NORTH PACIFIC MARINE SCIENCE ORGANIZATION (PICES)
PROJECT ON "*MARINE ECOSYSTEM HEALTH AND HUMAN WELL-BEING*" (MarWeB)

SCIENTIFIC PROGRESS REPORT YEAR 4 (APRIL 1, 2015 – MARCH 31, 2016)

1. BACKGROUND

In December 2011, the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA), approved funding for a 5-year PICES project on "*Marine ecosystem health and human well-being*" (MarWeB). The project began in April 2012, with the ending date set as March 31, 2017. The project's goal is to identify the relationships between sustainable human communities and productive marine ecosystems in the North Pacific, under the concept of fishery social-ecological systems (known in Japan as the "*Sato-umi*" fisheries management system). It recognizes that global changes are affecting both climate and human social and economic conditions. Key questions of the project are: a) How do marine ecosystems support human well-being? and b) How do human communities support sustainable and productive marine ecosystems? The project is also intended to foster partnerships with non-PICES member countries and related international organizations/programs. This contribution is from the Official Development Assistance (ODA) Fund and therefore, involvement of developing Pacific Rim countries in activities is required under this project.

The following organizational principles, agreed upon by MAFF/JFA and PICES, apply to the project:

- The Project is expected to have strong connections and interactions with, and to involve and support the relevant activities of, the PICES FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) science program and PICES expert groups (Project Principle 3.1; Fig. 1).
- The project is directed by a Project Science Team (PST), co-chaired by Drs. Mitsutaku Makino (Fisheries Research Agency, Japan, mmakino@affrc.go.jp) and Ian Perry (Department of Fisheries and Oceans, Canada; Ian.Perry@dfo-mpo.gc.ca), with membership from PICES and non-PICES countries, as deemed appropriate (Project Principle 3.2).
- The PST Co-Chairmen are responsible for the scientific implementation of the project and annual reporting to MAFF/JFA and PICES Science Board. This report should be submitted to JFA within 120 days after the close of each project year ending March 31, and include a summary of the activities carried out in the year, with an evaluation on the progress made, and a work plan for the following year (Project Principle 3.3).

This progress report summarizes the activities carried out for Year 4 (April 1, 2015 to March 31, 2016) and includes a work plan for Year 5 (April 1, 2016 to March 31, 2017).

The Project Coordinator, Dr. Alexander Bychkov (bychkov@pices.int), is responsible for the management of the MAFF Fund and annual reporting on its disposition to MAFF/FRA and PICES Governing Council within 120 days after the close of each project year. The financial report for Year 4 is being submitted as a separate document simultaneously with this progress report.

2. WORK PLAN FOR YEAR 4

(1) Project Science Team meetings

- Organize one Project Science Team meeting, at the PICES 2015 Annual Meeting (October 2015, Qingdao, China).

(2) Case studies

In Indonesia

- Complete the multi-trophic aquaculture pond experiment and theoretical modeling of potential carrying capacity with Indonesian partners at Karawang experimental site, including site visit by Project Science Team members;
- Organize a workshop to develop manual and identify lessons learned regarding human-environment interactions (*Sato-Umi*) during pond experiments.

In Guatemala

- Continue the oyster project and expand from the estuary to the nearshore region to potentially include pearl oysters;
- Engage an eco-health expert to provide recommendations related to both aquaculture and economic health in the two study communities. This assessment will include recommendations for potential funding opportunities that will allow these communities to build upon our work and improve their overall health;
- Report to Guatemalan local people and Project Science Team on results of social science survey and aquaculture assessment.

(3) Human well-being surveys

- Continue analyses of the data and review the results from the human well-being surveys conducted in Japan, Korea, United States, Indonesia;
- Conduct web-based surveys in Russia and China.

3. PROGRESS OF YEAR 4

3.1 Project Science Team Meetings

The Project Science Team was established in August 2012 (Year 1) in order to review the scientific progress, and make recommendations for the implementation of the project. The PST membership was unchanged in Year 4. As of April 2015, the PST membership includes 13 scientists: 4 from Canada, 3 from Japan, 2 from Korea and 3 from USA, and a representative from the PICES Secretariat (Table 1). A total of 5 PICES expert groups are represented on the Team: Section on *Hunan Dimensions* (S-HD), Section on *Climate Change Effects on Marine Ecosystems* (S-CCME), Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB), Working Group on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* (WG 28) and FUTURE Scientific Steering Committee (FUTURE SSC).

Table 1 Membership of the Project Science Team (as of April 2015)

Name	Affiliation	Country/Group
Dr. Harold Batchelder	PICES Secretariat	PICES
Dr. Keith Criddle	University of Alaska, Fairbanks	USA/S-HD
Ms. Juri Hori	Rikkyo University	Japan/S-HD
Dr. Masahito Hirota	Fisheries Research Agency	Japan/S-HD
Dr. Suam Kim	Pukyong National University	Korea/S-CCME
Dr. Mitsutaku Makino	Fisheries Research Agency	Japan/S-HD
Dr. Grant Murray	Vancouver Island University	Canada/S-HD
Dr. Jongoh Nam	Pukyong National University	Korea
Dr. Ian Perry	Department of Fisheries and Oceans	Canada/WG 28/FUTURE SSC
Dr. Thomas Therriault	Department of Fisheries and Oceans	Canada/FUTURE SSC
Dr. Vera Trainer	Northwest Fisheries Science Center	USA/S-HAB
Dr. Charles Trick	University of Western Ontario	Canada/S-HAB
Dr. Mark Wells	University of Maine	USA/S-HAB

In Year 4, one PST meeting was held. It was convened on October 14, 2015, in conjunction with the 2015 PICES Annual Meeting in Qingdao, China. The key objectives of the meeting were to: (a) develop plans for the Guatemala case study, (b) further develop the Indonesia case study, (c) review progress and plans for the social science survey project (the "Well-being CUBE" analysis) and (d) prepare the detailed work plan for *FY* 2015–2016. The report from the 2015 PST meeting and other materials will be available on the project's web page at http://www.pices.int/ projects/MarWeb_default.aspx.

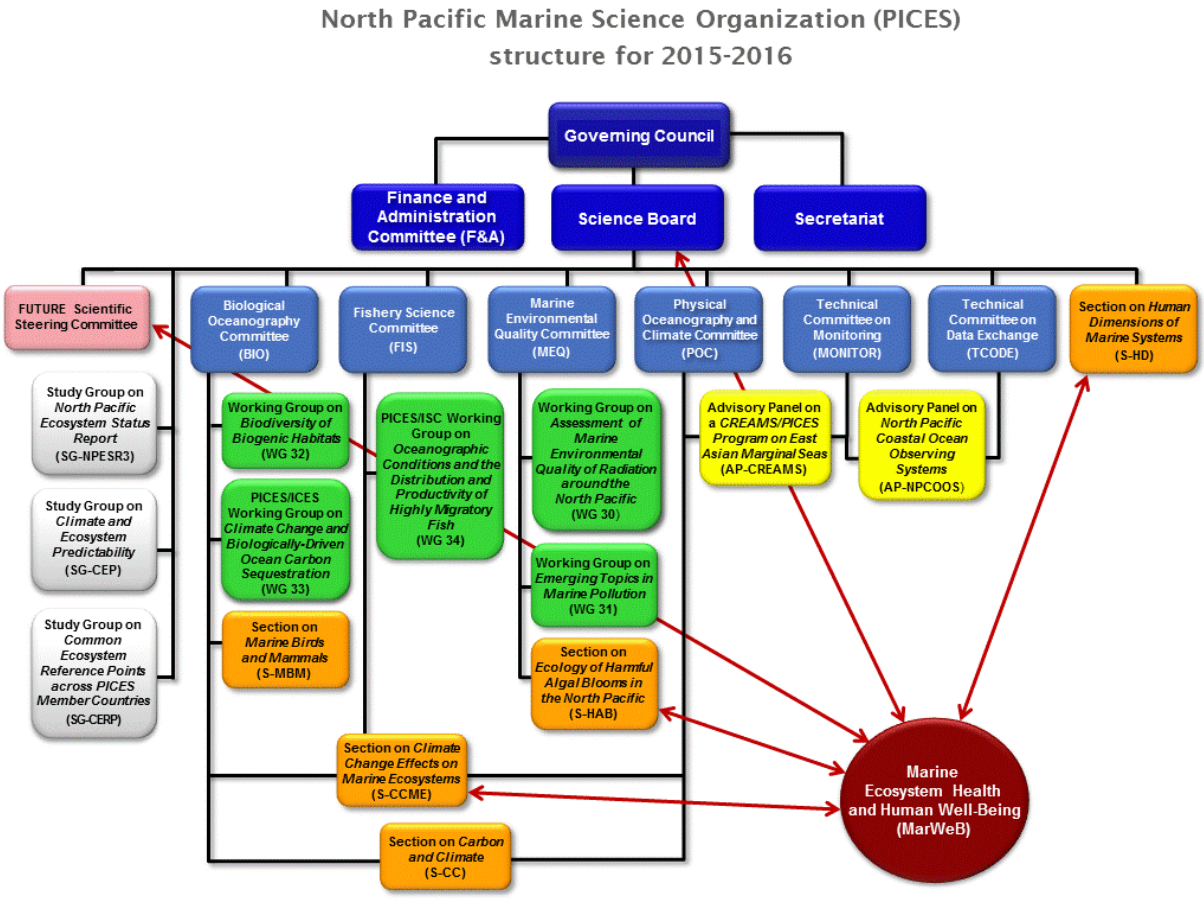

Fig. 1 PICES (North Pacific Marine Science Organization) structure for 2015–2016 showing links between the MarWeB project and expert groups.

3.2 Case studies

3.2.1 Indonesia

<u>*Ecological systems*</u>

"Sato-umi" is the concept of the sustainable management where human intervention in the management of fishery resources in coastal and marine areas can increase productivity and diversity of fishery resources. More broadly the concept strives to achieve a balance between the utilization natural resources, while maintaining ecosystem stability. The MarWeB project is investigating the use of multi-trophic aquaculture in brackish water shrimp and Tilapia ponds in Indonesia. Intensive shrimp aquaculture activities were highly developed in the Karawang area (3 hours from Jakarta) in the 1990s. This led to de-forestation, then marine pollution, shrimp mass-diseases, and ultimately to pond abandonment. The main issue is serious environmental degradation and land erosion as a result of removal of mangroves and building of coastal shrimp ponds. This has resulted in a current ecological system with intensive monoculture of shrimp.

The goal of this activity is to optimize the balance between maximizing harvesting of the primary economic product (shrimp or *Tilapia*), adding further income through by-production of co-cultured food or marine products, and minimizing the excess nutrient discharge from these operations into coastal waters, which currently leads to degradation of coastal ecosystems. The focus has been on experimenting with methods and approaches that are amenable to the low-intensity, low technology, and limited financial resource conditions that describe community scale aquaculture in Karawang so that the project outcomes can have tangible effects

on improving human well-being in this region. This MarWeB activity is conducted in collaboration with Indonesian colleagues at the Agency for The Assessment and Application of Technology (BPPT) in Jakarta, and the National Center for Brackishwater Aquaculture (NCBA), in Karawang, Indonesia.

In 2015, the MarWeB project supported a second Pond Experiment which built upon the findings of the first experiment in the summer/fall of 2014. The 2015 experiment was run for 100 days at the end of which both shrimp and *Tilapia* were successfully harvested. The experimental results were reviewed in a small workshop held in Karawang in April 2016 that comprised the collective participants from PICES, BPPT, and the personnel at NCBA who were responsible for the day-to-day operation of the ponds and the extensive sample analyses. The experimental design for the 2015 experiment followed the general principle of the 2014 experiment, but was run in 1000 m^2 ponds, which are easier to maintain. The growth of shrimp and *Tilapia* were compared in the presence and absence of two co-cultured species; the macroalga *Gracilaria*, a common food and industrial aquaculture product, and the clam *Anadara* (Fig. 2). The experimental design comprised two controls (shrimp alone, *Tilapia* alone), 2 treatments (shrimp + *Gracilaria* + *Anadara*, and *Tilapia* + *Gracilaria* + *Anadara*), and a treatment that contained all 4 species (shrimp + *Tilapia* + *Gracilaria* + *Anadara*). The experiment was run for 100 days and was ended when the tilapia and shrimp in all ponds began showing signs of stress.

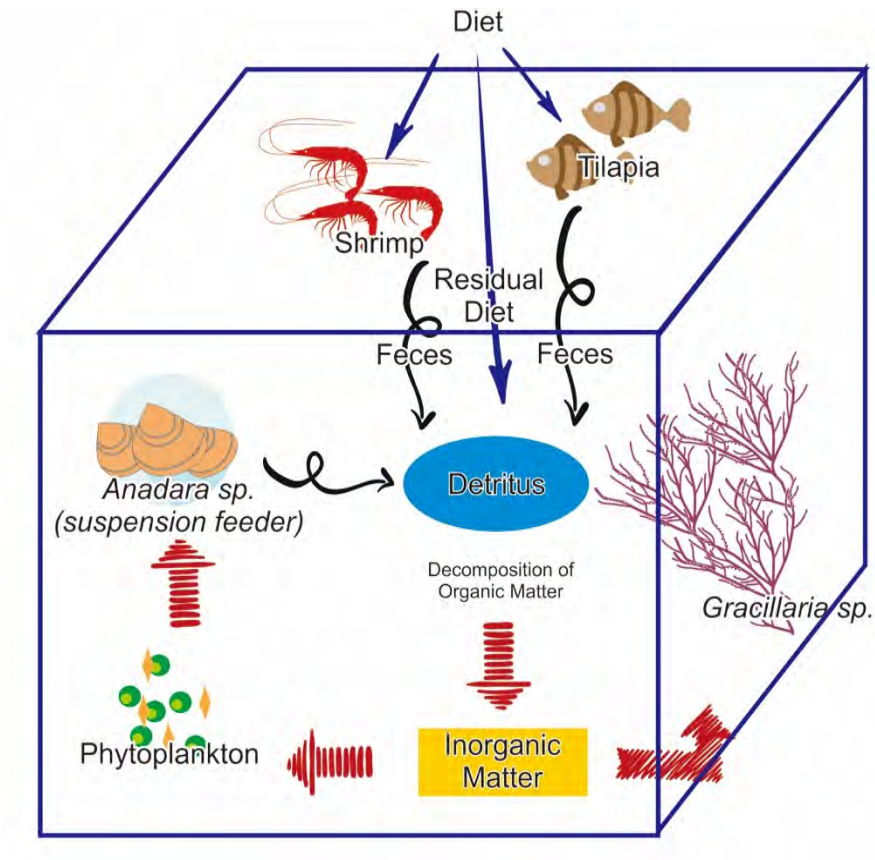

Fig. 2 Recycling waste generated by the cultivation of the main species (fish) into a source of energy and nutrients for the cultivation of other commodities, resulting in a product that can be harvested, and can reduce environmental impact (graphic provided by NCBA).

In terms of preliminary general results, the 2015 experiment was more successful than in 2014 in that there the Whiteleg shrimp (*Litopenaeus vannamei*) and *Tilapia* sp. showed good growth in all treatments, although the overall yield was less than NCBA staff had hoped. Overall health of these primary aquaculture products (the economic mainstays) was good up until the final few days of the experiment when signs of stress were observed in all ponds at equal levels (*i.e.*, there was no correlation with treatments or controls). A detailed

report on the findings from this experiment is being prepared for publication. In addition, a draft plan for a follow-up experiment to be conducted in the fall of 2016, derived from discussions during the April 2016 workshop, is also being developed.

The two experiments conducted to date (in 2014 and 2015) have benefited greatly from the enthusiasm and expertise of the BPPT and NCBA participants. The project findings have been very encouraging, and the steps taken forward have been broadly communicated to other agencies and communities in Indonesia. There is a strong interest within the Indonesian community to follow on with the development of this type of integrated multi-trophic aquaculture, as the country is moving forward to greatly expand aquaculture output over the next decade. An article was published describing this project (Wells *et al*. 2016. PICES Press 24(1): 29-31).

Social systems

Social science research in Indonesia focused on the development of commodity chains and how people valued their marine environment. In 2015, this research was expanded to Sulawesi, Sumatra, Indonesia. The approach was also expanded to include: (1) a preliminary analysis of the human geography of the areas of interest, (2) stakeholder mapping, which is to be followed by (3) a workshop for consensus building. As a result of a change in the research duties of one of the key social science researchers with the Indonesia case study, comparisons of methods to identify how people interact with their marine environment have been expanded to include Thailand. The survey method to identify commodity chains was also simplified so that it could be applied by people, such as local officers, who may not have scientific training. An example of how this approach can be integrated and presented is provided in Figure 3.

3.2.2 Guatemala

The MarWeB project activities in Guatemala during Year 4 were focused on two studies: (1) a Community Needs Assessment (CNA) of two small coastal communities, and (2) an oyster aquaculture project (for cross-comparisons with MarWeB activities in Indonesia).

A CNA is a systematic process for determining the needs (*e.g*., economic, nutritional, and social) and the definable goals of a community. CNAs can assist in directing resources and energies into creating the desired future of a community and can be used to address "gaps" between current conditions and desired conditions. CNAs are performed before major actions are implemented as part of a strategic planning process. In collaboration with colleagues at the Universidad de San Carlos de Guatemala, the MarWeB Project engaged in a series of conversations with community members from two villages along the Pacific coast of Guatemala – Las Lisas and Monterrico. The question for the communities on the first visit (in January 2014) was simply "What is your relationship with the sea?" The fishermen and fisherwomen of Las Lisas enthusiastically responded that the sea is their life and, while fishing is a struggle and challenging occupation, they would like to create a balanced approach to fisheries so that the next generation has ample resources for the community. In other words, they wish to develop a sustainable relationship with the sea. Collectively they accepted responsibility for the dwindling fish stocks and confided that they had overfished the estuaries and coastal waterways. In one community, the fishers felt they may be the "last fisherman" in Guatemala. The communal statements were clear and honest and reflected a fear for the future. These were communities motivated to make a change, but felt that change would be limited, and were unsure how to proceed. The second visit (in February 2015) focused on a CNA in these villages to permit a greater understanding of the complex community dynamics of Las Lisas and Monterrico in regards to their relationship with the sea and their well-being.

For the CNAs of Las Lisas and Monterrico, both surveys and interviews were conducted. Multiple families were interviewed: 20 families in Las Lisas, and 29 families in Monterrico. The questionnaire consisted of 34 questions. The questions fell into four areas: (1) questions to introduce the process so that the families could familiarize themselves with the approach and diminish any anxiety associated with the survey itself; (2) questions that helped delineate the demographics of the responder; (3) questions that probed the demand and accessibility of fish/protein supply; and (4) questions that examined the willingness of respondents to change their relationship with the resources of the sea.

Fig. 3 An example of how the simplified social survey can be presented to develop a marine commodity chain.

Separate reports were provided to each community, with a synthesis of the survey results, conclusions and recommendations. A synthesis of the major recommendations includes the following:

<u>for Las Lisas</u>

1. A more healthy lifestyle in Las Lisas can be facilitated with opportunities for:
   - better education
   - sustainable, environmentally-friendly tourism
   - environmentally-considerate aquaculture opportunities
2. Protection of the lagoon waters is essential, as these waters are breeding grounds for many major economically valuable species.
3. Community-wide, coordinated eco-tourism and fishing trips for tourists can be implemented to create a more sustainable alternative to fishing for food.
4. Alternative source of fish-based food supplies must be sought – such as through aquaculture.

<u>for Monterrico</u>

1. Communities leaders may use the report as a tool to secure funding for future eco-friendly development, while carefully considering which opportunities best promote community as well as ecosystem health.
2. The community of Monterrico has a unique relationship with the Universidad de San Carlos de Guatemala research lab and should work with this lab to develop sustainable (but perhaps not immediately obvious) associations. In this case, sustainable aquaculture must also protect the natural beauty of the Monterrico region to allow ecotourism to flourish.
3. A more healthy future in Monterrico can be facilitated with opportunities for better education, with young and enthusiastic community members returning "home" from the big city with new ideas.
4. Monterrico has moved away from the natural fisheries operation but tourist fisheries are important to the eco-tourism opportunity. A switch to eco-tourism means major changes for the community. Housing and feeding visitors will be the most difficult change.

The aquaculture project in Guatemala had difficulties due to left of equipment. The focus species is the Japanese oyster *Crassiostrea gigas*, which has been cultivated in Guatemala in previous research projects. During the site visit in early 2016, it was agreed that the experimental culture setup would be moved to the nearby Naval Base until the oysters are large enough to survive the higher sediment load in the waters of the La Barrona estuary. The 3-year agreement with the Navy to use a small area of the port facility will benefit the community and strengthen the relationship between the community and the Navy. Currently, a small number of pearl oysters and local oysters are being grown to test the water conditions and objectives of the project. The plan is to purchase oysters for food and start growing them shortly. This collaborative project with the Guatemala Navy, the University of San Carlos experts in oyster aquaculture, and a community near the border of El Salvador called La Barrona, serves as a model for bringing an alternative food source to an impoverished community in a developing nation. This partnership has opened avenues of collaboration among the local communities, the military, and the University. It can serve as an example for similar coastal communities in Guatemala and elsewhere.

3.2.3 Palau

A preliminary research investigation was conducted for the MarWeB project in Palau by Dr. Kumiko Suzuki, a Research Scientist with the Japan Wildlife Research Center. The fishery of Palau is categorized into six types: Coastal commercial, Coastal Subsistence, Offshore locally-Based, Offshore Foreign-Based, Freshwater, and Aquaculture. The offshore fishery is dominated by foreign fishing vessels, which mainly export tuna and bonito from Palau. The main catch in coastal area is reef fish, such as groupers, snappers, *etc*., which is used for domestic consumption. Fish consumption is decreasing gradually in Palau. However, compared to other island countries in the Pacific region, such as Samoa and the Solomon Islands, the consumption of fish is relatively high.

Fresh fish are landed in the fish markets and distributed to the local communities. There were 16 fish markets which were operated by fishing associations under the Palau Federation of Fishing Association (PFFA). At present, most of these fishing associations are ceasing operations, and the number of local fish markets is

decreasing. Newly opened hotels and restaurants are trying to get fresh fish for the guests directly from the local fishermen. As a result, the distribution system through fish markets is not currently functioning well.

At the national level, the environmental conservation policy is dominated by the Palau National Marine Sanctuary Act. This Act was approved in October 2015, to protect natural resources and the marine environment in Palau. A total of 80%of Palau's EEZ is designated as a fully protected marine reserve in which extractive activities such as fishing or mining are prohibited. The marine sanctuary will be implemented over a 5-year period, and the number of foreign vessels will decrease annually. The remaining 20% of the EEZ is a Domestic Fishing Zone reserved for local fishermen, and small-scale fisheries are allowed only for the domestic market. The zone is designated to ensure food security in Palau and the fish supply for tourists. Monitoring of illegal fishing is a challenge, which is being addressed. Previously, fishing vessels operating in Palau's EEZ monitored for poaching, but the monitoring by fishermen cannot be expected once the fishing activities are prohibited in the EEZ. As a result of these changes, the state will lose 5–10 million dollars of fishing rights from the foreign vessels annually. It is another issue for the state to secure the fund to strengthen a monitoring system.

The Protected Area Network Act was adopted in 2003 to enable the national government to be involved and to enhance the efficiency of protected areas by networking with the regional activities. The Act defines that the national government should provide technical assistance or funding to facilitate the effective management of protected areas in the region. At the State level, Koror state has set up strict regulations for visiting the Rock Islands Southern Lagoon (RISL), located in the south of Koror. RISL is a World Heritage Site and the most popular tourist site in Palau. Koror state collects $50 from visitors as an Entry Permit fee, which is used to strengthen monitoring in the RISL area. There are seven protected areas in RISL, and all areas are no-take. In the process of designation of no-take areas, the state government met with local fishermen and sought their cooperation. Currently, local fishermen are members of the advisory team of the Koror Pride Campaign which is conducted by the state government to enhance conservation of this marine ecosystem.

In summary, designating the National Marine Sanctuary may have negative impacts not only on the foreign-based fisheries but also on the domestic market. The bycatch of sword fish or *mahi mahi* fisheries are consumed locally, and represent 20% of the total catch. By restricting the fisheries in the EEZ, this bycatch cannot be distributed in the local market. Local fishermen are allowed to fish in the Domestic Fishing Zone, however they do not fish regularly, and therefore the supply of fish is likely to be intermittent. Consequently, the volume of fish used for local consumption is likely to decrease. Large increases in tourism can cause damage to the natural resources in Palau, as a result of overfishing due to the growth of demand for fish with increasing tourism. In conclusion, disseminating the "Sato-umi" concept may not be appropriate in Palau, because the current marine policy of Palau is leading to exclusion of the fisheries industry.

3.3 Analysis of human well-being in relation to environmental conditions

"Well-being" is defined by psychologists as involving peoples' positive evaluations of their lives such as positive emotions, engagement, satisfaction, and meaning. As defined in the Millennium Ecosystem Assessment, human well-being (HWB) has multiple constituents, including basic materials for a good life, freedom and choice, health, good social relations, and security. The HWB constituents, as experienced and perceived by people, are situation-dependent, reflecting local geography, culture, and ecological circumstances. These factors are complex and value-laden. In the present study, HWB is being explored as a means to connect ecosystem services, human well-being, and freedom of choice and action, and in part to understand motivations for these choices and actions.

The "Well-being CUBE" was developed to understand the structure of HWB in relation to the sea (*i.e.*, in a *Sato-umi* context). A short paper describing this approach is published in PICES Press (Hori, J. 2015. A psychological perspective on "human well-being": an international comparison of the well-being structure. PICES Press 23(2): 28-30). In Year 1, a survey of 1000 people in Japan was conducted to assess their relationships with the sea. In Year 2, the same questionnaire was used to survey 500 people in each Korea and the United States. In Year 3, a survey of 200 people was conducted in collaboration with BPPT in several Indonesian provinces. In Year 4, the same questionnaire was used to survey 500 people in each China and Russia. Preliminary results of these surveys are summarized in Figure 4, and show clear differences among countries.

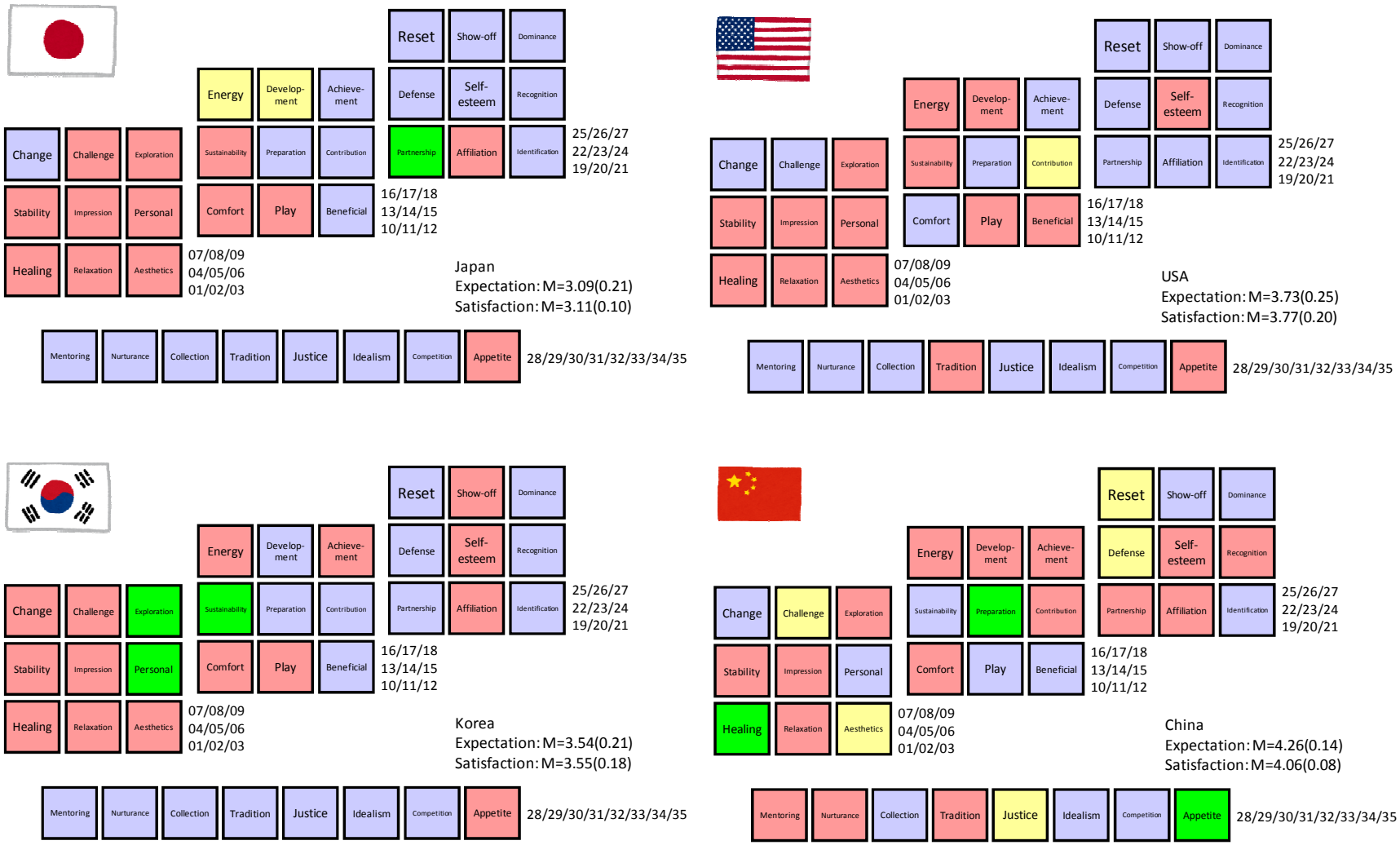

Fig. 4 Preliminary results of the well-being surveys conducted in four PICES countries for the MarWeB project. Red shows high-expectation and satisfaction needs, blue is low-expectation and satisfaction needs, yellow is high-expectation and low-satisfaction needs, and green is low-expectation and high-satisfaction needs. The clear differences among countries can be observed.

4. WORK PLAN FOR YEAR 5

(1) Project Science Team meetings

- Organize two Project Science Team meeting: in June 2016 in Victoria, BC, Canada and in November 2016 at the PICES Annual Meeting in San Diego, California, USA. The June meeting will focus on integration among the MarWeB activities, and development of the manual.

(2) Case studies

In Indonesia

- Conduct a third multi-trophic aquaculture pond experiment with Indonesian partners at Karawang experimental site, including site visit by Project Science Team members;
- Organize a workshop to develop manual and identify lessons learned regarding human-environment interactions (*Sato-Umi*) during the pond experiments.

In Guatemala

- Continue the pilot oyster project by providing further guidance to the involved community members of the village of La Barrona;
- Engage with the United Nations Development Programme (UNDP) to synergize the results of the MarWeB project with the goals of the recently funded UNDP project on Marine Protected Areas (MPAs) to develop the new MPAs proposed for the coastal communities of Las Lisas and Monterrico;
- Contribute to the establishment of a community outreach program at the Center for the Study of the Sea and Aquaculture (CEMA) in Monterrico, by providing an example of how to build and operate a sustainable aquaculture pond in the coastal region.

(3) Human well-being surveys

- Conduct web-based surveys in Canada;
- Analyze the data and review the results from the human well-being surveys conducted in all PICES member countries (Canada, China, Japan, Korea, Russia and USA) and Indonesia.

(4) Database

- Continue to develop the database containing a bibliography of human-natural systems interactions and the well-being survey data and information from the Indonesia and Guatemala case studies.

(5) Synthesis and integration

- Synthesis/integration of two case studies;
- Development of the manual and database.