data (bottom right).

From December 11–13, 2018, a 3-person Hokkaido University team visited Pabean Ilir village in Indramayu. On-site events included a public hearing, practical training with the project analytical tools (the foldscope and FishGIS (Ver. 1) and HydroColor applications), and discussions and interviews with fishers and other community members (Fig. 12). In each case, a minimum of 10 locals were involved. The outcome was that participants were able to better appreciate the underlying reasons for the monitoring activities, improve their understanding of the project tools, and effectively navigate through the smartphone applications to successfully collect environmental and fisheries data. In addition, the experience identified further refinements needed for the FishGIS application and steps to adapt the guidelines/manual for use this application in Bahasa.

This visit also provided an opportunity to collect information on local fisheries, target species (there is great diversity of fishes in the area – more than 20 species) and livelihood of local fishers and fish farmers for socio-economic research. The Hokkaido University team had a chance to talk with the fishers on sustainability of local fishing grounds, and find out what their visions were for future fishing and stocking, and their use of the project tools and monitoring. The fishers summarized these activities themselves afterwards, showing that there was general consensus within the community. In the final discussion, fishers participated in a "game experiment" to understand how cooperation can influence their decision-making process. First, fishers individually chose a number of fish to catch based on information about the size of the fishery stock, and then removed this number from an opaque bag containing the entire "stock". The initial game outcome showed a rapid depletion of the stock by overfishing, to the surprise and dismay of the fishers. However, they then quickly learned to transition their decision-making towards a more altruistic fishing the shared resources, leading to a "sustainable" fishery. This rapid shift in strategy suggests there is a high potential for achieving sustainable fishing by local fishers in these communities once clearer explanations are given about the purposes, activities and tools provided in the interactive training. One observation from small group interviews was that though community members feel uncertain about their environment and are highly motivated to join the proposed monitoring activities, it is financially challenging for them to invest in upgrading their phones or purchasing new phones compatible with the FishGIS and HydroColor applications. So, further technical support for local people is required to continue monitoring.

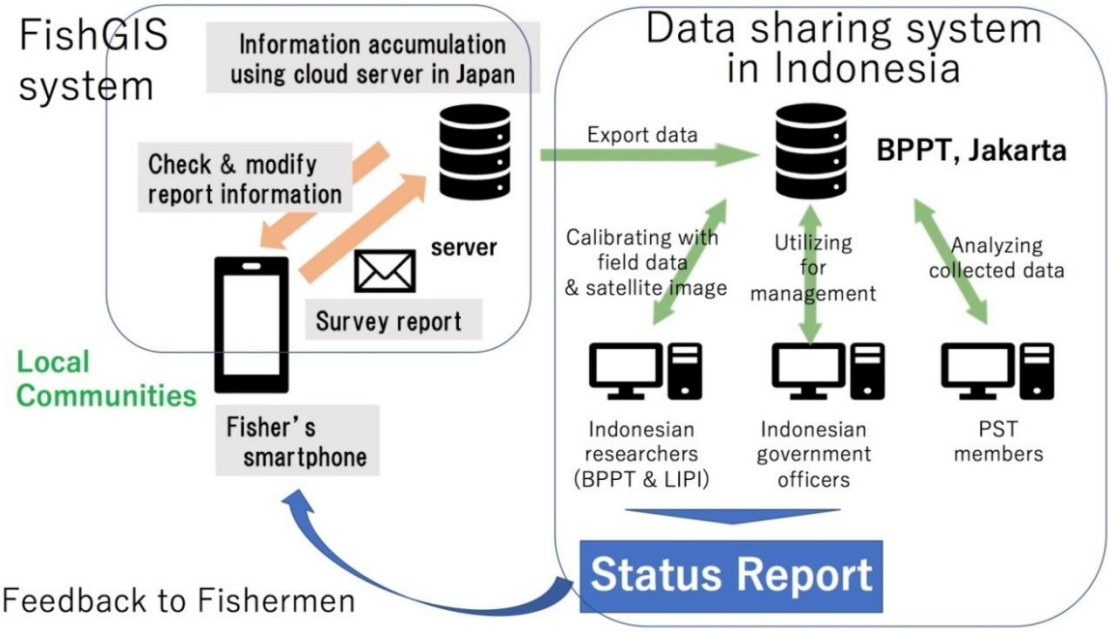

Fig. 13 Data management scheme for the FishGIS project.

The main goal of the February 2019 visit by the PICES team to Indonesia was to assess the suitability of two new locations in western Java recommended by BPPT partners as the potential case study sites for the project (Fig. 3 and Fig. 4). The Banten and Pelabuhan Ratu sites have distinct regional differences from Muara Gembong and Indramayu in that they have more diverse fishing targets, a greater variety of fishing methods and technology levels, and are generally better informed on sustainable resource uses. This visit provided an additional opportunity to test the project tools, including Ver. 2 of the FishGIS application, and to evaluate the approaches for disseminating a longer-term project vision. The importance of environmental and fisheries monitoring and the value of the data to be collected in the daily lives of the local people was emphasized at the meetings held in Karangantu Port of Banten (February 4) and Sukabumi of Pelabuhan Ratu (February 6). The same game conducted in December 2018 in Pabean Ilir village in Indramayu was played with the local fishers and fisheries officers in Sukabumi, with the same ultimate outcome – initial overfishing was replaced with sustainable fishing by the end of the game. This learning activity on responsible resource uses was an effective tool on calling to attention of the locals to the overall significance of the proposed monitoring. At the end of the visit, a scheme for the management of data to be collected using smartphone applications was refined through discussion with BPPT technicians (Fig. 13). There is mutual understanding that eventually the data server will be located and managed in Indonesia.

Similar to the December 2018 visit, additional information about the local fisheries and socio-economic conditions (*e.g.*, supply chain, fish prices, *etc*.) was collected from local authorities and is being analyzed.

WORKPLAN FOR YEAR 3

Analytical tools – modification and refinement of the smartphone applications

The project is supporting the development of a GIS-based fisheries data application that uses smartphones to take photographs of fisheries catches to develop a fish catch database to inform fisheries management. After testing the prototype FishGIS application during the July 2018 training workshop, work has been done to simplify the steps for recording data and to develop guidelines for using the application in the main Indonesian language, Bahasa. The improved version (operational for Android version 5 and later) will be beta-tested under real-world conditions during the Year 3 training workshop.

The water quality assessment HydroColor application has been also translated into Bahasa, and is being automated for data upload. These changes will be completed before the Year 3 training workshop, and the application will be distributed for beta-testing to the local fishers. There are further plans to have BPPT staff, or community members, prepare video instructions in Bahasa, with the idea that this resource could be available for expanding training to other regions.

July 2019 training/capacity building workshop

The original plan for the Year 2 workshop was to conduct the training in each community (Muara Gembong and Indramayu), but it was revised to bring community members to Jakarta instead. This change increased the cost of the training program (in terms of accommodation and food expenses), but the outcomes showed that it was the best decision from a training perspective as (1) distractions that would have occurred during training in the villages were eliminated, (2) members from different communities had the opportunity to interact with each other and to meet and communicate with a large number of BPTT and LIPI staff, and (3) the overall high-level BPPT and LIPI participation signaled how important both agencies feel this project is for the communities.

In some ways, the logistics for training in Year 3 is similar to that of Year 2 – members of four communities involved in the project (Muara Gembong, Indramayu, Banten and Pelabuhan Ratu), along

with representatives from other regions who are interested in learning more about this expanding program, will be brought to one location. The difference is that this time the location will be not Jakarta but Banten, which has a strong regional Ministry of Fisheries with interest and capabilities to co-sponsor and host the planned workshop. Having this event in Banten ensures dedicated participation by the regional fisheries personnel, will be a keen point of pride for the community, and will help to establish another center of FishGIS expertise in Indonesia to expand the project goals beyond the end of the program. The workshop, organized in cooperation with BPPT and Banten Province, and supported by LIPI, MMAF and the Ministry of Environment and Forestry (MEF), will be held in July 2019.

The Year 3 workshop will follow the same successful protocol as the July 2018 workshop and will have three components: (1) training of fishers (defined here as including both wild- and aquaculture-based fisheries) in the use of the GIS-based fisheries data smartphone application being developed in this project, (2) training of fishers in use of the water quality assessment smartphone HydroColor application (work will continue with BPPT staff to collect the needed data to enable calibration of this application), and (3) training of community members in water and plankton collection and phytoplankton observations, including HAB species, with foldscopes. In addition, significant time will be devoted to data/information gathering with community members using a combination of socio-ecology interview tools such as "clicker views and discussion" and conversational interviews. The aim of this set of exercises is to assess the "wellness" of the human–fisheries connection and the first indication of the use of technology to improve community understanding of the present and future fisheries. Besides community training, PST members will also continue training BPPT and LIPI staff and local management officers to ensure sustainable citizen-science monitoring activities after project completion.

Post-workshop community training

Considering the success of the post-workshop community training in Indramayu (December 2018) in helping fishers with continued use of the applications and in communicating the benefits management can bring to sustainable fisheries, similar efforts will continue in Year 3 and will be expanded to Banten and Pelabuhan Ratu.

Project Science Team meetings and post-project assessment

The third PST meeting is scheduled for October 16, 2019, in conjunction with the PICES Annual Meeting in Victoria, Canada. The meeting will examine the results from the July 2019 training workshop in Banten, along with ongoing data collections from the four communities involved in the project, and review the timelines for project final reports and products. One expected outcome from the PST meeting is the framework for the post-project assessment planned for January or February 2020. It is imperative that discussion with the local communities be arranged so PST members can evaluate the success or improvements needed in FishGIS activities. On the final visit to Indonesia, all four communities will be interviewed to access what impact the project has made on their perception of fisheries issues, and the preliminary steps to take towards fisheries and HABs monitoring in these regions. The concluding fourth PST meeting will be held at the end of the visit.

Dissemination of results/outcomes

Three posters on different aspects of the project were presented at PICES-2018. In the final year of the project, efforts will be made to disseminate results/outcomes through publications and presentations at scientific events and conferences; possible options include the second international symposium on "*Marine Socio-Ecological Systems*" (MSEAS-2020) to be convened in May 2020, in Yokohama, Japan, and the PICES Annual Meeting to be held in October 2020, in Qingdao, China.

APPENDIX 1: PROJECT SCIENCE TEAM MEMBERSHIP (*as of June 21, 2019*)

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