PICES/MAFF PROJECT ON "*MARINE ECOSYSTEM HEALTH AND HUMAN WELL-BEING*"
FOURTH MEETING OF THE PROJECT SCIENCE TEAM
April 13, 2014
Kohala Coast, Hawaii, USA

The fourth meeting of the Project Science Team (PST) for the PICES/MAFF project on "*Marine Ecosystem Health and Human Well-Being*" (MarWeB), funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA), was held April 13, 2014, at Kohala Coast, Hawaii, USA. The meeting was co-chaired by Drs. Mitsutaku Makino (Japan) and Ian Perry (Canada).

The objective for this meeting was to review progress since the third PST meeting (October 10, 2013, Nanaimo, Canada), specifically:

- planning for the Guatemala case study;
- development of the Indonesia case study;
- preparing the detailed workplan for the Year 3 of the project (FY 2014: April 1, 2014 – March 31, 2015), with special attention to the 2014 PICES Annual Meeting in Yeosu, Korea.

The PST members and meeting participants are identified in *Appendix 1*.

1. ADOPTION OF THE AGENDA

The provisional agenda circulated prior to the meeting was adopted without changes (*Appendix 2*).

2. INTRODUCTION OF THE PROJECT

The goal of this project 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. In particular, considering that global changes are affecting both climate and human social and economic conditions, the project is expected to determine: (a) how marine ecosystems support human well-being, and (b) how human communities support sustainable and productive marine ecosystems.

Dr. Makino noted this was an 'extra' PST meeting, taking advantage of PST members attending the PICES FUTURE Open Science Meeting. He reviewed the background and context for the project and briefly summarised the major activities to date, including:

- First PST meeting in conjunction with PICES-2012 (October 11, 2012, Hiroshima, Japan);
- First Indonesia workshop (March 13–14, 2013, Jakarta and Karawang, Indonesia);
- Second PST meeting (June 10–12, 2013, Honolulu, USA);
- First Indonesia social survey (October 2–3, 2013, Karawang, Indonesia);
- Third PST meeting in conjunction with PICES-2013 (October 10, 2013, Nanaimo, Canada);
- Guatemala scouting visit (January 27–31, 2014, Guatemala City, Guatemala);
- Second Indonesia workshop and second social survey (March 24–27, 2014, Karawang, Indonesia);
- Fourth PST meeting (April 13, 2014, Kohala Coast, Hawaii, USA);
- Progress and financial reports for Year 1 (April 1, 2012 – March 31, 2013) submitted to MAFF in July 2013;
- Two articles published in PICES Press: Vol.21, No. 1 (winter 2013) and Vol. 21, No. 2 (summer 2013).

Reports from previous PST meetings and other project-related materials are available on the project website at http://meetings.pices.int/projects/marweb.

3. PROGRESS REPORTS

3.1 Annual Reports for Science Board and MAFF

The progress and financial reports for Year 1 (FY 2012: April 1, 2012 – March 31, 2013), accepted by MAFF/JFA, are available at the project website. Drafts of the progress and financial reports for Year 2 (FY 2013: April 1, 2013 – March 31, 2014) are due in June 2014 for submission to MAFF in July 2014. It was recommended to submit the 2014 progress and financial reports to MAFF together, and to post the Japanese version of the progress report on the project website.

3.2 Results of the third PST meeting

Dr. Perry briefly reviewed the report from the third PST meeting (October 10, 2013, Nanaimo, Canada). No revisions were requested, and the report is now available on the project website.

3.3 Plan for research activities and workshops in Guatemala

An exploratory trip to Guatemala was conducted January 27–31, 2014, to assess the possibility of Guatemala as a case study within the MarWeB project to evaluate the relationship between coastal communities and sea and the potential to develop the use of multi-trophic aquaculture as components of the "Sato-umi" initiative. Four representatives from PICES spent time meeting and discussing potential options for the work with government representatives, academic researchers and community leaders and members in Guatemala City and along portions of the Pacific coast. The reconnaissance team was made up of Dr. Vera Trainer (Northwest Fisheries Science Center, NOAA-Fisheries, USA), Dr. Charles Trick (University of Western Ontario, Canada), Dr. William Cochlan and Mr. Julian Herndon (Romberg Tiburon Center for Environmental Studies, SFSU, USA). A detailed report of this scouting visit is provided in *Appendix 3*.

On January 27, the MarWeB project goals were presented to University and other Guatemalan officials in Guatemala City. In turn, these officials provided an overview of the current and historical conditions of shrimp farming in Guatemala, including the government and academic support infrastructures associated with the industry. The feasibility of testing the addition of macro-algae to the shrimp ponds to improve water quality was discussed, as were opportunities to reduce environmental impacts and provide an additional commodity product along with the shrimp. A variety of unknowns quickly became apparent such as: (1) issues associated with introducing macro-algae to areas of the coast that do not naturally have these algae, (2) potential problems with making the water too clear for the shrimp to grow well, (3) adding a layer of complexity to cultivation systems and approaches that already work very well, and (4) a lack of financial incentive to change current practices.

The "well-being cube" approach to assessing human coastal well-being was presented to a well-educated test group of 5 University students, 1 social scientist and 1 laboratory technician. The English version was not understandable to them. Comments were provided that Guatemalans do not readily express their feelings to others, many coastal people are poorly literate (suggesting instead a group rather than individual approach to completing the questionnaire), and lack of clarity as to the objectives for the questionnaire.

A 3-day field trip to coastal villages occurred on January 28–30. The villages visited were Monterrico, Hawaii and Las Lisas. Complex relationships became apparent between members of the communities, shrimp farmers and government and academic institutions that varied in every community. These relationships appeared to be influenced by the degree of financial stability, the health of the estuaries and the degree of diversification of occupations, including fishing, aquaculture, agriculture and emerging tourism.

Recommendations from the scouting trip are:

<u>For social science pillar</u>:

- Separate "well-being cube" analysis and multi-trophic aquaculture as there is no link between them;
- Restructure or eliminate the "cube" (it will not add to our knowledge base);
- Replace "cube" with a community needs assessment model (assess differences in the determinants of health in a community).

<u>For multi-trophic aquaculture pillar</u>:

- Multi-trophic aquaculture for shrimp ponds will place primary aquaculture in serious jeopardy;
- The secondary product is of limited quality in Guatemala;
- Primary aquaculture is limited by money and land;
- The MarWeB project could introduce alternatives to shrimp aquaculture (*e.g.*, shellfish aquaculture);
- Tremendous experience in upper management level to support new aquaculture facilities (Guatemala does not need the MarWeB project to show them how to do aquaculture);
- Demand is currently not met by imports (freshness).

Possible objective: Collaborate with Guatemalan experts to expand economic potential (shellfish aquaculture), thereby bringing greater well-being to coastal communities. This would be a self-sustaining enterprise managed by a cooperative.

A proposal had been developed previously by Lic. Leonel Carrillo and Lic. Carolina Marroquin (University of San Carlos, Guatemala City) to enhance the culture of oysters. Its goal was to test the feasibility of growing, processing and marketing *C. gigas* (mangrove oyster) with the Integral Fisheries Cooperative, Pacific coast of Guatemala. The potential outcomes include the generation of incomes for coastal people, and improved health and well-being.

Proposed Guatemala workplan for 2014–2015:

Social science (How do marine ecosystems support human well-being?):

- A new social survey to be designed to address "Sato-umi in developing nations" (perhaps in collaboration with a recently graduated student with M.S. in Public Health);
- Translation of the revised survey into Spanish;
- Trip to Guatemala to perform social science assessment of "Sato-umi" with Silvia Guerra Bone (social science professor) and Guatemalan University students. Possible tools include community meetings, cameras, *etc.*;
- Outreach and acknowledgement could include distribution of books to community, cash thank-you, *etc.*;
- Another trip in 2015–2016 to bring this information back to the community;
- Suggested MarWeB leads are Drs. Trick and Trainer; most likely community would be Las Lisas, although an open question is why one community feels it is 'healthy', whereas adjacent communities feel they are not 'healthy' (*e.g.*, a possible comparison between Las Lisas and Hawaii or Monterrico).

Multi-trophic aquaculture (How do human communities support healthy marine ecosystems?):

- Focus on developing the oyster aquaculture project led by University of San Carlos professors with key collaborators, in particular its growth, processing and marketing (this would build upon existing expertise);
- Check progress and fulfillment of project goals regularly *via* Skype;
- Multi-trophic aquaculture possibilities can come next (if desired).

In discussion, the necessity for better communications between the two case studies (Indonesia and Guatemala) with respect to the social science studies was noted, *i.e.* the commodity chain mapping and pond culture experiments in Indonesia with the community contributions of oyster aquaculture in Guatemala. It was also recommended that a community needs approach (proposed by Dr. Trick) be adopted for Guatemala, with a focus on the three coastal communities visited here, to determine the local view of community health in relation to the sea. A broad web-based survey was recommended for the "well-being cube" analysis in Guatemala, possibly conducted in Year 4. A question was raised as to whether the commodity chain analysis approach, similar to that conducted in the Indonesia case study, should also be conducted in Guatemala. In regards to the oyster culture project, it was noted that to grow oysters and het them to market would likely take more than one year. Therefore, funds may be needed for a second year of his work.

Actions:

- The MarWeB leads on social study in Indonesia and Guatemala projects, Drs. Masahito Hirota and Charles Trick, to communicate their ideas and plans and try to collect comparable information.
- Dr. Trick to provide a community needs assessment model to the MarWeB Co-Chairs, and discuss the similarities and differences of the two approaches with Dr. Hirota to make them as common as possible.
- Dr. Trainer to examine the options and need for conducting a commodity change analysis in the Guatemala case study, comparable to that done in the Indonesia case study.

3.4 Pond experiments, training workshop, and research support plan in Karawang, Indonesia

Intensive shrimp aquaculture was developed in the Karawang area (3 hours from Jakarta) in the 1990s, and 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 shrimp monoculture.

A preferred approach would be integrated multi-trophic aquaculture (IMTA), possibly including seaweed, bivalves, shrimp and fish, which would have low emissions of deleterious materials into the natural environment and would help stabilize the coastline (forestation). In the social system, present practice is to export shrimp to Japan, Canada, USA, and the EU. It would be desirable to produce shrimp for export and to use other products for local consumption, local job creation, and improved food self-sufficiency.

MarWeB activities in Indonesia include the following:

Ecological systems
- Workshops to disseminate the concept of "Sato-umi" in Indonesia (March 2013, September 2014);
- Material circulation box-model construction (2013–);
- Training workshop for nutrient analysis and phytoplankton identification (March 2014);
- Pond experiment for IMTA (April 2014–).

Social systems
- Collection of basic social information (statistics) (January 2013–);
- Commodity chain analysis for IMTA products (October 2013–);
- Preliminary study using an "analytic hierarchy process" (AHP) approach to support local decision-making (AHP is a structured technique for organizing and analyzing complex decisions);
- Psychological analysis for well-being ("well-being cube" analysis) (January 2013–).

A Nutrient and Phytoplankton Training Workshop was held March 25–26, 2014, at the National Center for Brackishwater Aquaculture in Karawang. It was conducted for MarWeB by Dr. Mitsutaku Makino, Dr. Mark Wells, Mr. Julian Herndon and Mr. Brian Bill, with 16 official Indonesian participants (8 for nutrient analyses and 8 for phytoplankton identifications). The workshop began with an opening welcome ceremony, followed by Dr. Makino's lecture on "Sato-umi" concept, a presentation on the previous IMTA experiment conducted by Dr. Suhendar Sachomar (looking at the increased product output and not water quality aspects), a brief summary of the big picture of aquaculture and coastal ecosystem health issues by Dr. Wells, and then by hands-on training sessions. Overall, the workshop was felt to be a success, with the objectives fully met, and the sampling and analytical methods raised to the quality needed for publication of the pond experiment results (see below).

An experimental plan for a MarWeB-sponsored "Gempita" ("Sato-umi") pond experiment was developed, which would also take place at the National Center for Brackishwater Aquaculture in Karawang. A detailed experimental plan is provided in *Appendix 4*. The main purpose of this experiment is to investigate the effect of IMTA on: 1) the economic return of pond operation, and 2) the water quality of the ponds. Water quality is defined in terms of the (macro-)nutrient concentrations of nitrate/nitrite, ammonia, and phosphate, in addition to the other parameters (*e.g.*, salinity, oxygen, phytoplankton, bacteria, *etc.*). The hypothesis being studied is whether the addition of bivalves (oyster) and *Gracilaria* (seaweed) into pond aquaculture of fish (Tilapia species) or shrimp will allow successful growth of all species, and decrease the nutrient (nitrite/nitrate, ammonia, phosphate) concentrations in the pond waters.

In practice, the experiment is a balancing act between maintaining high biomass but low nutrients, *i.e.* adding two "stressors" to the pond environment: oysters to remove excess phytoplankton and seaweed to remove excess nutrients. A short follow-up visit to Karawang in late June/early July by Dr. Wells is recommended to assess progress to date and to respond to any issues that may have arisen.

3.5 Progress of social research for Indonesia

Social science field research in Karawang was conducted from March 24–27, 2014. It focused on mapping of the commodity chains and collection of statistics in Indonesia. This information consisted of questions on:
- "human dimensions" (number of employees, income level of owner and employees, employee's education, age, sex, side jobs, work schedule, welfare or medical costs in terms of employment);
- business matters (commodities and commodity chain, value and amount of production, price, types of trading partners);
- technical matters (original method, costs, environmental damages, new culture methods, strategies and perspectives on the future).

A revised/updated commodity chain map for Karawang marine culture was presented by Dr. Hirota (Fig. 1).

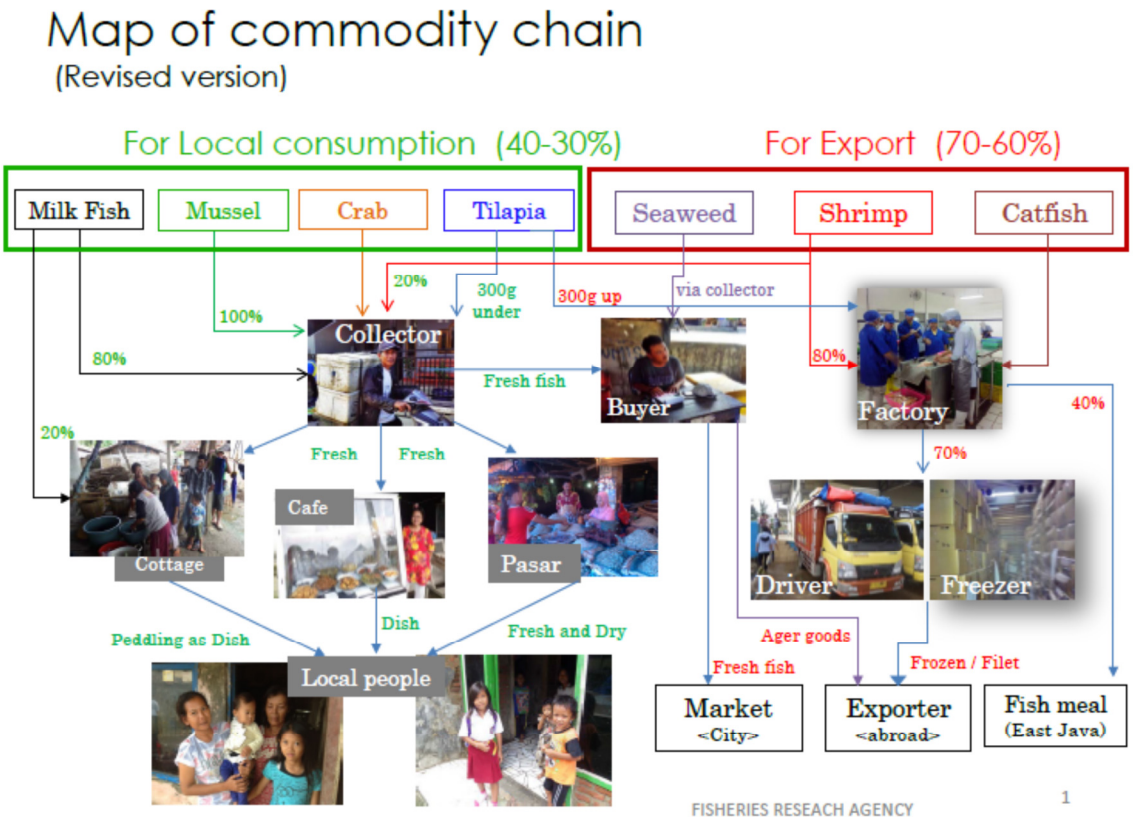

Fig. 1 Revised commodity chain map for marine aquaculture products in Karawang, Indonesia (from presentation by M. Hirota at the fourth PST meeting, April 13, 2014).

Ms. Juri Hori presented new results on the "well-being cube" approach applied to Indonesia (surveying 200 respondents and carried out in collaboration with Indonesia BPPT). To date, "cube" analyses have been conducted in Japan, Korea, and the United States, each showing distinctly different results. Overall results for Indonesia were consistent with a "high expectation" type outcome, although results for different regions within the country showed different outcomes. There are many important factors ("cube" pieces), and the challenge is to identify those that contribute most to happiness.

The 2014–2015 workplan for Indonesia was proposed to include:

- Follow-up visit to Karawang by Dr. Wells (June 2014): Pond experiment and theoretical modeling processes;
- Third Indonesia workshop for manual development in Pekalongan in September 2014 (location selected by Indonesian partners);
- Third social survey in Karawang by Dr. Hirota and Ms. Hori; one of goals is to increase the sample size for the AHP analysis from the current 6 to 50 to be achieved using paper surveys conducted in collaboration with BPPT to translate from English to Indonesian.

In discussion, the PST encouraged the publication of the "well-being cube" concept and the initial analyses of the surveys in Japan, Korea and the US (and possibly Indonesia) or at least for Japan and one other country. Therefore, "well-being cube" surveys in the remaining PCIES member countries (Russia, China and Canada) may need to wait until Year 3, or possibly in Year 4 of the MarWeB project.

3.6 Topic Session on IMTA at PICES-2014 at Yeosu, Korea

The MarWeB-sponsored Topic Session at the 2014 PICES Annual Meeting, titled "*Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture*" (Session S11), has been prepared

and is described in *Appendix 5*. In discussion, a field trip was suggested to an IMTA site near Yeosu. This would be coordinated with a Korean co-convenor of this session, and an appropriate date would need to be found within the (already busy) schedule for this meeting.

Action: Dr. Hirota to work with Dr. Naesun Park about possible arrangements.

4. PROJECT MANAGEMENT

4.1 Revision of PST membership

It was suggested to replace Dr. Dohoon Kim (National Fisheries Research and Development Institute, Korea) with Dr. Jungho Nam (Maritime Institute, Korea). Also, Dr. Charles Trick (University of Western Ontario, Canada) was recommended as a new member, with special responsibility for co-ordinating the Guatemala case study.

4.2 Project case studies

The original plan for the MarWeB project included 3 case studies: Indonesia, Guatemala, and Palau. It is now recommended to discontinue Palau as a case study because of: (1) reductions in the MarWeB annual budget and (2) banning of fishing and conversion of the entire Palau's EEZ into a marine protected area.

Action: Dr. Makino to discuss dropping the Palau case study with the responsible officer at MAFF.

5. DISCUSSION ON THE YEAR 3 (APRIL 1, 2014 – MARCH 31, 2015) PLAN AND BUDGET

The estimated budget for Year 3 (FY 2014: April 1, 2014 – March 31, 2015) is $75,000 – $85,000. In addition, about $35,000 was carried over from Year 2 (FY 2013: April 1, 2013 – March 31, 2014). After removal of the PICES overhead, about $105,000 remains for MarWeB activities in Year 3. The PST recommends the following as a budget for its activities in Year 3 (all numbers are Canadian dollars):

Indonesia		
Follow-up visit by Dr. Wells in June (Pond experiment and model instruction)	$ 2,000	$30,000
3rd Social survey by Dr. Hirota and Ms. Hori	$ 5,000	
3rd Workshop for manual development in Pekalongan (incl. travel costs for Drs. Makino and Hirota)	$23,000	
Guatemala		
2nd Guatemala Workshop (Dr. Trainer lead)	$50,000	$50,000
Palau		
Meetings		
Travel support for Hawaii FUTURE OSM meeting	$ 8,000	$25,000
Travel support for PICES 2014 Annual Meeting	$16,000	
IMTA field trip in Yeosu	$ 1,000	
TOTAL		**$105,000**

6. OTHER MATTERS

No additional items were suggested.

7. CONCLUDING REMARKS

Dr. Makino thanked the participants for their on-going efforts in support of the MarWeB project. The meeting was adjourned at 1800.

Appendix 1

Project Science Team membership

Harold (Hal) Batchelder	PICES Secretariat
Keith Criddle	University of Alaska, Fairbanks, USA
Masahito Hirota	Fisheries Research Agency, Japan
Juri Hori	Rikkyo University, Japan
Dohoon Kim	National Fisheries Research and Development Institute, Korea)
Suam Kim	Pukyong National University, Korea
Mitsutaku Makino (Co-Chairman)	Fisheries Research Agency, Japan
Grant Murray	Institute for Coastal Research, Canada
Ian Perry (Co-Chairman)	DFO, Pacific Biological Station, Canada
Thomas Therriault	DFO, Pacific Biological Station, Canada
Vera Trainer	Northwest Fisheries Science Center, NOAA-Fisheries, USA
Mark Wells	University of Maine, USA

Participants of the fourth Project Science Team meeting for the PICES/MAFF project on "Marine ecosystem health and well-being". Left to right: Masahito Hirota, Suam Kim, Mitsutaku Makino, Vera Trainer, Alexander Bychkov, Yuri Hori, Ian Perry, Thomas Therriault and Harold Batchelder.

Appendix 2

Fourth Project Science Team meeting agenda

1. Adoption of the agenda
2. Introduction of the project and this meeting (Co-Chairs)
3. Progress reports
   - 3.1 Annual Reports for Science Board and MAFF (Co-Chairs)
   - 3.2 Results of the third PST meeting (Co-Chairs)
   - 3.3 Plan for the research activities and workshops in Guatemala (Vera Trainer)
   - 3.4 Pond experiments, training workshop, and research support plan in Karawang, Indonesia (Mark Wells and Mitsutaku Makino)
   - 3.5 Progress of social research for Indonesia (Masahito Hirota and Juri Hori)
   - 3.6 Topic Session on IMTA at PICES-2014 (Masahito Hirota and Mark Wells)
   - 3.7 Other reports

4. Project management
   4.1 Revision of PST membership (Co-Chairs)
   4.2 Project case studies (Co-Chairs)
5. Discussion on the Year 3 (April 1, 2014 – March 31, 2015) plan and budget
6. Other matters
7. Concluding remarks

Appendix 3

MarWeB Guatemala Scouting Visit Report

An exploratory trip to Guatemala was undertaken in January of 2014 to assess the possibility of conducting a survey to evaluate the relationship between coastal communities and sea and the potential to develop and evaluate the use of multi-trophic aquaculture as components of the "Sato-umi" initiative funded through the government of Japan. Four representatives from PICES spent time meeting and discussing potential options for the work with government representatives, academic researchers and community leaders and members in Guatemala city and along portions of the Pacific coast. The reconnaissance team was made up of Dr. Vera Trainer (Northwest Fisheries Science Center, NOAA-Fisheries, USA), Dr. Charles Trick (University of Western Ontario, Canada), Dr. William Cochlan and Mr. Julian Herndon (Romberg Tiburon Center for Environmental Studies, San Francisco State University, USA).

An introductory meeting took place on January 27, with Guatemalan researchers and officials at the Center for the Study of the Sea and Aquaculture (CEMA) of the University of San Carlos (USAC) and included Leonel Carrillo (Lic., MS, CEMA professor), Carolina Marroquin (Lic., MS, CEMA professor), Carlos Francisco Marin Arriola (Ing., Director of Fisheries and Aquaculture Regulatory Division, Vice-ministry of Agricultural Health and Regulations, Ministry of Agriculture, Cattle and Food (MAGA)), Luis Arturo Lopez Paredes (Lic., Head of Department of Continental Fishing, Fisheries and Aquaculture Regulatory Division, MAGA), Roberto Gutierrez (Lic., Head of Department for Hydrobiological Development, VIDER, MAGA) and Silvia Guerra Bone (Lic., MS, a social scientist w/degrees in Aquaculture and Rural Development).

The MarWeB project goals were presented to University and other Guatemalan officials. In turn, these officials provided an overview of the current and historical conditions of shrimp farming in Guatemala, including the government and academic support infrastructures associated with the industry. The feasibility of testing the addition of macro-algae to the shrimp ponds to improve water quality was discussed, as were opportunities to reduce environmental impacts and provide an additional commodity product along with the shrimp. A variety of unknowns quickly became apparent, including: (1) issues associated with introducing a macro-algae to areas of the coast that do not naturally have macro-algae, (2) potential problems with making the water too clear for the shrimp to grow well, (3) adding a layer of complexity to cultivation systems and approaches that already work very well, and (4) a lack of financial incentive to change current practices. Some of the aquaculture facilities use seawater mixed with fresh water from wells and some use water straight out of the local estuaries along the coast. Waste water, usually dumped at the end of harvest, is pumped out, untreated to the estuary or beach. Typically there are no water exchanges during the cultivation period, but water is added to replenish that lost to evaporation or infiltration through the sand and clay bottom ponds (newer ponds are plastic lined, reducing this problem). The aquaculture officials were informed about our intent to work with academic colleagues in Guatemala and their students at the test lab on the coast. Ideally, a shrimp farmer who is really interested in collaboration would permit us expand to a commercial site.

The majority of shrimp aquaculture in Guatemala is on the Pacific side. Benthic trawling for shrimp in the ocean has decreased in output over the years, and the fleet has dwindled, likely as a result of overfishing reducing stocks and increased fuel costs affecting the profit margin. In 2013, there were 39 farms operating on 1,070 hectares of land and employing approximately 1200 people. The price for shrimp is as high as it is ever been. Domestic shrimp consumption has increased since 2007 and is a special treat, mostly associated with vacations to the coast or parties and drinking on weekends because of its expense. In general, there are 3 shrimp harvests per year. Mexico's shrimp production has decreased due to viruses. There are fewer problems with viruses in Guatemala – smaller farms are better controlled with regards to feeding rates and environmental

conditions such as temperature, salinity, oxygen, *etc*. They do not exchange water, so they also do not exchange disease with their neighbors. The new shrimp disease (EMC – a type of *Vibrio* parahemolyticus with a phage or something that makes it toxic) was imported from Asia to Mexico. For this reason, imports from Mexico to Guatemala are now closed (no nauplii imported).

Lic. Bone, the social scientist, indicated that it is difficult for Guatemalans to express feelings, especially to strangers. A 3–4 page survey is the maximum that could be done or, perhaps, something more tangible than a written survey would be better. It is more common and appropriate to ask questions to village leaders during workshops.

The "well-being cube" questionnaire was presented to a well-educated test group of 5 University students, 1 social scientist and 1 laboratory technician. The English version was not understandable to them. They could not even complete the first page of the questionnaire. For example, they did not know whether the questionnaire meant "sea or whole coast – estuary or related area".

Suggestions from the test group regarding the survey:
- Some of the questions could have been combined.
- Draw the sea and show your relationship with it (given to families); draw a picture of yourself with the sea.
- Some freedom is needed for participants to express their relationship with the sea. However, it was not known how results could be measured if such freedom was given.
- There was concern that if participants were given choices that they would tell you what they thought you want to hear.
- Fishermen in the sea *vs*. estuary are very different.
- Lic. Bone requested clarifications on our objective as her goal was so to find a better way to ask our questions in Guatemala where the literacy rate is very low.
- Group *vs*. individual questionnaires are desired because (1) some leaders do not read or write, (2) some individuals are too shy, (3) individuals will give you the answers that you want, (4) Guatemalans are not good at expressing feelings – seamen are supposed to be tough, and (5) there will be no expression of feeling to someone who is not part of the community.

Suggestions for workshops:
- Guides work with students;
- Look at needs that their professional backgrounds can address;
- Questions to ask – (1) how do you invest time? (2) socio-economic questions and needs (male/female, income), (3) conflict between mayor and religious leader.
- There may be better reception with some groups *vs*. others. Students and Lic. Bone have worked with fisherman, but others may not be as receptive.
- Discussion?
- Pictures? Either draw pictures or give disposable cameras to families.

Some communities (few) have health centers where they get vaccines. However, students have information on specific communities – Is it ok to work with these "known" communities rather than working toward coast wide surveys? Health and economic data may be available from past studies. Use FACT model *vs*. CUBE model?

Needs for the scientific study:
- Shrimp feed is required as it is the largest expense, along with electricity for aerators.
- Analytical equipment is kept at labs in Guatemala City because the coast lab is not secure. Autoanalyzers are found at University of San Carlos' water quality labs.

A 3-day field trip to coastal villages occurred on January 28–30, with stops in Iztapa, Monterrico, Hawaii and Las Lisas. We met with a wide spectrum of community members, including shrimp farmers, fishers, leaders from community development associations, fishing associations and cooperatives, shrimp hatchery managers and technicians and government officials, and had the opportunity to tour an assortment of shrimp farms using old and new methods of production. We also toured the only operating shrimp hatchery in the country and got an in-depth overview of the state of the technological abilities of the local production facilities and a summary of the historical events and scientific research that have led to the current shrimp seed supply and cultivation approach in Guatemala.

Through these interactions, complex relationships became apparent between members of the communities, shrimp farmers and government and academic institutions that varied in every community. These relationships appeared to be influenced by the degree of financial stability, the health of the estuaries and the degree of diversification of occupations including fishing, aquaculture, agriculture and emerging tourism.

Many expressed concern regarding the apparent environmental degradation that has reduced the availability of fish and shrimp in the estuaries, possibly resulting from (1) effluent from shrimp farm affecting marine and estuary life, (2) effluent from sugar cane releases following heavy rains carry pesticides and sediment load to the estuaries and the sea, and (3) overfishing through the use of illegal nets with increasingly smaller holes. Currently, a common technique is to use window screening intended to keep mosquitoes out of homes to fish in the estuary. In one town meeting, a life-long fisherman, Mr. Jose Manuel Diaz, who at "over 50" believes himself to be a very old man, proceeded to give an apparently unrehearsed assessment of their communities' current predicament, roughly paraphrased as follows:

"*I am an old man of over 50 years. I have been a fisherman my whole life. We destroyed our own fisheries, both the estuary and the ocean. This is the reason why we have no jobs. All we know is the sea and fishing. As fishermen we spend our time finding ways to improve our profession. We made better nets and so did my colleagues, up to and including using window screening, so now we are catching everything that is left. We have no choice but to catch whatever we can to feed our families and pay our bills. I believe that within two years there will be nothing left. Some people get out of fishing and find work at a hotel for 5-6 hours and earn only 50 quetzals (about $6 USD). Alternatives include shrimping illegally or harvesting and selling turtle eggs. If they are confiscated by the police, the police sell them.*"

This statement, which was more plainly and sincerely given than what we can convey here, and was considerably longer than what we have annotated, was strongly supported by the rest of the group present. Dr. Trick asked if it would be OK to share their story. Then, perhaps together we could find alternatives for their community. They want to share their story for the benefit of today's youth.

A final meeting with Lic. Carrillo and Lic. Marroquin was held on Friday, January 31. Possibilities for science project include:

- Marine fish and inland ponds – Mexico has experience with this approach. *Lutjanus* (red snapper) and *Centropomus* (robalo) are both carnivores but feed on invertebrates in the first year. Both can be purchased in Mexico and Costa Rica. They were not careful in previous attempts to bring these fish into culture.
- Mollusk cultivation. A student did some work at Las Lisas – she mistakenly used a pearl oyster instead of a food oyster. A market study was done for oysters in a village near El Salvador. A proposal has been written for shellfish cultivation in Las Lisas. Students were going to measure fecal coliform and heavy metals in the proposal (total cost was $16–20,000 US). Students (after school) and women were involved in the project and could run it. Lic. Marroquin thinks the proposal would cost ~$10,000 without the heavy metal or fecal coliform testing (just for the shellfish culture). Dr. Trick mentioned potential Canadian funding for Guatemala – sustainable foods directed by women.
- Lic. Carrillo – 2000 red Tilapia in marine water (tolerate salinity up to 32 ppt) – can be called "cherry snapper" instead of Tilapia. There is a possibility for multitrophic aquaculture of this Tilapia with shrimp.
- The mayor of Iztapa was interested in providing Tilapia seed to families. He is willing to give equipment and seed. An idea for a "cherry snapper festival" was discussed. Seawater grown red Tilapia is supposed to taste better than freshwater grown varieties, however feed would be the big expense.
- Multi-trophic: bacteria – phytoplankton – shrimp. Bacteria reduce organic loads – promote the use of bacteria at more of the farms. ~25% of the shrimp farmers do not use bacteria.
- Seaweed (macro-algae) idea is not going to work given the current operational success of shrimp cultivation in Guatemala.

Social science:

- How can we do "Sato-umi" better? Dr. Trick has a student who can do a practicum in Guatemala. Cost will be $5,000. Need to know early next year for May 2015.

Summary:

There is definitely an important relationship between the Guatemalan coastal communities and the sea. At the most fundamental level it is a source of livelihood for many and a component of their immediate environment. Characterizing the relationship may be difficult given the cultural barriers and apparent literacy problems of portions of the coastal population. We encountered a diverse group of people and were surprised that the narrative regarding the relationship to the sea that we learned in each village had to be updated or altered to reflect the different experiences and attitudes of the people we met in the different towns. The successes and troubles of each area were different, even though at first glimpse, each town appeared similar, and they were all in close proximity to each other. We found the people on the coast to be initially guarded in their interaction with us, but quickly warmed to us and our proposal to study their communities. There was a definite interest in any type of project-based aid that we could provide or help facilitate. The people we spoke to were courteous, well-spoken and took their meetings with us seriously as they sent their community leaders, well dressed and organized to meet us and listen to what we had to say. In our colleagues at the University of San Carlos we have found individuals committed to the education and improvement of the students they mentor and dedicated to trying to make their country a better place for all of its people. Their country appears to be making a concerted effort to lift itself out of the current disarray and economic stagnation influenced by the violent civil war and political repression of the past.

As for multi-trophic aquaculture, it is difficult to say if there is a way to integrate macro-algae to the existing shrimp farm infrastructure in a way that will be beneficial and sustainable in real life practice. The shrimp aquaculture is strong, well-organized and very successful, especially considering the lack of sophisticated regional analytical facilities and the apparent low budget approach utilized by most of the facilities. It demonstrates a strong will to succeed and impressive resourcefulness.

Recommendations:

Social survey: The current survey is too long and complex as well as not clearly translated from Japanese to English to be effective in any of the potential study sites in Guatemala. A different approach will be necessary if there is any useful knowledge to be gained. Options for the social survey need to be discussed, but may include a shorter survey with different sections, some multiple-choice and some allowing for more creative answers like written responses or drawings. Perhaps the use of disposable cameras distributed to individuals or families in the area would yield a better picture of the communities' relationship with the sea. A local social scientist working with a member of the PICES group or a US or Canadian graduate student may work. Care needs to be taken in deciding how to distribute cameras or in selecting members of the community to take the survey. It is imperative to work with the community leaders and academics we encountered to ensure a successful outcome of any social science study.

Multi-trophic cultivation: It is clear that the shrimp farming industry is in a very good shape. There are knowledgeable technical staff and business personnel involved, and there is strong support from the Guatemalan government and academic institutions. The shrimp farmers will likely be risk averse and hesitant to try out something that has not been demonstrated. Adding macro-algae to shrimp ponds may not add much value or benefit to the current infrastructure. Perhaps a different type of multi-trophic activity would be more successful. Two potential projects present themselves initially:

(1) Combining red Tilapia in marine water with shrimp and a bacterial flocculation community may be one possible approach. There is existing infrastructure and knowledge for Tilapia cultivation in the country. Choosing a community close to the CEMA laboratory on the coast would ensure easier collaboration with aquaculture students and faculty doing work on the coast. In Iztapa there may even be support from the mayor and municipal resources.
(2) A project already previously outlined by CEMA faculty and students for oyster cultivation in the town of Las Lisas would be easier to get off the ground. There is an existing proposal, including a market study that was submitted to the Guatemalan government, but was not funded as the funds were given to a fishing cooperative instead.

Whatever the chosen project, it is important that sufficient funds and time be allocated to a single project in order to maximize the chance of success in one community and to have a demonstration of what is possible for other communities to see and potentially follow. It should be a community based project that allows for not

only integration of multi-trophic cultivation technology, but also successful interaction with community members who feel left out of the rapidly changing economic and environmental situation in their towns.

Appendix 4

Gempita (Sato-umi) Pond Experimental Plan

National Center for Brackishwater Aquaculture, Karawang

Purpose

The main purpose of the Gempita pond experiment is to investigate the effect of integrated multitrophic aquaculture (IMTA) on: 1) the economic return of pond operation, and 2) the water quality of the ponds. Here, we define water quality in terms of the (macro-)nutrient concentrations of nitrate/nitrite, ammonia, and phosphate, in addition to the other parameters (*e.g.*, salinity, oxygen, phytoplankton, bacteria, *etc*.).

Hypothesis

The addition of bivalves (oyster) and *Gracilaria* (seaweed) into pond aquaculture of fish (Tilapia species) or shrimp (species) will allow successful growth of all species, and decrease the nutrient (nitrite/nitrate, ammonia, phosphate) concentrations in pond waters.

Ideal pond conditions

The optimal pond conditions for shrimp and fish are a high phytoplankton biomass, including diatoms and green algae, with low light penetration. The phytoplankton provide additional food which enhances the flavor of the shrimp and fish. Low light penetration is preferred as it creates less stress for the shrimp (and fish?) and prevents the growth of grasses in the pond. For these reasons, nutrients (nitrate, phosphate) are added to high concentrations at the very start, quickly ramping up and maintaining high biomass over the pond duration. In some cases, silicate also is added to encourage diatom growth.

Experimental design

The experiment will use 4 x 4000 m^2 ponds at the National Center for Brackishwater Aquaculture, Karawang:
Pond 1 – Shrimp only
Pond 2 – Shrimp + *Gracilaria* + oysters
Pond 3 – Tilapia only
Pond 4 – Tilapia + *Gracilaria* + oysters

All ponds are being prepared for an early May start, which depends on them drying out sufficiently before adding the brackish water. Water will be drawn from a tidal canal, mixed with river water, if needed, to establish a low salinity (~17-20 ppt?).

Gracilaria will need to be placed in enclosures (10 cages distributed around the pond) to prevent the fish feeding on it. These cages will use as large a net mesh size as feasible to maximize the water flow through them. We will use the same distribution of cages for the *Gracilaria* in the shrimp ponds, again using the largest net mesh size as appropriate.

The oysters will be placed in several (10?) designated patches where the bottom sediment is selected to be appropriate for the oysters. Using these patches (rather than distributed randomly across the pond bottom) will help us for sampling and monitoring of oyster health and survival.

It is essential that the primary aquaculture species (shrimp and Tilapia species) are successfully raised for market. If these species begin to experience poor health or growth success during the experiment, conditions must be altered at the discretion of Mr. Waru to ensure a healthy outcome.

Sampling

A primary measure needed in this experiment is the total amount of biomass product achieved (shrimp, Tilapia, *Gracilaria* and oysters). In addition to assessing the health and growth rates of these species on a regular (monthly?) basis, the following water quality measurements will be made:

<u>Two times per week:</u> Temperature, salinity, dissolved oxygen, pH, ammonium, nitrate/nitrite, phosphate, silicate (we need to send down the kit for this measurement), light penetration (Secchi);

Once per week: Suspended solids, chlorophyll a, phytoplankton community composition, bacteria (total + total vibrio);

Once every 2 weeks: Total organic matter.

Pond operation

As mentioned above, the primary concern is that the Tilapia and shrimp species remain healthy during the pond experiment. A concern raised by Mr. Wadi is that *Gracilaria* may decrease the nutrients too much, decreasing then the phytoplankton abundance impacting both the Tilapia and shrimp, as well as possibly allowing light to penetrate to the bottom of the pond (which would allow grass growth). To avoid this problem, Mr. Wadi will vary the amount of *Gracilaria* in the pond as needed, either cutting it back or removing it entirely if nutrient levels drop too far. Ideally, we will find a balance, where nutrient concentrations are decreased but not enough to adversely affect the phytoplankton biomass.

Day-to-day management

Mr. Wadi will use his considerable expertise to manage the ponds on a day-to-day basis, making the changes he feels are essential to maintain the health of the shrimp and Tilapia. Drs. Suhendaran and Wells will keep in close contact, with weekly updates and data exchanges with Agus Dwiono and Atri Triana. When difficulties arise, they will communicate by phone and/or e-mail to determine the best steps to take, but will defer to Mr. Wadi's final assessment of the best way forward.

Appendix 4

Proposal for a ½-day MarWeB Topic Session at PICES-2014 (Yeosu, Korea)

Title: *Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture*

Co-Convenors: Masahito Hirota (Japan), Jianguang Fang (China), Mitsutaku Makino (Japan), Grant Murray (Canada), Naesun Park (Korea) and Mark Wells (USA)

Invited Speakers:
Thierry Chopin (University of New Brunswick, Canada)
Mark Flaherty (University of Victoria, Canada)
Susanna Nurdjaman (Bandung Institute of Technology, Indonesia)
Suhendal Sachoemar (Indonesian Agency for the Assessment and Application of Technology, Indonesia)

Several recent studies and reports suggest that increased aquaculture production is essential if we are to meet the growing world demands for marine protein. However, the rapid current development of intensive fed aquaculture (*e.g*., finfish and shrimp), in both developed and developing countries, has generated concerns about the environmental impacts of these often monospecific practices. To help address such issues, Integrated Multi-Trophic Aquaculture (IMTA) has been attracting global attention as a means to conduct aquaculture activities, while at the same time improving/rehabilitating coastal environmental conditions and improving the well-being of the people living in coastal areas. By integrating fed aquaculture with inorganic and organic extractive aquaculture (seaweed and shellfish), the wastes of one resource become a resource (fertilizer or food) for the others. This "ecosystem-like" approach provides nutrient bioremediation capabilities, mutual benefits to the co-cultured organisms, economic diversification by production of other value-added marine products, and increased profitability and food security for the local community. This session seeks contributions and case studies of how to implement and conduct IMTA activities, in particular that reduce negative impacts to the quality of the local environment and improve the well-being of the local human communities. Examples of activities in tropical and semi-tropical locations are particularly welcome, as well as examples of general methods and approaches that can be applied in many different environments. This session is a contribution of, and towards, the work of the PICES Project on "*Marine ecosystem health and human well-being*" (MarWeB).